# Fire and Emergency New Zealand Wildfire Investigation Report

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|---|---|
| **District Fire Name:** | Central North Otago |
| **Fire Name:** | Lake Ōhau Fire, Lake Ōhau Road |
| **Fire Date:** | Sunday 4 October 2020 |
| **Time Reported:** | 03:06:59hrs |
| **FENZ ICAD:** | F3088958 |
| **Sponsor:** | Graeme Still, Principal Rural Fire Officer Otago |
| **Version:** 211111 | |

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## 1. Terminology

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| **Aerial Fuels** | All live and dead vegetation located in the forest canopy or above the surface fuels, including tree branches and crowns, snags, moss and high brush. |
| **Aspect** | The direction a slope is facing, i.e. its exposure in relation to the sun. |
| **Available Fuels** | Those fuels which burn during a passage of a flaming front under specific burning and fuel conditions. |
| **Burning Period** | That part of each 24-hour period when fires will spread most rapidly. Typically, this is from about mid-morning to about sundown, or late afternoon. |
| **Combustion** | The rapid oxidation of combustible materials that produces heat energy. |
| **Continuity of Fuels** | The proximity of fuels to each other that governs the fire's capability to sustain itself. This applies to aerial fuels and surface fuels. |
| **Control Line** | An inclusive term for all constructed or natural fire barriers and treated fire edges used to control a fire. |
| **Crown Fire** | A crown fire is a fire that has ascended from the ground into usually forest canopy and is advancing from crown to crown in advance of the fire on the ground |
| **Direct Attack** | A method of suppression that treats the fire as a whole, or all its burning edge, by wetting, cooling, smothering or by chemically quenching it or mechanically separating it from unburned fuel. |
| **Diurnal** | Daily, especially pertaining to cyclic actions which are completed within 24 hours and which recur every 24 hours. |
| **Duff** | A mat of partially decomposed organic matter immediately above the mineral soil, consisting primarily of fallen foliage, herbaceous vegetation and decaying wood (twigs and small limbs). |
| **Elevation** | The height of the terrain above mean sea level, usually expressed in feet. |
| **Extreme Fire Behaviour** | Implies a level of wildfire behaviour characteristics that ordinarily precludes methods of direct control action. One or more of the following is usually involved: high rates of spread; prolific crowning and/or spotting; presence of fire whirls; a strong convection column. Predictability is difficult because such fires often exercise some degree of influence on their environment, behaving erratically and sometimes dangerously. |
| **Fine Fuels** | Fuels that are less than ¼ inch in diameter such as grass, leaves, draped pine needles, fern, tree moss and some kinds of slash which, when dry, ignite readily and are consumed rapidly. (Also known as Flash Fuels). |
| **Fire Pattern Indicators** | As a fire progresses, it will leave visible marks of its passage on combustible and non-combustible objects in its path. These markings are called fire pattern indicators. |

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| **Fire Perimeter** | The entire outer edge or boundary of a fire. |
| **Flanks of a Fire** | The parts of a fire's perimeter that are roughly parallel to the main direction of spread. |
| **Fuel Moisture Content.** | The amount of water in a fuel, expressed as a percentage of the oven dry weight of that fuel |
| **Ground Fire** | All combustible materials lying beneath the ground surface including deep duff, roots, rotten buried logs, peat and other woody fuels. |
| **Head of a Fire** | The most rapidly spreading portion of a fire's perimeter, usually to the leeward or upslope. |
| **Heavy Fuels** | Fuels of large diameter such as snags, logs and large limb wood that ignite and are consumed much more slowly than flash fuels (also known as Coarse Fuels). |
| **Hot Spotting** | Checking the spread of fire at points of more rapid spread, or special threat. It is usually the initial step in prompt control with emphasis on first priorities. |
| **Humidity** | The measure of water vapour content in the air. |
| **Indirect Attack** | A method of suppression in which the control line is mostly located along natural firebreaks, favourable breaks in topography, or at considerable distance from the fire and all intervening fuel is backfired or burned out. The strip to be backfired is wider than in the parallel method and usually allows a choice of the time when burnout or backfiring will be done. |
| **Ladder Fuels** | Fuel that can carry a fire burning in low-growing vegetation to taller vegetation. Examples of ladder fuels include tall grasses, low-lying tree branches and shrubs and trees under the canopy of a large tree.<br>This includes both living and dead fuels. |
| **Long-Range Spotting** | Large glowing firebrands are carried high into the convection column and then fall out downwind beyond the main fire-starting new fires. Such spotting can easily occur ¼ mile or more from the firebrands' source. |
| **Mop Up** | Extinguishing residual fire to make sure it doesn't continue to spread outside of an established containment area.<br>Mop up includes actions like breaking apart smouldering debris, ensuring embers are completely extinguished, or moving burned debris so it cannot roll downhill and ignite previously unburned fuels. |
| **Precipitation** | The collective name for moisture in either liquid or solid form large enough to pull from the atmosphere and reach the earth's surface. |
| **Rate of Spread** | The relative activity of a fire in extending its horizontal dimensions. It is expressed as rate of increase of the total perimeter of the fire; or as rate of forward-spread of the fire front; or as rate of increase in area, depending on the intended use of the information. Usually it's (forward) rate of spread is expressed in chains or acres per hour. |

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| **Relative Humidity** | The ratio of the amount of moisture in the air to the amount which the air could hold at the same temperature and pressure if it were saturated; usually expressed in percent. |
| **Smouldering** | Behaviour of a fire burning without flame and barely spreading. |
| **Spot Fire** | Fire set outside the perimeter of the main fire by flying (or rolling) sparks or embers. |
| **Spotting** | Behaviour of a fire producing sparks or embers that are carried by convection columns and/or the wind and which start new fires beyond the zone of direct ignition by the main fire. |
| **Surface Fire** | A fire that burns surface litter, debris and small vegetation. |
| **Surface Fuels** | All materials lying on, or immediately above, the ground including needles or leaves, duff, grass, small dead wood, downed logs, stumps, large limbs, low brush and reproduction. |
| **Thermal Belt** | An area of a mountainous slope that typically experiences the least variation in diurnal temperatures, has the highest average temperatures, and thus, the lowest average relative humidity. |
| **Topography** | The configuration of the earth's surface, including its relief and the position of its natural and manmade features. |
| **Vertical Arrangement** | The relative heights of fuels above the ground and their vertical continuity, which influences fire reaching various levels or strata (Surface fuels vs Aerial fuels and their relationships to one another). |
| **Wildfire** | 1. An unplanned wildland fire requiring suppression action, or other action according to agency policy, as contrasted with a prescribed fire burning within prepared lines enclosing a designated area, under prescribed conditions.<br>2. A free burning wildfire unaffected by fire suppression measures. |

## 2. Fire Investigators

**Name:** John Foley - Senior Specialist Fire Investigator

**Qualifications:**

NZQA: I hold NZQA unit standards in Fire and Rescue Services Vegetation Firefighting including Fire Investigation qualifications.

NZFS: I joined the New Zealand Fire Service Blenheim Volunteer Fire Brigade in 1987 where I achieved basic and advanced certificates in structural firefighting.

1998: I was appointed to the position of Fire Force Controller of the Waihopai Rural Fire Force a position I held for 19 years, until moving into Blenheim.

1999: I was appointed Deputy Principal Rural Fire Officer (DPRFO) for the Marlborough District Council (MDC).

2005: I was employed full time by the Marlborough District Council as the Emergency Services Officer, and in December 2012 was appointed Emergency Services Manager.

2006: I attended a National Rural Fire Authority (NRFA) Origin & Cause Fire Investigation course in Christchurch.

2011: I attended an Arson Fire Management course in Melbourne Australia.

2012: The Regions of Marlborough and Kaikoura became one enlarged rural fire district under the management of the Marlborough Kaikoura Rural Fire Authority (MKRFA). My day to day role was to manage operations, response, supporting volunteer crews, and training.

2013: I attended an Origin and Cause Fire Investigation refresher course in Melbourne Australia.

2015: I was engaged to assist with reviewing the National Origin and Cause Wildfire investigation course material and delivery of both level 1 & 2 courses.

2015: Appointed to the position of DPRFO Operations for the MKRFA.

2016: Lead tutor for the national level 1 & 2 Origin and Cause Wildfire Investigation courses.

2017: Appointed to the position of Principal Rural Fire Officer for Fire and Emergency NZ for the Marlborough Kaikoura fire District.

2019: Registered Fire Investigator with the AFAC.

2019: Attended Bushfire Arson Investigation Course Victoria Police Academy.

2019: Attended NSW Fire and Rescue Australia, Motor Vehicle fire origin and cause course.

2021: Undertaking International Association of Arson Investigator CFI Trainer.Net modules

**Fires Investigated:**

Some of the more significant fires I investigated have been:

| Date | Location | Event |
|---|---|---|
| 15/12/2003 | Wither Road | Grass fire, escaped burn |
| 24/12/2003 | Redwood Pass Road | Grass fire, train |
| 21/01/2004 | Tetley Brook Road | Grass fire, power line contacting fence |
| 12/12/2004 | Tyntersfield Road | Scrub fire, dumping hot ashes |
| 2005 | Waihopai Valley Road | Scrub fire, power line breaking and coming in contact with scrub |
| 12/10/2006 | Wharanui Beach Road | Scrub fire, Railways Contractor grinding operation |
| 20/02/2007 | Kenningtons Road | Excavator caught fire causing a small forestry fire |
| 24/03/2007 | Taylor Pass Road | Forest fire |
| 1/11/2008 | Douslins Gully Road | Scrub fire broken power wire |
| 29/11/2008 | Pukaka Valley Road | Forest fire |
| 01/12/2008 | Kaiuma Bay | Small forestry fire broken power line |
| 14/01/2009 | Wairau Bar Road | Scrub fire, campfire |
| 18/03/2009 | Waikawa Bay | Scrub fire, fireworks |
| 16/03/2010 | Daltons Bridge | Forest fire |
| Dec 2010 | Hawkesbury Road | Escaped burn |
| 04/02/2012 | Tapawera, Tadmar Valley | Arson (convicted) |
| 06/04/2012 | Tapawera, Tadmar Valley | Arson (convicted) |
| 21/12/2013 | Flagg Bay | Tree through power Line |
| 19/03/2015 | Wither Hills Farm Park | Forest fire |
| 11/02/2016 | Vernon Station | Broken power line |
| 06/06/2016 | Mount Studholme | Waimate undetermined |
| 28/11/2016 | Okuri Bay | Electrical network |
| 21/12/2016 | Wharanui Fire | Undetermined |
| 31/12/2016 | Taylor Pass / Wither Hills | Multiple ignitions |
| 10/01/2016 | Taylor Dam | Incendiary |
| 14/1/2017 | Wither Hills Farm Park | Multiple suspicious fires in and around the Farm Park |
| 2017 | Hanmer SH 7 Vegetation fire | Equipment failure |
| 4/2/2019 | Waihopai Bank House fire | Harvester |
| 24/2/2019 | Moutere Highway fire | Tasman/Nelson Arson (convicted) |
| 30/8/2020 | Pukaki Downs | Gas Cooker |

AUSTRALIAN CAPITAL TERRITORY
EMERGENCY SERVICES AGENCY

# CERTIFICATE OF ATTENDANCE

***John Foley***

attended the

Wildfire Arson Investigation Management Course

on 3 - 8 April 2011

*This course provides managerial level police and fire agency wildfire investigators with the skills to gather and manage intelligence, and plan investigations involving a multi-agency team, based on best practice, to achieve more successful investigations and subsequent prosecutions in Australia.*

Superintendent Richard Woods
ACT Rural Fire Service
Course Coordinator

**An Australian Government Initiative**

CFI trainer.Net, USA, International Association of Arson Investigators, Inc. (IAAI)

Certificates of completion have been issued in:

- Digital Photography and the Fire Investigator (2020)
- Documenting the Event (2020)
- Introduction in Youth Set Fires (2020)
- Motor Vehicles, The engine and the ignition, electrical and fuel systems (2019)
- Motor Vehicles, Transmission, Exhaust, Brake, and Accessory systems (2019)
- Investigate Motor Vehicle fires (2019)
- 3 Day Motor Vehicle Investigation course (October 2019 NSW Australia – Fire Rescue)
- Post Course theory test completed (18/4/2020)
- Electrical Arc Mapping Basics (2020)
- Fire Investigator scene safety (2020)
- Lithium-ion battery fires (2021)
- Electric & Hybrid Vehicle Fires (2021)

I am a member of the Emergency Management Professionalisation Scheme through AFAC.


emps

DEVELOPED AND MAINTAINED BY AFAC

afac

Emergency Management Professionalisation Scheme

By the authority of

THE NATIONAL COUNCIL FOR FIRE AND EMERGENCY SERVICES IN AUSTRALIA AND NEW ZEALAND

John Foley

Having fulfilled the requirements of the Emergency Management Professionalisation Scheme has been awarded the status of

Registered Fire Investigator

Stuart Ellis AM
Chair, Emergency Management Professionalisation Scheme Panel

Dated: 15 July 2019

VICTORIA POLICE

(Registered Training Organisation No. 4578)

*This is to certify that*

**John FOLEY**

*has fulfilled the requirements for:*

**70001827**
**Bushfire Arson Investigator Course**
**Course No. 40**

*Kevin Casey*
*Assistant Commissioner*
*People Development Command*
*Victoria Police*

Dated: 24th May 2019
Certificate No. 1233

**Fire Investigator:** Craig Chambers – Specialist Fire Investigator

My full name is Craig David Chambers.

I am a Specialist Fire Investigator (Structure and Wildfire) for Fire and Emergency New Zealand (Fire and Emergency).

I have served with the New Zealand Fire Service, now Fire and Emergency, since 1992 and have been responsible for determining the origin and cause of fires since 2016.

I have completed and passed the following training courses to achieve the FENZ qualification of Specialist Fire Investigator for structures and wildfire. This qualification is recognised by the Emergency Management Professionalisation Scheme (EMPS) that has been developed and is maintained by the Australasian Fire and Emergency Service Authorities Council and as such I have been appointed as a Registered Fire Investigator for this international body.

- New Zealand Fire Service Level 2 Structure Fire Investigation Course (2016)
- Unit Standard 14556 'Apply Fire Weather Index Data' (2016)
- Unit Standard 4648 'Demonstrate Knowledge of Vegetation Fire Behaviour' (2016)
- Fire and Emergency NZ Level 2 Wildfire Investigation Course (2017)
- Fire and Emergency NZ Inspector Training and Appointment (2017)
- Australasian Association of Fire Investigators Conference (Wildfire) (2018)
- Appointed as a Registered Fire Investigator as part of the Emergency Management Professionalization Scheme
- Canberra Institute of Technology Advanced Diploma Public Safety (Fire Investigation)

I was appointed as a FENZ Inspector under section 166 of the Fire and Emergency New Zealand Act 2017 on 1 July 2017

As a specialist Fire Investigator for FENZ I am required to respond to significant fires in accordance with Operational Instructions with the principal objectives being to co-ordinate, supervise or undertake investigations into major and serious fires, including fatal fires, by determining the point of origin of a fire and from this establishing the cause of the fire. As a result, I have attended and investigated over 120 fires in the build environment.

I have read the Code of Conduct for expert witnesses, Schedule 4 of the High Court Rules 2016 and agree to abide by them.

Significant Fires Investigated (Natural Environment)

- Mt Horrible Arthurs Pass (2017)
- Waimak Bluffs Arthurs Pass (2017)
- Waimarama Rd Hastings (2017)
- Knights Rd Rolleston (2017)
- Rock and Pillar Range Otago (2018)
- McLeod's Rd Burnside Dunedin (2018)
- Pineapple Walking Track, Flagstaff, Dunedin (2019)
- Stanton Fire Burkes Pass (2020)
- Pukaki Downs – 30 August (2020)

*The Authors of this report would like to acknowledge not only the loss of property suffered but also the psychological stress this incident has had on the Lake Ōhau and surrounding Communities.*

*Recovery from such incidents for communities can be complex and is not a one size fits all model, the medium to long term recovery will take many years.*

*A new normal will be forged from this disaster, as the community rebuilds both homes and social structures. This will be a journey for both the community and supporting agencies such as Fire and Emergency where we will need to engage and work closely together.*

*We would also like to acknowledge the support received from community members imparting their local knowledge of the area and in providing information of what they witnessed on the morning of the fire.*

*Their information, along with the comprehensive investigation, has assisted to formulate the final report.*

*We appreciate waiting for the report to be finalised has caused some stress to members of the community. Fire and Emergency has an obligation to ensure we undertake a thorough investigation to determine the most probable cause of the fire. None more so where a report may identify individuals or other parties responsible for the ignition of the fire.*

This report has been written after evaluating all of the evidence identified during the physical scene examination, interviewing witness, Agency support and provided documentation, and the use of Prometheus Modelling to identify an estimated fire growth model that is based on all the most current information at the time.

If new information becomes available, Fire and Emergency New Zealand would consider this to determine whether that would have any impact on what has been identified as the most probable cause.

## 3. Fire Investigation Terms of Reference

| 1. Incident Name | 2. Fire District | |
|---|---|---|
| Lake Ohau<br>CAD Number F308895 | Otago Fire District | **TERMS OF REFERENCE** |

**3. Location and Summary of the Incident**

- A fire was reported as pine trees on fire behind the Ohau village.
- The time of the first call was created at 03:06:59, the first responding appliance from Twizel went K1 at 03:16:33 at arrived on scene at 03:39:25.
- On arrival the first responding brigade were confronted with a very dynamic and fast moving fire through the village and surrounding area.
- The Ohau Village has an Evacuation/Tactical plan in place and activated their siren to alert the village residents of the approaching fire, from there they implemented the plan and managed to self-evacuate.
- The responding brigades were confronted with many structures on fire and carried out defensive work on structures they could save.
- The fuels around the village vary with a combination ranging from heavy to light fuels.
- Many structures were lost during this event.
- A National Incident Management Team has been set up to manage this significant fire which has caused considerable structure loss.
- Because of the nature of this event, level 3 and support investigators have been deployed.

**4. Names and Contact Details of Key Personnel**

Principal Rural Fire Officer (Acting for the Region Manager, Mike Grant)
Graeme Still [redacted]

**5. Agreed Terms of Reference**

1. Before entering the Fire Ground
    - report to the Incident Controller or Principal Rural Fire Officer on all aspects of the fire investigation
    - receive a briefing on the circumstances of the fire and any safety measures that are in place
    - obtain a current Incident Action Plan (IAP)
    - ensure that personal protective clothing is worn at all times while on the fireground

2. Determine the Origin and Cause of the Fire including
    - tracking Fire spread to determine impact on structures
    - taking steps initially to secure the scene
    - thorough documentation and collation of evidence
    - record and photograph burn and char patterns
    - describe the path of fire travel
    - report on the impact of the fire on property and the environment
    - fire behaviour
    - canvass witnesses
    - thoroughly document a description of the general area and point of origin of the fire

- secure and document factual evidence on the cause or most likely cause of the fire

3. Advise the PRFO when:
   - specialists or other experts are required i.e. electrical engineer
   - requesting the police if arson is suspected or other criminal activity is suspected
   - offences under the Fire and Emergency Act 2017 relating to the lighting of fires are determined
   - a formal interview is required with a person
   - Provide a preliminary finding by 05/11/2020

4. Completion:
   - provide a comprehensive written report on all aspects of the investigation as per the Fire and Emergency NZ wildfire template by 5/12/2020..............................(date etc)

**6. Specific Exclusions:**

The terms of reference do not include:

- Talking or discussing the fire origin or cause with the news media or anybody not entitled to such information
- The carrying out of formal interviews or taking of formal statements (not to be confused with canvassing witnesses)

**7. Authorised By:**

| | | | |
|---|---|---|---|
| **Fire District** | **Region Manager Te Kei** | | |
| **Name** | **Delegated by the Region Manager to Graeme Still** | **Agency Contact:** | **Graeme Still** |
| **Position** | **PRFO** | **Contact Ph:** | [redacted] |
| **Signature** | R.R. Still | | |
| **Time/Date** | **04/10/2020** | | |

**8. Accepted by Wildfire Investigator**

| | | | |
|---|---|---|---|
| **Name** | John Foley | **Ph:** | [redacted] |
| **Signature** | John Foley | | |
| **Time/Date** | 10/10/2020. | | |

# 4. Executive Summary

**4/10/2020**

**Incident Report Time:** 03:06:59

**Location:** Lake Ōhau Road Lake Ōhau – Waitaki District

**Area Burnt:** 5043 hectares

**GPS Co-ordinates:**

☒ Specific Origin Area -44.256085, 169.818040 (decimal degrees DD)

☐ Point of Origin

☐ Other (Explain)

**Property Owner:** Area of ignition, Department of Conservation

**Incident Injuries:** Nil

**Type:** Nil **Number:** Nil

## 4.1. Incident Information

**Investigator(s):** John Foley, Craig Chambers and Electrical Engineer Tony Mitton.

**Supporting/Other Agencies:** Police, Department of Conservation, Network Waitaki

**Classification of Fire Cause:** Accidental

**Ignition Source:** 11kV electrical short circuit

**The following ignition sources were considered during this investigation:**

- Electric fences
- Campfires
- Lightning
- Smoking
- Debris burning
- Incendiary devices / accelerants
- Equipment use
- Children
- Miscellaneous
  - Power lines
  - Glass / Bottles refraction / Magnification
  - Firearms use
  - Spontaneous combustion
  - Vehicle exhaust

With the sun setting over Lake Ōhau at approximately 19:50hrs, unbeknown to the residents within the next 24 hours, 48 homes and structures would be destroyed and another six severely damaged by a major wildfire.

Emergency preparedness was well established and tested within the Lake Ōhau community - the community had a plan and like most plans you don't ever expect to use it.

The plan and the response by those staying within the community on the morning of 4 October most certainly avoided injuries and possibly loss of lives.

An area of approximately 5043ha encompassing farmland and private properties both within the Lake Ōhau Village (the Village) and surrounding area, along with Department of Conservation land would eventually be burnt.

The fire's perimeter measured 54km's in length. The fire also destroyed infrastructure such as electrical power lines, fencing, reticulated water systems and other infrastructure required to sustain a community such as the Ōhau Village.

Despite significant rainfall leading up to the fire, there was little change to the degree of curing in the grass fuels. Warm weather and frosts assist with reducing the moisture content of grass fuels.

The combination of dry weather and low moisture content within the fine to medium fuels and a continuous available fuel load, assisted in the ignition and spread of this wind-driven fire.

The availability of forest fuels was a direct result of prolonged periods of dryness which exacerbated the natural drying of the fine fuels and the medium fuel component. The larger diameter fuels were not completely consumed by the fire due to their moisture content compared to the fine to medium fuels.

Strong winds experienced on the night are typical in the spring, although the strength and intensity of them during this wind event were extreme.

On the night of the fire, Lake Ōhau was experiencing some of the strongest winds that local residents have ever recalled with some suggesting wind speeds may have reached 160km/h. On 4 October, the Mid-South Canterbury Portable (MSCP) Remote Automatic Weather Station (RAWS) at Pukaki Downs recorded a wind gust of 127km/h at 03:30hrs.

The MSCP RAWS was relocated south of the Village around midday on 5 October and was recording site data from 13:27hrs. At 15:30hrs a gust of 114.5km/h was recorded. Further, on 6 October strong wind gusts of 163.5km/h at 04:29hrs and 167.2 km/h at 05:44hrs were also recorded.

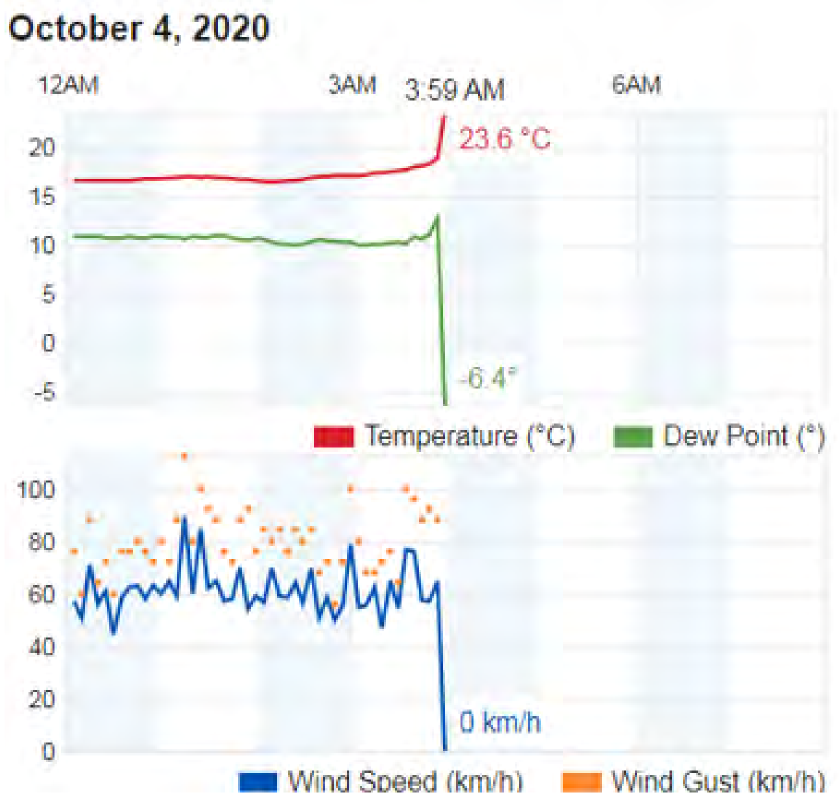
One long-time resident reported that the wind was so strong leading up to the fire that he thought his roof would lift as he lay in bed in those early hours.

The surrounding topography of the high mountains, the lake, surrounding slopes, and several gullies acting as chimneys, all played a part in the way the wind swirled around as it was pushed in a number of variable directions.

Residents have reported experiencing a westerly wind while others have said it was northwest depending on their location.

Without any calibrated RAWS based in the immediate area, we have relied on local residents to provide their interpretation on what the weather was doing at the time.

We have been able to source local home weather station data that provides a picture of how windy it was on the night. The graph below shows recorded variable wind speeds ranging from 60-90km/h gusting 80km/h to over 100km/h. The station stopped recording when it was destroyed by fire.




The weather conditions during the night of 3 October into the morning of 4 October were:

- Wind was variable, a westerly was blowing over the top of the mountain and a northerly was also being blowing down Lake Ōhau.
- Very strong winds and extreme gusts at times.
- We have used weather data taken from the three closest RAWS to Lake Ōhau.

Pukaki Aero, which is located approximately 20 kms to the northeast of Lake Ōhau, where wind speeds were recorded, do not reflect what was occurring on the night of the fire in the Lake Ōhau area.

Data from the MSCR RAWS situated at Pukaki Downs and the Glen Tanner RAWS situated at the top of Lake Pukaki was also interrogated.

Due to its location, the Pukaki Aero indices may not provide a true reflection of what Lake Ōhau fuel moisture codes and weather observations would have been on the night. Therefore, we are unable to predict a true reflection of the fire behaviour. Variation of the indices at Lake Ōhau to Pukaki Aero would be due to topographical influences of the mountain range on general winds and rain. Lake Ōhau may also have some influence on the relative humidity (RH) percentage.

Data from Pukaki Aero, Glenn Tanner and the MSCR RAWS does provide some indication of what the fire behaviour may have looked like at Ōhau.

Although data recorded at these stations may not be totally reflective of the weather occurring at Lake Ōhau, they do provide some insight into the wind speeds being experienced in the district that morning.

The fire caused significant structural loss both in the surrounding countryside and in the Village where the greatest structural loss occurred.

Scion Research was engaged to undertake Prometheus Modelling to estimate the fire's growth and direction of travel in the initial stages of the fire.

## 5. Process of Investigation

On Sunday 4 October two fire investigators were requested to undertake the investigation into the origin and cause of this fire.

A Safe Forward Point (SFP) was established 5.5kms south east of the entrance to the Village on Lake Ōhau Road.

Investigator Craig Chambers was first to arrive at the SFP at 12:35hrs. After receiving a briefing, Craig contacted the first 111 callers (witnesses 1 and 2) and arranged to meet with them. He then travelled to Twizel and completed an informal interview. During this interview the witnesses identified where they first saw the fire. Craig travelled back to the SFP and met with the Incident Controller. Craig requested the area to the west and north of the Village to have restricted access for all personnel in an attempt to preserve evidence for fire investigation purposes.

**Fig. 1.** Lake Ōhau map above.

The Incident Controller identified there had been work completed on the electricity infrastructure earlier in the day by lines staff from Network Waitaki who were still on site at the SFP. A conversation was had with Network Waitaki staff who advised they had made the power lines safe for fire crews and had undertaken some repair work to allow for the lines to be made live when Fire and Emergency allowed.

Repair work was carried out on pole 35693 to a cross-arm that had lost a bolt. Lines feeding the Village were also disconnected at ABS1298, while another set of lines were also dropped at LK4755.

Investigator John Foley arrived at 17:15hrs and received a briefing from Craig Chambers on the information known to date.

While there was still daylight, the investigation started southwest of the Village. Access to this location was down a gravel track at 1957 Lake Ōhau Road. The track took us 2.5kms along a maintenance track heading in a south easterly direction back towards the Village.

While travelling in, there were clear signs of the fire's direction of travel. On the right was a large area of what would have been grazing land burnt out. On the left were what appeared to be blocks of trees, some plantation and wilding pines.

**Fig. 2.** Looking northwest from the south side of the Village. Grass fuels to the left / forest fuels to the right.


**Fig. 3.** The yellow circle in the image above is the location of where the investigation was started.

The red arrow indicates the approximate direction one of the fire runs has come from.


**Fig. 4**. Image above identifies Network Waitaki 11kV lines (solid yellow line) and the private network (dotted yellow lines). The Network Waitaki infrastructure was positioned along the maintenance track used to access the investigation start point.


**Fig 5.** Left identifies the starting point of the scene investigation. While travelling into our starting point there were a large number of macro burn indicators. Macro burn indicators are the larger more obvious indicators that appear on objects such as trees, fences and rocks.

On inspecting the area around our starting point, fire pattern indicators such as protection, freezing, angle of char and white ash were all visible and indicating the fire had come from a west/northwest direction.

Following the Fire patterns, we came across a fallen power pole HF2879/T5723 with a transformer attached (refer to Fig.4). The pole was situated at the end of the private line running behind a plantation of trees. A number of other poles along this line were damaged and the lines themselves were laying on the ground.

Network Waitaki had disconnected this feeder from their network at pole LK4755.

We continued to follow the fire patterns back toward Freehold Creek, however, by the time we reached Freehold Creek it was too dark to carry on the investigation.

The following morning, we organised a time to meet up with the second 111 callers (Witnesses 3 and 4) [redacted]. On their arrival at the SFP we travelled up to their property to view where they had first seen the fire. On arriving at their property, it was obvious how lucky this couple had been not to have lost [redacted]

Witness 4 described the fire as being on the east side of Freehold Creek out on the flats and moving very fast in a southeast direction (refer to Fig.6 following page).

The Witness thought the fire was going to go past their property without burning into it. Over time he could see the fire spreading in their direction.

Witness 4 described the fire as a very long elliptical shape that appeared to be burning between Parsons Creek and Freehold Creek. It had also crossed Freehold Creek out onto the grass flats [redacted]

The distance described measures approximately 1.5km in length. We appreciate this was viewed at night and is not exact but does place the main fire between Parsons and Freehold Creeks.

Witness 4 was then asked if they could draw a location of where they saw the fire at the time using a mapping programme provided by John Foley called Fire Mapper. They then drew the image on the following page to the best of their knowledge (refer to fig .6).

Witness 3 who made the 111 call awoke noticing a very bright glow. Thinking it was the moon they believe they went back to sleep. Waking again, Witness 3 got out of bed to see what was so bright, but the hallway didn't provide a clear view of what was creating the light. Witness 3 woke Witness 4 who walked up the drive and was confronted by a large fire burning on the flats and back towards the hills. Witness 3 made a 111 at 03:12:54hrs.

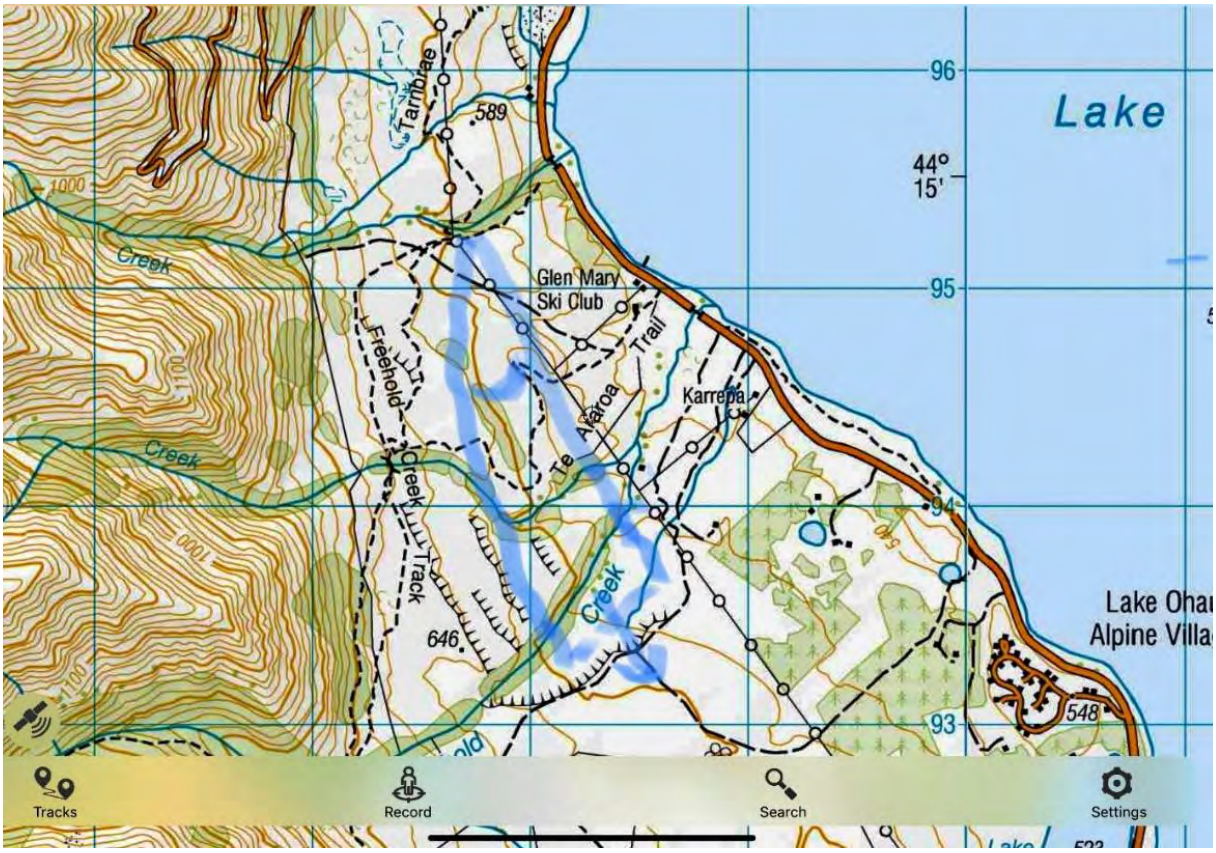


**Fig. 6**. Drawn by Witness 4 on the 5 October at 13:43hrs.

Craig Chambers spoke with the first 111 caller (Witness 1) who confirmed at the time of making the 111 call the fire was west of the Village in the distance.

The first 111 call was made at 03:06hrs. Witness 2, also living at the same address as Witness 1, has provided the image below (fig 7) of where they believe the direction of the fire was at the time of the 111 call. Witness 1 believes the fire was out near the end of the yellow shading, maybe on the end of the furthest trees. This places it in the general area Witness 4 indicated.

**Fig. 7**. Drawn by Witness 2.

An investigation team of two was initially established to undertake the investigation, with a Terms of Reference being provided and signed.

John Foley - Senior Specialist Fire Investigator (Wildfire) – Lead Investigator.

Craig Chambers - Specialist Fire Investigator (Wildfire and Structural).

An additional five investigators were brought in to undertake the structural damage inspections in the Village and surrounding area.

This report focuses on the origin and cause of the fire, not of the structural property losses that occurred within and outside the Village.

**External Scene Examination:**

The area burnt was approximately 5043h. Witness reports indicated the fire was northwest of the Village when reported. We decided that to confirm this we would start behind the Village in a southerly direction.

To access this location, Craig Chambers and John Foley (we) drove down a maintenance access track that took us onto the south side of the Village. While driving down to the area where we started the investigation, a number of Macro Indicators stood out indicating the direction of travel the fire had come from.

On reaching the area southeast of the Village we began to track our way across the landscape back towards the mountain range in the west. By the time we reached Freehold Creek it was dark, so we finished for the day.

On the 5 October, a number of fire investigators representing various insurers had assembled at Twizel and were keen to inspect the area. [redacted]. We agreed to take them into the area where we had started our investigation to allow them to have a look at the topography, fuel loadings and familiarise themselves with the area. By the time we completed this site inspection it was late in the day and we agreed to meet up in the morning to recommence the investigation.

The morning of 6 October proved to be extremely windy and delayed accessing the fire ground due to health and safety concerns with flying iron and loose debris. By the time we were given approval to enter the fire ground it was late morning and we had also been joined by [redacted], Fire Investigator representing [redacted]

Investigators entered the fire ground on the opposite side of Freehold Creek where we had completed our investigation on the evening of 4 October. As Freehold and Sawyer's Creeks were only 160m apart and all burn indicators were still indicating the fire had come from the north, everyone decided it was not necessary to climb down a very steep bank and cross the creek.

Looking down on the burnt area below, there were clear macro indicators identifying the fire had come from a northerly direction above Sawyer's Creek.


**Fig.8.** Left shows the short distance between Sawyer's and Freehold Creeks. This area was not walked through due to access issues.

Burn indicators in the area identified the fire had travelled from a WNW direction above Sawyer's Creek.

The red arrow identifies the direction of travel the head fire took burning across both Sawyer's and Freehold Creeks towards the Village.

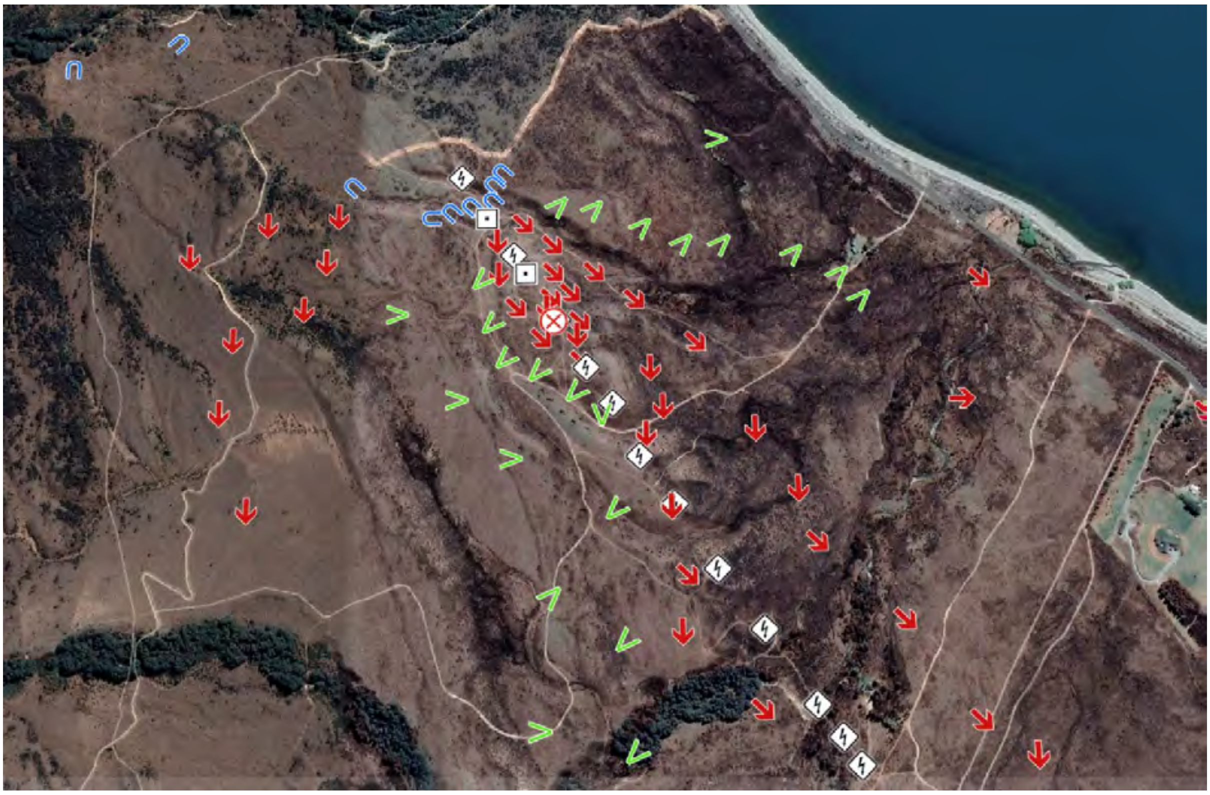


**Fig. 9.** Fire direction Red arrow – head fire, Green V – flanking fire (Standard colour for flanking fire is Yellow, the Fire Mapper Programme has changed these colours to green), Blue U - backing fire, White diamond power pole locations, White square area of interest, and Red circle specific origin area.

Zig zagging our way across the landscape from Sawyer's Creek in a northerly direction, we mapped head fire runs and areas where the fire has transitioned into flanking fire (refer to fig.9).

Fire pattern indicators were leading us back towards a spur which the 11kV power lines ran along.

At 1500hrs we called it a day as we had a meeting to attend at 16:30hrs.

On walking out, we came across a power pole that had no plastic identification number as it had burnt off. Inquiries identified this pole number as 17406 and was replaced at a later date with pole number 40456. The support stay had also burnt off and was lying on the ground. Near the base of the pole was a broken brown insulator, this looked freshly broken. We left the insurance investigators on site returning to Twizel for our meeting.

Later that evening, we met with the rest of our Fire and Emergency investigation team. Murray Milne-Maresca, Specialist Fire Investigator for Fire and Emergency had been tasked with completing an examination of the fire ground to determine if there were any traces of 'Volatile Organic Compounds (VOC's) present.

During this process, Murray encountered a gentleman who was wearing some form of Lines Company overalls and carrying a camera with a large lens.

He identified himself as an electrical engineer and had located what he thought may be the cause of the fire. He told Murray he had photos and showed him the photo on the back of his camera. The photo clearly showed some form of damage to an electrical conductor (refer to fig. 10). Two other Fire and Emergency specialist Investigators were also present at the time, Darren Aitkin and Grant Campbell.

Being made aware of this damage, we decided we should try and locate this before returning to our initial investigation. There had been a discussion with [redacted] for Network Waitaki, who had advised he wanted to have his crews enter the north area replacing lines where damage had been identified.

The Lines company had flown the 11kV network on the 5 October so had probably identified the damage on the line.

Craig Chambers and John Foley (we) drove into the general area identified by Murray Milne-Maresca, Fire and Emergency Specialist Fire Investigator, of where the unidentified electrical engineer had described taking the photos.

On arrival we looked at the fire pattern indicators on the ground identifying head fire runs, flanking and backing fire. An area was identified as low intensity burning where the fire had spread out from this location.

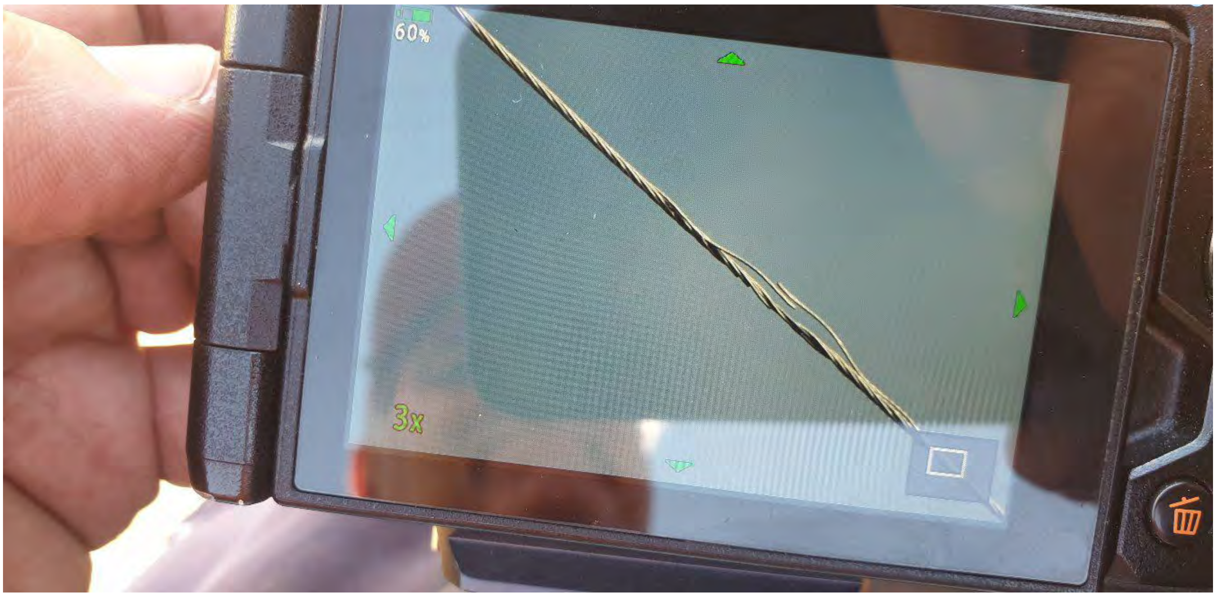



**Fig. 10.** Rear of electrical engineer's camera.

On looking at the lines overhead there was nothing obvious and certainly nothing that looked like the photograph they had been shown.

We climbed a bank to gain a better view of the lines but there was still no obvious damage. Undertaking another inspection of the ground only brought us back to the same area originally identified.

We climbed the bank again to gain a better view of the lines. By this time, the sun had become brighter allowing the lines to stand out better. On the centre conductor it became clear to view the damage that had been identified by the electrical engineer.

On returning to cell phone reception, John Foley phoned Geoff Douch, CEO of Network Waitaki, to advise there had been damage located on the centre conductor. John Foley also advised he was not saying this was the cause of the fire just an area of interest that needed to be looked at.

A discussion was had around lowering the lines for a closer inspection. John Foley sent a follow up email to Geoff Douch the next day with a photograph and GPS reference attached to identify the exact location being discussed.

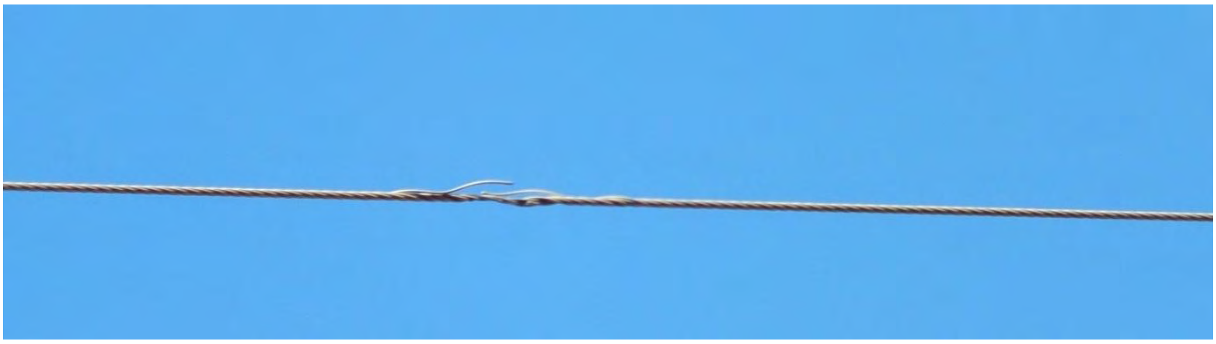


**Fig. 11.** Photo taken by John Foley the morning of the 7 October.


**Fig. 12.** Left is looking NW across the span of interest.

On returning to the fire ground the insurance investigation team continued on their own. We recommensed our investigation from where we had finished the previous day at pole number 17406.


Fig. 12a. Identifies where the investigation recommenced at pole 17406.

Following the fire pattern indicators back in a northerly direction, we came across pole 35693 that appeared to have arc or heat damage on both metal stay arms. Other than the arc marks the pole appeared in good condition.

On checking the pole number 35693, this was the pole identified by Network Waitaki as being the pole they had replaced a bolt that had fallen out.

As previously identified this work was carried out on the morning of the fire.

There were signs of low intensity burning around pole 35693 and the surrounding area. This appeared patchy with areas of grass that hadn't burnt. This burning could have occurred either by an ember landing in the dry grass causing a spot fire from the advancing fire coming from the north, or there had been some form of ignition source available on the pole to have started the fire, spreading out from this location.

As there was nothing obvious we flagged the pole as an area of interest and continued to track the fire indicators north.

On approaching pole 870452 that sits on the highest point, before spanning 175m across to pole 821215 on the far side of the gully, we noticed a number of different directional fire patterns.

There were indicators the fire had travelled from the north and flanked or back burnt up the slope to the top of the highest point where pole 870452 sits. On walking around the pole, we could see fire indicators where the fire has burnt up the slope from the north, gone around either side of the pole and burnt down valley towards Freehold Creek.

The investigation process at this point had identified a number of areas that required further investigation with the 11kV electrical network between Parson's Creek and Freehold Creek (refer to fig 13). The areas to be investigated further are noted below:

- pole 40456 (old pole No. 17406) broken insulator on the ground
- pole 35693 signs of arcing and bolt replacement
- the span and area between poles 870452 and 821215.

The length of the electrical network in question covers approximately 560m over five spans between six power poles.

Span distances are:

| | | | |
|---|---|---|---|
| Pole 870461 | – | Pole 17408 | 71m |
| Pole 17408 | – | Pole 35693 | 96m |
| Pole 35693 | – | Pole 870452 | 126m |
| Pole 870452 | – | Pole 821215 | 175m |
| Pole 870461 | – | Pole 40456 | 99m |

The above measurements were recorded using a handheld Nikon Ranger Finder.

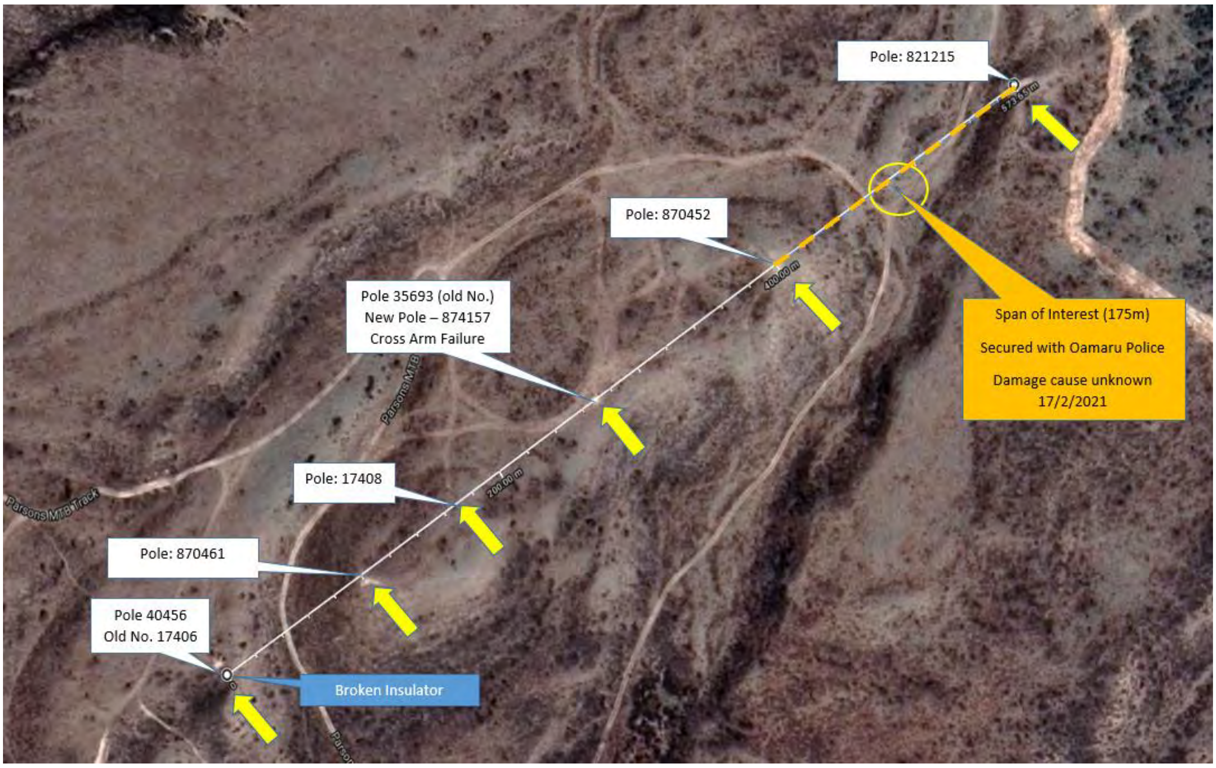



**Fig. 13.** Three areas of interest, span between poles 870452 and 821215, Pole 35693 and surrounding area, and pole 17406.

We continued past the span of interest in a WNW direction to identify what fire pattern indicators were present. This process would indicate the fires direction of travel such as a backing fire, flanking and any additional head fire runs.

We identified indicators that showed head fire travel in a southerly direction down valley towards Quailburn. This was due to a wind change the morning of 4 October. During this wind shift, the fire was pushed upslope on to the mountain faces. There were several head fire runs that could be seen providing a clear picture of the fires path of travel.

**General Origin Area - Internal Scene Examination:**

After looking externally at the head fire runs and identifying areas of transition into flanking fire, we began our internal investigation in an area we identified as the general origin area. This was situated along a spur where the 11kV electrical network ran. This covered approximately 560m in length and encompasses five spans between six power poles.

The first area we investigated was the area we had identified under and around the lines on the span between pole 870452 and 821215. It was agreed to lower the conductors to enable them to be inspected.

During this process there were a number of interested parties present. These included Network Waitaki Staff, and appointed Fire Investigator, Insurance Investigators and their Electrical Engineer, Fire and Emergency Investigators and Electrical Engineer, Department of Conservation staff and Police.

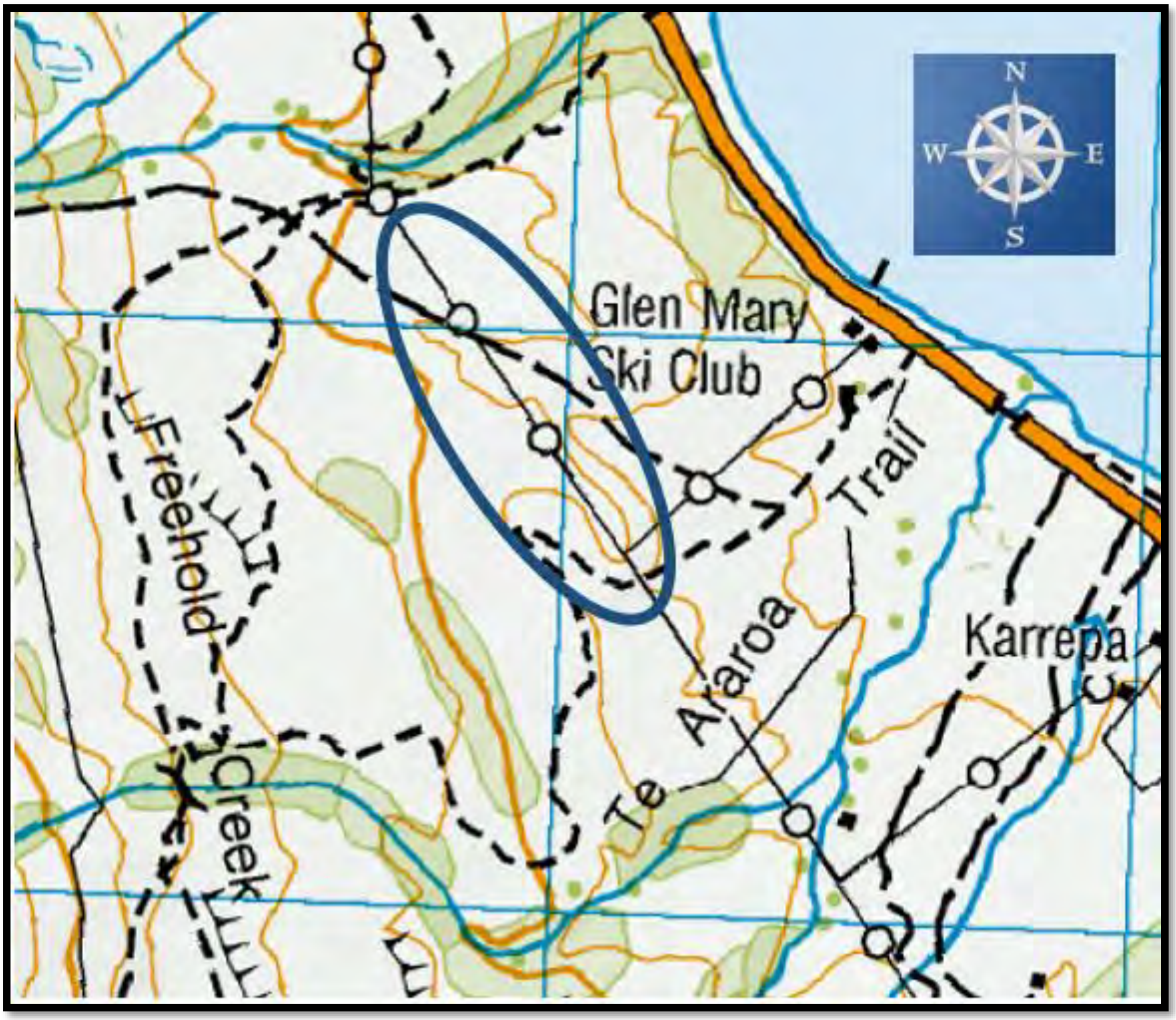



**Fig. 14.** Topographical map identifying General Origin Area (ellipse).

On inspecting the lines, John Foley requested through Geoff Douch CEO of Network Waitaki, that Fire and Emergency would like to secure the areas of damage on the conductors as separate exhibits along with the remaining sections of conductor. To maintain a chain of custody, it was agreed the exhibits would be held and secured by the Oamaru Police. Exhibits were secured in tubes and the coils wound up being handed to John Foley then to Police on scene. A total of approximately 500m of cable was secured (refer to Fig. 15 & 16).

Although there was damage to both the centre YELLOW phase (white tape) and minor damage to the lake side RED phase, none of this could be put down to an electrical arc until further expert opinion was sought. (Note: White tape was used to label the YELLOW phase as there was no yellow tape available.)


**Fig. 15.** Above exhibit cables secured in tubes.


**Fig. 16.** Above longer lengths of coiled conductor.

After investigating this area there were still a number of areas that required information gathering. They were:

- arcing on pole 35693 and the bolt that was replaced
- pole 17406 with the broken insulator on the ground
- what other ignition sources may have been responsible for the fire.

While the investigators remained in the Lake Ōhau area, they spoke with community members that wished to share information of what they knew of the fire on the night. While community input was greatly appreciated, the information forthcoming was mainly related to what occurred well after the fire had been reported.

One of the pieces of information gathered from community members present on the night was the appalling weather, with strong winds and severe wind gusts.

Five witnesses were identified as key to this investigation especially Witnesses 3, 4 and 5 who saw the fire on the flats east of Freehold Creek (refer Appendix 2).


**Fig. 17.** The map above identifies the Department of Conservation Land (PCL) in dark green.

The yellow ellipse is the approximate location of the general origin area.

**Structural Property Loss:**

The wildfire that occurred on the morning of the 4 October was the direct cause of loss of 48 residential structures and varying damage to numerous other buildings.

Due to the extreme fire behaviour, responding fire crews were disadvantaged by the magnitude and dangerous nature of the fire. They did, however, show exceptional operational awareness to rescue stranded residents and save any property that was saveable (refer fig. 18. below).

**Fig. 18.** A crew of firefighters entered this smoke-logged building, accessed the roof void by removing sections of ceiling in the lounge and kitchen and applied water into the roof space. This photo is taken in the roof space.

As identified above, there was varying damage to a variety of structures. This was (in the investigators opinion) primarily due to ember transfer travelling ahead of the main fire front that ignited plantings around buildings, flammable attachments such as decking, and fencing attached to buildings and roof spaces due to landing in guttering. All of which created enough heat transfer via radiation or conduction to ignite the structure.

**Fig. 19**. An example of a building that was destroyed.

**Fig. 20.** An example of a partially damaged building due to ember transfer.

Other structures were ignited by the radiant heat from a neighbouring structure that was already on fire, while some were directly impacted by the fire front as it passed. As identified in other sections of this report, the 'rate of spread' of the fire was exceptional due to weather and fuel conditions. The intensity and spread became more intense upon reaching the heavier fuels to the north and west of the Village and surrounding land parcels. Large areas of the forestry have become a sustained crown fire producing extreme head fire intensity, preheating the air and fuels in front of the head fire with an ember storm raining down hundreds of metres ahead of the advancing fire.

**Fig. 21.** Looking west/northwest toward the fire origin. Note: the ellipse identifies the heavy fuels the fire passed through at the rear of the Village that assisted in creating the extreme fire behaviour.

A team of Fire and Emergency fire investigators with both natural and built environment investigation qualifications, determined that all the damaged structures assessed as part of the wider origin and cause investigation, incurred varying degrees of damage as a direct result of this wildfire.

# 6. Fire Spread and Behaviour

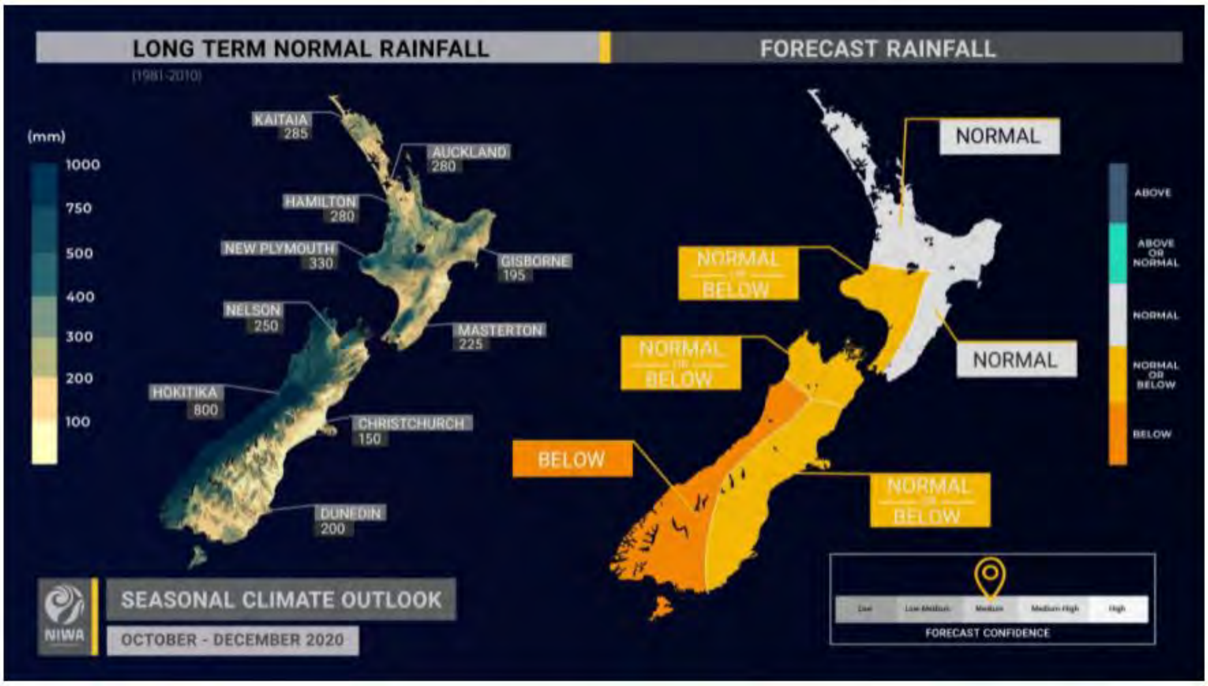
## 6.1. Weather Factors

Although significant rain had fallen in the Ōhau area, there had been little effect on the degree of curing of the grass fuels. Warm weather and frosts assisted in reducing the moisture content in the grass fuels. The combination of dry weather, low moisture content within the fine to medium fuels and a continuous available fuel load assisted in the ignition and spread of this wind-driven fire.

The availability of forest fuels came about through a combination of prolonged periods of dryness which exacerbated the natural drying off of the fine fuels and the medium fuel component. The larger diameter fuels were not completely consumed in the fire due to their moisture content compared to the fine to medium fuels.

The strong winds on the night are typical in the spring, although the strength and intensity of them during this wind event were extreme.

The following information was taken from the NIWA Seasonal climate outlook page for October to December 2020.



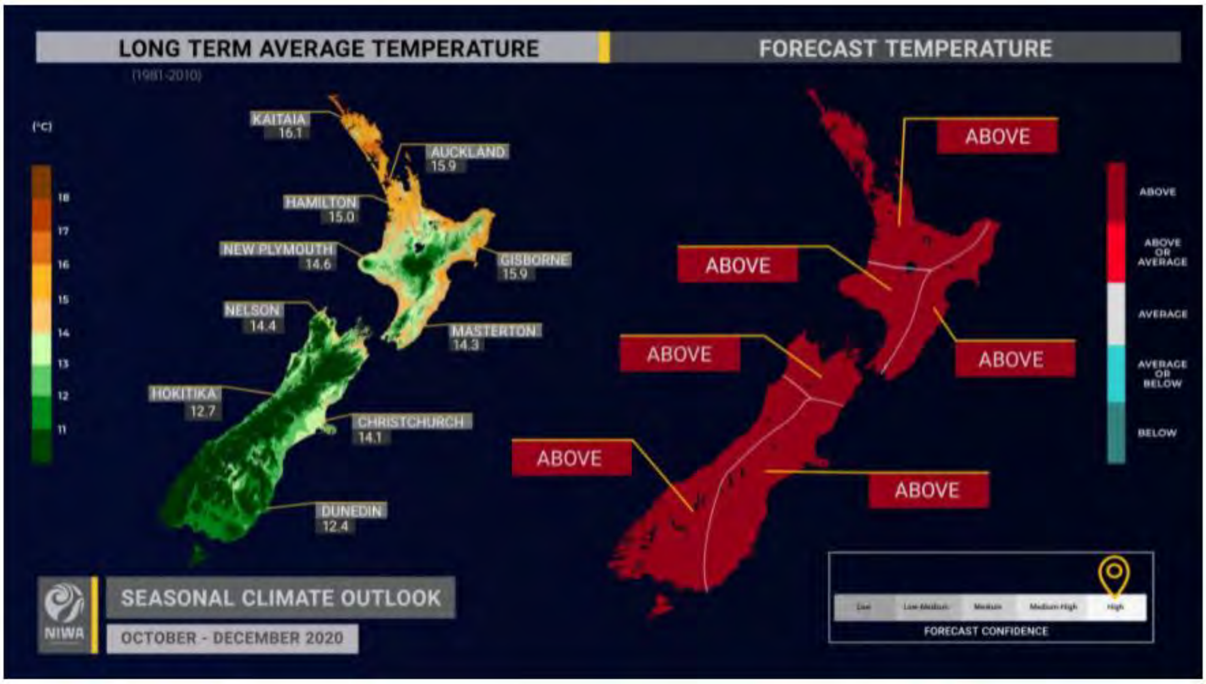

This information identifies the predicted climate outlook for the West Coast, Alps and foothills, inland Otago, and Southland.

Probabilities are assigned in three categories: above average, near average, and below average. The seasonal climate outlook shows:

- temperatures are very likely to be above average (70% chance)
- rainfall totals are most likely to be below normal (50% chance)
- soil moisture levels and river flows are equally likely to be below normal (40% chance) or near normal (35% chance).

Although predicted to be drier than normal, 344.9mm of rain was recorded for the months of July-October at Ōhau Station at the head of the lake. The rain had no apparent impact on the grass curing.

Where the rain did help, was by inceasing the soil moisture level of the duff layer and of the deep compact organic layers preventing the fire from becoming deep-seated.




**Fire Behaviour:**

Fire behaviour is determined by the surrounding conditions, influences and modifying forces of topography, fuel and weather. Unfortunately, there were no calibrated Fire and Emergency RAWS in the Ōhau area. Wind speeds taken from three RAWS provided some idea of what was occurring on the night. As these are some distance away, they may not provide a true reflection of what was happening in the Ōhau area.

With average wind speeds of around 50km/h gusting over 100km/h, the fires Rate of Spread (ROS) once established and running at its equilibrium was extreme.

Contributing factors for the fire to spread were:

- Weather - strong winds making this a wind-driven fire.
- Time of day - fighting any fire is dangerous but fires at night create many more safety issues for responding crews. The crews that responded to this fire put themselves at great risk to save what was savable. These dangers not only came from the fire itself but from flying debris such as roofing iron.
- High available fuel load (AFL) - both in grass, scrub and forest fuels.
- Topography - steep mountains, gullies squeezing the wind and increasing its speed as it blew down across the lake.

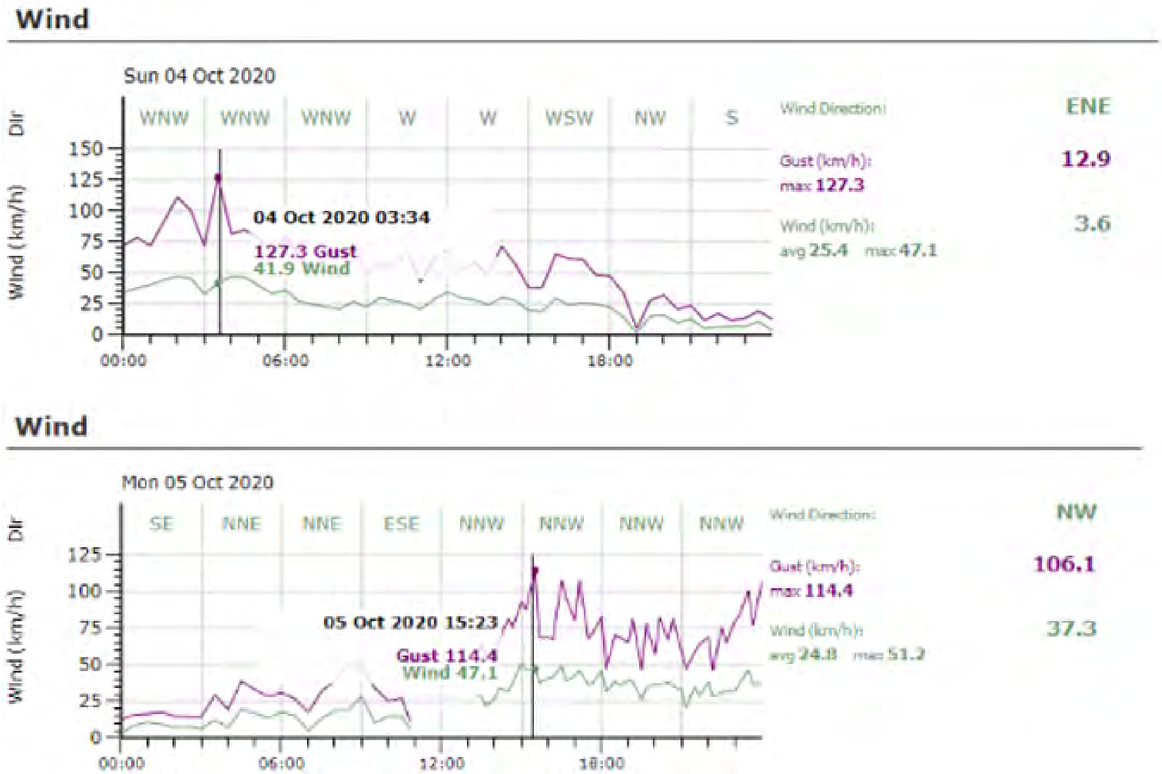



**Fig. 22.** Mid-South Canterbury Portable RAWS wind graphs above.

On the night of the fire the Mid-South Canterbury RAWS was located at Pukaki Downs. From Lake Ōhau the RAWS was approximately 25kms away in a northeast direction.

The RAWS was relocated on 5 October to Ōhau where it was recording data on site by 13:30hrs.


**Fig. 23.** Mid-South Canterbury Portable RAWS wind graphs above.

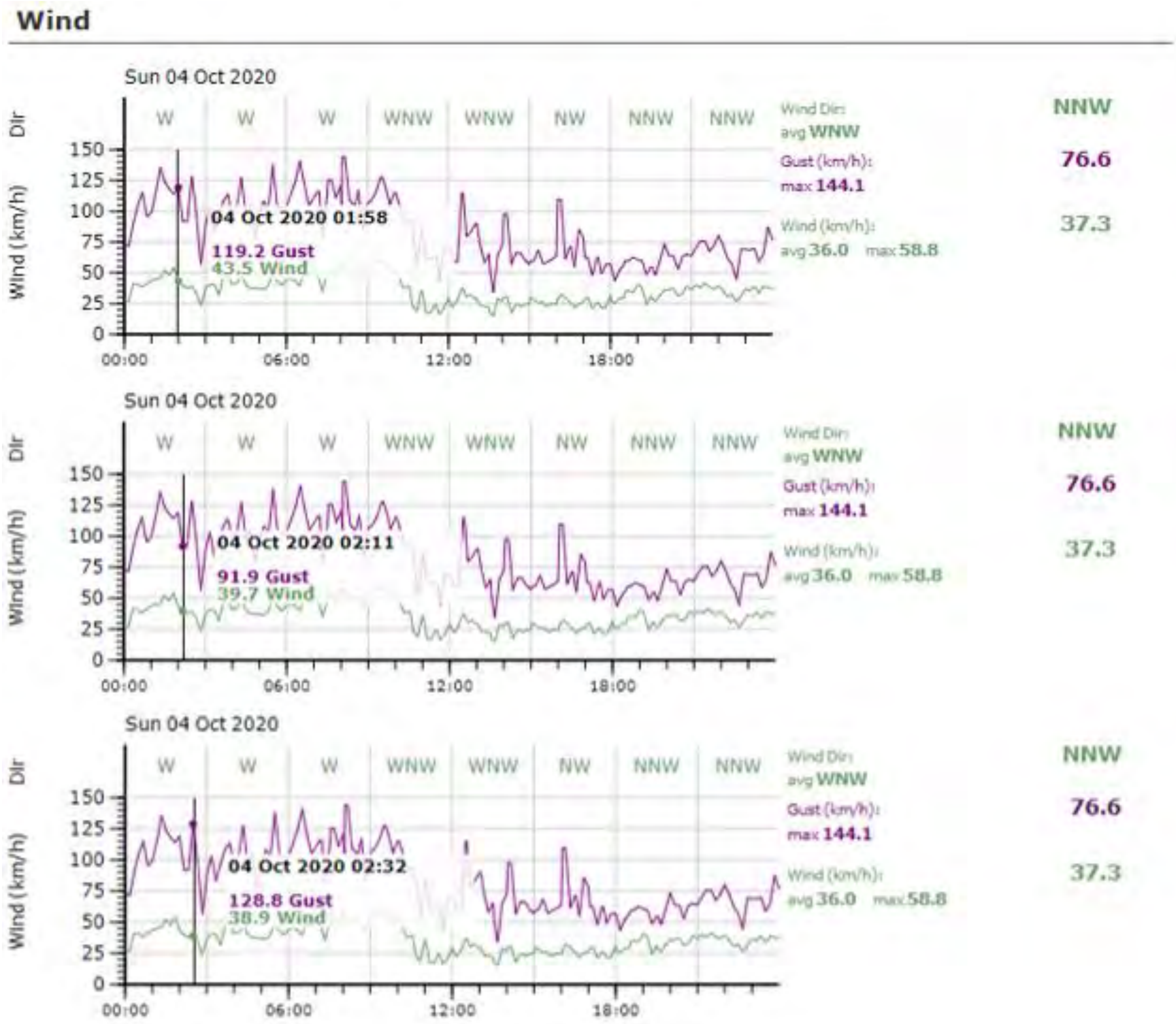



**Fig. 24.** Glentanner RAWS wind graph above.

| Date | Time hrs | Station | Wind Gust km/h | Av Wind Km/h |
|---|---|---|---|---|
| 4/10/2020 | 01:15 | Glentanner | 135.8 | 45.5 |
| | 01:19 | Portable | 91.6 | 44.5 |
| | 01:05 | Pukaki Aero | 85.4 | 41.3 |
| Approximate time of ignition | 02:11 | Glentanner | 91.9 | 39.7 |
| | 02:11 | Portable | 111.3 | 47.1 |
| | 02:10 | Pukaki Aero | 49.3 | 29.5 |
| | 02:32 | Glentanner | 128.8 | 38.9 |
| | 02:31 | Portable | 100.4 | 45.5 |
| | 02:31 | Pukaki Aero | 59 | 34.9 |
| | 03:34 | Glentanner | 96.9 | 31.9 |
| | 03:34 | Portable | 127.3 | 41.9 |
| | 03:33 | Pukaki Aero | 57.1 | 29.9 |
| 5/10/2020 | 15:23 | Glentanner | 101.8 | 58 |
| | 15:23 | Portable | 114.4 | 47 |
| | 15:22 | Pukaki Aero | 46.9 | 33.6 |
| 6/10/2020 | 04:24 | Glentanner | 118.8 | 67 |
| | 04:25 | Portable | 163.5 | 70 |
| | 04:24 | Pukaki Aero | 48.6 | 26.3 |
| | 05:44 | Glentanner | 76.5 | 51.1 |
| | 05:44 | Portable | 167.2 | 91.9 |
| | 05:43 | Pukaki Aero | 50.3 | 22 |

**Fig. 25.** Above, combined wind speed data from Glentanner, Pukaki Downs and the Mid-South Canterbury RAWS. Grey shading identifies wind speeds at the approximate ignition time.

Daily Mode | October | 4 | 2020 | View

**Summary**
**October 4, 2020**

| | High | Low | Average |
|---|---|---|---|
| Temperature | 23.6 °C | 16.4 °C | 17.0 °C |
| Dew Point | 12.7 °C | -18.7 °C | 10.0 °C |
| Humidity | 69 % | 6 % | 64 % |

| | High | Low | Average |
|---|---|---|---|
| Wind Speed | 89.6 km/h | 0.0 km/h | 37.7 km/h |
| Wind Gust | 112.7 km/h | -- | 49.2 km/h |
| Wind Direction | -- | -- | SE |
| Pressure | 1,016.59 hPa | 1,013.88 hPa | -- |

Graph | Table

**October 4, 2020**

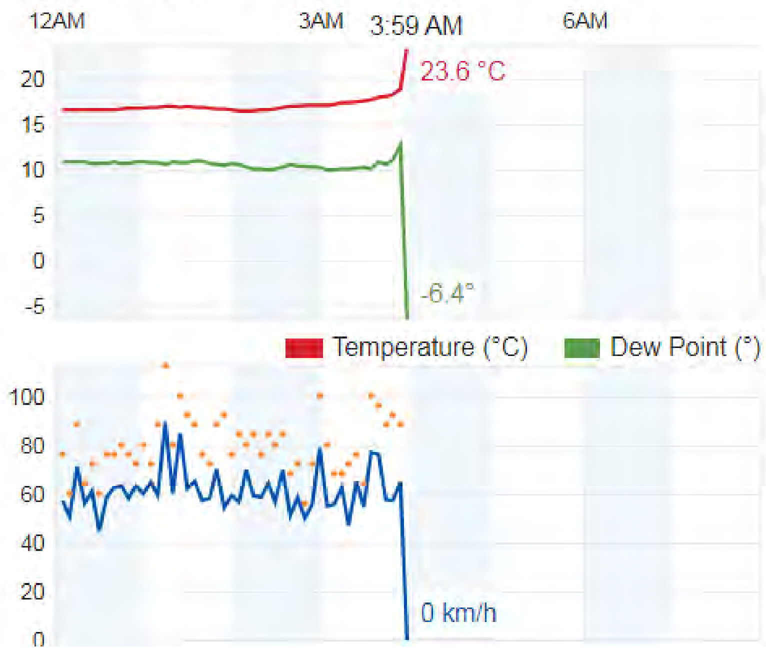



**Fig. 26.** IWAITAKI4 Weather Station data 4 October, stopped recording when overrun by fire.

(Private Weather Station based in Lake Ōhau)

## 6.2.Fuel Factors

Moisture content of fine fuels plays a major part in their availability to not only ignite but to sustain ignition. The fuels ability to increase and decrease its moisture content is influenced by the daily rise and fall of relative humidity (RH).

- Low RH in the mid-day period will lead to a low fine fuel moisture content in mid-afternoon.
- Low RH indicates an increase in the potential for ignition of fine fuels.
- RH affects the flammability of fuels because water vapour is continuously exchanging between the atmosphere and dead fine fuels. Dead fuels give up moisture to a dry atmosphere and absorb moisture from a humid atmosphere.

The available fine fuel loading was continuous in all directions from outside the specific origin area. This was predominately a mix of grass, scrub, and forestry. Forestry fuels involved were the needles and small diameter branches within the wilding pines.

**Fig. 27.** Average grass height outside of the burn area was approximately 300mm, with a ground cover of 80-100%.

Available Fuel loading for the grass/tussock fuels has been estimated at 4-6 t/ha.

Head Fire Intensity (HFI) in grass fuels based on flame lengths of 3m is calculated to be: 2500 – 3000 (kW/m).

Head Fire Intensity (HFI) within forest fuels is calculated to be 38500kW/m. This is based on flame lengths of 10m.

An HFI >2000-4000kW/m is too dangerous for ground crews to attack the head fire.

On site fire behaviour doesn't always follow the modelled fire behaviour, variation can and will occur when available fuel, fuel loadings and topography change.

**Fire Weather Indices:**

The Build Up Index (BUI) recorded at Pukaki Aero was 15. A BUI of >60 is considered as **Very High**.
The BUI is a numerical rating of the total amount of fuel available for combustion that combines the Duff Moisture Code (DMC) and the Drought Code (DC).
The closest Fire and Emergency RAWS to the fire site is Pukaki Aero situated approximately 30kms to the northeast of the general origin area.

Below: Pukaki Aero FWI figures observed 3-5 October 2020 12:00hrs NZST

| Date | Station Name | Forest | Scrub | Grass | FFMC | DMC | DC | ISI | BUI | FWI | TEMP | RH | DIR | WSP | RN24 | GC% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 Oct 2020 | Pukaki Aero | M | E | E | 89.5 | 11 | 59.2 | 25.1 | 15 | 24.3 | 19 | 38 | 279 | 36.4 | 0 | 85 |
| 4 Oct 2020 | Pukaki Aero | M | E | E | 92 | 14.30 | 64.41 | 22.4 | 18.39 | 24.35 | 23.4 | 28 | 250 | 27.4 | 0 | 85 |
| 5 Oct 2020 | Pukaki Aero | M | E | V | 93.1 | 17.9 | 69.6 | 13.7 | 21.8 | 18.6 | 23.6 | 23 | 285 | 14.4 | 0 | 85 |

To provide some context around the FWI figures, temperature, relative humidity, rainfall, wind speed and direction are the only actual figures recorded at 12:00 NZST (13:00hrs daylight savings). The additional figures are modelling projections for fire behaviour later in the day.

The following indices were showing as elevated: Fine Fuel Moisture Code (FFMC), Initial Spread Index (ISI) and Fire Weather Index (FW).

The grass curing percentage set at the Pukaki Aero RAWS is an estimate of the general area not a specific location within.

**Fine Fuel Moisture Code (FFMC) of 89.5:** means that, if an ignition source was applied to the fine fuels they would readily ignite.

**Drought Code (DC) of 59.2:** the Drought Code is a numeric rating of the average moisture content of deep compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and the amount of smouldering in deep duff layers and large logs that would occur during a fire.

- A DC of 128.1 would indicate (in most locations) the fire would not become deep-seated except in those areas which may contain heavier dry fuels.
- A DC of 300 indicates mop up will be difficult and prolonged.

**Initial Spread Index (ISI) 25.1:** an Initial Spread Index (ISI) of 8-15 indicates rapid spread of fire. An ISI of 16+ indicates an extremely fast-moving fire. The ISI is a numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on the rate of spread without the influence of variable quantities of fuel.

An (ISI) in the 30s indicated an extremely fast spreading fire. Observing the fire pattern indicators left behind by the fire as it travelled across the landscape is exactly what has occurred - a high intensity, fast moving, and therefore very difficult fire to control also exacerbated by the many spot fires that occurred from ember transfer among the fine fuels.

**Wind speed: Estimated 45-50-km/h, Gusting over 100km/h**

**Relative humidity (RH) reading of 38:** Relative Humidity is the amount of moisture in the air compared with the amount of moisture the air is capable of holding. When the air is saturated its RH is 100%, extremely dry air can have a reading of zero percent.

Relative humidity %

- Below 60% contributes to fire development
- Below 30% contributes to rapid fire development
- Below 15% contributes to extremely rapid-fire development

**Fire Weather Index (FWI) 24:** this fire would have demonstrated extreme head fire intensity and crews would have had difficulty trying to control the fire. The FWI figures are recorded 12:00 NZST and modelled for fire behaviour mid-afternoon.

Using the FWI figures from Pukaki Aero may not provide a true reflection of the conditions in Lake Ōhau area at the time of the fire. Regardless of their accuracy, the fine fuel on the night was receptive not only to an ignition but was able to sustain ignition spreading out to other available fuels becoming a wind-driven fire.

There are three Fire and Emergency RAWS within 30Kms of the fireground.

1. Glentanner RAWS
2. Pukaki Aero RAWS
3. Mid-South Canterbury


**Fig. 28.** Map above is a screen shot taken on the 2 March 21 for the purposes of identifying the following RAWS locations:

- Mid-South Canterbury RAWS located at Ben Ōhau on the morning of the fire, orange spot
- Pukaki Aero RAWS
- Glentanner RAWS.

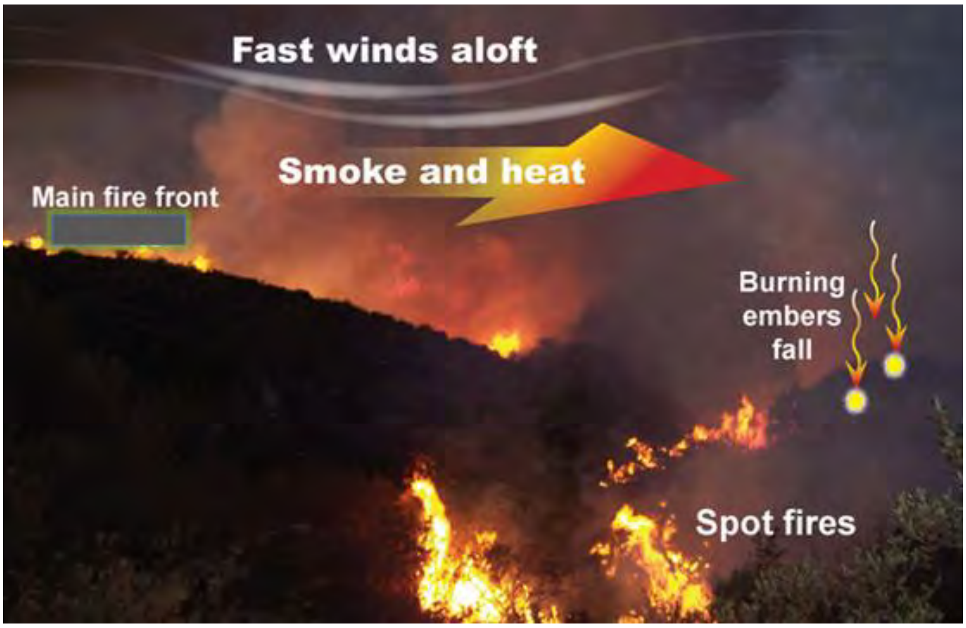
**Fig. 29.** Yellow arrows above indicate where the grass fuels were with the green arrows identifying the heavier scrub fuels. The white arrow identifies the approximate location of the Village.

The fire started in the grass fuels along the spur below the 11kV electrical network. With the wind blowing from the north down the lake and west through the gullies above the mountain range, the fire was pushed in an east-southeast direction towards the Village.

Once it had burnt over Freehold Creek there were two predominate fuel types, grass fuels out to the east southeast and forest fuels to the east northeast. The forest fuels lay in front of the Village.

**Fig. 30.** Looking North West from behind the Village.

Large areas of grass and tussock spread in an east-southeast direction. This enabled the fire to spread quickly in the winds on the night. To the east northeast lay an area of planted trees along with areas of wilding pines. Once the fire burnt into the trees the fire dynamics changed creating a very intense head fire causing the fire to crown, creating an ember storm.




This ember storm was like rain falling in front of the head fire creating spot fires. Some of the hot spots would have grown into larger fires quickly creating new fires ahead of the main fire. As these fires grew, they would have become the new head fire.

**Fig.31** Above demonstrates spot fire travel. **Image credit**: WA Parks and Wildlife Service.

**Fig. 32.** Mixed fuel types, grass, scrub, forest.

**Fig. 33.** General origin area predominately grass fuels.

**Fig. 34.** The above photograph shows the very high fuel loading within the wilding pines.

The driving factor in this environment of elevated wilding pines, was the high volume of available smaller diameter fuels (5mm±) which naturally occur as they die off in the tight confines of the trees growing space. Being so confined, the trees are forced to grow up towards the sun, with the upper section of the tree holding any green canopy. There is at least a 2m strip of vertical dead fuel available to burn from the ground upwards.

This was a fast-moving intense fire in the pines, and in most cases the fire has burnt off the smaller diameter branches leaving the heavier fuel behind. From the air you can see large areas where the fire has produced a crown fire. Fire on the forest floor has not become deep-seated, and only burning the top layer of pine needles as the fire travelled through.

**Fig. 35.** Above, boot mark in the duff layer, fire has only consumed the top layer of pine needles and not become deep-seated as the Drought Code was recorded at 59.2.

**Prometheus Modelling**

To provide a greater understanding of the predicted fire growth and ROS, Fire and Emergency engaged Scion Rural Fire Research (Scion) to undertake modelling of the fire predicted growth and spread.

Scion is a Crown research institute that specialises in research, science and technology development for forestry, wood products, wood derived materials and other biomaterial sectors.

Prometheus is a fire growth simulation modelling system based on the Canadian Forest Fire Danger Rating System (CFFDRS). Prometheus has been upgraded to use New Zealand fuel types and models and is (in the investigators opinion) the best fire behaviour tool relative to the New Zealand environment that is available today.

A thorough investigation has identified a specific location where we believe the fire started. With this location and the known position of the fire at 03:12 when the second 111 call was made, there are two waypoints that were able to be provided. The two waypoints were provided to Scion to provide land based injects into the model. As with all modelling there are variables with fuel types, topography, and wind speed.

The modelling does not initially include spot fires occurring. We believe this is a fair assumption as the initial run was through grass fuels and an area of scrub. It was not until the fire breached Freehold Creek burning across the flats into the forested area and creating a crown that fire spotting occurred.

Several fire runs were modelled using varying weather data from different RAWS; therefore, some fire directions have not burnt in the known direction. The runs that have burnt in the known direction have placed the head fire out on the flats on the east side of Freehold Creek where Witness 4 saw it.

The preferred RAWS data selected best represents the local conditions at Lake Ōhau on the night of the fire. The following is an extract from a report written for Fire and Emergency New Zealand by Scion Research.

**Fire behaviour observations:**

- 03:06:59 - 1st 111 caller, fire in distance west of Village
- 03:12:54 – 2nd 111 caller observes the fire's location on flats south of house
- Fire approximately in township by 0430 (TBC)
- Fire burns to end of township by 0455 (TBC).

**Fire weather:**

- The most representative station based on the Fire and Emergency fire weather station general areas was: Otematata.
- The closest stations (within 30km) were Pukaki Aero, Mid-South Canterbury Portable (based at Pukaki wildfire), Tara Hills, and four public weather stations.
- There are a number of Fire Weather Stations within an 80km radius from the area of ignition (maps 1 and 2 and Table 1 Refer to the full Prometheus report).
- 10m (surface level) and 500m 4km resolution gridded WRF files are available. These are weather research and forecasting models used for atmospheric research and operational forecasting applications.
- Hourly weather observations were imported from the EcoConnect FWSYS (Fire Weather System).
- Sub-hourly weather observations were imported from the Harvest website. This picked up strong wind gusts on site. Stronger than the hourly weather observations.

- **On-site Weather Observations:** Wind direction was observed by fire personnel funneling down Lake Ōhau on arrival, being more north or northwest than westerly recorded from the closest RAWS (Pukaki). The Lake Ōhau area is a narrow gully which would have (most likely) increased the wind speed as it is squeezed as it flowed down and across the lake. Residents in the Lake Ōhau area have described the wind that night as some of the strongest they had experienced, with some living there for 15-20 years plus.

**Summary of the fire growth modelling on the Ōhau wildfire:**

For each of the scenarios presented in the appendix or summarised in the results, the default parameters in Prometheus were calibrated to represent the actual conditions for the fireground on the day of ignition.

**Scenario calibrations:**

Unless otherwise stated, the following parameters and assumptions were applied:

- Actual Hourly Weather (wx) was obtained from the nearest wx stations
- **FFMC hourly calculation**: Van Wagner method was chosen as actual hourly observed weather was present
- **Duration:** 1min time step intervals, focusing specifically within the first two hours for fire investigation purposes
- Fuel type cover: LCDB4.1
- Grass curing default of 60% changed to 90%
- No fuel patches were required or applied
- Geographic features that could obstruct the progress of a fire (rivers, tracks, roads) were imported as vector fuel breaks. Addition of roads, and tracks as barriers to spread (10m, 7m, 5m, 2m, 1m, 0.5m).

**Assumptions:**

- Assumes no spot fires
- No suppression taken
- No diurnal wind trends i.e. up and down slope winds at night and morning. But diurnal FFMC changes are included
- The chosen weather stations and hourly weather streams reflect the onsite conditions
- Wind gusts were not included in the model
- LCDB4.1 cover map represents an accurate reflection of the fuel types present on onsite.

**Limitations:**

There is a note of caution with using any fire growth model, as the models tend to over predict. However, in the case of the Ōhau wildfire, it is likely to under-predict the timing of the fire impacting the town because spotting is currently not factored into the Prometheus software (a future feature). Once the head of the main fire spreads to the mature planted and wilding forests, the speed of the wind is likely to create spot fires 500 m – 1,000 km ahead of the main fire front. The weather stream supplied has a resolution of 1-hour intervals. However, this may not accurately reflect abrupt weather changes sub-hourly (i.e. 10 min observations), specifically sub-hour changes in wind direction and wind speed will not be reflected in the final fire growth. This option of temporal interpolation of weather is currently not available or validated for use in Prometheus.

Steps have been taken to reduce the chance of data, model and user errors that could impact the accuracy of fire growth simulations (Appendix 1). These include:

- Checking multiple weather stations rather than using the nearest station
- Peer review (quality checking) starting FWI codes and data downloaded
- Checking fuel types using aerial imagery match the landcover database used
- Changing the grassland curing value based on site visit and Fire Behaviour Analyst (FBAN) observations

Prometheus has been in use in New Zealand for over 10 years and over time bugs have been identified and rectified.

**Option 1:** Best fit for likely fire direction during early stages (first 1 hour) based on local observations. See Appendix 6 scenario 3 - 3e for an estimation on fire spread and direction for the first 3 hours.

**Prometheus burn parameters:**

| | |
|---|---|
| **Start date:** | 04/10/2020 |
| **Start time:** | 0210 (DST) |
| **Fire propagation display interval:** | 1min |
| **Maximum timestep during acceleration:** | 30 seconds |
| **Duration:** | 1 hour |
| **Terrain effects:** | on |
| **Breaching:** | on |
| **Physical barriers included**: | NZ walking and driving tracks imported, 3m width |

**Fire Weather:**

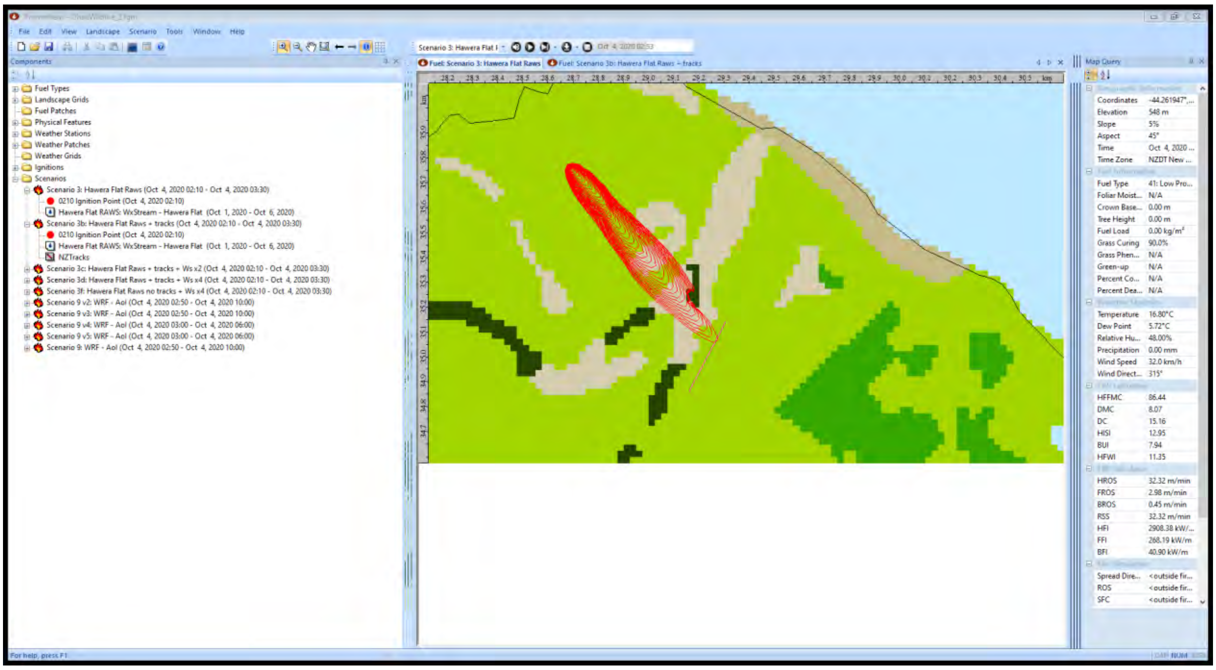
| | |
|---|---|
| **Weather station chosen:** | Hawea Flat RAWs |
| **Landscape Weather Patch:** | none. (approx. 30km winds on site) |
| Yesterday's starting FWI daily codes: | 01/10/2020 (started a few days back to ensure accurate calculation of ffmcs) |
| **FFMC:** | 79 |
| **DMC:** | 3 |
| **DC:** | 4 |
| **Rainfall:** | 0mm |
| **Today's hourly starting code:** | |
| **HFFMC:** | 80.7 RAWS |
| **Hour**: | 300 (DST) |
| **FFMC method of calculation:** | Van Wagner (hourly data was present). |

**Vegetation calibrations:**
Grass curing of 90% applied.

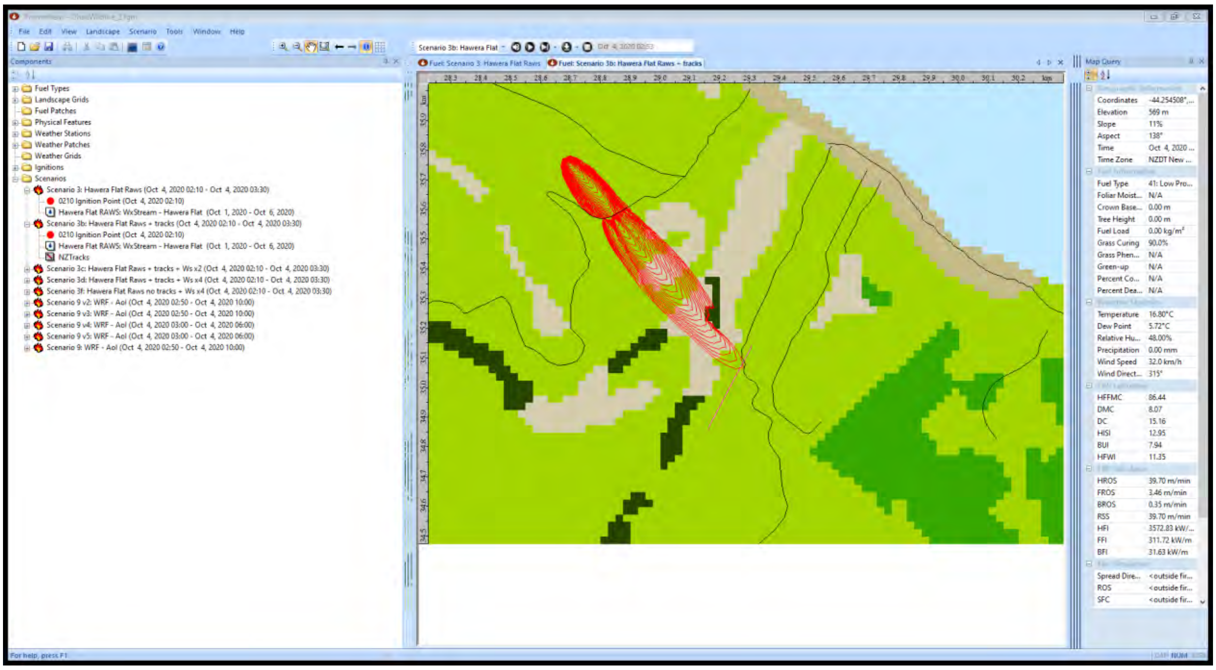
**Results:**

Scenario 3e was chosen as a best fit of the fire direction and timing of the 111-caller noticing the fire's location (pink line on Image 1 and 2). This used Hawea Flat "RAWS" weather.

- Figure 1: no calibrations. Fire arrives at 2nd 111 caller observations at 0253
- Figure 2: 3m wide tracks were included to act as a physical barrier (that could be breached depending on fire intensity). Fire arrives at 111 caller observations at 0253



**Prometheus Figure 1:** FGM scenario 3: Hawea Flat RAWS. No calibrations used. Arrival at the fire's location the 111-caller noticed at approx. 02:53.



**Prometheus Figure 2:** FGM scenario 3b: Hawea Flat RAWS. Calibrations include: 3m wide tracks included. Arrival at the fire's location the 111-caller noticed at approx. 02:54. We provided two waypoints. (Extract ends)

## 6.3. Topographical Factors

Generally, wind speed will progressively increase up slope to the crest of the hill as the wind from the lower elevation is compressed by the wind above it and is forced to speed up. A sharp ridge produces significant turbulence and eddies on the lee side of the hill.

Gorges funnel wind through with increased wind speed. The daily heating and cooling of the slopes can create local wind patterns. Slope steepness affects fire behaviour in that it affects the rate of spread and intensity, i.e. fires generally burn faster up slope than down slope or on level ground.

Slope or wind driven fires have a reduced angle between the flames and unburnt fuels, increasing the rate of radiant and convective preheating of those fuels, this in turn increases the ROS and therefore the level of fire intensity.

- The rate of fire spread on a 10° slope can be up to double that on level ground.
- On a slope of 20° the ROS can be four times faster than a fire on level ground.
- On a slope of 30° the ROS can be six times faster than a fire on level ground.

The Ōhau area has high mountains to the west and steep hills to the east. Both would assist the wind to be funnelled down the lake and out across the surrounding flatter land.

Around the base of the mountains the land is undulated with gullies and terraces which would all influence how the wind behaved as it travelled down the valley. Although the land the fire crossed was predominately flat, being a wind-driven fire it produced the same characteristics as if burning up slope.

## 6.4. Fire and Char Patterns

The fire contained a large number of indicators that allowed us to identify direction of travel, areas of lateral and back burning. Angle of char could clearly be seen on pole type fuels (trees) and in the foliage crowns (scrub fuels).

Several rocks exhibited spalling which is generally associated with the advancing fire and appears on the side of the rock exposed to the heat. Signs of Protection were seen around rocks and fuels shielding the unexposed side of the fuel from heat damage. Staining and sooting on rocks was also visible.

Curling was also visible, this occurs when green leaves curl inward towards the heat source. Leaf freeze was also predominant which is a good indication of the direction of any breeze or wind at the time. This may not always identify the direction of travel of the fire.

No one indicator should be used in isolation to identify the fires direction of travel. Investigators used as many as possible of the available fire pattern indicators to identify the general origin area.

## 6.5. Witness Observations

A number of key witnesses have been identified, who have provided information as to where they saw the fire in the early hours of the morning before it had burnt through the Village.

The information provided has supported what we identified during the investigation process.

## 7. Visual and Physical Evidence

Five key areas of interest were identified.

**Area 1:** Span from Pole 870452 – Pole 821215 - 175m

- Eight (8) exhibits in total were taken from the site and secured with the Oamaru Police (refer to Fig.15/16).
- Exhibits 1-3 were cut from the conductors and stored in plastic conduit.
- Exhibits 4-8 were the remaining longer lengths of conductor which were coiled up and labelled.

**Area 2:** Span from Pole 35693 – Pole 870452 - 126m

- This area included all three conductors which appear to have twisted together when the wooden cross-arm attached to pole 35693 rotated over, causing the lines to arc (refer to Fig 81).
- The conductors showed signs of arcing when they were examined at Network Waitaki's yard in Oamaru. The conductors are being stored by Network Waitaki (refer to Fig's 83-90).

**Area 3:** Pole 35693 and surrounding area

- Pole 35693 has been removed and replaced with a new pole 874157. The removed concrete pole has been stored at the Network Waitaki yard in Oamaru where it has been made available for inspection to everyone that has requested it.
- This pole has what appears to be burn holes within the concrete caused by arcing. The metal stay arms also have what appears to be arc damage and are also stored with the wooden cross-arm at the Network Waitaki yard in Oamaru (Refer to fig's 45-46, 65-79) (Photographs only).

**Area 4:** Span from Pole 35693 – Pole 17408 - 96m

- This area included all three conductors which appear to have come close to twisting together when the wooden cross-arm attached to pole 35693 rotated over to cause these lines to the north to arc.
- The conductors have been inspected by Network Waitaki and left in-situ as they were operationally sound and appeared to have no damage.

**Area 5:** Pole 17406 (new pole number 40456)

- A broken insulator was located on the ground and appeared to be freshly broken (refer to Fig's 41 and 42). (Photographs only)

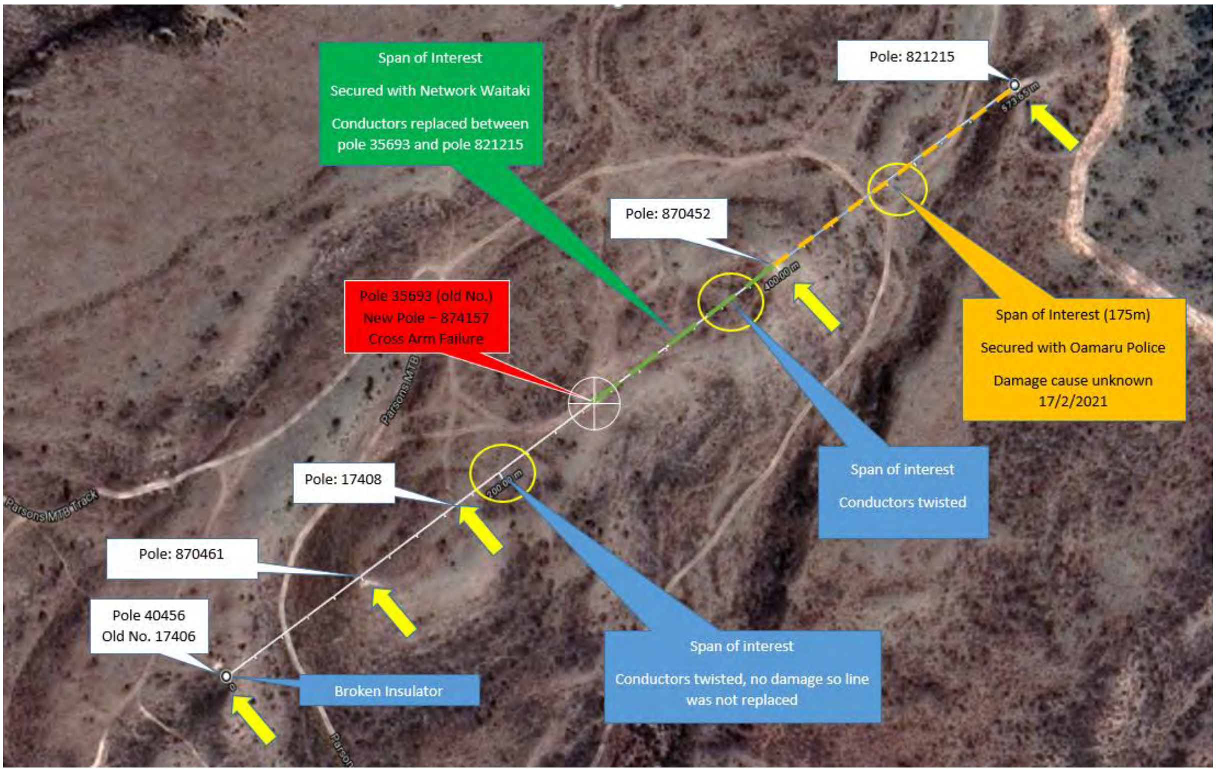



**Fig.36.** General Origin Area

## 8. Elimination of Possible Causes

Before a conclusion of causation could be established a thorough process of elimination was carried out. The following ignition sources were considered during this investigation:

- Electric Fences
- Camp fires
- Lightning
- Smoking
- Debris burning
- Incendiary devices / accelerants
- Equipment use
- Children
- Miscellaneous
  - Power lines
  - Glass / Bottles refraction / Magnification
  - Firearms use
  - Spontaneous combustion
  - Vehicle Exhaust

**Cigarettes:**
Research shows for a cigarette to 'likely' cause a fire the RH requires to be around 0-18%. An RH of 18-22% tends to make ignition marginal and unlikely, an RH of >22% no fire starts.

There are a number of other variables required to assist with an ignition, ash content which impacts on the exterior temperature of the tip, shrinkage of the tobacco during burning, exposure time between fuel and cigarette, fuel bed composition and dead fuel moisture content.

Fine dead fuel moisture (FDFM) of ground fuels is required to be less than 14%.

Steensland, Paul; Cigarettes as a Wildland Fire Cause

Countryman, Clive; **Ignition of Grass Fuels By Cigarettes**; Research Forester (R), USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Riverside, California.

We did not observe any discarded cigarette butts in the area.

**Electric Fences:**
There were no fences observed in the vicinity of the general origin area.

**Firearms/tracer ammunition:**
We did not observe any discarded ammunition cases in the general origin area.

**Incendiary devices / accelerant:**
After a thorough inspection we did not observe any signs of accelerant or any incendiary devices having been used.

**Spontaneous combustion:**
We have ruled out spontaneous combustion as we did not observe any piles of decaying organic matter or “bird’s nests” from any logging operations to support this hypothesis.

**Burning debris:**
Burning debris has been ruled out. We were made aware of a burn pile that had been lit some time before the fire. This pile was inspected and determined not to be the cause of the Lake Ōhau fire.

All fire pattern indicators around this pile indicated the fire had come from the north burning towards and away from this pile.

On inspecting the ash, it was cold and fine grey powder. We believe on the night of the fire this pile was cold and held no residual heat.

Photographs provided of the main fires location on the night when reported by the second caller also eliminate this burn pile.

**Deliberately Lit:**
This cause was investigated with the support of the Oamaru Police and was eliminated.

**Electrical Faults:**
After a thorough investigation there are several issues identified that occurred on the 11kV electrical network between Parsons Creek and Freehold Creek.

The length of the electrical network in question covers approximately 560m and covers five spans between six power poles.

An electrical fault or faults cannot be eliminated. We believe we have identified a credible hypothesis that supports the probable cause of the ignition to grass fuels on 4 October 2020.

We identified five areas of interest, the following three below have been ruled out as competent ignition sources for the following reasons:

**(A1) The span between poles 870452 and 821215.**

- On inspection of the damage on the YELLOW and RED phases, a clash could not be ruled out. We believe this occurred before the fire causing the conductor damage. Over time the stresses of the wind have stretched the cable causing the individual strands to pull apart.
- Although there was significant conductor damage to the YELLOW phase and minor pitting on the RED phase there was no supporting data identifying a YELLOW to RED phase to phase short before the fire was reported.
- Another option for this damage is what is known as Aeolian vibration [ee-oh-lee-uh n]. Aeolian vibration is a high frequency motion that can occur when a smooth, steady crosswind blows on aerial cables.

In a tutorial by “T&D World Managing Aeolian Powerline Vibrations” in October 2017 it describes how the vibrations are produced.

When a non-turbulent “smooth” stream of air passes across a conductor or overhead shield wire (OHSW), vortices (eddies) are formed on the leeward side (back side). These vortices create alternating pressures producing movement at right angles to the direction of the air flow.

T&D World 2017, Managing Aeolian Powerline Vibrations, viewed 25 February 2021, https://www.tdworld.com/resources/white-papers/whitepaper/20970197/managing-aeolian-powerline-vibrations-the-basics.


**Fig. 37.** Damage to Yellow Phase conductor (White tape).

The area below the damaged conductors demonstrated fire pattern indictors of advancing, flanking, and backing fire, representing a fire has started from this location.

In ruling out the damage above as a competent ignition source we considered the lack of supporting SCADA or R690 data, the height of the conductors in the span, the heat required to be sustained by falling molten aluminum globules, and lack of back burning.

The Fire pattern indicators in this area can be explained by the wind shift that occurred the morning of the fire pushing the fire to the south away from the Village.

As the fire had back burnt into the wind from the point/s of origin down into the gully to the lake side up the bank into the prevailing wind, it may have sent embers into the air dropping down onto the area below the span of interest, creating a spot fire which spread from this location.

Once the fire had started under the span of interest it has burnt up and around the point of the spur eventually burning into the backing fire from the initial or secondary fires further down the valley.

**Fig. 38.** Photo taken at 07:30 morning of the fire. Wind is blowing cross the span of interest.

**Fig. 39.** Area of interest below damaged conductors between poles 870452 and 821215
Yellow line is identifying the conductors lowered to the ground.
Yellow circle is the area of interest below the damaged conductors

**(A2) The span between pole 35693 and pole 17408 where electrical conductors have twisted.**

- Network Waitaki advised they had inspected the three conductors on this span reporting no damage. This span is still in place. With no damage being found and the fact that our fire pattern indicators have come from the north we have ruled this span out as a possible ignition source.
- Being the shorter span that twisted when pole 35693 cross-arm rotated, the span may not have been long enough to twist together.
- This area displays more of a head fire burning through than a fire starting under the twisting conductors.

**Fig. 40.** Above shows lines that had have twisted but may not have made contacted each other. These lines are attached to pole 35693 spanning down to pole 17408 in the background.

**(A3) Pole 40456 (old pole number 17406) broken insulator on the ground.**



**Fig. 41. and Fig. 42.** Above, broken insulator located near pole.

Information provided by Network Waitaki shows that the last scheduled inspection for this pole prior to the night of the fire was in April/May 2017. The records show the pole was inspected by a qualified line mechanic, who did not note any defects on the pole. All components were given a nominal remaining life of 25years.

In May 2017, the transformer pole at the Glen Mary ski lodge was replaced as a result of inspections completed following a heavy snowstorm. At the same time, as part of a planned post snowstorm maintenance work pack, the hardware was tightened on the spur line. This would most likely have included pole 17406, although this pole was not specifically noted for any maintenance actions in its records.

Network Waitaki believes the broken insulator to be old and must have been left behind from previous maintenance. Burn indicators in this area demonstrate a head fire burning through the area, rather than a fire starting here, and burning away.

We are confident nothing occurred at this pole to cause the initial fire.

We have been unable to rule out the remaining two areas of interest. The electrical short damaging pole 35693 has been identified as the most competent source of ignition causing the fire on the night.

The span between pole 35693 and pole 870452 to the north where the electrical conductors have twisted are a possible cause of a secondary ignition. A three-phase fault was recorded at 03:23hrs 17 minutes after the fire was first reported. We believe this fault corresponds with the conductors twisting together.

## 9. Fire Classification, Origin and Cause

**The Fire Classification for this incident has be classified as:**

☒ **Accidental Fire Cause Classification**
Accidental fires involve all those for which the proven cause does not involve an intentional human act to ignite or spread fire into an area where the fire should not be. (NFPA921, 2014 page 204 Chapter 20)

☐ **Natural Fire Cause Classification**
Natural fire causes involve fires caused without direct human intervention or action, such as fires resulting from lightning, earthquake, wind, and flood.

☐ **Incendiary Fire Cause Classification**
An incendiary fire is a fire that is deliberately set with the intent to cause a fire to occur in an area where the fire should not be.

☐ **Undetermined Fire Cause Classification**
Whenever the cause cannot be proven to an acceptable level of certainty, the proper classification is undetermined.

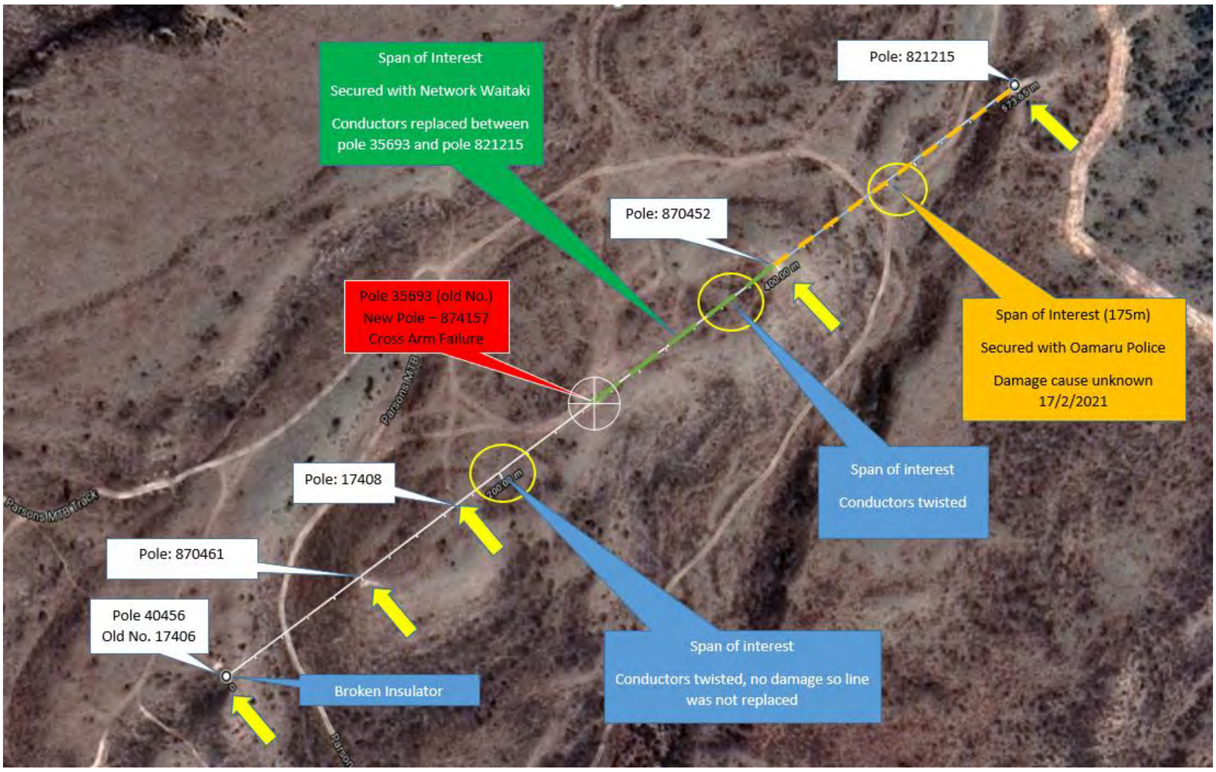



**Fig. 43.** Above – White circle identifies our primary specific origin area around Pole 35693 (874157).

**Establishing the Origin and Cause**

We have identified the origin and cause of this fire as pole 35693 where an electrical phase to earth fault has occurred at or around 02:10hrs. Location of pole is -144.256074, 169.818028.

A thorough investigation was undertaken to identify pole 35693 as the specific origin area and the faults that occurred at this pole being the most probable ignition source.

Our investigation began south west of the Village and from there we tracked our way across the landscape following the fire pattern indicators until we came across pole 35693 some 2.5kms away.

**Fig. 44.** Yellow arrow is the approximate area we initiated our investigation, following fire pattern indicators until we reached pole 35693 (red arrow)

A single arc mark on each of the metal stay arms attracted our attention at this location. There were also indications of low intensity burning to the fine fuels on the ground below the pole.

The stay arms were secured to the centre of the pole with a double nut and single bolt and splayed out to opposite sides of the wooden cross-arm where they were secured in place with a double nut and single bolt (refer to fig. 47).

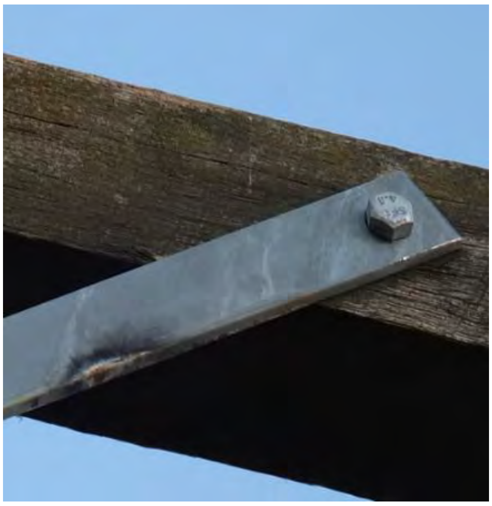


**Fig. 45.** Photograph (DSCF9361) above left identifies an arc mark to the lakeside metal stay arm on the upper section close to where it is secured to the wooden cross-arm with a double nut.

**Fig. 46.** Photograph (DSCF9365) above right identifies an arc mark on the hillside metal stay arm on the lower section close to where it is secured to the centre of the pole with a double nut.

**Fig. 47.** Upper section of pole 35693 when it was located on 7 October.

Other than what appeared to be arc marks on the metal stay arms, the rest of the pole looked in good operational condition. There also appeared to be damage to the concrete pole below where the two metal stay arms are secured to the centre of the pole (yellow arrow). This appeared to be old damage.

We had been advised by Network Waitaki they had undertaken repairs to a pole the day of the fire before fire investigators arrived on scene. Network Waitaki advised they had replaced a bolt that had fallen out of a pole. On checking the pole number provided, it corresponded to pole 35693.

Fire patterns around pole 35693 were patchy with areas of unburnt grass. This may have been caused by spotting from an advancing fire coming from the north or it may indicate the fire has started in the specific area around the pole from an ignition in this area.

The head fire hadn't burnt through this area as we would have expected it to have consumed all of the available fine fuels. As there was nothing else obvious at the time of our initial investigation, we could do no more at this pole.

One hundred and twenty-six (126) metres north of pole 35693 is pole 870452 which sits on the highest point of the spur. From this location the conductors span 175m over a small gully to pole 821215 to the north.

Damage was located on the YELLOW phase between poles 870452 and 821215. This damage is still of interest but has now been ruled out as a competent ignition source.

Interest remained with pole 35693 and what had caused the arcing on the metal cross-arms.

On revisiting the fire site on 16 November 2020, it was noted that pole 35693 had been replaced with pole 874157.

This raised several questions as to why the pole would have been replaced.

Basing ourselves at the Twizel Fire Station, we worked our way through the photographs we had taken. Looking at the photos of pole 35693 we identified there was more damage than just the arc marks on the metal stay arms.

Although not obvious to us on first viewing the photographs, John Foley identified there was a hole in the concrete below and to the right of where the two metal stay arms were secured to the centre of the pole. There also appeared to be a scrape mark above and below the hole on the surface of the concrete.

It was also identified through photograph DSCF9369, that there was some form of damage to the centre bolt and washer holding the two metal stay arms to the pole, along with some form of scrape damage to the edge of the metal stay arm on the opposite side of the pole.

**Fig. 48.** Photograph (DSCF9365) above shows the lower arc mark on the hillside metal stay arm, a hole below the stay arm and what appears to be a scrape mark on the right-hand side of the pole below the metal stay arm.

We had now identified a number of physical damage marks on this pole that are noted below:

- Arc mark to the upper lakeside metal stay arm
- Arc mark to the lower hillside metal stay arm
- A burn hole on the north side of the pole, hillside
- A burn hole next to the centre bolt securing the metal stay arms to the pole, south side
- Damage to the centre bolt and washer securing the metal stay arms to the pole
- Damage along the edge to the Hillside metal stay arm
- A small scrape mark on the wooden cross-arm
- What appears to be damage on the lakeside conductor next to the insulator.

**Fig. 49**. Photograph (DSCF9369) above identifies location of damage to centre bolt, washer, and damage to edge of metal stay arm.

On closer inspection of this pole the damage appears to be caused by arcing that has burnt a hole into the concrete 25mm deep.

**Fig. 50.** Photograph (DSCF9362) to the left has been zoomed in and cropped, the strands appear to have a rough edge to them.

**Fig. 51.** Photograph above is a zoomed-out image of photograph (DSCF9362) the area within the yellow ellipse shows a rough edge that appears to be damaged.

At this point we were still unaware of what, if anything had occurred at pole 35693 except for a repair carried out to the cross-arm. The repair and the fact the pole had been replaced heightened our interest in this pole.

While at the Twizel Fire Station, we worked on a number of hypotheses as to what could have occurred at this pole.

Craig Chambers suggested maybe a catastrophic failure may have occurred creating the damage identified.

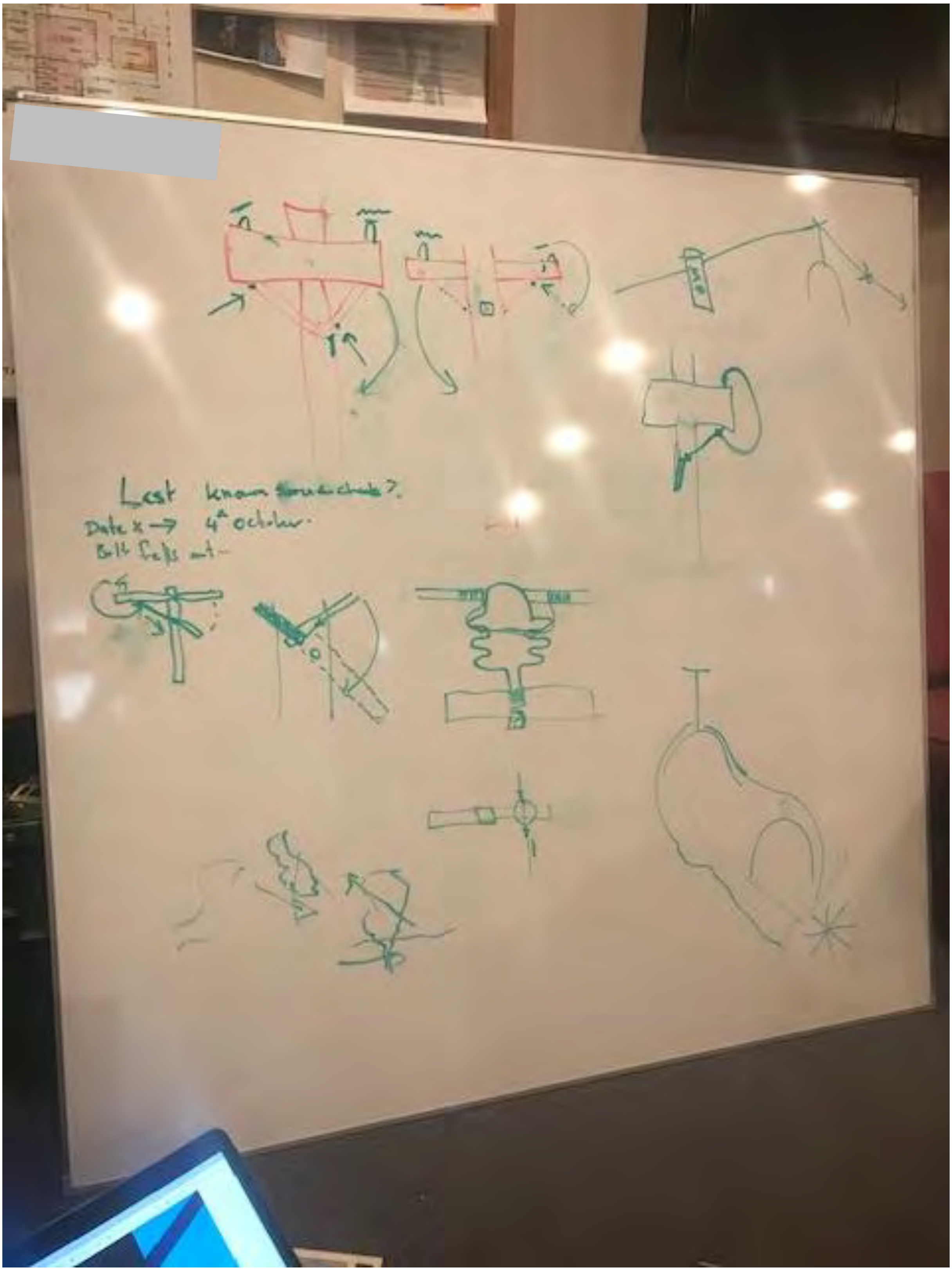



**Fig. 52.** Photograph taken at Twizel Fire Station on the 17 November 2020 @ 17:04hrs. (Iphone)

Figures 52 above and 53 below show drawings of our possible hypotheses on what occurred on pole 35693. Grey rectangle in Fig 52 is covering a crew members name, unrelated to this event.

Our hypotheses were based on a catostrophic failure at pole 35693. We theorised this would take one metal stay arm to lose a bolt and on the opposite side of the cross-arm the insulator binding to break, allowing the live conductor to swing underneath the lakeside metal stay arm creating a phase to earth fault causing the upper arc mark.

The lower arc mark would be created when the metal stay arms conduct electricity that create an earth to the pole, consequently burning a hole in the concrete.

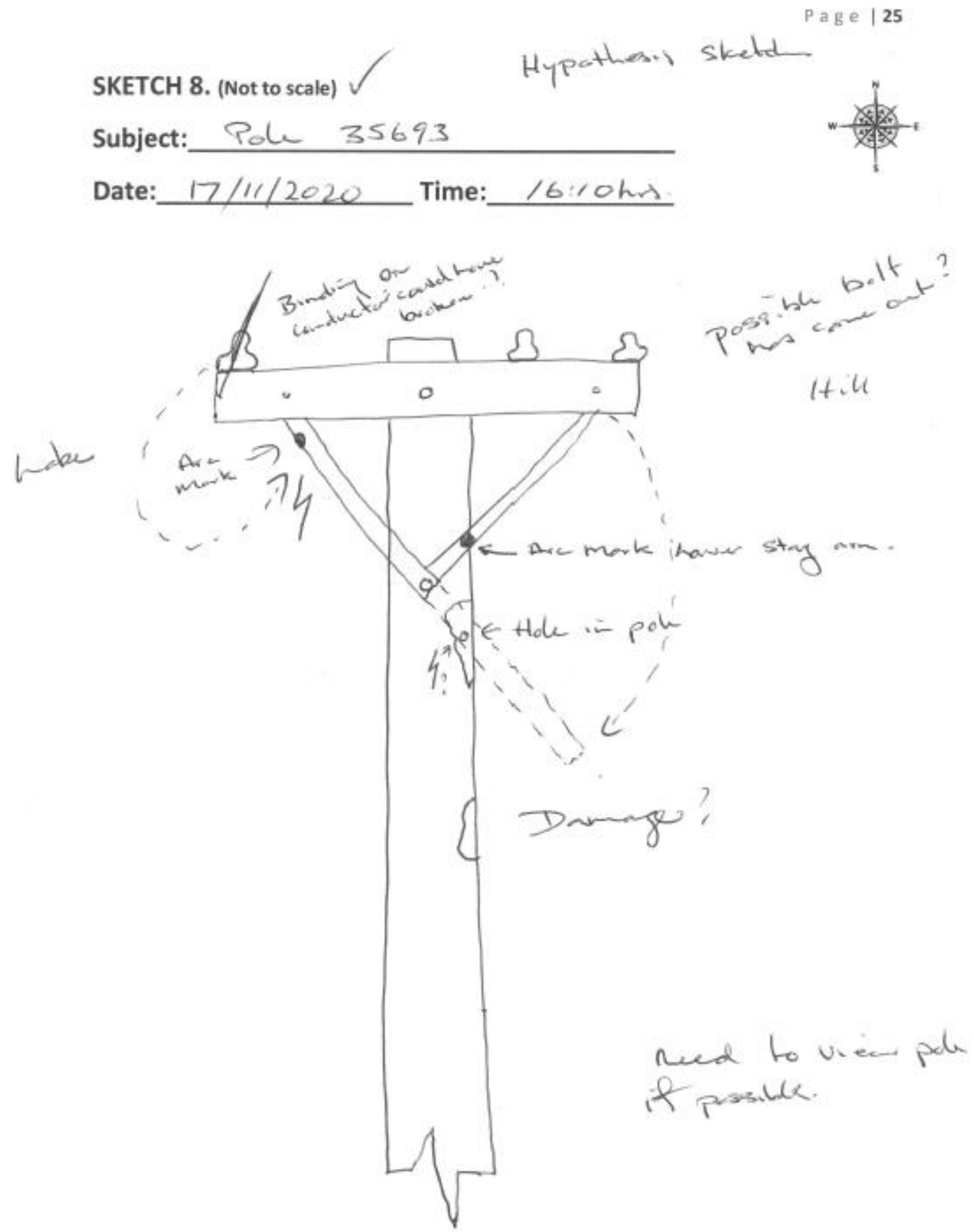



**Fig. 53**. John Foley drew the sketch above indicating what we thought may have occurred at pole 35693 as a result of our drawings from the white board above.

There remained some unanswered questions:

- How realistic would it be to have a catastrophic failure on a pole?
- Why were there new bindings on all three insulators on pole 35693?
- What caused such a heavy scrape mark on the right-hand side of the pole?
- What caused the scrape mark on the wooden cross-arm?
- What caused damage to the lakeside conductor next to the insulator?
- What caused the hole lower down to the right of the pole?
- What was the damage to the washer where the metal stay arms are secured to the centre of the pole?

We were aware that Network Waitaki had taken photos of pole 35693 when they were repairing the cross-arm. A request was made for information in relation to SCADA and R690 data for a 24hr period 3-4 October and the photographs in relation to pole 35693 from Network Waitaki.

On receiving the photographs, it became clear as to what occurred at pole 35693. We were on track with the catastrophic failure hypothesis with a metal stay arm coming free but wrong with the broken insulator binding.

**What occurred at pole 35693:**

Network Waitaki must be commended for their cooperation providing key technical data enabling investigators to determine our probable cause. The following information has been provided from SCADA, R690 data and photographs supplied by Network Waitaki.


**Fig. 54.** Photograph (IMG_0997.JPG) identifies pole 35693.

Photograph supplied by Network Waitaki.

**Fig. 55.** Photograph (IMG_1711.JPG) above shows the cross-arm rotated over.

Photograph supplied by Network Waitaki.

**Fig. 56.** Photograph (IMG_1712.JPG) above shows the lakeside metal stay arm hanging in the centre of the pole and the centre bolt that secured the wooden cross-arm to the pole has moved backwards but remains in the pole (note bolts have a single nut).

Photograph supplied by Network Waitaki.

Now we have an accurate picture of what occurred at pole 35693, we have been able to develop a number of hypotheses relating to this event.

**What we know to date:**

Two bolts have come out of the wooden crossarm by each losing a single nut (double nutted only after repairs carried out), and they were:

- The lakeside bolt holding the metal stay arm to the wooden cross-arm. The nut was on the opposite side to the metal stay arm. The bolt had to vibrate backwards the thickness of the cross-arm allowing it to fall out.
- The centre bolt attaching the wooden crossarm to the concrete pole has also lost its nut allowing the bolt to vibrate backwards enabling the wooden crossarm to come free with the bolt remaining in the top of the pole (Fig. 56 photograph (IMG_1712.JPG) page 73).

We have no indication of when either the nuts or bolts have fallen out, the following scenarios have been considered.

1. Both nuts have fallen off before the night of the fire.
2. Both bolts have vibrated backwards at a date unknown. The lake side metal stay has remained in position being held by the tension of the lower centre bolt. The wooden crossarm has dropped down and come to rest on the centre bolt holding the metal stay arms. This may have occurred on the morning of or sometime before 4 October 2020.
3. With the metal stay arm nut gone, the crossarm was secured in place by the centre bolt and the remaining stay arm. The centre cross-arm bolt has moved backward the morning of the fire allowing the cross-arm to swing over.
4. The centre bolt has fallen out before 4 October 2020 and was being held in place by the two metal stay arms balancing in place.
5. Both bolts have come out on the morning of the fire in high winds.

Any of the above are plausible and it is the investigators belief that the nuts became loose over time.

The most likely cause of this would be from Aeolian vibration.

**Most Probable Cause of Ignition:**

Two bolts have vibrated backwards on pole 35693 at a date unknown. The lake side metal stay has remained in position being held by the tension of the lower centre bolt. The wooden crossarm has dropped down and come to rest on the centre bolt holding the metal stay arms. This may have occurred on the morning of or sometime before 4 October 2020 (refer fig's 57 & 58).

1. At some point the lakeside metal stay arm that was fastened to the wooden cross-arm has lost the nut and over time, the bolt has vibrated backwards and eventually dropped out.

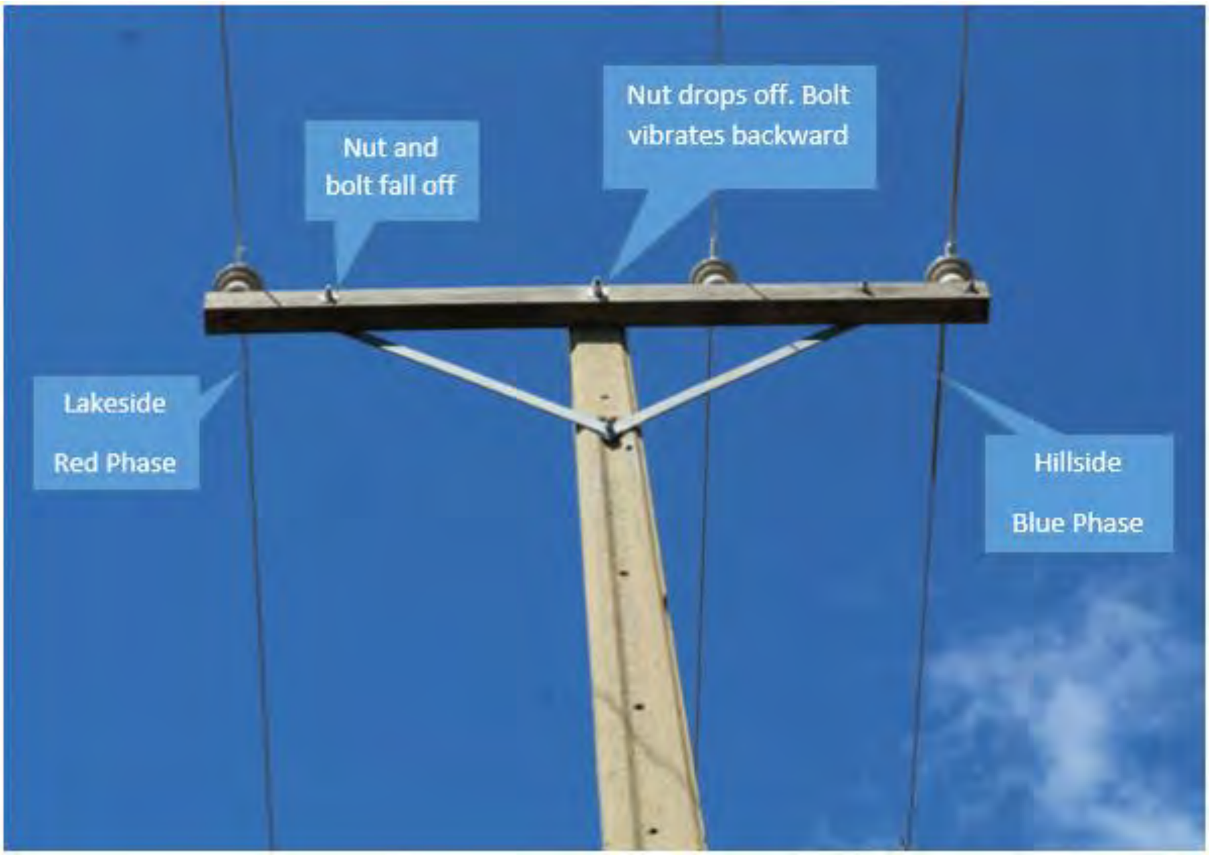



**Fig. 57.** Identifies Phases, and nuts and bolts that have moved.

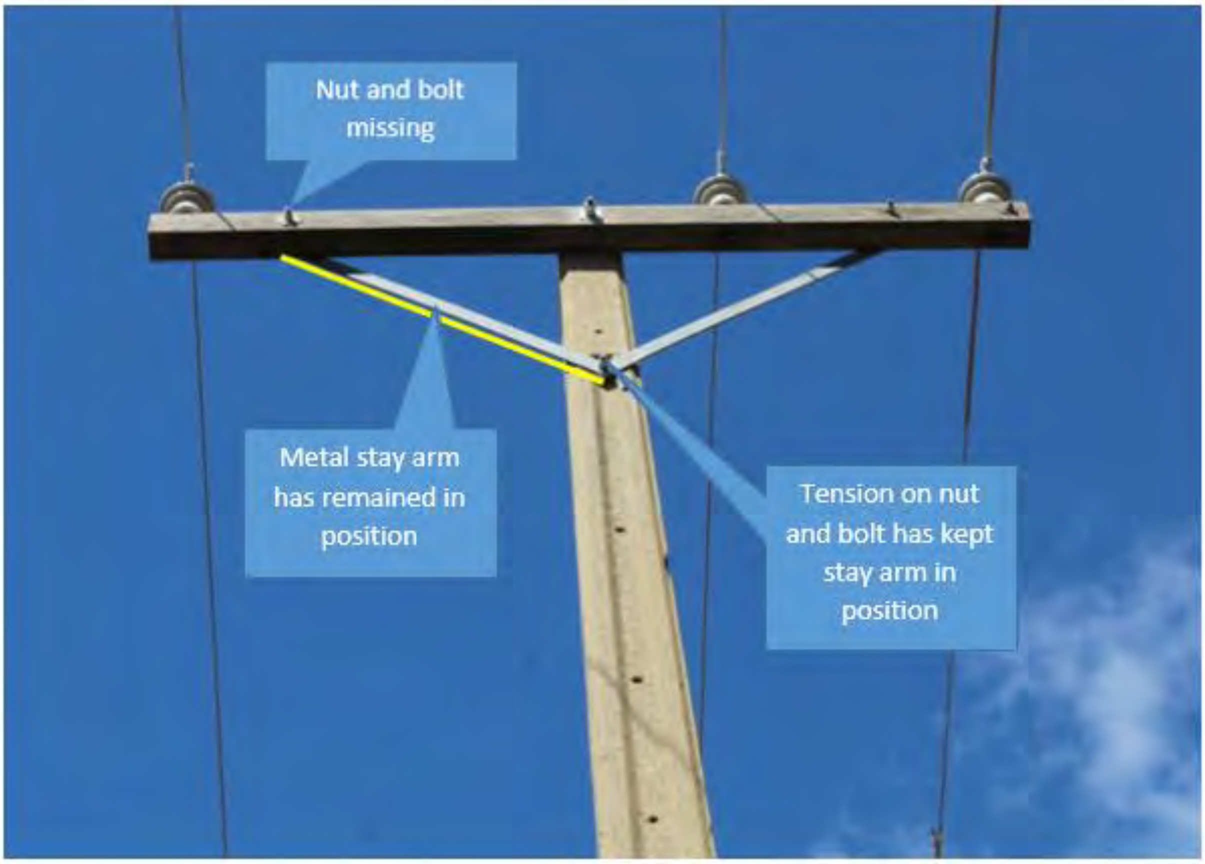



**Fig. 58.** Yellow line indicates the position the metal stay arm remained in once the bolt had fallen out.

**Fig. 59.** Above, balancing position of wooden cross-arm after centre bolt vibrated backwards. Note: crossarm has displaced towards the hill side (right of pole) by approximately 250mm off centre.

2. With the nut and bolt now gone, the metal stay arm has remained at its 45° angle.
3. At an unknown time/date the centre bolt holding the wooden cross-arm has vibrated backwards allowing the arm to drop down and come to rest on the lower centre bolt holding the metal stay arms (Fig. 60).
4. When the wooden cross-arm has moved downward coming to rest on the centre bolt the cross-arm has moved approximately 250mm towards the hillside (Fig. 59 off centre). This has placed the RED phase below and within reach of the lakeside metal stay arm.
5. It is unknown how long the cross-arm would have been in this position. It is possible it may have been weeks, days or it occurred on the night of the fire.

**Fig. 60**. Close up of cross-arm resting on bolt.

**Fig. 61**. Note fresh indentation in wooden cross-arm above bolt.

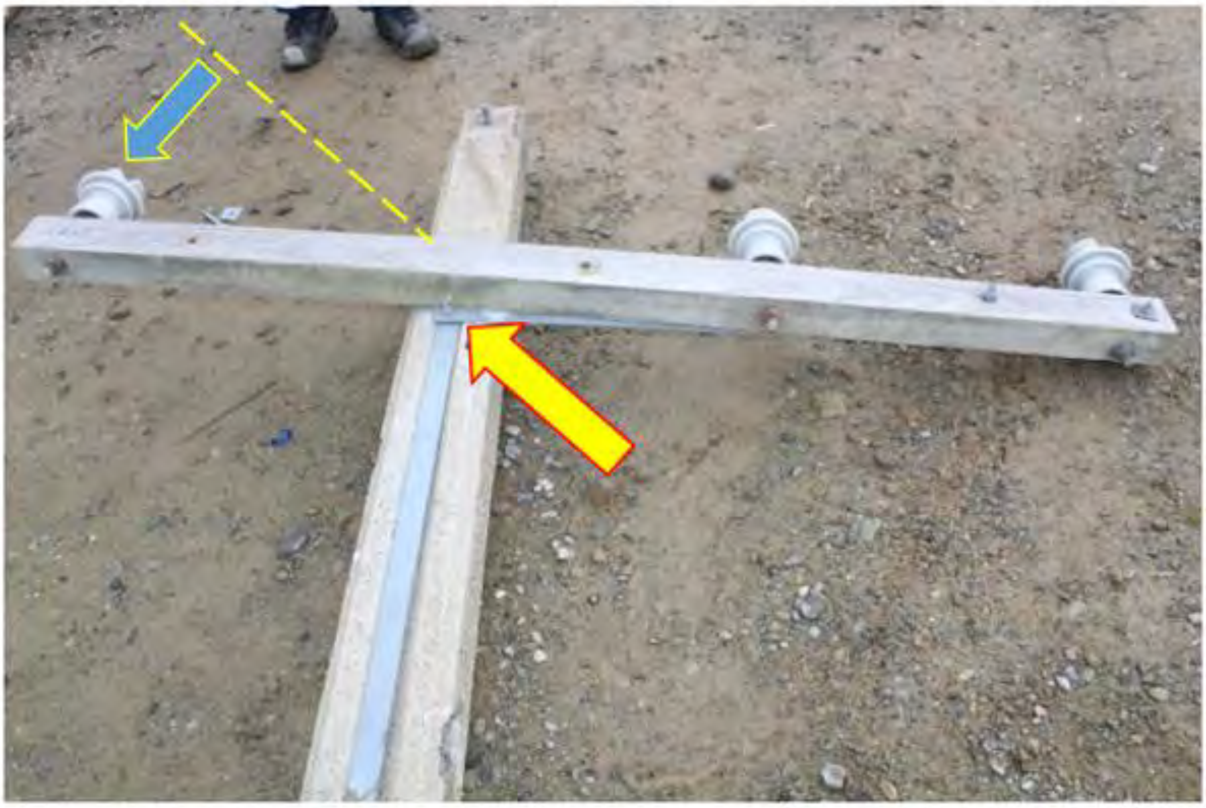


**Fig.62.** Above, position of metal lakeside stay arm above the RED phase. Held by tension on centre bolt.

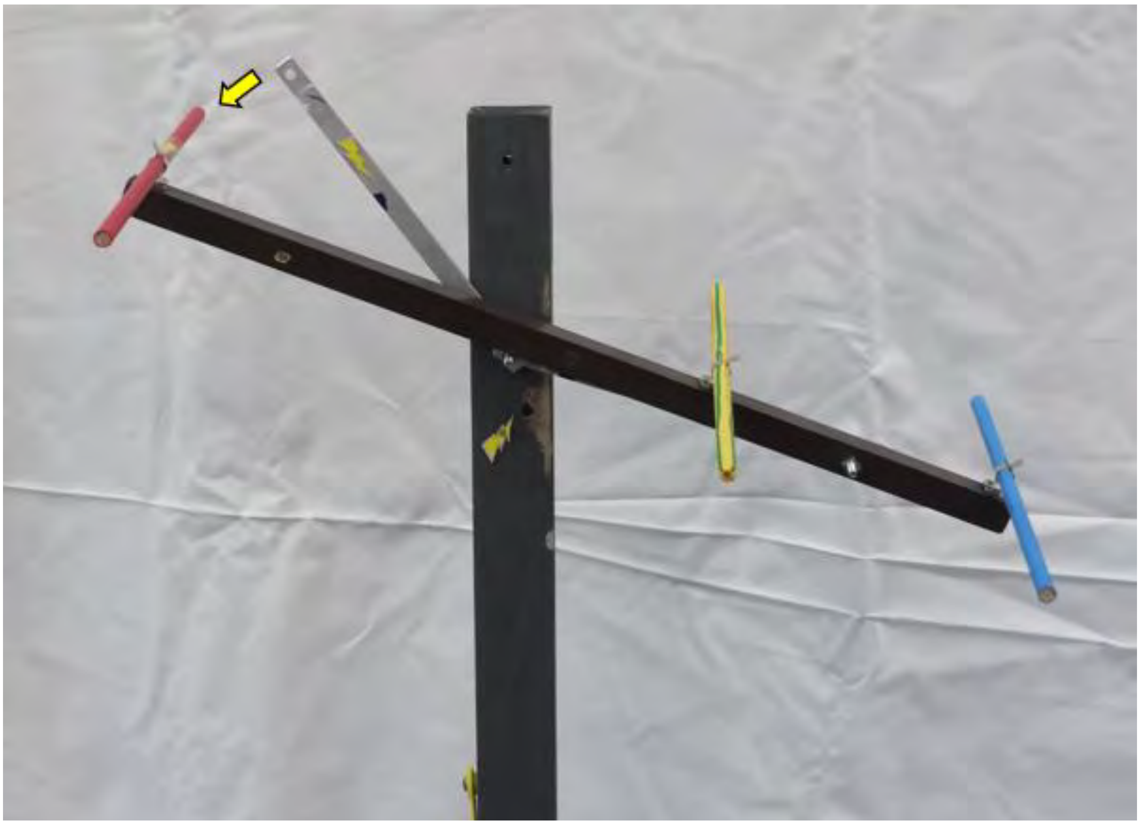


**Fig.63**. Not to Scale. Model represents how we believe the metal cross-arm has contacted the RED phase.

6. With the storm now impacting the Ōhau area, wind pressure on the conductors has begun to move the cross-arm resting on the centre bolt. As the cross-arm has rotated upwards the RED phase has contacted the underside of the lakeside metal stay arm. (Fig.63. Yellow arrow) eventually contacting the RED phase.

**Fig.64.** Arc mark of contact point on underside of Lakeside stay arm.

7. This contact has livened the metal stay arms causing a phase to earth fault and creating three burn holes in the concrete pole.
8. One hole on either side of the pole and one inside the centre bolt hole of the pole.
9. The two external burn holes are approximately 16mm in diameter with one 20mm deep and the other 27mm deep. The internal burn hole could not be measured.
10. R690 data provided by Network Waitaki shows a phase to earth fault was recorded at 02:10:03hrs and again at 02:11:15hrs. These may be two separate faults or one continuous fault. Scada also recorded an Earth fault at 02:13:00

| Date | 24hr Time | Fault | Amps | Phase | Location | Action | Comment |
|---|---|---|---|---|---|---|---|
| 4-Oct-20 | 02:10:03 | Earth | 7 | | R690 | | |
| 4-Oct-20 | 02:10:04 | | | | R690 | Load supply off | |
| 4 Oct-20 | 02:10:09 | | | | R690 | Load Supply on | |
| 4-Oct-20 | 02:10:09 | | | | R690 | Automatic recloses | |
| 4 Oct-20 | 02:11:51 | Earth | 7 | | R690 | | |
| 4 Oct-20 | 02:11:52 | | | | R690 | Load supply Off | |
| 4 Oct-20 | 02:11:57 | | | | | Load supply on | Auto Reclose |
| Scada Data | | | | | | | |
| 4- Oct-20 | 02:13:00 | Phase to Earth | 3 | | R690 | | Freehold Creek |

11. The heat energy required to turn sand contained in the concrete to molten liquid is around 1700ºC. This material may reach over 2000ºC while being heated as arching was taking place.
12. Some of this material may have evaporated during the arcing process while some has been expelled onto the ground.
13. Grass fuels would have been receptive to heat energy for ignition of around 300ºC.
14. It is not simply a matter of placing two temperature values alongside one another and concluding that molten liquid would be at a higher temperature, higher than that which vegetation ignites therefore the molten liquid would ignite vegetation.
15. Other factors such as fuel moisture content, available fuel load and weather all play a part in the ignition process.
16. The fuels around the pole were receptive to heat energy not only to ignite but to sustain ignition spreading to other available fuels. This was obvious with the rate of spread (ROS) the fire ran and the time it took to reach the village.
17. It is also highly likely the contact between the stay arm and RED phase would have caused arcing on the insulator binder wire or conductor. This could have sent molten aluminium to the ground.
18. Another major factor in the ignition and spread of the fire was the wind. Wind blowing at 50km/h is covering 13.88 m/s. The draft at ground level created by the wind has enabled the heat energy from the molten liquid/sparks to ignite and sustain flaming combustion thus spreading out to other available fuels such as grass and scrub fuels.

Scion undertook research into Ignition Thresholds in Grass Fuels and Management Applications for Public Conservation Land in Canterbury in 2010. (Scion Fire Technology Transfer Note No. 39, 2010 page 1-11).

**Research undertaken examined:**

- ignition thresholds in grass fuels using several different ignition sources
- hot metal contact
- metal sparks
- hot carbon emissions
- organic embers
- open flame.

**Some of the Key findings were:**

No difference was observed between the ignition behaviour of tussock and exotic grasses. Moisture Content was one of the key factors that determined the ignition and behaviour of grass samples.

| Ignition thresholds for management applications (Probability of ignition = 70%) | |
|---|---|
| FFMC | MC (%) |
| 77 | 26 |

Ignition thresholds for grasses exposed to contact from **metal spark** ignition sources. Ignition is dependent on grass moisture content (MC%) or Fine Fuel Moisture Content (FFMC).

| Scenario | Ignition thresholds for management applications (Probability of ignition = 70%) | |
|---|---|---|
| | FFMC | MC (%) |
| No wind | 78 | 25 |
| Wind = 1 m/s | 59 | 53 |

Not knowing how the molten material would react when exposed to the air as it fell, it may have begun to flame. The table to the left identifies ignition thresholds for grasses exposed to contact from open flame. Using an FFMC of 82 and above with no wind and wind of 1 m/s places the likelihood of ignition highly probable.

## Fine Fuel Moisture Code FFMC

This is a numerical rating of the moisture content of surface litter and other cured fine fuels. It shows the relative ease of ignition and flammability of fine fuels.

The moisture content of fine fuels is very sensitive to the weather. Even a day of rain, or of fine and windy weather, will significantly affect the FFMC rating. The system uses a time lag of two-thirds of a day to accurately measure the moisture content in fine fuels.

The FFMC rating is on a scale of 0 to 99. Any figure above 70 is high, and above 90 is extreme.

| Date | Station Name | Forest | Scrub | Grass | FFMC | DMC | DC | ISI | BUI | FWI | TEMP | RH | DIR | WSP | RN24 | GC% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 Oct 2020 | Pukaki Aero | M | E | E | 89.5 | 11 | 59.2 | 25.1 | 15 | 24.3 | 19 | 38 | 279 | 36.4 | 0 | 85 |
| 4 Oct 2020 | Pukaki Aero | M | E | E | 92 | 14.30 | 64.41 | 22.4 | 18.39 | 24.35 | 23.4 | 28 | 250 | 27.4 | 0 | 85 |
| 5 Oct 2020 | Pukaki Aero | M | E | V | 93.1 | 17.9 | 69.6 | 13.7 | 21.8 | 18.6 | 23.6 | 23 | 285 | 14.4 | 0 | 85 |

Fire and Emergency engaged the services of an investigative electrical engineer, Mitton Electrical Investigations. Using the services of a subject matter expert would provide investigators the expert knowledge required regarding the electrical network.

The electrical engineer arrived on site at Lake Ōhau on 9 October 2020. A visit to Network Waitaki's premises was undertaken on 17 December 2020. This enabled a more detailed examination of the conductors and failed cross-arm and pole.

Another inspection was undertaken of the exhibits held by the Oamaru Police and Network Waitaki on 16 June 2021, this included inspecting the conductor and pole as well as some other conductor that had not been closely inspected previously.

The following is an extract from a report written for Fire and Emergency New Zealand by Mitton Electrical Investigations.

*"The most likely cause of the fire was hot particles of metal and/or concrete emitted caused by the failure of the cross-arm on pole 35693. This pole is part of the 11 kV line in the valley and is located in the vicinity of the fire origin.*

*The cross-arm and stay bolts and nuts dislodged causing the cross-arm to partially detach from the pole and then rotate. This caused the 11 kV line conductor red phase to make contact with a cross-arm metal stay, resulting in an electrical fault event.*

*The electrical event occurred at approximately 02.10 on 4 October and resulted in an arc or repeated arcs between the conductor, metal stays, bolts and the pole. Particles of molten aluminium, steel or concrete most likely fell to the ground causing ignition of the vegetation below.*

*A second electrical fault event occurred, due to the twisting of the conductors, due to the failed cross-arm, in the span north of pole 35693. This occurred at 03:23, approximately 1 hr 13 mins after the failure of the cross-arm. This may have resulted in another point of fire ignition.*

*The damage on the yellow phase conductor between poles 870452 and 821215 did not appear to have occurred on the morning of the fire and is most likely due to conductor fatigue and/or a previous conductor clashing incident". (Extract ends)*

The conclusion of Mitton Electrical Investigations supports the findings of the Fire and Emergency fire investigators.

***The most probable cause of the initial fire was hot particles of metal and/or concrete emitted caused by the failure of the cross-arm on pole 35693.***

It is the opinion of the investigators that when the span between pole 35693 and pole 870452 to the north where the electrical conductors have twisted has caused a secondary ignition. A three phase fault was recorded at 03:23hrs 17 minutes after the fire was first reported. We believe this fault corresponds with the conductors twisting together.

We have not been able to eliminate the area as having created a secondary ignition. Fire patterns in this area also support low intensity burning an indication of a fire spreading out from this location.

(See - Second Area of Interest 2 - Span between Pole 35693 and Pole 870452, page 93)

**Damage identified at Pole 35693**

**Fig. 65.** Close up of the burn hole below the centre bolt holding the metal stay arms to the pole.

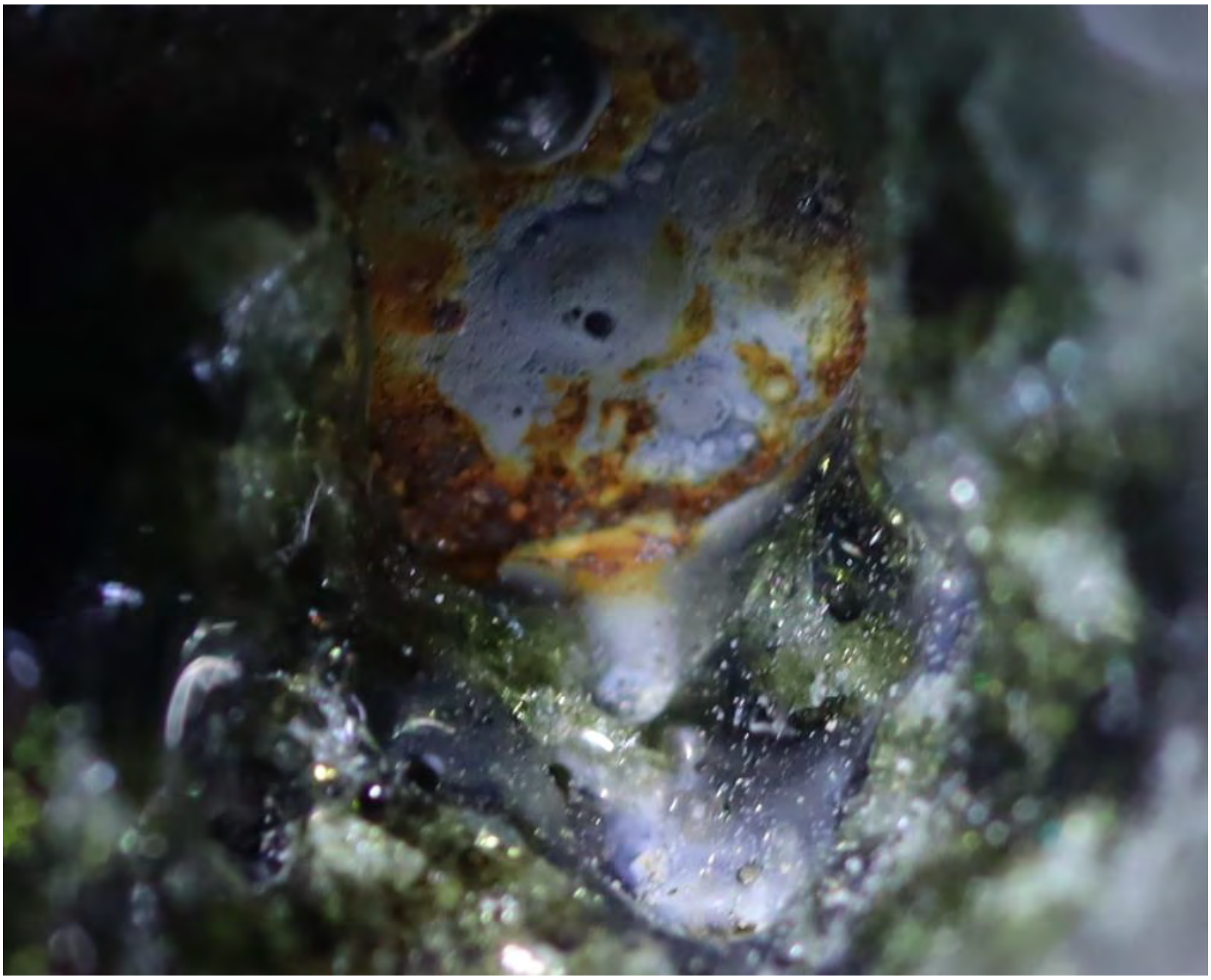


**Fig. 66.** IMG 1479JPG – cropped looking into burn hole, sand has melted like glass.

**Fig. 67**. Cropped IMG 1459JPG – hole left of centre. **Fig. 68.** IMG 1411JPG – 2nd hole below metal stay arms, opposite side of pole from Fig.67.

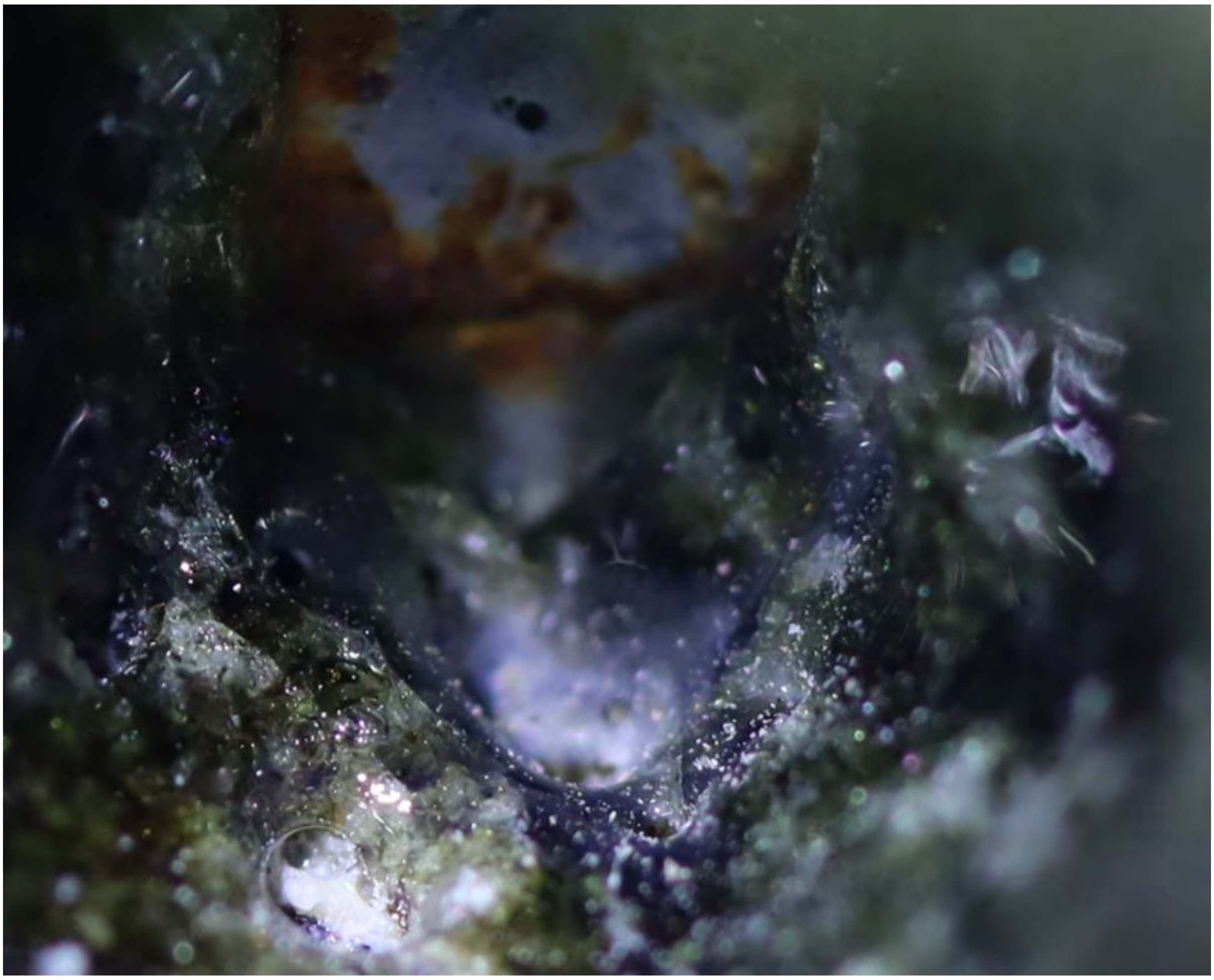


**Fig. 69.** Cropped IMG 1475 – Looking into burn hole.


**Fig. 70.** Cropped IMG 1449JPG – edge of hole has melted like glass.

**Fig. 71.** IMG_1449.JPG edge of hole and surface of pole has been exposed to intense heat.

**Fig. 72.** Burn hole washer side of pole IMG_1452.

**Fig. 73.** Cropped photograph of IMG_1452JPG.

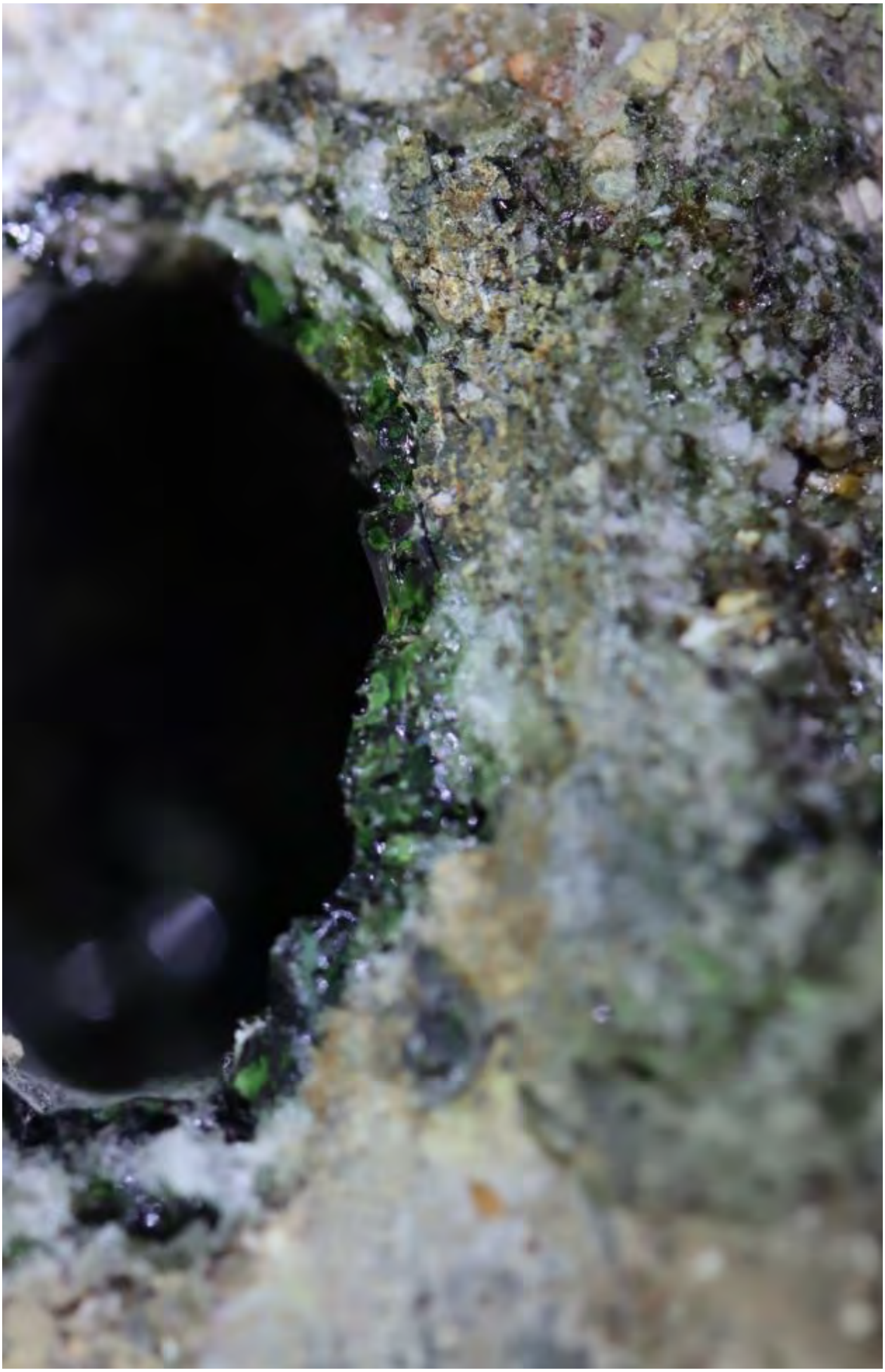


**Fig. 74.** Edge of hole and surface have appearance of melted glass.

**Fig. 75.** Looking into burn hole IMG_1481.JPG.


**Fig. 76.** Arc damage on bolt and washer – bolt holds both metal stay arms to centre of the pole. IMG_1444.JPG.

**Fig. 77**. Bolt from the centre of pole that held the metal stay arms with signs of heat damage. IMG_1440.JPG.

**Fig. 78.** Old damage on side of pole that lines up with the cross-arm when twisted over. IMG_1415.JPG.

**Fig. 79.** Looking into old damage appears to display old heat damage. IMG_1485.JPG.

**Second Area of Interest 2 - Span between Pole 35693 and Pole 870452**

The second area of interest that we have not been able to eliminate is the area north of pole 35693 and south of pole 870452 where the electrical conductors have twisted.

- These conductors have been inspected and have arc damage where the cables have twisted together.

With the information at hand, we believe the conductors within this span have twisted together and have started a secondary ignition. This has occurred after the initial fire was started at around 02:10 hrs. Fire patterns in this area also support low intensity burning an indication of a fire spreading out from this location.

There was a phase to phase fault recorded at 03:23:09 causing the R690 to activate attempting to auto reset locking out at 03:23:27.

We believe the phase to phase fault occurred in the span between pole 35693 and pole 870452 where the electrical conductors have twisted together.

**Fig. 80.** Pole 35693 Blue Phase touching pole. (Photo supplied by Network Waitaki)

**Fig. 81.** Photograph (IMG_1715.JPG) Although not clear it does show the twist in the lines.

(Photo supplied by Network Waitaki)

| Date | 24hr Time | Fault | Amps | Phase | Location | Action | Comment |
|---|---|---|---|---|---|---|---|
| 4-Oct-20 | 2:10:03 | Earth | 7 | | R690 | | |
| 4-Oct-20 | 2:10:04 | | | | R690 | load supply off | |
| 4-Oct-20 | 2:10:09 | | | | R690 | load supply on | |
| 4-Oct-20 | 2:10:09 | | | | R690 | automatic reclose | |
| 4-Oct-20 | 2:11:51 | Earth | 7 | | R690 | | |
| 4-Oct-20 | 2:11:52 | | | | R690 | load supply off | |
| 4-Oct-20 | 2:11:57 | | | | R690 | load supply on | |
| 4-Oct-20 | 2:11:57 | | | | R690 | automatic reclose | |
| 4-Oct-20 | 2:13:00 | Earth | 3 | | R690 | SCADA | Freehold Creek |
| | | | | | | | |
| 4-Oct-20 | 3:23:09 | Earth | 44 | | R690 | | |
| 4-Oct-20 | 3:23:09 | W max | 304 | Blue Phase = 304 Amp | R690 | | |
| 4-Oct-20 | 3:23:09 | V max | 306 | Yellow Phase = 306 Amp | R690 | | |
| 4-Oct-20 | 3:23:09 | U max | 291 | Red Phase = 291 Amp | R690 | | 03:23:09 Line Supply OFF |
| 4-Oct-20 | 3:23:10 | | | | R690 | automatic reclose | 03:23:10 Line Supply ON |
| | | | | | | | |
| 4-Oct-20 | 3:23:15 | Earth | 35 | | R690 | | |
| 4-Oct-20 | 3:23:15 | W max | 310 | Blue Phase = 304 Amp | R690 | | |
| 4-Oct-20 | 3:23:15 | V max | 307 | Yellow Phase = 306 Amp | R690 | | |
| 4-Oct-20 | 3:23:15 | U max | 291 | Red Phase = 291 Amp | R690 | | 03:23:15 Line Supply OFF |
| 4-Oct-20 | 3:23:16 | | | | R690 | automatic reclose | 03:23:15 Line Supply ON |
| | | | | | | | |
| 4-Oct-20 | 3:23:21 | Earth | 38 | | R690 | | |
| 4-Oct-20 | 3:23:21 | W max | 303 | Blue Phase = 304 Amp | R690 | | |
| 4-Oct-20 | 3:23:21 | V max | 306 | Yellow Phase = 306 Amp | R690 | | |
| 4-Oct-20 | 3:23:21 | U max | 294 | Red Phase = 291 Amp | R690 | | |
| 4-Oct-20 | 3:23:21 | | | | R690 | Line Supply off | |
| | | | | | | | |
| 4-Oct-20 | 3:23:26 | W max | 312 | Blue Phase = 312 Amp | R690 | | |
| 4-Oct-20 | 3:23:26 | V max | 307 | Yellow Phase = 307 Amp | R690 | | |
| 4-Oct-20 | 3:23:26 | U max | 291 | Red Phase = 291 Amp | R690 | | |
| 4-Oct-20 | 3:23:26 | | | | R690 | Line Supply off | automatic reclose |
| 4-Oct-20 | 3:23:26 | | | | R690 | automatic reclose | |
| 4-Oct-20 | 3:23:27 | | | | R690 | Lock Out | |

**Fig.82**. R690 Data provided by Network Waitaki. The table has been populated by our investigators. The fault recorded at 03:23:09 to 03:23:26 is one fault which has active the automatic reclose system. With the fault remaining the system locked out at 03:23:27.

The twisting of the lines and subsequent arcing that occurred have possibly started a secondary fire. A fire starting by the twisted conductors would explain the fire pattern indicators that have come from north of pole 35693.

**Fig. 83.** Close up of arcing on twisted conductors IMG_1568.

**Fig. 84.** Close up of arcing on twisted conductors IMG_1578.

**Fig. 85.** Microscope image – 21031010123374.

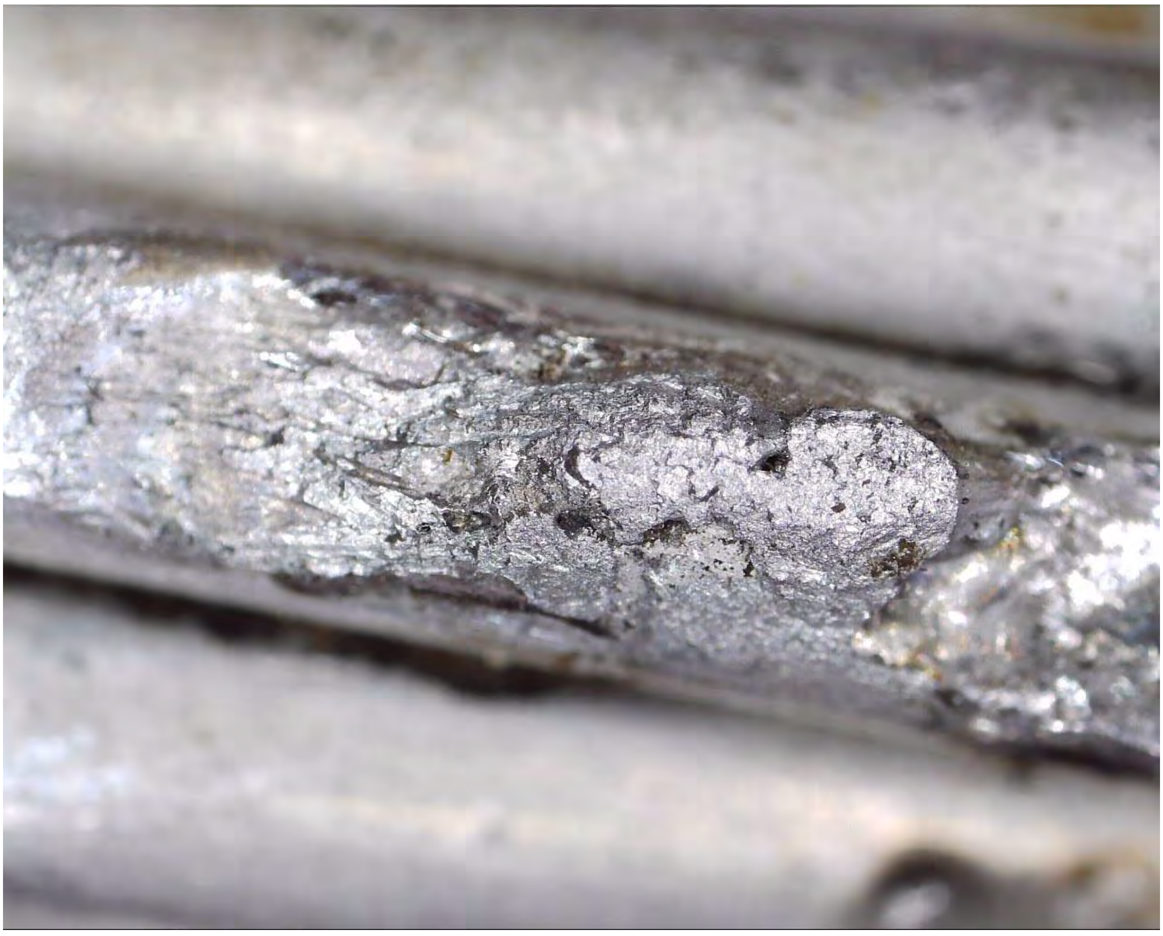


**Fig. 86** Microscope image – 210310103810354.

**Fig. 87.** Microscope image – 210310104357176.

**Fig. 88.** Microscope image – 210310104817272.


**Fig. 89.** Microscope image – 210310102531888.

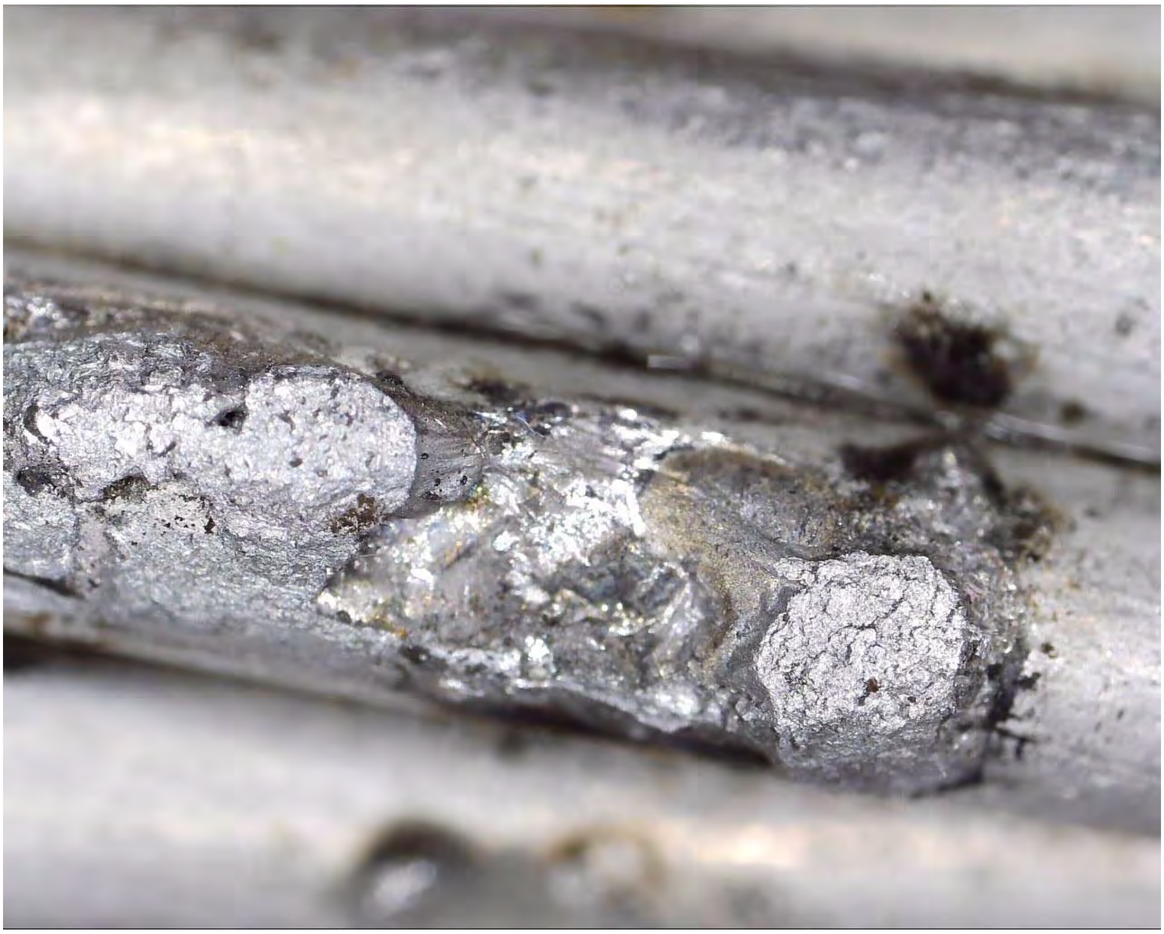


**Fig. 90.** Microscope image – 21031010382.

**Report completed by:**

Fire Investigators: Signature:

John Foley

Craig Chambers

## Appendix 1: Maps of Fire Area (Topographical, Satellite, Animated)


Above map identifies Public Conservation Land (PCL) darker shade of green. Yellow ellipse is the general origin area.

## Appendix 2: Statements

Witness statements have been provided by the following. [redacted]

[redacted]

| Witness Reference | Witness Name | Address |
|---|---|---|
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |

## Appendix 3: Sketches of General Origin Area


**Sketch 1.** Fire spread from Specific Origin Area.

Red X identifies two specific origin areas.

- Pole 35693
- Twisted cables between pole 35693 and 870452

Red arrows identify initial head fire run towards Freehold Creek to the South East

Yellow identifies flanking fire off the main head fire run

Yellow arrow identifies where the fire has burnt out towards Lake Ōhau Rd where it became ahead fire running down the side of the road

White square identifies an area of interest with the damaged conductors

Red arrow with yellow boarder identifies fire run when the weather changed pushing the fire south.


**Sketch 2.** Fire Runs down towards village.

## Appendix 4: ICAD Report Cover Sheet ONLY

Full report available on request.

# Fire and Emergency New Zealand
# Incident Report

**CADNumber** F3088958 **Start Date Time** 04 October 2020 03:06:59

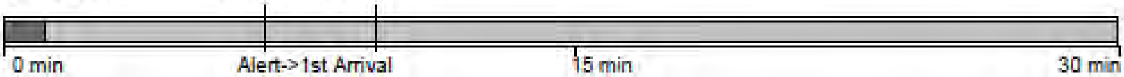
### Incident Details

**Type:** STRU **1st Caller:** [redacted]
**Method:** 111
**PFA:**
**Result:** 1100: STRUCTURE FIRE (STRU)
**Location:** LAKE OHAU RD, LAKE OHAU,WAITAKI DISTRICT **NZTM:** E 1348769 N 5092886

**Common Name:**
**Zone:** 375690 **Station:** 3590 TWIZEL
**Incident Info:** PINE TREES ON FIRE BEHIND THE VILLAGE - TX 3RD ALARM

### Incident History

| | | Elapsed Time (hh:mm:ss) |
|---|---|---|
| **Created:** | 03:06:59 04 Oct 2020 | |
| **Confirmed:** | 03:07:50 04 Oct 2020 | 00:00:51 |
| **Alerted:** | 03:08:07 04 Oct 2020 | 00:01:08 |
| **1st Response:** | 03:15:18 04 Oct 2020 | 00:08:19 |
| **1st Arrival:** | 03:39:25 04 Oct 2020 | 00:32:26 |
| **2nd Arrival:** | 03:53:47 04 Oct 2020 | 00:46:48 |
| **3rd Arrival:** | 03:54:49 04 Oct 2020 | 00:47:50 |
| **Stop:** | | |
| **Closed:** | 00:26:51 29 Oct 2020 | 59:19:52 |




### Responses

| Alarm Level | Call Sign | Dispatched Day | Dispatched Time | Response Time | Arrival Time | Departed Day | Departed Time |
|---|---|---|---|---|---|---|---|
| 3 | TWIZ9011 | 04 | 03:08:07 | 03:16:33 | 03:39:25 | 10 | 18:37:50 |
| 3 | OMAR567 | 04 | 03:08:10 | 03:15:18 | 03:53:47 | 06 | 08:08:55 |
| 3 | TWIZ907 | 04 | 03:25:06 | 03:28:51 | 03:54:49 | 05 | 08:52:28 |
| 3 | TWIZ9026 | 04 | 03:34:54 | 04:11:42 | 04:11:43 | 04 | 17:54:22 |
| 3 | OTEM571 | 04 | 03:25:20 | 04:12:33 | 04:12:34 | 04 | 14:16:53 |
| 3 | LAKE837 | 04 | 03:33:10 | 04:33:28 | 04:33:29 | 04 | 12:33:57 |
| 3 | LAKE8326 | 04 | 04:29:13 | 04:40:35 | 04:40:36 | 04 | 13:14:52 |

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