Australian Government
Australian Transport Safety Bureau

Collision with water involving a Sikorsky S-64E Skycrane helicopter, N173AC

Near Jericho, Victoria, on 28 January 2019

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2019-008
Final – 17 April 2020

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 2463 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Email: atsbinfo@atsb.gov.au
Website: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

What happened

On 28 January 2019, at 1908 Eastern Daylight-saving Time,[1] a Sikorsky S-64E Skycrane, registered N173AC and operated by Erickson Inc., collided with water at Wood Creek Dam, Victoria. The collision occurred following an approach to the dam to fill an external tank with water for firebombing operations. All the crew exited the aircraft and swam to shore. One crewmember was seriously injured and two were uninjured. The aircraft was substantially damaged.

What the ATSB found

The ATSB found that the approach path to the dam was incrementally shortened over the course of the days' operation. It is likely that the final tight approach path was at the upper margins of allowable speed and angle of bank, requiring a steep flare that contributed to the aircraft entering vortex ring state on approach.

Furthermore, the shape of the dam and surrounds of the site reduced the opportunity for recovery, and the aircraft impacted the water. The carriage of additional crew increased the risk of injury, while training for emergencies directly supported the crew's survival.

What's been done as a result

Erickson Inc. advised that the following safety action was taken in response to this occurrence:

- vortex ring state avoidance and recovery was to be emphasised in future training and checking
- a policy preventing non-essential personnel from being aboard during firefighting operations had been introduced.

In addition, the organisation that facilitated operation of the United States-registered Skycrane during Australian firebombing operations, Kestrel Aviation, advised that the following safety action was also undertaken:

- It was reiterated to pilots that, though aircrew work in close partnership and cooperation with aerial attack supervisors (AAS), AAS instructions are advisory. The pilot in command retains full authority to make decisions to ensure the safety of the aircraft and management support was available if escalation was required.
- Kestrel Aviation increased the frequency of contact with Erickson Inc. crews to provide safety management support, and reduce operational pressure.

Safety message

When performing aerial work it is easy to accept incremental changes that gradually reduce margins. While these changes often increase efficiency, it is worth checking how much an operation has deviated from earlier versions and re-evaluating elements if they appear less stable.

Helicopters excel in confined areas, yet are vulnerable when operating within them. Periodic reassessment of confined areas, and approach and departure profiles, should be done throughout the duration of an operation. Both supervising parties and operating crews are well-positioned to do this.

The ATSB has previously emphasised the importance of Helicopter Underwater Escape Training (HUET) for all over-water helicopter operators. This accident demonstrates the value of HUET in saving lives.

---

[1] Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) +11 hours.

Following an accident, it is common to overlook the need to unplug one's helmet. Using a good quality extension cable that will maintain the integrity of communications and release under tension in the event of an emergency can also save lives.

The occurrence

What happened

On 28 January 2019, a Sikorsky S-64E Skycrane, registered N173AC, operated by Erickson Inc., was prepared for firebombing flying activities at Essendon Airport, Melbourne, Victoria. The Crew Chief, a licenced aircraft maintenance engineer, confirmed the aircraft's serviceability and readied it for flight.

The crew of N173AC comprised three specialists:

- Pilot in Command (PIC), handling the aircraft and managing the task
- Second in Command (SIC), supporting the PIC with operational calculations and monitoring
- Crew Chief, voluntarily supporting the crew in flight with systems knowledge, and keeping a lookout for obstacles behind the aircraft, from a rearward-facing seat.

The crew were highly experienced in S-64 firebombing operations. The PIC had eighteen years' helicopter experience and had operated the S-64 for four years. The SIC had forty-four years' helicopter experience, twenty years flying S-64, and had been firefighting in Australia for twenty years. The Crew Chief had thirty-four years' experience in helicopter engineering, including twenty-six years maintaining and developing the S-64.

All the crew reported that they were acclimatised and well-rested. Both pilots acted as alternating PIC and SIC in two-hour cycles throughout the day. The PIC sat in the left seat, and the SIC in the right. The pilots exchanged positions and roles prior to the beginning of each cycle. The accident occurred on the third cycle of the day.

Figure 1: Sikorsky S-64E Skycrane helicopter, N173AC

Source: Uniform Photography

History of the flight

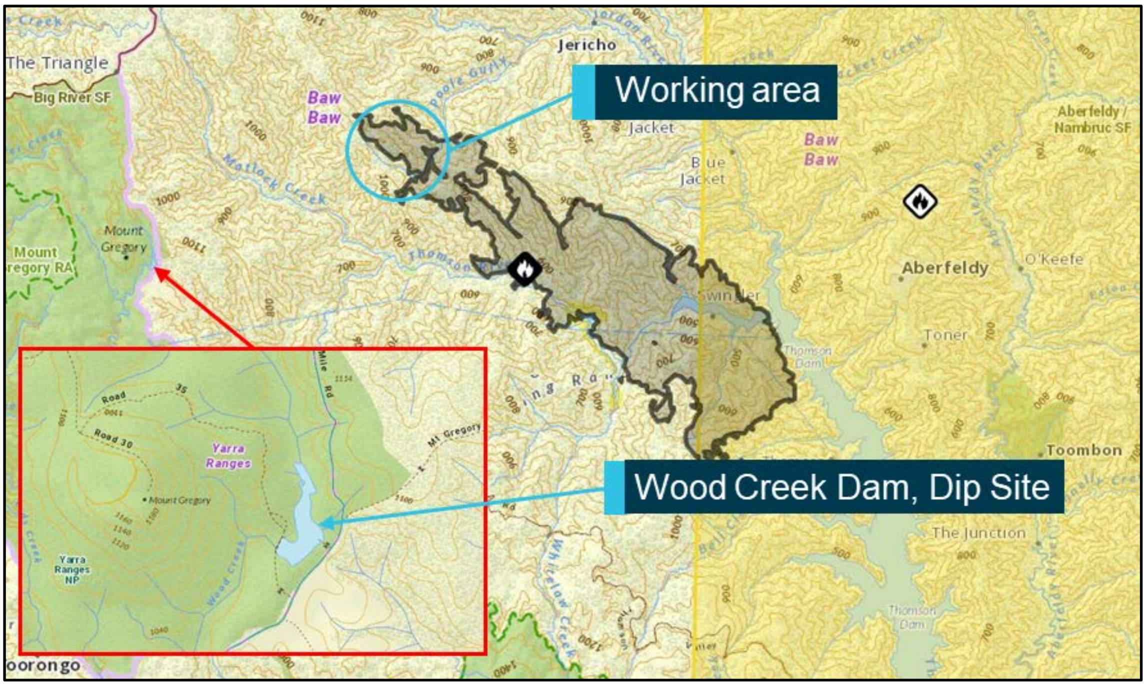
At about 1000 Eastern Daylight-saving Time,[2] the crew repositioned the aircraft to Latrobe Valley Airport, 125 km east of Melbourne. There, they rested and prepared the aircraft while awaiting further instructions. After lunch, the crew was tasked with firebombing activities to the west of Thomson Dam, Aberfeldy, Victoria (Figure 2).

An aerial attack supervisor (AAS) coordinated the aerial assets for the firefighting mission. The AAS identified a dip site.[3] The considerations for selection of the dip site included:

- no obstacles or wires
- that the site would remain clear of smoke
- the distance from the flame front allowing efficient delivery of suppressant
- aircraft working in concert could fill and drop their load while maintaining safe separation from each other.

Once the AAS identified the dip site, they showed the firebombing crew its location. The firebombing crew then had the final say on the dip site's suitability for the operation.

Figure 2: Dip site location (Fire boundary as of 31 January 2019)



Source: Country Fire Authority

The dip site was Wood Creek Dam, 7 km west of the fire front. It sat at 3,480 ft above mean sea level, at the eastern base of Mount Gregory, in the Yarra Ranges National Park, Victoria (Figure 3). It had a narrow body and steep sides surrounded by tall trees. The crew assessed the dip site as confined, but not outside acceptable limits of operation.

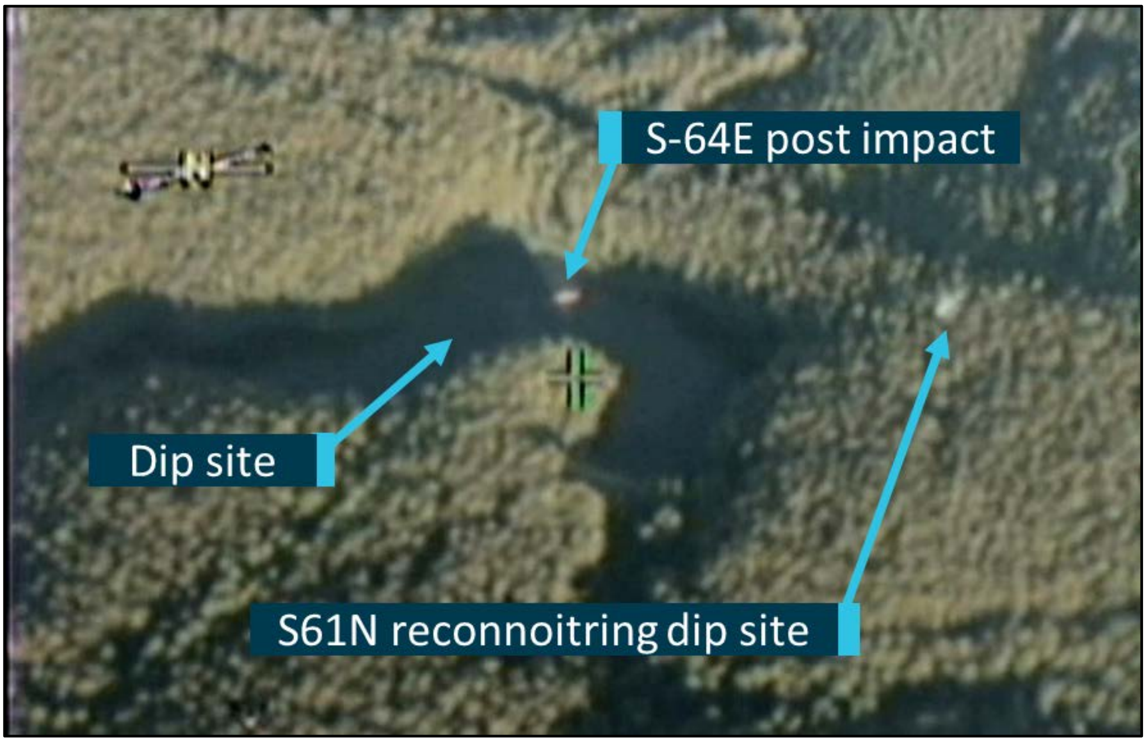
The flight crew used the Aircraft Weight Reference Guide to calculate how much water the aircraft could carry, and then reduced the calculated figure by 91 kg to optimise performance for departure from the dip site.

---

2 Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) + 11 hours.

3 Dip site: A body of water at which firebombing aircraft draw water for firefighting operations.

Figure 3: The steep sides and narrow body of the dip site pictured from the west



Source: Department of Environment, Land, Water and Planning, Victoria, annotated by the ATSB

The crew used the aircraft's pond snorkel[4] to fill the tank. The snorkel required the aircraft to be stationary for up to 45 seconds, and a dedicated pump provided the pressure to fill the tank. While there were operating instructions and a checklist, there were no specific procedures around approaching waterways with a pond snorkel.

The operator classified firebombing as an external load operation, since the suppressant can be jettisoned. Procedures for control of the aircraft during external load operations required:

- descent with any combination of airspeed and rate of descent as long as rate of descent was below 800 ft/min when below 200 ft above ground/water level
- landing with a nose-up attitude of less than 10° in order to avoid tail skid strike
- limiting angle of bank to 30° for safe operation when the Automatic Flight Control System (AFCS) was engaged
- AFCS to be engaged in normal operations in order to smooth pilot inputs
- minimum clearance to obstacles of half a main rotor diameter (11 m for the S-64).

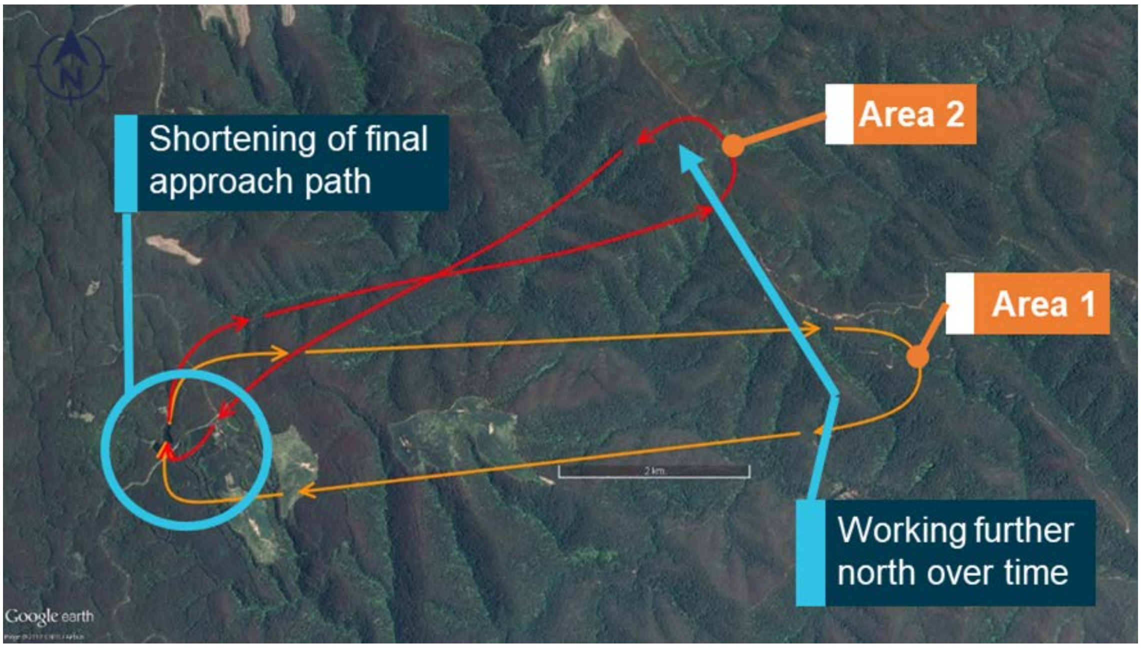
During filling, the helicopter was positioned one main rotor diameter from the left-hand side of the dam for the PIC to keep visual hover references. This left no more than two rotor diameters to the right.

On each fill, the crew flew a descending right turn, stopped in a high hover, then descended vertically into the dam. Satellite data showed early approaches had a final approach length of 300 m to 400 m. As the aircraft crossed the southern tree line of the dip site, airspeed averaged 30 kt, and the rate of descent averaged 630 ft/min.

4 Pond snorkel: A flexible hose which hangs below the helicopter to allow the tank to be filled from a variety of water sources.

After a number of water drops, the AAS re-tasked the crew to fight a flame front further north, which was east-northeast from the dip site. Each drop was also incrementally further north. This resulted in the crew gradually tightening the approach to the dip site (Figure 4).

Figure 4: Change in working location over time



Source: Google Earth, Kestrel Aviation, annotated by the ATSB

During the occurrence approach, the tighter approach resulted in a greater than normal flare[5] to arrest the aircraft at the aiming point in the dip site. The higher nose pitch up prompted the SIC to advise the PIC to move forward of the trees before descending any further to ensure tail rotor clearance. Clear of the trees, the flare was increased.

While descending with a nose-high attitude, the aircraft struck the water tail-first, submerging and removing the tail rotor, causing rapid rotation to the right through one and half turns. While rotating, the main rotor blades separated as they contacted water. The right cockpit door separated from the fuselage, and the aircraft came to rest on its left side, submerging the cockpit.

Each crewmember recalled the rehearsed drills from their helicopter underwater escape training (HUET). They identified their seat belt and nearest exit to orientate themselves in the aircraft. They all waited until the last moment to draw a breath, and did not unbuckle and exit the helicopter until motion had ceased. The crew reported that it was not possible to see anything underwater, and that jet fuel contamination was present.

The SIC in the right seat exited through his doorway, from which the door was already missing. The PIC could not open his door so he swam across the cabin (up) and was assisted by the SIC to exit through the right hand door. As the rear door was jammed, the crew chief in the aft seat pushed out a window from the rear of the cabin, and exited through it.

Neither pilot unplugged their helmet. However, the extension cords from the aircraft to the helmet plug allowed the plug to release, preventing the helmets from snaring the pilots. All three crew escaped, and inflated their life jackets. Two crew were uninjured, and one crewmember sustained a knee injury.

At the time of the accident, crews aboard S-76 and S-61N helicopters were assessing the potential of the dip site for later use in night operations. An AAS aboard the S-76 relayed details of the accident to an incident controller who enacted the emergency response plan. Neither the S-76

---

5 Flare: the nose-up pitch of a helicopter used to reduce airspeed and rate of descent.

nor the S-61N was equipped or able to provide direct assistance, other than monitoring, and relaying information.

Following exit from the helicopter, the only form of communication available to the Skycrane crew was hand signals. They gave thumbs-up indications to the crew of the overhead S-61N to advise that they were okay. The Skycrane crew then swam to shore and trekked through dense bush to a road where they were met by rescuers.

Meteorological information

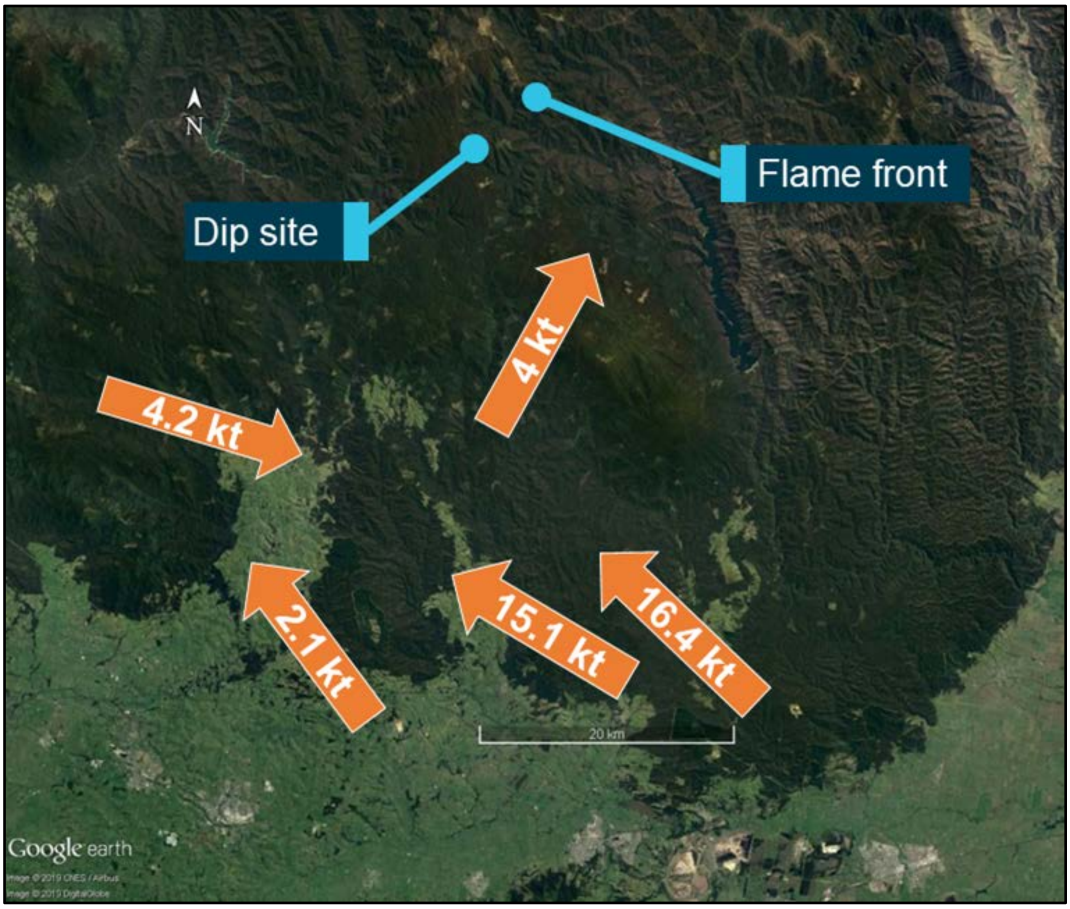
The crew received a situation report, including weather and a common barometric pressure[6] as they began the firefighting activity. Following the failure of a 4G-equipped iPad earlier in the day, beyond this report, the crew did not have access to up-to-the-minute weather data.

The weather on the day saw temperatures over 25°C, a significant reduction from recent heatwave conditions. Winds aloft were northerly and pushed plumes of smoke to the south. The crew and witnesses to the event all assessed the wind to have been a northerly. The crew of the Skycrane advised that the wind had dropped off from around 16 kt and remained a light northerly.

Turbulence was reported to be mild. Outside of smoke, visibility was greater than 10 km. At the time of the accident, the sun was at 258°, and 15° above the horizon.

Locations on the ground showed significant local variation in wind direction and strength throughout the day (Figure 5).

Figure 5: Local variation in wind speed and direction. (15-minute average 1900 to 1915)



Source: Google Earth, Wunderground, Bureau of Meteorology, annotated by the ATSB

6 Common barometric pressure: All aircraft in the vicinity set the same pressure on the subscale of the altimeter. This allows aircraft to more accurately maintain vertical separation from each other.

Flight recorders

It was a contractual requirement that all firefighting aircraft were equipped with satellite tracking devices. That data was stored remotely from the aircraft and was available shortly after the accident. The system recorded the location, altitude, heading, and groundspeed of the aircraft at 15-second intervals for the duration of operation.

The Skycrane was also fitted with a Universal Avionics CVR-120 cockpit voice recorder (CVR). Divers recovered the CVR 45 days after the event, once the complex task of recovering the helicopter allowed access to the device. The CVR, submerged for the duration, showed little outward damage, yet voice data could not be recovered from the unit.

Vortex ring state

Vortex ring state (VRS) is a condition of powered helicopter flight that causes a loss of lift in the rotor system. During normal operation, the rotor system pushes large amounts of air down while it produces lift. If the helicopter descends into this downwash, the air can recirculate back up and over the rotors instead of it flowing down and away. This causes the same parcel of air to circulate around the rotor. As a result, the rotor system no longer has the steady stream of air required to produce lift and the helicopter will descend despite the application of additional power.

The United States Federal Aviation Administration *Helicopter Flying Handbook* details the methods of VRS recovery as follows:

> The traditional recovery is accomplished by increasing airspeed, and/or partially lowering collective to exit the vortex. In most helicopters, lateral cyclic thrust combined with an increase in power and lateral antitorque thrust will produce the quickest exit from the hazard. This technique, known as the Vuichard Recovery (named after the Swiss examiner from the Federal Office of Civil Aviation who developed it) recovers by eliminating the descent rate as opposed to exiting the vortex.

The crew were trained to use the Vuichard recovery technique for recovery from vortex-ring state. In the Skycrane, it requires the pilot to apply full power, right cyclic[7] and left pedal to side slip the helicopter out of its own downwash and into the ascending air just outside of the rotor system.

Safety analysis

Shortening of approach and vortex ring state

The sun progressed to a point low in the west, opposing the crew's turn onto final approach, and casting long shadows from the steep sides, across the tree line and the surface of the dam. The crew reported that from their angle of approach the surface looked glassy, supporting their assessment of the wind becoming lighter. Video recorded shortly after the event showed that the shape of the dip site and shadows disguised a light tail wind. Wind was only visible on the surface through a 10-degree arc from the south-southwest.

A witness to the event reported that the aircraft had an apparent high rate of descent and a nose-high attitude. The crew reported that they did not feel that any of the parameters were excessive, though speed and angle of bank were felt to be at the higher end of their normal range.

The satellite data showed the accident approach was a right-hand turn, with about a 30° angle of bank, and a radius of 150 m. The rate of descent developed from 650 ft/min to 780 ft/min. All flight parameters were within operational limits, however the length of the final approach was considerably shorter than earlier approaches (Figure 6).

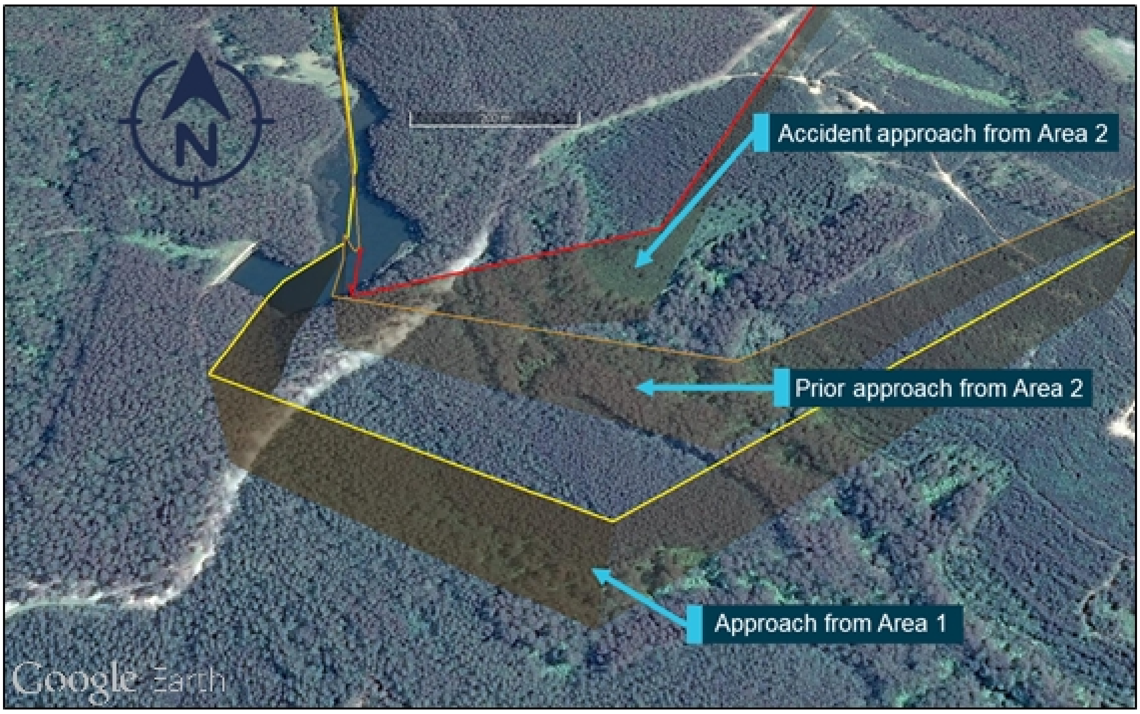
The shorter approach at the upper end of the acceptable envelope of operation required a steeper than normal flare to stop the helicopter. The crew reported that once they descended below the tree line, the aircraft generated no lift and fell into the dip site, colliding with water. The crew stated

---

[7] Cyclic: a primary helicopter flight control that is similar to an aircraft control column. Cyclic input tilts the main rotor disc, varying the attitude of the helicopter and hence the fore, aft, and lateral direction.

that they had very likely encountered vortex ring state (VRS). The topography, high rate of powered descent, and steep flare that reduced the airspeed, created conditions conducive to the onset of VRS. The crew reported that the rapidity of onset and dimensions of the dip site did not provide enough time or space to manoeuvre sideways to effect a recovery.

Figure 6: Shortening of final approach path



Source: Google Earth, Kestrel Aviation, annotated by the ATSB

Carriage of additional crew

The operator’s operations manual stated that only flight crew and crew essential to the operation could be carried aboard the aircraft during firefighting operations. The operation could be conducted without the Crew Chief and not all company Crew Chiefs were on board their aircraft during firefighting operations.

While the Crew Chief had significant system and task knowledge, he was not required to be on board the helicopter. On this occasion, his presence exposed him to the significant hazards associated with underwater egress. More generally, the carriage of additional personnel during specialised operations like firefighting exposes them to unnecessary risk.

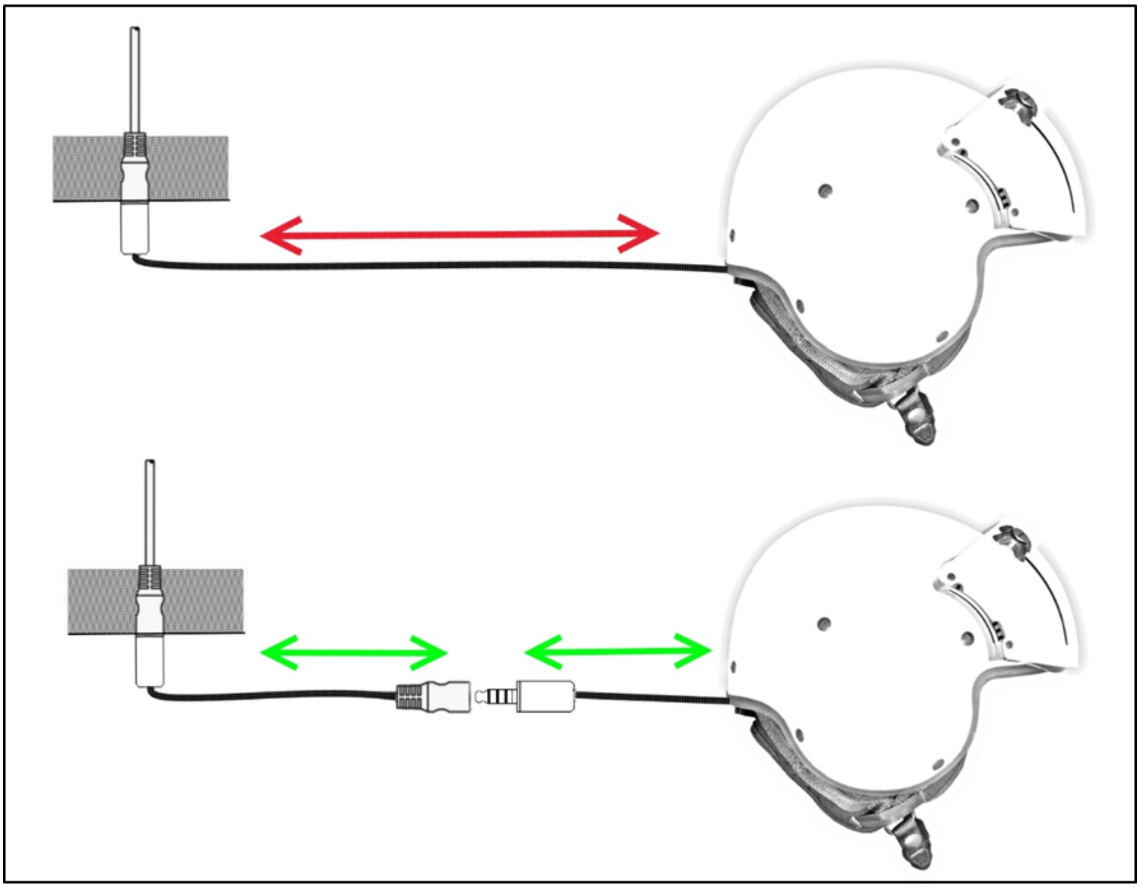
Egress from the submerged helicopter

Although two other helicopters were overhead, and their crews had activated the emergency response, no immediate assistance was available to the Skycrane crew. The crew had to rely on their own resources and equipment to survive.

The crew reported that Helicopter Underwater Escape Training (HUET) was fundamental to their survival. HUET enabled the crew to act rationally and decisively when submerged in the cockpit and to use the regularly-practiced drills to escape the aircraft.

Additionally, the helmet cord release mechanism (Figure 7) prevented snaring and potential drowning after the pilots exited the submerged aircraft without unplugging their helmets.

Figure 7: Helmet cord release mechanism



Source: ATSB

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The crew conducted a tight descending right hand turn into the dam, inside the upper margins of the flight envelope. This approach required a steep flare on arrival and likely resulted in the rapid onset of vortex ring state.
- The dam's steep sides and narrow tapered body provided limited opportunity for vortex ring state recovery actions, contributing to collision with water.
- The Crew Chief's presence aboard the aircraft during firebombing operations exposed him to unnecessary risk.
- All crewmembers credited their survival to skills learned and practiced in Helicopter Underwater Escape Training. In addition, the helmet cord extension cables detached easily from the aircraft, contributing directly to the crew's egress from the flooded cockpit.

General details

Occurrence details

Date and time:	28 January 2019 – 1908 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Collision with water	
Location:	Wood Creek Dam, Jericho, Victoria	
	Latitude: 37° 41.547’ S	Longitude: 146° 8.388’ E

Aircraft details

Manufacturer and model:	Sikorsky S-64E Skycrane	
Registration:	N173AC	
Operator:	Erickson Inc.	
Serial number:	64015	
Type of operation:	Firefighting	
Persons on board:	Crew – 3	Passengers – 0
Injuries:	Crew – 1	Passengers – 0
Aircraft damage:	Substantial	

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within the ATSB's jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.