Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT

R99W0133

MAIN TRACK SUBGRADE FAILURE / DERAILMENT

CANADIAN PACIFIC RAILWAY
FREIGHT TRAIN NO. 474-25
MILE 5.3, KEEWATIN SUBDIVISION
KEEWATIN, ONTARIO
26 JUNE 1999

Canada

Railway Investigation Report

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Summary

On 26 June 1999, at approximately 0516 central daylight time, Canadian Pacific Railway eastward train No. 474-25, travelling from Winnipeg, Manitoba, to Thunder Bay, Ontario, encountered a roadbed depression at Mile 5.3 of the Keewatin Subdivision near Keewatin, Ontario. Eight freight cars derailed. There was minor track and equipment damage but no injuries, and no dangerous goods were involved.

Ce rapport est également disponible en français.

Other Factual Information

Canadian Pacific Railway (CPR) freight train No. 474-25 (the train) departed Winnipeg, Manitoba, on June 25, travelling eastward on the Keewatin Subdivision, destined for Thunder Bay, Ontario. The train was approximately 6 300 feet long and weighed about 8 600 tons. It was powered by 2 locomotives and comprised 62 loaded cars and 40 empties.

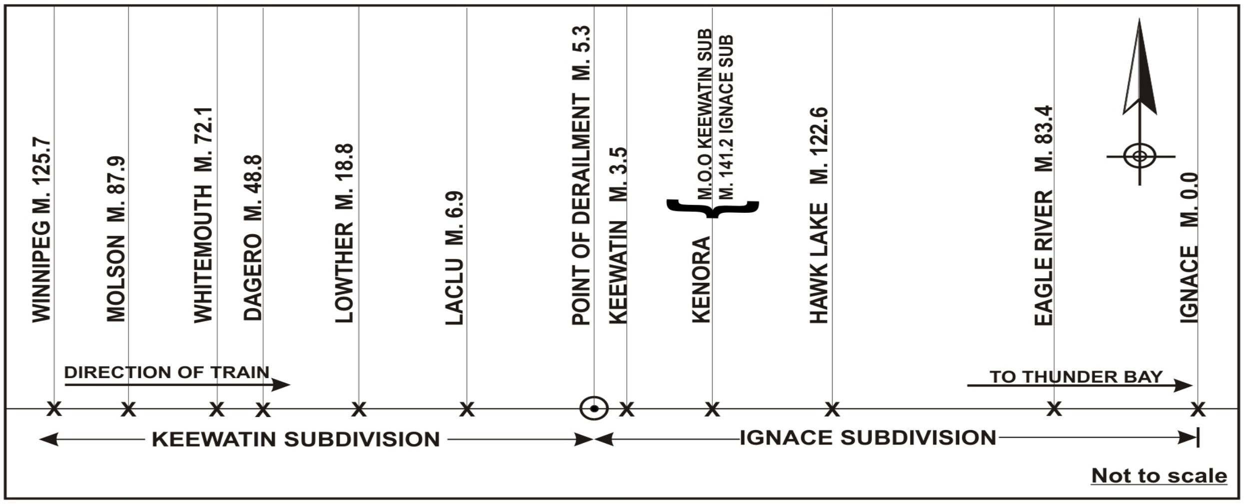

Figure 1 - Schematic showing key points along the CPR main track from Winnipeg to Ignace

As the train proceeded between Winnipeg and Mile 5.3 of the Keewatin Subdivision, the crew, which consisted of a locomotive engineer and a conductor, encountered heavy rain, high water, and signal outages. At about 0235 Central daylight time (CDT)[1] on June 26, the crew of train 486 reported to the rail traffic controller (RTC) that water was above the ties at Mile 22.0. At about 0306, the crew of train 474 reported to the RTC that the scanner[2] at Mile 44.4 was inoperative. The Centralized Traffic Control System (CTC) was out of service between Dagero, Mile 48.8, and Laclu, Mile 6.9, due to the storm, and trains were operating under Rule 564[3] of the Canadian Rail Operating Rules. The RTC authorized the crew of train 474 to proceed under Rule 564 to the signal at Mile 6.9. Upon approaching the signal at Mile 6.9, the crew members received a clear indication and began to increase speed after passing the signal. As the train rounded a left-

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1 All times are CDT (Coordinated Universal Time [UTC] minus five hours) unless otherwise stated.

2 Refers to a wayside inspection system that can detect hot journal bearings, hot wheels, and dragging equipment.

3 Rule 564: When a train is stopped by a block signal indicating "Stop," an RTC may authorize the train to pass the signal, but the train must move at restricted speed (a speed that will permit stopping within one-half the range of vision of equipment and prepared to stop short of a switch not properly lined and in no case exceeding SLOW SPEED), i.e. not greater than 15 mph.

hand curve approaching Mile 5.3, the crew observed what appeared to be water on the track about 400 feet ahead. When they saw the track suspended over a depression in the subgrade, the locomotive engineer initiated an emergency brake application.

The recorded train speed was 36 mph when the train encountered the subgrade depression. The locomotive dropped suddenly with a heavy impact, bouncing over the depression. The force of the accident threw the crew about in the cab, but no one was injured. After conducting the necessary emergency procedures, the conductor inspected the train and determined that both locomotives and the first 13 cars had passed over the suspended track and remained upright on the rails but that 8 of the following 12 cars had derailed and remained upright on the grade along the rails. No one was injured, and no dangerous goods were involved. The eight derailed cars sustained minimal damage. Approximately 260 feet of track was damaged.

The crew members were qualified for their respective positions and met established fitness and rest standards. A two-person crew was also returning to another terminal (dead heading) in the second locomotive; however, they were not involved in any train operations.

The following event sequence demonstrates the progressive development of weather-related problems between Dagero, Mile 48.8 of the Keewatin Subdivision, and Hawk Lake, Mile 122.6 of the Ignace Subdivision, approximately 72 miles:

TIME	EVENT
2200	CTC becomes inoperative between Dagero, Mile 48.8, and Laclu, Mile 6.9, on the Keewatin Subdivision
2258	Special track patrol reports water rushing onto the north track from a rock cut at Mile 123.0 of the Ignace Subdivision
0117	Train traffic on the Ignace Subdivision is stopped by the Network Management Centre due to high water
0130	Highway 1 washes out 65 km east of Kenora
0200	At Molson, Mile 87.9 of the Keewatin Subdivision, the crew from train 9107 questions the RTC about the validity of continuing operations, given the absence of a track patrol due to the severe rain storm
0210	Kenora Yard reports to the RTC that the west end public crossing is flooded
0235	Train 486 crew reports that water is above the ties but not over the rail in a tunnel at Mile 22.0 of the Keewatin Subdivision
0245	Taxi cannot pick up crew at Lowther, Mile 18.8 of the Keewatin Subdivision, due to flooding of the road
0306	Train 474 crew reports that the scanner at Mile 44.4 of the Keewatin Subdivision is inoperative
0432	Kenora Yard advises the RTC of a sinkhole in the yard just west of signal 144.4 on the north main track on the Ignace Subdivision
0516	Train 474 encounters a depression at Mile 5.3 of the Keewatin Subdivision

After consulting with the Network Management Centre (NMC) at 0243, the RTC attempted to advise the on-duty assistant track maintenance supervisor (ATMS) of the high water in the tunnel at Mile 22.0 but was unable to contact him by cellular phone or by radio. The ATMS was at Eagle River, Mile 83.4 of the Ignace Subdivision, arranging for track patrols and equipment to restore service on the Ignace Subdivision. The RTC also attempted unsuccessfully to call the regular (off-duty) track maintenance supervisor (TMS) for the Keewatin Subdivision at his home and on his cellular telephone. At approximately 0545, the RTC contacted the ATMS and advised him that a train crew had reported high water at Mile 22.0 of the Keewatin Subdivision. The ATMS called all the personnel on his call list for the Keewatin Subdivision but was unable to contact anyone to perform a special track inspection. The call list in his possession was later determined to be out of date and incomplete. Instead, he dispatched two men who were on patrol on the Ignace Subdivision to check the high water at Mile 22.0 of the Keewatin Subdivision.

In fall 1998, Transport Canada (TC) Rail Safety reviewed CPR engineering management's existing procedures for responding to floods and heavy storms. CPR presented to TC a proposed weather information system that would provide employees with accurate weather forecasts. The following is a chronology of the development of this system before the June 26 derailment to the present.

Since November 1997, CPR has had Rail Weather (RW), an Environment Canada (EC) software package, accessible to the Calgary NMC. This system provided a map of current and forecast weather conditions across Canada with the CPR rail network in the background. Track personnel had access to weather information through a series of dedicated EC 1-800 numbers. However, the RW system does not send out weather forecasts or severe weather alerts to track maintenance personnel.

CPR enlisted the services of World Weather Watch (WWW) effective on 23 November 1998 to provide weather information for its eastern network, extending as far west as Mactier, Ontario. The information system consisted of the following features:

- WWW regional forecasts and weather warnings distributed by e-mail;
- WWW forecasts issued twice daily between November 15 and March 31, and once daily between April 1 and November 14;
- 1-800 contact line with an EC forecaster, 24 hours a day, seven days a week;
- WWW severe weather notification using uniform severe-weather criteria across the eastern network; and
- a real-time computer link to WWW was installed in the Montréal NMC.

The above weather information was not available to CPR Keewatin Subdivision track personnel at the time of the derailment.

The weather in the Kenora area consisted of heavy intermittent rain accompanied by thunder and lightning. These conditions existed for approximately 11 hours before the derailment. The weather station at Kenora Airport reported that a total of 137 mm of rain fell between 1620 on June 25 and 0230 on June 26. The highest intensity of rain (71 mm) occurred between 1900 and

0100. The average intensity over a 12-hour period was 11.45 mm per hour. No formal weather warning system was in place to notify the ATMS on duty that the severe storm was affecting train operations on the Keewatin Subdivision.

At Mile 5.3 of the Keewatin Subdivision, the double main track was built along a rock slope that follows the south shore of Darlington Bay. The south and north tracks consisted of 136-pound continuous welded rail which was laid on 16-inch tie plates and fastened to No. 1 hardwood ties with four spikes per tie plate, box anchored every second tie. The ballast was crushed rock. All track components were in good condition. At the point of the derailment, the subgrade embankment was approximately 20 feet high and was built of local sand and silt materials.

A high volume of surface water from the heavy rain storm flowed from the rock face south of the tracks onto the track bed about 250 feet west of the slump. The south ditch at this location was blocked up to the top of the track ties with track ballast and rubble that had fallen from the rock slope over several years. The superelevation—cross slope on curves—on both tracks channeled the water along the median between the tracks toward the slump. At a tangent point along the tracks, coincident with the failure location, the overflow water fanned out and drained toward the north back slope of the embankment, saturating it and causing it to slump north toward the bay. The slump debris was contained by an environmental protection fence that had been installed in preparation for replacement of the existing culvert. The void caused by the slump was four feet below the south track, eight feet below the north track, and approximately 120 feet wide. The south shoulder of the embankment was undisturbed by the slide movement and remained stable.

At Mile 5.3, a 24-inch corrugated metal pipe culvert at the bottom of the fill and below the slump had been plugged with silt, sand, and track ballast before the slump. The crew of train 474 and first responders stated that the south ditch was not holding water, there were no signs of water backing up at the culvert invert, and there was no sign that water had been flowing through the south ditch. A second culvert, 18 inches in diameter, located approximately 160 feet west at the beginning of a rock cut, was covered with dirt at its south end. A third culvert (not found) was shown on CPR records to be located approximately 760 feet from the slump and 510 feet upstream from the blocked ditch.

CPR requires that annual culvert inspections be performed, and records maintained, in order to determine if the culverts are structurally sound and clear of debris and sediment to ensure that proper water flow can be maintained. CPR policy regarding culvert inspection (30 May 1997) states that culverts less than or equal to one metre in span or diameter (as at Mile 5.3) are to be inspected by track maintenance personnel, and those greater than one metre in span or diameter are to be inspected by Bridge and Structures personnel.

CPR listed 23 culverts one metre or less in diameter between Mile 2.11 and Mile 8.15 of the Keewatin Subdivision. Inspection records from the 1999 spring inspection indicated that five were blocked or buried, eight were not found, seven required cleaning and ditching, two had been affected by erosion, and one functioned as intended. Only limited remedial action was taken.

The track on the Keewatin Subdivision was last inspected before the heavy rain by a relief ATMS travelling in a Hi-rail vehicle. No deficiencies were noted. At approximately 0400, 1 hour and 16 minutes before the derailment, train 486 passed over the slump location and did not notice any flooding problems.

Before June 1999, one TMS and two ATMSs were assigned to the Keewatin Subdivision (125.7 miles of track), and one TMS and two ATMSs, to the Ignace Subdivision (146.2 miles of track). They rotated the standby duties within their respective subdivisions every third weekend. In June 1999, two ATMS positions were abolished, leaving one TMS and one ATMS assigned to each subdivision. Subsequently, each of the four supervisors assumed standby duties for both subdivisions (totalling approximately 270 miles) every fourth weekend. On the weekend commencing June 25, the relieving ATMS covering both subdivisions was located at Eagle River, Mile 83.4 of the Ignace Subdivision.

CPR's Standard Practice Circular (SPC) No. 32, "Frequency of Inspection," Section 4, stated that additional track inspections may be required in conditions of "(b) heavy rains or snow or repeated freeze-thaw cycles which may cause high water, washouts, rock falls or mud slides".

Section V, "Special Inspections," of subpart F of the *Railway Track Safety Rules*, approved by the Minister of Transport and applicable to railways under federal jurisdiction, requires that "In the event of fire, flood, severe storm, or other occurrences which might have damaged track structure, a special inspection must be made of the track involved as soon as possible after the occurrence."

TC monitors the safety of infrastructure, including culverts, by reviewing and auditing the records of the railway's own compliance monitoring programs and then validating railway records by inspecting a sampling of subdivisions. Random site inspections support this approach when deemed necessary. The latest TC inspection audit on the portion of the Keewatin Subdivision between Mile 0.0 and Mile 60.0 had been conducted on 23 August 1993. The TC audit report made no reference to the condition of culverts or drains.

Analysis

Train handling was not considered a contributory factor in the derailment. The analysis will focus on the conditions that existed leading up to the subgrade failure, the NMC and Engineering Services response to the heavy rain conditions, special track patrols, and the inspection and maintenance of culverts and ditches.

With normal levels of rain, the surface drainage area on the upward side of the railway grade would have remained relatively dry and posed no problems for the railway drainage system. However, because the south ditch was blocked and the culverts were plugged, the excess surface water from the heavy rain storm had no channel to drain away from the track bed. When the ditch overflowed and water entered the median between the north and south tracks, the embankment became saturated and failed catastrophically before the arrival of train 474. The slump started with the north track embankment and propagated to the south embankment.

The RTC and the NMC were aware of a number of weather-related conditions that were already affecting or had the potential to affect train operations in the area (e.g. signal outages, reported high water at Mile 22.0 on the Keewatin Subdivision, and highway washouts east and west of Kenora). They were also aware that the Ignace Subdivision was shut down for train operations. Despite the added risk that the rain storm imposed on the safety of the track infrastructure, trains were allowed to continue operating on the Keewatin Subdivision without a special track inspection being performed.

After the RTC had failed to make contact with either the ATMS on duty or with the regular TMS for the Keewatin Subdivision, no further effort was made to ascertain that the track was safe for operation. When the ATMS was contacted at about 0545 (approximately 30 minutes after the derailment), he was busy organizing personnel and equipment to restore service on the Ignace Subdivision. He was unable to contact anyone from the call list on the Keewatin Subdivision and finally resorted to redeploying two people who were already on patrol on the Ignace Subdivision.

The ATMS standby responsibility was spread over the two subdivisions, approximately 270 miles of track. Given that the Ignace Subdivision was his regular subdivision, and considering the severe rain storm, flooding, and shutdown of the Ignace Subdivision, his first priority was to restore the service on the Ignace Subdivision. He was unaware that the rain storm was also affecting train operations on the Keewatin Subdivision and consequently did not initiate a special track inspection. The guidelines in paragraph 4(b) of SPC 32 pertaining to such situations are general in nature and do not give specific criteria as to when a special inspection is to be made.

Although the area was experiencing severe rain conditions, the combined effect of poor communication, use of outdated phone lists, insufficient staffing levels on weekends, and standby responsibilities resulted in a timely special track inspection on the Keewatin Subdivision not being performed. A special track inspection would have given track maintenance employees an opportunity to identify the adverse effects the weather conditions were having on the track structure, including the slumped subgrade.

Although CPR had indicated to TC in 1998 that it had implemented the WWW system, no formal weather warning system was in place to alert the Keewatin/Ignace ATMS, located 70 miles from the derailment site, of a severe rain storm in the vicinity of Mile 5.3. Without a weather warning system in place to initiate special track inspections, potentially unsafe conditions remained undetected.

Although CPR had a clear policy on culvert inspection and drainage issues, the policy had not been fully implemented in the field. The company policy stated that to ensure the safety of train operations, ditches and culverts are integral to the control of surface water flow, particularly during periods of spring run-off or heavy rainfall. Proper surface water control and discharge from railway property is critical to maintaining the stability of railway embankments.

There was no indication before the derailment that high water was building up to cause a washout. However, despite the fact that inspection reports indicated that a number of small-diameter culverts were non-functional, no remedial action was taken to correct these deficiencies. Action was only taken when subsequent problems became evident. For example, the culvert located close to the track bed flooding, where the runoff water overflowed the ditch onto the track bed, had previously been noted on the inspection list as "blocked at both ends," but no reference was made as to what remedial action was required or when it should have been undertaken.

The 1999 culvert inspection records for the portion of the Keewatin Subdivision between Mile 2.11 and Mile 8.15 show that 22 of 23 culverts required various degrees of maintenance. In addition, ditching was required at seven locations. Even though blocked or missing culverts were shown on the inspection report, the only remedial action taken had been to replace the culverts at Mile 5.3 and Mile 4.99. The other locations still remained at risk for subgrade failure due to track bed flooding.

This portion of the Keewatin Subdivision had not been inspected by TC since 1993. At that time, TC inspections focused on track geometry issues and turnout conditions, and TC did not have a specific audit program in place to assess culvert inspection reports to ensure that the railway had a proper drainage system in place and was maintaining it to ensure safe train operations.

Findings

1. Train operations were allowed to continue on the Keewatin Subdivision—despite the heavy rainfall, signal outages between Dagero, Mile 48.8, and Laclu, Mile 6.9, and high water at Mile 22.0—without a special track inspection to ensure that the track was safe for train operations.

2. The blocked drainage ditch on the south side of the track and a plugged small-diameter culvert forced the storm water to flow between the north and south main tracks, causing the subgrade to become saturated and to fail before the arrival of train 474.

3. The blocked ditch and plugged culvert had been reported by CPR in the spring of 1999 but had not been corrected.

4. Under the circumstances experienced that night, the standby system (whereby one track supervisor covered both subdivisions) became unmanageable. The ATMS on duty was organizing personnel and equipment to restore the service on the Ignace Subdivision and was initially unable to contact any personnel to respond to the situation on the adjacent Keewatin Subdivision.

5. Poor communication procedures, use of outdated phone lists, and ineffective organization of standby responsibilities resulted in a timely special track inspection for the Keewatin Subdivision not being performed.

6. No advance weather warning system was in place to alert the ATMS on duty that a severe weather storm occurred in the vicinity of Mile 5.3 on the Keewatin Subdivision.

7. The guidelines in SPC 32 did not contain specific criteria as to when special track inspections were to be conducted.

8. Railway actions to inspect and to clean culverts shown on the culvert inspection forms were inadequate; some culverts remained plugged, and records of the specific locations of culverts remained inaccurate.

9. TC's audit program did not identify the risk to safe railway operations posed by the railway's surface drainage maintenance practices.

Causes and Contributing Factors

Heavy rainfall during the 11 hours before the derailment saturated the subgrade embankment, causing the track structure to fail. The drainage system did not provide the proper channeling for the excess water to flow under the subgrade because the south ditch was blocked and culverts were plugged; such conditions were identified by inspections but not corrected during regular maintenance.

Safety Action Taken

The on call arrangements for track supervisors have been modified such that there is now a supervisor on call each weekend for each of the Ignace and Keewatin subdivisions to allow for a quicker response to similar conditions in the future.

The responsibility for culvert inspection was returned from the maintenance-of-way track forces to Structures personnel. In addition, CPR has implemented a new bridge and culvert inventory/condition rating system, called BASIS, which requires more comprehensive condition reports than have typically been provided. Culvert inventory should be completed by the end of 2000, and condition reports and ratings will be entered into the system as annual culvert inspections are carried out during 2001. It is expected that, after two or three cycles of inspection, prioritizing location for remedial action will be considerably more accurate than in the past. All Engineering Services personnel, not just the supervisor, will have electronic access to this record.

In addition to the enhancements that have been in place since the derailment on 26 June 1999, the following initiatives are in development for inclusion in future revisions of the CPR weather information system and Severe Weather Alert Levels (SWAL) notification and response process:

- Analysis of antecedent rainfall. This information would be used to notify track maintenance personnel of severe antecedent rainfall conditions, which could contribute to increased slope stability and flooding hazards.
- The use of weather radar converted to rain-on-the-ground is being evaluated. This would potentially provide information on a continuous 2 km grid in comparison to the point measurements now available from the limited number of the real-time reporting meteorological stations.
- A post-event earthquake notification system.

- CPR is attempting to obtain meteorological information from various provincial and state agencies.
- Further refinement of severe weather notification criteria.
- Automatic notification of flood warnings in Canada.

On 10 November 1999, CPR expanded the coverage supplied by WWW to include the entire CPR rail network. Real time computer links to WWW are now provided to both the Calgary and Montréal NMCs.

On 01 June 2000, CPR formally implemented the SWAL system. The SWAL system includes a notification protocol, a graduated alert and response system, and severe rainfall and other weather hazards criteria set on a regional basis. The increase in SWAL alert levels activate increased response from Engineering Services, Field Operations, and NMC teams. The SWAL system is relatively new and consequently some aspects of it are still being refined.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 20 December 2000.