National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 16, 1998

In reply refer to: R-98-48 through -53

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About 5:56 a.m., on August 9, 1997, National Railroad Passenger Corporation (Amtrak) train 4, the Southwest Chief, derailed on the BNSF tracks about 5 miles northeast of Kingman, Arizona. Amtrak train 4 was en route from Los Angeles, California, to Chicago, Illinois, and had just left the Kingman station. The train was traveling about 89 mph on the eastbound track when both the engineer and assistant engineer saw a "hump" in the track as they approached bridge 504.1S. They applied the train's emergency brakes. The train derailed as it crossed the bridge. Subsequent investigation revealed that the ground under the bridge's supporting structure had been washed away by a flash flood. Of the 294 passengers and 18 Amtrak employees on the train, 173 passengers and 10 Amtrak employees were injured. No fatalities resulted from the accident. The damages were estimated to total approximately $7.2 million.[1]

The National Transportation Safety Board determined that the probable cause of this accident was displacement of the track due to the erosion and scouring of the inadequately protected shallow foundations supporting bridge 504.1S during a severe flash flood because the BNSF management had not provided adequate protection, either by inspection or altering train speeds to fit conditions. Contributing to the accident was the failure of the BNSF management to adequately address the erosion problems at bridge 504.1S.

In its investigation, the Safety Board identified a number of concerns regarding the safety of structures subject to damage in severe storms and the protection of employees on or adjacent to the track in the performance of their duties. With regard to the failure of bridge 504.1S, the investigation examined the adequacy of the design, maintenance, inspection, and drainage area characteristics of bridge 504.1S in light of the severe weather and flash flood conditions affecting the bridge and the subsequent failure of a crosswall and the bridge supporting structure.

[1]For more detailed information, read Railroad Accident Report—*Derailment of Amtrak Train 4, Southwest Chief, on the Burlington Northern Santa Fe Railway, near Kingman, Arizona, August 9, 1997* (NTSB/RAR-98/03).

Bridge 504.1S was supported by a shallow foundation consisting of timber mud sills and timber blocking. BNSF records showed that the bridge supports were susceptible to scouring and erosion as early as 1959, when it was necessary to add stones and grout to a portion of the streambed. In the succeeding years, additional stones and grouting were added. Records also showed that, in 1975, maintenance personnel were still concerned about the bridge supporting structure and its water-carrying capacity. In fact, they remained so concerned that they recommended that the bridge be placed on the Capital Improvement Program (CIP) list for replacement.

BNSF bridge records identifying the size of the drainage area for bridge 504.1 were inconsistent. One record showed the drainage area as encompassing 3.8 square miles, while another showed the drainage area as totaling 19.09 square miles. The size of the drainage area is an important element in determining the required waterway opening for drainage structures. After the accident, the BNSF's consultant (HDR Engineering, Inc.) determined that the drainage area for bridge 504.1 was 19.5 square miles. The consultant's report cited the accepted engineering practice of using the 100-year storm criteria to provide for drainage structures but noted that local conditions and circumstances, such as the desert nature of the Kingman area, allowed for making an engineering judgment resulting in higher or lower values. According to the consultant's report, the bridges located at milepost 504.1 at the time of the accident were capable of withstanding a 24-year storm. The storm related to this accident was determined to have been approaching a 50-year storm event of 2 hours' duration. (The August 9, 1997, storm's effect differed among the five railroad bridges in the area. Bridge 504.1 experienced an approximate 50-year storm event, while bridge 503.7, for example, experienced an approximate 10-year storm event.) The bridge with which the BNSF replaced bridge 504.1 following the accident is capable of withstanding a 40-year storm.

In 1975, Atchison, Topeka and Santa Fe Railway (BNSF)[2] management placed bridge 504.1 on the 1977 CIP replacement program because the results of engineering studies raised concerns about the bridge's ability to provide an adequate waterway opening and about recurring erosion problems. In early 1976, however, Atchison, Topeka and Santa Fe Railway (BNSF) bridge maintenance personnel made a field decision to build an unreinforced concrete crosswall on the downstream side of bridge 504.1. Bridge 504.1 was subsequently removed from the 1977 replacement program.

Only two instances of high water were recorded for bridge 504.1 and both took place in 1976. This was after 1971 work affecting the box culverts downstream from the BNSF bridges had been performed by the Arizona Department of Transportation (ADOT) and after bridge 504.1 had been removed from the CIP budget list. Before the 1997 derailment at bridge 504.1S, no accidents involving high water or bridge failure were recorded for the Kingman area.

The purpose of the unreinforced concrete crosswall was to allow silt to back up and accumulate around the mud sills, thus acting to mitigate further scouring and erosion. However,

[2]At this time, the merger between the Atchison, Topeka and Santa Fe Railway and the Burlington Northern Railroad had not yet taken place.

no engineering evaluation was performed on the design and construction of the unreinforced concrete crosswall to determine the necessary anchorage, the appropriate size, the need for reinforcement, or the hydrologic characteristics of the waterway.

The severe flash flooding and resultant stream flow between bridge 504.1 and Arizona State Route 66 caused severe erosion that rapidly progressed upstream. The Safety Board cannot determine whether channel improvements made in 1971 contributed to this development, but evidence of streambed erosion was found during the on-site investigation. This erosion progression caused the failure of the unreinforced concrete crosswall because it was not anchored and was only 33 inches in depth. Because it was unreinforced, the crosswall broke into several pieces when its shallow footing was undermined.

When the concrete crosswall failed, the rate of erosion accelerated through the accumulated silt to the point that it quickly progressed to the shallow foundation of the bridge. This process undermined the bridge's mud sills and timber blocking and compromised the bridge's ability to support Amtrak train 4. The Safety Board therefore concluded that the failure of the bridge 504.1S was caused by scour and erosion affecting the inadequately protected shallow foundations that supported the bridge; the scour resulted because a poorly designed concrete crosswall was built instead of a new and better-engineered bridge.

Another concern arose during the investigation. In its report to the BNSF,[3] HDR Engineering noted concerns regarding the concrete box culverts under Arizona State Route 66 adjacent to and downstream of the BNSF bridges in the accident area. Results of the BNSF hydrology study revealed that the highway box culvert downstream from railroad bridge 504.1 was apparently engineered to withstand a 25-year flood. According to the study,

> At this time, based on the bed degradation which has developed below all five of the downstream highway 66 bridge structures, the highway structures have the potential of being washed out with the next major flood event, with the potential for the resultant headcut (of a potential magnitude of 5 feet) proceeding through the railway bridges (Br. 503.1, 504.1, and 505.9).

ADOT inspectors did not find any significant problems with the bridge (box culvert) either during the last scheduled inspection in February 1997 or the postaccident inspection of August 12, 1997. While scour observations and measurements were made by the ADOT inspector, no scour calculations were made during either inspection. ADOT did not require scour calculations.

Although the Safety Board did not request that the BNSF conduct a hydrology study or a scour vulnerability assessment of either the highway box culvert or the railroad bridges for the Kingman investigation, the BNSF provided this information to the Safety Board in its report. The Safety Board is concerned about the statements made in the BNSF report regarding the vulnerability of the box culverts and the potential effect such culverts might have on the railroad bridges in another severe storm situation. However, the BNSF report did not include ADOT

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[3]"The report is entitled "System Analysis Seligman Subdivision Bridge No.'s 503.1-505.9."

bridge inspection data or pictures of the streambed dating back to 1971, information that would have been helpful in determining the relationship between the box culverts and the railroad bridges. The Safety Board therefore concluded that the relationship of the highway box culverts and the railroad bridges and their respective zones of influence is not fully understood.

The Safety Board investigation found deficiencies in the inspection procedures used by the BNSF when the flash flooding occurred in the Kingman area. The BNSF track supervisor inspecting the track and bridges stated that on the day of the accident he took no exception to anything that he observed. He stated that, based on his knowledge of bridge inspections at that time, he felt, "Completely 100 percent confident that my railroad was able to support traffic of any nature after I had made the inspection." He stated that if he had observed debris under the bridge, he would have become concerned, notified the dispatcher to stop trains in that area, and requested help from a roadmaster. He also stated that he had no knowledge that one bridge would be less able to support train traffic than another.

On the day of the accident, the presence of water above the bridge foundation would have prevented thorough inspection of the bridge supporting structure by anyone, even a qualified bridge inspector. However, the high water levels could have indicated a potential for structural failure of the bridge foundations. A track inspector with relevant bridge inspection training could have recognized that the flooding had the potential to cause problems with several bridges in the Kingman area—including bridge 504.1—and taken measures to stop train traffic until a thorough inspection of the bridge supporting structure could be conducted.

The Safety Board appreciates that, following the Kingman accident, the BNSF developed a 1-hour training program concerning bridge inspections for maintenance-of-way employees. The training describes various types of bridges and their supporting structures (such as shallow-foundation and deep-foundation bridges) and "tell-tale" signs that the structure may have been damaged. The track supervisor who inspected bridge 504.1 on the day of the accident has since taken the BNSF training, and, in hindsight, found that his knowledge of bridges at the time of the derailment would not have been adequate for him to assess possible damage.

For instance, before his training, the track supervisor was not alarmed by the presence of high water under bridge 504.1; however, since his training, he recognizes the possibility of the bridge supporting structure being damaged as a result of any amount of water around it. The BNSF expects that this training will provide basic insight for track inspectors to recognize the types of bridges susceptible to damage in severe flash flooding conditions when a qualified bridge inspector is not immediately available to perform an inspection. Also, it will teach track inspectors to stop trains before they reach the bridge if they have any doubt as to the bridge's safety. (The program has not been in place long enough to evaluate its effectiveness.)

Before the training program was instituted, the BNSF should not necessarily have relied on its track inspectors to adequately assess possible bridge damage caused by flooding conditions; rather, the BNSF should only have relied on qualified bridge inspectors to perform these inspections. In this case, had the qualified bridge inspector for the area been notified immediately of the flash flooding near Kingman, he would not have arrived in time to have inspected the bridge before Amtrak train 4 derailed. When the derailment occurred, the bridge inspector assigned to

this area was at home, on vacation, and he told investigators that it would have taken him at least 4 1/2 hours to drive to Kingman. Therefore, additional responsibility (such as for bridge inspections) was placed on the track supervisor, who at that time had not been trained to recognize the potential damage flood waters could cause to bridge foundations.

Because the track supervisor was not a qualified bridge inspector and had not received formal training in this area, he was ill-prepared to complete rudimentary bridge inspections. The BNSF understood that, during flooding conditions, a bridge inspector could take several hours to arrive on scene. As a result, the responsibility for ensuring the integrity of both the track and bridges was often placed on the track inspector (or, in this case, the track supervisor). The Safety Board concluded that Amtrak train 4 derailed when bridge 504.1S failed because the BNSF maintenance-of-way managers lacked proper foresight and planning regarding the assignment or training or both of personnel designated to conduct bridge inspections during severe weather.

Another concern raised by the Kingman accident was BNSF protection of trains during severe weather. On August 10, 1997, (the day after the accident) the BNSF issued a policy for trains operating during severe flooding through a Maintenance Alert. The Maintenance Alert was subsequently updated on February 20, 1998, because of severe storm-related conditions and traffic delays that affected the BNSF's Northern California Division through the San Joaquin Valley. The updated version of the alert is applicable only for that BNSF division. Trains on all other BNSF divisions must comply with the August 10, 1997, Maintenance Alert requirements of 40 mph for freight trains and "restricted speed" for passenger trains until the weather warning expires.

In the February 20, 1998, version, the train speed restrictions for both freight and passenger trains were relaxed from the earlier Maintenance Alert. When weather warnings are issued for a "flash flood warning," freight and passenger trains are restricted to 40 mph and 50 mph, respectively, except in the areas where the 14 bridges have been identified as being vulnerable to scour because their foundations do not have piling. In those instances, the BNSF's passenger trains and "key trains" (those transporting hazardous materials) are required to operate at restricted speed, but all other freight trains can operate at 40 mph. The Maintenance Alert stays in effect until the weather warning expires.

The Safety Board recognizes the added safety for the train crews and passengers provided by reducing the speed of the passenger trains to a level from which they can be stopped in a relatively short distance in the event of an emergency. The Safety Board does not understand, however, the safety rationale for BNSF freight train crews being permitted to travel at speeds that may still require stopping distances of up to a mile.

The Safety Board concluded that when, because of flash flooding conditions, the integrity of bridges has yet to be validated, it is critical that trains be operated at a reduced speed such as "restricted speed." Train operations at restricted speed provide a margin of safety for the engineer to operate the train at a speed slow enough, while not exceeding 20 mph, to be able to safely stop the train within one-half his range of vision, which could be affected by weather conditions such as heavy rain or darkness or both. A thorough analysis is needed to determine the appropriate personnel, inspection, and operating policies to be used during flash flooding conditions and

establish procedures designed to ensure the safe passage of all trains. The analysis should address the minimum training requirements for personnel responding to emergency inspections and should evaluate current inspection procedures and response actions to determine their adequacy during abnormal or emergency situations.

Finally, the Kingman accident investigation indicated that the BNSF could improve the protection it provides to its employees on or adjacent to the track in the performance of their duties. The Federal Railroad Administration (FRA) was required by the Rail Safety Enforcement and Review Act of September 3, 1992, to review the Track Safety Standards and revise them based on information derived from that review. One of the issues identified to be addressed was the safety of maintenance-of-way employees working on or along the railroad right-of-way. This issue was separated from the ongoing review of the Track Safety Standards and assigned to a separate Railroad Safety Advisory Committee, which was to study the issue and develop recommendations.

As part of this study, FRA records identified 22 fatalities that occurred in the period between 1989 and 1993. An independent labor-management task force focused on 43 accidents that resulted in 46 fatalities and 150 injuries from 1986 through 1994. Most of the fatalities occurred while some form of protection system was available or in use. Through this process, the FRA initiated rulemaking activity, which resulted in the Roadway Worker Protection (RWP) regulations (found in 49 *Code of Federal Regulations* 214) that became effective January 15, 1997.

The track supervisor involved in the Kingman accident was, while inspecting the main track, operating with a track car operator informational line-up. This practice was permissible under the requirements of the FRA RWP regulations.

Class I railroads, including the BNSF, were required to be in compliance with the new regulations as of March 15, 1997. The regulations also provided that carriers each prepare a plan for compliance and notify the FRA, at least 1 month before March 15, 1997, that its plan was prepared and available for FRA review.

The RWP regulations permitted railroads that used informational line-ups as of March 14, 1996, to continue using them. However, the RWP regulations also required that the carrier's plan for compliance with the regulations contain a schedule for the discontinuance of the informational line-up procedure by a definite date.

The BNSF developed a plan as required by the regulations and notified the FRA before March 15, 1997. The plan called for the use of both train location line-ups and track car operator line-ups to be discontinued by August 1, 2016. The FRA reviewed this plan with the BNSF on April 9, 1997, at BNSF headquarters in Fort Worth, Texas. (As of July 14, 1998, the FRA had not approved the BNSF plan.)

An internal BNSF memorandum, dated February 13, 1998, stated that, as of January 29, 1998, train location/track car operator line-ups were still in use on 14 branch lines and 4 main line subdivisions. The memo further stated that, although the BNSF had committed to discontinue the use of these line-ups by August 1, 2016, ongoing efforts were underway to employ alternate

methods wherever possible, given communications constraints. The BNSF timeline for eliminating the use of line-ups was tied to expansion of cellular telephone coverage on remote territories and implementation of emerging control and voice communications technologies.

Although the operational practices that the track supervisor used during his special inspection were not factors in the derailment of Amtrak train 4, the Safety Board is concerned about the potential risk to employees engaged in special inspections while located on or adjacent to the railroad tracks. In this accident, the track supervisor confirmed that no mechanism was in place to protect him or other track inspectors if they could not contact the dispatcher for any reason. He considered it the employee's responsibility to get out of the way of trains. Track inspectors believe that their protection lies in the informational line-up, even though they know that the line-up is only valid for about 4 hours and that the dispatcher would not try to locate them. This practice places the responsibility on the employee to protect himself, and generally he can. If, however, the track inspector becomes incapacitated, or the communications equipment fails, or the dispatcher does not stop trains from entering the area occupied by the inspector, the inspector could be put in jeopardy.

The RWP regulations were intended to provide protection and safety for on-track workers. They specifically address the need to discontinue the use of informational line-ups as the sole protection for track inspectors. The Safety Board concluded that the BNSF's 18-year timeframe for discontinuing the practice of using informational line-ups to ensure worker safety is too long and, until eliminated, the practice has the potential to place railroad workers in danger.

Therefore, the National Transportation Safety Board makes the following safety recommendations to the Burlington Northern Santa Fe Corporation:

> Identify and perform a risk assessment of all system bridges that have shallow foundations of similar construction to the bridge that failed in the Kingman, Arizona, accident, and replace those bridges determined to be susceptible to undermining and loss of the supporting foundation structure. In conjunction with the risk assessment, perform a hydrology study on shallow foundation structures with questionable drainage areas to determine their current drainage areas. (R-98-48)
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> Evaluate, and improve as necessary, your basic bridge inspection training program for track inspectors to ensure that appropriate procedures are used in emergency situations. (R-98-49)
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> Require your management to periodically review bridge inspection training for track inspectors to ensure that it meets program objectives. (R-98-50)
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> Conduct a thorough analysis to determine the appropriate personnel, inspection, and operating policies to be used during flash flooding conditions, and establish procedures designed to ensure the safe passage of all trains. The analysis should address the minimum training requirements for personnel responding to emergency inspections and evaluate current inspection procedures and response actions to determine their adequacy during abnormal or emergency situations. (R-98-51)

Change your policy regarding freight train operating speeds so that it is consistent with the required operating speeds of other trains during flash flooding weather warnings, as noted in the August 1997 Burlington Northern Santa Fe Maintenance Alert. (R-98-52)

Immediately discontinue the use of informational line-ups. (R-98-53)

Also, the Safety Board issued Safety Recommendations R-98-54 through -57 to the Federal Railroad Administration, H-98-41 to the Federal Highway Administration, H-98-42 to the Arizona Department of Transportation, R-98-58 through -61 to the National Railroad Passenger Corporation (Amtrak), R-98-62 to the Mohave County Sheriff's Department, R-98-63 to the International Association of Chiefs of Police, R-98-64 to the National Sheriffs' Association, R-98-65 to the Association of American Railroads, and R-98-66 to the American Short Line and Regional Railroad Association.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations R-98-48 through -53 in your reply. If you need additional information, you may call (202) 314-6430.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed By

By: Jim Hall
Chairman