Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R99S0100

CROSSING COLLISION/DERAILMENT

VIA RAIL CANADA INC.
PASSENGER TRAIN NO. 85
MILE 33.54, GODERICH-EXETER RAILWAY
(GEXR) GUELPH SUBDIVISION
LIMEHOUSE, ONTARIO
09 NOVEMBER 1999

Canada

Railway Investigation Report

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Synopsis

On 09 November 1999, at approximately 0900 eastern standard time, VIA Rail Canada Inc. passenger train No. 85, travelling westward on the main track of the Goderich Exeter Railway Guelph Subdivision, collided with a dump truck, heading north, on Fourth Line Road in the community of Limehouse, Ontario, in the region of Halton Hills.

Upon impact, the locomotive and four passenger coaches derailed to the north of the main track and west of Fourth Line Road. The derailed locomotive became disengaged from its trucks, rolled onto its side and rotated 180 degrees, eventually stopping 395 feet west of the crossing parallel to the main track. The dump truck was thrown westward 120 feet and catapulted southward approximately 33 feet. Fuel oil was spilled from both the locomotive and the dump truck fuel tanks, but did not ignite.

The locomotive and first coach behind the locomotive were extensively damaged. The three remaining coaches sustained only minor damage. Eleven passengers, two on-train service crew members and the two locomotive engineers sustained minor injuries. Two passengers were seriously injured. The dump truck was demolished; the driver sustained fatal injuries.

Ce rapport est également disponible en français.

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1.0 Other Factual Information

1.1 The Accident

At approximately 0900 eastern standard time (EST)[1] on 09 November 1999, VIA Rail Canada Inc. (VIA) westward passenger train No. 85 (VIA 85), consisting of one locomotive and four passenger coaches, derailed 15.3 miles east of Guelph, Ontario, after colliding with a dump truck on the Fourth Line Road public level crossing. The truck was observed to accelerate as it approached the crossing. It is not known whether the driver looked along the railway line as he approached the signals.

Locomotive event recorder data indicated that the train brakes were placed into emergency while the train was travelling at 63 mph. Impact occurred at approximately 60 mph, at which time the train derailed to the north, struck a large earth bank where the locomotive rolled onto its left-hand side, rotated 180 degrees and stopped 395 feet west of the crossing. By the time it came to rest, the locomotive had become completely detached from both of its trucks. Examination of the locomotive trucks and the locomotive undercarriage determined the truck side bearing clips had broken away from the locomotive undercarriage.

The first car behind the locomotive tracked westward, in the derailed position, until it became detached from the locomotive. It travelled in a west-southwest direction, stopping 362 feet west of the crossing, perpendicular to the track. The following three coaches tracked parallel with the main track, leaning at varying angles. The back end of the last car came to rest at a point 52 feet west of the crossing.

Figure 1 -Accident site, looking east to the crossing.

Figure 2 - Accident site, looking west from the crossing.

The dump truck, which weighed approximately 34 tons with its load, was dragged westward and thrown in a southwesterly direction. The frame and operating compartment of the truck came to rest upside down in a ditch, 120 feet south of the track and 33 feet west of the crossing. The dump box was ripped from the truck frame and propelled 63 feet west of the crossing and

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

15 feet south of the track. Parts of the truck were strewn on both sides of the track as far away as 234 feet from the crossing. Appendix A contains a site diagram showing approximate locations and measurements

1.2 Weather

At the time of the accident, weather conditions were observed as clear visibility, with light variable winds, a temperature of 10 degrees Celsius and no precipitation.

1.3 Train Information

VIA 85 was a westward passenger train, operating daily between Toronto, Ontario, and Chicago, Illinois, U.S., through the international border at Sarnia, Ontario. It consisted of a VIA locomotive and Amtrak stainless steel coaches, marshalled from front to rear as follows:

- Locomotive 6422
- Coach 34036 - Superliner bi-level coach
- Coach 34051 - Superliner bi-level coach
- Coach 34006 - Superliner bi-level coach
- Coach 35005 - Superliner bi-level combination coach / snack car

The operating crew of VIA 85 commenced duty at 0700 on 09 November 2000 and the service manager commenced duty at 0600. They readied the train for departure from Toronto Union Station, destined for Sarnia. At 0605, the VIA service manager inspected the coach interiors and determined that the temperature in lead coach 34036 was too warm. Due to this condition, and a light passenger load of 31 passengers, the decision was made to seat passengers in the third coach, Amtrak (AMT) 34006. Once pre-departure requirements were completed, the train departed Toronto at 0750.

1.3.1 Amtrak Stainless Steel Passenger Equipment

All coaches on VIA 85 were built in 1979-1980 for passenger train service in the United States and leased to VIA for use in service between Toronto and Chicago. The car bodies were constructed of welded carbon steel frames, covered with stainless steel sheeting, with an overall length of 85 feet and a height of 16 feet 2 inches. The gross weight of each coach was 148 000 pounds.

There were two types of passenger coach on VIA 85: three superliner bi-level passenger coaches, AMT 34000 series (see Appendix B), and one superliner bi-level coach / snack bar car, AMT 35000 series (see Appendix C). Plan and profile drawings of these series are found in appendices B and C respectively. The AMT 34000 series coaches seat 74 passengers—62 in the upper level and 12 in the lower level. The last two cars, coach and snack bar combination cars, were identical to the two leading coaches in every aspect in the upper level. However, in the lower level, the seating area was equipped with a food-serving area and limited seating consisting of four double seats.

Vestibules, measuring 9 feet 3 inches wide by 3 feet 9 inches deep, were located through the middle of the cars, with seats on either end. Passengers entrained and detrained through manually controlled hinged doors, 2 feet 9 inches wide by 6 feet 2 inches high, which opened into the vestibule area. There was a wheelchair-accessible washroom located just inside the vestibule, complete with hand rails, washbasin, toilet and baby change table. The hinged washroom door, 2 feet 6 inches wide by 6 feet 2 inches high, opened out into the vestibule area. There was a narrow corridor, 2 feet 5 inches wide, which led from the vestibule to the stairwell accessing the upper level and a luggage storage area. It was the only access into the 12-passenger seating area and wheelchair storage area. This area measured 3 feet wide by 5 feet 7 inches long, and could accommodate four wheelchairs. There was no apparent method of securing wheelchairs in this position. On the other side of the vestibule, a narrow corridor 2 feet 2 inches wide led into five small washrooms, each equipped with a washbasin and toilet. Doors of these washrooms are 1 foot 6 inches wide by 6 feet 3 inches high and open into the washroom. The upper level consisted of 31 double-occupancy seats.

1.3.2 Damage to Passenger Equipment

AMT coach 34036, the first (lead) car behind the locomotive, sustained major damage to the right (north) side. When the locomotive separated from its trucks, the lead car was dragged westward, striking the displaced locomotive trucks. Just east of the mid-section of the car, a large section of the stainless steel sheeting, measuring 6 feet 3 inches high by 20 feet 3 inches long, was torn away by the impact. The double-occupancy seats in this area were exposed to the outside, and the stairwell to the upper level seating was crushed. A large hole at the extreme east end of the car, measuring 6 feet 3 inches high by 11 feet long, destroyed the compartment housing electrical and plumbing controls for the operation of the car, and a window was ejected from the upper level. A total of 12 Z-type construction posts were destroyed along with approximately 35 feet of longitudinal channel beam. This coach eventually separated from the locomotive and came to rest across the main track, causing additional damage to the undercarriage.

Figures 3 & 4 - Damage to coach 34036

The second coach, AMT 34051, remained coupled to the lead car. The leading end of AMT 34051 was buckled inward where it had struck that car.

The five washrooms located on the lower level of this coach sustained substantial damage. The doors bent and buckled and the frames twisted, resulting in some doors being jammed partially open and others jammed shut. The doors that were jammed open into the narrow corridor restricted access to the washrooms. Washroom supplies and accessories were torn from their mountings and strewn about the washroom compartment.

The last two coaches sustained minor damage to the wheels and running gear.

1.3.3 Crashworthiness of Structural Design

As a result of several accidents, including this one, which involved damage to the sides of passenger cars, the TSB Engineering Laboratory produced a report, LP 110/2000, which examined the adequacy of crashworthiness of the structure of the sides of passenger cars.

The report noted that, to ensure adequate crashworthiness, passenger rail cars should:

- resist extreme structural deformation and separation of main structural members in order to ensure the survivability of occupants;
- protect against penetration of passenger compartments;
- protect occupants from being ejected from the occupied compartments; and
- protect occupants from secondary impacts within the occupied space.

Cars are constructed to design standards and regulations published by:

- the Association of American Railroads (AAR)—Standard S-034-69 "Specifications for the Construction of New Passenger Equipment Cars"
- the Federal Railroad Administration (FRA)—Regulation Part 238 "Passenger Equipment Safety Standards"
- the American Public Transit Association (APTA)—Standard SS-C&S-018-99 "Standard for Car Body Side Strength for Passenger Railway Equipment"
- specific railway companies may also impose additional requirements

In the case of the four accidents reviewed in TSB Engineering Laboratory Report LP 110/2000, external material had penetrated the passenger cabin, sliced through or crushed passenger seats and left large gashes or peeled the side sheathing away. The structural design did not protect against the magnitudes and types of loads that were experienced.

1.4 The Locomotive

VIA 85 was powered by a General Motors (GM) F40PH-2D locomotive, manufactured in September 1987 by GM Diesel of Canada. The locomotive is designed to operate with the short hood leading. It is a four-axle 3000 horsepower (HP), diesel-electric locomotive intended for passenger service.

1.4.1 Damage to Locomotive

Substantial mechanical damage was sustained by the undercarriage of the locomotive when the locomotive struck the bank and separated from its locomotive trucks. The damage included the severance of the axle generator connections required to monitor the train speed and other recorded functions. The impact also broke the bolts securing the side bearing clips to the bottom of the locomotive chassis, permitting the trucks to separate from the locomotive. Additional damage was sustained when the locomotive subsequently rolled onto its left side (north side) and rotated 180 degrees. Track road bed material partially filled the cab of the locomotive, causing additional damage.

1.4.2 Evacuation of the Locomotive

Before the locomotive came to rest, the two operating employees had been thrown from their seat and tossed about the cab. When all movement had stopped, the two locomotive engineers exited the locomotive through the small cab window on the locomotive right-hand side which was facing upwards. To exit the cab, the crew members had to climb over the locomotive control stand, pulling themselves through the window. Once on the outside, one of the locomotive engineers jumped down to the ground, and the other climbed down over the damaged locomotive.

1.5 Dump Truck Information

The 1975 International Paystar truck was registered to and owned by a local gravel haulage company, and had a valid Ontario Ministry of Transportation annual inspection certificate. The truck was powered by a six-cylinder, 270 HP, Cummins diesel engine. The rear hinged dump box body was made of aluminum with a gross vehicle weight rating (GVWR) of 56 080 pounds. A front axle modification had been made to allow a GVWR of 68 080 pounds.

1.5.1 Damage to Dump Truck

The impact destroyed the truck—the dump box, engine and front axle separated from the truck chassis. The truck frame was bent, broken and twisted, and the operating cab was heavily crushed and twisted.

1.5.2 Ministry of Transportation Post-Accident Inspection Results

An Ontario Ministry of Transportation inspection of the remains of the truck revealed the following:

- The front axle, suspension and steering assembly was separated from the vehicle at spring hanger-to-frame connections.

- The operating cab was separated from the vehicle chassis at the mounts.

- The engine was separated from the chassis assembly.

- The aluminum dump box was separated from the chassis frame.

- The right front corner of the box was torn away from the box.

- The brake lines, hoses and tubing forward the transmission were torn away or damaged.

- The fender and hood assemblies were missing.

An inspection of the brakes, springs and other mechanical systems was attempted; however, not all components could be tested because of the severe damage sustained. The components and systems that were able to be inspected were found to be within acceptable Ontario Ministry of Transportation requirements.

Inspection of the driver's log book indicated that a non-functioning signal light was the only entry made in the weeks preceding the accident.

1.5.3 Truck Design and Interference to Driver's View

Design standards for International Model 5070 Paystar trucks essentially remained unchanged from manufacturing years 1972 to 1995. Mechanical components, such as truck cabs, body panels, windshields, side door windows, are interchangeable on the basic model, and cab dimensions, visual sight lines, and side mirror location are identical.

The truck windshield has approximately 1390 square inches of glass in the forward viewing area. Windows in each of the doors have approximately 104 square inches of glass. The right-hand side mirror (the one that would have been used) is approximately 16 inches long by 7 inches wide set at an approximate 40-degree angle for optimum visual coverage, and covers an area of 16 inches by 4 inches or 64 square inches, more than half the viewing area of the side window from the position at which a driver is seated.

1.6 Occurrence Site Information

Figure 5 shows an aerial view of the site taken just after the accident. The area surrounding the occurrence site was primarily rural/residential with homes in three of the four quadrants. The southwest quadrant has a large earth bank obscuring an eastward train movement from 100 feet south of the crossing. A growth of trees, shrubs and other vegetation concealed a commercial gravel pit operation 360 feet south of the crossing. A grove of trees and shrubs stretched approximately 200 feet south along the east side of the roadway and 500 feet east along the railway tracks.

The southeast quadrant, which lay between the truck and VIA 85, had a number of private dwellings and buildings, large trees, decorative shrubs and other vegetation that partially obscured westward train movements from northbound drivers. More than 200 feet (60 m) south of the crossing, the sight line to the east was completely obstructed by buildings. At 200 feet (60 m), the sight line to the east was 760 feet (228 m). Closer than that, the trees and shrubs blocked the southeast quadrant sight line until 100 feet (30 m) from the crossing, where the sight line to the east was 150 feet (45 m). At 50 feet (15 m), the sight line to the east was 225 feet (67.5 m).

The northwest quadrant had a large earth berm approximately 6 feet (1.8 m) high, stretching westward for approximately 120 feet (36 m) where it met with a natural elevation in the land topography.

Figure 5- Aerial view of crossing looking south.

The northeast quadrant was clear of sight line obstructions.

There were hydro poles, trees and shrubs along the eastern side of the roadway, but they did not obstruct the view of the crossing signals by approaching northbound motorists. There was a clear view along the track for 1000 feet (300 m) to the east from the stop line at the crossing.

1.6.1 Crossing Description

The Fourth Line Road crossing intersects with the rail line at a 78-degree angle, with a 27-foot (8.1-m) asphalt surface. Three advance warning signs (AWS) were posted on both approaches to the crossing. Signals were located on both sides of the crossing with an audible bell on the north side. The approach from the south is straight. A four per cent ascending grade is encountered south of the crossing, and a one per cent ascending grade is encountered north of the crossing, until approximately 25 feet (7.5 m) north and south of the crossing, at which time the approach becomes level.

1.6.2 Crossing History

In July 1966, an application for upgraded crossing protection by the township authorities was made to the Board of Transport Commissioners (BTC). The BTC subsequently ordered the railway (at the time Canadian National [CN]) to upgrade the crossing protection from reflectorized crossing signs (crossbucks) to flashing light signals and a bell. The operation of the bell is intended to alert pedestrians of a train's approach.

In November 1982, the railway was granted permission by the Canadian Transport Commission, the BTC's successor agency, to remove and relocate the siding trackage in this area. This work required alteration of the existing crossing protection, by relocating the signals. At that time, there were four lamp units on the east mast which were aimed along Fourth Line Road to the south, as well as two lamp units on the west mast aimed to the south, but focused on a point closer to the crossing. This design philosophy is intended to provide good coverage for approaching motorists.

The track circuits for the crossing were of the direct current (DC) type, designed to provide a minimum warning time of 22 seconds to approaching highway vehicles of a train's approach. The design speed of the circuits was 70 mph. A train approaching at half that speed would provide twice as much time of operation of the signals, or 44 seconds. Most passenger trains operating over the crossing travelled at speeds ranging from 55 mph to 70 mph, and most freight trains operating over this crossing travelled at speeds ranging from 35 mph to 50 mph. VIA 85 was travelling at about 63 mph, which would have resulted in the signals operating for just over 24 seconds.

Before this accident, the last recorded crossing inspection by a Transport Canada (TC) officer was made in November 1983, at which time the crossing was reported to be in compliance with regulatory requirements. During the inspection, it was noted that a vehicle approaching from a northward direction would experience restricted sight lines in the northeast due to the topographical change in elevation and the heavy vegetation. Sight lines in the northwest had some restrictions due to private dwellings and vegetation along the roadway allowance.

Before this accident, and since 1980, TSB records indicate one previous accident, which occurred in July 1994, when the track was owned and operated by CN. An automobile was struck by a CN freight train and its two occupants were seriously injured.

Over the last 10 years, TSB records indicate that 63 crossing accidents have occurred involving heavy trucks at signalized crossings with and without automatic gates.

1.6.3 Post-Accident Description

Just west of the roadway centreline, two marks were observed on the paved crossing surface. The marks diverged from both the north and south rails, parallel to each other, in a west-to-northwesterly direction. The marks continued onto the track roadbed and into the adjacent land terminating at a large earth bank, 205 feet north of the tracks. The measured distance between these marks was consistent with the distance between locomotive wheels mounted on an axle.

1.7 Method of Train Control

Train movements on the Goderich-Exeter Railway (GEXR) Guelph Subdivision are governed by the Occupancy Control System (OCS) authorized by the Canadian Rail Operating Rules (CROR) and supervised by a rail traffic controller (RTC) located in Stellarton, Nova Scotia. Six passenger trains and four freight trains are scheduled on this line daily.

1.8 Personnel Information

The operating crew included two VIA locomotive engineers located in the locomotive cab. They were both qualified for their respective positions and met fitness and rest standards.

Two on-duty on-train service (OTS) employees were positioned in the coaches, attending to passenger needs. The service manager was a VIA employee and the snack car attendant was an AMT employee.

1.9 Truck Driver Information

The 22-year-old male truck driver had been hauling gravel from the quarry on Fourth Line Road for several months. He was in possession of a valid Ontario Class A driving permit. The driver was paid according to tonnage hauled, not by hourly rate.

The driver's activities over the previous 48 hours before the accident are not known. The toxicology report indicated no prohibited substances in his system. There was no indication of fatigue when he reported to work on the morning of the accident.

A witness indicated that the driver accelerated as he approached the crossing and did not make any attempt to stop before the collision.

1.10 Recorded Information

Event recorder data indicated that, at a recorded time of 0900:00, the train was proceeding at approximately 60 mph in throttle position No. 8 with the brakes released. The next significant recorded event was at 0900:30 when the train speed increased to 62 mph and the bell and whistle were activated. At 0900:43, the train speed was 63 mph, the emergency brake was initiated, the throttle was placed into the idle position, and a reduction of two pounds per square inch (psi) was made in the brake pipe pressure. At 0900:45, train speed decreased to 60 mph, brake cylinder pressure registered 41 pounds and the brake pipe pressure exhausted to 3 psi. Within one-tenth of a second, speed registered 0 mph. It is likely that this was the time when the axle generator connection required to monitor the train speed and other recorded functions was severed. It is most probable that impact occurred at this time. Further detail of the last 46 seconds of the train movement are shown in Appendix D.

1.11 Particulars of the Track

The Guelph Subdivision extending from Silver, Mile 30.0, to London, Mile 119.9, consists of a single main track, with an authorized timetable speed of 70 mph for passenger trains and 55 mph for freight trains. The track at the crossing was tangent, with an east-to-west ascending grade of one per cent.

The track consisted of 115-pound continuous welded rail manufactured and laid in 1975. Track components were in good condition and met TC's *Railway Track Safety Rules*.

1.11.1 Damage to the Track

As a result of the accident, approximately 300 feet of track was damaged, requiring 150 ties to be replaced and 250 feet of new rail to be installed. The fibre-optic lines on the north side of the track were also severed.

Soil and track roadbed, contaminated by leaking diesel fuel, was excavated and removed to a landfill site for disposal.

1.12 Particulars of the Roadway

Fourth Line Road was under the jurisdiction of the municipality of Halton Hills, situated in Limehouse, Ontario, in the regional municipality of Halton. The roadway consisted of two paved lanes and a two-foot sloped gravel shoulder on both sides of the road. The total road allowance is 66 feet. The posted operating speed was 80 km/h.

1.13 Regulatory Requirements

The *Railway Safety Act* of 1989, administered by TC, incorporated the *Railway-Highway Crossing at Grade Regulations* of the former Canadian Transport Commission, which specify criteria for design and construction of crossings.

1.13.1 Railway-Highway Crossing at Grade Regulations

The type of warning provided at a grade crossing is dependent upon road and rail traffic volumes and speeds, the types of vehicles and trains using it, recent accident history and its particular physical surroundings. The horizontal and vertical alignment of the road through the grade on the crossing approaches are also considered in the design of the warning system. There is a variety of automated warning systems which are typically installed at single-track crossings, the simplest being mast-mounted flashing lights and bell with DC track circuits. The most complex system is normally mast and cantilever-mounted flashing lights and bell, with alternating current, constant warning time, track circuits and automated half barriers (gates). The constant warning time circuits allow for a standard operating time of the signals, which is believed to enhance credibility of the system to highway drivers, because of the avoidance of excessive signal operation. Excessive operation is considered to occur after about 35 seconds and is considered to lead to a lack of signal credibility for highway users, with a subsequent disrespect for the signal indications when they operate. When warning times at a crossing exceed 40 seconds more than very occasionally, credibility is lost for a large number of drivers and violations increase sharply.[2]

1.13.2 Sight Line Requirements

Sight line requirements apply to all grade crossings: public, farm, private and those for the use of customers of the railway company. Sight lines are the lines of clear view for persons on a grade crossing or its road approaches and the grade crossing, its crossing warning signs, signals and for approaching trains where the crossing is not signalized. Part II, Section 8, of TC's draft crossing manual entitled *Road/Railway Grade Crossings—Technical Standard and Inspection, Testing, and Maintenance Requirements* states:

> Required sightlines along the railway and road rights of way, and over any other property must not be obstructed by:
>
> (i) signs, utility poles, other roadside installations;
> (ii) parked vehicles, buses stopped to load or unload passengers;
> (iii) trees, brush, crops, hedges or other vegetation, plowed snow, or stored equipment or materials; or

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2 S.H. Richards, R.A. Margiotta and G.A. Evans, *Warning Time Requirements at Railroad-Highway Grade Crossings with Active Traffic Control*, Report No. FHWA-SA-91-007, 1991.

(iv) a building, fence, or any other structure.

Road signs and utility poles along the road approaches, or poles along the railway right of way are not normally considered obstructions to sightlines between persons on the road and approaching trains. They are to be considered an obstruction when obscuring sightlines between persons on the road and crossing warning signs or signals.

Where signals are located at the crossing, the primary sight line requirement for approaching highway drivers is a clear view of the signals. Views along the track can offer secondary information to a highway driver approaching the crossing, such as the exact location of an approaching train.

1.13.3 Provincial Regulatory Requirements

The province of Ontario does not have specific sight line requirements enforceable under a provincial law. The province was however consulted by the federal regulator when the latest federal requirements were developed. The Ontario Ministry of Transportation adopted the federal requirements in its design manual. In the case of those signalized crossings in Ontario equipped with flashing light signals, provincial law permits a driver, after having stopped at a crossing where the signals are operating, to proceed if it is safe to do so. In the case of crossings equipped both with flashing light signals and with gates, the requirement is that the driver remain stopped until after the train's passage and subsequent raising of the gates.

1.14 Impact of Sight Line Obstructions

Appendix E shows calculations regarding the relative positions of the truck and the train as they approached the crossing. Observation of gravel truck drivers operating from the gravel pit to the south of the crossing (three drivers were observed) determined that an average of 29.3 seconds were needed to travel the 360 feet between the gravel pit access road and the crossing. The relative positions from the crossing, for the truck involved in this accident, were calculated using that information, with the non-critical assumption that acceleration from a stop was uniform over the 29.3-second period. Table 1 below contains the results of those calculations.

Table 1—Truck and train locations before the collision

Seconds to collision	Truck distance (feet)	Train distance (feet)	Visual field location (degrees)
24	346	2208	92.9
23	340	2116	92.7
22	334	2024	92.4
21	328	1932	92.1
20	320	1840	91.9
19	312	1748	91.6
18	302	1656	91.3
17	292	1564	91.1
16	282	1472	90.8
15	270	1380	90.5
14	258	1288	90.3
13	244	1196	90.0
12	230	1104	89.7
11	216	1012	89.5
10	200	920	89.2
9	184	828	88.9
8	166	736	88.7
7	148	644	88.4
6	130	552	88.4
5	110	460	87.9
4	90	368	87.6
3	68	276	87.3
2	46	184	87.1
1	24	92	86.8

Referring to the table above, sight lines are blocked until 200 feet (60 m) from the crossing, when the driver (10 seconds from collision) would have been able to see 760 feet (228 m) down the track. At that time, the train was 920 feet (276 m) down the track, and hidden from the driver's view by buildings. As the driver moved closer to the track, his view down the track became blocked by trees and heavy shrubs. When he was 100 feet (30 m) and about 5 seconds from the crossing, he would have been able to see 150 feet (45 m) down the track but would not have seen the train, which was more than 400 feet (120 m) from the crossing. When he was 50 feet (30 m) and about 2 seconds from the crossing, he had a view 225 feet (67.5 m) down the track. At that time, the train was about 200 feet (60 m) down the track and had just emerged into the driver's view from behind the trees and heavy shrubs. However, the crew did not see the driver look toward the train.

1.15 Passenger Safety

In July 2001, Railway Safety Advisory 05/01 was sent to TC and VIA, outlining passenger safety issues as identified from five ongoing investigations, including this particular one. The advisory appended a report with observations on common, relatively minor safety issues which, when aggregated, gave some indication of a possible risk to the travelling public. The following information offers more detail in some specific areas related to this accident.

1.15.1 Passenger Seating and Restraints

Several passengers were thrown from their seats after the collision with the truck. They were projected through the coaches, striking either seats, other passengers or train service equipment. Passenger coach seats are not equipped with personal restraint systems to keep passengers in their seats during emergency stopping or accident situations. Most of the minor injuries experienced by passengers and OTS crew resulted from these secondary types of impacts.

The G forces (deceleration) experienced by passengers and OTS crew from the forces exerted by emergency braking, the impact with a large highway vehicle and the resulting lateral motion of the coaches as they derailed caused some seats to involuntarily pivot. The seats are designed to be turned by disengaging a locking mechanism at the floor and pivoting seats. When partially pivoted, seats reduce the width of the centre aisle between the two rows of seats by approximately eight inches. Partially pivoted seats restrict access to emergency exit windows and egress between the two rows of seats. A number of leg rests separated from their seats and became projectiles, other leg rests were involuntarily extended outward and jammed against the seat ahead. This condition created another source of potential injury and impeded access to the emergency windows.

1.15.2 Carry-on Baggage and Heavy Items

Overhead luggage racks above the seats are designed to accommodate smaller pieces of carry-on baggage, while larger items were to be stored in a large compartment in the lower level at the entrance to the downstairs seating area. These designated luggage storage areas were not equipped with restraint mechanisms to hold luggage in place. In this accident, one person reported baggage falling from the overhead luggage compartment, injuring her right arm. Others reported objects from both the overhead luggage rack and the larger storage compartment being thrown around the coach.

Numerous pieces of safety equipment are stored in different locations throughout the coaches and in various containers. A large steel box, approximately 34 inches by 11 inches by 7 inches and weighing approximately 47 pounds, used to contain emergency tools, safety items and other maintenance items, was stored on the floor between the last rows of seats and the wall of the baggage compartment area. There was no method of securing this box in its designated storage area and it was found in the aisle approximately four feet away from its designated storage between two rows of seats.

Two large blue plastic boxes used to store safety items, such as flashlights, first-aid kits, megaphones and other safety-related items, were stored in the first car behind the locomotive and the other in the second last car. These boxes were located on one of the shelves in the large baggage compartment of the coaches. There was no method of securing these boxes in place. One of these boxes was thrown into the designated wheelchair area of the coach.

1.15.3 Train Service Equipment/Supplies

Train service equipment and supplies include such items as food stuffs, cleaning supplies, beverages, and the equipment used for dispensing, preparing or storage of these items. Numerous pre-packaged foods and a variety of canned and bottled soft drinks were stored on open shelves. Larger items such as cases of soft drinks, boxes of silverware, plates and other utensils were piled two and three boxes high in various locations both in the seating and serving areas. Other items, including steel storage containers, plastic storage bins and coffee urns, were also stored throughout the serving and seating area. There was no means of securing items in place or preventing them from becoming projectiles in an accident situation.

1.15.4 Emergency Equipment and Supplies

Emergency equipment and supplies include items such as fire extinguishers, first-aid kits, multi-trauma kits, emergency blankets and flashlights, and megaphones. Signage on the interior wall of the coaches aided in locating the extinguisher and the small first-aid kits. However, items were kept in various coloured, unlabelled containers stored in the open baggage compartments and on the floor behind passenger seats. Due to the larger sizes of these items, they could not be placed with the readily identified items, like the extinguisher and small first-aid kits. Items stored in the locked compartments are secured with a unique locking system requiring a small round tool to be inserted into a hole in the door frame, commonly called a pencil latch. The tool is inserted into the hole and inward pressure is applied while the door is opened with an outward pressure.

1.15.5 Safety Information Instructions/Signage

Emergency information cards are intended to be available to each passenger. They contain safety-critical information. Information cards were not available to every passenger at their seat and the location of emergency equipment was not included on the information cards.

Emergency signage regarding the location of some equipment, such as fire extinguishers and first-aid kits, was conspicuous; however, identification of other equipment was not displayed. There were no signage or instructions describing the operation of the doors that provided security and securement for the extinguisher and first-aid kits. There was non-luminescent emergency signage indicating the location of emergency exit windows, making it ineffective in a dark or smoke-filled environment.

1.15.6 Transportation of Passengers with Disabilities

A designated area for passengers travelling in wheelchairs was provided. In these bi-level coaches, there was no means to secure wheelchairs to the car. A ramp located in the coaches to evacuate wheelchair passengers was in an area adjacent to the narrow corridor, secured with bungee cords. In one coach, the ramp had slid out of its storage area, blocking the aisle. The ramps, when put into place at the doorway, have two brackets that are inserted into slots in the doorway threshold to secure them in place. These brackets were misaligned, permitting only partial insertion into the securement slots.

A wheelchair-accessible washroom, located on the lower level of the bi-level coaches, was configured so that, when the main emergency exit door was secured in the open position, it would block the door to the wheelchair-accessible washroom thereby trapping any occupant of the washroom. It was impossible to open the washroom door when the exit door was locked in the open position. The lock on this door was a coach key lock with keys available to only crew members.

1.16 Injuries

The truck driver was fatally injured, having multiple skull fractures and upper body and chest injuries.

Both locomotive engineers, the OTS service manager and snack car attendant sustained minor bruises.

Eleven of the 31 passengers received minor injuries and were treated at hospital. Two passengers were seriously injured. One was released and the other was admitted for observation. Some other passengers had previously been treated at the accident site by ambulance attendants and released.

1.17 Passenger Evacuation

1.17.1 VIA On-train Service (OTS) and Operating Crew

The decision to order the evacuation of the passengers is normally made by a locomotive engineer. Immediately after the collision, the VIA service manager, located in coach 34006, had made several attempts to contact the locomotive engineers with her radio, but was unsuccessful. The service manager had herself received minor injuries when thrown from her seat. When she realized that a collision had occurred and was unable to contact the locomotive engineers by radio, she placed a call to the VIA operations centre, on her cellular phone, for instruction and advice.

She subsequently set out to determine the condition of the passengers. One of the locomotive engineers, upon extricating himself from the overturned locomotive, entered derailed coach 34006 and immediately ordered all passengers to move to coach 35005 due to the strong odour of diesel fuel present in coach 34006. Within minutes, he was joined by the second locomotive engineer and both assisted in the movement of injured passengers into the last coach. Had the aisle or stairwell been completely blocked, it would have required anyone in the upper levels to evacuate through the emergency exit windows. Exit from the upper level windows would have required evacuees to drop 15 feet (4.5 m) to the ground below, providing the ground below was level. Lead coach AMT 34036 came to rest across the roadbed, making the drop from the emergency exit windows in excess of 18 feet (5.4 m), into wreckage and debris.

1.17.2 First Responders

The first responders included the local police, ambulance service, fire department, and employees from CN, GEXR and VIA. The local police, with the assistance of the fire department, upon arrival at the scene, started evacuating passengers from the north side of the last coach (35005) into arriving buses and vans for transport to the local police station and hospitals. The ambulance service attendants administered first-aid to those passengers requiring immediate attention and transported the most seriously injured passengers to the local hospitals. The police conducted an inspection of the full train to determine that all people on board had been removed from the train.

1.18 Post-Accident Handling of Passengers

Once passengers and crew members were evacuated from the train, ambulance attendants performed an evaluation to determine the nature and extent of the injuries. Those not injured were transported by bus to the local police station where on-duty police officers took statements. Others who showed signs and symptoms of injury or trauma were taken by ambulance or van to local hospitals for examination and further treatment.

1.19 Canadian Requirements for International Passenger Equipment

TC’s regulatory approach regarding non-Canadian equipment operating into Canada is that, unless specifically exempted by the Minister, all equipment shall adhere to the applicable rail safety rules and regulations.

1.20 Railway Passenger Car Inspection and Safety Rules

The *Railway Passenger Car Inspection and Safety Rules* were approved by TC on 25 June 1997. They prescribe the minimum safety standards for passenger cars operated by railway companies at speeds not exceeding 125 mph subject to the jurisdiction of the *Railway Safety Act* as administered by TC. At the time of the accident, the *Passenger Handling Safety Rules* developed by the Railway Association of Canada (RAC) had been submitted but not yet approved by the Minister of Transport. These latter rules outline the procedures and emergency equipment needed for safe management of passengers in the event of an accident or need for evacuation. They received ministerial approval on 31 March 2000. The rules were subsequently amended on 08 November 2001.

For equipment ordered before 01 April 2001, every passenger car that operates over public highway crossings and uses the same trackage as freight trains was to be designed and constructed in accordance with the AAR *Manual of Standards and Recommended Practices* or to an equivalent standard. This provides for safe operation and for the protection of passengers, operating crews, and property from accidents caused by functional failure of car equipment. Each railway company that operates or hosts passenger train service would be required to file passenger car inspection and safety rules and seek approval of these rules. These rules take into account current railway practices, safety plans, training, inspections, passenger awareness programs, emergency procedures, evacuation and safety equipment requirements. The RAC, on behalf of its member railways operating in Canada under federal jurisdiction, submitted and gained approval of the required rules. The amended rules included a clause whereby, after 01 April 2001, any new equipment would be designed and constructed in accordance with APTA standards and recommended practices, or equivalent.

2.0 Analysis

2.1 Introduction

VIA 85 was operated in accordance with company operating instructions and government safety standards. The method of train operation played no role in this occurrence.

This collision and subsequent derailment was the 67th where a VIA passenger train was involved in a collision or derailment since 1990 and which was investigated by the Board. The low incidence of death and serious injury sustained by train passengers in these accidents are notable, considering the potential forces exerted on a train as a result of impacts with heavy highway vehicles, or a collision with other rail equipment, and a derailment sequence, where passenger equipment derails and may roll over. In some cases, the injuries incurred were most probably a result of the lack of securement of carry-on baggage and items of mass, or the lack of personal restraints; however, these injuries are not easy to identify.

The train collided with the 34-ton dump truck at a public level crossing equipped with activated automatic warning devices and advance warning signs. The automatic warning devices at the crossing functioned as designed. The driver would have been in a position to see the signals activate about six seconds after he turned onto the highway, as there were six lamp units flashing to alert him to the approaching train. Additionally, the train whistle was being sounded for 27 seconds before occupying the crossing. Nevertheless, the driver continued into the path of the train, accelerating for the 30-second period preceding the collision.

The analysis will address crossing warning systems, the behaviour of highway drivers, equipment crashworthiness and passenger safety.

2.2 Driver Behaviour

2.2.1 Driver Expectancies

Driver expectancy regarding the appearance and speed of trains at crossings is the factor that most strongly affects the likelihood of a decision-making error. Furthermore, the likelihood of error detection and recovery is reduced by the tendency of drivers not to look for trains if they are familiar with the crossing, if warning credibility is low, and if train frequency is low.[3] Drivers are also less likely to look if sight lines are obstructed.[4]

At the Fourth Line Road crossing, a driver was 3 1/2 times more likely to be delayed by a freight train than by a passenger train. Although more passenger trains (6) than freight trains (4) are scheduled over the crossing daily, a passenger train travelling at 65 mph would have activated the signals for a total of 26 seconds, whereas a 100-car freight train travelling at 35 mph would have activated them for 144 seconds. Therefore, a driver seeing the crossing signals activate would likely have expected a freight train to arrive at the crossing about 40 to

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3 N. Lerner, D. Ratte and J. Walker, *Driver Behaviour at Rail-Highway Crossings*, Report No. FHWA-SA-90-008, 1990.

4 L. Aberg, “Driver behaviour at flashing-light, rail-highway crossings”, *Accident Analysis & Prevention*, vol. 20(1), 1988, 59-65.

44 seconds later. If the occurrence driver saw the signals activate about six seconds after he entered the highway (about 24 seconds before he reached the crossing), he may therefore have expected the approaching train to arrive at the crossing about 16 to 20 seconds after he had crossed the tracks himself. His observation of the signal onset, combined with his overestimation of warning time, may have led him to expect that clearance time was adequate, and that there was no need to look for the approaching train.

2.2.2 Visibility of the Train

As the driver left the gravel pit and made his way north toward the crossing, sight lines were partially obstructed by buildings and vegetation. The right-hand side mirror reduced the available viewing area of the passenger-side window by approximately 40 per cent. Because the crossing angle is 78 degrees, the train was at about 87 degrees to 93 degrees in the driver's peripheral visual field, where it was likely to be behind the mirror, the rear of the passenger-side door or the truck cab, when it was not behind external sight line obstructions. It is therefore highly probable that, if the driver did check for an approaching train after leaving the gravel pit, it would not have been in view.

2.2.3 Driver Decision Making

Most drivers who cross despite active crossing protection believe that their decision to cross is rational, given that no train is in sight, or that it is too distant to pose a risk.[5] The most common reason given to justify violating an active signal is that "the train was not in sight."[6] The incorrect conclusion is drawn that the train is out of sight due to its distance from the crossing, whereas the correct conclusion would be that its location and arrival time are unknown and crossing risk is high. Indeed, crossing protection is often installed to mitigate poor crossing sight lines.

Several other motivational forces also influence driver decision making at rail crossings. Drivers of commercial vehicles paid by tonnage hauled will ascribe a higher cost to delays at a crossing than drivers paid by the hour. Overestimation of delay time (54 per cent of drivers estimate that a train will delay them by over five minutes[7]) will further increase the likelihood of a crossing violation. Finally, the low risk of police enforcement at rail crossings means that drivers perceive the cost of ignoring the signal to be low.

The driver proceeded across the level crossing without slowing, despite the active crossing protection, likely under the strong expectancy that the approaching train was a freight train and that he had at least a margin of safety of 16 to 20 seconds. He very probably did not see the approaching train until just before he entered the crossing, if he saw it at all.

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5 Operation Lifesaver, "Grade-Crossing Safety", *Traffic Safety*, March/April 1993.

6 J. Abraham, T.K. Datta and S. Datta, "Driver behaviour at Rail-highway crossings", *Transportation Research Record* 1648, 1998, 34.

7 R.G. Mortimer, "Human factors in highway-railroad grade crossing accidents", *Accident Reconstruction Journal*, vol. 5(2), 1993, 26-35.

2.3 View of Crossing Warning System

Visibility through a truck windshield and side windows should, optimally, present a driver with a good view, both to the front and to the sides of the vehicle. The installation of the right-hand side mirror reduced the viewing area through the side window to approximately 60 per cent. The buildings, homes and shrubs as well as the reduced visibility through the side window, would have substantially affected his ability to see an approaching train as he made his approach toward the crossing from the pit entrance. However, the presence of the flashing light signals did provide a clear warning of the approach of a train as the view through the front windshield was unobstructed.

2.4 Crashworthiness and Damaged Equipment

Heavy post-accident damage to the coaches resulted in deformation of the car body and upper deck stairwell, which heavily impeded egress from the washrooms and upper seating area. The side sheathing and structural side post of AMT 34036 were extensively damaged when the coach struck the detached locomotive trucks, tearing a large hole in the side sheathing. The cars are designed to resist an inward transverse load; however, the loads experienced were in excess of the design requirement.

The forces involved in this accident were not studied, nor was the energy absorbed by the coaches determined. However, the forces were of sufficient energy to cause extensive internal damage to the first two coaches.

2.5 Passenger Safety

In the aftermath of an accident, the effectiveness of an evacuation and success of the first responders are dependent upon a number of fundamental requirements, such as appropriate training, proper equipment, and effective communication. All passengers and crew members were handled promptly and effectively by the first responders.

The emergency response and rescue in this accident were carried out with no significant problem. However, a number of issues were identified which could enhance emergency response procedures and passenger safety.

2.5.1 Seating and Restraints

Numerous passenger seats rotated during the accident. Examination of these seats determined that the locking mechanisms used to secure the seats in their appropriate location had not failed. It was therefore concluded that these seats were not locked into the appropriate position and rotated upon impact.

Several passengers sustained minor injuries as a result of being thrown from their seats and receiving secondary impact with seats and other equipment stored in the passenger car. Had the seating been equipped with personal restraint systems and had they been used, injuries to passengers from secondary impacts due to their being thrown from their seats would have been reduc1ed.

2.5.2 Carry-on Baggage, Supplies and Heavy Items of Mass

A number of areas throughout the passenger car are designated to store carry-on baggage. Numerous pieces of safety equipment, in various size containers, are stored throughout a passenger car. These items were not secured, thereby allowing them to be thrown from their designated storage area, blocking egress routes and striking passengers. Additionally, train service equipment and supplies stored in various areas in the serving and seating area of the combination coach and snack car had no means of securement, allowing these items to become projectiles.

2.5.3 Emergency Equipment and Instructions

The location and use of the safety equipment, such as fire extinguishers and small first-aid kits, is readily identifiable by the appropriate information signage. Other items, such as trauma kits, tools and assistive devices stored in plastic containers, had no signage indicating their location, while other items were stored in cabinets equipped with pencil locks, with no instructions on how to open the door or operate the equipment contained within. Without instruction on the operation of or the appropriate tool for unlocking the cabinets, it is unlikely that passenger or emergency responders could open the locked cabinets.

2.5.4 Transportation of Passengers with Disabilities

Barrier-free access to passengers with disabilities on passenger trains requires the provision of easy egress, and accessibility to services and security in seating during train movement. A wheelchair-accessible washroom on the lower level was configured so that, when the passenger coach exit door was in the open position, such as during evacuation, this door could not be opened. When this door was locked from the inside, the door was secured with a coach style lock mechanism that required a specific key to open the door .

In the event that crew members were incapacitated, other passengers would have no way of unlocking this door, and no instructions were available advising passengers to obtain assistance of a crew member to open the door.

A portion of the lower level reserved for passengers with wheelchairs was located directly across from the storage area for carry-on baggage. The carry-on baggage had no means of securement, allowing items stored in this area to be thrown into the wheelchair-designated area during an accident. There was no means of securing wheelchairs in this position during transit.

2.5.5 Passenger Evacuation

The impact damaged the coach stairs, which impeded egress from the upper deck of the bi-level passenger coaches. Had the damage prevented egress down the stairs, the passengers on the upper deck would have had to exit through the emergency exit windows. This would have involved a drop to the ground of approximately 15 feet (4.5 m), with a resultant high probability of passenger injury.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. Despite warnings provided by both the crossing signals and the train whistle signal, the driver continued ahead into the path of the train.

2. The side visibility through the truck side windows was partially obstructed by the roof pillar and side mirror, and the view of the approaching train was additionally obstructed by the presence of shrubs and buildings in the southeast quadrant of the crossing.

3. There was extensive damage to the lead coach of the train, both to the interior and to the exterior. The loads experienced by the passenger car were in excess of its transverse load design specifications.

4. The driver would have had a clear, unobstructed view of the crossing lights, well in advance of the crossing.

3.2 Other Findings

1. Because of the lack of any restraint systems, baggage and passengers were thrown around the coaches.

2. Passengers and emergency responders had difficulty finding emergency equipment because of the lack of signage identifying their locations.

3. Without a proper tool, it is unlikely that passengers and emergency responders could have unlocked locked wheelchair-accessible washroom doors or cabinets used to store emergency equipment.

4. The wheelchair-accessible washroom on the lower level of the car is configured in a manner that would trap occupants in the washroom during an emergency evacuation.

5. The impact damaged the coach stairs, which impeded egress from the upper deck of the bi-level passenger coaches. Had the damage prevented egress down the stairs, the passengers on the upper deck would have had to exit through the emergency exit windows, dropping approximately 15 feet (4.5 m) to the ground.

4.0 Safety Action

4.1 Action Taken

On 04 April 2001, the TSB forwarded Rail Safety Advisory 02/01 to Transport Canada (TC), indicating that the side walls of some passenger cars do not provide sufficient protection during a lateral impact, and can result in serious or fatal injuries to occupants. TC responded that the issue has subsequently been raised with the U.S. Federal Railroad Administration (FRA). The FRA has been discussing this concern and continues to discuss it with the American Public Transit Association (APTA). Work is also underway with the Railway Association of Canada (RAC) to incorporate the latest APTA standards, by reference, into the *Railway Passenger Car Inspection and Safety Rules*.

On 25 April 2001, the crossing signal protection was enhanced by the addition of automatic gates and constant warning time track circuitry.

Rail Safety Advisory 05/01 to TC, referred to in section 1.15, related to a comprehensive overview of passenger safety issues identified during the investigation of five passenger train derailments. On 20 July 2001, TC indicated that discussions had commenced with VIA Rail Canada Inc. (VIA) to confirm action taken, underway, or proposed, related to these issues.

TC has prepared an amendment to Canada Motor Vehicle Safety Standard 111 that will allow the required reflected field of view to be fulfilled with smaller rearview mirrors that present less direct view obstructions, and it is presently awaiting approval. Other activities associated with direct view obstruction criteria problems, which include a survey of drivers, has a project commencement date targeted for this fiscal year.

On 04 July 2002 TC issued a Notice to VIA Rail under Section 31 of the *Railway Safety Act* regarding baggage restraints, advising that VIA Rail had failed to fulfill its commitment to apply cargo netting to all coach luggage areas. VIA Rail is implementing an action plan that will address this safety concern with the work scheduled for completion by April 2003.

VIA Rail has advised TC that all emergency equipment, such as trauma kits, blanket kits, is now properly identified with different coloured flourescent bands.

Amtrak and VIA Rail have restricted the stainless steel superliner equipment for use in Canada. The Heritage and AM Fleet 2 equipment, which does not present the problem of locked wheelchair-accessible washrooms, has now been introduced to this service.

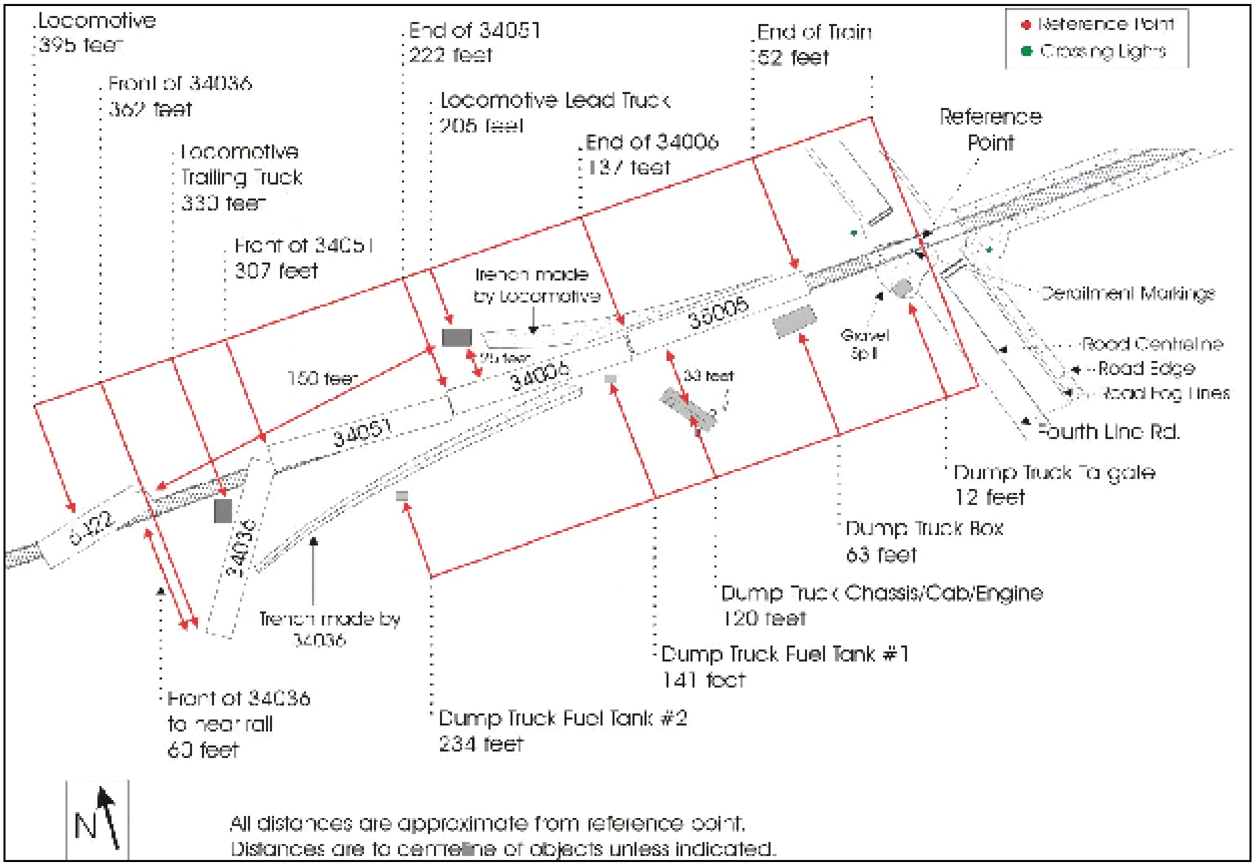
The FRA expressed TC and FRA's combined concerns with the ATAP at a meeting held in fall 2002, concerning the sidewall strength of passenger coaches.

VIA Rail has taken action in several areas, such as safety equipment upgrades, emergency lighting upgrades, emergency window locations, procedural changes and passenger safety briefings. Discussions between TC and VIA Rail concerning action in other areas is ongoing.

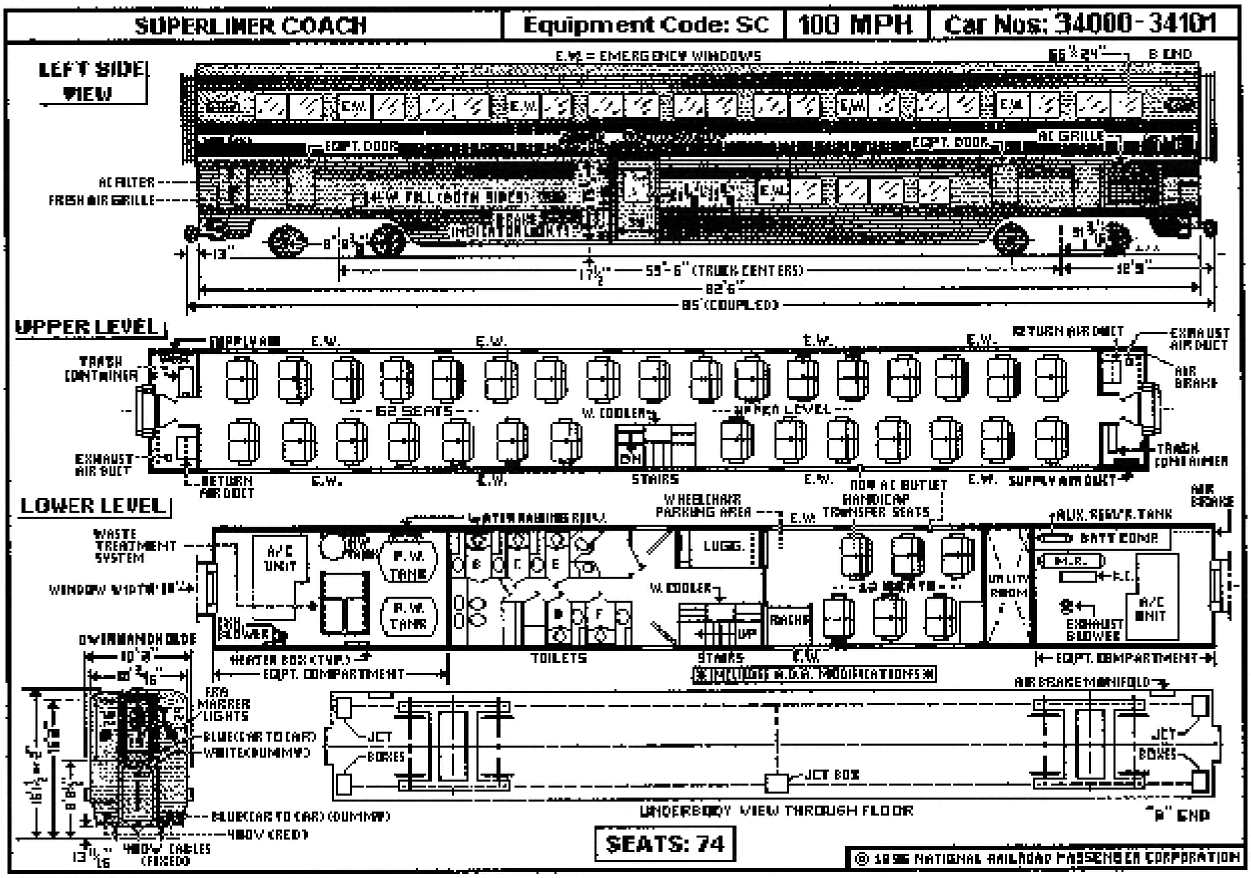
VIA Rail has completed the identification of areas, on the roof of their passenger cars, where emergency responders can get access to the occupied coach seating/sleeping areas.

This report concludes the TSB's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 December 2002.

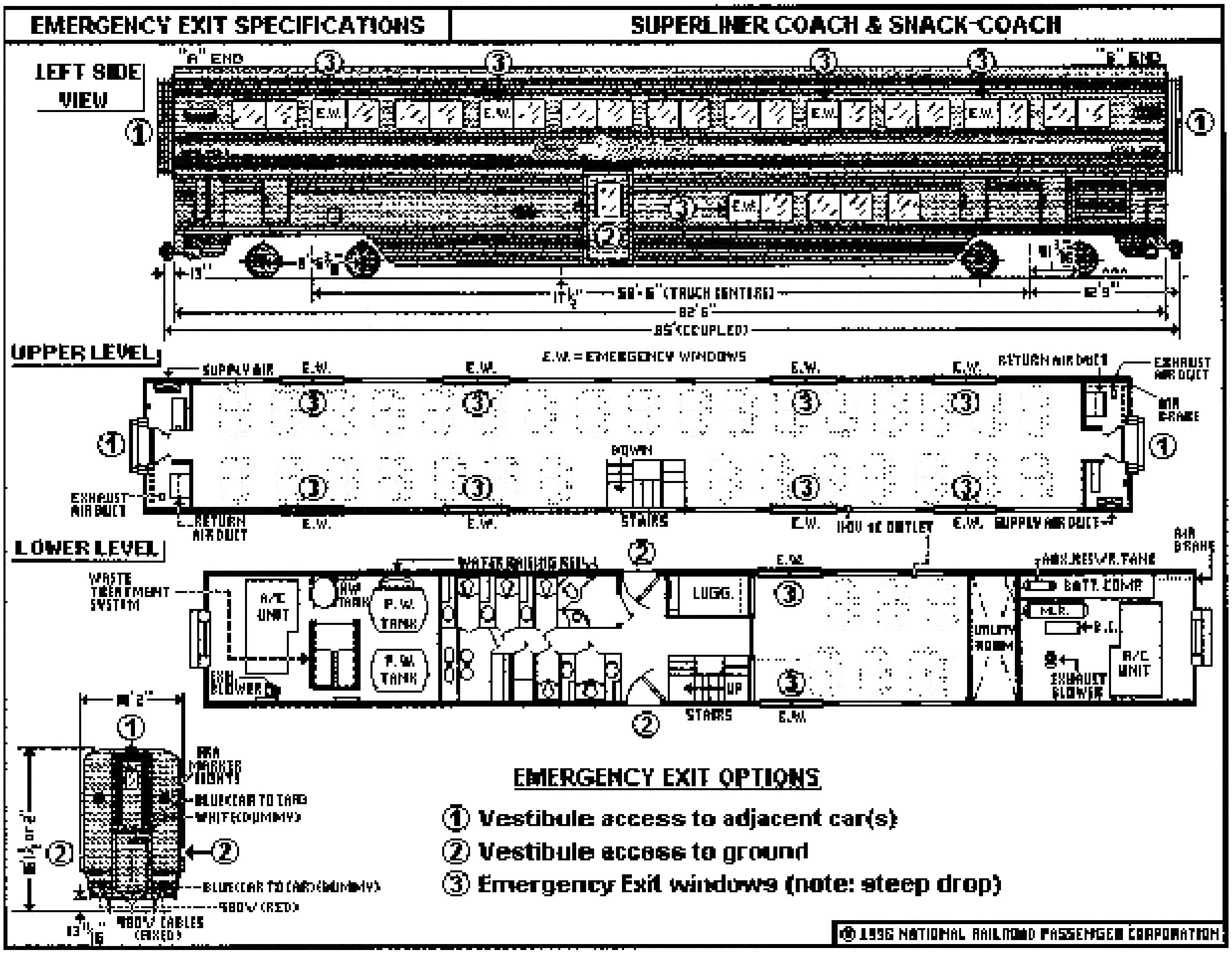
Appendix A—Diagram of Accident Site



Appendix B—Profile Drawing for AMT 34000 Series Cars



Appendix C—Profile Drawing for AMT 35000 Series Cars



Appendix D—Event Recorder Data

The following is a summary of the last 46 seconds of event recorder data for locomotive 6422 on 09 November 1999:

TIME	SPEED	BRAKE CYLINDER PRESSURE	BRAKE PIPE PRESSURE	THROTTLE POSITION	BELL ACTIVATED	WHISTLE ACTIVATED	EMERGENCY BRAKE INITIATED	COMMENTS
0900:00	60	0	106	8	NO	NO	NO	
0900:30	62	0	106	8	YES	YES	NO	BLOWING FOR CROSSING AT 1/4 MILE POST
0900:43	62	0	104	1	YES	YES	NO	INITIAL APPLICATION OF BRAKE
0900:43.3	62	0	104	IDLE	YES	YES	YES	EMERGENCY BRAKE INITIATED
0900:43.5	62	0	97	IDLE	YES	YES	YES	
0900:43.9	63	1	58	IDLE	YES	YES	YES	BRAKE CYLINDER PRESSURE INCREASING
0900:44.6	63	9	17	IDLE	YES	YES	YES	
0900:44.7	60	13	8	IDLE	YES	YES	YES	
0900:45.6	60	41	3	IDLE	YES	YES	YES	IMPACT OCCURS
0900:45:7	0	43	2	IDLE	YES	YES	YES	AXLE GENERATOR CONNECTION SEVERED

Appendix E—Calculation of Truck and Train Positions, and Train Location in Driver's Visual Field

The following data and calculations were used to determine truck and train distances before the collision, and the position of the train in the truck driver's visual field as he accelerated toward the crossing. The truck entered the roadway from a standing stop (i.e., Vi = 0) 360 feet from the crossing. The train approached the crossing at a constant velocity of 63 mph. The crossing angle was 78 degrees, as shown in the diagram below. Two simplifying assumptions are made: first, that truck acceleration was constant, and second, that train velocity was constant (although the train had actually slowed to 60 mph under emergency braking when the collision occurred). These assumptions affect the calculations by a few feet at most.

The train and truck distances from the crossing for the 24 seconds preceding the collision were calculated from the known train speed and the derived truck acceleration respectively, as shown below.

Train distance (D_{train}) is the product of time to collision (ttc) and train speed (63 mph or 92 feet/second), or:

$$D_{train} = V * ttc$$

Truck distance (D_{truck}) is the total distance (360 feet) minus the distance travelled since the truck entered the roadway. $D = Vi * t + ½ at^2$, but Vi = 0, so $d = ½ at^2$. Therefore, the distance travelled is equal to one-half the square of the product of truck acceleration (0.839 ft/sec^2, as derived below) and the time since the truck entered the roadway, or:

$$D_{truck} = 360 \text{ ft} - ½ (0.839 \text{ ft/sec}^2 * (29.3 \text{ sec.} - ttc)^2)$$

For example, when ttc = 15 sec:

$$D_{train} = 92 \text{ ft/sec} * 15 \text{ sec}$$
$$= 1380 \text{ ft}$$

and

$$D_{truck} = 360 \text{ ft} - ½ (0.839 \text{ ft/sec}^2 * (29.3 \text{ sec} - 15 \text{ sec})^2)$$
$$= 360 \text{ ft} - ½ (0.839 \text{ ft/sec}^2 * 204.5 \text{ sec}^2)$$
$$= 274 \text{ ft}$$

Measured truck time to crossing (3 observations, observer unseen)

trial 1	28.2 sec
trial 2	30.8 sec
trial 3	28.9 sec
average	29.3 sec

Acceleration calculation (assuming constant acceleration)

$d = \frac{1}{2} at^2$

$360 = \frac{1}{2} a * 858.5 \text{ sec}^2$

solve for a:

$a = 720 \text{ ft}/858.5 \text{ sec}^2$

$= 0.839 \text{ ft/sec}^2$

Additional information

$\sin 12^\circ = 0.2079$, $\cos 12^\circ = 0.9781$

Collision geometry diagram and calculations

Truck and train distances from the crossing determine the train's location in the driver's visual field, as shown in the diagram and final formula below.

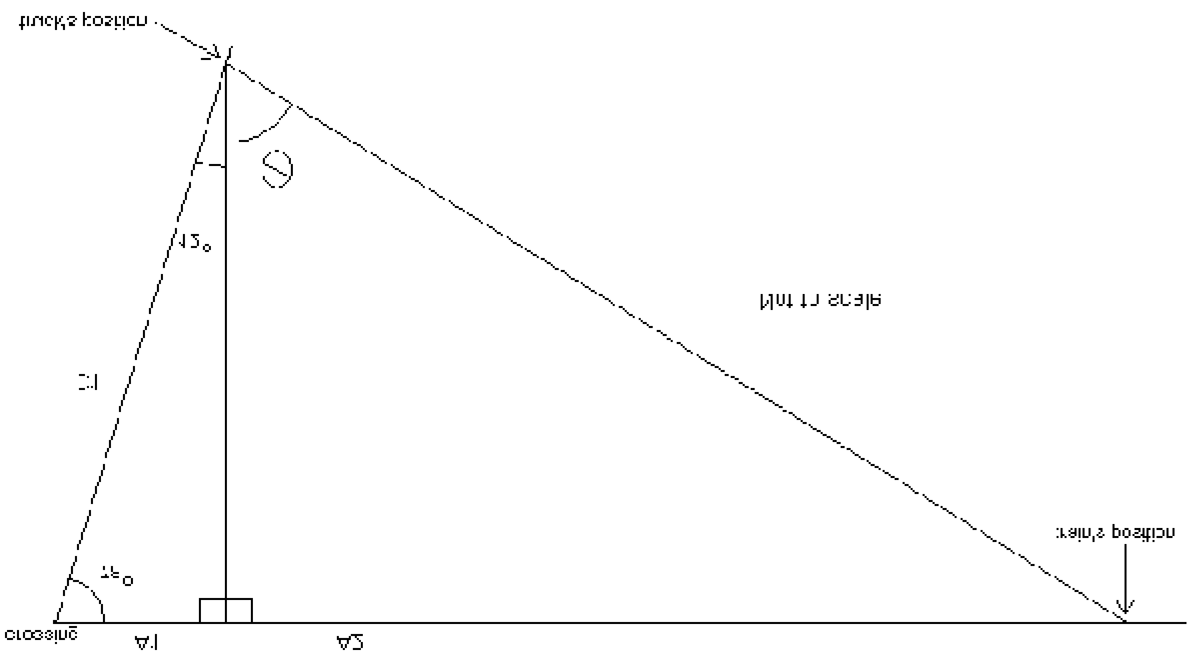
Let $A1 + A2 = D_{train}$

Let $C1 = D_{truck}$

$$\tan\varnothing = \frac{A1 + A2 - (C1 * \sin 12^\circ)}{C1 * \cos 12^\circ}$$

Therefore, the train's position in the driver's field of view is $12^\circ + \varnothing$, or:

$$12^\circ + \tan^{-1} \frac{(D_{train} - D_{truck} * \sin 12^\circ)}{D_{truck} * \cos 12^\circ}$$



Appendix F—Glossary

AAR	Association of American Railroads
AMT	Amtrak (National Railroad Passenger Corporation)
APTA	American Public Transit Association
AWS	advance warning sign
BTC	Board of Transport Commissioners
CN	Canadian National
CROR	Canadian Rail Operating Rules
DC	direct current
EST	eastern standard time
FRA	Federal Railroad Administration
ft	foot
ft/sec	feet per second
GEXR	Goderich-Exeter Railway
GM	General Motors
GVWR	gross vehicle weight rating
HP	horsepower
km/h	kilometre per hour
mph	mile per hour
OCS	Occupancy Control System
OTS	on-train service
psi	pound per square inch
RAC	Railway Association of Canada
RTC	rail traffic controller
sec	second
TC	Transport Canada
TSB	Transportation Safety Board of Canada
ttc	time to collision
U.S.	United States
UTC	Coordinated Universal Time
VIA	VIA Rail Canada Inc.