Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAIL TRANSPORTATION SAFETY INVESTIGATION REPORT R18T0006

CROSSING COLLISION

Canadian National Railway Company
Freight train Q14891-08
Mile 77.66, Dundas Subdivision
London, Ontario
09 January 2018

Canada

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 3 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

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.

Citation

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Summary

On 09 January 2018, at about 0940 Eastern Standard Time, Canadian National Railway Company freight train Q14891-08, proceeding eastward on the Dundas Subdivision, struck a snowplow on the sidewalk at the Colborne Street public crossing at Mile 77.66 in London, Ontario. The crossing was equipped with flashing light signals, a bell, and gates. The lone occupant of the snowplow was fatally injured.

1.0 FACTUAL INFORMATION

1.1 The accident

On 08 January 2018, at about 1900,[1] Canadian National Railway Company (CN) freight train Q14891-08 (the train) departed Chicago, Illinois, U.S., destined for Montréal, Quebec (Figure 1). The train entered Canada at Sarnia, Ontario (Mile 57.2 of the Strathroy Subdivision), and travelled eastward to London, Ontario, where the Strathroy Subdivision joins the Dundas Subdivision. The train continued eastward on the south main track of the Dundas Subdivision.

The train comprised 2 head-end locomotives and 30 cars totalling 80 platforms. The train weighed approximately 4645 tons and was about 5015 feet in length. The lead locomotive (CN 5605) was a General Motors SD70i model locomotive with a 3-flute horn installed. The trailing locomotive (CREX 1520) was a General Electric ES44AC model locomotive. The train

[1] All times are Eastern Standard Time.

crew, consisting of a locomotive engineer and a conductor, were familiar with the territory and met fitness and rest standards.

Figure 1. Occurrence location (Source: Railway Association of Canada, Canadian Rail Atlas, with TSB annotations)

On 09 January 2018, at about 0940, as the train approached the Colborne Street public crossing (Mile 77.66) in London, the train crew observed a snowplow travelling slowly northward toward the crossing while clearing snow from the sidewalk. Travelling onto the crossing, the snowplow continued to clear snow. The locomotive engineer sounded the locomotive whistle to alert the snowplow operator to the oncoming train. When it became apparent that the snowplow would not be clear of the crossing before the train reached it, the locomotive engineer initiated an emergency brake application. However, the train was not able to stop before the crossing and struck the snowplow. In the seconds leading up to impact, the snowplow operator did not look toward the train. As a result of the collision, the lone occupant of the snowplow was fatally injured. The snowplow was destroyed. The train and the track were not damaged.

1.2 Site examination

The head end of the train came to rest about 2200 feet east of the crossing. The snowplow came to rest about 250 feet east of the crossing on the south side of the south main track. The snowplow operator was thrown from the snowplow. The blower from the snowplow came to rest north of the south main track.

There was a cellphone in the snowplow operator's shirt pocket, with earphones attached. One earphone speaker was in the operator's ear. The phone appeared to be undamaged. No

music-playing application was open, and no music was heard coming from the earphones. The cell phone and earphones were sent to the Transportation Safety Board of Canada (TSB) laboratory for further examination.

1.3 Weather

As reported by the Government of Canada weather station in London, the temperature at the time of the occurrence was −4 °C, with the wind blowing at about 12 km/h from the west. Visibility was approximately 9 km.

In the 2 days preceding the occurrence, snow had been falling, beginning at 1500 on 07 January 2018 and continuing until 1200 on 08 January 2018. About 11 cm of snow had accumulated on the ground.

1.4 Recorded information

1.4.1 Locomotive event recorder

The locomotive event recorder download was examined. It was determined that

- while approaching the crossing, the train was travelling at about 44 mph with the train brakes released and the throttle in idle;
- the train horn was sounded almost continuously for 19 seconds leading up to the crossing; and
- the train brakes were applied in emergency before the train reached the crossing.

1.4.2 Signal bungalow download

The download from the signal bungalow was examined. It was determined that

- the bell and lights began to operate about 29 seconds before the train occupied the crossing;
- the gates began to descend 4 seconds later, and it took 13 seconds for all 3 gates to descend fully; and
- the train occupied the crossing about 12 seconds later.

1.4.3 Security camera recording

A security camera recording was retrieved from a nearby office building and sent to the TSB Engineering Laboratory for examination. The following was determined:

- The snowplow approached the Colborne Street public crossing on the east sidewalk from the south while clearing snow with the blower (Figure 2).
- The snowplow approached the crossing while travelling at a speed that varied between 2.6 km/h and 7.3 km/h.
- The snowplow was adjacent to the crossing warning system mast and gate when the lights on the grade crossing warning devices (GCWDs) began to operate.
- The snowplow was about 4.6 m beyond the crossing mast when the gates began to descend.

- The snowplow continued onto the crossing while travelling at about 1.4 km/h and continued to blow snow.

Figure 2. Movement of the snowplow as it approached the Colborne Street public crossing (Source: Google Earth, with TSB annotations)

Position marked on Figure 1	Video time	Activity	Train's approximate speed between positions (km/h [mph])	Snowplow blowing snow
1	0938:06	Snowplow proceeding north along Colborne Street	6.0 (3.7)	Yes
2	0938:09	Snowplow stops. Snowplow starts at 0938:20	6.8 (4.2)	Yes
3	0938:21	Snowplow stops. Snowplow starts at 0938:24	7.3 (4.5)	Yes
4	0938:29	Snowplow stops and reverses	3.6 (2.2)	No
5	0938:41	Snowplow stops reversing. Snowplow starts forward at 0938:42	2.9 (1.8)	Yes
6	0939:02	Snowplow stops and reverses slightly. Snowplow starts forward at 0939:05	2.6 (1.6)	Yes
7	0939:34	Lights on raised warning gate begin to flash	4.1 (2.5)	Yes
8	0939:38	Gates begin to descend	1.4 (0.9)	Yes
9	0939:49 0930:49–0939:56	Gates are fully lowered Snowplow changes throw angle of blower	1.0 (0.6)	Yes, with adjustments
10	0940:05	Train collides with snowplow		

1.4.4 Cellphone analysis

The cellphone and earphones recovered from the accident site were examined. The cellphone battery was discharged when it was received at the TSB Engineering Laboratory but the phone was undamaged. One of the earphone speakers was detached from the wire and was missing.

It could not be determined whether the phone had been playing music at the time of the occurrence. The media-playing volume was set at one sixteenth of the total volume. The text message audio alert level was set to nine sixteenths of the total volume. No phone calls or text messages had been received or transmitted during the time leading up to the occurrence.

1.5 Subdivision information

The Dundas Subdivision consists of double main tracks, extending from Mile 0.0 (Bayview Station near Burlington, Ontario) to Mile 78.2 (London). The track is classified as Class 4 track according to the Transport Canada–approved *Rules Respecting Track Safety*. Train movements on this subdivision are governed by the centralized traffic control method of train control, as authorized by the *Canadian Rail Operating Rules* (CROR), and supervised by

a rail traffic controller located in Toronto, Ontario. Train traffic consists of about 28 trains per day.

In the vicinity of the crossing, the Dundas Subdivision is oriented in an east–west direction. The timetable speed is 60 mph for freight trains and 70 mph for passenger trains. Between Mile 77.5 and Mile 78.2, there is a permanent slow order of 50 mph for freight trains and passenger trains.

1.6 Crossing information

At the Colborne Street public crossing, road traffic on both the north approach and the south approach is protected with flashing light signals (some on cantilevered structures), a bell, standard reflectorized crossing signs, and gates (Figure 3). The gate at the north approach is installed at the roadside and extends across 2 lanes of traffic. The south approach has 2 gates, with 1 gate installed on the boulevard in the middle of the roadway extending across 1 lane of traffic, and 1 gate installed at the roadside extending across the other lane of traffic.

In all 4 quadrants, there is a sidewalk approach to the crossing. There are no gates to specifically protect pedestrians at this crossing. The crossing surfaces between the sidewalks are paved with asphalt extending at least to the outside edge of the sidewalks, and are in compliance with Part B of the Transport Canada (TC) *Grade Crossings Standards*.

Figure 3. Colborne Street public crossing, looking north (Source: TSB)

Each crossing approach is equipped with 10 light signals. There are 6 front lights facing the traffic for the lane being protected: 4 front lights on the cantilever structure and 2 front lights on the warning system mast. There are 4 back lights facing the oncoming traffic in the opposing lane: 2 back lights on the cantilever and 2 back lights on the mast. Each light is equipped with light-emitting diodes.

The alignment of the lights is tested monthly. Following the occurrence, the light alignment was tested. No adjustments were required.

At the crossing, there are 4 sets of railway tracks. There is a sign on each crossing mast informing vehicle drivers of the number of tracks. The southern-most track was not in use, as the rail on each side of the roadway had been removed. The next 2 tracks are the south main track and the north main track of the Dundas Subdivision. The most northerly track is a yard track.

The crossing was designated as an anti-whistling crossing.[2] The clearance distance[3] for the crossing was 85 feet. The amount of warning time provided by the GCWDs was designed in

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2 At anti-whistling crossings, railway movements are not required to sound their horns in advance of the crossing, per Rule 14(l) of the *Canadian Rail Operating Rules*.

3 The clearance distance is the distance that the crossing design vehicle travels to go from a position 2 m in front of the gate to clearing the last rail by 2.4 m.

accordance with subsection 12(1) of the *Highway Crossings Protective Devices Regulations*, which were in force at the time of installation in 1997. Signals were required to be active 25 seconds prior to a train entering the crossing. This time included the distance that the designated design vehicle must travel to be clear of the 4 sets of tracks.

These regulations were repealed when the new *Grade Crossings Regulations* and *Grade Crossings Standards* came into effect in 2014. The new regulations and standards refer to Part 3 of the 2013[4] AREMA (American Railway Engineering and Maintenance-of-Way Association) *Communications and Signals Manual of Recommended Practices* when determining signal warning times at crossings. Part 3.3.10, which provides instructions on determining warning times, indicates that the total warning time is the sum of the minimum time (20 seconds), the greater of the clearance time[5] and the exit gate clearance time,[6] and the buffer time.[7] In this occurrence, with the snowplow travelling at about 1.5 km/h, it would have taken about 62 seconds to travel over the 85-foot clearance distance.

1.7 Regulatory inspection and assessment

Following the occurrence, TC inspected the crossing and noted no regulatory infractions. TC identified the following concerns:

- the crossing design plan conditions;[8]
- the distance from the south crossing warning system mast to the southern-most operational track;
- the audibility of the bell by pedestrians; and
- the visibility of the warning signals once a pedestrian is past the visible cone of the existing front warning lights.

TC also identified a concern when work such as snow removal on the crossing was being conducted without procedures or practices in place to ensure adequate situational knowledge to work safely. In February 2018, TC issued a Letter of Concern to the City of London (the City) on this issue.

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4 The *Grade Crossings Standards* were amended on 01 January 2019 to reference the 2014 edition of the AREMA *Communications and Signals Manual of Recommended Practices*. The amendment came into force on 01 March 2019.

5 The clearance time is determined by adding 1 second for every 10 feet that the minimum track clearance distance exceeds 35 feet.

6 For 4-quadrant gate systems, the exit gate clearance time is the amount of time provided to delay the descent of the exit gate arm(s) after the entrance gate arm(s) begin to descend and is determined in accordance with the U.S. Department of Transportation Federal Highway Administration's *Manual on Uniform Traffic Control Devices*.

7 The buffer time is discretionary and may be provided to accommodate minor variations in train handling.

8 The plans are not dated or signed to indicate when changes were made. The data recorder label for the recording of the "Gate Control" output is listed as "TEST SWITC" in the event recorder logs.

1.8 Risk ranking of crossings

Each year, TC ranks all provincially and federally regulated grade crossings based on their level of risk. The risk is determined based on a number of factors, including

- number of rail occurrences at the crossing;
- volume of road and railway traffic;
- maximum train and vehicle speeds;
- number of tracks and lanes;
- urban or rural environment; and
- warning systems in place at the crossing (such as gates, bells, lights).

The risk-ranking methodology does not consider sightline visibility, crossing gradient, crossing angle, or proximity to nearby intersections.

According to the risk ranking compiled in April 2017, out of 23 464 crossings in Canada, the Colborne Street public crossing had the 312th-highest level of risk. On the Dundas Subdivision, 3 other crossings in the vicinity of the Colborne Street public crossing had higher risk rankings. In the 2018 risk rankings, the Colborne Street public crossing's assessment of risk included this occurrence. Based on the updated risk assessment, the crossing had the 36th-highest level of risk.

1.9 Responsibility for snow clearing at crossings

The physical maintenance of a crossing is a shared responsibility between the railway and the road authority. Each year, CN issues letters to road authorities that provide guidance on performing snow-clearing operations in the vicinity of a crossing, and had issued a letter to the City before the 2017–2018 winter season.

1.10 Snow-clearing operations for the City of London

To keep the road and sidewalk surfaces clear of snow and ice, the City employed a team of maintenance personnel, who were trained and qualified to perform their assigned duties. The City had also arranged contracts with private snow-clearing companies to supplement its core snow-clearing services.

When snow clearing was required, the City employees were the first to be dispatched to begin clearing the main roads and sidewalks. If needed, the contractor companies were then called to help clear the secondary roads and sidewalks. If the snowfall was heavy, the contractors could be called in sooner.

To manage the snow-clearing effort, the City was divided into 4 districts. Each district was subdivided into beats.[9] District supervisors had a team of City employees and a list of contractor companies dedicated to clearing snow from the beats in their district. The contractors were typically assigned to specific beats.

In 2015, the City initiated a contract-tendering process for snow-clearing companies with the mandate to help perform the work of plowing/sanding on sidewalks and at bus stops.[10] The period of the contract was 6 years. The tender contained the specific terms and conditions for the potential bidders, including the following:

> **General Conditions, Instructions & Information for Bidders**
>
> […]
>
> **21. Sub-Contracts**
>
> The Successful Bidder shall not, without the written consent of the City, make any assignment or sub-contract for the provision of any goods or services hereby bid on. […]
>
> **3-0 Requirements at Time of Execution**
>
> […]
>
> 3-4 **Safety Policies and Procedures and Related Documentation**
>
> […]
>
> a) Their written health and safety policy and program where required under Section 25 (2) (j) of the Occupational Health and Safety Act. […]
>
> **5-0 Terms & Conditions**
>
> […]
>
> 5-9 **Equipment Operators**
>
> […]
>
> d) The successful bidder will provide a copy of their snow plow training documents, along with a list of trained operators. […]
>
> 5-15 **Successful Bidder's Responsibilities**
>
> […]
>
> d) The successful bidder must ensure all equipment operators have at a minimum an Ontario Class "G" drivers license and provide a copy upon request by the City.[11]

9 A beat is a geographical grouping of roads. Each beat represents the approximate amount of work that a single snow-clearing operator can complete in one 12-hour shift.

10 The Corporation of the City of London, Purchasing and Supply, Specification Number 975-66-04 (05 May 2015).

11 The Corporation of the City of London, Tender 15-19: Winter Maintenance Equipment with Operators – Sidewalk Snow Plows/Sander Unit.

In conjunction with Tender 15-19, the City issued a Purchasing and Specification document that identified additional requirements for the successful bidder, including the following:

> **2.0 Equipment Operators**
>
> a) The successful bidder's operator shall be qualified to drive the sidewalk snow plow/sander unit being supplied by the successful bidder. […]
>
> **7.0 Conditions of Employment**
>
> a) All operators must be in possession of a valid driver's license.
>
> b) The successful bidder will provide the Manager of Operations – Roadsides with the following on or before November 15th, of each year (on forms supplied by the City):
>
> A written list stating the operators(s) proper names and telephone numbers. Additional operators MAY NOT BE USED without the approval of the Managing Director of Environmental & Engineering Services & Engineering Services & City Engineer/designate. […]
>
> **8.0 Hours of Work Restrictions**
>
> […]
>
> c) The successful bidder […] will […] be responsible for training of his operators.[12]

1.11 Jackson Pools Inc. and Wee Bee Contracting

Jackson Pools Inc. (Jackson Pools) operated a pool installation and maintenance service business in the summer and a snow-clearing service in the winter. In the winter, Jackson Pools had 5 part-time employees, including 3 employees for clearing snow. Jackson Pools owned 3 Bobcat skid-steer loaders, 2 of which were outfitted with attachments for snow clearing.

In 2015, Jackson Pools participated in the City's tendering process for a contract to clear snow from sidewalks. Jackson Pools was successful and was awarded a 6-year contract to supply 3 snowplows and operators to clear snow from sidewalks in 3 beats. Only 1 of its snowplows was allocated to the City's contract. The other 2 snowplows allocated to the contract were supplied by Wee Bee Contracting (Wee Bee), along with the operators, through a verbal agreement with Jackson Pools.

Wee Bee operated flea markets in the summer and provided snow-clearing services in the winter. The company owned 2 Bobcat S130 skid-steer loaders,[13] both outfitted for snow-clearing operations (Figure 4). Each of these snowplows was equipped with either a blade or a blower, a cab, and meshing on the side windows. To fulfill its obligation to Jackson Pools, Wee Bee employed 4 snowplow operators.

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12 The Corporation of the City of London, Purchasing and Supply, Specification Number 975-66-04 (05 May 2015).

13 The Ministry of Transportation of Ontario stated in correspondence with the TSB that the occurrence snowplow is considered a "road building machine," and as such does not require a licence to operate.

Figure 4. Bobcat S130 skid-steer loader equipped with a blower (Source: TSB)

When the City required Jackson Pools' snow-clearing services, it called Jackson Pools, which would in turn contact Wee Bee. Although the City would at times communicate with Wee Bee directly, it was unaware that Wee Bee employees were not Jackson Pools employees. A list of qualified Wee Bee or Jackson Pools employees, including proof of their valid driver's licences, had not been provided to the City.

1.12 Training for snowplow operators

All new City employees undergo a 3-day classroom corporate orientation program along with any practical driver training required for their position. The corporate orientation program covered general orientation training, health and safety training, and a driver development program.

The driver development program consisted of classroom training and practical driver training to ensure that all drivers of City vehicles, including sidewalk snowplows, had the proper licences and were adequately trained for the work. Employees' attendance at these courses was tracked and monitored. Refresher training and recertification programs were offered to employees as needed.

The practical driver training consisted of up to 40 hours of in-seat time to master the operation of up to 9 different machines. Snowplow operators were typically drawn from a pool of experienced full-time City employees. These employees often did not require additional practical driver training. To ensure that the training program was complete, the City also conducted risk assessments on individual tasks, including sidewalk plowing and sanding.

The driver development program came with a manual. The manual addressed railway crossings, stating that

> 15. 2 All railroad crossings must always be treated with extreme caution. Driver should follow this procedure:
>
> a) Slow to a speed that, in the event a train is approaching or the crossing signal is activated, will allow the vehicle or equipment to be safely brought to a stop no closer than 5 meters (15 feet) from the nearest track; and
>
> b) The driver shall check in both directions while approaching the track(s).[14]

The driver development program also covered a document entitled *Employee Rules and Regulations*. Section 8 of that document addressed the driver's conduct at a railway crossing:

> A very hazardous situation can occur if snow or ice is deposited on a railway track or against railway gate-arms resulting in the gates not being able to drop. City snow plows and graders must not plow across railway tracks.[15]

The driver development program also covered "Tips for Snow Plow Operators," developed by Operation Lifesaver.[16] This document provided guidance on the use of flag persons at crossings; how to deal with emergency situations; the use of snow, salt, and chemicals at crossings; and how to approach crossings. The document also provided strategies to operators of roadway snow-clearing vehicles relating to crossing the tracks safely, including these:

> - Ensure it is safe to cross the tracks by looking both ways. Open windows/doors and turn off radios or fans so as to see and hear better […];
> - Raise the plow blade and wing or other attachments high enough to clear the tracks and signals;
> - To avoid stalling, use a gear which will let you cross the tracks without shifting; […]
> - After you have started over the tracks, if the crossing lights begin to flash ***KEEP GOING***. It is safer to continue forward than to reverse.[17]

Sidewalk snowplow operators who were City employees were taught to lift their blades or blowers to the top notch (more than 12 inches above the roadway when crossing railway tracks).

In 2015, when the snow-clearing contracts were awarded, the City met with all the contractors to discuss the City's performance expectations and the administration of the contract. After the contracts began, meetings between the City and the contractors were ad hoc. No safety meetings were held to discuss safe operating practices specifically. The

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14 City of London, *Driver Development Program* (May 2017), Section 15.0 Railroad Crossings, p. 9.

15 City of London, Environmental Services Department, Outside Works Division, *Employee Rules and Regulations* (April 1996), Section 8.03 Railway Crossing Snowplowing, p. 28.

16 Operation Lifesaver is a railway industry group dedicated to promoting safety around railway infrastructure.

17 Operation Lifesaver, "Tips for Snow Plow Operators" [pamphlet].

City offered no formal training programs to its snow-clearing contractors or to the employees of their contractors, nor did it give them the CN guidance letter on snow clearing.

Neither Jackson Pools nor Wee Bee provided a formal training program to their employees. Any instructions to snowplow operators were given through informal communication. Jackson Pools did not provide the City with any documents relating to a training program for snowplow operators.

Through informal communication with the City, or through previous experience, some employees at Jackson Pools and Wee Bee were aware of the requirement to raise the snowplow blade or blower and not to apply sand or salt over crossings. They raised the blade to a height where it would not damage the track. Some snow-clearing contractor companies advised their operators to raise the blade just to a height that would not damage the track when travelling over crossings, while other companies advised their operators to raise their blade above the snow. Neither Jackson Pools nor Wee Bee had been aware of Operation Lifesaver.

1.13 The snowplow operator

The snowplow operator had worked for Jackson Pools from September 2017 to December 2017 as a seasonal construction worker. During that period, he was trained in the operation of Bobcat S130 model vehicles. He had operated various off-road vehicles and equipment for at least 5 years.[18]

Starting in December 2017, he was employed by Wee Bee to clear snow from sidewalks, which was a new job for him.

On 15 December 2017, the snowplow operator worked his first shift clearing snow. During that shift, he cleared snow from sidewalks on Beat 1, which included the Colborne Street public crossing. At the time of the occurrence, the snowplow operator was working his 5th shift that involved clearing snow from sidewalks. During the 3 previous shifts, he had been assigned to Beat 16, which included some railway crossings. Although Wee Bee had given the snowplow operator informal training on operating the snowplow, he had not received specific training or advice on how to cross a railway crossing safely in a snowplow.

On the morning of 08 January 2018, the snowplow operator woke up at about 1115 and remained awake for the rest of the day. At about 2040, he received a call from Wee Bee informing him that he would be working that night. The snowplow operator was picked up at about 2230 and began his shift shortly afterward. When not working, the snowplow operator typically went to bed between midnight and 0600 and would wake up in the morning or early afternoon. He had not worked during the 2 days preceding the occurrence.

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[18] The snowplow operator was also a qualified aerial lift operator and a qualified forklift driver.

The snowplow operator held a G1[19] driver's licence, as he had not yet passed the on-road portion of the licence examination to receive a G2 licence. He had not enrolled in any practical driving instruction courses. The snowplow operator did not hold a Class G driver's licence, which the City's contract required.

Having grown up in London, the snowplow operator was familiar with the road environment near the Colborne Street public crossing. However, he had limited experience with the crossing as a motor vehicle driver, and so was likely not familiar with the number of active tracks (3), the crossing geometry (including width and length), and any sightline challenges from a position on the east sidewalk facing north.

1.14 Ontario *Occupational Health and Safety Act*

In Ontario, provincially regulated employers are subject to the *Occupational Health and Safety Act* (the Act). The provincial Minister of Labour is responsible for administering the Act and has a number of powers and duties, including

- promoting occupational health and safety and the prevention of workplace injuries and occupational diseases;
- promoting public awareness of occupational health and safety;
- educating employers, workers, and others about occupational health and safety;
- fostering a commitment to occupational health and safety among employers, workers, and others; and
- providing grants, in such amounts and on such terms as the Minister considers advisable, to support occupational health and safety.[20]

Under section 1 – Definitions of the Act, an employer

> means a person who employs one or more workers or contracts for the services of one or more workers and includes a contractor or subcontractor who performs work or supplies services and a contractor or subcontractor who undertakes with an owner, constructor, contractor or subcontractor to perform work or supply services[21]

Part III – Duties of Employers and Other Persons states:

> Duties of employers

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19 A G1 licence is the first stage of the Province of Ontario's graduated driver's licensing system. This system uses a multi-tiered approach to licensing to help novice drivers (regardless of their age) gain experience while at the same time managing the risks they pose to themselves and others. A G1 driver's licence comes with multiple restrictions designed to keep new drivers safe. Ontario's *Highway Traffic Act*, Ontario Regulation 340/94, outlines the requirements for obtaining a driver's licence in Ontario. For drivers with a G1 licence, this regulation places conditions on the allowable blood-alcohol level, the time of day during which the driving occurs, and the number of passengers in the car. As well, a G1 licence requires that a fully licensed driver with a minimum of 4 years of driving experience be in the front passenger seat.

20 Government of Ontario, R.S.O. 1990, c. O.1, *Occupational Health and Safety Act*, Part II, subsection 4.1(2).

21 Ibid., Part I, section 1.

> 25 […]
>
> (2) Without limiting the strict duty imposed by subsection (1), an employer shall,
>
> (a) provide information, instruction and supervision to a worker to protect the health or safety of the worker; […]
>
> (d) acquaint a worker or a person in authority over a worker with any hazard in the work and in the handling, storage, use, disposal and transport of any article, device, equipment or a biological, chemical or physical agent; […]
>
> (h) take every precaution reasonable in the circumstances for the protection of a worker; […]
>
> Additional duties of employers
>
> 26 (1) In addition to the duties imposed by section 25, an employer shall, […]
>
> (k) where so prescribed, provide a worker with written instructions as to the measures and procedures to be taken for the protection of a worker; and
>
> (l) carry out such training programs for workers, supervisors and committee members as may be prescribed.[22]

Under the Act, the *Occupational Health and Safety Awareness and Training Regulation* was developed to ensure that workers who perform work for an employer, and supervisors who oversee that work, complete a basic occupational health and safety awareness training program. The training program for workers must cover the following topics:

1. the duties and rights of workers under the Act;
2. the duties of employers and supervisors under the Act;
3. the roles of health and safety representatives and joint health and safety committees under the Act;
4. the roles of the Ministry, the Workplace Safety and Insurance Board, and entities designated under section 22.5 of the Act with respect to occupational health and safety;
5. common workplace hazards;
6. the requirements set out in Regulation 860 (Workplace Hazardous Materials Information System (WHMIS)) with respect to information and instruction on controlled products; and
7. occupational illness, including latency.

The training program for supervisors must cover the following topics:

1. the duties and rights of workers under the Act;
2. the duties of employers and supervisors under the Act;
3. the roles of health and safety representatives and joint health and safety committees under the Act;

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22 Ibid., Part III, sections 25 and 26.

4. the roles of the Ministry, the Workplace Safety and Insurance Board, and entities designated under section 22.5 of the Act with respect to occupational health and safety;
5. how to recognize, assess, and control workplace hazards, and evaluate those controls; and
6. sources of information on occupational health and safety.

No employer can contract out to a third party the obligations imposed upon them under the provisions of the Act.[23]

1.15 Audio analysis during re-enactment at the crossing

On 20 February 2018, audio measurements were taken at the Colborne Street public crossing to assess train horn audibility. During the audio testing, a locomotive similar to CN 5605 (CN 5601) and a snowplow similar to the occurrence snowplow were used.

Audio measurements were taken from both inside the snowplow and outside the snowplow. These measurements were taken

- with the window open and the window closed,
- with the locomotive blowing its horn, and
- with the train travelling at speeds similar to the occurrence.

There are 3 levels of audibility of a sound stimulus:

- The **threshold level** for detection occurs when a sound is simply recognized as being present. This needs to be 6.5 dB above the background noise. However, no other characteristics of the sound may be known.
- **The recognition level** normally occurs between 3 dB to 8 dB above the threshold level of detection.
- The **alerting level** of an auditory stimulus occurs at the point at which a person would become aware of and alerted to its presence. This typically occurs when the sound rises at least 15 dB above any background noise level.[24]

Based on the audio analysis, the following was determined:

- With the snowplow's windows open, the train horn level rose above the background noise to an alerting level about 3 seconds prior to the locomotive entering the crossing.
- With the snowplow's windows closed, the train horn level was at an alerting level less than 1 second prior to the locomotive entering the crossing.

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23 *R v. Grant Forest Products Inc.*, [2002] O.J. No. 3374, pp. 11–12, and *Ontario (Ministry of Labour) v. Sunrise Propane Energy Group Inc.*, [2013] O.J. No. 3086, pp. 46, 58-59, 63–64.

24 S. Fidell, "Effectiveness of audible warning signals for emergency vehicles," *Human Factors*, Vol. 20 (1978), pp. 19–26.

- Under the occurrence conditions, the audio levels from the train horn and the crossing bell that the snowplow operator perceived were likely insufficient to alert the operator to the oncoming train with sufficient time to avoid the impact.
- It was not possible to determine whether the snowplow operator's earphones were in use at the time of the occurrence. However, their use would have had a minimal effect on the audibility of the train horn.

Train horns are often described as a secondary alerting system because their effectiveness is influenced by other factors.[25] A number of TSB investigations[26] have shown that the effectiveness of the horn can be compromised by the speed of the train, the dampening of sound through the road vehicle shell, and the ambient noise present within the vehicle.

1.16 Sightline from within the snowplow cab

With the snowplow positioned in the southeast quadrant of the crossing so that the operator was approximately adjacent to the GCWDs, the southeast warning system mast, lights, and gates were approximately 90° from the operator's forward view. At this position, when the operator was looking straight ahead, the lights and gates would not have been in his forward view.

In addition, at this position, the A-pillar (front left pillar) of the snowplow cab frame obstructed the view of

- the northwest crossing mast,
- the gate (even if it was in the full down position),
- the lights facing south that were affixed to the mast, and
- the lights facing south that were affixed to the cantilever above the road (Figure 5).

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25 G. W. English, F. A. Russo, and T. N. Moore, TP 14103E, *Locomotive Horn Evaluation: Effectiveness at Operating Speeds* (June 2003), prepared for the Transportation Development Centre, Transport Canada, by TransSys Research Ltd..

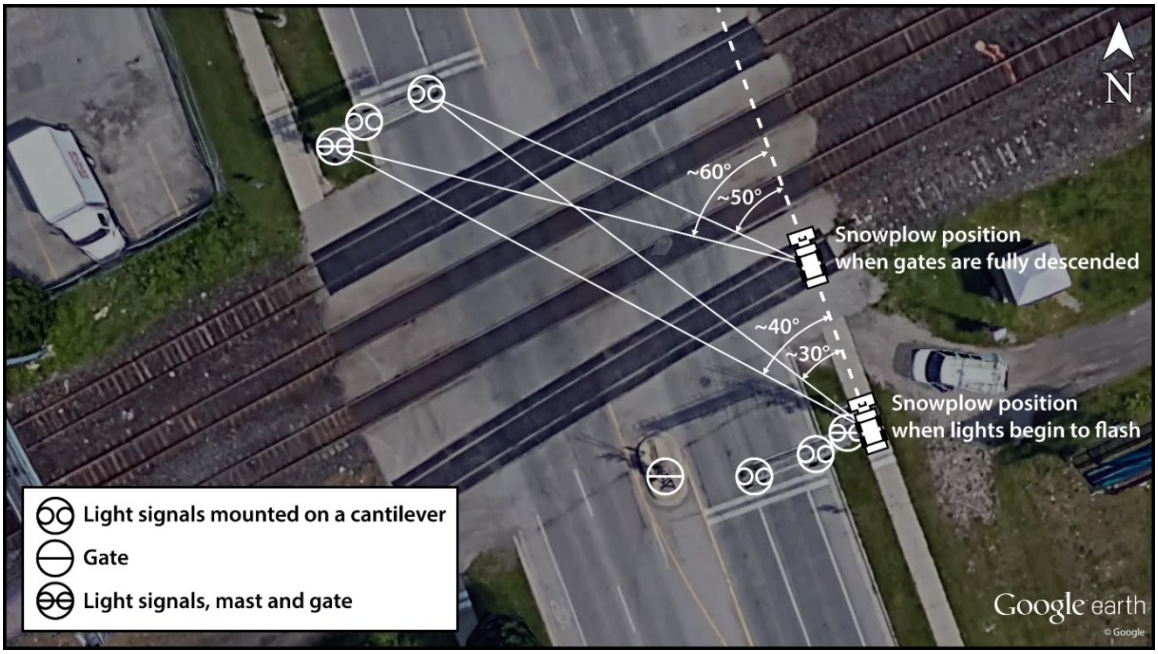
26 TSB railway investigation reports R13D0001, R13W0083, R12W0182, R11T0175, R10W0123, R08M0002, R04H0014, and R02W0063.

Figure 5. Photo taken from a driver's seated eye position in the snowplow showing the view toward the northwest quadrant of the crossing when the snowplow was positioned adjacent to the southeast quadrant crossing warning system mast (the location of the snowplow when the gates began to descend) (Source: TSB)

When the snowplow operator was adjacent to the crossing mast in the southeast quadrant of the crossing, the lights and gates in the northwest quadrant were more than 30° from the forward view (Figure 6).

The viewing angles of the crossing lights and gates in the northwest quadrant from the snowplow cab were more than 50° from the forward view when the snowplow occupied the 1st set of tracks.

Figure 6. Location of the snowplow and viewing angles from the cab to the grade crossing warning devices (Source: Google Earth, with TSB annotations)



1.17 Hazard detection and information processing by humans

Because human information processing takes place constantly, and because there is so much information available in the environment, people must cope with this flow by filtering out less important information to attend to the important information. However, although they are able to switch attention rapidly from one information source to another, humans can attend well to only one information source at a time,[27] particularly when driving.

For drivers to interrupt what they are doing to react to a hazard, a condition, or a stimulus, it needs to be visible or detectable (available to the senses), perceived (assigned meaning), and recognized (as sufficiently important).

The field of view of human vision is large, extending 90° to the left and 90° to the right. The peripheral visual field makes up approximately 90% of the total field of vision; only a small area—a cone of approximately 2° to 3° directly ahead of the viewer—allows for clear and

27 P. L. Olson, R. Dewar, and E. Farber, "Vision, audition, vibration and processing of information," in: *Forensic Aspects of Driver Perception and Response*, 3rd edition (Tucson, AZ: Lawyers & Judges Publishing Company, 2010), ch. 3.

accurate vision.[28] Outside of this cone, visual acuity and contrast sensitivity[29] drop rapidly, so it is important for motor vehicle drivers to search visually for trains at railway crossings.

Whether or not a driver chooses to search visually at a railway crossing, and despite limits in acuity and contrast sensitivity, an approaching train is most likely to be detected first in a driver's peripheral visual field because the eye is more sensitive to movement in the periphery than in central vision.[30]

A vehicle operator intently focusing attention at a fixation point is less likely to notice objects in the visual periphery—a phenomenon referred to as tunnel vision or attentional narrowing. Several factors can lead to tunnel vision,[31] including

- deep concentration on a difficult task,
- limited experience performing a task,
- the effects of fatigue,
- the effects of drugs or alcohol,
- increased workload, and
- environmental stressors such as loud noises.

1.18 Vehicle operator attention

Human attention and the capacity to process information are limited. These limitations can create difficulties, as operating any kind of vehicle requires the division of attention among control tasks (such as staying in the lane or on the sidewalk), guidance tasks (such as avoiding uneven surfaces), and navigational tasks (such as looking for street name signs).

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28 J. Osaka, "Speed estimation through restricted visual field during driving in day and night: Naso-temporal hemifield differences," in A. G. Gale, M. H. Freeman, C. M. Haslegrave, et al. (eds), *Vision in Vehicles II: Proceedings of the Second International Conference on Vision in Vehicles* (Nottingham, UK, 14–17 September 1987), pp. 45–55.

29 M. Green, "Visibility Analysis 2," in M. Green, M. J. Allen, B. S. Abrams, et al. (eds), *Forensic Vision with Application to Highway Safety*, 3rd edition (Tucson, AZ: Lawyers & Judges Publishing Company, 2008), pp. 311–312.

30 J. Osaka, "Speed estimation through restricted visual field during driving in day and night: Naso-temporal hemifield differences," in A. G. Gale, M. H. Freeman, C. M. Haslegrave, et al. (eds), *Vision in Vehicles II: Proceedings of the Second International Conference on Vision in Vehicles* (Nottingham, UK, 14–17 September 1987), pp. 45–55.

31 M. Green, "Visibility Analysis 2," in M. Green, M. J. Allen, B. S. Abrams, et al. (eds), *Forensic Vision with Application to Highway Safety*, 3rd edition (Tucson, AZ: Lawyers & Judges Publishing Company, 2008), pp. 311–312.

Attentional resources are required for effective hazard detection[32] and for maintaining situational awareness.[33]

The task of operating the snowplow to clear snow from sidewalks involved attending to controlling and guiding not only the vehicle, but also the snow blower, as well as monitoring the snow feed to ensure that it was not contaminated with objects that could be thrown from the blower. It is common for a snowplow operator's attention to be focused either straight ahead at the oncoming sidewalk or off to the right to monitor the placement of snow.

1.19 Expectations and knowledge

Expectations about a situation can affect whether and how appropriately a vehicle operator will respond to hazards in the environment. When people receive information that they expect to receive, they tend to react quickly and without making errors. However, when they receive information that is contrary to their expectations, their performance tends to be slow or inappropriate.[34]

Training and experience enhance a person's knowledge and understanding of a situation or environment. Vehicle operators who are learning new tasks, or new aspects of a familiar task, tend to devote more attention to and experience higher levels of workload than more experienced drivers when engaged in the new, unpractised tasks.[35]

1.20 Fatigue

Recent research[36] shows that, similar to commercial motor vehicle drivers, winter maintenance operators (i.e. snowplow operators) are likely to be at an increased risk of becoming fatigued while driving due to long shifts, environmental stressors, and limited opportunities for sleep. Fatigue can impair information-processing speed, slow active eye

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32 P. N. J. Lee and T. J. Triggs, "The effects of driving demand and roadway environment on peripheral visual detections," *APRB Proceedings,* 8 (1976), pp. 7–12.

33 M. R. Endsley, "Toward a theory of situation awareness in dynamic systems," *Human Factors*, Vol. 37, No. 1 (1995), pp. 32–64.

34 G. J. Alexander and H. Lunenfeld, "Driver expectancy in highway design and traffic operations," U.S. Department of Transportation report no. FHWA-TO-86-1, April 1986.

35 C. J. D. Patten, A. Kircher, J. Östlund, et al., "Driver experience and cognitive workload in different traffic environments," *Accident Analysis & Prevention*, 38 (2006), pp. 887–894.

36 M. C. Camden, A. Medina-Flintsch, J. S. Hickman, et al., "Prevalence of operator fatigue in winter maintenance operations," *Accident Analysis and Prevention*, 126 (2019), pp. 47-53.

movements, and limit a person's ability to process information from the peripheral visual field.[37]

Research[38] shows that uncontrollable brief episodes of sleep, commonly known as "micro-sleeps" (sleep lasting 3 to 4 seconds) and "state instability" (because wakefulness cannot be maintained), begin to occur in most individuals after 22 hours of continuous wakefulness. This is therefore considered to be the threshold at which fatigue causes almost all aspects of human performance to decline.

Unlike sleep-related fatigue, mental (or "task-related") fatigue is a psychological state that results from spending extended or intense periods of time on a task.[39,40] Although people experiencing mental fatigue may feel tired, they do not necessarily fall asleep more quickly than a normally rested person; that is, they are not necessarily "sleepy." Concentrating for long periods of time can result in mental fatigue and corollary performance impairments, including decreased vigilance and situational awareness, and reduced attention-switching abilities.[41]

1.21 Effects of tetrahydrocannabinol on human cognitive functions

Tetrahydrocannabinol (THC) is the principal psychoactive cannabinoid[42] found in marijuana and hashish and their derivatives. Acute THC intoxication impairs several cognitive functions that are involved in the safe operation of motor vehicles, including a person's ability to divide attention among multiple tasks.[43]

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37 N. A. Kaluger and G. L. Smith, "Driver eye movement pattern under conditions of prolonged driving and sleep deprivation," *Highway Research Record*, 336 (1995), pp. 92–106.

38 M. Beaumont, D. Batejat, C. Pierard, et al., "Slow release caffeine and prolonged (64-h) continuous wakefulness: Effects on vigilance and cognitive performance," *Journal of Sleep Research*, Vol. 10, No. 4 (2001), pp. 265–276.

39 T. J. Balkin and N. J. Wesensten, "Differentiation of Sleepiness and Mental Fatigue Effects," in P.L. Ackerman (ed.), *Cognitive Fatigue: Multidisciplinary Perspectives on Current Research and Future Applications* (Washington, DC: American Psychological Association, 2011), pp. 47–66.

40 J. Leonard, L. J. Trejo, R. Kochavi, et al., "Measures and Models for Estimating and Predicting Cognitive Fatigue," Proceedings of the 44th Annual Meeting of the Society for Psychophysiological Research (Santa Fe, NM, 2004).

41 M. A. S. Boksem, T. F. Meijman and M. M. Lorist, "Effects of mental fatigue on attention: An ERP study," *Cognitive Brain Research,* 25 (2005).

42 A cannabinoid is any of a group of closely related compounds, which include cannabinol and the active constituents of cannabis.

43 P. Bondallaz, H. Chtioui, B. Favrat, et al., "Assessment of Cannabis Acute Effects on Driving Skills: Laboratory, Simulator, and On-road Studies," in: V. R. Preedy (ed.), *Handbook of Cannabis and Related Pathologies* (Cambridge, MA: Academic Press, 2017), pp. 379–390.

Both immediate and long-term exposure to THC impair driving ability and increase the risk of being involved in a motor-vehicle accident.[44,45] According to a meta-analysis review of experimental studies, THC concentration of between about 3.5 and 5 nanograms per millilitre (ng/ml)[46] in the blood correlates with driving impairment comparable to that caused by a blood alcohol concentration of 0.05%, and has therefore been proposed as a suitable legal driving limit.[47]

On 17 October 2018, it became legal in Canada for adults to possess small amounts of cannabis.[48] However, it is illegal to operate a motor vehicle while drug-impaired.[49] The maximum legal concentration of THC in the blood within 2 hours of driving is 2.0 ng/mL.[50]

In Ontario, as of 01 July 2018, young drivers, novice drivers, drivers of vehicles requiring a Class A to F licence, drivers of vehicles requiring a Commercial Vehicle Operator's Registration, and drivers of road-building machines are prohibited from having any THC in their system.[51]

Legal limits for driving under the influence of THC differ around the world. For example, in the U.S., where some states permit the use of THC, the legal driving limits range from 1 ng/mL (Pennsylvania) to 5 ng/mL (Washington, Colorado, Montana). In the European Union, the legal driving limits range from 0.5 ng/mL to 3 ng/mL.[52]

When THC concentrations in the blood following toxicology testing are interpreted, a number of factors can significantly influence the results, including these:

- THC is detectable in blood for up to 2 days after use. However, even a high dose of smoked THC typically causes acute impairment of driving skills for only 3 to 4

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44 N.D. Volkow, M. D. Ruben, D. Baler, et al., "Adverse health effects of marijuana use," The New England Journal of Medicine, Vol. 370, No. 23 (2014), pp. 2219–2227.

45 O. Rogeborg and R. Elvik, "The effects of cannabis intoxication on motor vehicle collision revisited and revised," *Addiction,* Vol. 111, No. 8 (2016), pp. 1348–1359.

46 Equivalent to 7 to 10 ng/mL in serum.

47 F. Grotenhermen, G. Leson, G. Berghaus, et al., "Developing limits for driving under cannabis," *Addiction*, Vol. 102, No. 12 (2007), pp. 1910–1917.

48 Government of Canada, *Cannabis Act*, S.C., 2018, c. 16, paragraph 8(1)(a).

49 Government of Canada, *Criminal Code*, R.S.C., 1985, c. C-46, paragraph 253(1)(a).

50 Department of Justice Canada, *Blood Drug Concentration Regulations*, SOR/2018-148, section 1.

51 Government of Ontario, "Cannabis and driving," at https://www.ontario.ca/page/cannabis-and-driving (last accessed on 22 May 2019).

52 K. Wong, J. E. Brady and G. Li, "Establishing legal limits for driving under the influence of marijuana," *Injury Epidemiology*, Vol. 1, No. 26 (2014).

hours.[53] Recency of use is therefore an important factor in estimating level of impairment.

- An individual's pattern of use can also affect THC pharmacokinetics.[54] Positive blood THC levels in habitual, regular cannabis users do not necessarily signify recent use.[55]

An autopsy was performed on the operator's body about 23 hours after the occurrence. Toxicology test results were positive for THC, indicating that there was a concentration of 11.9 (+/− 1.5) ng/mL of THC in femoral blood. No drug paraphernalia was found on or near the snowplow operator's body following the occurrence. However, the investigation determined that the snowplow operator had been smoking cannabis regularly for many years, and was a habitual user.

Interpreting post-mortem levels of THC in blood is complicated by post-mortem redistribution, which results in changes to THC concentrations (either increasing or decreasing) in the blood after death.

These factors mean that it is not possible to reliably correlate post-mortem blood concentrations of THC with performance impairment effects at, or near, the time of death. Similarly, post-mortem blood THC cannot accurately estimate pre-mortem timing of last use.

1.22 Other crossing accidents involving snow-clearing equipment

On 24 January 2013, at 0856 Central Standard Time, eastbound CN freight train L51141-23 struck a road grader that had stopped on the public grade crossing at Mile 33.70 of the Blackfoot Subdivision, in Saskatchewan.[56] As a result of the collision, the grader operator was fatally injured. The road grader was heavily damaged. The train crew were not injured. The locomotive and 16 tank cars carrying dangerous goods derailed. Approximately 106 000 L of crude oil were released from 4 cars. At the time of the collision, the grader operator was resetting the road grader's blades for snow-clearing operations. The investigation found that

> With the grader operator's attention likely focused on resetting the road grader's blades for snow clearing in the vicinity of the crossing, the operator did not detect the approaching train from the west.

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53 F. Grotenhermen, G. Leson, G. Berghaus, et al., "Developing limits for driving under cannabis," *Addiction*, Vol. 102, No. 12 (2007), pp. 1910–1917.

54 Pharmacokinetics means the mechanisms of bodily absorption, distribution, metabolism, and excretion of a drug or substance.

55 R. B. De Boni, R. P. Limberger and T. R. V. Sousa, "Cannabis and Traffic Accidents," in: V. R. Preedy, *Handbook of Cannabis and Related Pathologies* (Cambridge, MA: Academic Press, 2017), pp. 234–243.

56 TSB Railway Investigation Report R13E0015.

On 23 December 2013, at 0328, Canadian Pacific Railway freight train 132-22 was proceeding eastward at 50 mph through Perth, Ontario, when it struck a dump truck that was occupying the Wilson Street public crossing at Mile 12.44 of the Belleville Subdivision while participating in snow-clearing operations.[57] The crossing was equipped with an automated warning system, including flashing light signals, bell, and gates. Following the collision, the truck was dragged about 2300 feet before it came to rest at approximately Mile 12.0. The vehicle operator sustained serious but non-life-threatening injuries. The truck was destroyed and the locomotive was damaged. The GCWDs at Wilson Street and Drummond Street (Mile 12.20) were also damaged. It was determined that

- the truck driver was not specifically aware of the risks posed while working near railway infrastructure; and
- no safety briefing was held before the work started, contrary to common practice in other industries.

Since 2009, there have been 4 other occurrences where a train struck a snowplow or a similar type of vehicle at a federally regulated crossing.[58]

1.23 TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP023/2018 – Audio Analysis
- LP024/2018 – Cell Phone Analysis
- LP037/2018 – Video Analysis

57 TSB Rail Safety Information Letter 01/14; TSB Occurrence R13T0287.

58 TSB occurrences R14T0096, R13D0092, R10M0001, and R09E0005.

2.0 ANALYSIS

Neither the actions of the train crew nor the condition of the equipment or the rolling stock were contributing factors to the accident. There was no indication that the snowplow operator had any medical or psychological condition that would have contributed to the accident. The analysis will focus on the conditions leading to the snowplow operator being unaware of the oncoming train, training, the level of oversight of snow-clearing contractors by Jackson Pools Inc. (Jackson Pools) and the City of London (the City), and the effectiveness of grade crossing warning devices (GCWDs) during sidewalk snow-clearing activities.

2.1 The accident

The accident occurred when the snowplow travelled onto the railway crossing while continuing to clear snow from the sidewalk. The horn of the approaching train was sounded before the snowplow occupied the south main track; however, the snowplow operator was not alerted to the oncoming train and the snowplow continued onto the track, where it was struck by freight train Q14891-08 (the train).

The snowplow was clearing snow from the sidewalk as it approached, and then travelled onto, the crossing from the south. The lights in the southeast quadrant of the crossing first activated when the snowplow was adjacent to the crossing warning system mast and gate. Owing to the positioning of the snowplow beside the south GCWDs when they became active, the flashing lights were not in the operator's field of view and therefore did not alert him to the presence of the oncoming train. He continued past the crossing mast and gate and, as he was approaching the tracks, the gates began to descend. When the snowplow had reached the southern-most track, the gates had completed their descent. The snowplow continued forward onto the south main track, where the collision occurred.

As the snowplow travelled onto the crossing and into the path of the train, the snowplow operator's attention was focused either directly forward at the sidewalk that was about to be cleared of snow or off to the right-hand side where the snow was being thrown toward the east. As a result, the crossing warning system mast and gate in the northwest quadrant of the crossing, as well as the lights on the cantilever, were in the operator's peripheral visual field, reducing the likelihood that they would be detected.

The operator's view from the cab of the snowplow was restricted. The front-left cab frame pillar obstructed the sightlines to the crossing lights and gates in the northwest quadrant when the snowplow was on the crossing. As well, the screening on the side windows hindered the view along the tracks. The restricted sightline further reduced the likelihood of the operator detecting the activated GCWDs or the oncoming train.

The bells at a crossing, and the train horn, are meant to alert crossing users to the presence of a train. However, the background noise of the operation of the snowplow prevented both the crossing bell and the train horn from alerting the operator.

2.2 Visual scanning at the crossing

The speed at which the snowplow was travelling on the crossing was conducive to stopping quickly in advance of the train, if the operator had detected the train. However, the snowplow did not stop to avoid the train. Moreover, adjustment of the blower just before the plow occupied the south main track indicates that the operator's attention at that time was directed to his right, away from the direction of the oncoming train. The operator did not look toward the train during the seconds leading up to impact. Therefore, the investigation determined that the snowplow operator was focused on clearing snow at the crossing and was not monitoring for approaching trains.

Training, experience, and expectations can influence the effectiveness of a driver's visual search for trains and warning cues at railway crossings. The snowplow operator was not experienced at clearing snow from crossings, having worked just 5 shifts in total; it was only his 2nd shift involving the accident crossing. In addition, he was not an experienced motor vehicle driver and had received little, if any, training on how to approach and operate over railway crossings. His limited experience with railway crossings in general, and with the occurrence crossing in particular, and his lack of training on safe working practices when clearing snow at railway crossings inhibited the effectiveness of the operator's visual scanning. As a result, he did not detect the oncoming train.

The snowplow operator, who had been awake for more than 22 hours and on the job for about 11 hours, was likely experiencing fatigue. Due to a combination of the effects of fatigue, the effects of an increased demand for attentional resources from a relatively new and complex task of clearing snow, and the effects of loud background noise from the snowplow, the snowplow operator was likely experiencing tunnel vision or attentional narrowing toward the snow-clearing task. The effect of tunnel vision exacerbated by fatigue likely also diminished the snowplow operator's visual scanning behaviour in the moments leading up to the occurrence.

2.3 Fatigue

Many cities across Canada have railway crossings with sidewalks that need to be cleared of snow at some point during the winter. Because the timing of the snowfall is somewhat predictable, snowplow operators in these cities have some warning time prior to beginning their shift to adjust their wake–rest pattern to ensure that they attain adequate rest. However, sometimes the amount of warning time provided is not long enough for the operator to obtain adequate rest, or occurs at a time during the operator's wake–rest cycle that is not conducive to resting. In these instances, it may not be possible for snowplow operators to obtain the rest required to remain alert during an entire 12-hour shift. Due to the nature of the work, snowplow operators cannot always obtain adequate restorative rest.

2.4 Tetrahydrocannabinol

Post-mortem toxicology testing determined that tetrahydrocannabinol (THC) was present in the snowplow operator's system, indicating that he had consumed cannabinoids at some point before the accident. THC has been shown to affect cognitive function and performance, and is associated with an increased risk of traffic accidents. Although the amount of THC present in the snowplow operator's blood exceeded the legal limits for driving, the time at which the THC was last used could not be determined, nor could it be determined whether impairment was a factor in this occurrence.

Regardless, the use of THC by vehicle operators can lead to impaired cognitive function and performance.

2.5 Training

Under the Ontario *Occupational Health and Safety Act* (the Act), employers have concurrent responsibility to ensure the health and safety of employees and to take every precaution reasonable in the circumstances to protect a worker. The Act and the Ontario *Occupational Health and Safety Awareness and Training Regulation* require employers to provide information, instruction, and supervision to workers to protect their health and safety; to ensure that workers, or persons in authority over workers, are informed of any safety hazard and the measures and procedures to be taken to ensure the workers' safety; and to ensure that workers are adequately trained. In this occurrence, employers did not provide any training to the snowplow operator.

The City has a training program to instruct its employees on the proper and safe execution of their duties, including sidewalk plowing. To ensure that the training program is complete, the City has also undertaken risk assessments on individual tasks, including sidewalk plowing and sanding. Employees' attendance at these courses is tracked and monitored, and any requirement for recurrent training is identified. With these procedures, the City's objective is to prepare its sidewalk snowplow operators with the information, training, and supervision they need to perform their duties safely. The City also stipulated training requirements for contractor employees in its contracts.

However, Jackson Pools did not have programs for its snowplow operators or for its subcontractors. Wee Bee Contracting (Wee Bee) hired an inexperienced employee who did not hold a Class G licence and provided no formal training program to ensure that the employee had the skills and knowledge to perform his duties safely. As a result, the employee received no formal training and instruction on safely operating over railway crossings or on clearing snow from sidewalks over railway crossings.

2.6 Oversight of contractors

To fulfill the conditions of the snow-clearing contract with the City, Jackson Pools had 1 snowplow, and the necessary operators, dedicated to snow removal. Jackson Pools had

also subcontracted to Wee Bee the use of 2 additional snowplows and the necessary operators.

Despite certain requirements specified in the contract with the City, and the responsibilities under the provincial act, Jackson Pools did not ensure that Wee Bee had a training program that met the requirements of the *Occupational Health and Safety Awareness and Training Regulation*, or that the Wee Bee operators were fully informed of the workplace hazards, and related work procedures, while on duty. In addition, Jackson Pools did not ensure that all Wee Bee operators met the requirements specified in the contract. Therefore, the oversight by Jackson Pools did not ensure that its employees and subcontractors assigned to the snow-clearing contract for the City were properly trained and qualified.

The City, through its tendering process, placed requirements on its contractors to ensure that the contractors' operators were qualified to perform their duties safely. For example, the tender required the City's contractors for sidewalk snow-clearing operations to submit a list of qualified machine operators, ensure that their operators had a Class G driver's licence, be responsible for training those operators, and use only those operators on the list. Moreover, contractors were not to enter into any subcontracting agreement without first obtaining the City's consent. Jackson Pools subcontracted part of the work under its City of London contract to Wee Bee without obtaining approval from the City.

As well as not ensuring that the contractors had developed and conducted an adequate training program, the City did not maintain a list of qualified snowplow operators, did not ensure that only those operators on the list were used, did not ensure that no unapproved subcontractor was employed, and did not ensure that those operators maintained their Class G driver's licence. Once the contract was awarded to the contractors, none of the requirements listed in the tender were verified. For this reason, the City's oversight of its snow-clearing contractors did not identify that snowplow operators did not have sufficient training and qualifications to perform their duties safely.

2.7 Safe work procedures at crossings during snow-clearing operations

The snowplow was travelling at about 1.5 km/h while clearing snow over the railway crossing. The GCWD provided about 30 seconds of warning time from when the bell and lights were first activated to when the train occupied the crossing. The snowplow would have taken more than 60 seconds to travel from the gate to a position clear of the far track, assuming that it did not stop to perform additional snow clearing. As a result, the GCWD does not provide adequate protection for machines performing snow clearing on the crossing, particularly when they are travelling at a slow speed, nor is the GCWD intended to do so. Because the GCWD is not designed to protect crews while they are clearing snow on the crossing, safe work procedures are required. If snow-clearing contract companies do not have safe work procedures and related training in place for work at railway crossings, there is an increased risk of crossing accidents.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

1. The accident occurred when the snowplow travelled onto the railway crossing while continuing to clear snow from the sidewalk.

2. Owing to the positioning of the snowplow beside the south grade crossing warning devices when they became active, the flashing lights in the southeast quadrant were not in the operator's field of view and therefore did not alert him to the presence of the oncoming train.

3. The crossing warning system mast and gate in the northwest quadrant of the crossing, as well as the lights on the cantilever, were in the operator's peripheral visual field, reducing the likelihood that they would be detected.

4. The restricted sightline due to the cab frame pillar and the screening on the side windows further reduced the likelihood of the operator detecting the activated grade crossing warning devices or the oncoming train.

5. The background noise of the operation of the snowplow prevented both the crossing bell and the train horn from alerting the operator.

6. The snowplow operator was focused on clearing snow at the crossing and was not monitoring for approaching trains.

7. The snowplow operator's limited experience with railway crossings in general, and with the occurrence crossing in particular, and his lack of training on safe working practices when clearing snow at railway crossings inhibited the effectiveness of the operator's visual scanning. As a result, he did not detect the oncoming train.

8. The effect of tunnel vision exacerbated by fatigue likely also diminished the snowplow operator's visual scanning behaviour in the moments leading up to the occurrence.

9. Wee Bee Contracting hired an inexperienced employee who did not hold a Class G licence and provided no formal training program to ensure that the employee had the skills and knowledge to perform his duties safely.

10. The oversight by Jackson Pools Inc. did not ensure that its employees and subcontractors assigned to the snow-clearing contract for the City of London were properly trained and qualified.

11. The oversight by the City of London of its snow-clearing contractors did not identify that snowplow operators did not have sufficient training and qualifications to perform their duties safely.

3.2 Findings as to risk

1. If snow-clearing contract companies do not have safe work procedures and related training in place for work at railway crossings, there is an increased risk of crossing accidents.

3.3 Other findings

1. Due to the nature of the work, snowplow operators cannot always obtain adequate restorative rest.

2. The time at which the tetrahydrocannabinol was last used could not be determined, nor could it be determined whether impairment was a factor in this occurrence.

3. The use of tetrahydrocannabinol by vehicle operators can lead to impaired cognitive function and performance.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 City of London

Following the accident, the City of London required snowplow operators employed by its sidewalk snow-clearing contractors to participate in a City-led review of safe operating practices at railway crossings. Guidance documents on clearing snow at crossings were distributed to snowplow operators at this review session.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 08 May 2019. It was officially released on 17 July 2019.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.