Derailment of CN Freight Train U70691-18 With Subsequent Hazardous Materials Release and Fire
Cherry Valley, Illinois
June 19, 2009

Accident Report

NTSB/RAR-12/01
PB2012-916301

National Transportation Safety Board

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Railroad Accident Report

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National
Transportation
Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2012. ***Derailment of CN Freight Train U70691-18 With Subsequent Hazardous Materials Release and Fire, Cherry Valley, Illinois, June 19, 2009*****. Railroad Accident Report NTSB/RAR-12/01. Washington, DC.**

Abstract: About 8:36 p.m., central daylight time, on Friday, June 19, 2009, eastbound Canadian National Railway Company freight train U70691-18, traveling at 36 mph, derailed at a highway/rail grade crossing in Cherry Valley, Illinois. The train consisted of 2 locomotives and 114 cars, 19 of which derailed. All of the derailed cars were tank cars carrying denatured fuel ethanol, a flammable liquid. Thirteen of the derailed tank cars were breached or lost product and caught fire. At the time of the derailment, several motor vehicles were stopped on either side of the grade crossing waiting for the train to pass. As a result of the fire that erupted after the derailment, a passenger in one of the stopped cars was fatally injured, two passengers in the same car received serious injuries, and five occupants of other cars waiting at the highway/rail crossing were injured. Two responding firefighters also sustained minor injuries. The release of ethanol and the resulting fire prompted a mandatory evacuation of about 600 residences within a 1/2-mile radius of the accident site. Monetary damages were estimated to total $7.9 million.

As a result of this accident investigation, the National Transportation Safety Board makes safety recommendations to the U.S. Department of Transportation, the Federal Railroad Administration, the Pipeline and Hazardous Materials Safety Administration, the Association of American Railroads, the American Association of State Highway and Transportation Officials, the National Association of County Engineers, the American Public Works Association, the Institute of Transportation Engineers, the National League of Cities, the National Association of Counties, the Association of State Dam Safety Officials, the National Association of Towns and Townships, the U.S. Conference of Mayors, and the Canadian National Railway Company. The National Transportation Safety Board also reiterates two previously issued recommendations to the Federal Railroad Administration and to the Pipeline and Hazardous Materials Safety Administration.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Acronyms and Abbreviations

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
AEI	automatic equipment identification
AREA	American Railroad Engineering Association
AREMA	American Railway Engineering and Maintenance of Way Association
ASME	American Society of Mechanical Engineers
ASOS	Automated Surface Observing Systems
BNSF	BNSF Railway
CDT	central daylight time
CFR	*Code of Federal Regulations*
CN	Canadian National Railway Company
CVFPD	Cherry Valley Fire Protection District
DOT	U.S. Department of Transportation
DOT-111	Tank cars built to DOT specification 111-A100W1
EMS	emergency medical services
EPA	U.S. Environmental Protection Agency
FRA	Federal Railroad Administration
GPS	Global Positioning System
HM-ACCESS	hazardous materials–automated cargo communications for efficient and safe shipments
IC	incident command
ksi	kips per square inch (1 kip equals 1,000 pounds of force)
MP	milepost
NASA-TLX	National Aeronautical and Space Administration Task Load Index

NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PHMSA	Pipeline and Hazardous Materials Safety Administration
psig	pounds per square inch, gauge
RFD	Rockford Fire Department
ROC	regional operations coordinator
RSPA	Research and Special Programs Administration (predecessor to the Pipeline and Hazardous Materials Safety Administration)
RTC	rail traffic controller
SWM	storm water management
TMDS	Train Management Dispatching System
TTML	Tensile Testing Metallurgical Laboratory
UP	Union Pacific Railroad

Executive Summary

About 8:36 p.m., central daylight time, on Friday, June 19, 2009, eastbound Canadian National Railway Company freight train U70691-18, traveling at 36 mph, derailed at a highway/rail grade crossing in Cherry Valley, Illinois. The train consisted of 2 locomotives and 114 cars, 19 of which derailed. All of the derailed cars were tank cars carrying denatured fuel ethanol, a flammable liquid. Thirteen of the derailed tank cars were breached or lost product and caught fire. At the time of the derailment, several motor vehicles were stopped on either side of the grade crossing waiting for the train to pass. As a result of the fire that erupted after the derailment, a passenger in one of the stopped cars was fatally injured, two passengers in the same car received serious injuries, and five occupants of other cars waiting at the highway/rail crossing were injured. Two responding firefighters also sustained minor injuries. The release of ethanol and the resulting fire prompted a mandatory evacuation of about 600 residences within a 1/2-mile radius of the accident site. Monetary damages were estimated to total $7.9 million.

The National Transportation Safety Board determines that the probable cause of the accident was the washout of the track structure that was discovered about 1 hour before the train's arrival, and the Canadian National Railway Company's (CN) failure to notify the train crew of the known washout in time to stop the train because of the inadequacy of the CN's emergency communication procedures. Contributing to the accident was the CN's failure to work with Winnebago County to develop a comprehensive storm water management design to address the previous washouts in 2006 and 2007. Contributing to the severity of the accident was the CN's failure to issue the flash flood warning to the train crew and the inadequate design of the DOT-111 tank cars, which made the cars subject to damage and catastrophic loss of hazardous materials during the derailment.

The following safety issues were identified during this accident investigation:

- Effectiveness of the CN's internal emergency communication system
- Effectiveness of the CN's weather alert policies and rules
- Vulnerability of the DOT-111 tank car shells and fittings to damage and subsequent release of lading during derailments
- Inspection and maintenance of storm water detention ponds
- Accuracy of train consist (a listing of all the cars and their order within the train) information
- Construction standards for underground pipelines at railroad crossings
- Adequacy of storm water drainage system assessment
- The CN's toxicology and fatigue evaluations

As a result of this accident investigation, the National Transportation Safety Board makes safety recommendations to the U.S. Department of Transportation, the Federal Railroad Administration, the Pipeline and Hazardous Materials Safety Administration, the Association of American Railroads, the American Association of State Highway and Transportation Officials, the National Association of County Engineers, the American Public Works Association, the Institute of Transportation Engineers, the National League of Cities, the National Association of Counties, the Association of State Dam Safety Officials, the National Association of Towns and Townships, the U.S. Conference of Mayors, and the Canadian National Railway Company. The National Transportation Safety Board also reiterates two previously issued recommendations to the Federal Railroad Administration and to the Pipeline and Hazardous Materials Safety Administration.

1. Factual Information

1.1 Accident Synopsis

About 8:36 p.m., central daylight time,[1] on Friday, June 19, 2009, eastbound Canadian National Railway Company (CN) freight train U70691-18 (the accident train) derailed at a highway/rail grade crossing in Cherry Valley, Illinois. The train consisted of 2 locomotives and 114 cars, 19 of which derailed. All of the derailed cars were tank cars carrying denatured fuel ethanol, a flammable liquid. Thirteen of the derailed tank cars were breached or lost product and caught fire. At the time of the derailment, several motor vehicles were stopped on either side of the grade crossing waiting for the train to pass. As a result of the fire that erupted after the derailment, a passenger in one of the stopped cars was fatally injured, two passengers in the same car received serious injuries, and five occupants of other cars waiting at the highway/rail crossing were also injured. Two responding firefighters also sustained minor injuries. The release of ethanol and the resulting fire prompted a mandatory evacuation of about 600 residences within a 1/2-mile radius of the accident site. Monetary damages were estimated to total $7.9 million.

1.2 Accident Narrative

The accident train was initially assembled at an ethanol plant in Tara, Iowa, on June 19, 2009. The train departed the Tara plant about 5:55 a.m., with two locomotives pulling one “buffer” car containing gravel[2] and 75 tank cars loaded with a total of 2,158,724 gallons of denatured fuel ethanol. After a crew change in Waterloo, Iowa, the train arrived at Dubuque, Iowa, where another two-member crew (engineer and conductor) was assigned to take the train about 175 miles from Dubuque (milepost [MP] 183.2) to Hawthorne Yard (MP 8.9) near Chicago, stopping along the way at Freeport, Illinois, MP 115.6, to add more cars to the train: 2 loads and 36 empties. (See figure 1.) Along the route, the train would pass through Rockford, Illinois, then through the village of Cherry Valley, Illinois,[3] at about MP 80.[4]

[1] All times in the report are central daylight time.

[2] Federal regulations prohibit positioning a hazardous materials car (such as one containing ethanol) next to a locomotive, so a nonhazardous materials car was used as a buffer.

[3] The village of Cherry Valley is about 10 miles southeast of Rockford, Illinois. Cherry Valley residents generally consider the village to be a suburb of Rockford.

[4] Milepost numbers decreased from west to east.

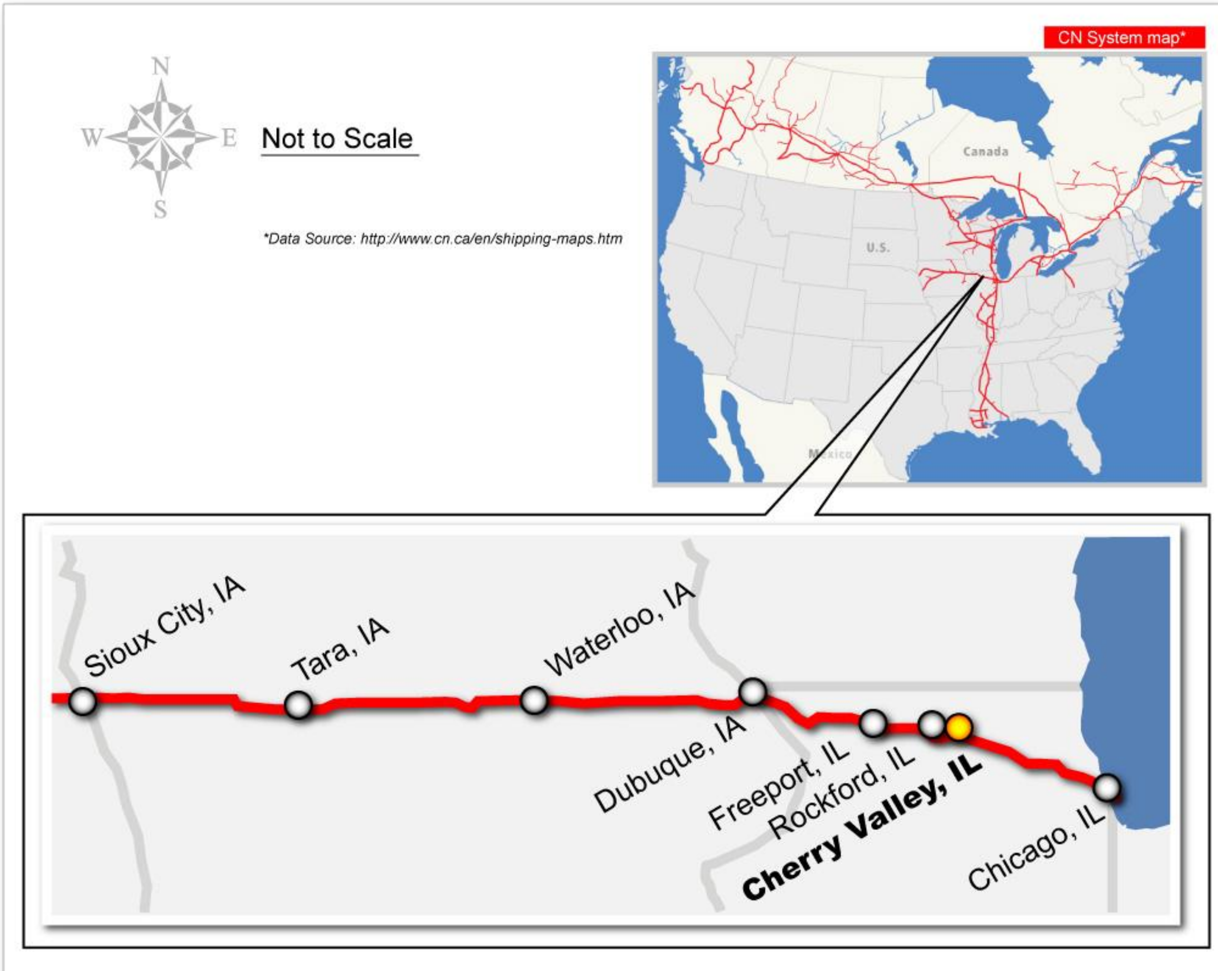

Figure 1. CN system map showing route from Sioux City, Iowa, to Chicago, Illinois.

The accident train crew went on duty at 2:00 p.m. on June 19, 2009, at the CN Dubuque yard. After receiving the paperwork for the train at the yard office and conducting a job briefing,[5] the two crewmembers were transported to the train. The dispatcher's records indicated that the train departed Dubuque at 2:28 p.m. via the CN's Dubuque Subdivision, which would take the train over the Mississippi River into Illinois where it would traverse several miles of BNSF Railway (BNSF) track before going back onto CN property.

As instructed, the crew stopped at Freeport, Illinois, MP 115.6, to pick up the additional cars (2 loads and 36 empties) that had been assembled and staged on a passing track. The additional cars were added to the head end of the train. The train then consisted of two locomotives; cars 1 through 39, which were an assortment of boxcars and other nontank cars; and cars 40 through 114, which were tank cars containing ethanol.

[5] A job briefing typically includes a discussion about where the crew will work, the train's consist, and any track warrants and bulletins from the various territories over which the crew would be operating that day.

While the train was operated between Dubuque and Freeport, and later while the cars were added at Freeport, the rail traffic controller (RTC) who was the on-duty train dispatcher[6] at the CN's Southern Operations Control Center in Homewood, Illinois, (about 100 miles southeast of Cherry Valley) received two severe weather alert bulletins for areas along the train's route. The first AccuWeather[7] bulletin, Alert No. 1055—Thunderstorm Watch, was received at 5:34 p.m. and was effective until 10:00 p.m. The alert reported the following:

> Severe Thunderstorm Watch: Wind Gusts to 70 mph and localized flash flooding conditions: Freeport Sub-Division MP 74 to MP 108 [which incorporated the Cherry Valley area].

About 1 hour later, at 6:36 p.m., the RTC received a second severe weather alert, Alert No. 3146—Flash Flood Warning. The alert was effective until 10:40 p.m. and stated the following:

> Rain and storms continue on track with rainfall rates approaching 2 inches/[hour] in the heaviest storms. Look for total rain accumulation of 2.5–5 inches. Watch out for water on the tracks and possible washouts.[8]

This alert was in effect for the Freeport Subdivision from MP 50 to MP 115 (which incorporated the Cherry Valley area) and for the Dubuque Subdivision from MP 116 to MP 128.

The CN operating rule book and special instructions that were in effect for the Freeport and Dubuque Subdivisions at that time included Rule X, which required that, "When weather warnings are received, the RTC will notify all trains and terminals in the warning area." In the case of flash flood warnings, "trains [will] operate prepared to stop short of obstructions."

The CN further required RTCs, after receiving warnings of flash flooding meeting a criteria of 2 inches of rain in 1 hour, 3 inches in 2 hours, or 4 inches in 4 hours, to notify track personnel in the area to inspect track before a train's arrival, to advise trains in the affected area of the warnings, and to advise train crews to proceed at a speed that allows the train to stop within one-half the range of vision until the track is inspected or the track supervisor has given permission to resume normal operation. (The CN's weather policies and procedures are discussed in more detail later in this report.)

At 7:16 p.m., the conductor of the accident train called the RTC by radio from Freeport requesting authorization to continue eastbound. The RTC issued track authority giving the train track rights through Rockford and Cherry Valley, but he did not advise the crew of the weather alerts that he had received and that were in effect for territory over which the accident train would be operating. At 7:21 p.m., the train crew again made radio contact with the RTC to request a signal indication that would allow the train to depart Freeport. During this conversation, which lasted about 3 minutes, the RTC did not mention the weather alerts.

[6] Within the CN system, train dispatchers are referred to as rail traffic controllers.

[7] AccuWeather is a for-profit company that provides weather forecasting services to clients worldwide.

[8] A *washout* is the loss of supportive ballast or subballast structure underneath the track, caused by erosion from moving water, that compromises the ability of the track to support the safe passage of a train.

Meanwhile, several people in the vicinity of the CN South Mulford Road (referred to hereinafter as Mulford Road) grade crossing in Cherry Valley, Illinois, noted that high water conditions were affecting the tracks and notified authorities. At 7:35 p.m., a citizen called the Rockford, Illinois, police department to report flooding of the CN railroad track in the vicinity of the Mulford Road grade crossing. About that same time, a citizen with experience in transporting hazardous materials observed the washout condition. He said he was aware that railroads normally posted their contact information at all grade crossings but that he could not find the contact information at the Mulford Road crossing,[9] so he called 911 instead. This first call to the Winnebago County 911 center, at 7:40 p.m., was followed by several additional calls over the next 10 to 15 minutes, with some of the callers reporting that "the track is washing away." At 7:52 p.m., a citizen called to report that water was "going under the tracks."

At 8:03 p.m., the Winnebago County sheriff's office learned that the Rockford Police Department had no one available and dispatched a Winnebago County deputy sheriff to investigate.

While the dispatched deputy was en route to the scene, a deputy in the 911 center then attempted to identify the owner of the tracks to report the washout. At 8:09 p.m., the 911 deputy called the BNSF and was informed that it was not BNSF track. At 8:10 p.m., he contacted the Union Pacific Railroad (UP) (whose track crosses Mulford Road about 500 feet north of the CN crossing) and advised the UP that its track was washed out. The UP employee who received the call told the deputy that UP dispatchers would hold all their trains.[10]

The deputy sheriff dispatched to investigate the reports arrived at the scene at 8:14 p.m. to find a washout condition just west of the CN crossing. He reported his finding back to the Winnebago County 911 center. By this time, the track had been identified as belonging to the CN, and at 8:16 p.m., a deputy in the county 911 center contacted the CN Police Emergency Call Center in Montreal, Quebec, Canada, and spoke with the police officer staffing the call desk. The deputy informed the call desk officer that a major storm with flash flooding had occurred in the Rockford, Illinois, area and that "water has washed out rail lines that do belong to you" near Mulford Road.

The call desk officer attempted to contact the RTC for the affected area by phone, but the line was busy. After several unsuccessful attempts to reach the RTC, the call desk officer asked another call desk officer to keep trying to contact the RTC. Meanwhile, the first call desk officer attempted to reach the CN chief dispatcher at Homewood by phone in an attempt to have him relay the information to the RTC.

At 8:23 p.m., the deputy sheriff sent to Mulford Road to investigate the complaint advised his dispatcher that "both tracks are washed out about 6 to 8 feet beneath the tracks." A forward-facing video camera on the deputy's patrol car was operating at the time and captured video images of the washout area. The video depicted a section of track and roadbed about

[9] According to the CN signals supervisor, the contact information had been posted on the signal bungalow. When the bungalow was replaced during a crossing upgrade, the contact information had not been reposted.

[10] In response to this notification, UP track inspectors were directed to the scene where they found a washout area (smaller than the washout affecting the CN tracks) just to the west of the Mulford Road grade crossing, along with several other washout areas nearby. These washouts were repaired before the UP track was reopened to traffic.

17 feet long along the west side of Mulford Road where water was rushing under the track. (See figure 2.)

Figure 2. A still image produced from deputy sheriff's dashboard video recorder looking from a point on west berm of Mulford Road facing south.

The water flow had washed the ballast section out from under the track beginning at a point about 4 feet from the west edge of Mulford Road. The track structure was hanging, with no support under the crossties and rail. The video showed about 10 crossties spiked to the rails that were suspended about 1 foot above the flowing water. Weeds and other debris visible against the north side of the rail and ties indicated that the water level had originally been even higher.

Around this time, at 8:17 p.m., as the accident train approached the signal at a rail crossing in Rockford, MP 85.6, the crew contacted the RTC to request a *proceed* signal.[11] After talking with the RTC, the crew received a favorable signal and continued eastbound. The dispatching system recorded that the train entered the rail crossing at Rockford at 8:18 p.m.

At 8:32 p.m., a CN police dispatcher at the Emergency Call Center in Montreal called the Winnebago County 911 deputy back to confirm the location as Mulford Road and to report that the railroad would be "sending someone out."

[11] Under a traffic control system, train dispatchers have the capability to control certain wayside signals remotely.

The accident train continued to operate eastbound from Freeport to the Rockford area, a distance of about 30 miles. The crew told investigators that as they traveled through Rockford, they noticed high water near the Rockford Diamond (a junction of tracks). The conductor stated that water was not over the rails at that point but that it was near the top of the rails. The crew encountered high water again about 1/2 mile east of MP 81. The conductor said he then contacted the RTC to report the high water at the Rockford Diamond and MP 81. CN records indicate that the RTC received the radio transmission from the conductor at 8:35 p.m.

While moving through the Rockford area, and traversing the rail crossing at Rockford, the engineer operated the train between 17 and 18 mph and continued at that speed range after observing and reporting the high-water conditions. After the train crested the hill at MP 81.2, the engineer placed the train in throttle position 6 and increased the speed to 36 mph. The crew reported no unusual track conditions in the authorized 50-mph territory through Cherry Valley.

As the train approached Mulford Road, the train was operating on straight track with a slightly descending grade. According to postaccident interviews, the conductor was seated at his desk on the left side of the locomotive cab facing forward; the engineer was seated at the controls on the right side of the cab (south side of the locomotive), also facing forward and activating the locomotive horn for the approach to the Mulford Road crossing. Locomotive event recorder data showed that the horn and bell were in the “On” position at 8:34:15 p.m. The crew stated that they could see that the lights and flashers at the grade crossing were activated and that the gates were down.

When the head end of the train was about 57 car lengths past Mulford Road, the train was traveling about 36 mph when the brake pipe pressure decreased from 86 psi to 80 psi. According to event recorder data, the train-initiated emergency brake application occurred at 8:35:58 p.m., and the throttle position changed from 6 to 0. Thirty seconds later, at 8:36:28 p.m., the train stopped. About this same time, the RTC was calling the Edmonton Walker Call Desk to relay the reports from the train of water over the rails at the Rockford Diamond and at MP 81. In response to this call, the Edmonton Walker Call Desk dispatched a track inspector to the area.

At 8:42, the train engineer radioed the RTC that the train had gone into emergency between MP 80 and 81. The conductor said that when the train stopped, he dismounted the locomotive and began walking back to determine the cause of the brake application. He said that after walking back about 39 cars, he saw an “orange glow” in the sky and sparks rising from the rear of his train. He said he decided it was unsafe to go any farther and notified the engineer by radio before returning to the locomotive. At 8:55 p.m., the track inspector who had been dispatched by the Edmonton Walker Call Desk (in response to the RTC’s report of high water) called the RTC and asked for authority to inspect the track from MP 79 eastbound. The RTC told the track inspector that he could follow the train that had reported the high water, the accident train, which at that point was not known to have derailed. About 8:59 p.m., the engineer contacted the RTC to report what the conductor had seen, which was a fire possibly involving an ethanol car about 58 or 59 cars from the head end. The RTC then called the CN Police Emergency Call Center and relayed the report.

The investigation determined that the locomotives and the lead 58 cars, roughly the east half of the train, separated from the derailed cars near the crossing. The separation occurred between the 58th and 59th cars (the 19th and 20th tank cars) on the train. The 57th and 58th cars—the rear two tank cars of the head end portion of the train that stopped east of the crossings—had partially derailed (two of the north wheels on each car) but remained upright. Seventeen tank cars—the 59th through 75th cars on the train—derailed, with 15 of those cars contributing to a 400-foot-long pileup that engulfed the grade crossing. (See figure 3.) Shortly after the accident, the forward portion of the train, including the two derailed tank cars at the rear of the forward portion, was pulled away from the wreckage.

Figure 3. Aerial view, looking northwest, of derailed tank cars after locomotives and first 58 cars have been pulled away from wreckage.

At 8:40 p.m., the first CN call desk officer in Montreal reached the chief dispatcher at the Homewood control center, and about this same time, the second call desk officer made telephone contact with the RTC. The second call desk officer reported to the RTC that, "apparently we've got some flooding in the Rockfield [*sic*], Illinois, area on the Freeport sub." The RTC then asked, "Rockford, Illinois?" After the caller checked with the first call desk officer and confirmed that the correct location was Rockford, the RTC said, "I have the report of water over the rails—a train [the accident train] reported it already." The call lasted about 30 seconds. Neither the call desk officer nor the RTC used the term "washout" in their communication with each other, and the location of Mulford Road was not specified. The term "washout" was also not used in the conversation between the first call desk officer and the chief dispatcher at Homewood.

1.3 Emergency Response

1.3.1 Local Response

At 8:36 p.m., callers began contacting local emergency response authorities to report the incident.[12] At 8:36 p.m., a cell phone call reported a "bus/truck" fire at the crossing. One minute later, at 8:37 p.m., several other callers reported the derailment. The Winnebago County 911 Emergency Call Center received a total of 19 calls reporting the accident.

At 8:38 p.m., Rockford 911 Dispatch began dispatching resources of the Rockford Fire Department (RFD). About a minute later, Rockford 911 issued a secondary, or follow-up, dispatch[13] of resources of the Cherry Valley Fire Protection District (CVFPD), which immediately responded. The first responding CVFPD resource arrived at the scene at 8:46 p.m., followed shortly by additional responding CVFPD units and mutual aid resources from neighboring communities. The CVFPD chief subsequently determined that the incident had actually occurred within the jurisdiction of Cherry Valley rather than Rockford.

With his arrival on scene, the CVFPD chief assumed the role of incident commander. He observed from a distance obvious major fire involvement over a relatively widespread area. The characteristics of discharging flame suggested a "pressure fire."[14] Flames were impinging on several nonburning tank cars in proximity to the burning cars, and the chief stated that he heard numerous pressure relief valves[15] opening.

By this time, the flames extended several hundred feet into the air. (See figure 4.) It was not known if the pressure relief valves on the derailed and overturned tank cars were either damaged or inoperable. It was not known if any pressure tank cars[16] were involved in the wreckage pileup. At that point, responders did not know the contents of the burning cars because the placards indicating contents were not readily visible. They also did not know if any locomotives or train crew might be involved.

[12] The information in this section is based on incident response data and communications information supplied by the emergency service agencies involved, as well as on individual interviews with key personnel of the emergency services agencies and the railroad.

[13] A follow-up dispatch can occur when an event location is at or close to the boundary with another emergency response jurisdiction. The operational protocol prescribes that the agency closest to the physical location of the event should be expediently dispatched to the scene.

[14] Characteristics of a pressure fire include a "focused" flame indicating that the substance fueling the fire is under pressure as it is ignited.

[15] Tank cars are equipped with valves designed to open automatically to relieve pressure and prevent a tank rupture in the event that excess heat or other factors cause pressure within the tank to rise to a dangerous level.

[16] Pressure tank cars are designed to carry chemicals or petroleum products under pressures usually exceeding 100 pounds per square inch. The ethanol being transported by train U70691-18 was not under pressure during regular transit. It is permissible to transport denatured ethanol in both general service and pressure tank cars.

Figure 4. Looking north along Mulford Road toward burning tank cars at crossing.

From his vantage point on the north side of the site, the CVFPD chief could see several motor vehicles in the roadway on the north side of the tracks near the grade crossing; however, no determination could be made as to whether any of the vehicles had been damaged by the derailing railcars or the subsequent fire. The chief said he assumed that a similar situation (vehicles stopped in a queue that may have been directly affected by the derailment and fire) existed on the south side of the grade crossing.

The nearest dwelling was about 600 feet from the derailed equipment. The closest building to the site was a commercial facility on the south side of the tracks about 300 feet from the crossing. The business was closed at the time of the accident, and the building was unoccupied.

The CVFPD chief requested a mutual aid response to the scene, including an RFD hazardous materials response team with a decontamination unit. He also established an initial incident command (IC) at the intersection of Mulford Road and Abbington Court, about 1,400 feet north of the fire perimeter. By radio, he advised the next responding fire department chief, who was an RFD responder, to set up an initial south sector command at the intersection of Mulford Road and Sandy Hollow Road, about 900 feet south of the fire perimeter.

A situation report from the south sector command to the CVFPD chief indicated major fire involvement with multiple railroad tank cars burning. South of the crossing, several vehicles were in the roadway near the derailed equipment, with one vehicle on fire. An emergency medical services (EMS) crew was attending to several injured persons.

At this time, responders had not been able to identify the contents of the tank cars or to determine whether pressurized rail tank cars were involved. Based on the volume of fire involvement and the observation of flame discharge from the pressure relief devices, the CVFPD chief consulted the *2008 Emergency Response Guidebook* and determined that the area needed to be evacuated. At 9:02 p.m., the CVFPD chief contacted RFD Dispatch to implement a mandatory evacuation within a radius of about 1/2 mile from the fire perimeter. The evacuation was to be executed by the local law enforcement personnel.

At 9:09 p.m., RFD Dispatch advised the CVFPD chief that the CN had informed the RFD that the tank cars contained ethanol. Based on that information, the CVFPD chief requested that RFD Dispatch locate quantities of fire-suppressing foam. A few minutes later, at 9:12 p.m., RFD Dispatch notified the IC that the railroad indicated that only one tank car contained ethanol. In order to make a positive identification of the contents of the burning rail cars, the IC initiated a search for the train crew. The crew would have a train consist (a listing of all the cars and their order within the train) as well as the shipping papers[17] for the hazardous materials being carried. Shortly before 9:50 p.m., a firefighter notified the IC that the crew had been located and that the two crewmembers were on their way to the IC with the train's shipping papers.

At 10:10 p.m., law enforcement officers requested fire department help in implementing the mandatory evacuation. Fire companies and an ambulance were dispatched to assist in the effort. About 10:30 p.m., two CN dangerous goods officers arrived on scene and became hazardous materials liaisons to the fire departments. The officers provided additional guidance for the incident response.

About 10:20 p.m., the two CN crewmembers arrived at the IC post and presented the train consist and the hazardous materials shipping papers documenting that the tank cars contained ethanol. Upon receipt of the shipping papers, the IC recognized that the car positions shown on the printed train consist were not correct based on the visual identification of the cars in the pileup. It was not until 1:22 a.m. the next morning that the IC received an e-mail from the CN containing the correct consist. (Errors in the train consist are discussed in detail in the "Train Consist Inaccuracy" section of this report.)

Having learned that the source of the fire was ethanol, the incident commander considered the following factors: (1) the volume of burning cargo, (2) the fact that extinguishing the fire would require large quantities of foam, which were not available on short notice, (3) the overall topography of the widespread wreckage pileup, (4) the fact that the fire no longer was an immediate hazard to life or property, and (5) the fact that the fire would consume the cargo content, which would help reduce the effects of a hazardous materials product release into the

[17] As required by Title 49 *Code of Federal Regulations* Part 172 Subpart C, each shipper of a hazardous material must provide a properly prepared shipping paper that, at a minimum, identifies the material by its proper shipping name, hazard class or division number, identification number, packing group (if any), and total quantity. Additional hazard warning and handling information, such as "Poisonous–Inhalation Hazard," must be also entered on the shipping paper.

environment. Based on these considerations, the incident commander decided to allow the cargo content to burn itself out; the CN dangerous goods officers concurred with this decision.

After about 1/2 hour at the IC, the two train crewmembers were asked by IC and CN personnel to return to their locomotive and move the train forward a short distance to provide a greater separation between the fire and the remaining (nonburning) railcars of the train. The two crewmembers returned to the train, and the train was subsequently pulled forward a short distance.

About 11:00 p.m., two CVFPD firefighters, using an off-road vehicle, were assigned to check the area southeast of the accident site for fire and to determine the location and condition of the remaining railcars of the train. During that mission, the firefighters were apparently exposed to toxic fumes, with one of them experiencing disorientation. The two firefighters were subsequently transported, as a precautionary measure, to a local medical facility for evaluation.

The IC principals had seen yellow fiberglass warning markers in the vicinity of Mulford Road near the accident site indicating the presence of an underground natural gas pipeline in the area. They were not aware of the specifics of the pipeline, such as its exact location, its size and product pressure, and how deep it was buried. Because the incident commander believed underground natural gas pipelines are typically buried deep enough to be protected from the impact of a heavy surface vehicle making forceful contact with the soil, he was not immediately concerned that the integrity of the pipeline might be threatened by the derailment and wreckage pileup. The IC was also in possession of map documentation received from a pipeline training contractor that did not indicate the presence of a pipeline in that area. About midnight, as a precautionary measure, one of the IC officers made an inquiry to Nicor Gas,[18] the local pipeline operator, for information about the pipeline. Nicor Gas personnel reported that no gas pipelines were located in that area and that the closest gas main pipeline was about 0.7 mile south of the accident site.[19]

By midday on June 20, 2009, the ethanol was substantially burned off, and it was expected that the fire would self-extinguish within a few hours. At 5:00 p.m. on June 20, the IC declared that all fires were extinguished. At 5:30 p.m., the IC suspended the mandatory evacuation, and about 8:00 p.m., released mutual aid resources. The CVFPD firefighting resources stood by, monitoring the situation throughout the night and through the following day in case the fire rekindled.

At 5:00 p.m. on June 21, after conferring with principals of the CN, the shipper, and other responding organizations about the status of the event, the incident commander terminated the on-scene operations.

A total of 35 separate fire department entities with 250 personnel and about 80 vehicles responded or were part of the mutual aid response. Additionally, the Winnebago County

[18] Northern Illinois Gas was formed in 1954. In 1997, Northern Illinois Gas began operating its natural gas business as Nicor Gas.

[19] This information provided to the IC by Nicor Gas was incorrect, and was based on a clerk's misreading a map. As noted in the report, in response to an inquiry from the CN about 6 hours later, Nicor corrected its error and stated that it did have a pipeline located at the accident site.

Sheriff's Department responded with 20 units (officers), which were supported by resources from 31 other law enforcement agencies.

1.3.2 CN Response

The CN activated its emergency response plan, which resulted in CN technical personnel and equipment resources being dispatched to the scene. Corporate resources that responded included CN environmental and dangerous goods (hazardous materials) responders, CN police, CN freight claims and damage prevention personnel, and CN operational personnel. Through execution of its "Foam Bank" program, the CN identified the closest source of fire suppression foam and arranged for quantities to be brought to the scene. Although the IC made the decision (in consultation with the CN) to allow the fire to self-extinguish while the foam was en route, the foam supplies were delivered to the scene and were available had they been needed.

About 6:30 a.m. on June 20, the CN contacted Nicor Gas and, to follow up the IC's inquiry, asked the pipeline operator about a natural gas pipeline possibly being located at the accident site. Upon rechecking their data, Nicor Gas personnel responded that, contrary to their earlier report, there was a 12-inch natural gas transmission pipeline[20] at the accident site. The IC was not concerned that the pipeline had been breached because about 10 hours had elapsed since the accident occurred without any indication that the pipeline was leaking gas.

1.3.3 Nicor Gas Response

About 7:06 a.m. on June 20, Nicor Gas dispatched several technical representatives to the accident scene to support the wreckage recovery and clean-up operations and to prevent excavation damage to its natural gas pipeline during those activities. The representatives located the exact path of the pipeline, which also served as a distribution pipeline in that area, and subsequently advised that their instrumentation, which they installed within a vault located near the site, indicated no pressure drop in the pipeline. Subsequent indications from responding technical representatives confirmed that the pipeline had not been breached.

Since the loaded tank cars derailed west of the crossing on a section of unsupported track over the washout area, and the east edge of the washout was adjacent to and above the location of the natural gas pipeline, the derailed equipment fell into the void caused by the washout and dug in close to the location of the pipeline. When investigators observed the derailed equipment near the pipeline and the west edge of the crossing, the gas pipeline was not exposed but covered in debris from the derailment and soil movement from the washout. The railroad equipment recovery contractor, at the request of and under the direction of Nicor Gas, excavated the pipeline and found that a railcar wheel and axle assembly had impinged on the pipeline, severely denting it. Further excavation revealed a flattening of the 16-inch-diameter steel casing[21] that surrounded the pipeline, with sharp angular bends at two locations where it made contact with

[20] In general, *transmission* lines are larger diameter and higher pressure lines used to transport gas between states, counties, cities, and towns. *Distribution* pipelines are usually smaller diameter and lower pressure lines used to deliver gas directly to local homes and businesses.

[21] Pipeline casings have historically been used at road and railroad crossings to accommodate higher dead and live loads and to help prevent third-party damage to the pipeline.

the rail car wheel assembly. Nicor Gas continued a technical representation presence at the accident site for several additional days.

1.4 Injuries

As a result of the product release and fire after the derailment, one person was killed, three people were seriously injured, and six people, including two emergency responders, received minor injuries. (See table 1.) Among the seven civilians who were transported by EMS or who self-transported to local medical facilities for examination and treatment, three sustained life-threatening burn injuries; three had minor burn injuries; and one sustained a minor strain or sprain injury. The one fatality from the accident had been in the first vehicle stopped in the queue on the south side of the grade crossing. That person suffered fatal burn injuries.

Table 1. Injuries.

Injury Type[a]	Train crew	Citizens	Emergency Responders	Total
Fatal	0	1	0	1
Serious	0	3	0	3
Minor	0	4	2	6
Total	0	8	2	10

[a]Title 49 *Code of Federal Regulations* 840.2 defines fatality as the death of a person either at the time an accident occurs or within 24 hours thereafter.

1.5 Damages

1.5.1 Tank Cars

Fifteen of the 19 derailed cars were destroyed in the accident and subsequent fire. The four other derailed cars were damaged but deemed repairable. The CN eventually reported the total equipment cost at $1,292,460.

1.5.2 Signal, Track, and Structures

As a result of the derailment, about 1,230 feet of the main track was destroyed, which required the installation of 31 1/2 track panels.[22] An open deck timber bridge[23] spanning a small creek west of Mulford Road received washout damage that pushed the east retaining wall inward. No other damage to the bridge was evident or reported. To the west of the bridge, about 0.1 mile from the accident site, debris was found deposited on the top of the track structure. The direction of water flow and the debris area are shown in figure 5. The CN reported the track and

[22] Track panels are generally 39 feet long and are preconstructed of two rails affixed to crossties.

[23] An open deck timber bridge is one in which the rails are affixed to timber bridge crossties supported by longitudinally aligned timber stringers with no ballast section supporting the actual track on the bridge span.

structures damages at $437,706. Damages to the highway/rail grade crossing warning system were reported at $125,000.

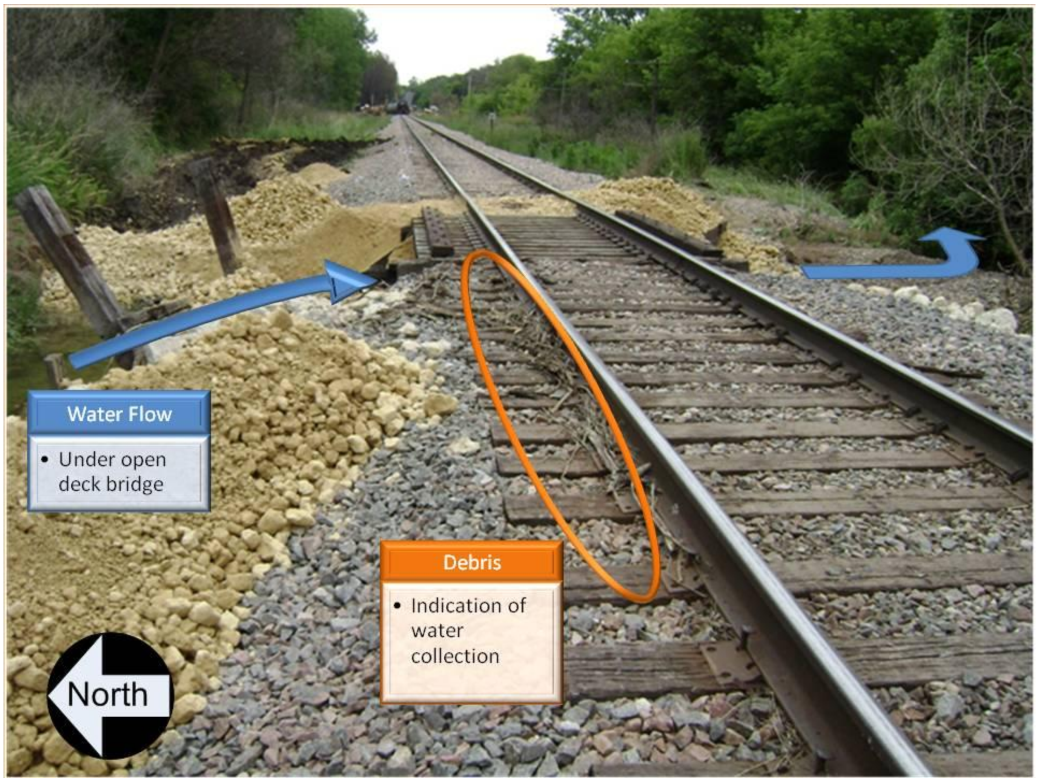

Figure 5. Photo shows storm water debris on the track, near the open deck bridge (0.1 mile west of the accident site). Water flow under open deck bridge is also indicated as flowing in southeast direction.

1.5.3 Total Monetary Damages

The CN estimated the total monetary damages at $7.9 million, including an estimated loss of lading of $900,000 and wreckage removal of about $300,000.

1.6 Personnel Information

1.6.1 Crew of Accident Train

The crew of the accident train consisted of an engineer and a conductor. CN train and engine personnel are required to take operating rules classes every 3 years. Both crewmen had attended rules classes and were qualified on railroad operating rules. Both crewmen stated that they were aware of the requirements of Rule X for unusual weather conditions and weather alerts.

When the crew went on duty on the day of the accident, they had been off duty more than 10 hours. In their interviews with investigators, they indicated they were rested and in compliance with the hours-of-service regulations. Both crewmembers were in good health and neither one was taking any prescription or nonprescription medications at the time of the accident. The crew told investigators that leading up to the accident, their workload had been normal.

Engineer. The engineer, age 49, was hired as a brakeman on February 22, 1994. He was promoted to conductor on March 8, 1994, and promoted to locomotive engineer on October 31, 1996. His most recent operating rules classes were on March 17, 2008. During the previous 12 months, the engineer had received 34 efficiency tests[24] on the railroad operating rules with no failures. The CN did not have a specific efficiency test for Rule X.

The engineer stated that he had traversed the accident territory numerous times as a brakeman or conductor. While the accident trip was his first time operating a train eastbound from Dubuque to Chicago as an engineer, he had previously operated trains as an engineer in the westbound direction.

Conductor. The conductor, age 47, was hired on August 22, 2008, as a conductor. He attended operating rules classes on that date. During the previous 12 months, he had been efficiency tested on carrier operating rules five times with no failures. As a conductor, he had made 10 trips (6 westbound and 4 eastbound) through Cherry Valley.

1.6.2 On-Duty CN Rail Traffic Controller

The on-duty RTC, age 24, was hired on November 27, 2006, as a CN rail traffic controller. Before becoming an RTC, he had worked about 8 months for the UP railroad as a tower operator in the Chicago area. At the time of the accident, the RTC had been dispatching CN trains for about 2 1/2 years.

The RTC was initially trained and qualified to dispatch trains on desk 7 (Iowa zone).[25] He later became qualified to dispatch trains on desk 1 (Chicago terminal).[26] At the time of the accident, the RTC worked a shift that required that he work both desks simultaneously. The RTC worked at a single location that had two monitors: one for desk 1 and one for desk 7. His responsibilities on the combined desks included a traffic control system[27] and dark (nonsignaled) territory. The dispatcher who had trained the RTC said he believed that the accident RTC was one of the better students and he (the trainer) did not have any concerns about his ability to dispatch the combined desks. Since becoming a train dispatcher, the RTC had not been cited for a dispatching violation. Management and coworkers who were interviewed regarded him as a professional employee and a conscientious worker.

[24] An efficiency test is a documented observation as a regulatory requirement. During this testing, an employee is observed to assess compliance with railroad company operating or safety rules.

[25] "Desk" generally refers to the specific territory each RTC is required to dispatch. Desk 7 included CN consecutive subdivisions from Council Bluffs, Iowa, into the Chicago area. Desk 7 responsibilities involved freight train traffic exclusively.

[26] Desk 1 included various subdivisions terminating into the greater Chicago area in a hub-and-spoke configuration. Desk 1 responsibilities included the movements of commuter trains as well as freight traffic.

[27] Under a traffic control system, dispatchers control train movement and manage traffic flow by remotely operating wayside signals at control points along the route.

He said that on the day of the accident, his health was good, his vision and hearing were normal, and he was not taking any drugs or prescription or nonprescription medications that may have affected his performance.

The RTC did not work on Tuesday and Wednesday before the accident, which were his scheduled days off. On his days off, he typically does chores and maintains a sleep schedule similar to the one on the days he works. He routinely goes to sleep between 12:30 a.m. and 1:00 a.m. and sleeps to about 9:00 a.m. After waking up, he typically eats breakfast, watches television, and relaxes. The day before the accident (Thursday), he went on duty at 3:00 p.m. and worked his full shift, which ended at 11:00 p.m. After his Thursday shift, he drove home, ate dinner, and then slept from 12:30 a.m. to 9:00 a.m. He spent Friday morning doing chores and departed the house about 2:15 p.m. (for his 15-minute commute to work). He went on duty at 3:00 p.m. and worked until 11:00 p.m.

1.7 Toxicological Information

Pursuant to Title 49 *Code of Federal Regulations* (CFR) Part 219, Subpart C, the CN engineer and conductor provided postaccident toxicological blood and urine specimens that were tested for the presence of alcohol and illegal drugs.[28] The specimens were collected between 1:30 a.m. and 3:00 a.m. on June 20, 2011, at a hospital in Rockford, Illinois. Test results were negative for alcohol and illegal drugs.

The on-duty RTC was not asked to provide specimens for postaccident toxicological testing. According to a CN assistant superintendent, specimens were not requested from the RTC because the RTC was not initially believed to have been directly involved in the accident. As the investigation progressed, CN officials determined the following day that the RTC may have had some direct involvement. However, by that time, the RTC had gone off duty, and CN officials incorrectly believed that the RTC could not be required to provide specimens for testing. In fact, 49 CFR 219.203(b)(4)(ii) states that an employee may be immediately recalled for testing if "the railroad's preliminary investigation (contemporaneous with the determination required by § 219.201) indicates a clear probability that the employee played a major role in the cause or severity of the accident/incident." After the accident, the Federal Railroad Administration (FRA) determined that the CN had violated Title 49 CFR 219.203(b)(4)(ii).

1.8 Meteorological Information

At the time of the accident, Greater Rockford Airport, about 5 miles southwest of the accident site, was reporting calm winds, visibility of 10 miles, high broken clouds, and temperature of 66° F. About 2 hours before the accident, at 6:16 p.m., the airport reported a squall line moving across the airport with thunderstorms and moderate rain with wind gusts to 45 knots. Rainfall rates rapidly increased with the passage of this squall line, and between 6:17 and 6:54 p.m., the airport weather station reported visibility of 1/2 mile or less in thunderstorms with heavy rain. Rainfall data collected at 1-minute intervals at the Greater

[28] The specimens were screened for cannabinoids, cocaine, opiates, amphetamines, methamphetamines, phencyclidine, barbiturates, benzodiazepines, and ethyl alcohol.

Rockford Airport indicated a total of 4.18 inches for June 19, 2009. An estimated 3.59 inches of rain fell during the evening storm (6:09 to 7:39 p.m.).

The airport weather station reported a total of 4.24 inches of precipitation in one 24-hour period from June 18 through June 19, 2009. On only one other day in June 2009 had precipitation exceeded 1 inch. Total June precipitation was reported as 7.36 inches—about 2.56 inches above the average for the month.

The Chicago National Weather Service (NWS) office reported between 10 and 15 inches of precipitation in the 90-day period ending in June, with a year-to-date rainfall total of 25.23 inches, or about 10 inches above average. A review of NWS data showed the following local severe weather conditions reported by the Chicago NWS Weather Forecast Office on June 19, 2009:

> 1812 CDT Wind gust of 52 mph at Rockford Airport [about 5 miles southwest of accident site]
>
> 1820 CDT Trees and power lines downed in the city due to high winds
>
> 1836 CDT 14-inches of running water in the intersection of Woodridge & Javelin Rds. [about 2 miles northeast of accident site]
>
> 1839 CDT Wind gust to 70 mph on I-39 just south of Rockford [about 1/2 mile east of accident site]
>
> 1845 CDT several roads under water. One rescue where car was stranded in flood water at Alpine & Newburg [about 1 mile northeast of accident site]
>
> 1854 CDT One hour rainfall of 3.25 inches reported by ASOS[29] at Rockford Airport
>
> 1912 CDT Water 10 inches deep on Lyford Road just north of State Street [about 2 miles northeast of accident site]
>
> 1933 CDT 6 to 10 inches of water in the intersection of 11th and 22nd streets [about 2 miles northwest of accident site]
>
> 2045 CDT Flash flooding caused railroad tracks to wash out near Milford [*sic*] Road causing train derailment. Large fire reported in progress. Multiple injuries reported.

On the day of the accident, sunset was at 8:36 p.m., and sunrise the next day was at 5:20 a.m.

[29] The Automated Surface Observing Systems (ASOS) program is a joint effort of the National Weather Service, the Federal Aviation Administration, and the Department of Defense. The ASOS is the nation's primary surface weather observing network.

1.9 Site Description

1.9.1 General

The village of Cherry Valley, Illinois, lies primarily in Winnebago County (with a small portion in Boone County) in the north central portion of the state. It is southeast of Rockford, Illinois, and is about halfway between Chicago, Illinois, and Dubuque, Iowa. The most recent census (2010) indicated a population of 3,161.

The derailment occurred just west of the CN grade crossing at Mulford Road, a two-lane, paved county road oriented north and south. At this location, the center line of Mulford Road represented the jurisdictional boundary between Rockford and Cherry Valley.

The grade crossing was protected by active warning devices for both directions of traffic. The warning devices included four post-mounted, 12-inch-diameter flashing light unit pairs, two fully reflectorized red-and-white-striped gate arms with lights, and bells mounted on the signal masts. A Safetran grade crossing predictor (GCP-3000) monitored railroad traffic and controlled the activation of the warning devices. The GCP-3000 was configured to provide a constant minimum warning time of 25 seconds for approaching trains before they occupied the crossing at any speed up to the maximum allowable speed of 50 mph. The GCP-3000 was also configured with a data logger that captured train movement information in nonvolatile memory.

The area in which the accident occurred included residential as well as light industrial properties. About 480 feet north of the CN's main track was an east/west UP industrial lead track that paralleled the CN track for about 1/2 mile and that crossed Mulford Road to the north of the CN crossing. (See figure 6.)

Figure 6. Accident site.

1.9.2 Track and Structures

The track on which the derailment occurred was owned, inspected, maintained, and operated by the CN. The Freeport Subdivision, in the vicinity of the derailment, consisted of a single main track signaled for operations in either direction. In the area of the derailment, the track was oriented, both geographically and by timetable, in an east-west direction. The track was designated as FRA Class 4 track.[30]

The CN operated two to three through-freight trains daily over this portion of the Freeport Subdivision. The through-freight trains and some local freight operations accounted for an estimated annual tonnage over the line of 8.5 million gross tons (as of 2008).

The rail throughout the area was 115-pound[31] continuous welded rail[32] seated and affixed in 13- by 7 3/4-inch double-shoulder tie plates. The track structure in the derailment area was built on 6 to 8 feet of fill and was supported by a mixture of limestone and granite ballast to an estimated depth of 18 to 24 inches under the crossties. The shoulder ballast extended about 10 to 12 inches off of the end of the crossties.

In the hour before the accident, the train traversed the track segment between Freeport and Cherry Valley. According to the CN track profile, this track segment comprised 26 curves, 5 bridges, and 7 sets of ascending and descending grades, with some grades multiple miles in length.

The railroad maintained a ditch line on both the north and the south sides of the tracks. About 0.2 mile west of Mulford Road, the CN maintained a 20-foot-long open deck bridge that spanned a small creek.

1.10 Train and Mechanical Information

1.10.1 Accident Train

At the time of the accident, the accident train consisted of 2 locomotive units and 114 cars. The 78 loaded and 36 empty cars gave the train a trailing weight of 11,125 tons. Including locomotives, the train was 6,940 feet long.

Before the train left the ethanol plant on the morning of June 19, 2009, the train crew (which was not the accident crew) inspected the 76-car train and conducted an air brake test. No exceptions were noted. At Freeport, Illinois, when the accident crew added 2 loaded and 36 empty cars to the head end of their train, they inspected the cars and tested the air brakes on the additional cars. No exceptions were noted during either the inspection or the air brake test.

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[30] Railroads determine how they will classify various segments of their track. As the class designation increases, the track must meet increasingly higher Federal standards for construction, maintenance, and inspection. Federal regulation also establishes maximum train speeds for each class of track.

[31] Rail weight is referenced per yard of track; thus a 3-foot length of 115-pound rail weighs 115 pounds.

32 *Continuous welded rail* is defined as rail in which rail segments have been welded together to form rail lengths of 400 feet or more.

The train passed five wayside inspection scanners before the derailment with no exceptions reported.

1.10.2 Derailed Cars

All of the 19 cars in the derailment were tank cars manufactured by Trinity Tank Car, Inc. as U.S. Department of Transportation (DOT) specification 111-A100W1 (DOT-111) tank cars and were intended to transport ethanol. DOT-111 cars, under 49 CFR Part 173, may be used in general service to transport commodities or nonpressurized hazardous materials. The nominal full water capacity of the cars was 30,145 gallons. As DOT-111 cars, they were not required to be equipped with head shields (extra protection at the ends of the tank to resist puncturing), jackets, or thermal protection. The dates of manufacture of the tank cars ranged from December 2006 to October 2008.

Two of the 19 derailed cars (car numbers preceded by reporting marks TILX) were owned by the railcar leasing division of Trinity Industries, Inc.; 9 cars (car numbers preceded by NATX) were owned by GE Equipment Services; and 8 cars (car numbers preceded by CITX and CTCX) were owned by CIT Rail.

The tank cars involved in this accident had bottom outlet valves and multiple fittings. Title 49 CFR 179.200-17 requires that DOT-111 cars equipped with bottom outlet valves be built with design elements intended to prevent damage to the valve and subsequent loss of lading during a derailment. These design features could take the form of recessed valves, breakaway designs for the structures below the valves, skid protection structures around the valves, or a combination of these. The valve operating mechanisms must also be provided with a locking arrangement to ensure that the valve stays closed during transit. The Association of American Railroads (AAR) *Manual of Standards and Recommended Practices* for tank cars specifies that bottom outlet valve handles, unless stowed separately, must either be designed to bend or break free on impact or be positioned so that the handles, in the closed position, are above the bottom surface of a protective skid plate.

All of the derailed cars were equipped with 4-inch flanged bottom outlet ball valves surrounded by "skid protection" systems that consisted of an angular steel structure mounted adjacent to the bottom outlet fittings. The skid protection structure was designed to protect the bottom outlet valve if the bottom of a derailed tank car came into contact with the ground, track, or other object. Attached to the ball valve flanges were outlet adaptor assemblies or nozzles that protruded outward of the skid protection. The outlet adaptor assembly was designed to shear from the valve flange during an accident so as to minimize damage to the closed valve.

The cars owned by CIT Rail (CITX and CTCX) were originally constructed with outlet valves oriented so that the valve handles operated longitudinally. On June 4, 2008, Trinity Tank Car filed an R-1, "Report of Tank Repairs, Alteration or Conversion," with the FRA for the CIT Rail cars, indicating that the outlet valves on those cars had been rotated 90 degrees such that the handle operated in the transverse direction rather than in the longitudinal direction. A hole in the valve handle was designed to weaken the handle and cause it to break away on impact to allow the valve to remain closed. (See figure 7.)

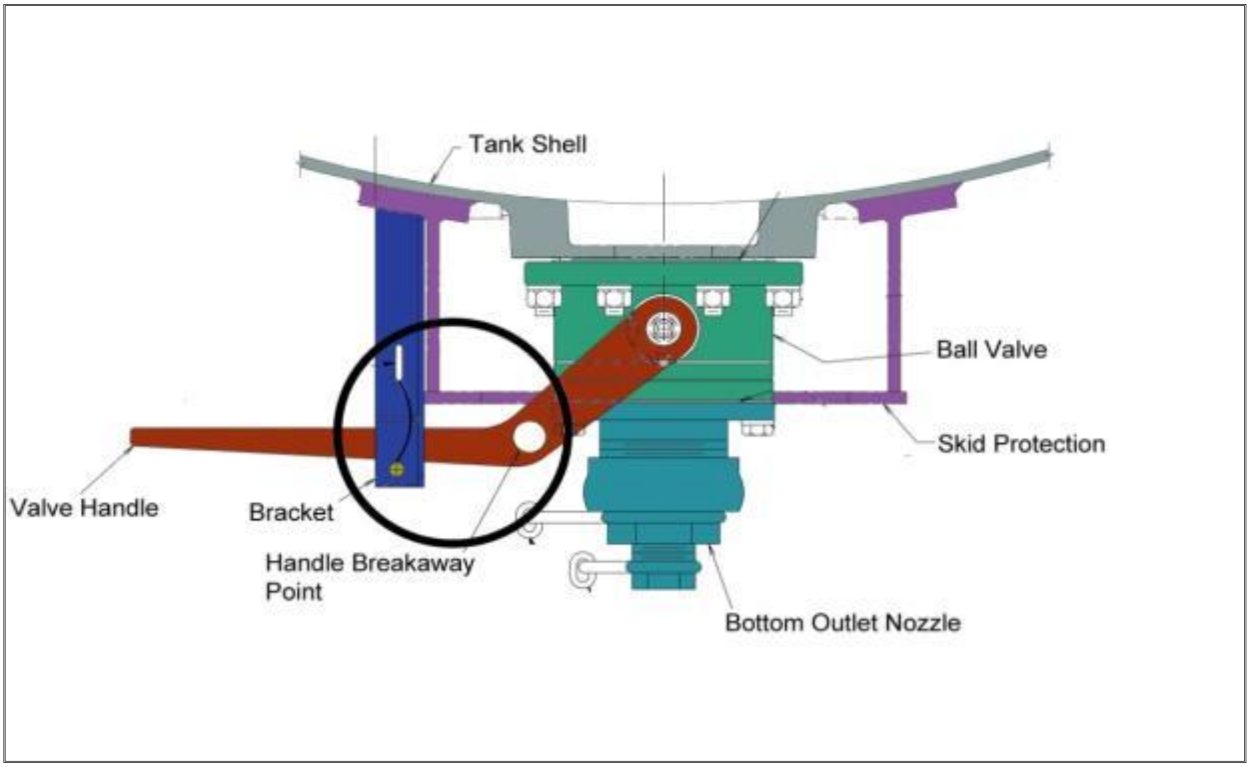

Figure 7. Bottom outlet valve configuration, as modified from original design, for derailed CITX and CTCX cars. (Not to scale) The operating handle securing bracket is circled. (Adapted from a Trinity Tank Car drawing)

The cars owned by GE Equipment Services (NATX) and by Trinity (TILX) were equipped with a 4-inch ball valve of the type shown in figure 8. The valve operating handle extended upward along the side of the tank where it could be secured in its closed position by a bracket and retaining pin. A transversely oriented handle extension attached to the valve through a hole in the skid protection structure. The valve was opened by moving the handle longitudinally.

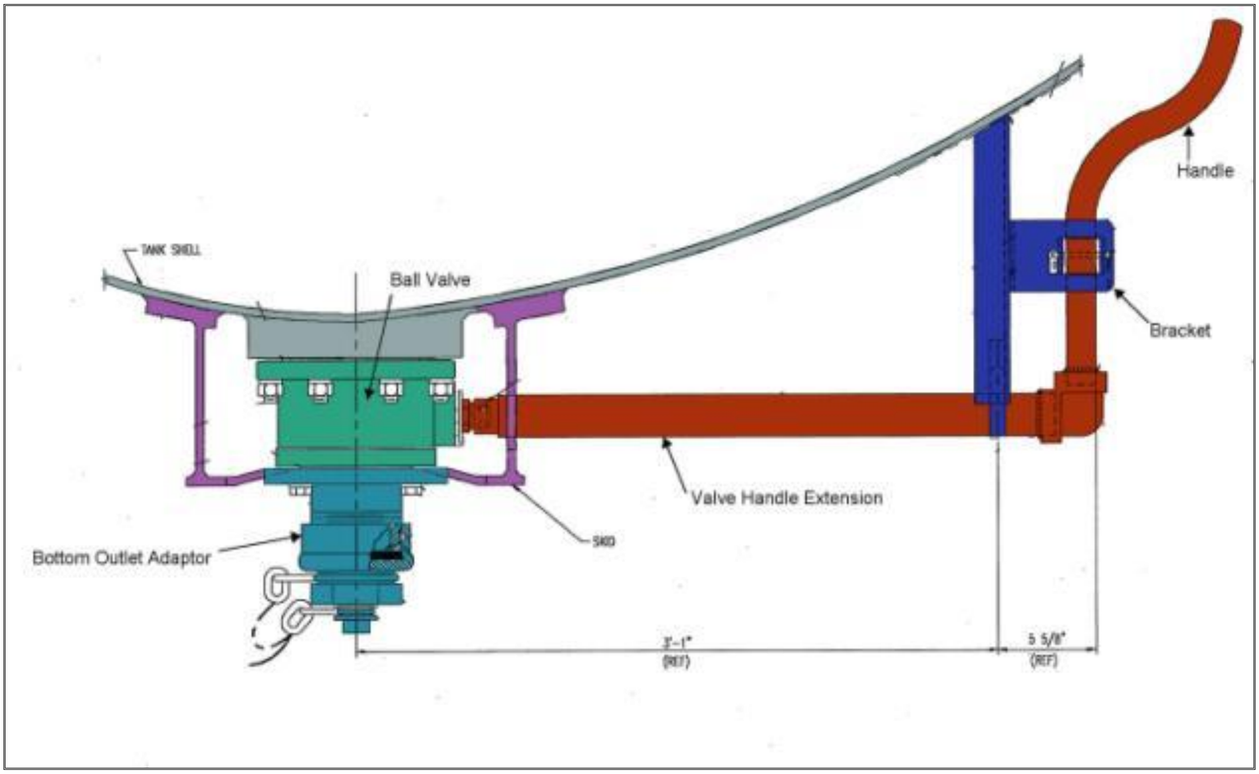

Figure 8. Bottom outlet valve arrangement (not to scale) used on derailed NATX and TILX tank cars. (Adapted from a Trinity Tank Car drawing)

The tops of the derailed tank cars were equipped with a number of fittings and appurtenances such as loading and unloading valves, pressure and vacuum relief devices, and manways (openings that allow access to the inside of the tank for inspection, maintenance, or cleaning). Although the products carried in DOT-111 tank cars are not pressurized, the tank cars involved in this accident were manufactured to a test pressure of 100 pounds per square inch, gauge (psig). Each of the derailed tank cars was fitted with a single pressure relief valve that is designed to prevent excessive pressure buildup within the tank if exposed to fire. At the time of the accident, FRA regulations (Title 49 CFR 179.200-16) required manufacturers of non-pressure tank cars with top-mounted loading and discharge devices to protect those fittings with steel covers and sidewalls that were at least 0.119-inch thick.

All of the tank cars on the train were relatively new, and all the required inspections were up to date. Before the tank cars were loaded for the accident trip, the shipper inspected them to ensure that they were in proper condition to transport denatured fuel ethanol. According to the shipper's documentation, these inspections revealed no defects or damages to any of the tank cars.

1.11 Hazardous Materials Information

Denatured fuel ethanol is a colorless, water-soluble liquid with an alcohol- and gasoline-like odor. The product is regulated by the DOT as a flammable liquid. In the Energy Policy Act of 2005, Congress directed the U.S. Environmental Protection Agency (EPA), in coordination with the U.S. Department of Agriculture and the U.S. Department of Energy, to design a program that requires the blending of renewable fuels[33] into the nation's motor-vehicle fuel supply. This program, called the Renewable Fuel Standard, Title 40 CFR Part 80, Subpart M, is intended to reduce U.S. dependence on foreign sources of petroleum and also is expected to provide reductions in greenhouse gas emissions. On February 3, 2010, the EPA issued a final rule that revises the Renewable Fuel Standard Program as required by the Energy Independence and Security Act of 2007.[34] These revisions, known as RFS2, mandate incremental increases in the annual production of renewable fuels that must be used in transportation fuel from the 2010 level of 12.95 billion gallons to 36 billion gallons by the year 2022.

According to the Renewable Fuels Association, in January 2009, 170 ethanol bio-refineries were operating in 26 states, with 20 new facilities under construction. Although pipelines are a preferred method for transporting petroleum products over long distances, ethanol is not shipped by pipeline because it is thought to cause stress corrosion cracking in pipeline walls. In a notice of proposed rulemaking,[35] the EPA states that because of the uncertainties regarding the future use of pipelines, the agency assumes that ethanol will continue to be transported from production facilities by rail, barge, and truck to petroleum terminals where it will be blended into gasoline. The EPA believes that distribution by these modes can be further optimized primarily through increased shipment by unit train,[36] potentially tripling the current number of ethanol shipments being transported in DOT-111 tank cars over the next 10 years.

In 2008, denatured ethanol was the most common hazardous material commodity transported by railroad in North America, with 218,902 tank car shipments originating in the United States. By comparison, the second most travelled commodity by railroad in 2008 was liquefied petroleum gas, with 105,364 tank car shipments.

1.12 Postaccident Environmental Monitoring and Remediation

After investigators inspected the tank cars, the cars were pumped and purged of product. Between June 21 and June 24, about 107,745 gallons of ethanol, or about 25 percent of the original 431,708 gallons of lading from the 15 tank cars involved in the pileup, were recovered. The total amount of lading consumed by fire or released to water, soil, and air in the accident was about 323,963 gallons.

1.12.1 Air Monitoring

The CN contracted with a company to monitor releases of hazardous materials to air and water. Real-time air sampling began about 4:02 a.m. on June 20, 2009, and continued through June 25, 2009. The results of air monitoring at various locations for volatile organic compounds, ethanol, and particulate matter indicated no concentrations requiring additional action.

[33] Renewable fuels are fuels produced from plant or animal products or wastes rather than from fossil fuels. The most widely known renewable fuels are ethanol and biodiesel.

[34] The final rule was effective July 1, 2010.

[35] *Federal Register*, vol. 74, No. 99 (May 26, 2009), p. 25003.

[36] A *unit train* is designed to move as a single unit from origin to destination.

1.12.2 Contaminated Soils

On the morning of June 21, 2009, investigators observed evidence of spilled ethanol in the tank car staging yard adjacent to the accident site. The CN's environmental contractor excavated and stockpiled contaminated topsoil from an estimated 1/2-acre area in the staging yard. The excavated soil was commingled with contaminated soil removed from the derailment area. On June 23, 2009, testing of the stockpile characterized the soils as nonhazardous material, and from June 24 through June 27, contractors transported 82 truck loads consisting of about 1,733 tons of contaminated soil to a landfill.

Between June 25 and June 30, 2009, CN contractors completed 57 soil borings and dug 6 monitoring wells in the derailment zone and in the staging yard in order to investigate the presence or extent of any subsurface soil and groundwater contamination. Samples were tested for a wide range of chemical contaminants, including ethanol and petroleum hydrocarbons. The soil and groundwater results yielded no concentrations of these compounds that exceeded applicable remediation objectives.

1.12.3 Water Pollution

The EPA, as the Federal on-scene coordinator, estimated that about 60,000 gallons of ethanol were released into a tributary of the Rock and Kishwaukee Rivers, resulting in a significant fish kill. The EPA reported that the fish kill likely resulted from depressed dissolved oxygen levels in the river from the natural degradation processes of the ethanol.

On June 21, 2009, about 8:00 a.m., the Illinois Conservation Police began receiving reports of fish dying in the Grand Detour area of the Rock River. The fish kill ultimately affected about 53.6 miles of the Rock River between Grand Detour and Erie, Illinois. For about 36 hours following the initial fish kill report, Illinois Department of Natural Resources biologists measured, counted, and sorted affected fish species. The Department of Natural Resources estimated that about 72,350 fish were killed with an associated value of about $272,300.

Other pollutants of concern were the components of the gasoline that was used as a denaturant for the ethanol. On June 21 through 24, 2009, water samples were collected at several stations along the Rock and Kishwaukee Rivers and tested for total petroleum hydrocarbons and gasoline-range organics. These tests did not yield any levels of detectable chemical compounds in excess of human health and ecological screening levels.

Tests were performed on water samples from a community well that served about 200 households about 1/2 mile north of the derailment site, as well as seven additional residential wells from nearby communities. The samples were tested for total petroleum hydrocarbons and gasoline-range organics, yielding no detectable chemical concentrations in excess of their human health screening levels.

1.12.4 Waste Disposal

The CN contracted for accident site waste remediation. Depending on the degree of product contamination caused by the fire, waste materials resulting from transfer of liquids from the damaged rail cars were shipped either as recycled hazardous material or as hazardous waste. Virgin denatured fuel ethanol pumped from the tank cars was transported by motor carriers under hazardous materials bills of lading. Burnt sludge and residues were transported for disposal as characteristically ignitable hazardous waste.

1.13 Pipeline Information

The Nicor natural gas pipeline at the site of the derailment was constructed in 1965. The pipeline ran parallel to the west side of Mulford Road and consisted of a welded 12-inch-diameter pipeline installed inside a 50-foot-long segment of 16-inch steel pipe casing. Both pipes had a nominal wall thickness of 0.375 inches. The casing pipe had 2-inch-diameter vents along each side. The pipe had a technical specification indicating a minimum tensile strength of 60,000 psi and a minimum tensile elongation of 22 percent. At the time of the accident, the pipeline was operating at a pressure of 288 psig. At the site of the derailment, the top of the pipe was about 11 feet below the surface.

Yellow fiberglass markers indicating the presence of the gas pipeline and providing the owner's name and emergency contact number were in place on the north and south sides of the tracks before the derailment. The nearest marker on the south side of the grade crossing was about 50 feet south of the tracks on a utility pole that was destroyed in the postderailment fire. A second, legible pipeline marker was about 250 feet south of the tracks within a tuft of vegetation along Mulford Road. The nearest visible postfire marker on the north side of the derailment was between the CN and UP tracks. Another marker, about 525 feet north of the grade crossing on the west side of Mulford Road, was not damaged in the accident.

1.14 Postaccident Inspections and Testing

1.14.1 Mechanical Systems

After the accident, investigators inspected the general mechanical condition of the locomotive and the cars that did not derail. The inspections determined that the running gear and foundation brake rigging were within specification on every car. The two locomotive units were designated for road service with all required inspections current. No exceptions were taken to the mechanical condition of the locomotives. The only mechanical exceptions taken were to preexisting broken coupler knuckle pins[37] on three of the nonderailed tank cars. For all of the cars, no exceptions were taken to air brake piston travel, brake pipe leakage, brake shoe condition, or any other aspect of any car.

[37] A *knuckle pin* acts as a hinge pin to keep the knuckle in place within the coupler body while the knuckle is being either opened or closed.

1.14.2 Track

NTSB investigators recorded track geometry measurements for 62 stations[38] leading up to the first section of damaged track. One station that incorporated damaged track was also measured. In addition to measurements for gauge (distance between the rails), cross level (difference in height of the rails in tangent track), and alignment (the "straightness" of the tracks), investigators also looked for evidence of movement. Gauge, cross level, and alignment measurements on nondisturbed track were within FRA allowable measurements for Class 4 track. The track showed no evidence of rail movement in the area leading up to the derailment footprint.[39] The ballast cribs (the spaces between the crossties) were full in the immediate vicinity of the track to the west of the derailment footprint.

Portions of broken rail segments retrieved from the track wreckage were reassembled on scene. The reconstruction revealed that a piece of the north rail had a blunt strike mark on the gauge (inside) corner of the rail head. The rail piece was later identified as a match to another piece of rail that contained a weld typically associated with in-track welding. Interviews about Mulford Road upgrades/renewals and a review of ultrasonic data confirmed that this weld had been about 8 to 10 feet west of the crossing. The rail pieces did not exhibit any defective rail condition.

Witnesses to the accident said that the rails were bending west of the crossing and that the freight cars were "bouncing" at that location before they derailed. Investigators observed marks on some of the north wheel flanges of the last two cars on the forward portion of the train—the first two cars to derail and the two cars just ahead of the point at which the derailing cars caused the train to separate into two sections. Based on these data, investigators determined the point of derailment to be at MP 80.18, about 8 feet west of the Mulford Road crossing and within the area where the track was unsupported because of the washout of the track structure.

1.14.3 Signals

Investigators inspected and tested the signal system and the highway/rail grade crossing warning system to the extent possible. All signal units and signal cases were found locked with no indication of tampering or vandalism that would interfere with the operation of the signal system. Although the wayside signal system did not incur damages as a result of the derailment, the subsequent fire destroyed the signal case that housed the highway/rail grade crossing equipment as well as the masts on which the flashing warning lights and crossing gates were mounted. The GCP-3000 unit and data logger were recovered, but the data were not downloadable because of damage from the postaccident fire.

Investigators reviewed CN signal maintenance reports for the wayside signals and the highway/rail grade crossing warning equipment. The maintenance records indicated that all signal tests and inspections had been conducted in accordance with FRA regulations and CN requirements.

[38] Typical postaccident station measurements are recorded on the leading side of a point of derailment, where possible, in 15 1/2-foot increments.

[39] The derailment *footprint* refers to the limits of the damaged track and resting positions of the derailed cars.

1.14.4 Pipeline

As the wreckage was removed from above the pipeline, Nicor crews discovered that a railcar wheel and axle assembly had impinged on the pipeline. Although the pipeline was buried about 11 feet deep, the rail car wheels had contacted the 16-inch-diameter protective casing that surrounded it. Photographs taken of the pipeline damage by Nicor crews as they worked through the evening of June 21, 2009, to excavate and inspect the pipeline revealed severe flattening of the pipe casing. Crews also observed sharp angular bends at two locations where the casing was contacted by the rail car wheel assembly.

1.14.5 Derailed Tank Cars

Between June 21 and June 22, 2009, investigators visually inspected the 15 derailed tank cars (positions 59 through 73) that constituted the 400-foot-long pileup across Mulford Road. The car inspections were conducted after the CN had staged the damaged cars on a vacant lot west of Mulford Road between the UP and CN tracks.

All 15 tank cars in the pileup were damaged as a result of the derailment and subsequent fire, with only 2 of the cars (the first two cars in the pileup) retaining their entire lading. Of the 13 cars that released all or part of their contents, 11 were breached. Most of the cars sustained varying degrees of dents, deformations, and breaches. The derailed tank cars sustained a total of 15 head punctures or tears (figure 9), and 4 tank shell punctures or tears (figure 10). Head failures in seven of the cars were caused by coupler or draft sill strikes. Two of the tank heads were breached by other striking objects or tank car structures. Additionally, side shells of three of the tank cars were breached as a result of car-to-car impacts. Eleven of the tank cars involved in the derailment were fire-damaged as evidenced by scorched or burned-away paint.

Figure 9. Tank head punctures in two derailed tank cars (outlined with white paint). (Federal Railroad Administration photo)

Figure 10. Breach in tank car NATX 303504. (Federal Railroad Administration photo)

Many of the cars had valve and fitting damage ranging from sheared nozzles to broken valve handles. The postaccident inspection found six cars in which the bottom outlet valve nozzle sheared from the ball valve flange, as designed. Of these six cars, three of the ball valves had opened, contributing to the release of product from their respective cars. The ball valves had opened on three of these six cars, contributing to the release of product from those cars. The postaccident inspection revealed that the valves had opened when the valve levers were bent or pulled away from their retaining brackets during the derailment. Valve and valve configurations of both types (modified CIT and NATX/TILX) were involved in the product release. (See figures 11 and 12.) As evidenced by the burn patterns on the tank shells around the center sides of the three tank cars, the release of product through the bottom outlet valves contributed to the postaccident fire.

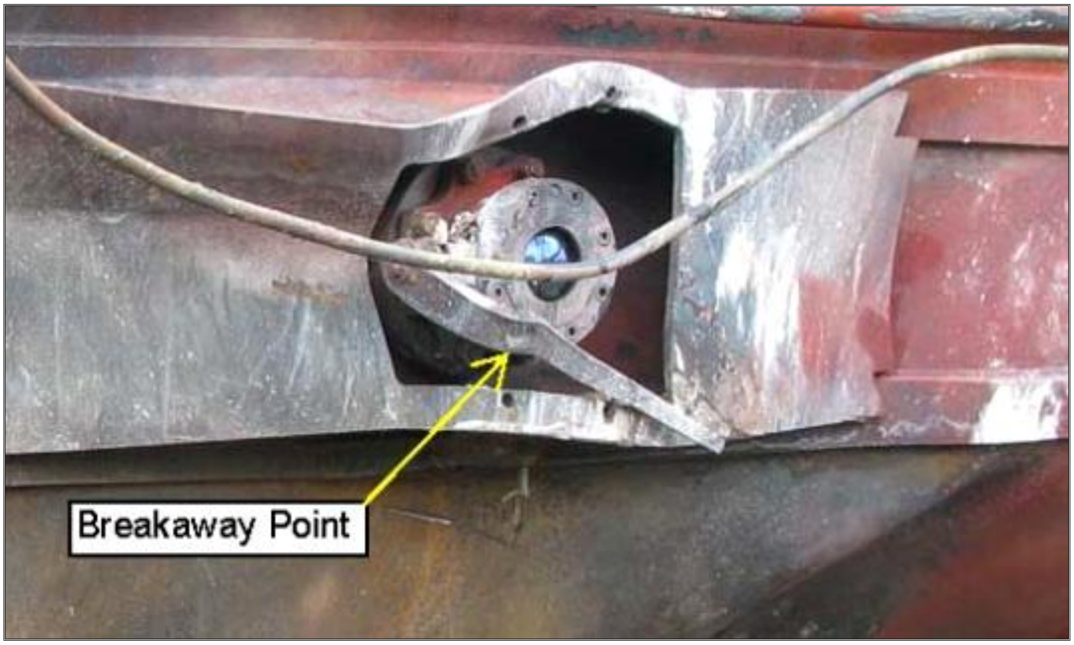

Figure 11. Bottom outlet valve of car CTCX 731599 showing exposed valve and bent but intact valve operating handle. Handle retaining bracket is missing. (Valve was opened during derailment but was closed by emergency responders.)

Figure 12. Bent valve handle and exposed and partially open bottom outlet valve on car NATX 303504. (Federal Railroad Administration photo)

Three top valves were also found to be damaged and either partially or fully open. In the case of one car, CTCX 224236, the protective housing separated from the car, and both the liquid and the vapor valves were sheared from their threaded pipes, causing the car to lose about 26,357 gallons of product. The protective housing cover of car TILX 193772 (figure 13) was knocked askew in the derailment, breaking the vapor valve from its fitting and contributing to the release of product from that car. While the protective housing did prevent damage to fittings in the case of one car (CTCX 731600), which came to rest lying upside down in a muddy stream channel, the top fittings were damaged in other instances where the protective housings contacted harder objects.

Figure 13. Top fitting damage, car TILX 193772. (Overall photo by Trinity Tank Car. Inset photo by the CN.)

Six of the derailed cars were selected for detailed examination and materials testing. The results of that effort are detailed in the "Tests and Research" section of this report.

1.15 Track Inspections in Accident Area

1.15.1 CN Track Inspections

Records showed that the CN operated a geometry test car over the Freeport Subdivision five times between November 1, 2007, and the day of the accident. On the most recent test, on March 2, 2009, the data indicated an incipient profile value (a short dip in the track affecting both rails) in the track geometry west of Mulford Road that did not require a slow order (a reduction in operating speed for the trains). The CN surfaced that portion of track beginning in May 2009. The second most recent test, on December 2, 2008, indicated some minor geometry conditions that required a 50-mph slow order. The order had no real effect, as the slow-order speed was the same as the maximum authorized speed for that portion of the subdivision. The geometry data recorded prior to the two most recent tests did not show any deficiencies near the derailment area.

FRA regulations (49 CFR 213.233(c)) require that Class 4 track be inspected twice weekly with a 1-day interval between inspections. The FRA reviewed the records of CN track inspections for the 12-month period before the accident and took no exception to the type or frequency of inspections except for some recordkeeping items. A review of CN track inspection records for the 12 months prior to the accident indicated that no track deficiencies had been noted in the derailment area.

In postaccident interviews, a CN track inspector said that on the day of the accident he reported for work about 5:30 a.m. and proceeded to inspect track from Freeport eastbound (including the accident area). A welder helper and a laborer who worked the same area that day recalled that after reporting for duty, they went to MP 108 to make two welds. The track supervisor stated that he was at the Freeport headquarters until he received a call from the CN's Edmonton Walker Call Desk advising him of a severe weather alert (high winds). The track supervisor said he contacted the welder helper and the track inspector and directed them to inspect the track from MP 100 to 79 and from MP 53 to 36, respectively. He indicated that he, himself, would inspect the track between MP 79 and MP 53.

The track inspector said that he did not note any significant water conditions at Mulford Road when he went by about 7:30 a.m. The welder helper and the laborer stated they did not see anything abnormal when they came through about 1:00 p.m. The welder helper said he did observe a "little more water than normal," but "nothing very high at all," and no washouts. The welder helper recalled that the track supervisor, during his Hy-rail[40] trip, discovered a tree blocking the track at MP 74.0 and told the welder helper and the laborer to go to that location and remove the tree. They said that they removed the tree and then returned to Freeport where they went off duty. The track inspector stated that he completed his inspection and special patrol for high winds about 11:30 a.m. and returned to Freeport.

The track supervisor stated that while he was returning to Freeport, he decided to drive by Mulford Road and check that area. He said that upon arriving at Mulford Road about 2:00 p.m., he pulled over to the west side of the road and observed both ditch lines, taking no exception to the amount of water present. He said that he then proceeded to Freeport and went off duty for the weekend.

Investigators interviewed a number of CN engineering personnel working on the Freeport Subdivision. Based on those interviews, except for the initial high-winds alert, none of them were contacted by either Edmonton Walker Call Desk personnel or by the RTC about any weather-related alerts or track problems affecting the Rockford area on the day of the accident.

[40] *Hy-Rail* refers to a vehicle, usually a pickup truck, that has been modified to operate both on the highway and along the rails.

The track inspector stated that he was familiar with the territory and knew where severe weather could be a particular concern. The track supervisor, the track inspector, the manager of engineering, and the regional chief engineer said their understanding of the CN's weather alert policy was that they would be called by Edmonton Walker Call Desk personnel or by the RTC if one of those parties received information indicating that weather could affect operations. The engineering employees also stated that they are empowered to initiate track inspections based upon observing severe weather even if they have not been notified and directed to do so.

1.15.2 FRA Track Inspections

On October 28, 2008, an FRA track inspector inspected the track between MP 73.0 and MP 115.0 (which included the accident area) on the Freeport Subdivision. The only exception noted was a defective weld at MP 107.3.

1.15.3 Ultrasonic Rail Testing

CN records indicated that the company conducted ultrasonic tests of the rail on the Freeport Subdivision several times per year. The rail was tested three or more times in 2007, five times in 2008, and twice in 2009 leading up to the day of the accident. The most recent ultrasonic rail test had been conducted on February 19, 2009. The only defect noted for the accident area during that test was a defective weld at MP 81.18, which was repaired.

1.16 Previous CN Track Washouts Near Mulford Road

The CN track supervisor told investigators that about 3 years before this accident, in September 2006, heavy rains led to significant water runoff into the swale between the CN and UP tracks west of Mulford Road. A subsequent track inspection found a loss of ballast along the north shoulder west of the crossing and the south shoulder east of the crossing. The loss of north rail shoulder ballast extended for about 200 feet; the loss east of the crossing was located adjacent to the crossing. The ballast was not washed out under the ties, and only the shoulders were affected (a longitudinal washout). A water backup caused a swirling motion of water that caused a loss of ballast along the track on the east side of the crossing. The track supervisor said the ballast loss on the east side was only down to the bottom of the crossties and that no crossties were "hanging." At all of the locations of ballast loss, the ballast section was restored and the track was tamped.

In August 2007, according to the CN track supervisor, the Cherry Valley area experienced an 8-inch rain storm. The track supervisor said that he went to the scene and found that the water had caused a washout area 5 to 6 feet long and about 4 feet deep under the tracks about 40 feet west of the Mulford Road crossing. To help prevent future washouts, the CN installed a 36-inch-diameter corrugated steel pipe at the site of the washout. The CN indicated that no calculations had been performed to size the 36-inch pipe. The CN also indicated that such designs are based on the expected water flow, but no design calculations are actually performed. The pipe was laid through the washout opening and secured with ballast and rip rap (piles of large rocks). After installation was complete, the top of the pipe was about 1 foot below the bottom of the crossties. At this height, about 8 feet above the bottom of the ditch line, it would not be a culvert for normal water flow but could serve as a “relief” outlet that would allow flooding waters to drain from the north ditch line to the south side of the tracks. The area to the west of the grade crossings was so severely damaged by the derailment that the 36-inch pipe was not found after the accident.

The CN did not consult with the Winnebago Highway Department or any other jurisdictional entity to determine why excess water sufficient to cause a washout had collected. Nor was there a consultation with the Winnebago County Highway Department before the CN made the decision to install the 36-inch pipe in the washout area.

1.17 Hydrological Information

1.17.1 Rainfall Estimates

Investigators initially relied upon the statistical rainfall amount from the Greater Rockford Airport, which is about 5 miles southwest of the accident scene, as the amount of rain that had fallen in the accident area on the day of the accident. Although the official rainfall at the airport was measured at 3.25 inches from a rain gauge, Doppler images indicated a much higher intensity of rainfall as the severe storm was developing and moving over the area surrounding the accident site. Rainfall data indicated rainfall rates ranging from 3.25 inches per hour to 8.9 inches per hour during a 50-minute period before the accident. The rain storm caused flooding in many areas of Winnebago County, including in Rockford and Cherry Valley. Local residents interviewed stated that it was the worst flooding they had seen.

1.17.2 Culverts

The Mulford Road grade crossing and the area to its north and east had a number of hydrologic features designed to manage and direct the flow of storm water. These included, in addition to the 36-inch pipe the CN had installed under its tracks in 2007, an 18-inch-diameter corrugated metal pipe culvert under Mulford Road just north of the UP Mulford Road crossing, a 24-inch-diameter corrugated metal pipe culvert under Mulford Road north of the CN crossing, and a 5- by 10-foot reinforced concrete box culvert under Mulford Road just south of the CN crossing. The pipes and culvert were installed by the Winnebago County Highway Department in 1970 as part of the reconstruction of Mulford Road. (See figure 14.)

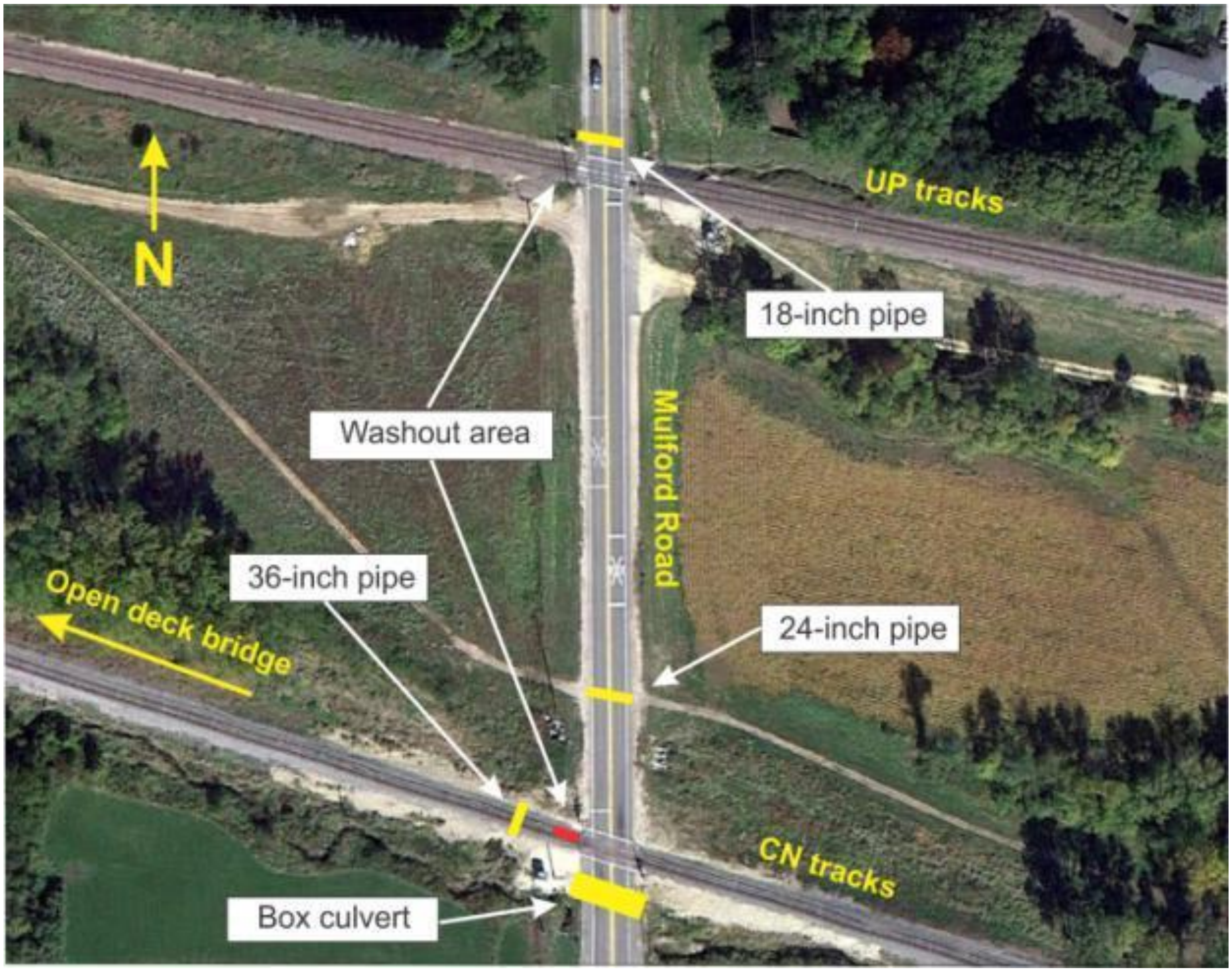

Figure 14. Aerial view illustrating CN and UP grade crossings and location of culverts and washouts on day of accident.

When asked why no actions had been taken with regard to the 24-inch and 5- by 10-foot culverts on either side of the CN crossing after the heavy storms had caused flooding in 2006 and 2007, Winnebago County highway officials responded that the storm water had damaged the CN tracks but that Mulford Road had not been affected. The officials stated that the highway department had sent inspectors in 2007 to observe the installation by the CN of the 36-inch pipe to ensure that no damage was done to Mulford Road.

According to Winnebago County highway officials, the concrete box culvert to the south of the CN crossing was the primary structure for conveying runoff generated within the upstream drainage basin. The 24-inch culvert immediately north of the CN tracks was to serve as a relief pipe for runoff that collected in the swale between the UP and CN tracks along the west side of Mulford Road—it was not intended to convey any significant storm flows. The primary storm water path was along the south side of the CN tracks, and its primary conveyance past Mulford Road was the concrete box culvert. According to the officials, the box culvert was sized in accordance with this drainage plan. After the 2007 rain storm, the Winnebago County Highway

Department did not make any changes to the drainage system for Mulford Road where it intersected with the CN tracks.

The methodology used by the Winnebago County Highway Department to design culverts (or pipes) under public roadways was contained in the Illinois Department of Transportation *Drainage Manual*. The manual was used as a matter of policy and was referenced in the county's surface water management ordinance. According to the *Drainage Manual*, culverts or pipes intended for two-lane roadways (such as Mulford Road) were to be sized based on a 30-year flood frequency (3 percent probability of occurring in any one year), and those for four-lane roadways were to be based on a 50-year flood frequency (2 percent probability of occurring in any one year).

1.17.3 Detention Ponds

A little more than 1/2 mile northwest of the CN Mulford Road crossing, the residential subdivision of Harrison Park was the site of two storm water management (SWM) detention ponds,[41] both built in 1997. (See figure 15.) Based on design drawings, the larger of these, referred to in this report as SWM pond 1, measured 400 by 255 feet at the pond bottom and 458 by 306 feet at the top of the berm. According to county officials (and as is typical within municipalities) the storm sewers and inlets that were tributaries for SWM pond 1 were designed to the 10-year storm (10 percent probability of occurring in any year), while the pond itself was designed to the 100-year storm event (1 percent probability of occurring in any one year).[42]

[41] A *detention pond,* sometimes called a dry pond, temporarily stores water after a storm, but it eventually empties at a controlled rate downstream to another location.

[42] A 1989 Illinois state water survey report provided statewide frequency distributions for heavy rainfall events in Illinois. The distributions were determined for rain periods ranging from 5 minutes to 10 days and recurrence intervals varying from 2 months to 100 years. Based on the hourly precipitation rate of 3.38 inches at the Greater Rockford airport (about 5 miles from the derailment) on June 19, 2009, that heavy rainfall event would be considered to fall between a 50-year flood and a 100-year flood.

Figure 15. Aerial view showing location of Harrison Park subdivision detention ponds in relation to accident site.

During the postaccident investigation, SWM pond 1 was found to have a breach in its southeast corner at the site of the pond outlet. The breach measured 12 feet high by 18 feet wide with water continuing to flow out from north to south. Inside the pond, investigators found a small stream leading to the breach. The stream was 4 to 6 inches deep and 2 to 3 feet wide. The remains of several pieces of 27-inch-diameter reinforced concrete pipe were found scattered at the bottom of the breach opening. (See figure 16.)

Further investigation of the breach revealed a plume of material (sand, clay, dirt, small rock) as well as flowing water (2 to 4 inches deep) extending southeast out of the retention pond and toward the UP track. Investigators followed traces of water flow that led to the UP track and discovered washout damage (about 15 to 20 different locations from below the outlet going east to Mulford Road that varied in length and depth below the bottom of the ties and outside of the end of the crossties). From the UP washout, the water appeared to flow in a southeast direction.

Figure 16. Postaccident photograph showing breach in SWM pond 1 as viewed from inside pond looking south.

Investigators interviewed several residents who lived adjacent to SWM pond 1. The residents told investigators that the berm directly over the outlet of the pond had been deteriorating for the past several years. The managing agent (a local realty firm) for the Harrison Park Landowners Association[43] provided investigators with an April 2008 photograph (figure 17) showing a view looking north from the downstream end of the outlet area of the detention pond.

[43] The detention ponds were owned in common by the landowners in the Harrison Park subdivision.

Figure 17. View looking north from downstream end of outlet area of SWM detention pond 1 showing erosion over top of outlet culvert and erosion below outlet. (Photo taken in April 2008.)

The recorded plat of the Harrison Park subdivision notes that “the maintenance of the drainage and storm water detention easement shall be the sole responsibility of the individual property owner.” According to the records of the Harrison Park Landowners Association, after the deterioration at the outlet of SWM pond 1 had been noted in April 2008, a local construction company submitted a bid to repair the damage for $23,436. In 2009, the association agent began assessing Harrison Park landowners to pay for the repairs. At the time of the accident, the balance in the fund to repair the damage was $23,288.11. The breach was repaired on September 3, 2009, at a cost of $23,500.

The city of Rockford had a permit with the Illinois Environmental Protection Agency that required the city to inspect storm water management detention ponds as part of a larger program to prevent water pollution. The ponds, including privately owned ponds, were to be inspected for the presence of sediment, floatables, and water. According to city officials, privately owned storm water management detention ponds were inspected only during dry weather. The city had conducted citywide inspections that included detention ponds in 1997, 2004, and 2008.

1.18 RTC Training and Duties

CN RTCs fill the role that has traditionally been referred to as “train dispatcher.” RTCs direct the movement of trains within a division and coordinate train movement from one division to another. Their duties include arranging train meets and passes and managing unexpected delays and emergencies. RTCs regularly communicate with train crews and maintenance-of-way workers by radio or telephone.

1.18.1 Training

At the time of the accident, CN RTC training consisted of about 2 months of classroom work, which included teaching candidates how to use the computerized Train Management Dispatching System (TMDS) that had been implemented in the summer of 2008. Following the classroom training, students typically spent from 8 to 20 weeks at a dispatch desk under the supervision of a qualified RTC. NTSB Investigators interviewed the on-duty RTC and the chief dispatcher and visited the CN’s Homewood, Illinois, control center to examine the CN’s weather procedures and to assess RTC workloads.

1.18.2 Duties Related to Weather Alerts

Train operations on the Freeport Subdivision were governed by the Chicago Division Timetable No. 5, effective 1200 Sunday, April 5, 2009, as well as the CN U.S. Operating Rules, 4th edition, effective June 13, 2008. The CN operating rule book and special instructions that were in effect in the Cherry Valley area at the time of the accident included, in part, the following rules:

> **Rule D:** Reporting Injuries and Defects [which states, in part]
>
> Threatening conditions including, but not limited to, mechanical failures, defects in track, bridges, or signals, must be reported. … Before trying to use any track or structure endangered by flood, fire, or other cause, employees must make a personal inspection and take all precautions to avoid an accident.
>
> **Rule X:** Weather Warnings
>
> When weather warnings are received, the RTC will notify all trains and terminals in the warning area. Quick and precise communication by all employees is absolutely necessary during severe weather conditions.
>
> High Winds in excess of 60 mph - Employees on trains in the warning area may proceed at normal speed if the local weather conditions are not as severe as the weather warning indicated. If local weather conditions are such that the crew in the warning area is concerned about their safety, the train will operate prepared to stop short of obstructions. If conditions require operating at less than normal speed, the crew must notify the RTC immediately.

> Flash Flood Warnings - At locations specified by the RTC, timetable or Operating Bulletin, trains will operate prepared to stop short of obstructions.

A July 16, 2008, CN weather alert policy further instructed RTCs, after learning of warnings of flash flooding, river floods, and saturated ground, with rain criteria of 2 inches in 1 hour, 3 inches in 2 hours, or 4 inches in 4 hours:

> Trains and Track personnel should be contacted - Track personnel if in area should inspect track before train's arrival. RTC Actions requires that trains in the affected area are to be advised of the flash flood warnings and are to proceed at a speed, prepared to stop within one half the range of vision, until the track is inspected or the Track Supervisor has given verbal permission to resume normal operation.

Two severe weather bulletins were in effect on the Freeport Subdivision around the time of the accident. The first weather bulletin, a severe thunderstorm watch, was in effect from 5:34 p.m. to 10:00 p.m. and covered the area from MP 74 to MP 108. The second weather bulletin, a flash flood warning, was in effect from 6:36 p.m. to 10:40 p.m. and covered the area from MP 50 to MP 115 on the Freeport Subdivision and from MP 116 to MP 128 on the Dubuque Subdivision. According to postaccident interviews, the second bulletin, the flash flood warning, was delivered to the Homewood control center by the AccuWeather system shortly after 6:36 p.m.

The TMDS used by the RTCs incorporated computer screens capable of displaying all track segments within an RTC's territory. The RTC could add temporary "labels" to the TMDS screens to highlight significant information about a particular track segment or as a reminder to the RTCs about the status of track or about operating bulletins in effect. To create a label, the RTC would display the affected section of track on his or her computer screen then call up (display) a form and enter the relevant information. The information on this form would then be inserted as a label onto the screen.

Labels could be "restrictive" or "nonrestrictive." Restrictive labels appeared in light blue on the screen and included information that the RTC must communicate to train crews entering the affected area. An RTC who attempted to authorize trains to operate through an area with a restrictive label would receive a TMDS warning as a reminder to notify the crews who would be transiting this area. Information contained in nonrestrictive labels was not required to be communicated to train crews and included, for example, reminders to RTCs of the presence of equipment on a section of track.

When an RTC received a severe weather bulletin—such as a forecast for flash flooding or high winds—that affected the RTC's territory, the RTC was required to add a restrictive label to the computer displays and to notify the crews of trains operating within areas affected by the alert. If trains were already operating in the affected area when the weather bulletin was received, the RTC had to communicate this information immediately to the crew.

Sometime after 6:36 p.m., the regional operations coordinator (ROC) retrieved the severe weather bulletin[44] and walked it over to the RTC working desk 7. The specific communication between the ROC and the RTC during the handoff of the weather bulletin could not be recalled. However, the CN has no written protocol describing the information required to be communicated during this type of handoff. The RTC could not recall how the weather bulletin was handed off (that is, handed directly to him or placed on his desk). After he delivered the weather bulletin, the ROC departed to tend to his other duties. Neither the ROC, nor any other supervisor, was required to verify if the RTC took appropriate action in response to the weather bulletin.

Although the RTC could not recall the specific task he was performing the moment he received the weather bulletin, he believes that he was talking on the radio to a train crew at that time. His radio conversations that evening typically lasted between 1 and 3 minutes. Consistent with his training, he completed his radio communication before addressing his next task, which may have been answering another radio call. (He often had radio calls waiting in the queue.) The RTC had recognized that it was a weather bulletin that had been handed to him. Based on his training and experience, he understood the significance of severe weather bulletins, the requirement to put labels on his computer screens, and the need to notify the trains operating within the mileposts of the weather bulletin. However, he did not read the bulletin and, consequently, did not take appropriate action. He eventually placed the weather bulletin on a stack of papers containing other weather bulletins he had received earlier in his shift. When asked if he should have slowed the train down, he stated that the train crew should have operated the train according to the rules, based upon the conditions that they observed.

The RTC also received a number of telephone calls during his shift. If the RTC was on the telephone or could not take the call (for example, he was talking on the radio), the unanswered calls would be placed in a queue, including the calls from the CN police before the accident.

At the time the weather bulletins were received, the chief dispatcher was on duty at the Homewood control center monitoring the weather and the RTCs. The chief dispatcher told investigators that he was aware of heavy rains and weather alerts on the Freeport Subdivision but that it was the RTC's responsibility to post them. He said he had not monitored the delivery of the weather alerts to the RTC or noted whether the regional operations controller had actually placed the alerts on the RTC's desk. Although the chief dispatcher could have monitored the weather alert process, he did not.

1.19 CN Internal Emergency Communications

CN police representatives told investigators that, upon being notified of a problem at a crossing, the first task of a call desk officer is to locate the crossing. The desk officers may enter the name of the CN subdivision and milepost number into an Internet-based system that responds by displaying a map of the area, or they may use a system that responds with the subdivision and milepost number when the name of the road is entered. The CN representatives said it took no

[44] Weather reports are typically written on a single page with the heading "AccuWeather" written in large, bold print at the top right of the page.

more than 1 or 2 minutes to find Mulford Road and to determine the appropriate contact information.

The CN police emergency response center had telephone lines programmed to contact the various CN RTCs. When notified of the washed-out track near Mulford Road, the CN police used this “speed dial” feature in an attempt to contact the RTC and the chief dispatcher. Calls made directly from the emergency response center to an RTC go into a queue—first in, first answered. If the phone call does not go through, call desk officers may use a dedicated “hotline” to contact the chief dispatcher. According to CN officials, the hotline was restricted to police use and was to be monitored by the chief dispatcher around the clock.

According to the call desk officers on duty during this incident, between 8:18 p.m. and 8:23 p.m. they were looking up the location of Mulford Road while simultaneously dealing with other calls. One of the call desk officers said:

> I was trying to get hold of the dispatcher as soon as I could, but … I was dealing with other calls as well. … I know it was a busy night … but my first priority was trying to get hold of desk 7.

According to response center records, CN call desk officers made calls at 8:23, 8:26, 8:33, and 8:40 p.m. in an attempt to contact the chief dispatcher or the RTC for desk 7. The call desk officer who entered the crossing data for Mulford Road into the mapping system noted that UP tracks crossed Mulford Road just north of the CN tracks, so at 8:30 p.m., the officer called the Winnebago County 911 operator to confirm the location at Mulford Road. At 8:32 p.m., the CN police dispatcher advised Winnebago County 911 that the CN would be “sending someone out” to the crossing. About 8:40 p.m., when call desk officers in Montreal did reach the RTC and the chief dispatcher, neither of the call desk officers reported a track washout.

The call desk officers did not use the hotline to reach the chief dispatcher because they said they had had difficulty getting the line in the past because of CN conference calls being conducted on the line. Also, one call desk officer told investigators that:

> My experience in using [the hotline is that it] depends on how occupied they are on the other end. Sometimes you try to reach them and nobody answers. Sometimes we call and we hear the dispatcher putting the phone on the table without answering, or we have some long time waiting, like the dispatcher is not picking up the line.

During postaccident tests of the line to desk 7 conducted by investigators, the CN police dispatcher waited about 1 minute for the desk 7 RTC to answer. A test call using the hotline was answered in 4 seconds.

See table 2 for a washout notification timeline. A comprehensive timeline of the June 19 event is at appendix B.

Table 2. Washout notification timeline, June 19, 2009.

Time (CDT)[a]	Activity
7:35 p.m.	A citizen calls the Rockford, Illinois, Police Department to report a washout of CN track near the Mulford Road grade crossing in Cherry Valley, Illinois.
7:40 p.m.	Winnebago County 911 (WC911) in Rockford begins receiving multiple calls from citizens about the washout.
8:03 p.m.	WC911 dispatches a Winnebago County sheriff's deputy to Mulford Road to investigate reports.
8:09 p.m.	WC911 deputy attempts to determine owner of tracks with reported washout. Calls BNSF Railway and is told the track is not BNSF.
8:10 p.m.	WC911 deputy calls UP Railroad to report washout. UP tracks are about 500 feet north of CN tracks at Mulford Road.
8:14 p.m.	Sheriff's deputy reaches Mulford Road; calls and advises WC911 deputy that the tracks are washed away.
8:16 p.m.	Having determined that the track belongs to the CN, WC911 deputy contacts the CN Emergency Call Center in Montreal, Quebec, Canada, and informs the call desk officer of washout of CN tracks at Mulford Road in Rockford, Illinois: "Water has washed out rail lines that do belong to you."
8:18 p.m.	CN emergency call center desk officer in Montreal makes first unsuccessful attempt to contact the rail traffic controller (RTC) at Homewood, Illinois, control center. Officer asks another call desk officer to continue calling the RTC while the first officer attempts to reach the chief dispatcher at Homewood. Call desk officers make a total of three more calls each before reaching the RTC and chief dispatcher.
8:32 p.m.	CN emergency call desk officer in Montreal calls WC911 to confirm the location at Mulford Road and to inform authorities that CN would be "sending someone out."
8:35 p.m.	After passing MP 81 (less than 1 mile west of Mulford Road), crew of the accident train calls the RTC to report having encountered high water at Rockford Diamond (a junction of tracks) and water near the tops of the rails near MP 81.
8:36 p.m.	Shortly after the head end of the accident train passes over the Mulford Road grade crossing, the train experiences an automatic emergency brake application as the train derails and separates behind the 58th car.
8:36 p.m.	RTC calls Edmonton Walker Call Desk in Edmonton, Alberta, Canada, to relay the accident train's report of high water at Rockford Diamond and water near the tops of the rails at MP 81. Edmonton Walker Call Desk dispatches local track inspector (who lives in Freeport, Illinois) to the area.
8:40 p.m.	CN Montreal Emergency Call Center desk officers reach the chief dispatcher and RTC at Homewood. Neither caller mentions "washout." RTC responds that he has already reported the high water.
8:42 p.m.	With the head end of their train near MP 79.5, the crew of the accident train radios the RTC to report that the train is in emergency but the cause has not been determined.
8:55 p.m.	Local track inspector dispatched by Edmonton Walker Call Desk contacts RTC and asks to inspect the track east of MP 79. RTC advises him to follow the train that had reported the high water (the accident train, which has already derailed).
8:59 p.m.	The accident train engineer calls RTC to report fire involving at least one ethanol tank car.

[a] Investigators checked and verified two 911 center clock systems with the National Institute of Standards and Technology in Boulder, Colorado, and through a review of paired outgoing and incoming calls with the 911 centers, extended the time validation to the CN's Montreal and Homewood dispatch offices.

1.20 Train Consist Inaccuracy

Title 49 CFR 174.26, "Notice to Train Crews," requires that a train crew have a train consist that reflects the current position in the train of each rail car containing a hazardous material. The train consist must be maintained on board the occupied locomotive of every train. The train crew must update the train consist to indicate changes in the placement of a hazardous material rail car within the train. The regulation states that when changes to the train consist occur en route as a result of pickups or set outs, a train crew must update the train consist by handwriting on it or by appending or attaching another document.

Before the accident train departed Tara, Iowa, the crew was given a consist showing the cars on the train (identified by car number and contents) and their order in the train. About 7 miles east of Tara, in Fort Dodge, Iowa, the train passed an automatic equipment identification (AEI) scanner,[45] which automatically updated the consist. However, according to the scanner report, only 3 of the 76 cars in the train were in the positions indicated on the printed train consist carried by the crew. Although the CN had electronically updated the consist information and train crew changes had occurred in Waterloo, Iowa, and Dubuque, Iowa, neither train crew received an updated paper consist document. At crew change locations, the new train crew typically accepts the paperwork from the crew being relieved, without actually conducting an inspection to check the accuracy of the train consist against the information provided to them. The train continued with the incorrect consist for another 259 miles, to Freeport, Illinois. At Freeport, 38 nonhazardous rail cars were added to the head of the train. Before leaving Freeport, the train crew received a track list[46] for the additional cars, but the consist for the 76 tank cars that were now at the rear of the train remained in error. The conductor did not update the train consist information.

During the emergency response effort on the day of the accident, about 10:20 p.m., the train crew arrived at the IC and presented to emergency responders the Freeport track list and the original Tara consist. The train crew told hazardous materials responders that although they did not know which specific cars were involved in the derailment, all of the tank cars behind the 39th car contained ethanol. The emergency responders concluded from the documents presented by the train crew that each of the tank cars involved in the derailment contained ethanol.

At 1:22 a.m. on June 20, 2009, the CN chief dispatcher e-mailed an accurate train consist to the Region 2 coordinator of the Illinois Emergency Management Agency, who provided the document to the IC.

As a result of the discrepancy in the accident train consist, the FRA issued a July 28, 2009, inspection report directing the CN to develop a transportation action plan to identify the operational procedures and documentation requirements for the transportation of hazardous materials. The FRA indicated that the action plan should address efficiency testing of train crews for hazardous materials consist compliance and announced that it would monitor the CN's efficiency testing by conducting its own unannounced train consist inspections to determine compliance with 49 CFR 174.26.[47]

[45] AEI scanners identify cars on a train by reading the identification tags on cars as they pass the scanner. The AEI reader automatically relays information back to the CN's central computer to update the master train consist.

[46] The term "track list" refers to the order, shipping data, and number of cars as they were placed on a given track.

[47] The CN's response to the FRA's direction to develop an action plan is discussed later in this report in "Postaccident Actions by the CN."

1.21 Tests and Research

1.21.1 Tank Car Specimens for Examination

After the initial on-scene examination of the damaged tank cars, investigators selected six of the cars for further analysis. Pieces and parts of the selected cars were retained, and in some cases, coupons (specimens for testing) were cut from the tank shells and delivered to the NTSB's Materials Laboratory in Washington, DC, for examination and testing.

The detailed examinations focused on the B ends[48] (cut beyond the 5-6 ring[49] weld seams) of tank cars NATX 302968, NATX 302974, NATX 303504, and TILX 193767. The manway and the valves and pressure-relief devices from car NATX 302974 also were removed for examination.

1.21.2 Tank Car Construction

The DOT-111 tank cars involved in this accident were constructed with a draft sill design, where the draft sills[50] of each car were attached to steel "pads" that were attached to the tank. Because the cars did not incorporate a center sill that extended the entire length of the car, the draft sills are also referred to as "stub" sills. Body bolsters and their associated body bolster pads centered above the railcar trucks supported the tank and protected it against lateral forces. The draft sill center plate served as the attachment point between the tank car body and the truck assembly. Reinforcing bars extended underneath the tank between the draft sills on each car. (See figures 18 and 19.)

[48] Because rail cars have no front or rear, for descriptive purposes, the ends of the cars are designated "A" and "B." The B end of a car is the end equipped with the wheel used to manually set the car's brakes. The end without the brake wheel is the A end. As trains are assembled, either end of a tank car may be placed in the front or rear position.

[49] The tank shells were constructed of six "rings" welded together. By convention, ring 1 is at the A end and ring 6 at the B end.

[50] Draft sills incorporate the draft gear that is designed to transfer longitudinal draft (tension) and buff (compression) forces throughout the length of a train.

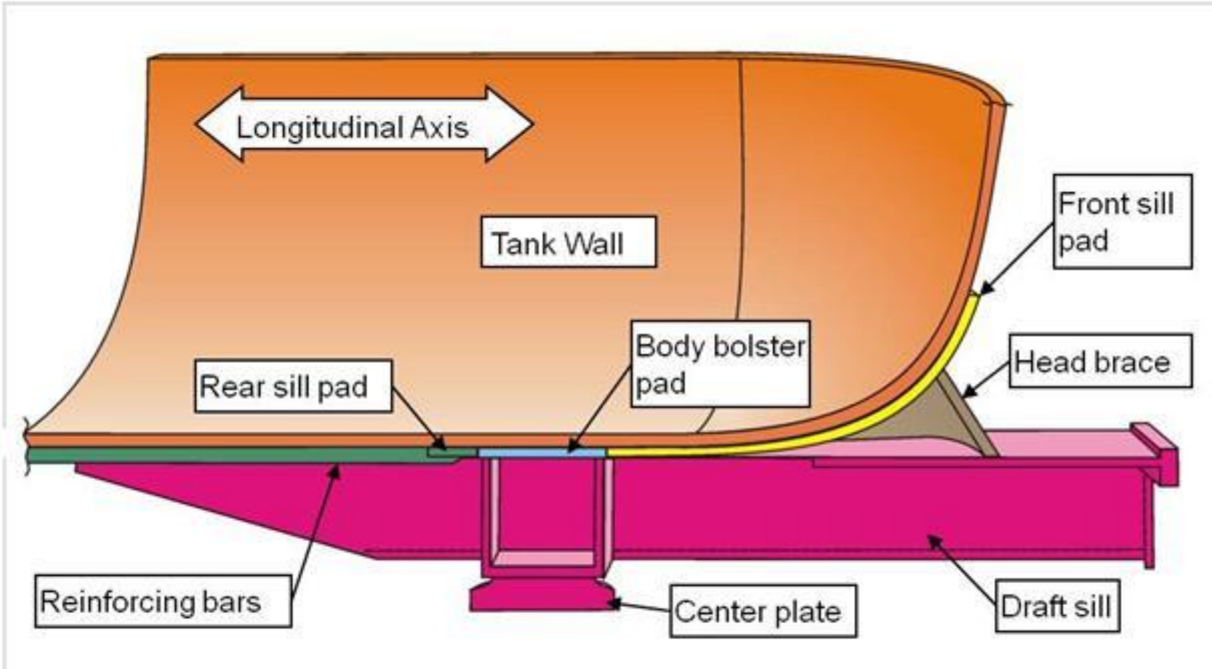

Figure 18. Schematic cutaway view (not to scale) of end of tank car showing major components.

The body bolster pads and front sill pads were attached to the tank with fillet welds.[51] On the body bolster pads, all the edges of the pad were welded. On the front sill pad, the front and sides were welded, as were all inside edges of the rectangular cutout at the center of the front sill pad. (See figure 19.) At the rear edge of the front sill pad, a butt weld[52] attached the front sill pad to the body bolster pad and to the fillet weld attaching the body bolster pad to the tank shell. Fillet welds at the interior and exterior sides of the head brace attached the head brace to the front sill pad, and an exterior fillet weld attached the head brace to the draft sill. To the rear of the head brace, the draft sill was welded to the front sill pad, body bolster pad, and reinforcing bars.

[51] *Fillet welds* are the types of welds used to join two surfaces at right angles. In cross section, fillet welds appear triangular.

[52] *Butt welds* are used to join the squared edges of two pieces that do not overlap.

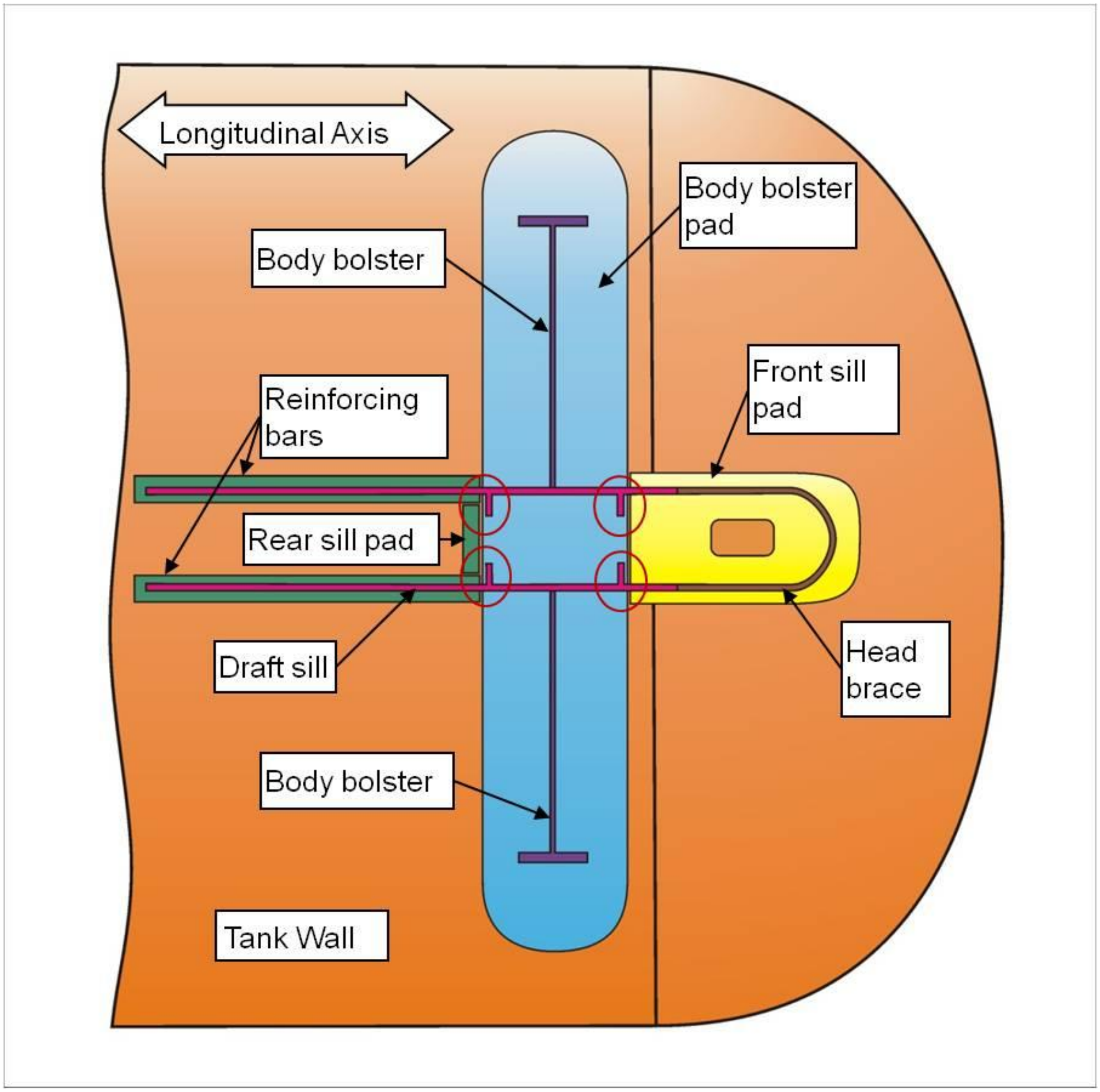

Figure 19. Schematic drawing (not to scale) from below showing body bolster, draft sill, and head brace attachment locations to pads on underside of tank cars. Circled areas indicate where transverse portions of draft sill are welded adjacent to transverse weld of body bolster pad.

1.21.3 Tank Car Construction Standards

Industry standards for stub sill/pad/shell attachments are contained in the Association of American Railroads (AAR) *Manual of Standards and Recommended Practices*.[53] Key requirements for the stub sill attachments are listed below:

1. The throat area[54] of welds attaching the stub sill to the pad must be no more than 85 percent of the throat area of welds attaching the pad to the tank.

2. Pads must extend at least 1 inch transversely on either side of the stub sill.

3. The front sill pad must extend beyond the head brace attachment weld toe[55] by a distance set by a specified formula [~3 inches in the accident tank cars].

With regard to standard 1, the car manufacturer stated that the design complied with the 85 percent rule. As detailed later in this section, NTSB investigators measured the fillet welds from polished and etched cross-section specimens from tank cars NATX 303504 and TILX 193767 and found that they generally corresponded to the sizes specified in the construction drawings. The welds appeared to be workmanlike in both external appearance and in microstructural cross-section. With regard to standard 2, the draft sill was at least 1 inch from the edges of the pads in the transverse direction. With regard to standard 3, the front sill pads on the accident cars extended about 5.5 to 6 inches beyond the head brace weld toe.

1.21.4 Field Examination

Car NATX 303504. An initial examination of the damage at the B end of tank car NATX 303504 (car 66 in the train) showed that the draft sill was deformed downward almost 90 degrees relative to the tank axis. (See figures 20 and 21.) The tail plates of the draft sill (vertical sides to the rear of the center plate) were buckled. The tank shell was fractured circumferentially around about 104 inches of the circumference adjacent to the front edge of the body bolster pad. All fracture surfaces were on slant planes, consistent with ductile overstress fracture. The front sill pad on the car was fractured from the tank shell and remained attached to the head brace and draft sill.

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[53] *AAR Manual of Standards and Recommended Practices*, Association of American Railroads, Washington, DC (October 2007).

[54] For the purposes of this report, the *throat area* can be defined as the thickness of the weld.

[55] The weld *toe* is the point at which the *face* of the weld (the exposed surface of a weld on the side from which the welding was done) meets the base metal (the metal being welded).

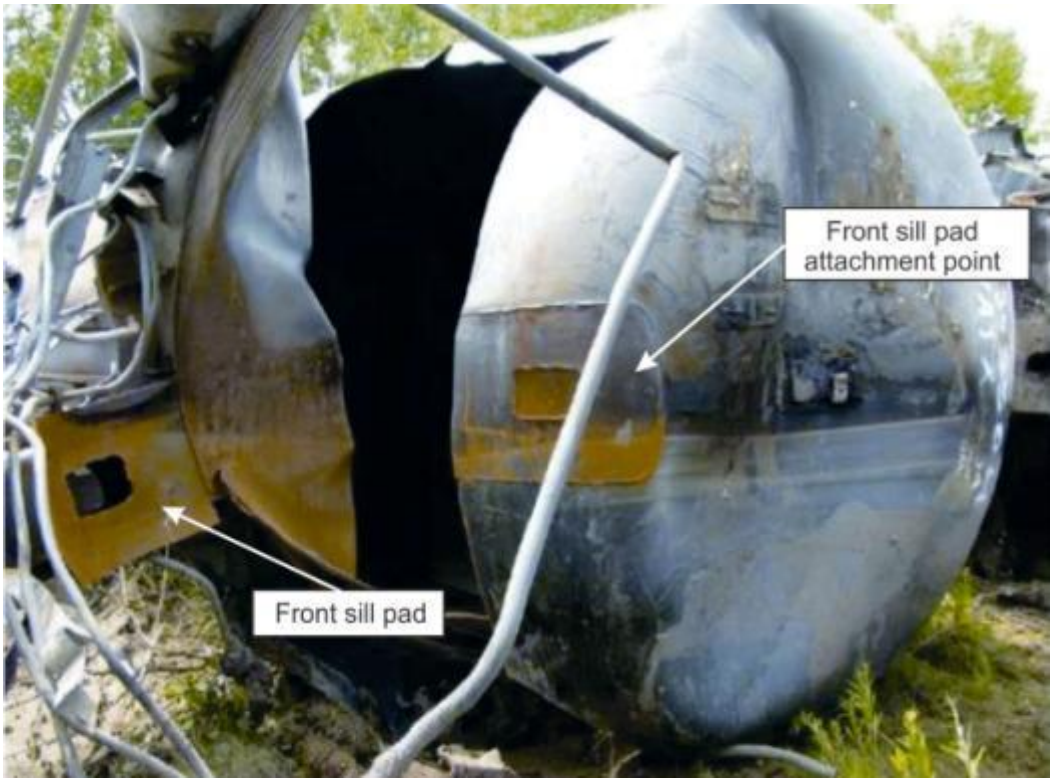

Figure 20. B end of car NATX 303504.

Figure 21. Underside of B end of tank car NATX 303504 as viewed from A end.

Examination of the lower side of the tank at the front sill pad attachment area showed that the fillet weld attaching the sill pad to the tank shell had fractured through weld metal. The weld fractures occurred in various planes from parallel to the tank outer surface to almost perpendicular to the tank surface. The fracture features had a matte gray appearance with a light orange oxide, consistent with ductile overstress fracture with some postfracture oxidation. The fracture features were generally uniform in color and texture, with no evidence within the welds of slag, undercuts, porosity, lack of fusion, or cracks. The portions of the weld metal remaining attached to the tank surface had features that were consistent with fracture propagation from front to rear along the sides of the front sill pad. The weld fractures at the edges of the front sill pad ended at the edge of the body bolster pad, a position also corresponding to the location of the circumferential fracture through the shell. At the lower surface of the tank car, the circumferential shell fracture occurred adjacent to the fillet weld for the body bolster pad and the butt weld attaching the front sill pad to the body bolster pad and bolster pad fillet weld. Investigators did not find evidence of preexisting damage such as fatigue cracking.

NATX 302974. Examination of the B end of tank car NATX 302974 (car 67 in the train) revealed that the head was deformed and had a 25-inch-wide by 44-inch-long opening. An impact mark about 8 inches wide was observed on the lower side of the opening, and head material at the upper side of the opening was folded over on itself three times. A 32-inch-long crack extended upward at the 12 o’clock position from the opening. A closer examination of the draft sill showed that the right side of the draft sill had a torch-cut surface. Adjacent to the cut surface, the right side wall showed “S”-shaped deformation consistent with buckling, and the lower right flange showed upward bending deformation. The left side of the draft sill was fractured on a slant plane with little out-of-plane deformation, consistent with overstress fracture in tension. The upper surface was fractured and folded over on itself. The front sill pad was fractured where it intersected the front portion of the head brace adjacent to the head brace to front sill pad weld. All fractures showed features consistent with overstress fracture with no evidence of preexisting damage such as fatigue cracking.

NATX 302968. The tank head at the B end of car NATX 302968 (car 69 on the train) was deformed inward, and the left side[56] of the tank was fractured circumferentially, with 100 inches of the fracture along the circumferential weld between the head and the shell. The end of the shell at the fracture location was folded over on itself and deformed outward. Fracture features were on slant planes, consistent with overstress fracture. The examination found no evidence of preexisting damage such as a fatigue cracking. The B end of the stub sill was deformed upward relative to the tank longitudinal axis.

TILX 193767. Investigators cut portions of the draft sill and the tank shell at the B end of tank car TILX 193767 (car 72 in the train) where it fractured adjacent to the weld attaching the head brace to the draft sill weld and where the front end of the draft sill was deformed downward relative to the tank car axis. Fracture surfaces of the draft sill were on slant angles, which was consistent with ductile overstress fracture.

[56] Right and left are referenced from the center of the tank car looking toward the A end.

1.21.5 Laboratory Examination

Investigators assessed parts and specimens from the damaged tank cars to determine if they met tank car engineering drawings and AAR specifications. The shells of the tank cars examined by the NTSB were manufactured of AAR specification TC-128 Grade B (TC-128B) steel, and the heads were manufactured of either ASTM International[57] specification A516 Grade 70 (A516-70) steel or AAR specification TC-128B steel.

Investigators examined specimens torch-cut from the B ends of tank cars NATX 302974, TILX 193767, and NATX 303504. The examinations focused on the attachment welds for the draft sill, head brace, and front sill pad. The results of those examinations are as follows:

NATX 302974. A cross-section of the piece cut from the B end of tank car NATX 302974 showed the tank shell and front sill pad were deformed inward along the axis of the draft sill. The head and front sill pad were deformed from a curved surface to a relatively flat plane in the area above the head brace. No cross-sections of the welds were prepared from this piece.

TILX 193767. NTSB investigators saw-cut cross-sectional pieces from the B end of tank car TILX 193767. The cross-section depicted outward deformation of the front sill pad from the tank head surface, with greatest outward displacement of the front sill pad at the head brace attachment location. The magnitude of deformation was less than that observed in NATX 303504 (discussed below). Pieces of the cross-section were polished and etched to reveal the weld microstructures for examination. The welds were formed from multiple passes for weld sizes greater than 0.25 inch. Welds generally showed good coverage through the thickness of the weld.

NATX 303504. NTSB investigators saw-cut cross-sectional pieces from the B end of tank car NATX 303504. Outward deformation of the front sill pad from the tank head surface was evident in the cross-sectional view, with the greatest magnitude of displacement occurring at the point of head brace attachment. Pieces of the cross-section were polished and etched to reveal the weld microstructures. Welds were formed from multiple passes for weld sizes greater than 0.25 inch. Welds generally showed good coverage through the thickness of the weld. A crack was observed in the front sill pad at the toe of the front fillet weld between the head brace and the front sill pad. The crack extended through about one-half the thickness of the front sill pad.

1.21.6 Mechanical Testing and Chemical Analysis

During the on-scene and group examinations, investigators removed rectangular samples of shell material about 2 to 3 feet in size from tank cars CTCX 730958, NATX 302974, NATX 303174, and TILX 193767. The samples, which were cut from parts of the tanks that showed no evidence of high heat damage, were sent to the NTSB's Materials Laboratory for tensile testing and chemical analysis. The selected tank cars represented a range of dates of manufacture; the oldest was built in 2006, and the newest, in 2008.

[57] Known until 2001 as the American Society for Testing and Materials (ASTM), ASTM International is an international standards organization that develops and publishes voluntary consensus technical standards for a variety of materials, products, systems, and services.

Construction records indicate that heads and shells of tank cars NATX 302974, NATX 303174 and NATX 303504 were fabricated from normalized[58] AAR TC-128B steel. Construction records for cars CTCX 730958 and TILX 193767 indicated that the tank shells of those cars were fabricated from nonnormalized AAR TC-128B steel. According to the *AAR Manual of Standards and Recommended Practices,* tank head and shell material may be furnished in either as-rolled or normalized condition unless the cars are specified for low-temperature service, in which case the material must be normalized. The derailed tank cars in this accident were not specified for low-temperature service.

As described above, tank car NATX 302968 had a 100-inch-long circumferential fracture at the B end that propagated adjacent to the head-to-shell weld. In tank car NATX 303504, a circumferential fracture occurred in the shell adjacent to the body bolster pad while the circumferential head-to-shell weld remained intact. The samples that were cut from both cars included intact head-to-shell circumferential welds so that tensile tests could be performed across the welds.

Mechanical testing and chemical analysis was completed by Tensile Testing Metallurgical Laboratory (TTML) in Cleveland, Ohio, at the direction of the NTSB. TTML conducted the tests in accordance with ASTM International standard ASTM A-370.

Tensile Tests of Shell Material. A total of six specimens were tested from each shell piece removed from tank cars CTCX 730958, NATX 302974, NATX 303174, and TILX 193767, with three specimens oriented in the longitudinal direction (relative to the plate rolling direction) and three specimens oriented in the transverse direction. Tensile properties of all 24 tensile specimens met the tensile property requirements for AAR specification TC-128B steel.

Tensile Tests of Head-to-Shell Weld. Three tensile tests were conducted on each of the two samples containing head-to-shell welds that were taken from tank cars NATX 302968 and NATX 303504. The tests were conducted on specimens with the weld located at the middle of the specimen. Test results showed an ultimate stress of 88.0 to 88.5 kips[59] per square inch (ksi) for specimens from tank car NATX 302968, and 94.3 to 95.1 ksi for the specimens from tank car NATX 303504. All specimens showed ductile fracture features. Test specimens from tank car NATX 303504 fractured in the base metal. Among test specimens from tank car NATX 302968, one specimen fractured in the base metal, the other two specimens fractured in the heat-affected zone.[60]

Chemical Analysis of Shell Material. TTML conducted chemical analysis on each shell piece removed from tank cars CTCX 730958, NATX 302974, NATX 303174, and TILX 193767. One deviation from the chemical requirements was measured in the phosphorus level of the sample from NATX 302974, in which phosphorus in the specimen was 0.002 percent higher,

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[58] *Normalized* steel has undergone a heat treatment process that generally produces higher strength and toughness of the steel relative to the as-rolled condition, thereby increasing the amount of energy required to cause fracture at most temperatures. Since 1989, pressure tank car shells have been required to be fabricated from normalized steel.

[59] One *kip* (kilo-pound) equals 1,000 pounds of force.

[60] *Heat-affected zone* refers to the area of base material that has had its microstructure altered by welding.

by weight, than specified. Other elements from the specimen from tank car NATX 302974 and all elements in specimens from the other three tank cars were within specifications.

1.21.7 Locomotive Recorders

The event recorder from the lead locomotive of the accident train was sent to the NTSB's Vehicle Recorder Lab for readout and evaluation. Event recorder data indicated that at 8:34:36 the locomotive bell was activated for 21 seconds and the horn transitioned from "On" to "Off" a few times during this period. One minute 22 seconds later (8:35:58), a train-initiated emergency brake application occurred, and the throttle position transitioned from 6 to 0. The accident train was traveling 36 mph at this time. Thirty seconds later, at 8:36:28, the train stopped. The train was not equipped with any onboard video recorders, nor were they required.

1.22 Actions Taken Since the Accident

1.22.1 Postaccident Actions by the CN

The CN has informed the NTSB of the following actions it has taken in response to the derailment:

Weather Alert Procedures. Shortly after the June 19, 2009, derailment, the CN implemented new procedures for the handling of weather bulletins. For U.S. operations, AccuWeather no longer transmits weather alerts to the CN's Edmonton Walker Call Desk but rather sends them directly to the Homewood control center. Additionally, a supervisor or a chief dispatcher who delivers a weather bulletin to an RTC is now required to ensure that the RTC applies a restrictive label to the TMDS and notifies crews or other personnel in the area. The control center is also automating the dispatching desks so that RTCs will receive alert warnings directly via the TMDS. When a weather alert is received, the RTC must acknowledge the alert and select the option to automatically apply the appropriate restrictive label in the TMDS. The RTC must then issue the weather alert to the trains in the territory.

Since the accident, the CN has also changed its engineering personnel notification policy for weather alerts. Weather alerts arriving at the Homewood control center are now forwarded to an engineering coordinator at Homewood whose job it is to notify engineering personnel and coordinate an appropriate response. To "declutter" the reporting process, the CN no longer responds to weather "watches" and instead focuses exclusively on "warnings," believing that "watch" notifications were unnecessarily adding to the RTC's workload.

Emergency Call Procedures. On September 18, 2009, the CN issued new instructions for emergency call procedures. The CN offices in Canada (Edmonton, Toronto, and Montreal) were provided with hotline phone numbers for the 12 RTC desks in the Homewood control center. If a call to one of the hotline numbers is not answered within 7 seconds, it will roll over to an emergency line. If that line is not answered within 7 seconds, it will roll over to a back-up emergency line. The new instructions further provide that direct telephone lines are assigned to each RTC/signal desk at Homewood, Montreal, Toronto, and Edmonton, and that calls on these lines take priority. A red light flashes when those lines ring.

At the time of this accident, the CN was in the process of updating procedures to be used by CN Police Emergency Call Center personnel when contacting the chief dispatcher or RTCs at Homewood. The updated procedures manual[61] added 40 new procedures for call center personnel, including actions to be taken (that is, phone calls to make and information to be transmitted) when a train must be stopped following the notification of a washout.

After the accident, all CN RTCs were required to attend a 1-week "Emergency Service Dispatcher" training course provided by College Montmorency in Laval, Quebec, Canada. The training has been provided to all existing employees and must be taken by all new hires.

Drainage Improvements. After the accident, the CN replaced the 36-inch corrugated metal pipe (which was destroyed in the accident) under the track west of the crossing with two 48-inch-diameter cast iron pipes installed near the site of the previous 36-inch pipe. The Winnebago County Highway Department determined that, based on design calculations, the 24-inch-diameter pipe under Mulford Road north of the CN tracks should be replaced with a single 48-inch-diameter corrugated metal pipe. However, according to county highway department representatives, the CN "insisted" that two 48-inch pipes be installed. Because of a lack of conclusive information about the cause of the washout and the desire to reopen Mulford Road as quickly as possible, Winnebago County provided the CN with one 48-inch, one 36-inch, and one 24-inch corrugated metal pipe to be installed in place of the original 24-inch pipe. Winnebago County officials continued to maintain that these pipes were to be considered relief pipes only and that all significant storm flows would be directed through the box culvert south of the crossing.

Crossing Emergency Notification Signage. After the derailment, the CN installed a new emergency notification sign on the signal bungalow at the Mulford Road grade crossing. The new emergency notification sign conformed to the 2009 Edition of the *Manual on Uniform Traffic Control Devices*. The telephone number on the new sign is for the CN's Southern Operations Control Center in Homewood, Illinois.

Train Consist Accuracy. As a result of the discrepancy in the accident train consist, the FRA issued a July 28, 2009, inspection report directing the CN to develop a transportation action plan to identify the operational procedures and documentation requirements for the transportation of hazardous materials. On August 10, 2009, the CN responded to the FRA's directive by establishing a "Hazardous Materials Action Plan" for its Iowa Subdivision. This plan specifies that cars carrying hazardous materials must not be handled unless a train crewmember has all of the proper documents showing the current position of all hazardous material shipments in the train. The plan requires that when picking up or setting out cars, the documents must be updated before the train departs the location. The plan states that the CN will perform efficiency tests on an around-the-clock basis. Every transportation officer in the CN's Iowa zone is to perform a minimum of five hazardous materials placement tests per month on trains that pick up or set out cars en route, and three hazardous materials placement tests per month on trains leaving the initial terminals. The plan specifies follow-up testing within 10 days for employees who have been found in violation of the rules.

[61] The CN's revised procedures document, *Call instructions and procedures used by the CN Police Emergency Call Center for contacting the Chief Dispatchers and RTCs at Homewood,* is dated October 28, 2009.

The plan also states that the CN will place renewed emphasis on its existing efficiency testing program, which involves testing train crews on hazardous materials documents, train placement, and hazardous materials placards. According to CN representatives, between July 2009 and December 2010, the CN conducted 167 efficiency tests in its Chicago region, which includes the Cherry Valley area, and found no defects in the area of consist accuracy.

1.22.2 Postaccident Actions by the FRA

According to the FRA, from September 2009 through December 2009, FRA safety inspectors audited the CN's emergency call system in Homewood, Illinois. During the FRA audits, the CN conducted mock emergency calls (drills) to the service center help desk to determine the effectiveness of the emergency call system. The CN changed the routing of emergency calls to a trouble desk located inside the dispatcher center at Homewood (instead of to Montreal, Quebec, Canada). This enhanced notification process included reducing the number of telephone rings before rolling a call to the chief dispatcher or other managers. As part of the call testing, the rings were timed and counted to ensure that calls that rang four times were immediately forwarded to the chief dispatcher's office and a mass notification list.

The FRA also performed tests involving four police departments making mock emergency calls. The phone number that the CN issued to the local police departments was correct. All calls were answered within four rings, verifying that changes the CN had implemented were, in fact, effective.

The FRA also performed audits on CN train consist list accuracy. From September 2009 through December 2009, FRA Region 4 hazardous materials safety inspectors conducted 14 train consist audits of trains operating between Rockford, Illinois, and Dubuque, Iowa. Of the 14 trains reviewed, lists from 3 trains were found to be inaccurate according to the physical placement of hazardous materials rail cars being transported within the train. The FRA issued three violations to the CN, one for each of the three inaccurate consist lists.

1.22.3 Postaccident Actions by the AAR

After the Cherry Valley accident, the AAR Tank Car Committee formed a task force to consider several DOT-111 protective systems or changes in operations that include the following:

- Half-height and full-height head shields
- Tank jacket, with or without insulation
- Increased shell thickness
- Increased head thickness
- Removal of bottom fittings
- Increased outage requirements

The task force asked researchers at the University of Illinois to conduct a statistical analysis of tank car accident data to determine the overall effectiveness of shell breach risk reduction options, including installing head shields, installing jackets, and increasing the thicknesses of the heads and shells. In its status report for the October 20–21, 2010, committee meeting, the task force presented data suggesting that the greatest reduction in the estimated amount of lading released from DOT-111 tank cars, about 50 percent, could be achieved through a combination of thicker steel, tank jackets, and head shields.

The DOT-111 tank cars currently used to transport ethanol and crude oil have a minimum plate thickness of 7/16 inch nonnormalized TC-128B or A516-70 steel, with no provision for a head shield. However, tank cars ordered after October 1, 2011, for denatured fuel ethanol and crude oil service in Packing Groups[62] I and II must be constructed in accordance with AAR circular letter CPC 1230, the requirements of which have also been included in an AAR petition for rulemaking that was filed with the Pipeline and Hazardous Materials Safety Administration (PHMSA) on March 9, 2011. The new AAR requirements increase the minimum head and shell thickness to 1/2 inch for TC-128B nonjacketed cars and 7/16 inch for jacketed cars. Shells of nonjacketed tank cars constructed of A516-70 steel must now be 9/16 inch thick; shells of jacketed cars must be 1/2 inch thick. The new AAR requirements also specify that both the heads and the shells must be constructed of normalized steel and that in all cases, a 1/2-inch-thick head shield must be provided. The new AAR requirements are to be effective until such time as a government/industry task force (designated task force T87.6) determines whether additional risk mitigation enhancement is appropriate for these cars.

1.22.4 Postaccident Actions by Nicor Gas

Pipeline Replacement. After the accident, Nicor Gas replaced the damaged section of its pipeline with welded 12-inch-diameter American Petroleum Institute 5L Grade X-42 steel pipe with 0.250-inch wall thickness. In coordination with the CN, Nicor installed about 700 feet of replacement pipe parallel to the west side of Mulford Road about 350 feet north and 350 feet south of the CN crossing. The new pipeline was installed adjacent to the existing pipeline, which was purged of product, capped, and retired in place. The replacement pipeline was installed at a depth of 22 feet below the centerline of the tracks.

Communication and Notification Protocols. Nicor Gas maintains two 24-hour response and dispatch centers and has on-call personnel throughout the service territory to respond to events that occur after normal business hours. According to company representatives, since this accident, Nicor Gas has revised its communication and notification procedures to ensure that dispatch personnel review pipeline maps and corroborate their findings concerning the location of pipelines with the field duty supervisor to avoid providing erroneous information to emergency response agencies.

Emergency Responder Information. Nicor Gas also reported that it has sent letters to the fire departments serving each of the 640 communities in its service area informing them of

[62] The *packing group* indicates the degree of danger presented by a hazardous material in transport. Packing Group I indicates great danger; Packing Group II, medium danger; and Packing Group III, minor danger.

the availability of the National Pipeline Mapping System.[63] Instructions were included on how to use the National Pipeline Mapping System to identify transmission pipelines within the fire departments' jurisdictions. Additionally, Nicor Gas has recommended that the preplanning books for pipeline events be periodically updated to ensure that pipeline facility and operator contact information remains current. On an ongoing basis, this information will be emphasized through Nicor's public awareness program.

1.22.5 Postaccident Actions by the City of Rockford

Officials representing the city of Rockford informed the NTSB that the city has taken the following actions in response to the washout and derailment at Mulford Road:

The city has developed a storm water inspection program for large detention ponds after a major storm event. Rockford's major storm event monitoring program is set to include inspections of public and private major detention ponds, bridges, culverts, and major creeks and drainage ways.

The city has revised its detention basin evaluation form to include data on the physical condition of the detention pond's embankments, outlets, and spillways. Inspectors will rate the conditions found as "Good," "Fair," or "Poor." Any component rated other than "Good" will be further inspected by the storm water section manager.

The city is encouraging private homeowners associations and their management companies to notify the city immediately if there is any physical damage to a storm water management detention pond, drainage way, or culvert after a major storm event or whenever such damage is detected.

1.22.6 Postaccident Actions by the Cherry Valley Fire Protection District

In response to a request from the CVFPD, Nicor Gas provided the CVFPD with maps showing the locations of natural gas pipelines within the CVFPD district in early September 2009. The CVFPD also procured a railroad tank car that was involved in the derailment for 'live-action use or real-world application' at the CVFPD training facility, which is also used by the RFD hazardous materials response unit.

[63] The National Pipeline Mapping System is a geographic information system created by the Office of Pipeline Safety within PHMSA in cooperation with other Federal and state government agencies and the pipeline industry. The mapping system shows the locations of pipelines, population levels/densities, the locations of roadways, the names and contact details for the pipeline operators, and a list of products that may be transported.

1.23 Other Information

1.23.1 Performance of DOT-111 Tank Cars in Accidents

In addition to its numerous investigations of accidents involving DOT-111 tank cars, the NTSB conducted a 1991 safety study[64] that examined the performance of 84 DOT-111 tank cars in accidents that occurred between March 1988 and February 1989. The study found that 54 percent of the DOT-111 cars involved in these accidents released product, with head and shell punctures accounting for 22 percent of the releases. The study found that the rate at which the DOT-111 tank cars experienced head or shell punctures or failures was double that of DOT-105, -112, and -114 pressure tank cars. The NTSB concluded that the DOT-111 tank cars, which are frequently used to transport hazardous materials, have a high incidence of failure when involved in accidents.

On July 1, 1991, the NTSB recommended to the Research and Special Programs Administration (RSPA, predecessor to the Pipeline and Hazardous Materials Safety Administration), the FRA, the AAR, the Chemical Manufacturers' Association (now the American Chemistry Council), the American Petroleum Institute, and the National Fire Protection Association that these organizations work together to develop a list of hazardous materials that should be transported only in pressure tank cars with head shield protection and thermal protection (if needed) and to establish a working agreement to ship the listed hazardous materials in such tank cars.

Subsequently, RSPA, in cooperation with the FRA, published regulations requiring stronger and better protected tank cars for certain classes of hazardous materials. Under these regulations, a wider variety of hazardous materials must be transported in pressure tank cars that have head and shield protection and thermal protection, as applicable, as well as enhanced puncture protection for tank cars used to transport compounds that pose environmental hazards.

The Chemical Manufacturers' Association reported that some of its members had made voluntary equipment modifications and implemented operating practices to enhance the performance of their DOT-111 tank cars, such as increased head and shell thickness, head shields, elimination of bottom outlets where feasible, and removal of unused fittings and valves.

The most recent NTSB investigation that considered the performance of DOT-111 tank cars was of an accident that occurred on October 20, 2006, in New Brighton, Pennsylvania, in which a Norfolk Southern Railway ethanol unit train derailed 23 tank cars.[65] Twenty of the 23 derailed DOT-111 cars lost an estimated 485,278 gallons of denatured ethanol following the derailment and subsequent fire. In that accident, 12 tank cars lost full loads, and 8 tank cars lost partial loads.

[64] *Transport of Hazardous Materials by Rail*, Safety Study NTSB/SS-91-01 (Washington, DC: National Transportation Safety Board, 1991). <http://:www.ntsb.gov>

[65] *Derailment of Norfolk Southern Railway Company Train 68QB119 With Release of Hazardous Materials and Fire, New Brighton, Pennsylvania October 20, 2006*, Accident Report NTSB/RAR-08/02 (Washington, DC: National Transportation Safety Board, 2008). <http://:www.ntsb.gov>

1.23.2 DOT Hazard Communications Initiative

On October 13–14, 2009, PHMSA hosted a public meeting to solicit input for an upcoming proof-of-concept study on the use of electronic data sharing in lieu of paper hazardous materials shipping papers. The initiative is titled HM-ACCESS (hazardous materials-automated cargo communications for efficient and safe shipments). The goal of HM-ACCESS is to define regulations and guidelines to allow the electronic communication of shipping paper information and to evaluate the feasibility and potential benefits of allowing the use of electronic shipping papers. The proposed benefits of this program include improving the availability and accuracy of hazard and response information for shipments and packages that are tracked electronically while improving the speed by which information is available to emergency responders when accidents occur. While PHMSA considers methods to ensure that emergency response agencies are capable of receiving real-time hazard communications, it notes that if regulatory authorization were provided, rail transport organizations would be prepared to use electronic shipping paper technology.

1.23.3 Pipeline Construction Standards and Regulations

The industry standard for pipeline construction in 1965, when Nicor installed the natural gas pipeline at the accident site, was ASME B31.8, *Gas Transmission and Distribution Piping Systems*.[66] The 1963 ASME B31.8 standard 841.14, "Cover, Clearance, and Casing Requirements Under Railroads, Roads, Streets, or Highways for Buried Steel Pipelines and Mains," stated that 24 inches of cover was required in normal soil for pipelines.

The current applicable state construction regulation is contained in Title 83 *Illinois Administrative Code* Part 590, which, as of January 1, 2009, incorporates the standards contained in 49 CFR Parts 191.23, 192, 193, and 199 as the minimum safety standards for the transportation of gas and for gas pipeline facilities.

The current Federal construction regulation that addresses cover for pipelines at railroad crossings is contained in 49 CFR 192.327, which requires cover of 36 inches in normal soil for transmission pipelines. An exception to the minimum cover standard is authorized when an underground structure prevents installation at the required depth, in which case additional protection, such as a casing, must be provided to withstand the anticipated external loads.

According to Nicor Gas, the company conforms to railroad owner specifications when designing and installing pipelines under railroad tracks. The specifications typically have incorporated American Railway Engineering and Maintenance of Way Association (AREMA) specifications as a standard. Before 1993, the American Railway Engineering Association (predecessor to AREMA) *Manual for Railway Engineering* recommended that pipelines carrying flammable gas and liquids under railroad beds be encased in a larger steel pipe to prevent crushing by train loads.

[66] The American Society of Mechanical Engineers (ASME) B31.8 code is an American national standard of engineering requirements deemed necessary for safe design and construction of pressure piping.

The CN has adopted AREMA standards that were developed in 1993 for pipelines under railroad tracks or across or along railroad rights-of-way. These standards specify that cased pipelines carrying flammable products under pressure must be buried a minimum of 5 feet 6 inches beneath main tracks. The standard further requires that pipelines carrying flammable products located within 25 feet of the centerline of any track must be encased or be of a special design approved by the railway chief engineer. The standard allows the use of uncased natural gas pipe if the pipe is constructed of steel and installed a minimum of 10 feet below the rail ties.

2. Analysis

2.1 Introduction

This analysis begins with a summary of the accident sequence and includes discussion of the following safety issues identified in this report:

- Effectiveness of the CN's internal emergency communication system
- Effectiveness of the CN's weather alert policies and rules
- Vulnerability of the DOT-111 tank car shells and fittings to damage and subsequent release of lading during derailments
- Inspection and maintenance of storm water detention ponds
- Accuracy of train consist information
- Construction standards for underground pipelines at railroad crossings
- Adequacy of storm water drainage system assessment
- The CN's toxicology and fatigue evaluations

The remainder of this introductory section discusses those elements of the investigation that the NTSB determined were not factors in the accident. The balance of the analysis addresses the factors that were found to have caused or contributed to the accident, or to have contributed to its severity.

All of the tank cars on the train were inspected before being loaded with ethanol, and no mechanical defects were noted. As the train was en route toward Cherry Valley, it passed five wayside inspection scanners with no exceptions reported. The locomotive units and all the cars of the train were inspected after the accident, and no significant mechanical defects were found in the locomotives or any of the cars.

Results of tensile tests of shell material samples from four of the tank cars were consistent with AAR requirements for the steels used in fabrication of the tank car shells. Chemistry results for three of the four samples were consistent with AAR requirements. The fourth sample contained a slightly higher level of phosphorus than permitted, but this was not considered significant given the satisfactory tensile test performance.

The rail in the accident area had been most recently ultrasonically tested on February 19, 2009, about 4 months before the accident. The only defect noted for the accident area was a defective weld, which had been repaired. Examination of rail pieces from the point of derailment revealed no preexisting defects.

Investigators inspected and tested the signal system and the highway/rail grade crossing warning system to the extent possible. Portions of the signal system that had not been damaged in the accident functioned as designed. Maintenance records indicated that all signal tests and inspections had been conducted in accordance with FRA regulations and CN requirements.

The investigation determined that the two train crewmembers, as well as the RTC responsible for the accident area, were trained and qualified for the work they were to perform.

Blood and urine specimens were collected from the train crewmembers within 7 hours of the accident. The specimens were tested and found to be negative for alcohol and illegal drugs. The NTSB concludes that the use of alcohol or illegal drugs by the RTC as a factor in the accident could not be determined because there was no toxicological testing conducted.

Fatigue was evaluated as a possible human factors issue for the engineer, the conductor, and the RTC. A variety of fatigue factors, including sleep (acute sleep loss, cumulative sleep debt, and sleep quality), continuous hours awake, circadian disruption, sleep disorders, medication use, disruptive environmental factors, and shift work considerations were examined. None of the fatigue factors emerged as an indication of significant fatigue for the RTC at the time of the accident. However, the information obtained for the train crew is insufficient to determine whether fatigue for these two individuals was a factor in the accident.

The NTSB therefore concludes that the following were not factors in the accident: mechanical condition of the locomotives and cars on the train; material properties of steels used in the tank car construction; integrity of the track structure, culvert, and rails leading up to the point of derailment; functioning of the signal system and the grade crossing warning system; use of alcohol or illegal drugs by the train crew; training and qualifications of the train crew and the RTC; and fatigue of the RTC.

2.2 Accident Summary

On the afternoon of Friday, June 19, 2009, the accident train, which had originated in Tara, Iowa, was en route to Chicago, Illinois, with 114 cars, 75 of them tank cars loaded with denatured fuel ethanol. While the train was en route, the CN Southern Operations Control Center in Homewood, Illinois, received two severe weather bulletins affecting the train's route. The first alert, a severe thunderstorm watch, was received at 5:34 p.m. and was effective until 10:00 p.m. The second alert, a flash flood warning, was received at 6:36 p.m. and was effective until 10:40 p.m. Under CN operating rules in effect at the time, the RTC at the Homewood control center should have informed the crew of the accident train about the weather alerts, but he did not do so even when he was in communication with the crew about other matters.

At 7:35 p.m., a citizen called the Rockford, Illinois, police department to report flooding of the CN railroad track in the vicinity of the Mulford Road grade crossing in Cherry Valley, Illinois. This was about 1 hour before the accident train was scheduled to arrive at the crossing. About 7:40 p.m., a citizen who had been unable to find the railroad's contact information posted at the crossing called 911 and stated, "Well, anyway, underneath the tracks is washed out, so if a train goes over there, it is going to derail." Over the next few minutes, the 911 center received several other calls reporting that the track near the Mulford Road crossing was washed out or was "washing away."

Shortly after 8:00 p.m., a deputy sheriff went to the scene and found a 17-foot-long washout beneath the track west of the grade crossing, which he reported to the Winnebago County 911 call center. A deputy sheriff in the call center succeeded, at 8:16 p.m., in reaching the CN emergency call center. Officers assigned to the CN emergency call desk then attempted, without success, to reach the chief dispatcher and the RTC at Homewood to alert them to the washout and to have them stop train movements through the area.

About 8:34 p.m., as the freight train approached the Mulford Road crossing, the crossing warning lights were flashing, and the crossing gates were down. Several motor vehicles were stopped on both sides of the crossing to await passage of the train. About 8:35, when about one-half of the train had passed Mulford Road, tank cars began to derail west of the crossing. The derailing cars separated from the front portion of the train and formed a pileup of tank cars across Mulford Road. Thirteen of the derailed tank cars were punctured or otherwise breached or had fitting failures or valve activations that allowed ethanol to escape and fuel a fire that killed one person and injured nine.

At 8:40 p.m., CN emergency call desk officers finally reached the chief dispatcher and the RTC at the Homewood control center to report the water conditions affecting the track, but by then the accident had already occurred.

2.3 Emergency Response and Recovery Efforts

UP and CN railroad hazardous materials managers provided firefighting advice to fire department crews within 1 hour of the accident, and the fire department appropriately allowed the burning ethanol to be consumed while cooling uninvolved adjacent tank cars. Real-time air monitoring that was established by the CN's contractor around the perimeter of the accident scene about 7 1/2 hours after the accident found no air pollutant concentrations in excess of applicable action levels.

The EPA oversaw the recovery and restoration efforts that began immediately after the fire was extinguished. Tank car residues, spillage, and contaminated soils were promptly removed from the accident scene under the surveillance of the EPA Federal on-scene coordinator. Testing showed that the groundwater and nearby community wells were not polluted by the tank car spillage.

About 25 percent of the lading was recovered from the 15 tank cars involved in the pileup. The remaining 75 percent of the lading was consumed in the postaccident fire, released into the air and soil, or discharged into a waterway that entered the Rock and Kishwaukee Rivers. Once the postaccident fire was extinguished, spilled ethanol that entered the surface waters could not be recovered. Although the discharged ethanol dissipated through dilution and natural bio-gradation processes, a significant fish kill resulted downriver from the accident scene and was most likely due to dissolved oxygen consumption rather than any toxic effect of the discharge.

The NTSB concludes that both the emergency response to the accident and the environmental recovery efforts after the fire were timely and appropriate.

2.4 Determination of Point of Derailment

A combination of ultrasonic rail testing data, evidence from the rail reconstruction efforts, marks found on multiple rail cars, and eyewitness accounts of the mechanics of the derailment helped the NTSB determine that the point of derailment was at the location of a field weld in the north rail about 8 feet from the west edge of the Mulford Road grade crossing. The broken rail was within the area where the washout of the track structure had created a severely compromised track condition. The markings on the inside gauge corner of the rail and on the wheel flanges of the north wheels of the lead two cars that derailed provided evidence that these cars derailed due to a broken rail.

Although the washout resulted in a complete loss of support structure for a significant portion of track, 2 locomotive units and 56 cars of the train—17 of which were loaded tank cars—were, in fact, able to successfully traverse this weakened track section. The NTSB considered how half of the train was able to negotiate the unsupported track before the rail failed and caused a derailment.

Although, according to video evidence, the washout area before the arrival of the train was about 17 feet long, it very likely widened under passage of the train. Investigators retrieved a portion of the north rail that exhibited a wheel strike mark at the gauge corner of the east fractured face of a field weld (receiving end strike) that was consistent with the marking observed on the wheel flange on what investigators determined was the first car derailed. A follow-up examination of ultrasonic rail testing data confirmed that the field weld was located about 8 feet west of the crossing. With the passage of the 57th car, the overstressed north rail fractured at its weakest point because of the unsupported track, which was caused by the washout. The NTSB, therefore, concludes that the derailment occurred when wheel loads on rails that were unsupported because of a washout of the track structure caused the north rail to fracture at a field weld about 8 feet west of the Mulford Road grade crossing.

2.5 Effectiveness of CN Emergency Communications

One of the first citizens to note the conditions affecting the track at Mulford Road was a person with experience in transporting hazardous materials. He said he was aware that railroads normally posted their contact information at all grade crossings but that he could not find the contact information at the Mulford Road crossing.

According to the CN, the emergency contact information for the Mulford Road crossing (which included not only a telephone number for the CN but a unique identification number for this particular crossing) had at one time been posted on the signal bungalow. When the bungalow was replaced as part of a crossing upgrade, the emergency contact information was not reposted.

When the citizen could not locate the railroad contact information, he called the Winnebago County 911 center. This call was made at 7:40 p.m., about 56 minutes before the derailment. Had the emergency contact information been available, the citizen would likely have called the CN instead of 911, or both. Even though the 911 center was able to identify the crossing, it was not until 41 minutes after the initial 911 call that the CN Police Emergency Call Center in Montreal was notified of the track washout. The absence of emergency contact information at the crossing thus caused a delay in reporting the track conditions, which decreased the time available to notify RTCs and to stop any trains approaching the washout area. The NTSB, therefore, concludes that had the required CN grade crossing identification and emergency contact information been posted at the Mulford Road crossing, the railroad would likely have been notified of the track washout earlier, and the additional time may have been sufficient for the RTC to issue instructions to stop the train and prevent the accident. Therefore, the NTSB recommends that the CN implement a process, consistent with the principles of a safety management system, to ensure accuracy and visibility of emergency contact information at all highway/rail grade crossings on its system. Since the derailment, the CN has installed a new emergency notification sign on the signal bungalow at the Mulford Road grade crossing.

Although the CN Police Emergency Call Center was not notified of the washout as soon as it should have been, it did receive notification of the track washout at 8:16 p.m., almost 20 minutes before the arrival at the crossing of the accident train. Despite this advance warning, emergency call desk personnel were unable to establish contact with dispatchers at the CN Homewood control center in time to prevent the accident.

Emergency call center personnel spent the first few minutes after the initial notification attempting to identify the crossing so that the appropriate RTC could be notified. After the crossing was located, several additional minutes elapsed before the first attempt was made to contact the RTC. At 8:23 p.m., a police call desk officer made the first call to the RTC at Homewood. When the first calls did not go through because the lines were busy, a second caller was enlisted to try to reach the RTC while the first caller attempted to contact the chief dispatcher overseeing the RTC.

The two call desk officers each made three unsuccessful calls before the chief dispatcher and the RTC were finally contacted at 8:40 p.m. Even then, the officer speaking with the RTC initially gave a muddled and incomplete report, saying "apparently we've got some flooding in the Rockfield [*sic*], Illinois, area." The location was subsequently clarified (although neither "washout" nor Mulford Road was mentioned), but by then it was too late because the derailment had already occurred.

At no point did emergency call officers attempt to use the dedicated police "hotline," that was routed directly to the desk of the chief dispatcher and that was supposed to be monitored around the clock. The CN police stated that they had experienced difficulty getting access to the hotline in the past and that, even when calls were made using the hotline, if the chief dispatcher had a heavy workload at the time, the ringing hotline phone would often be ignored.

The inability of emergency call center officers to make telephone contact with either the chief dispatcher or the RTC indicates a breakdown in the policies, procedures, and equipment on which the CN relied for emergency communication. Specifically, the dispatch center had no written policies on how the AccuWeather weather alerts were to be delivered to the RTC from the printer. And, although the RTC was required to post the weather alerts on the computer system, there were no written procedures to ensure that the RTC completed this action or that the information was delivered by radio to trains in the affected territories. Finally, the telephone equipment used in the dispatch center did not have a rollover feature so that incoming calls could be answered efficiently when the RTC was working with trains or workers on other activities.

Often, the phone would just ring, or it would be picked up and laid down until the desk personnel finished their current work tasks. By failing to provide and reserve a dedicated line of communication that was used for emergency purposes only and that took precedence over any other communication, the CN created an environment in which emergency communication with life-saving implications could be—and in this accident were—subordinated to routine operational communications. The NTSB concludes that the CN police emergency communication system in place at the time of this accident was inadequate, with the result that CN police were unable to prevent the derailment even though adequate time was available for them to have done so.

Since the accident, the CN has updated its emergency communication system policies, procedures, and equipment. The CN offices in Canada have been provided with hotline phone numbers for the 12 RTC desks in the Homewood control center. If a call to one of the hotline numbers is not answered within 7 seconds, it will roll over to an emergency line. If that line is not answered within 7 seconds, it will roll over to a back-up emergency line. Additionally, direct telephone lines were assigned to each RTC/signal desk at the Homewood, Montreal, Toronto, and Edmonton centers, and calls on these lines take priority. A red light flashes when a call is received. The new procedures and the equipment upgrades are designed to prevent a recurrence of the breakdown in communication that occurred on the day of this accident. However, policies, procedures, and safety devices are effective only if the procedures are followed and if the devices are actually used and are regularly tested for proper function. The NTSB therefore recommends that the CN implement a program consistent with principles of safety management systems to periodically test all aspects of its internal emergency communication system to ensure that personnel are familiar with the system's operation and that emergency notifications can be communicated immediately to any chief dispatcher or RTC in the CN system.

2.6 Deficiencies in Postaccident Drug and Alcohol Testing

After the accident, the CN identified two employees—the conductor and the engineer of the accident train—for postaccident toxicological testing pursuant to 49 CFR 219.203 ("Responsibilities of railroads and employees"). As mentioned in section 219.203(a) "Employees tested,"

> Following each accident and incident described in 49 CFR 219.201, the railroad (or railroads) must take all practicable steps to assure that all covered employees of the railroad directly involved in the accident or incident provide blood and urine specimens for toxicological testing by FRA.

In addition, 49 CFR 219.203(2) states,

> Such employees must specifically include each and every operating employee assigned as a crew member of any train involved in the accident or incident. In any case where an operator, dispatcher, signal maintainer or other covered employee is directly and contemporaneously involved in the circumstances of the accident/incident, those employees must also be required to provide specimens.

The CN initially determined that the RTC would not be required to undergo postaccident toxicological testing because he was not believed to have been directly involved in the accident. As a result, the RTC was allowed to go off duty without being tested for drugs or alcohol. The NTSB, however, does not believe that the CN appropriately followed 49 CFR 219.203(4), which states, “covered employees who may be subject to testing under this subpart must be retained in duty status for the period necessary to make the determinations required by 49 CFR 219.201.” Specifically, the NTSB does not believe that the CN had sufficient information about the circumstances of the accident before the end of the RTC’s shift to make that determination.

The next day, as the CN continued to investigate the accident, it realized that the RTC may have been directly involved in the accident. However, the CN mistakenly believed that the RTC could no longer be required to provide specimens for testing. Federal regulations state that an employee may be immediately recalled for testing if (per 49 CFR 219.203(b)(4)(ii)) “the railroad’s preliminary investigation (contemporaneous with the determination required by 49 CFR 219.201) indicates a clear probability that the employee played a major role in the cause or severity of the accident/incident.”

The RTC had not undergone required postaccident toxicological testing. As a result, it could not be determined if drugs or alcohol were a factor in his performance. Moreover, the NTSB is concerned that the CN did not adequately follow regulations requiring it to keep the RTC in on-duty status long enough to make an accurate determination regarding his role in the accident, and the CN’s failure to understand its responsibility to conduct postaccident toxicological testing even if the RTC had gone off duty. The NTSB concludes that the failure of the CN to conduct postaccident toxicological testing on the RTC demonstrates that the CN postaccident toxicological program was ineffective. Therefore, the NTSB recommends that the CN examine and revise its postaccident toxicological testing program to ensure that RTCs are tested unless there is clear and convincing evidence that they were not involved in the accident.

2.7 CN Weather Alert Policies and Rule X

In this accident, because the RTC did not convey the flash flood warning to the accident train, Rule X was not invoked by the train crew. As a result, the effect of its implementation on this accident can never be known. One reason for the difficulty in making such an assessment is the vagueness of Rule X. For example, the rule states that in the case of a flash flood warning, the train is to be operated at a speed that will allow it to be stopped short of an obstruction. The speed or the type of obstruction that might be expected is not specified. The problem with this lack of specificity is that a speed that would allow a train to stop short of a readily visible obstruction such as a tree over the tracks or a rockslide would probably be too fast for the train crew to see and respond to an impediment such as high water, a track washout, or misaligned rail—the types of hazards most likely to occur as a result of a flash flood.

It is not clear what information the RTC would have provided to the train crew if he had, in fact, informed them of the alert. He might have read the warning to the conductor as written, including the advisory to “Watch out for water on the tracks and possible washouts,” but because a verbatim reading of the alert was not required by CN policy, the crew may not have been alerted to the specific hazards.

Weather alerts and their effects on train speeds were also addressed in a July 16, 2008, CN weather alert policy that instructed RTCs, after learning of warnings of flash flooding, to contact track personnel in the area to inspect the track before passage of a train. The policy directed RTCs to inform train crews of flash flood warnings and to advise them to operate their trains at a speed, "prepared to stop within one half the range of vision, until the track is inspected or the Track Supervisor has given verbal permission to resume normal operation."

Presumably, if no track inspector were immediately available to inspect the track, trains would continue to operate at the lower speed until an inspector could be dispatched. However, a track washout, which is a common hazard during flash flooding, is extremely difficult to detect from a locomotive cab, even when the train is traveling at a reduced speed, and especially when that speed is determined by the crew based on their estimate of the train's stopping distance. Thus, a train crew, using its own discretion to determine an appropriate speed, may not be able to prevent an accident involving high water or a washout.

The RTC also did not notify a track inspector in response to the flash flood warning. A track inspector was dispatched by the Edmonton Walker Call Desk in response to the RTC's relaying the accident train's report of high water, but the RTC's report was made even as the train was derailing, and the track inspector would not be en route until about 20 minutes later.

The CN's policies and rules for responding to severe weather alerts are inadequate to prevent the type of accident that occurred in Cherry Valley, Illinois. They do not require that an RTC provide train crews with the full text of weather alerts; they do not require that trains be operated at specified restricted speeds through areas affected by severe weather warnings; they do not require that track be inspected before trains are allowed to travel through weather-affected areas at more than restricted speed; and they do not consolidate weather policies in a single rule accessible to all operating personnel. The NTSB concludes that the CN's weather policies and rules in effect at the time of the accident were inadequate because they provided insufficient and vague guidance in not requiring RTCs to read weather alerts verbatim to train crews; did not clearly specify whether train crews should operate trains at a restricted speed after receiving an alert; provided no notification requirement that track inspectors conduct severe weather related inspections prior to train operations; and did not consolidate weather alert notices and the appropriate operation of trains into a single rule. The NTSB therefore recommends that the CN modify its weather warning operating and safety rules and procedures to (1) consolidate weather policies in a single rule, accessible to all operating personnel, (2) require that RTCs promptly and precisely notify affected train crews of weather alerts and identify for train crews the specific hazards to train operation represented by a weather alert, and (3) require either that a track inspector inspect the affected track before train operations are permitted within an affected weather alert area or that engineers operate their trains at restricted speed and crews watch for water on tracks, possible washouts, and misaligned track in the affected areas until the track is inspected.

2.8 Performance of the RTC

Under CN weather procedures, in response to the flash flood warning that he received at 6:36 p.m. on the day of the accident, the RTC should have inserted a restrictive label into the computerized TMDS. A restrictive label would have required that the RTC notify the crews of trains operating through the area affected by the weather alert. For example, had a restrictive label been applied on the day of the accident, the RTC would not have been able to issue track authority (in automatic block signal territory) to the accident train at Freeport without verifying that he had informed the crew of the flash flood warning. But because the restrictive label had not been created, the track authority was issued without the crew having been informed of the severe weather and the potential for washouts along their route. When the crew reached traffic control system territory at Rockford, they requested that the RTC provide a signal indication to proceed. A restrictive label would again have prompted the RTC to inform the train crew of the weather alert. Instead, the RTC gave the train crew a permissive signal to proceed but did not discuss the possible flooding.

The train crew spoke with the RTC by radio at least four times between Freeport and the accident site. At no time during those conversations did the RTC relay the weather bulletin information to them. The RTC was aware that weather bulletins had been delivered to his desk by his supervisor hours before the CN train derailed, and he understood the steps that had to be taken in response to severe weather alerts. After the accident, the RTC recalled receiving the 6:36 p.m. flash flood warning and placing it on top of a pile of other papers. Although he said he had intended to take action in response to the weather alert, he did not do so. Moreover, the fact that the RTC did not mention the flash flood warning to the accident train crew even when the crew called to inform him of high water along their route indicates that the RTC likely did not read the bulletin.

The weather warnings, if given, would have triggered the implementation of Rule X, which required that the crew operate their train at a speed that would allow the train to stop short of an obstruction. If the RTC had informed the accident train crew of the flash flood warning while the train was in Freeport, the crew would have been operating under Rule X when they departed Freeport at 7:21 p.m. Because of the weight of the train and the large number of curves, bridges, and ascending and descending grades the train would encounter over the approximately 35 miles between Freeport and Cherry Valley, the train crew would likely have operated the train at less than the normal track speed the train attained on the day of the accident. Even if the lower speed had not prevented the derailment, it would have lessened the dynamic forces acting on the derailed tank cars, reducing the amount of product released and likely mitigating the effects of the accident.

The NTSB therefore concludes that if the RTC had followed CN weather procedures and alerted the crew of the accident train to the potential for heavy rains and flash flooding along their route, the crew would have been required to operate the train at a lower speed, which would have reduced the severity of the accident.

The NTSB recognizes that the RTC was consistently busy throughout his shift. His workload had been increased recently when he began dispatching trains from a desk that a month earlier had been formed by combining two separate desks. Like all RTCs, he was responsible for managing and strategically prioritizing numerous tasks. He understood the significance of severe weather bulletins and the actions he needed to take upon receiving them. However, when the RTC received the severe weather bulletin he was engaged in other dispatching tasks, did not read the bulletin, and ultimately forgot about it.

The NTSB further recognizes that the CN did not take effective measures to reduce the likelihood that critical tasks would go unaddressed. For instance, there was no standard protocol for exchanging critical information when the weather bulletins were hand-delivered to the RTC. An effective handoff would have immediately alerted the RTC about the significance of the new weather bulletin, thereby prompting him to take immediate action. Additionally, in appearance (that is, headings, color, and font size of weather warnings and watches) all weather bulletins are identical; there is nothing that physically distinguishes different bulletins or alerts the RTC to their significance until the contents are read. The ability to immediately identify the criticality of the weather bulletins would aid RTCs in prioritizing their tasks. Finally, the RTC did not answer the emergency phone call from CN police regarding the condition of the track before the accident occurred. It was not possible for the RTC to distinguish between incoming routine and emergency calls. However, the RTC or another CN official would have been able to respond more quickly to incoming emergency phone calls if those calls were rerouted to another destination or to a designated emergency phone rather than being placed in queue. The NTSB concludes that a thorough work risk assessment of dispatching operations may have identified several deficiencies that, if corrected, would have ensured safety-critical tasks were addressed appropriately.

2.9 Hydrological Information

The rain storm on the day of the accident caused flooding in many areas of Winnebago County, in particular, the city of Rockford and the village of Cherry Valley. The city of Rockford's storm water drainage system surrounding the residential neighborhoods north of the CN and UP tracks and west of Mulford Road captured the runoff created by the storm and directed water into the two detention ponds constructed for the Harrison Park subdivision.

2.9.1 Breach in Harrison Park SWM Pond 1

The investigation revealed that the larger of the two detention ponds, SWM pond 1, had sustained significant deterioration before the storm of June 2009. Local homeowners provided documentation showing severe erosion of the upper portion of the berm over the outlet pipe more than 2 years before the accident. The erosion rendered the portion of the pond berm above the outlet significantly lower than when the pond was originally constructed. When the unusually high water level in the pond on June 19 rose to the bottom of the deteriorated berm section, the water began to escape through the opening. Once the water was able to overflow, it quickly began to further erode the berm, thus allowing more water to outflow and accelerating the deterioration. Although the water pouring out of this breach added to the water from the heavy rains, the investigation was unable to determine the amount of water from the detention pond release that may have reached the intersection of the CN tracks and Mulford Road.

The presence of debris on the top of tracks to the west of the open deck bridge about 0.1 mile west of the crossing indicated that at some point, the water that had collected in the area between the UP and CN tracks attempted to follow the natural water drainage route. Normally, the runoff would have flowed under the tracks at the open deck bridge. From there, it would have gone into the creek running along the south side of the tracks and would have continued south as part of this creek, passing through the concrete box culvert under Mulford Road. On the day of the accident, however, the opening at the open deck bridge was not large enough to accommodate the volume and flow rate of the storm water. The damage to the retention wall on the east side of the bridge was evidence that the water level was high enough to cover the bridge retaining wall and wash away the soil from behind it. As with other physical evidence, this indicates that the amount of water present before the derailment overwhelmed the existing water management system.

2.9.2 Maintenance of Storm Water Management Detention Ponds

Maintenance of detention ponds is typically the sole responsibility of property owners. In the case of Harrison Park SWM pond 1, the party responsible for maintaining the pond was the Harrison Park Landowners Association as represented by a local real estate firm. In April 2008, the association was aware that erosion over the outlet pipe was affecting the integrity of the pond, and in the same month the landowners' agent received a proposal to repair the pond. However, the landowners' agent did not begin assessing homeowners to pay for the work until the beginning of 2009, ensuring that the damage to the pond would not be corrected until more than a year after the deterioration had first been documented. At any point during that time, a heavy flood storm could have occurred that would have enlarged the initial breach and created a safety hazard for those downstream, as occurred on the day of the accident. The NTSB therefore concludes that the breach in Harrison Park SWM pond 1 that was documented in 2008 posed a downstream risk in the event of a heavy storm, and more timely measures should have been taken to repair the defect and restore the integrity of the pond.

When a storm water management detention pond is breached or otherwise loses its structural integrity, damage can occur downstream with regional consequences. For that reason, although maintenance of a detention pond is usually the responsibility of the property owner, local storm water management authorities have a vital interest in ensuring that the ponds are functional.

The city of Rockford was required by the state of Illinois to inspect detention ponds, but only from the perspective of water pollution. The ponds were not inspected for function. Even for water pollution, inspections by the city were infrequent, with only three citywide inspections having been performed in the 5 years before the accident.

After the accident, the city of Rockford developed a storm water inspection program for large detention ponds, both public and private, after a major rain storm. In addition to detention ponds, the city's major storm monitoring program now includes inspections of bridges, culverts, major creeks, and drainage ways. The city also evaluates the physical condition of storm water detention ponds and requires inspections by storm water authorities if any physical aspect of a pond is rated less than "good." Finally, the city has contacted local homeowners associations and required that they immediately notify the city of any physical damage to a storm water management detention pond, drainage way, or culvert after a major storm event or whenever such damage is discovered. Had these provisions been in force and followed before the accident, city inspectors would likely have discovered the deterioration in Harrison Park SWM pond 1 and may have been able to work with the property owners to effect a more timely repair. The NTSB concludes that regular inspections by municipalities or other government authorities of storm water detention ponds, both public and private, would help ensure that the ponds function as designed to reduce the likelihood of damage to property or injuries to people. The NTSB therefore recommends that the National League of Cities, the National Association of Counties, the Association of State Dam Safety Officials, the National Association of Towns and Townships, and the U.S. Conference of Mayors inform their members of the circumstances of this accident and emphasize the importance of periodically inspecting storm water management detention ponds (both private and public) to ensure that no deterioration has occurred that would result in the failure of a pond to function as designed.

2.9.3 Upgrade of Drainage Pipes At Mulford Road

At the time of the accident, two drainage pipes—a 36-inch pipe under the CN tracks and a 24-inch pipe under Mulford Road—were in place to handle runoff that collected in the area bounded by the UP tracks to the north, the CN tracks to the south, and Mulford Road to the east. According to representatives of the CN and the Winnebago County Highway Department, neither of these pipes was intended to be a primary conveyance for water. Instead, each was to be a relief pipe to provide an escape route once the water level in the swale area rose to the height of the pipes. On the day of the accident, the water level did rise to the height of the pipes, but the pipes were unable to accommodate the excess water, which allowed the water to back up and overflow the track and the road.

This was not the first time excess water had affected the integrity of the CN tracks at this location. Twice in the previous 3 years, water in the swale area had risen to a level sufficient to remove support from underneath the tracks. In 2006, water rushing across Mulford Road removed ballast from track on both sides of the crossing. Less than a year later, in 2007, water caused a washout area 5 to 6 feet long and about 4 feet deep under the tracks about 40 feet west of the grade crossing. The NTSB concludes that the storm water drainage system in place in the area of the accident was inadequate as evidenced by the washout of the CN tracks on the day of the accident and by previous water damage to the track structure that occurred in 2006 and 2007.

It was in response to the 2007 washout that the CN installed the 36-inch relief pipe. The CN did not attempt to determine why the water had been able to rise to the level that a relief pipe was needed or to evaluate the existing drainage system in light of two water incidents in less than 1 year that had threatened the integrity of its tracks.

The Winnebago County Highway Department did not take any action in response to the two high water incidents because Mulford Road had not been directly affected. Highway department involvement was limited to observing the installation of the 36-inch pipe to make sure the roadway was not damaged. County officials did not consult with the CN about the sizing of the pipe, nor did the CN and the county attempt to work together to identify the reason for the unexpectedly high water levels.

The NTSB concludes that this accident demonstrates that storm water issues can affect more than one entity—in this case, the CN and Winnebago County—and can require that multiple entities work jointly in a collaborative effort to solve any underlying defects or inadequacies. The NTSB therefore recommends that the DOT develop a comprehensive storm water drainage assessment program to be conducted jointly by railroads and public entities that ensures the adequate flow of water under both railroad and highway facilities, and require railroads and public entities to coordinate any changes to storm water drainage systems before their implementation. In the interest of safety in the short term, the NTSB recommends that the DOT notify railroads and public entities about the circumstances of this accident and the importance of exchanging information related to storm water drainage system design issues that may adversely affect the adequate flow of water under both railroad and highway facilities. The NTSB also recommends that the American Association of State Highway and Transportation Officials, the National Association of County Engineers, the American Public Works Association, and the Institute of Transportation Engineers inform their members about the circumstances of this accident and the importance of exchanging information related to storm water drainage system design issues that may adversely affect the adequate flow of water under both railroad and highway facilities.

After the accident, the CN installed two new 48-inch-diameter cast iron pipes at the site of the previous 36-inch pipe. The CN also replaced the existing 24-inch relief pipe under Mulford Road with a new 48-inch-diameter pipe, a new 36-inch-diameter pipe, and a new 24-inch-diameter pipe, all supplied by Winnebago County. The new pipes significantly increased the drainage capacity for the area in which the high water occurred that precipitated this accident, but an opportunity was missed, in that similar steps could have been taken in the wake of previous instances of high water.

2.10 Accuracy of Train Consist Information

The original consist for the accident train had only 3 of the 76 cars in their proper positions on the train. This was not the first instance in which the CN failed to comply with 49 CFR 174.26, "Notice to Train Crews," which requires that a train crew have a train consist that accurately reflects the current position of each rail car containing hazardous material in a train. In a July 10, 2005, accident in Anding, Mississippi,[67] in which one of the train consists was destroyed in the collision of two freight trains, the CN subsequently delivered an inaccurate consist that caused confusion during the emergency response. During the FRA's 2006 national hazardous materials audit focusing on the level of compliance with hazardous materials communications, it also found that 22.3 percent of the CN trains audited had improper hazardous materials car documentation, consist errors, train crews failing to update the train consist to reflect actual car placement, or trains dispatched with erroneous consist information.

In this accident, because the tank cars of the accident train made up a unit train consisting of a single commodity, no confusion occurred as a result of the train crew's failure to update the train consist. If different hazardous commodities had been commingled in the train, emergency responders would have been unable to locate them based upon the train consist. The NTSB therefore concludes that the inaccurate train consist carried by the crew did not affect the emergency response to this accident; however, had a mixture of hazardous commodities been involved, the inaccurate consist information could have hampered the response effort or put the safety of emergency responders and others at risk.

[67] *Collision of Two CN Freight Trains Anding, Mississippi July 10, 2005*, Railroad Accident Report NTSB/RAR-07/01 (Washington, DC: National Transportation Safety Board, 2007). <www.ntsb.gov>

Electronic transmission of shipping paper information did occur in this accident, albeit about 3 hours after the train crew provided emergency responders with an inaccurate paper document, and about 4 hours after the dispatcher orally conveyed hazardous materials information to the fire department. When first contacted about the accident about 9:15 p.m. on the day of the accident, the CN could have at that time faxed or e-mailed the correctly ordered train car consist directly to the IC. Since this accident, the CN has provided its emergency responders with the capability, through e-mail, to receive the train consist, hazardous materials waybills, and material safety data sheets. Accuracy of the train consist information would be ensured through AEI readers that relay train consist data to the CN's central computer. With this increased use of technology, remote access to the CN's database should ensure that updated train car consist and hazardous materials information is available to emergency response personnel at accident scenes in a more timely manner.

As a result of its investigation of the Anding, Mississippi, train collision, the NTSB recommended that the FRA (Safety Recommendation R-07-2) and PHMSA (Safety Recommendation R-07-4) work together to develop PHMSA regulations requiring that railroads immediately provide to emergency responders accurate, real-time information about the identity and location of all hazardous materials on a train.

PHMSA, in a January 22, 2008, response to Safety Recommendation R-07-4, indicated to the NTSB that it was examining (1) ways to improve the availability of accurate and immediate information for emergency responders on the scene of an accident, and (2) strategies for enhancing emergency response planning and training efforts. Additionally, PHMSA indicated that it was evaluating the emergency response issues raised in the safety recommendation and the Federal, state, and local government, and industry programs intended to address those issues. Based on this response, the NTSB classified Safety Recommendation R-07-4 "Open—Acceptable Response."

In an October 10, 2007, response to Safety Recommendation R-07-2, the FRA noted the ongoing efforts of the AAR, CHEMTREC,[68] and the American Short Line and Regional Railroad Association to enhance the availability of hazardous materials information during an accident. But the FRA maintained that the current practice of requiring the physical hand-off of train consists and other hazardous materials information "remains the most accurate method of transferring this information when an accident occurs." The FRA stated that it had no reason to believe that regulatory revisions are necessary to address this issue.

In an April 12, 2011, follow-up response to the safety recommendation, the FRA noted that its regulations require that information on the identity and location of hazardous materials shipments on a train be maintained by a member of the train crew for the benefit of emergency responders. Further, with the FRA's encouragement, the AAR issued a circular offering to provide hazardous materials information on the top 25 commodities to local emergency response organizations to assist in training and preparing for emergencies. Finally, with the FRA's encouragement, CSX Transportation, Inc. and CHEMTREC established a real-time information

[68] CHEMTREC (the Chemical Transportation Emergency Center), is an around-the-clock service available to firefighters, law enforcement officials, and other emergency responders who need immediate response information for emergency incidents involving chemicals, hazardous materials, and dangerous goods.

process that provides car content and train consist information on a "one-call" basis. The FRA indicated that it continues to evaluate this process to determine if additional regulations are necessary.

While acknowledging the activities and contributions of the AAR, CHEMTREC, and industry stakeholders to facilitate the rapid communication of hazardous materials information, in a January 10, 2011, letter, the NTSB reminded the FRA that the intent of Safety Recommendation R-07-2 was to require railroads to provide to emergency responders information about the identity and location of hazardous materials on a train at the time of an accident and that the FRA had not identified any initiatives it had taken to move this recommendation forward. Therefore, the NTSB continues to classify Safety Recommendation R-07-2 "Open—Unacceptable Response."

The NTSB also supports the HM-ACCESS initiative of PHMSA, which will allow the electronic communication of shipping paper information and improve the availability and accuracy of hazard communications to emergency responders. If implemented as envisioned, railroads will be able to quickly transmit electronically updated and accurate train consist data to emergency responders when accidents occur.

However, although PHMSA began its HM-ACCESS initiative with public meetings on October 13–14, 2009, to discuss an upcoming proof-of-concept study on the use of electronic documents for hazardous materials shipments, no rulemaking has been initiated by PHMSA or the FRA to require railroads to immediately provide accurate consist information to emergency responders. Therefore, the NTSB reiterates Safety Recommendations R-07-2 and R-07-4 to the FRA and PHMSA, respectively.

2.11 Performance of DOT-111 Tank Cars in Accidents

2.11.1 Damage to Tank Heads, Shells, and Top Fittings

During a number of accident investigations over a period of years, the NTSB has noted that DOT-111 tank cars have a high incidence of tank failures during accidents. Previous NTSB investigations that identified the poor performance of DOT-111 tank cars include a May 1991 safety study[69] as well as NTSB investigations of a June 30, 1992, derailment in Superior Wisconsin;[70] a February 9, 2003, derailment in Tamaroa, Illinois;[71] and an October 20, 2006, derailment of an ethanol unit train in New Brighton, Pennsylvania.[72] In addition, on February 6, 2011, the FRA investigated the derailment of a unit train of DOT-111 tank cars loaded with ethanol in Arcadia, Ohio, which released about 786,000 gallons of product.

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[69] NTSB/SS-91/01.

[70] *Derailment of Burlington Northern Freight Train No. 01-142-30 and Release of Hazardous Materials in the Town of Superior, Wisconsin, June 30, 1992*, Hazardous Materials Accident Report NTSB/HZM-94/01 (Washington, DC: National Transportation Safety Board, 1994). <www.ntsb.gov/>

[71] *Derailment of Canadian National Freight Train M33371 and Subsequent Release of Hazardous Materials in Tamaroa, Illinois, February 9, 2003*, Railroad Accident Report NTSB/RAR-05/01 (Washington, DC: National Transportation Safety Board, 2005). <www.ntsb.gov/>

[72] NTSB/RAR-08/02.

The fact that DOT-111 general service tank cars experience more serious damage in accidents than pressure tank cars, such as DOT-105 or the DOT-112 cars, can be attributed to the fact that pressure tank cars have thicker shells and heads. The pressure cars are also usually equipped with metal jackets, head shields, and strong protective housings for top fittings. They do not have bottom outlet valves, which have been proven to be prone to failure in derailment accidents. (See appendix C of this report for a listing of previous NTSB recommendations addressing tank car head shields, bottom outlet valves, and top fittings.)

Of the 15 derailed DOT-111 tank cars that piled up in this accident, 13 cars lost product from head and shell breaches or through damaged valves and fittings, or a combination of the two. This represents an overall failure rate of 87 percent and illustrates the continued inability of DOT-111 tank cars to withstand the forces of accidents, even when the train is traveling at 36 mph, as was the case in this accident. Head breaches resulting in the release of denatured fuel ethanol occurred in 9 of the 15 tank cars in the pileup. Head failures in seven of the cars were apparently caused by coupler or draft sill strikes. Two of the tank heads were breached by other striking objects or tank car structures. Additionally, side shells of three of the tank cars were breached as a result of car-to-car impacts. Clearly, the heads and shells of DOT-111 tank cars, such as those that are used to transport denatured fuel ethanol in unit trains, can almost always be expected to breach in derailments that involve pileups or multiple car-to-car impacts. The inability of the DOT-111 tank car heads and shells to retain lading in this accident is comparable to previously mentioned ethanol unit train accidents that occurred in New Brighton, Pennsylvania, in which 12 heads or shells of 23 derailed tank cars were breached, and in Arcadia, Ohio, in which 28 heads and shells of 32 derailed tank cars were breached.

DOT-111 tank cars make up about 69 percent of the national tank car fleet, and denatured fuel ethanol is ranked as the largest-volume hazardous materials commodity shipped by rail. This accident demonstrates the need for extra protection such as head shields, tank jackets, more robust top fittings protection, and modification of bottom outlet valves on DOT-111 tank cars used to transport hazardous materials. The NTSB concludes that if enhanced tank head and shell puncture-resistance systems such as head shields, tank jackets, and increased shell thicknesses had been features of the DOT-111 tank cars involved in this accident, the release of hazardous materials likely would have been significantly reduced, mitigating the severity of the accident.

Although hazardous materials are better protected when transported in pressure tank cars, the majority of pressure tank cars, which are currently used for other hazardous materials such as liquefied petroleum gas, chlorine, and anhydrous ammonia, would be required to supply the demand for ethanol transportation alone. The FRA estimates there are about 40,000 class DOT-111 general service tank cars currently in ethanol service, while the total fleet of pressure tank cars of all specifications consists of about 62,000 cars.[73] Since this accident, the AAR has opted to increase the crashworthiness of newly constructed class DOT-111 tank cars used in ethanol and crude oil service in Packing Groups I and II. AAR requirements for new tank cars increase the minimum head and shell thickness to 1/2 inch for TC-128B nonjacketed cars and 7/16 inch for jacketed cars. Shells of nonjacketed tank cars constructed of A516-70 steel must now be 9/16 inch thick; shells of jacketed cars must be 1/2 inch thick. The AAR requirements also

[73] Association of American Railroads, UMLER, February 2009.

specify that both the heads and the shells must be constructed of normalized steel and that in all cases, a 1/2-inch-thick head shield must be provided.

The AAR requirements do not provide a retrofit solution for the existing fleet of about 40,000 tank cars that are dedicated to transporting denatured fuel ethanol. In its March 9, 2011, petition for rulemaking, the AAR specifically recommended that no provisions be adopted to require modifications or retrofitting of existing DOT-111 tank cars. In the petition, the AAR notes that it considered applying risk-reduction options both to the existing fleet and to new tank cars; however the Railway Supply Institute conservatively estimates the cost of retrofitting existing cars with head shield and jackets to be more than $1 billion over the life of a retrofit program, not including cleaning and out-of-service costs. The AAR argues, by contrast, that a member survey for information on the consequences of derailments involving Packing Groups I and II[74] hazardous materials from 2004 to 2008 found 1 fatality, 11 injuries, and the release of about 925,000 gallons of materials with associated cleanup costs of about $63 million.

The AAR cited other impediments to retrofitting DOT-111 tank cars with head shields or jackets. For example, the AAR contends that the extra weight of these safety features could overload tank cars designed to 263,000 pounds gross rail load even when the cars' draft sills are designed for 286,000 pounds. While increasing the thickness of existing tank car tank heads and shells would require replacement of the tank, retrofitting tank cars with head protection systems is not without precedent. When improved tank car construction specifications were adopted for certain tank cars used to transport flammable gasses, anhydrous ammonia, or ethylene oxide, RSPA took action to prohibit the use of tank cars built to older construction standards for these products. On January 27, 1984, RSPA issued a final rule that required after December 31, 1986, all DOT-105 tank cars constructed before March 1, 1981, as well as all DOT-111 tank cars used to transport these specifically identified hazardous materials to be equipped with the same tank head and thermal safety systems that are required on newly built DOT-105 tank cars and on all specification DOT-112 and DOT-114 tank cars used to transport those same hazardous materials.[75] The final rule noted that RSPA took this action to increase the safety of transportation by rail of hazardous materials.

The FRA reported that there are currently no plans to require phaseout or retrofitting of existing tank cars in the ethanol fleet.[76] The decision not to phase out or retrofit existing tank cars allows new DOT-111 tank cars with improved protection to be commingled in unit train service with the existing fleet of insufficiently protected tank cars. The decision thus ignores the safety risks posed by the current fleet of about 40,000 ethanol tank cars that are on average 8 years old with an estimated service life of 30 to 40 years. There will be increasing need for general service tank cars to meet transportation demands due to the mandated tripling of the amount of ethanol blended into the nation's fuel supply by 2022. Notwithstanding the anticipated growth in the volume of ethanol transported by railroad, existing DOT-111 tank cars will continue to make up a large percentage of the tank car fleet for many years.

[74] The *packing group* indicates the degree of danger presented by a hazardous material in transport. Packing Group I indicates great danger; Packing Group II, medium danger; and Packing Group III, minor danger.

[75] *Federal Register*, vol. 49, no. 19 (January 27, 1984), pp. 3468–3473.

[76] E-mail communication with FRA Hazardous Materials Division staff, November 2, 2011.

In addition, the FRA reports recent orders for 10,000 new general service tank cars to provide for crude oil unit train transportation in the northwest United States and Canada due to the lack of pipeline infrastructure. Tank cars for crude oil service have the same specifications as cars used for ethanol, therefore design alternatives would easily apply to tank cars in both services. Over the past 3 years, annual rail shipments of crude oil from the Bakken region of North Dakota alone have increased from 500 carloads to more than 13,000 carloads, and volume is expected to grow to 70,000 carloads annually.[77] There would be significant benefit to developing improved design standards prior to the construction of large numbers of additional tank cars, including avoiding the need to later include these cars in a retrofit or phase-out program.

Improvements in tank car safety would most effectively be targeted to those hazardous materials commodities that are transported by unit train, such as denatured fuel ethanol and crude oils, and which pose the greatest risks when released, such as those commodities in Packing Groups I and II. The risks are greater in unit train operations because hazardous materials are transported in high density. For example, a unit train of 75 to 100 fully loaded 30,000-gallon tank cars typically transports between 2.1 million and 2.8 million gallons of hazardous materials.

Considering that 10 of the 13 cars that released product in this accident did so as a result of punctures and fractures of the tank heads and shells, the NTSB welcomes the AAR's actions requiring that new DOT-111 tanks cars built for Packing Groups I and II service have head shields and be constructed of thicker and higher quality steels. However, these actions do not address existing tank cars and would not ensure that all tank cars used to transport hazardous materials such as fuel ethanol will meet enhanced puncture-resistance standards. Because of the impediments to retrofitting the existing tank car fleet with puncture-resistance systems, a phase-out of existing tank cars to other service may be the best option for the immediate future. The NTSB concludes that the safety benefits of new specification tank cars will not be realized while the current fleet of DOT-111 tank cars remains in hazardous materials unit train service, unless the existing cars are retrofitted with appropriate tank head and shell puncture-resistance systems.

Top fittings on tank cars generally project from the tank and are thus vulnerable to impact damage in derailments where the fittings may impact the ground or another object with the entire weight and momentum of the tank car behind it. Although housings used to protect the top fittings of DOT-111 tank cars involved in this accident were fabricated in accordance with 49 CFR 179.200-16, the postaccident inspection of the derailed tank cars revealed that the housings were not effective in preventing damage to the top fittings of two tank cars, resulting in subsequent loss of lading.[78] While the housing did protect the fittings in the case of one car, which came to rest lying upside down in soft mud, the top fittings were damaged in other instances where the housings contacted less compliant objects. In one case, the housing separated from the car, and both the liquid and the vapor valves were sheared from their threaded pipes, thereby causing the car to lose about 26,357 gallons of product. The housing cover of another car was knocked askew in the derailment, breaking the vapor valve from its fitting and contributing to the release of product from that car. Clearly, unprotected top fittings are vulnerable to impact

[77] Association of American Railroads' *Insider Newsletter*, December 12, 2011.

[78] One tank car released product from both a damaged top fitting and a bottom outlet valve.

damage and release of hazardous materials even when tank cars are otherwise less severely damaged, as was the case with the tank cars described above. The NTSB concludes that requirements for protection of the top fittings of the DOT-111 tank cars involved in this accident are inadequate because the protective housings were not able to withstand the forces of the derailment.

In order to demonstrate the viability of possible solutions for top fittings protection for non-pressure tank cars, the FRA, in October 2009, published the preliminary results of a report following testing of three concepts: adding a roll bar assembly to the top of the tank, incorporating a fabricated deflective skid to the top of the tank, and recessing the fittings into the interior of the tank.[79] Under an FRA contract, researchers created computer models, designed the concepts, and conducted full-scale dynamic rollover tests as recently as August 2010 in order to validate the models. Each of the concepts proved effective in preventing rollover damage to the top fittings; however, PHMSA has not initiated rulemaking to require enhanced top fittings protection for general service tank cars.

Notwithstanding PHMSA's inaction in mandating top fittings protection, the AAR, which by regulation is responsible for approving tank car designs, as of July 1, 2010, now requires that all new non-pressure tank cars used to transport Packing Groups I and II hazardous materials be equipped with discontinuity protection[80] housings for top fittings. The top fittings are subject to an impact performance standard incorporated into the AAR's *Manual of Standards and Recommended Practices*. Essentially, top fittings may be grouped inside a more robust pressure-car-type protective housing or mounted on nozzles or flanges within rollover skid protection. Although the top liquid and vapor valve fittings on each derailed tank car were contained within a housing, this housing was not nearly as strong as a pressure-car-type protective housing that would be required by the new AAR standard.

The current AAR standard addresses new construction only and does not require retrofitting of the current tank car fleet with top fittings protection. With about 40,000 existing DOT-111 tank cars that the FRA estimates are transporting denatured fuel ethanol, with an estimated service life of 30 to 40 years, this represents the potential for tank cars with inadequately protected top fittings to continue to release products in accidents.

Therefore, the NTSB recommends that PHMSA require that all newly manufactured and existing general service tank cars authorized for transportation of denatured fuel ethanol and crude oil in Packing Groups I and II have enhanced tank head and shell puncture-resistance systems and top fittings protection that exceeds existing design requirements for DOT-111 tank cars.

[79] *Survivability of Railroad Tank Car Top Fittings in Rollover Scenario Derailments Phase 2 Final Report*, Federal Railroad Administration Report DOT/FRA/ORD-09-20 (Washington, DC: U.S. Department of Transportation, 2009).

[80] *Discontinuity protection* refers to a housing or skid-plate structure designed to protect fittings and valves from damage in a derailment.

2.11.2 Bottom Outlet Valves

During the derailment, three bottom outlet valves opened as a result of valve operating levers being bent and pulled away from their retaining brackets. The bottom outlet nozzles were also sheared off outward of discontinuity protection during the derailment, thus exposing the open outlet valves. The open bottom outlet valves resulted in the release of most, if not all, of the product from those cars.

Bottom outlet discontinuity protection of the type that existed on the accident tank cars has been shown to be of limited effectiveness in preventing product releases from bottom outlets during accidents. Cited in the Transportation Research Board report, *Ensuring Tank Car Safety*, the AAR and the Railway Progress Institute reviewed the accident data for lading releases from bottom outlet valve damage and found that tank cars with damaged bottom outlets had a 30 percent failure rate when protected, compared with a 66 percent failure rate when nonprotected. The rate of release for even the protected bottom outlet valves thus remains at such frequency that it is likely that some DOT-111 tank cars will release product during derailments involving a substantial number of these cars.

One of the derailed cars with an open bottom outlet valve was a car owned by CIT Rail with a bottom outlet valve and handle configuration that had been modified from the original design. The bottom outlet valve handle on the car was constructed with a breakaway point that was designed to allow the handle to break free in an accident without causing the valve to open. But the valve operating handle was too robust and failed to break away when the handle struck the ground or another object. (See figure 7.) Instead, the retaining bracket broke, and the intact handle, though bent, opened the valve and allowed lading to be released. (See figure 11.)

The AAR *Manual of Standards and Recommended Practices Specifications for Tank Cars* specifies that "bottom outlet valve handles … must be designed to either bend or break free on impact, or the handle in the closed position must be located above the bottom surface of the skid." In the modified valve arrangement, although the handle was designed to bend or break free on impact, the end of the handle protruded outward such that it could become caught by other objects, debris, or soil, and the breakaway point feature was ineffective.

The other two cars with bottom outlet valves that opened during the derailment were cars owned by GE Equipment and by Trinity that used a bottom valve handle arrangement in which the valve handle extended out from the center of the tank and then upward and was secured to the right side of the tank. Moving the handle longitudinally from the A end toward the B end of the car opened the valve. (See figure 8.) This design does not have a breakaway feature for the valve handle, instead relying on the fact that the handle extends above the bottom surface of the skid protection plate in satisfaction of the AAR standard. Postaccident inspection of the two cars revealed that bottom outlet valve handles were bent and pulled away from their retaining brackets and that the exposed ball valves were open, thus allowing release of lading through the sheared nozzles.

The risks of releases from bottom outlet valves on general service tank cars has been recognized for many years, as illustrated by the Chemical Manufacturers' Association's June 7, 1994, correspondence with the NTSB concerning the status of Safety Recommendation R-91-11 in which it reported that some of its members had made voluntary equipment modifications to enhance the performance of their DOT-111 tank cars and that these modifications included eliminating bottom outlets where feasible.

The AAR Tank Car Committee task force that considered several DOT-111 protective systems or changes in operations discussed removal of bottom outlets from new and existing DOT-111 tank cars in ethanol and crude oil service. The task force concluded that although bottom outlet removal would be a significant improvement to tank car release performance and could be easily accomplished, removing the bottom fittings would have major impact on existing loading and unloading infrastructure. Therefore, AAR Circular letter CPC 1230 that includes new requirements for tank cars ordered after October 1, 2011, failed to address removal or further protection of bottom fittings.

The Hazardous Materials Regulations at 49 CFR 179.200-17(a)(4) and 173.31(d)(2) require that outlet nozzle construction ensure against the unseating of the valve and that closures on tank cars be designed and closed such that there will be no release of a hazardous material under conditions normally incident to transportation, including the effects of temperature and vibration, but the regulations are silent on the performance of bottom outlet valve operating mechanisms under accident conditions. All bottom outlet nozzles are provided with a score section around the piping or bolts that allow the nozzle to break away when struck in an accident, thus preventing the bottom outlet valve from being damaged. When the bottom outlet nozzle is stripped away by the forces of an accident, it is essential that the valve remain closed, otherwise product will be free to drain from the tank.

To prevent unintended opening of bottom outlet valves during derailments, the valve operating handles should be weak enough to readily break free before forces acting on the handle become sufficient to break the retaining pin and rotate the bottom valve to its open position. Alternatively, operating handles could be made of a detachable design such that no protruding mechanism is present that could inadvertently open the bottom outlet valve during an accident. The NTSB therefore concludes that the existing standards and regulations for the protection of bottom outlet valves on tank cars do not address the valves' operating mechanisms and therefore are insufficient to ensure that the valves remain closed during accidents. The NTSB therefore recommends that PHMSA require that all bottom outlet valves used on newly manufactured and existing non-pressure tank cars are designed to remain closed during accidents in which the valve and operating handle are subjected to impact forces.

2.11.3 Draft Sill and Sill Pad Attachments

Tank car NATX 303504 had a large breach that occurred as the draft sill was loaded downward relative to the tank. The draft sill is attached to pads that are attached to the tank car. The pads should help protect the tank from fracture caused by loads applied to the draft sill. The strength of the welds attaching the draft sill to the pad should be no more than 85 percent of the strength of the welds attaching the pad to the tank. Thus, it is expected that the draft sill should separate from the pad before the pad separates from the tank. However, in the case of NATX 303504, the front sill pad fractured from the tank and remained attached to the draft sill.

The fracture of the front sill pad for tank car NATX 303504 occurred at its edges within the fillet welds where it was attached to the tank. Overall deformation and fracture patterns indicated the fracture initiated at the front edge of the front sill pad due to downward loading of the head brace relative to the tank. Fractures at the edges of the front sill pad all showed ductile overstress features with no evidence of preexisting damage such as weld defects or fatigue cracks.

As the draft sill deformed further downward during the accident sequence, the front sill pad separated completely from the tank, but the body bolster pad remained attached to the tank, and the draft sill remained attached to the body bolster pad. As a result, the downward deformation of the draft sill led to a circumferential rupture of the tank shell adjacent to the front edge of the body bolster pad.

AAR standards require that the pads extend at least 1 inch transversely on either side of the draft sill attachment and must extend some distance from the head brace in the longitudinal direction as defined by a formula. However, there is no other requirement for distance that the pads extend in the longitudinal direction. In the tank cars involved in this accident, transverse portions of the draft sill attachment above the center plate were welded to the body bolster pad adjacent to the edge of the bolster pad where the pad was welded to the tank (see circled areas in figure 19). This area also corresponded to the tank circumferential fracture location. While separation of the front sill pad made tank failure more likely, the proximity of the attachment welds for the pads and the draft sill in this area provided a location where draft sill loads could be transferred directly to the tank wall rather than going first through the pads.

According to AAR standards for other substantial attachments such as brackets (AAR MSRP C-III Appendix E 15.2.4), the distance between a bracket and the edge of the pad shall not be less than three times the thickness of the pad in any direction. However, there is no similar requirement for draft sills in the longitudinal direction except between the head brace and the front edge of the front sill pad. The NTSB concludes that tank car design standards for the attachments of draft sills to sill pads and of sill pads to the tanks are insufficient to protect the integrity of the tanks in accidents in which the draft sills are subjected to significant downward deformation. The NTSB believes that the requirements for draft sills should be reviewed to ensure that appropriate distances are maintained between the draft sill/pad attachment welds and the pad/tank welds in all directions throughout the entire length of the draft sill attachment. The NTSB therefore recommends that the AAR review the design requirements in the AAR *Manual of Standards and Recommended Practices C-III*, "Specifications for Tank Cars for Attaching Center Sills or Draft Sills," and revise those requirements as needed to ensure that appropriate distances between the welds attaching the draft sill to the reinforcement pads and the welds attaching the reinforcement pads to the tank are maintained in all directions in accidents, including the longitudinal direction.

The revised AAR standard would address tank cars constructed after the changes are published and would not be expected to require retrofitting of the tank car fleet existing at the time the changes are published. Given the estimated tank car service life of 30 to 40 years, this represents the potential for tank cars with susceptibility to tank failure from loads applied to the draft sill to exist long after changes are made to the design standards.

Therefore, the NTSB recommends that PHMSA require that all newly manufactured and existing tank cars authorized for transportation of hazardous materials have center sill or draft sill attachment designs that conform to the revised Association of American Railroads' design requirements adopted as a result of Safety Recommendation R-12-9.

2.12 Safety Management Systems

A safety management system is a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures. An effective safety management system program can help companies reduce and prevent accidents and accident-related loss of lives, time, and resources. Currently, there are a number of industry sectors worldwide that have recognized the benefits of effective safety management, including aviation and the maritime communities. Moreover, the NTSB has included safety management systems for all modes of transportation on its Most Wanted List.

A safety management system provides for goal setting, planning, and measuring performance. An effective safety management system should, at a minimum:

- Define how the organization is set up to manage risk
- Identify workplace risk and implement suitable controls
- Implement effective communication across all levels of the organization
- Implement a process to identify and correct nonconformities
- Implement a continual improvement process

The NTSB investigation identified several risks and failures that had they been properly addressed may have prevented the accident. First, inadequate grade crossing identification and emergency contact information resulted in personnel failing to communicate early notifications of the track washout conditions to the proper property owners. Second, the RTC failed to communicate the prevailing weather conditions to the crew of the accident train, and the RTC's supervisor failed to exercise sufficient oversight to ensure that the RTC performed safety-critical tasks properly and in a timely manner. The CN failed to conduct a work risk assessment of dispatching operations that may have identified deficiencies that resulted in these errors. Third, the CN internal communications system failed to provide timely and precise knowledge of the washed out track conditions to the train dispatch center; in part, this failure was due to known difficulties associated with contacting personnel at the dispatch center. These considerations point out multiple failures at different levels across organizations that contributed to this accident.

In addition to these communication and emergency response failures, other potential safety-critical operations were inadequate. For instance, the vagueness of Rule X did not provide the operating crew sufficient guidance for operating under severe weather conditions. Additionally, in 2006 and 2007, the CN had the opportunity to address storm water management at the crossing where the accident occurred but failed to effectively analyze and mitigate the problem. Finally, the CN was aware of Federal regulations applicable to this accident, such as the need for accurate information on the train consist and the need to perform toxicological testing on personnel potentially involved in the accident. But, the CN failed to take steps to ensure compliance with these regulations. If the accident train had been carrying a mixture of hazardous materials, the emergency responders would not have been able to locate them based on the inaccurate train consist and the response effort could have been hampered. Likewise, it was not possible to rule out toxicological impairment of the RTC because the tests were not performed.

These inadequacies and lapses in safety-critical operations that were present in this accident suggest a lack of quality control and a weakness in the CN's safety culture. The CN was either unaware or did not respond effectively to the existing risks and failures that ultimately led to the accident. The NTSB concludes that had an effective safety management system been implemented at the CN, the inadequacies and risks that led to the accident would have been identified and corrected and, as a result, the accident may have been prevented. Therefore, the NTSB recommends that the FRA require that safety management systems and the associated key principles (including top-down ownership and policies, analysis of operational incidents and accidents, hazard identification and risk management, prevention and mitigation programs, and continuous evaluation and improvement programs) be incorporated into railroads' risk reduction programs required by Public Law 110-432, Rail Safety Improvement Act of 2008, enacted October 16, 2008.

2.13 Nicor Gas Pipeline

2.13.1 Construction Standards for Pipelines at Railroad Grade Crossings

The pipeline crossing under the CN tracks at Mulford Road on the day of the accident exceeded Federal standards for protective ground cover by a factor of 3. It was also five times as deep as the industry-recommended protection requirement for depth of cover that was in effect at the time the pipeline was constructed. Yet, as the wreckage was removed from above the pipeline, Nicor's crews discovered that a railcar wheel and axle assembly had impinged on the pipeline. Although the pipeline was buried about 11 feet deep and protected within a 16-inch-diameter casing, the rail car wheels impacted and severely dented the pipeline. The impact caused a severe flattening of the pipe casing with sharp angular bends at two locations where it was contacted by the rail car wheel assembly. This degree of deformation to the 16-inch casing pipe likely caused similar damage to the 12-inch carrier pipe. The NTSB concludes that had the gas pipeline been installed at the railroad crossing with the minimum level of ground cover permitted by the current Federal and industry pipeline construction standards, it likely would have failed as a result of being struck by derailed equipment in this accident.

Although the pipeline did not leak as a result of this accident, even minor dents and nicks are capable of causing pipeline failures. Pipeline damage caused by an accident may result in a catastrophic pipeline failure that occurs some period of time after the damage was inflicted, as was the case following the derailment of a Southern Pacific Transportation Company freight train on May 12, 1989, in San Bernardino, California.[81] Thirteen days after the derailment in San Bernardino, a 14-inch pipeline at the derailment site ruptured, released gasoline, and ignited. The San Bernardino pipeline failure and subsequent fire resulted in 2 fatalities and 19 injuries and illustrates the potential outcome had a release occurred at the Cherry Valley, Illinois, derailment site.

Research of pipeline incident records by PHMSA found only five reportable incidents[82] since 1984 in which a train derailment caused damage to a pipeline crossing under the track. Although PHMSA does not collect data that would reflect the number of incidents in which pipelines are damaged by train derailments at locations in railroad rights-of-way other than crossings, the aforementioned San Bernardino pipeline failure illustrates that buried pipelines can be damaged when present near railroad accident scenes. Despite the infrequency of such incidents, the NTSB believes that pipeline operators and railroad companies should be informed about the potential risk of damages to pipelines whenever a train derails. Given the prevalence both of underground pipelines and aboveground railroad tracks, the two must, of necessity, cross at numerous locations. Responsible pipeline operators may wish to consider protection methods that offer a higher level of safety when installing pipelines at these critical locations. The NTSB therefore recommends that PHMSA inform pipeline operators about the circumstances of the accident and advise them of the need to inspect pipeline facilities after notification of accidents occurring in railroad rights-of-way. The NTSB also recommends that the FRA inform railroads about the circumstances of the accident and advise them of the need to immediately notify pipeline operators of accidents occurring in railroad rights-of-way and ensure that pipeline inspections have been accomplished prior to resumption of service.

2.13.2 Pipeline Hazard Communications

The emergency responders who were engaged in the derailment and subsequent fire were unaware of the underground pipeline in the area. The pipeline marker closest to the Mulford Road crossing was destroyed by the postaccident fire, and neither the first responding fire department nor the railroad reconnaissance teams took notice of pipeline markers located farther from the accident scene.

About midnight on the day of the accident, the fire department located a pipeline marker south of the accident scene and contacted Nicor's dispatch center for further information about the location of the pipeline. Any concern the fire department may have had about the pipeline was put to rest by the map in its Pipeline Preplan Book (which was later found to contain incorrect information) and by the Nicor Gas dispatch clerk, who misread a map and erroneously reported that no pipeline was located in the vicinity of the Mulford Road grade crossing. After CN hazardous materials managers assessed the situation, they contacted Nicor again, and this time the operator confirmed the presence of the pipeline. At that point, Nicor appropriately dispatched a watch-and-protect team to the accident scene.

[81] *Derailment of Southern Pacific Transportation Company Freight Train on May 12, 1989, and Subsequent Rupture of Calnev Petroleum Pipeline on May 25, 1989, San Bernardino, California*, Railroad Accident Report NTSB/RAR-90/02 (Washington, DC: National Transportation Safety Board, 1990). <http://:www.ntsb.gov>

[82] Damage to the pipeline that does not involve the release of gas is not necessarily reported.

At the time of the accident, Nicor had in place a 24-hour response and dispatch operation, including an emergency response process that established responsibilities for reporting and handling trouble and unusual conditions. Had the communications error not been made, Nicor likely would have dispatched proper field personnel to test and monitor the pipeline under its existing protocol. The NTSB concludes that the erroneous pipeline hazard communication to emergency responders by Nicor Gas Company likely occurred as a result of the Nicor dispatch center clerk's misreading of a map.

Since this accident, Nicor has made improvements to its communication and notification protocol by ensuring that dispatch personnel review pipeline maps and corroborate their findings with the field duty supervisor to avoid providing incorrect information when contacted by emergency response agencies during an emergency.

3. Conclusions

3.1 Findings

1. The use of alcohol or illegal drugs by the rail traffic controller as a factor in the accident could not be determined because there was no toxicological testing conducted.

2. The following were not factors in the accident: mechanical condition of the locomotives and cars on the train; material properties of steels used in the tank car construction; integrity of the track structure, culvert, and rails leading up to the point of derailment; functioning of the signal system and the grade crossing warning system; use of alcohol or illegal drugs by the train crew; training and qualifications of the train crew and the rail traffic controller; and fatigue of the rail traffic controller.

3. Both the emergency response to the accident and the environmental recovery efforts after the fire were timely and appropriate.

4. The derailment occurred when wheel loads on rails that were unsupported because of a washout of the track structure caused the north rail to fracture at a field weld about 8 feet west of the Mulford Road grade crossing.

5. Had the required CN grade crossing identification and emergency contact information been posted at the Mulford Road crossing, the railroad would likely have been notified of the track washout earlier, and the additional time may have been sufficient for the rail traffic controller to issue instructions to stop the train and prevent the accident.

6. The CN police emergency communication system in place at the time of this accident was inadequate, with the result that CN police were unable to prevent the derailment even though adequate time was available for them to have done so.

7. The failure of the CN to conduct postaccident toxicological testing on the rail traffic controller demonstrates that the CN postaccident toxicological program was ineffective.

8. The CN's weather policies and rules in effect at the time of the accident were inadequate because they provided insufficient and vague guidance in not requiring rail traffic controllers to read weather alerts verbatim to train crews; did not clearly specify whether train crews should operate trains at a restricted speed after receiving an alert; provided no notification requirement that track inspectors conduct severe weather related inspections prior to train operations; and did not consolidate weather alert notices and the appropriate operation of trains into a single rule.

9. If the rail traffic controller had followed CN weather procedures and alerted the crew of the accident train to the potential for heavy rains and flash flooding along their route, the crew would have been required to operate the train at a lower speed, which would have reduced the severity of the accident.

10. A thorough work risk assessment of dispatching operations may have identified several deficiencies that, if corrected, would have ensured safety-critical tasks were addressed appropriately.

11. The breach in Harrison Park storm water management detention pond 1 that was documented in 2008 posed a downstream risk in the event of a heavy storm, and more timely measures should have been taken to repair the defect and restore the integrity of the pond.

12. Regular inspections by municipalities or other government authorities of storm water detention ponds, both public and private, would help ensure that the ponds function as designed to reduce the likelihood of damage to property or injuries to people.

13. The storm water drainage system in place in the area of the accident was inadequate as evidenced by the washout of the CN tracks on the day of the accident and by previous water damage to the track structure that occurred in 2006 and 2007.

14. This accident demonstrates that storm water issues can affect more than one entity—in this case, the CN and Winnebago County—and can require that multiple entities work jointly in a collaborative effort to solve any underlying defects or inadequacies.

15. The inaccurate train consist carried by the crew did not affect the emergency response to this accident; however, had a mixture of hazardous commodities been involved, the inaccurate consist information could have hampered the response effort or put the safety of emergency responders and others at risk.

16. If enhanced tank head and shell puncture-resistance systems such as head shields, tank jackets, and increased shell thicknesses had been features of the DOT-111 tank cars involved in this accident, the release of hazardous materials likely would have been significantly reduced, mitigating the severity of the accident.

17. The safety benefits of new specification tank cars will not be realized while the current fleet of DOT-111 tank cars remains in hazardous materials unit train service, unless the existing cars are retrofitted with appropriate tank head and shell puncture-resistance systems.

18. Requirements for protection of the top fittings of the DOT-111 tank cars involved in this accident are inadequate because the protective housings were not able to withstand the forces of the derailment.

19. The existing standards and regulations for the protection of bottom outlet valves on tank cars do not address the valves' operating mechanisms and therefore are insufficient to ensure that the valves remain closed during accidents.

20. Tank car design standards for the attachments of draft sills to sill pads and of sill pads to the tanks are insufficient to protect the integrity of the tanks in accidents in which the draft sills are subjected to significant downward deformation.

21. Had an effective safety management system been implemented at the CN, the inadequacies and risks that led to the accident would have been identified and corrected and, as a result, the accident may have been prevented.

22. Had the gas pipeline been installed at the railroad crossing with the minimum level of ground cover required by the current Federal and industry pipeline construction standards, it likely would have failed as a result of being struck by derailed equipment in this accident.

23. The erroneous pipeline hazard communication to emergency responders by Nicor Gas Company likely occurred as a result of the Nicor dispatch center clerk's misreading of a map.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the washout of the track structure that was discovered about 1 hour before the train's arrival, and the Canadian National Railway Company's (CN) failure to notify the train crew of the known washout in time to stop the train because of the inadequacy of the CN's emergency communication procedures. Contributing to the accident was the CN's failure to work with Winnebago County to develop a comprehensive storm water management design to address the previous washouts in 2006 and 2007. Contributing to the severity of the accident was the CN's failure to issue the flash flood warning to the train crew and the inadequate design of the DOT-111 tank cars, which made the cars subject to damage and catastrophic loss of hazardous materials during the derailment.

4. Recommendations

As a result of its investigation of this accident, the National Transportation Safety Board makes the following safety recommendations:

4.1 New Recommendations

To the U.S. Department of Transportation:

> Develop a comprehensive storm water drainage assessment program to be conducted jointly by railroads and public entities that ensures the adequate flow of water under both railroad and highway facilities, and require railroads and public entities to coordinate any changes to storm water drainage systems before their implementation. (R-12-1)
>
> Notify railroads and public entities about the circumstances of this accident and the importance of exchanging information related to storm water drainage system design issues that may adversely affect the adequate flow of water under both railroad and highway facilities. (R-12-2)

To the Federal Railroad Administration:

> Require that safety management systems and the associated key principles (including top-down ownership and policies, analysis of operational incidents and accidents, hazard identification and risk management, prevention and mitigation programs, and continuous evaluation and improvement programs) be incorporated into railroads' risk reduction programs required by Public Law 110-432, Rail Safety Improvement Act of 2008, enacted October 16, 2008. (R-12-3)
>
> Inform railroads about the circumstances of the accident and advise them of the need to immediately notify pipeline operators of accidents occurring in railroad rights-of-way and ensure that pipeline inspections are accomplished prior to resumption of service. (R-12-4)

To the Pipeline and Hazardous Materials Safety Administration:

> Require that all newly manufactured and existing general service tank cars authorized for transportation of denatured fuel ethanol and crude oil in Packing Groups I and II have enhanced tank head and shell puncture-resistance systems and top fittings protection that exceeds existing design requirements for DOT-111 tank cars. (R-12-5)
>
> Require that all bottom outlet valves used on newly manufactured and existing non-pressure tank cars are designed to remain closed during accidents in which the valve and operating handle are subjected to impact forces. (R-12-6)

Require that all newly manufactured and existing tank cars authorized for transportation of hazardous materials have center sill or draft sill attachment designs that conform to the revised Association of American Railroads' design requirements adopted as a result of Safety Recommendation R-12-9. (R-12-7)

Inform pipeline operators about the circumstances of the accident and advise them of the need to inspect pipeline facilities after notification of accidents occurring in railroad rights-of-way. (R-12-8)

To the Association of American Railroads:

Review the design requirements in the Association of American Railroads *Manual of Standards and Recommended Practices C-III*, "Specifications for Tank Cars for Attaching Center Sills or Draft Sills," and revise those requirements as needed to ensure that appropriate distances between the welds attaching the draft sill to the reinforcement pads and the welds attaching the reinforcement pads to the tank are maintained in all directions in accidents, including the longitudinal direction. (R-12-9)

To the American Association of State Highway and Transportation Officials, the National Association of County Engineers, the American Public Works Association, and the Institute of Transportation Engineers:

Inform your members about the circumstances of this accident and the importance of exchanging information related to storm water drainage system design issues that may adversely affect the adequate flow of water under both railroad and highway facilities. (R-12-10)

To the National League of Cities, the National Association of Counties, the Association of State Dam Safety Officials, the National Association of Towns and Townships, and the U.S. Conference of Mayors:

Inform your members about the circumstances of this accident and emphasize the importance of periodically inspecting storm water management detention ponds (both private and public) to ensure that no deterioration has occurred that would result in the failure of a pond to function as designed. (R-12-11)

To the Canadian National Railway Company:

Implement a process, consistent with the principles of a safety management system, to ensure accuracy and visibility of emergency contact information at all highway/rail grade crossings on your system. (R-12-12)

Implement a program consistent with principles of safety management systems to periodically test all aspects of your internal emergency communication system to ensure that personnel are familiar with the system's operation and that emergency notifications can be communicated immediately to any chief dispatcher or rail traffic controller in your system. (R-12-13)

> Examine and revise your postaccident toxicological testing program to ensure that rail traffic controllers are tested unless there is clear and convincing evidence that they were not involved in the accident. (R-12-14)
>
> Modify your weather warning operating and safety rules and procedures to (1) consolidate weather policies in a single rule, accessible to all operating personnel, (2) require that rail traffic controllers promptly and precisely notify affected train crews of weather alerts and identify for train crews the specific hazards to train operation represented by a weather alert, and (3) require either that a track inspector inspect the affected track before train operations are permitted within an affected weather alert area or that engineers operate their trains at restricted speed and crews watch for water on tracks, possible washouts, and misaligned track in the affected areas until the track is inspected. (R-12-15)

4.2 Reiterated Recommendations

As a result of this accident investigation, the National Transportation Safety Board reiterates the following previously issued safety recommendations:

To the Federal Railroad Administration:

> Assist the Pipeline and Hazardous Materials Safety Administration in developing regulations to require that railroads immediately provide to emergency responders accurate, real-time information regarding the identity and location of all hazardous materials on a train. (R-07-2)

To the Pipeline and Hazardous Materials Safety Administration:

> With the assistance of the Federal Railroad Administration, require that railroads immediately provide to emergency responders accurate, real-time information regarding the identity and location of all hazardous materials on a train. (R-07-4)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Member

Adopted: February 14, 2012

5. Appendixes

5.1 Appendix A: Investigation

The National Response Center notified the NTSB of the Cherry Valley accident on June 19, 2009, and the NTSB sent one investigator from its Chicago, Illinois, office. The next day, the investigator-in-charge and other members of the NTSB investigative team were launched from the headquarters office in Washington, DC, and additional investigators arrived from field offices in Chicago; Atlanta, Georgia; Los Angeles, California; and Arlington, Texas. Investigative groups were established to study track and structures, signals, operations, mechanical, survival factors, human performance, pipeline and hazardous materials, and highway factors. Member Robert L. Sumwalt accompanied the team to the accident site.

Parties to the investigation were the Canadian National Railway Company; the Federal Railroad Administration; the Illinois Commerce Commission; the Brotherhood of Locomotive Engineers and Trainmen; the United Transportation Union; the Brotherhood of Maintenance of Way Employes; the Cherry Valley Fire Protection District; the city of Rockford, Illinois; Winnebago County, Illinois; Valero Energy Corporation; Nicor Gas, and Trinity Tank Car, Inc.

5.2 Appendix B: Comprehensive Timeline of Accident Events

Times in this timeline are derived from the following sources:

CN Homewood Southern Operations Control Center Train Management Dispatcher Sheet (time adjusted)
Cherry Valley Fire Protection District–National Fire Information Reporting System Report
CN radio log (time adjusted from CN Homewood Southern Operations Control Center)
Event Recorder data (independent time source, not adjusted)
Rockford and Winnebago County 911 centers (time source certified with GMT universal clock)
CN Emergency Call Center in Montreal (time adjusted)
NTSB interviews
NOAA weather data

Adjusted times: Investigators checked and verified two 911 center clock systems with the National Institute of Standards and Technology in Boulder, Colorado, and through a review of paired outgoing and incoming calls with the 911 centers, extended the time validation to the CN's Montreal and Homewood dispatch offices.

Acronyms and abbreviations used in the timeline:

CVFPD	Cherry Valley Fire Protection District
Homewood	CN's Homewood Southern Operations Control Center, Homewood, Illinois
IC	Incident command
MP	railroad milepost
RFD911	City of Rockford 911/Emergency Services Dispatch Center
RFD	Rockford Fire Department
RPD	Rockford Police Department
RTC	CN rail traffic controller—the RTC responsible for the territory on which the accident occurred
WC911	Winnebago County 911/Emergency Services Dispatch Center

Friday, June 19, 2009

Time (CDT)	Event/Activity
2:00 p.m.	CN Train U70691-18 (accident train) goes on duty at MP 183.2 in Dubuque, Iowa, with accident crew.
2:28 p.m.	Accident train departs Dubuque with 75 loaded tanks cars of denatured fuel ethanol.
3:00 p.m.	RTC goes on duty at Homewood.
3:30 p.m.	A CN train passes through Cherry Valley and crosses Mulford Road without incident.
5:34 p.m.	CN's Homewood control center receives AccuWeather thunderstorm warning alert, which is delivered to the desk of the RTC.
6:00 p.m.	A severe rain event begins moving through the Rockford and Cherry Valley area.
6:36 p.m.	CN's Homewood control center receives AccuWeather flash flood alert, which is delivered to the desk of the RTC.
7:00 p.m.	Accident train stops at Freeport (MP 115.6) to pick up 38 cars, which will be added to the head end of the train.
7:16 p.m.	With the pickup of addition cars complete, accident train receives authority from RTC to depart Freeport. The RTC does not mention the 6:36 p.m. flash flood alert.
7:21 p.m.	RTC gives accident train track authority to operate from West Seward to MP 16, with no restrictions. Again, the RTC does not inform the crew of the flash flood alert.
7:35 p.m.	A citizen calls RPD concerning a washout of the CN track near Mulford Road.
7:40 p.m.	WC911 receives the first of multiple calls from local citizens about the crossings at Mulford Road, with one saying: "the tracks [are] washing away."
7:52 p.m.	A citizen calls WC911 to report that the tracks at Mulford Road are washed out and that water is going under the tracks.
8:03 p.m.	WC911, after learning that RPD has no patrol officers available to respond, dispatches a Winnebago County sheriff's deputy to investigate the washout reports.
8:09 p.m.	WC911 deputy attempts to determine owner of tracks with reported washout. Calls BNSF Railway and is told the track is not BNSF.
8:10 p.m.	WC911 deputy calls UP Railroad to report washout. UP tracks are about 500 feet north of CN tracks at Mulford Road.
8:14 p.m.	Winnebago County deputy sheriff dispatched by WC911 arrives at Mulford Road.
8:15 p.m.	Accident train radios RTC to request a signal at MP 85.6 that will allow the train to pass over a rail crossing at Rockford.
8:16 p.m.	Having determined that the track belongs to the CN, WC911 deputy contacts the CN Emergency Call Center in Montreal and informs the call desk officer of washout of CN tracks at Mulford Road in Rockford, Illinois: "Water has washed out rail lines that do belong to you."
8:18–8:23 p.m.	CN emergency call desk officers make repeated unsuccessful attempt to reach the RTC and/or chief dispatcher at Homewood to relay the report of washed-out tracks.
8:18 p.m.	Accident train passes signal at Rockford (MP 85.6). The crew notices high water at the Rockford Diamond and water near the top of the rails about 1/2 mile east of MP 81.
8:32 p.m.	CN emergency call desk officer in Montreal calls WC911 to confirm the location as Mulford Road and to inform authorities that CN would be "sending someone out."
8:35 p.m.	As accident train crests a hill at MP 81.2, it picks up speed to 36 mph. After passing MP 81, crew calls the RTC to report having encountered high water at the Rockford Diamond and water near the tops of the rails near MP 81.
8:36 p.m.	Shortly after the head end of accident train passes over the Mulford Road grade crossing, the train experiences an automatic emergency brake application as the train derails and separates behind the 58th car. Locomotive event recorder data show the train moving at 36 mph at the time.
8:36 p.m.	RTC calls Edmonton Walker Call Desk in Edmonton, Alberta, Canada, to relay accident train's report of high water at Rockford Diamond and water near the tops of the rails at MP 81. Edmonton Walker Call Desk dispatches track inspector (who lives in Freeport, Illinois) to the area.
8:36 p.m.	RFD911 receives a call from a citizen reporting a bus/truck fire in the vicinity of Mulford Road.
8:37 p.m.	A caller to RFD911 reports "a train has derailed, four explosions, box cars are exploding." RFD911 dispatches fire department (RFD) resources to the scene.

Time (CDT)	Event/Activity
8:37 p.m.	WC911 receives a call reporting a fire on the railroad tracks near Mulford Road. This is the first of 19 calls received by WC911 reporting the incident.
8:40 p.m.	CN Montreal Emergency Call Center desk officers reach the chief dispatcher and RTC at Homewood. Neither caller mentions "washout." RTC responds that he has already reported the high water.
8:41 p.m.	CVFPD resources arrive on the scene of the derailment and fire.
8:42 p.m.	With the head end of their train near MP 79.5, the crew of accident train radios the RTC to report that the train is in emergency but the cause has not been determined.
8:46 p.m.	CVFPD chief arrives on scene and radios RFD911 to advise of a major fire with multiple tank cars derailed and burning. The CVFPD chief initiates the IC process, and IC posts are established on both the north and south sides of the derailment. Two CVFPD ambulances inform the chief that there are burn victims from vehicles that were stopped at the railroad crossing at the time of the derailment.
8:55 p.m.	Local track inspector dispatched by Edmonton Walker Call Desk contacts RTC and asks to inspect the track east of MP 79. RTC advises the track inspector to follow the train that had reported the high water (accident train, which has already derailed).
8:56 p.m.	Cherry Valley and Rockford hazardous materials personnel report to IC.
8:59 p.m.	Accident train engineer calls RTC to report a fire involving at least one ethanol tank car.
9:00 p.m.	Because of the lack of information about the cargo involved in the fire and the question of whether pressurized cars are involved, the CVFPD chief implements an evacuation of the area.
9:02 p.m.	Because the type of product fueling the fire is unknown, IC directs the police to begin evacuating the residential subdivisions on the north side of the derailment within a 1/2-mile radius.
9:09 p.m.	RFD advises IC that the railroad has identified the burning product as ethanol. IC asks RFD911 to start making calls to locate large quantities of fire-suppression foam.
9:12 p.m.	RFD911 advises IC that it has been informed by CN that only one tank car contains ethanol. IC asks RFD911 to inquire with CN about other products that may be involved since multiple tank cars are burning. IC sends a firefighting team to attempt to locate the train crew, make sure they are safe, and bring them to the IC post.
9:25 p.m.	RTC radios accident train and asks the crew move the nonderailed segment of the train 1/2 mile east to provide separation from the fire.
9:50 p.m.	A firefighter (of the train crew search team) approaches the locomotive cab of the accident train and asks the two crewmembers to accompany him to IC with their shipping papers. Train crew begins process of shutting down the locomotives and setting brakes on the railcars.
10:15 p.m.	A CN dangerous goods officer arrives on scene and confers with IC.
1020 p.m.	The train crew arrives at IC and provides a paper consist showing that all tank cars involved in the derailment contain ethanol.
11:00 p.m.	Two-member CVFPD Unit 562 is instructed to go east through a field to determine how far the derailment extends and how many tank cars are burning.
11:21 p.m.	CVFPD Unit 562 advises IC that, while proceeding on foot, one of the firefighters has become ill. IC advises the unit to return to its vehicle. IC deploys a rapid intervention team to locate and bring the unit back.
11:36 p.m.	Members of CVFPD Unit 562 arrive back at the south sector (south side of the crossing). IC orders both crewmembers to be transported to a hospital to be checked for possible exposure to hazardous materials. Crewmembers are evaluated at the hospital and released to return home.

Saturday June 20, 2009

Time (CDT)	Event/Activity
12:01a.m.	IC calls Nicor Gas asking about the location of any pipelines along Mulford Road near the accident site. Nicor Gas responds that no gas pipelines are in the area and that the closest pipeline about 0.7 mile from the accident site.
1:30 a.m.	IC is advised that the primary evacuation had been completed.
1:30 a.m.	Crew of accident train is tested for alcohol and illegal drugs.
2:28 a.m.	IC is advised that the extended evacuation has been completed.
3:30 a.m.	IC begins releasing mutual aid (firefighting) units from staging area. Some resources are retained in case of any unforeseen event.
6:30 a.m.	CN contacts Nicor Gas with a second inquiry about the location of a pipeline at the site. Nicor confirms that a gas transmission pipeline is located at the accident site.
7:06 a.m.	Nicor Gas dispatches technicians to the scene to prevent excavation damage during the wreckage recovery and clean-up operations.
10:00 a.m.	Fires on the west side of Mulford Road have burned down to a point that two unmanned monitors (cooling sprays) are put into operation. Fires will be extinguished at a steady pace over the next several hours, and water flow will be maintained for an additional hour for cooling.
3:00 p.m.	Fires on the east side of Mulford Road have burned down to a point that unmanned monitors (cooling sprays) are put into place. The fires are extinguished at a steady pace, and water flow will be maintained for an additional 2 hours for cooling.
5:00 p.m.	IC declares that all fires have been extinguished.
5:30 p.m.	Evacuees are allowed to return to their homes.
10:00 p.m.	All mutual aid firefighting companies are released.

Sunday, June 21, 2009

Time (CDT)	Event/Activity
4:00 p.m.	IC and railroad officials confer and agree that a fire department presence is no longer needed. The CVFPD chief terminates IC operations.

5.3 Appendix C: Tank Car Safety Recommendation History

Head Shields

To the Research and Special Programs Administration (R-85-61) and the Federal Railroad Administration (R-85-64):

> In consultation with the American Association of Railroads, conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture and mandate installation of the head shield at an early date.
>
> **Status:** Closed—Acceptable Action.

To the Association of American Railroads:

> In consultation with the Federal Railroad Administration and the Research and Special Programs Administration conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture and incorporate installation of the head shield at an early date as a rule in the car interchange requirements. (R-85-63)
>
> **Status:** Closed—Acceptable Alternate Action.

To the Research and Special Programs Administration:

> Require that all tank car shipments of hazardous materials with an isolation radius of one-half mile or more, as recommended by the U.S. Department of Transportation Emergency Response Guidebook, be transported in tank cars equipped with head shield or full tank head protection. (R-85-105)
>
> **Status:** Closed—Acceptable Action/Superseded by Safety Recommendation R-91-11.

To the Research and Special Programs Administration:

> Evaluate present safety standards for tank cars transporting hazardous materials by using safety analysis methods to identify the unacceptable levels of risk and the degree of risk from the release of hazardous material, then modify existing regulations to achieve an acceptable level of safety for each product/tank car combination. (R-89-80)
>
> **Status:** Closed—Acceptable Action.

To the Research and Special Programs Administration (R-91-11), the Federal Railroad Administration (R-91-12), the Association of American Railroads (R-91-14), the Chemical Manufacturers Association (R-91-19), the American Petroleum Institute (R-91-20), the American Fire Protection Association (R-91-21):

Establish a working group [with the assistance of the other named organizations] to expeditiously improve the packaging of the more dangerous products (such as those that are highly flammable or toxic, or pose a threat to health through contamination of the environment) by (a) developing a list of hazardous materials that should be transported only in pressure tank cars with head shield protection and thermal protection (if needed); and (b) establishing a working agreement to ship the listed hazardous materials in such tank cars.

Status: Closed—No Longer Applicable (R-91-11, -12, -20, and -21)
Closed—Acceptable Alternate Action (R-91-14 and -19)

To the U.S. Environmental Protection Agency:

Establish, in cooperation with the Department of Transportation (DOT), criteria to identify materials that are harmful to the environment or pose long-term threats to public health, and evaluate, with the DOT, the severity of harm posed by the release of these materials from bulk containers, including tank cars, in transportation. (I-94-2)

Status: Closed—Acceptable Action.

To the Federal Railroad Administration:

Validate the predictive model the Federal Railroad Administration is developing to quantify the maximum dynamic forces acting on railroad tank cars under accident conditions. (R-04-6)

Status: Open—Acceptable Response.

Bottom Outlet Valves

To the U.S. Department of Transportation:

Take immediate steps to cause the modification of both new and existing tank cars so that damage to the top fittings and bottom outlet valves is minimized in train accidents. (R-80-13)

Status: Closed—Acceptable Action.

To the Association of American Railroads:

Determine through analysis of your “Reports of Repairs” records the causes of tank car attachment failures. (R-87-52)

Status: Closed—Acceptable Action.

Revise present attachment standards for new tank cars and require appropriate modification of existing tank cars based on deficiencies identified in its analysis of the causes of tank car attachment failures. (R-87-53)

Status: Closed – Acceptable Action.

Establish a quality control program that includes on-site inspection to determine that tank car manufacture, repairs, modifications, and alterations are performed in compliance with the tank car specifications. (R-87-54)

Status: Closed—Acceptable Action.

Top Fittings

To the U.S. Department of Transportation:

Take immediate steps to cause the modification of both new and existing tank cars so that damage to the top fittings and bottom outlet valves is minimized in train accidents. (R-80-13)

Status: Closed—Acceptable Action.

To the Federal Railroad Administration (R-89-48) and the Research and Special Programs Administration (R-89-53):

Assist and cooperate in amending 49 CFR Part 179 to require that closure fittings on hazardous materials rail tanks be designed to maintain their integrity in accidents that are typically survivable by the rail tank.

Status: Closed—Unacceptable Action

To the Federal Railroad Administration (R-89-49) and the Research and Special Programs Administration (R-89-54):

Assist and cooperate in amending 49 CFR Part 179 to require that specifications for securing closure fittings, such as minimum torque values for sealing bolted closures and gasket specifications, be determined and provided by tank car designers and manufacturers.

Status: Closed – Acceptable Action.