

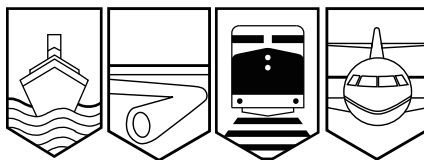
Transportation Safety Board
of Canada



Bureau de la sécurité des transports
du Canada

RAILWAY INVESTIGATION REPORT

R02W0063



CROSSING ACCIDENT AND DERAILMENT

CANADIAN NATIONAL
FREIGHT TRAIN NO. E20251-30
MILE 88.83, RIVERS SUBDIVISION
NEAR FIRDALE, MANITOBA
02 MAY 2002

Canada



The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Railway Investigation Report

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Synopsis

At 1612 central daylight time on 02 May 2002, Canadian National (CN) train E20251–30, proceeding eastward to Toronto, Ontario, from Edmonton, Alberta, derailed 2 locomotives and 21 freight cars after colliding with a loaded southbound tractor-trailer. The collision occurred at a public crossing near Firdale, Manitoba, at Mile 88.83 of CN's Rivers Subdivision. The derailed equipment included five tank cars carrying dangerous goods. During the derailment, four of the tank cars sustained multiple punctures and released their products. The products ignited and a large fire engulfed the derailed cars. A fibre-optic cable was severed and the Trans-Canada Highway was closed briefly. A total of 156 people were evacuated from the vicinity of the derailment for two days. There were no significant injuries to either the train crew or truck driver.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 The Accident

At approximately 1315 central daylight time (CDT)¹ on 02 May 2002, Canadian National (CN) freight train E20251-30 (the train) departed Rivers, Manitoba, destined for Toronto, Ontario. At approximately 1611, the train crew observed a school bus approaching from the south and then crossing the public railway crossing located on Forrestville Road at Mile 88.83 (the crossing) of CN's Rivers Subdivision. The railway crossing, near Firdale, Manitoba, in the Rural Municipality (RM) of North Norfolk, was equipped with stop signs and railway crossbucks.

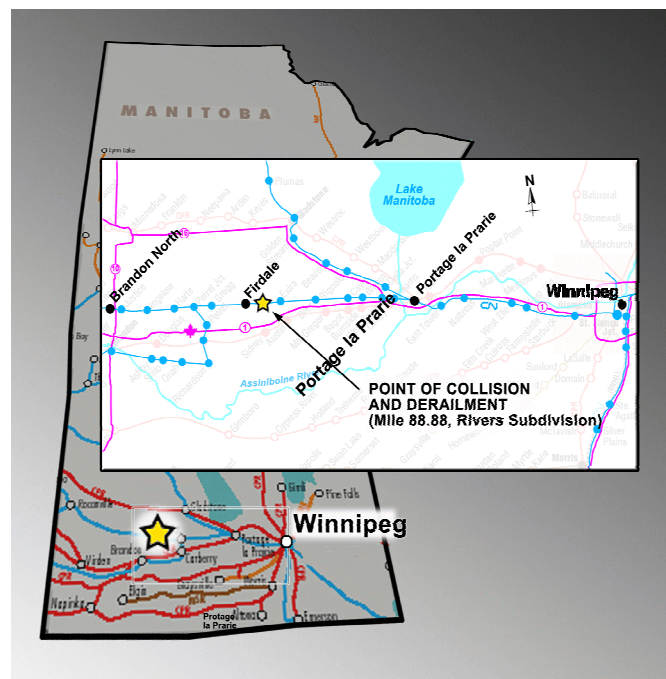


Figure 1. Accident location

As the train approached the crossing, the crew observed a southbound tractor-trailer (the truck) approaching from the north side of the track. The locomotive engineer sounded the locomotive horn as required under Rule 14, Section 1 (i and ii) of the *Canadian Rail Operating Rules* (CROR).² The driver of the truck did not appear to respond and when it became apparent that the truck

¹ All times are CDT (Coordinated Universal Time minus five hours).

² CROR Rule 14, Section 1, states that engine whistle (horns) must be sounded (i) at every whistle post and (ii) at least one-quarter of a mile from every public crossing at grade, to be prolonged or repeated according to the speed of the movement until the crossing is fully occupied by the engine or cars.

was not going to stop, the crew laid down on the floor of the lead locomotive to brace themselves for the collision. At approximately 1612, the train collided with the rear portion of the truck's trailer and derailed.

During the derailment, the lead locomotive separated from the train and came to a stop, upright between the rails, approximately 750 feet from the crossing. While the conductor initiated emergency communication procedures, the locomotive engineer exited the cab from the side door as the front door was blocked. The locomotive engineer observed that the tractor unit and the front two-thirds of the trailer remained connected and upright on the road on the south side of the crossing. The truck driver appeared to be unharmed. The locomotive engineer then returned to the cab and attempted to move the upright locomotive. Failing in that effort, the crew then exited the locomotive and left the site.

The 2 locomotives and the following 21 cars had derailed, predominantly to the south side of the track. The derailed equipment included 12 covered hopper cars containing plastic pellets, five tank cars carrying dangerous goods (DG) and a tank car carrying ethylene glycol. The DG products included aromatic concentrate (UN 1993), with benzene and dicyclopentadiene being the primary constituents, and alpha olefin C6, with hexene (UN 2370) being the primary constituent. During the derailment, four of the DG tank cars sustained multiple punctures, releasing and igniting the hazardous materials.

As a result of the derailment, a large fire ignited and burned for 2.5 days. No significant physical injuries were reported as a result of the accident or the ensuing emergency response.

1.2 *Weather*

At 1600 on 02 May 2002 near Firdale, the sky was clear and the temperature was 7.7°C. Visibility was 24.1 km, the relative humidity was 46 per cent, and the wind was from the east-northeast at 9 km/h.

1.3 *Train Information*

The train originated in Edmonton, Alberta, and consisted of 2 locomotives and 70 freight cars (66 loads and 4 empties). It was 6059 feet long and weighed approximately 6135 tons. There were two empty gondola cars in the train, and the train itself was restricted to a maximum of 50 mph, as required by CN's General Operating Instructions. The train crew consisted of a locomotive engineer and a conductor. Both crew members were familiar with the territory, qualified for their positions, and met fitness and rest requirements.

Train movements on the Rivers Subdivision are governed by the Centralized Traffic Control System (CTC) of the CROR and are supervised by a rail traffic controller located in Edmonton. The train had “clear” signal indications approaching the two wayside signals before the crossing, which indicated that the train could proceed with no restrictions.

1.3.1 *Recorded Information*

The locomotive event recorder download from the lead locomotive (CN 2440) was sent to the TSB Engineering Laboratory for analysis (report LP 049/02). The download revealed that, as the train approached the crossing, speed was controlled primarily through the use of the locomotive dynamic brake (DB).³ At 1612:11, with the DB applied, the throttle in idle and the train travelling at approximately 50 mph, the locomotive engineer began sounding the train horn at Mile 89.04. The horn was fully engaged from Mile 88.99 to Mile 88.87, a distance of approximately 630 feet. For the 200 feet preceding the crossing, the horn was not sounded.

At 1612:26, a 5 psi (pound per square inch) drop in brake pipe pressure (BPP) occurred. A 2 psi rise in BPP and a wheel slip indication were then recorded, followed by a series of BPP reductions down to 1 psi at 1612:27. At 1612:28, with the throttle in idle and the DB still engaged, the train began decelerating and then experienced a train-initiated undesired emergency brake application (UDE), followed by further wheel slip indications. A long wheel slip was recorded from 1612:31 to 1612:34, and the final wheel slip occurred at 1612:37 and ended at 1612:40. At 1612:43, the lead locomotive came to rest upright on the track approximately 750 feet east of the crossing.

1.4 *Emergency Response*

Once the RM of North Norfolk was notified, its emergency plan was activated and various agencies began to arrive at the scene. The agencies included local fire departments, the Royal Canadian Mounted Police (RCMP), the Office of the Fire Commissioner of Manitoba (OFC), the Manitoba Emergency Measures Organization (MEMO) and CN. The Trans-Canada Highway (Highway 1) was closed between Highway 16 and Highway 5, from 1620 to 2020 on 02 May 2002.

Due to the magnitude of the fire and the resources necessary to bring it under control, the OFC assumed the role of Incident Commander for the duration of the firefighting. A command centre was established 2.5 miles south of the derailment site on Forrestville Road. The OFC managed the accident site and enacted the plan for fighting the fire. CN coordinated its personnel (including contractors) during the response and site remediation.

³ DB is a locomotive electrical braking system that converts locomotive traction motors into generators to provide resistance against the rotation of the locomotive axles. The DB system can be used alone or in conjunction with the train air brake system.

Residents living within a two-mile radius of the derailment site were evacuated. The MEMO ensured that the evacuees were looked after and provided logistical and technical support. The RCMP established road blocks to maintain the perimeter of the evacuation.



Photo 1. Aerial photo of collision and derailment site looking northwest

A Notice to Airmen (NOTAM BR041) was issued by Transport Canada (TC), which established a no-fly zone to prevent aircraft from accessing the area. A ground reconnaissance team of DG technicians surveyed the site with binoculars from a safe distance. After determining that the site could not be safely accessed, the fire was allowed to burn throughout the night.

1.4.1 *First Emergency Responder on the Scene*

By 1614, volunteer firefighters from the Austin and MacGregor, Manitoba, fire departments were called. A firefighter in the area observed the large smoke plume and responded prior to receiving notification. Arriving on the scene, he climbed over the derailed cars to check the truck driver's condition. A fire was in progress approximately 200 feet to the east. The firefighter was not wearing any personal protective equipment (PPE). After observing that the tractor was intact and that the driver had exited safely, he climbed back over the cars and met with the train crew.

The firefighter was trained to Fire Fighter Level I, under the National Fire Protection Association (NFPA) 1001 Standard for Fire Fighter Professional Qualifications. He was also trained to the Hazardous Materials Awareness Level, as outlined under the NFPA 472 Standard for Professional Competence of Responders to Hazardous Materials Incidents, Chapter 2. He had neither received refresher DG training nor responded to a rail DG incident since his initial training approximately six years prior to the accident.

1.4.2 *Emergency Response Training*

In Canada, firefighting and emergency response is a provincial responsibility. In Manitoba, regulations made under the *Fires Prevention and Emergency Response Act* govern the responsibilities and operation of the OFC. The OFC works with each RM to establish fire prevention by-laws governing the operation and training of local fire departments.

Firefighting training is conducted at the Manitoba Emergency Services College. Most volunteer firefighters in Manitoba are trained to Fire Fighter Level I, as outlined under the NFPA 1001 Standard for Fire Fighter Professional Qualifications. These firefighters are further trained to the Hazardous Materials Awareness Level, as outlined under the NFPA 472 Standard for Professional Competence of Responders to Hazardous Materials Incidents, Chapter 2. The Hazardous Materials Awareness course is 16 hours in duration and is the most basic level of training. The more advanced levels include Hazardous Materials Operations and Hazardous Materials Technicians. Training specific to rail transportation of bulk DG is limited to 30 minutes for the Hazardous Materials Awareness course, 1.5 hours of training for the Hazardous Materials Operations Level, and six hours of training for the Hazardous Materials Technician Level.

In TSB accident investigation reports R99T0256 and R01M0061, the Board raised a safety concern that emergency response personnel in small communities may not be provided with the necessary tools, protective equipment and training to be fully aware of and prepared for the risks associated with DG transported through their communities. In September 2002, the Province of Manitoba enacted legislation requiring all emergency personnel who may attend a DG incident to be trained to the Hazardous Materials Awareness Level. However, there is no requirement for refresher training in Manitoba, nor in other provinces.

In the United States, DG responders are trained in accordance with the U.S. Code of Federal Regulations (CFR) Title 29, Volume 5, Part 1910.120, Section q (8). The CFR regulations state that DG emergency responders, "shall receive annual refresher training of sufficient content and duration to maintain their competencies, or shall demonstrate competency in those areas at least yearly."

1.4.3 *Scope of Response*

In Manitoba, most fire departments have mutual aid agreements on joint action in the case of a major incident. In this occurrence, mutual aid was requested from neighbouring fire departments and was later expanded to include firefighters from across the province. Approximately 580 personnel representing more than 75 different companies, government agencies and fire departments attended the site in response.

1.4.4 *Evacuation*

The decision to evacuate was based on two concerns: the fire involved products known to be carcinogenic after prolonged exposure and the potential for the spread of brush fires. The initial evacuation from a two-mile radius around the site was carried out at approximately 1700 on 02 May 2002. Later in the evening, after a change in wind direction, the zone was increased to four miles north of the site to include the town of Edrans. A total of 156 people were evacuated from their homes until the evacuation order was lifted at 1800 on 04 May 2002.

1.4.5 *Fighting the Fire*

The OFC required all parties to submit a written Incident Action Plan (IAP) to be approved by the Safety Officer. Each IAP detailed who would have access to the site, how the site was to be accessed, PPE to be used, the task to be performed, and the expected duration of time on site.

CN established a written Safe Work Plan, which governed all work at the site by CN employees and contractors. All workers were provided with protective equipment and briefed prior to each task. Thresholds for air-quality readings were established to determine the level of PPE required. Staff from the Centre for Toxicology and Environmental Health provided technical expertise to deal with the DG and to assist with air-quality monitoring.

On the morning of 03 May 2002, aerial reconnaissance revealed that the fire was still burning out of control and had ignited grass fires along the railway right-of-way. A three-stage plan was then implemented to fight the fire. Water bombers would be used to control brush fires and cool the derailment fires. Remote unmanned hoses would be used to cool the fire at specific locations. Once the fire was under control, manned hoses would then be used to control isolated fires.

On 03 May 2002, a berm was constructed on the south side of the derailment site to contain the fire suppression water. Manitoba Hydro de-energized a 7200-volt power line, which ran through the site. Aerial water bombing commenced on 03 May 2002, was suspended for the night, resumed on the morning of 04 May 2002, and concluded that afternoon. Approximately 100 loads (844 000 litres) of water containing Class A foam⁴ was dropped on the area. Class B foam⁵

⁴ Class A foam is generally used to fight combustible solid fires. It contains additives that make it more effective in extinguishing such fires and is typically used when water bombing forest fires.

⁵ Class B foam is used to combat flammable liquid fires that commonly involve hydrocarbons. Once applied, it forms a thin layer over the product, preventing fumes from escaping and igniting. The integrity of the protective layer must be maintained to retain its effectiveness.

was applied to the fire by manned hoses from the night of 03 May 2002 until the foam ran out on the morning of 04 May 2002. Subsequently, the fire flared up and required additional water bombing.

1.5 *Equipment Damage*

A preliminary assessment on 04 May 2002 determined that four tank cars containing DG had lost most of their load. Tank car TILX 290117 loaded with aromatic concentrate had survived the fire and remained full of its product, while tank car TILX 290118 retained approximately 4000 gallons of product.

A subsequent assessment on 05 May 2002 confirmed that 23 rolling stock had derailed. The lead locomotive (CN 2440) had come to rest upright approximately 750 feet east of the crossing. The wheels on the conductor's side of the locomotive (north) had derailed and were resting on the ties while the wheels on the locomotive engineer's side were resting on the web of the overturned south rail. A gap of 157 feet separated the lead locomotive and the second locomotive. The second locomotive (CN 5363) had come to rest at an approximate 45-degree angle along the embankment to the south side of the track. The first six covered hoppers came to rest in various positions at the base of the embankment. The following 13 derailed cars were strewn about the site east of the crossing over a distance of approximately 200 feet. The last two derailed cars, a box car and a gondola car, blocked the crossing.

The first 17 cars from the head end were destroyed, having sustained varying degrees of fire and derailment damage. The second car, covered hopper UTCX 59289, had been impaled diagonally from the bottom of the B-end to the top of the A-end by a long piece of the south rail. All derailed freight cars and their recovered mechanical components were inspected. No defects were found that were considered causal to the derailment.

1.5.1 *Tank Cars*

Five loaded, low-pressure tank cars carrying DG were involved in the derailment. Four of these tank cars contained aromatic concentrate, with a primary constituent of benzene (UN 1993). One other car contained hexene (UN 2370). These five DG cars were built under tank car construction specification DOT 111A100W1 in 2000. One tank car, the seventh car in the consist, derailed to the north side of the track and remained intact. The tank shell and underframe

displayed various dents, scrapes and gouges, as well as fire damage from flame impingement. The other four tank cars lost most of their product after sustaining multiple punctures to the tank shells. These cars also sustained significant fire damage.

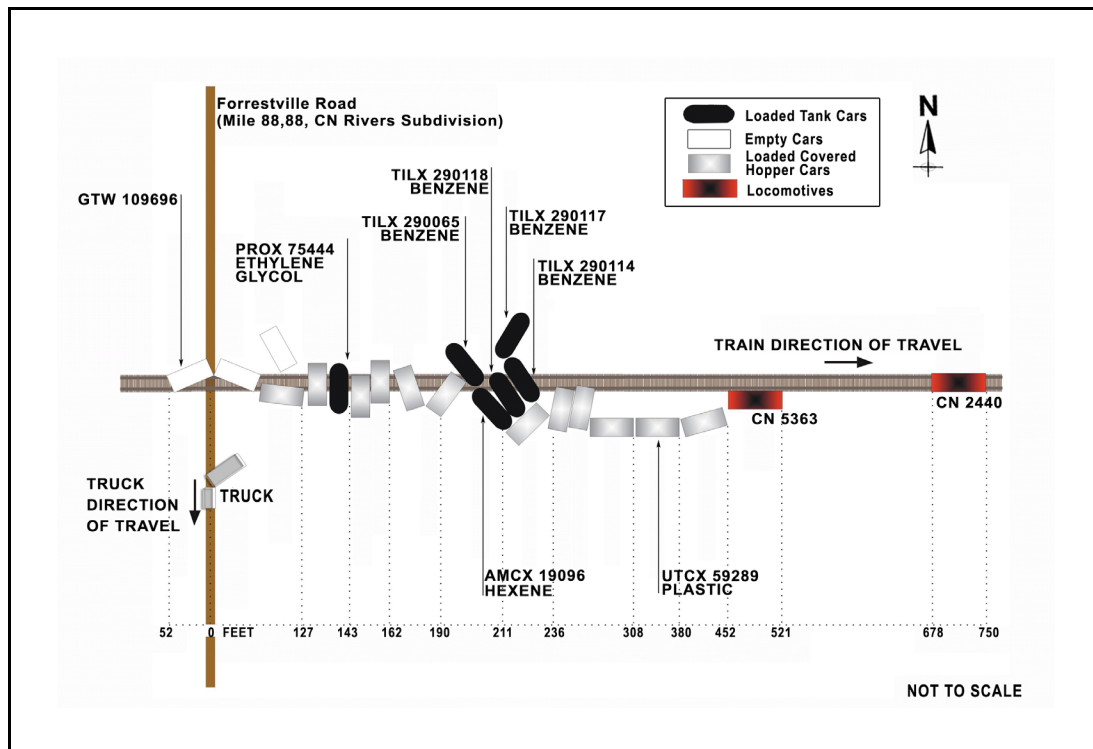


Figure 2. Accident site sketch

1.5.2 Locomotive Damage

The train was powered by two locomotives: the lead locomotive was a General Electric (GE) Dash 8 built in 1992, and the trailing locomotive was a General Motors (GM) SD-40-2 built in 1980.

The front of the lead locomotive sustained impact damage during the collision with the truck. The front angle cock, which had broken in the body of the valve, would not function and had to be replaced at the site to release the brakes in order to move the locomotive. Truck tire marks were observed on the conductor's side (north), the left front portion of the locomotive pilot, otherwise known as the snow plow.

Dash 8 locomotives have four egress points: a nose door and two side doors in the cab area, and a door at the rear of the unit. On the lead locomotive, the handrail on the front crossover was bent inward, blocking the front nose door. In addition, the conductor's side front lower handrail and side exit handrail were bent, blocking the stairway and doorway, respectively.

The front cab windows of the lead locomotive were shattered. The rubber seal had released on both left front cab windows. The centre window had completely dislodged, allowing debris from the truck to enter the cab area. All six locomotive traction motor assemblies had split open. The rear coupler knuckle had split vertically, causing the locomotives to separate during the derailment. A TSB examination (report LP 115/02) determined that the knuckle failed in a combination of tension and torsion, likely as a result of an overstress rupture.

The trailing locomotive sustained extensive damage from the derailment and subsequent fire.

1.6 Track Infrastructure Damage

The left-side wheels of the lead locomotive derailed to the gauge side of the north rail. Approximately 450 feet of the south rail was overturned at the east end of the site. The right-side wheels of the locomotive came to rest on the gauge side web of the overturned rail. Approximately 700 feet of the south rail, 450 feet of the north rail, and many of the ties immediately east of the crossing had been destroyed. The severity of the track damage made it impossible to identify the exact point of derailment (POD).

1.7 Truck Damage

The tractor unit and front two-thirds of the trailer remained upright and came to rest approximately 100 feet south of the crossing. The tractor unit survived intact and remained positioned in the centre of the road. The attached front portion of the trailer had swung approximately 45 degrees to the east and came to rest over a steep embankment. The fire, which had started in the rail cars, ultimately spread and consumed the tractor unit and the remaining portion of the trailer.

1.8 Other Damage

A fibre-optic cable buried alongside the track was severed during the derailment. An above-ground diversion cable was run to bypass the site, restoring service within 24 hours of the accident.

1.9 *Dangerous Goods*

The DG cars were moving under the authority of Equivalent Level of Safety (ELS) permit SR 4651.⁶ Approximately 773 000 pounds of benzene-dicyclopentadiene mixture (UN 1993) and 162 000 pounds of hexene (UN 2370) were being transported in tank cars. These products are Class 3 flammable liquids that will easily ignite, presenting a significant risk of fire and explosion. The *2000 Emergency Response Guidebook (ERG)*⁷ states that, for large fires involving tank cars containing these products, water spray, fog or foam should be used. Remote-control hose holders or monitor nozzles should also be used. However, if it is not possible to treat such a fire in this manner, the product should be left to burn. When exposed to heat, these fuels may boil and create excessive pressure, causing tank cars to rupture. For large fires, an area within a half-mile (800 m) radius of the site should be isolated and evacuated.

Approximately 548 000 pounds of the benzene-dicyclopentadiene mixture and the entire load of hexene either burned in the fire or were not recovered.

1.9.1 *Transportation of Dangerous Goods*

The transportation of DG by air, marine, rail and road is regulated under the 1992 *Transportation of Dangerous Goods Act* and the *Transportation of Dangerous Goods Regulations* (TDG regulations). The 1992 regulations required that there be at least five non-DG buffer cars placed behind the locomotives and in front of any trailing DG cars. Historically, trains consisting of all placarded tank cars did not require any buffers, and when train length did not permit, only one buffer was required. Since the occurrence, the TDG regulations have been revised, and new TDG (Clear Language) regulations came into effect on 15 August 2002. The new regulations require a minimum of one buffer car to separate the locomotive from DG cars located in the train.

⁶ Part IV of the *Transportation of Dangerous Goods Regulations* requires that a copy of the original shipping document accompany the DG from origin to destination. ELS permit SR 4651 allows carriers to use a railway computer-generated shipping record containing all relevant information instead of the original shipping document.

⁷ The ERG is commonly used as a reference during an investigation because of its simplicity and widespread use by first responders and the general public. The ERG was developed jointly by Transport Canada, the U.S. Department of Transportation, and the Secretariat of Transport and Communications of Mexico.

The change in regulations was based primarily on consultants' reports on the marshalling of DG railway cars. These reports included the Bowring Protection Consultants study completed for the British Railways Board, the Battelle study carried out for the Federal Railroad Administration, and the Canadian Institute of Guided Ground Transport (CIGGT) Working Paper⁸ completed for TC.

The objective of the CIGGT study was to summarize the work of the other two reports, in addition to providing the institute's own analysis. The CIGGT report concluded that there was not sufficient evidence at that time to suggest that overall railway safety could be improved through modifications of the existing regulations. The report also noted that the existing regulatory requirement for a five-car separation between an occupied locomotive and DG would likely reduce the risk of injury to crews in the event of a derailment, but that the magnitude of the reduction was difficult to quantify. The report further noted that the switching required to meet the train marshalling requirements of the TDG regulations is an activity that has its own risks for employee injury and equipment derailment.

1.9.2 *Emergency Response Plans*

When shipping any DG listed in Schedule I of the TDG regulations,⁹ an emergency response plan must be developed and approved by the Minister of Transport. In addition, carriers that transport these products from outside Canada, through Canada and to a final destination outside Canada must also have emergency response plans in place. In this occurrence, the train originated and would have terminated in Canada, and the DG products were not listed in Schedule I of the TDG regulations. Therefore, an emergency response plan was not required.

In TSB accident investigation report R99H0010 on the derailment in Mont-Saint-Hilaire, Quebec, it was noted that firefighters ran out of Class B foam and the fire flared up, delaying access to the site until more foam could be located and brought in. The Board recommended that a comprehensive emergency response plan would enhance emergency response and alleviate post-accident risks.¹⁰

⁸ G.W. English et al, *Assessment of Dangerous Goods Regulations in Railway Train Marshalling, Working Paper* (Canadian Institute of Guided Ground Transport, March 1991).

⁹ Products such as explosives, flammable gases, certain acids, and toxic substances. Schedule I replaced Schedule XII, with the publication of the new TDG (Clear Language) regulations on 15 August 2002.

¹⁰ TSB Recommendation R02-03, issued 26 September 2002:
Transport Canada review the provisions of Schedule I and the requirements for emergency response plans to ensure that the transportation of liquid hydrocarbons is consistent with the risks posed to the public.

1.10 *Environmental Impact and Site Remediation*

Recovery of the remaining product and site clean-up began as soon as the fire was brought under control. Since the derailment area was located above a large sub-surface aquifer, there were concerns for the possible contamination of surface water, groundwater and soil. Initial water sampling determined that there was no significant impact to surface or groundwater quality.

Soil samples were taken from various locations in the vicinity of the derailment. Approximately 13 000 tonnes of impacted soil was excavated and removed for treatment. Vacuum trucks removed approximately 347 000 litres (76 500 gallons) of free product and contaminated water from the site. The mixture was treated using carbon filtration and was subsequently disposed of.

During the two months following the derailment, groundwater sampling wells were installed in the immediate vicinity. Water sampling, performed on 12 June 2002 and 09 July 2002, determined that hydrocarbon contamination was present in the groundwater at the site. Additional water samples were taken on 24 July 2002. In these samples, benzene concentrations had decreased to 13 per cent of the concentrations recorded on 12 June 2002. As of September 2004, some groundwater monitoring was still going on.

1.11 *Particulars of the Track*

The track in the derailment area consists of single main tangent track on a 0.50 per cent descending grade. It is rated as Class 4 track with maximum permitted speeds of 60 mph for freight trains and 80 mph for passenger trains. Rail traffic consists of 28 freight trains and 2 passenger trains per day.

The track is constructed on fill, placing the track approximately 18 feet above the surrounding land near the crossing. The track structure consists of 136-pound continuous welded rail (CWR) laid on a mixture of hardwood and softwood ties, with an average of 60 ties every 100 feet. Some new ties had been installed in the area of the derailment one year prior to the accident. Double-shouldered 14-inch tie plates with three spikes per tie plate secure the rail to the tie. The rail is box anchored at every tie. The ballast is crushed rock with a nominal size of 2.5 inches. The track shoulders extend approximately 24 inches from the end of the ties.

According to CN records, the track structure was in good condition with no significant defects prior to the accident. Track geometry measurements taken in the 500 feet west of the crossing on 10 May 2002 confirmed that there were no significant track defects in this area.

1.11.1 *TSB Rail Inspection*

Most of the broken rail was recovered and re-assembled for examination (details are found in TSB Engineering Laboratory report LP 115/02). The rail fracture surface displayed characteristics typical of catastrophic brittle failure associated with recent overstress ruptures. Several fractures exhibited torsional characteristics consistent with rail rollover. No pre-existing rail fractures were observed. A significant number of the rail fractures occurred at thermite welds, which act as stress raisers in CWR.

Approximately 309 feet east of the crossing, a tight, wholly enclosed, internal longitudinal seam defect, measuring approximately 3 inches high by 18 inches long, was observed in broken pieces south of the rail. However, wheel flange marks on the web of the rail, along with torsional characteristics observed on fracture surfaces prior to this defect, indicated that the derailment had already started and that the rail likely fractured as it rolled over.

1.12 *The School Bus and Driver's Actions*

Just before the accident, a local school bus was travelling northbound on Forrestville Road. As the school bus stopped at the crossing, the driver observed a truck approximately one-quarter mile (400 m) away, approaching the crossing from the opposite direction. Upon looking westward, the bus driver observed a train approaching from approximately 1 mile (1.6 km) away. After determining that the train was a safe distance away, the bus driver proceeded through the crossing.

The bus driver observed the truck pull off to the side on to a flat area approximately 800 feet ahead and stop to allow the bus to pass. The bus and the truck each measured 9 feet 8 inches wide to the outside of the exterior mirrors. Approaching the truck's position, the drivers acknowledged each other and the bus driver continued on. Shortly after, the bus driver looked in the side mirror and saw a ball of flame and a plume of smoke erupting from the area of the crossing.

1.13 *The Truck*

The truck, which includes the tractor unit and the trailer, was 72 feet long. The truck was registered to Porter Trucking Ltd. of Calgary, Alberta.

The tractor unit was a 1996 Freightliner, equipped with standard equipment, including an air conditioner, an AM/FM cassette radio and a sleeping compartment. The tractor unit was not equipped with an event data recorder (EDR). EDRs have been available for a number of years and are offered as optional equipment by several truck manufacturers. The tractor unit had passed the Manitoba Vehicle Safety Inspection on 01 April 2002. No mechanical problems had been reported prior to the accident.

The 53-foot-long covered trailer was manufactured in 1996 by Fruehauf and had a hauling capacity of approximately 53 000 pounds. On the day of the accident, the trailer was carrying 33 342 pounds of mixed lading, which included auto parts. The trailer had passed an Alberta Commercial Vehicle Safety Inspection on 16 August 2001. No mechanical problems had been reported prior to the accident.

1.14 The Truck Driver

The truck driver had a Province of Manitoba Class 1 driver's licence, with an air-brake endorsement, and had approximately eight years' experience driving trucks. The driver had recently moved into the area and lived near the derailment site.

The driver's employment with Porter Trucking Ltd. began on 06 March 2002. On 07 March 2002, the driver completed Porter Trucking Ltd.'s new driver orientation training. This orientation consisted of an overview of company rules and regulations, equipment checks, work schedules, and DG training. In addition, the orientation included a review of the handbook *National Safety Code: A Trucker's Guide*, distributed by the Canadian Trucking Alliance (CTA), and Porter Trucking Ltd.'s employee handbooks.

1.14.1 Truck Driver's Work Schedule Prior to Occurrence

Two days prior to the occurrence, on the evening of 30 April 2002, the truck driver had returned to work after six days off. He departed Portage la Prairie, Manitoba, at 1900 en route to Swift Current, Saskatchewan. With the exception of a 30-minute stop around midnight, he drove straight through and arrived in Swift Current at approximately 0830 on 01 May 2002. The truck driver departed for Winnipeg at 2100 that evening. Before departure, he slept for eight hours in the sleeper berth of the truck. He arrived in Winnipeg at 0800 on 02 May 2002. After dropping off the trailer and then collecting a new trailer destined for Calgary, the driver left Winnipeg at approximately 1100 and proceeded home, arriving there at approximately 1300. During the time at home, he took a 30-minute "cat-nap" and departed at approximately 1600. The driver reported feeling fit and rested at the time of the accident.

1.14.2 Circadian Rhythm and the Effects of Fatigue

Virtually every function in the body (e.g. body temperature, digestion, hormone levels) follows a daily cycle known as a circadian rhythm. These cycles follow a pattern of approximately 24 hours, with the lowest point of activity normally in the early morning and a second, less pronounced low occurring in the early afternoon. Disruptions in circadian rhythms can affect

performance and cognitive functioning,¹¹ with decreased performance levels correlating to these low points in the circadian rhythm. Shift workers in particular demonstrate impairments in cognitive functions and never fully acclimatize to night work.

In addition, fatigue is normally greatest during the first night after rotating to night work, since the body's expectation is to sleep during hours of darkness. Many rotating shift workers find it difficult to sleep during the day prior to rotating onto nights.^{12, 13} Researchers have found that adjustment of the human circadian system occurs at a rate of 1.5 hours per day if the shift rotation is clockwise or one hour per day with a counter-clockwise adjustment.¹⁴

Based on a study quantifying performance impairment,¹⁵ it was determined that the performance level on various tasks analogous to driving will deteriorate steadily after 17 hours without sleep.

1.14.3 Truck Driver's Actions

The truck driver departed from home and proceeded south on Forestville Road, which runs directly to the Trans-Canada Highway. Approaching the crossing from the north side, he observed a school bus pulling up to the crossing from the south. Due to the narrow roadway, he pulled his truck to the side of the road and stopped to allow room for the bus to pass. After the bus passed, he began moving toward the crossing. He started off in first gear and continued through to the crossing in second gear. The passenger side window was rolled up and the radio was turned on. He did not hear the train whistle. Upon approaching the crossing, the driver looked left (east) down the track, then looked in the left-hand mirror and entered the crossing without stopping at the stop sign. After entering the crossing, the driver looked right (west) along the track and observed the approaching train. Since the truck was already on the crossing, the driver decided to continue through, still in second gear. Shortly after, the rear section of the trailer was struck by the train.

¹¹ T. H. Monk, "Shift Work: Determinants of Coping Ability and Areas of Application," *Advances in the Biosciences*, 73 (1988), pp. 195–207.

¹² A.D. Baddeley and G. Hitch, "Working Memory," *The Psychology of Learning and Motivation: Advances in Research and Theory*, 8 (New York: Academic Press, 1974), pp. 47–89.

¹³ S. Folkard, P. Knauth, T.H. Monk and J. Rutenfranz, "The Effect of Memory Load on the Circadian Variation in Performance Efficiency Under a Rapidly Rotating Shift System," *Ergonomics*, 19 (1976), pp. 479–488.

¹⁴ K.E. Klein and H.M. Wegmann, *Significance of Circadian Rhythms in Aerospace Operations*, NATO AGARDograph (Neuilly sur Seine, France: NATO AGARD, 1980), p. 247.

¹⁵ N. Lamond and D. Dawson, "Quantifying the Performance Impairment Associated with Fatigue," *Journal of Sleep Research*, 8 (1999), pp. 255–262.

1.15 Professional Truck Driver Training

Professional truck driver licensing falls under provincial jurisdiction. Each province develops its own driver training material and related publications.

In Manitoba, to obtain a Class 1 licence with an air-brake endorsement, the driver must initially have a valid Class 5 automobile licence. The driver must then pass additional tests. Test preparation will normally involve reviewing the *Professional Driver's Manual* distributed by the Province of Manitoba. This manual contains approximately two pages of general material related to railway crossings. There is little reference to additional risks that a driver of a tractor-trailer must consider to safely negotiate a public passive rail crossing. The Manitoba *Highway Traffic Act* (HTA) sets forth requirements for drivers when stopping at a railway crossing. The Manitoba driver's manual reflects the requirements of the HTA and indicates that "when stopping at a railway crossing, keep at least 5 m (16 feet) away from the nearest rail in a restricted speed area and at least 15 m (49 feet) away in a non-restricted speed area." The 15 m distance is intended to ensure that there will be sufficient space to stop should the surface be slippery. In addition, the 15 m distance provides a measure of safety for the truck, should the train derail. A restricted speed area is any area within a city, town or village. The crossing in this occurrence was within a non-restricted speed area.

1.15.1 Other Professional Driver Training Material

Driver handbooks and professional truck driver manuals were obtained from eight provinces in which federally regulated railways operate; the provinces of Prince Edward Island and Newfoundland and Labrador were excluded. All manuals contain general railway crossing information and, with the exception of Manitoba, indicate that truck drivers are required to stop their vehicles no closer than 5 m (16 feet) and no further than 15 m (49 feet) from the nearest railway track at a crossing. The Province of New Brunswick does not have a separate manual for professional drivers. The Province of Quebec makes no reference to the standard railway crossbuck sign in its driver training manuals. Saskatchewan's professional driver's handbook contains no reference to the risks posed to heavy trucks at public passive crossings, even though Saskatchewan has one of the highest populations of crossings in the country. On the other hand, British Columbia's guide for professional drivers contains a specific section on crossing railway tracks in a large vehicle. Information in this section identifies additional risk factors for the driver of a tractor-trailer to consider to safely negotiate a public passive crossing. These risk factors include the following:

- The weight and length of a truck, as well as the length of time it takes for various truck configurations to clear a crossing from a stop.
- The angle at which the track intersects the roadway, and the available sight-lines of the railway track from the roadway approach to the crossing.

- The presence of steep roadway approach gradients and rough crossing surfaces, and their effect on truck performance.
- Truck performance and operation, including the effect of dragging truck brakes and laws against shifting gears on a crossing.

In 1987, the federal, provincial and territorial transportation ministers agreed to develop and implement a National Safety Code (NSC) to encourage trucking safety, promote efficiency in the motor carrier industry, and achieve consistent safety standards across Canada. The NSC was based on a consolidation of existing provincial and territorial legislation and regulations, supplemented with new initiatives designed to further enhance safety across the country. It comprises 15 standards, covering all aspects of commercial vehicle, driver and motor carrier safety. It was developed collaboratively by governments and stakeholders under the auspices of the Canadian Council of Motor Transport Administrators, the official body responsible for coordinating matters relating to motor vehicle transportation and highway safety. The NSC is used as a guideline for the trucking industry with regards to licensing, mechanical standards, trip inspections and general safety procedures.

The CTA publishes the handbook *National Safety Code: A Trucker's Guide*. Some member companies, including Porter Trucking Ltd., utilize the CTA handbook as their safety guide. Section 11 deals with railway crossings, but contains no specific information regarding the risks associated with a tractor-trailer negotiating a passively protected railway crossing. Section 4 outlines the requirements of TC's *Commercial Vehicle Drivers Hours of Service Regulations, 1994*, which govern hours of service for federal carriers. Professional truck drivers are not normally allowed to drive unless they have had eight consecutive off-duty hours. If preceded by at least eight consecutive off-duty hours, the driver is allowed to spend up to 15 hours on duty, with a maximum of 13 hours driving.

Porter Trucking Ltd. is a federally regulated carrier. The Porter Trucking Ltd. employee handbook contains company policies, procedures, general safety tips and references to federal government regulations, including hours of service. Each new employee is required to review the handbook as part of Porter Trucking Ltd.'s employee orientation. This handbook does not have specific information regarding the risks associated with a tractor-trailer negotiating a public passive railway crossing.

1.16 *Public Crossings*

Public crossings with high road traffic volumes on multi-track, high-speed or high-density rail lines are normally equipped with automated warning devices. Typically, these devices include flashing lights, bells and, often, automatic gates. For lower volume roads, public crossings are normally equipped with reflectorized crossing signs (crossbucks) on wooden posts. A railway

crossbuck sign means that drivers must yield the right-of-way to a train. The crossbucks may also be accompanied by a stop sign on the post or on the roadway approach. Crossings with this type of protection are referred to as public passive crossings.

With respect to public passive crossings, the railway is responsible for the physical maintenance of the crossing up to a point 18 inches (46 cm) beyond the outside rails. The road authority is responsible for maintaining the roadway structure beyond that point and for installing roadway signage where required. The roadway geometrics in the vicinity of the crossing must also satisfy TC's *Grade Crossing Regulations*.

Developed by the Transportation Association of Canada (TAC), the *Manual of Uniform Traffic Control Devices for Canada* is a guideline for the use of traffic control devices. The manual includes various types of roadway signage used at rail crossings. It notes that railway advance warning signs should be used to warn motorists of upcoming highway/railway grade crossings. In comparison, in the Province of Ontario, non-standard advance warning signs have been used at some passive grade crossings. These diamond-shaped signs are used to warn drivers of the presence of high-speed trains, reduced visibility, or the need to stop at an upcoming crossing. Advance warning signs are not uniformly used on all roadways across Canada.

1.17 *The Crossing*

The Forrestville Road crossing, which was opened in September 1907, crosses the CN single main line at 90 degrees. The crossing planks measure 26 feet (8 m) in length. The roadway approach from the north was approximately 15 feet (4.15 m) wide. It was equipped with reflectorized crossbucks mounted on wooden posts on both sides of the track. A standard traffic stop sign was attached to each wooden post just below the crossbucks. There were no roadway advance warning signs. There was no record of any previous accident at this crossing.

1.18 *Forrestville Road*

Forrestville Road is a typical rural, municipal road constructed of soil with a gravel surface, similar to many other roads built throughout the Prairies in the late 1800s to early 1900s. There are no weight or vehicle restrictions on these municipal roads. Since many provincial roads in Manitoba have weight restrictions in effect in the spring, it is not uncommon for loaded tractor-trailers to take local municipal roads to get to Highway 1.

Forrestville Road has a speed limit of 90 km/h and is used year round for access to farms and residences on each side of the rail line. The road is narrow, making it difficult for two large vehicles to pass. The roadway has narrow shoulders with sharp drops of 15 to 20 feet to drainage ditches on both sides.

1.19 *Public Crossing Safety Initiatives*

TC and Operation Lifesaver are cooperating on several initiatives targeted at improving professional driver training across Canada.

Following an independent review of the *Railway Safety Act*, it was recommended that highway/railway grade crossing collisions and trespassing incidents should be reduced by 50 per cent from the 1996 level, over a 10-year period. The program Direction 2006 was created with the goal of meeting this target by 2006. This program is a partnership between public and private sector stakeholders, including TC, provincial governments, the Federation of Canadian Municipalities, the railway industry, railway unions, law enforcement agencies, public safety organizations, and community groups. The primary objective for this initiative is to increase public awareness on safety issues surrounding rights-of-way and railway grade crossings. Direction 2006 also calls for the development of additional rail safety information for provincial driver education manuals and training handbooks.

Operation Lifesaver is a national public crossing safety program sponsored by the Railway Association of Canada and TC. Established in 1981 and primarily staffed by volunteers, Operation Lifesaver's mandate is in part to educate the public on the risks associated with railway crossings. The Operation Lifesaver program is one of several industry and regulatory approaches that have contributed to a reduction in highway/railway accidents of more than 60 per cent in the last 20 years. Operation Lifesaver's active educational program includes the development and distribution of printed material for driver education, along with public presentations on railway crossing safety.

1.19.1 *New Safety Initiatives for Public Crossings*

Direction 2006 has developed extensive material on grade crossing safety to assist provincial authorities when updating driver training manuals. In May 2002, this information was distributed to provincial authorities through the Canada Safety Council.

In 2002, Direction 2006 and Operation Lifesaver jointly developed new professional driver training material on railway crossing safety. This material included new modules on highway/railway crossing awareness training for school bus drivers, emergency responders, and professional truck drivers. Each module contains information regarding the specific risks that professional drivers encounter when negotiating a public passive railway crossing.

1.20 TSB Accident Re-enactment

An accident re-enactment was performed by the TSB (report LP 115/2002) to determine the available sight-lines from the north roadway approach, measure the north roadway approach gradient, and determine the actual time it would take for a similar truck to negotiate the crossing. All vehicles used in the re-enactment were of a similar type and weight to those involved in the accident.

From several positions along the north roadway, the distance from the crossing to the front bumper of the truck and sight-lines to the east and west of the crossing were recorded. To establish the sight-lines, the locomotive was positioned near the crossing and then moved away from the crossing until it was no longer in view from the driver's seat in the truck. The sight-line was recorded from the driver's seat of the truck, approximately 8 feet (2.5 m) from the front bumper, in order to achieve an accurate representation of the conditions affecting the vehicle driver's perception at that location. The recorded sight-lines are contained in Table 1.

Table 1. Recorded Sight-lines

Truck Position on the Road North of the Crossing	Sight-line to the West of the Crossing (the Train Approach)	Sight-line to the East
Truck at stop sign 23 feet (7 m) from centreline of crossing – Driver at 31 feet (9.5 m)	1537 feet	Unlimited
246 feet (75 m) from centreline of crossing – Driver at 254 feet (77.5 m)	854 feet	832 feet
553 feet (170 m) from centreline of crossing – Driver at 561 feet (172.5 m)	720 feet	555 feet

The north approach roadway gradient was measured along the centreline of the road at 5 m increments from the crossing up to 100 m away. A gradient of 5.5 per cent was recorded 8 m from the crossing. The maximum gradient recorded was 8.4 per cent, measured at a distance of 15 m from the crossing. Average gradients over various distances are contained in Table 2.

Table 2. Average Gradients Recorded at Various Distances

Distance (m) from Crossing	Average Gradient (%)
0-8	4.9
8-25	7.3
25-50	4.5
50-75	2.6
0-75	4.6

The accident re-enactment determined the time it took for the truck to negotiate the crossing from a stop at the north side. The north approach stop sign was located 23 feet from the centreline of the crossing. From the stop sign, the truck proceeded up to and through the crossing in second gear. Time was recorded from the point when the truck started to move until the rear of the trailer cleared the south stop sign, approximately 18 feet beyond the centreline of the crossing. On two different runs, times of 20 and 21 seconds were recorded for the truck to clear the crossing. The maximum speed attained through the crossing was 5 km/h.

1.20.1 *Train Speed*

The train was travelling at approximately 50 mph as it approached the crossing. At 50 mph, the train would travel 1540 feet in the 21 seconds necessary for the truck to safely travel over the crossing. Table 3 outlines the distances that trains travel at various speeds.

Table 3. Train Distance Travelled Over Time at Various Speeds

Time (Seconds)	Train Distance Travelled (feet) at 50 mph	Train Distance Travelled (feet) at 60 mph	Train Distance Travelled (feet) at 70 mph	Train Distance Travelled (feet) at 80 mph
10	733	880	1027	1173
15	1100	1320	1540	1760
20	1466	1760	2053	2347
21	1540	1848	2156	2464

1.21 *Grade Crossing Regulations and Guidelines*

Public passive grade crossings in Canada are governed by TC regulation CTC-1980-8-Rail. Prior to this regulation (and since 1965), the Board of Transport Commissioners' General Order No. E-4 (E-4), *Standard Regulations Respecting the Construction of a Crossing of a Highway and a Railway at Grade*, had been in effect.

- E-4 applied to crossings constructed prior to and after 01 February 1965. Part II, Section 4 of E-4 stipulates that "at all crossings, the approaches of the highway whether ascending or descending shall not exceed a gradient of 5 per cent unless otherwise authorized by the Board." This regulation governed the occurrence crossing.
- CTC-1980-8-Rail was implemented on 18 September 1980. Public crossings constructed prior to this date remain governed by E-4. Section 8 of this regulation stipulates, "At all crossings, the gradient of the approaches of the highway shall not be greater than 1 m of rise or fall for every 20 m of the horizontal length of the approaches."
- On 14 January 1985, CTC-1980-8-Rail was amended. The amendment focused on changes to railway crossing signage. However, the regulation allowed railway crossing signs erected prior to this date to be maintained in accordance with the standard to which the signboard was constructed until the signboard is replaced.

In addition, TC guidelines were established to address crossing safety issues not covered by the regulations. In 1992, TC adopted a modified version of the earlier Canadian Transport Commission guideline (G4-A): *Minimum Railway/Road Crossing Sightline Requirements for all Grade Crossings without Automatic Warning Devices*. Public passive crossings are included in this guideline. G4-A establishes minimum sight-lines to provide motorists with a 10-second warning of an approaching train. An additional provision states, "Where gradients within 8 m of rail exceed 5% or heavy or long vehicles regularly cross, clear view from a vehicle stopped at the crossing must also extend a minimum of 50% beyond "T" [minimum sight-line distance contained in the guideline], and more if necessary, so stopped vehicles have sufficient time to start up and cross safely."

1.22 *Transport Canada's Proposed New Grade Crossing Regulations*

TC is in the process of developing new Grade Crossing Regulations that will apply to all grade crossings, pursuant to the *Railway Safety Act*. Concurrent with the regulations, TC has developed Draft RTD 10, a manual entitled *Road/Railway Grade Crossings: Technical Standards and Inspection*,

Testing and Maintenance Requirements. This manual, along with the new regulations, describes the best engineering practices and procedures for railway crossing safety. Some of the relevant items in the proposed regulations include the following:

- The responsibilities of various authorities at crossings with respect to maintaining safety defences. The regulations require that, within five years of the new regulations and “at least every five years after that date, every responsible authority shall conduct a detailed safety assessment of its unrestricted (public) grade crossings with other responsible authorities,” in accordance with the practices set forth in Draft RTD 10.
- The requirements for minimum road geometry with respect to roadway approach gradients at a railway crossing. Part B, Section 7 of Draft RTD 10 states that “the maximum gradients for roads at a grade crossing shall not exceed a ratio of 1:50 (2 per cent) within 8 m of the nearest rail and 1:20 (5 per cent) for 10 m beyond, at unrestricted grade crossings (public passive) for vehicular use.”
- The sight-line requirements for vehicles stopped at a railway crossing based on modern engineering principles and a design equation.

Draft RTD 10 outlines the criteria for installing railway advance warning signs, as specified in the *Traffic Control Devices Manual*.

The new Grade Crossing Regulations have been in the drafting and consulting stage for more than 15 years. In TSB report No. R99T0298, the Board issued recommendation R01–05, which urged TC to expedite the promulgation of new grade crossing regulations.¹⁶ In TSB report No. R00T0257, the Board observed that, while there had been a recommendation on expediting the issuance of the new regulations, it was clear that delays continued.

1.23 *Transport Canada’s Grade Crossing Inspection Programs*

Under TC’s Grade Crossing Monitoring program, 5 per cent of crossings should be inspected annually. Crossing inspections are conducted on a program basis using a risk-based approach. Greater priority is given to locations where crossing accidents have occurred and to public crossings with high traffic exposure.

Detailed inspections are performed by a railway works engineer. The inspections involve assessing the safety of the crossing; collecting road and rail traffic data; and checking the condition of the roadway approaches, the road surface, the sight-lines and the signalling systems. Information collected during the detailed inspection is entered into a crossing database.

¹⁶ TSB Recommendation R01–05, issued 24 October 2001

Cursory crossing inspections are also performed by TC infrastructure officers during their track inspections. Under cursory inspections, any crossing that does not appear to comply with crossing requirements is identified for further review.

The last regulatory inspection at the Forrestville Road crossing was on 01 October 1966. TC has no record of any cursory inspections of the crossing. In TC's crossing database and based on the 1966 inspection, road traffic volume was recorded as 15 vehicles per day. The database had no information on the presence of bus or heavy vehicle traffic at the crossing.

1.23.1 *Inspection History of CN's Rivers Subdivision Public Passive Crossings*

Based on TC's crossing database, CN's Rivers Subdivision has 208 public passive grade crossings. A breakdown of when these crossings were last inspected is summarized in Table 4.

Table 4. TC Detailed Inspection of Public Passive Crossings on the Rivers Subdivision

Year of Last Crossing Inspection	Number of Years Since Last Inspection	Number of Crossings	% of Rivers Subdivision Public Passive Crossings
1950–1956	> 45	38	18
1957–1967	35–45	80	38
1968–1977	25–34	18	9
1978–1982	20–24	10	5
1983–2002	< 20	62	30
TOTAL		208	100

1.23.2 *Post-Accident Inspection of Forrestville Road Crossing*

On 24 July 2002, a TC railway works engineer performed a detailed crossing inspection of the Forrestville Road crossing. The inspection report stated that the crossing met existing regulations. The updated crossing record for Forrestville Road was obtained after the inspection. The gradient of the north road approach was recorded as 4.65 per cent. TC's standard practice for measuring gradient is to take the average gradient from the top of the rail to the point where the approach levels out to the lay of the land. Using this method, the north approach gradient was measured over approximately 245 feet (75 m).

1.24 *Macro Analysis of Grade Crossing Accidents*

The TSB reviewed road and grade crossing accident data¹⁷ from the past 10 years to identify safety issues at public passive crossings related to heavy trucks. The analysis revealed the following:

- Between 1994 and 1998, there was an average of 49 grade crossing accidents (all crossing types) per year involving heavy trucks. This accounted for a very small proportion (0.1 per cent) of all heavy truck road collisions.
- When involved in a grade crossing accident, the relative risk of an occupant of a heavy truck being fatally injured was 33 times greater than when involved in a road accident (annual average of 65 fatalities out of 43 483 accidents vs. annual average of 2.4 fatalities out of 49 accidents).
- Heavy trucks accounted for 15 per cent of all accidents at public passive crossings, while they accounted for 58 per cent of the accidents that resulted in a derailment.
- Eighty per cent of the accidents involving a heavy truck at public passive grade crossings occurred during daylight hours.
- For daytime occurrences, a heavy truck drove in front of and was hit by a train in 87 per cent of the cases. Where the impact location was recorded, 77 per cent of the impacts occurred at the rear of the truck trailer.
- While the total number of heavy truck crossing accidents decreased in 2002, the number of derailments resulting from this type of accident increased slightly. Figure 3 illustrates the number of accidents involving heavy trucks at public passive grade crossings and the percentage resulting in derailment from 1993–2002, inclusive.

¹⁷ Transport Canada Road Safety and Motor Vehicle Regulation Directorate, 2001, Heavy Truck Collisions, 1994–1998.

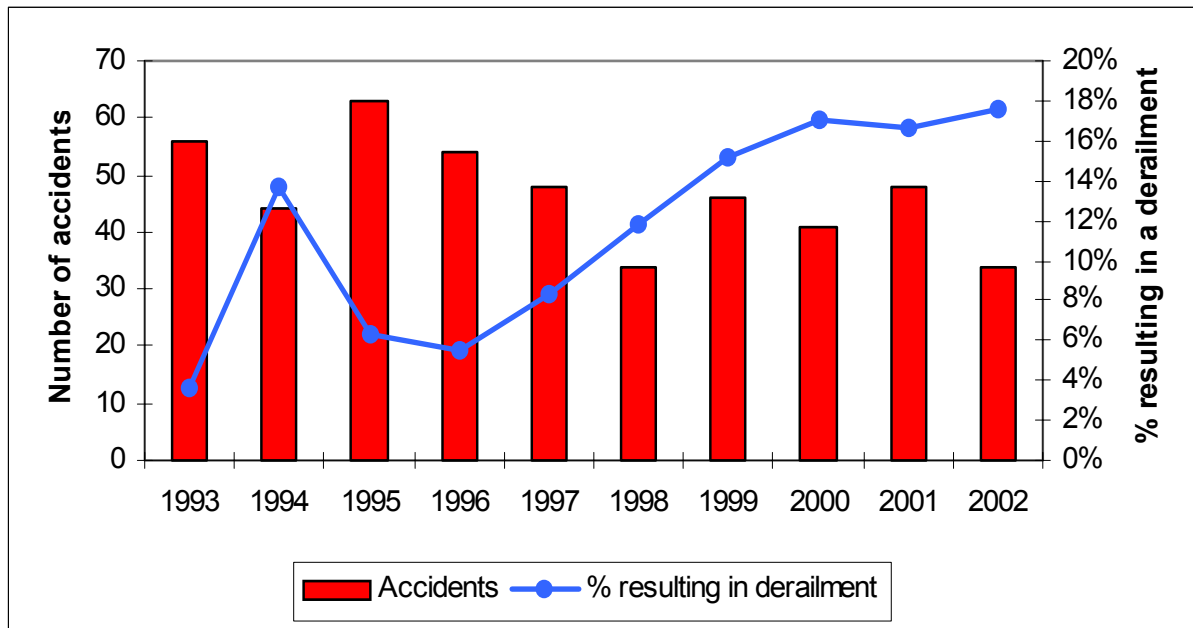


Figure 3. Accidents involving heavy trucks at public passive crossings

1.25 National Transportation Safety Board – Safety Study

In July 1998, the National Transportation Safety Board (NTSB) in the United States released a report¹⁸ that discussed the adequacy of existing warning systems to alert drivers to the presence of an oncoming train at passive grade crossings. The report reviewed the need for uniformity in signage at passive crossings and the adequacy of existing vehicle driver education material regarding the dangers of passive grade crossings.

The study determined that drivers generally underestimate the frequency of trains at crossings, as less than 30 per cent of drivers look both ways as they approach a public passive crossing.¹⁹ Those who do look tend to do so quite late, such that by the time they see the approaching train, they may already be in the crossing. This tendency increased when drivers were familiar with the crossing. Other relevant findings from the NTSB study include the following:

- The noise level of a 96-decibel (dBA) train horn measured in the interior of a 1996 Freightliner conventional truck tractor 100 feet away was recorded at 12 dBA with the vehicle windows closed and the engine idling. The sound level was further reduced to

¹⁸ NTSB Safety Study, *Safety at Passive Crossings*, Volume 1: Analysis, NTSB/SS-98/02, PB98-917004, Notation 7036, adopted 21 July 1998.

¹⁹ E.C. Wigglesworth (1976). Reported in NTSB Safety Study (1998).

7 dBA when the heater fan or air conditioning was operating. In Canada, TC's *Railway Locomotive Inspection and Safety Rules*, Part II, Section 11.1 (a), stipulate that a train horn "must produce a minimum sound level of 96 dBA²⁰ at any location on an arc of 30.5 metres (100 feet) radius subtended forward of the locomotive by angles 45 degrees to the left and to the right of the centreline of the track in the direction of travel."

- The motoring public does not clearly understand the level of risk at passive grade crossings. The NTSB reviewed material from various driver education programs in the U.S. to determine if the inherent risk at passive crossings was being adequately addressed. The NTSB concluded, "the dangers of passive grade crossings are not adequately addressed in current driver education material or in States' written driver examinations." The NTSB recommended that agencies involved with driver training and licensing include in their training manuals, presentations and printed education material, additional information about the dangers of passive crossing and the risks associated with negotiating them.²¹ The NTSB also recommended that "an appropriate training module specific to passive grade safety be developed and included in the organizations' highway safety education programs" for truck drivers.

²⁰ The decibel scale is the sound scale to which human hearing is measured.

²¹ NTSB Safety Recommendations H-98-34 to H-98-37 (11 August 1998).

2.0 *Analysis*

Crossing accidents involving heavy trucks often result in derailment or significant damage to locomotives and rail cars. When DG cars are derailed or damaged, these accidents pose significant risks to motor vehicle occupants, train crews, rail passengers, and those living in the surrounding area.

In this occurrence, there were no deficiencies identified with respect to the operation or the mechanical condition of the train. There were no significant defects noted with the track infrastructure contributing to the accident. The analysis will focus on crossing design and regulations, driver behaviour, regulatory inspections, locomotive angle cock protection, emergency response, and regulatory requirements for buffer cars.

2.1 *The Accident*

As the truck approached the crossing, the locomotive engineer sounded the locomotive horn as required. The truck driver proceeded over the crossing without hearing the train whistle, without stopping at the stop sign, or looking in both directions for approaching trains. When it became apparent that the truck was not going to stop, the crew stopped sounding the horn and laid down on the floor of the locomotive to protect themselves from the impending collision. As a result of the collision, the train derailed.

Much of the track structure east of the crossing was destroyed, making it impossible to identify the precise POD. However, since the second car from the head end was impaled diagonally by a section of the south rail removed from an area 160 feet east of the crossing, this car must have already derailed prior to this point. Extensive damage observed to the south rail, in combination with a large number of freight cars derailed within a short distance east of the crossing, indicates that the POD was likely on the south rail in the immediate vicinity of the east end of the crossing.

TSB analysis of the locomotive event recorder data from the lead locomotive (report LP 049/02) concluded that it is unlikely that impact forces alone would have caused the locomotive to derail. It was also determined that the maximum buff forces at the locomotives and the first car were not sufficient to cause the derailment. This indicates that the train-initiated UDE likely occurred at nearly the same time that the trailing cars derailed; as such, the UDE is not considered causal in this occurrence. The absence of any significant markings on the south rail head or gauge face in the immediate vicinity of the crossing made it difficult to identify the precise derailment sequence after the train struck the truck. However, since the wheels on the locomotive engineer's side (south) of the lead locomotive came to rest on the gauge side web of the overturned south rail, the derailment mechanism was likely rail rollover. Immediately after the collision, trailer debris encountered by the locomotives and the head-end cars may have contributed to the rail rollover.

2.2 *Crossing Features and Truck Driver's Actions*

The Forrestville Road crossing has a number of physical features that affect how vehicles negotiate the crossing. These features include a narrow roadway (approximately 15 feet wide) with a sharp drop off on both sides. The north approach also has a road gradient ranging from relatively level ground 75 m from the crossing to a maximum gradient of 8.4 per cent 15 m from the crossing. When travelling south towards the crossing, sight-lines to the west are restricted by trees, making it difficult for drivers to see approaching trains. To alleviate these problems, the municipality had installed stop signs on both sides of the crossing, requiring vehicles to stop before proceeding into the crossing.

The truck driver was initially prevented from approaching the crossing due to the narrow roadway. The truck driver stopped about 800 feet from the crossing on the north approach to allow the school bus to pass. At this location, it was not possible to see the approaching train. Subsequently, with the passenger side window rolled up and the radio turned on, the driver did not hear the train's whistle that was sounded for approximately 12 seconds prior to impact.

2.3 *Driver Fatigue and Hours of Service Regulations*

The truck driver reported feeling fit and rested at the time of the accident. However, there were a number of indicators in the driver's work schedule suggesting a sleep debt and fatigue. He had just rotated to the night shift after six consecutive days off. Shift workers never fully acclimatize to night work. In addition, fatigue is normally greatest during the first night after rotating to night work, since the body's expectation is to sleep during hours of darkness. Many rotating shift workers find it difficult to sleep during the day prior to rotating onto nights. In this occurrence, the truck driver had slept for only 9 of the 45 hours preceding the accident. With the exception of a 30-minute nap in the afternoon of the accident, he had been awake for at least 19 hours prior to the accident. Sixteen of those 19 hours had been spent working. In addition, the accident took place just after 1600, corresponding to the afternoon circadian low,²² which is usually accompanied by a reduced level of alertness.

²²

S. Coren (1996) cites research indicating a bi-modal distribution of traffic accidents by time of day. The most significant peak occurs between 1:00 and 4:00 a.m. when, although there are fewer vehicles on the road, there is the greatest number of accidents. The second peak occurs between 1:00 and 4:00 p.m., when drivers are experiencing the afternoon low point in their alertness cycle.

Becoming preoccupied, decreased vigilance, and disregarding warning signs are typical of the types of attentional deficits associated with fatigue. A study on performance impairment²³ indicated that performance on a number of tasks analogous to driving deteriorated steadily after 17 hours without sleep. Since the truck driver had only slept for 30 minutes in the previous 19 hours, it is possible that fatigue affected his ability to safely negotiate the crossing.

Section 4 of the CTA handbook *National Safety Code: A Trucker's Guide* outlines the hours of service regulations for federally regulated motor carriers that operate across Canada. These regulations are the primary administrative defence to reduce driver fatigue in the road transport industry. In this occurrence, the truck driver's duty time prior to the accident was longer than permitted under the regulations and the period of rest prior to departure from home was shorter.

At Porter Trucking Ltd., employee service hours are monitored using a handwritten log book maintained by the employee. This method is commonly used by Canadian trucking companies. Driver log books are reviewed by the company to ensure driver compliance. However, the review occurs only after the driver has completed driving and made the entry. Without a system of company management overview to identify drivers who may be fatigued before they exceed the maximum hours of service, fatigued truck drivers may make inappropriate decisions, thereby increasing the risk to themselves and the general public.

2.4 Current Regulatory Defences for Public Passive Crossings

The current regulatory defences for public passive crossings consist of the installation of railway crossing signs (crossbucks) and a requirement under the CROR to sound the train horn at crossings. There are no other physical defences in place to warn vehicle drivers of approaching trains. In contrast, signalled crossings contain train-activated devices to warn drivers of a train's approach. It is imperative for drivers to understand the meaning of the passive warning signs and to hear or see an approaching train. Therefore, driver vigilance is essential at these grade crossings.

The installation of crossbucks at a passive crossing and their related message complement provincial highway traffic acts or codes, which stipulate that a driver of a vehicle approaching the railway crossing sign shall yield to a train approaching the crossing. The railway crossing sign is included in the TAC *Manual of Uniform Traffic Control Devices for Canada*. The intent and meaning of the crossing sign is also reinforced by Section 26.2 of the federal *Railway Safety Act* (RSA), which states, "The users of a road shall give way to railway equipment at a road crossing if adequate warning of its approach is given." The railway crossing sign does not warn of a train's approach. The onus is on the road user to verify whether a train is approaching or is

²³ N. Lamond and D. Dawson, "Quantifying the Performance Impairment Associated with Fatigue," *Journal of Sleep Research*, 8 (1999), pp. 255–262.

present on the crossing. CROR Rule 14 provides an administrative defence to warn of a train's approach by requiring that a prolonged or repeated train horn be sounded at least one-quarter mile from every public crossing at grade, until the crossing is fully occupied by the train. However, the 1998 train horn audibility study, conducted by the U.S. NTSB, demonstrated that a train horn is virtually inaudible to a heavy truck from distances exceeding 100 feet and, therefore, does not provide a consistently effective defence to warn heavy-truck drivers of an approaching train.

The current regulations are deficient concerning sight-line requirements, but TC's Guideline G4-A (G4-A) contains sight-line requirements for vehicle drivers stopped at or approaching a grade crossing. However, G4-A is only a guideline and not enforceable under the RSA. Based on G4-A, the minimum sight-line distance should provide the motorist with a 10-second warning of an approaching train. The minimum sight-line is extended to 15 seconds when road approach gradients exceed 5 per cent within 8 m of the rail, or when heavy or long vehicles regularly use a crossing. The north approach gradient at the Forrestville Road crossing exceeds 5 per cent at the 8 m point, and this road is known to be used by school buses and heavy vehicles.

In the case of train E20251-30, which was travelling at 50 mph, the warning time was approximately 21 seconds based on a sight-line of 1537 feet. During the accident re-enactment, the tractor-trailer took approximately 20 seconds to negotiate the crossing after stopping at the north stop sign. The sight-line at the north approach is adequate for a 50 mph freight train. However, based on the maximum permissible speed of 80 mph for passenger trains, the sight-line from the stop sign at the north approach should have been at least 1800 feet in each direction. With a sight-line of 1537 feet, the driver would only have approximately 13 seconds of advance warning for an 80 mph passenger train.

2.5 *Advance Warning Roadway Signage*

For a vehicle operator, the task of negotiating a rail crossing involves being aware of the crossing, determining whether there are any approaching trains, and then determining whether it is safe to cross. The truck driver in this occurrence was aware of the crossing, since he had to wait on the north roadway while the school bus negotiated the crossing. The roadway signage at the crossing consisted of a crossbuck sign and a stop sign at each approach. However, as concluded in the NTSB study on *Safety at Passive Grade Crossings*, these signs indicate the presence of a railway crossing, but not the approach of a train.

In Canada, the TAC *Manual of Uniform Traffic Control Devices for Canada* is used as a guideline for road signs by provincial authorities. For railway crossings, there are standard advance warning signs to identify upcoming rail crossings and the angle at which they intersect the road. However, local municipalities do not necessarily install advance warning signs. In addition, some jurisdictions use non-standard signs to warn of passive grade crossings. Given that the use

of advance warning signs is not uniform across Canada, drivers may not be familiar with some signs or may expect to see advance warning signs that may not be utilized in the area in which they are driving. While TC recommends that railway advance warning signs should be installed on all road approaches leading to grade crossings when average annual daily traffic exceeds 100, these signs do not indicate whether the crossing ahead is passive or active. Consequently, drivers may not clearly understand the hazards associated with an upcoming public passive railway crossing. The lack of a uniform application of advance warning signs on roadways across Canada, to warn drivers of their approach to a public passive railway crossing, increases the risk that drivers may not understand the level of attention required to safely negotiate a passive grade crossing.

2.6 *Driver Education*

The number of grade crossing collisions involving a train and a heavy truck is relatively low when compared to all commercial vehicle road accidents. However, as demonstrated in this occurrence, a single crossing accident can have far greater consequences than a single road accident. Historically, 80 per cent of the collisions between a train and a heavy truck at public passive grade crossings have occurred during the day. In these occurrences, 87 per cent of the heavy trucks were hit by a train, with many of the impacts occurring at the rear of the truck trailer.

This suggests that some truck drivers either fail to identify oncoming trains, or underestimate the speed of the train and the time required to get the tractor and trailer across the tracks. It further demonstrates a lack of driver awareness regarding the risks associated with negotiating a heavy truck over a public passive grade crossing. While current passive crossing regulations meet existing highway traffic requirements, they fail to provide other defences that will alert drivers of heavy trucks to the possible presence of an approaching train. A possible additional defence for drivers negotiating public passive crossings may be enhanced driver education.

The NTSB study on *Safety at Passive Grade Crossings* concluded that the motoring public does not clearly understand the level of risk at passive grade crossings, nor the need for full driver attention when negotiating these crossings. A review of material from various driver education programs in the U.S. indicated that very little information is provided on the dangers of passive grade crossings or the actions required of vehicle drivers.

Professional driver training material varies a great deal from province to province with regard to outlining the risks for large trucks at public passive railway crossings. While British Columbia's training material is relatively comprehensive, all other provincial professional driver manuals contain little information with regard to the risk factors for the driver of a tractor-trailer in safely negotiating a public passive crossing. None of the manuals reviewed identified the length and tonnage of trains, the speed at which they may travel, the distance travelled over various time intervals, or the distance necessary to bring a train to a stop. Besides the manuals used in

professional driver training, other publications that influence trucking safety also lack the necessary information to increase driver awareness of the risks. The CTA handbook *National Safety Code: A Trucker's Guide* does not contain specific information on the risks associated with heavy trucks negotiating public passive railway crossings.

More detailed material on railway crossing safety is available through the Direction 2006 and the Operation Lifesaver programs. The success of these initiatives is dependent on partnerships with the trucking industry and distribution of the material as part of driver training. There is limited distribution of this material when compared to the number of professional driver training manuals distributed by the provinces. Since Operation Lifesaver primarily relies on volunteers, the delivery of this material depends on the availability of presenters.

It appears there is a lack of awareness by some drivers regarding the hazards present for a heavy truck at a railway crossing. Increased awareness of railway crossing safety for professional drivers is a crucial step in reducing the number of passive grade crossing accidents. Inadequate training material on railway crossing safety in most provincial professional driver training manuals increases the risk that professional drivers remain unaware of the safety issues associated with negotiating heavy trucks over public passive railway crossings.

2.7 *Manitoba Rural Public Passive Crossing Requirements for Vehicles*

When describing crossings such as the one at Forrestville Road, most provincial driver training manuals specify that drivers must stop their vehicles between 5 m (16 feet) and 15 m (49 feet) from the nearest rail. In Manitoba, the provincial HTA requires drivers to keep at least 15 m away from the nearest rail when stopping at a railway crossing in a non-restricted speed area. Manitoba driver training manuals, both standard and professional, reflect this HTA requirement. Based on TC's Guideline G4-A, sight-lines are determined from a stopped position of 8 m (26 feet) from the nearest rail. The 15 m stopping requirement has the potential to significantly alter the sight-lines necessary to determine whether it is safe to proceed.

2.8 *Present Crossing Regulations vs. Proposed Regulations*

Under existing regulations, the railway is responsible for the physical maintenance of the crossing up to 18 inches (46 cm) on either side of the rails. This portion of the crossing structure at Forrestville Road met regulatory requirements. Regulations for grade crossings have been updated several times since 1965; however, crossings built prior to these revisions are exempt from some of the requirements. Although not mandatory, TC guidelines have been implemented to address areas not covered by present regulations. These exemptions and additional guidelines result in a confusing mix of new regulations, old regulations and guidelines governing passive crossings in Canada.

The majority of crossings in Canada are governed by regulations that have not changed significantly since the early 1900s. Yet over this period, there have been technological advances and changes in roadway design and motor vehicle use, as well as technological advances in the rail and truck transportation industries. Issues not addressed by current regulations (CTC–1980–8–Rail) include the following:

- The current regulations reference a maximum gradient of 5 per cent for public passive roadway approaches, but do not specify the distance(s) over which the gradient must be measured.
- There are no criteria for determining the necessity of stop signs at a railway crossing or whether advance warning signs are required on the road approach.

Consequently, each road authority can interpret and implement these aspects of the present regulations at their discretion.

TC's proposed new Grade Crossing Regulations and the accompanying Draft RTD 10 technical manual are based on a more comprehensive look at crossing safety issues. The proposed regulations incorporate some safety defences for passive crossings that do not exist in present *Grade Crossing Regulations*. For example, within five years of coming into force and at least every five years thereafter, the proposed regulations would require that each road authority conduct a detailed safety assessment of its unrestricted grade crossings. Limits for roadway gradients, including the distance over which the gradient is to be measured, are clearly defined in Draft RTD 10. The draft also establishes a method of determining adequate sight-lines and establishes criteria for railway advance warning signs.

2.9 *Crossing Inspections*

Under TC's Grade Crossing Monitoring program, 5 per cent of crossings are to be inspected annually. In theory, all crossings are to receive a detailed inspection within a 20-year period. However, crossings are inspected on a program basis with greater priority given to high-speed, high-volume subdivisions, as well as to subdivisions with a high accident record. From an overall risk perspective and based on available inspectors, this is a reasonable approach. There are, however, many public passive crossings throughout Canada for which the interval between detailed inspections exceeds 20 years. For instance, the Forrestville Road crossing was last inspected on 01 October 1966, 35 years prior to the accident. Of the 208 public passive grade crossings on the Rivers Subdivision, 56 per cent have not been inspected in more than 35 years.

Both General Order E-4 and CTC–1980–8–Rail establish a maximum gradient of 5 per cent for public passive roadway approaches. However, this requirement does not specify the distance over which the gradient must be measured. Using TC's "lay of the land" method, the north approach gradient at the Forrestville Road crossing was recorded as 4.65 per cent, averaged over

a distance of approximately 245 feet (75 m). The TSB Engineering Laboratory measured a maximum gradient of 8.4 per cent at a distance of 15 m north of the crossing. Vehicle performance is affected by the gradient in the immediate vicinity of the crossing (5–15 m) and not the entire 75 m leading up to the crossing. Consequently, the current method of recording gradient increases the risk that excessive road gradients will not be identified.

The Forrestville Road crossing had a number of physical characteristics making it difficult for heavy vehicles to cross safely. These included excessive gradient in the immediate vicinity of the crossing and narrow roadway approaches with essentially no shoulders on either side of the crossing. These issues are addressed to some extent in G4–A. However, G4–A is only a guideline and is not enforceable under the RSA. Despite this, TC can issue a Notice, or Notice and Order, to railway companies when there is a threat to safe railway operations (e.g. lack of adequate sight-lines). Normally, such instruction is only issued after TC performs an inspection and determines that there are conditions requiring attention. In the absence of a detailed crossing inspection, unsafe conditions may remain undetected.

2.10 Locomotive Angle Cock Protection

The train crew did not initiate an emergency brake application. The force of the collision between the train and truck trailer fractured the lead locomotive's front brake pipe angle cock in the body of the valve, leading to the train-initiated UDE. It is likely that the UDE occurred at nearly the same time as the trailing cars derailed. While the UDE was not considered causal, in-train buff forces generated by such action can potentially cause a rail rollover, wheel climb and/or wheel-lift derailment. Previous TSB reports (R00H0004 and R01M0061) identify risks associated with in-train buff forces as a result of emergency brake applications that were causal factors in those derailments.

The positioning of the front angle cock and the size and configuration of various components (e.g. locomotive pilots/snow plows) on the front of locomotives can affect the survivability of the front angle cock during a head-end collision. Locomotive snow plow arrangements and the location of the front angle cock vary slightly from one type of locomotive series to another. On GE Dash 8 locomotive units, the snow plow in the area of the angle cock measures approximately 28 inches high and is located approximately 17 inches beyond the front of the locomotive frame. In contrast, the snow plow on GM SD–40–2 locomotives measures approximately 33 inches and is located approximately 19 inches beyond the front of the locomotive frame. In addition, the front angle cock on a GE Dash 8 locomotive extends approximately three inches further than the angle cock on a GM SD–40–2 locomotive. On the whole, the front angle cock of the GE Dash 8 locomotive is more exposed than on the GM SD–40–2 locomotive. Photo 2 shows the configuration of the angle cock on the two locomotives.

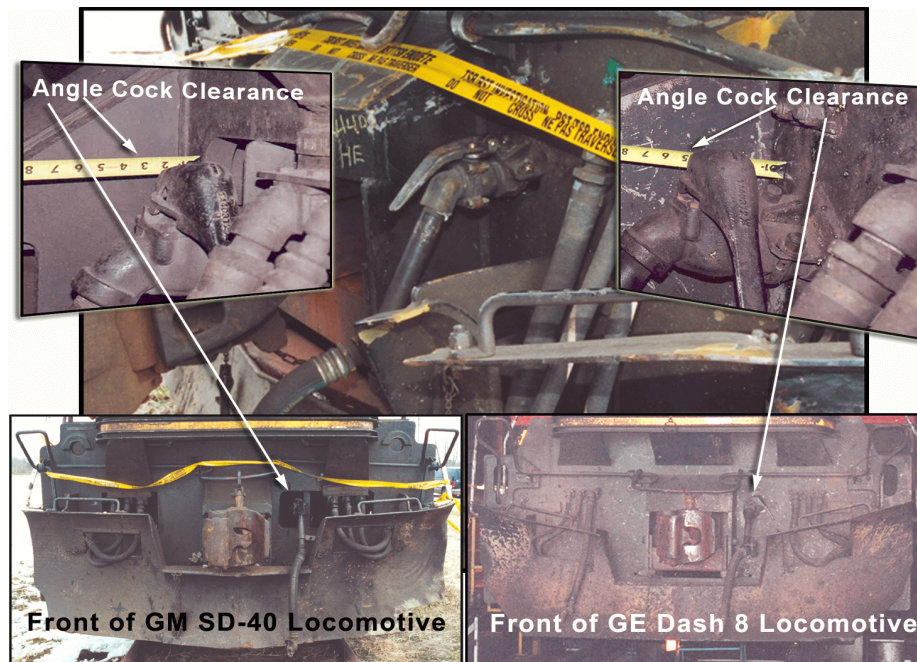


Photo 2. Angle cock configuration on locomotive

Due to its location, the front angle cock on locomotives is partially exposed and susceptible to failure upon impact. GE offers alternate locations for the angle cock at the time of locomotive manufacture; however, the locations of the valve and brake pipe hose are typically specified by the purchasing railway, based on the railway's needs. Although the locomotive snow plow was not designed to protect the front angle cock, these attachments do provide a measure of protection. In the event of a head-end collision with a vehicle at a crossing, insufficient protection and/or the location of the angle cock on the lead locomotive increases the risk of an angle cock valve failure. Such valve failures have been known to initiate a UDE from the head end of the train, and the resulting in-train buff forces can potentially cause a rail rollover, jackknife, wheel climb and/or wheel-lift derailment.

2.11 *Emergency Responder Training*

An emergency responder at a rail DG fire should initially assess the situation from a safe distance. No intervention should be attempted until there is a complete understanding of the products involved, the risks during intervention, and the level of protection required. In some circumstances, it may be preferable to let the DG fire burn itself out rather than attempt a response. This is contrary to firefighting training that emphasizes rapid response and intervention to protect life and property.

Since railway personnel are not always first on the scene, local emergency responders throughout Canada, many of them volunteers, continue to play a significant role. As first responders, they are expected to initiate the critical steps of assessment and perimeter containment. In this occurrence, a volunteer firefighter was the first on the scene. The firefighter, who was not wearing any personal protective equipment, climbed over the rail cars derailed at the crossing, seemingly unaware of the potential for regulated products to be involved in the fire. The firefighter had been trained to both NFPA 1001 Level I Fire Fighter and NFPA 472 Hazardous Materials Awareness Level. However, since taking his initial DG training six years prior to the accident, he had not received any refresher training, nor had he responded to a rail DG incident. The firefighter's lack of familiarity with the rail transportation of DG, coupled with an understandable concern for the safety of the truck driver, placed him at significant risk.

Across Canada, the level of training required to be a firefighter is determined by each fire authority at the municipal level. In Manitoba, the training component specific to the transportation of bulk DG by rail is limited to 30 minutes. This training does not provide firefighters with sufficient appreciation for the complexities of a rail occurrence involving DG. Once the Hazardous Materials Awareness course is completed, there is no requirement for additional refresher training. Most volunteer fire services have implemented some form of ongoing training for standard firefighting. However, little time is spent on DG emergency response to a rail occurrence. Consequently, firefighters may not be adequately prepared for the potential risks posed by rail transportation of DG. The Board raised similar concerns in TSB reports R99T0256 and R01M0061.

2.12 Emergency Response Plans

Although the hazardous nature of the DG posed a risk to public safety to the degree that an evacuation was necessary, the toxicity and reactivity of the hydrocarbons were not considered significant enough to be listed in Schedule I of the TDG regulations. Since the train originated and would have terminated in Canada, and the DG products were not listed in Schedule I of the TDG regulations, neither the shipper nor CN was required to have an emergency response plan.

Similar to circumstances in TSB investigation R99H0010, the firefighters ran out of Class B foam while fighting the fire. Subsequently, the fire flared up, further delaying access to the site. An emergency response plan would have accelerated firefighting efforts by providing an inventory of the foam and equipment available in the region. Without an emergency response plan when dealing with DG, it is often difficult to ensure that immediate and appropriate action is taken.

2.13 *Transportation of Dangerous Goods Regulations*

The TDG regulations in force at the time required that there be five non-DG buffer cars placed behind the locomotives but in front of any DG cars. The train in this occurrence was marshalled in accordance with these regulations. This train had six covered hopper cars loaded with plastic pellets placed at the head end directly behind the locomotives, followed by five tank cars loaded with DG. During the derailment, the second car behind the locomotives (covered hopper) was penetrated diagonally by a large section of rail from the bottom of the car's B-end to the top of the A-end. The buffer cars provided an adequate measure of safety for the train crew.

New TDG (Clear Language) regulations came into effect on 15 August 2002, and the train marshalling requirements were modified to require only one buffer car to separate the locomotive from any DG cars located in the train. The change was based on consultants' reports on the subject of marshalling DG railway cars.

The CIGGT report concluded there was not sufficient evidence at that time to suggest that overall railway safety could be improved by modifying the existing regulations. Moreover, while recognizing that a five-car separation would reduce the risk of injury to crews in the event of a derailment, the report found that the magnitude of the reduction would be hard to quantify. It also noted that switching, required to meet train marshalling requirements of existing TDG regulations, is an extra activity that also has a risk of employee injury and equipment derailment. However, the report failed to quantify these implied additional risks. In addition, the report did not note that switching operations are a normal daily activity in the rail industry and that such operations are generally performed at low speed in a controlled movement of the train. At low speeds, both the risk of injury to operating crews and the consequences of a derailment involving DG are reduced when compared to a derailment occurring at or near track speed as a result of a head-end collision. In the event of a head-end collision, the removal of buffer cars based on the new TDG (Clear Language) regulations (2002) may increase the risk to train crews in cases where DG cars at the head end are breached.

3.0 *Conclusions*

3.1 *Findings as to Causes and Contributing Factors*

1. The accident occurred when the truck driver proceeded over the crossing without hearing the train whistle and without stopping at the stop sign or looking in both directions for approaching trains.
2. The train struck the truck and the train subsequently derailed. Rollover of the south rail was the derailment mechanism, with the point of derailment likely occurring on the south rail close to the east end of the crossing. Trailer debris encountered by the locomotives and the head-end cars as a result of the collision may have contributed to the rail rollover.
3. The truck driver had slept for only 30 minutes in the previous 19 hours. It is possible that fatigue affected the truck driver's ability to safely negotiate the crossing.

3.2 *Findings as to Risk*

1. In the absence of a system of company management overview to identify drivers who may be fatigued before they exceed the maximum hours of service, fatigued truck drivers may make inappropriate decisions, thereby increasing the risk of adverse consequences to themselves and the public.
2. The lack of a uniform application of advance warning signs on Canadian roadways, to warn drivers of their approach to passive railway crossings, increases the risk that drivers may not understand the level of attention required to safely negotiate the crossing.
3. Inadequate training material on railway crossing safety in most provincial professional driver training manuals increases the risk that professional drivers will remain unaware of the risks associated with negotiating heavy trucks over public passive railway crossings.
4. In the Province of Manitoba, the requirement for heavy trucks to keep at least 15 m (49 feet) away from the nearest rail when stopping at public passive crossings in a non-restricted speed area increases the risk that these drivers will not have adequate sight-lines from the stopping point.
5. The current method of calculating road gradient based on the "lay of the land" increases the risk that excessive gradients in the immediate vicinity of the public passive crossing will not be identified as a safety hazard for heavy vehicles.

6. Emergency response personnel may not be provided with sufficient training to be aware of the risks associated with the rail transportation of dangerous goods (DG). The lack of refresher training for DG emergency responders, specifically relating to rail DG accidents, increases the risk for serious consequences during the response.

3.3 *Other Findings*

1. In the event of a head-end collision with a vehicle at a crossing, insufficient protection and/or the location of the angle cock on the lead locomotive increases the risk of an angle cock valve failure. Such valve failures have been known to initiate an undesired emergency brake application from the head end of the train, and the resulting in-train buff forces can potentially cause a rail rollover, wheel climb, and/or wheel-lift derailment.
2. The five buffer cars required by the *Transportation of Dangerous Goods Regulations* (TDG regulations) in place at the time of the occurrence provided an adequate measure of safety for the train crew. The removal of four buffer cars in the new TDG (Clear Language) regulations (2002) may increase the risk to train crews in the event of a head-end collision resulting in derailment.

4.0 *Safety Action*

4.1 *Action Taken*

4.1.1 *Canadian National*

Canadian National (CN) met with the Rural Municipality (RM) of North Norfolk and reviewed the crossing conditions. Both agreed to remove potential obstructions to further improve the crossing sight-lines.

4.1.2 *Rural Municipality of North Norfolk*

The RM will reduce the roadway approach gradients to the crossing and erect advance warning signage on Forrestville Road, to warn of the presence of a rail crossing.

4.1.3 *Commercial Drivers Hours of Service Regulations*

The *Commercial Vehicle Drivers Hours of Service Regulations, 1994*, will be repealed and replaced with the *Commercial Vehicle Drivers Hours of Service Regulations*, published in Part I of the *Canada Gazette* on 15 February 2003. Transport Canada has been working with the provincial and territorial governments and other stakeholders to revise the rules that govern extra provincial truck and bus hours of service. It is anticipated that the proposed changes will be implemented, in conjunction with similar provincial regulations, in fall 2004. The main objective of the proposed regulations is to reduce the risk of fatigue-related commercial vehicle accidents by providing drivers with the opportunity to obtain additional rest.

The new regulations aim to reduce the complexity of the rules by reducing the number of cycles and eliminating the options to reduce off-duty time. Changes in the proposed regulations²⁴ include the following:

- increasing the minimum daily off-duty period by 25 per cent, from 8 hours to 10 hours;
- requiring that no fewer than eight of the hours of off-duty time be taken consecutively, with the additional two hours to be taken in increments of no less than one-half hour;
- reducing the daily maximum driving time by 18.8 per cent, from 16 hours to 13 hours;

²⁴ *Commercial Vehicle Drivers Hours of Service Regulations, Regulatory Impact Analysis Statement, Canada Gazette, Part I (February 2003), p. 485.*

- reducing the daily maximum on-duty time by 12.5 per cent, from 16 hours to 14 hours, of which no more than 13 hours can be driving time;
- eliminating the option to reduce the off-duty time from eight hours to four hours;
- increasing the minimum rest period for co-drivers using a sleeper berth, from two hours to four consecutive hours;
- permitting, within defined parameters, the averaging of on-duty and off-duty time over a 48-hour period;
- reducing the number of available work/rest cycles from three to two; a maximum 70-hour cycle over 7 days, and a maximum 120-hour cycle over 13 days;
- requiring, for drivers who wish to switch or reset cycles, a minimum of 36 consecutive hours off-duty before “resetting the clock to zero” for the 70-hour cycle and a minimum of 72 consecutive hours off-duty for the 120-hour cycle; and
- requiring a minimum 24-hour off-duty period at least once every 14 days for all drivers.

4.2 *Action Required*

4.2.1 *Driver Training Material*

The railway crossbuck sign is the primary defence for vehicles at public passive crossings. There is a common misconception among drivers that crossbuck signs are simply indicating the presence of a crossing, rather than also suggesting the possibility of an approaching train or a train occupying the crossing. This perception is further reinforced by a number of vehicle driver training manuals indicating that a railway crossbuck sign identifies the presence of a railway crossing.

In addition to the railway crossbuck sign, *Canadian Rail Operating Rules* (CROR) Rule 14 provides a secondary defence to warn the vehicle driver of a train’s approach. A train horn is to be sounded at least one-quarter mile from every public grade crossing until the crossing is fully occupied by the train. However, the 1998 National Transportation Safety Board (NTSB) train horn audibility study demonstrated that a train horn is virtually inaudible to a heavy truck from distances exceeding 100 feet and, consequently, does not provide a consistently effective defence to warn heavy-truck drivers of an approaching train.

Since the railway crossbuck sign is subject to misinterpretation, and considering that the train horn is an ineffective defence for heavy trucks, the key to public passive crossing safety for heavy trucks resides in driver education and awareness. In the U.S., an NTSB study concluded that the risks associated with passive grade crossings were not adequately addressed in driver education material. The study recommended that this training material be revised to include information on the risks associated with negotiating public passive railway crossings.

Increased awareness of rail crossing safety for professional drivers is a crucial step in minimizing the number of these crossing accidents involving heavy trucks. The TSB is of the opinion that an effort to increase truck driver awareness of the hazards involved at railway crossings could come from Direction 2006. This program, sponsored by Transport Canada (TC) and the Railway Association of Canada, is described as “. . . a partnership between all levels of government, railway companies, public safety organizations, police, unions and community groups whose objective is to reduce grade crossing collisions and trespassing incidents by 50 per cent by the year 2006.” As such, Direction 2006 is in an excellent position to involve the regulator, the provinces, and the trucking industry in an educational initiative to reduce accidents between trucks and trains. While Operation Lifesaver, a crossing awareness initiative by the railways and the regulator, has literature pertaining to the issue, it is not clear that the information is getting widespread distribution to professional drivers. Therefore, the Board recommends that:

The Department of Transport, in consultation with the provinces and the trucking industry, review and update, as necessary, educational and training material for drivers with respect to the risks associated with a heavy vehicle negotiating a public passive railway crossing.

R04-02

4.2.2 *Emergency Responder Training*

Railway personnel are not always the first on the scene of a train derailment involving dangerous goods (DG). Consequently, local emergency responders, including medical, police and fire service personnel, many of them volunteers, play a significant role in these responses across Canada, particularly in rural communities. These emergency responders are expected to initiate the critical steps of assessment and perimeter containment based on their knowledge and expertise. In this role, familiarity with rail equipment and the risks associated with the bulk transportation of DG is crucial.

In previous TSB accident investigation reports (R99T0256 and R01M0061), the Board raised the concern that emergency response personnel may not be provided with the training to be fully aware of and prepared for the risks associated with DG being transported by rail through their communities. Emergency first responders continue to place themselves at risk through inappropriate decisions with regard to the rail transportation of DG. The Board is concerned

that the lack of consistent training requirements to maintain emergency responder competencies, specific to rail DG accidents, increases the risk for adverse consequences to occur during a response. Therefore, the Board recommends that:

The Department of Transport, in consultation with other federal, provincial, and municipal agencies, implement consistent training requirements that ensure emergency first responders remain competent to respond to rail accidents involving dangerous goods.

R04-03

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board approved this report on 07 July 2004.

Visit the Transportation Safety Board of Canada Web site (www.tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There, you will also find links to other safety organizations and related sites.

Appendix A – Glossary

BPP	brake pipe pressure
C	Celsius
CDT	central daylight time
CFR	Code of Federal Regulations (U.S.)
CIGGT	Canadian Institute of Guided Ground Transport
cm	centimetre
CN	Canadian National
CROR	<i>Canadian Rail Operating Rules</i>
CTA	Canadian Trucking Alliance
CTC	Centralized Traffic Control System
CWR	continuous welded rail
DB	dynamic brake
dBA	decibel
DG	dangerous goods
EDR	event data recorder
ELS	Equivalent Level of Safety
ERG	<i>2000 Emergency Response Guidebook</i>
GE	General Electric
GM	General Motors
HTA	<i>Highway Traffic Act (Manitoba)</i>
IAP	Incident Action Plan
km	kilometre
km/h	kilometre per hour
m	metre
MEMO	Manitoba Emergency Measures Organization
mph	mile per hour
NFPA	National Fire Protection Association
NOTAM	Notice to Airmen
NSC	National Safety Code
NTSB	National Transportation Safety Board (U.S.)
OFC	Office of the Fire Commissioner of Manitoba
POD	point of derailment
PPE	personal protective equipment
psi	pound per square inch
RCMP	Royal Canadian Mounted Police
RM	Rural Municipality
RSA	<i>Railway Safety Act</i>
TAC	Transportation Association of Canada
TC	Transport Canada
TDG regulations	<i>Transportation of Dangerous Goods Regulations</i>

TSB	Transportation Safety Board of Canada
UDE	undesired emergency brake application
U.S.	United States
°	degree