Resilience Lessons:

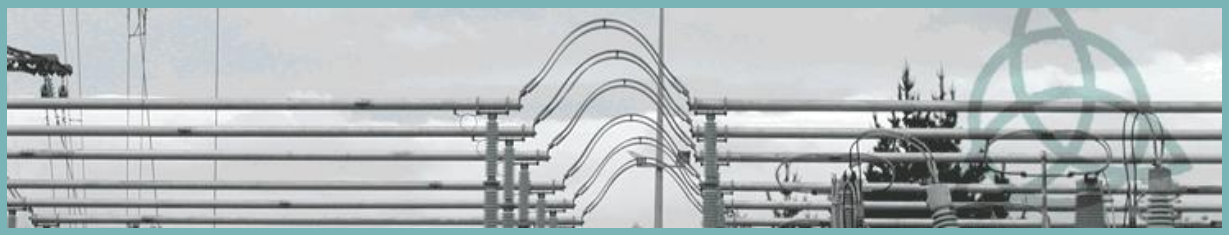
Orion's 2010 and 2011

Earthquake Experience

Independent Report

Kestrel Group

September 2011



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Executive Summary

A shallow magnitude 7.1 earthquake occurred near Christchurch on 4 September 2010. Widespread damage occurred in Christchurch and the surrounding area. Then, on 22 February 2011, a magnitude 6.3 earthquake ruptured a fault almost directly beneath the city. The February earthquake generated extensive liquefaction and extreme shaking resulting in damage to or collapse of many buildings and other assets.

For many years, Orion has actively sought continued service improvements to meet customer needs. Orion's approach has included identifying and initiating work to improve network resilience so as to minimise economic impacts caused by outages including outages caused by earthquakes.

The improvement programme can be traced back to the mid-1990s Christchurch Lifelines report, *Risks and Realities*. This report led to the inception of an ongoing seismic strengthening programme that commenced in 1996 and progressed systematically each year.

Since the mid 1990s, Orion has invested $41 million in increasing the resilience of its network, learning from events such as the 1987 Edgecumbe earthquake and from engineering and geotechnical assessments. All new structural assets and existing strategic structural assets, e.g. sub-transmission lines and zone substations, are designed to withstand a 500 year seismic event with little or no service disruption. The seismic strengthening component cost $6 million, an investment estimated to have saved Orion $30 to $50 million in direct asset replacement costs in the earthquakes. The balance between costs and benefits is even more pronounced when societal benefits (i.e. gains to the community that don't appear in Orion's accounts) are taken into account.

The February 2011 earthquake had a very much larger impact than the September 2010 event. It took about 10 days to restore electricity to 90 per cent of consumers compared to just one day in September. February direct costs have been estimated at over $40 million compared with $4 million in September. Major damage occurred to the underground network – 50 per cent of Orion's 66 kV cables suffered multiple damage in February.

Orion and Orion's contractors worked effectively to restore electricity as rapidly as possible following the earthquakes. Design and construction work for new overhead lines following the February earthquake were achieved extremely quickly. For example, an 3.5 km 66 kV line to supply the New Brighton substation, together with installation of a temporary transformer, were completed in March. Orion's operations and engineering groups experienced huge workload increases following both earthquakes – the teamwork culture that Orion fosters assisted greatly in maintaining morale and restoration momentum.

Much of the earthquake damage to electricity (and other) assets was a result of liquefaction and lateral spreading. The seismic strengthening generally, and successfully, addressed shaking hazards. Little can be done to mitigate risks to buried assets such as cables arising from ground failure. While much electricity supply was lost as a result of cable damage, the extensive interconnections in Orion's 11 kV and 400 V network facilitated electricity restoration by providing routing options not available in radial (non-networked) distribution systems.

The earthquakes are likely to have shortened the life of some underground and (to a lesser extent) overhead assets.

Orion notes that permanent earthquake repairs will take 3 years and cost $70 million overall. Full restoration to previous levels of reliability is expected to take three to five years. To put this in context, Orion's Asset Management Plan includes around $730 million in capital and operating expenditures across the network over the next 10 years.

Risk management is prominent in Orion's management practices. For example, Orion has adopted the "4 R's"[1] in its emergency management arrangements quite explicitly. Integration of emergency management with operational management functions in this way may be unique in New Zealand Lifeline circles.

Looking ahead, a balance will need to be found between longer-term reliability and expenditure on security. It is unlikely that electricity supply reliability will recover to previously favourable levels without a significant ongoing commitment of resources to underground repairs. Aesthetics may also be a factor – overhead lines generally perform better than underground cables in areas subject to liquefaction, and are easier to repair should further earthquakes occur.

The question arises: how will earthquake impacts on Orion's performance be accommodated under the Commerce Commission's new price-quality regulatory regime? Orion is currently engaged in discussions with the Commission on these matters. It seems necessary that a sensible arrangement be developed under which earthquake-related operating and capital costs are able to be recovered over time and Orion's community and results-oriented approach is able to continue.

The main conclusions in this report are:

- Orion's management approach featuring systematic and sustained investment in seismic mitigation was central to rapid and effective electricity restoration
- Since the September earthquake, Orion has demonstrated an ongoing willingness to seek self-improvement
- The importance of maintaining safety as a top priority despite the pressure of work

Opportunities for improvement are reflected in the recommendations in the following section.

The possibility also arises that Orion's earthquake experiences could inform other line business and/or CDEM authorities, and we recommend that Orion consider steps to bring the main learnings to a wider audience.

[1] Risk Reduction, Readiness, Response and Recovery.

Recommendations

We recommend that:

- efforts continue to further support the Contact Centre's role in meeting customer expectations, that this include ways to manage an influx of staff from other parts of the business, and that a focus be retained on ensuring that the arrangements mesh with the new "PowerOn" system and are kept fresh
- introduction of the Outage Management System (OMS) include attention to data management for small, moderate and large emergencies, and that introductory arrangements be designed to meet the needs of all Orion users
- consideration be given to extending PowerOn to cover the LV as well as the HV network
- steps be taken with all contractors to facilitate identification and consideration of emergency response matters such as job referral processes and business continuity
- Orion's / Connetics' mutual aid experience be written up, in conjunction with the Electricity Networks Association, for future reference and consideration in the context of development of the mutual aid arrangements (including HSE angles)
- Orion discuss HSE issues with contractors with a view to improvements (improvements could be documented in Orion processes, the mutual aid agreement or referred to regulators if significant issues are identified)
- Orion reconsider aspects of its spare parts management taking into account location, likely timing of delivery of new supplies (both from alternative New Zealand sources and overseas suppliers) and storage rack design
- Orion take fully into account the approaches set out in the national loadings standard A/NZS 1170 Part O in considering future premises
- Orion write to the Ministry of Civil Defence & Emergency Management to add its concerns about cordon and demolition management, so that cordon management takes the needs of infrastructure companies and their contractors more effectively into account in future events.

The possibility also arises that Orion's earthquake experiences could inform other line business and/or CDEM authorities, and we recommend that Orion consider steps to bring the main learnings to a wider audience.

Introduction

On 4 September 2010, a shallow magnitude 7.1 earthquake occurred on a previously unknown fault, now known as the Greendale Fault, near Christchurch. Although the earthquake was centred in a predominantly rural area to the west of Christchurch, the shaking and severe liquefaction in areas of soft soil led to widespread damage throughout Christchurch and the surrounding area. Civil defence Emergencies were declared for Christchurch City, Selwyn District and Waimakariri District.

The earthquake, later named the Darfield Earthquake, affected much Christchurch infrastructure including electricity. Eighty per cent of the Orion network experiencing immediate disruption. Restoration of supply was rapid. It required a range of responses from resetting of tripped transformers through to physical repairs to the network.

The September 2010 earthquake was followed by thousands of aftershocks, many much closer to Christchurch. For example, a magnitude 4.9 earthquake occurred at 10:30 a.m. on 26 December, interrupting electricity supply to around 40,000 customers (full electricity restoration took approximately an hour).

Then, on 22 February 2011, a magnitude 6.3 earthquake ruptured a fault almost directly beneath Christchurch. The February earthquake generated extreme ground shaking intensities resulting in the damage or collapse of many buildings and extensive liquefaction. A national civil defence emergency was called. 181 lives were lost and many other people sustained injuries.

A further major aftershock (magnitude 6.3) occurred on 13 June 2011, slightly further to the east. Some damage occurred, setting back recovery efforts.

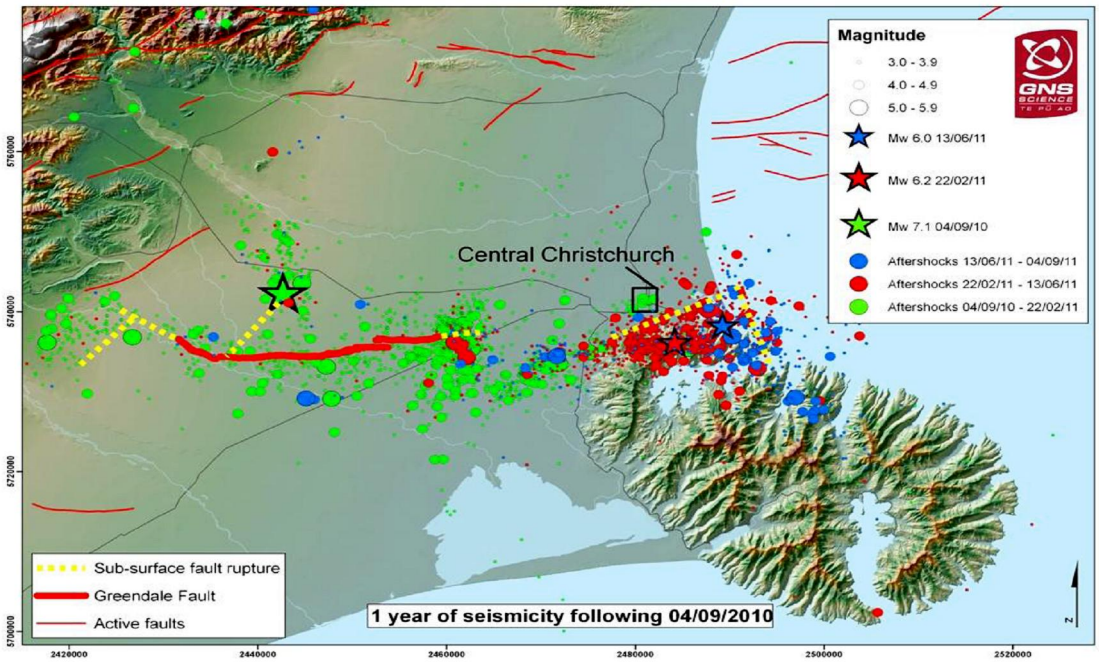

Figure 1: The 2010-2011 Canterbury earthquake sequence

The impact of the February earthquake is considered to be seven to ten times the September earthquake assessed in terms of restoration time, direct costs and customer minutes lost.

The areas where the earthquakes had their major impacts coincide closely with Orion's network. Orion conveys electricity from Transpower's transmission system to final consumers within the supply area bounded by the Waimakariri and Rakaia Rivers, the Canterbury coast and Arthur's Pass.

Figure 2: Orion's network spans the area bounded by the Waimakariri and Rakaia Rivers, the Canterbury coast and Arthur's Pass

A very strong and wide-ranging set of immediate measures were required by Orion to restore electricity supplies especially after the February earthquake. Looking ahead, Orion has reported that permanent earthquake repairs will take 3 years and cost $70 million overall.[2] Full restoration to previous levels of reliability is expected to take three to five years. To put this in context, Orion's Asset Management Plan includes around $730 million in capital and operating expenditures across the network over the next 10 years.

Kestrel Group was commissioned to carry out an independent assessment of Orion's responses to the earthquakes, including the performance of Orion's infrastructure and systems, and reflecting on mitigation and preparedness over preceding years. This report is the culmination of that assessment.

In preparing this report, Kestrel reviewed documentation detailing work Orion had commissioned in the years prior to the earthquake in order to improve seismic resilience, conducted interviews with Orion staff, contractors, customers and other stakeholder, and carried out an internal staff survey (see Attachment 1 for a high level survey summary). The purpose was to enable comment to be

[2] The $70 million includes an anticipated expenditure of around $18 million on accelerated sub-transmission work.

made on Orion's earthquake preparedness, the effectiveness of Orion's response and the role that organisational culture played in response and recovery.

This report identifies ways that Orion has been proactive in building a resilient electricity supply. Recommendations are included for Orion's consideration.

Part 1: Background: Orion, Risk Management and Lifelines Engineering

1.1 Overview

Corporate History

For many years, Orion's predecessors, and other local electricity businesses in New Zealand, operated as city council departments[3] or power boards. These electricity businesses provided distribution, electricity retailing, and often, generation.

Orion's origin can be traced back to a 1989 joint venture between the Christchurch City MED, the Central Canterbury Electric Power Board, and smaller entities covering Riccarton and Port Hills. This venture was known as Southpower.

Major national changes commenced in the early 1990s when the Government passed the Energy Companies Act 1992, requiring that the departments and boards be set up as companies; and the Electricity Act 1992, which inter alia, set up the framework for competition and regulation. The new company was called Southpower Ltd. Shares were issued to Christchurch City and Selwyn District Councils.[4]

Following the Electricity Industry Reform Act 1998, Southpower's retail activities were sold to an energy trading company. Southpower Ltd., rebranded as Orion New Zealand Ltd., became a distribution-only business.

Given that electricity distribution is a natural monopoly, the government introduced economic regulation on this sector (and transmission) in parallel with the organisational structural reforms. Regulation focused initially on information disclosure including information on current performance and asset management planning. Regulation was later strengthened with the threat of control by the Commerce Commission for company performance that appeared to justify stronger intervention.[5]

These corporate and regulatory changes were accompanied by less visible, but far-reaching, reconsideration by Orion of how it can, and should, add value to local consumers (examples - next page). Finding and implementing improvements in practices such as these have become integral to the way Orion thinks about its business. Common to these improvements is a focus on customer needs.

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[3] Municipal Electricity Departments (MEDs).

[4] Banks Peninsula District Council also acquired a small holding.

[5] See *Chronology of New Zealand Electricity Reform*, http://www.med.govt.nz/templates/MultipageDocumentTOC 6477.aspx, for a more complete description of electricity reform elements and timing.

Examples of Innovation

Focusing on core business

Orion has reduced its involvements in wider energy issues such as hot water heating (Transflux) and other domestic heat and power systems (Whisper Tech). Orion also contracts most line work from external/independent companies. With these and other changes, Orion is now focused largely on electricity distribution assets and systems.

Customer relationships

Electricity consumers on Orion's network (with very few exceptions) contract with energy retailers for line services and energy. However, Orion maintains a strong customer inter-face. Orion's contact centre is the primary point of contact for customers with problems. Orion also holds six-monthly seminars for major customers, with agendas covering a wide range of commercial issues including security and reliability. The message that no electricity industry party can offer guaranteed supply is a regular theme. Activities such as these mean Orion enjoys a positive relationship with the community.

Peak pricing

Orion's line pricing for large consumers includes very high charges for peak winter periods and much lower off-peak prices. This is designed to reduce peak loads and allow consumers to manage their energy costs, while, in turn improving capacity utilisation and reducing/deferring the need for expensive investment. Many major customers avoid these charges by installing in-house generation. Primarily designed to improve efficiency, these alternative supply sources also improve resilience to electricity outages (plants must run regularly to avoid the peak charge, offering regular testing under load). On-site generation amounting to 20 MW was run following the September 2010 earthquake (Christchurch's capacity under these arrangements is around 50 MW – approximately 30 MW was unused for reasons including earthquake-related impediments to normal business).

A driver for these improvements has been to avoid major outages. Orion has coined the term "MOCHED" – Major Outage Causing Huge Economic Disruption – as a situation to be avoided. The term is understood by Orion staff at all levels and appears to strongly motivate staff behaviours. The term also appears in formal Orion documentation reflecting the way Orion presents itself to stakeholders. An Orion report indicates that the continued efforts to avoid major outages have made Orion one of the most reliable electricity suppliers in New Zealand.[6]

General Risk Mitigation and the Security Standard

Orion has taken many steps over the years to improve supply security to deal with seismic and other hazards. $6 million has been spent on seismic strengthening (an average of $0.4 million per year). These include measures to strengthen supply to sites critical to other infrastructure providers.

[6] See *Network Quality Report: A Report on the Reliability of Orion's Electricity Distribution Network 2010/11,* http://www.oriongroup.co.nz/downloads/Orion_NQR10.pdf.

Recent and future improvements are outlined in Orion's Asset Management Plan (AMP)[7] and Network Quality Report. For example, Orion has invested $13 million on Christchurch CBD supply security. This includes the additional 66 kV supply from Bromley. Further strengthening from the north of Christchurch is also planned.

A joint replacement programme is largely complete following EA Technology's report, drawing lessons from Auckland outages in 1998.[8] Orion has also recently conducted a review of Transpower's Christchurch substations to ascertain exposure to occurrences such as failure of earth wires.[9]

Orion's security standard is a cornerstone of its network planning. The standard, adopted following the 1998 Auckland developments and reviewed in 2007, is set out in Orion's annual AMP. The AMP describes the risk management process which combines desktop and software approaches. The approach is consistent with ISO 31000:2009, Risk Management - Principles and Guidelines (superseding AS/NZS 4360:2004). Risk summaries are included in Orion's AMPs. An Asset Risk Management Plan has also been prepared that focuses on physical risks; addressing various hazards including earthquakes. Outcomes are measured in terms of outage duration per customer (SAIDI[10]) and average number of customers affected (SAIFI[11]).

Orion's Track Record

The nature of Orion's business and its performance are summarised in the following statistics, drawn from Electricity Line Business 2010 Information Disclosure Compendium.[12]

- ***Profitability:*** Orion is ranked slightly below the middle in terms of revenue per kWh (5.8 cents) and connections ($989), but above the middle in terms of return on investment[13] (8.6 %, 9th of the 29).

- ***Capital Expenditure:*** Orion recorded relatively low capital expenditure in relation to asset replacement cost (2.57%, 19th out of 29) and connections ($219, 20th of 29), but recorded relatively high capex in relation to circuit length (3,936 per kilometre, 9th of 29).

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[7] Orion NZ Ltd. *Asset Management Plan - Summary of a 10-Year Management Plan for Orion's Electricity Network from 1 April 2010 to 31 March 2020*, http://www.oriongroup.co.nz/downloads/AMP_apr10_mar20.pdf.

[8] EA Technology Ltd. *EA Technology Review of the Integral Energy Technical Report – Cable Failures, following the Auckland Power Failure,* 1998.

[9] Failure of an earth wire caused a serious outage in Auckland in 2006.

[10] SAIDI – system average interruption duration index. This is the average total duration of electricity supply interruptions that a customer experiences in a year.

[11] SAIFI – system average interruption frequency index. This is the average number of electricity supply interruptions that a customer experiences in a year.

[12] PricewaterhouseCoopers. *Electricity Line Business 2010 Information Disclosure Compendium.* PricewaterhouseCoopers, October 2010.

[13] Adjusted for discounts and tax allowances, but including revaluations.

- ***Operational Expenditure:*** Orion recorded relatively low operational expenditure in relation to asset replacement cost (2.88%, 17th out of 29) and connections ($213, 23rd of 29), but recorded relatively high opex in relation to circuit length (3,819 per kilometre, 7th of 29).

Taken as a whole, these and other figures suggest a well-managed network from a financial point of view. However, in terms of this report, the network reliability performance figures are of most interest.

Orion's overall outage performance during the year to March 2010 was very favourable. Orion's index value for outage duration per total customers (SAIDI) was 61.2 (27th out of 29). The value for the average number of customers affected (SAIFI) was 0.6 (the lowest of the 29). However, while Orion customers collectively experienced reliable supply, those customers that did have outages tended to be without power for relatively long periods - CAIDI[14] was 107.3 (the 7th highest). The overall outage figures for the years to March 2008 and 2009 were similar.

1.2 Regulatory Issues

Orion's focus is on cost-effective electricity security including working with the local community to achieve good results, i.e. an accepted balance between security and prices. For example, Orion's AMP states that "trade-offs between price and electricity supply reliability are a constant focus."

Government's electricity line business control regime addresses the same issues. The Commerce Commission's June 2010 Draft Reasons Paper "*Input Methodologies (Electricity Distribution Services)*" notes that there is a natural tension between providing suppliers with incentives to invest and limiting their ability to extract excessive profits. This is very close to the reference to trade offs in Orion's AMP. However, the way the Commission proposes to discharge the bulk of its recently revised line business price-quality control responsibilities appears to depart from Orion's participative, results-oriented approach. The regulatory approach largely involves meeting pre-set (five yearly) outcome tests/requirements assessed through compliance with standardised input methodologies.

The following issues are among those that distributors generally face under the new price-quality regime:

- How investment to meet high impact/low probability (HILP) events can be justified when prices are reset. Views may differ on the merits of investment to mitigate risks of this type.
- The extent to which legitimate differing circumstances of individual line businesses can be accommodated within standardised approaches. For example, Orion's network covers a wide variety of terrain and is exposed to a range of hazards.[15]

The Commission's approach to regulation includes features intended to help accommodate significant unexpected events. A mechanism, under which line businesses may apply for

[14] CAIDI – customer average interruption index. This is the average duration of electricity supply interruptions for customers who experienced a supply interruption in the year.

[15] A brief 2004 analysis by Opus International Consultants Ltd indicates that Orion's overhead line costs are higher than other New Zealand due to costs of meeting ice and snow impact standards.

"customised price paths" (CPP), is available in the event of a catastrophic event for distributors on a "default price path" (DPP). This mechanism would allow for special factors, but it is not clear that it can easily accommodate very large, severe shocks.

1.3 CDEM and Lifelines Engineering

Civil Defence Emergency Management

A new national approach to civil defence was being developed in the 1990s at around the same time as Government electricity policy changes. The Civil Defence Emergency Management (CDEM) Act 2002 requires a comprehensive risk-management based approach to hazard management, comprising risk reduction, readiness, response and recovery (known as the "4 R's").

The CDEM framework provides for electricity distributors, as "Lifeline Utilities," to be directly involved in CDEM hazard and risk management through regional CDEM Groups. Orion is a member of the Canterbury CDEM Group and has well-formed relationships with other Canterbury CDEM Group members.

The Guidelines for Lifeline Utilities issued by the Ministry of Civil Defence & Emergency Management state that:

> "*improving New Zealand's CDEM regime will include:*
>
> - *strengthening relationships between sectors and agencies involved in CDEM activity*
> - *encouraging cooperative planning for continuity of service and contribution to disaster response*
> - *seeking commitment to deliver more effective risk management; especially risk reduction thorough a range of policy and planning initiatives."*[16]

Section 60 of the CDEM Act, *inter alia*, places obligations on Lifeline infrastructure providers to ensure that they are able to function, if necessary at a reduced level, during and after an emergency, and to participate in CDEM planning.

Emergency Management

Risk management is prominent in Orion's management practices and planning documents. Orion has explicitly adopted the "4 R's" in its emergency management arrangements. Figure 3 shows the allocation of responsibility for risk reduction, readiness, response and recovery amongst senior staff.

Integration of emergency management with operational management functions in this way is considered to be unique in New Zealand Lifeline circles. Readiness and reduction are regarded as the main emergency responsibilities from an operational viewpoint. Public communication includes media management. During the interviews held as this report was prepared, Orion staff commented favourably on the role clarity inherent in this structure.

[16] See *Working Together: Lifeline Utilities & Emergency Management, Director's Guidelines for Lifeline Utilities (DGL 3/02)*.Ministry of Civil Defence & Emergency Management. December 2002.

Orion is an active participant in annual CDEM Group exercises such as "Pandora". The extent of Orion's involvement in these exercises is however limited, and seldom tests Orion processes to the extent that is regularly experienced in responding to actual emergency events (storms have been the main examples until 2010).

Lessons gained from response are typically captured through post-emergency debriefs. These then lead to action programmes to improve future performance. For example, an Orion report to the Canterbury CDEM Group soon after a major 2006 snowstorm identifies impacts that included power loss to approximately 8,000 (mostly) rural customers. The report describes the nature of damage (mostly tree-fall), and notes the risk mitigation that had taken place (closer placement of poles and use of stronger poles to support transformers). Fourteen points are noted in the summary, mostly relating to management of the restoration process involving repair crews. A consultant's report[17] commissioned by Orion following this event found that design standards were generally adequate although work was recommended in some areas. Each event offers different challenges to different parts of Orion's business, and new insights into ways Orion can adapt.

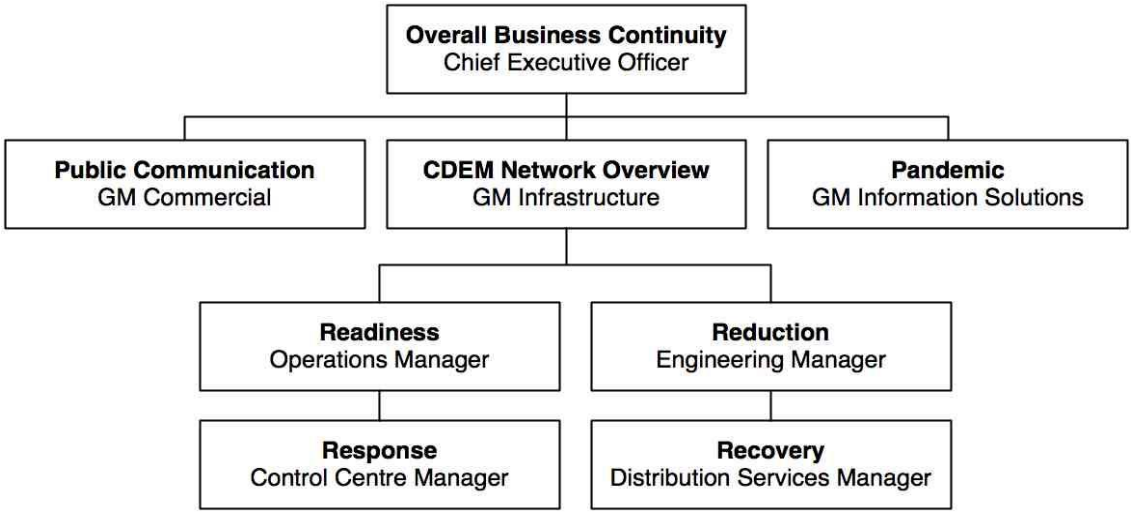

Figure 3: Key emergency management responsibilities

Lifelines Engineering

Prior to 2002 when the CDEM Act was passed, but consistent with the approach the Act envisaged, studies in a small number of regions were conducted to identify infrastructure vulnerability to natural hazards. The first of these, led by the Centre for Advanced Engineering (CAE), addressed Wellington earthquake issues.[18] This study can be regarded as an evolution of the good work already done in New Zealand on building performance in earthquakes. A Christchurch study

[17] Orion NZ Ltd. *Disaster Resilience Summary NW70.00.14 Amendment No.5*, 4 December 2009.

[18] *Lifelines in Earthquakes. Wellington Case Study. Project report*. Centre for Advanced Engineering, University of Canterbury, 1991.

followed. – the 1997 report published by the Christchurch Engineering Lifelines Group, *Risks and Realities - A Multi-Disciplinary Approach to the Vulnerability of Lifelines to Natural Hazards*, addressed a range of hazards relevant to Christchurch City.[19] These projects, and others that followed, usually involved the active participation of staff from the Lifeline entities that provide infrastructure services within those regions.

A perhaps unexpected outcome of these and the other regional projects was a high degree of socialisation between the personnel involved. This led to recognition of common issues and to the formation of Engineering Lifeline Groups. The Groups' activities enhanced response coordination through strengthened relationships and the establishment of more formal arrangements. The initial work programmes of some of the Groups included a focus on collaborative follow-up work to their projects, including work on hazard risk mitigation.

Risks and Realities

The Christchurch *Risks and Realities* study stands out for its quality and, perhaps more notably, for its enduring influence on hazard mitigation in the local Lifelines community. The study, *inter alia*, details the systematic vulnerability assessment of key electricity substations and selected other sites conducted at the time.

Orion's internal post-2010 earthquake report states that an

> "*encouraging outcome is how closely over the last 15 years that consultants had predicted the weak points in our network. This has allowed us over time to build resilience*".

A report by the structural engineers Kingston Morrison[20], summarised in *Risks and Realities*, identified older substations (built prior to 1965) as particularly vulnerable to earthquakes. A risk-based approach was taken to substation building strengthening assuming an earthquake of MM VII to VIII intensity, based on an Alpine Fault movement with a likelihood assessed at 65% over 50 years. Particular comment is included in *Risks and Realities* on seismic exposure where cables cross Armagh Street bridges.

Orion has taken many steps to strengthen its network since completion of *Risks and Realities*. In particular, the study led to the inception of an ongoing seismic strengthening programme that commenced in 1996 and was pursued systematically each year. All new structural assets, together with existing strategic structural assets, e.g. sub-transmission lines and zone substations, are designed to withstand a 500 year seismic event with little or no service disruption. Other existing (non-strategic) structural assets were reinforced to withstand a 150 year earthquake. Non-structural assets that would be expected to require long repair times, such as the 66 kV cables crossing Armagh Street bridges and the Dallington footbridge, were given particular attention.

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[19] *Risks and Realities - A Multi-Disciplinary Approach to the Vulnerability of Lifelines to Natural Hazards* Christchurch Engineering Lifelines Project.. Centre for Advanced Engineering. November 1997.

[20] *Southpower Substation Seismic Risk Evaluation,* Kingston Morrison Ltd. September 1995.

Risks and Realities addresses Christchurch's vulnerability to infrastructure damage from natural hazards.

The report was prepared by the Christchurch Engineering Lifelines Project. A broad approach was taken to address hazards including earthquakes, flooding, tsunami and meteorological hazards. Standard Lifeline sectors were covered, but the project also included emergency buildings (broadcasting, police and fire stations, ambulance bases, etc.). The study scope was limited to the area that was then Christchurch City (i.e. the study did not include areas now part of the enlarged city); nor was the wider Canterbury region covered. The report was completed in 1994 (including an international peer review), updated in 1996 and published by the Centre for Advanced Engineering (CAE) in 1997.

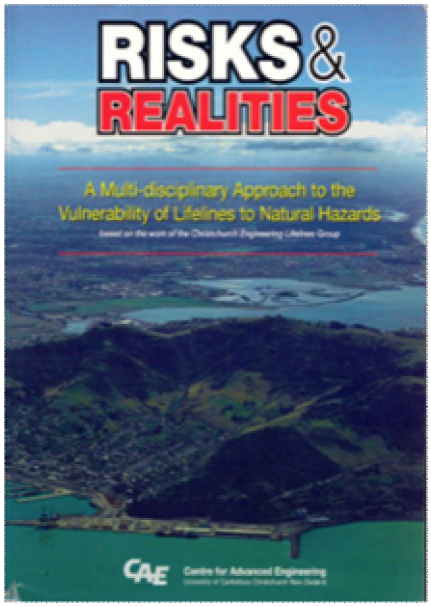

Figure 4: Risks and Realities - A Multi-Disciplinary Approach to the Vulnerability of Lifelines to Natural Hazards

Detailed work was conducted by task groups including organisations such as Orion's predecessor, Southpower. Utility networks were described at component level with each assessed for vulnerability to individual hazards. Mapping work included overlaying networks and hazards. Twenty-one of the resulting hazard maps, much reduced in size, are included in the report.

The assessment considered "importance" to the network (recognising wider impact of damage of the component in question), "vulnerability" and "damage impact" assessed in three time-frames: immediately after the event, period following, and time for return to normality. Assessments were presented on Vulnerability Charts. Assessment was followed by consideration of mitigation.

The report includes a brief section on interdependencies. For this, matrices display interdependencies for two scenarios, i.e. for normal operation (if A fails, B fails), and for response (restoration of B requires prior restoration of A).

Figure 5 outlines the components and progress of the risk reduction programme following *Risks and Realities*. This programme was nearing completion when the 2010 earthquake occurred. Of particular note, improved seismic standards had been achieved (or substantially achieved) in relation to district/zone, network and distribution substations, and to major cables including cables over bridges. The cost of these improvements was of the order of $6 million[21].

[21] Improvements have also been made to the control centre, spares storage and management, emergency contracting and other operational matters.

All of these upgraded facilities remained serviceable following the September 2010 earthquake and almost all remained serviceable after the February 2011 earthquake. The $6 million investment is estimated to have saved Orion $30 to $50 million in direct asset replacement costs in the earthquakes. The economic value provided by the enhanced resiliency of the assets would be many times larger, a crucial matter from a societal point of view that is easy to overlook. The seismic strengthening programme has been pursued progressively over time and the benefits reflect consistent commitment to the programme over many years.

Consequence Rating	Asset (Orion owned)		Seismic std achieved %	
			Oct 2009	Oct 2008
1	Major cables (66 & 33 kV)		100%	100%
2	Switchyards		48%	42%
3	District/zone substations		100%	100%
4	Network substations	Total	99%	76%
		Orion	99%	99%
		Consumer	99%	17%
5	Distribution substations	Total	99%	40%
		Orion	99%	97%
		Consumer	99%	22%
6	Dual pole substations		76%	60%
7	Single pole substations >150kVA		65%	63%

Figure 5: Seismic risk reduction progress

Seismic standard achieved generally means:

- for older substations, strengthened for a 1 in 200 year event (a slightly higher standard than the 150 years in the building code)
- for newer substations, strengthened for a 1 in 500 year event

Other Risk Mitigation Work

Analysis of seismic risks to Orion's network did not stop with *Risks and Realities*. Consulting engineers (Soils and Foundations) were engaged to evaluate liquefaction hazards at key substations in 1998.[22] Two Grid Exit Points (GXPs) and six zone substations were identified as being on potentially liquefiable ground. Risks arising from ground failure and post-earthquake settlement were noted.

Working with Transpower, Orion also commissioned a review of liquefaction risks at the four major Christchurch GXPs. Where liquefaction risk was identified, Orion gave attention to alternative supply routes (since liquefaction is difficult to mitigate). An example of this work is the investment in alternative CBD supply from Bromley.

Sections 2.2. and 2.3 of this report comment on the performance of key assets in the earthquakes. The point that liquefaction and lateral spreading were pervasive is made. The resulting damage would have been greater had the duration of the earthquake been longer.

[22] *Summary of 10-Year Management Plan for Orion's Electricity Network from 1 April 2009 to 31 March 2019.* OrionGroup, http://www.oriongroup.co.nz/downloads/AMP_apr09_mar19.pdf. .

Much of the earthquake damage to electricity assets (and to other underground infrastructure assets) was a result of liquefaction and lateral spreading. The seismic strengthening generally, and successfully, addressed shaking hazards. Little can be done to mitigate risks to key buried assets such as cables arising from ground failure. While much electricity supply was lost as a result of cable damage, Orion has extensive interconnections at the 11 kV and 400 V levels. The interconnections facilitated electricity restoration by providing routing options not available in radial (non-networked) distribution systems. Work is continuing on more extensive interconnection at the 66 kV level.

Liquefaction risk is difficult to mitigate and there appears to be sound justification for Orion's strategy of focusing on supply route diversity. However, value is likely to be obtained from reviewing Orion's 1998 work on liquefaction hazards at key substations[23] in light of recent seismic experience. This review would focus mainly on cables and associated encasements, including bridge abutments and connections with surface equipment.

A full investigation, based on a cable inventory, would include correlation with observed ground deformation in order to ascertain actual cable performance. Representatives from the U.S. Technical Council on Lifeline Earthquake Engineering (TCLEE)[24] have commented that such a case study would likely inform a proposed international buried cable seismic design manual.

Orion has also given particular consideration to spare parts management including seismic risks relating to spares storage. A risk-based approach to anticipating failure rates has taken into account credible natural events that may impact Orion's ability to meet its security standard. Audits of stock levels and security are undertaken, with additional precautions in relation to transformers.

The two events that dominate in determining spare parts levels (in excess of normal failure modes) are earthquakes (65% chance of an Alpine Fault earthquake in the next 50 years) and storms (100% chance in the next 50 years). On average, snow storms affect twice as many customers as wind. However, Canterbury is particularly vulnerable to high winds. These two weather conditions when occasionally combined make storms more damaging to the overhead network than is typical in other parts of the country.

Figure 6: Storage racks at Connetics

Risks and Realities and recent Orion documents, such as the AMP, note that attention has been given to bracing storage racks and providing restraints to prevent items falling from shelves. Storage hold-downs have since been improved – these are designed for ground accelerations of 1 to2 g, the equivalent of a "maximum credible event."

[23] Reports were produced by Montgomery Watson New Zealand Ltd and Soils & Foundations Geotechnical Consulting Engineers.

[24] TCLEE operates under the American Society of Civil Engineers.

Part 2: The Earthquakes, Impacts on Orion and Immediate Response

2.1 The Earthquakes

The 2010 earthquake occurred at 4:36 a.m. on 4 September 2010 on the Greendale Fault. The fault was previously unmapped, being one of a set of such faults, and may not have moved for 16,000 years. The main characteristics were[25]:

- The earthquake was located 40 km west of Christchurch near Darfield, 10 km below the surface.
- The earthquake's magnitude was 7.1. Maximum felt intensities reached MM VIII. Maximum vertical peak ground acceleration, at Greendale, was 1.26 g. Horizontal peak ground acceleration at the same site averaged 0.74 g. The five monitored sites closest to the rupture (all within about 5 km) had vertical accelerations of greater than 0.7 g, and ratios of vertical to horizontal accelerations of 1.5. Shaking in Christchurch itself was less than these values – most horizontal accelerations were in the 0.18 g to 0.25 g range.[26]
- The duration of shaking was relatively short for an earthquake of magnitude 7.1.

The February 2011 earthquake (an aftershock from the 2010 event) was smaller in magnitude. However, it was much more damaging than the 2010 earthquake in its impact on infrastructure and buildings, especially CBD buildings. It occurred on 12:51 p.m. on 22 February. 181 deaths occurred and a further 164 were seriously injured.

- The 2011 earthquake was located near Lyttelton, 10 km south-east of Christchurch.
- The earthquake's magnitude was 6.3. Maximum felt intensities reached MM IX. The highest shaking was recorded at Heathcote Valley Primary School at 2.2 g, with readings of 1.88 g at Pages Road Pumping Station and 1.07 g at Hulverstone Drive Pumping Station.

Liquefaction and lateral spreading around watercourses were very pervasive in both earthquakes, and may have been more so had the duration been longer.

A further significant aftershock occurred on 13 June 2011 (magnitude 6.3). This earthquake was also close to Christchurch (centred under the Port Hills) was shallow (6 km) and was very sharply felt. Further significant liquefaction occurred to the east of the city.

Numerous other aftershocks have occurred, several of them greater than magnitude 5.

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[25] Much information on these and other earthquakes is available from Geonet, see http://www.geonet.org.nz/earthquake/. Geonet is a collaboration between GNS Science and the Earthquake Commission.

[26] *Learning from Earthquakes: The Mw 7.1 Darfield (Canterbury), New Zealand Earthquake of September 4, 2010, EERI Special Earthquake Report — November 2010.* EERI Team http://www.eeri.org/site/images/eeri_newsletter/2010_pdf/EERI_NewZealand_EQRpt-web.pdf.

2.2 Impact on Electricity Supply – September 2010

Orion's customers experienced extensive outages following the earthquakes.

Outages in the Transpower system affected Orion. In September, three 220/66kV transformers tripped at Islington GXP, and 66/33kV transformers tripped at Springston and Hororata GXPs. Transmission damage is described (by Transpower) as minor. Transpower notes that a partial loss of service occurred, restored at 8:30 a.m. (4 hours after the earthquake) following safety checks and minor repairs, with full capacity but with reduced security for a period.

Some Orion transformers at zone / district substations also tripped in September due to vibration impacts on safety devices (surging within mercury switches). Some similar impacts occurred in the September 8 aftershock (magnitude 5.1). Together with the Transpower interruptions, these events accounted for about 80 percent of Orion's outages. These readily manageable events may have been fortuitous insofar as they reduced electrical damage to the lower voltage parts of the network. These outages may also have reduced the incidence of fire in the city.[27]

Orion's Control Centre, in one of its Manchester Street buildings, suffered little damage in September and no failure of control systems occurred. Back-up services were also available.

Damage to the Orion system in September 2010 comprised:

- ***Zone substations:*** Many sustained minor/superficial damage. Three sustained more significant impacts (Greendale, Pages and Brighton) but not at a level that affected normal operations. All of the substation buildings had been seismically reinforced or, in the case or newer structures, were built to current seismic standards.

- ***Other substations (including distribution buildings, kiosks, transformers, switchgear and buildings):*** These sustained minor damage. Buildings had been strengthened and damage was confined to some cracking in walls and floors. There were also a few instances of ground subsidence.

- ***Underground network:*** Damage occurred in areas where ground moved laterally, mostly in the Brighton, Dallington and Avondale areas. Supply was restored via alternative supply routes or use of generators. Oil pressures were maintained. The 66kV cables crossing the Avon River at Dallington were damaged but remained functional. Strengthening of the approaches to the footbridge conveying the cables, part of the strengthening programme initiated in 1996, was effective in maintaining supply to the Dallington area at that stage. Damage to 66kV cables at Brighton was also suspected, and these cables were down-rated. Multiple faults occurred in around 30 11kV underground cables (about 4 per cent of the installed network).

- ***Overhead network:*** 66kV towers and poles appeared undamaged. Some insulators and binders were damaged along 33kV lines. Damage occurred in rural 11kV lines (insulators, binders, liquefaction and ground movement). Some pole foundation failures occurred in the

[27] The low number of fires has been a matter of interest to members of the Technical Council on Lifeline Earthquake Engineering (TCLEE) team that visited Christchurch in December 2010 and April 2011.

urban 400V system. The incidence of failure was small and did not seriously impact restoration.

All failures were in older cables, averaging 40 to 50 years since installation. Some failures of older cables occurred in the CBD due to building damage. Since the earthquake, fault levels have been higher than normal and further cable damage may yet be discovered.

Additional staff started arriving at the Control Centre within 30 minutes of the earthquake. A significant number reported for duty that day. An initial visual assessment indicated that assets sustained only limited damage. This proved accurate and the majority of the network was quickly restored. By 9:00 a.m. on the day of the earthquake, Orion was able to say with some confidence that "*by dark we will have 90 per cent of the city up*".

The re-livening process began almost immediately. The initial high-level approach involved:

- patrolling overhead HV lines before relivening
- relivening underground HV cables
- surveying the CBD and disconnecting damaged buildings prior to relivening.

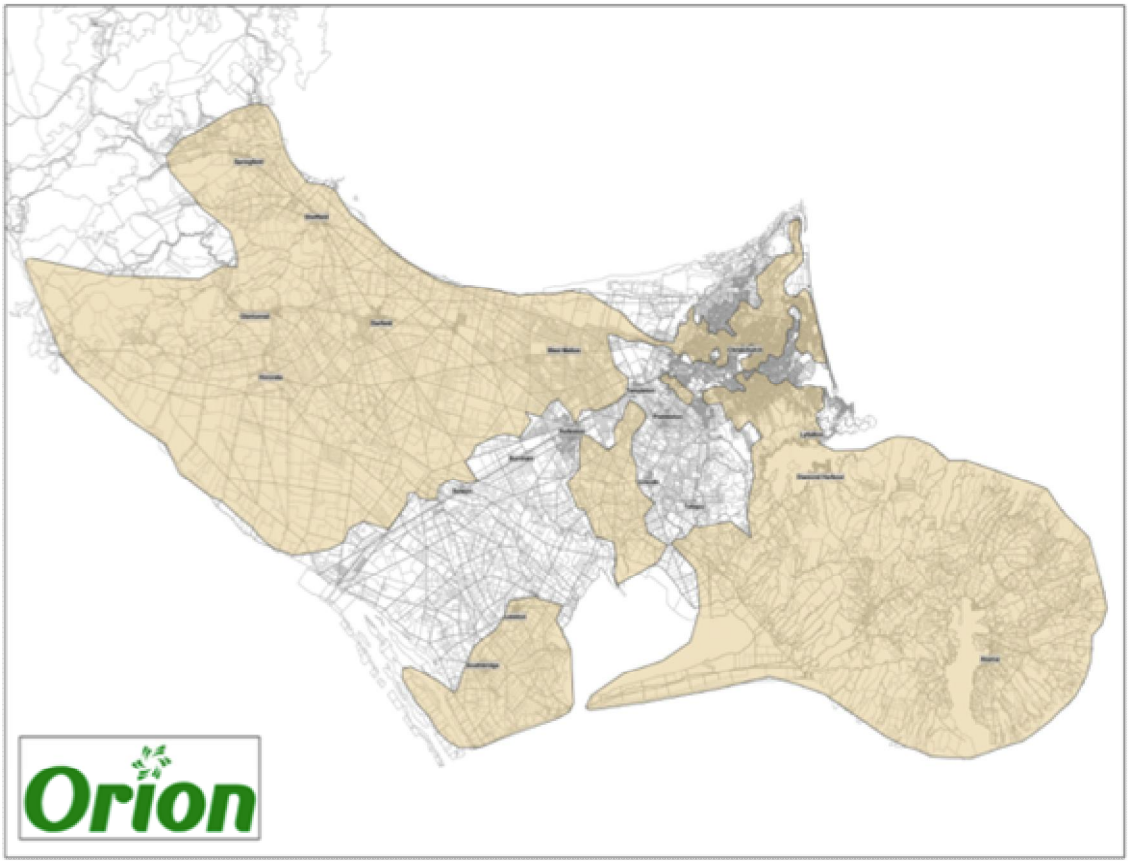

Figure 7: Area with power loss due to the September 2010 earthquake

2.3 Impact on Electricity Supply – February 2011

As in September, some Transpower transformers tripped in the February earthquake. Moderate damage occurred to transmission infrastructure at the Bromley substation (6 km from the epicentre) and some damage also resulted at the Papanui substation. Supply (full capacity) was restored at 17:29 p.m., less than 5 hours after the earthquake, albeit initially with reduced security at Bromley. Some liquefaction also occurred at Bromley and some cracks occurred around tower foundations but these did not impact supply.

Orion notes that the February 2011 earthquake had a very much larger impact than the September 2010 event (broad estimates range from 7 to 10 times).

- It took about 10 days to restore electricity to 90 per cent of consumers (compared to just one day in September).[28]
- Direct costs were estimated at over $40 million compared with $4 million.
- 630 million customer minutes were lost, compared to 88 million minutes.

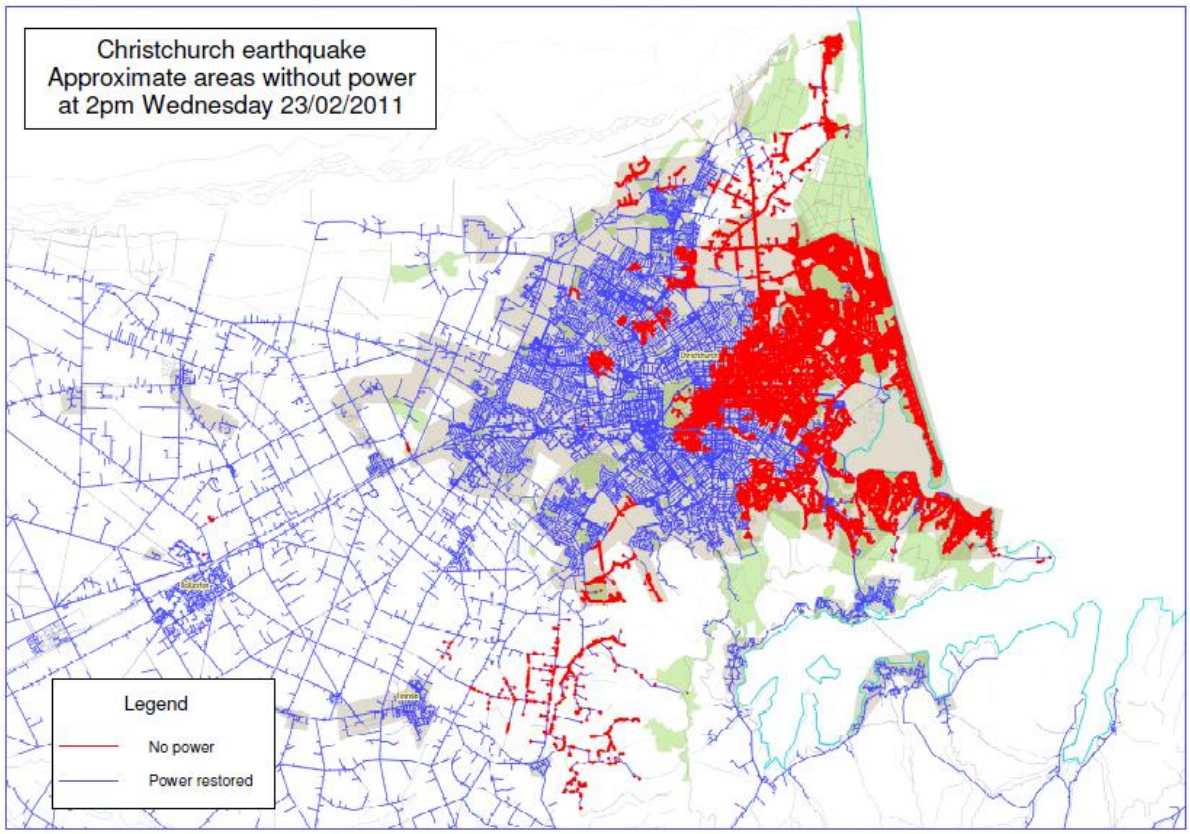

Figure 8: Area with power loss due to the February 2011 earthquake

The following summarises the impacts on assets:

[28] Power was restored to 98 per cent of customers by 12 March.

- ***Zone substations:*** One Zone substation (out of 51) was lost due to liquefaction. This substation was at New Brighton (Pages Road). Muddy water to a level of 0.5 meters entered the substation building.

- ***Other substations (including distribution buildings, kiosks, transformers, switchgear and buildings):*** One Primary / Network substation (out of 300) suffered extensive ground failure (New Brighton Road 111). Two further Primary / Network substations were damaged by rock fall (Wakefield Avenue and St Andrew's Hill). A few of Orion's numerous kiosks moved.

The following Figure shows the benefits of seismic strengthening. The part of the building to the right, where the substation is housed, had been strengthened.

Figure 9: Redcliffs waterworks substation

- ***Underground network:*** Major damage occurred to the underground network. Fifty per cent of 66 kV cables suffered multiple damage. The 66 kV cables supplying the Dallington and Brighton substations failed, including failure of the Dallington footbridge. Damage to 66 kV cables also occurred at Armagh Street. At the 11 kV level, 10 per cent of cables suffered multiple damage. A small amount of damage also impacted LV cables.

- ***Overhead network:*** Again, damage to the overhead lines (including poles) was generally light. Eighty poles moved but none broke.

Orion staff evacuated their main buildings on Manchester Street. Understandably, it appears (based on comments during interviews) that many staff were dazed by the severity of the event. Many were concerned about family and other personal needs. Some Control Centre personnel attempted to resume activity in the damaged building but this was quickly reversed in favour of use of the hot site, notwithstanding its limited size.

Some Orion staff have described the first day or two as chaotic as a balance between electricity restoration and personal needs was re-established in an environment where buildings were inaccessible and aftershocks were continuing. Many Orion staff (and many staff of Orion's contractors) returned to their homes to deal with personal circumstances pending more orderly resumption of activity.

Orion's initial actions were determined by an over-riding concern for public and staff safety. Attention then turned to understanding the nature and extent of damage, focussing initially on the HV network. Electricity was restored quickly where it was possible to safely liven supply, for example, overhead HV lines were inspected from the ground and electricity restored where possible (LV lines were disconnected in many cases pending inspections). Connetics[29] had twelve technician teams doing location work, followed by jointers to fix identified faults.[30] Hundreds of underground cable faults occurred.

Generators were connected to the LV network in areas where they could accelerate resupply. Generators are not as reliable as mains power, raise deployment challenges and are expensive to operate. Nevertheless they often enable restoration of electricity supply where cable repairs appear likely to take much time. Larger generators also proved helpful in supporting capacity in higher voltage situations including at key constrained zone substations.

Some particular issues arose in the CBD. The 66 kV cables failed on both sides of the Armagh Street Bridge, although 11 kV cables serving the CBD survived. It was necessary to disconnect many buildings to facilitate emergency response (search and rescue, and demolitions as identified by CDEM authorities). Cordon access restrictions imposed for safety reasons proved problematic for Orion, a matter mentioned later in this report. Electricity retailers have important roles in managing consumer relationships but it was not possible to manage the huge number of emergency disconnections and Civil Defence instructions while following industry protocols developed for use in normal conditions (Orion informed energy retailers after disconnections had occurred).

Orion established very quickly that a substantial asset restoration programme including new building would be needed to restore electricity. The main new construction included:

- an emergency 3.5 km 66 kV overhead line to supply the existing New Brighton substation at Pages Road, together with installation of a temporary transformer at New Brighton
- a new New Brighton substation on Keyes Road to replace the substation at Pages Road
- a 4.5 km temporary 66 kV overhead line from Bromley to Dallington
- a 1.5 km temporary 66 kV overhead line from Pages Road to Keyes Road

[29] Connetics is 100 per cent owned by Orion.

[30] Connetics also worked on 66 kV repairs, splitting its resources into teams for the purpose.

The design and construction work for these assets was achieved extremely quickly. Approvals for both temporary and permanent lines were issued by the Minister for Canterbury Earthquake Recovery drawing on powers in the Canterbury Earthquake Recovery Act 2011. The emergency 3.5 km 66 kV line was completed in March. Concern about home heating over the winter period was a main driver for very rapid construction and other restoration work.

The following diagram shows the earthquake in relation to other significant events over the last 20 years. Snow storms have been particularly problematic in terms of outages over recent years, the 2010 earthquake substantially eclipses even the largest snow storm (1992), and the 2011 earthquake dwarfs all earlier events.

The question arises; how will earthquake impacts affect Orion's performance in the year to March 2011, and subsequently be accommodated under the Commerce Commission's new price-quality regime?[31] Orion is engaging with the Commerce Commission on these matters. It seems necessary that a sensible arrangement be developed under which earthquake-related operating and capital costs are able to be recovered and Orion's community and results-oriented approach, mentioned earlier in this report, is able to continue.

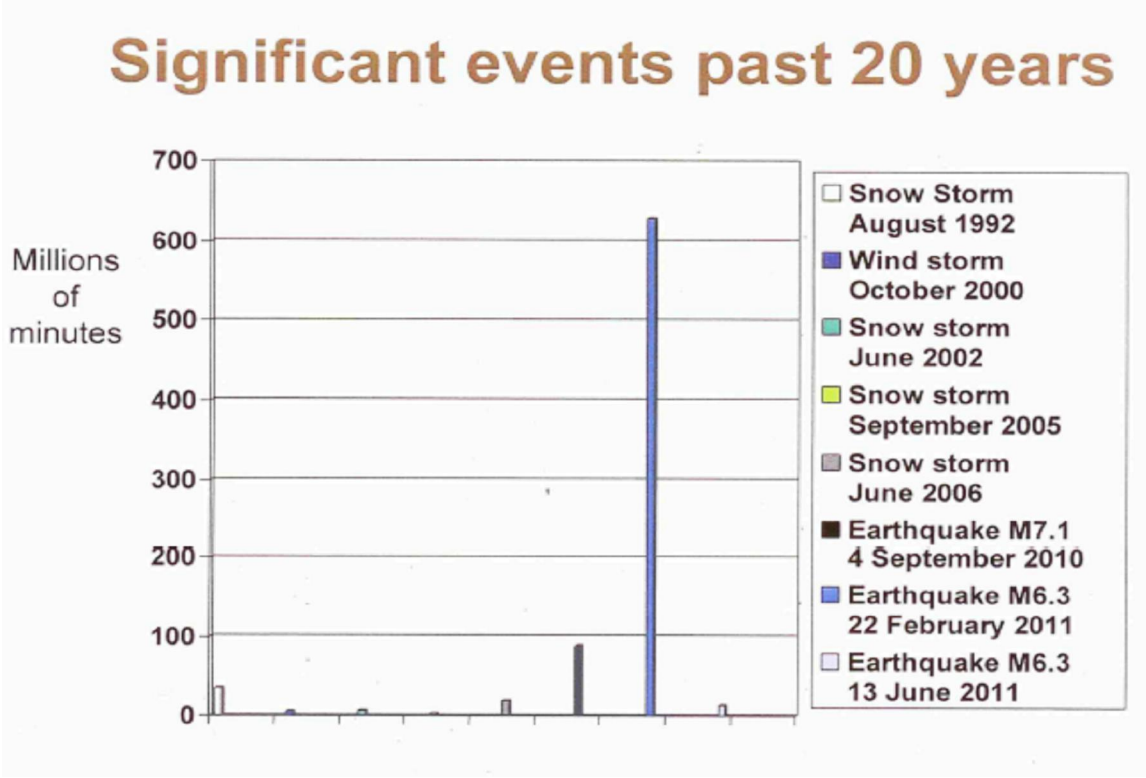

Figure 10: Significant events over the last 20 years

[31] Asset write-downs of $104 million were made in the year to March 2011, due in approximately equal parts to earthquake damage and regulatory requirements.

2.4 Electricity Supply Impacts – June 2011 – and Looking Ahead

Many staff and most contractors commented that the June 2011 earthquakes weren't so damaging. Electricity was restored to 90 per cent of customers within 24 hours and to 99 per cent of customers within 2 days (100 per cent excluding the CBD). No damage occurred to Orion's 66 kV cables.

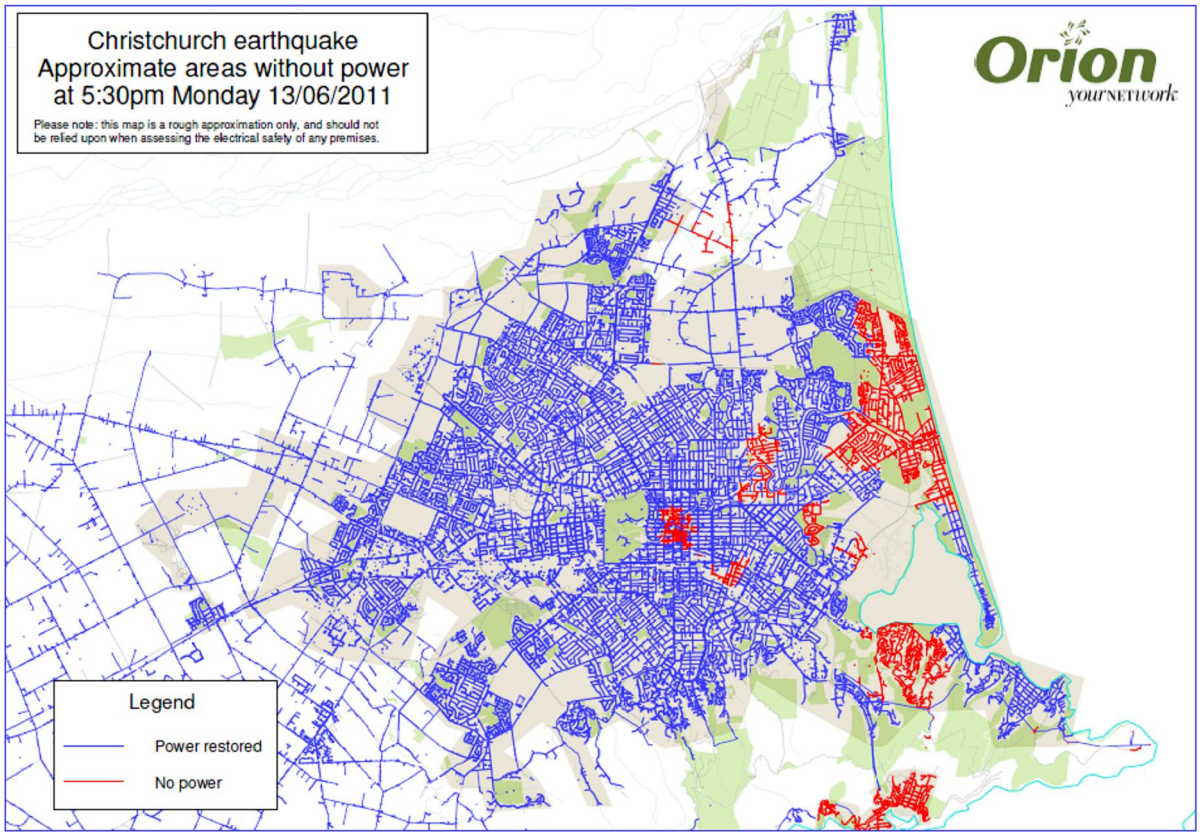

Figure 11: Area with power loss due to the June 2011 earthquake

Orion estimates that the direct network costs arising in June were a little under $4 million compared to over $40 million in February and $4 million in September.

Fault levels have been higher than normal since the earthquakes. Further cable damage may yet be discovered. It is also likely that earthquake damage to overhead lines may become apparent over time, for example insulators cracked by contact with steel pins may fail over years to come.

Looking ahead, a balance will need to be found between longer-term reliability and expenditure on security. It is unlikely that electricity supply reliability will recover to previously favourable levels without a significant ongoing commitment of resources to underground repairs. Aesthetics may also be a factor – overhead cables generally perform better than underground cables in areas subject to liquefaction, and are easier to repair should further earthquakes occur.

Part 3: Learnings and Recommendations

Kestrel interviewed a wide range of Orion staff (mostly in management positions), Orion's line and cable contractors, several larger consumers and some other stakeholders to discuss Orion's earthquake performance and assess possible improvements. The interviews were held in December 2010 and September 2011. The interviewees are listed in Attachment 2. In December, we also surveyed Orion staff (69 survey forms were completed).

The following material and recommendations are drawn from input provided supplemented with information from Orion documents. A summary of the results from the staff survey is in Attachment 2.

3.1 Main Themes

The main themes emerging from these enquiries were:

- The need to pace staff and the value of pauses to promote teamwork
- The value of a fully developed outage management system
- The scope for improvements in contractor management
- The need for improved (and perhaps tailored) communication arrangements with major customers including telecommunications companies
- The need to maintain safety as a top priority despite the pressure of work
- The case for reconsideration of aspects of spares management
- The continued effort to find and put in place further improvements to already-good restoration performance since September,

3.2 Orion as a Learning Organisation

Orion has now had extensive seismic experience since the first earthquake in September 2010. In our September 2011 interviews we sought information on lessons and improvements since the earthquake sequence began.[32]

It is apparent that much has been learnt and that improvements have been made to response and recovery practices. For example:

[32] A "Learning Organisation" is an entity that facilitates the learning of its members and continuously evolves as a result of pressures, enabling continued organisational relevance over time. A learning organisation has five main features; systems thinking, personal mastery, mental models, shared vision and team learning. The concept was developed by Peter Senge in his book *The Fifth Discipline.*

- A range of debriefs have occurred. Because every emergency event is different, it seems appropriate that debriefs look to identify issues at a "thematic" level, be event-agnostic and aimed at forward improvements consistent with Orion's high-level, "plan to plan", approach to emergency response.

- Many improvements have been made to Contact Centre practices where particular pressures occur in emergencies. Further improvements will arise when the Outage Management component of the new PowerOn system is operating (these matters are covered in the following sections). Social media (Twitter) is now used.

- At least some senior managers have developed prioritised check lists for action covering a wide range of specific improvements, with roles and deadlines assigned.

- Many customers, including some major ones, noted that Orion's website was very helpful in communicating key information on network status and plans, and that improvements were made between the earthquakes – amongst other matters this assisted telecommunication companies with generator allocation.

- Communication processes involving contractors were also improved. One contractor, preferring email over other media, noted that emails were passing through mailboxes of individual Orion staff in September (and that these were often monitored only when that staff member was present) but added that this was fixed by February.

- It seems that internal communications improved – in particular the cafeteria has emerged as a location of highly beneficial informal discussion and semi-formal staff briefings.

- A Guide to Disconnections has been prepared following September experience.

- It is evident that Orion (and contractors including Connetics) took steps to manage staff in a way that minimised over-tiredness.

- The integrity of equipment that may have been damaged in September has been re-assessed, for example storage racks at Connetics were re-strengthened and tie downs re-examined.

3.3 Contact Centre

The Contact Centre is in effect Orion's storefront window. It received a massive influx of calls after the earthquakes and remained the focal point for most customer enquires in the following days.

We heard many favourable reports about Contact Centre issues. The value of having the Centre in-house was also mentioned by many.

Contact Centre systems came under pressure immediately following the September earthquake. For example:

- Calls were initially recorded on paper rather than being logged in the computer system.

- Staff unfamiliar with Contact Centre procedures were co-opted to lend support, a transition many found challenging.
- Contact Centre staff felt that they were not sufficiently informed about Orion's rapidly evolving restoration planning and that this impeded their effectiveness.

A number of adjustments to procedures were considered following September and many changes were made by February:

- Steps were taken with Information Solutions to ensure that "nothing leaves the call centre on paper."
- Kits were readied including prompts to support phone staff so that appropriate information was obtained pending an opportunity to update computer records – these kits were inaccessible immediately following the February earthquake but alternatives were developed quickly.
- Improved arrangements are in place for contacting Call Centre staff and "Go-To Person" arrangements have been put in place in the Centre to assist problem-solving.
- Phone messaging was used to advise callers of the status of restoration to particular areas, also noting when advice was to be updated (this supplemented media releases and web-based information).
- Twenty to 30 additional people were rostered for Contact Centre work following the February earthquake but we understand that not all remained in Contact Centre roles over the ensuing days. Further work is planned: Job descriptions are to be developed to promote role clarity including information on work hours and breaks, some training is planned and log-on steps are to be addressed. Ways need to be found to ensure that these arrangements mesh with the Outage Management system to be introduced soon, and are kept fresh for use at short notice.
- Improved arrangements for calling customers back are also planned.

Under present arrangements, some gaps exist in information flow processes between the Contact Centre and other parts of Orion responsible for restoration. Normally, faults are referred by the Contact Centre to the Control Centre. Orion's practice in large emergencies however is to direct LV fault calls to Distribution Services. Data management systems used by the Contact Centre (the "Call Management" system) differ from those in use by Distribution Services giving rise to a need for data to be entered twice. Contact Centre staff also found some information on Orion's restoration difficult to interpret (information was available on the HV system whereas most callers were interested in their connections which were at LV level).

We understand that the new "PowerOn" system should assist with the first of these matters (jobs will be logged once only). Issues relating to the nature of restoration information provided to the Contact Centre (the second issue) are addressed below.

We recommend that efforts continue to further support the Contact Centre's role in meeting customer expectations, that this include ways to manage an influx of staff from other parts of the business, and that a focus be retained on ensuring that the arrangements mesh with the new "PowerOn" system and are kept fresh.

3.4 PowerOn

"PowerOn" is the brand name for Orion's new electricity network management and control system (often called "ENMAC").

Orion's internal September post-earthquake report notes that "*although not complete ENMAC performed very well*." We understand for example that PowerOn greatly facilitated aspects of restoration work. Development of switching rules to enable repairs to be programmed, in the absence of software such as PowerOn provides, has involved days of labour-intensive effort. The task was greatly simplified using PowerOn, materially reducing restoration time (one estimate was that restoration time was halved).

Orion's September internal report goes on to note that "t*he OMS (Outage Management System), yet to be completed, will provide better systems for handling the high numbers of fault calls and provide field crews and management with more accurate information for future events".* The same comment applies to the February earthquake (OMS is currently due in October 2011).

The OMS part of PowerOn contains features that will facilitate identification of areas of the network where outages are aggregating, and of particular network components (e.g. kiosks) where a fault causing observed outages may have occurred. These should also improve restoration performance.

Some changes in data management systems will be needed to ensure that the full benefits of OMS are obtained especially for large emergencies. Consideration will also need to be given to an introductory process and documentation enabling OMS to be initially embedded into Orion systems. We understand that outage simulations and user-friendly documentation are to be developed jointly by the Contact Centre and Distribution Services and we support collaboration of this type.

PowerOn is designed to promote visibility and improve management of the HV system. By contrast, much of the Contact Centre's focus in the earthquakes was on LV outages. Contact Centre staff may need support to enable then to easily respond to customer enquiries in emergencies such as earthquakes where a very large number of LV customers are impacted. Repairs to the network also often require solutions involving LV work (e.g. LV ties). Extending PowerOn to cover LV as well as HV systems seems likely to further improve information and system management performance.

We recommend that:

- introduction of the Outage Management System (OMS) include attention to data management for small, moderate and large emergencies, and that introductory arrangements be designed to meet the needs of all Orion users
- consideration be given to extending PowerOn to cover the LV as well as the HV network.

3.5 Contractor Management

Electricity restoration on Orion's network is largely undertaken by contractors. Connetics and Independent Line Services (ILS) have emergency works contracts.[33] Others such as Power Jointing and Lemacon also have ongoing arrangements with Orion to assist with responses to earthquakes, snowstorms and other outage events.

Following the February earthquake, Orion asked Connetics to manage restoration of the 11 kV work.

Contractors' earthquake experiences, as described in interviews, varied in terms of both their relationships with Orion and their own preparedness.

- The liaison process between Connetics and Orion for managing 11 kV repairs appears to have worked well. Spread sheets were developed and these were shuttled between Connetics and Orion hourly (Orion determined repair priorities).[34]

- ILS consider that arrangements in their case were less efficient. Work requirements were notified by individual emails (some with attachments) – many hundreds of these were received during the restoration period. The process subsequently involves invoicing for each job separately. ILS notes that a spread sheet approach as used in September is preferred from their viewpoint.

- Power Jointing noted that jobs, initially notified by phone and confirmed by email, were often referred (by different Orion staff) direct to crews by phone. The incidence of referrals direct to crews was quite high in September. While the number reduced in February, Power Jointing noted that the issue was never entirely resolved. Direct referrals make it difficult for Power Jointing managers to schedule work, maintain control standards and raise invoices.

In our December interviews, we heard many claims that dispatch arrangements did not always promote efficient outcomes. For example, instances were noted where specific locations were visited several times to address a single fault. Contractors also noted instances where faults were not well described and where inappropriate crews were dispatched (e.g. HV v LV, crane trucks requested but not required).[35]

It appears that fewer concerns of this nature arose following the February earthquake. ILS further noted that despatch coordination improved quite quickly in the days immediately following the February earthquake, reducing the number of kilometres driven and increasing the proportion of crew time on actual repairs. The contractors exercised a degree of licence in grouping jobs to reduce unproductive driving time.

[33] Connetics' contract is for Christchurch city, Canterbury plains and the high country, ILS's is for Banks Peninsula.

[34] Orion noted however that a special arrangement (allocation of a dedicated Orion staff member) was needed to monitor Connetic's progress, information necessary to keep the public informed.

[35] Orion's practice is to maintain lines up to point where they enter customers' buildings. Many of the jobs undertaken by ILS related to barge-board damage at residences and other small buildings.

Contractors expressed varying interest in understanding the wider issues relating to Orion's approach to restoration (broad priorities and other contextual information behind the detailed work orders referred to them). We understand that daily briefings normally take place during emergencies, but that arrangements were uneven between the contractors – they may also have differed between the earthquakes. ILS drew on information on Orion's website but would have preferred more. Power Jointing did not get context information but didn't find the lack to be problematic.

There appear to be material differences in approaches taken by Orion's contractors to their own business continuity. ILS's large generator was used in both September and February.[36] ILS uses radio communications extensively and this medium remained functional after the earthquakes. Connetics did not have access to back-up electricity or communications, both of which were down in February. ILS is proposing to further invest in a secondary "hotsite" from which they could operate, including further communications resilience.

We understand that a "high level" meeting focussing on February events has been held between Orion and Connetics, and that Orion also meets contractors monthly mainly to discuss current work programme issues. There may be a case for extending the agendas to enable a clear focus on emergency response matters (experience and intentions) at least over the coming few months while experience remains fresh and aftershocks continue.

We recommend that steps be taken with all contractors to facilitate identification and consideration of emergency response matters such as job referral processes and business continuity.

Emergency response can sometimes draw attention to scope for ongoing process improvements. Power Jointing noted that the electronic access to maps ("web maps") agreed in February will assist ongoing efficiency (previously these were available only on case-by-case request). ILS also noted that ongoing access to network plans assisted their work.

3.6 Mutual Aid

Orion is a party to the standing mutual aid arrangements in electricity distribution. The mutual aid agreement, under the auspices of the Electricity Networks Association (ENA), sets out objectives and administrative / logistical arrangements under which assistance from other New Zealand Line companies may be requested in civil defence and other emergencies.

It was not necessary to call on mutual aid support in September although offers were made.

Following the February earthquake, assistance was initiated between parties to the agreement. Orion first made approaches to a range of companies large enough to provide both support and own systems for rotating significant staff numbers. Twelve of these supplied resources. The request was then extended to other line companies.

[36] In February, ILS's generator also supplied a nearby caterer, enabling needed food supplies for ILS's and others' repair crews.

Mutual aid was also initiated separately by the ENA. To aid coordination, Connetics advised ENA of the nature of the requirements and asked that enquiries be extended to Australia. Two groups (cable jointers) were sourced from Australia as a trial.

Mutual aid brought benefits and challenges. Three controllers from WEL Networks made a strong contribution to the coordination effort, once initiated. Orion asked Connetics to handle the challenging accommodation and other logistical issues arising from the broader influx of personnel. Significant issues relating to accommodation (mostly motels), food (including 250 lunches per day for consumption at repair sites), PPEs and the like needed to be addressed. Around 40 companies came to help, by far the largest mutual support exercise of its type ever seen in New Zealand. All together, 700 workers were involved.

Orion / Connetics has demonstrated that it is large enough to handle moderate to large natural hazard events and also that they have the scale to manage a resource influx for the very large ones. However, the experience draws attention to questions of role clarity relative to ENA. There will no doubt also be other learnings for mutual aid arrangements including logistics.

We recommend that Orion's / Connetics' experience be written up, in conjunction with the Electricity Networks Association, for future reference and consideration in the context of development of the mutual aid arrangements (including HSE angles – see next section).

3.7 HSE Issues

HSE issues fall into one of two categories, maintenance of general safety standards, and vulnerability to earthquake hazards.

- Connetics notes that HSE inductions were undertaken for incoming crews, drawing attention to earthquake-related hazards (e.g. hazards from nearby weakened structures, weakened poles, cavities under road surfaces, weakened bridges and approaches). In addition, most incoming crews were supervised in the field by a Connetics staff member.
- ILS undertook specific staff briefings (in open space outside the office building) following the September and February earthquakes. In addition, ILS inoculated staff against hepatitis A and C. At Orion's request, ILS staff participated in on-the-ground inspection of a line to Lyttelton immediately after the February earthquake – the inspection was free of mishap although a member of the public was killed by rockfall in the same area a few days later (this was not an electricity-related incident).
- Power Jointing conducted safety briefings that are understood to have been relatively informal (in September, Power Jointing also withdrew staff in consultation with Orion when sewerage started seeping into trenches around the Rawhiti Domain sub-station currently under construction).

More generally, electrical safety rules in New Zealand are common to all qualified industry personnel (safety is regulated) although we understand that Orion follows some additional procedures that may be less widely known to incoming crews. Power Jointing for example noted that general (i.e.

non-earthquake-specific) procedures are well understood by staff who generally have electrical qualifications. However, standard "operating order" processes normally followed in Orion work, which involve many time-consuming steps,[37] were often not followed given the extent of sudden work involved, possibly creating a safety vulnerability.

It does not appear that there additional requirements were placed on contractors with respect to safety and knowledge of hazards beyond that covered in the Emergency Works Technical Specification NW72.20.03 and in Emergency Works Contract Appendices. These relate to HSE workplace hazards, with Appendix 3 of the Emergency Works Contract providing specific workplace safety expectations. The use of wet weather gear is mentioned but not environmental hazards that may give rise to emergency works e.g. working in snow, or hazards related to unstable ground such as landslides and earthquakes.

We recommend that Orion discuss HSE issues with contractors with a view to improvements (improvements could be documented in Orion processes, the mutual aid agreement or referred to regulators if significant issues are identified).

3.8 Spare Parts

Connetics maintains a store of spare parts for Orion's emergency use at its site in Chapmans Road, Woolston. Connetics also holds its own spare parts for day to day use and supplies cable to other contractors from the site. Further, ILS has some spares at its site two doors along Chapmans Road.

Many spare parts are imported and delivery delays need to be (and are) taken into account in spare parts management decisions.

In emergencies, spares may be obtained from other line companies but compatibility issues arise (New Zealand line businesses do not all use the same parts). Following the February earthquake, for example, a need arose for Magnefixes (11 kV switches commonly used in kiosks and substations) and 90 were made up at short notice (only a few New Zealand line businesses use these). Further, only a few jointing kits were on hand but additional kits were quickly obtained with the cooperation of the Auckland supplier and the German parts manufacturer (the German company undertook a special production run to meet the order).

Chapmans Road is vulnerable to natural hazards. The ground may be subject to liquefaction and the area may also be vulnerable to tsunamis. There was potential for earthquake damage to have isolated Orion's spare parts held at Connetics' and ILS's sites through road damage and through physical damage to the facilities that house them.

We heard that Connetics yard was not generally open during the period immediately following the September earthquake. This meant that contractors needed to make special arrangements for access, resulting in some delays and confusion.

[37] Several days are involved in prior approval of operating orders for work considered high-risk.

The pallet racks holding Orion's spare parts provided adequate protection in September but signs of stress on the cross-bracing cables was evident following that earthquake. Storage racks were re-strengthened and tie downs re-examined following September.

BRANZ has recently issued a Guide for Seismic Design of Storage Racks[38]. Although mainly intended for systems accessible to the public, the BRANZ guide may prove useful in assessing Orion's present storage systems.

We recommend that Orion reconsider aspects of its spare parts management taking into account location, delivery timing (both from alternative New Zealand sources and overseas suppliers) and storage rack design.

3.9 Premises

Orion's two Manchester Street office buildings, although not up to standards expected for Lifelines, survived the September earthquake.[39] In February when the buildings were damaged and not suitable for ongoing use, Orion was fortunate to be able to relocate its staff and functions to another building on the Manchester / Armagh Street campus (200 Armagh Street, see Figure 12).

A structural engineer inspected Orion's main buildings including the office buildings immediately following the earthquakes. Structural engineers are in high demand following large earthquakes and securing priority agreements (pre-event) for emergency work warrants consideration by all infrastructure providers. The ability to assure rapid damage assessment of structural assets enhances both the safety of staff and assists with service resumption.

[38] Beattie, G., Deam, B.. *Design Guide - Seismic Design of High Level Storage Racking Systems With Public Access.* Branz. 2007. viewed 5 February 2011. http://www.branz.co.nz/cms_show_download.php?id=0e49e1b30b4b9967c4493a8648d226d14d506e43 . Appendix "recommendations for Store Operators" is of particular relevance.

[39] AS/NZS 1170 Part 0, Table 3.2 categorises structure design load levels according to the Importance Level (IL) of the function of the structure, including post-disaster functions.

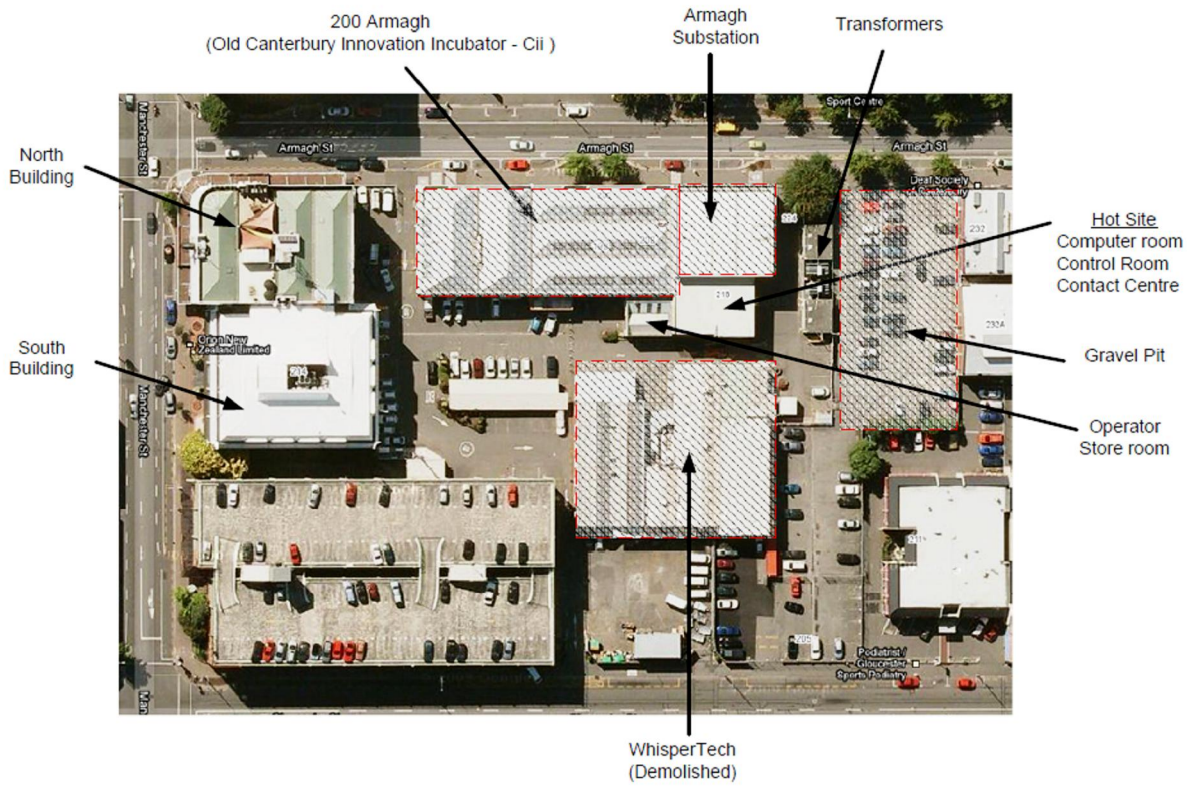

Figure 12: Orion's campus on the corner of Armagh and Manchester Streets

Armagh Street runs east-west along the top of the figure. Manchester Street runs north-south down left side. The east-west street at the bottom is Gloucester Street.

Orion's hot site, also located on the campus, was too small and under-equipped for earthquake response purposes. It was designed to accommodate a Control Centre, computer room and Contact Centre in a "business as usual" event impacting Orion only, rather than for a wide emergency when substantial increases in inward calls and response activity occur. Quick arrangements were made for expansion into adjacent rooms.

The Manchester Street office buildings remained standing but unusable at the time this report was prepared (September 2011). However, the WhisperTech building was badly damaged and was quickly demolished. The sizeable area is now taken up with Portacom buildings allowing for overflow from 200 Armagh Street.

For the longer term, a new building is under consideration, providing an opportunity to ensure that all critical functions are adequately protected, i.e. housed in a post-disaster facility designed to Importance Level 4 requirements under the national loadings standard A/NZS 1170 Part O.

A decision on location of a new building will need to take into account ground conditions, wider city planning considerations, diversity relative to other Orion-related facilities (e.g. spares storage), emergency access and staff recruitment / retention. The cafeteria arrangements 200 Armagh Street have promoted informal discussion and facilitated semi-formal staff briefings, and appear to have

been very well received by staff and managers – arrangements like this should be incorporated in the design for new premises.

In the meantime, Orion has invested in a portable data centre to help ensure continued network operation and control (the existing system was in a damaged Manchester Street building although it remained functioning for a period). Orion is also planning an ethernet ring around Christchurch to enable the locations of key functions to be separated, reducing or eliminating exposure to hazards that might compromise the entire present Manchester Street / Armagh Street site.

We recommend that Orion take fully into account the approaches set out in the national loadings standard A/NZS 1170 Part O in considering future premises needs.

3.10 Telecommunications

A very heavy reliance on mobile phones and related cellular equipment was noted in the interviews. Most Orion staff including staff in the field, and most contractors, rely extensively and increasingly on this technology for voice communication and various types of data transfer.[40] Orion maintains radio links – these were helpful following the earthquake but they were often congested.[41] Radio is at best only a part substitute for mobile phones as it lacks the ubiquity that phones offer.

Looking further afield, Transpower also notes a reliance on cell phones. Infrastructure providers and other societally important users in sectors beyond electricity similarly report heavy and increasing reliance on cell phones.

For their part, there is an increasing reliance on electricity by telecommunication companies for functioning of their services including mobile phones. Batteries and generators are increasingly available and deployed, but telecommunications' reliance on mains electricity nevertheless appears to be on the increase. Typically the demand is in the LV network, where electricity restoration must await HV repairs.

There was little physical damage to telecommunications infrastructure in the earthquakes. A few cell towers were affected especially in February but not generally to the point that performance was impacted. There were no major cable or exchange failures. However, a very substantial increase in calls occurred. Cellular systems quickly came under pressure in areas where electricity supply was disrupted.

After both the September and February earthquakes, strong response measures were required by the telecommunication companies to maintain electricity to mobile and other telecommunications sites. Generators took some of the load but caller demands quickly eroded battery life at other locations. Around 200 generators were used in February, and Vodafone needed eight people working 12 hour shifts to keep their generators refuelled in the days immediately following that

[40] Examples: Job notifications to contractors, remote access to Orion records, and new "mobile management" devices under development as part of PowerOn.

[41] Connetics commented that their radio link to Orion is often congested even in non-emergency (business as usual) conditions. Orion's UHF and VHF radio systems are backed up with an emergency generator and UPS.

earthquake. Generator deployment and refuelling were greatly facilitated by fuel availability[42] and relatively easy road access to sites, but it may have been difficult to maintain mobile coverage even in these favourable conditions had electricity outages been longer.

Electricity and telecommunications are often regarded as the two most important Lifelines for post-emergency restoration. The interdependencies between these two (and, in a back-up role, roading and fuel supplies) are a point of social and commercial vulnerability. Telecommunications stands out amongst infrastructure as being the only sector where large sudden increases in demand occur in emergencies. Increasing use of cellular systems for emergency response and recovery coordination implies that cellular reliability is a key concern.

There is a need for improved understandings about system design and performance expectations between electricity distributors and telecommunication companies. On both sides, performance expectations appear to be greater than readily achievable performance levels. A brief workshop has been scheduled in November 2011 at which these matters can be explored further.

3.11 CDEM Relationship

The Director of Civil Defence Emergency Management (who was also the National Controller in the Christchurch Response Centre (CRC) following the February earthquake) considers Orion to be an exemplar of good emergency response, revealing good preparation and organisational capability, and recognising the resilience of the network itself. The Director also noted that Orion's CEO offered a good early description of network status together with an outline of what would be involved in restoration. Assistance from Civil Defence Emergency Management (CDEM) was not required other than for approval of new lines. The Director noted that the Resilient Organisations Research Group has developed descriptive tests for organisational resilience, adding that Orion clearly meets these standards.[43]

The extent of cable damage in the eastern areas of Christchurch in February left Orion with no realistic option other than to quickly install new overhead lines (mentioned in section 2.3 of this report). CDEM officials facilitated the necessary approvals were granted quickly by the Minister for Canterbury Earthquake Recovery.

Much of the interface between Orion and the CRC appears to have taken place at CEO level, especially in February. A separate review on how the CRC performed in relation to Lifeline coordination generally is underway – a preliminary conclusion is that involvement of the Lifeline Utility Coordinator (LUC)[44] desk was uneven across the various infrastructure sectors. It is possible

[42] Initial difficulties experienced in obtaining fuel were quickly overcome following the earthquakes. Bulk supply resumed quite quickly. Orion's contractors benefitted from normal supply arrangements, favourable access to lanes at some service stations. *Ad hoc* fuel supply arrangements developed at the time also assisted.

[43] The Resilient Organisations Research Programme is based at the University of Canterbury. The three hallmarks developed by Programme members are management of keystone vulnerabilities, situation awareness and adaptive capacity.

[44] Lifeline Utility Coordinators staff the desk on a rotation basis. The role is to liaise between infrastructure providers and the relevant emergency operations centre during response periods. They assist with information flows and requests for support.

that the Ministry of Civil Defence & Emergency Management (MCDEM) will address this matter in its forthcoming work programme.

Orion staff and others had differing perspectives on the effectiveness of civil defence emergency management response following the two earthquakes. Much of the differences related to CBD cordon management. Special cordon needs arose for Orion – much Orion work was required in the CBD which gave rise to a need for access by field staff and contractors, and Orion's premises are inside the CBD which gave rise to a need for office and support staff to enter the cordoned area to undertake emergency-related office roles.

Little difficulty was experienced in setting up the needed cordon access arrangements in September – special arrangements were quickly agreed and all cordon entry points notified within four hours. However, it proved much more difficult to set up satisfactory arrangements in the weeks following the February earthquake – it seems that working relationships between CDEM, Police and Army personnel were unsatisfactory (inflexible) to the point that response and recovery objectives were compromised (cordon access arrangements changed frequently over the post-earthquake weeks). A person who handled much of the LUC work in the CRC noted that there appeared to be no way to contact the relevant decision-makers / command structure so that the issues could be addressed.

Issues also arose relating to demolition management in the CBD. Some demolition works commenced following the September earthquake without first isolating electricity. While there may have been some initial frustrations following the February earthquake, we understand that Orion handled demolition arrangements well including advising the CRC about transformer locations that might not have been obvious to demolition crews.

Issues relating to cordon access and demolition management were also of concern to telecommunication companies. These companies are taking steps to draw the issues to MCDEM's attention for further work.

We recommend that Orion write to the Ministry of Civil Defence & Emergency Management to add its concerns about cordon and demolition management, so that cordon management takes the needs of infrastructure companies and their contractors more effectively into account in future events.

3.12 Customer Relationships

Orion takes a pro-active role in managing relationships with all connected customers.

Customer relationships in emergencies are handled through the Contact Centre, Orion's website, Twitter, and active use of the media.

Media and related communication initiatives were initiated very early by Orion after both earthquakes. The messages provided reassurance to customers, no doubt significantly limiting the number of phone enquiries received. The role taken by the CEO in communicating public messages successfully allowed other staff to carry out other emergency roles.

Orion expects major customers to communicate through their commercial account manager relationships in normal conditions, and, in the first instance, in emergencies too. Some major customers have expressed a preference for tailored arrangements that they consider might better

meet their own and Orion's needs. The Port, for example, notes that the nature / size of its connection with Orion's network calls for a degree of coordination when the Port network is disconnected and reconnected, and would prefer 24/7 telephone communication arrangements direct with Orion's Control Room.

Telecommunication companies have differing perspectives on their emergency relationships with Orion. In September, Vodafone reported a good relationship including twice-daily phone calls (Vodafone noted the value of Lifelines in fostering personal contacts). Chorus however reported some difficulties in making contact with Orion in September. We understand that communication between telecommunication companies and Orion raised fewer concerns in February.

Other significant customers have particular needs. The Ministry of Education for example expressed a wish (following the September earthquake) for firm arrangements for site-specific supply information relating to their many schools (about 180) and early child education buildings (they need to meet regulatory heat and light requirements especially for the latter, numbering just over 400). In their case, the numerous information needs are local but the unified supply contract is with Wellington head office.

While there may be some concerns in these areas, we understand that Orion's website and other information meet most customer needs adequately. It may be appropriate for issues to be explored further in the six-monthly seminars for major customers or bilaterally (with selected customers) as part of the ongoing commercial relationship.

Part 4: Concluding Comments

Orion actively integrates risk management and emergency preparedness into its management approach, treating them as core business. A longstanding commitment to resilience served Christchurch well following the 2010 and 2011 earthquakes. Investment in seismic mitigation, integration of emergency management responsibilities into day-to-day management, and building a security conscious workforce were all vital to electricity restoration that was rapid and effective given the damage that occurred.

Orion's approach features continued improvements to meeting customer expectations, in particular by identifying and undertaking work that improves resilience so as to minimise economic impacts caused by outages. The approach reflects both commercial drivers and its strong sense of corporate responsibly. A feature has been that the mitigation effort has been systematic and sustained over time.[45]

Since publication of *Risks and Realities*, Orion has invested in network resilience, learning from the lessons of events such as the 1987 Edgecumbe earthquake as well as from engineering and geotechnical assessments. Seismic strengthening costing $6 million is estimated to have saved Orion $30 to $50 million in direct asset replacement costs. This mitigation work was highly effective in limiting damage in the earthquakes – very little major or structural damage occurred to any of Orion's 314 substations, although a small number suffered from ground failure particularly in February. Underground cables were extensively damaged by ground failure. Very rapid installation of a new line from to the New Brighton substation enabled electricity restoration large affected areas.

The financial benefits of the seismic strengthening programme have substantially exceeded the implementation costs. The balance between costs and benefits is even more pronounced when societal benefits (i.e. gains to the community that don't appear in Orion's accounts) are taken into account. From a national policy viewpoint, Orion has been highly effective in the way it has integrated resilience into its evolution since the electricity reforms of the early 1990s.

Orion, being the third largest line business in New Zealand[46], has much of the size needed to support rapid supply restoration. A sizeable management team was able to handle the many new pressures that arose. Orion staff were able to be reallocated to business areas where sudden needs were identified. The question arises: Is there a size below which electricity distributors' capacity could inhibit community recovery through delayed electricity restoration?

[45] It is noteworthy that Orion's board receives presentations throughout the year on key aspects of the AMP, an approach enabling systematic review of asset management.

[46] Measured in terms of asset values, circuit length and number of connections.

1998 Auckland Power Supply Failure

The 1998 Report of the Ministerial Inquiry into the Auckland Power Supply Failure[47] had this to say:

- *"An essential feature in the management of risk in network companies is a strong corporate structure, with effective checks and controls arising from the interaction of the owners, the board and the executive of the company.*
- *In a network company with monopoly characteristics serving the public, security of supply is a vital objective.*
- *Under effective corporate governance, a network company will give first emphasis to the maintenance of the core business, which is distribution of electricity to consumers.*
- *The preservation or enhancement of security of a network should be ranked ahead of expansion onto other areas outside the company's primary customer base."*

Orion appears to meet these tests.

Orion's approach to emergency planning is to keep documents at a high, principle-focused, level, relying on trained and motivated staff to make sound decisions once the nature and extent of the emergency is known. This approach appears to have worked well following the earthquakes. We heard of many sound restoration-oriented initiatives by staff and contractors, many of them taken "on the fly". These included:

- focussing on HV issues – HV restoration was managed by Orion Control Room directly leaving LV crews to be managed by Distribution Services working with Connetics (Orion, September and February earthquakes).
- Repair crews were quickly assembled and tasked in ways designed to meet the needs of the situation (contractors, September and February earthquakes).
- restoration task allocation between two key staff, one to focus on the CBD and the other on residential areas (Orion, September earthquake).
- a contractor sought additional resources (e.g. from Arbor-tek to enable use of bucket trucks) without mandate from Orion (a contractor, September earthquake).
- work was done on telecom and electricity poles at the same time (an efficiency measure) without works orders (a contractor, September earthquake).
- The value of pauses and time-outs was noted by several senior Orion managers, including those who commented favourably on the regular meetings between senior staff fully engaged on intensive operational work – these meetings provided a welcome opportunity

[47] *Auckland Power Supply Failure 1998, report of the Ministerial Inquiry into the Auckland Power Supply Failure,* Ministry of Commerce.

for identification of key issues and for development of media messages (Orion, September and February earthquakes).

Orion's public communication was effective. Regular position statements were particularly helpful in managing expectations. The community was unified by the general earthquake experience enabling the statements to present Orion as a key community response contributor. Many unsolicited favourable comments were received from the public. The public relations challenges would have been much greater if the outages were due solely to failures within the electricity system.

The CEO at the time, in the course of a conversation in September 2011, noted that Orion assumed after the first earthquake that "matters can't get much worse than this". It may therefore have come as an unwelcome surprise that a much more serious event could (and did) occur. Orion's ability to respond well to the more destructive event is evidence of a capacity to adapt to new circumstances, a hallmark of resilient organisations.

The earthquake may have shortened the life of some underground and overhead assets. Some functioning components of the underground network are likely to have been affected by ground movement (in restoring September damage it was noted that protection around 66kV cables had been compromised and that some were placed under tension). Insulators in overhead lines may have been weakened and may fail over years to come. Weaknesses left from the earthquakes thus seem likely to be reflected in increased failure rates in years to come. Much more work will need to be done to restore reliable electricity supply and a balance will need to be found between longer-term reliability and expenditure on security.

Orion's recovery performance needs to be seen in a wider context. The September earthquake occurred outside working hours. Staff were generally able to quickly assess family needs and home condition, in many cases facilitating early reporting for duty. Because of the timing of the February earthquake (during working hours), and due to transport and communication difficulties, it took a little longer for staff to check on family circumstances on that occasion – for this reason, and more significantly because of the much more disruptive nature of that earthquake, commencement of restoration activity took a little longer in February than in September.

The performance of other lifelines after the earthquakes was less than normal, but was generally sufficient to support recovery of electricity and other services. Telecommunications performed adequately following the earthquakes (patchy cell phone coverage improved quickly after two or three days) enabling Orion to communicate readily with staff, contractors and others throughout the restoration process. Roads remained generally accessible and petroleum supplies were available, facilitating access around the network and generator use.

Orion is an example to other lifeline utilities in terms of its commitment to resilience. The benefits from risk mitigation are clearly demonstrated. A commitment to continued work of the type undertaken in the past, together with a substantially increased capital works programme, will enable a return to reliability and strengthen Orion's ability to deal with future emergencies.

Attachment 1

ORION STAFF SURVEY: MAIN POINTS

Following the September earthquake, Kestrel conducted a survey of Orion staff to identify issues relating to Orion's performance and communication from their perspective.

Survey questions were compiled in consultation with Orion. All Orion staff were invited to respond and 69 responses were received. This Appendix describes the main, high-level, survey results.

The September earthquake occurred in the early hours of a Saturday morning. Most staff would have been at home. The Orion workforce was probably generally affected by electricity loss to the same extent as Christchurch overall.

This report notes that Orion made many improvements following the September earthquake. It is possible that many of the issues identified below have been addressed.

Survey Results

A very large number of respondents recognized that they would be needed at work. Just over half of those who completed the survey came to work on 4 September, with the majority coming in of their own volition. Many of them were concerned to ensure family security and some were concerned about home security. Workplace safety and travel safety were also mentioned as issues taken into account in deciding whether to come to work.

Others were advised or believed that they were not required – this was the main reason for not coming in. Many noted that they were needed to meet the needs of family and/or attend to other home-related matters (aftershocks were a concern). Some were logistically unable to come in.

The reason many came to work was that they believed that they had skills that were urgently needed. For those with a family who came into work, being able to stay in contact with family was a very high concern.

Over half of those who came to work on 4 September performed work other than their normal work.

Although initially there may not have been sufficient staff working in all areas to meet response needs, respondents indicated that this was remedied as the response developed. The majority of respondents said the earthquake created added difficulties in completing tasks, two thirds of these were earthquake-specific and one third was due to increased activity levels. Innovative ways were developed to help teams achieve objectives.

The balance of response-focused vs. normal business-focused personnel appears to have taken some time to equilibrate but it seems that a balance was achieved. The majority of respondents believed that their teams performed as expected or better than expected. The majority of respondents considered that they were sufficiently trained for the emergency response requirements of their job or believed that they did not require emergency response training for their job.

Responses indicated that communication regarding strategic direction was an issue and 35 per cent of respondents said that they were inhibited in their ability to carry out tasks by difficulties in accessing information. However, Orion's internal communication appears to have been sufficient to meet needs of the majority of respondents. The areas respondents noted for improvement included clarity and frequency of information, and information about Orion's approach and progress relative to CDEM recovery generally.

A number of areas were listed where further training should be considered. These included issues relating to staff communication with the public, priority setting, and a range of operational matters.

Of those managers who used Orion's emergency management documents, two thirds thought that the plans met their needs, were current and easy to use. Staff suggestions included reviewing documents, e.g. to ensure that they are up to date, to test their applicability to sustained events and to see that they adequately cover issues such as roles, responsibilities, reporting and records. One staff member however noted that the plans are generic to emergencies arising from a number of causes, that specific emergencies have their own characteristics and that plans should be regarded as a principled approach statement. Some staff suggested ways to improve access to the plans.

Respondents believe Orion is better prepared and performed better than other infrastructure providers. Responses generally indicated pride in the organisation and an enthusiasm for improving Orion's performance.

Overall, respondents believed the public were kept (including major customers) well informed although clarity of information and information about Orion's restoration strategy appeared to warrant further consideration.

Attachment 2

INTERVIEW LIST

Thanks are due to the following persons interviewed during preparation of this report.

Orion Personnel	
• Roger Sutton	December 2010
• Rob Jamieson	December 2010 and September 2011
• John O'Donnell	December 2010 and September 2011
• Shane Watson	December 2010 and September 2011
• Stu Kilduff	December 2010 and September 2011
• Darryl Hodgson	December 2010 and September 2011
• Brendan Kearney	December 2010
• Colin Wright	December 2010 and September 2011
• Dayle McDrury	September 2011
• Craig Kerr	December 2010 and September 2011
• Susie Hamilton	December 2010 and September 2011
• Anthony O'Donnell	December 2010 and September 2011
• Merv McKay	December 2010 and September 2011
Contractors	
• John Goodenough - Connetics	December 2010 and September 2011
• Danny Vis - Power Jointing	December 2010 and September 2011
• Matt Southorn - ILS	December 2010 and September 2011
• Garry O'Malley - Lemacon	December 2010
Consumers	
• Mark Christison - CCC	December 2010
• Mike McGlinchy - Port	December 2010 and September 2011
• Coralanne Child - MinEdu	December 2010
• David Reason - Telecom	December 2010
• Colin Foster - Chorus	December 2010 and September 2011
• Julie Rae - Mobil	December 2010
• Matt Williams - Airport	December 2010
• Pete Anderson - Vodafone	December 2010
• Evan Smith – Riverside Community Group	December 2010
• Tom Taylor - Halswell Residents' Ass'n	December 2010

Others	
• Anthony Merritt - Commerce Commission	December 2010
• John Hamilton – Director of Civil Defence Emergency Management	September 2011
• Murray Sinclair – CCC CDEM	December 2010
• Mark Gordon – CDEM / LUC	December 2010
• George JasonSmith – CDEM LUC	September 2011
• Gideon DuToit - Transfield (Transpower)	December 2010 and September 2011
• Russell Thoms - Marsh (Insurers)	September 2011
• John McKenzie	December 2010 and September 2011
• Margot Christeller - CERA	September 2011
• John Lamb – Manager of the *Risks and Realities* project (mid 1990s)	December 2010