Department of **Consumer and Employment Protection**
Government of **Western Australia**

Energy Safety Division

ELECTRICAL INCIDENT REPORT

POWER LINE FAULT & BUSH FIRE AT TENTERDEN, WESTERN AUSTRALIA ON 27 DECEMBER 2003

16 January 2004

Report prepared by:

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Tenterden Fire Report.doc

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1. INTRODUCTION

A ground fire occurred near Tenterden on 27 December 2003 and it was reported by the Fire and Emergency Service (FESA) that it was suspected the cause of the fire was a fault or failure of some kind on a Western Power 22 kV overhead power line. An investigation was carried out and this report summarises the findings. The cooperation and assistance of officers of Western Power, the WA Police Service and FESA is acknowledged.

It should be noted that a ground fire which threatened Mt Barker on 28 December 2000 was later identified as having originated from a defect in the same Western Power line.

1.1 Time and Date of Occurrence

Approximately 13:08 hours on Saturday 27 December 2003.

1.2 Notification of Incident

Mr Doug Ayre, Principal Engineer Electricity Supply of the Energy Safety Division, was notified of the incident by Mr Phil Cribb an officer of the Western Australian Fire and Emergency Service (FESA) late on the evening of Saturday 27 December 2003. Mr Ayre (who was on leave) advised the Director of Energy Safety Mr Albert Koenig, who arranged for an investigation to commence in liaison with FESA and Police on the following day, at Tenterden.

1.3 Investigating Inspectors

The investigation was carried out by the following designated Inspectors (Electricity):

- Mr Alan K Naber, Acting Chief Electrical Inspector, Electrical Inspection Branch, Energy Safety Division; Department of Consumer & Employment Protection, and

- Mr Anthony D Seneviratne, Senior Engineer Electricity Supply; Technical Services Branch, Energy Safety Division, Department of Consumer & Employment Protection.

Mr Naber initially inspected the fire scene on 28 December 2003 and both Mr Naber and Mr Seneviratne visited the site on a number of occasions subsequent to that.

2. SUMMARY

Considering all the information gathered and the circumstances of wind and weather at the time it is concluded that a short-circuit fault due to conductor clashing occurred on a Western Power 22 kV overhead line north of Mt Barker at a point approximately midway between poles 721 and 722 at approximately 1308 hours on 27 December 2003.

More specifically, this fault appears to have been caused by the live red phase conductor and the underslung earth wire making direct contact with each other due to erratic movement of both wires in the strong gusting wind and high ambient air temperature. There is a high probability that the subsequent discharge of electricity resulted in the creation of molten hot metal globules that then fell to the ground and provided a source of ignition to the dry stubble in the vicinity of the power line.

The clashing of conductors as described points to either a design or construction defect, since conductor separation should have been sufficient to avoid such a fault. This is not the first time this 22kV line has been identified as the source of ignition of a ground fire, for much the same reasons.

3. ORIGIN OF THE GROUND FIRE

Mr Keith Parsons, a local resident, was driving north on Albany Highway at approximately 1330 hours and witnessed a small grass fire burning in the paddock on the east side of the Highway near Ballochmyle Road. As there was a severe fire risk condition at the time he realised that this indicated a particularly dangerous situation and decided to report it but noted that the fire brigade was already in the vicinity.

Albany Police advised that they had received a report via the Tenterden Store, from Mr and Mrs Maddison, who were driving south along the Albany Highway in the same vicinity between 1315 hours and 1320 hours. This report indicated that a fire was burning in the paddock on the left hand side of the Highway (i.e. on the east side) between two power poles (the poles were later identified as Western Power poles 721 and 722, carrying an overhead 3 phase 22 kV line with an underslung earth wire).

Subsequently to this FESA investigators estimated that the point of ignition was on the ground in a paddock east of the Albany Highway between the Cranbrook turnoff and Tenterden and 300 metres north of the junction with Ballochmyle Road.

An inspection of the perceived area of origin of the fire indicated that a large area of grass paddock had burnt out adjacent to the 22 kV overhead line. The fire had continued in a southerly direction that is consistent with the fire being driven forward from the supposed point of ignition by wind coming from the North.

4. INVESTIGATION ANALYSIS

4.1 Fire Damage to the 22 kV Overhead Line

The Western Power Mt Barker overhead 22 kV feeder line is constructed as follows:

- the phase conductors: steel cored aluminium;
- Underslung earth conductor: galvanised steel wire; and
- Poles: wood.

The feeder line enters the Mt Barker town site from the south and splits into a north branch and a south branch at a local substation. A number of overhead power line poles were damaged or destroyed by fire in the general area south of the ignition point. Western Power staff became aware of the loss of electricity supply and responded by dealing with the immediate damage to the 22kV lines and restoring electricity supplies to the area over a period of time. More extensive repairs took some days.

There was evidence of damage to the overhead line conductors between poles 721 and 722 on the feeder. The damage consisted of electric arc burn marks on the aluminium of the conductor on the centre phase and on the underslung earth wire, subsequently broken, immediately below it. Damage to the poles themselves in the vicinity (including a fire in the top of pole 721) is considered to have most likely resulted as a consequence of sparks produced by the ground fire rather than being the source of ignition of the ground fire. This is because no reason for electrically caused "pole top fire" could be identified.

4.2 Weather Conditions and Topography

FESA provided the following weather information for 27 December 2003.

- **Katanning** (with Albany similar to Katanning):
  NW wind at 37 kph, with gusts to 54 kph.
  Relative Humidity 12%.
  Ambient air temperature 41ºC

- **Rocky Gulley**
  NW wind at 40 kph with gusts to 60 kph.
  Ambient air temperature 39.8 ºC

The sky was clear and there was no evidence of lightning in the area.

The ground between poles 721 and 722 is mostly level with a slight slope rising south for part of the distance towards pole 721. The ground was covered with dry stubble from a crop.

4.3 Implications of the Damage and Repairs to the 22kV overhead line

The span length between poles 721 and 722 was approximately 187 metres.

The under-slung earth wire that had broken between poles 721 and 722 was measured from the break point and the 2 lengths were 102.9 metres and 77.0 metres. A repair sleeve ("patchrod") had been fitted by Western Power to the lower phase conductor approximately 106 metres from pole 722. As it was difficult to measure the length of the earth wire

accurately, and as small lengths of it had been left attached to the poles when it was cut, it is reasonable to conclude that the damage to the lower phase conductor coincided with the damage at the point of break for the earth wire.

Given this situation, it is concluded that the fire was initiated when the conductors clashed at 1308 hours, as:

(1) this is when Western Power's auto-reclose switch correctly operated due to the momentary short circuit, and it is believed this is when the earth conductor broke and fell to the ground (having been weakened by the energy release at the point of contact); and
(2) this coincides with the first fire reports between 1315 and 1320 hours, at the same location.

To summarise, it was clear to investigators on the basis of the time of the initial fire reports, the fire start location and direction, the time of operation of the auto-reclose switch, the damage (and need for later repair) to the phase conductor, and the break (and need for later repair) of the earth conductor, that the fire originated at the power line, between poles 721 and 722.

Consideration was given to various possibilities in regard to the source of ignition at the power line, such as an electrically caused pole-top fire, a high tensile physical failure of the steel earth wire which may have caused it to flick up into the phase conductor above, or wind-borne material (such as twigs) striking and snagging on the line, however all the evidence led to the conclusion that the source of ignition was the clashing of the conductors. For example, the earth wire exhibited damage at the break point that is consistent with electrical arcing between it and another conductor. Significantly, aside from the need for the phase conductor to be repaired at the point where contact with the earth wire is believed to have been made, there was evidence of other burn marks on the phase conductor, indicating this type of contact (and momentary short circuit) had taken place on more than one occasion.

4.4 Reasons for, and the Effect of a Short Circuit on Overhead Power Line Conductors

The reason why conductors contact each other is explained in Appendix 4.

When two live bare conductors come together they cause an arc to develop across the air gap between them or at the point of actual contact. In both cases a significant amount of electric energy passes between the two conductors and a large quantity of heat is produced in the metal at the point where the arc is formed. The heat causes melting of the metal resulting in welding of the conductors and/or the formation of molten metal globules that would disperse away from the arc and fall to the ground whilst still hot.

5. CONCLUSIONS

There are a number of inter-related events, circumstances and factors that coincided on the day of the bushfire. These are summarised as follows:

- There were no suspicious circumstances relating to the origin of the fire.
- Taking account of the burn pattern on the ground, and the prevailing wind at the time, it is concluded that the fire originated in the dry stubble on the ground below the 22 kV overhead power line in the paddock north of Mt Barker at a point approximately midway between poles 721 and 722.
- Conductor damage had been repaired between poles 721 and 722 on the 22 kV line. Western Power employees carried out this repair work as an emergency measure immediately after the fire.
- The weather conditions at the time of the fire were hot and dry with a very low relative humidity and strong gusting winds from the North.
- The spans of conductor on the overhead power line, which at 187 metres are long, could have resulted in erratic movement (galloping) of conductors and this is highly probable due to the adverse wind, exposed terrain with a gentle rise and conductor sag conditions.
- The safe clearance of live conductors can be compromised by excessive sag of the wire between the supporting poles, usually in combination with erratic conductor movement. Such a situation would be exacerbated by high ambient air temperatures and the use of steel as an underslung earth conductor below an aluminium and steel current carrying conductor that has a greater coefficient of expansion than steel alone and sags more as a consequence. This is the scenario relevant to the 22 kV line in question.

Taking all of the above into account it is concluded that:

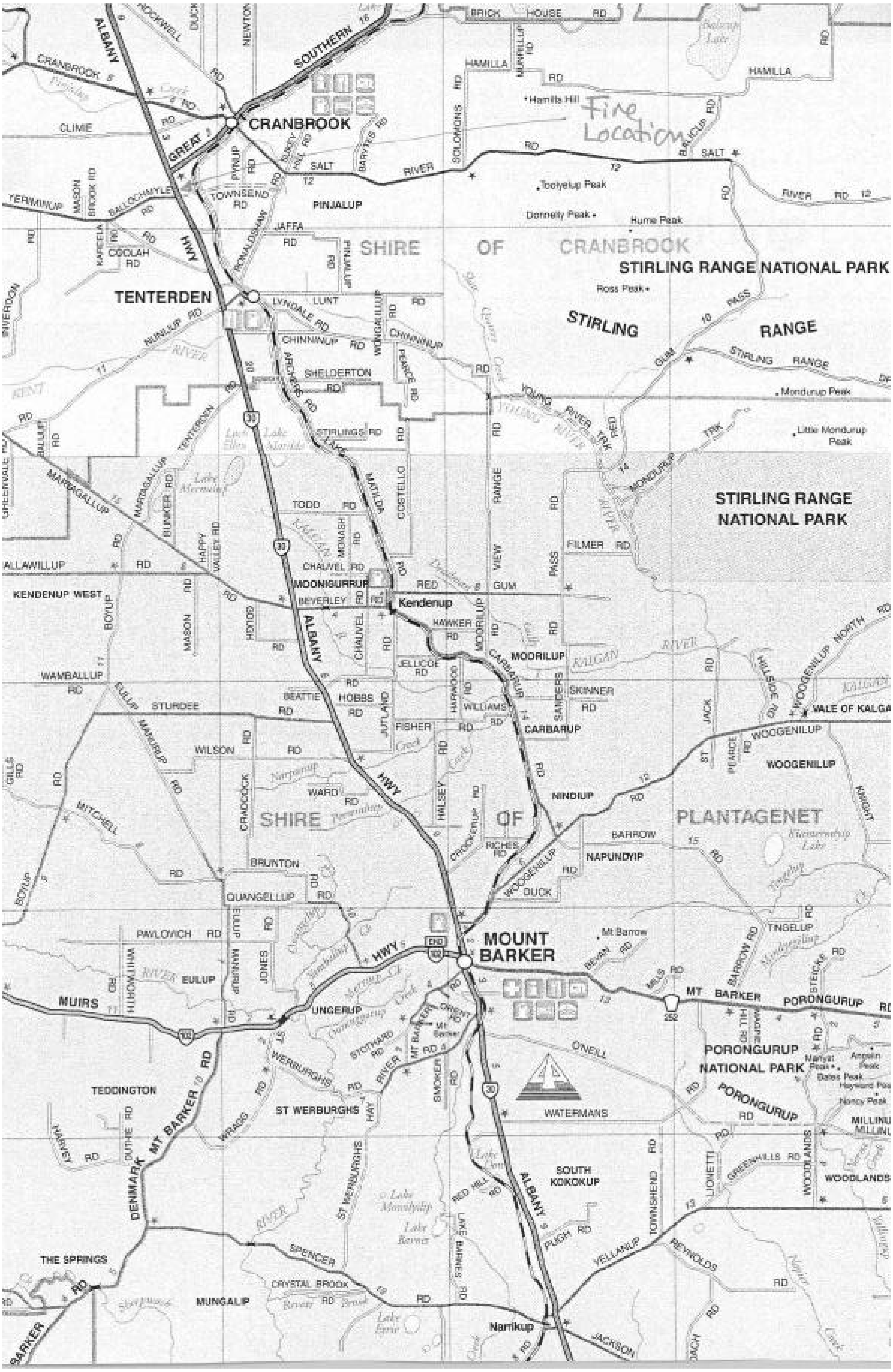
- The fire incident originated in the vicinity of Western Power poles 721 and 722, east of the Albany Highway between Cranbrook turn-off and Tenterden and 300 metres north of the junction with Ballochmyle Road.
- The fire was caused by the ignition of the dry stubble on the ground due to hot metal globules falling from a “live” 22 kV conductor clashing with an underslung earth wire on the Western Power overhead power line, between these two poles.

The clashing of conductors as described points to either a design or construction defect, since conductor separation should have been sufficient to avoid such a fault.

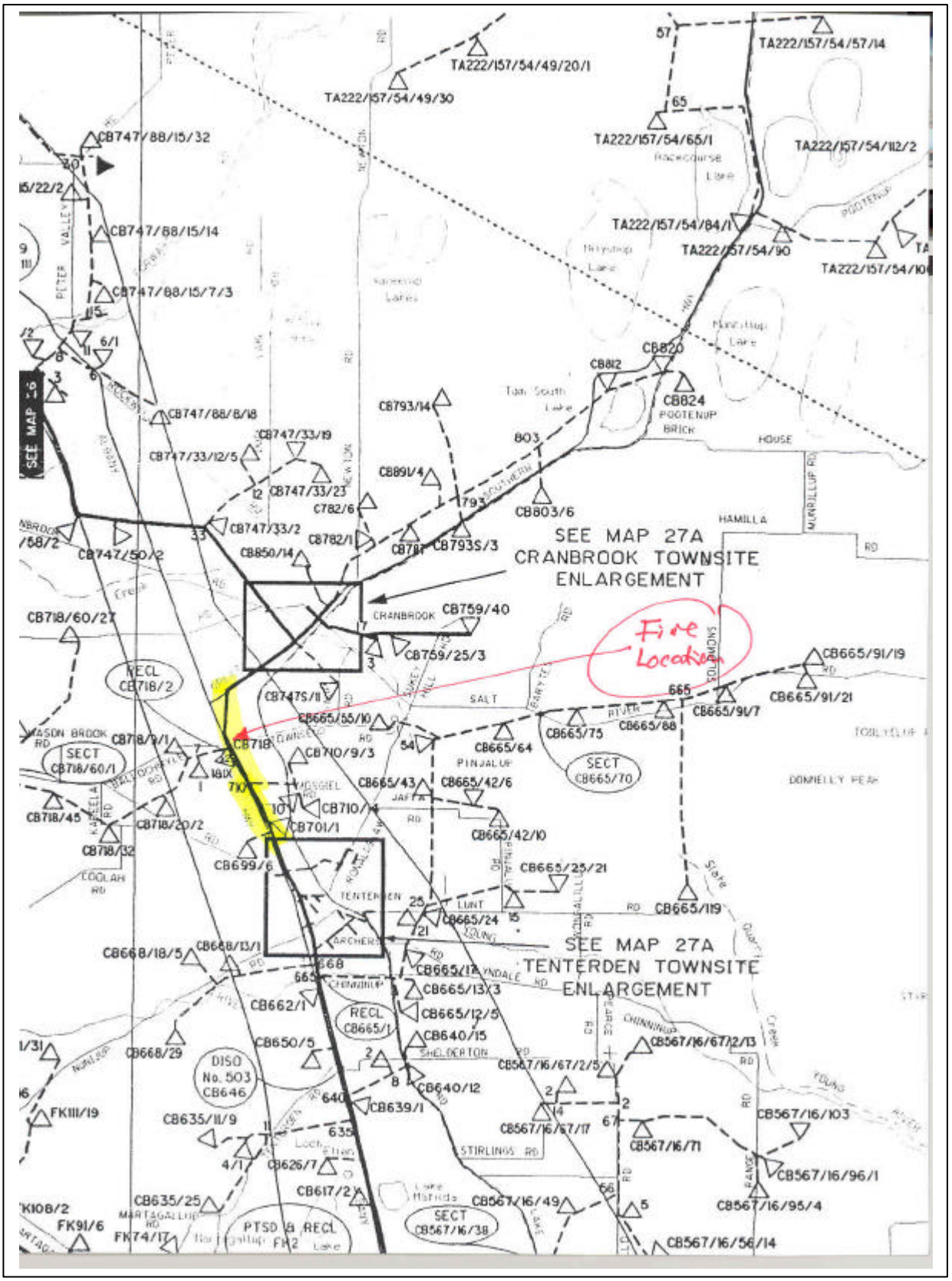
It should be noted that a similar incident and ground fire occurred in this area, on the same 22kV feeder and not far from this recent fault, on 28 December 2000. As a follow up to Energy Safety’s investigation of that incident, Energy Safety requested Western Power to survey its overhead lines in the area and to take remedial action to prevent future conductor clashing, such as by installing poles in the middle of very long spans.

Western Power has stated that it responded appropriately to Energy Safety’s request at that time.

APPENDIX 1 LOCATION MAP



APPENDIX 2 NETWORK DIAGRAM



APPENDIX 3 STRUCTURE OF THE OVERHEAD LINE

APPENDIX 4 CAUSES OF ERRATIC MOVEMENT OF OVERHEAD POWER LINE CONDUCTORS

A wire suspended between two supports sags under its own weight and under the force of gravity. The amount of sag depends upon the weight of the wire, the length of the span between the supports, and the mechanical tension in the wire. The sag is more pronounced where the span is longer and / or the tension is less. The sag also increases with higher ambient air temperature because the metal conductor expands in length.

Similarly a rise in conductor temperature due to electric current flow can also be a factor but airflow over the conductor will tend to provide a cooling effect unless the ambient air temperature is high. Under such conditions, and in the case of the Cranbrook Feeder, the upper steel cored aluminium conductor carrying an electrical load and being larger and heavier would tend to sag more than the smaller gauge and non-load carrying steel earth conductor located immediately below it. An ambient air temperature of 40 °C would have produced this extreme effect and resulted in the upper conductors having considerably more sag than the steel earth conductor below with the result that they could be quite a lot closer together and capable of touching each other, when the lower conductor is moving upwards due to wind effects, as described below.

When the wind blows across an overhead cable it causes turbulence behind the wire as well as twisting of the wire due to the forces resulting from the airflow over the surface of the helical stranding of the conductor. This produces aeolian vibration, which is not normally a significant problem in practice with normal wind speeds as vibration dampening devices, can be provided which absorb the vibration. However, when a strong wind flows across a conductor at an angle of the order of 30° to 45° the aeolian vibration can be severe and result in erratic movement of the conductor. In the case of strong gusting wind the mechanical energy transferred to the conductor can produce twisting of the conductor and result in an erratic upwards and sideways movement. The magnitude of this movement will become extreme when the conductor is slack i.e. approximately in the middle section of the line span length with large sag.

Another factor to consider is the effect of the wind flowing up the gently rising slope and the fact that the open paddock where the power line is located is exposed to the prevailing wind. Wind rising up such a slope tends to cause a lifting of the conductor that adds to any movement caused by aeolian vibration. A combination of wind speed, gusting and the rising ground would probably produce an erratic force that would alternately push, twist, lift and drop the conductor resulting in violent and erratic movement.

The resulting movement, or “galloping”, is a well known phenomena on overhead power lines in exposed situations with strong winds running at an angle to the power line. This could produce sufficient movement in the conductors, under maximum sag conditions, to enable them to make contact with each other.

APPENDIX 5 PERSONS CONTACTED

FESA Operations Manager Albany
McCallum Johnston

Police Arson Investigation Unit
Detectives Senior Constable Investigators
Jim Miles & Peter Sloan

Albany Police
Detective Peter Fuderer

Albany Police Detective
Detective S/C 8800 Barclay Bailey

Local Landowners
Andrew John (Jock) Clapin & John Clapin

Passing Motorists
Keith Parsons
Mr Douglas and Mrs Maureen Maddison

Western Power
Supervisor, Albany
Carl Swarbrick

Western Power Investigatgions
John Zannello

Rick Hinch and Associates.
Ric Hinch

Legal Adviser for WPC staff
Michael J Bowden