TRANSPORT ACCIDENT INVESTIGATION COMMISSION

TE KOMIHANA TIROTIRO AITUA WAKA

AIRCRAFT ACCIDENT REPORT

No. 89-047

HUGHES 369HS ZK-HXA
Upper Icefall, Fox Glacier
2 May 1989

Transport Accident Investigation Commission
Wellington - New Zealand

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Transport Accident Investigation Commission
Wellington

Chief Commissioner
Transport Accident Investigation Commission

The attached report summarises the circumstances surrounding the accident involving Hughes 369HS ZK-HXA near Fox Glacier on 2 May 1989 and includes suggested findings and recommendations.

This report is submitted pursuant to Section 8(2) of the Transport Accident Investigation Commission Act 1990 for the Commission to review the facts and endorse or amend the findings and recommendations to the contributing factors and causes of the accident.

21 February 1991

R CHIPPINDALE
Acting Chief Executive

APPROVED FOR RELEASE AS A PUBLIC DOCUMENT

20 March 1991

M F DUNPHY
Chief Commissioner

AIRCRAFT:	Hughes 369HS	**OPERATOR:**	Alpine Adventures Limited
REGISTRATION:	ZK-HXA	**PILOT:**	W.G. Crawford
PLACE OF ACCIDENT:	Upper Ice-fall of Fox Glacier, 10 km south-east of Fox Glacier township	**OTHER CREW:**	Nil
DATE AND TIME:	2 May 1989, 1720 hours	**PASSENGERS:**	Four

SYNOPSIS:

The Office of Air Accidents Investigation was advised at 0835 hours on 3 May 1989 that ZK-HXA, missing since the previous day, had been located and had sustained an accident. Mr D.G. Graham was appointed Investigator in Charge. The field investigation commenced later that day. During the course of a scenic flight over Fox Glacier, the helicopter's engine seemed to lose power and the pilot made an autorotational descent onto the glacier. Two of the passengers were fatally injured during the ensuing impact on the extensively crevassed and pinnacled ice-fall, and the pilot and one of the two surviving passengers received serious injuries.

1.1 HISTORY OF THE FLIGHT:
See page 4.

1.2 INJURIES TO PERSONS:
Pilot: Serious
Pax: 2 Fatal
1 Serious
1 Minor

1.3 DAMAGE TO AIRCRAFT:
The aircraft was destroyed

1.4 OTHER DAMAGE
Nil.

1.5 PERSONNEL INFORMATION:
See page 6.

Flight Times

	Last 90 days	Total
All Types	74	234
On Type	61	86

1.6 AIRCRAFT INFORMATION:
See page 8.

1.7 METEOROLOGICAL INFORMATION:
See page 8.

1.8 AIDS TO NAVIGATION:
Not applicable

1.9 COMMUNICATION:
See page 10.

1.10 AERODROME:
Not applicable

1.11 FLIGHT RECORDERS:
Not applicable

1.12 WRECKAGE AND IMPACT INFORMATION:
See page 10.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION:
The pilot was in good health at the time of the accident. There was no evidence of any medical factor which may have affected the pilot's ability to conduct the flight.

1.14 FIRE:
Fire did not occur

1.15 SURVIVAL ASPECTS:
See page 12.

1.16 TESTS AND RESEARCH:
See page 14.

1.17 ADDITIONAL INFORMATION:
See page 17.

1.18 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES:
Nil

2. ANALYSIS:
See page 21.

3. FINDINGS:
See page 25.

4. SAFETY RECOMMENDATIONS:
See page 26.

APPENDICES:
1. ZKHXA Flight Path

* All times in this report are NZST

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Alpine Adventures Limited was one of several helicopter operators providing scenic and charter flights from Fox Glacier township. The company operated Hughes 369HS helicopter ZK-HXA. Flights departed from, and returned to, a prepared "pad" at the Motor Park located a short distance from the township.

1.1.2 One of the most popular and frequently operated flights comprised a 10 minute "round trip" over the nearby Fox Glacier which afforded passengers the opportunity to view not only the glacier itself but also the surrounding mountain and bush scenery.

1.1.3 In conjunction with the Department of Conservation, local helicopter operators had developed a "standard route" for scenic flights over the glacier. This involved flying up the true right (northern side) of the glacier, climbing to an altitude of some 6500 feet, dependent upon conditions and overflying the upper snowslopes in an orbit to the right before descending the face of the glacier in a zig-zag pattern, then returning to the township. (See Appendix 1).

1.1.4 On the day of the accident a party of tourists from Singapore had arrived at Fox Glacier township. The weather was unsuitable for scenic flying over the glacier at the time of their arrival, but by late afternoon conditions had begun to improve and the pilot of ZK-HXA contacted a group of three Singaporeans who had earlier made an inquiry regarding the "Glacier Flight", indicating that the flight could now go ahead.

1.1.5 The helicopter had seating for four passengers, so the pilot offered the remaining seat to an employee at the Motor Park who had not seen the glacier from the air.

1.1.6 Before take-off the pilot ensured that each of the passengers had their lap belt securely fastened. Each passenger was provided with headphones to reduce the ambient noise level and to enable the pilot to give a brief commentary regarding items of interest from time to time during the flight.

1.1.7 The engine start and pre-flight operating checks presented no unusual indications and ZK-HXA departed on the anticipated 10 minute flight at about 1710 hours. After take-off the pilot followed the "standard route", skirting the northern ridges while climbing to the upper snow slopes above the glacier. The improved weather conditions enabled him to reach 6500 feet and carry out a wide sweeping turn to the right, around the upper neve. At the conclusion of this manoeuvre, approaching the northern side of the glacier and already descending, the pilot began a turn to the left, intending to follow the usual "zig-zag" flight path from side to side of the glacier while continuing the return descent to Fox Glacier township.

1.1.8 As the pilot continued the turn to the left, heading ZK-HXA across the glacier, at a height of some 200 to 300 feet above the surface of the ice-fall which fell away steeply below, and at a speed of about 70 knots, the helicopter suddenly yawed to the left and began to lose height rapidly. The pilot commented later that the unexpected "yaw" was similar to the abrupt effect of a tailwind gust when coming to a hover, although the helicopter's speed was relatively high at the time. The torque reading during the turn was 35 to 40 psi. The pilot raised the collective in an attempt to arrest the descent but this was ineffective so he lowered collective fully, considering that at that stage of the turn his only option within the height remaining was to carry out an immediate autorotational landing on the surface of the glacier. He did not recall hearing any "warning horn" in his headphones, nor did he have any recollection of illumination of the "engine out" warning light at the time of the apparent loss of engine power.

1.1.9 The pilot applied right pedal to correct for the yaw and was able to stop the aircraft turning as it descended. Prior to contact with the ice he remembered "pulling all the collective" available but recalled nothing further. After "coming to", an unknown time after impact, he realised that the passenger who had occupied the middle seat adjacent to him had been thrown from the helicopter and the passenger in the right front seat, had received fatal injuries, during the impact sequence. The forward section of the helicopter had been demolished but the instrument panel pedestal was still loosely attached to the lower structure. The pilot noted at this stage, that none of the warning indicators were illuminated, and it appeared that the main power supply had been disrupted due to the severe damage sustained. He turned the master switch "off" as a precautionary measure before extricating himself from his exposed position in the left front seat of the helicopter.

1.1.10 The severely injured pilot joined the two passengers in the rear compartment of ZK-HXA, who had also received varying degrees of injury. The compartment was relatively intact so the survivors removed the seats to create more space and donned additional clothing from the survival kit, also utilising the "survival blankets" as a covering, to combat the low temperature during the night. The pilot retrieved the emergency locator transmitter (ELT) which had been activated on impact. At about 2100 hours he turned the ELT off with a view to conserving the unit's batteries, should the search for the helicopter be prolonged. He turned the ELT on again at about 0700 hours next morning. The Singaporean passenger operated the "flash" unit on her camera a number of times after dark in an endeavour to attract attention should any search party have been in the vicinity.

1.1.11 The Singaporean passenger who had occupied the right seat in the rear compartment later recalled that the early part of the flight proceeded uneventfully. "We were enjoying the scenery and taking photos". She was unable to remember details of the flight immediately before the accident but indicated that "everything happened very fast ... there was a sort of a bang and ... I saw the glass all smashed, I think I was flung to the left ... eventually everything stopped".

1.1.12 The Motor Park employee occupied the left rear seat of ZK-HXA. He stated later that the flight had proceeded smoothly initially and the pilot provided a commentary as they passed over various points. In the latter part of the flight he recalled a major turn to the right. His next recollection was that the helicopter was descending and that it was banked to the left at an angle of about 45°. He remembered seeing the ground but it was "pretty far away". He reported that the static noise in the headphones he was wearing suddenly "went dead", but he could not recall exactly when this occurred in relation to the accident sequence. Neither of the two rear passengers recalled hearing any "warning horn" or unusual noise apart from "static" in their headphones at any time during the flight.

1.1.13 A group of Singaporeans from the same tour, accompanied by a New Zealand guide, had undertaken the "Fox Glacier Walk" to view the lower section on foot, and were about 600 m up from the terminal face on the true right side of the glacier. At approximately 1710 hours they were preparing to leave the glacier and saw the helicopter flying overhead. The guide reported that "the Hughes flew over at about 3000 feet — quite high". The guide was familiar with the routes flown by helicopters in the area and noted nothing unusual about the flight of ZK-HXA as she watched it proceed up the glacier.

1.1.14 The owner of Alpine Adventures Limited had spoken to the pilot of ZK-HXA by telephone at approximately 1645 hours on the day of the accident, advising him that he required the helicopter for a further flight that evening, following the scenic flight over Fox Glacier. When ZK-HXA had failed to return by 1730 hours, he became concerned for the safety of the flight. After local inquiries had been made in an attempt to establish the helicopter's whereabouts, the Police were advised that ZK-HXA was overdue and the Rescue Coordination Centre (RCC) was subsequently informed regarding the missing helicopter. Department of Conservation (DOC) staff at Franz Josef and Fox Glacier listened out on the emergency frequency of 121.5 mHz but nothing was heard, and no transmissions were received on this frequency by high-altitude aircraft overnight. (It was established later that the pilot had turned the ELT "OFF" during the night — see 1.1.10). The RCC re-opened at 0600 hours next day, and a search helicopter departed from Franz Josef at 0745 hours.

1.1.15 Signals from the ELT were picked up at 0813 hours and the searching helicopter located the wreckage of ZK-HXA at approximately 0820 hours. The fuselage was lying at a precarious angle in a deeply crevassed and pinnacled region of the upper ice-fall of the glacier. Mountaineering staff of the Department of Conservation were able to reach the accident site with suitable alpine equipment after being landed on a nearby ice-slope and the passenger from the Motor Park, who was least injured and capable of walking, was brought out from the site at about 1000 hours. Specialist mountain rescue personnel from Mount Cook assisted in recovering the pilot and remaining passenger from the glacier at about 1100 hours. The pilot and passenger were subsequently admitted to Grey Hospital. The pilot was later transferred to Burwood Hospital.

1.1.16 The accident occurred in daylight at about 1720 hours. The accident site was on the upper ice-fall of Fox Glacier, approximately 300 m south-west of its northern edge at an elevation of 4900 feet amsl. The site was about 10 km south-east of Fox Glacier township. National Grid Reference 781576. (NZMS 1 Sheet S79 "Mount Cook") Latitude 43°31'00"S, longitude 170°07'30"E.

1.5 Personnel information

1.5.1 The pilot, Wayne George Crawford, 22, commenced an approved course of helicopter flying training in September 1987. He obtained Private Pilot Licence — Helicopter number 1133 on 20 October 1987 and was issued with Commercial Pilot Licence — Helicopter number 570 on 23 December 1987. At the time of the accident the Validity Certificate associated with this licence was valid from 14 December 1988 to 21 September 1989.

1.5.2 Mr Crawford's basic flying training was conducted on the Hughes 269A helicopter. He later obtained a rating on the Robinson R22 helicopter and in early November 1988 obtained a rating on the Hughes 369HS turbine powered helicopter.

1.5.3 At the time of the accident Mr Crawford had flown a total of 234 hours 50 minutes on helicopters. This included 7 hours of night flying. He had flown 86 hours 20 minutes on the Hughes 369HS helicopter. Mr Crawford had not flown any other type of turbine powered helicopter. He had not undertaken any training in fixed wing aircraft.

1.5.4 From 7 November 1988 until the end of February 1989 Mr Crawford was employed as a charter pilot on hunting and fishing safari work, based at Makarora. He flew a total of 63 hours 15 minutes while engaged in this work, exclusively flying a Hughes 369HS helicopter. At the end of March/early April 1989 Mr Crawford visited the United States of America and flew 13 hours on the Bell 47G helicopter at that time.

1.5.5 On 13 April 1989, before commencing formal employment with Alpine Adventures Limited, Mr Crawford undertook a "check flight" in ZK-HXA with the Chief Pilot/Owner of the company. During this flight he demonstrated two autorotational descents and satisfied the Chief Pilot as to his proficiency in operating ZK-HXA to an acceptable standard. He again flew with the Chief Pilot on 18 April 1989. The flights carried out with the Chief Pilot amounted to a total of 1 hour of flying.

1.5.6 As an introduction to the operation of scenic flights from Fox Glacier, Mr Crawford had accompanied the existing resident pilot in ZK-HXA on a number of occasions when seating capacity permitted. This arrangement enabled him to become familiar with the route flown and the technique involved in conducting the scenic "Glacier Flight" as well as other flights offered by Alpine Adventures Limited in the local area. Mr Crawford took over the duties of the resident pilot on the latter's departure.

1.5.7 The flights carried out by Mr Crawford with the Chief Pilot, together with those flown with the resident pilot, before commencing scenic operations as pilot in command, were intended to satisfy the requirements of Civil Aviation Regulations 76 and 77 in regard to Alpine Adventures Limited operations. Mr Crawford had flown the scenic "glacier flight" pattern in company with the resident pilot, but had not flown with the Chief Pilot over the precise route he was following on the day of the accident. The Alpine Adventures Limited Operations Manual and Operations Specifications had not been the subject of specific discussion or review.

1.5.8 Mr Crawford commenced tourist flying with Alpine Adventures Limited on 21 April 1989. Analysis of the company's flight sheets indicated that up to the date of the accident he had completed 22 flights as pilot in command involving a similar flight profile to that of the "Glacier Scenic Flight" totalling approximately 7 hours flying. He had flown a total of 19 hours and 30 minutes in Hughes 369HS ZK-HXA, within a period of 18 days preceding the accident.

1.5.9 During the last 90 days he had flown a total of 74 hours and 25 minutes, of which 61 hours 25 minutes was on the Hughes 369HS. He had completed satisfactorily a Helicopter Competency Check (Regulation 76 Check) on 14 December 1988 conducted by the General Aviation Inspector (Helicopter Operations) of the Civil Aviation Division of the Ministry of Transport.

1.6 Aircraft information

1.6.1 Hughes 369HS helicopter ZK-HXA, serial number 2405645 was constructed in 1974 and imported to New Zealand in 1984. It had flown 4549 hours 45 minutes since new and 8 hours 40 minutes since the last routine inspection.

1.6.2 The Allison 250-C20 engine, serial number CAE 822630 had run a total of 4538 hours 5 minutes.

1.6.3 A non-terminating Certificate of Airworthiness (C of A) in the Standard Category was issued on 16 August 1985. Its validity was dependent on the aircraft being maintained in accordance with James P. Scott Approved Air Transport Operators Maintenance Manual.

1.6.4 ZK-HXA had received regular maintenance in accordance with the required schedule. The last maintenance inspection prior to the accident was a 50 hour inspection carried out on 27 April 1989. At the time of the inspection an engine output/main rotor transmission input shaft alignment check was completed. Maintenance Release number A121904 was issued following the inspection and would have remained in force until 27 September 1989 or the attainment of 4591 total aircraft time in service, whichever occurred earlier. No defects or operating difficulties had been experienced in the operation of ZK-HXA in the period between this inspection and the occurrence of the accident.

1.6.5 The gross mass of the helicopter at the time of the accident was estimated to have been approximately 1030 kg with the longitudinal centre of gravity (CG) 2500 mm aft of the datum. The lateral CG was estimated to have been 0.5 mm to the right of the centre line.

1.6.6 The maximum authorised mass of ZK-HXA was 1156 kg. At a mass of 1030 kg the longitudinal CG limits were 2464 and 2642 mm aft of the datum. The lateral limits at 2500 mm aft of the datum were 76 mm either side of the centre line.

1.7 Meteorological information

1.7.1 On 2 May 1989 a shallow trough lay to the west of New Zealand and a weak moist northerly airstream covered the country. At Hokitika 115 km north-east of Fox Glacier, in the early afternoon the main cloudbase was 2000 feet with patches of stratus at 500 feet. Rainfall increased during the afternoon. By 1700 hours the main base had lowered to 1000 feet with another layer at 700 feet and patches at 500 feet. At 1800 hours the base was 500 feet with patches at 400 feet. At Haast, 90 km south-west of Fox Glacier the rainfall was much lighter. No cloud information was available.

1.7.2 The weather recorded locally at Fox Glacier township at 1100 hours was as follows:

Wind:	050/2 knots
Visibility:	30 km
Temperature:	+17°C
Dew Point:	+16°C
Cloud:	7/8 cloud at 1000 feet. Slight drizzle (cloud moving from the north)

It had been completely overcast with drizzle but the weather was clearing.

1.7.3 Local residents, including a helicopter pilot, based at Fox Glacier township, reported that when ZK-HXA departed, the cloudbase was about 3000 feet amsl. "Looking up towards the valley (of the glacier), there was quite a bit of broken cloud". The weather conditions were gradually improving from the rainy period experienced over the preceding few days.

1.7.4 The guide conducting the "Glacier Walk" reported that at the time that ZK-HXA flew overhead, the weather was clearing and it was reasonably fine over the glacier. About 15 minutes later "a bit of rain came in — just drizzle and wind". There was a typical light katabatic wind as the party made their way off the glacier.

1.7.5 The surviving Singaporean passenger from ZK-HXA stated that "before we went up in the helicopter there was light drizzle ... when we went up higher there was no rain really". In regard to cloud she recalled "I could see quite clearly". The Motor Park employee reported that during the flight "it was spitting a wee tiny bit, but only very light". There was no low cloud and the flight was quite smooth. Photos taken by the Singaporean passenger at Fox Glacier township before the flight and over the glacier during the flight, confirmed that although the surrounding ridges and mountains were obscured, the glacier itself was clear of cloud.

1.7.6 The pilot reported that the mountain tops were covered in cloud, but the glacier was clear. There was no significant precipitation and he did not consider that in the existing conditions there was any likelihood of engine icing. He believed that there was very little wind at the time of the accident and his recollection after the helicopter had come to rest was that conditions were calm. During the night, however, some rain fell intermittently, the wind freshened, and was boisterous for a short period in the early hours.

1.7.7 The General Manager of the New Zealand Meteorological Service in an "aftercast" of the meteorological situation commented as follows in regard to likely wind and air temperature:

> "The gradient wind flow would have been north or north-east with speeds generally less than 10 knots below 10000 feet. However speeds are likely to have been greater than this across the ridge lines. Because the ranges tend to lie west to east the winds over the glacier itself were probably light and variable with possibly some katabatic effect, that is a flow down the glacier.
>
> In the free air, that is away from the glacier, the freezing level was about 10000 feet and the temperature at 5000 feet about 8 degrees Celsius. The ice of the glacier may have had some cooling effect on the air close to it."

1.7.8 A pilot with considerable helicopter flying experience in the area, which included many "glacier" scenic flights, reported that on one occasion, quite unexpectedly, he had experienced marked "downflow" in the lee of Chancellors Ridge. He encountered the downflow at a height of approximately 5500 feet while climbing up the centre of the glacier and adjacent to the end of the ridge. There was no prior evidence of the downflow and no turbulence associated with it, but the severity of the "sink" required the application of full power and a flat turn away from the rising glacier. A significant feature of the encounter was that further down the glacier, at about 4000 feet, there was no noticeable wind. This localised effect occurred during north-easterly conditions similar to those which existed at the time of the accident to ZK-HXA.

1.9 Communications

1.9.1 ZK-HXA was equipped with a Narco 11A VHF transceiver and an Aircom 10/100 HF transceiver. An "intercom" system was also installed to enable the pilot to give an in-flight commentary to the passengers who were provided with headsets.

1.9.2 At the time of the accident, the arrangement of the intercom installation required the pilot's microphone and headphone combination to be plugged directly either to an "intercom" connection, or alternatively to a separate "radio" connection.

1.9.3 There were no radio communications from ZK-HXA on VHF or HF frequencies during the accident flight. Reports from the surviving passengers indicated that the "intercom" system functioned satisfactorily during the flight, with a degree of background "static".

1.9.4 Destruction of the helicopter's forward structure on impact, with consequent disruption to the power supply and severe damage to the radio and electrical installations prevented any RTF transmissions either VHF or HF, from ZK-HXA after the accident.

1.12 Wreckage and impact information

1.12.1 The wreckage of ZK-HXA was located in an extremely broken and unstable region of the upper ice-fall of Fox Glacier some 5 km up the glacier from the terminal moraine, and about 300m south-west of the glacier's northern edge. The glacier was approximately 900 m wide at this point and flowed downwards in a north-westerly direction. The immense irregularities of the crevassed and pinnacled ice-fall precluded an accurate slope assessment, but the general downslope of the surface in the area of the accident site was estimated as about 25°.

1.12.2 The fuselage had come to rest part way down the side of a deep ice fissure, and lay on a heading of approximately 200°T. The fuselage had remained upright but was tilted steeply rearwards at an angle of about 60° and rested precariously with the engine compartment held against protrusions of ice. The adjacent fissure was partly filled with tumbled blocks of ice but numerous slots, melt holes and deep crevasses surrounded the area.

1.12.3 A 1.5 m length of landing skid lay on the undulating surface of an ice-ridge, located about 3 m above and 4 m to the north-west of the fuselage. The horizontal stabiliser and vertical fin, still attached to a 1 m length of the tailboom which had been severed from the helicopter during the impact sequence, had fallen into a deeper part of the ice fissure and lay about 10 m north-east of the fuselage. The tail rotor gearbox housing had fractured, completely exposing the tail rotor input shaft helical gear. The major portion of the gearbox together with the tail rotor blade assembly was missing. The latter items were not recovered, but oil splatters on the surface of the ice were consistent with fracture of the tail rotor gearbox and departure of the tail rotor assembly as a result of impact forces.

1.12.4 There were few recognisable impact marks on the hard icy surface during an early aerial reconnaissance, and some melting had occurred when the site was more closely examined by mountaineers at the time of recovery of the main wreckage. The marks noted and the disposition of the wreckage, however, indicated that ZK-HXA had struck the ice-fall initially on an approximate south-easterly heading (i.e. towards the general fall-line of the glacier).

1.12.5 The broken and contorted nature of the ice-fall rendered it impracticable to determine the attitude or speed of the helicopter at impact. However the extent and distribution of damage to the fuselage, which included the complete destruction of the forward section on the right side and severe crushing of the helicopter's undersurface suggested that initial impact occurred with considerable forward and downward energy.

1.12.6 Portions of the main rotor blades were scattered up to 40 m from the fuselage, in an arc to the south and west. At least two of the blades had fractured into short lengths, but one blade, although severely bent, remained near full length. A significant portion of one main rotor blade ("red" blade) was wrapped tightly through 360° around the rotor mast beneath the swash plate. Blade and pitch link failures at the rotor head itself were all consistent with the severe impact forces likely to have been sustained. The fragmentation of two of the main rotor blades and the "corn-cobbing" of the main rotor head (shedding of the pitch housings from the straps), suggested that the engine was delivering relatively high power at the time that the main rotor blades struck the ice.

1.12.7 Parts of the skid assembly and a skid support were observed to have fallen into an ice hole some 3 m north-west of the fuselage together with various items including pieces of Perspex from the doors or "bubble" and a short strop which had been stowed in the aircraft's cabin. The front sections of the left and right skids and both forward skid supports had broken away from the helicopter on impact. The rear skid supports remained attached but the middle section of the left skid was bent upwards at an angle of some 45°. Another deep ice-hole close to the fuselage contained a left door, seats from the aircraft, and a number of small items including head sets, aircraft documentation and personal equipment.

1.12.8 The forward seat structure was severely deformed. The right seat pan and centre seat structure had been deflected downwards. The underfloor structure had been forced upwards. The pilot's seat pan was buckled and folded rearwards. The centre and right passenger lapstraps were still done up, but structural damage had occurred to the left centre lapbelt attachment. At the time of rescue operations, it was noted that the seat squabs were missing from the right side of the forward seat assembly.

1.12.9 The inboard upper section of the tailboom, adjacent to and above the tailboom/fuselage attachment had been struck by the rotating main rotor blades. The tailboom itself had separated into three sections, the outboard section remaining attached to the empennage and tail rotor assembly. The tail bumper and lower vertical fin had fractured adjacent to the tailboom due to impact and the upper fin was bent to the right at the top. Extensive damage to the upper left side of the fuselage and other areas, was consistent with gyrations in roll and pitch as the helicopter struck various protrusions on the irregular surface of the ice-fall during the impact sequence.

1.12.10 The fuselage of ZK-HXA, the displaced aft section of the tailboom and stabiliser assembly and other components recovered at the site, were transported to the operator's base and later transferred to an approved maintenance facility for detailed inspection. A number of components were observed but not recovered because of the hazardous exposure of their locations within the ice-fall.

1.12.11 Initial examination at the roadhead included the following observations:

Master Switch		"OFF"
Generator		"ON"
Fuel		"ON"
Start Pump		"OFF"
Auto Ignition		"ARMED"
Radios	— VHF	"OFF"
	— HF	"OFF"

Relevant instrument indications were:

Torque	"34 PSI"
Engine Oil Temperature	approx 90° to 100°

(Both these indications were apparent "trapped" readings.)

Photographs of the instrument panel taken "on-site" prior to the wreckage being lifted out confirmed the above observations. A considerable quantity of fuel remained in the helicopter's fuel tank, although the upper surface of the tank was torn.

1.15 Survival aspects

1.15.1 The broken, crevassed ice-fall was formidable terrain for an attempted autorotational landing. Irregularly shaped ice islands were interspersed with projecting "ice pinnacles" amongst a maze of deep fissures and slots. The undulating, unyielding and slippery nature of the surface also combined to present hazards reducing the likelihood of a successful outcome for any landing in which the helicopter was not under full control.

1.15.2 Despite the extensive impact damage to ZK-HXA, the pilot, seated on the left in the front, and the two passengers seated in the rear compartment, survived the accident, with the passenger on the left sustaining the least injury.

The MD Hughes 500 series helicopter had a considerable background of military use and development and the structural strength of the rear compartment assisted in protecting the rear passengers during the impact sequence. In addition the relatively intact compartment served as a necessary refuge for the survivors against the effects of exposure, until their rescue the following morning.

1.15.3 The three survivors, irrespective of their seating positions, all sustained varying degrees of spinal injury, indicating that there was a significant vertical descent component in the helicopter's flight path at impact. However, the pilot and front seat passengers were clearly most vulnerable in the event of collision with any ice protrusions or pinnacles encountered during the attempted landing and to subsequent exposure once the integrity of the cockpit "bubble" was lost. During the accident sequence the main rotor blades of ZK-HXA continued to rotate under at least some power and damaged and deflected from their normal track as a result of impact forces, presented a hazard to the occupants. However, there was no structural damage to indicate that a main rotor blade, or portion thereof, had swept through the upper right area of the front cockpit.

1.15.4 All occupants were wearing lapbelts. The pilot had a shoulder harness available to him but was not wearing it during the flight. He did not wear a protective helmet. Damage to ZK-HXA suggested that it had rolled and pitched severely during the accident sequence. The structure adjacent to the attachment fitting on the left side of the centre front passenger's lapbelt had torn away. This damage and the extensive disruption of the seatpan itself was likely to have reduced the restraint of the centre front passenger's lapbelt assembly. The body of the passenger who had occupied the centre front seat was found some 5 m from the fuselage, in a position consistent with having been ejected from the helicopter shortly before it came to rest.

1.15.5 While the pilot and the two rear seat passengers survived this accident, the passenger in the front right seat received a massive head injury. The death of the front centre seat passenger who was ejected, resulted from severe chest and abdominal injuries. The cause of the injuries in both cases was not determined but it was probable from the overall injury and damage pattern that the most severe frontal and vertical impact forces were sustained on the right forward and lower structure of the helicopter. The evidence suggested that in this particular accident the wearing of a shoulder harness, had one been installed, would not have enhanced the front right seat passenger's likelihood of survival. In the same manner, while it could not be proven, the loss of lapbelt effectiveness and the disruption to the structure rendered it unlikely that a shoulder harness, (had one been available in the centre seat position), would have assisted in restraining the front centre passenger within the helicopter.

1.15.6 Survival blankets, clothing and food from the survival pack carried on board ZK-HXA, was utilised by the survivors and helped to reduce their discomfort. It was fortuitous that this equipment had been stowed in the rear compartment and remained accessible to the occupants. Various items stowed in the front cockpit were ejected from the helicopter before it came to rest and due to the nature of the terrain, became impossible to retrieve.

1.15.7 The pilot's action in turning off the ELT during the night "to conserve the batteries", while well intentioned, held the potential for delaying rescue. In this instance however, the opportunity for survival of those on board was not affected. Such action was inadvisable, as a major purpose of the ELT was to enable the helicopter's occupants to be located with the least possible delay, of critical importance in the case of seriously injured passengers or crew. Irrespective of specific action taken by the Rescue Coordination Centre (RCC) which may frequently involve night search sorties by suitably equipped aircraft, the emergency frequency of 121.5 mHz, on which ELT signals were transmitted, was monitored routinely by air transport aircraft operating both within New Zealand and proceeding to and from this country by day and night. In addition, information regarding ELT transmissions within New Zealand was often obtained from regular satellite passages and relayed to the RCC.

1.16 Tests and research

1.16.1 A sample of fuel taken from the operator's drum stock from which ZK-HXA was last refuelled, was tested and met all the relevant specifications for Jet A1 turbine fuel.

1.16.2 The wreckage of ZK-HXA was transported to an approved maintenance and overhaul organisation for detailed examination and tests. Findings included the following:

"1. The lower parts of the engine compartment doors were buckled and deformed. The engine outer combustion case was dented and the engine mount structure slightly deformed due to impact forces, resulting in some misalignment of the engine output shaft to the main rotor gearbox input.

The main rotor gearbox was free to rotate. A subsequent bulk strip of the transmission disclosed no abnormality or malfunction.

2. The pattern and extent of exhaust smoke deposits on the external surfaces of the rear structure above the exhaust ducts indicated that exhaust smoke was emitted from the ducts for a period after the helicopter had come to rest. The smoke pattern was consistent with continued operation of the engine for some time with the fuselage in a nose-up attitude of some 60°. A section of the tailboom, wrinkled by impact forces was smoke stained, but clean areas at the base of the skin wrinkles confirmed that the exhaust smoke staining had occurred after impact.

3. The engine intake/particle separator structure had been torn from the fuselage and there was evidence of minor foreign object damage (FOD) to the first stage compressor blades.

The fan screen of the starter/generator had been pushed into the fan, and all fan blades were deformed. Significant scoring indicated that the generator was rotating at the time of impact.

Inspection showed that the fuel control throttle was set to the maximum power position. The acceleration adjuster was set at the mid position. The engine anti-ice valve was "closed". The bleed valve was tested and assessed as operating satisfactorily.

Inspection and testing of the fuel system and control system air circuit, was carried out to determine whether any discrepancies existed in these systems which may have contributed to a partial, or temporary, disruption or contamination of the fuel flow to the engine with the attendant possibility of a "flame-out".

It was noted that the engine driven fuel pump filter bowl did not have a drainage valve fitted. A threaded plug and packing was installed at both vent holes, with a standard drain valve fitted at the firewall location. The stem of this valve had been bent on impact, but vacuum leak checks disclosed no discrepancies or leakage sources within the fuel pump and filter bowl assembly, or at the firewall drain valve.

The fuel inlet connector to the engine driven pump was found to be a military application emergency shut-off breakaway- design. This adaptor had an integral check valve which normally remained open, but in the event of hose fracture would automatically close to cut off fuel flow. Removal of this connector disclosed that an "O" ring packing was missing from the groove which served to seal the assembly when threaded onto the connector. (See also Tests and Research paragraph 1.16.7)

The fuel nozzle was removed from the engine and inspection revealed a small amount of carbon on the tip of the nozzle. During a motoring check of the engine N_1 drive system, allowing fuel to discharge through the fuel nozzle there was a momentary hesitation to flow but after 2 to 3 seconds the nozzle cleared and formed a conical spray pattern. Subsequent flow checks on a test rig confirmed that the nozzle met all service requirements for flow/pressure and pattern angle.

The fuel control, power turbine governor, and fuel pump were removed from the engine and sent to an approved overseas facility for functional testing to confirm their servicability. The units satisfied all relevant fuel flow requirements and no discrepancies were found which would have resulted in inability to correctly schedule fuel to the engine's fuel nozzle.

The engine driven fuel pump filter was removed for inspection and found to be reasonably clean with only a small amount of accumulated debris. The filter by-pass switch was removed and vacuum checked separately. No external leakage was evident but a leakage path across the switch diaphragm was found on a vacuum check.

Disassembly of the turbine module disclosed that post impact N_2 "lock-up" had occurred as a result of carbon jamming in the third stage turbine wheel labyrinth seals. This provided further evidence that the engine was operating after the fuselage had come to rest, with inadequate scavenging of the 6/7 bearing compartment occurring due to the unusual attitude of the engine and the inability of the N_2 (power turbine) rotor to rotate freely with the impact restrictions to rotation of the main rotor head. Oil spewing across the labyrinth seals in the presence of combustion temperatures resulted in carbon formation in the seals.

Carbon and oil stains in the first stage nozzle guide vanes and on the first and second stage gas producer wheel blades also confirmed that the engine was running following impact."

The manufacturer of the helicopter confirmed that the damage sustained by the main rotor head was indicative of a significant amount of torque being transmitted by the engine to the main rotor during the impact and subsequent rotation of the rotor.

1.16.3 Microscopic examination of the filaments of the light bulbs in the relevant "warning" and "system status" indicators mounted in the instrument panel disclosed the following information:

The "Auto-Reignition" light was illuminated at impact.
The "Armed" light in the auto-reignition circuit was probably "ON".
The "Generator OUT" light may have been "ON".

Tests on a production aircraft at the manufacturer's facilities indicated that the "Generator OUT" light would illuminate just below ground idle engine speed (+65%N_1). However this speed was dependent on the strength of the battery since the light was actuated when the generator voltage drops below the battery voltage.

1.16.4 The fuel filter bypass switch (part number 369H8144-3) was examined and tested at the switch manufacturer's facilities in the United States. Initial examination indicated some relative movement between the two halves of the housing and no electrical continuity. Subsequent disassembly and testing resulted in the following conclusions:

(a) The fuel filter bypass switch was inoperable —
   (i) Output wire was broken
   (ii) Output elbow was approximately 50° from centre
   (iii) Diaphragm had a hole

   (It could not be established with certainty, however, whether the output wire was broken and the elbow twisted prior to the accident or whether this occurred as a result of impact or recovery action)

(b) Corrosion and rust indicated significant water in the switch assembly.

(c) The internal switch functioned as designed.

   In such a case water and/or contaminants would flow past the filter and into the fuel control and engine. With the fuel filter bypass switch not working, the pilot would have had no warning indication on the instrument panel in the event that the fuel filter was restricted and bypassing.

1.16.5 The fact that the fuel pump filter bowl on ZK-HXA was not fitted with a drainage valve held potential for water and/or other contaminants to accumulate within the filter. It was evident from the condition of the internal switch that water had been present in the switch and therefore within the fuel filter at an unknown stage in the history of the component. However, the corrosion and condition of the diaphragm, suggested that this had occurred some considerable time earlier.

1.16.6 Throughout the operation of the helicopter in New Zealand the filter bowl assembly of ZK-HXA had been subject to regular inspection during periodic maintenance and the pilot's pre-flight inspection on the morning of the accident flight had included a check for the presence of water within the overall fuel system. No residual water was found within the filter bowl or fuel system when the engine installation was tested and disassembled following the accident. While the possibility could not be discounted, it was concluded that a sudden power loss due to accumulation of water within the fuel system of ZK-HXA was unlikely to have occurred.

1.16.7 Fuel system rig testing and test cell research was undertaken by the engine manufacturers approved agency in relation to the performance of the military type fuel inlet connector installed on ZK-HXA. It was found that with the prescribed "O" ring removed, loosening the knurled fitting by approximately one quarter turn permitted air bubbles to enter the fuel system. While this fitting was a potential source of air ingress, there was no conclusive evidence that this had occurred prior to the accident. Other tests undertaken by the engine manufacturers approved overhaul agency indicated that any source of air leakage into the suction side of the engine driven fuel pump held potential for air bubbles to accumulate in the fuel pump filter bowl. Research had shown that should such an accumulation break free, due to unusual attitudes or manoeuvring of the helicopter, the interruption to the fuel supply would result in a flame-out.

1.17 Additional information

1.17.1 The "standard route" scenic flight pattern developed by the local helicopter operators in conjunction with the Department of Conservation and the Civil Aviation Division of the Ministry of Transport reduced the danger of possibly conflicting flight paths flown by the various operators in the region and also minimised environmental intrusion by helicopter traffic, particularly in relation to parties on guided walking tours over the lower part of the glacier. In addition, the rapid initial gain of height while flying up the northern side of the glacier and the subsequent "zig-zag" pattern down the glacier, was intended to provide a suitable compromise, enabling passengers to obtain an impressive view of the area, yet allowing opportunity for an autorotational descent to suitable terrain at the side of the glacier, the terminal moraine at the base of the glacier, or to lower ground beyond, in the event of an engine malfunction. The availability of an autorotational descent path to the latter areas varied considerably, however, dependent on the aircraft's height at the time above the glacier surface, the slope of the glacier in the immediate vicinity and the distance from the terminal moraine which was most likely to offer the nearest suitable landing surface.

1.17.2 The flights undertaken by Alpine Adventures Limited were authorised under the provisions of Air Service Certificate Number 345 issued to the operator James Patrick Scott.

1.17.3 The Operations Specifications forming part of the Air Service Certificate included the following general operating conditions, under the heading 2.1 Regulations: (reproduced in part only)

> "The air transport operations of ... the company are to be conducted in accordance with the provisions of the Civil Aviation Regulations 1953 and associated orders, requirements and instructions, these operations specifications, the approved company operations manual, the approved company route guide and the approved helicopter flight manual for each aircraft type to be used."

1.17.4 The Operations Specifications, Section 2.4 Terrain Clearance contained the following condition, "The terrain clearance minima shall be not less than that required by Regulation 38".

1.17.5 Regulation 38 of the Civil Aviation Regulations (1953) included the following: (reproduced in part only)

"38 Minimum safe heights

(1) Subject to the provisions of these regulations, no aircraft shall be flown over any city, town, or populous area except at such altitude as will enable the aircraft to complete a safe landing should engine failure or other cause necessitate a forced landing.

(2) Without limiting the provisions of subclause (1) hereof, no aircraft shall be flown over —

(a) Any city town or populous area at a lower height above the area than 1000 feet; or

(b) Any other area at a lower height above the area than 500 feet.

[(2A) A height specified in subclause (2) hereof is the height above the highest point of the terrain or any obstacle thereon, within a radius of 2000 feet of a line extending vertically below the aircraft.]

(3) The provisions of subclauses (1) and (2) of this regulation shall not apply if —

(a) Through stress of weather [encountered enroute] or any other unavoidable cause it is essential that a lower altitude be maintained.

(b) The aircraft is engaged [in] operations of a nature which necessitates low flying and approval has been given by the Director either for all flights or for a specific flight [or flights to be made at a lower altitude and the flight is in accordance with such conditions as the Director may prescribe]. ..."

1.17.6 The approved company Operations Manual in Part 1 3.1 Terrain Clearance contained the following requirement:

"The terrain clearance minima shall not be less than that required by Regulation 38 of Civil Aviation Regulations 1953, i.e. 1000 feet above highest point of the terrain or any obstacle thereon over cities, towns or populous areas and 500 feet above highest point of the terrain or any obstacle thereon over any other area."

1.17.7 Part 1 Section 5 of the Operations Manual referring to flight routes, included the following instructions (in part):

"(a) Flight paths within the National Park to conform with standard concession flight path routes as agreed by Civil Aviation, the Westland National Park Board, and existing operators.

(b) Outside the National Park flight paths are to conform with Civil Aviation requirements.

A 500 feet terrain clearance is to be maintained, unless weather conditions prove otherwise a lower altitude can be used to ensure the safety of the flight."

1.17.8 Part 2.1.1 of the Operations Manual, under the heading Safety included the following information:

"Safety can be assured by strict compliance with:

(a) Operating limitations procedures and techniques specified in Operating Manuals

(b) Civil Aviation Regulations and James Patrick Scott's orders.

(c) Intelligent flight planning.

The pilot in command is responsible for the safety of the helicopter in flight, the persons and cargo carried, the safety and conduct of the crew and briefing of passengers."

1.17.9 In addition to scenic flying ZK-HXA was also utilised for deer recovery work, and general charter. The latter operations were normally carried out from the operator's base at Karangarua where the helicopter was hangared overnight. Stocks of Jet A1 drum fuel were kept at the base. ZK-HXA had been refuelled from this stock at the conclusion of flying on the day before the accident, at which time the fuel tank was filled to capacity.

1.17.10 The Hughes 500 Model 369HS Owners Manual for ZK-HXA contained the following information in Section 5.3:

"FUEL SERVICING

In order to prevent contamination due to ice formation at temperature below 40°F (4°C) the fuel used must contain an anti-icing additive conforming to MIL-I-27686 (by volume, minimum concentration 0.035 percent maximum concentration 0.15 percent) ...

(a) Use fuel containing anti-icing additive whenever engine operations are conducted below 40°F (4°C)"

No "anti-icing" additive was included in the fuel uplifted.

1.17.11 On the day of the accident, the pilot had carried out a standard pre-flight inspection, which included draining a sample of fuel into a container. The pilot had noted no defects on the helicopter and the fuel drain check was normal. Prior to departing from Karangarua to position ZK-HXA at Fox Glacier in readiness for scenic flying during the day, the pilot had carried out the routine pre-start and after-start procedure as outlined in the Hughes 500 Model 369HS Owners Manual. The procedure included the following:

"Press to test" check of warning lights for proper condition.

"Engine out" warning system for proper operation.

Check of engine controls — N_2 high beep range 104% or more

N_2 low beep range 100% or less

Activation of low rotor rpm system with rpm less than $98\pm1\%N_2$

All warning lights "OUT" prior to take-off.

The pilot recalled no abnormal indications during these checks. He subsequently flew ZK-HXA to the Alpine Adventures Limited helicopter "pad" at Fox Glacier. The flight, of some five minutes duration was uneventful. ZK-HXA remained on the "pad" until departure on the flight during which the accident occurred.

1.17.12 In conditions of high humidity and relatively low outside air temperature (OAT), it is possible for ice to form in the engine intake of the Allison 250 series with a consequent risk of engine deceleration due to air starvation. To avoid this possibility ZK-HXA was equipped with an anti-icing system which operate by allowing hot air to bleed from the compressor output through a simple valve assembly and thence to be injected in and around the compressor intake. The position of the anti-icing valve could be controlled by the pilot by means of an overhead handle connected to the valve by cable. The Hughes 500 Model 369HS Owner's Manual for ZK-HXA contained the following information in Section 2.6(c):

"Use engine anti-icing when OAT is below 5°C (41°F) and visible moisture conditions prevail".

1.17.13 On the flight during which the accident occurred the pilot of ZK-HXA did not consider that conditions were conducive to engine intake icing and the anti-ice control remained in the "OFF" position. The Chief Pilot of Alpine Adventures Limited had extensive experience of operating ZK-HXA, and other Hughes 369HS helicopters, in the local mountainous terrain. He indicated that in weather conditions similar to those existing at the time of the accident and at a similar operating height, he had not encountered any evidence of engine intake icing.

1.17.14 ENGINE AUTOMATIC REIGNITION SYSTEM (described in part only)

"The engine automatic reignition equipment provides an automatic engine restart capability in the event of flame-out during flight, without using the starter generator ... The 250-C20 engine system receives the power out signal from the N_1/N_R engine power out warning system, whenever N_1 rpm is below 50% to 55% or rotor rpm (N_R) is below approximately 98%.

The following is a general description of the re-ignition sequence. The guard-covered switch circuit breaker on the circuit breaker and switch panel below the instrument panel is used to arm the automatic reignition circuits for automatic restart. The ARMED sector of the press-to-test RE-IGN and ARMED indicator display screen on the same panel provides visual indication that circuits are armed. When the engine power out signal is received, the re-ignition circuits are energised (ignition exciter and igniter) to re-ignite (restart) the engine. Re-ignition system operation is indicated by the RE-IGN light illuminating. After engine restart and an increase in power to above the engine out signal point, the re-ignition system can be reset by pressing the indicator display screen. The ARMED light will remain illuminated and the RE-IGN light will go off. The system operates, providing ignition spark, whenever it is armed and the engine power out signal is supplied."

1.17.15 Section 17 of the Basic Handbook of Maintenance Instructions (HMI) for the Hughes 500 Model 369H series helicopter also included the following information (reproduced in part only):

"The sensing equipment of the N_1/N_R engine power out warning system produces an output for flashing the "ENGINE OUT" warning light and actuation of the audible warning horn, generating a separate audible warning tone for headsets and providing engine restart voltage when low N_R rpm is sensed ..."

1.17.16 A wide-spread survey was carried out in 1977 by the Federal Aviation Administration in the United States to analyse unexplained flame-outs and power losses experienced with the Allison 250 series engines. This survey involved reports from operators of various makes of helicopter in which the Allison 250 series engine was installed and included 13 reports of power loss problems in Hughes 369 helicopters. Six of these instances were classified as "no response to power demand". No distinct patterns were disclosed in the analysis of these reports and the incidents themselves remain unexplained. It was evident however that the problems experienced were related to fuel system performance. Commercial Service Letter (CSL) Number 1080 subsequently produced by the engine manufacturer provided a summary of operational and maintenance guidelines for the Allison Model 250 engine fuel system to assist operators in preventing the possible occurrence of flame-out or power loss and to improve overall fuel system reliability.

2. ANALYSIS

2.1 The pilot had joined Alpine Adventures Limited recently and had taken over the scenic flight operation, on a sole charge basis, less than two weeks before the accident. However, the flight during which the accident occurred followed a pattern flown routinely and the pilot in the brief time in which he had been with the company, had undertaken 22 similar flights over Fox Glacier successfully.

2.2 The operation of Alpine Adventures Limited scenic flights in the area was dependent largely on the local weather conditions. While some flights might be booked well in advance, the majority would be conducted on demand, as long as weather conditions were suitable. The decision regarding the suitability or otherwise, of the weather rested with the pilot in command. It was normal operating practice for a requested flight to be deferred pending an improvement in local weather if such an arrangement was acceptable mutually to the clients and the operating pilot.

2.3 On the day of the accident the poor weather which had persisted for some time obliged the pilot of ZK-HXA to defer any scenic flying until later that day. However conditions improved and by 1700 hours the weather was such that it was reasonable for the flight to be undertaken. While there was cloud over the peaks and ridges bordering the glacier, the glacier itself was clear and there was little precipitation. The precise meteorological conditions in the accident area could not be determined, but the "aftercast" report by the Director of the Meteorological Service suggested conditions at the time which were consistent with those recalled by the pilot and surviving passengers. These conditions included a likely air temperature at 5000 feet of about 8°C (possibly less, close to the ice surface) with light and variable winds and the probability of some "katabatic" flow down the glacier. The gradient wind flow was north to north-east and the wind freshened at a later stage.

2.4 A pilot with considerable helicopter flying experience in the area reported having encountered a region of sudden severe downflow in the lee of Chancellor Ridge during north-easterly weather conditions. The effect was very localised, but required the application of full power and an immediate turn away from the glacier (see Meteorological information Paragraph 1.7.8). The accident to ZK-HXA occurred in a similar location at a similar height. It was possible that a strong but localised smooth downflow may have existed in the area due to the developing north-easterly situation.

2.5 The pilot's recollection of events indicated that as he continued a descending turn to the left at a relatively low height above the glacier, the helicopter yawed to the left. Subsequently, on briefly raising the collective, he was unable to arrest the uncommanded high rate of descent which had developed. The pilot did not, however, note any warning horn, nor did he recall any illuminated warning light on the instrument panel to alert him regarding an "engine out" or "low rotor rpm" condition. The surviving passengers were both seated in the rear compartment of the helicopter. Neither passenger was in a position to have observed any illuminated warning light on the instrument pedestal of the helicopter. Both passengers were wearing headsets connected to the intercom system but neither passenger recalled hearing any warning horn at the time of the accident.

2.6 The relatively high airspeed (some 70 knots) and the sudden yaw clearly recalled by the pilot at the time of the events rendered it unlikely that the helicopter had entered a typical power settling regime.

2.7 The possibility existed however that ZK-HXA may have unexpectedly encountered a region of isolated but severe downflow, the "yaw" being associated with a tailwind gust as the helicopter descended in a turn to the left. In such a circumstance, despite the pilot's action in fully raising the collective at the conclusion of the autorotational descent, ZK-HXA may have struck the glacier surface before engine power could take effect. The application of full collective was likely to have caused a droop in rotor rpm and consequent activation of the auto-relight system.

2.8 The pilot's description of events, including the yaw to the left, raised the alternative possibility that a sudden loss of engine power occurred during the descending turn to the left.

2.9 The extensive damage sustained by the main rotor blades was consistent with torque being transmitted to the rotor head at the time of impact. The extent of power available could not be established with certainty. While the "trapped" torque reading of 34 psi may have been representative of the instruments indication at the time that it received severe impact damage, this indication could not be relied upon as accurate. Damage to the main rotor head itself suggested a relatively high power level. Other indications confirmed rotation of the engine at impact and that it had continued to run for an undetermined period after the helicopter had come to rest. Light bulb analysis showed that the "AUTO-REIGNITION" light was illuminated at impact. Further indications, while not conclusive, suggested that the "ARMED" light in the auto-reignition circuit was probably "ON", and the generator "OUT" light may have been "ON".

2.10 A comprehensive series of engineering tests, which included a complete strip of the engine, disclosed no mechanical failure of the engine, gearbox or transmission components. The possibility could not be eliminated, however, that a sudden deceleration of the engine occurred with a consequent loss of available power in flight as the pilot manoeuvred the helicopter over the glacier.

2.11 It was noted during the investigation that the fuel filter bypass switch was unserviceable, and its internal condition showed that water contamination had been present within the engine fuel system at some period prior to the accident. There was no evidence to conclude, however, that any significant quantity of water was present in the system at the time of the accident and fuel drain checks carried out regularly by the Operator minimised the likelihood of such contamination.

2.12 The possibility of a cumulative build up of air within the fuel system, resulting from the absence of the "O" ring seal in the military type fuel fitting at the firewall, could not be entirely eliminated.

2.13 Although there was no anti-icing additive in the fuel and the pilot did not use the engine anti-icing system it was unlikely that the ambient air temperature was reduced to or below the 4 to 5 degrees Celsius at which engine intake icing and or fuel filter icing may have occurred.

2.15 Operating experience over many years has demonstrated that while satisfactory under all normal operating circumstances, the fuel system of the Allison 250 series engine, installed in the Hughes 369 helicopter, was sensitive to any ingress of air, or the presence of water or other contaminants, and the single fuel nozzle installation was vulnerable to flame-out under such conditions, particularly in combination with manoeuvring of the helicopter.

2.16 In the case of a temporary or transient interruption of the fuel supply resulting in a flame-out, the auto-reignition system, as installed in ZK-HXA, was intended to restore engine power with a minimum of delay and obviate the need for any pilot directed re-start action. However, the time required for automatic re-start, could be expected to vary, dependent on the extent and nature of fuel system contamination, or other flame-out cause.

2.17 The evidence indicated that the engine auto-reignition circuits were activated and the engine was delivering considerable power to the rotor head during the impact sequence. It was not practicable to determine the time at which any auto-reignition took place, nor to determine whether, had sufficient power been re-established at an earlier stage, the accident could have been averted. The rapidity with which events occurred suggested that the pilot, who was committed to an attempted autorotational landing, would have been fully occupied in directing his attention to the latter task.

2.18 The relatively low height above the glacier at which ZK-HXA yawed to the left and developed a high rate of descent, resulted in the pilot carrying out an immediate autorotational landing onto extremely hazardous terrain. Little or no opportunity was available to execute a planned descent to the most suitable area and assess or monitor the helicopter's instrumentation during the descent as would have been the case had the events occurred at a greater height.

2.19 The company Operations Manual and operating Specifications required that a minimum terrain clearance of 500 feet was to be maintained (in accordance with the provisions of Civil Aviation Regulations (1953) Regulations 38). Terrain clearance was defined in Regulation 38 (2A) as the height above the ground within a 2000 foot radius of the aircraft. Therefore in the glacial "U" shaped valley the aircraft would have been flown 1000 feet or higher above the glacier surface during the descent over the Fox Glacier particularly as the aircraft flew a zig-zag path. The proviso that the aircraft could be flown below the minimum height if en-route weather conditions so dictated was not relevant with the existing cloud base.

2.20 It was clear from the circumstances of the accident that the low height at which ZK-HXA was operating at the time reduced the options open to the pilot and decreased the likelihood of a successful forced landing, in the event of an in-flight emergency. This was especially relevant in view of the inhospitable nature of the glacier surface.

2.21 The Operations Specifications required company pilots to observe terrain clearance minima of not less than that required by Regulation 38".

2.22 The relevant portion of Regulation 38 stated that no aircraft should be flown over any area at a lower height above the area than 500 feet above the highest point of the terrain or any obstacle thereon, within a radius of 2000 feet of a line extending vertically below the aircraft but it continued that the minimum height requirement would not apply if "Through stress of weather [encountered enroute] or any other unavoidable cause it is essential that a lower altitude be maintained."

2.23 However the Operations manual misquoted the regulation in two respects. In Part 1 section 3 after specifying a requirement to comply with Regulation 38 it purported to detail the requirements of the Regulation but omitted the section relating to highest point within a radius of 2000 feet and in Part 1 Section 5 included a paragraph which appeared to give pilots a free hand to fly at lower altitudes if the weather did not permit a height of 500 feet to be maintained.

2.24 A company operations manual was intended to be a guide to company pilots on specific interpretations and advice for the conduct of the company's operations. It was approved by the Ministry of Transport and thus should not have required pilots to check it for accuracy particularly when it contained references to the Civil Aviation Regulations.

2.25 Regulation 38 paragraph 3 b stated that the provisions requiring the aircraft to remain at least 500 feet above ground level should not apply if the aircraft was engaged in operations of a nature which necessitated low flying and approval had been given (by the MOT) for flights to be made at a lower altitude and the flight was in accord with the prescribed conditions.

2.26 The omission of parts of Civil Aviation Regulation 38 in the quote which formed part of the approved Company Operations Manual could have been interpreted as approval by the (MOT) for the operation to be carried out at a minimum height of 500 feet above the glacier rather than 500 feet above the highest terrain within a 2000 foot radius of the aircraft.

2.27 The operations manual, in which a specific intepretation of Regulation 38 had been made, and the route had been approved by the Ministry of Transport and the scenic flights over the glacier were likely to have been flown at low altitudes to provide the most dramatic views for tourists by this and other operators. This could then be interpreted as an approval from the Ministry of Transport under paragraph 3 b of Regulation 38 for the flights to be carried out at a lower altitude.

2.28 It should not have been necessary to quote the Regulation in any other document for the benefit of Commercial Pilots as they were required to be familiar with the Regulations and any amendments thereto. If an exemption were intended then the exemption should have been stated unequivocally.

2.29 The Allison 250 series engine with which this aircraft was equipped had a history of unexplained power losses particularly when installed in the Hughes 369 series helicopters.

2.30 The company's operations manual stressed that the safety of passengers was the pilot's responsibility. Therefore the pilot's decision to fly the helicopter over inhospitable terrain at low altitude, even if it could be argued that this was permitted by ambiguities in the operations manual, was inappropriate. The known history of unexplained power losses with the engine installation underlined the need for sufficient height to be maintained at all times for the aircraft to reach a suitable forced landing area in the event of a complete loss of power from the engine.

2.31 The use of single engined helicopters for air transport operations dictates that the pilot always maintain a flight path which will give him the optimum prospect to carry out a forced landing in the event of an engine failure.

3. FINDINGS

3.1 The pilot in command held a valid Commercial Pilot Licence — Helicopter and Type Rating for the Hughes 369HS helicopter.

3.2 The aircraft's Certificate of Airworthiness and Maintenance Release were valid.

3.3 The aircraft's estimated all up mass and centre of gravity were within the specified limits at the time of the accident.

3.4 By switching off the ELT during the night the pilot delayed the location of the accident site by the search and rescue personnel.

3.5 Prior to the start of the descent over the glacier the aircraft and its engine had performed normally.

3.6 During a left turn above the glacier, the helicopter yawed to the left and developed a high rate of descent.

3.7 The engine was delivering power to the helicopter's main rotor when the aircraft collided with the glacier.

3.8 The engine re-ignition system was activated during the descent.

3.9 Another pilot had experienced a wind downflow phenomenon in similar conditions in the area of the accident on a previous occasion.

3.10 Whether the helicopter entered a region of severe downflow or the engine suddenly lost power, could not be established.

3.11 The pilot attempted to carry out an autorotational landing on the surface of the glacier.

3.12 The pilot flew the aircraft some seven to eight hundred feet below the minimum height required by the Civil Aviation Regulation cited in the Company Operations Specifications.

3.13 The relatively low height of the aircraft at the time of the event and the hazardous nature of the glacier surface, reduced the likelihood of a successful emergency landing.

3.14 The company Operations Manual, which was approved by the Ministry of Transport, did not quote the Civil Aviation Regulation 38 in full.

4. SAFETY RECOMMENDATIONS

4.1 It was recommended to the General Manager of The Air Transport Division of the Ministry of Transport that he:

Review the Operations Specifications and the associated Operations Manuals of each helicopter operator licenced to conduct scenic air transport operations to ensure:

The need for the pilots of helicopters to maintain a safe height above the terrain, is stated unequivocally and,

Any minimum height dispensations are reviewed in relation to the requirement for the pilot to have an optimum chance of conducting a successsful forced landing in the event of an engine power loss and,

Any minimum height dispensations are given in specific detail and,

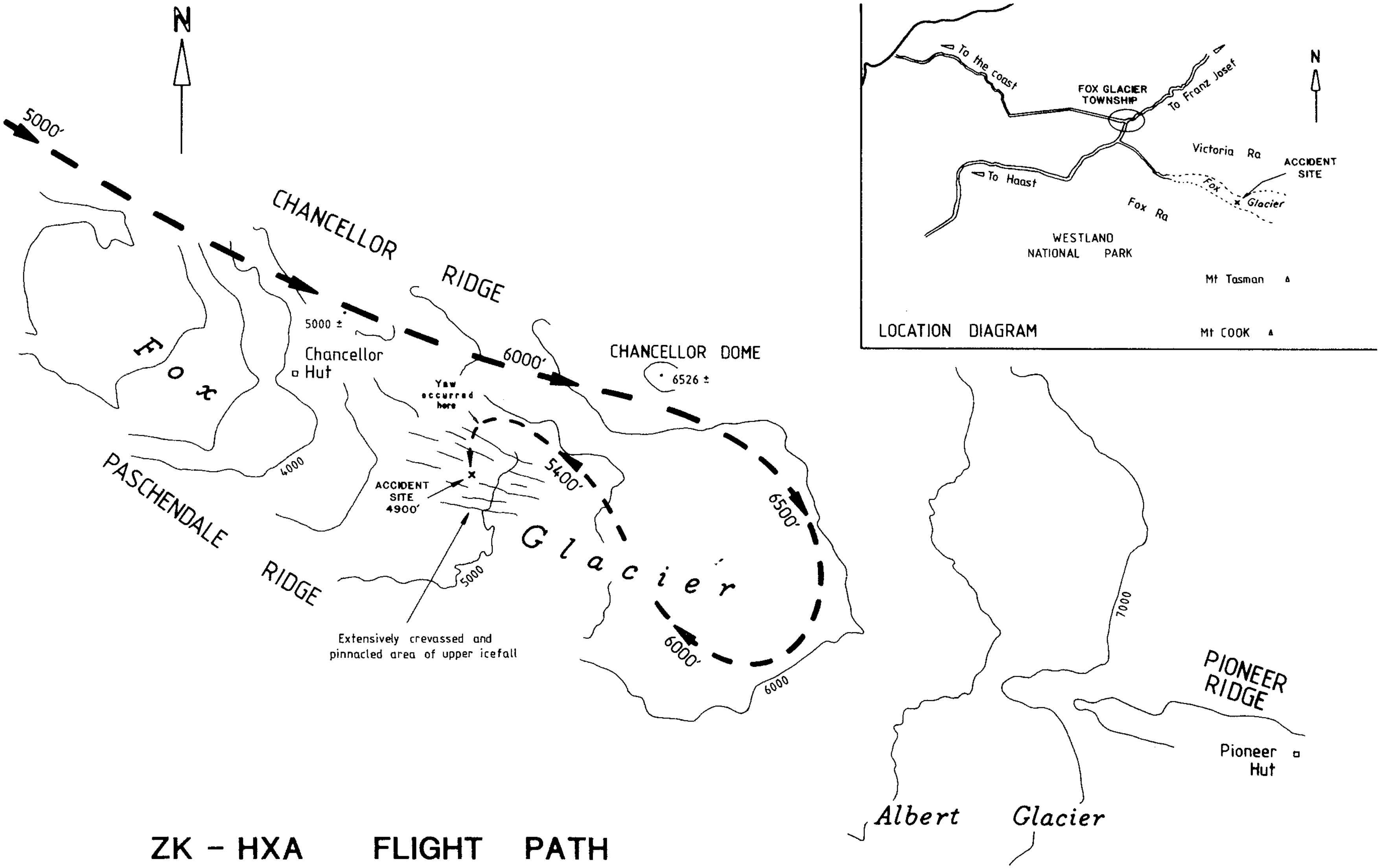
Any reference to dispensations for lower minimum height to be flown in adverse weather be reviewed in relation to the terrain and the overall consideration of passenger safety and,

Any Civil Aviation Regulation is referred to only by its number and if necessary specific paragraph or,

Each quotation of a Civil Aviation Regulation be checked to ensure it is current, correct and complete.

20 March 1991

M.F. DUNPHY
Chief Commissioner



ZK - HXA FLIGHT PATH

Appendix 1