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

AVIATION INVESTIGATION REPORT
A12O0071

LOSS OF CONTROL AND COLLISION WITH WATER

COCHRANE AIR SERVICE
DE HAVILLAND DHC-2 MK.1, C-FGBF
LILLABELLE LAKE, ONTARIO
25 MAY 2012

Canada

Aviation Investigation Report

Loss of Control and Collision with Water

Cochrane Air Service
de Havilland DHC-2 Mk.1, C-FGBF
Lillabelle Lake, Ontario
25 May 2012

Report Number A12O0071

Summary

The Cochrane Air Service de Havilland DHC-2 Mk.1 Beaver floatplane (registration C-FGBF, serial number 168) departed Edgar Lake, Ontario, with 2 passengers and 300 pounds of cargo on board. The aircraft was destined for the company's main base located on Lillabelle Lake, Ontario, approximately 77 miles to the south. On arrival, a southwest-bound landing was attempted across the narrow width of the lake, as the winds favoured this direction. The pilot was unable to land the aircraft in the distance available and executed a go-around. At 1408, Eastern Daylight Time, shortly after full power application, the aircraft rolled quickly to the left and struck the water in a partially inverted attitude. The aircraft came to rest on the muddy lake bottom, partially suspended by the undamaged floats. The passenger in the front seat was able to exit the aircraft and was subsequently rescued. The pilot and rear-seat passenger were not able to exit and drowned. The emergency locator transmitter activated on impact.

Ce rapport est également disponible en français.

Table of Contents

Table of Figures

Table of Photos

1.0 Factual Information

1.1 History of the Flight

The DHC-2 Mk.1 Beaver floatplane (C-FGBF) departed Lillabelle Lake, Ontario, at approximately 1105 [1] for a flight to Nettogami Lake, Ontario, with 3 passengers and cargo on board. Following this flight, the aircraft flew empty to Edgar Lake, Ontario, approximately 9 nautical miles (nm) to the northeast, to pick up 2 passengers and cargo, and was then scheduled for a return flight to Lillabelle Lake. The aircraft departed Edgar Lake at approximately 1252 and, due to a strong head wind, took approximately 76 minutes to complete the 77 nm flight.

When the aircraft was approaching Lillabelle Lake, the pilot contacted company operations on the radio and was informed that the winds were very strong. The pilot was also informed that after landing, the aircraft should be taxied to the dock on the western shore, next to the company's contracted maintenance facility. The pilot elected to make a southwest approach into the wind on the narrow northern portion of the lake, which ends near the maintenance dock.

This portion of the lake, if approached in a southwest direction, provides approximately 1800 feet for landing. The western shore on the windward side of the planned landing surface is upward sloping and lined with irregular bunches of large trees (Figure 1). As the aircraft approached this landing area, it encountered very gusty conditions. The aircraft entered the flare at a position appropriate for the landing surface available; however, due to wind gusts, the pilot was unable to get the aircraft to settle onto the water. Approximately halfway across the lake, the pilot decided to abort the landing and overshoot. Full power was applied, and the aircraft nose pitched up. In the first few seconds following power application, the aircraft rolled quickly to the left and struck the water in a partially inverted attitude, first with the left wing, then followed quickly by the cockpit and the right wing. The aircraft fuselage quickly submerged, and the aircraft came to a rest inverted, resting on the muddy bottom of the lake, partially suspended by the undamaged floats.

Company and maintenance personnel who witnessed the accident tried to get to the scene as quickly as possible, but were hindered by the wind and rough waters. The company's rescue boat was initially submerged, and a few minutes went by before the boat departed the main dock. When the first persons to respond reached the aircraft, the seriously-injured front-seat passenger had egressed the aircraft and was resting on top of a float. The responders were able to open the left main door, but were unable to locate anyone else due to the gasoline-covered murky waters. The survivor was subsequently transported to hospital.

---

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

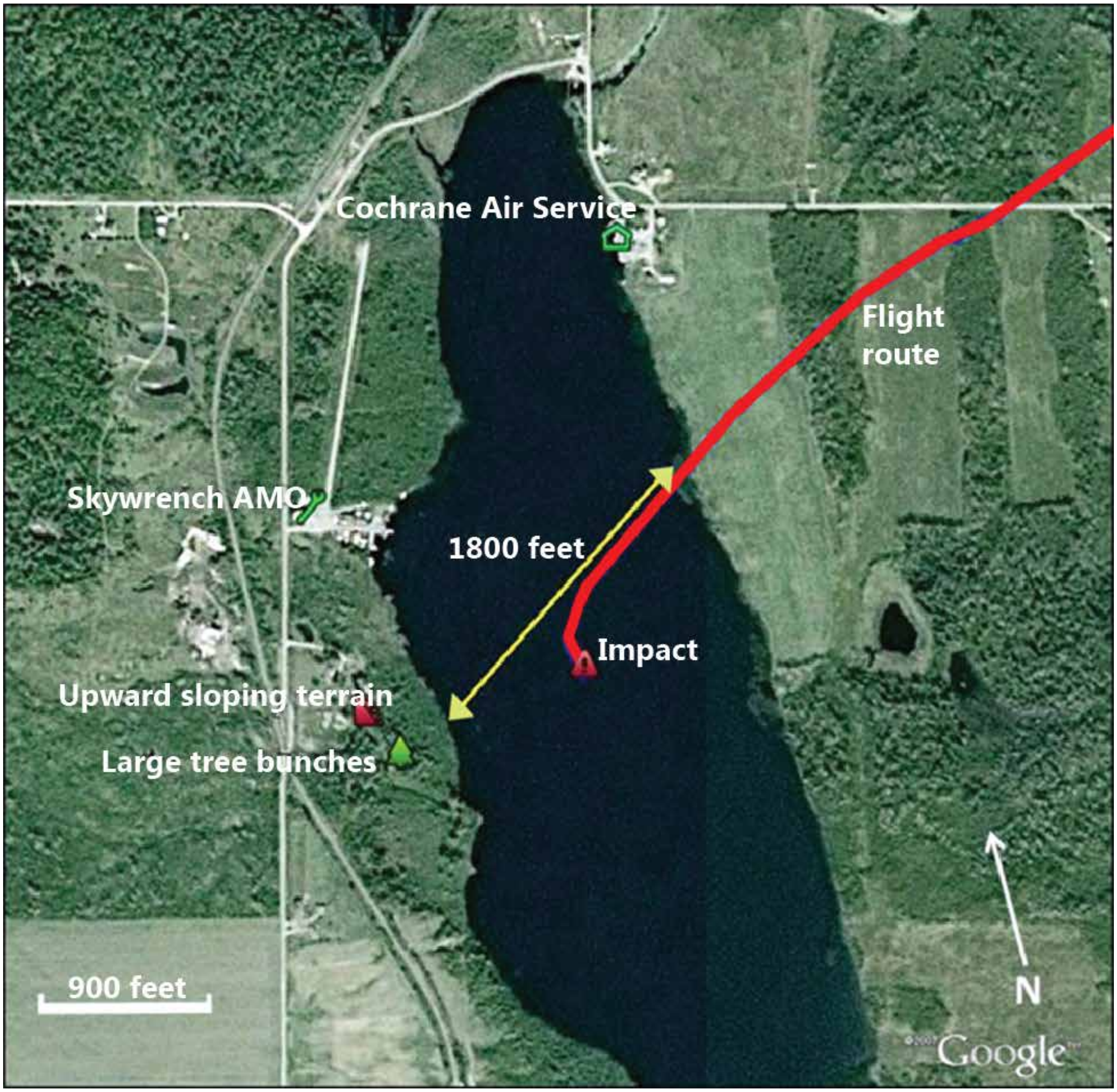

Figure 1. Lillabelle Lake

1.2 Weather

Although the ceiling was generally higher than 3000 feet above ground level (agl) and the visibility was greater than 6 statute miles (sm), the wind speed and gusts were increasing throughout the day, peaking shortly after the time of the accident.

There is no weather reporting station at Lillabelle Lake or at the nearby Cochrane Airport (CYCN). Therefore, pilots refer to the nearest 3 stations to get an estimate of the weather conditions and forecast.

Timmins (CYTS), located 36 nm to the south, Kapuskasing (CYYU), located 59 nm to the northwest, and Earlton (CYXR), located 99 nm to the southeast, were all reporting similar conditions at the time of departure and providing similar forecasts for the arrival. On average, winds were reported as, and were forecast to continue to be, 20 knots, gusting to 30 knots.

The Ontario Ministry of Natural Resources has several environmental monitoring stations in the area, which recorded weather conditions at the time of the occurrence. At 1250, sensors recorded wind speeds near Edgar Lake of 10 knots, gusting to 17 knots. Winds in Cochrane at 1100 were recorded as 8 knots, gusting to 23 knots, and increasing at 1400 to 17 knots, gusting to 34 knots.

The winds peaked in Cochrane at around 1700, when gusts as high as 46 knots were recorded.

Wind shear is defined as a sudden change of wind velocity and/or direction. While widespread, wind shear is normally associated with frontal surfaces, convective clouds, or microbursts. Localized wind shear can also occur near surface obstructions such as hills, trees, and large buildings. On gusty days, wind direction and velocity can change almost instantly due to obstacles on the windward side of the landing surface. [2]

In addition, surface obstructions can cause mechanical turbulence, also referred to as eddies. These eddies can spin in either the vertical or horizontal plane and vary considerably in size and intensity, depending on the speed of the wind.

1.3 Slow Speed and Stall Characteristics

Aircraft flying at low airspeed, a high-power setting, and a high angle of attack encounter a significant left yawing and turning tendency due to the effects commonly refered to as torque, slipstream, and asymmetric thrust. [3]

The DHC-2 Beaver flight manual indicates a stall speed with landing flaps of 45 mph indicated airspeed (IAS). To meet performance specifications, the manual also suggests a final approach speed of 1.3 times the stall speed, or approximately 60 mph. Initial climb speed following an aborted landing is indicated as 65 mph.

The flight manual states that during a stall, "if yaw is permitted, the aircraft has a tendency to roll. Prompt corrective action must be initiated to prevent the roll from developing." [4]

1.4 Pilot

The pilot held a commercial pilot licence with a seaplane endorsement and was certified and qualified for the flight in accordance with existing regulations. The pilot had approximately 1100 hours total flight time, with 700 hours on float aircraft and 300 hours on the de Havilland DHC-2 Beaver. This was the pilot's second season with Cochrane Air Service (CAS) and his fourth season flying float aircraft commercially. At the beginning of May, the pilot received

---

[2] William K. Kershner, *The Advanced Pilot's Flight Manual*, 5th Edition (Iowa State University Press, 1992), p. 200.

[3] Aviation Publishers Co. Ltd., *From the Ground Up* (26th Edtion, 1991), p.25.

[4] De Havilland, *DHC-2 Beaver Flight Manual*, PSM 1-2-1 (1956), section IV.

company recurrent training, which included training on take-offs, landings, rejected landings, and stalls. Since then, the pilot had completed approximately 30 hours of flying.

The pilot had not completed underwater egress training, nor is such training required by regulation.

The day of the accident was the fourth work day in a row following 2 days off duty. The pilot was considered well rested, and fatigue was not considered to be a factor.

1.5 Aircraft

1.5.1 General

C-FGBF was originally manufactured in 1952, and had since accumulated approximately 22 000 hours of air time. The aircraft was certified, maintained, and equipped in accordance with existing regulations. The aircraft was being operated within the weight and balance limitations set out in the pilot operating handbook.

The de Havilland DHC-2 Beaver aircraft type has undergone numerous modifications, and supplemental type certificates (STCs) have been issued over the years to improve or adapt the original design. These modifications are generally optional, unless mandated by an airworthiness directive.

1.5.2 Egress

In recent years, to address egress difficulties following accidents, Viking Air Limited (VAL), the current holder of the DHC-2 type certificate, has designed modifications to replace the original recessed rotary-style door handles with ones that are more accessible and easier to operate (service bulletin V2/0004). Viking has also designed pop-out windows for the rear passenger doors to replace the standard fixed ones (service bulletin V2/0003). These modifications were not mandated or completed on C-FGBF.

1.5.3 Stall Warning

Aircraft design regulations [5] require that aircraft certified in the normal, utility, aerobatic, and commuter category be equipped to provide the pilot with a clear and distinctive stall warning, with the flaps and landing gear in any normal position, in straight and in turning flight. The regulation also states:

> … that this warning may be furnished either through the inherent aerodynamic qualities of the aeroplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself. [6]

---

5 *Canadian Aviation Regulations* (CARs), 523.207, "Stall Warning".

6 Ibid.

Flight tests completed during certification of the DHC-2 type in the 1940s determined that the aerodynamic buffeting near the stall was a clear and distinctive stall warning. As this was deemed to have met the design requirements, no further device or stall warning system [7] was mandated to be installed.

In practice, very few aircraft types still in commercial operation today were type-certified without a stall warning system. The few types remaining in commercial operation were certified prior to 1960.

In more recent years, a VAL modification (STC# SA92-63) was made available to increase the gross weight of the DHC-2, and it included the installation of a stall warning system; however, this STC is not mandated nor was it completed on C-FGBF.

Since 1998, the Transportation Safety Board (TSB) has published 12 investigation reports on accidents involving aircraft that stalled and crashed and that were not equipped with a stall warning system. Ten of these reports involve a de Havilland DHC-2 (Appendix C).

1.5.4 Personal Restraint System

The pilot and co-pilot seats of C-FGBF were solid metal, high-back, military-style seats (Photo 1), equipped with four-point seat belts. The lap belt portion was standard, and the shoulder harness was a detachable adjustable-length-style split Y (non-inertia reel). When this type of shoulder harness is tightened, it can become very difficult for the average person to easily reach essential cockpit controls.

Regulations require pilots to fasten their safety belts during flight. [8] Safety belts are defined in the regulations as a personal restraint system consisting of either a lap strap or a lap strap combined with a shoulder harness.

The rear passenger seat belts were lap belts only. Regulations for newer-design aeroplanes in the normal, utility, or aerobatic category require the installation of rear passenger shoulder harnesses [9] to prevent serious injury in the event of an accident. These requirements were not in effect at the time of design of C-FGBF.

Photo 1. C-FGBF pilot seat after the accident

[7] A stall warning system is a device that provides a clear and distinguishable stall warning to the pilot which is independent of the pilot's recognition of inherent aerodynamic qualities near the stall, such as buffeting.

In 2009, a limited STC was approved to incorporate rear shoulder harnesses on the DHC-2 Mk.3 aircraft type. However, there are currently no modifications or STCs to incorporate shoulder harnesses on the DHC-2 Mk.1.

The aircraft was not equipped with onboard recorders, nor was it required by regulation.

1.6 Wreckage

During the examination of the aircraft during and following the recovery, the following was determined:

- The flaps were in the landing position.
- The right cockpit and passenger doors were pushed in beyond their frames and were inoperable.
- The windows of both front doors were broken out.
- The cockpit windscreen was shattered, and the roof was caved in.
- The left passenger door was undamaged and operable.
- The pilot’s door was bent and partially jammed in the frame, and the opening mechanism was only operable with significant leverage (Photo 2).
- The pilot’s shoulder harness was found tucked into a storage pouch after the accident.
- The front-seat passenger’s shoulder harness was found hanging from its ceiling attachment point.

Photo 2. Pilot's door mechanism

The examination determined that there were no pre-existing mechanical defects which would have prevented safe flight.

---

8 CAR 605.27(3)

9 CAR 523.785(b)

1.7 Survival Aspects

The 2 passengers were frequent travelers with CAS and on float aircraft in general. During boarding at Edgar Lake, the pilot gave only an abbreviated safety briefing and did not ensure that the passengers were aware of the location of the life jackets, the operation of the door exits, or the usage of the shoulder harness where available. Safety cards, which described these items, were available, but were not pointed out or examined.

The pilot and front-seat passenger were only wearing the lap belt portion of their safety belts.

The front-seat passenger was unconscious for a short time after the impact. Upon regaining consciousness, this passenger was able to remove the lap belt and exit the aircraft using the small hole resulting from the missing right cockpit door window. During egress, the passenger did not have time to grab a life preserver and was not aware of its location had time been available.

After impact, after apparently removing the lap belt, the pilot attempted to locate an egress point, but was unable to do so.

Divers from the Ontario Provincial Police were able to access the cabin during recovery. They found the pilot unrestrained in the main cabin, and the rear-seat passenger still with a seat belt in the left rear-passenger seat. Post-mortem examination confirmed that both individuals had drowned; however the rear passenger also suffered a severe forehead injury.

The TSB has found that the risk of serious injury or death is increased for occupants of light aircraft who are not wearing upper-torso restraints. [10] Crashworthiness studies conducted in the United States [11] and Canada [12] have consistently concluded that the probability of surviving impact forces is significantly greater if occupants of small, general aviation aircraft are protected by upper-torso restraints. In 2010, a study by the FAA examined 649 accidents between 2004 and 2009, 97 of which included fatal or serious injuries. The FAA determined that 40% of the deaths could have been prevented by enhanced crashworthiness, and nearly half of those might have been avoided with the use of shoulder harnesses, primarily in passenger seats.

The use of a three-point or four-point safety restraint (safety belt and shoulder harness) is known to reduce the severity of upper body and head injuries and more evenly distribute impact forces. [13] Occupants of a seaplane may drown in a sinking aircraft if they are unconscious; loss of consciousness is normally caused by head trauma. If restrained and

---

10 Transportation Safety Board, Aviation Safety Study SA9401, *A Safety Study of Survivability in Seaplane Accidents* (see Appendix A).

11 Federal Aviation Administration, Aviation Safety, Alaskan Region, *Fatal and Serious Injury Accidents in Alaska, A Retrospective of the years 2004 through 2009 with Special Emphasis on Post Crash survival* (December 2010).

12 (1) *Small Aircraft Crashworthiness*, Volume 1, TP 8655E (prepared by Sypher: Mueller International Inc., July 1987), page 46. (2) Canadian Aviation Safety Board, *Study of the Influence of Shoulder Harnesses in Aviation Safety* (1987).

13 National Transportation Safety Board, Safety Report, NTSB/SR-85/01, *General Aviation Crashworthiness Project, Phase Two – Impact severity and potential injury prevention in General Aviation accidents* (March 15, 1985).

protected during the impact sequence, occupants may maintain consciousness and stand a better chance of successfully exiting a sinking aircraft.

The aircraft damage and impact forces during the accident were survivable, [14] however 2 of the 3 occupants did not survive. According to past research into accidents where helicopters were submerged in water, typically only 10% to 15% of people are able to carry out the required egress actions effectively. [15] Another 10% to 15% of people typically fail to act from extreme stress, greatly reducing their chance of survival. The remaining 75% may be stunned or shocked by the event; however, most are able to escape successfully if they are well trained and have rehearsed for such an event. Restrictions to normal exits, water temperature, darkness, and disorientation following water impact further reduce the ability to exit. Escape training and passenger briefings emphasize the importance of memorizing exit locations. Exits are clearly indicated in the passenger briefing cards; however, passengers may not regularly refer to these cards.

Seaplane travel is common in Canada, particularly in British Columbia. In the Vancouver Harbour alone, there are about 33 000 floatplane movements per year, carrying approximately 300 000 passengers.

The TSB has found that the risk of drowning for occupants involved in seaplane accidents is high. [16] TSB and British Columbia Coroners Service data show that, over the last 20 years, about 70% of the fatalities resulting from accidents where aircraft crashed and were submerged in water were attributed to drowning. Half of the deceased were found in the submerged wreckage.

If an individual is successful in escaping an aircraft that has impacted water, continued survival is also a significant concern. TSB Aviation Safety Study SA9401 suggests it is unlikely that persons faced with the urgency of escape in water will retrieve the life-vests stored in the aircraft. Without a life-vest, considerable amounts of energy are expended to remain above the surface. This physical effort can result in a loss of body heat, fatigue, and eventual drowning. Survival without a life-vest is further complicated by injuries.

1.8 Previous Examination of Floatplane and Seaplane Safety

Over the last 20 years, the TSB has produced safety studies and safety advisories (Appendix A), as well as numerous aircraft accident investigation reports (Appendix B), that highlight issues related to floatplane and seaplane safety.

---

14 A survivable accident is one in which the forces transmitted to the occupant through the seat and restraint system do not exceed the limits of human tolerance to abrupt accelerations, and in which the structure in the occupant’s immediate environment remains substantially intact to the extent that a livable volume is provided throughout the crash sequence. (National Transportation Safety Board, Safety Report, NTSB/SR-83/01, *General Aviation Crashworthiness Project, Phase One* [June 27, 1983], page 3.)

15 C.J. Brooks, C.V. MacDonald, L. Donati, and J.T. Taber, “Civilian Helicopter Accidents into Water: Analysis of 46 Cases, 1979-2006,” *Aviation, Space, and Environmental Medicine*, 79, 10 (2008), pp. 935-940.

16 TSB Aviation Safety Study SA9401 (Appendix A)

As a result of these studies and investigations, the TSB has published several recommendations throughout the years regarding floatplane safety issues, including most recently:

> Recommendation A11-05: The Department of Transport require that all new and existing commercial seaplanes be fitted with regular and emergency exits that allow rapid egress following a survivable collision with water.
>
> Recommendation A11-06: The Department of Transport require that occupants of commercial seaplanes wear a device that provides personal flotation following emergency egress.

In 1992, after a floatplane accident in which all the occupants suffered head injuries, the TSB recommended that:

> Recommendation A92-01: The Department of Transport expedite legislation to require the use of a seat-belt and shoulder harness during take-off and landing of small, commercial fixed-wing aircraft.

In 1994, in *A Safety Study of Survivability in Seaplane Accidents* (SA9401), the TSB was slightly more specific:

> Recommendation A94-08: The Department of Transport require the fitment of lap belts and shoulder harnesses in seaplanes and require their use by all pilots during take-offs and landings before the 1995 seaplane season begins.

After recommendation A94-08 was issued, Transport Canada (TC) made the following additions to the *Canadian Aviation Regulations* (CARs):

> CAR 703.69 – No person shall operate an aircraft unless the pilot seat and any seat beside the pilot seat are equipped with a safety belt that includes a shoulder harness.
>
> CAR 605.24 (3) – No person shall operate a small aeroplane manufactured after December 12, 1986, the initial type certificate of which provides for not more than nine passenger seats, excluding any pilot seats, unless each forward- or aft-facing seat is equipped with a safety belt that includes a shoulder harness.

Upon completion of these regulatory changes, the TSB evaluated the response to recommendation A94-08 as fully satisfactory. However, for older aircraft, the regulation only addressed the cockpit seats and not the remaining passenger seats, contrary to what was intended by the recommendation.

In October 2011, the British Columbia Coroners Service convened an Aviation Death Review Panel to examine the facts and circumstances surrounding 4 floatplane / seaplane accidents on the West Coast. The formal report, published in March 2012, echoed TSB recommendations A11-05 and A11-06 and added 17 recommendations, including the following 4, which are particularly relevant to this occurrence:

> 3) It is recommended that Transport Canada create a regulatory requirement that illumination strips identifying emergency exits be installed onboard all commercial seaplanes.
>
> 5) It is recommended that Transport Canada undertake a formal review of the efficacy of available stall warning systems, including angle of attack indicators, for applications in all certified aircraft, with the objective of identifying systems that would enhance pilot's awareness of the angle of attack and allow for early recognition of situations that may result in an aerodynamic stall if uncorrected.
>
> 9) It is recommended that Transport Canada develop a process for issuing of Operational Directives, similar to the existing Airworthiness Directives processes, to enable speedy and efficient dissemination of safety related information and directives addressing operational safety issues.
>
> 12) It is recommended that Transport Canada develop standardized curriculum for underwater egress training and make underwater egress training mandatory for flight crews involved in commercial seaplane operations; and further, that enhanced safety briefings outlining underwater egress procedures be mandatory on all commercial seaplane flights. [17]

TC has completed several floatplane safety reviews and studies throughout the years in an effort to address the continuing risk of accident and injury in the industry. In 2005, TC conducted a Floatplane Safety Review, which looked at several possible methods of mitigating the risks involved with underwater egress from submerged floatplanes. Among the suggested methods were increased training and briefing, required installation of shoulder harnesses, improvements to emergency exits, and a requirement to wear life preservers. In 2008, TC indicated that the results were inconclusive and did not release a public report or make any substantive changes to existing regulations. During the risk assessment portion of this safety review, TC evaluated the risk that “A passenger may become injured because there was no shoulder harness” [18] was an acceptable risk.

More recently, in the summer of 2011, TC created a focus group to address the latest TSB recommendations and other floatplane safety issues. The focus group mostly agreed with recommendation A11-06, but indicated that the cost to implement recommendation A11-05 was too high and unsustainable for the industry. To mitigate the risk associated with egress raised in recommendation A11-05, the focus group proposed the following regulatory changes:

- That TC require all commercial floatplane operators to placard each emergency exit location with luminescent markings to ease flight crew and passengers egress in cases the aircraft is submerged in water.

- That TC introduce for consideration to foreign civil aviation authorities and ICAO a new harmonized regulation to address enhanced rapid egress for new type design aircraft used in floatplane operations.

---

17 Report to the Chief Coroner of British Columbia, *Death Review Panel: Four Fatal Aviation Accidents Involving Air Taxi Operations on British Columbia’s Coast* (March 2012).

18 Transport Canada Civil Aviation, Floatplane Safety Review, Risk assessment.

- That TC require all commercial floatplane operators to have initial underwater egress training for flight crews. This requirement should consider giving operators sufficient time to implement this training.

- That TC require all commercial floatplane operators to have re-current Pilot Decision Making (PDM) required regardless of operations specifications.

- That TC develop a formal floatplane type rating within its crew licensing regulations. [19]

These proposals were presented to TC during a Canadian Aviation Regulation Advisory Council (CARAC) meeting. After an in–depth review, TC senior management agreed with the proposals. TC indicated that a process is currently underway to initiate the drafting of appropriate regulations using an accelerated procedure, but it did not provide a timeframe for these actions.

In advance of changes to regulation, TC published a Civil Aviation Safety Alert (CASA No. 2011-03) titled “Voluntary Adoption of Floatplane Safety Best Industry Practices”. This CASA was intended to encourage floatplane operators to adopt the following 4 practices:

- upper body restraints to be used by front seat passengers;
- comprehensive safety briefing to passengers, including the proper usage of personal flotation devices during and after emergency egress;
- emergency egress training for flight crew; and
- the adoption of aircraft safety design improvements facilitating egress. [20]

Additionally, TC published a webpage available to the public and to seaplane operators to promote seaplane safety. [21] It could not be determined what percentage of passengers view this webpage before flying aboard a seaplane.

---

19 Transport Canada, Safety Risk Assessement, TSB Accident Report A00P0397 – Lyall Harbour Recommentation A11-05 (October 2011).

20 Transport Canada, Civil Aviation Safety Alert No. 2011-03, “Voluntary Adoption of Floatplane Safety Best Industry Practices,” (2011-06-03).

21 Transport Canada, “Flying On Board Seaplanes/Floatplanes,” http://www.tc.gc.ca/eng/civilaviation/standards/commerce-floatplanes.htm, last accessed on 25 September 2013.

2.0 Analysis

The investigation determined that the aircraft was maintained in accordance with existing rules and regulations, and that the company was operating within the rules and guidelines laid out in the *Canadian Aviation Regulations* (CARs) and the company operations manual. The analysis will therefore focus on the pilot, on the particular circumstances that led to the aircraft impacting the water, and on the underlying systemic safety issues within the floatplane industry.

The wind at the time of the occurrence was very strong and gusty. While these conditions were known to the pilot, changes in wind speed and direction, as well as the mechanical turbulence caused by the wind's passage over obstacles on the windward side of the approach, would have made for challenging landing conditions.

There likely was an increase in headwind, which in turn increased the float time of the aircraft while in the landing flare. As the available landing distance was used up in this landing flare, the pilot decided to conduct a missed approach, applied power, and increased the aircraft angle of attack. It is possible that the pilot inadvertently allowed the aircraft speed to bleed off, or perhaps a change in the headwind component due to the gusty winds (wind shear) resulted in a sudden drop in airspeed below the stall speed. The rapid application of full power caused the aircraft to yaw to the left, and a left roll quickly developed. This movement, in combination with a high angle of attack and low airspeed, likely caused the aircraft to stall. The altitude available to regain control before striking the water was insufficient. The aircraft was not equipped with a stall warning system, which may have given the pilot additional warning of an impending stall.

The rear-seat passenger did not have an upper body restraint and suffered a serious head injury when the aircraft struck the water. This injury rendered the passenger unconscious, which resulted in drowning. This passenger was seated next to the only operational exit. Even though this door was operational, the physical obstacle of the unresponsive passenger may have made this exit unusable.

Due to the damage to the pilot's door, significant torque on the handle was required to open it. As well, the original small recessed rotary interior door handles of this aircraft had not been replaced with ones that are more accessible and easier to operate. Either of these factors may have prevented the pilot from opening the door. The pilot survived the impact, but was unable to exit the aircraft, possibly due to difficulties finding or opening an alternate exit. The pilot subsequently drowned. Commercial seaplane pilots who do not receive underwater egress training are at increased risk of being unable to exit the aircraft following a survivable impact with water.

The pilot did not provide a full safety briefing to the passengers before takeoff, possibly because they were frequent travellers. However, the passengers were not aware of the location of the life preservers, and the front-seat passenger was not aware of the shoulder harnesses. The injuries received by the front passenger were likely aggravated by the fact that the available shoulder harness was not worn. Not wearing a shoulder harness can increase the risk of injury or death in an accident.

3.0 Findings

3.1 Findings as to Causes and Contributing Factors

1. On the windward side of the landing surface, there was significant mechanical turbulence and associated wind shear caused by the passage of strong gusty winds over surface obstructions.

2. During the attempted overshoot, the rapid application of full power caused the aircraft to yaw to the left, and a left roll quickly developed. This movement, in combination with a high angle of attack and low airspeed, likely caused the aircraft to stall. The altitude available to regain control before striking the water was insufficient.

3. The pilot survived the impact, but was unable to exit the aircraft, possibly due to difficulties finding or opening an exit. The pilot subsequently drowned.

4. The rear-seat passenger did not have a shoulder harness and was critically injured. The passenger's head struck the pilot's seat in front; this passenger did not exit the aircraft and drowned.

3.2 Findings as to Risk

1. Without a full passenger safety briefing, there is increased risk that passengers may not use the available safety equipment or be able to perform necessary emergency functions in a timely manner to avoid injury or death.

2. Not wearing a shoulder harness can increase the risk of injury or death in an accident.

3. Not having a stall warning system increases the risk that the pilot may not be aware of an impending aerodynamic stall.

4. Commercial seaplane pilots who do not receive underwater egress training are at increased risk of being unable to exit the aircraft following a survivable impact with water.

4.0 Safety Action

4.1 Safety Action Taken

4.1.1 Cochrane Air Service

Following the occurrence, the company began providing a printed graphic area forecast to pilots each morning. All pilots are required to sign the printed weather report and verify that the conditions are suitable for the planned flight.

4.2 Safety Action Required

4.2.1 Underwater Egress Training for Commercial Flightcrews

Seaplane travel is common in Canada, particularly in British Columbia. In the Vancouver Harbour alone, there are about 33 000 floatplane movements per year, carrying approximately 300 000 passengers.

The Transportation Safety Board (TSB) has found that the risk of drowning for occupants involved in seaplane accidents is high. TSB and British Columbia Coroners Service data show that, over the last 20 years, about 70% of the fatalities resulting from accidents where aircraft crashed and were submerged in water were attributed to drowning. Half of the deceased were found in the submerged wreckage. While it could not be determined in all cases, some investigations found that the occupants were conscious and able to move around the cabin before they drowned. These past occurrences validate the probability that able-bodied persons can be trapped in sinking aircraft and drown as a result.

This investigation concluded that the pilot survived the impact, but was unable to locate a suitable exit and drowned. Pilots who receive underwater egress training have a greater probability of escaping from the aircraft and a greater chance of surviving the accident.

Transport Canada (TC) has recognized the critical importance of underwater egress training. However, at this point, such training remains voluntary. TC indicated that a process is currently underway to initiate the drafting of new regulations requiring underwater egress training using an accelerated procedure, but it did not provide a timeframe for these actions.

The TSB is concerned that pilots who have not received training in underwater egress may not be able to exit the aircraft and subsequently help passengers to safety. Therefore, the Board recommends that:

> The Department of Transport require underwater egress training for all flight crews engaged in commercial seaplane operations.
>
> A13-02

4.2.2 Passenger Shoulder Harnesses

The TSB has found that the risk of serious injury or death is increased for occupants of light aircraft who are not wearing upper-torso restraints or shoulder harnesses. The results of previous safety studies completed by the TSB (SA 9401, TP 8655E) have been more recently supported by a Federal Aviation Administration (FAA) study into fatal and serious injury accidents in Alaska.

A significant portion of the commercial floatplane fleet in Canada was manufactured before shoulder harnesses were required for passenger seats, and remain in this configuration today.

In the event of a seaplane accident, the occupants of the aircraft may drown if they are unconscious; loss of consciousness is normally caused by head trauma. If restrained and protected during the impact sequence, occupants may maintain consciousness and stand a better chance of successfully exiting a sinking aircraft. The use of a three-point safety restraint (safety belt and shoulder harness) is known to reduce the severity of upper body and head injuries and more evenly distribute impact forces.

The TSB has previously recommended (A94-08, A92-01) that small commercial aircraft be fitted with seatbelts and shoulder harnesses in all seating positions. Following these recommendations, changes to regulations were made to require shoulder harnesses in all commercial cockpits and on all seats in aircraft with 9 or fewer passengers manufactured after 1986. [22] This regulatory change did not address the vast majority of the commercial floatplane fleet, which was manufactured prior to 1986.

The TSB considers that, given the additional hazards associated with accidents on water, shoulder harnesses for all seaplane passengers will reduce the risk of incapacitating injury, thereby improving their ability to exit the aircraft. Therefore, the Board recommends that:

> The Department of Transport require that all seaplanes in commercial service certificated for 9 or fewer passengers be fitted with seatbelts that include shoulder harnesses on all passenger seats.
>
> A13-03

4.3 Safety Concern

4.3.1 Stall Warning Systems for DHC-2 Aircraft

Current regulations require that aircraft certified in the normal, utility, aerobatic, or commuter category be designed with a clear and distinctive stall warning. The stall warning may be furnished either through inherent aerodynamic qualities of the aeroplane or by a device that gives clearly distinguishable indications.

When the DHC-2 was certified, a stall warning system was not included as it was determined that the aircraft had a natural aerodynamic buffet at low airspeeds and high angles of attack, and that this was a clear and distinctive warning of an impending stall. Therefore, if a pilot does

---

[22] *Canadian Aviation Regulations* (CARs), 605.24, "Shoulder Harness Requirements".

not recognize or misinterprets buffeting as turbulence while at a low airspeed or high angle of attack, there is a risk that the warning of impending stall will be unrecognized. A stall warning system providing visual, aural, or tactile warning can give pilots a clear and compelling warning of an impending stall.

A large number of DHC-2 aircraft continue to operate in Canada. The TSB has determined that the frequency and consequences of DHC-2 aircraft accidents following an aerodynamic stall are high (Appendix C).

Stalls encountered during critical phases of flight often have disasterous consequences. Therefore the Board is concerned that the aerodynamic buffet of DHC-2 aircraft alone may provide insufficient warning to pilots of an impending stall.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 19 September 2013. It was officially released on 23 October 2013.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. 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.

Appendices

Appendix A – TSB Safety Studies and Safety Communications Related to Floatplane and Seaplane Safety

- *A Safety Study of Piloting Skills, Abilities, and Knowledge in Seaplane Operations (*TSB report number SSA93001*)*: This 1993 study examined 1432 seaplane accidents. Although the study did not focus on survivability issues, it did compare the ratio of fatal accidents to total accidents for float-equipped aircraft to that of wheel-equipped aircraft (for those makes and models of aircraft most frequently float-equipped). When these aeroplanes were on wheels, 10% of the accidents were fatal. However, when they were on floats, 17% were fatal. In the study, 10 safety recommendations were made aimed at reducing the number of seaplane accidents.

- *A Safety Study Of Survivability in Seaplane Accidents* (TSB report number SA9401)*:* This 1994 TSB safety study analyzed seaplane accidents in Canada over the fifteen-year period from 1976 to 1990. During that time, there were 1432 such accidents, of which 234 resulted in 452 fatalities. The safety study contained 6 recommendations to enhance the survivability of persons involved in seaplane accidents, including a recommendation on wearing personal flotation devices during the standing, taxiing, takeoff, approach, and landing phases of flight (TSB Recommendation A94-07).

- *TSB Safety Advisory A000003-1, Escape from a Submerged Seaplane*: The TSB issued this safety advisory following an accident in 2000 involving a de Havilland DHC-2 Beaver. Amongst other things, the safety advisory suggested that quick release mechanisms or push-out windows would enhance rapid egress. Transport Canada (TC) did not, however, implement requirements for these modifications to floatplanes.

- *TSB Safety Advisory A040044-1, Egress from Submerged Seaplanes*: The TSB issued this safety advisory following a 2004 accident involving a Cessna A185F seaplane carrying 1 pilot and 3 passengers. In this occurrence, the pilot and the right front-seat passenger were unable to open either of the main exits and egressed through the broken window in the left cabin door. The 2 rear-seat passengers drowned, despite the fact that they had not sustained any physical injuries during the occurrence. The advisory stated that modifications to seaplane doors to provide a quick release mechanism or the fitting of pop-out windows would enhance the opportunity for rapid egress in the event that the aircraft becomes submerged. The advisory suggested that TC may wish to consider additional methods to facilitate rapid emergency egress from seaplanes in the event that the cabin becomes submerged. In its response, TC indicated that jettisonable doors and large frangible or pop-out windows that would facilitate emergency exits is within the authority of the state of design authority, and that TC would not take any action relating to this issue.

- *TSB Aviation Safety Information Letter A040046, Passenger Briefings and Safety Features Cards in Seaplane Operations*: This information letter was produced following the 2004 accident involving a Cessna A185F seaplane cited in the previous paragraph. The information letter highlighted that the regulations were not instructive with regard to a requirement for the briefing to include information specific to underwater egress procedures in seaplane operations. Furthermore, there is no requirement for seaplane safety feature cards to contain information or special procedures unique to underwater egress. The information letter concluded by highlighting that the risks associated with seaplane passengers and pilots being trapped inside a submerged aircraft are increased when the pre-flight safety briefing and the safety features cards do not include information specific to underwater egress. In its response, TC advised that it sent 100 copies of its revised brochure entitled *Seaplanes – A Passenger's Guide* (TP 12365) to every commercial seaplane operator in Canada, with instructions on how to order more if needed.

Appendix B – TSB Aircraft Accident Investigation Reports Citing Seaplane Egress Difficulties

Occurrence	Type	Fatalities	Comments
A10Q0087	Lake Buccaneer	6	The 2 occupants of the aircraft were seriously injured due to the lack of effective restraints. These injuries rendered them unconscious and they were unable to survive the post-crash water environment.
A09P0397	DHC-2 Beaver	6	Because of impact damage, only 2 of the 4 exits were usable following the crash. Five of the 6 persons who drowned removed their seatbelts after the impact, which indicates that they survived the impact, but were unable to locate a suitable egress point. The TSB published recommedations A11-05 and A11-06 following this report.
A05O0147	Cessna 185F	1	In this occurrence, the pilot drowned. The Board indicated its concern as follows: “Based on historical data, occupants of submerged seaplanes who survive the accident continue to be at risk of drowning inside the aircraft. Existing defences against drowning in such circumstances may not be adequate. In light of the potential loss of life associated with seaplane accidents on water, the TSB is concerned that seaplane occupants may not be adequately prepared to escape the aircraft after it becomes submerged. Of equal concern is that the rescuers, in this occurrence, could not access the cabin from outside.”
A05Q0178	Cessna 185	1	After the aircraft capsized while attempting to take off, 5 occupants were able to escape. One occupant, seated in the front right seat, was unable to escape the submerged cabin and drowned.

A04W0114	Cessna 185F	2	The survivors were unable to locate the interior door handles after the seaplane became inverted and submerged in the water, thus preventing them from using the doors as emergency exits. The TSB report presented the following Board concern: "Based on historical data, occupants of submerged seaplanes who survive the accident continue to be at risk of drowning inside the aircraft. Existing defences against drowning in such circumstances may not be adequate. In light of the potential loss of life associated with seaplane accidents on water, the TSB is concerned that seaplane occupants may not be adequately prepared to escape the aircraft after it becomes submerged. The Board is also concerned that seaplanes may not be optimally designed to allow easy occupant egress while under water."
A03F0164	Cessna 185	1	One passenger was unable to escape from the aircraft and drowned.
A03Q0083	Cessna U206F	1	The pilot exited the aircraft and told the passenger to follow. The passenger, disoriented, went to the rear of the aircraft and drowned.
A00P0103	DHC-2 Beaver	3	In this fatal occurrence, the aft centre of gravity contributed to the cause of the accident. This aircraft had no stall warning system. Two passengers were unable to escape the aircraft and another drowned while attempting to swim to shore.
A98P0215	DHC-2 Beaver	5	All 5 occupants drowned following a survivable impact with water. Medical information revealed that the occupants had been restrained during the initial impact and rollover.
A97P0230	Cessna 180J	3	All 3 occupants drowned following a survivable impact with water.
A97C0090	Cessna TU206G	2	The 2 passengers were unable to exit the aircraft and drowned.
A96Q0114	Cessna U206F	4	The pilot and 3 passengers drowned inside the aircraft. Prior to this occurrence, the Canadian Aviation Safety Board forwarded an Aviation Safety Advisory to TC indicating that the rear double cargo door of the Cessna 206 was hard to open. No measures were taken to have the doors modified.

A94O0213	Cessna A185E	3	One passenger was able to exit the aircraft through the left door window and swim to shore. The pilot and the other 2 passengers did not survive. Both doors remained closed throughout the impact, but both side door windows were fully open when the aircraft was located.
A91Q0267	Cessna A185F	2	The handle of the right door was broken, however, the passenger occupying the right front seat managed to exit the aircraft through the window of the right door. The pilot and rear seat passenger, who had no signs of physical trauma on their bodies, drowned.
A91C0122	DHC-2 Beaver	1	The pilot survived the impact, but drowned while trying to escape from the wreckage.
A90W0265	DHC-2 Beaver	2	One passenger was able to exit the aircraft; however, the pilot and second passenger did not and drowned. Damage to the wings blocked both right doors and the left cabin door.
A89O0369	Cessna TU206G	1	The pilot exited the aircraft by kicking open the port-door window. However, there was no door beside the front passenger; that passenger was unable to egress and drowned.
A89C0089	Cessna A185	1	One of the 4 occupants was trapped in the aircraft and drowned.
A88O0203	DHC-2 Beaver	2	The pilot and front-seat passenger were unable to escape from the sinking aircraft and drowned.
A87P0901	Cessna 180J	1	The pilot was able to escape from the submerged aircraft through the left door. He then repeatedly dove underwater in an attempt to rescue the other occupant, but was unable to locate her. She was found by rescuers at the rear of the cabin 20 minutes later, but died in hospital several days after the accident. Neither occupant suffered incapacitating injuries during the crash sequence.
A87P0021	Cessna A185F	1	The pilot was unable to escape from the submerged aircraft and drowned.
A86P0058	DHC-2 Beaver	5	The pilot escaped with serious injuries and 5 passengers drowned. The report highlighted that, when the centre seat is installed, the rotary knob for opening the rear door is located behind the seat. As such, the door cannot easily be opened by passengers sitting in the centre seat.

Appendix C - TSB Aircraft Accident Investigation Reports of Stall Accidents involving an Aircraft Without a Stall Warning System.

Occurrence	Type	Fatalities	Synopsis
A11C0100	DHC-2 Beaver	5	The Lawrence Bay Airways Ltd. float-equipped de Havilland DHC-2 (registration C-GUJX, serial number 1132) stalled and crashed on departure. All 5 occupants suffered fatal injuries. The aircraft was not equipped with a stall warning system.
A10Q0117	DHC-2 Beaver	2	The Nordair Québec 2000 Inc. de Havilland DHC-2 Mk. 1 amphibious floatplane (registration C-FGYK, serial number 123) stalled and crashed on departure. Two of the 5 occupants suffered fatal injuries. The aircraft was not equipped with a stall warning system.
A09P0397	DHC-2 Beaver	6	The Seair Seaplanes Ltd. de Havilland DHC-2 Mk. 1 (serial number 1171, registration C-GTMC) stalled and crashed on departure. Six of the 8 occupants suffered fatal injuries. The aircraft did not have a functioning stall warning system, which the TSB noted as a cause or contributing factor.
A08A0095	DHC-2 Beaver	0	The Labrador Air Safari (1984) Inc. float-equipped de Havilland DHC-2 (Beaver) aircraft (registration C-FPQC, serial number 873) stalled and crashed during an attempted forced landing. Five of the 7 occupants suffered serious injuires. The aircraft was not equipped with a stall warning system.
A05Q0157	DHC-2 Beaver	1	The float-equipped de Havilland DHC-2 Beaver (registration C-FODG, serial number 205) stalled and crashed during departure. The pilot, who was the only occupant, suffered fatal injuries. The aircraft was not equipped with a stall warning system.
A04C0098	DHC-2 Beaver	4	The Pickerel Arm Camps de Havilland DHC-2 Beaver (C-GQHT, serial number 682) stalled and crashed on approach. All 4 occupants suffered fatal injuries. The aircraft was not equipped with a stall warning system.
A01Q0166	DHC-2 Beaver	3	The Air Saint-Maurice Inc. float-equipped Beaver de Havilland DHC-2 Mk. 1 (registration C-GPUO, serial number 810) stalled and crashed on approach. Three of the 7 occupants suffered fatal injuries. The aircraft was not equipped with a stall warning system, and the TSB noted this fact as a risk factor.

A01P0194	DHC-2 Beaver	5	The Wahkash Contracting Ltd. de Havilland DHC-2 Beaver floatplane (C-GVHT, serial number 257) stalled and crashed on approach. All 5 occupants suffered fatal injuries. The aircraft was not equipped with a stall warning system, and the TSB noted this fact as a finding.
A00Q0006	DHC-2 Beaver	3	The Cargair Ltd. DHC-2 Beaver (C-FIVA, serial number 515) stalled and crashed during climb. Three of the 6 occupants suffered fatal injuries. The aircraft was not equipped with a stall warning system.
A98P0194	DHC-2 Beaver	0	The Air Rainbow Midcoast float-equipped de Havilland DHC-2 Beaver (C-GCZA, serial number 1667) stalled and crashed during an attempted overshoot. The occupants were not injured, but the aircraft suffered significant damage. The aircraft was not equipped with a stall warning system, and the TSB noted as a cause or contributing factor the fact that the pilot had no warning of the impending stall.