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

MARINE TRANSPORTATION SAFETY INVESTIGATION REPORT M21C0265

CAPSIZING

Rescue boat *1864*
Off Île au Diable
Montréal, Quebec
17 October 2021

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.

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Summary

On 17 October 2021, Service de sécurité incendie de Montréal rescue boat *1864*, with 4 firefighters on board, was dispatched to rescue a pleasure craft that had had an engine failure and was drifting toward the Lachine Rapids in Montréal, Quebec. The rescue boat attempted to tow the pleasure craft through the rapids. During this operation, the rescue boat suddenly capsized, and the four firefighters fell into the water. Three firefighters were rescued and treated for hypothermia. First responders, the Service de police de la Ville de Montréal, Canadian Armed Forces helicopters and the Sûreté du Québec assisted in the search for the missing firefighter. The search continued into the next day, when the firefighter's body was located and recovered.

1.0 FACTUAL INFORMATION

1.1 Particulars of the vessels

Table 1. Particulars of the vessels

Vessel	Rescue boat 1864	Pleasure craft
Registration number	C16264QC	Private owner
Flag	Canada	Canada
Type	Work / Rescue boat	Pleasure craft
Gross tonnage	4.61	4.99 (tonnage not calculated)
Construction material	Reinforced plastic	Reinforced plastic
Length	6.40 m	5.80 m
Width	2.60 m	Unknown
Built	2009, Rosborough Boats, Halifax (Nova Scotia)	Tempest Boats

Propulsion	A 173 kW Steyr diesel engine driving a Hamilton jet propulsion system	89 kW Mercury inboard/outboard gasoline engine
Crew	4	2
Registered owner	Ville de Montréal – Services des incendies	Private owner
Authorized representative (AR)	Ville de Montréal – Services des incendies	Not applicable

1.2 Vessel descriptions

1.2.1 Rescue boat *1864*

Rescue boat *1864* was one of 8 identical HammerHead RFV-22s purchased by the Service de sécurité incendie de Montréal (SIM) in 2008–2009 for its water rescue program.

Rescue boat *1864* was constructed of reinforced plastic with fibreglass and a foam core. The hull is a continuous deep V with a transom. Positive level flotation is provided via foam installed within the space below deck. The height above deck level of the hull's sides ranged from 67 cm astern to 74 cm above the deck in the forward part of the vessel, forming a large well. Two self-draining scuppers were fitted on either side of the transom at deck level.

The inboard motor was protected by a drum and driven by reaction propulsion (waterjet). A towing line reel and towing bit were installed aft of the drum (Figure 1).

The steering console was protected by a fibreglass roof supported by an aluminum frame, and the standing area was 88 cm wide, 36 cm deep, and 200 cm high. The console was equipped with a multifunction display that could show radar images, depth, or an electronic chart including satellite position;[1] a depth sounder; a very high-frequency radiotelephone (VHF); a transceiver on a communication frequency reserved for Montréal emergency services; a magnetic compass; and an engine kill switch with a lanyard.

[1] Global positioning system (GPS).

Figure 1. HammerHead RFV-22 (sister boat to the occurrence boat) with tow cable reel, towing bitt and swim platform labelled (Source: TSB)

An aluminum platform was mounted on the outside of the transom, above the propulsion system. The rescue boat had been built with a side door, but the door had been sealed,[2] which meant the boat now had a freeboard height of 63 cm above the waterline when fully loaded.

1.2.1.1 Stability

As part of TSB investigation M09L0068 into the capsizing of SIM rescue boat *1815* on 01 May 2009, the TSB analyzed the stability and initial buoyancy assessment of a HammerHead RFV-22 that had been carried out in accordance with standard ISO 12217-1. This stability assessment determined that rescue boat *1815* had a maximum total load of 1007 kg.[3] In this occurrence, the load of rescue boat *1864* was around 840 kg.

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2 As indicated in TSB Marine Investigation Report M09L0068, following the internal investigation by the Service de sécurité incendie de Montréal (SIM) completed in July 2009, the doors were bolted shut permanently so as to prevent their use.

3 To assess stability and buoyancy, a total load of 6 people, provisions, equipment, and/or cargo was used.

1.2.2 Pleasure craft

The pleasure craft had been purchased on the day of the occurrence. The vessel had an 89 kW Mercury gasoline engine driving a propeller. The vessel was equipped with navigation lights and a horn and carried lifejackets, an anchor with rope, a buoyant heaving line, a waterproof flashlight, and an oar. The vessel had been purchased with the safety equipment already on board. All the ropes were old and in poor condition.

1.3 Injuries

Three firefighters suffered hypothermia after the vessel capsized. The fourth firefighter drowned.

Neither of the 2 occupants on board the pleasure craft was injured.

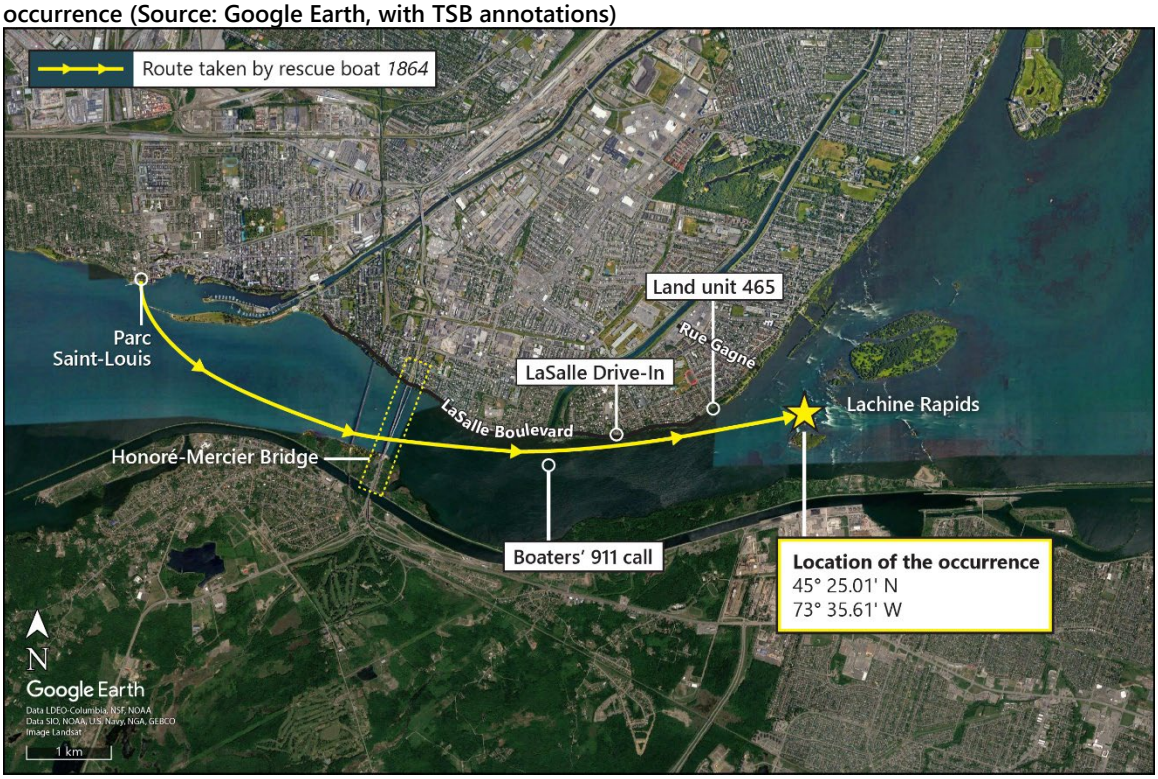
1.4 History of the occurrence

1.4.1 The drifting pleasure craft

On 17 October 2021, 2 boaters decided to take a test ride on a pleasure craft they had purchased that day. At around 1830,[4] the pleasure craft was launched from the ramp at Parc Saint-Louis in the borough of Lachine in Montréal, Quebec. After about 10 minutes of testing on the St. Lawrence River, the boat's engine began to overheat and stopped. The engine compartment fan was switched on in an attempt to cool the engine. Meanwhile, the current was carrying the pleasure craft toward the Honoré-Mercier bridge and the Lachine Rapids (Figure 2).

[4] All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

Figure 2. Map showing the route taken by rescue boat 1864 between Parc St-Louis and the site of the occurrence (Source: Google Earth, with TSB annotations)



After about 20 minutes, the boaters tried to restart the engine, with success, but the engine stopped again after about 2 minutes.

At around 1907, the pleasure craft had arrived in the vicinity of Parc de l'Aqueduc when one of the occupants of the pleasure craft called 911 for help. The 911 dispatcher relayed the information to the Service de police de la ville de Montréal (SPVM) and the SIM. In addition, because this was a marine incident, the dispatcher transferred the call to the Marine Rescue Sub-Centre (MRSC) in Québec, Quebec. The MRSC advised the boaters to drop anchor and don their lifejackets because they were approaching the Lachine Rapids. The boaters were already wearing their lifejackets. They dropped anchor to slow the vessel's drift, but the anchor did not catch. The MRSC informed them that emergency services were on their way. The MRSC dispatched 2 vessels from the Canadian Coast Guard Auxiliary and requested air support from the Joint Rescue Coordination Centre in Trenton, Ontario.

The SIM communications centre informed the MRSC that SIM was sending 2 nautical units to respond to the call. The SIM command centre dispatched 2 land units from fire station 65 (265 and 465), a chief of operations (C/O) and 2 nautical units from fire stations 64 and 55 (*1864* and *1855*) to rescue the pleasure craft. Units *1864* and *1855* typically respond on Lac Saint-Louis upstream of the Honoré-Mercier Bridge but can respond anywhere around the Island of Montréal.

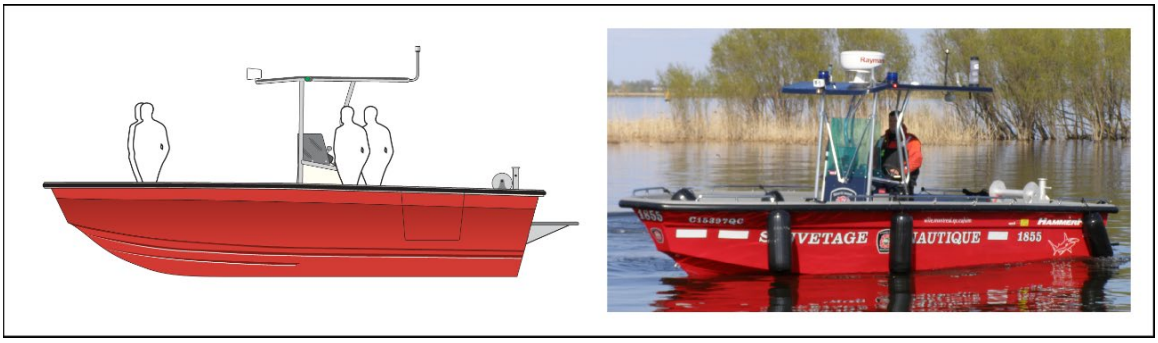
At around 1912, unit *1864* reached the ramp at Parc Saint-Louis. Unit *1855* headed for the borough of Verdun, Quebec, downstream of the rapids, to launch its boat. Land unit 265

moved to LaSalle Boulevard., near Gagné Street, to establish visual contact with the drifting boat. Unit 265's lieutenant, who was first on the scene, took charge of the command post with support from the C/O, who was also on site near Bishop-Power Blvd. At 1916, ground units established visual contact with the pleasure craft.

That evening, unit *1864* consisted of 4 firefighters: 2 lookouts, 1 coxswain, and 1 lieutenant. With the water temperature at 17 °C, the unit members donned their rain gear and personal flotation devices (PFDs) and quickly launched the boat (figures 3 and 4).

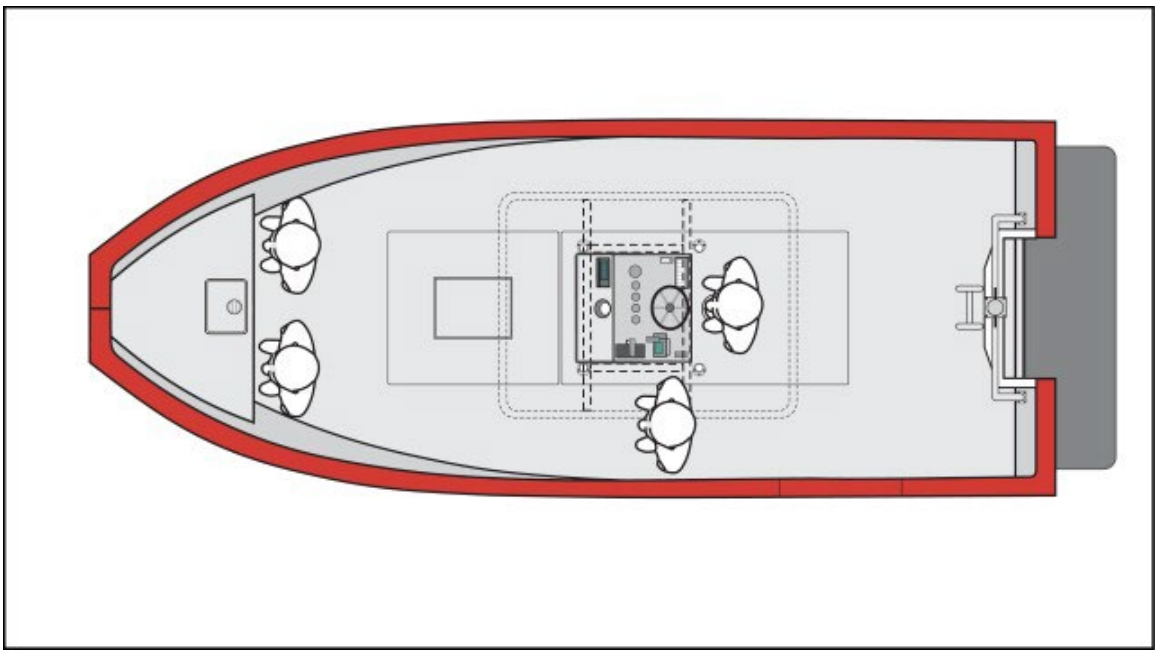
At around 1917, the lieutenant of unit *1864* heard on the firefighters' communications radio that the pleasure craft had passed the LaSalle Drive-In. The coxswain turned on the multifunction display to use the GPS and electronic marine charts to get an indication of water depth but was unable to adjust the display's brightness, so he turned it off. When unit *1864* was ready, the coxswain brought the boat up to full speed[5] towards the drifting craft.

Figure 3. Side view of a HammerHead RFV-22 with 4 people on board (left) and photo of the 1855 (sister ship to the 1864) with 1 person on board (right) (Source: TSB)



[5] At full speed, the speed over the ground was around 60 km/h.

Figure 4. Overhead view of a HammerHead RFV-22 with 4 people on board (Source: TSB)



At 1917, the lieutenant of unit *1864* asked the command post for more information on the location of the pleasure craft. In the meantime, the command post had moved to LaSalle Blvd. at Raymond Street to get a better view of the boat and direct unit *1864* toward it. The rescue boat continued to travel at full speed so that unit *1864* could respond before the vessel reached the Lachine Rapids.

At 1918, the command post informed the team that the situation was urgent, as the vessel was approaching the rapids. The lieutenant replied that if the boat started to descend into the rapids, another nautical unit would have to respond downstream of the rapids. The command post advised the lieutenant to communicate directly with the 2nd nautical unit. Unit *1855* confirmed that it would respond downstream of the rapids and was preparing to launch its boat at the Verdun Marina.

At 1920, the 2 land units reported that they estimated that the boat would enter the rapids at most 1.5 to 2 minutes later, and unit *1855* reconfirmed that it was launching its vessel at Verdun. About 2 minutes later, the command post asked unit *1864* for confirmation that the message had been heard by the lieutenant. Unit *1864* confirmed that it had copied the message.

At 1922, the pleasure craft entered the white water of the rapids as rescue boat *1864* passed under the Honoré-Mercier Bridge. Unit *1864* confirmed that it was attempting to respond before the pleasure craft reached the rapids. The pleasure craft turned under the increasing force of the current and continued down the rapids backwards. Land units continued to direct rescue boat *1864* toward the vessel over the radio.

1.4.2 The capsizing of rescue boat *1864*

At approximately 1924, rescue boat *1864* passed the LaSalle Drive-In. At 1926, following instructions from the command post, unit *1864* headed for the pleasure craft, which was now close to the first standing wave.[6] Rescue boat *1864* and the pleasure craft were bow to bow. One of the boaters threw a buoyant heaving line toward unit *1864*. Lookout 1 managed to grab the line, but it snapped before he could attach it. Meanwhile, the command post asked unit *1864* if it could tow the pleasure craft. Lookout 2 grabbed a rope that was already attached to the port cleat of rescue boat *1864*, wrapped it twice around the pleasure craft's railing and held it in his hand. As lookout 2 held the rope, the coxswain reversed propulsion, and rescue boat *1864* began backing up and towing the pleasure craft.[7]

As rescue boat *1864* reversed, it lost power. Seeing that the vessel was approaching the standing wave, the coxswain turned to starboard and applied forward thrust to escape the rapids. Lookout 2 released the tensioned rope. Rescue boat *1864* then struck the pleasure craft hard on the port side. The bow of rescue boat *1864* was caught in the wave, and the boat began to list to starboard. The water flooded the boat, and this flooding, combined with the current and eddies, caused the vessel to capsize rapidly, throwing lookout 2 into the rapids. The other three firefighters were trapped under the hull of rescue boat *1864*. The force of the impact pushed the pleasure craft past the standing wave.

Lookout 2 resurfaced about 6 to 7 m from the hull of rescue boat *1864* in a lull in the rapids. Swimming toward the drifting rescue boat *1864*, lookout 2 saw the coxswain resurface alongside the vessel. Arriving at rescue boat *1864*, lookout 2 climbed onto the overturned hull. At around 1928, the coxswain, who was drifting close to the boat, and lookout 2 saw the lieutenant resurface beside the boat. Lookout 2 asked the other 2 firefighters if they had seen lookout 1. But, still disoriented, they were unable to answer. When the coxswain regained his composure, he activated the distress light on his PFD. From his position on the hull, lookout 2 tried but was unable to spot lookout 1. He then sent a MAYDAY on his personal radio. Meanwhile, rescue boat *1864* continued down the rapids; lookout 2 fell back into the water and was unable to provide any information on the radio. Once in the water, lookout 2 activated the distress light on his PFD and drifted away from rescue boat *1864*. The firefighters and rescue boat *1864* continued down the rapids (Figure 5).

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6 "A large, pyramid-shaped wave [...] often indicating a deep but relatively narrow channel" (*Guide des rivières sportives au Québec*, 1980, as cited by Government of Canada, TERMIUM Plus, "Standing wave," at https://www.btb.termiumplus.gc.ca/tpv2alpha/alpha-fra.html?lang=fra&i=1&srchtxt=VAGUE+PYRAMIDALE&codom2nd_wet=1#resultrecs [last accessed 27 December 2023]).

7 Bow-to-bow towing is an unplanned, unpractised, and non-routine manoeuvre for SIM.

Figure 5. Map showing the area of the occurrence just before capsizing and of the standing waves in the Lachine Rapids (Source: Google Earth, with TSB annotations)

At 1929, the command post broadcast code 10-50[8] on the radios to indicate that an emergency was in progress. The command post tried to contact lookout 2 but was unsuccessful. It then asked unit *1855* if it was now underway. Unit *1855* confirmed that it was finishing launching at Verdun and estimated that it would reach the bottom of the rapids approximately 10 minutes later.

At around 1935, unit *1815*, which had been called in as backup, was advised to launch its boat at the Verdun Marina. The command post also requested assistance from nautical units[9] on Montréal's south shore.

While lookout 2 was adrift, trying to communicate the situation and his position to the command post, he spotted the pleasure craft crossing the rapids. Once in calmer waters, lookout 2 guided unit *1855* to it by radio. Unit *1855* picked up lookout 2 and headed for the pleasure craft.

At around approximately 1950, unit *1815* launched its vessel.

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8 SIM code 10-50 indicates a priority request. Because communications between rescuers were shared on the dedicated channel for Montréal emergency services, the Marine Rescue Sub-Centre was not informed of the capsizing until 1935.

9 The Longueuil, Varennes, La Prairie, and Châteauguay fire departments (all in Quebec) offered assistance.

While adrift, the coxswain caught sight of the hull of rescue boat *1864* a few times. When he reached calmer waters, he heard the lieutenant shouting for help. He swam toward the lieutenant, and they stayed in the water together.

The boaters heard the coxswain and the lieutenant calling for help. They managed to restart the engine and headed toward the 2 firefighters, following their calls for help. They stopped the engine, and one of the boaters helped the firefighters climb aboard. Meanwhile, the other boater called 911. He gave his cellphone to the coxswain, who explained the situation to the 911 dispatcher. The boat's occupants then tried to restart the engine but were unsuccessful. The coxswain continued communicating with the 911 dispatcher to direct unit *1855* to them.

At around 1955, rescue boat *1855* reached the pleasure craft. Unit *1855* attended to the lieutenant, who was suffering from hypothermia, and gave a blanket to the coxswain, who remained on the pleasure craft. Unit *1855* took the lieutenant and lookout 2 to the Verdun Marina, where emergency services were waiting. The coxswain had kept lookout 2's radio, but it was no longer working. Now in calm waters, and with the danger over, the pleasure craft was set adrift to allow other responders to continue the search for lookout 1.

At approximately 2005, rescue boat *1815* headed for the overturned hull of rescue boat *1864*. At approximately 2020, unit *1815* contacted the command post to request the assistance of La Prairie Fire Department in the recovery of the pleasure craft.

In the meantime, unit *1815* tried unsuccessfully to find any indications that lookout 1 was beneath the hull. Rescue boat *1864*'s hull was caught on the riverbed, and unit *1815*'s efforts to right it were unsuccessful.

At around 2025, unit *1857* joined the search for lookout 1. It launched its boat upstream of the rapids in the Lachine borough. To assist in the search and resolve communication problems, unit *1857* asked the command post to use the search and rescue grid and indicate in which section they should concentrate their search (Appendix A). The command post told unit *1857* to continue searching upstream of the rapids, because lookout 1might have remained at the top of the rapids.

At 2039, unit *1815* marked the position of rescue boat *1864*, then went to help recover the pleasure craft.

At around 2045, SIM requested assistance from the SPVM's Groupe tactique d'intervention (GTI) diving unit. The head of Jet Boating Montreal (Saute-Moutons)[10] was also asked to assist in the search of the rapids.

At around 2058, unit *1815* began towing the pleasure craft alongside to the boom near the Côte-Sainte-Catherine locks. Ambulance crews were waiting on site.

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[10] Jet Boating Montreal (Saute-Moutons) offers excursions on the Lachine Rapids with a propulsion boat specially designed for rapids.

Later that evening, helicopters from the Canadian Armed Forces and the Sûreté du Québec arrived on the scene to join the search. Other SIM units were also added to search along the riverbanks.

At one point, helicopters focused their search on the spot where rescue boat *1864* had capsized in the rapids.

At around 0245 on 18 October, the GTI diving unit boarded rescue boat *1857* to head for the hull of rescue boat *1864*, which had drifted and snagged on the bottom once out of the rapids. At 0313, the divers were able to scan the underside of the boat using an underwater camera. They confirmed that lookout 1 was trapped under the vessel.

At around 0835 on 18 October, the body of lookout 1 was recovered from the water. He was wearing his PFD.

1.5 Environmental conditions

At the time of the event, the weather was clear and it was dark. Sunset was at 1804. The air temperature was 10 °C, and the wind was from the west-northwest at about 13 km/h. The water temperature of the St. Lawrence River at the borough of LaSalle was 17 °C.

1.5.1 Lachine Rapids

The Lachine Rapids are located downstream of Lake Saint-Louis, east of Kahnawake, Quebec; south of the borough of LaSalle; and north of Île du Seigneur. At this point, the St. Lawrence River narrows and flows down to the La Prairie basin, passing under the Honoré-Mercier Bridge. Two nautical miles upstream of the Honoré-Mercier Bridge, a seasonal buoy indicates the presence of rapids downstream. The buoy had been removed on 09 October 2021, for the winter season.

The Lachine Rapids have a 13 m drop between Lake Saint-Louis and the La Prairie Basin and are classified as level IV on an international scale of river difficulty.[11] On the day of the accident, the average flow measured at the Saint-Laurent LaSalle hydrometric station (020A016) was around 9000 m^3/s.[12] Despite being dangerous, the Lachine Rapids are popular with rafting, kayaking, and surfing enthusiasts.

On nautical charts for the area, no water depths are indicated for the section between the borough of Lachine and the Victoria Bridge, and the section is unmarked. Rapids are indicated by ripple marks.

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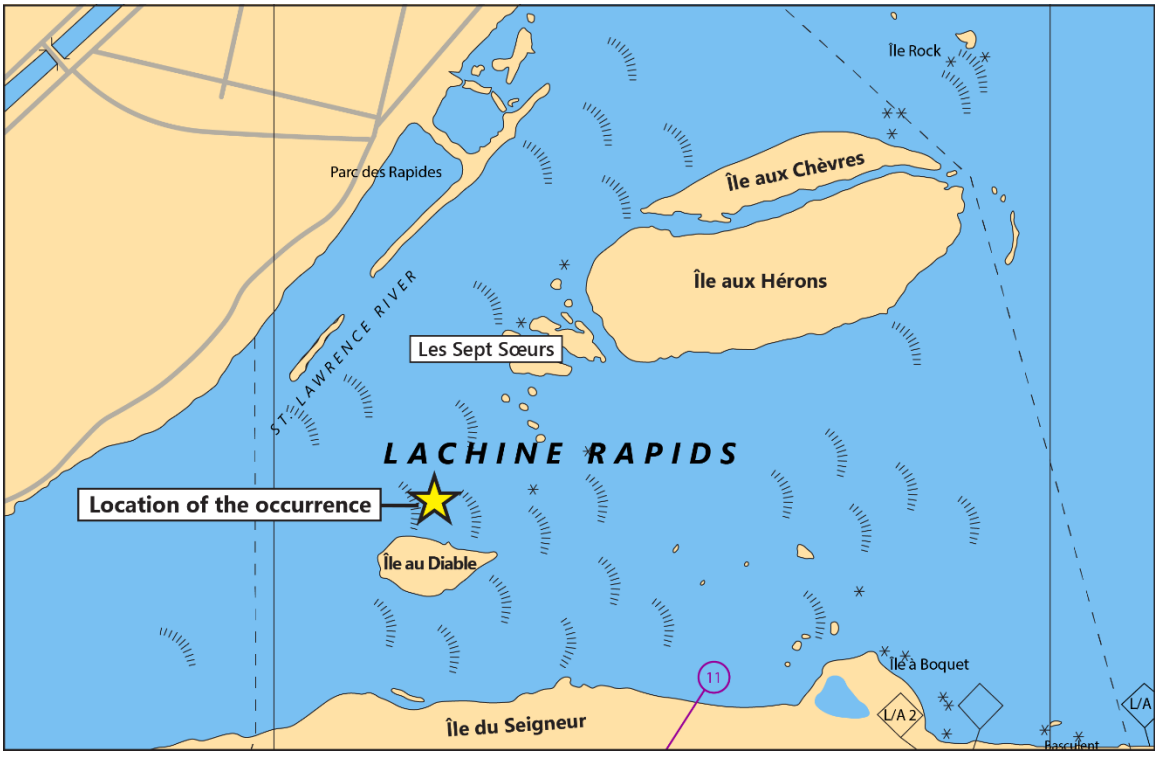
11 Rivers and/or rapids classified according to this scale are assigned a level from I to VI, with I being easy to cross and VI representing mortal danger. This rating takes into account the strength of the current, the presence of obstacles such as rocks or waves, the topography, and the difficulty of carrying out recovery manoeuvres.

12 Government of Canada, "GReal-Time Hydrometric Data Graph for SAINT-LAURENT (FLEUVE) A LASALLE (02OA016) [QC]," at https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=02OA016 (last accessed on 27 December 2023).

Figure 6. Lachine Rapids section (Source: Canadian Hydrographic Service Chart 1429 - Canal de la Rive Sud, with TSB annotations)



1.6 Damage to rescue boat *1864*

The capsizing and subsequent refloating operations damaged the structure of the rescue boat. The hull had various scratches, deformations and dents. The navigation console was ripped off. The inboard motor and electrical wiring were water-damaged. The fibreglass roof and aluminum framing were torn off and could not be salvaged. The boat was declared a total loss.

1.7 Certification and inspection

As a vessel of 15 gross tonnage or less operating for commercial purposes, the *1864* was required to be registered with Transport Canada (TC) but was not required to undergo periodic inspections by TC or to have an inspection certificate to operate. The *1864* had a TC-issued conformity label.[13] The label had been applied to the steering console by the builder to certify that the boat complied with TP 1332 – Construction Standards for Small Vessels, applicable to pleasure craft.

Subsection 14(1) of the *Canada Shipping Act, 2001* stipulates that every Canadian vessel must have an authorized representative (AR) who is responsible for acting with respect to any matters relating to the vessel that are not otherwise assigned to any other person.

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13 Conformity labels were previously issued by Transport Canada at the request of a builder, provided that the necessary documentation concerning a boat or series model has been duly completed and the applicable fees have been paid. As of 2011, conformity labels are required to be issued by the builder.

Subsection 106(1) of the *Canada Shipping Act, 2001* stipulates that the AR of a Canadian vessel shall

> a) ensure that the vessel and its machinery and equipment meet the requirements of the regulations made under this Part;
>
> b) develop procedures for the safe operation of the vessel and for dealing with emergencies; and
>
> c) ensure that the crew and passengers receive safety training.[14]

The AR of vessel C16264QC (1864) was the Ville de Montréal – Services des incendies.

1.8 Personnel certification and experience

1.8.1 Rescue boat *1864*

The operator of a vessel up to 8 m in overall length (other than a fishing vessel, tug, or passenger-carrying vessel) making voyages in sheltered waters and voyages within 2 nautical miles of shore is required to hold a Pleasure Craft Operator Card (PCOC).[15]

All firefighters on board were considered crew members, but only the coxswain was required to have a PCOC.

Each member of the *1864* nautical unit had a PCOC. The coxswain also held a restricted radio operator certificate.

The lieutenant had 14 years' water rescue experience with SIM. The coxswain had 10 years of experience in water rescue with SIM. Lookout 1 and lookout 2 had 16 years and 4 years of water rescue experience, respectively, with SIM.

The lieutenant of unit 265, at the command post at the start of the rescue operation, had received SIM nautical training in 2004 and had acquired 6 months' experience with a nautical unit in 2004.

1.8.2 Pleasure craft

Anyone operating a motorized pleasure craft must hold proof of competency; the PCOC is the most common proof of competency. A PCOC can be obtained by taking a boating safety course in person or online and passing the exam at the end of the course. The operator of the pleasure craft held a PCOC.

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14 Government of Canada, *Canada Shipping Act, 2001* (S.C. 2001, c. 26, as amended 30 July 2019), subsection 106(1).

15 A marine certificate of competency is not required if the person holds a Pleasure Craft Operator Card. Source: Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (amended June 23, 2021), Part 2: Crewing, subsection 205(3).

1.9 Jet propulsion (hydrojet)

In jet propulsion systems, water is drawn into an intake duct from an opening under the vessel's hull. A propeller is placed in this duct to increase the speed of water expulsion at transom level. An adjustable deflector above the water outlet redirects the jet and controls the boat's direction.

Jet propulsion has several advantages:

- Excellent maneuverability and rapid acceleration
- Ability to access shallow and whitewater areas
- The absence of an external propeller reduces the risk of breakage and injury to people in the water

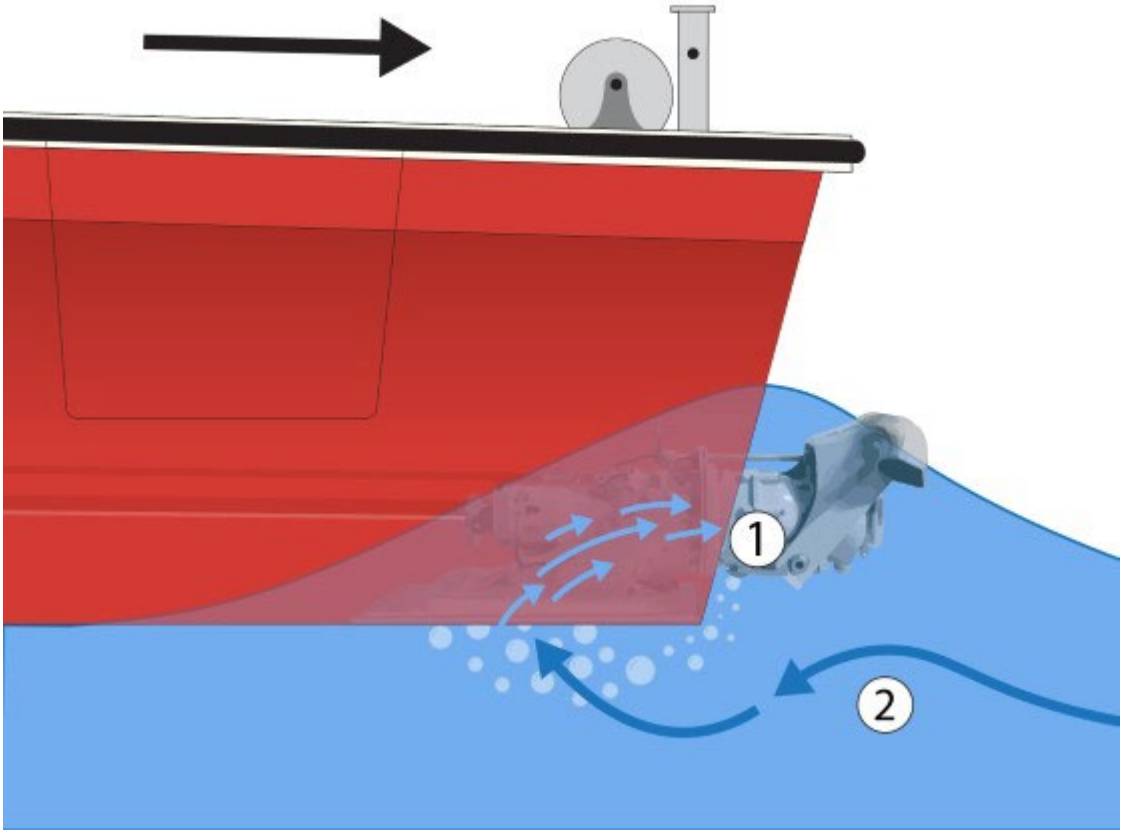
However, jet propulsion has some drawbacks:

- Control of the vessel diminishes with reduced speed (lower power).
- At high speeds, this type of propulsion generates more noise.
- Backward propulsion power is up to 60% less than forward propulsion due to cavitation[16] in the water intake caused by air bubbles and/or exhaust gases (Figure 7).

In this accident, rescue boat *1864* experienced a loss of propulsion and control when the boat was put into reverse in turbulent waters.

[16] Cavitation is the formation of vapour bubbles inside a liquid in areas of low pressure when the liquid has been accelerated to high speeds, as in the operation of marine propellers.

Figure 7. Diagram of a boat with reverse propulsion, showing exhaust system gases (1) mixing with water flow (2) (Source: TSB).



1.10 Towing

According to the National Fire Protection Association (NFPA), towing procedures can vary significantly depending on many factors, including boat size, waves and currents, weather conditions, and the nature of the operation. The use of inappropriate methods can present a risk of downflooding or capsizing of one or both boats. Crew members must know their boat and how to tow safely. They must also recognize the conditions under which towing must be abandoned.[17]

The SIM participant's handbook for water rescue includes a detailed section on towing, which refers to Canadian Coast Guard (CCG) recommendations. These state that SIM units should tow only when human life is at risk. If the situation is not life-threatening, specialized towing companies should be called in. The handbook also states that units must

[17] National Fire Protection Association (NFPA), *Standard on Operations and Training for Technical Search and Rescue Incidents*, standard 1670, A.21.3.5(7) (2017). This standard was consolidated at the end of 2022 and is now part of the 2500 standard.

not tow a boat at night. Nevertheless, firefighters will occasionally tow a vessel back to port, usually by towing alongside.

For workboats like those owned by SIM, towing is done with a towline attached to a towing bitt at the stern of the vessel. If manoeuvring room is limited and control is essential, towing alongside is also possible. Before towing, even in unforeseen situations such as search and rescue, planning in the form of a risk assessment can reduce the threat to people, the environment, and property.[18]

1.11 National search and rescue program

Canada's National Search and Rescue Program is the responsibility of the Canadian Armed Forces, which delivers the program in collaboration with various federal, provincial and municipal agencies. Maritime operations are handled by the Department of Fisheries and Oceans, through the CCG.[19] The waters of the St. Lawrence River, including the Lachine Rapids, are classified as federal waters and therefore fall under the CCG's search and rescue jurisdiction.[20]

The Program has several types of units and can also rely on units of opportunity[21] to deliver its program. The Canadian Armed Forces has aircraft, and the CCG has vessels. The Program can also call on various provincial and municipal services when no unit is available in the appropriate area.

1.11.1 Search and rescue response in the Lachine Rapids area

The units available for the area around the island of Montréal vary according to the season. In summer, the CCG has a student program for inshore rescue boat service,[22] which is typically in place from May to September. Then there are the Canadian Coast Guard Auxiliary volunteer auxiliary units, which are typically available from May until weather conditions require them to store their boats for the winter. However, these units are not equipped to respond in the Lachine Rapids, which are classified as whitewater and require a higher level of training and specialized equipment. Therefore, the CCG relies on the Ville de Montréal's fire and police departments to respond in this area. SIM has several boats

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18 Shipowners Club, "Loss Prevention: Tugs and Tows – A Practical Safety and Operational Guide," at https://shp-13383-s3.s3.eu-west-2.amazonaws.com/media/5216/8779/4999/PUBS-Loss-Prevention-Tug-and-Tow-Safety-and-Operational-Guide_A5_onscreen.pdf (last accessed 11 December 2023).

19 As set out in paragraph 41(1)(b) of the *Oceans Act* (S.C. 1996, c. 31)

20 Canadian Coast Guard, *Level of Service: Search and Rescue* (May 2010), at https://www.ccg-gcc.gc.ca/publications/corporation-information-organisation/levels-of-service-niveaux-de-service/page09-eng.html (last accessed 29 December 2023).

21 The assistance of local commercial and recreational vessel owners may be requested in the event of a marine accident.

22 Government of Canada, "Inshore Rescue Boat student program," at https://www.ccg-gcc.gc.ca/search-rescue-recherche-sauvetage/irb-esc/student-prog-etudiant-eng.html (last accessed 29 December 2023).

capable of responding in unmarked areas. The police have surveillance boats, as well as a diving unit (which are part of the GTI).

Most of SIM's nautical operations are routine, low-risk (towing a boat that has broken down, recovering a person from the water in calm water), and have no negative consequences. SIM's *Rapport d'activités 2021* (2021 activity report) states that, in 2021, 229 water rescue operations and 24 ice rescues were carried out by the water and ice rescue division.[23] These nautical responses are few in number when compared to first responder responses (65 097), minor fires (967) and major fires (278). Since 2018, however, the number of water rescue operations has been on the rise,. The 2021 activity report does not mention the number of tows performed by nautical units.

1.12 National Fire Protection Association standards

The NFPA[24] is a U.S.-based international non-profit organization dedicated to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. Among other things, the NFPA publishes codes and standards designed to minimize the risks and effects of fire by establishing minimum criteria for construction, processing, design, service, and installation worldwide. The NFPA also sets minimum standards for training and provides training materials for firefighters and first responders.

NFPA standards are the benchmark for most fire departments.

1.12.1 Incident response models

NFPA 1670 establishes the levels of functional capability for efficiently and efficiently conducting operations during technical search and rescue incidents, while minimizing the risks to rescuers.[25] It stipulates, for example, that the organization must identify the hazards and assess the risks within the response area and must determine the feasibility of technical search and rescue operations before commencing the response.

NFPA 1006 describes in detail the minimum knowledge and skills required to perform various types of technical rescue operations, including calm water, swift water, and boat search and rescue operations.[26]

The standard specifies that, after an initial response to a call, the response team must

- analyze the situation

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23 Service de sécurité incendie de Montréal, *Rapport des activités 2021* (2021), Statistiques 2021, p. 43, at ville.montreal.qc.ca/sim/file/rapport-des-activites-2021 (last accessed 27 December 2023).

24 National Fire Protection Association, "About us," at nfpa.org/about-nfpa (last accessed 04 January 2024).

25 National Fire Protection Association, *NFPA 1670: Standard on Operations and Training for Technical Rescue Incidents* (1999)

26 National Fire Protection Association, *NFPA 1006: Technical Rescue Personnel Professional Qualifications* (2003).

- plan the response
- implement the response
- follow up on the response

In the SIM training handbook, follow up is described briefly as the process of reapplying the first 3 steps to the current situation.

1.13 Fire departments in Canada

There are over 3000 fire departments in Canada. Of these, approximately 80% are volunteer fire departments, 17% are a mix of volunteers and career firefighters, and the rest are professional fire departments.

The Canadian Association of Fire Chiefs, in collaboration with the National Advisory Council, surveyed a sample of 629 Canadian fire departments as at 01 April 2022.[27] The sample included 100% of the 22 largest cities (metropolitan departments), around 50% of professional fire departments, around 30% of the country's composite departments (volunteer and career firefighters) and around 10% of volunteer fire departments. Of this sample, 85 departments offer water and ice rescue; 22% of these departments are volunteer, 21% are composite, 31% are professional, and 26% are metropolitan.

1.13.1 Service de sécurité incendie de Montréal

SIM operates throughout the Island of Montréal. In addition to its regular fire department duties, SIM carries out various types of specialized responses: hazardous materials response, technical rescue, rescue from heights and confined spaces, and water and ice rescue.[28]

At SIM, fire station personnel provide service 24 hours a day, 7 days a week. To provide this service, firefighters and officers are divided into 4 rotating teams, working 24-hour shifts based on a 28-day calendar. Each fire station comprises 1 or more units. Each unit includes an officer and 2 or 3 firefighters.[29]

SIM has 67 fire stations, 8 of which include a nautical unit providing water and ice rescue services on inland waterways and around the Island of Montréal. In the event of a water or ice rescue, all units of the station may be called upon to respond.

Each specialized team is led by a C/O. The C/O of Water & Ice Rescue is in charge of training for nautical unit members, as well as of managing the risks associated with water and ice rescue. The position of Water & Ice Rescue C/O, in charge of the 8 nautical units, had been vacant for several years at the time of the accident. The investigation could not determine

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27 Canadian Association of Fire Chiefs, "2022 Census Results," at cafc.ca/page/2022Censusresults (last accessed 29 December 2023).

28 Service de sécurité incendie de Montréal, "Specialized teams," at https://ville.montreal.qc.ca/sim/en/specialized-teams (last accessed 29 December 2023).

29 Firefighters and officers are always attached to the same fire station and unit.

exactly how long this position had been vacant, but it had been at least 5 years. Responsibility for the rescue fleet and supervision of water and ice rescue operations was therefore divided between the other 2 C/Os. None of them had any training or experience in water and ice rescue beyond the training they had received as part of their secondary school vocational diploma (SSVD).

SIM also includes an occupational health and safety division and a training division that oversee all divisions of SIM.[30]

1.14 Firefighter training in Quebec

In Quebec, the mission of the École nationale des pompiers du Québec is [translation] "to ensure the relevance, quality, and consistency of qualifying professional training for firefighters and other municipal personnel working in fire safety."[31]

In addition to offering training programs, the École [translation] "administers and supervises professional qualification examinations. Certification issued by the École allows firefighters and officers to hold various positions in fire safety departments in Quebec municipalities." [32] Although Quebec does not officially recognize NFPA standards, they are used for training purposes. In addition, certificates of qualification issued by the École bear the seal of the International Fire Service Accreditation Congress (IFSAC). The training required for a firefighter position depends on the population of a town or municipality (Table 2).

Table 2. Firefighter training programs

Training	Population	Number of hours
Firefighter 1	0 to 24 999 inhabitants	255 hours
Firefighter 2	25 000 to 199 999 inhabitants	Firefighter 1 + 120 hours
SSVD (1 year)	200 000 or more inhabitants	1185 hours
College diploma (2 years)	In accordance with municipal requirements	SSVD + 4 sessions
Officer 1	Required when supervising firefighters: • –Before starting work for towns/cities with 200 000 or more inhabitants	Firefighter 2 + 150 hours

30 Service de sécurité incendie de Montréal,"Organigramme" (French only), at ville.montreal.qc.ca/sim/sites/default/files/organigramme-sim-2023-03-08_3.pdf (last accessed 29 Dcecember 2023).

31 École national des pompiers, "Informations générales" (French only), at https://www.ecoledespompiers.gouv.qc.ca/index.php?id=19 (last accessed on 29 December 2023).

32 École national des pompiers, "Programmes de formation" (French only), at ecoledespompiers.gouv.qc.ca/index.php?id=20 (last accessed 29 December 2023).

	• Within 48 months of assuming duties for towns/cities with up to 199 999 inhabitants	
Officer 2	Required when supervising other officers in towns/cities with populations of 25 000 or more	Officer 1 + 150 hours

For a large city like Montréal, the minimum requirement is an SSVD in fire safety response, which takes 1185 hours and lasts 10 months. The vocational program includes 45 hours of water rescue training.[33] Some of Quebec's larger cities also require a college diploma in "Techniques de sécurité incendie" (fire safety techniques), which adds a further 2 years of training.

1.14.1 Training for members of Service de sécurité incendie de Montréal nautical units

One of the prerequisites for enrollment in the SSVD is a Pleasure Craft Operator Card.[34] Firefighters in SIM's nautical units have a DEP as a minimum, which includes a component on risk management in response situations. Risk management is covered in greater depth for those with a DCS or Officer 1 and Officer 2 levels.

The training curriculum for members of nautical units was developed by SIM's training division. Training includes basic theory, practical training, and mandatory simulations.

1.14.1.1 Service de sécurité incendie de Montréal basic water rescue training

The introductory training course covers 75 hours of theory and practical training and is based on the 2004 edition of the participant's handbook. The participant's handbook contains, among other things, established CCG search and rescue protocols and NFPA standards. The handbook is divided into several sections containing information on vessels and equipment, navigation, response and guidelines. The handbook, at more than 800 pages long, is comprehensive. It details various rescue and towing operations that SIM's nautical units can carry out; however, it does not contain sections on abandoning an operation or transferring it to another unit, nor on manoeuvring or towing with a jet propulsion system.

The training handbook also describes the characteristics of the various bodies of water around and on the Island of Montréal, including the Lachine Rapids, with accompanying images. The images of the Lachine Rapids (figures 8 and 9) show only 2 waves in the area, focusing on the roughest parts of the rapids. The handbook states that rescue by boat in this section of the river should only be carried out by experts. However, the handbook does not define "expert."

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33 Académie des pompiers, "Modules DEP" (French only), at academiedespompiers.ca/wp-content/uploads/2019/03/pdf-page-modules-dep.pdf (last accessed 29 December 2023).

34 Institut de protection contre les incendies du Québec, "Admission pour les élèves canadiens" (French only), at ipiqlaval.com/devenir-pompier/admission-pour-les-eleves-canadiens/ (last accessed 29 December 2023).

Figure 8. The Devil's Drop in the Lachine Rapids, between Goat Island and Heron Island, from the Service d'incendie de Montréal training handbook (Source: Service d'incendie de Montréal, training division, Sauvetage nautique : manuel du participant [2004])

Figure 9. The Big Joe wave in the Lachine Rapids, off Goat Island, from the Service d'incendie de Montréal training handbook (Source: Service d'incendie de Montréal, training division, Sauvetage nautique : manuel du participant [2004])

The handbook also describes how a heroic attitude contradicts the responder's survival objectives. Such heroic attitudes lead to an underestimation of the dangers to the rescuers themselves. In several places, the handbook describes the importance of situational analysis to counter this heroic attitude. For example, for night and poor-weather operations, it states the following [translation]:

> Operations at night and in poor weather require considerable effort on the part of the crew. For this reason, it is essential to analyze the situation beforehand by answering the following 2 questions:
>
> Do we have the skills to handle this situation?
>
> Is our vessel capable of responding to the situation?

Although a crew must make it their duty to assist, safety must come first.[35]

1.14.1.2 Ongoing training

To stay current in their water and ice rescue skills, firefighters in these units must complete 5 practical exercises at the start of each season: organizing a team, analyzing risk, using equipment, performing a rescue, and administering first aid. Other practical exercises are carried out during the season at the discretion of the marine unit lieutenants.

Before performing these 5 practical exercises, each lasting an hour, the lieutenant can consult the corresponding sheet in the handbook. However, firefighters are not required to review the theory part of the exercise. Three of these practical exercises focus on the risks to the individual being rescued.

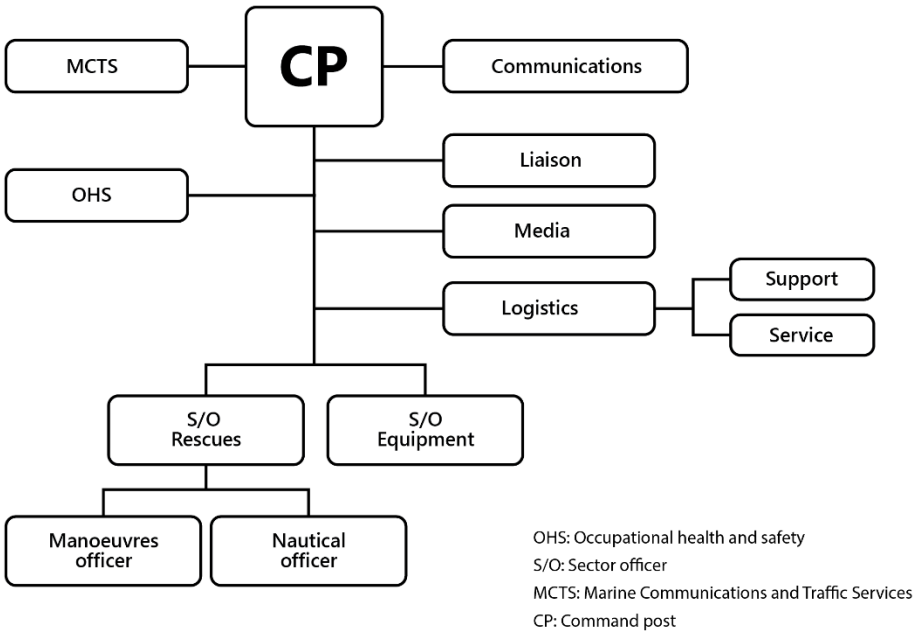
1.15 Water rescue operations

SIM is organized into units. Nautical units comprise 4 firefighters (1 lieutenant, 1 coxswain, and 2 lookouts) and a rescue boat, while ground units consist of a team of firefighters and a firefighting vehicle. Each firefighter carries a non-waterproof portable radio to communicate with other units on a channel reserved for Montréal's emergency services.

In the SIM chain of command, the command post is responsible for identifying hazards and making operational decisions (Figure 10).

[35] Service de sécurité incendie de Montréal, Training Division, *Sauvetage nautique : Manuel du participant* (2004) Module 2 : Navigation, Lesson 2.4 : Navigation de nuit et par mauvais temps, section 5: Interventions sur les plans d'eau ceinturant l'île de Montréal, sous-section 5.3 : Analyse préalable, p. 32.

Figure 10. Diagram of nautical command structure used by the Service de sécurité incendie de Montréal. (Source: TSB, based on Service d'incendie de Montréal, Division de la formation, Sauvetage nautique : manuel du participant [2004])



For a water rescue, SIM deploys as follows:

1. The SIM command centre dispatches 2 land units and 2 water units, as well as a C/O.
2. The first officer (officer in charge) on site, a captain or a lieutenant, takes charge of the command post, supported by the C/O.
3. The units try to get a visual on the boat in distress and communicate with the units by radio.
4. The rescue operation continues, adapting and expanding as required.

The first officer on the scene, who takes charge of the command post, is not necessarily trained in water rescue and may be unable to assess the situation. Situational updates are given by radio.

1.16 Provincial occupational health and safety legislation

The Quebec *Act respecting occupational health and safety* requires employers to develop and implement a prevention program.[36] The objective of such a program is to "eliminate, at the source, risks to the health, safety and physical and mental well-being of workers."[37]

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36 Government of Quebec, *Act respecting occupational health and safety* (c. S-2.1), section 58.

37 Ibid., section 59.

1.16.1 Prevention program

A prevention program[38] is an effective measure for making workplaces safe. Prevention programs are specific to each organization and aim to eliminate and control workplace hazards through specific measures.

The prevention approach is a 3-step process based on continuous improvement.

1. Implement measures to identify workplace hazards.
2. Correct these situations and minimize risks.
3. Implement monitoring measures to prevent risks from recurring.[39]

SIM had set up a prevention program under section 58 of the *Act respecting occupational health and safety.* In 2021, the program contained 46 modules, of which only 2 were specific to water rescue: one related to the ongoing training of employees involved in water rescue response, and the other applied to all SIM responses and required a post-mortem to be conducted following the transmission of a response message (10-07) or a major response.

The post-mortem reports contain the following sections:

1. Response objectives
2. Situational analysis
3. Strategies
4. Tactics
5. Duties
6. Controls

These post-mortem reports are identical for all SIM operations and are therefore not adapted to nautical operations. For example, Section 2, Situational analysis, does not mention assessing water conditions (e.g., temperature, waves, currents) in terms of risk to the victims and rescuer.

In this occurrence, a partial analysis was carried out by the command post, but the report was not shared with the members of the fire station, nor with the health and safety committee. In their comments in the report, the authors identified the following strengths [translation]:

> Communication between the initial units.[40]
>
> CP [command post] teamwork and communication.

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38 Commission des normes, de l'équité, de la santé et de la sécurité du travail, "Programme de prévention" (French only), at https://www.cnesst.gouv.qc.ca/fr/prevention-securite/organiser-prevention/faire-un-programme-prevention/programme-prevention (last accessed 29 décembre 2023).

39 Ibid.

40 Land and water teams.

Good communication between shore and water.

Location of final CP.[41]

The authors also identified the following areas for improvement:

Better assessment of the exclusion zone for withdrawing teams.

Addition of nautical search booklet in shoreline fire stations.

Vessels better adapted for operations in rough waters (rapids).

Training for whitewater operations.[42]

1.16.2 Results of the internal investigation into the 2010 capsizing

Following the capsizing of a vessel similar to the *1864* in the Lachine Rapids in April 2010,[43] SIM conducted an internal investigation as required by Section 51 of the *Act respecting occupational health and safety* and its prevention program. SIM's investigation led, notably, to the following recommendations [translation]:

- Draft a memo on maintaining the exclusion zone in the Lachine Rapids, including a detailed plan, and supervise navigation in other areas where there are rapids marked for pleasure boating.
- Save nautical exclusion zones in the memory of all SIM GPS units and require personnel to use these tools at all times when navigating.
- Ensure that SIM GPS tracking is continuously updated.
- Prepare a memo detailing all the personal protection equipment required at all times when navigating on the water.
- Organize a meeting between the manager in charge of water rescue and the instructors to make them aware of the obligation to navigate using electronic navigational aid equipment. [44]

Once the investigation was completed, a memo was sent to the chiefs of operations of the water rescue stations. This memo informed them of the ban on navigation in the Lachine Rapids, both for training and rescue operations, and was accompanied by a diagram of the exclusion zone (Figure 11). For any operations within this perimeter, the command post had to request assistance from the CCG via the communications centre.[45]

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41 Service de sécurité incendie de Montréal, *Analyse rétrospective d'une intervention (Intervention 87310, région 2, groupe 3)* (17 November 2021), p. 7.

42 Ibid.

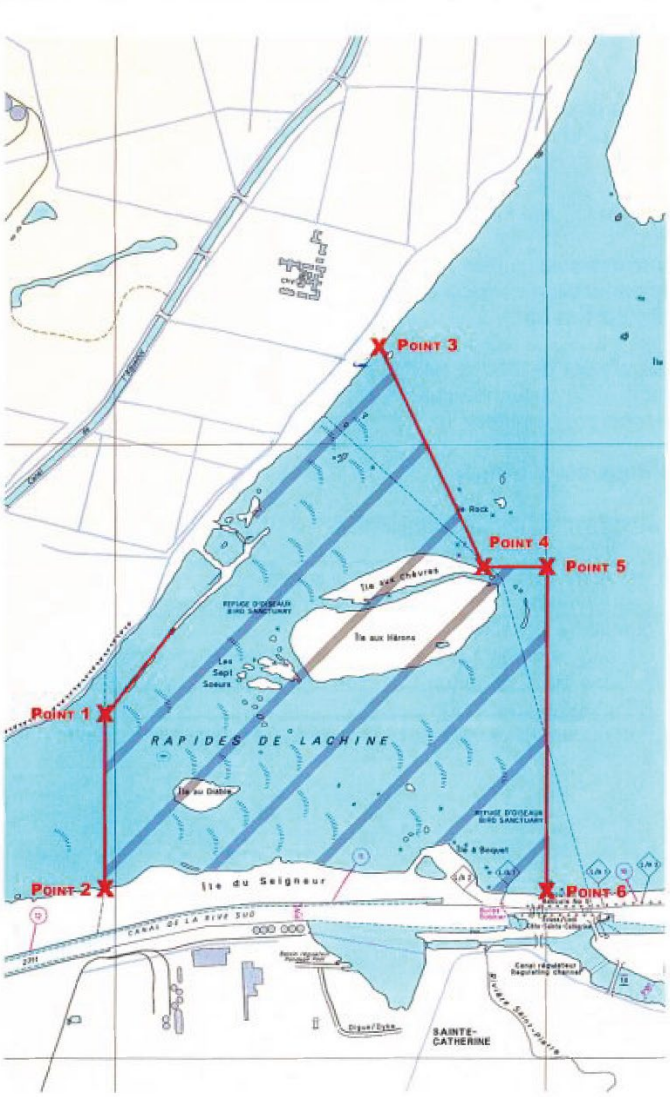
43 TSB marine transportation occurrence M10L0026.

44 Service de sécurité incendie de Montréal, *Rapport chavirement de l'unité 1802 le 25 mars 2010* (February 2011) (French only).

45 Service de sécurité incendie de Montréal, email from the division chief to the chiefs of operations of the water rescue stations (12 April 2010), Note – Navigation dans les rapides.

The Lachine Rapids nautical exclusion zone was not saved in the SIM GPS units, nor was it mentioned in the participants' handbooks.

Figure 11. Diagram of nautical exclusion zone in the Lachine Rapids (Source: Service de sécurité incendie de Montréal, Rapport chavirement de l'unité 1802 le 25 mars 2010 (February 2011)



SIM had reported the 2010 occurrence to the Commission de la santé et de la sécurité du travail (CSST),[46] and the CSST deemed it unnecessary for an investigator to deploy, as there had been no major injury during the occurrence.

[46] The Commission de la santé et de la sécurité du travail was abolished on 01 January 2016, when the Commission des normes, de l'équité, de la santé et de la sécurité du travail was created.

1.17 Safety equipment

After the accident, the TSB inspected rescue boat *1864*, as well as a similar SIM vessel. Both vessels carried all the required safety equipment.[47] They also carried a first-aid kit, first-aid equipment,[48] and additional safety equipment. However, some fire extinguishers had expired, the 4 extra lifejackets were partly mouldy, and most of the pyrotechnic distress signals had expired. Safety equipment, including the oxygen tank, was haphazardly stowed with other equipment in the stowage compartments. The tow line was placed on the lid of one of the storage boxes, considerably restricting access to the contents.

The coxswain checks the boat before each shift using a checklist, and the firefighters perform equipment maintenance during downtime on their shifts. A review of the maintenance and pre-departure check records showed that the trailer was always checked. The boat, engine, and electronic equipment were checked occasionally. The safety equipment was not on the checklist; it was checked once a year, after annual maintenance by contractors. No records were available demonstrating that safety equipment had been checked.

1.17.1 Reboarding device

SIM's Hammerhead RFV-22 rescue boats were built with a side door that provided easier access to the water with a loaded freeboard of 0.075 m and facilitated reboarding. However, the freeboard was so low that one of these boats was submerged when the door was opened.[49] Following this occurrence, in 2009, the doors on SIM boats were sealed, meaning that the boats now have a freeboard of 0.71 m (now measured from the waterline to the highest point of the hull, because there is no door to open). Thus, these boats now require a separate boarding device to comply with federal regulations.[50] The crew uses a swimming platform, which is installed at the stern of the vessel, as a reboarding device.

However, although each boat has a swim platform, there is no specific reboarding device. To retrieve a person from the water, firefighters must hoist them onto the platform and then into the boat, which is difficult if the person is immobile and weighed down by wet clothes.

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47 As workboats with a gross tonnage of 15 or less, SIM rescue boats were required to be fitted with certain safety equipment, and this equipment was required to be in good working order, easily accessible, well maintained and replaced in accordance with the manufacturer's recommendations. Source: Transport Canada, SOR/2010-91, *Small Vessel Regulations* (last amended June 23, 2021), subsection 5(1).

48 Medical oxygen kit, multi-purpose splint, and dressings.

49 TSB Marine Investigation Report M09L0068.

50 Transport Canada, SOR/2010-91, *Small Vessel Regulations* (last amended 23 June 2021), paragraph 5(1)(b).

Finding: Other

The swimming platform used as a reboarding device on SIM vessels may not facilitate reboarding in an emergency, especially if the person is unable to reboard or if there is no one on board to assist.

1.17.2 Position tracking

A boat's position can be tracked visually or by a GPS signal. SIM's rescue boats were equipped with GPS to allow the command post to continuously monitor their position via a website. The position is updated approximately every 2 minutes. In a typical water rescue operation, however, these updates do not allow real-time tracking. In this occurrence, rescue boat *1864* was moving at a very high speed, so it covered a great distance between each position update.

1.17.3 Personal protective equipment

SIM firefighters were equipped with a variety of personal protective equipment (PPE) to handle the hazards of water rescues. PPE included a helmet, the option of a rain suit or immersion suit, a PFD with a knife on a lanyard, a flashlight, a carabiner, a whistle and a manual distress light, plus a radio transceiver that was tuned to a communication band reserved for Montréal emergency services and was attached to a radio belt. The portable radios were not waterproof.

Unit *1864*'s PPE was inspected by the TSB, and the following observations were made:

- **PFD distress light**. PFDs are equipped with a manual (rather than automatic) distress light, requiring firefighters to activate it once in the water.
  During the investigation, the TSB tested several PFD lights and found that some were very weak, and one did not work. In addition, the distress lights (0.75 candelas) are not visible from more than 1.2 km away, particularly in choppy waters with a strong current.
- **Helmets**. The TSB found that some helmets had been fitted with a light attached by cable ties. Some of these helmets had lost their lights. Although these lights were not mandatory PPE accessories, because PFDs were fitted with a light, they helped firefighters to see at night. It was noted that the lights on the helmets were not installed or maintained consistently.
- **Boots**. The TSB also found that firefighters had different styles of boots: some had Velcro straps on the top, while others had clips. The latter seemed more difficult to grab and quickly detach in the event of a snag.

Given the risk of heat loss and drowning when operating near whitewater such as rapids, the following equipment was also examined:

- **Immersion suits**. In the event of a fall into cold water, an immersion suit provides protection against hypothermia. Immersion suits also help individuals stay afloat in both whitewater and calm water. The firefighters don their immersion suits when the water temperature is below 15 °C.

- **Rain gear**. Rain gear provides some protection from the elements when firefighters are on the boat. However, they offer no protection against hypothermia in the event of a fall. Furthermore, rain gear can restrict a firefighter's freedom of movement in the water, particularly in whitewater. The varying density of whitewater reduces the ability to stay afloat, even with a PFD. Wearing a rain suit adds extra drag, further reducing the ability to stay afloat in whitewater. SIM firefighters don rain gear when the water temperature is 15 °C or higher. Although not considered “cold water” without protective gear, waters from 16 °C to 21 °C still feel cold and can lead to considerable heat loss, especially in whitewater.
- **Personal flotation device (PFD)**. Firefighters wear Salus SAR 770 PFDs[51] approved for 22 pounds of buoyancy. These PFDs have additional buoyancy so that one rescuer can support the weight of a 2nd person.

1.18 Factors related to the organization and management of operations

Organizational and management factors in an operation can contribute to unsafe conditions, negatively impact human performance, and prevent proactive identification and mitigation of risks. Gaps in organizational risk management and in risk monitoring and reporting are examples of organizational and management factors that can impact safety. All organizations must reconcile safety and operational objectives.[52]

1.19 Supervision of operations

Supervision is a method of administrative control that reinforces compliance with procedures, priorities, workload, and other human factors. Supervision can have a significant impact on many of the factors that influence workplace behavior.[53] Having supervisors who are not directly involved in the action makes it possible to independently validate decisions and assess risks. Specifically, supervisors limit the risk of an operation by focusing on the execution of the operation (task-oriented) rather than its safety (threat-oriented). In addition, senior managers and supervisors often have to meet specific skill and qualification requirements, such as taking threat management courses, which are not required of other employees.

Although supervision is a key aspect of safety, its effectiveness can be compromised if a supervisor also plays an active role in operations, because their attention is then focused on operational tasks, limiting their ability to monitor and supervise the overall operation effectively.

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51 Salus Marine Wear Inc., “SAR-770 Technician,” at https://salusmarine.com/products/pro-sar/sar-770-technician/ (last accessed 28 December 2023).

52 J. Reason, *Managing the Risks of Organizational Accidents* (Ashgate Publishing, 1997), pp. 107–124.

53 M. Fleming, Offshore Technology Report 1999/065, "Effective Supervisory Safety Leadership Behaviours in the Offshore Oil and Gas Industry" (2001).

During SIM water rescues, supervision of operations is essentially the responsibility of the commanding officer at the command post and the officer on board the boat. The commanding officer at the command post is responsible for the organization and supervision of deployed units. However, the commanding officer does not always have visual contact with the rescue operations in progress and does not necessarily have experience or training in water rescue.

The officer on board the vessel is in charge of the rescue unit in question and also takes part in operations.

1.20 Practical drift

Procedures dictate the specific steps that an individual should take to accomplish a task, and practices reflect the way that work is done in day-to-day operations. For inexperienced workers, following established procedures can help compensate for a lack of skill and knowledge. For experienced workers, who may complete tasks from memory, following procedures can help slow down the execution of the task and remind the worker of all the steps needed to complete the task.

Practical drift is a term used to describe a situation in which practices drift away from operational guidance and procedures, and those practices then become routine. In an ideal world, practices and procedures would be identical. However, practical drift can occur for a number of reasons. If procedures do not accommodate the actual conditions facing the worker or organization, workers may modify the procedure steps to complete the task. If departing from procedures results in immediate and tangible rewards with no obvious negative consequences, these modified steps may become entrenched practices.

Practical drift often occurs incrementally over time and can cause a degradation of safety, usually without workers realizing it. Furthermore, practical drift may be reinforced because other goals are achieved as a result—operations or production continue, money is saved, efficiency is achieved, or organizational goals are met.

1.21 Situational awareness and limited planning

Situational awareness (SA) can be broken down into 3 levels: the perception of the elements in the environment, the comprehension of their meaning, and the projection of their status in the near future. [54] Acquiring accurate SA depends on factors such as the quality and quantity of information available, the ability of an individual (or team) to perceive relevant cues in the environment, and an individual's knowledge and skills. Acquiring SA in real time, without a pre-established plan and while under time pressure, demands a great deal of cognitive resources and can limit a person's ability to identify, monitor, and mitigate risks present in the environment.

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[54] M. R. Endsley “Toward a theory of situation awareness in dynamic systems,” *Human Factors* Vol. 37, Issue 1, pp. 32–64.

Poor situational awareness can develop at all 3 levels of SA. Someone who develops incorrect SA may misunderstand the situation they are facing and make inappropriate decisions.

For example, when searching for real-time visual cues in the environment, and particularly in a context of time pressure, people usually start by looking for the most significant information. By focusing on the cues that seem most relevant, people can miss other available cues that are deemed less important operationally, but which may be key elements in risk assessment. This phenomenon is known as "perception bias."[55]

The workload imposed by searching for visual cues in real time can be considerable, particularly in the context of time pressure. Reduced visibility at night increases the workload of a visual search. In addition, as workload increases, the perception of auditory signals, such as radio communications, can diminish. These 2 factors can affect a person's ability to acquire accurate SA and to identify, recognize, and mitigate hazards and risks present.

All operational safety management should therefore consider the inherent risks associated with real-time information acquisition, ideally by means of generic safety rules, procedures, and criteria that objectively delimit the operational risk of each situation.

1.22 Interpretation of cues and construction of mindset

Knowledge-based performance is largely conscious and occurs when a person experiences new situations and learns from the results of their actions and observations.[56] With experience, the person builds rules, and their performance becomes more and more focused on a conditional model (if . . . then). People develop their mental models by integrating knowledge and rules specific to a context or situation.[57] Mental models are a structural representation of a person's understanding of what they have learned—for example, how to navigate a particular river. Accurate mental models can be developed during training using specific information such as maps, descriptions, and images. The accuracy of a person's mental model of a given situation influences the quality of the decisions they make. In teamwork situations, the quality of decisions is also influenced by the similarity between the mental models of the people involved.[58]

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55 F. H. Allport, *Theories of perception and the concept of structure* (Wiley, 1955).

56 J. Reason, *The Human Contribution: Unsafe acts, accidents and heroic recoveries* (Ashgate Publishing, 2008), pp. 13, 38.

57 C. D. Wickens, *Engineering Psychology and Human Performance*, 3rd edition (Pearson, 1999), p. 280.

58 J. Reason, *The Human Contribution: Unsafe acts, accidents and heroic recoveries* (Ashgate Publishing, 2008), ch. 3.

In this occurrence, the command post did not use objective reference documents, such as laminated reference maps. On board rescue boat *1864*, navigation was based solely on visual cues and information transmitted by the command post.

With practice, a person can reinforce mental models through processes such as recognition and recall. For example, recognizing a hazard from an image provided during training, and then remembering that this hazard could lead to an accident. Practice also enables instructors or supervisors to verify that the person has an accurate understanding of the situation.

Rule-based or knowledge-based errors[59] occur when a person misapplies or does not apply a rule correctly. This can happen if the rules are unclear and/or the person lacks experience because they have not been able to practise the rule in a relevant scenario.

1.23 Cold water immersion

Whether close to or on the water, falls overboard, hypothermia, and drowning can happen quickly. In Canada, falling overboard is one of the top causes of death in the marine industry.

Hypothermia is a drop of body temperature below normal (37 °C), which occurs following prolonged exposure to cold. A fall into cold water exacerbates heat loss, because water is a highly conductive medium (approximately 25 times more conductive than air). Water is generally considered cold when its temperature is less than or equal to 15 °C; however, some sources consider water to be cold when its temperature is less than or equal to 21°C.[60, 61] It is important to note that, even if we apply the standard of water temperature less than or equal to 15 °C, a person who enters water that is 16 °C to 21°C, especially suddenly and without thermal protection, will still experience the water as cold and be exposed to potentially dangerous effects.

When a person is suddenly immersed in cold water, immersion is usually followed by water ingestion and hypothermic shock, which produces heavy panting and uncontrollable hyperventilation, hypertension, and increased cardiac workload.[62] This response reduces a person's ability to hold their breath,[63] making it very difficult to keep the mouth closed to avoid ingesting water or to hold one's breath while swimming. If the person remains in the water, there will be a progressive cooling of the body's extremities, leading to “a decrease in

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59 Ibid.

60 G. G. Giesbrecht et A.M. Steinman, “ Immersion into cold water”, dans : P.S. Auerbach (dir.) *Wilderness Medicine*. 6th Ed. (Elsevier, 2012), pp. 143 to 170.

61 M. Tipton and G. Maidment, “ Human physiology in the thermal environment”, in D.P. Gradwell and D.J. Rainford (eds), *Ernsting's Aviation and Space Medicine,* 5th ed.. (CRC Press, 2016), pp. 194–195.

62 M. Tipton and G. Maidment, “ Human physiology in the thermal environment”, in D.P. Gradwell and D.J. Rainford (eds), *Ernsting's Aviation and Space Medicine,* 5th ed.. (CRC Press, 2016).

63 Ibid.

manual dexterity, speed of movement, strength and mechanical efficiency."[64] This will make it very difficult to perform survival tasks. Core body temperature will begin to drop, and hypothermia will worsen, eventually leading to heart failure.

1.24 Previous occurrences

The TSB has investigated 7 other occurrences involving workboats of 15 gross tonnage or less.

M04C0090 – On 10 December 2007, a workboat carrying four people capsized while leaving a work site on Payette Island in Georgian Bay, Ontario. Three people were rescued and one person drowned.

M08M0062 – On 17 September 2008, the *Fireboat 08-448B* capsized during training and familiarization exercises in Halifax Harbour, Nova Scotia. All 8 persons on board were recovered from the water by a CCG rescue boat.

M09L0068 – On 01 May 2009, SIM rescue boat *1815* capsized off Sainte-Thérèse Island, within the Port of Montreal, while participating in a training exercise. The 4 people on board were recovered from the water by another SIM rescue boat. There were no injuries.

The TSB issued Marine Safety Information Letter 04/09 to TC highlighting the importance of taking into consideration all downflooding openings, such as side doors, and their intended use, when evaluating the stability and buoyancy of a vessel. TC concurred with these observations. Following the occurrence, SIM sealed the side door on its HammerHead RFV-22 vessels.[65]

In the investigation report for this occurrence, the Board issued the following safety concern:

> until such time as builders and operators become more knowledgeable and an audit or inspection program is implemented, there will remain a residual risk that vessels will be built and placed into service despite being non-compliant with the standards and possibly unsafe.[66]

M10L0026 – On 25 March 2010, SIM rescue boat *1865* capsized in the Lachine Rapids during an exercise. The 4 crew members were recovered by another SIM boat. There were no injuries.

SIM analyzed the events leading up to the capsizing, as required by law[67] in order to draw conclusions and issue recommendations.

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64 Ibid.

65 Following SIM's own internal investigation completed in July 2009, the doors were bolted shut permanently to prevent them from being used.

66 TSB Marine Investigation Report M09L0068.

67 Government of Quebec, *An Act respecting occupational health and safety* (chapter S-2.1), Division II, sections 49 and 51.

On 03 May 2010, SIM met with the CSST, union representatives, and managers. During that meeting, various issues related to the incident, including occupational health and safety, were raised.

On 01 June 2010, the TSB conducted a stability test on one of the HammerHead RFV-22 boats. On 03 June 2010, the TSB sent Marine Safety Information Letter 03/10 to the Director of the SIM concerning the capsizing of the rescue boat. The TSB investigation revealed the following information:

- The water jet intake screen was not in place.
- The vessel did not have a redundant propulsion system.
- A sail plan had not been filed before waterborne operations.
- There was no holster to secure the portable radiotelephone, which was lost when the boat capsized.

M19A0025 – On 29 January 2019, the workboat *Captain Jim*, with two crew members and one passenger on board, began taking on water and became disabled 2.8 nautical miles from its home port of Eastern Passage, Nova Scotia. A short time later, the vessel sank rapidly. One of the crew members and the passenger managed to board the vessel's life raft. They were rescued by a Halifax Harbour pilot boat and taken to Halifax,. Divers located the body of the other crew member inside the vessel's wheelhouse later that day.

M19P0029 - On 07 February 2019, the Royal Canadian Marine Search and Rescue vessel *Spirit of Sooke* was returning to its station after a training exercise when it ran aground on Christie Point in Sooke Harbour, British Columbia. The vessel had 4 volunteer crew members on board and was proceeding at approximately 27 knots at the time of the grounding. The impact caused serious injuries to all of the crew members. The vessel sustained damage and was temporarily removed from service.

M20C0101 – On 12 May 2020, 3 of the *Manitoulin*'s crew members were crossing over a submerged mooring line in the vessel's workboat while proceeding to shore near Sombra, Ontario, when tension came on the line and it struck the workboat. The impact caused all of the crew members to fall overboard. One of the crew members swam to shore and the other 2 re-boarded the workboat. No injuries were reported.

1.25 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

Safety management is a Watchlist 2022 issue. Although SIM was not required to have a safety management system for its rescue boats, it was required to take steps to manage safety through various processes. The investigation revealed shortcomings in the effectiveness of its risk management in terms of training, operations monitoring, ongoing risk assessment, and distribution of information.

ACTION REQUIRED

The issue of **safety management in marine transportation** will remain on the Watchlist until

- TC implements regulations requiring all commercial operators to have formal safety management processes; and
- operators that do have an SMS demonstrate to TC that it is working—that hazards are being identified and effective risk-mitigation measures are being implemented.

1.26 TSB laboratory reports

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

- LP005/2022 – Vessel and equipment visual inspection

The TSB laboratory conducted a thorough visual inspection of the vessel and its onboard equipment, as well as some of the crew's PPE, clothing and personal effects. A thorough inspection of the propulsion system (engine, turbine system, and jet drive) revealed no mechanical factors that could have led to a loss of propulsion and steering control. In addition, no abnormal operation of the drive train had been reported immediately before the occurrence.

2.0 ANALYSIS

Rescue boat *1864* capsized in the Lachine Rapids while rescuing a pleasure craft that had experienced an engine failure. The 4 firefighters ended up in the water, and one drowned. The analysis will focus on the causal and contributory factors of the capsizing. The analysis will also cover the training of nautical teams, risk assessment, and the management of nautical units by the Service de sécurité incendie de Montréal (SIM).

Inspection of the boat at the TSB laboratory revealed no mechanical defects that could have contributed to the capsizing. In addition, following analysis of the stability assessment carried out as part of TSB investigation M09L0068, it was established that, apart from the presence of a side door, which had since been removed, the stability and buoyancy of these boats met current design standards.

2.1 Risk management and supervision

Risk management aims to identify hazards, analyze and assess the risks associated with these hazards, and put in place mitigation measures, such as training. Effective risk management is a continuous process involving all levels of an organization. Operational risks are dynamic; they are not permanent and can change over time. It is essential, therefore, for organizations to revise their risk assessments regularly in order to adapt to changes and include new hazards, as well as existing hazards that may have been overlooked at the outset. For risk management to be effective, it is also important that the mitigation measures implemented are communicated to all members of the organization for whom they are intended, and that they are monitored to ensure that they are being applied.

Effective risk management is a 2-step process. First, a broad analysis of the territory covered by the organization helps determine the ongoing risks present in the area, such as the presence of whitewater. This analysis is carried out beforehand to identify the risks that need to be considered and the mitigation measures that need to be taken throughout an operation in the area in question. SIM conducted a risk analysis of the Lachine Rapids area following a capsizing in 2010. To mitigate the risks associated with water rescue in this area, SIM had designated an exclusion zone where no rescue operations were to take place. However, this mitigation measure had not been effectively communicated to SIM officers and nautical units.

Second, a response-specific risk analysis carried out before commencing operations aims to identify risks specific to the situation in hand (e.g., visibility, wind). This analysis is carried out in real time, and requires a comprehensive overview of the situation. During water rescue operations, SIM deploys a chief of operations (C/O), in addition to the officers in charge of the deployed teams (captains and lieutenants). The officer in charge of the command post is responsible for identifying risks and making operational decisions. The lieutenant aboard the boat is the officer in charge of supervising operations inside the boat. However, during water rescues, the officer in charge of the command post may not be able to visually monitor the operation in progress, which considerably limits their ability to assess the risks involved. The lieutenant on board the boat does have a direct view of what

is happening on board, but they are also directly involved in the operations and do not have the perspective and overview necessary to properly assess the risks.

Supervision is an administrative control that supports or reinforces various aspects of performance, including training, compliance with procedures, priorities, and workload. Supervision can have a significant impact on many of the factors that influence workplace behaviour.

Although a key aspect of safety, supervision can be compromised if a supervisor also plays an active role in operations, because the supervisor's attention is divided between the specific tasks at hand and monitoring operations. Given that information processing is a continuous process, and the amount of information available in the environment is vast, people need to filter out less important information and concentrate on that which is essential to the task at hand. People can quickly shift their attention from one source of information to another, but they can concentrate on only one source of information at a time and so attempting to perform several tasks simultaneously leads to a reduction in performance on each task.

Finding as to risk

If a person in a supervisory position is not aware of what is happening in deployed units or if they are directly involved in ongoing operations, there is a risk that this person will not be able to effectively monitor the situation and assess the risks..

2.1.1 Training of nautical crews

Training is one way of mitigating hazards and controlling risks associated with the use of equipment and the performance of tasks. It also helps reinforce response procedures, particularly for rare situations requiring a high level of efficiency.

Members of SIM's nautical units receive specific training to conduct various types of water rescue and become familiar with the vessels and their equipment. The participant's handbook had last been revised in 2004. It was found that the handbook did not include information on the HammerHead vessels (acquired in 2008–2009), nor on the new navigation equipment available at the time of the accident. Furthermore, training did not include towing exercises or water rescue simulations in which all units were expected to participate. SIM nautical units had been required to stop performing rescues in certain rapids since 2010. As a result, they received no specific training in operations around the Lachine Rapids exclusion zone or in whitewater rescue, including objective risk assessment for boaters who accidentally find themselves there.

Finally, no effective operational feedback on the training and education program for nautical teams had been provided for several years. As a result, the training provided to water rescue team members was no longer adequate for routine water rescue operations.

Finding as to risk

If theoretical and practical training is not kept up to date and is not representative of actual response conditions, there is an increased risk that rescuers will not have the knowledge and skills required to perform a water rescue safely.

2.1.2 Risks related to water rescues

Quebec's *Act respecting occupational health and safety*, which recognizes the importance of risk management, requires employers to develop, implement, and monitor a prevention program. Reviewing and evaluating operational processes are critical elements of a risk prevention program that help organizations ensure compliance with their policies and procedures, thereby reducing the likelihood of practical drift.

At the time of the accident, SIM had a prevention program in place. However, the investigation determined that very few procedures applied to the water rescue division. Some of the risks associated with water rescue operations and the means of mitigating these risks were defined in the participant's handbook. However, this information had never been transformed into policies, procedures and/or directives. As a result, they were not binding on employees. Without safety procedures and/or guidelines in place, there can be no operational review and no structured processes for identifying hazards, assessing risks and implementing mitigation measures.

Finding as to risk

If a prevention program has no effective means of monitoring an organization's activities, the organization may continue to operate despite the existence of unmitigated risks, thereby compromising the safety of people, property and the environment.

2.1.3 Pre-rescue analyses and abandonment criteria

Circumstances can change unexpectedly during a rescue operation. Best practice calls for a situation-specific risk assessment and action plan to be completed before a rescue is undertaken. The action plan must include all units involved in the response, whether on land or water. Because the situation is likely to evolve during the response, the plan must include criteria for abandoning the operation and criteria for transferring the operation to another unit. The action plan enables members of all units to develop a similar mental model, which helps them assess the situation during the operation.

The investigation determined that pre-rescue analysis was not carried out before a water rescue operation. In addition, personnel had no reference document on risk analysis for a water rescue operation that contained the key points to be assessed before starting the operation. A pre-departure checklist was available, but it covered only the working order of the trailer and boat.

With no action plan and no objective abandonment criteria, the question of whether or not to continue was never addressed in this occurrence.

Finding as to risk

Without a detailed risk assessment process that includes clearly defined abandonment criteria, a rescue operation may continue when it should be abandoned, endangering rescue teams and increasing the number of people in distress.

2.1.4 Management and supervision

The C/O for SIM's water/ice rescue division is responsible for overseeing boating operations, including ensuring vessel compliance with the *Canada Shipping Act 2001* (CSA 2001) and applicable regulations, training boating unit members, and managing risks specific to water/ice rescue. At the time of the accident, the position of C/O of the water/ice rescue division had been vacant for at least five years. The C/O of the Technical Rescue Division and the C/O of the Hazardous Materials Response Division shared the responsibilities associated with the position of C/O of the Water/Ice Rescue Division, in addition to the responsibilities associated with their respective positions. However, none of them had any training or experience in water and ice rescue beyond the training they had received as part of their secondary school vocational diploma.

The investigation revealed that no one at SIM was aware of SIM's responsibilities as an authorized representative. SIM had limited knowledge of the key sections of the CSA 2001 and its regulations, and as a result was unaware of what an authorized representative is, or what an authorized representative's specific responsibilities are to ensure the safe operation of these vessels.

Finding as to risk

If authorized representatives have only limited knowledge of the minimum regulatory requirements under the CSA 2001, vessels and crews risk continuing to operate without the minimal defences afforded by compliance with regulatory requirements.

Furthermore, because both C/Os were unfamiliar with water and ice rescue operations, they were unable to provide supervision that met operational needs. In addition, the investigation showed that the deficiencies and risks associated with water and ice rescue and reported through the SIM prevention program were not being addressed. The information conveyed was lost without any mitigating measures being taken. Training needs specific to water and ice rescue were also not well understood. For example, boat towing was not included in the practical training of nautical units, because existing C/Os believed that SIM never performed this type of operation. However, the investigation showed that SIM did occasionally carry out towing operations.

Finding as to risk

If the senior managers responsible for a rescue program are unfamiliar with the operational requirements of that program and are unable to provide supervision that meets operational needs, operational safety may be compromised.

2.1.5 Communication and dissemination of information

Information dissemination capacity, i.e., the extent to which information is accessible to individuals and institutions via communication channels and media, is a key element of risk management. If risks are identified but not communicated effectively within the organization, employees will be unaware of their existence and unable to take appropriate mitigating action. Clear communication of risks and mitigation measures is the responsibility of managers.

After one of its rescue boats capsized in the Lachine Rapids in 2010, SIM carried out an analysis of the accident, which identified the risks posed by operations in the Lachine Rapids and resulted in a ban on rescue operations there. A memo, accompanied by a diagram showing the exclusion zone and associated GPS data, was distributed within the department, along with recommendations. One of the recommendations was that the exclusion zone be included in the GPS of the department's rescue boats. However, there was no follow-up to these control measures, and the coordinates of the area were not entered in the electronic maps of the multifunction display nor mentioned in the participant's handbook. Thus, during this occurrence, nautical units had limited access to information that would have enabled them to determine their position and avoid the exclusion zone.

Finding as to risk

If safety information is not communicated effectively to the appropriate personnel and followed up on, there is a risk that this information will not be known or utilized during a rescue operation, compromising the safety of the operation.

2.2 Entering the Lachine Rapids area

2.2.1 Pleasure craft

All that is required to operate a pleasure craft is online training to obtain a Pleasure Craft Operator Card. The training covers only basic navigation skills, with little emphasis on recognizing risks on the water. Two nautical miles upstream from the Honoré-Mercier Bridge is a buoy indicating the presence of rapids downstream, but this had been removed a few days before the event.

During attempts to restart the pleasure craft's engine, the vessel continued to drift toward the Lachine Rapids, an area considered unnavigable by the Canadian Coast Guard. Not knowing what to do, and unaware of the danger and the difficulty for emergency services to perform a rescue in the rapids zone, the boaters did not contact 911 until the boat was at Aqueduct Canal Park, some 10 to 15 minutes away from the first standing waves of the Lachine Rapids.

Finding as to causes and contributing factors

The proximity of the pleasure craft to the Lachine Rapids at the time of the 911 call limited the boaters' chances of being rescued before entering the rapids, increasing the urgency of the situation.

2.2.2 Unit *1864*

As with all water rescue calls to 911 on Ville de Montréal territory, 2 land units and 2 water units were assigned to the operation. The sun had already set nearly an hour before they arrived on the scene. Visibility was affected by the bridges, the city lights on the north side, and the contrast with the industrial sites on the south shore. Ground units moved along LaSalle Boulevard to establish visual contact with the pleasure craft and confirm that it was drifting toward the Lachine Rapids. The pleasure craft's navigation lights were visible from LaSalle Boulevard, where the 265 shore team was located. Meanwhile, rescue boat *1864* was launched upstream of the Honoré-Mercier Bridge and headed for the Lachine Rapids. Because of reduced visibility on the water and the initial distance between the rescue boat and the pleasure craft, the 265 ground team, acting as command post, directed unit *1864* by radio. Rescue boat *1864* was travelling at very high speed in an uncharted and unmarked area, increasing the risk to unit members. By the time 911 received the emergency call, the pleasure craft was already close to the exclusion zone, making it impossible for a marine unit to arrive in time for a safe response.

The land and water units did not perform a situation-specific risk analysis, nor did they draw up a joint action plan before commencing operations. Specifically, they did not address the following:

- Units were unfamiliar with the area of the Lachine Rapids.
- This section of the river was unmarked, and the charts did not indicate the depth, so there was a risk of striking the bottom during operations.
- It was dark, and few visual cues were available.
- The Lachine Rapids were a known danger zone, including an exclusion zone.
- Night towing was prohibited by SIM.
- It was not possible to arrive on site in time to carry out a safe operation.
- No abandonment criteria or transfer of operations to another unit had been considered or established.

SIM's practical training did not include any realistic accident simulations in which land and water units were required to participate. As a result, firefighters had no opportunity to practise procedures and make up for their lack of experience in a rare but possible situation. For instance, they did not practice conducting a risk analysis and developing a joint action plan before undertaking a water rescue operation, identifying exclusion zones, or handing over the rescue to another team. This lack of knowledge was not apparent to the firefighters in the nautical unit nor to SIM management.

Given that an action plan had not been established, decisions were made on the fly. The land and water teams had no shared support on which to base their mental model, so they had to build it as the operation progressed, increasing their mental workload and reducing the possibility of developing a mental model shared by all team members. Moreover, without access to specific, easily identifiable visual cues even in reduced visibility, neither the land nor the water units could develop an accurate mental model of the exclusion zone's location. For example, at 1920, the command post contacted unit *1864* to say that the pleasure craft would enter the rapids about 2 minutes later when, in reality, the craft was already in the exclusion zone. Unit *1864* replied that it would try to intervene before the craft drifted into the rapids. This misunderstanding likely contributed to an inaccurate mental model of the exclusion zone.

Unit *1864* and the ground teams knew that the rapids were an exclusion zone, but they did not know exactly where this zone began. The training handbook offered few visual criteria for identifying the exclusion zone; only images depicting the roughest parts of the rapids were provided, even though the exclusion zone begins much further upstream. Moreover, no practical exercises had taken place near this zone.

Finding as to causes and contributing factors

With no pre-departure risk assessment or action plan in place, the teams began the response with an inaccurate mental model of the exclusion zone's boundaries.

Normally, nautical units use their instruments, such as a magnetic compass, charts, and a depth sounder, to help them navigate. However, the response zone was unsurveyed and uncharted, and the exclusion zone had not been entered into the GPS. Furthermore, because the coxswain was unfamiliar with using the multifunction display, he could not adjust its brightness and turned it off because it was blinding him. The training handbook contained no information on how to use the multifunction display. Even though the area is not surveyed or mapped on the Canadian Hydrographic Service charts, entering the exclusion zone onto the multifunction display would have provided the crew with an objective source of information to help them gain more accurate situational awareness, recognize their position and realize that they were in the rapids.

With no objective tools available, the crew had to rely on visual cues identified in real time, as well as radio guidance from the command post, to determine their position and that of the pleasure craft. Because it was dark, sensing and interpreting elements of the environment was more complex and required more attentional resources than in daylight. In addition, the visual cues for locating the pleasure craft, i.e., the navigation lights, were difficult to distinguish from the city lights in the background. Moreover, the team was primarily focused on visually locating the pleasure craft rather than determining its own position. Rescue boat *1864* was moving at high speed, leaving the crew little time to collect and interpret relevant information. In this environment, the crew probably exhibited a perceptual bias, focusing more on information that would enable them to locate the pleasure craft at the expense of other information that would have enabled them to better determine their own position. Because their attentional resources were primarily directed

toward acquiring real-time information to locate the pleasure craft, the crew developed incomplete situational awareness and did not realize they were entering the exclusion zone and endangering themselves.

Finding as to causes and contributing factors

Given unit *1864*'s lack of experience in the area, the reduced visibility, its concentration on searching for the pleasure craft, and the speed of the vessel, unit *1864* did not realize it was entering the exclusion zone.

When unit *1864* made visual contact with the pleasure craft, it had already entered the exclusion zone. It was about 2 minutes from the first standing wave, drifting backwards. Unit *1855* was preparing to launch its boat downstream of the rapids. Despite this, the command post was still giving instructions to unit *1864*, which likely reinforced the firefighters' perception that it was acceptable to continue rescue operations. In such a situation, it is challenging for rescuers to stop, especially when they have visual contact with people in danger.

Finding as to causes and contributing factors

With no objective criteria for abandoning and transferring the operation to unit *1855* downstream of the rapids, rescue boat *1864* entered the exclusion zone to continue the operation.

2.3 Towing attempt and capsizing

When rescue boat *1864* reached the pleasure craft, the 2 boats were about one minute from the first standing wave. Faced with the urgency of the situation, unit *1864* decided to tow. Because it was bow to bow with the pleasure craft, it undertook a reverse tow.

The training handbook mentioned the Canadian Coast Guard's recommendation not to tow unless lives are at stake. The section did describe various towing methods, but the information in the handbook was not suitable for HammerHead vessels. The handbook also stated that boats should not be towed at night.

SIM management believed that nautical units never towed. Therefore, towing was not included in practical exercises. However, the investigation showed that nautical units did occasionally perform tows, usually alongside. Towing is a risky operation. Because towing was not included in the practical training, the members of the nautical units did not have the opportunity to familiarize themselves with the procedures in place, to recognize and mitigate the risks, or to recognize the operational limits of their rescue boat.

Most towing operations carried out by SIM nautical units take place during the day, in calm waters and in fair weather. Most of the time, boaters are not in danger, so these are not emergency situations. In these conditions, marine units have more time to plan their operations than they would in an emergency situation. For example, they have more time to position themselves and carry out a less risky tow, such as an alongside tow. In this

occurrence, the urgency of the situation meant that the team chose the only towing method that did not require repositioning.

The culture within the fire service can be summed up by the saying “risk a lot to save a lot, risk a little to save a little, and risk nothing to save nothing.” This implies that risks to rescuers are accepted, even expected, when risks to those in distress are perceived to be high. The training handbook deals with "heroic attitude" and its associated risks. The handbook clearly states that this attitude runs counter to the responders' survival objectives and causes firefighters to underestimate the dangers to themselves. To counter this heroic attitude, the handbook repeatedly mentions the importance of analyzing the situation before taking action. However, neither the handbook nor the practical exercises give firefighters any advice to help them deal with situations where the risk to their safety limits their ability to act, such as how to handle interaction with people in danger when abandoning a rescue operation.

Any type of towing involves risks, but towing in reverse is a complex and abnormal operation for a boat with jet propulsion. When jet propulsion is reversed, the power of the water jet can be reduced by up to 60%, and the risk of cavitation is much higher, especially in whitewater.

In this case, rescue boat *1864* experienced a loss of power and, consequently, of steering, probably due to cavitation. In an attempt to keep the boat out of the roughest part of the rapids, the coxswain turned the wheel to starboard and applied forward propulsion to regain control of the boat. Rescue boat *1864* hit the pleasure craft hard on the port side, and its bow ended up in the trough of the wave. Water entered the boat, and it began to list to starboard before rapidly capsizing.

The perceived urgency of the situation prompted the crew of unit *1864* to carry out a risky towing operation in a difficult situation, with the aim of rescuing the boaters they perceived to be in imminent danger, at the expense of their own safety.

Findings as to causes and contributing factors

Because of their perception of the risk to the lives of the boaters, the firefighters undertook a risky rescue operation under difficult conditions for which they were not trained.

While towing in reverse in whitewater, the rescue boat lost reverse propulsion and steering. In reaction to the situation, the vessel's propulsion was shifted forward, causing it to collide with the pleasure craft, resulting in the downflooding and sudden capsizing of rescue boat *1864*.

2.4 Cold water immersion and loss of life

The risks of cold water immersion and hypothermia are described in the participant's handbook. Immersion suits are part of the personal protective equipment for water and ice units. For water rescue, SIM based its decision on available documentation and set a minimum water temperature of 15°C for donning rain gear. If the water temperature was below 15 °C, firefighters had to wear their immersion suits. In this occurrence, the water

temperature was 17 °C. The firefighters therefore opted to don rain gear, as SIM procedures allowed. However, heat loss is much more rapid in whitewater than in freshwater, and the rain gear did not protect the firefighters from the effects of cold water immersion.

When rescue boat *1864* capsized, the 4 firefighters found themselves in cold water. The sudden immersion in cold water probably caused the four firefighters to enter hypothermic shock and ingest water. Because they were not wearing immersion suits, 3 of the firefighters developed hypothermia after 30 minutes of immersion.

Finding as to causes and contributing factors

Due to the water temperature and the fact that they were not wearing immersion suits, the 3 firefighters who were rescued suffered hypothermic shock, ingested water and developed hypothermia.

When the boat capsized rapidly, lookout 2 was ejected into the rapids and the other 3 firefighters were trapped under the boat's hull. The hull was deep and presented several risks of becoming trapped in the event of capsizing. At the time of the incident, the firefighters were wearing personal flotation devices (PFDs) designed for search and rescue operations, with a buoyancy rating 2 times higher than an ordinary PFD. This made it more difficult for the firefighters to overcome the buoyancy and escape from under the overturned hull. The coxswain and lieutenant managed to get out from under the hull, but lookout 1 remained trapped and drowned. The investigation was unable to determine the exact reasons why lookout 1 drowned.

Finding as to causes and contributing factors

Following the capsizing of rescue boat *1864*, a firefighter was trapped under the hull and drowned.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. The proximity of the pleasure craft to the Lachine Rapids at the time of the 911 call limited the boaters' chances of being rescued before entering the rapids, increasing the urgency of the situation.

2. With no pre-departure risk assessment or action plan in place, the teams began the response with an inaccurate mental model of the exclusion zone's boundaries.

3. Given unit *1864*'s lack of experience in the area, the reduced visibility, its concentration on searching for the pleasure craft, and the speed of the vessel, unit *1864* did not realize it was entering the exclusion zone.

4. With no objective criteria to abandon and transfer the operation to unit *1855* downstream of the rapids, rescue boat *1864* entered the exclusion zone to continue the operation.

5. Because of their perception of the risk to the lives of the boaters, the firefighters undertook a risky rescue operation under difficult conditions for which they were not trained.

6. While towing in reverse in whitewater, the rescue boat lost reverse propulsion and steering. In reaction to the situation, the vessel's propulsion was shifted forward, causing it to collide with the pleasure craft, resulting in the downflooding and sudden capsizing of rescue boat *1864*.

7. Due to the water temperature and the fact that they were not wearing immersion suits, the 3 firefighters who were rescued suffered hypothermic shock, ingested water, and developed hypothermia.

8. Following the capsizing of rescue boat *1864*, a firefighter was trapped under the hull and drowned.

3.2 Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. If a person in a supervisory position is not aware of what is happening in deployed units or if they are directly involved in ongoing operations, there is a risk that this person will not be able to effectively monitor the situation and assess the risks.

2. If theoretical and practical training is not kept up to date and is not representative of actual response conditions, there is an increased risk that rescuers will not have the knowledge and skills required to perform a water rescue safely.

3. If a prevention program has no effective means of monitoring an organization's activities, the organization may continue to operate despite the existence of unmitigated risks, thereby compromising the safety of people, property and the environment.

4. Without a detailed risk assessment process that includes clearly defined abandonment criteria, a rescue operation may continue when it should be abandoned, endangering rescue teams and increasing the number of people in distress.

5. If authorized representatives have only limited knowledge of the minimum regulatory requirements under the *Canada Shipping Act, 2001*, there is a risk that vessels and crews will continue to operate without the minimal defenses afforded by compliance with regulatory requirements.

6. If the senior managers responsible for a rescue program are unfamiliar with the operational requirements of that program and are unable to provide supervision that meets operational needs, operational safety may be compromised.

7. If safety-related information is not communicated effectively to the appropriate personnel and followed up on, there is a risk that this information will not be known or utilized during a rescue operation, compromising the safety of the operation.

3.3 Other findings

These items could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. The swimming platform used as a reboarding device on SIM vessels may not facilitate reboarding in an emergency, especially if the person is unable to reboard or if there is no one on board to assist.

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4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Service de sécurité incendie de Montréal

Following the occurrence, the Service de sécurité incendie de Montréal withdrew all HammerHead RFV-22 boats from service on 30 September, 2022, and replaced them with TITAN outboard-powered boats.

4.1.2 Commission des normes, de l'équité, de la santé et de la sécurité du travail

Following the occurrence, the Commission des normes, de l'équité, de la santé et de la sécurité du travail prohibited the Service de sécurité d'incendie de Montréal from operating in the unmarked area of the Lachine Rapids until measures were put in place to ensure safe navigation.

The Commission also recommended that the Ministère de la Sécurité publique set up a working group to determine the various measures and best practices for improving the health and safety of the various responders, including firefighters and the police force, during water rescue operations.

4.1.3 Bureau du coroner du Québec

On 26 April 2023, the Bureau du coroner du Québec filed its inquest report[68] from Géhane Kamel on the death of the firefighter during the occurrence. The coroner made recommendations to the Ministère de la Sécurité publique, all cities in the greater Montréal area, the Service de sécurité incendie de Montréal, the Canadian Coast Guard, and Transport Canada to better protect human life.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 06 December 2023. It was officially released on 31 January 2024.

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.

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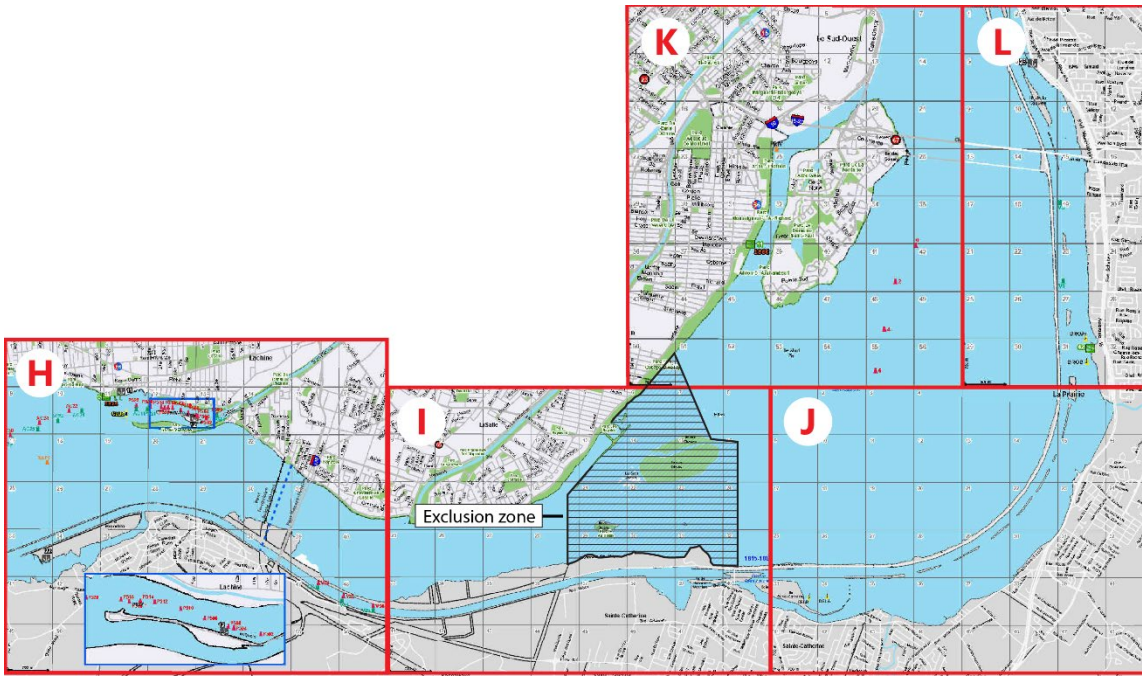
[68] Bureau du coroner du Québec, *Rapport d'enquête pour la protection de la vie humaine 2022-00280* (French only), at https://www.coroner.gouv.qc.ca/fileadmin/Enquetes_publiques/2022-EP00280-9.pdf (last accessed on 12 September 2023)

APPENDICES

Appendix A — Search and rescue grid from the *Guide de localisation nautique* (2014)



Source: Service de sécurité incendie de Montréal, *Guide de localisation nautique* (2014), with TSB annotations showing the exclusion zone.