CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION (FSI)

FINAL REPORT

FILE NUMBER: 1010-139308
DATE OF REPORT: 1 May 2003
AIRCRAFT TYPE: CH139 JET RANGER
DATE/TIME: 021712Z Jul 2002
LOCATION: Southport, MB
CATEGORY: "A" CATEGORY ACCIDENT

SYNOPSIS

The Standards Officer was conducting a proficiency check ride on one of the instructors from the Basic Helicopter School in Southport. The focus of the flight was to assess the instructor's proficiency in autorotations. Following a brief warm up, the crew proceeded to 'Grabber Green' autorotation landing area. They completed a number of successful 'straight ahead' and 500 foot turning autorotations. During the landing portion of a 250 – foot turning auto, the aircraft struck the ground. Both crew members received serious back injuries. The aircraft sustained "A" Category damage.

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1 FACTUAL INFORMATION

GENERAL

The flight was the first trip for the instructor following a night autorotation accident five days earlier. The mission was scheduled as a confidence builder and to allow the Standards Officer to assess the instructor's autorotation proficiency.

1.1 History of the Flight

The crew commenced the mission with some basic flight manoeuvres in Area North as a means of warm-up and to burn the fuel load down to the allowable weight for autorotations. Following this they proceeded to 'Grabber Green' to conduct autorotation training. On arrival they received the site brief from one of the other Jet Rangers working in the area. The autorotation lane was rated ideal and the winds reported as 240-280º at 8-10 knots. Circuits were variably oriented to section lines west and south-westerly, dependent on wind direction. The Standards Officer and Instructor took turns executing a variety of autorotations. They commenced the exercise with straight ahead autos from 500 feet, then progressed to 500 foot turning and finally to 250 foot turning autos. Both pilots overshot their first attempt at the 250-foot turning auto due to airspeed control problems. The Standards Officer then successfully executed a low level turning auto during which it was noted that it took considerably more power to maintain 100 knots downwind in the circuit than during previous iterations. The instructor then initiated another 250 foot turning auto and it was during the flare portion of this manoeuvre that the aircraft entered an unusually high rate of descent. The Standards Pilot took control at 30-40 ft AGL and concentrated on levelling the aircraft. Throttle was applied but seemed to have no effect in arresting the rate of descent. The helicopter hit the ground extremely hard in a relatively level attitude. The skid gear collapsed resulting in belly contact with the ground. The tail boom was severed at the attachment point to the fuselage. The main rotor blades cut the vertical fin in two places as the tail boom departed the aircraft. The helicopter became airborne again due to impact forces and the collective and throttle position the Standards Officer had initiated for the overshoot. With the loss of the tail rotor, the aircraft rotated through several revolutions due to the main rotor torque. The Standards Officer closed the throttle to minimize the spinning and the helicopter came to rest in an upright position facing the original direction of flight. The crew shut down the aircraft and was evacuated by rescue personnel.

1.2 Emergency Response

The fire hall has one truck and response crew stationed at 'Grabber Green' while the helicopter school is conducting autorotation training. The fire fighters at 'Grabber Green' saw the aircraft shortly after it impacted the ground and called the Southport Tower to declare the one bell emergency and ask for fire and ambulance support. The 'Grabber Green' firefighters were at the helicopter within 60 seconds and secured the scene. They did an initial medical assessment of the pilots and told them to remain in their seats until the ambulance arrived. They stabilized the Instructor's neck with a cervical collar as he was complaining of back pain. The Southport fire trucks were on-scene within 7 minutes, the town of Portage ambulance and fire trucks arrived within 13 minutes. Both pilots were immobilized on backboards and transported to the Portage Hospital. The Instructor was subsequently transferred to Winnipeg due to the seriousness of his injuries.

1.3 Injuries

	Crew
Fatalities	0
Major injury	2
Minor injury	0

1.4 Damage to Aircraft

The skid gear completely collapsed causing the cross tubes to penetrate the floor structure and fuel tank (Photo 4). The tail boom was severed at the attachment point to the fuselage and came to rest approx 50 ft right of the main fuselage (Photo 1). The main rotor blades cut the vertical fin in two places as the tail boom departed the aircraft (Photo 6). One rotor blade was extensively damaged at the outboard tip due to contact with the vertical fin (Photo 5). The fuselage was considerably wrinkled on all sides due to impact forces. The plexiglass in the chin bubbles and windscreen was fractured due to flexing of the window frames (Photo 4). There was extensive gouging of the transmission fuselage housing due to contact with the pitch horns (flight control linkages to the main rotor). The forward end of the main drive shaft flexed downwards far enough to put a gouge through the drag link (component designed to dampen transmission movement). The transmission cooler mounted on the forward part of the transmission moved sufficiently left to gouge the support strut for the cyclic actuator (flight control that changes the tilt of the main rotor). The aircraft has been assessed as un-repairable ('A' Category damage).

1.5 Collateral Damage

Nil

1.6 Personnel Information

	Instructor Pilot	Standards Pilot
Rank	Capt.	Maj
Currency	Current B Cat Instructor	Current A1 Cat Instructor
Medical Category valid	Yes	Yes
Total flying time	2362	4865
Flying hours on type	523	2036
Flying hours last 30 days	30	10.6
Flying hours last 48 hours	0.9	0.9
Flying hours on day of Occurrence	0.9	0.9
Instructional	185	1258

1.7 Aircraft Information

The aircraft was serviceable prior to the occurrence.

1.8 Meteorological Information

TAF: 021116Z 021223 25010KT P6SM SCT100 BECMG 1517 25015G25KT

Actual 1712Z: 100 FEW 15SM Temp 24/10 Wind 250/13G18 ALT 29.91 RMK Wind 210V280

Upper Winds and Temperatures:
For use 09-18
YPG 500 ft AGL 2715 kt
250 ft AGL 2615 kt

Density Altitude: 2330 feet

1.9 Aid to Navigation

Not Applicable.

1.10 Communications

Within 60 seconds of the crash, the firefighters stationed at ‘Grabber Green’ had called the Southport Tower to report the ‘one bell’ emergency and were on scene. Tower initiated the fire response from the Southport fire hall and fire and ambulance support from the Town of Portage. Communication issues were not a factor in the response to this occurrence.

1.11 Aerodrome/Alighting Area Information

‘Grabber Green’ is a 500 x 500 meter grass field located 8 kilometres east of the Southport airport. It is has a windsock and crash fire equipment and personnel are stationed there whenever autorotations to touchdown are being practiced. There is no wind data recording equipment at ‘Grabber Green’.

1.12 Flight Recorders

The Jet Ranger aircraft in Southport are not equipped with any onboard recording devices. The determination of what the aircraft was doing in the last minute of flight was made more difficult and was established with less certainty by the lack of such devices.

1.13 Wreckage and Impact Information

The aircraft initially struck the ground just short of the marked landing area while heading approximately 240 degrees magnetic. It bounced back into the air, commenced spinning due to the loss of tail boom/tail rotor (anti torque thrust) and touched down again 50 feet from the initial impact point. It continued to spin several times on the ground and then came to rest in an upright manner 64 feet from the point of initial impact. The aircraft’s final heading approximated the direction of the initial approach path (220 degrees). The tail boom broke off and came to rest 50 feet from the 3 o’clock position of the fuselage. Pieces of the tail fin ended up in the 5 o’clock position at 40 feet and 7 o’clock position at 42 feet (see Annex B for a site diagram).

1.14 Medical

The two pilots were transported to the Portage hospital where a non-Flight Surgeon qualified civilian doctor examined them. The Standards pilot suffered a broken tail bone, a cracked rib and neck strain. He remained overnight in the Portage hospital for observation and was released the following day. The Instructor suffered a compression fracture of the L1 vertebrae and was transferred to the Winnipeg Health Science Centre. The Southport MIR had used all their toxicology sampling kits following the 27 Jun 03 accident. Sampling for this crew was delayed while kits were sent from 17 Wing Winnipeg. The toxicology tests were negative except for the presence of pain killers administered by the medical attendants.

1.15 Fire, Explosive Devices, and Munitions

Nil

1.16 Survival Aspects

1.16.1 Crash Survivability

This was a survivable occurrence. Both sets of restraints held the pilots in position. There was no significant contact between the pilots' heads or limbs and the internal structures of the aircraft. The landing gear (skids) and seat cushions absorbed most of the impact forces. The Instructor was using a low profile seat due to his seated height. The centre of the seat pan was depressed approximately 1½ inches. The pilots were wearing approved Aircrew Life Support Equipment (ALSE), including helmet, gloves, boots and flight suits.

1.16.2 Emergency Transmitters

The impact forces activated the ELT.

1.16.3 Search and Rescue

Not applicable.

1.17 Test and Research Activities

The engine and main transmission were sent to third line contractors to verify working condition prior to impact. No anomalies were found in either component.

1.18 Additional Information

Nil

2 ANALYSIS

2.1 General

Analysis of the aircraft maintenance log, engine and transmission confirm that the aircraft was serviceable prior to impact. The investigation thus focused on the actions of the crew and the wind conditions at the time of the accident.

2.2 The Crew

The aircraft captain (AC) was a Standards Officer and an A1 Level Instructor. This is the highest instructional level that a pilot can achieve. Very few of these qualifications are awarded and they are only given to individuals who have consistently demonstrated superior piloting and instructional skills. This was his second tour as a member of the instructional staff in Southport. The flight instructor under assessment was a B Level Qualified Flying Instructor (QFI). This is the qualification held by most line instructors.

2.3 Description of the Low Level Turning Autorotation

The pilot enters the manoeuvre abeam the landing area (adjusted for wind) at 250 feet above ground and 100 knots. The entry speed for this manoeuvre is higher than other autorotations in order to conserve altitude in the turn. The throttle is rolled to idle and the collective lowered to conserve rotor RPM (RRPM). The degree of bank, cyclic backpressure, collective input, and nose pitch attitude must all be carefully managed to control the RRPM (within the green arc) and airspeed (approx 60 kts) during the turn to final. An aggressive turn to final will bring the aircraft around the turn faster and theoretically allow more time to prepare for the landing, but quickly bleeds the airspeed due to the ‘g’ applied. In this case the pilot must lower the nose pitch attitude to maintain airspeed. This increases the rate of descent and negates the altitude conservation benefits of the tight turn. A gradual turn to final allows for easier RRPM and airspeed control, but if too gradual will result in the loss of too much altitude. The turn to final is therefore the critical element of this manoeuvre. Once the turn is complete the pilot must ensure the requirements of the 100 foot check are met: landing area made, RRPM in the green (90-107%), airspeed minimum 50 knots (60 kts desirable) and bank, drift and crab are eliminated. The intent of this last parameter is to ensure the aircraft is no longer manoeuvring to make the area and is tracking straight along the ground. Wind variations and cross winds can result in cross controlling similar to a fixed wing landing; this may require some bank being applied during the final descent. If any parameters of the ‘100-foot’ check are not met, an overshoot must be initiated. If the parameters are met, the pilot will flare the aircraft at approximately 75 feet to reduce the rate of descent and forward speed and to build RRPM for the landing. When the flare is no longer effective (~10 feet) the aircraft will be levelled and cushioned onto the ground using the remaining rotor energy (collective input). On touchdown, the RRPM has usually decayed to the point that further flight is not possible.

2.4 Overshoot Procedures

The normal descent rate for an autorotative glide in the Jet Ranger is 1500 feet per minute or 25 feet per second. The time from the '100 Foot Check' to the flare is thus only 1-2 seconds. The purpose of the '100 Foot Check' cannot be overstated; it allows sufficient time and altitude to safely recover if the aircraft is not in a position to land. If the conditions for the 100 foot check are not met, the overshoot would normally be initiated from a 60-knot attitude with flat pitch on the collective (fully down). Engine response and RRPM recover more quickly when starting from a flat pitch position. To overshoot, the throttle is increased from idle to full as quickly as possible without over-speeding the rotor or over-torquing the transmission and collective is applied while monitoring the rise in torque and RRPM. Coincident with this, the nose attitude is adjusted to achieve a normal climb at 70 knots. A positive rate of climb should be established before the aircraft descends below 50 feet above any obstacles within 200 feet of track.

A 'low level save' technique is taught to flying instructors for use in situations where the 100 foot check requirements are met but the instructor subsequently determines that the aircraft cannot be safely landed. This allows an autorotation to be successfully terminated or overshot during the landing phase. A 'low level save' can be initiated any time up to and including the collective check following flare termination. The ' save' is initiated by rolling the throttle to full, leveling the aircraft, increasing collective and accelerating to a normal climb transition. If the 'save' is initiated later than the collective check, it is normally terminated in the hover or to touchdown.

2.5 Aircraft Performance Variables

With the engine at idle, collective pitch increase will bleed off RRPM due to increased drag. When the RRPM gets too low it will no longer provide lift. It takes considerable skill and practice to consistently judge the amount of collective application required. The amount of headwind will affect the degree of flare required - the greater the headwind, the less flare required because there is less groundspeed to reduce. In light winds the flare must be more aggressive (steeper) to achieve the same final groundspeed. Density altitude (DA) also affects the performance of an aircraft during autorotation. The higher the DA value, the less dense the air and the less effective the lifting surface (rotor). In high DA conditions the flare must also be more aggressive to achieve the same deceleration effect present during low DA conditions.

2.6 Environmental Conditions

The ground elevation at Southport is 885 feet, but due to temperature and humidity conditions on the day of the accident, the DA was relatively high (2330 feet). This reduced the effectiveness of the rotor lift characteristics, but was well within the DA limit of 3500 feet indicated in the school orders. The wind in Southport was measured at 500 AGL as 270 degrees at 15 kts and at 250 AGL as 260 degrees at 15 kts. The only wind indicator at 'Grabber Green' is a surface mounted windsock. It was indicating approximately 240-280º at 8-10 knots, and crews were altering their landing headings to match wind direction at the time of landing.

There is no recording of the surface wind at 'Grabber Green' nor is there any measurement of the upper level wind. However, an instructor in one of the other Jet Rangers working there at the same time reported that he had experienced problems with his autorotation landings. He reported having to add throttle to cushion each landing and to adjust his entry point on downwind due to strong winds aloft. The crew of the accident aircraft also experienced problems with airspeed control on some of their autorotations, overshooting on several (both pilots' first attempt at 250 foot turning auto). These facts and the statements of the crews working in 'Grabber Green' at the time of the accident point to a change in the speed and/or direction of the wind as the aircraft were descending from circuit altitude to the ground. It is thus likely that a decreasing performance wind shear affected the aircraft on descent.

2.7 The Accident

2.7.1 General. The accident manoeuvre was the Instructor's second attempt at the 250 foot turning auto. The Instructor was sitting in the right seat and flying right hand circuits. The entry was normal, but during the turn to final the instructor used considerable bank and backpressure to expedite the turn. This bled off the airspeed to below the '60 knot' ideal. As they lined up for the landing phase, the aircraft was banked approximately 10° right for wind correction, airspeed was just above 50 knots and the altitude was just under 100 feet AGL. Although this met the requirements of the '100 foot' check, the aircraft was on the 'low' end of parameter acceptance (low and slow). Informal discussions with other instructors indicated that it was not uncommon to be on the low end of the acceptance scale for the parameters of the '100-foot' check when executing the 250 turning auto. The Instructor commenced the flare at 50-60 feet AGL. As the nose of the aircraft was pulled up for the flare both pilots stated that the airspeed dropped off quickly and the aircraft developed an excessive descent rate. The Instructor indicated he was somewhat startled by the aircraft reaction and did not immediately initiate the overshoot. The Standards Officer took control at 30-40 feet and applied throttle and then collective ("low level save"). He stated that this did not seem to have any effect and therefore concentrated on getting the aircraft level prior to impact.

2.7.2 Winds. As noted in paragraph 2.6 above, it is likely that there was a change in the headwind component during final descent. This, coupled with a relatively high DA, resulted in a marked decrease in aircraft performance. The crew had safely executed several autorotations in similar wind conditions prior to the accident, but had to overshoot several as well. Wind speed and direction, then, were variable enough (varying with both time and altitude) that autorotations could be safely accomplished for some of the conditions seen that day, but not for others. Though it may not be possible to quantify exactly how much variability is “safe”, it is probably possible to identify, based on experience as well as theory, a degree of variability associated with increased risk similar to the density altitude limit.

2.7.3 Aerodynamic Factors. Other factors that may have affected the last 50 feet of this autorotative landing were also reviewed and analyzed. One of the aerodynamics engineers at the Directorate of Technical Airworthiness reviewed the factual data and offered possible scenarios that may have contributed to the accident. The following paragraphs are a summary of his analysis however; it is speculative in nature due to the lack of recorded aircraft parameters.

The airspeed in the autorotative glide was low as a result of a turn that bled off more energy than normal. If the descent rate was 1500 fpm (book value for established glide), then it would have taken only 1.6 seconds to descend from the point where they lined up for final approach (just under 100 ft AGL) to flare initiation at 50-60 ft AGL. Given that there was some residual bank angle, it is possible that the transition out of the turn and into forward autorotation may not have been "clean enough" (perhaps the autorotative glide was not effectively established until lower than 100 ft AGL). This would have left even less time to develop a steady forward autorotative glide prior to flaring. With low airspeed, the descent rate would be higher than desired.

At the commencement of the flare, the rate of descent notably increased coincident with a marked decrease in airspeed. It is perhaps at this point that the aircraft entered a zone of decreasing performance shear.

It is possible that these two factors (glide and shear), in combination, created conditions where the flare would be unable to effectively reduce the rate of descent.

Vortex Ring State (VRS) may also have been a contributory factor during the landing phase. VRS is an aerodynamic condition that can develop when a helicopter moves through the disturbed air created by its own rotor blades (vortices), typically during steep descents or aggressive flares. Since the strength of the vortices is proportional to the lift being created, application of increased collective pitch (power) can aggravate the situation and the aircraft may develop a rate of descent from which recovery is not possible at low altitudes. VRS symptoms include airframe bounce and vibration, control sluggishness (or even temporary loss of attitude control) and vibration, and increase in and/or severe fluctuations in required power to control altitude. For this accident, the steep descent and/or the sudden increase in rotor thrust during the power recovery attempt may have combined to create conditions for VRS to occur. However, the rotor must be generating significant lift for VRS to develop fully, and that would have occurred only after collective and throttle application. These occurred too close to the ground for VRS to develop sufficiently to have had material effect. Also the only VRS symptom reported was the inability of the power recovery to arrest the descent, but this symptom is by no means exclusive to VRS. For these reasons it is unlikely that fully developed VRS was a factor in the accident. However, it is possible that the application of power during the 'low level save' put the aircraft into the incipient stage of VRS, thereby reducing the effectiveness of the overshoot attempt.

2.7.4 Timing of Overshoot. Regardless of which aerodynamic or environmental factor(s) affected the sudden increase in rate of descent, the timing of the overshoot decision was a contributing factor. Had the crew initiated the overshoot on initial indication of the rapid descent, they would have had more altitude for the aircraft to respond to the application of power. There is very little room for error in this manoeuvre due to the entry altitude, even less room if the manoeuvre is commenced on the low side of accepted parameters.

Following this accident, the school implemented an interim change to the entry altitude (350 feet) to allow more time for the set-up of the sequence.

2.8 Peripheral Issues

The rationale for teaching the low level turning autorotation was to prepare students for an out of wind single engine emergency during a solo low level navigation flight. As evidenced by the results of this flight, the 250-foot turning autorotation is a difficult manoeuvre to execute, even for two qualified instructors who knowingly enter autorotation. To successfully execute this turn during a surprise low level engine failure is very likely too much to ask of an ab-initio student. If students only have to remember to lower collective and flare for a straight ahead landing, they may have a better chance of walking away from the impact than if they try the difficult turning autorotation. This is perhaps a moot point as students no longer fly low level solo missions at Southport; the 250 foot navigation trips are only flown with an instructor. The low level turning autorotation is therefore no longer a tested item for students, but the instructors continue to demonstrate the manoeuvre.

1 CAD recently canvassed the operational communities and all agreed that 250-foot navigation is a necessary skill for helicopter pilots. Indeed, this requirement has been included for the next iteration of the CFTS contract. There has never been an engine failure in the Jet Ranger at Southport during low-level navigation.

3 CFFTS feels the risk of flying at 250 feet is minimised by both the instructors' proficiency at doing autorotations from 350 feet and by the low probability of an engine failure at 250 feet when the aircraft is 180 degrees out of wind.

The initiative to move the entry altitude from 250 feet to 350 feet would seem reasonable. However, its effectiveness at reducing risk should be validated. Is the increased training value worth the risk of conducting turning autos below 500 feet? There have been 11 accidents involving Jet Ranger / Kiowa training aircraft during autorotation training. Six of these occurred during low level turning autos. There is no doubt that helicopter pilots need to know how to execute an autorotation. However, it may be appropriate to conduct a formal review of this aspect of the Course Training Standard to rationalize the training required and achieved against the risk incurred. It may also be appropriate to teach pilots to consider whether the likelihood of damage or injury when an autorotation is actually required at low level is reduced more by conducting a potentially dangerous turn into the wind or by minimizing the turn and accepting an out of wind component on landing.

3 CONCLUSIONS

3.1 Findings

3.1.1 The aircraft was serviceable prior to impact.

3.1.2 The crew were qualified and current for the mission parameters.

3.1.3 The Standards Officer was conducting an assessment of the instructor's ability to execute autorotations.

3.1.4 Some of the crews operating at the autorotation area experienced difficulties with landings due to wind speed variations from circuit altitude to touchdown.

3.1.5 Wind conditions at the time of the accident were variable in speed and direction (possible "decreasing performance shear").

3.1.6 At the termination of the manoeuvring phase of the final autorotation, the airspeed and altitude parameters were near the low side of the acceptable range.

3.1.7 A 'low level save' was initiated at 30-40 feet above ground but did not prevent impact with the ground.

3.1.8 The low-level navigation portion of the training syllabus is still being flown at 250 feet AGL.

3.1.9 Toxicology testing was delayed as Southport did not have time to replenish the kits used for the 27 Jun 03 accident.

3.2 Causes

3.2.1 The lower and slower turn to final coupled with adverse wind conditions (probable decreasing performance sheer) and relatively high DA reduced flare performance and created conditions at the point of low level power recovery which precluded a successful landing.

3.3 Contributing Factors

3.3.1 While it is unlikely that Vortex Ring State ever became fully developed, it is possible that an incipient VRS detracted from the effectiveness of the "low level save".

3.3.2 A momentary delay in initiating overshoot on detection of the abnormal rate of descent reduced the already very short time available for the "low level save".

3.3.3 The entry altitude for the accident autorotation made it difficult to ensure that autorotative flight was fully established before the flare was initiated.

4 SAFETY ACTION

4.1 Safety Action Taken

4.1.1 The entry altitude for the low level turning autorotation has been raised from 250 feet above ground to 350 feet above ground to allow more time for the set-up of the sequence.

4.2 Safety Action Recommended

It is recommended that:

4.2.1 a formal review of the policy for autorotation training be conducted. The resulting policy must ensure that pilots have the skills and knowledge to preserve life and limb during helicopter emergencies requiring autorotation. It should also maximize the potential for saving the aircraft in such an emergency, but only to the extent that it does not unnecessarily jeopardize aircraft or crew in training.

4.2.2 as a part of the above review, the possibility of establishing wind variability limitations for autorotation training be investigated.

4.2.3 the feasibility of employing wind and video recording equipment at ‘Grabber Green’ be investigated.

4.2.4 17 Wing evaluate the number of toxicology kits required in Southport.

4.2.5 more emphasis be placed during Supervisory and Proficiency Checks on low level save techniques and recognizing the parameters when a low level save/overshoot is required.

4.3 DFS Comments

Unusual wind conditions in the last few seconds of this touchdown autorotation resulted in two very experienced and capable instructor pilots receiving serious injuries and writing off an aircraft. Risk level is a function of both probability of occurrence and severity of outcome, so though these wind conditions may occur rarely, the risk level is significant. Measures to minimize that risk should thus be considered.

Practicing low level turning autorotations has resulted in several accidents, and while this was not the main cause of this one, it did contribute to workload just before the flare. It has been suggested that one of the reasons the manoeuvre is conducted is that it is required as a discriminator to weed out those who cannot meet the standards expected of helicopter pilots. In light of the record, perhaps the question should be asked whether this is the best way of determining whether prospective helicopter pilots meet the standard.

Recent as well as not so recent experience tells us that autorotation proficiency is a tool with which we must equip every helicopter pilot. They must always be able and prepared to use this tool to preserve life and, if feasible, their aircraft. This requires thorough initial and ongoing training. But that does not mean that they need to be capable of textbook perfect engine out landings from every condition of flight. The probability of many of those conditions occurring is very low and the risk of training for them sufficiently high that some of the specific training is not warranted. Rather, the required tool is the one which will preserve life and limb during those rare emergency conditions – rapid entry and establishment of autorotative glide, and enough proficiency in the flare to reduce airspeed and rate of descent to survivable values before ground contact.

The results of this investigation could have been more conclusive and the recommendations more focused had the aircraft been equipped with an onboard recording device. New aircraft purchased for operation in Portage should have this capability.

R.E.K. Harder
Colonel
Director of Flight Safety

Annex A – Photographs

Photo 1: Impact site - starboard side / Lieux d'impact - tribord

Photo 2: Wreckage – Rear View / Épave – Vue arrière

Photo 3: Wreckage – Front View / Épave – Vue avant

Photo 4: Wreckage – Port Side View
(Doors removed by emergency crews)
Épave – Vue latérale gauche
(Portes retirées par les membres de l'équipe de secours)

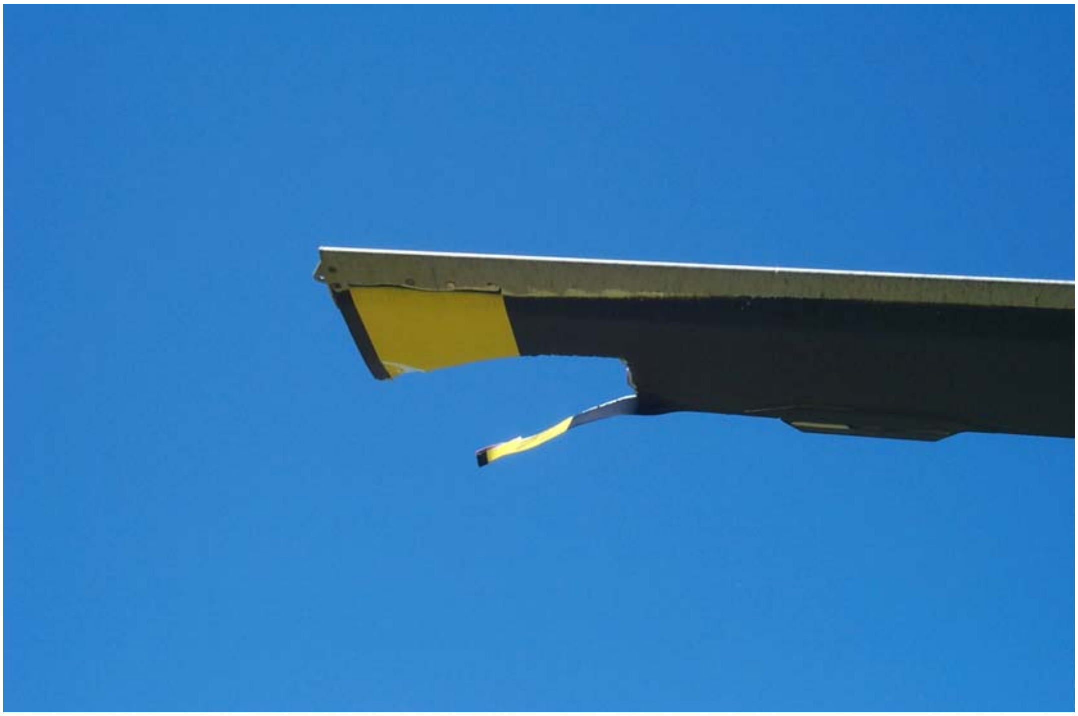

Photo 5: Main Rotor Blade – Damage from tail fin strike
Pale du rotor principal – Dommages dus à l'impact avec la dérive

Photo 6: Tail Boom – Tail fin damage
Poutre de queue – Dommages subis par la dérive

Annex B – Site Layout