Westland District Council Lifelines Study

Alpine Fault Earthquake Scenario

Westland District Council

June 2006

IMPORTANT NOTES

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Earthquake Hazard Maps

The hazard maps contained in this report are regional in scope and detail, and should not be considered as a substitute for site-specific investigations and/or geotechnical engineering assessments for any project. Qualified and experienced practitioners should assess the site-specific hazard potential, including the potential for damage, at a more detailed scale.

Westland District Council Lifelines Study

Alpine Fault Earthquake Scenario & Lifelines Vulnerability Assessment

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Cover photograph:

State Highway 6 at McCulloughs Creek. The road climbs onto a fan from Parker Creek and runs virtually along the Alpine fault trace, which comes into the photograph from the left within the bush. Beyond Parker Creek, the fault crosses the Whataroa River to the right and re-crosses SH 6 again, a few kilometres north of Whataroa Township.

EXECUTIVE SUMMARY

Introduction

This report was commissioned by the West Coast Engineering Lifeline Group. It has been written specifically for Westland District Council engineers and managers, and Councillors. However, it also contains material that is relevant to other lifeline operators on the West Coast along with those involved in CDEM.

The aim of the report is to raise issues and make recommendations as to what should be done to make the Council and hence the community better able to withstand the effects of a major earthquake disaster and to recover from it more effectively. However, the consultants have not carried out a formal risk analysis. Hence, the report identifies issues that are important, but prioritisation has not been defined in detail. To have done so would have required a more extensive analysis involving quantified risks, which would have needed a far more detailed investigation of earthquake hazards, frequencies and consequences.

It focuses primarily on lifelines; the network services of water, sewage, transport, power and communications which are essential to the functioning of a community. The report provides:

- Recommendations for improving the resilience of specific lifelines;
- Recommendations on things that need to be addressed, particularly where different lifelines and organisations have mutual interdependencies; and
- Recommendations on broader issues such as leadership, and suggestions for ways forward in this area.

The report uses an Alpine Fault earthquake scenario as a tool for, and as a means of, identifying important issues. The scenario is quite precise about what happens but it is still only a speculation on what might happen. It is NOT intended as a prediction of what would actually happen in an earthquake. An actual earthquake might be worse, or less severe, or significantly different on some way. The scenario is developed and used in this report for two specific purposes. Firstly, it provides a means of producing a checklist of what needs to be done to improve community resilience. Secondly, the scenario is presented to assist those responsible for infrastructure assets to perceive a broader picture that allows them both to imagine how their particular system fits into a much wider setting, and also to see how interdependencies between services might affect their own.

The Alpine Fault earthquake was chosen because there is a high probability of it occurring within the next few decades, and because it will be the most devastating natural event likely to affect not just Westland district, but the whole of the West Coast and adjoining regions. Although some of the things we have said do indeed relate specifically to earthquakes, nevertheless the general points we have made and also many of the detailed recommendations will apply to any large disaster.

Alpine Fault Earthquake Scenario

The direct effects of an Alpine Fault earthquake on the district are likely to be serious for the following reasons:

- It will have by far the greatest impact on Westland District than any other natural event and certainly any other earthquake, as the Alpine Fault runs virtually up the centre of the whole length of the district.
- It will certainly occur at some stage, and has a high probability of occurring within the next 50 – 100 years.
- It will affect not just the West Coast but also the whole of the central South Island, including all the main transportation routes, and therefore brings in issues relating to the wider geographical setting of the District.
- It is the same scenario used for the Buller District and Grey District Lifeline studies. It will have the greatest overall impact on the West Coast region as a whole and therefore this scenario provides the best regional overview.

The Alpine Fault runs the entire length of the district, but for the purposes of the scenario presented in this report, a rupture is assumed to start at Paringa, 125 km north of the southern boundary to Westland District. The whole of the district, which all lies within 30 km of the fault, will be strongly shaken, particularly as the earthquake is expected to be a particularly long duration earthquake.

The earthquake will result in:

- Ground rupture destroying buildings, roads and railways on or crossing the fault;
- Shaking damage to buildings, bridges and infrastructure;
- Landslides, particularly in the MM VIII and IX zones and in the mountains, are expected to be extensive, with some of them likely to create dams across rivers. Landslides are not expected to impact directly on urban areas to any significant extent, but will cause major damage to roads;
- Liquefaction in sandy areas within river valleys, in low swampy ground, and the coastal strips, particularly the estuary and river margin areas; and
- Seiches (water waves generated by seismic oscillations) would be produced on Lake Kanieri and the other smaller lakes.

Indirect and longer-term impacts will result from the large volumes of landslide material entering rivers, particularly those with catchments in the Southern Alps close to the fault. The increased sediment load will result in high river water turbidity, river aggradation and channel avulsion with implications for drinking water quality, river control, stop banks, and bridges. Ongoing difficulties with these effects may make it impracticable to rebuild SH 6 south of Franz Josef for some years.

The Alpine Fault earthquake scenario presented in this report affects the Westland District infrastructure as follows:

Transportation: Most roads in the District within about 10 km of the Fault are effectively closed due to landslides, destruction of the road surface or damage to bridges. The District remains isolated from other centres on the West Coast for the first 48 hours and it is almost a week before any transport can reach Hokitika from Nelson. Fuel shortage becomes a concern. In South Westland, extensive landslides and bridge damage effectively cut the district into a series of isolated areas. An optimistic scenario has road access re-established over Arthur's Pass after 7 months, to Haast (over the Haast Pass) after 3 months, to Harihari after 2 months, Franz Josef after 4 months and Fox Glacier after 9 months. The Hokitika airport is largely undamaged and can be used almost immediately. Railway lines are damaged in many places with severe damage on the Midland Line, and because of the anticipated ongoing debris flow hazard it is assumed in this scenario that restoration of the rail connection to outside the district is not resumed for over 12 months.

Drainage: Large landslide dams develop in the district as a result of the earthquake. Rainfall in the following weeks breaches some dams and the resulting flood waves cause flooding and further damage. All stop bank systems are damaged. Aggradation in all rivers is an ongoing problem.

Sewerage: Hokitika sewers and oxidation ponds are affected in areas subject to liquefaction. Rain exacerbates sewer damage causing sewage flow on the ground surface. The Franz Josef system is severely damaged.

Water Supply: The Hokitika water supply main from Lake Kanieri is damaged and it takes several days to restore the service. Turbidity in the lake affects water quality for several weeks. There is wide spread damage to older AC reticulation, and some damage to the reservoirs. All other supplies are affected by some damage, slips and turbidity.

Power Supply: Power supply is lost throughout the district. Resumption to full power from local generation is delayed due to lack of national grid support for synchronisation and damage to the distribution network that cannot be fixed due to poor access. A reduced power supply is reinstated from the north to the Hokitika area after 48hours, to Waitaha after 1 week, Harihari after 2 weeks and one month to Franz Josef.

Telecommunications: There is large network failure including the mobile phone network and damage to all fibre optic cables out of the district effectively isolates Westland District. Telecommunications are re-established to much of the district within a week. However, they continue to be unreliable for some time.

Individual and community needs change as recovery from the Alpine Fault scenario earthquake proceeds. The two needs of leadership and inwards and outwards information flow remain important throughout the first year after the earthquake. Rescue, medical aid, and evacuation are important needs initially but are soon replaced by the need for insurance payments, income, and counselling. Of slightly lower priority are the basic needs for lighting, heating, food, shelter, security, water, and sanitation.

Some communities are cut off, separated by loss of transport routes and effectively isolated. A depth of resourcefulness is needed in individual communities to provide leadership, co-ordination of efforts, rescue and first aid. Isolated communities will need to manage almost on their own for some time without significant outside assistance.

Co-ordination, information, and leadership will be the three highest needs required of, and by, the Council. One area of Council's management identified as likely to need a high level of resources after a major earthquake is building inspection and repair. Building inspection, prioritising and allocating building materials and skilled workers are likely to be a Council responsibility.

Facing a Major Earthquake

The highest priority lifelines to meet individual, community, and Council's needs after a major earthquake are considered to be, in priority order:

- Transportation, including roads, airports, harbours, river transport, and rail,
- Communication, including telecommunication (landlines and cellular network), one way and two way radios, local radio stations, etc,
- Power supply,
- Water supply,
- Sanitation, and
- Storm water.

The focus of the report is on the effects of a major earthquake on WDC lifelines and physical assets, and what WDC needs to address. The scenario is used as a means of identifying what the WDC should address to best prepare itself for an earthquake. In so doing it is likely to also be well prepared to meet other lesser disasters. Sections are included on infrastructure owned and operated by other companies, such as power supply and telecommunications, in order to identify interdependency issues, but a full vulnerability / lifeline study has not been carried out for these services. Based on the scenario, the priorities and proposed strategies for attending to WDC lifelines after a major earthquake, such as the Alpine Fault earthquake described in the scenario, are as follows:

1. *Airport*. Immediately after an earthquake the airport at Hokitika is likely to be the main route for getting expertise and urgent supplies into Westland District, and the West Coast region, and for getting the severely injured out for medical assistance. The airport runway is not expected to be damaged to any extent in the quake. Air access to areas such as Franz Josef, Fox and Haast will be very important particularly for evacuating tourists as road access to these areas is unlikely to be open for months.

2. *Roads*. District roads have a high reliance on the State Highway system to interconnect them. In addition to roading, State Highway bridges sometimes have other important network functions in that they can provide structural support for telecommunications, power, water supply and other services. An example is the Arahura Bridge north of Hokitika, which not only forms part of a critical road link between Hokitika and Greymouth, but also carries communication cables. Because of these issues, it is essential that WDC and Transit agree beforehand on road reinstatement priority, mitigation work that should be undertaken now, and how WDC and Transit will work together after a major earthquake.

   After a major earthquake the highest priority road access will be to CDEM co-ordination centres and key facilities such as the airport, critical communication infrastructure and medical centres. These will be followed by access to Greymouth and then between higher population centres such as Ross, Harihari and Whataroa. Road access between Ross and Franz Josef is expected to take between one to three months to reinstate. Other forms of transport, possibly boats in some areas, but more likely aircraft, will therefore be required during this period. Road access will also be required to important utilities such as power and water supply systems to get them functioning on an emergency basis.

   The infrastructure in the Haast area remains largely intact in the scenario presented in the report. However, it is isolated from the rest of the South Island because of damage to SH roads. The wharf at Jackson Bay and its associated district roads and bridges take on an elevated level of importance as a transport link into the area.

3. *Water supply*. After a major earthquake water supply systems are likely to have no power to drive pumps. Water supplies close to the fault trace, such as at Franz Josef, are likely to be severely damaged. It is anticipated that an emergency water supply for affected supplies will be established according to size of community. The target for re-establishing water supply systems to regional

and district centres like Hokitika is four days, one week for sub-district towns like Ross, 2 weeks for local centres like Kumara, Harihari, and Haast, and up to 3 weeks for local community centres like Otira and Hannah's Clearing. Return to a normal water supply level of service is anticipated to take between three to six months.

4. *Sewerage.* As for water supplies, it is expected that after a major earthquake, power to drive pumps will be lost and sewerage schemes close to the fault, such as at Franz Josef, will suffer significant damage. It is anticipated that where necessary and possible, individuals will arrange their own toilet facilities e.g. pit latrines. Priority will be given to providing a normal sewerage service to the Hokitika CBD where it is anticipated the District's recovery effort will be based. The remainder of the Hokitika sewerage system and the other systems will be assessed and repaired or components replaced as required. Normal levels of service are expected to be reinstated in 6 to 12 months.

5. *Storm Water*. It is unlikely that much will be done about storm water systems immediately after a major earthquake, as efforts will be focused elsewhere. However, provisions do need to be in place to address flooding in low-lying populated areas. This is particularly important in parts of Hokitika where failure of both the sewerage and storm water systems may lead to ponding of storm water mixed with sewage, with consequential health issues.

Recommendations

To be more prepared for a large and devastating earthquake WDC should address the recommmendations in this report. They are summarised in Section 11 and are presented briefly as follows:

Communication is of paramount importance. It has many aspects and issues. Controllers need to know what is happening, and so in fact do all stakeholders. Instructions, assessments, information, and requests all need to be routed to the right recipient. Moreover, sound leadership is critical, and good communication is essential for its success. And those operating locally need to be aware of the overall extent of the disaster and the wider situation outside their own area. Because good communication is so centrally critical following a disaster, it is strongly recommended that;

- The communication issues raised in this report should be thoroughly explored where they relate to technical communication between personnel and organisations in the response and recovery periods; and
- Expert-led training sessions should be held regarding post-disaster communication with the public, with a particular emphasis on those who would be expected to provide community leadership.

Failures with Compounding Consequences. Failure that would lead to a fundamental change in the landscape and/or have significant implications on the long-term viability of affected infrastructure. An example is widespread failures and inadequate or slow re-building of infrastructure and services leading to a large exodus of people from the Westland District effecting the long-term sustainablity of infrastructure and the Westland District economy in general.

Interdependencies: Services and lifelines are not independent but are connected in various ways. Some are more obvious than others. It is important to take the interdependencies into account in the response and recovery stages of disaster management, and this requires that they be well understood beforehand. A good working relationship with other lifeline providers is essential to allow common protocols and linkages to be established. We recommend that interdependencies be considered carefully by the groups and individuals concerned, possibly by means of a workshop. Those concerned should include the main lifeline operators on the West Coast. Aspects to be considered should include:

- Road access requirements and constraints;
- Dependencies on infrastructure owned by others leading to common causes of failure. For instance, a slip on a road might take out telecommunications, water and other services as well as the road, or a bridge failure might do the same;
- Failure of backup. For example, under normal conditions if sewer pumps or pipes fail surcharging sewage would flow over land and drain via the storm water system. However, in a strong earthquake the storm water system might also have failed;
- Dependence on a common need by different organisations for contractors, plant, personnel, equipment, materials, fuel, transport (surface and air) and so on;
- Storage and accessibility of information;
- Facilities which need several services to be up and running in order to function effectively – a hospital, for instance; and
- Information channels.

Fuel will be in high demand after a major disaster like the Alpine Fault earthquake and supplies will be limited. There is no bulk fuel storage on the West Coast and it may be up to a week before roads are open to bring supplies into the region. It is recommended that:

- Alternative methods of supplying fuel to the area need to be identified and agreements made for supplying fuel under emergency conditions;
- Consideration be given to alternative means of extracting fuel from underground tanks, that are not dependent on power from the national grid;
- Protocols be developed for fuel allocation, and
- Consideration is given to how fuel will be supplied to where it will be needed.

Critical Infrastructure: It is recommended that Council identify the following critical infrastructure elements, consider level of risk and seismic resilience then prioritise and implement mitigation measures where appropriate:

- Key transport routes including:
  - Airports (Hokitika, Franz Josef, Fox and Haast) including access to the airports,
  - Jackson Bay wharf;
  - Access via rivers; and
  - Roads and bridges managed by Transit and WDC including the preparation of hazard maps to identify roads that may become damaged or impassable.
- Bridges and bottlenecks involving multiple lifelines;
- Key water supply, sewerage and storm water mains including pump stations, treatment plants, key mains, important valves, water supply reservoirs. Also restraining of equipment in pump stations, treatment plants etc;
- Locations for standpipes, the number of standpipes required and how these are to be provided; and
- Means of draining areas where sewage and/or storm water are likely to pond and create a public health hazard.

Other lifeline operators such as telecommunication, power companies, railways, etc should also be encouraged to routinely share knowledge about the seismic resilience and vulnerability of their assets with Council.

Strategy and Response: It is recommended that Council prepare detailed strategies and response plans for recovery of Council lifelines after a significant earthquake or other disaster as well as the Council's wider roles in the recovery process. Aspect to be considered should include:

- Availability of staff, outside professionals, and contractors;
- Availability of plant and equipment,
- Management and servicing of outside aid and aid organisations;
- Training of people from outside WDC so that they can be mobilised to the district and effectively assist in the recovery effort allowing WDC staff to attend to their own and their family's' requirements;
- Flexible contracts along with building inspections and resource consent procedures for use in emergencies;
- Appropriate emergency levels of service. Some emergency levels of service are proposed in this report;
- The best means of inspection and assessment of damage to infrastructure to allow damage to be quickly identified and prioritised;

- Prioritising, deployment and management of plant, manpower and other resources;
- Spare part requirements;
- Water supply, waste water, power, and other service requirements of emergency centres and essential businesses and industry; and
- Monitoring of response and recovery activities.

Database: It is recommended that Council establish a database that includes:

- Holders of satellite phones and VHF facilities;
- Major road cuttings and embankments to allow progressive upgrading to be undertaken;
- High fire risk/high value areas along with alternative fire fighting options for these areas as the water supply may not be available after an earthquake;
- Discharge requirements of major waste water producers after a major earthquake;
- Location and volume of fuel storage facilities; and
- Owners and operators of earth moving resources.

Asset Upgrading: It is recommended that Council continue replacing and upgrading infrastructure assets largely adopting a "business as usual" approach and following normal asset management principles. However, priority should focus on:

- Upgrading weak bridges based on the seismic audit;
- Assessment of pipe work that is suspected or known to be at risk of failure and replacement or upgrading as required e.g. older asbestos cement pipe work in Hokitika;
- Replacement of sewers and storm water pipes starting from discharge points and working upstream; and
- Building towards greater resilience including:
    - Upgrading with more earthquake resistant materials e.g. replacement of key water mains with PE pipe or similar,
    - Installation of burst control valves on water supply reservoirs, and
    - Considering installing standby generators for the airport, and sewerage and storm schemes, and possibly some water supplies.

PART I – Introduction and Methodology

1 INTRODUCTION

1.1 The Lifeline Study

Westland District Council (WDC) is responsible for managing key infrastructure assets including water supply, sewerage, storm water and district road assets. WDC has an essential role to play in being ready for, reducing the effects of, responding to and recovering from any disaster in the district. In view of this role, WDC engaged the consultants to identify significant vulnerabilities in WDC's lifeline assets. This will aid in prioritising work to make these assets more resilient in the event of an earthquake and also help with the planning for an appropriate response to a major disaster.

This report aims to raise issues and make recommendations as to what should be done to make the Council and hence the community better able to withstand the effects of a major earthquake disaster and to recover from it more effectively. It focuses primarily on lifelines; the network services of water, sewage, transport, power, and communications which are essential to the functioning of a community. However, it also considers some broader issues such as leadership, which have been shown to have a major effect on the ability of a community to recover.

The consultants have used a disaster scenario as a means of sharpening understanding of the issues and requirements and of suggesting recommended actions. The scenario is not in any way meant to predict what would actually happen. Rather, it gives a plausible and feasible picture of a possible major and widespread disaster simply to enable the needs and priorities of the WDC and the community in general to be better understood. A scenario approach is particularly helpful in identifying the main interactions required between the many stakeholders involved. Thus this report necessarily considers its specific recommendations for the WDC in the broad context of community needs and interactions. The consultants have not, however, carried out a formal risk analysis. Hence, the report identifies issues that are important, but prioritisation has not been defined in detail. To have done so would have required a more extensive analysis involving quantified risks, which would have needed a far more detailed investigation of earthquake hazards, frequencies and consequences.

The selected disaster scenario assumes a major Alpine Fault earthquake. It is selected because;

- It will have a far greater impact on Westland district than any other natural event and certainly any other earthquake, as the Alpine Fault runs virtually up the centre of the whole length of the district.
- It will certainly occur at some stage, and has a high probability of occurring within the next 50 – 100 years.

- It will affect not just the West Coast but also the whole of the central South Island, including all the main transportation routes, and therefore brings in issues relating to the wider geographical setting of the District.
- It is also the same scenario used for the Buller District and Grey District Lifeline studies. It will have the greatest overall impact on the West Coast region as a whole and therefore this scenario provides the best regional overview.

Of other natural hazards, a heavy rainfall event, with associated flooding, slips and possibly debris flows, is a real hazard faced by WDC and the West Coast. However, in terms of the area that would be significantly affected, a large storm would be much more limited in effect, e.g. Harihari to Franz Josef or Kumara to Ross, than the Alpine Fault earthquake. The probability of a volcanic eruption impacting on the West Coast is extremely low and while there is reasonable probability of a tsunami occurring, it would impact on the immediate coast only.

The Alpine Fault earthquake scenario was presented at a workshop to discuss district lifeline assets held at Punakaiki on the 20th & 21st of September 2005. Those invited to the workshop included:

- Buller DC
- WCRC
- MCDEM
- NZ Police
- Westland DC
- Grey DC
- Fuel companies
- Helicopter pilots
- Rockgas
- Hokitika airport
- Communications contractor
- Electricity Companies
- Communication companies
- Ontrack/NZ Rail Corp
- Regional & Local Controllers
- Buller Port
- Greymouth Port
- NZ Fire Service
- Transit NZ/Opus
- St Johns Ambulance

A list of those who attended the workshop is presented in Appendix E.

The workshop used the scenario as a basis for identifying and examining lifeline issues, constraints, and weaknesses and identifying interdependencies between the lifeline assets. The participants also looked both at priorities for improving lifeline asset infrastructure prior to occurrence of an Alpine Fault earthquake and also at priorities during the recovery period after the earthquake.

The workshop provided useful information on detailed issues, needs, and priorities, and this has been a substantial input into the present report. Some findings, such as the need for leadership, showed that prior preparation would require more than a straightforward concentration on physical assets, and such insights have also been included here.

Part II of this report deals with the earthquake scenario. Its development proceeds in three stages. First, the earthquake itself is discussed. The second step looks at the resulting damage and effects. Finally, in order to ensure that all issues have been captured as far as possible, a bottom-up approach is used in which, as part of the scenario, the situation, reactions and needs of four hypothetical people are considered.

The Alpine Fault earthquake is clearly the most damaging earthquake that can affect Westland district. In the scenario presented the effects are devastating for much of the district south of Ross, and serious for the northern area. A rupture extending further south than Paringa, past Haast and Jackson Bay, would have the greatest impact on Westland, and a second scenario is presented at the end of the main scenario outlining alternative damage for this possibility.

Section 2 describes the setting for an Alpine Fault earthquake and the background to earthquake effects such as shaking, liquefaction, landslides and seiche. This information has been collated from various available sources. No new research has been carried out. Because existing information is very limited in many areas, or is of a very generalised form, the risk to individual components of the lifelines networks is uncertain.

Section 3 outlines the earthquake scenario and provides a description of the physical damage. It is based on experience of earthquakes elsewhere in New Zealand and the world. The scenario was drafted, the consultant team worked through details, and aspects were checked in the field. The description of the physical damage in the scenario has been deliberately kept muted; very much more severe impacts in an actual earthquake are quite conceivable. As a “reality check”, a description of the actual impacts of the 1929 Buller earthquake is presented in Appendix C. This was a smaller earthquake with the major area of damage largely away from developed areas, and a much smaller affected area, but the actual impacts can be compared with the Alpine Fault scenario to demonstrate that the scenario is not extreme.

In Section 4 the stories of four individuals – a Hokitika businessman, a farmer from Kokatiha, a tourist at Franz Josef, and a resident of Hokitika – have been developed to tease out the likely needs and priorities of people in communities affected by the Alpine Fault earthquake.

In Section 5 the situation and needs of the four individuals are examined over the first three days, at the end of the first month, and at the end of one year. These needs and the lifelines available to meet them are then examined from the perspective of the Council.

Normal and emergency levels of service are defined for WDC’s lifeline infrastructure. The levels of service are based on four community types, which are determined based on population and on role as a service centre.

Sections 6 to 9 examine WDC’s key infrastructure assets in detail after a major earthquake suggesting key principles for re-instating roads and defining emergency levels of service in the case of Hokitika’s water supply, sewerage and storm water systems. Strategies for re-instating normal levels of service are presented and improvements identified to allow recovery after the earthquake to proceed more effectively.

Section 10 looks at lifelines in Westland District operated by others. These include telecommunications and energy (electricity and fuel supply). The assets are described, significant risks identified and improvements suggested.

Finally, Section 11 concludes the report. It both summarises the recommendations of the previous sections and also introduces more general recommendations, which, though not specifically addressing infrastructure assets, are nevertheless important matters for the Council to consider.

PART II – The Alpine Fault Earthquake Scenario

2 ALPINE FAULT EARTHQUAKE

The Alpine Fault has been studied in detail (Yetton, 2000; Yetton *et al*, 1998; Wells *et al*, 1998). The earthquake scenario presented in this study and its likely characteristics are derived directly from these sources.

The scenario is a time series of snap shots of the possible situation during and after an Alpine Fault earthquake. By its nature it cannot be precise. Rather, it provides a plausible framework within which interdependencies and priorities can start to be considered.

2.1 Alpine Fault and Earthquake Predictions

The Alpine Fault is the largest active fault in New Zealand and extends over 650 km from Milford Sound to Blenheim. The location of the Alpine Fault in the Westland District is shown in Figure 2.1. It runs virtually up the middle of the whole length of the district, with the high mountains to its east and the lower hill lands and alluvial flats to its west. South of Ruatapu, effectively all of the habitable areas within the district are within 15 km of the fault.

Overall movement on the fault has been both vertical, with the east side rising relative to the west side and hence uplifting the Southern Alps, and horizontal with geological rock types matching across the fault but offset by about 470 km. Field evidence suggests that the horizontal offset is episodic and each movement of several metres is accompanied a large earthquake.

The most active part of the fault is the central section, which forms the western boundary of the Southern Alps from Haast to Inchbonnie, i.e., the length of Westland District. Further north the fault becomes progressively less active as movement is spread to numerous branch faults within Marlborough.

Yetton *et al*, 1998 used four methods to estimate the timing of past movements of the fault. These were direct trenching across the fault trace and dating organic material within sheared layers, dating landslides and aggradation terraces, using the age of forests re-established after earthquake related destruction, and tree ring chronology which records periods of stress related to earthquake damage to trees living through an earthquake. The methods produce a consistent record and indicate two earthquake events, one at about 1620 from the Paringa River to north of the Matakitaki River, over 300 km in length, and one in 1717 with a surface rupture from Milford sound to Haupiri, a distance of at least 375 km.


GREYMOUTH
GREY DISTRICT
Jacksons
Kumara
HOKITIKA
Kanieri
Ruatapu
Ross
Harihari
Whataroa
Franz Josef
Alpine Fault
Alpine Fault
SELWYN
ASHBURTON
SMYTH RANGE
N
0 10 20 30km
Sheet Title
Map of Westland District
(1 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.1a

Fox Glacier
Bruce Bay
Haast
Jackson Head
Alpine Fault
WAITAKI
OTAGO
0 10 20 30km
Sheet Title
Map of Westland District
(2 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.1b

The implied pattern of earthquakes combined with analysis of similar fault behaviour around the world gave Yetton *et al* (1998) a probability estimate of the next earthquake as 65 +/- 15% over the next 50 years increasing to 85 +/- 10% over the next 100 years. This estimate was made in 1998, and current probabilities will be higher. Rhoades & Van Disson (2003) reviewed the probability of a fault rupture, allowing for uncertainties and using four methods. Their estimates were between 22% and 44% (34% average) over the next 50 years starting in 2002, and between 39% and 68% (54% average) over the next 100 years. While Rhoades & Van Disson's method is mathematically robust, their probabilities are likely to be underestimates, as they do not allow for the physical limits of horizontal displacement and slip rates, or the behaviour of similar faults internationally. What is clear is that both sets of probabilities point to a high probability of an Alpine Fault earthquake within the next few decades.

An Alpine Fault earthquake can be expected to rupture over a length of about 300 km. All evidence suggests that the earthquake will be large, with a magnitude of at least M8 (magnitude is a measure of the energy released by the earthquake at its source).

The earthquake is likely to produce very strong shaking in locations close to the Southern Alps. In particular, locations such as Arthur's Pass, Otira, Mount Cook and Franz Josef will be seriously affected. Hokitika, Greymouth, Reefton and Hanmer will also be strongly shaken. Predicted intensities are generally less on the east coast, as it is further from the fault, but in virtually all central South Island locations the next Alpine Fault earthquake will be stronger than any other earthquake experienced in the last 150 years or more.

The whole of the Westland District will experience strong shaking. It will be most intense closest to the Southern Alps and the fault trace. The townships of Harihari, Whataroa, Franz Josef and Fox Glacier are all very close to the fault trace and can expect the most intense shaking, but nearly the whole of the district will all experience Modified Mercalli Intensity shaking of MM IX or greater (refer to Section 2.2 below for an explanation of the MM scale). The exceptions are the northern corner between Hokitika and Kumara, which will experience MM VIII shaking, and the southern part of the district, but only if the fault rupture is north of Paringa as occurred in 1620, rather than further south past Jackson Bay as occurred in 1717. In the main scenario present in this report it is assumed that the fault rupture is north of Paringa. There is no doubt that the shaking will be the strongest experienced anywhere within the district since settlement of the district. Previous highest intensities for Hokitika were about MM VI in both the 1929 Buller (Murchison) earthquake and the 1968 Inangahua earthquake.

Direct effects of the earthquake will include:

- Ground rupture destroying buildings, roads and pipelines on or crossing the fault
- Shaking damage to buildings and bridges, and to infrastructure such as water supply systems, sewerage, power and telephone

Secondary effects from earthquake shaking include:

- Liquefaction in sandy areas within river valleys, in low swampy ground near lakes, and the coastal strip north of Ross, between the modern beach and higher terraces.
- Landslides, particularly in the MM VIII and IX zones and in the mountains, some of which are likely to create dams across rivers. Landslides may cause local damage to parts of Hokitika. Slips and landslides will cause considerable damage to roads.
- Seiches (water waves generated by seismic oscillations) could be produced on Lake Kanieri and other smaller lakes.

Indirect and longer-term impacts will result from the large volumes of landslide material entering rivers, particularly those with catchments in the Southern Alps. The increased sediment load will result in high river water turbidity, debris flows, river aggradation and channel avulsion with implications for drinking water quality, river control, stop banks, and bridging. These effects will alter the environment in the Westland District and some will result in totally new infrastructure being required to accommodate new landscape. Water supply and sanitation services will be disrupted for weeks and potentially for many months resulting in a significant increase in public health risks. Aggrading riverbeds will affect bridges for many years.

2.2 Ground Shaking Hazard

The lifelines are assessed at a general level in this report. However, when an engineer looks at specific structures needing modification they can use the detailed information provided here on the impact of an earthquake.

The most widespread and predominant effect of earthquakes is ground shaking experienced as seismic waves generated by the release of energy at the epicentral area propagate through the earth. These waves are modified by the underlying geology, soils and terrain, and generally reduce with distance from the earthquake source. The shaking hazard can be defined in terms of the maximum accelerations caused by the seismic waves, or indirectly in terms of effects. The scale of effects used in New Zealand is the Modified Mercalli (MM) scale of shaking intensity. This is a descriptive scale, which reflects the intensity of shaking according to the resulting damage and felt effects.

The variation in Modified Mercalli shaking intensity from the Alpine Fault earthquake event postulated for this study is shown in Figure 2.2 for the whole of the South Island, and across the Westland District in Figure 2.3. This map is based on the synthetic isoseismals for the 1620 earthquake in Yetton *et al* (1998). The map shows a decrease in shaking across the District toward the northwest as distance increases from the Alpine Fault, and to the southwest for the assumed rupture being north of Paringa only. If the rupture extends south of Jackson Bay (as described in the second scenario in section 3.13), then the isoseismals will extend parallel to the fault over the whole of the district.

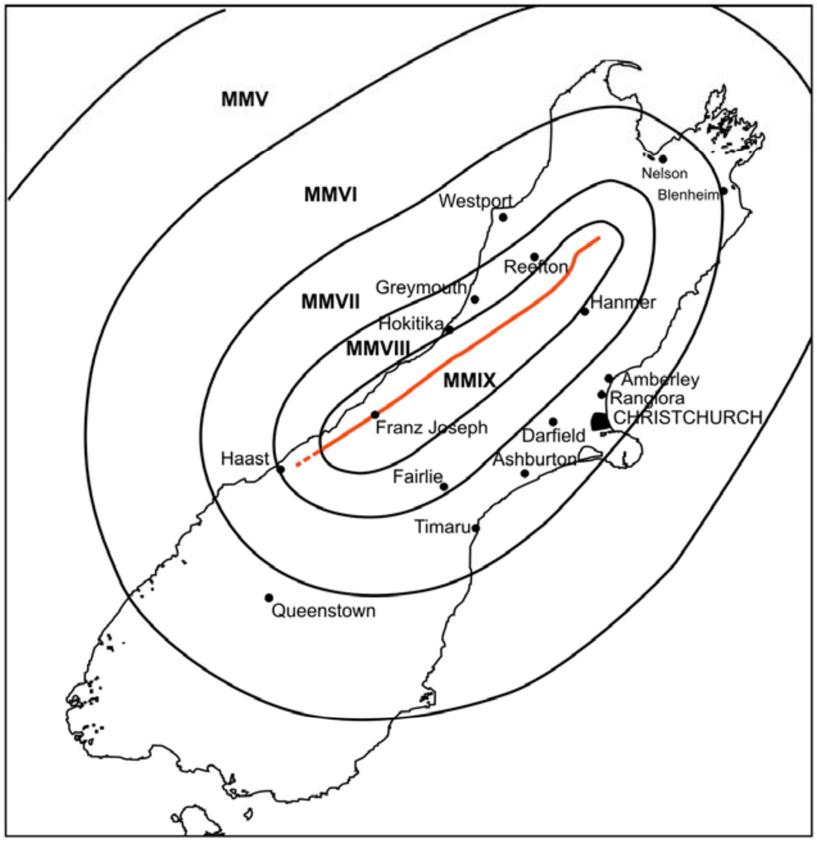
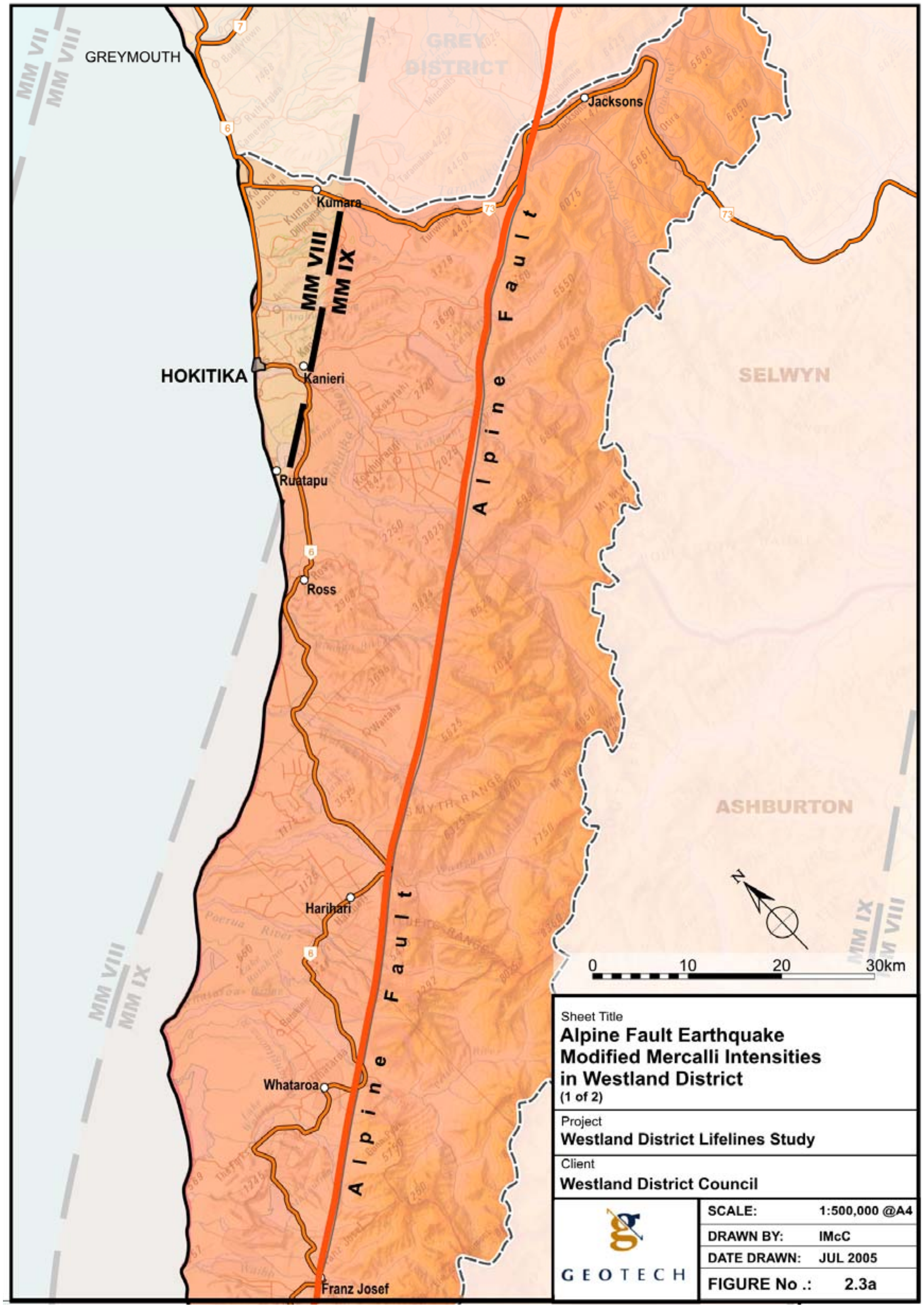
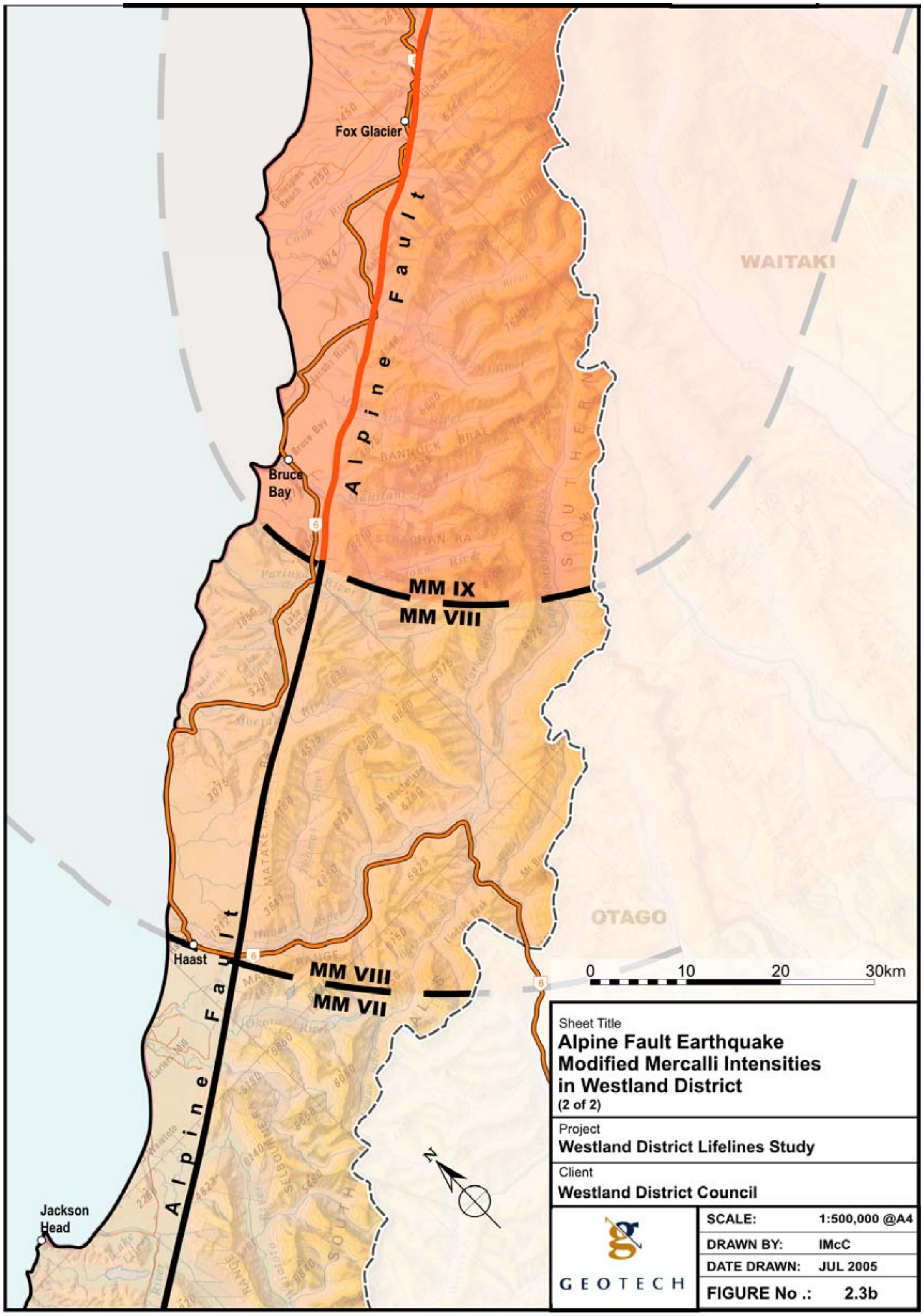


Figure 2.2: Estimated Modified Mercalli intensity isoseismals (lines defining equal shaking intensity) for the Alpine Fault earthquake scenario (adapted from Yetton et al. (1998) 1620 AD earthquake, modified for fault rupture further to the north).


GREYMOUTH
GREY DISTRICT
Jacksons
Kumara
MM VIII
MM IX
HOKITIKA
Kanieri
Ruatapu
Ross
Alpine Fault
SELWYN
ASHBURTON
Harihari
Whataroa
Franz Josef
MM VII
MM VIII
MM IX
0 10 20 30km
Sheet Title
Alpine Fault Earthquake Modified Mercalli Intensities in Westland District
(1 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.3a

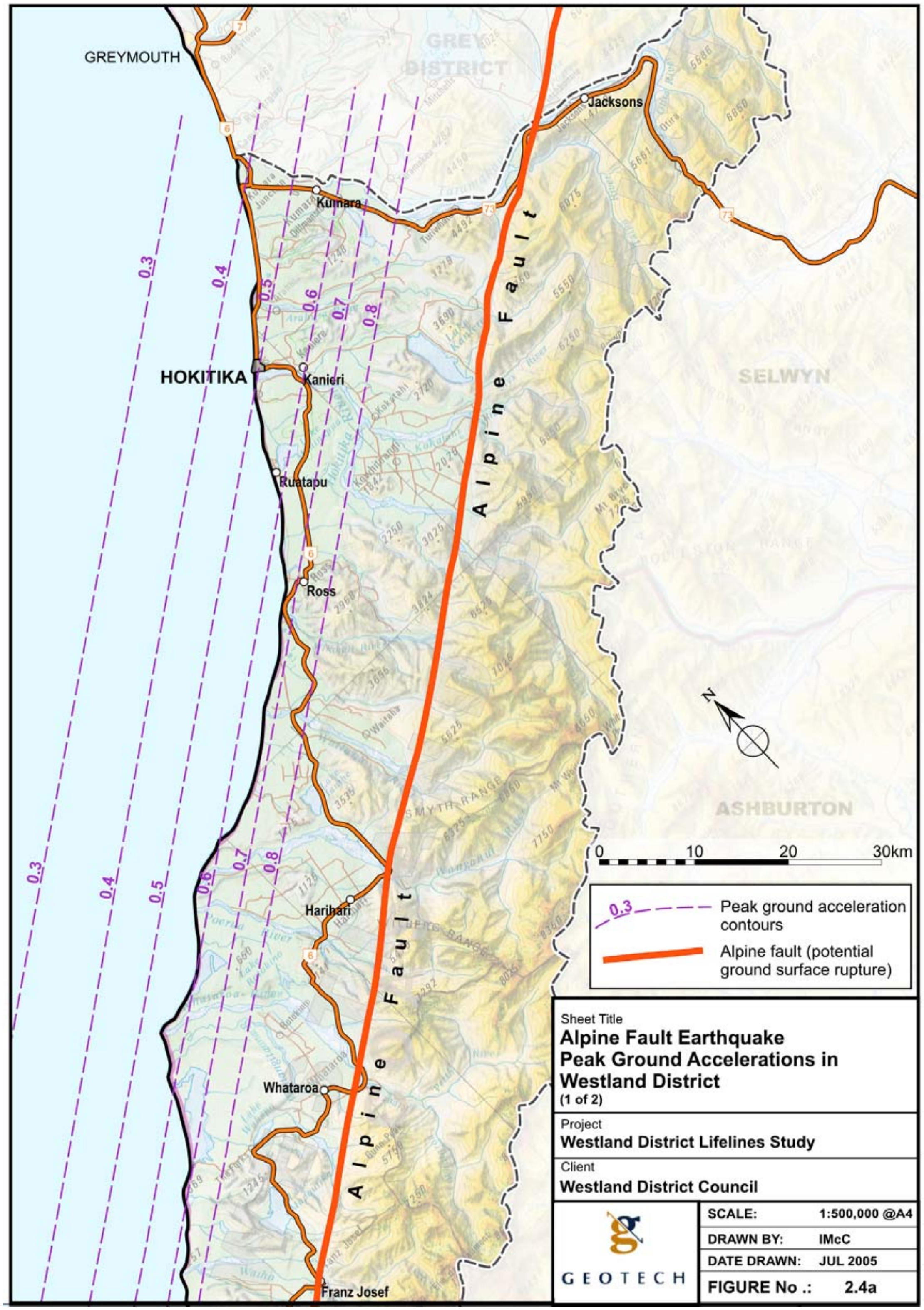


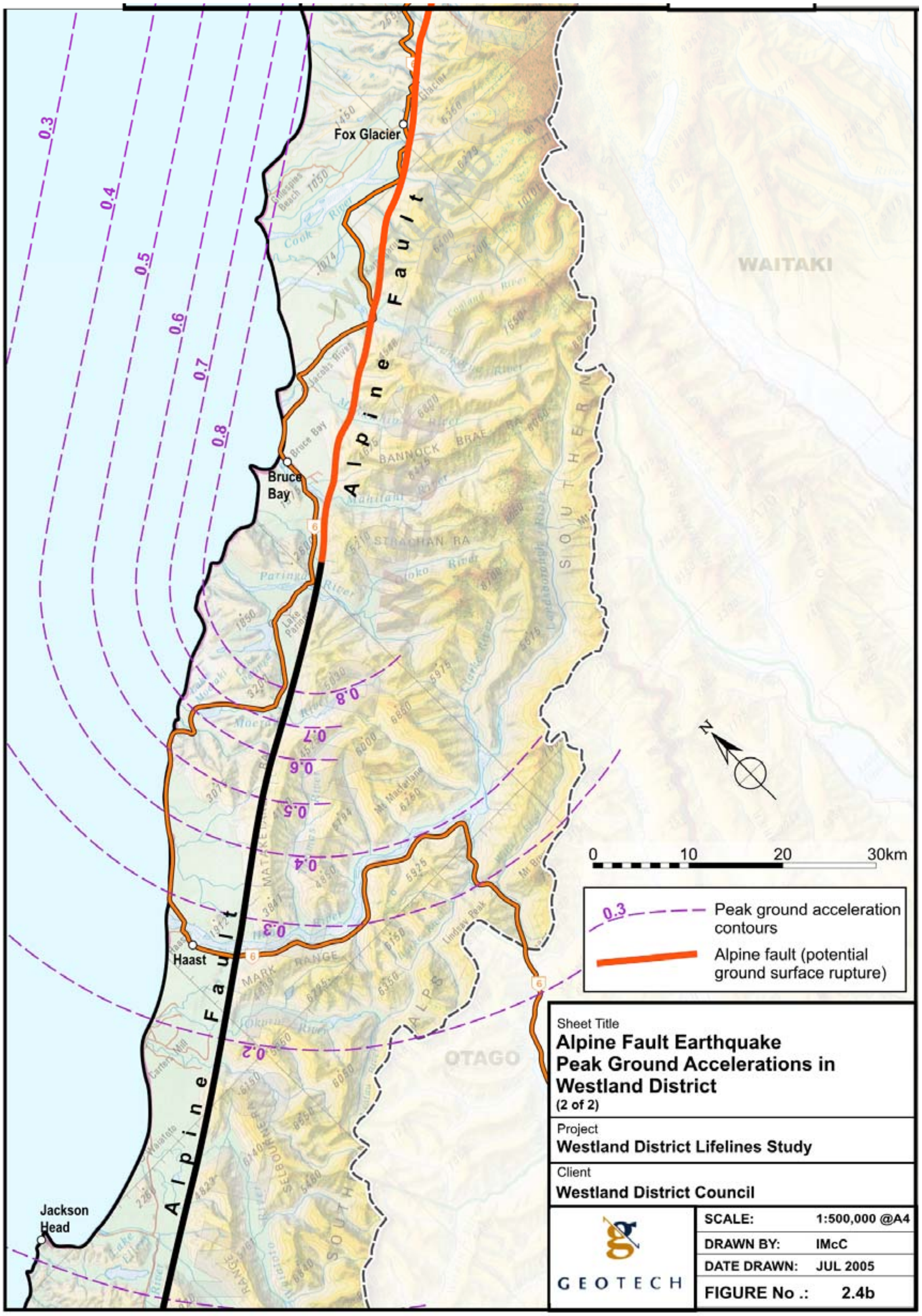
Fox Glacier
Alpine Fault
Bruce Bay
MM IX
MM VIII
WAITAKI
OTAGO
Haast
MM VIII
MM VII
Jackson Head
Alpine Fault
0 10 20 30km
Sheet Title
Alpine Fault Earthquake Modified Mercalli Intensities in Westland District
(2 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.3b

Associated with shaking intensity is ground acceleration, and contours of possible peak ground acceleration are shown on Figure 2.4.

Both maps are for average ground conditions. For both shaking and acceleration, there will be some additional variation due to local site conditions such as the nature of the underlying rock and soils, their relative thickness and their depths. Areas underlain with deep, recent soils can be expected to have increased shaking intensities, particularly at longer periods, relative to areas underlain with strong rock at shallow depths.

This variation in response has been recognised in New Zealand Loadings Code, with three site subsoil categories in NZS 4203:1992, and five site subsoil classes (A – strong rock, B – rock, C – shallow soil, D – deep or soft soil, E – very soft soil) in the new NZS 1170.5:2004. In theory, it would be possible to zone an area into the different classes if there is sufficient knowledge about the underlying geology. Some indication can be gained from regional geology maps. The greywacke, schist and granite bedrock areas are likely to be class A, the softer tertiary rocks and old well consolidated glacial moraine and outwash gravel are likely to behave as class B or C, and class D and E sites will be confined to the recent alluvial areas. However these broad geological divisions are indicative only and a district wide zoning has not been attempted for Westland, except that areas of recent alluvial soils are shown on Figure 2.5 for the District and for the Hokitika area at a larger scale in Figure 2.6. The recent alluvial soils are of particular interest as most of the infrastructure and population areas are located on them, and as well as indicating areas of class C – E sites, these areas are also where liquefaction is possible. Most of the recent alluvial soils will correspond to site subsoil classes C or D, depending on the depth of alluvium, but there may be some limited areas of site subsoil class E (very soft soil sites), particularly around the mouths and the delta areas of the rivers, both into lakes and the sea.


GREYMOUTH
GREY DISTRICT
Jacksons
Kumara
HOKITIKA
Kanieri
Ruatapu
Ross
Harihari
Whataroa
Franz Josef
SELWYN
ASHBURTON
Alpine Fault
Alpine Fault
0.3
0.4
0.5
0.6
0.7
0.8
N
0 10 20 30km
Peak ground acceleration contours
Alpine fault (potential ground surface rupture)
Sheet Title
Alpine Fault Earthquake Peak Ground Accelerations in Westland District
(1 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No.: 2.4a


Fox Glacier
Bruce Bay
Haast
Jackson Head
Alpine Fault
WAITAKI
OTAGO
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30km
0.3 Peak ground acceleration contours
Alpine fault (potential ground surface rupture)
Sheet Title
Alpine Fault Earthquake Peak Ground Accelerations in Westland District
(2 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.4b

In terms of effects of shaking and ground accelerations a simpler three zone system can be used rather than the five classes in NZS 1170.5, as the uncertainties in earthquake prediction and the lack of information on subsurface conditions makes five classes unrealistic for a regional scale study such as this. The three zones are listed in Table 2.1.

Table 2.1: Ground Shaking Zones

Zone	**1**	**2**	**3**
Site Subsoil Class NZS 1170.5:2004	C or D, depending on depth of sediment, possible areas of E	B or C	A
Geology	Deep Soils Soils more than 20m deep, of moderate density. Recent alluvium or Holocene age	Intermediate ground Weak or soft rock with soil cover, firm deep soils	Rock Strong hard rock at shallow depth
Geological unit	Holocene sediments	Glacial outwash gravel and till, soft tertiary siltstones	Older sandstone, limestone, greywacke, schist, granite
Ground shaking	As shown on map	Up to 0.5 unit MM scale *decrease*	Up to 0.5 to 1.0 unit MM scale *decrease*
Peak ground acceleration	As shown on map	Up to 15% *decrease*	Up to 30% *decrease*
Ground Settlement	Some settlement where loose to medium dense granular soils may compact	None	None

Identification of the geology at a particular site can be used to refine the shaking and peak ground accelerations in Figures 2.3 and 2.4, which assume average conditions and site subsoil class C. Zone 2 and 3 areas can have the shaking intensities and ground accelerations reduced from those shown on Figures 2.3 and 2.4 in accordance Table 2.1, although any reduction of effects close to the epicentral[1] area should be made only with caution.

In the larger scale map of Hokitika (Figure 2.6), there is an additional Zone IA, covering the softest soils of lagoonal and estuarine silt. There is likely to be somewhat greater shaking on these soft soils, with possibly a 0.5 unit MM scale increase.

The zones of recent alluvium shown on Figure 2.5 have been derived directly from published geological maps (Warren 1967, Gair, 1967, Mutch & McKellar, 1965). It should be appreciated that limitations in the available data, and the scale of work undertaken in a District wide study such as this, means that the zoning shown in Figures 2.5 & 2.6 has been simplified for application on a broad scale. It is likely that within each zone there will be local areas that would be better included in one of the other zones, and in many places the zone boundaries are approximate. The zones shown are intended

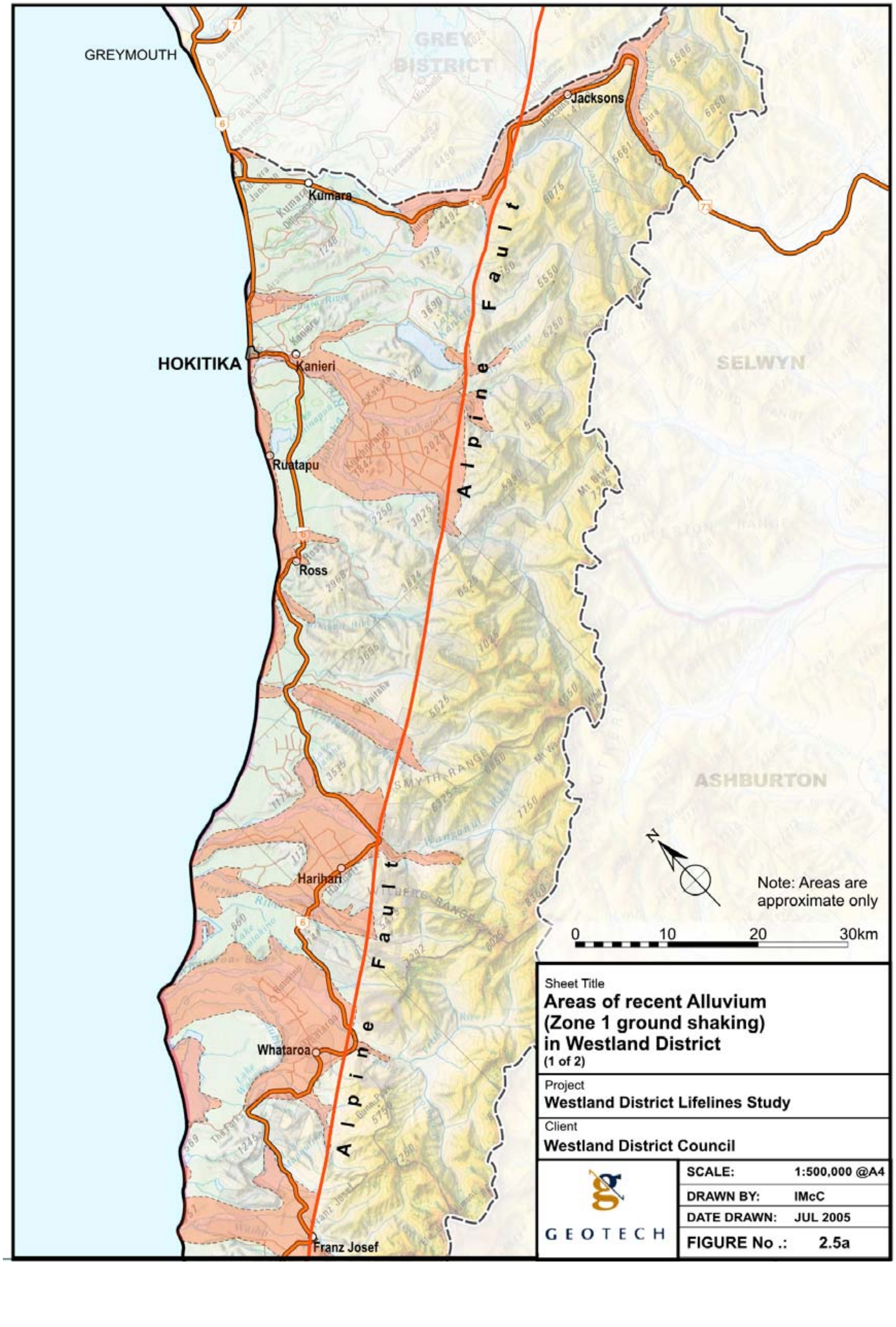
[1] For this report, the epicentral area is defined as being that area within 5km of the fault rupture.

to be indicative only, and it is recommended that any critical facility should have a site specific analysis.

Ground shaking intensities can also be affected by both surface and buried topography. Topographic focussing on ridges has been identified in earthquakes, as has increased damage where recent alluvium lies over buried sloping rock hillsides. Attenuation from topography also occurs. It is not yet possible to map these phenomena, and the variation in shaking shown in Figure 2.5 is based solely on the underlying geology, without reference to topography.

Peak ground accelerations (PGA) is the maximum acceleration that occurs at the ground surface during an earthquake, and is normally expressed as a factor of the acceleration due to gravity. PGA is introduced here because it is useful for the detailed review of structural capacity of structures, as used in the Transit screening of bridges (refer to Section 6.2.3) and in liquefaction analysis.

The PGA at any location can be estimated from the attenuation model of Cousins *et al* (1999). These are shown as PGA contours across the District on Figure 2.4, for soft rock sites. Cousins' model is derived from New Zealand data. However, the data set does not include any very large earthquakes, and hence the attenuation for a M8 (Magnitude 8) earthquake such as the Alpine Fault is extrapolated and must be used with caution. This warning is particularly relevant to Westland, as most of the District is so close to the fault. These PGA contours are indicative only. The actual accelerations at any site will be subject to many variables, including the site ground conditions. An empirical relationship relating PGA to MM shaking intensity has been used to indicate the variation in PGA that might be expected between different ground conditions [$\text{Log}_{10}(\text{PGA}) = -0.384 + 0.347(\text{MM Intensity})$, where PGA is in cm/sec^2 units, ref Stirling *et al*, 1999 p14]. Using an average decrease in shaking intensity of 0.5MM unit between zones, the equation has been used to calculate the corresponding change in PGA for zone 2 and 3 relative to zone 1, as shown in Table 2.1.


GREYMOUTH
GREY DISTRICT
Jacksons
Kumara
HOKITIKA
Kanieri
Ruatapu
Ross
Harihari
Whataroa
Franz Josef
SELWYN
ASHBURTON
Alpine Fault
Alpine Fault
Note: Areas are approximate only
0 10 20 30km
Sheet Title
Areas of recent Alluvium (Zone 1 ground shaking) in Westland District
(1 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 2.5a

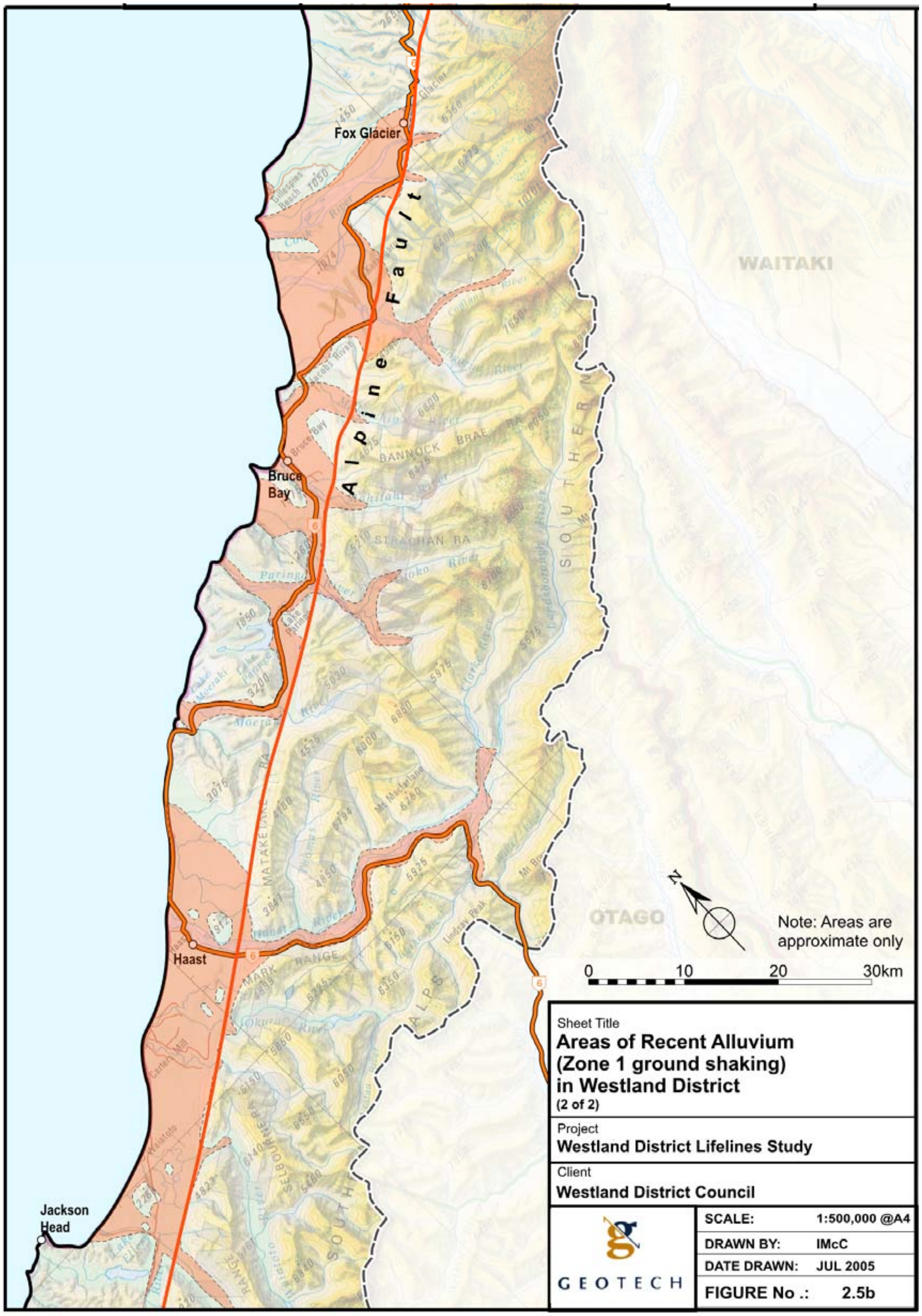

Fox Glacier
Alpine Fault
Bruce Bay
Haast
Jackson Head
BANNOCK BRAE RA
STRACHAN RA
WAITAKI
OTAGO
Note: Areas are approximate only
0 10 20 30km
Sheet Title
Areas of Recent Alluvium (Zone 1 ground shaking) in Westland District
(2 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
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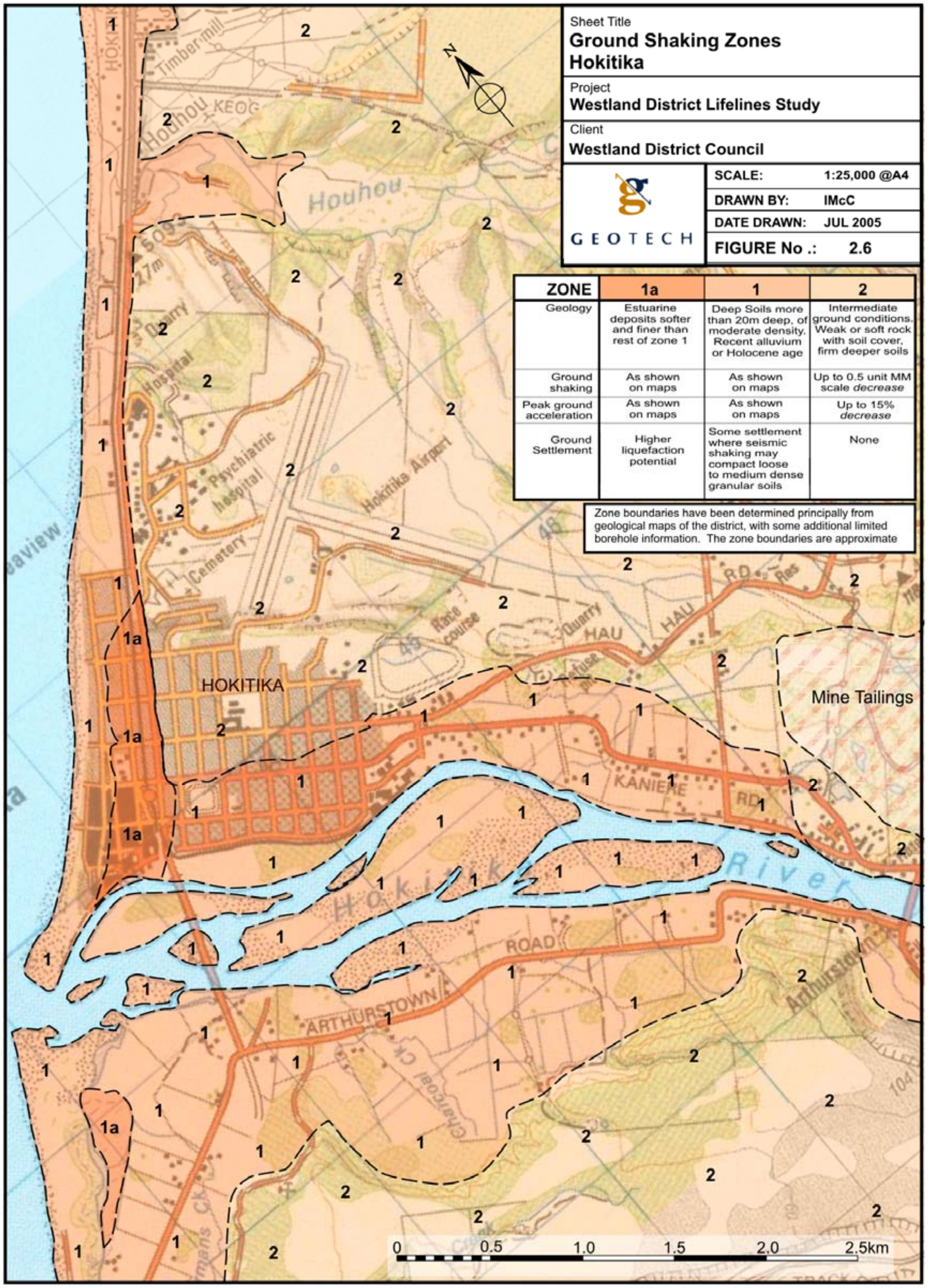
FIGURE No .: 2.5b


Sheet Title
Ground Shaking Zones Hokitika
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:25,000 @A4
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DATE DRAWN: JUL 2005
FIGURE No.: 2.6
ZONE | 1a | 1 | 2
Geology | Estuarine deposits softer and finer than rest of zone 1 | Deep Soils more than 20m deep, of moderate density. Recent alluvium or Holocene age | Intermediate ground conditions. Weak or soft rock with soil cover, firm deeper soils
Ground shaking | As shown on maps | As shown on maps | Up to 0.5 unit MM scale decrease
Peak ground acceleration | As shown on maps | As shown on maps | Up to 15% decrease
Ground Settlement | Higher liquefaction potential | Some settlement where seismic shaking may compact loose to medium dense granular soils | None
Zone boundaries have been determined principally from geological maps of the district, with some additional limited borehole information. The zone boundaries are approximate
HOKITIKA
Mine Tailings
Houhou
Hokitika Airport
Psychiatric hospital
Hospital
Cemetery
Race course
KANIERE RD
ARTHURSTOWN ROAD
Hokitika River
0 0.5 1.0 1.5 2.0 2.5km

Peak ground accelerations are only loosely related to shaking intensity, and a range of PGA expected for each step in the intensity scale is shown in Table 2.2. The first column comes from Yetton *et al* (1998) and is derived from correlations from overseas data. The third column uses the attenuation model by Cousins *et al* (1999) and corresponds to the PGA as shown on Figure 2.4. The fourth column is derived from the equation in Stirling used above.

Table 2.2: Correlation Between Peak Ground Acceleration and Shaking Intensity

	Peak ground acceleration (g)			
MM Intensity	Yetton (1998)	Transit (2000)	Cousins (1999)	Stirling (1999)
VII	0.05 – 0.10	0.1 – 0.2	0.05 – 0.2	0.1 – 0.25
VIII	0.1 – 0.2	0.2 – 0.3	0.2 – 0.6	0.25 – 0.55
IX	0.2 – 0.4	0.3 – 0.4	0.6 – 1.0	0.55 – 1.2
X	0.4 – 0.8			1.2 -

To assist lifeline engineers in their appraisal of the vulnerability of lifeline infrastructure, a damage assessment chart has been prepared (Appendix A). It is divided into sections for structures, in-ground pipe work, and transport, with comments on expected damage for a range of Modified Mercalli Shaking Intensities, for each of the three ground shaking zones.

2.3 Liquefaction Hazard

2.3.1 Extent of Liquefaction potential

Loose granular soils tend to compact on strong shaking, (similar to the effect of shaking a bowl of loose sugar). If the soil is saturated, however, the soil cannot immediately compact as the water in the voids prevents the movement of the particles into a denser state. Instead, the pressure of the pore water increases, and if the shaking is strong and sustained enough, then the pore water pressure can markedly reduce the friction between soil grains and a reduction or even total loss of strength can result. The pore water pressure increase occurs over a number of shaking cycles, and the extent of liquefaction is greater for earthquakes of longer duration. The Alpine Fault earthquake is expected to be a particularly long duration earthquake and hence liquefaction is likely to be severe in susceptible areas.

Liquefaction induced soil deformation can occur as:

- Flow failure, where ground on even very gentle slopes moves laterally,
- Ejection of sand and water onto the ground surface,
- Post liquefaction consolidation, with consequent ground settlement, and
- Large ground oscillations during the earthquake.

Damage from liquefaction is commonly seen as:

- Flotation of buried structures such as manholes and large pipelines,
- Lateral spreading of ground on gentle slopes with resultant ground fissuring, stretching and shear damage to services and structures,
- Settlement of large areas due to consolidation, and
- Foundation failures, as the liquefied soil loses its shear strength and its ability to support structures.

Liquefaction can occur in a range of soils from silts to gravely sand. However, it is most likely to occur in saturated, relatively uniform fine sands and coarse silts, which are in a loose state, at depths less than 10 to 15m below ground level, and where the water table is within a few metres of the surface. Typically only geologically recent (Holocene age) sediments are susceptible as consolidation and cementation of older sediments prevents the compaction tendency.

Those areas that could contain liquefiable soils are the recent alluvial floodplains of the rivers and late Holocene terraces bordering them, and the coastal strip, as shown on Figure 2.5. These areas also tend to have more development than elsewhere. The floodplains tend to be gravel dominated with only lenses of sand (except for some lake sediments). With the high river gradients in most of South Westland, widespread liquefaction is not expected in the main river floodplains. However, there are areas where finer sediment could have accumulated, in the delta areas infilling the small lakes held by moraine walls, such as Lake Ianthe, in coastal lagoons, and in the coastal area of Haast.

While there is only limited potential for liquefaction in the Westland District on an area basis, any susceptible deposits can be expected to liquefy with shaking from an Alpine Fault earthquake. Of significance is the expected long duration of strong shaking with the Alpine Fault. Of particular importance to the District is that at least some liquefaction is probable in the commercial part of Hokitika, which is underlain at least in part with estuarine deposits.

The majority of the District is underlain with rock and hill soils or gravel dominated glacially derived alluvium of Pleistocene age or older. The age and predominant gravel grading of this material preclude liquefaction in all but very rare combinations, for example, limited areas of loose sand that has not undergone any cementation with age in an area of high water table.

Within the mountain zone, there are the infilled glacial basins along the major rivers. Some of these areas may have finer grained sediments infilling former lakes, which might be expected to liquefy with strong shaking. There is no information available about soil types and soil densities to confirm this. The recent river delta deposits of existing lakes such as at Ianthe and Wahapo may also be at risk of liquefaction. Liquefaction was reported in a lake delta setting at Lake Sumner for the 1929 Arthur's Pass earthquake.

Liquefaction only occurs with saturated soils, and where the water table is within a few metres of the ground surface. There is no information of water table depths for the District as a whole, but again, high water tables are expected in the recent floodplain areas rather than the higher and older glacial gravel deposits.

Although Carr (2004) records many localities on the West Coast that have experienced liquefaction historically, there has not been strong enough shaking in Westland District to cause liquefaction in susceptible soils.

Liquefaction is expected to occur in susceptible soils at distances of up to 250 km from the earthquake epicentral area. As the whole of the Westland District is within 30 km of the Alpine Fault, liquefaction can be expected anywhere within the District where there are susceptible soils. At the very closest distances, some liquefaction is possible in more gravel rich sediments not normally considered liquefiable, because of the intense and long duration shaking expected.

2.3.2 Liquefaction Zones

The Liquefaction zones correspond with the ground shaking zones in Table 2.1. Zone 1 is most susceptible, and as this is the area of recent alluvium, it is shown in Figure 2.5. The location of any site within this zone does not imply that liquefaction will, or will not occur, but it designates the relative risk. For important structures a site-specific investigation is required to determine the actual degree of hazard.

Zone 1 includes the main areas of recent or Holocene age alluvium. These are essentially the recent flood plain and riverbed areas of the major rivers. The soil is predominantly gravel but includes lenses of sand and silt, and the proximity to rivers allows for water tables to be close to the surface. Given the known historical cases of liquefaction that have occurred on the West Coast, there is a high probability of local areas of saturated sand within this area liquefying with strong seismic shaking. Any liquefied areas are probably going to be limited in extent and area, and would still constitute a very small proportion of the overall District area.

For all the rivers, the surfaces assessed as being Holocene to present age may overlie Holocene or younger deposits, or may be erosion surfaces with a thin veneer of reworked gravel over much older glacial outwash gravel, in which case the possibility and extent of liquefaction is reduced.

It should also be noted that the risk of liquefaction in these deposits is likely to decrease with distance from the coast to the foothills, because gravel predominates closer to the river headwaters. The increased river gradients away from the coast tend to carry sand sized particles away, and the higher energy environment will generally produce denser deposits of any sand beds that do form. However, Holocene age deposits within the eastern parts of the District may be more susceptible, in places where lake deposits and low river gradients are present.

There is an area marked as Zone 1A on Figure 2.6 as having a higher liquefaction potential, being the area of estuarine deposits under Hokitika. The boundary to this zone is approximate only, as there is insufficient data to define this area, and no in-situ testing to verify that a liquefaction hazard does in fact exist.

Areas of alluvium older than Holocene age will mainly be dense gravel dominated soils. There may be small areas of Holocene alluvium in places, along watercourses and the like. Much of this zone will have ground water tables at considerable depth, and liquefaction would require a combination of a perched water table as well as loose sand. There is a very small risk of liquefaction of small, isolated areas within this zone.

Remaining areas that are underlain with rock or hill soils would not be expected to contain any liquefiable deposits. No guarantee can be given that liquefaction cannot occur in these areas, because of the very broad nature of the geological mapping at a regional scale, but the risk is considered to be low.

2.4 Landslides

Landslides are a common effect of earthquakes where shaking occurs in steep terrain. A high number of landslides can be expected given that the combination of the steepest and most elevated area of relief in New Zealand coincides with the epicentral region of strongest earthquake shaking. A measure of the landsliding that may be expected is that produced by the 1929 Buller earthquake. This magnitude M = 7.8 event is thought to have triggered over 50 very large landslides with volumes between 1 and 200 million m^3, and many others of several thousand cubic metres. One estimate is for 410 slides within the Matiri catchment alone (about 100 km^2); another estimate is for 3,000 – 4,000 slides within the central affected area between Matiri and Wangapeka Rivers; a distance of about 50km, or about 25% of the length of the Alpine Fault rupture within Westland District north of Paringa. The total number of landslides could have been about 10,000. Fourteen of the 17 deaths in the 1929 Buller earthquake were from landslides. The Buller earthquake occurred in a wetter than normal June, and the extent of landslides will be somewhat dependent on the antecedent rainfall and climatic regime.

Another example is the 2003 Fiordland earthquake (M7.2) which triggered over 400 landslides within the MM VIII isoseismal; a length of about 80km. The15 largest are estimated to have volumes of 50,000 – 70,000 m^3 each (Hancox et al, 2003)

There is evidence of landslides associated with the Alpine Fault. Wright 1998 has identified two debris lobes between McCulloghs Creek and Little Man River north of the Whataroa River bridge, and a large rock avalanche deposit on the left bank of the Wanganui River immediately upstream of SH 6 bridge. The Round Top debris avalanche is located inland from Kowhitirangi, in the area of Lake Arthur, which was formed by the debris deposition. Yetton (1998) dates it as about 1050 years old with an estimated volume of 45+/- 28 million cubic metres and a run out distance of up to 3.5 km. Korup (2004) reports a further 27 landslides or slip areas on the Alpine Fault between the Waitaha River and Jackson Bay.

Most of the landslides expected will be relatively shallow rock falls and surface soil failures. Deeper seated failures of the underlying rock are less common, although the major landslides and the more significant damaging ones in the Buller earthquake were of this type. The least common landslides are likely to be rock avalanches.

There are a number of empirical methods to assess the extent of landslides. Yetton *et al*, 1998, has applied three methods and concludes that they all indicate that there will be major impact from slope failures within 30 km of the region of maximum shaking (this encompasses the whole of Westland region along the fault rupture). His conclusions are summarised in Table 2.3.

Table 2.3: Relative Slope hazard triggered by Alpine Fault Earthquake (after Yetton et al, 1998)

Location	Distance from axis of maximum shaking (km)	Impact, in terms of relative abundance and impact
Otira	5	Major
Franz Josef	10	
Arthur's Pass	10	
Main Divide	1 –20	
Mt Cook Village	20	
Hokitika	35	Moderate
Greymouth	50	
Twizel	60	
Canterbury Foothills	60 - 80	
Buller Gorge	100	Low
Port Hills Chch	130	

A zoning for potential earthquake induced slope instability has not been carried out for this study, because even a simple classification must include a combination of underlying geology and slope. However, the ground shaking zones in Table 2.1 can be used as a rough guide.

- Zone 1 areas are all recent alluvial or marine sediments, and as such are of low relief, with little likelihood of any significant slope failure.

- Zone 2 includes areas underlain with glacial gravel deposits and soft sedimentary rocks. This zone is generally of moderate relief, including some nearly level old outwash alluvial surfaces as well as eroded scarps. The steeper slopes have a moderate risk of slope instability, particularly given the weaker geological units underlying this zone.

- Zone 3 includes a range of stronger rock types, but also generally delineates those areas of steep relief and high slopes. There is a significant risk of earthquake induced instability under moderate to strong earthquake shaking (MM intensities of MM VII or greater, which includes the whole District for the Alpine Fault earthquake).

The impact of landslides can be much wider than the immediate transportation of rock and soil material. Wright (1998) postulates the following scenario, based on what is thought to have occurred with the landslide on the left bank of the Wanganui. This landslide is thought to have occurred in 1717, during the last rupture event.

- Slope failure during the earthquake
- Rapid transportation and deposition of debris, which dams the Wanganui River (three houses would now be in the debris path)
- Formation of a lake in the Wanganui River upstream of the landslide, before overtopping around the north eastern side of the debris, over a terrace about 5m above current river level.
- Rapid erosion of the terrace material and toe of the landslide debris, possibly releasing a large volume of water and sediment downstream.
- Post earthquake aggradation of the river bed, particularly close to the landslide, and flooding of lower terraces close to the river
- Possible long term diversion of the river around and downstream of the landslide.

The potential for long term impacts from landslides initiated by a large earthquake should not be underestimated. A recent example is from Taiwan where the Chi Chi M7.6 earthquake of 1999 is estimated to have triggered over 20,000 landslides with a total area of about 113 km^2 in an area of 2,400 km^2 in central Taiwan. Chen (2005) reports that heavy rainfall associated with a typhoon in 2001 remobilised the displaced material on the hill slopes and induced debris flows and landslides that killed over 240 people. In 2004, another typhoon again remobilised landslides. Within a study area in the Tachia River valley, 45 km of newly completed trans-Taiwan highway was destroyed by slope failure. While its construction cost $53 million, estimates of restoring the road range from $133 to $272 million, i.e. 2.5 to 5 times the original cost. Because of the extent of debris on the highway route, it has been decided not to rebuild this section of road in the foreseeable future.

Landslide debris has also overloaded the river with sediment, to the extent that the bed level has aggraded by up to 18m in places. This has buried the flood banks and the sediment laden floodwaters are highly destructive with many buildings destroyed. The effects on the rivers are leading to large scale disruptions a long distance downstream from the initial event.

There are sufficient similarities between the geology, terrain and tectonic setting of Taiwan and New Zealand to make this example relevant, particularly with the high rainfall in Westland and particularly in the ranges immediately east of the Alpine Fault, where shaking and landslides are likely to be the most intense.

This type of effect is illustrated by another example from the district. Although not triggered by an earthquake, it was the result of high rainfall on an area of shattered and sheared rock associated with the Alpine Fault. Robinson Slip is in the catchment of McGregor Creek ….“…*near the head of the Waitaha Plain. Here, about ten years ago, what is said to have been a spur of Mt Allen began to break away. Slipping of the broken schist rock went on for years, till at last a deep valley was formed where the crest of the spur had been, and the debris covered almost a square mile of country [….] The debris reached the Waitaha River, forcing its channel to the west, and raising its bed by several feet for some miles down. The finer material gave rise to quicksands, which, however, have now almost disappeared. Another effect of the slip was the almost total destruction of the various grassy islands in the river, as well as, of course, the agricultural land over which the debris spread [….]. The crushed, broken nature of the rock which slipped shows that this part of Mt Allen has been subject to fault-movement on a large scale*.” (Morgan 1908 as quoted in Korup, 2004)

This slip demonstrates the size and effect of slope instability that could easily be initiated by the Alpine Fault earthquake or heavy rainfall in earthquake disturbed terrain.

2.5 Seiches

Strong seismic shaking can induce water in lakes to oscillate (or “slop”) at a particular frequency determined by the lake size and depth. These oscillations are referred to as seiches. Seiches were reported at both Lake Brunner and Lake Rotoroa in the 1929 Buller earthquake. At Lake Rotoroa, the lake water withdrew to expose 50m of lakebed, before rising to flood over the shore and carry off the Gowan River bridge which was destroyed. Another example from 1929 was Lake Brunner, where “*the centre of the lake sank into a great cavity, and then the waters rose in a terrifying fashion, and a great wave swept towards the edges. [Mr Peat’s] boat was thrown clean out of the water and over the [Moana] slip. There was great commotion in the lake for some time afterward.”* (Press, 20 June 1929). A 4m high wave was reported at Lake Tennyson. Seiches can be expected in all the lakes in the District. Seiches in Lake Kanieri would be the most significant in terms of effects, because there are dwellings and roads along its shores.

If a large landslide fell into a lake, a large wave could be generated. An example occurred during the 2003 Fiordland earthquake. A rock fall into Charles Sound created a wave that travelled 800m across the sound and damaged vegetation up to 4 – 5 m above high tide level, with trees debarked and rock stripped of vegetation. Similar damage occurred on a small island, and a helipad on piles and adjacent wharf were displaced and moved several metres up the beach. (Hancox et al, 2003). An event of this type could easily occur in Lake Kanieri with high steep hillsides rising directly from the lake within 1 and 7 km from the fault line.

A third possible cause of waves in lakes is from submarine slides of sediment deposited in the deltas of inflowing rivers. Such slides can generate tsunami, and have been recorded historically within lake settings in the world. In 1937 an earthquake triggered a slump on the Dart-Rees delta at the head of Lake Wakitipu, although apparently without large wave generation, (Brodie and Irwin 1970) and slump failures have been identified in Lakes Tekapo and Pukaki. Such events could cause local flooding of adjacent roads and overtopping of outlet structures.

2.6 Tsunami

Overall the tsunami risk to Westland District is regarded as low, but the coastal settlements, including the area of Hokitika west of the railway, are at some risk (Travers, 2005).

Tsunami are waves produced by displacement of the sea floor, either by sudden earthquake related uplift, or by submarine landslides. Tsunamis can be initiated by an event far away from the coast being considered (as in the 2004 Boxing day tsunami in the Indian Ocean) or by a local event (near field tsunami). The West Coast is not exposed to likely far field tsunami, as New Zealand shields it from the most likely far sources along the North and South American coast and north Asia. Australia has a very low level of seismicity. The impact of a far field tsunami is regarded as being very small to nil, and hence the risk to the West Coast is low to very low (Travers, 2005).

Near field tsunamis are a real possibility for the West Coast. There are reports of tsunami associated with the 1913 Westport earthquake (a 1 – 1.5m high wave near Westport), the 1929 Buller earthquake (unusually high waves at Karamea and Farewell Spit, possibly from a large cliff failure south of Little Wanganui), and the 2003 Te Anau earthquake with a small wave just measurable at Jacksons Bay. There is also evidence of a catastrophic inundation of the Okarito Lagoon in pre European times (Goff et al, 2004). Near field tsunami are of greater hazard to people as there is often very little time between the precipitating event and the arrival of the tsunami.

Damaging tsunamis need a significant area of up thrust or subsidence or both of the seabed, and shallow water approaching the coast to steepen the waves. The seabed movement of the scale needed could be produced by a large M7 or greater magnitude earthquake offshore, or a large M7 – 8 magnitude earthquake onshore. Large submarine landslides, which may be caused by a large earthquake, are also considered able to generate damaging tsunami.

Tsunami heights can be increased significantly as they approach coasts over gently shelving and shallow seabed. For the Westland coastline, water depths increase rapidly from the coastline, and only little to moderate increase in tsunami height is expected. There is a known offshore earthquake source with the Cape Foulwind Fault extending south past Greymouth. It is thought to have a low recurrence interval of 3,000 – 10,000 years, but could generate large earthquakes (M7.8 – 8.2), and could generate a large tsunami. A tsunami from this source could be damaging, particularly as the time of arrival would be very short, and there would be little warning after the earthquake. Areas that could be affected are all the low-lying land along the coast and river mouths and estuaries. These include the area of Hokitika west of the railway, whitbaiters baches and low bridges on rivers close to their mouths, and the coastal settlements of Okarito, Okrur and Neild Beach. The beaches are, of course, subject to significant storm-wave action, generally with storm ridges above the high tide level. A tsunami would have to be of a reasonably large wave height to affect the open beach coastline.

The Alpine Fault only approaches the coast in Fiordland, and deformation sufficient to cause a tsunami is only likely in this area. A tsunami associated with an earthquake on the Alpine Fault is possible, but less likely, and much less likely to generate damaging waves, given the deep water close inshore at Fiordland, and the distance any wave would travel parallel to the coast to reach Buller. The effect might be considerable erosion of the beaches, but the impacts in terms of run-up onto land are likely to be much less than for a wave series approaching the coast directly.

The Alpine Fault earthquake scenario assumed for this study has the fault rupture extending on land only from Paringa northwards. Alpine Fault earthquakes are not generally expected to produce regional submarine uplift or deformation and a coastal tsunami is unlikely, and no tsunami has been included in the scenario. It is still possible that submarine or coastal landslides of sufficient volume could produce local tsunami, but again given the ruggedness of the coastal beaches, the probability of damage from this source is considered low. The most vulnerable locations are probably bridges and roadways across river mouths and estuaries, but these are designed for large floods which are likely to be greater than the effects of a tsunami likely to be generated by the Alpine fault earthquake.

3 EARTHQUAKE SCENARIO FOR WESTLAND DISTRICT

3.1 Introduction

This section outlines a possible Alpine Fault earthquake scenario for Westland District with particular regard to the potential impact of an earthquake on the lifelines systems. We have only a limited knowledge of the various networks and components and their capacity and/or resistance to withstand the impact of a significant earthquake. The scenario below is realistic with respect to the potential level of earthquake shaking and the associated secondary effects (liquefaction, landslides etc) that could occur. It is not intended to be predictive with respect to the precise lifeline impacts or the exact locations of any impact. It is likely to be optimistic in terms of damage and the speed of recovery. A plausible second scenario could have SH 6 closed south of Whataroa for several years because of initial damage and ongoing landslides, debris flows and river aggradation in this area of high rainfall.

In effect this is a preview of the types of issue that may follow as an end result of a detailed study of the susceptibility of each lifeline. The impacts listed are intended to help focus thinking on the way that lifelines systems can be affected by a strong earthquake and suggest some of the interdependency issues between lifelines.

The scenario also includes possible damage that may occur to the main lifeline links between Westland District, the surrounding Districts and the remainder of the South Island. This is because impacts outside the District will have a direct and significant effect on the ability and speed with which Westland District can respond to the earthquake and the consequential damage.

The scenario has been set for a particular time of day and year. In terms of the lifelines, this is not so significant, except that rainfall patterns both before and after the earthquake will impact on the number and nature of landslides both immediately and following the event, and the likelihood of damaging floods. If the scenario is used as a basis of emergency planning, the timing becomes more significant. For instance, visitor numbers in the summer are much higher than in winter, and initial response may be significantly more complicated with large numbers of people trapped in South Westland and outlying areas of the District. An earthquake during the day would result in many travellers being caught on the road network, whereas a night event would have most people at home or in accommodation. While these may appear small details, such variability could have a significant effect on the focus and availability of resources during the early part of recovery, which could in turn affect the re-establishment of lifeline services.

3.2 Time zero - 10:15am on a weekday morning in late winter

For a brief description of the experience of being close to the centre of a large earthquake refer to the beginning of Appendix C.

For several days there have been a series of minor tremors registered by seismographs but too small to be felt, in the vicinity of Mt Cook and the central Southern Alps. At 10.15am there is a very large earthquake (M 8) on the Alpine Fault with an epicentre near the Whitcombe Pass, about 10km east of the Alpine Fault trace.

The earthquake affects much of the South Island. The likely pattern of isoseismals across the South Island is shown in Figure 2.2 and Figure 2.3 shows Westland District at a larger scale. Shaking intensities for localities within the district and across the South Island are listed in Table 3.1. The fault ruptures over a length from Paringa in the south to north of the Matakitaki Valley in the north. The fault movement on the section through the Westland District increases from 1m horizontally and 0.3 m vertically at the south end of the rupture at Paringa to 8m horizontally and 1m vertically by Franz Josef and continuing at that magnitude to beyond the north boundary of the district (at Inchbonnie). The bracketed duration of strong shaking (defined as acceleration exceeding 0.05g) lasts for approximately one minute in the epicentral area (within the MMIX isoseismal) for virtually the whole of the District.

Note that this scenario has the rupture stopping about 125 km north of the south boundary to the district, to replicate the 1620 event. It is entirely possible that in an actual earthquake the rupture could extend further south to Milford, in which case the southern most settlements of lake Paringa, Haast, Okuru and Jackson Bay would all experience shaking intensities of MMIX or stronger (refer second scenario, Section 3.13).

Table 3.1: Shaking Intensities at Selected South Island Centres

Intensity	Localities in Westland District		Localities within South Island	
MM IX +	Otira	Whataroa	Franz Josef	Arthur's Pass
	Kokatahi	Franz Josef	Mt Cook	Springs Junction
	Ross	Fox Glacier		
	Harihari	Bruce Bay		
MM VIII	Kumara	Lake Paringa	Greymouth	Hamner
	Hokitika	Haast	Hokitika	Springfield
			Reefton	Fairlie
			Inangahua	Twizel
			Murchison	Haast
MM VII	Okuru		Westport	Ashburton
	Jackson Bay		Nelson	Timaru
			Kaikoura	Wanaka
			Christchurch	
MM VI			Oamaru	Dunedin
			Wellington (N.I.)	Queenstown

Appendix B outlines in full the criteria that establish these Modified Mercalli intensity classes but the descriptions of MM VIII and IX as defined by the Study Group (1992), modified for the environmental criteria as proposed by Hancox (12002), are presented in Table 3.2.

Table 3.2: Definition of Modified Mercalli Intensities VIII and IX (Study Group, 1992)

MM VIII	
People	Alarm may approach panic Steering of motorcars greatly affected
Structures	Buildings Type I (i.e. buildings of weak materials such as mud brick, rammed earth, poor mortar) heavily damaged, some collapse. Buildings Type II (i.e. average to good workmanship and materials with some reinforcement but not designed to resist earthquakes) are damaged, some seriously. Buildings Type III (i.e. designed to resist earthquakes with codes operative prior to around 1980) damaged in some cases. Monuments and elevated tanks twisted and brought down. Some masonry infill panels and brick veneers damaged. Weak piles damaged. Houses not attached to foundations may move.
Environment	Cracks appear on steep slopes and wet ground Small to moderate landslides widespread, significant areas of shallow regolith landsliding. A few large landslides from coastal cliffs, and possibly large rock avalanches from steep mountain slopes. Larger landslides in narrow valleys may form small temporary lakes. Roads damaged and blocked by small to moderate failures of cuts and slumping of road fills. Evidence of liquefaction common with small sand boils, localised lateral spreading along river banks and other manifestations of liquefaction.
MM IX	
People	General panic
Structures	Many buildings Type I destroyed. Buildings Type II heavily damaged, some collapsing. Buildings Type III damaged, some seriously Buildings Type IV (i.e. designed and built to codes operative since around 1980) are damaged or suffer distortion in some cases. Brick veneers fall and expose framing.
Environment	Cracking of ground conspicuous Landslides widespread & damaging in susceptible terrain on slopes steeper than 20^{o} Extensive areas of shallow regolith failures and many rock falls and disrupted slides on slopes steeper than 20^{o}, cliffs, and man-made cuts. Many small to large failures and some very large landslides on steep susceptible slopes. Very large failures on coastal cliffs and low-angle bedding planes in tertiary rocks. Large rock avalanches on steep mountain slopes. Landslide – dammed lakes in narrow valleys. Damage to road and rail infrastructure widespread with moderate to large failures of road cuts and slumping of fill edges. Liquefaction effects widespread with numerous sand boils on alluvial plains and extensive, potentially damaging lateral spreading along banks. Spreading and settlement of stop banks likely.

3.3 Time zero plus 1 minute

Within one minute of the first shaking there is damage to lifelines in the epicentral[2] and near epicentral areas as follows:

3.3.1 Transport

<u>(a) North of Ross</u>

SH 73: There are extensive landslides and rock falls throughout the Arthur's Pass area. SH 73 is closed at the Otira Bridge and by slips between Otira and Aickens and near Rocky Creek. There is severe damage from ground movement between Rocky Creek, where the road is severed by fault rupture, and Griffen Creek. The Taipo Bridge suffers partial collapse, and there is significant damage to the Big Wainihinihi and Turiwhate Creek bridges. Batter failures effectively block the road in several places between Wainihinihi and Kumara.

SH 6: Liquefaction causes cracking and distortion to the road in several places between Rautapu and Serpentine Creek. The Arahura Bridge suffers some damage.

District Roads: There are batter failures effectively blocking the back roads in many places, closing the Stafford Loop Road east of Stafford, Lake Kaniere Road east of McKay Creek, and Dorothy Falls Road along the side of Lake Kaniere. A large landslide into Lake Kanieri off Conical Hill sends a wave across the lake, washing over the road through Hans Bay and the road and bridge at the lake outlet.

Dorothy Road and Upper Kokatahi Roads are severely damaged by ground distortion and fault rupture close to the Styx River. The Upper Styx Bridge is effectively destroyed with pier damage and the beams unseated. There is damage throughout the Kokatahi – Kowhitiangi area from local slumping, liquefaction and bridge and culvert damage. The Kokatahi Bridge is damaged.

Roads in Hokitika suffer some damage from cracking and distortion. Part of the batter above the bottom of Seaview Hill Rd has collapsed, bringing half a house down onto the road.

Railway: The railway suffers some embankment distortion north of Hokitika and is affected by the damage to the Arahura Bridge. There is extensive damage on the Midland line between Jacksons and the Otira tunnel with slumping and slips.

Airport: The Hokitika airport is relatively undamaged other than building contents falling to the floor. A number of helicopters on the Coast have been damaged on the ground through overturning.

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[2] For this report, the epicentral area is defined as being that area within 5km of the fault rupture.

<u>(b) Ross – Franz Josef</u>

SH6: There is minor damage between Ross and the Wanganui River, with batter failures, slumping etc, although slumping at bridge abutments effectively closes the road. The fault ruptures the road in two places just east of the Wanganui River with 8m horizontal and 1m vertical displacements. The east end of the Wanganui Bridge is within 200m of the fault rupture and is severely damaged with pier movement resulting in 3 spans collapsing. A slip blocks the road just east of Poerua River, and that bridge suffers damage plus abutment slumping. There are numerous small slips over Mt Hercules, as well as a large one that completely buries the road at Hercules Creek. Liquefaction causes severe slumping and lateral spread in three places close to Gunn Creek.

At Parker Creek the bridge and 0.5km of road is destroyed by fault rupture along it, the fill to McCulloughs Creek Bridge is badly damaged and slips destroy another 100m of road to the south of Parker Creek. The bridge over the Whataroa River is severely damaged. The road is sheared by the fault rupture 400m west of the bridge.

The Waitangitanoa Bridge is significantly damaged with one pier collapsing and the east abutment slumps. There is liquefaction damage to 0.6 km of road near the head of Lake Wahapo, and batter failures along the lake. The Tatare Bridge is damaged. In Franz Josef, the road is sheared by the fault rupture, which also destroys the petrol station and ruptures the fuel storage tanks and pipe work.

District Roads: The roads on the alluvial flats in the Waitaha, Harihari and Whataroa areas suffer only minor damage with some slumping of fill at bridge approaches, and liquefaction fissuring in local areas of sandier soils. The road to Okarito is blocked by a slip 0.5km south of the Forks and slips along the side of the lagoon. The bridge over the Okarito River is only slightly damaged.

Airstrips: Grassed airstrips are virtually undamaged, although there is some distortion of the runway surfaces.

<u>(c) Franz Josef - Haast</u>

SH6: The Waiho River Bridge, despite being within 400m of the fault, survives the shaking with some distortion. The road is severed by the fault rupture 700m from the bridge. The stop bank along the road fails in many places and 1km of road is covered with gravel debris.

The road over Cook Saddle is severely damaged. A 6km length between Paddy Creek and Clearwater Creek is 70% destroyed by fault rupture and large landslides. Large slides also destroy the road in the Kiwi Jacks Valley and on the west side of Omoeroa River. Kiwi Jacks Bridge is destroyed by shaking damage and a large rock fall, and the Waikukupa Bridge is effectively destroyed by pier failure.

The three suspension bridges over the Fox, Cook and Karangarua Rivers are all virtually on the fault. The Fox and Karangarua bridges collapse by failure of the towers, and the Cook Bridge is significantly damaged.

There are numerous slips and batter failures west of Ohinetamatea River, where the bridge is also damaged. There is damage to Manakaiaua, Jacobs and Mahitahi River bridges. The Paringa Bridge is within 300m of the fault, but suffers only minor damage, although the embankments at each abutment slump.

There are slips and rock falls on the Moeraki Bluffs and between Whakapohai River and Seal Creek on the Knights Point section. There is some damage to the Moeraki River, Ship Creek, Waita River and Haast River bridges.

The 2km of raised road between the Haast Bridge and the Haast Township is affected by slumping and batter failure. There is significant landslide and rock fall damage to the road between Haast and Wanaka.

District Roads: There is some slumping on the Haast - Jackson Bay Road in areas of fill and bridge approaches, and minor damage to bridges. Some rock falls and slips and localised liquefaction occur on the Jackson Bay Road. The Jackson Bay wharf is only superficially damaged. More extensive batter failure and slumping occurs on the Gillepsies Beach Road.

Airstrips: Grassed airstrips are not significantly affected.

3.3.2 Drainage

There are large landslide dams in the valleys of the Kokatahi, Toaroha, Whitcombe, Waitaha, Poerua, Tatare, Callery and Cook Rivers. The rivers are completely blocked at all these locations.

Liquefaction under some short lengths has damaged the Hokitika River stop bank within the town. This has also broken two of the storm water outlet pipes to the river. Stop banks throughout the district, including those in the Kowhitirangi and Kokatahi areas, on the Wanganui, Waitangitanoa and Waiho Rivers are damaged with slumping of the batters and rare liquefaction induced spreading. The stop bank on the south bank of the Waiho is destroyed on the fault trace by the rupture.

3.3.3 Sewerage

The oxidation pond at Hokitika is moderately damaged with distortion of the embankments and cracking of wave band concrete. Liquefaction in sands under the site causes lateral spreading that damages the north east end embankment wall, and allows water ingress into ground fissures. The sewers are damaged, particularly in the business area where liquefaction causes gross pipe displacement, and on the main pipeline north to the oxidation ponds. All pump stations are stopped due to power supply interruption, and the Gibson Quay pump station is affected by liquefaction such that the inlet and outlet pipes are broken at the structure's wall leaving a gap of 10 cm.

The sewer system at Franz Josef is significantly damaged. All pipes crossing the fault are destroyed and most of the system suffers severe damage with breaks at junctions and manholes. The oxidation ponds are damaged with cracking to the waveband and slumping of the embankments.

The Haast township system escapes major damage and the oxidation pond is not affected.

3.3.4 Water supply

The Hokitika supply main from Lake Kaniere is broken in several places, including at the abutments of Kennedy Creek and Kaniere River bridges. There is damage at the treatment plant with one of the tanks rupturing, and several breaks in the pipe work. The Cement Lead Rd reservoirs are cracked. The distribution system is damaged, particularly in the business district with liquefaction in some areas, and breaks in the brittle AC pipes.

At Ross, the reservoir is undamaged, but a landslip has broken the intake supply pipe. There are breaks throughout the distribution system.

The Harihari and Whataroa schemes suffer numerous breaks. The Franz Josef system is completely disabled. The reservoirs collapse, releasing their contents downslope and the distribution lines are severed at the fault rupture. All water drains from the system within 10 minutes.

3.3.5 Power Supply

Power supply is lost throughout the whole District. All links into the District lose supply, all the local generation is shut down by the earthquake, and there is significant shaking damage at substations. The Transpower line through Arthur's Pass is cut in three places by loss of poles and near Otira by a landslide destroying three transmission towers. There is extensive damage to the Electronet system with poles down and other breakages. A pylon on the north bank of the Wanganui River is destroyed, dropping the wires into the river. The line between Franz Josef and Fox Glacier is destroyed for 40% of its length.

The power stations at Dillmans escape significant damage, although there is movement to the dams. The Fox power station suffers a penstock failure and subsequent damage from released water. The Turnbull station at Okuru and the distribution system between Haast and Jackson Bay is only slightly damaged and remains operational.

3.3.6 Telecommunications

Fixed line phones within parts of Hokitika remain working, but the larger network fails, as does the mobile phone network. The fault rupture cuts the fibre optic cable over Arthur's Pass in four places, and the fibre optic cable to Nelson is also cut in three places due to bridge abutment settlements and road dropout. The fibre optic cable between Greymouth and Hokitika is severed at the Arahura Bridge due to slumping of the south abutment. The fibre optic cable between Hokitika and Franz Josef suffers multiple breaks at points where it crosses the fault (near Harihari and Whataroa), at failed bridge abutments (at bridges over the Wanganui, Whataroa, Waitangitanoa and Tatare rivers) and due to landslides near Porters Creek. The fibre optic cable on power poles between Franz Josef and Fox is damaged beyond repair.

3.4 Time zero plus 1 hour

(a) Transport

The situation in the epicentral zone close to the Alpine Fault between Paringa and the Taramakau River is one of widespread devastation with most roads effectively blocked and most bridges damaged (refer to Figure 3.1). SH 73 is impassable east of Turiwhate and damage to SH 6 has effectively divided South Westland into isolated districts around Harihari (SH 6 destroyed at Wanganui River), Whataroa (SH6 severed on both sides of Whataroa River), Franz Josef (SH6 bridge down at Waitangitanoa plus slips at Lake Wahapo), Fox Glacier (SH 6 destroyed over Cook Saddle), Jacobs River – Paringa (bridges destroyed at Fox and Karangarua) and the Haast area (slips blocking SH 6 over the Haast Pass and around Knights Point.

Other roads vary from little damage able to be used by normal cars to impassable because of slips or settlement at bridge abutments. The road north towards Greymouth is passable by four wheel drive, but fissuring from liquefaction prevents immediate car use in places.

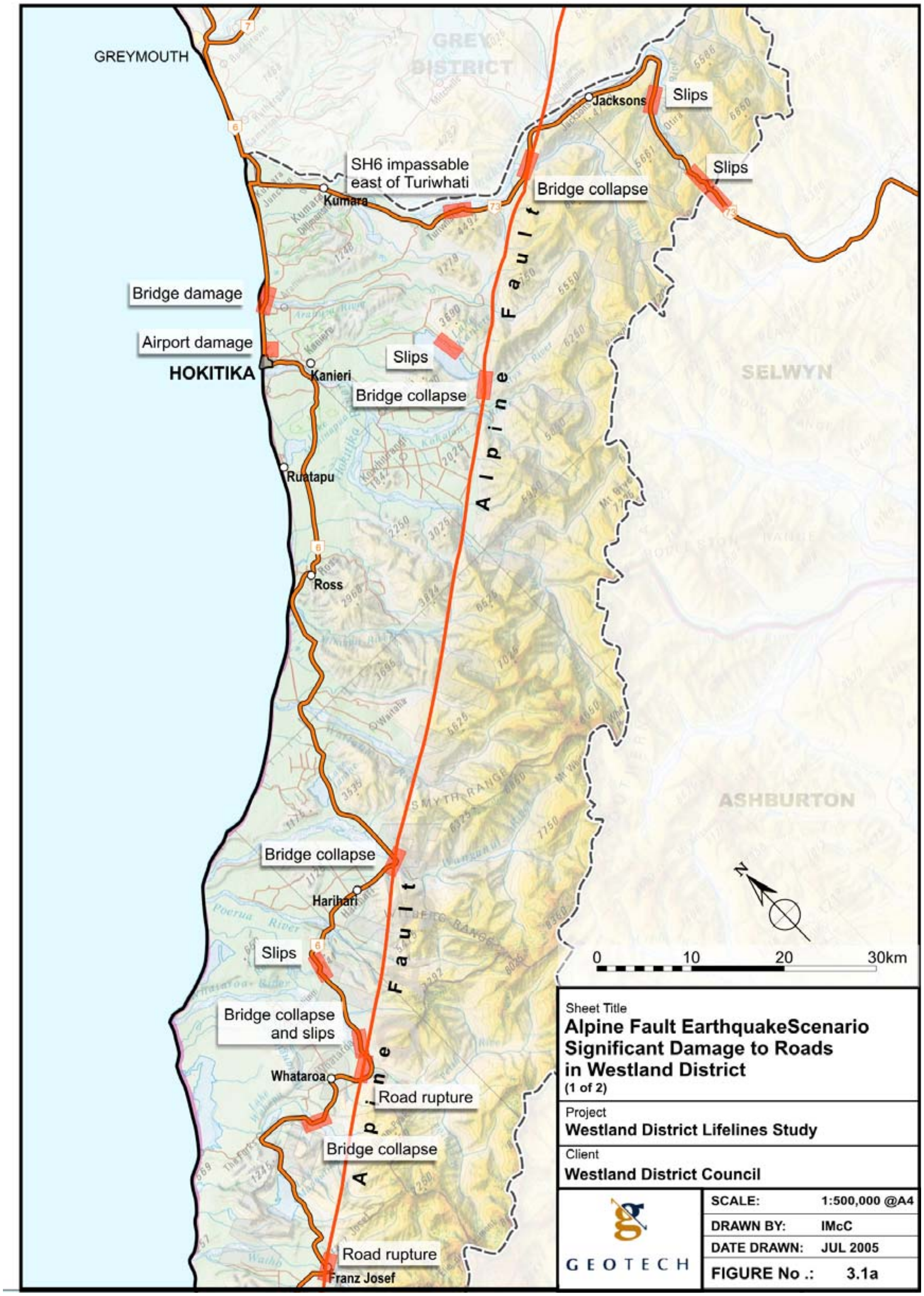
All traffic on the railway has been suspended

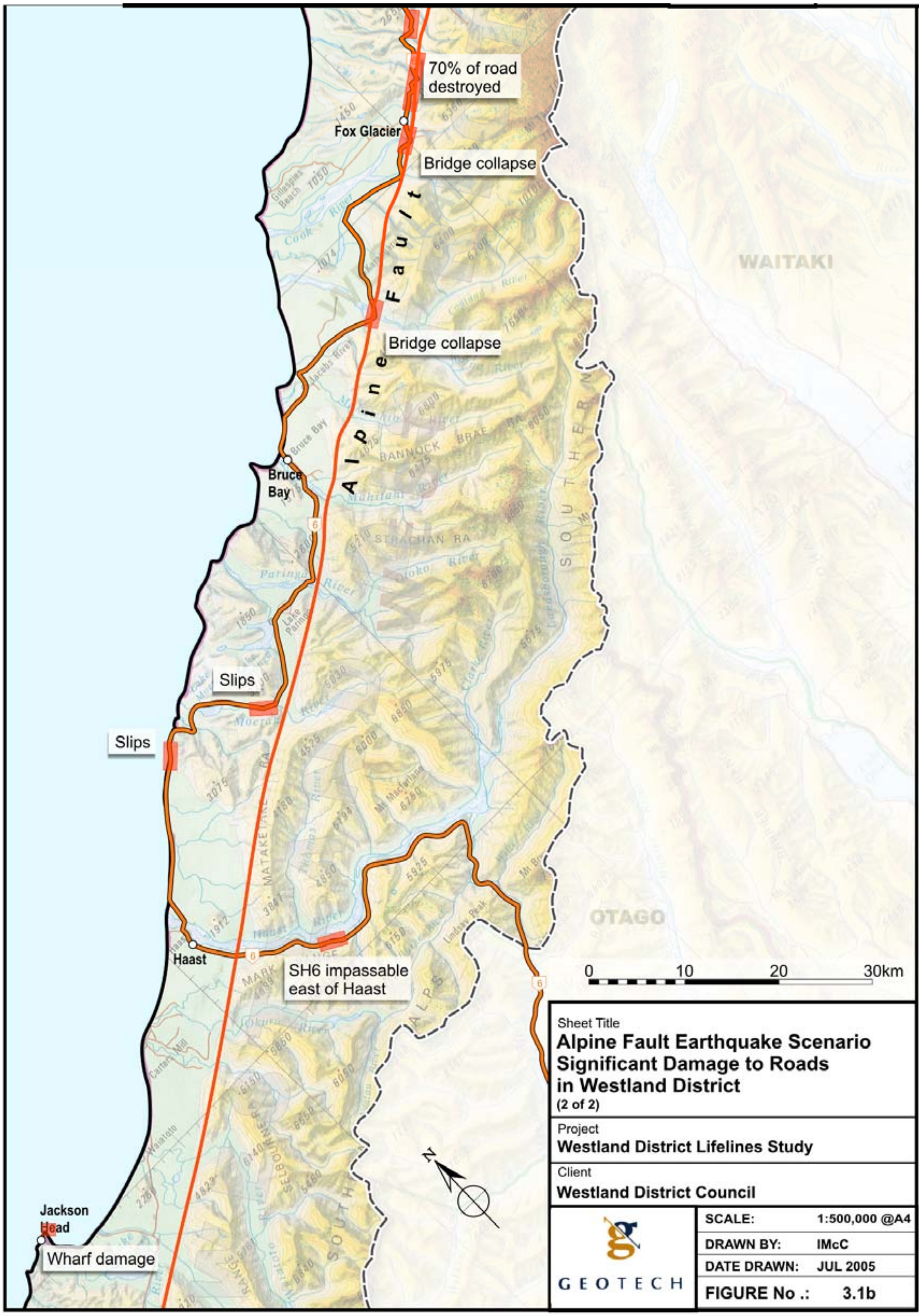
(b) Drainage

There is no immediate issue with priorities elsewhere.

(c) Sewerage

Sewerage is flowing on the ground in two locations in the Hokitika business area. The seepage into the damaged bank at the Hokitika oxidation ponds causes a bank failure, and within a short time the north pond has drained and effluent is covering the paddock to the north.


GREYMOUTH
GREY DISTRICT
Jacksons
Slips
SH6 impassable east of Turiwhati
Kumara
Bridge collapse
Slips
Bridge damage
Airport damage
Slips
HOKITIKA
Kanieri
Bridge collapse
SELWYN
Alpine Fault
Ruatapu
Ross
ASHBURTON
Bridge collapse
Harihari
Slips
Bridge collapse and slips
Whataroa
Road rupture
Bridge collapse
Road rupture
Franz Josef
0
10
20
30km
Sheet Title
Alpine Fault EarthquakeScenario Significant Damage to Roads in Westland District
(1 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 3.1a


70% of road destroyed
Fox Glacier
Bridge collapse
Alpine Fault
Bridge collapse
WAITAKI
Bruce Bay
Slips
Slips
Haast
SH6 impassable east of Haast
OTAGO
Jackson Head
Wharf damage
0 10 20 30km
Sheet Title
Alpine Fault Earthquake Scenario
Significant Damage to Roads
in Westland District
(2 of 2)
Project
Westland District Lifelines Study
Client
Westland District Council
GEOTECH
SCALE: 1:500,000 @A4
DRAWN BY: IMcC
DATE DRAWN: JUL 2005
FIGURE No .: 3.1b

(d) Water supply

The breaks in the main pipes into and out of the Hokitika reservoirs are discharging water, the reservoirs are emptying and the whole system has no pressure. Similar draining of reservoirs is occurring at Ross.

A number of fires have broken out in Hokitika and throughout the District from damage to fireplaces and stoves. In one location, fire from one house has spread into an adjacent house. A fire crew is on site, but are only able to prevent the fire spreading due to lack of water. A fire in Franz Josef has been fuelled by petrol escaping from the damaged fuel tanks at the service station destroyed by fault rupture, and has engulfed a block in the township. There is no water to fight it with, and people, who are completely shocked anyway, are being evacuated out of the township to the hotels north of the town.

(e) Power Supply

Power remains off throughout the whole District. Back up generators at the Hokitika hospital and Council are working. The Upper Waitaki Hydro stations are all off line following the earthquake, and there is damage throughout the network on the East Coast.

(f) Telecommunications

All the telephone links out of the region and between districts, the mobile network, paging, and Eftpos services are all down.

3.5 Time zero plus 3 hours

(a) Transport

The Hokitika Bridge has been officially re-opened for light traffic. A front end loader has cleared debris from the road to the airport and from SH 6 at the corner of Seaview Hill Road, but the bottom of Seaview Hill Rd itself remains blocked. There is little traffic other than people attempting to return to their homes.

(b) Drainage

There is no immediate issue, with priorities elsewhere.

(c) Sewerage

With the loss of water and hence little inflow into the system, there is no immediate critical issue.

(d) Water supply

All valves on the main distribution lines within Hokitika have been closed, and the flow out of the reservoirs stopped with half their contents remaining. All other systems except Kumara are effectively inoperative with no water. The Ross reservoir half drained before the valve was closed.

(e) Power Supply

No change

(f) Telecommunications

No change.

3.6 Time zero plus 9 hour

Some news is now reaching Hokitika from outlying areas. There are 15 confirmed deaths in South Westland and two from the Kanieri area.

(a) Transport

It is now dark. SH 6 is open for essential traffic as far south as the Mikonui River but remains blocked in many places further south. To the north, SH 6 has been closed for vehicular traffic at Arahura as the Arahura River bridge has suffered some damage to piers and the superstructure. SH 6 north of Arahura has been reopened for essential four wheel drive traffic to Greymouth, and SH 73 to Dillmans. The roads to Lake Kaniere and Kokatahi are passable following some local filling to bridge abutments, but the Kokatahi Bridge remains closed due to abutment damage. All traffic on the railway has been stopped.

(b) Drainage

There is no immediate issue, with priorities elsewhere.

(c) Sewerage

No change.

(d) Water supply

A milk tanker is ferrying water to the Civil Defence posts at the schools and the hospital in Hokitika. Other than this, all systems remain inoperative.

(e) Power Supply

The whole District is without power except for those facilities with back up generators.

(f) Telecommunications

All cell phone towers are inoperable because of loss of link to national network, but are now without power due to battery depletion.

3.7 Time zero plus 24 hour

(a) Transport

Most local roads in the Hokitika area are negotiable by four-wheel drive vehicles. Seaview Hill Road has been cleared for one-way traffic. The Arahura bridge remains closed, still severing Greymouth and Hokitika. The Haast – Jackson Bay road is negotiable by four-wheel drive, as are the roads on the flats immediately adjacent to Whataroa and Harihari. SH 6 remains blocked at the major river crossings throughout South Westland. The road between Whataroa and Franz Josef is still closed close to Lake Wahapo and at the Waitangitanoa. A helicopter is traversing SH 6 south of Franz Josef to locate the many travellers stranded on cut-off sections of the road. Another helicopter is assisting in the recovery of survivors and bodies from a tourist bus that was caught by a landslide and rolled off the road near Cook Saddle.

Outside the District, the inland route between Greymouth and Westport through Reefton and Inangahua is expected to open within a few hours, but it is clear that the SH links of SH 6, SH 7 and SH 73 will all be closed for some days (if not weeks). The West Coast is effectively isolated.

(b) Drainage

There is no immediate issue, with priorities elsewhere. The landslide dam in the Whitcombe River has overtopped, without any problems downstream, as the dam break peaks were moderated through the Hokitika Gorge.

(c) Sewerage

No change.

(d) Water supply

Repairs are underway to the Hokitika supply main from Lake Kaniere. There was some damage to the intake on the lake from the seiche, as well as breaks in the pipeline. Water distribution is being made by tanker.

(e) Power Supply

Trustpower have checked the Dillmans Hydro scheme and restarted it at low output (less than 1 MW), but are unable to operate at higher output in isolation as it needs the grid for synchronisation to control the frequency. The small stations in Westland District are similarly affected, except for the Turnbull scheme at Okuru, which has restarted and is supplying power to Haast and Hannahs Clearing. Repair to distribution lines is happening, but is constrained in part by road damage restricting access.

(f) Telecommunications

A team of cable specialists has arrived from Wellington to start repairing breaks in the fibre optic cables.

3.8 Time zero plus 48 hour

The situation in the Hokitika area is stabilising, and the first emergency aid has arrived at the airport. All people resident within about 5km of the fault have been evacuated to Hokitika. A Hercules aircraft has arrived with troops to provide support and tents for accomodation of people evacuating to Hokitika. In South Westland the situation is grim. The number of deaths reported has risen to 35 and there are many tourists missing. Strong aftershocks continue to be felt. Supplies and adequate housing at Franz Josef are insufficient. Many helicopters were toppled and damaged by the earthquake leaving only a few to assist in emergency and recovery work. Light aircraft are being used to evacuate the most seriously injured people. Communication is restricted to a few radio sets. Some injured have been evacuated from Franz Josef and Fox to Hokitika. The Haast area, being south of the fault rupture and the worst shaking, is isolated, but relatively self sufficient, even though the whitebaiting season has swelled the population from the usual few hundred to well over a thousand.

(a) Transport

Clearing of roads in the northern part of the district continues, although traffic is confined to single lanes in many places. The Arahura Bridge has had some immediate strengthening work carried out, and has been reopened to essential light vehicles only, to reconnect Greymouth and Hokitika. The road between Franz Josef and Whataroa has been cleared for four-wheel drive vehicles, but the bridge collapse at Waitangitanoa prevents through access. Access to Haast via SH 6 east of Haast is still blocked and is unlikely to be cleared for some time because of the demand for resources to complete other work. Fuel supplies are of concern, and are available to essential vehicles and plant only. No work has been started on the railways as the extent of damage and options for reinstatement of the whole network are still being assessed.

(b) Drainage

The landslide dam in the Toaroa River has overtopped, but only limited scour of the dam occurred and no significant flood resulted downstream.

(c) Sewerage

No change

(d) Water supply

The main pipe from Lake Kaniere was thought to have been repaired, but on filling several other leaks became apparent and the pipe is still being worked on. One of the mains from the reservoirs has been repaired and part of the distribution system has been checked and ready for water once the supply is re-established. Water tankers continue to take water to the Civil Emergency posts in both Hokitika and Ross.

At Franz Josef, water is being sourced by bucket from the local streams.

(e) Power Supply

Transpower has reinstated supply from the north, and Hokitika is on reduced power. No power is available inland from Kokatahi or south of Ruatapu due to line damage.

(f) Telecommunications

Faults on the fibre optic cable in the Grey Valley and at the Arahura River bridge are repaired and telephone communication is re-established between Westport, Greymouth, and Hokitika. Mobile phones and Eftpos are still down as the fibre optic link to the national network is still cut.

3.9 Time zero plus 1 week

(a) Transport

Strong aftershocks on day 3 delayed road repair work by bringing down more landslides and damaging temporary repairs to some bridge abutments.

The first transport from Nelson reached Hokitika on day 6 after the earthquake. Supplies of food and fuel were among the first deliveries. SH 7 over the Lewis Pass remains closed. Repair work to the Arahura Bridge has allowed heavy vehicles to move between Greymouth and Hokitika. People have been evacuated from the Franz Josef, Whataroa and Harihari areas by vehicle between damaged bridge crossings, on foot over the bridges and by bulldozer and jet boat over the Wanganui River downstream of the bridge. All tourists and most locals are choosing to leave because of the devastation and ongoing aftershocks.

Fishing boats have delivered supplies to Jackson Bay and tourists and temporary residents in the Haast area have been evacuated by air to Dunedin and Invercargill.

(b) Drainage

The landslide dam on the Waitaha River overtopped on day 4, resulting in damage to farmland but no infrastructure damage. A helicopter survey of the mountain catchments on day 4 has identified a further twelve landslide dams with the potential to breach and cause flooding downstream. It has started to rain heavily in the alpine areas for the first time since the earthquake.

(c) Sewerage

Temporary drains have been excavated in places to take sewerage into the Hokitika River from the damaged pipes in the business area.

(d) Water supply

The strong aftershock on day 3 damaged the temporary pipe repairs at the Kaniere Bridge abutment, but water supply to the reservoirs was reinstated on day 5. The water is turbid as a result of landslides into and within the lake, as well as into tributary creeks. Repairs to the water supply systems are continuing, although the aftershock caused further pipe breaks delaying work as the repair crews had to go back over sections that had been repaired. Ross remains serviced with standpipes, as repairs to the distribution system and intake pipe have to wait until more urgent repairs are done.

(e) Power

Power supply has been reinstated to 80% of the area and 90% of the habitable properties north of and including the Waitaha Valley. Apart from the Haast area, there is no power south of the Waitaha.

(e) Telecommunications

The fibre optic link to Nelson through Springs Junction has just been repaired. This allowed landline communication to outside the West Coast for the first time since the earthquake. Mobile phones and Eftpos are expected to be operable again in Westport, Greymouth and Hokitika within 24 hours. The fibre optic cable is repaired at the Wanganui River Bridge by installing 1500m of cable over land from near the fault rupture north of the bridge to near the fault rupture west of the bridge. A helicopter was used to lay the cable over the bridge and the cable is attached to bridge piers where two bridge spans are missing. Teams in helicopters realign the microwave stations at Mt Hercules, Omaroa, and Franz Josef and install a temporary station near Fox with capacity for 10 calls at one time. Telephone communication is restored to Harihari by day three and to Whataroa, Franz Josef and Fox by day four.

3.10 Time zero plus 2 week

(a) Transport

Rain during the second week triggered a large number of slips within earthquake weakened ground, including two cut faces to the higher terrace in Hokitika. Slips destroyed two houses. All essential routes north of the Wanganui River are open to traffic, although at reduced speed and often with single lane width only. Dorothy Falls Road, the Upper Kokatahi Road and the Totara Valley Road into the upper Mikonui all remain closed with no intention for reinstatement in the near future. Haast remains isolated.

Most people including permanent residents have been evacuated to Timaru from the Fox and Franz Josef areas. Some residents have elected to stay on in Okarito, Whataroa and Harihari.

(b) Drainage

Intermittent heavy rain during the second week caused all the main rivers in the District to rise. The landslide dam on the Kokatahi River breached on day 12. The resulting flood wave caused flooding in the flats downstream, destroying some farmland and killing stock, but caused no problem to infrastructure. A dam break on the Poeroa River on day 10 resulted in the north abutment to the bridge being washed out. The landslides in the Tatare River and Callery River breached on day 12. The Tatare dam break resulted in a debris flow onto the head of the fan which caused the river to change course and wash out SH 6 300m south of the bridge, destroy the airstrip and narrowly miss damaging the school. The Callery dam break impacted immediately on the Waiho River. Fortunately the flood wave did not impact significantly on the north bank, but destroyed the damaged SH 6 bridge over the Waiho, and washed out the stopbank on the south bank where the rupture had breached it, resulting in a major portion of the flow following down SH 6 to and around the south and west sides of Canavans Knob before returning to the riverbed. The dambreak in the Cook River on day 10 did little damage.

Stop bank damage resulted in flooding problems in Vine Creek, along the Wanganui River near Harihari, and on the Poerua, where the dam break exacerbated the issues resulting in two houses being flooded on the north bank. The damaged SH 6 embankment upstream of the Haast Bridge was washed out in one location resulting in local flooding and the cutting off of Haast township from Okuru for 3 days.

(c) Sewerage

The rain has exacerbated the effects of the sewer damage in Hokitika, with isolated pockets of sewage flowing on the ground surface. The flood in the Hokitika River caused problems with outflow from the business area due to the damaged pump station.

(d) Water supply

Repairs to the water supply systems are continuing, with water reinstated to 60% of Hokitika, although at a reduced pressure. The outlying systems remain as they were at week 1.

(e) Power

A temporary line has been strung across the Wanganui River to supply power to Harihari. There is no power south of Harihari township.

(f) Telecommunications

Slips cut the fibre optic link to Nelson for 3 days before access and another repair kit brought into the area allowed repair.

3.11 Time zero plus 1 month

(a) Transport

The roading network within the District north of the Wanganui River is largely functional again, although there are many areas with metalled surface, one way sections and weight and speed limitations on bridges. The situation south of the Wanganui remains unchanged, although a start has been made on a temporary link across the destroyed spans of the Wanganui bridge. SH 6 remains severed at the Wanganui and Whataroa Rivers, dependent on fords on the Poerua, Waitangitanoa and Tatare Rivers, and closed between Franz Josef and Haast.

The Lewis Pass route was reopened 16 days after the earthquake to essential traffic only. The Arthur's Pass route remains closed between Turiwhate and Arthur's Pass, with no immediate plans of repairing the remaining length, due to other priorities for resources. Haast Pass, although not as extensively damaged as the other passes, remains closed because of a bridge failure and priorities for resources elsewhere. Access to the Haast area is considered lower priority because of the small population and because the wharf and the airstrip provide alternative transport routes to and from the area.

The railway line between Hokitika and Ngakawau could be used for transport within the region and between the ports, but CDEM has decided to concentrate resources on the road system, because of the greater versatility of the road network.

(b) Drainage

It has already become apparent that aggradation of the rivers draining the alpine areas is occurring. In the most affected epicentral area between the Taramakau and Paringa rivers, virtually all the local catchments are choked with landslide debris. During heavy rain, debris flows and the streams carry material onto the outwash fans and the lower stream channels have become unstable and are changing course with virtually every fresh. The roads in the immediate area of the range front, badly damaged by the earthquake, are now being covered by debris, which has effectively buried some of the damaged bridges. Heavy rain has produced debris flows in many catchments, overwhelming any training work that may have existed. Similar problems are also occurring in some locations away from the fault area, such as at Fergusons farm south of the Mikonui with resultant flooding of SH 6.

(c) Sewerage

The sewer reticulation in Hokitika is functioning although still damaged, with repairs to the obstructed points, but discharge is still to the river, and the local waters are polluted.

(d) Water supply

Repairs to the water supply systems are continuing, with water reinstated to 90% of Hokitika. The Ross intake and pipe have been reinstated and the upper part of the town has a restricted water supply. The lower part is still requiring repair and water is being tankered in to a series of temporary tanks and standpipes.

(e) Power

Power has been restored to Franz Josef.

(f) Telecommunications

Telecommunications are back to normal to 95% of the district from Harihari northwards. Between Whataroa and Franz Josef the capacity is limited by the microwave transmission capacity and between Fox and Haast the telephone link is still limited and unreliable.

3.12 Time zero plus 1 year

(a) Transport

The roading network north of Ross is essentially back to pre-earthquake condition, although with many speed and weight restrictions in place, and with the roads close to the fault remaining closed. The Dorothy Falls Road remains closed past Rose Creek as does the Upper Kokatahi Road at Styx River. Some key elements, such as the Arahura Bridge remain with weight restrictions, and can only be fully rectified with replacement structures. SH 73 was reopened 7 months after the earthquake but is still subject to delays at several temporary bridges and sections still being worked on.

SH 6 south of Ross was reopened with a temporary bridge over the Wanganui River 2 months after the earthquake, to Franz Josef after 4 months, and to Fox Glacier after 9 months. From Haast, the road over Haast Pass was reopened after 3 months, to Bruce Bay after 6 months and to Fox Glacier after 8 months, with temporary bridges over the Karangarua and Fox Rivers. There are weight restrictions on many bridges, and some fords. The road is single lane with a metalled surface in many places and is subject to frequent closure due to instability and flooding at bridge sites. In places, debris flow and stream aggradation issues close the road after nearly every heavy rainstorm.

The railway north of Hokitika was re-opened ten months after the earthquake, with Government funding for its reconstruction, to re-establish a means for the bulk export of coal. Prior to this, coal has been transported by road to the ports for export by barge.

(b) Drainage

Problems with aggradation are ongoing. The areas most affected are close to the hills and mountains throughout South Westland. Major rivers are aggrading and flooding and depositing sediment over land that was previously hardly ever flooded. There are concerns that as aggradation continues, maintenance of the stopbanks and clearance to bridges will become increasingly difficult and expensive. The Alpine Fault rupture produced a 1 m step in all the riverbeds north of Fox Glacier, resulting in local channel instability. Initially this produced degradation upstream of the fault, but this was rapidly reversed to aggradation as slip debris worked down river. Smaller streams are disgorging large quantities of sediment over fans. Aggradation is threatening the future of Haast, and has already made it impossible to rebuild Franz Josef on its original site. Aggradation and debris into the Otira River has changed its course to destroy 60% of the Otira township, which was evacuated soon after the earthquake.

(c) Telecommunications

Telecommunications are back to normal for 95% of the district.

3.13 Second Scenario for Haast

If the fault rupture extends further south than assumed in the scenario above, then the Haast area will be much more severely affected. The whole area will be subjected to MM IX or stronger shaking. Initial damage could involve the following:

- The Haast Pass section of SH 6 is extensively damaged with several bridges destroyed or badly damaged and large rock falls and landslides bury the road in many places. SH 6 is severed by the fault rupture inland from the Haast township. The Haast River bridge suffers partial collapse, as does the Pleasant Flat Bridge. The bridges on the Okuru, Turnbull and Waiatoto rivers all are significantly damaged. The Arawhata Bridge loses one span. The Jackson Bay wharf is badly racked and is unsafe.
- A large landslide south of Knights Point entirely destroys 400m of SH 6 with the whole coastal escarpment collapsed into the sea. Several large slips bury the road to Jackson Bay. There is extensive liquefaction damage to the roads inland of Neils beach and near Okuru. The Turnbull hydro station suffers several failures in both the low-pressure supply pipe and the penstock; flow out of a break in the supply pipe scours a large ravine.
- The area is largely evacuated by the end of week 2 after the earthquake. The damage to SH 6 takes 6 months to clear and re-establish the road to Wanaka. It takes a further 6 months to rebuild the destroyed sections of road and bridges between Haast and Paringa.

4 ALPINE FAULT EARTHQUAKE SCENARIO –EFFECT ON INDIVIDUALS

In order to ensure the fullest understanding of the communitiy's needs and the interactions between them, we next consider four hypothetical individuals and what might be happening to them as time passes following the earthquake. The four individuals are a Hokitika businessman, a Kokatahi farmer, a tourist in Franz Josef and a Hokitika resident.

Although the four individuals are fictional, the events presented in the stories are plausible. It is stressed that this section describes possible circumstances, events and reactions for four fictional individuals to illustrate the human dimension of the earthquake. Through identifying the needs, priorities for re-instating lifelines can be established and appropriate emergency levels of service defined along with time periods for return to normal service. Finally the stories look at wider needs than those directly linked to lifeline assets and so touch on leadership, counselling, insurance, income etc. These are important needs so must be addressed by Council in its overall planning and prioritisation. Some of these needs may also require the support of lifelines to be effective.

4.1.1 Hokitika Businessman

John lives in Hokitika. He is a businessman, owning an adventure tourism business with his head office in Hokitika and branches in Westport and Franz Josef. He has about 40 staff ranging from experienced guides to receptionists. Each branch has a building centred round a reception/booking area and contains a café and souvenir shop.

At the time of the earthquake, John was upstairs at the Hokitika premises sorting out some accounts. The receptionist had called in to say she was sick and couldn't come into work. The café manager, Jan, was working in the café and a driver, Bill, had come in to set up the four-wheel drive vehicles for the afternoon trips. Jan, Bill and John all live in Hokitika. Jan is married but does not yet have children. John has two children at the local primary school while Bill's children have grown up and moved away from the West Coast. It was mid morning. There were no customers in the shop at the time although there were two adventure tours booked for that afternoon and two of John's small buses would be arriving around lunchtime with clients.

First three days

When the earthquake hit, John's first thoughts were for his family. John had dived under the desk when the earthquake began. The office and computer equipment were now strewn all over the place. Some of the ceiling tiles and light fittings had come down. It was rather a struggle to open the door to get out. Downstairs the cafeteria was a mess, with broken crockery and glassware scattered around. The souvenir shop had its contents strewn over the floor and anything breakable was broken. Although the plate glass shop front window had shattered, structurally the building seemed to be mostly undamaged.

Jan was on the floor in some pain. She looked a mess as she was covered in blood from cuts caused by the flying glass and being knocked to the floor by a glass cabinet, which had hit her. Bill came in from outside. Bill took one look at Jan, rushed back outside, and brought back a first aid kit from one of the vehicles. Bill had up-to-date first aid training and immediately attended to Jan's cuts. John hurried over to help Bill with Jan. He went to fetch water but there was no water in the cold tap. However the hot water cylinder had been secured for an earthquake and John was able to get water from the hot water tap.

John left Bill to attend to Jan and considered what to do. He wanted to find out about his family. His children were at school and his wife at home. John tried to contact his wife with his cell phone but couldn't get through. He tried on the landline but there was no dial tone. He tried to send a text message to his wife but got a "message not sent" response. John looked up again now feeling overwhelmed at the devastation in front of him and wondering what his other premises on the West Coast were looking like. Were his other staff all right, was his wife all right and were his children all right ?……

Bill had cleaned up Jan as best he could and she was looking much better. They agreed that Bill would take Jan home in one of the four-wheel drive vehicles and then go to his own home.

John could not drive all the way to the school because the road was blocked but got within easy walking distance. He got out of the vehicle and joined other worried parents heading in the direction of the school. John found the school was in a state of relative chaos although the children were being organised and were safe. The children displayed a range of responses to the earthquake. A few children were excited as if this experience was an adventure. Others were traumatised. Some of these children were sitting "shell shocked" while others were hysterical and their hysteria was affecting other children. John found his own children. They were very pleased to see him and needed a long hug before discussing anything with their father. John reassured them before telling the person in charge that he was taking them home. John had briefly considered leaving the children at the school but the children would not let their father leave without them.

John drove them home. The drive was difficult as there was debris on the road and at some locations the road was dangerous and uneven. Some power and telephone poles had fallen or were leaning at acute angles. The house was in a considerable mess, especially the kitchen, and his wife had been hurt by the television. Fortunately it was a minor injury and no bones were broken, but she was shivering and suffering from shock. John helped his wife to the couch where she lay down and the children gathered around to be comforted. After-shocks continued, some quite large. The power and telephone were out, and there was no water supply. However, the house structure was relatively undamaged.

Using some of their emergency supplies, John boiled some water on a camp stove for a cup of tea and some Milo for the children. He then set about clearing the kitchen as a matter of urgency so that they could try to put together some sort of meal. First, though, he checked on his elderly neighbour, and talked briefly to others who were outside. Someone had a battery radio, and was able to catch an AM broadcast with the news. Clearly the earthquake was very large and reports of damage were coming in, but no one knew much in the way of detail, and there was no reported news from much of the West Coast. They did find out the earthquake had measured 8 on the Richter scale and the epicentre was near Whitcombe Pass.

John began again to think about the business. His immediate concern was where the two buses were. He began to worry about the welfare of his other staff and also about the state of his other business premises in Westport and Franz Josef, which he was unable to contact.

Heavy rain started. When John left the business earlier he had not thought to collect important documents and records. He decided to go back to get them.

He went upstairs to the office to find rain coming in through the ceiling at one end and that some of the paperwork was already soaked. He was glad he had backed up his vital booking and financial records. He collected these along with cash takings, cheque books and some important documents, turned off the electricity and the gas then left as there was little more he could do. He was worried about security but decided to leave any action till the next day. He ran into others in the street, and found there had been a number of injuries in the town and some building collapses. They also said that several Civil Defence posts had been established in schools and people without shelter were going to these. Although a Control and Information Centre had been established the overall picture of what was going on and the extent of affected areas was still not clear.

During the next two days, a clearer picture emerged. John was able to contact all his Hokitika staff and get some of them to come in to clear up the mess as much as possible. Three of his guides were able to take the four-wheel drive vehicles and help the rescue efforts attempting to reach families in outlying areas. Although a number of bridges were impassable there were places where rivers could be forded. Co-ordination of their efforts was initially difficult until the telecom network, which the vehicle radios rely on, was functioning again. The vehicles ferried injured people to an emergency medical aid centre that had been set up in Hokitika. Then once a ford had been established across the Arahura River the vehicles were also used to take people requiring hospital treatment to Greymouth. The staff managed to salvage some food from the cafeteria, but there was not much there as there was very little stock held on site. Finally, on the third day he was able to contact the manager of the Westport Branch and found that the damage there was much less than at Hokitika. In fact, the Westport Branch was fully functional, though naturally it was not operating as no tourists were coming in.

The two buses that were due in Hokitika at midday on the day of the earthquake had been delayed and in the end had not left Westport. The clients were still in Westport and John's staff were helping them look for some way to get out of the West Coast.

His worries about his Hokitika premises were lessened as the shop front and broken windows had been boarded up.

John began to turn over ideas of reorienting his business and using its capability in some other direction. He was still intensely worried about his Franz Josef business as there had as yet been no contact. He continued to try to get information on Franz Josef with increasing urgency. By now the picture of the areas affected by the quake were becoming clearer, and he was beginning to think about the future of his business and how long it might be before it could be up and running again. He was particularly worried about the effect of the quake on the tourist industry as it was the mainstay of his income. Mostly, though, his focus was on immediate survival, and providing basic needs for his family like food and warmth. A series of frequent large aftershocks had traumatised his wife and made her desperate to get out of the area.

One month after

One month after the quake, the essential services of water and sewage were operational, and road access over the Alps was re-established for the flow of goods and people. Telephones were working, and the EFTPOS/ATM services vital to John's business were operational. The township of Franz Josef had been virtually abandoned so his business there had closed. The road through to Haast and Wanaka would not be open for some time, so few tourists came through Hokitika. However, a few had begun to travel through Westport, so that part of his business was operating, though still at less than a quarter of the number of people normally expected.

John had gone to the Council to ask about using his business premises and perhaps having them inspected. However, he found the Council staff were very busy. Priorities for inspections had been established and all building inspectors were out looking at the highest priority structures. Council appeared also to be taking on the role of co-ordinating the supply and distribution of tradesmen and building materials to ensure the highest priority structures were repaired first. John left his details with a Council staff member and was told to check back in a week when hopefully Council would be clearer about when they could inspect John's business premises.

John had sat down with his staff and brainstormed what they should do. There was a small but increasing number of visitors coming to look at the devastation caused by the earthquake. John decided to try a new venture of disaster tourism. They began taking more intrepid visitors to see some of the places most devastated by the earthquake as access was now possible for his four wheel drive vehicles.

However, the business still experienced serious cash flow problems and John was forced to dismiss some of his staff. He reduced his staff in Westport by half and Hokitika by two thirds, although half the guides were not originally from the area and had decided to leave as soon as they could get out anyway. Those wanting to take significant household effects with them had to put their name on a waiting list. There was a high demand on land transport, the roads to the West Coast were still in a rough state and were closed from time to time because of fresh landslides and/or flooding and debris at aggrading rivers. Two of his staff decided it was time for them to leave home and travel elsewhere as the future outlook in Hokitika seemed bleak. The receptionists and office staff were permanent residents of the area, but were worried about their future and sought support from the temporary disaster relief agency office the Government had established in Greymouth and Hokitika.

The local chamber of commerce was co-ordinating efforts to support local businesses and to encourage them to stay in the area. John managed to obtain a bank loan to tide him over, but the state of his finances was an ongoing worry. While the cost of repairing the physical damage was not high, there was just no cash, and the loss of income, both immediately and a long time into the future was of particular concern. Insurance assessors had visited the premises but had been unable to give answers to his questions although it did appear his premises would be covered under EQC. Though some of his staff were capable handymen, it was not clear if they would be paid if they carried out necessary repairs themselves. There was a shortage of building supplies anyway. In particular there was very little window glass available.

His wife had left the area with their children and was living with her sister in Dunedin.

One year after

A year later, we find that John has relocated his business and his family to Kaikoura.

John has avoided bankruptcy, although it was a close thing. He has shut down his Hokitika and Franz Josef operations, but keeps the Westport Branch going on a break-even basis. The basic problem is that tourist numbers on the West Coast are too few – still only a very small fraction of those coming before the earthquake. He thinks it will take another 2-3 years to get trading back to anything like it was pre earthquake.

4.1.2 Kokatahi Farmer

Pete lives and works on his diary farm with his wife and their three teenage children. The house is a seventy-year-old weather board structure.

First three days

The earthquake occurred mid morning, just as the family was having morning coffee together. The children were at home for the day as the secondary school teachers were having a teachers-only day. The movements were violent, and everyone and everything were thrown around. The free-standing wood burning stove in the kitchen broke loose. It caught Pete's wife Jane, breaking one and burning both her legs. All the contents of the kitchen shelves and cupboards fell out onto the floor and the fridge toppled over. The living room chimney broke off and came through the roof leaving a major hole. Fortunately no one was in the living room at the time. The house itself slewed off its piles at one end, punching holes in the floor and breaking the connection from the water tank, which, in turn, fell off its stand. The house still stood though, despite the damage, and so did the barn and milking shed, though they also leaned out of plumb. There were major slips on the hills behind the farm.

The immediate issue was to attend to Jane and deal with the stove. Pete and his son levered the stove away so that they could pull Jane free and carry her to a bed. Although she was in great pain, they could not attend to her until sparks from the stove and broken flue had been doused with what little water they could find in the wreckage. The fire continued to burn in the stove, but Pete decided that it was safely contained, although it was rapidly filling the house with smoke. It was clear that Jane's injuries were serious, but as the telephone and power lines were dead, it was not possible to call for help. Pete and his daughter dressed her wounds as best they could, and after much difficulty found some painkillers.

There was now time to look at each other and their situation. The house was a shambles with damage throughout, holes in both floor and roof, distorted and twisted. All the floors were strewn with debris, rain was leaking into the living room and smoke from the fires pervaded the air. The devastation seemed so great that they all found it hard to think of what to do or where to start. Pete and the boys walked around the house and immediate farm buildings trying to comprehend the damage. Jane's moans reminded them that action was needed and Pete sent his older son off in the pickup to try to get help and find out what was going on.

Their son got back an hour later. Although he had been able to negotiate several sections of the road that were badly deformed, he had been unable to pass the bridge over the Kokatahi River as it was damaged. He had reached some of the neighbours, and found some were in a worse position. They also worried about the river, as the flow seemed to have reduced significantly. He had also brought back the next door neighbour's wife, who was a trained St Johns ambulance volunteer, to look at Jane.

Pete's next job was to go and check on the animals and farm buildings. The milking season was just starting. About 25% of the cows had calved and these cows were heading towards the cowshed for their afternoon milking. There was no power to drive the milking machines and shed was in disarray anyway. Pete and his younger son arranged for the cows to be put back with their calves. At least that way the cows would continue to produce milk so that when the milking machines could operate again they could continue milk production.

There had been occasional showers and it was getting dark by the time Pete and his son got back from their farm work. The whole family was hungry, so it was decided to check what food was available. The freezer was full and would stay frozen for a day or two, and there was a good stock of flour and vegetables. Cooking was a problem, but they knew they could make a fire outside, and use the barbecue.

They tidied up the master bedroom, moved Jane in and all slept together. They had a sleepless night, with severe aftershocks and damp cold bedding. They really needed to get out of the house. The next morning they decided to take up their neighbour's offer to move in with them. Their house had suffered less damage and was still relatively sound.

Jane had to be taken to hospital somehow. Going by road to Hokitika seemed unlikely, so the eldest son was sent off to try to get through on his trail bike, to call for a helicopter and medical aid. There was no battery radio and the family was desperate to hear from the outside world, and to know the extent of the earthquake. And of course the two younger children could not go to school.

Their son reached Hokitika, found the CD controller's location, delivered the message and found out that the quake was very widespread. He was assured that help would be sent as soon as possible, but that helicopter transport was stretched to the limit as many aircraft had been damaged and because the quake had caused a massive demand for helicopters. He was able to get some more pain killers for Jane, though. Unfortunately, he could not get any petrol to take him all the way back. He rode as far as he could, then set off on foot, arriving late in the afternoon. He was able to bring a picture of the extent of the earthquake, though it was confused and with many gaps.

During the second day after the quake, two neighbours ventured up the Kokatahi River to see why it had stopped flowing. However, they found the going impossible due to rockslides and fallen trees and turned back before they were able to reach the point where the river was blocked.

Towards the end of the third day a reaction was setting in. No help had arrived yet. Everyone was tired, hungry, cold, and increasingly grubby. Conditions were cramped in their neighbours house and frustration showed. They were able to get water from a nearby stream, and dug a latrine outside. Information trickled in, and they counted themselves lucky. Finally, at the end of that day a helicopter arrived and Jane could be evacuated to Hokitika.

What to do? Pete decided to try to send the two youngest children to Christchurch to stay with his brother. Pete and his eldest son continued to live with their neighbour while they worked on the farm and got their own home to a state where they could live in it again.

One month

After contacting the dairy factory, Pete was advised that milk processing had stopped indefinitely due both to damage at the plant and to transportation difficulties. He decided to keep the calves with the cows and allow the cows to dry off naturally. Power and telephone connections had now been restored. Pete and his son had been able to do some house repairs including jacking the house back to level and weatherproofing the roof but they would still need to have the house checked by Council before the house was considered safe. Four wheel drive access was now possible to Hokitika, and he was finally able to buy much-needed groceries and some limited hardware supplies. Jane had been taken to Christchurch and was able to walk with crutches. Physiotherapy was helping, but it would be a while before she would be back to normal. Back at the farm, the cooking was, well, basic.

Physical things were now almost fixed up. About five days after the earthquake the Kokatahi River level rose significantly with some minor flooding and then over the next day or so went down again. The locals assumed the river had been dammed by a major slip and the river had over topped the slip and washed it out. They all hoped that the river level would not rise again.

The house was habitable but required a complete repair and repainting of damaged interior walls. The farm buildings were useable. About 10% of the farm was affected by flooding and debris carried down from landslides on the neighbouring hills. Neighbours had helped each other. Pete now faced two major problems. The first was to do with immediate finance. He had a bank loan, but it was reaching its limit and he needed cash to pay for repairs. The other was his day to day living costs, quite apart from the costs of his wife and children in Christchurch. And there was no income from milking, and neither would there be any till at least the next season when milking could start again. There would be some income from the calves and they were doing well. Of more concern was their longer-term future. Would the dairy factory be up and running next season? Would the factory be able to rollover this year’s supply contracts for next year? He needed sound advice, and a clear picture of what the dairy factory’s plans were and what the Government would be providing in the way of the help they had promised. Some cash, he knew, would be coming from the EQC, and assessors had already been round; but how much and when was not clear. Some community meetings held in Kokatahi by Federated Farmers had led to useful discussion, and the presence of the Mayor of Westland was helpful. The mayor’s regular broadcasts on local radio led to a feeling that something was being done and the long-term future was looking better.

There was still plenty to do, but it was hard.

One year

At the end of a year, Jane was back and so were the two younger children. They were living in two small portable buildings donated by an international organisation. One building was used for kitchen and ablutions and the other for bedrooms. Their home had been demolished and with a pay out from their insurance company builders had started building a new home. Construction was very slow because of the huge demand for tradesmen and materials as the West Coast slowly rebuilt.

The dairy factory had an agreement with Pete to take all the milk he could produce that season. The eldest son had left, though, and gone to Australia. Half the businesses in Hokitika had reopened – the important half, as far as Pete was concerned, as the rest were mainly aimed at tourists. But the town did not look good – it looked half-dead, and many people had left. Clearly there was no longer much money around. It was not much fun for the children. They could hardly wait to leave and go on to university as they had planned to do. Jane found it very hard. To add to her troubles she kept having very real and vivid flashbacks to the earthquake. These episodes did not seem to diminish. She went to the doctor and was told it was Post Traumatic Stress Disorder (PTSD). He went on to say that fortunately it was fixable, but that she would need a competent counsellor. One was available, so she signed up for a course of therapy.

4.1.3 Franz Josef Tourist

First three days

Rudi, a young German tourist, had been walking on some of the Franz Josef tracks the previous day, thoroughly enjoying himself, and was setting out on another track when heavy rain set in. He decided to return to the crowded backpackers' and was swapping stories and information with some of the others when the earthquake hit; it was sudden, it seemed interminable and it was devastating. Everyone was thrown around. Some were hurt by flying furniture, cooking pots, and glass. Two were quite badly scalded, another two probably had broken limbs and one seemed to have a back injury. Rudi himself had minor cuts from broken glass, and a few bruises. Though the blood from his cuts was spectacular, he was not badly hurt and went to the help of some of the others, particularly three pinned down beneath a fallen mezzanine floor. Fortunately the wood stove did not cause a fire, although the stovepipe wrenched a hole in the roof. Most windows were broken, and the rain blew in. It was difficult to move around in the mess. In any case, all the doors had jammed and the building was badly twisted out of shape.

Rudi and a couple of others put their parkas on and went out to find out what was happening. The scene was appalling. The roads were impassable to vehicles. All buildings were damaged, and some had collapsed. They tried to remember where the Park Headquarters was, and went there. A Conservation Officer appeared and told them there had been a major earthquake, but he had no idea of its extent. The group was told to go to the school, and get injured people there if possible. So they went back to their backpackers' and relayed the message. A violent aftershock meant that some left the building in any case with whatever gear they could collect.

Rudi decided to go to the school. He had no food left. Normally he relied on buying whatever food he needed on a day-by-day basis. The school was crowded, with many injured people. His own cuts were minor in comparison. A Council employee seemed to be in charge. There was some food, but very little, so an expedition was sent to the wrecked supermarket to try to salvage what could be found. Others had the same idea. There was a major problem as to how to get the food to the school – sacks pushed on bikes seemed to be the best solution. And still it rained.

Rudi was cold, wet, hungry and thirsty. There was rainwater to drink, but bushes had to suffice for toileting. There was little sleep that night. By the morning he was hungry again, and cold. Rudi was looking forward to hopefully better weather and thinking that his first priority would be to get out of there in whatever way he could. He and his friends desperately wanted information as to what was happening. Rudi realised that his family back in Germany would be anxious, and he wanted to let them know he was safe. Telephones were out of action. He began to pester anyone he could find in authority about this, but with little success. He was heartened, though, by the presence of a sort of control centre where people seemed to know what they were doing. Announcements were coming out as to what to do and where to go. Everyone desperately hoped for a break in the weather so that much-needed medical aid could be flown in by helicopter. And still Rudi's underlying priority was to get out of the area as soon as possible.

By the third day, Rudi was cold, grubby, hungry and very nervous of the aftershocks that still came. An additional worry was a rumour that the river might flood through the town and potentially reach as far as the school and the airport.

One month after

By the end of the month everyone had been evacuated, and the Franz Josef township has been declared a restricted area; off limits to all but authorised personal. Because of continuing after shocks, the serious destruction of buildings and infrastructure and concerns about the rising bed level of the Waiho River that could potentially cause the river to flow through the town, the town is uninhabited except for a security person. No repair work has been carried out and the future of the township is being debated.

Rudi is home in Germany. The earthquake remains a vivid experience to him and he still recounts his adventures frequently. However, the trauma and the chaos that followed the earthquake have coloured his view of New Zealand and he shakes his head when travel to New Zealand is mentioned.

One year after

Rudi is working now and saving for his next trip – this time to South East Asia. He has heard that it is very difficult to go to areas on the West Coast of the South Island south of Hokitika because of on going problems with road access.

4.1.4 Hokitika Resident

Margaret is 63 and lives in a 30-year old brick veneer house with her husband, Dick. He is retired and a few years older than Margaret.

First three days

When the earthquake hit, Margaret was just about to get the car out and go shopping. Dick was sitting reading the paper. The shaking seemed to go on for ages. In the kitchen, cupboard doors flew open and plates, glasses, jars and bottles flew around. All Margaret could do was hold on to the kitchen sink as best she could, crying and screaming with fright. The fridge shifted halfway across the room. Fortunately Margaret was unhurt apart from a few minor bruises. In the next room Dick was fixated on finding his glasses in the debris on the floor and seemed to be in a state of shock. It was difficult for Margaret to get him outside.

Outside, neighbours gathered in the street. All the houses seemed to be standing, but she could see big diagonal cracks in the brickwork of her own, and the carport had collapsed on to the car. Beyond saying “It’s a big one,” no one seemed to know what was going on. Margaret ventured back in the house and set about trying to clean up the mess. She was feeling tired and would dearly have loved a cup of tea, but this was impossible. She fairly drove Dick to help, but he was ineffective, needing to be told what to do. By now it was the middle of the day so she made sandwiches with the last remaining bread. There was nothing to drink, so she put out saucepans to catch rainwater. A knock on the door brought a neighbour. The police had asked him to check on all the people on the street and tell them a little news – that the earthquake was very widespread on the Coast and that the roads over the Alps were cut but that they were expecting aid to come over by helicopter shortly. There was food and shelter available at the school. Margaret felt very relieved. She was very tired indeed but knew she had to do something. There was no edible food in the house and it was cold. She needed to go to the toilet and went behind a bush in the garden as best she could in the rain.

After another big after shock Margaret was frightened the roof would come down so she and Dick got out of the house and began to walk to the school a kilometre away. At least they could get something to eat and a cup of tea. They decided to settle into the school hall for a few days where there was some food and plenty of people to keep them company.

That first night was terrible. It was cold, damp, dark and although there were lots of people around, it was still lonely. The three large aftershocks were also very frightening. Nobody slept much that night. Several of the people tried to console others, but most were pretty scared.

The next day things were both cheerful and grim at the school. Some people told stories while others set out to make the place more habitable. Latrines were dug outside, but they were primitive and open to the rain. There was food but no washing facilities except for hand basins by the latrines. It was cold, and everything was damp. Regular reports came in as to what was happening, though, and several times the Mayor came in and spent time talking to people. It was clear that Hokitika had got off lightly compared with some places. Standpipes were now in service for water, and it seemed that power would be restored to Hokitika in another day or so – though individuals might not get power for a few days more because of damage to street poles. There was a limited supply of tarpaulins and building material to try to patch buildings up temporarily, and many able-bodied people were directed to help. More people were trickling in from outlying areas.

Margaret's worry was the security of her house. She had heard that there was some looting going on and abandoned unsecured homes were a prime target. She and Dick went home with a young person Margaret had met at the school. They gathered up their most valuable small possessions and the young person helped them carry them back to the school.

Margaret longed for decent food. There was no bread, and they had to eat potatoes, pasta and rice, some of it flown in from Australia. Tents were set up in the school grounds. Surprisingly, the old Post Office had survived the earthquake well, and was being used as a food distribution centre. No shops or service stations were operating though.

Margaret felt tired and helpless, and resentful of Dick who lay around all day. She felt grubby and unclean, as there were no opportunities even for a sponge bath, and she had run out of clean clothes. It would have been of great comfort to be able to talk to her sister in Ashburton or her daughter in Auckland, but there was no phone connection out of the area. Still, the Mayor cheered them up with her optimism. She talked with the Methodist minister and at his suggestion she started organising some of the women to help with the cooking and cleaning. At least she was doing something now, and felt better for it.

One month after

They were back in their house, despite the damage. At least it was weatherproof and warm, and water and power were on. In the last week they were able to use the toilet, and the television gave them a link to the outside world. But Hokitika seemed a strange place. The crowds of tourists had disappeared. The car had been repaired and she could use it for shopping – what shopping was possible, for many things were in short supply as the only way by land was through the Lewis Pass of from Nelson, and on both routes, traffic was still restricted. She could buy bread, and unpasteurised milk brought in from a nearby farm. Tinned food was available but all other perishable food was in short supply as it had to come over from Christchurch. Dick was at last showing some energy after help from the doctor, and was pottering around carrying out a few repairs. They discussed whether to move out of the area. Hokitika had been their life, though, and that was where their friends were, so they decided to stay. In fact, it was really surprising the strong community spirit had developed. This was helped by regular meetings at the school hall. Many people had turned their hand to construction because of the extent of damage to buildings and facilities. The insurance assessors had been, and they had been very helpful, giving an assurance of rapid pay out.

One way that Margaret was able to help was with evacuees from South Westland. The whole area had been hit hard, and still people were coming into Hokitika in a state of shock after losing everything and having some terrible experiences. Prefabricated buildings were being brought in, but what the evacuees seemed to need most was hope, and care, and this is what Margaret and her friends tried to give. Many had now gone on to other parts of New Zealand, but a significant number wanted to stay. Fortunately the Government was helping with emergency payments. The Mayor led a programme to establish a “buddy system” where people severely affected by the quake received care and support from volunteer relief agencies that had come into the area as well as members of the Hokitika community.

One year After

Things were getting back to normal for Margaret and Dick. They were busier than they had been for years, organising repairs to their home and helping a charity organisation and a craft co-operative. Everyone seemed spurred on by the Mayor’s slogan, “Westland can Win!” There was a new optimism around.

PART III – Interdependencies & Lifelines

5 INTERDEPENDENCIES – POST EARTHQUAKE

5.1 Individual Needs

The needs of a Hokitika businessman, a Kokatahi dairy farmer, an international tourist at Franz Josef and a Hokitika resident were discussed above in Section 4.

Analysis of the needs of these individuals resulted in thirteen generic needs. These are presented in Table 5.1. The needs may be met by the individuals themselves or by the community. Individuals' means of meeting needs are characterised by independence, and self-sufficiency. For example, for sanitary needs individuals can use a shovel and construct a latrine in most locations on the West Coast, except perhaps for CBDs. Communities on the other hand often use networks including system and infrastructure networks to meet the needs of individuals more efficiently and effectively. Individual solutions may well be necessary early in the response, but expectations would be that these solutions would be temporary, until such time as the community networks are restored. For instance, for a few days, water supply from rainwater would be acceptable to most individuals, but after that an expectation would be for community supplied water from a standpipe within a convenient distance, and not too long after that a full restoration of piped supply.

Table 5.1: Generic Needs

Need	Means of Meeting Needs	
	By Individual	**Via Community Networks**[1]
Leadership	Leaders	Leaders, protocol, communication
Information in/out	Word of mouth, loudhailer, letters, notices, 1-way radio, 2-way radio	Radio, Telephone, TV, armed forces, notice boards
Rescue/ Medical Aid	Rescues by individuals/groups of people/First Aid	Skilled people, plant/equipment, transport[2], armed forces, shelter, medical station, medical supplies, communication
Security	Security in small groups	CD controller, police, armed forces
Evacuation[3]	Walking, off road vehicles, boats	Transport[2], communications, protocols, triage, welfare centres
Relocation[3]	Walking, off road vehicles	Transport[2], communications, protocols, welfare centres
Psychological support / Counselling	Family & friend support	Support agencies
Insurance & Income	Self-employment, multi-skilled individuals	Employers, Insurance companies, Earthquake Commission
Water	Shallow well, springs, rain water tanks, streams etc	Community water supply, transport[2] to access water supply facilities
Sanitation	Shovel	Facilities at community centres, community centre sanitation protocols, morgues
Shelter	Tents, tarps, mobile homes (vehicles) materials from damaged buildings, undamaged homes, new homes	Community centres, transport[2] to bring in tents, tarps, new homes
Food	Farm & wild animals, local fruit & vegetables	Supply point, transport[2], distribution points
Lighting & Heat (Cooking + Warmth)	Candles, gas cylinders, torch, gensets, wood, coal	Functioning generation plants, functioning grid & distribution system, gensets, functioning fuel distribution systems

1. The "community networks" are defined as infrastructure and systems that may function at a local, regional, national or international level.
2 Transportation includes transport networks and vehicles (boats, cars, aeroplanes, helicopters, trucks etc).
3 Evacuation is defined as an immediate emergency response required because of injury or unliveable conditions e.g. no food, clean water, shelter, security etc. Includes the evacuation of people and where necessary, value items. Relocation is a planned response where the move is required because of employment or education needs and the move happens after a period of considering options.

Based on the hypothetical effects (refer Section 4) of the earthquake on the four individuals, the importance of each of these thirteen needs is explored. The importance of each need is assessed by assigning two grades: one for level of need and one for reliance on community networks. The two numbers are summed for each category of need. The grades used for level of need and reliance on networks are presented in Table 5.2.

Table 5.2: Need & Reliance Grades

Grade	Level of Need	Reliance on Community Networks
0	No need	No reliance
1	Normal every day need	Small reliance
2	High need	Large reliance
3	Very high need	Total reliance

Needs of individuals and their reliance on community networks vary after the earthquake. The importance of all needs is considered for the four individuals for three time intervals after the earthquake; the first three days, the end of the first month and the end of the first year. Two objectives of this assessment are firstly to identify individual needs that will be met predominantly by community networks and secondly to establish priorities. The full assessment is presented in Appendix C and the summary results presented in radar graphs in Figure 5.1. The “importance scores” for each need for the four individuals have been added together and the results presented in Table 5.3. The same results are presented graphically in Figure 5.2. Note that the numerical scores are purely relative and have no meaning by themselves.

It can be seen in the table and figures that the importance of each need changes depending on the time following the earthquake. The results are discussed in detail in the following sections.

Figure 5.1: Individual Needs – 3 day, 1 month & 1 year

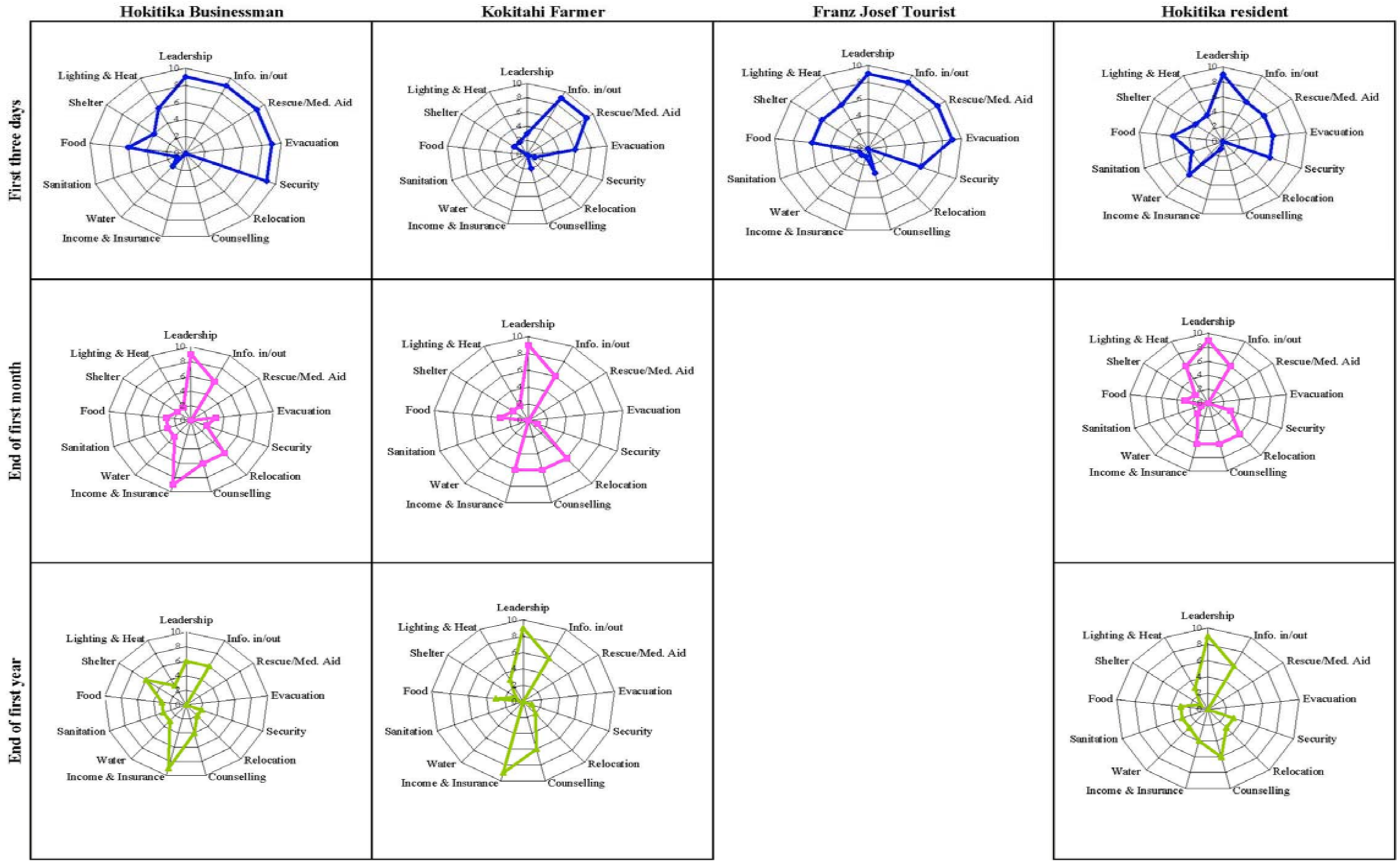
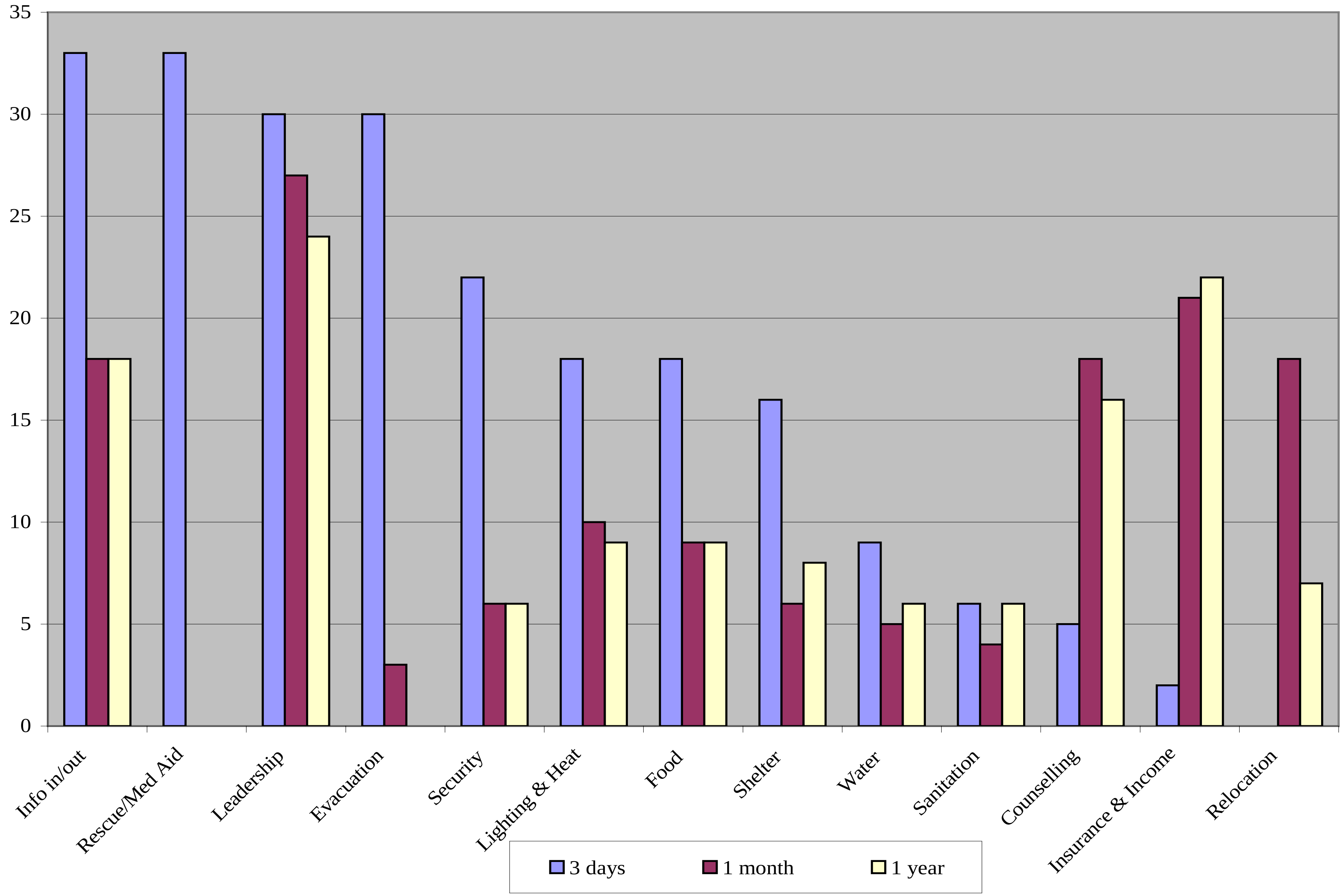


Table 5.3: Priority of Needs

Priority	3 days	Sum	1 month	Sum	1 year	Sum
1	Information in/out	33	Leadership	27	Leadership	24
2	Rescue/Medical Aid	33	Insurance & Income	21	Insurance & Income	22
3	Leadership	30	Information in/out	18	Information in/out	18
4	Evacuation	30	Relocation	18	Counselling	16
5	Security	22	Counselling	18	Lighting & Heat (Cooking + Warmth)	9
6	Lighting & Heat (Cooking + Warmth)	18	Lighting & Heat (Cooking + Warmth)	10	Food	9
7	Food	18	Food	9	Shelter	8
8	Shelter	16	Security	6	Relocation	7
9	Water	9	Shelter	6	Security	6
10	Sanitation	6	Water	5	Water	6
11	Counselling	5	Sanitation	4	Sanitation	6
12	Insurance & Income	2	Evacuation	3	Rescue/Medical Aid	0
13	Relocation	0	Rescue/Medical Aid	0	Evacuation	0

Figure 5.2: Bar Graph of Priority Needs for the Four Individuals



5.1.1 Three Days

From the assessment presented in Figure 5.1, Table 5.1 and Figure 5.2, it can be seen that for the four individuals considered, the dominant needs in the first three days are leadership, information in and out, rescue and medical aid, and evacuation. These are important for the following reasons:

- *Leadership*: Because of the widespread impact of the quake it is almost certain that normal lines of communication will be down or only provide a marginal service. Individuals will be almost totally reliant on leadership to provide responses to address, for example, the wellbeing of isolated and vulnerable people, direct an effective response effort, and to maintain security. Leadership will be required from a local community level through to national and international level. The leadership will be dealing with emergency needs created by the quake as well as co-ordinating a potentially massive assistance response from outside the area and outside New Zealand. Leadership will also be required to keep up morale and provide hope. It is noted that the Kokatahi farmer is the only one of the four individuals who has a lower need for leadership. This is expected because farmers, due to the nature of their work, operate fairly independently;
- *Information:* Information is going to be important particularly for isolated people (the Kokatahi farmer and the Franz Josef tourist) and for those who run networks on the Coast (the businessman along with all infrastructure operators). Everyone will want to know if they have any family or friends that are hurt, how badly they are hurt, and where they are. Network operators will also want to know about the condition of their assets; what is damaged, the extent of damage and the impact of damage on the operation of the network. People in areas badly affected by the quake will want to get information regarding who is hurt and who is not, where help is needed immediately, what is needed etc. Information is likely to be just as critical for residents in the main urban centres such as Hokitika, Greymouth and Westport. However, they are likely to be less reliant on formal information networks (telephone, battery radio, etc) as they will be able to use word of mouth to pass on information from the CD control centre and from those who have a battery radio or a functioning telephone.
- *Rescue and Medical Aid:* It is almost certain there will be injuries and deaths from the earthquake. Some people may be trapped under rubble or under plant. For those living or working near the fault trace, the need for professional rescuers and medical aid will be higher and they are likely to be totally reliant on outside support. Examples are the Hokitika businessman with staff and clients at Franz Josef, the Kokatahi farmer and the Franz Josef tourist. The further from the fault trace the lower the likelihood of injuries, and so the less the need for rescue and medical aid;
- *Evacuation:* As for rescue and medical aid, the group of people with the highest need for evacuation is likely to be those nearest to the fault rupture e.g. Otira, Franz Josef and Fox. As well as buildings becoming uninhabitable and people needing to be evacuated because of injuries, it is likely that people will want to leave because of trauma and the ongoing after shocks. Another group of people likely to require evacuation is tourists anywhere on the Coast. For example, for

the late winter (August) period chosen for the scenario, there is likely to be in the order of 1,600[3] tourists on the Coast; there could be as many as 5,600 in the peak of the tourist season (January).

Communication and transport lifeline networks will be critical to allow the needs for leadership, information in and out, rescue, medical aid and evacuation to be met. It is likely that a variety of communication and transportation networks will be required to meet these needs.

Security, lighting and heating, food and shelter are likely to be the next most important needs to be met for the four individuals:

- *Security:* Damage to buildings is likely to make some buildings vulnerable to looting. Security will be required to ensure that finite and limited food supplies are managed equitably until food supplies arrive from outside the earthquake-effected areas. Some people may also take advantage of the situation and loot valuables from damaged and vacant buildings. Security will be important for business operators but will also be important for people who have been forced to abandon their homes because they are uninhabitable;
- *Lighting and Heating:* Lighting and heating is likely to be important and difficult. People living in temporary shelter such as light timber structures (garages), tents etc may have no heating. Equipment for lighting, cooking and heating such as candles, gas camping equipment, gas heaters and barbecue units may not be accessible in badly damaged buildings or may have been damaged in the earthquake. Even where people can stay in their homes, damage such as broken windows and doors that no longer close may make heating difficult. Heating will be particularly important if the earthquake occurs during a cold and/or wet period;
- *Food:* Some households will have access to a reasonable food supply. Food is unlikely to be an issue for those who live away from main centres and buy in a stock of food, say weekly, as part of their normal lifestyle e.g. farming communities, and those who are prepared and have established a food stock for an event such as an earthquake. For others however they may have only limited food either because the earthquake made their food inaccessible or because they only keep a limited amount of food with them anyway, e.g. tourists. These people will rely heavily on others to provide them with food; and
- *Shelter:* The earthquake is likely to make many homes uninhabitable particularly in areas close to the earthquake fault. Those with homes that remain habitable or those with access to alternative shelter e.g. tents, a caravan or a light timber structure such as a garage, may be able to make their own shelter arrangements. Those with homes that are uninhabitable will depend on others to provide shelter.

[3] Statistics New Zealand website.

Again transport networks are important to allow food to be brought in and evacuation of those who do not have shelter. The power supply network along with other energy sources such as gas will be required to provide lighting and heating.

Water and sanitation are less likely to be critical. Water is relatively abundant on the West Coast and it is likely that water can be obtained, although it may need boiling before it can be consumed. The exception may be urban areas where there are fewer natural water sources which are also more likely to be contaminated. Toilets are unlikely to function. However, except in business districts, people can make alternative arrangements such as digging a hole at a private location or going behind some bushes.

Counselling, insurance and income, and relocation are unlikely to be important in the first three days.

5.1.2 End of First Month

By the end of the first month the priority ranking of needs has changed. The Franz Josef tourist has gone home and no longer has any needs to be met by the West Coast community. *Leadership* and *information* have remained important while *insurance and income* along with *relocation* and *counselling* have become important:

- *Leadership:* Leadership remains important to provide direction and support as the recovery phase gets fully underway;
- *Information in/out:* Information required in the first three days focused on what has happened and the status of friends and family. After one month, information about how recovery is to be achieved and where to go to get guidance, counselling and support as well as financial and banking needs (ATMs) have now become more important;
- *Insurance and income:* People will have been able to assess their situation. They will be making insurance claims and may be worried about income, as it is almost certain that the earthquake has affected their place of work. People will be considering their income options. There may be no market for businesses that depend on tourism. There may be a huge demand for freight transport (e.g. building materials) once sufficient roads are open to allow freight to be transported. In the short to medium term there is also likely to be huge demand for tradesmen and labourers;
- *Relocation:* Where some or all services such as power, telecommunications, water, sewerage, banking, schools etc are likely to be unavailable for months, people may chose to relocate to another area or at least relocate their family until conditions improve; and
- *Counselling:* People are likely to need counselling to deal with stress due to loss of family members or friends, or just due to the level of devastation as well as on how to re-establish and get on with life. Those that are to provide the counselling services will require normal basic services

(accommodation, power, telecommunications, water, sewerage, food supply) to be able to carry out their tasks effectively;

All the above needs (*Leadership*, *information*, *insurance and income*, *relocation* and *counselling*) will require communication and transport networks. As the region moves out of the response phase and into the recovery phase, more and more of the other service networks such as water and sewerage will be required. Transport networks will be particularly important for:

- Moving people and goods in (tradespeople, food, spare parts, building materials etc) and out (people moving out of the area with their household goods) of the region; and
- Accessing other networks (water, sewerage, power, telecommunication etc).

The next most important needs by the end of one month are *lighting and heating*, *food*, *security*, *shelter*, *water* and *sanitation*:

- *Lighting and Heating:* There is likely to be a normal need for lighting and heating and for most, there will be an increased reliance on outside sources of energy such as the national grid, gas, diesel etc. In some instances generators may be used to provide more reliable power until the electricity networks are fully functioning again;
- *Food:* Although some people may have access to some foods e.g. the farming communities and some home gardeners, these are unlikely to provide a complete diet; flour, bread, eggs, meat, potatoes are unlikely to all be available locally. The demand for food is likely to increase rapidly as private supplies are used up. There will be an increasing reliance on supply networks to bring food into the West Coast communities;
- *Security:* Security is likely to have improved. Damaged and vacant buildings will probably have been made secure or valuable items removed. With some form of normality returning to many communities, security will be less of a problem;
- *Shelter*: In areas close to the earthquake fault where damage is serious but communities have largely remained (Reefton, Moana, Ross etc) it is likely that many people may still be in community shelters although some will have repaired their homes sufficiently adequately to return. Further from the fault there will be less damage and less repairs required for shelter;
- *Water and Sanitation*: As people try to return to a normal life there will be an increasing need to have normal water supply and sanitation facilities to allow people to cook, obtain drinking water, wash and toilet. However it is likely that standpipe supplies and long-drop toilets will be the norm in many areas for some time. A higher level of service is likely to be required for:
  - The business districts so that viable businesses e.g. retail outlets can return to business as quickly as possible;
  - Mass accommodation for people whose homes are uninhabitable but who want to remain in the area; and
  - Offices required for recovery services such as EQC, insurance companies, social services etc.

The *rescue* and *emergency medical aid* phase is well over and the only *evacuation* remaining is the evacuation of valuables from areas that are uninhabitable for the time being e.g. Franz Josef. This may include retrieving valuable items from abandoned shops, money (automatic teller machines), etc.

To encourage people to remain in the district, services need to be re-established as quickly as possible. At the very least, an emergency level of service is required that is acceptable both in terms of the level of service and the length of time until a normal level of service can be re-established. Where relocation is the preferred option, communication networks will be required for planning and affordable transport networks will be required.

5.1.3 End of First Year

For our three remaining individuals, need priorities have not changed significantly since the end of the first month. *Leadership*, *information*, *insurance and income* and *counselling* remain important while relocation is the only need that has dropped in importance.

- *Leadership*: Recovery is underway. Leadership is required to sustain a fast recovery and recovery is likely to take a number of years;
- *Information in/out:* By now people will expect a normal level of information service. Communication traffic is likely to be greater than normal, both because of families being split with part being relocated, and also because those on the Coast will be actively seeking information on how they can re-establish viable work/business;
- *Insurance and income:* Many people will still be in the process of re-establishing themselves and their work/business. They will require insurance payments to replace what is damaged and an income stream to keep them going until their work/business is profitable again; and
- *Counselling:* Many people will be severely affected by the earthquake event and require counselling. Ongoing advice will also be required for those who remain to re-establish their work/business or set up a new business.

The remaining needs of *lighting and heating*, *food*, *security*, *shelter*, *water* and *sanitation* as well as services such as schools, banks, shops etc are all required to re-establish a normal life. Families can only relocate back to any area affected by the earthquake when these are in place.

5.1.4 Summary

For our four individuals *leadership* and *information* remained the highest priority needs throughout the first year. *Rescue*, *medical aid* and *evacuation* were important in the first three days, and possibly longer than this. However, by the end of the first month they had been replaced by *insurance and income*, *counselling,* and *relocation*. *Insurance and income* and *counselling* still remain important at the end of the first year.

Communities will be cut off, separated by loss of transport routes and effectively isolated. There is a need for a depth of resourcefulness in individual communities to provide leadership, co-ordination of efforts, rescue and first aid. These isolated communities will need to manage almost on their own for some time (probably much longer than just three days) without any significant outside assistance.

The importance of basic needs such as *lighting and heating, food, shelter, security, water* and *sanitation* although varying a little, remained relatively consistent throughout the first year. This constant and medium importance of these needs, rather than a significant increase in importance as occurs with *leadership* and *information,* is attributed to the availability of alternatives and the ability of the West Coast community to adapt to using them. Water can be obtained from alternative sources and a simple long drop can be dug in the back for toilet needs. Food is, however, always at the top of this group of needs because of the limited number of alternative complete food sources, and results in a high reliance on transport networks to bring food in.

Based on the needs assessment presented in this section the order of priority for getting infrastructure functioning again is as follows:

- Transport, including roads, airports, harbours, river transport and rail;
- Communication including telecommunication (land lines and cellular network), one way and two way radios, local radio station, etc;
- Power supply,
- Water supply,
- Sanitation, and
- Storm water.

5.2 Council Responsibilities and Priorities

The analysis of the previous section establishes sets of needs together with their relative importance. This is helpful in establishing priorities. However, the analysis considers each need in isolation. It does not take into account the interdependencies between them.

The interdependencies can be dealt with in general terms by developing a dependency diagram connecting the needs of individuals (as in the previous section) with the lifelines available to meet these needs. The number of links to the nodes of the diagram give some idea as to the relative importance of the nodes.

A dependency diagram for the response and recovery periods of the Alpine Fault earthquake is shown in Figure 5.3. The convention used is that the need/lifeline at the head of the arrow is dependent on the need/lifeline at its tail.

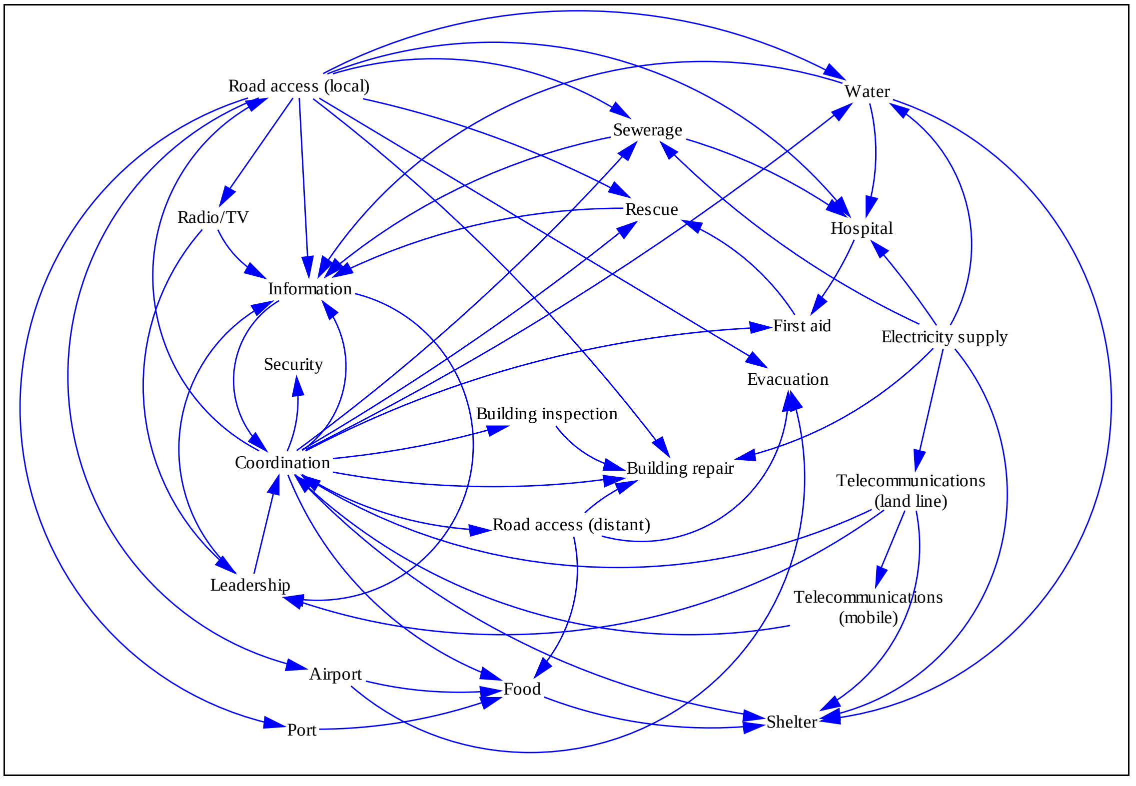


Figure 5.3: Dependency Assessment

Generally, the more links to any node in the diagram, the greater its importance. The two most highly linked nodes in the diagram are *Co-ordination* (pre-eminently) and *Information*. But this does not give the whole picture, for *Leadership* actually contributes to all activity, and these contributing links are not shown in the diagram. The next most important need, beyond these three, is *Local road access*. What is missing are the mechanisms by which the necessary information flow for *Co-ordination* is gathered and sent out and also the relative importance as some links will be more important than others. A working radio station for example is a very important requirement for *Leadership*, as also is the leader's requirement for information.

In system terms, any management activity requires the three elements of *decision*, *implementation* and *monitoring*. For example, it may be decided to repair a bridge as the next priority. It is important that when the work is carried out, the controllers monitor the situation to get feedback on the progress of the work, particularly its completion. The diagram (Figure 5.3) does not show how decision, implementation and monitoring are to be achieved. This needs to be considered by the Councils and other lifeline providers beforehand.

After the Alpine Fault earthquake there will be a high need for *building inspection* and *building repair*. Many buildings and structures, including lifeline structures, will be damaged and need to be assessed to determine whether they are safe to use again. Some structures will need to be assessed by structural engineers, and for others and at different times, building inspectors will be involved. Buildings will need to be repaired or replaced which will require building materials and skilled workers. Building inspections, prioritising and allocating building materials and skilled workers may be a Council responsibility, at least initially.

Management and resource needs of the Council are not discussed in any more detail. However this preliminary assessment has highlighted a few areas where input from Council is likely to be required.

Based on the simple dependency assessment presented in Figure 5.3 and only considering the dependence of others on a particular lifeline i.e. the number of arrow tails leaving a lifeline, the priority for re-establishing lifelines from the Council's perspective is as follows:

- Transportation – primarily local roads but also national roads, airports and ports,
- Electricity supply,
- Telecommunications,
- Water supply, and
- Sewerage

5.3 Community Importance

The level of importance of townships and villages (centres) as community centres after the Alpine Fault earthquake can be established based on:

- The number of people living in the centre, and
- How much the centre functions as a service centre for people living around that centre.

West Coast townships have been allocated an importance category as shown in Table 5.4, where 4 represents highest importance.

Table 5.4: Township Importance Categories

Type	Category	BDC	GDC	WDC
Regional/ District Centres	4	Westport	Greymouth[1]	Hokitika
Sub-District Centres	3	Reefton	Runanga Dobson	Ross
Local area centres	2	Karamea Inangahua Hector – Granity[2] Waimangaroa Ngahawai	Moana, Ahaura Blackball Gladstone Camerons Taylorville	Kumara Kaniere Harihari Whataroa Franz Josef Fox Glacier Haast
Local Community centres	1	Punakaiki Little Wanganui Mokihinui Seddonville Denniston Millerton Charleston Ikamatua	Rapahoe Barrytown Nelson Creek Kopara – Haupiri Ngahere Stillwater Gladstone Iveagh Bay Rotomanu	Otira Arahura Rimu Kokatahi Kowhitirangi Ruatapu Okarito Jacob's River Okuru Hannahs Clearing Neil's Beach Jacksons Bay

1. Includes all communities between Cobden and Paroa
2. Includes urban area of Granity – Ngakawau - Hector

Based on the categories defined in Table 5.4, emergency levels of service have been established for each lifeline and these are used to identify vulnerabilities and to determine improvements.

6 TRANSPORTATION

6.1 Overview

6.1.1 Westland District Transport systems

The Westland District is served by the following transport systems:

- State Highway network, of which the major routes are:
    - SH 6 runs the length of the region from Greymouth to Haast Pass
    - SH 73 links Hokitika with Christchurch over Arthur's Pass
- District roads, which form a network with some interconnections in the northern part of the district, but are essentially single roads feeding off SH 6 in South Westland;
- A railway line connecting Hokitika to Greymouth and the Midland line through the Otira Tunnel to Canterbury;
- Regular airline flights into Hokitika airports, and local small plane and helicopter operations from three other aerodromes; and
- A wharf at Jackson Bay for small ships.

6.1.2 Role of Transport on the West Coast

The West Coast is heavily reliant on transport for survival.

- Most food and essential supplies are processed out of the region and are brought in on an almost daily basis by road;
- There is minimal fuel storage in the area;
- A large component of the economy is export of bulk products reliant on transport, including milk products from Hokitika by road and rail; and
- Transport is central to tourism.

While transport disruption of a few days has little effect on bulk exports, it can have a significant effect on daily supplies and tourism. Thus, while the centralisation of food and basic commodity production and storage to Christchurch may have made some economic savings, it has also made the West Coast much more vulnerable to transport system disruption. Supermarkets for instance usually only have a few days' supply of high turnover goods and rely heavily on refrigeration for food preservation. The Franz Josef Civil Defense Response Plan notes that the town relies on daily supplies of food with no provision for bulk supplies and if road access was closed for more than a few days then aerial re-supply would be needed. Some time ago the only bulk fuel tank farm on the West Coast at Karoro was decommissioned resulting in the only fuel storage being that held in service station underground tanks, with limited overall supply.

In the event of a major Alpine Fault seismic event the West Coast may have to be heavily reliant on the stores of food, equipment, spares and other items held in the area for survival and recovery until transport links are restored and such stock becomes available. It is important to keep in mind that other areas are also likely to be significantly affected and there may be a shortage of food and supplies over much of the South Island, as well as means of transport.

For the above reasons, it is important that mitigating potential disruption to the transport system be given careful consideration.

6.1.3 Transport Situation Following an Alpine Fault Earthquake

As explained in the following sections, the following situation is likely to occur after an earthquake on the Alpine Fault:

- The West Coast road network is extensively damaged over the length of the region from Haast to Springs Junction, close to the fault line. In particular, South Westland can be expected to be cut into a series of isolated areas by destruction of roads by landslides and by destruction of major bridges, and the three mountain pass routes will suffer extensive landslide and bridge damage. In addition, catchments in the vicinity of the Alpine Fault are expected to experience significant aggradation and debris flow events in streams and rivers, which will threaten many bridge sites for some years. Damage will be severe enough to make road reinstatement take weeks or months in and close to the mountains, with high long-term maintenance requirements at bridge sites and to clear slips from destabilised slopes.
- Road links out of the District are likely to be restricted to the routes north of Greymouth being SH 6 to Nelson and SH 7 to Christchurch via the Lewis Pass for some time after the earthquake. SH 73 over Arthur's Pass may take several months to reopen.
- Road damage away from the fault line will be progressively less with increase in distance, and the northern area around Hokitika and Kumara should suffer only moderate damage.
- The airport at Hokitika should remain operable, and this facility is likely to be central to the emergency period immediately following the earthquake. Access disruption may severely limit the utility of the Franz Josef aerodrome.

- There will be an enormous demand on helicopters for rescue, reconnasance, and transport for some time after the earthquake. There are issues around potential earthquake damage to helicopters (toppling over and hangers collapsing onto them), pilot availability, fuel supply and prioritisation of use.
- The Midland railway will suffer great damage between Moana and south of Arthur's Pass. The lines west of Moana will be damaged to a lesser degree, but such that all train services would be stopped. While ONTRACK have assured us that in general it is quicker to reinstate railways than roads, the extent of landsliding and ongoing aggradation and debris issues at river and creek crossings within the mountainous areas may make restoration and mainenance of the Midland line difficult. It would depend on the situation, but it is possible that a rail link across Arthur's Pass could be restored relatively quickly and this might have significant implications in the restoration period.
- The Haast area is likely to be isolated from road access for some time. The aerodrome and wharf at Jackson Bay are likely to be critical links for transport in and out of the area.

6.1.4 Key Principles for reinstatement of Transport

The key principles for re-establishing transport links after an Alpine Fault earthquake, such as that described in Section 3, are as follows. To begin with, the initial priorities for providing transport will be for:

- Access to critical emergency management co-ordination centres;
- Search and rescue and evacuation of injured people;
- Assessing the impact of the earthquake on the District e.g. damage to infrastructure such as bridges and roads, potential hazards such as landslide dams, etc;
- Access to repair critical communication infrastructure;
- Access to civil defence community centres and between communities starting with communities of highest population;
- Access to power infrastructure;
- Access to sites that will require drainage because they have potential to pond sewage/storm water;
- Access to water supply assets to set up emergency water supplies;
- Access to outside the district to establish transport routes for supplies;
- Immediate post earthquake needs of co-ordination, rescue and evacuation and, for transport of initial supplies into the district with the airports being of highest priority.

The order is arbitary and not in any order of priority. Helicopters may play a key role in transport reinstatement, in identifying damage with the aid of video cameras and GPS locations.

The road network is the prime transportation system in terms of people and general freight movement as well as access to all parts of the region. Air transport is significant, and will play a crucial role during the emergency phase of the earthquake response. Boat access across rivers in South Westland may be important during the response period, as will the Jackson Bay wharf. Depending on the nature of the damage, the rail link to Canterbury might assume significant importance.

6.1.5 Possible Regional and District Transport Strategies

The following strategies are suggested.

The road links into the West Coast from Nelson and via the Lewis Pass are likely to be the first routes able to be reopened and are critical to the District's recovery, although they lie outside the District.. The higher, steeper and more rugged nature of the Arthur's Pass route, the known history of large rock avalanches and the greater predicted rupture on the closest section of fault, suggest that SH 73 is likely to be more significantly damaged than SH 7 over the Lewis Pass. It is suggested that priority for seismic strengthening work be given to SH 6 and SH 7 in preference to SH 73.

SH 6 is the lifeline for South Westland. It is particularly vulnerable at a number of places where bridges or sections of road on steep potentially unstable slopes are very close to the fault line. The priority in improving this road could be to progressively work down from the north. For instance strengthening the Wanganui Bridge could reduce reinstatement times for access to Harihari from one to three months to a few days. Between Franz Josef and Haast, the small population served and the extent of damage likely raises the question of whether this section should even be attempted to be reinstated for perhaps some years until slope damage and river systems have regained some stability. Upgrading work on this section may take a much lower priority as the result of such consideration.

There is little doubt that the Haast area will be isolated from road access for several weeks to several months depending on the severity of the earthquake at this end of Westland and the availability of resources to reinstate roads. Even if damage to the Haast Pass road is less than to other roads it still may not be opened for sometime as the priority will be to reinstate roads to more populated areas or areas with no other form of access. The wharf at Jackson Bay takes on a new significance as the only facility for bulk supplies to be delivered for some time. The Jackson Bay Road also becomes more important, as do the bridges. In terms of seismic resilience, these district bridges are probably more important than the State highway bridges south of Franz Josef. The Haast aerodrome also becomes a significant facility.

Even if the West Coast remains isolated, if good access between Hokitika and Greymouth can be re-established quickly, it would significantly assist in the recovery of both towns with the ability to share resources and expertise, give Hokitika access to Grey Hospital and Greymouth access to Hokitika airport. Hence SH 6 between Hokitika and Greymouth becomes a critical link. The Arahura Bridge has been identified as being seismically weak, and is the only crossing of this river. Transit has commenced investigations for a replacement bridge, but pressure should be maintained to ensure that a new road bridge is built expeditiously. Saltwater Creek Bridge and the South Beach overbridge in Grey District have also been identified as being at some risk, although there would be alternative routes possible. The Taramakau Bridge cannot be bypassed easily, but appears to be seismically adequate.

As the Hokitika airport is likely to be a major transport link for several weeks after an Alpine Fault earthquake, facilities and equipment here should be secured as much as practicable, and the route between the airport and Hokitika township should be checked for vulnerabilities.

The possibility that the rail link to Canterbury could be repaired fairly rapidly should be explored with ONTRACK.

6.2 Roads

6.2.1 Characteristics of the Road System

The Westland District is characterised by its long narrow shape, low traffic volumes, frequently mountainous or hilly terrain with high rainfall, and the many rivers and streams that cross the main routes. There are only four links to the rest of the South Island; two bridges across the Taramakau River into the Grey District, and the Arthur's Pass and Haast roads crossing mountain passes. Within the District there are some interconnected roads north of Arahura and inland from Hokitika, but south of Ruatapu, there is essentially one single road with short side branches serving the whole of South Westland. This combination of relative lack of redundancy, low traffic volumes to justify major upgrades, challenging environment and length of fault rupture make the roading system particularly vulnerable in the event of an Alpine Fault earthquake.

Table 6.1: Westland Road Statistics

	Transit (SH)	**Westland District**
Roads		
Total length	445	685
Urban sealed		53
Rural sealed		297
Rural gravel		335 (49%)

Bridges		
Number	151	289
Length (km)		3.2
Longer than 10m		97(34%)
Single lane		161 (56%)
Timber no.		28

There is also a significant length of roads in the district not maintained by the District Council such as forestry and mining access roads, which may be significant as alternative 4WD routes.

Relative traffic volumes on the state highways in the district are indicated below. Arthur's Pass carries a similar volume as the Lewis Pass, but over twice as much as the Haast Pass.

Table 6.2: Annual Average Daily Traffic volumes (Transit for 2004)

SH	Location	AADT	SH	Location	AADT
6	Taramakau Bridge	3200	6	Ross	1100
73	Otira	1280	6	Whataroa	1020
73	Taipo River	990	6	Franz Josef	1130
73	Kumara Junction	1710	6	Cooks Saddle	710
6	Arahura bridge	3380	6	Haast	630
6	Hokitika Fitzherbert St	4740	6	Haast Pass	560

6.2.2 System Vulnerabilities

It is virtually certain that in an Alpine Fault earthquake the roading system will be significantly, and in some areas severely, affected. Immediate damage will result from earthquake shaking directly and also from secondary effects such as liquefaction and landslides. Damage is likely to include:

- Fault rupture offsetting the road vertically and horizontally,
- Structural damage to at least some bridging, and in some cases resulting in bridge closure,
- Slumping of abutment fill that may close bridges temporarily,
- Slips that either deposit material onto roadways, or result in the carriageway falling away, and
- Liquefaction induced slumping and fissuring in local areas.

Damage subsequent to the earthquake will result from aggradation and flooding in rivers, debris flows covering roads with debris and water and destroying bridges and culverts, and damage to culverts resulting in washouts.

6.2.3 State Highways

The State Highway system provides all the external links beyond the District, and the principal network within the District. Although it is not the WDC's responsibility, its performance will impact greatly on the district's resilience to an earthquake event. The West Coast State Highway system is shown in Figure 6.1.

Figure 6.1: West Coast State Highway Sytem

Transit NZ has carried out a seismic screening of all the bridges on the state highway system. The report on region 12 – West Coast – was prepared in 1999. This study identified the following bridges in the region (Table 6.3) at risk of serious damage or collapse, requiring closure. Other bridges are at risk of damage, but have not been included in Table 6.3, and the table does not include the vast majority of bridges where little or no damage is expected.

Table 6.3: SH Bridges with Significant Seismic Risk – Transit Study

State Highway	Bridge	PGA EQ (1)	PGA cause (2)	Dam -age (3)	Likelihood (4)	Comments
6	**Greymouth – Hokitika**					
	South Beach O/B	0.35	0.4	3	C	Settlement, distortion from liquefaction
	Saltwater	0.35	0.5	3	C	Probable collapse from pier failure
	New River	0.35	0.5	3	D	
	Taramakau	0.4	0.5	3	D	Possible pier damage
	Arahura **	0.45 0.45	0.5 0.5	3 3	D C	Racking + loss of beam support Pier damage, severe distortion, damage
73	**Arthur's Pass – Kumara**					
	Yorkeys Point	0.8+	0.5	3	B	Bearing failure, settlement deck damage
	Otira	0.8+	0.5	3	B	
	Taipo	0.8+	0.4	5	B	Possible collapse from pier failure
	Big Wainihinihi	0.8+	0.5	3	B	
	Turiwhaite	0.8+	0.4	3	B	
6	**Hokitika – Franz Josef**					
	Donelly Creek	0.7	0.5	3	C	
	Mikonui	0.7	0.5	5	C	Poor linkage - Span collapse
	Kakapotahi	0.8	0.5	3	C	Damage and settlement from pier failure
	Waitaha	0.75	0.5	5	C	Poor linkage - Possible collapse spans
	Wanganui	0.8+	0.5	3	B	Severe damage, settlement from pier failure
	Paerua	0.8+	0.5	3	B	Severe damage, settlement from pier failure
	Whataroa	0.8+	0.5	3	C	Bridge settlement from pier failure
	Waitangitanoa	0.8+	0.5	5	C	Probable collapse
	Tatare	0.8+	0.5	3	C	Damage, settlement from pile cap failure

(1) Probable peak ground acceleration (PGA) at the bridge location from the Alpine Fault earthquake. Other earthquake sources, or different rupture lengths on the Alpine Fault will produce different PGA
(2) Minimum PGA to cause significant damage to bridge
(3) Extent of damage to bridge
1 – insignificant; superficial damage, no disruption to traffic
3 – moderate; significant damage in a number of locations requiring closure
5 – Catastrophic; damage requiring replacement of more than one span
(4) likelihood of risk event
A – very likely B – likely C – moderate D – unlikely E – very unlikely
** Transit have started investigations for a replacement Arahura Bridge
*** Strengthening of these three suspension bridges is planned to allow the removal of current weight restrictions. Seismic resistance may be improved as part of this work.
# Transit plans include a realignment and new bridge at Gates of Haast within 3 – 10 years

Table 6.3: SH Bridges with Significant Seismic Risk – Transit Study (continued)

State Highway	Bridge	PGA EQ (1)	PGA cause (2)	Dam -age (3)	Likelihood (4)	Comments
6	**Franz Josef – Haast**					
	Waiho	Temporary, not analysed				Very close to fault – damage very likely
	Kiwi Jacks	0.8+	0.5	5	C	rockfall onto bridge - possible collapse
	Waikukupa	0.8+	0.5	3	C	damage, settlement from pile cap failure
	Fox River ***	0.8+	0.5	5	C	Probable collapse from tower buckling
	Cook River ***	0.8+	0.5	5	C	Probable collapse from tower buckling
	Ohinetamatea	0.8+	0.5	3	C	
	Karangahua ***	0.8+	0.5	5	C	Probable collapse from tower buckling
	Manakaiaua	0.8+	0.5	3	C	
	Jacobs River	0.8+	0.45	3	C	
	Papakeri	0.8+	0.5	3	C	
	Mahitahi	0.8+	0.5	3	C	damage, settlement from pile cap failure
	Windbag	0.8+	0.5	3	C	
	Moeraki	0.6	0.6	3	C	Pile failure- settlement
	Whakapohai	0.6	0.4	3	C	damage, settlement from pile cap failure
	Ship Creek	0.4	0.6	3	C	Pile failure - settlement
	Waita	0.35	0.6	3	C	Pile failure - settlement
	Haast River	0.3	0.5 0.5	3 5	C C	Linkage damage to joints and abutment Pier failure, possible collapse 2 lane settlement / closure 1 lane
6	**Haast – Haast Pass**					
	Greenstone Creek	0.3	0.5	5	C	Poor linkage - Possible span collapse
	Pivot Creek	0.3	0.6	3	C	
	Pleasant Point	0.3	0.4	3	C	Bearing damage, spans distorted
	Gates of Haast #	0.3 0.3	0.4 0.5	3 5	C C	Linkage + bearing failure Collapse from abutment instability

(1) Probable peak ground acceleration (PGA) at the bridge location from the Alpine Fault earthquake. Other earthquake sources, or different rupture lengths on the Alpine Fault will produce different PGA
(2) Minimum PGA to cause significant damage to bridge
(3) Extent of damage to bridge
1 – insignificant; superficial damage, no disruption to traffic
3 – moderate; significant damage in a number of locations requiring closure
5 – Catastrophic; damage requiring replacement of more than one span
(4) likelihood of risk event
A – very likely B – likely C – moderate D – unlikely E – very unlikely

** Transit have started investigations for a replacement Arahura Bridge
*** Strengthening of these three suspension bridges is planned to allow the removal of current weight restrictions. Seismic resistance may be improved as part of this work.
# Transit plans include a realignment and new bridge at Gates of Haast within 3 – 10 years

It should be recognized that these bridges have been identified from a preliminary screening study, and detailed analysis may reduce (or increase) the relative risk.

Comparison of the PGA expected with the Alpine Fault and the PGA needed to initiate the serious damage indicated in the damage column shows that a number (27) of State Highway bridges in Westland district will be subjected to seismic forces well in excess of the damaging level. All the major bridges on SH 73 to Arthur's Pass can be expected to be closed or destroyed. Between Ross and Franz Josef, nine bridges will be closed of which three will suffer collapse (a fourth – the Wanganui Bridge at Harihari should be added given its proximity to the fault). All of these bridges are long multi span structures. South of Franz Josef, there are thirteen bridges which will be shaken sufficiently to cause serious damage requiring closure. Of these, four are likely to collapse.

It should also be borne in mind that the **importance of a bridge**, and hence its acceptable risk level, will be **influenced by the volume of traffic using it, access to vital facilities or communities, the presence of other services on the bridge etc**.

A full and detailed assessment of the State Highway system has not been carried out, but preliminary review and common sense suggest the following is probable. Immediate links outside the regional boundary are included as these also impact directly on the regional resilience.

1	***Link***	***SH 6 Hokitika - Greymouth***
	Importance	Very high: main link to Greymouth, hospital, port, poulation
	EQ Shaking	MM VIII
	Time to reopen	1 – 2 days
	Damage	Possible bridge damage including Arahura, possible liquefaction in places.
2	***Link***	***SH 73 Turiwhate – Arthur's Pass***
	Importance	High: shortest route to Christchurch, fibre optic cable route, transpower line route.
	EQ Shaking	MM IX – X
	Time to reopen	Greater than six months
	Damage	Fault rupture, bridge collapse (Taipo) bridge damage, extensive landslides, possible rock avalanche, ongoing debris and aggradation issues at streams and rivers.
3	***Link***	***SH 73 Turiwhate to Kumara Junction***
	Importance	High: part of Arthur's Pass route, main access to Kumara
	EQ Shaking	MM VIII
	Time to reopen	A few hours
	Damage	Small landslides inland from Kumara, minor bridge damage
4	***Link***	***SH 6 Hokitika to Ross***
	Importance	high; main link to south
	EQ Shaking	MM VIII – IX
	Time to reopen	A few hours
	Damage	Minor bridge damage, liquefaction

5	***Link***	***SH 6 Ross – Franz Josef***
	Importance	Very high: only road access to main centers of South Westland
	EQ Shaking	MM IX – X
	Time to reopen	One to three months
	Damage	Landslides, especially over Mt Hercules, bridge damage, possible bridge collapse at Wanganui, Whataroa, Waitangitanoa, fault rupture at Wanganui River, Whataroa River and Franz Josef. Ongoing debris and aggradation issues.
6	***Link***	***SH 6 Franz Josef to Haast***
	Importance	High; One of only two access road to South Westland.
	EQ Shaking	MM IX –X
	Time to reopen	Greater than six months
	Damage	Severe bridge damage or collapse at several major crossings, fault rupture at Franz Josef and over Cook Saddle, widespread and large landslides, particularly over Cook Saddle and Knights Point. Ongoing debris and aggradation issues.
7	***Link***	***WDC Haast to Jackson Bay***
	Importance	High: only road link between Haast communities, local power system and Jackson Bay wharf
	EQ Shaking	Scenario 1: MM VII for fault rupture only north of Paringa Scenario 2: MM IX+ for fault rupture through Haast area
	Time to reopen	Scenario 1: a few hours Scenario 2: several months
	Damage	Scenario 1: slips near Jackson Bay, minor bridge damage, minor liquefaction Scenario 2: extensive landslides near Jackson Bay, widespread liquefaction, severe bridge damage.
8	***Link***	***SH 6 Haast to Wanaka***
	Importance	High: only alternative road into South Westland
	EQ Shaking	Scenario 1: MM VII - VIII for fault rupture only north of Paringa Scenario 2: MM VIII - IX+ for fault rupture through Haast area
	Time to reopen	Scenario 1: one to two weeks possible Scenario 2: several months
	Damage	Scenario 1: landslip, rockfall, some bridge damage, Scenario 2: extensive landslides and rockfall, major bridge damage and possible collapse (Gates of Haast). Ongoing debris and aggradation issues

In general, the times to reopen are for basic four-wheel drive and truck access, with one-lane sections as necessary. The time to restore full service levels comparable to pre-earthquake may take much longer – from weeks to months, and in some instances perhaps even years.

As SH 6 south of Hokitika is critical to transport in the District, the damage is expanded in more detail as follows:

Lake Ianthe – Wanganui River	Minor slips easily cleared, weight restriction on damaged minor bridges.
Wanganui River	Fault rupture cuts road in two places east of the river; requires excavator one day for temporary repair. Bridge very close to rupture, identified seismic weaknesses, bridge closed for several weeks for repair or replacement of collapsed spans. All access south blocked here until repaired.
Wanganui River – Whataroa River	Possible bridge failure at Poerua River, but smaller river more able to be forded. Widespread slips over Mt Hercules; 1 – 2 weeks to clear once plant able to get to site.
Whataroa River	Fault rupture destroys 600m length of road and Parkers Creek bridge on north bank. One week to establish temporary road on new alignment to allow ford to Parkers and McColloughs Creeks. Whataroa bridge damaged and closed for time taken to access plant & material to site plus several weeks for repair. Fault rupture on south bank; one day for temporary repair.
Whataroa River – Franz Josef	Probable damage to Waitangitanoa Bridge; requires ford off Richardsons Road to bypass. Slips from high batters along Lake Wahapo and in places through to Potters Creek – several days to clear. Tatare bridge closed; bypass with ford. Fault rupture in Franz Josef township.
Franz Josef – Fox Glacier	Waiho Bridge damaged, but possibly able to carry light traffic. Otherwise a ford is needed to access the south bank including the aerodrome. Fault rupture on south bank and debris from stop bank over 1.2km. High risk of flooding and complete loss/burial of 1.5km of road. Most of road between Docherty Creek and Fox vulnerable to landslides and rupture on westward fault trace. Bridge loss probable at Kiwi Jacks and Waikukupa. A reasonable scenario is for several kilometers of road in this area to be 90% destroyed.
Fox Glacier – Bruce Bay	The three suspension bridges over the Fox, Cook and Karangarua rivers are all very close to the fault line. Currently they have identified weaknesses in bracing, and it is reasonable to assume that they will all collapse. Alternative access for people could be provided by boat at the bridge sites. The nature of the failure is likely to leave little that could be incorporated into even a temporary bridge, and reinstatement of these crossings would require some months of construction of even a temporary bridge, once access to the site is possible. South of Ohinetamatea River, where the bridge will be untrafficable, about 3km of road would be blocked in places by slips off the adjacent steep hillside. Both Manakaiaua, Jacobs River and Papakeri bridges will be damaged enough to be untrafficable.

Bruce Bay - Haast	Some damage to road and bridges to Lake Paringa including Mahitahi bridge. Paringa River bridge is about 300m from the fault, and is likely to suffer some damage, while the approach fills will slump and fissure, requiring earthworks to restore use. Slips in the Moeraki Valley and along the lake will take several days to clear once plant accesses the area. Windbag, Moeraki, and Whakapohai bridges all damaged and unuseable for traffic. The section around Knights Point is on steep unstable terrain, and took several years to complete when first built. Although shaking intensities are falling off for the scenario with fault rupture to the north of Paringa only, extensive landslides should be expected on this length, perhaps requiring several weeks to clear once plant accesses the area. South of Ship Creek the road is on relatively level ground, but both the Ship Creek and Waita bridges would be damaged if fault rupture extended south of Paringa. In this scenario, the Haast bridge would also be at risk of partial collapse, requiring some months to reinstate at crossing once plant accessed the site.

The damage outlined above is direct damage from the earthquake. Ongoing effects will result from the combination of steep to very steep and high terrain, with many slips and de-stabilised slopes, and high rainfall. Many slip areas originally caused by earthquake shaking are bound to move again when subject to heavy rain. Sediment input into the rivers will cause aggradation, and debris flows will discharge from many small catchments. It is likely that many lengths of road in South Westland will be subject to frequent closure from slips, debris and flooding for many months to years after the earthquake. There is also an unpredictable hazard from flooding and debris as a consequence of earthquake dam breaks.

6.2.4 Westland District Roads

The WDC road network runs through a considerable variation of terrain from river valleys to more hilly areas with embankments and cuttings. Where the roads are in relatively flat areas, the main hazards are liquefaction or being within an active earthquake fault zone, and there is little that can be done practically to improve robustness against these hazards. Embankments and cuttings are a vulnerability that can be reduced in some cases by bank stabilization and maintenance.

A major concern is the relatively extensive bridging on the WDC road network. At present the WDC does not have a comprehensive database on the condition of its bridges. There will be at least some bridges vulnerable to earthquake damage due to insufficient structural robustness at the shaking intensities expected through much of the district. It is therefore recommended that bridges on critical routes be structurally audited for robustness against seismic attack and flood damage potential.

It is assumed that rural areas in general will be expected to be more self reliant, as well as less populated, and therefore where appropriate would be less of a priority for reestablishing access. Roads will be reinstated in the first instance, to a four-wheel drive level of service for access within the district.

While key roads managed by Westland District can be identified prior to the earthquake, the order of priority for reinstating access along them will be influenced by the actual damage sustained. The priority is also closely linked to the State Highway network, and Transit and Westland District must work closely together in co-ordinating the road recovery. While this may be forced on both parties through the emergency management that will be imposed after the earthquake, liaison between the parties prior to any emergency could greatly enhance the speed and ease of recovery.

The district roads, which are likely to have priority in reinstatement are listed below. Comments on their vulnerability are also given. These comments are based on superficial observations of the topography and related features. There is no detailed inventory of the routes and additional surveys of the roads are recommended to better identify vulnerabilities and any mitigation measures that might be taken prior to an earthquake. A model for such a study is outlined in Speed & Brabhaharan, 2006. This model uses six factors to prioritise road links; average annual daily traffic, percentage heavy vehicles, detour routes, no-exit roads, average property values, and land use, and considers a range of impacts for each of the earthquake consequential hazards. Other than some limited links north of Hokitika, most of the district roads are short, no exit, branches off the state highways. Reinstatement can really only follow the re-opening of the state highways.

Priority roads are:

- Roads within the Hokitika urban area providing access to the airport, water supply reservoirs, medical center and CD posts. There is redundancy in access roads, and a basic level of service is expected to be obtainable quickly. The commercial area may suffer some liquefaction damage, as well as partial obstruction caused by any building collapse, but this is unlikely to prevent four wheel drive access.
- Kanieri Road. Little significant damage is expected on this road, with only three short bridges, but it gives access to Kanieri, Arthurstown and the roads further inland as well as one of the water supply trunk mains supplying Hokitika.
- Kowhitirangi Road. This road gives access to the Kowhitirangi – Kokatahi farming communities. The section to Kokatahi is expected to sustain little significant damage. There are five bridges, but all are relatively small. The Kanieri River bridge is a 3 span bridge from 1961 and could suffer some damage, but an alternative ford should be easy to establish. Beyond Kokatahi, the roads are all close to the fault and more damage is expected, although apart from bridges this should not prevent vehicle access. The Kokatahi Bridge is a 310m long 15 span bridge built in 1949. It will

be subject to 0.8+ PGA and some significant damage is very likely. Alternative access across the river for heavy vehicles may be difficult given the size of the river.

- Lake Kanieri Road. This road provides access to the Hokitika water supply intake and pipeline, as well as the two small hydro stations, which if still operable could provide limited power to Hokitika, and the settlement at Lake Kanieri. There is a risk of landslips where the road closely follows the river. The nine bridges are all relatively small, except for the 3 span Kanieri River bridge, but some damage is likely. (The Upper Kokatahi – Dorothy Falls Road is likely to be severely damaged with bridge damage or collapse, landslides and possible fault rupture.)
- Haast – Jackson Bay Road. This road links the communities in the area with each other, the Haast aerodrome at the north end and the wharf at the south end. As road access out of Haast is likely to be cut for some time, these transport nodes and access between the communities for greater self-reliance become important. It also provides access to the local power system. If the fault rupture does not extend south of Paringa, this road may escape significant damage beyond some liquefaction and bridge abutment damage. If the fault rupture extends through the area, then damage is likely to be severe. Slips on the coastal escarpment close to Jackson Bay could easily bury lengths of the road. Liquefaction could be severe in places, requiring some earthworks before access for even four wheel drive vehicles is possible. However the main problem would be the bridges. There are five large multi span bridges on the road. Four of these are reinforced concrete structures thought to date from the 1940s, and likely to suffer severe damage with the strong shaking expected at their 4 – 7 km distance from the fault. The fifth is the 260m long Arawhata bridge, only 1 km from the fault line.
- Okarito Road is the only access to the township of Okarito off SH 6. This road could be blocked by slips along the side of Okarito Lagoon and close to Okarito Forks.
- Other roads in South Westland are generally on flat land with only minor stream crossings, and serve dispersed farm communities. The major difficulty in reinstating service on any of these roads that might be damaged is initial access to the area, as SH 6 is expected to be severed in a number of places. All the communities south of and including Harihari are going to have to "make do" for a long time after the earthquake.

It is clear that an Alpine Fault earthquake rupturing through Westland District is going to cause enormous disruption to the road system inland of Turiwhati, Kokatahi and south of Lake Ianthe. In particular SH 6 will be severed in many places, isolating the small communities throughout South Westland.

6.2.5 Upgrades and Improvements

Given that the actual extent of damage cannot be predicted completely accurately in advance, it is still possible to identify some key routes for priority for reinstatement following a major catastrophic event using the key principles outlined in section 5.1.4. These routes include:

- Local roads to access key facilities, infrastructure and the airport in Hokitika;
- The airport at Hokitika, as this facility is of regional importance in gathering information for damage assessment, rescue and evacuation, and delivery of emergency supplies;
- Access to Medical Centres and Community Emergency Centres firstly within each community then from outlying areas;
- Links between population areas with centres of highest population (potential areas of greatest need) and those close together being given priority. For instance Hokitika and Kanieri;
- Access to critical lifeline installations such as major sub stations (electricity), telephone exchanges (communications), water pumping stations and reservoirs (potable water supply) and including the Lake Kanieri Road;
- The road between Hokitika and Greymouth, as these two centres connected will be stronger than isolated as they offer complimentary services, eg airport at Hokitika, hospital and port at Greymouth; and
- Reinstatement of SH 6 progressively south towards Franz Josef.

It is assumed that rural areas in general will be expected to be more self reliant, as well as less populated, and therefore where appropriate would be less of a priority for reestablishing access.

In addition, there are some key links, which WDC could assess in terms of vulnerabilities and potential to reduce the risk. These include:

- Bridges on the roads to Lake Kanieri and Kowhitirangi, especially the Kokatahi River bridge, which is the only access to the Kowhitirangi area;
- Okarito Forks Bridge; and
- Bridges on the Haast – Jackson Bay Road

While key roads in the region can be identified prior to the earthquake, the order of priority for reinstating access along them will be subject to the actual damage sustained. The priority is also closely linked to the State Highway network, and Transit and District Councils must work closely together in co-ordinating the road recovery. While this may be forced on both parties through the emergency management that will be imposed after the earthquake, liaison between the parties prior to any emergency could greatly enhance the speed and ease of recovery.

An example of this is the Arahura Bridge. Transit seismic assessment provides a ranking of importance within the Transit system. This ranking may be quite different to the importance the Westland District may have for the bridge as not only does it forms part of a critical link between Hokitika and Greymouth, but it also carries communication cables. Damage to this bridge could have severe repercussions on the ability of the district to respond quickly after the earthquake, and some additional mitigation work on the bridge may be warranted from the district perspective. In other words the acceptable level of risk may be quite different to the two parties, and this would be best openly discussed and management procedures reviewed before a major earthquake.

It is recommended that the District Councils meet with Transit, and any other important stakeholders, to review the prioritisation of bridges and the need for any mitigation measures. The criteria for prioritisation should be agreed by the parties involved, but should probably include:

- Average annual daily traffic (traffic volume as indicator of importance and possible disruption)
- Percentage of heavy vehicles (as indicator of economic impact)
- Detour routes (are there any, how far and in what condition)
- Services supported by the bridge (water, sewer, telephone, power etc)
- Role of bridge in access to key lifeline facilities in an emergency
- Impact on community and overall social resilience.

6.3 Airports

6.3.1 Westland District Airports

There are four aerodromes listed with the Civil Aviation Authority within the Westland District:

- Hokitika
- Franz Josef
- Fox (Helipad)
- Haast

Hokitika airport is owned by WDC through a subsidiary holdings company. It is the busiest airport on the coast, serving both Hokitika and Greymouth with several commercial flights a day, as well as being used by helicopter and charter flights. It has two sealed runways, one being 1314m by 30m and the second 1176m by 18m. Only the first runway and taxiway have lighting; there is no standby power. There are fuel facilities and a passenger terminal.

Franz Josef aerodrome consists of a single 800m by 9m sealed runway 5km SW of the township. There is no lighting but it does have a fuel facility. It is operated by Air Safaris and Services, based in Lake Tekapo. Helicopter operations are based from helipads adjacent to the township.

Fox Heliport is operated by Glacier Southern Lakes Helicopters Ltd and is 1.5km west of the township. There is no lighting or facilities, and it is limited to 15m long helicopters. There is a grass airstrip about 700m long 0.5km north of the township.

Haast aerodrome is a 700m by 60m grass runway operated by Heliventures Ltd, 0.5km south of the Haast Hotel and DOC centre. It has no lighting but does have a fuel facility.

There are numerous smaller private grassed airstrips on the West Coast able to be used by light aircraft that are not on the civil aviation register. These include the following as shown on 1:50,000 maps:

- Kanieri 2.5km to SE near Taminelli Creek Milltown (upper Arahura valley)
- Kokatahi, Whites Rd, 2km north
- Kowhitirangi, Stopbank Rd, 4km south
- Ruatapu Falls Creek Rd, 6km south
- Okuru (Haast)
- Okarito
- Tatare, 2km north of Franz Josef township
- Fox, 6km west of township
- Karangarua, 1.5km west of the bridge
- Neils Beach (Jackson Bay).

6.3.2 Airport Vulnerability

Of the listed aerodromes, Hokitika is on a high terrace of consolidated outwash gravel. The others are on alluvial surfaces, which have a low probability of liquefaction damage.

For the Alpine Fault earthquake, Hokitika airport is likely to sustain very little damage to the runway and aircraft areas, but the shaking could cause significant damage to the terminal building contents. This airport should be able to be functional within a short time following the earthquake. The lack of back up power should be checked, and standby power arranged if necessary.

Franz Josef aerodrome could play a crucial role in evacuating people from the area. However, it is less than 5km from the fault line and will be subjected to very strong shaking. The runway is likely to remain useable, although some distortion to the surface and damage to seal is possible. A major risk to the utility of this aerodrome is its location on the south side of the Waiho River. The road will be cut by the fault rupture in two places, the bridge could well be damaged or destroyed, and 1.5km of road is vulnerable to debris from the adjacent steep battered stopbank, and flooding and debris flows from the river.

Fox Glacier heliport is about 1.5km from the fault line. Damage to the hanger and fuel facility is probable. It should be possible to land small aircraft at one or both of the two airstrips at Fox.

The Haast aerodrome should remain functional, particularly if the fault rupture does not extend as far south as Haast as postulated in the scenario.

6.4 Ports

6.4.1 Jackson Bay Wharf

The Jackson Bay wharf is operated and maintained by the Westland District Council. The wharf is about 65m long, with a 145m long trestle approach from the shore. It is of timber construction and was built in 1937-38. The water depth and load capacity of the wharf are not known, but it would be adequate for the size of vessel able to use Greymouth port. Jackson Bay is currently used as a base for fishing boats.

The wharf's seismic capacity is not known. It should survive an Alpine Fault earthquake with rupture north of Paringa with little damage, but could be significantly damaged if the fault rupture extended south to or of the Arawhata River. It is recommended that its seismic strength be checked.

While currently of limited use and probably of marginal economics to keep functional, this wharf could be of great importance post an earthquake when all road access to the Haast area is expected to be cut for a significant period. While the permanent Haast population is less than 300 people, from late August to mid November the whitebaiting season swells the population to over 1,000, and numbers stay high through the summer from tourism.

6.4.2 Other boat transport

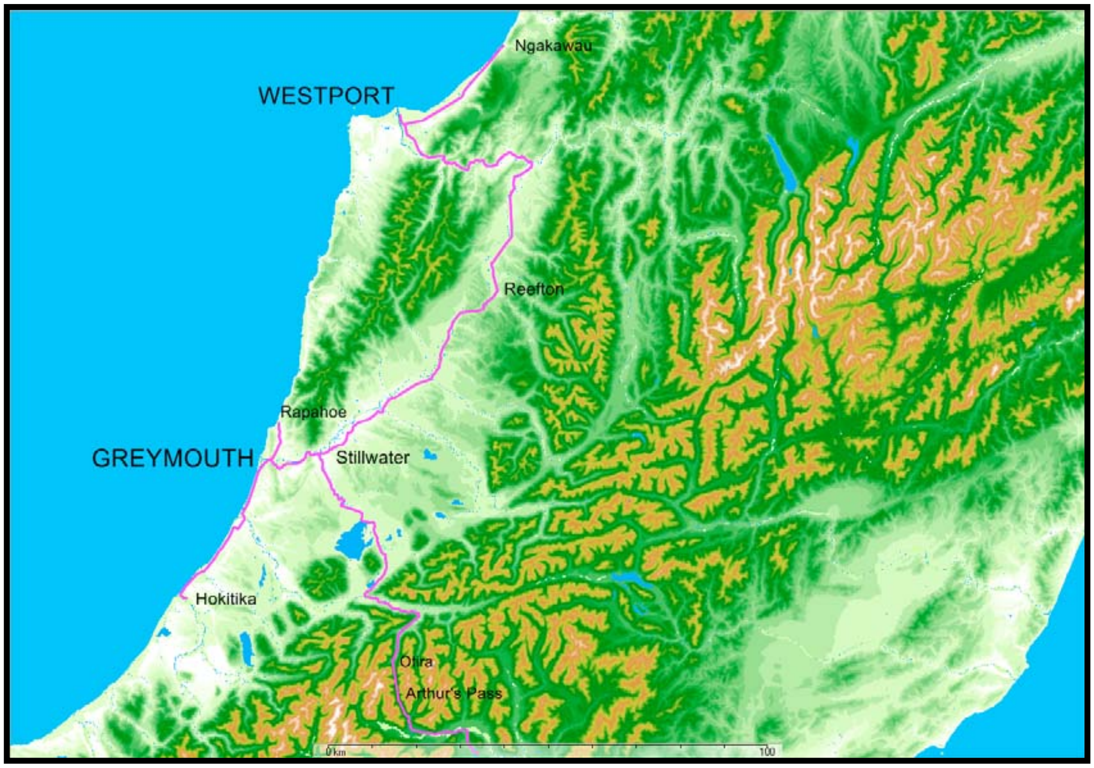
Boat access up the some of the rivers would be an immediate alternative to damaged roads. For instance, jet boat travel up the Hokitika and Kokatahi Rivers could allow early inspection of at least part the Kowhitirangi area if the bridges are lost. Boats on rivers in South Westland may have a longer-term role in ferrying people and small freight across major rivers while the damaged bridges are repaired or replaced. Small seafaring vessels may have a role in evacuation or delivery of supplies to the small communities at Bruce Bay and Okarito (weather and sea conditions permitting) as well as to the Haast area across the Jackson Bay wharf.

6.5 Railways

6.5.1 General Description

The West Coast railway network is shown in Figure 6.2. The West Coast is linked to the national rail network via the Midland Line from Rolleston (Christchurch). At Stillwater it splits to a north line to Westport and Ngakawau. A south line leads to Greymouth, Rapahoe, and Hokitika. The line is single tracked with numerous passing loops and varies considerably in age and condition. The major traffic on the line is coal transport from Ngakawau (Stockton Mine) and Rapahoe (Spring Creek Mine) through Otira to Christchurch.

Figure 6.2: West Coast Rail Network



The railway network has recently been split with rails and infrastructure reverting back to Government ownership (ONTRACK) and the rolling stock and transport business being owned by Toll Holdings. Significant investments are currently being made in replacing bridges, upgrading track and extending crossing loops to allow this traffic to be increased.

6.5.2 Significant Asset Risks.

The railway network on and to the West Coast, like the highways, passes through mountainous and in places unstable country. This means that even with the best intent, it is not practicably possible to safeguard the railway against unexpected land slips and bridge damage. With railways, alignment and gradients are much more critical than for roads, and therefore it is particularly vulnerable to disruption. Temporary bypasses are much harder to implement and sometimes completely impractical. Therefore it must be assumed that the railway will take a significantly longer time to reinstate than the highway system[4].

6.5.3 Earthquake effects on Railway

The Midland line will be severely damaged, to the extent that it is likely to be closed for a long time. The line from Hokitika to Greymouth and beyond to Westport will be less damaged, and could be made operable again within a month. However, it seems unlikely that without the transalpine connection the railway could not provide any advantage over the road system, and it is likely that little effort would be expended on it in the short term.

[4] Since preparing the scenerio ONTRACK have been contacted. ONTRACK state that they can reinstate railway track after an earthquake faster than roads can be reinstated.

6.6 Transport Improvement Schedule

Improvements identified in Section 6.1 to Section 6.5 are summarised in Table 6.4.

Table 6.4: Improvement Schedule -Transport

Importance[1]	Action	Completion date	Responsible
	General		
H	Establish fast and flexible contract procedures with contractors, and establish availability of plant and equipment, and professional engineers where appropriate. It is noted that these are largely in place.	Dec '06	WDC
	Hokitika Airport		
M	Assess seismic resilience of the airport, including building contents and power supply. Implement identified measures to ensure the airport can function within a short time following an earthquake.	Assess Dec '08 Implement Dec '11	WDC
	South Westland		
M	Check condition of airstrips and size of aircraft that could use them. In particular, airstrips at Okarito, Tatare (both possible alternatives to Franz Josef), Fox Glacier, Okuru and Neils Beach.	Dec '06	WDC
	Franz Josef		
M	Investigate possible alternative landing strips on the north side of the Waiho River.	Dec '06	WDC
L	Investigate possible alternative access means between the township and the aerodrome should SH 6 link become unusable. It is noted that there is alternative access by helicopters and by fording the Waiho River where and when possible	Dec '10	WDC
	Jackson Bay Wharf		
L	Review strength of structure and implement any measures to enhance its seismic resilience. Note that a structural review was recently undertaken	Dec '10	WDC
	Roads		
H	In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify, prioritise and manage immediate clearing and repairs.	Dec '06	WDC
H	Liase with Transit about key routes in the district and establish contacts for good co-operation after an earthquake. In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify, prioritise and manage immediate clearing and repairs. This is particularly important in South Westland where SH 6 is such a pivotal lifeline.	Dec '06	WDC & Transit
H	Annually update database in emergency plans of owners and operators of earthmoving resources that could be used in a major disaster for road and bridge repair.	Completed	WDC

1. H = High Priority; M= Medium Priority; L = Low Priority

Table 6.4: Improvement Schedule –Transport (Continued)

Importance[1]	Action	Completion date	Responsible
M	In conjunction with the other West Coast Councils, Tasman District Council, and Transit screen SH 6 between the West Coast and Nelson and SH 7 over the Lewis Pass for specific vulnerabilities and prioritise works that might reduce its risk to earthquake damage. It is noted that OPUS undertakes work in this area on an ongoing basis.	Dec '10	WCRC,BDC GDC, WDC & Transit
L	Recommend that WDC prepare a route hazard map to identify which roads may become damaged or impassable. Hazards should include slips on cuttings and embankments, landslide and rockfall potential, potential liquefaction areas and areas within those where lateral spreading of the road is possible. WDC has some concern that it will be difficult to predict these hazards to this level of detail.	Dec '12	WDC
L	Establish a database for major cuttings and embankments within the Westland District so that a programme of progressive upgrading and improvements can be established and periodic inspections can be formalised.	Dec '10	WDC
	WDC Bridges		
H	Recommend that all bridges on critical routes or carrying other services be structurally audited for seismic robustness and behaviour followed by a progressive survey of remaining significant structures from most to least important.	Dec '07	WDC
H	A plan should be prepared based upon the above audit to progressively upgrade weak bridging over a reasonable but achievable period of time.	Dec '07	WDC
	Railway		
L	Assess in more detail the likely time required to restore rail access to Canterbury.	Dec '15	ONTRACK

1. H = High Priority; M= Medium Priority; L = Low Priority

7 WATER SUPPLY

7.1 Introduction

Water supplies are provided in Westland District Council through community water supplies and rainwater storage at individual dwellings. The list of the supplies managed by WDC including some relevant data is presented in Table 7.1.

Table 7.1: WDC Managed Water Supplies

System	Popn Served (people)	Source Gravity/pumped	Treatment	Storage (m^3)	Dominant pipe materials[1]
Kumara	300	Spring, pelton wheel powered pump to reservoir, Gravity to distribution	None	250 elevated	PE 37% PVC 32% AC 24%
Arahura	85	Ground water, Bore pump to reservoir, Gravity to distribution	None	60 elevated	AC PVC
Hokitika including Kaniere	3,700	Lake Kaniere Mostly gravity to main reservoir Gravity & pumped to distribution	Chlorine	5,620 elevated	PVC 35% AC 35% PE 15%
Ross	409	Minahan & Jones Creeks Gravity supply	None	270 elevated	PVC 82%
Harihari	506	Harold Creek Gravity supply	None	250 elevated	PVC 72%
Whataroa	230	Whataroa flat bore Pumped	UV & lime	150 ground	PVC 67%
Franz Josef	300 to 1,500	Callery Creek Gravity to treatment. Pumped to reservoir Gravity to distribution	Filter + chlorine	600 elevated	PVC 64% AC 24%
Fox	235 to 800	Creek Gravity to treatment. Pumped to reservoir Gravity to distribution	Filter + chlorine	450 elevated	PVC 38% AC 20%
Haast	80 to 820	Haast River bore Pump to reservoir Gravity to distribution	None	200 elevated	PVC 89%
Hannah's Clearing	80 to ??	Haast Jackson Bay Rd Bore Pumped	Filtration Fe removal	None	PE 85%

1. PE = Polyethylene, PVC = Poly vinylchloride, AC = Asbestos Cement

Ten other community water supplies in the District not operated by WDC are listed below:

- Franz Josef Motor Camp
- Lake Moeraki Wilderness Lodge
- South Westland Area School
- Lake Kaniere Motor Camp
- Haast School
- Kokatahi School
- Jacob's River School
- Okarito
- Otira
- Rautapu

7.2 Level of Service – Water Supply

The minimum target levels of service to be provided to communities after the Alpine Fault earthquake are presented in Table 7.2.

Table 7.2: Levels of Service – Piped Community Water Supplies

Service Description	Target period for Achieving Level of Service Community Category (Refer Section 5.3)			
	1	2	3	4
Emergency Level of Service One standpipe in community per 100 people supplying 60L/person/day. The water may not be treated. Fire fighting capacity may not be available.	3 weeks	2 weeks	1 weeks	4 days
Interim Level of Service Emergency level of service continued to residential areas. Reticulated supply to selected facilities supplying 200L/person/day.[1] The water may not be treated. Fire fighting capacity may not be available.	-	3 weeks	2 weeks	1 weeks
Normal Level of service	6 months	6 months	4 months	3 months

1. Selected facilities may include regional and district emergency facilities include CDEM centres, hospitals & medical centres, police stations, CD sector posts, essential businesses and industry and government offices (existing or established after the emergency) meeting needs arising from the disaster. Essential business and industry should be determined before the earthquake.

It is important that key facilities such as CD centres and CBD areas, out of which support agencies, food and building material distribution centres etc will operate, are given higher priority than residential and rural areas as the key facilities will be providing services to the community at large.

WDC will be directly responsible for Council owned water supplies and will provide assistance to reinstate other community water supplies as required.

It is expected that after the earthquake reinstatement of individual point source supplies such as wells and rainwater tank systems will be undertaken by the owner with assistance as required.

The target periods for achieving these levels of service apply to communities that are not evacuated. The target periods are measured from the time of the Alpine Fault earthquake occurring.

7.3 Strategy – Water Supply

The success of the proposed emergency and interim levels of service for piped water supplies and return to normal supply will depend on the following measures being in place before the Alpine Fault earthquake event occurs:

- Strengthening of intake infrastructures so that water supply sources can function again as quickly as possible after the earthquake;
- Identifying and upgrading where necessary key mains between the water sources and/or water storage sites and strategically located community standpipes, important industry and business, and Civil Defence posts and other emergency facilities. It is important that the key mains suffer minimal damage during the earthquake. It should be noted that key mains might not necessarily be primary trunk mains. Where key mains are not primary trunk mains it is not essential to size the key main to primary trunk main capacity as emergency flows are likely to be significantly less than primary main flows;
- Installing burst control valves on reservoirs to prevent water loss from the reservoirs after the earthquake. The burst control valves will be activated during the earthquake;
- Where supplies are dependent on pumps, establishing reliable alternative power sources at individual water supplies where necessary with adequate fuel supply;
- Establishing alternative options for fire fighting;
- Establishing a formal response plan that identifies;
    - Those responsible for key tasks. The plan will need to take into account the need for flexibility given that some personnel might not be available following the earthquake. Almost certainly the actual situation will not match the planned or theoretical expectation;
    - Backup plans;
    - Methodology for assessing damage and prioritising of repairs;
    - The location of as-built drawings, backup copies and updating requirements; and
    - Training requirements.
- Ensuring adequate spare parts are in stock to allow repairs to key water supply assets e.g. key mains, to be undertaken after the earthquake to ensure the emergency and interim supplies function effectively. Given the large distances between supplies and the likely difficult access after the

earthquake consideration should be given to a store of spare parts at each water supply location and suitably qualified people to make repairs;

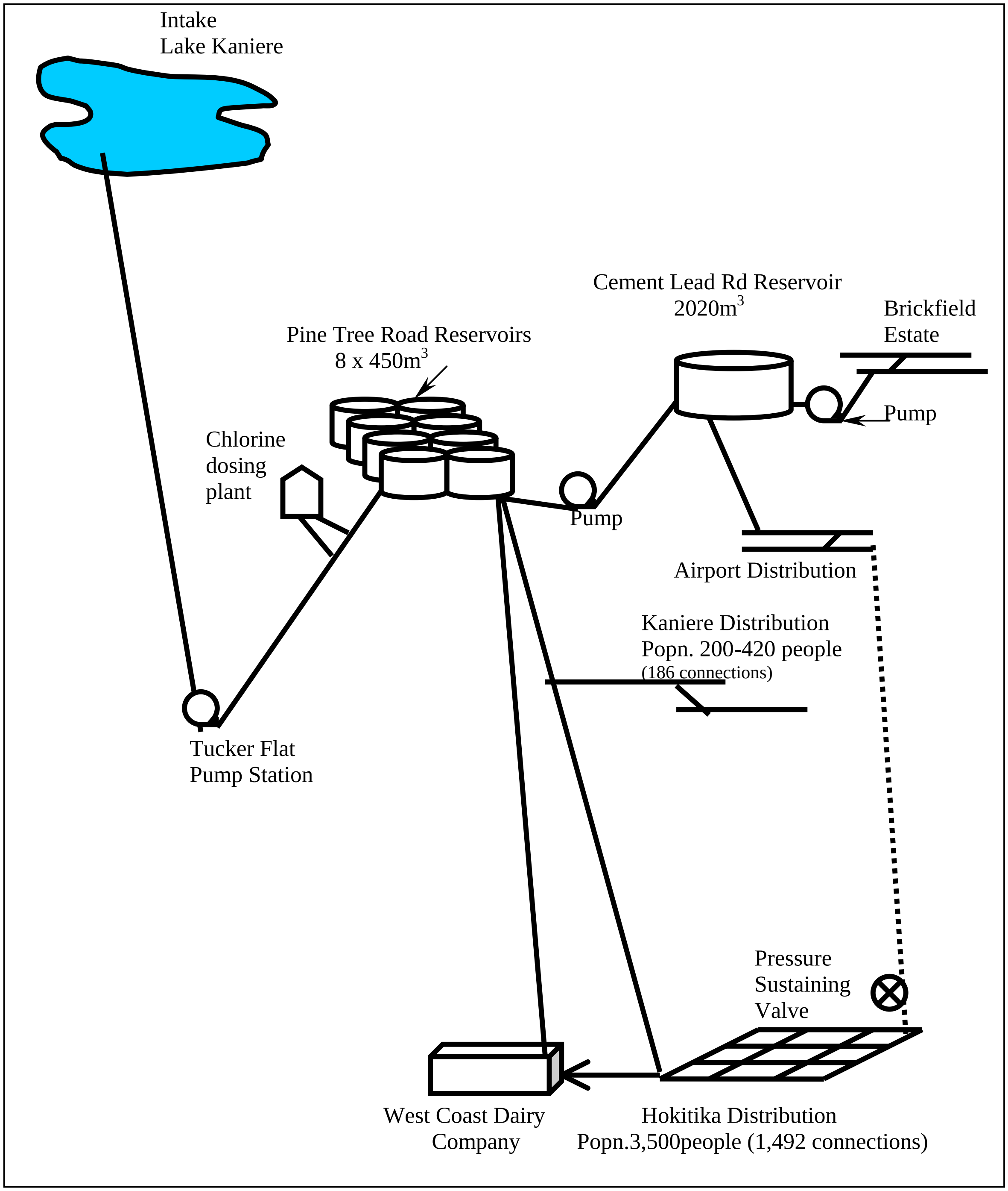
- Ensuring operation manuals are located on site at all supplies; and
- Reviewing all water supply pump stations and treatment plants to ensure all equipment and plant is adequately secured against movement in the event of an earthquake.

This report considers the Hokitika water supply in detail. Vulnerabilities of the supply in the face of an earthquake and the proposed service level requirements are examined. Upgrades and improvements are identified to address the vulnerabilities. No further details are provided for the remaining water supplies in Westland District.

7.4 Hokitika Water Supply

7.4.1 Description

Figure 7.1: Hokitika Water Supply



The Hokitika water supply is shown in Figure 7.1 and is described as follows:

- An intake pipe extends into Lake Kaniere and is located approximately 10m metres below normal lake level;
- Water flows under gravity from the lake to the Pine Tree Road reservoir site. When the lake level is low the supply capacity is increased using the pumps at the Tuckers flat pump station;
- The water from the lake is chlorinated before it enters the reservoirs at Pine Tree Road;
- Water from the Pine Tree Road reservoirs is distributed as follows:
    - Water flows under gravity via a 200mm steel pipe to the West Coast Dairy Factory;
    - Water flows via a 250mm main asbestos cement under gravity to the Kaniere distribution and the Hokitika distribution. Excess water from the Hokitika distribution can also be supplied to the West Coast Dairy Factory; and
    - Water is pumped to the Cement Lead Road Reservoir.
- Water from the Cement Lead Road Reservoir is distributed as follows:
    - Water is pumped to the Brickfield estate, and
    - Water flows under gravity to the airport distribution. Water can also flow from the airport distribution via a pressure-sustaining valve to the Hokitika distribution as demand from the Hokitika distribution dictates.

The Hokitika water supply is essentially a gravity supply. Because of the large reservoir storage capacity at two strategic sites, water supply can be maintained to much of distribution (except the Brickfield Estate) without the need for electricity to pump water.

The composition of the Hokitika transmission and distribution systems is presented in Table 7.3.

Table 7.3: Composition of Pipes in the Hokitika Water Supply

Location	Pipe Material	Length	Percentage
Transmission	Asbestos	2,000	14%
	PVC	12,000	86%
Total Transmission		**14,000**	**100%**
Reticulation	Asbestos	12,484	35%
	Cast Iron	2,580	7%
	Polyethylene	5,277	15%
	PVC	12,477	35%
	Unknown	2,912	8%
Total Reticulation		**35,730**	**100%**

For the purposes of this document the transmission is defined as the pipeline from the intake to the Pine Tree Road reservoirs. The remainder of the pipe is considered to be reticulation.

According to the Council's current draft Activity Management Plans, approximately 13% of the reticulation network is considered to be in poor condition; the remainder of the reticulation is considered to be in moderate condition or better.

7.4.2 Vulnerabilities – Hokitika Water Supply

In the event of the major Alpine Fault earthquake described in Part II it is expected that Hokitika will experience strong intensity MM VIII shaking. The area between approximately Pine Tree Road and the Alpine Fault trace at the eastern end of Lake Kaniere will experience even stronger intensity MM IX shaking. The shaking will induce damage to the water supply system.

Much of Hokitika is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. Some liquefaction can be expected in the area bounded approximately by Revill Street, Tudor Street and Fitzherbert Street. The soils are firmer in the area north of approximately Stafford Street and east of Fitzherbert Street and structures this area are likely to sustain less damage than in other parts of Hokitka (refer Figure 2.6).

There is a risk that the Hokitika water supply may fail partially or totally due to the following:

- Transmission pipeline failure. Damage is likely to the transmission line between the intake and the Pine Tree Road reservoirs with breaks likely in weak sections and at bridge abutments;

Table 7.4: Estimate of Likely Transmission Pipe Joint Failure

Pipe Material	Length (m)	Projection of joint failure	
		Optimistic	Pessimistic
Asbestos	2,000	5%	10%
PVC	12,000	1%	2%
Total	**14,000**	**1.6%**	**3.1%**

From Table 7.4 it can be seen that up to 10% of asbestos cement pipe joints (33 joints) and up to 2% of PVC pipe joints (40 joints) may fail;

- Failure at the reservoirs. There are no automatic burst control valves on the pipelines from the reservoir sites or between reservoirs to prevent the reservoirs draining due to pipe and reservoir failures caused by the earthquake. Pipe connections between the reservoirs are thought to be rigid and damage at the reservoir entries is probable;
- Failure of the reticulation network. Approximately 15% of Hokitika is located on soils that are potentially liquefiable in the Alpine Fault earthquake and a further 30% of Hokitika is located on soils where settlement may occur as a result of siesmic shaking. Assuming even distribution of the pipe types and based on the damage assessment charts in Appendix A, projections of entry and junction failures have been calculated and presented in Table 7.5.

Table 7.5: Estimate of Likely Reticulation Pipe Failure[1]

Pipe Material	Length (m)	Projection of entry and junction failure (m)	
		Optimistic	Pessimistic
Asbestos	12,484	4,307 (35%)	5,992 (48%)
Cast Iron	2,580	316 (12%)	955 (37%)
Polyethylene	5,277	0 (0%)	0 (0%)
PVC	12,477	1,528 (12%)	3,494 (28%)
Unknown	2,912	357 (12%)	1,077 (37%)
Total	**35,730**	**6,508 (18%)**	**11,518 (32%)**

1. The data in this table is drawn from the draft WDC Water Supply Activity Management Plan (July 2005). The draft plan indicates there is 2,580m of Cast Iron pipe and no steel pipe. It is also noted that maps produced from the Council's GMS system indicate there is little or no cast iron pipe and at least 2,400m of steel pipe.

From Table 7.5 it can be seen that between 18% to 32% of entries and junctions are expected to fail in the reticulation network.

There are three mains that can supply Hokitika township. Two of the mains are from the Pine Tree Road reservoirs; one to the dairy factory via Hau Hau Road and the other to the Hokitika reticulation via Pine Tree Road, Kaniere Road and Hampden Street. The remaining supply main is from the Cement Lead Road reservoirs to Bonar Drive via Hokitika airport. Although the three mains provide some redundancy, two of the mains are made up to some extent of asbestos cement (AC) pipe that is likely to be vulnerable in an earthquake.

The AC pipeline via Pine Tree Road and Kaniere Road is vulnerable as the line passes through ground with a Zone 1 classification – some settlement expected under seismic shaking. The acidic water conditions on both sides of the pipe are likely to have reduced the strength of the AC making it more vulnerable to failure in an earthquake.

The condition of the 200mm diameter AC pipeline from the Cement Lead Road reservoirs to Pine Tree Road is not known. However, because it is AC pipe it is more vulnerable to failure than some other pipe materials.

The 150mm diameter AC pipeline from the airport to Whitcombe Terrace, Bonar Drive and on to Tudor Street is in poor condition. Although the ground conditions are classified as Zone 2 (ground settlement unlikely) joint failure is expected because of the poor condition of the pipe.

- Three pipelines connect the reticulation network on either side of the railway line; a 150mm AC pipe on Tudor Street, a 200mm Steel pipe on Hampden Street and a 100mm PVC pipe on Gibson Quay. All three of these pipelines lie in ground with Zone 1A classification. There is likely to be

50% to 70% junction failure due to liquefaction and it is likely that the supply to the Hokitika community west of the railway line may be lost;

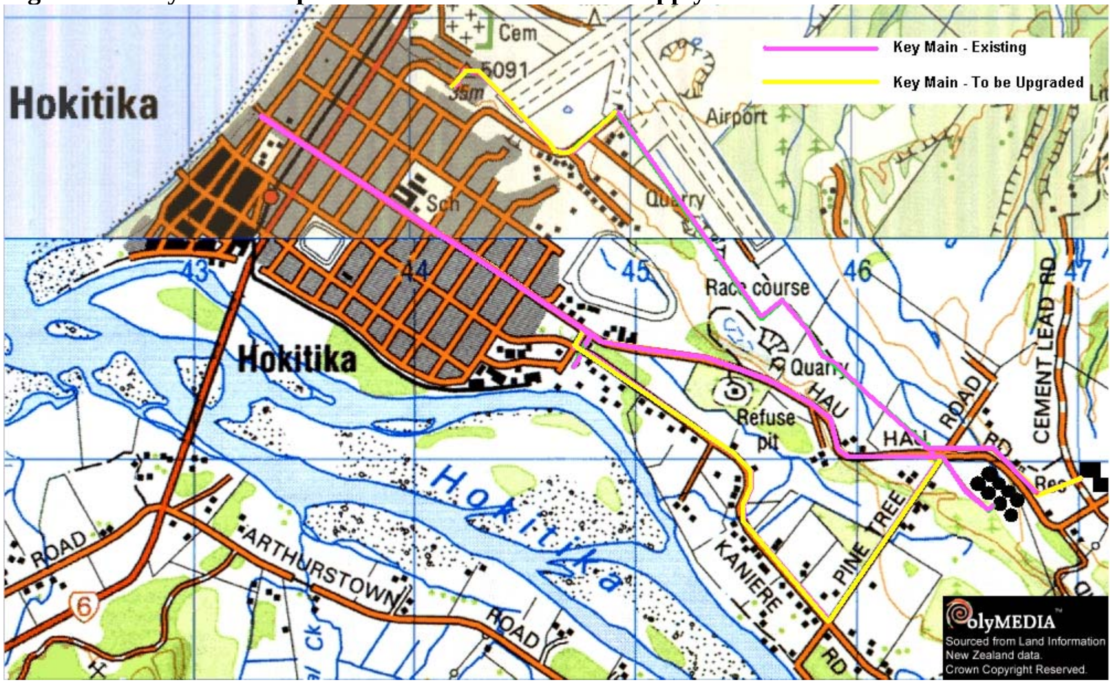
- The water supply may not be able to be used to fight fires due to damage to and leakage from the reticulation network;
- Insufficient spare parts in stock to repair wide spread damage of pipelines; and
- Potential for damage due to inadequately restrained equipment at the pump stations or at the treatment plant (chlorine dosing).

7.4.3 Upgrades & Improvements – Hokitika Water Supply

To address the vulnerabilities identified in the previous section the following improvements are proposed:

- The remaining sections of AC pipe on the transmission main should be replaced with a more earthquake resistant pipe material;
- Pipe work attached to reservoirs at Pine Tree Road and Cement Lead Road should be assessed and where necessary (and where possible) modified to reduce the likelihood that pipe joints will fail at the connection to the tank. The reservoirs at both locations should be assessed to determine the most appropriate locations to install burst control valves;
- Improve the security of supply from the reservoirs to Hokitika and Kaniere by replacing the sections of AC pipe in the key mains (shown in yellow in Figure 7.2) with pipe materials that are more earthquake resistant;
- Define a list of essential businesses and industry that require a water supply as a priority and strengthen pipe networks to these businesses and industries;
- Review the risk of loosing supply to the Hokitika community west of Fitzherbert Street due to failure of one of the three pipelines supplying this area;
- Review spare part requirements and available stock. Spare parts should include a stock of materials for stand pipes or standpipes that are already made up;
- Review restraint of equipment at pump stations and the treatment plant.

Figure 7.2: Key Mains Replacement – Hokitika Water Supply



After the above improvements have been implemented it is anticipated that the recovery of the Hokitika water supply after the Alpine Fault earthquake will take place as follows:

- Power to pumps and treatment plant fails at time zero; the time of the earthquake;
- There are some minor failures of the transmission line and key mains in the distribution however they remain largely intact;
- The reservoir burst control valves are actuated and prevent water from flowing from the reservoirs;
- The water supply service staff manually shut down branch lines from the key mains as well as valves on the key mains. The reservoir burst control valves are opened and valves on the key main re-opened in stages assessing for leaks at each stage. Where leakage remains unacceptably on a key main it is shut down in favour of using one of the other key mains;
- Once one or all of the key mains are fully pressurised again standpipes can be set up probably at fire hydrants;
- Where fires have broken out every effort can be made to direct flow to the fires by opening branch valves from the key mains. It is possible that there will be substantial leaks in the branch lines and water may not reach the area of the fire with sufficient pressure.
- The combined storage capacity at the two reservoir sites is 5,620m^3; Pine Tree Road site 3,600m^3 and Cement Lead Road site 2,020m^3. These reservoirs can provide about 33 hours of stored water at present average demand; the average demand for 2004/05 was 4,100m^3/day. Assuming that 25% of the 5,620m^3 is lost due to leakage and fire fighting this leaves 4,215 m^3 for consumption.

There is unlikely to be demand for water from the West Coast Dairy Factory for some days following the earthquake because of damage to the factory and because of damaged roads and dairy farms and no electrical power supply prevent the supply of milk to the factory.

The demand on the water supply is thus likely to be around 60 lcd (litres per capita per day) and assuming a population of say 6,000 people the combined reservoir storage could provide water for more than 11 days. The water may however be untreated.

- In these 11 days the transmission line from Lake Kaniere will be checked, repaired and put in operation again.
- Pipe work to essential business and industry will be repaired and a normal water supply re-established to them within two weeks. The water may still be untreated.
- Repair and reinstate treatment.
- Water supply will be progressively reinstated to all of Hokitika. Sections of pipe will be assessed for damage and where damage is considered to be extensive the whole main will be replaced rather than undertaking a repair.

7.5 Water Supply Improvement Schedule

A summary of improvements is presented in Table 7.6.

Table 7.6: Improvement Schedule – Water Supply

Importance[1]	Action	Completed by	Responsible
	General		
H	Establish a formal response plan that identifies those responsible for key tasks, backup plans and training requirements. It may be important to identify local people at the smaller supplies especially the remote supplies that can undertake repairs. The plan should identify the location of as-built drawings as well as backup copies of the drawings. The response plan should provide a methodology for assessing damage and prioritising repairs.	Dec '07	WDC
H	Review options for multi-tap standpipes and assess the number required for each water supply. Fabricate adequate multi-tap standpipes for all supplies and identify where the standpipes are to be stored.	Dec '07	WDC
H	Define remaining high fire risk/high value areas and identify appropriate secondary fire fighting options.	Dec '06	NZ Fire Service
M	Review the proposed levels of service after an earthquake and strategies to ensure the levels of service are appropriate and achievable.	Dec '08	WDC/CD EM
M	Assess the remaining piped water supplies in the District including non-WDC supplies and document as for Hokitika in this plan.	Dec '08	WDC
M	Investigate strategies for supporting these supplies for various earthquake scenarios.	Dec '08	WDC
	Hokitika		
H	Review spare part requirements	Dec '06	WDC
H	Review restraint of equipment at pump stations and the treatment plant	Dec '06	WDC
M	Replace the remaining sections of AC pipe on the transmission main	Dec '09	WDC
M	Assess and modify where appropriate the pipe work at the Pine Tree Road and Cement Lead Road reservoirs. Install burst control valves at the reservoirs	Dec '08	WDC
M	Replace the 200mm diameter AC pipeline from the Cement Lead Road reservoirs to Pine Tree Road	Dec '09	WDC
M	Define essential businesses and industry and strengthen pipe networks to them.	Dec '12	WDC
L	Replace the 150mm diameter AC pipeline from the airport to Whitcombe Terrace, Bonar Drive and on to Tudor Street	Dec '12	WDC
L	Progressively replace the 250mm diameter AC pipeline with a more earthquake resistant material from the Pine Tree Road reservoirs via Pine Tree Road and Kaniere Road to the Dairy factory.	Dec '13	WDC
L	Review the risk of loosing supply to the Hokitika community west of Fitzherbert Street due to failure of one of the three pipelines supplying this area	Dec '13	WDC

1. H = High Priority; M= Medium Priority; L = Low Priority

8 SEWERAGE

Westland District Council manages 4 sewerage schemes:

- Hokitika (including Kaneire)
- Franz Josef
- Fox Glacier
- Haast

Other privately run community sewerage schemes were not documented at the time of the preparation of this report.

8.1 Level of Service – Sewerage Schemes

The minimum target levels of service to be provided to communities after the Alpine Fault earthquake are presented in Table 8.1.

Table 8.1: Levels of Service – Community Sewerage Schemes

Service Description	**Target period for Achieving Level of Service**			
	Community Category (Refer Section 5.3)			
	1	**2**	**3**	**4**
Emergency Level of Service CD centres, residential & rural areas – individual pit latrine[1] CBD areas – no service Surcharge areas will be discharged to natural waterways and the areas sanitised.	4 days	4 days	4 days	4 days
Interim Level of Service Residential & rural areas – e.g. individual pit latrine CD centres & CBD areas – normal service Surcharge areas will be discharged to natural waterways and the areas sanitised.	-	-	-	2 weeks
Normal Level of service	12 months	12 months	8 months	6 months

1. Some residents can continue using their septic tank where it has not failed

It is important that key facilities such as CD centres and CBD areas, out of which support agencies, food and building material distribution centres etc will operate, are given higher priority than residential and rural areas as the key facilities will be providing services to the community at large.

The target periods for achieving these levels of service apply to communities that are not evacuated. The target periods are measured from the time of the Alpine Fault earthquake occurring.

8.2 Strategy – Sewerage

The strategy for achieving effective recovery of sewerage schemes after the earthquake is as follows:

Pre-earthquake

- Establishing a formal response plan that identifies;
    - Those responsible for key tasks. The plan will need to take into account the need for flexibility given that some personnel may not be available following the earthquake. Almost certainly the actual situation will not match the planned or theoretical expectation;
    - Backup plans,
    - Adequate provisions are in place to sanitise areas contaminated by sewage overflows e.g. quicklime for household spills;
    - Methodology for assessing damage and prioritising of repairs;
    - The location of as-built drawings, backup copies and updating requirements, and
    - Training requirements.
- Ensuring adequate spare parts are in stock to allow repairs to sewerage assets e.g. sewers from key facilities such as CD centres & CBD areas, to be undertaken after the earthquake;
- Discharge requirements of major waste water contributors will be assessed and any necessary provisions put in place to manage identified problems with sewage flows immediately after the Alpine Fault earthquake;
- Surcharge areas will be identified and likely public health risk assessed. Appropriate emergency discharge arrangements will be identified and implemented as required;
- Sewerage asset replacement will continue to follow normal asset replacement principles. However, where sewer pipe replacement is planned priority should be given to replacement immediately upstream of discharge points. This will reduce the risk of surcharging at locations where new pipe work resistant to earthquake failure meets older rigid downstream pipes that fail completely in the earthquake; and
- New sewerage scheme structures will be adequately designed for earthquake loads.

Post-earthquake

- It is assumed house occupiers will dig their own pit latrines for use following the earthquake. Where they are unable to do so neighbours and friends will assist with support from Council as resources allow e.g. Council may arrange to supply of quicklime to reduce public health risk;

- It is unlikely that CBD businesses, hotels etc will be able to set up emergency toilet facilities such as pit latrines. It is unlikely that these places can function until an interim level of service can be established;
- During the interim level of service in areas where offices are established to assist in the recovery effort (EQC and other insurance assessors, WINZ and other financial assistance organisations, distribution/logistics centres), sewers will be made operable. This may involve some repairs to allow sewage to drain away and co-ordinated with the re-establishment of water supply. Sewage will be discharged to natural waterways. No attempt will be made to treat the sewage;
- Repair and replacement of sewerage schemes components after achieving the interim level of service will be based on assessment of the assets e.g. CCTV inspection of pipes. Lateral failures are known to have been an issue at other earthquake locations (Edgecumbe) and will require assessment if inflow and infiltration (I/I)[5] flows are to be kept at a manageable level; and
- WDC will be responsible for Council owned schemes. Council will provide support to owners of individual sewage schemes e.g. septic tank systems, as required and as resources become available.

In the following sections a detailed description is provided of the Hokitika sewerage scheme, its vulnerabilities in the face of a major earthquake and upgrades and improvements that can be made to address the vulnerabilities. No further details are provided for the remaining sewerage schemes in Westland District.

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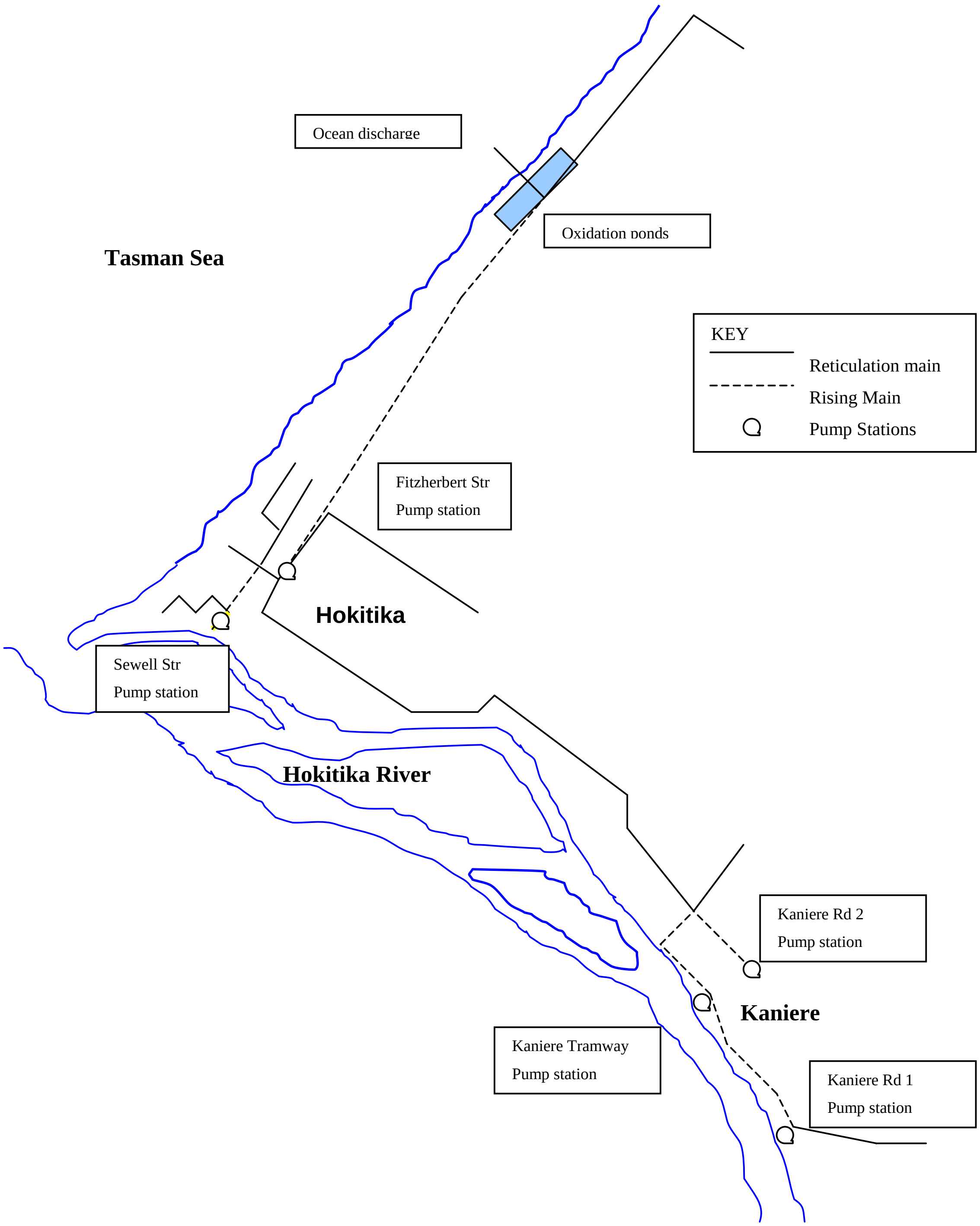
[5] Inflow and infiltration. Inflow is the flow of rainwater from the surface directly into the sewer either through illegal connections or breaks in the pipe. Infiltration occurs where there are breaks in a sewer and ground water can flow into the sewer. Both inflow and infiltration increase the flow in the sewer reducing the capacity of the sewer to carry sewage.

8.2.1 *Description*

Figure 8.1: Hokitika Sewerage Scheme



The Hokitika sewerage scheme is shown in Figure 8.1 and can be described as follows:

- The Hokitika sewerage scheme collects sewerage from Hokitika and Kaniere.
- The Hokitika reticulation is made up of four subsystems:
    - South Kaniere: The south Kaniere reticulation collects sewage from the area south eastern of Kaniere Road and discharges it to Kaniere Road No. 1 Pump station;
    - Kaniere Tramway: Sewage from the Kaniere Road No. 1 Pump station and from Dents Road are discharged to the Kaniere Tramway pump station;
    - Kaniere Road: Sewage from a small catchment on Kaniere Road discharges to the Kaniere Road No. 2 Pump station; and
    - South West Hokitika: Sewage from a small low lying catchment at the south western end of Hokitika between Beach Street and Fitzherbert Street discharges to the Sewell Street pump station.
- Sewage from the Kaniere Tramway pump station and the Kaniere Road No. 2 pump station discharge via rising mains into the Hokitika sewer network. Sewage from the Sewell Street pump station and the remainder of Hokitika sewer discharge to the Fitzherbert Street pump station.
- All sewage discharged to the Fitzherbert Street pump station is pumped via a rising main to two oxidation ponds;
- There is also a small catchment to the north of the oxidation ponds; West Drive sub division. Sewage from West Drive sub division flows under gravity to the oxidation ponds;
- The combined sewage flow is discharged towards the centre of the ponds via a discharge pipe supported above the pond water surface; and
- The sewage is treated in the oxidation ponds before discharging under gravity to the ocean outfall. The outfall is support above the sea on columns.

The composition of the pipe network in Hokitika sewerage scheme is presented in Table 8.2.

Table 8.2: Composition of Pipes in the Hokitika Sewerage Scheme

Pipe Material	Length	Percentage
Asbestos	16,700	47%
Concrete	3,600	10%
Polyethylene	1,000	3%
PVC	7,000	19%
Unknown	7,700	21%
Total Reticulation	**36,000**	**100%**

According to the Council's current draft Activity Management Plans, 95% of the reticulation network is considered to be in very good condition; the remainder of the reticulation is considered to be in good condition.

8.2.2 Vulnerabilities – Hokitika Sewerage Scheme

In the event of the major Alpine Fault earthquake described in Part II it is expected that Hokitika will experience strong intensity MM VIII shaking. Much of Hokitika is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. Liquefaction can be expected in the area bounded approximately by Revill Street, Tudor Street and Fitzherbert Street. The soils are firmer in the area of Hokitika north of approximately Stafford Street and east of Fitzherbert Street and structures in this area are likely to sustain less damage than in other parts of Hokitka (refer Figure 2.6).

There is a risk that the Hokitika sewerage scheme may fail because of the following:

- Reticulation pipeline failure. Projections of likely damage to the reticulation network is presented Table 8.3;

Table 8.3: Estimate of Reticulation Entry & Junction Failure – Hokitika Sewerage

Pipe Material	Length (m)	Projection of entry and junction failure	
		Optimistic	Pessimistic
Asbestos	16,700	34%	48%
Concrete	3,600	12%	37%
Polyethylene	1,000	0%	0%
PVC	7,000	12%	28%
Unknown	7,700	12%	37%
Total	**36,000**	**22%**	**39%**

From Table 8.3 it can be seen that between 22% to nearly 40% of the entries and junctions may fail in the sewerage reticulation network. Likely failures also include pipe joints and connections to the 469 manholes and five pump stations.

- It is almost certain that the power supply will fail there will be no power to the five pump stations;
- Manholes and pump stations structures are likely to move particularly structures that are empty in saturated soils and that have not been designed for earthquake lifting forces. This movement is likely to cause pipes to fail at entries and exists, especially where joints are rigid. This may allow soil material to be washed into the pipes and structures when pumps are started again;
- Damage is likely at the oxidation ponds including cracking of the wave band, failure of the aerial discharge pipes into the ponds and lateral spreading of the embankment walls, particularly the north-east end embankment; and
- Damage and possible partial collapse of the aerial ocean outfall.

After the earthquake flow to the sewer and to the pump stations will be influenced by the following:

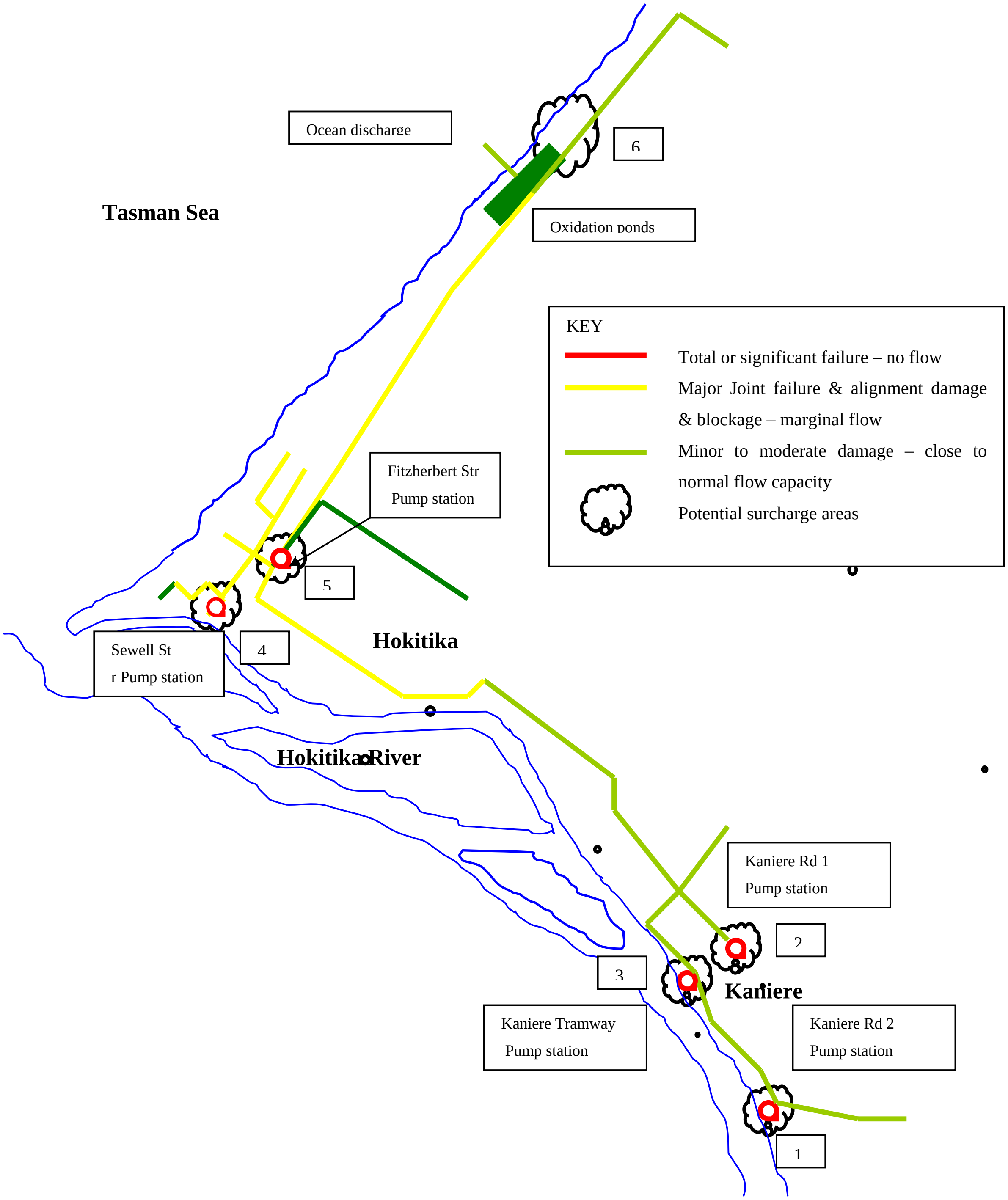
- Flow from domestic sources will continue for a short while but will essentially cease once flow from the water supply fails.
- Where sewers are located below the water table and joint failure occurs infiltration to the sewer is likely to increase. Joint failure is especially likely at service connections.
- Flow in the sewers will continue although where serious pipe or joint failure occurs that results in blocking of the pipe some surcharging is likely at nearby manholes in low areas.

An assessment of failure of scheme components and resultant surcharging of sewage (6 locations) are presented in Figure 8.2 and described as follows:

- Surcharging at surcharge location Nos. 1 to 3 is likely to be minor. The pump stations will fail due to loss of power, sewage from the relatively small catchments is likely to continue to flow to the pump stations and the pump stations will surcharge. Surcharging will be more extensive if there is a large I/I flow component. However, the I/I flow should be relatively uncontaminated and as long as the surcharge water does not pond the I/I flow will assist to carry the sewage away. At surcharge location Nos. 1 and 3 surcharge water will drain to the Hokitika River while at location No.2 it will flow to Shanandoah Creek, which drains to the Hokitika River;
- Surcharging location No. 4 at Sewell Street pump station is also likely to be minor on pump failure because the catchment is relatively small. However, at Sewell Street there may be an issue with ponding. This is discussed in more detail in Section 9.
- Surcharge location No. 5 at the Fitzherbert Street pump station is likely to be more serious. The catchment is larger so the flow to the pump station is likely to be larger and for a longer period. On pump failure sewage is likely to surcharge on to the street and drain to the storm water system. The storm water system drains to the Hokitika River via a storm water pump at Bealey Street. If heavy rainfall occurs during or after the earthquake event ponding of storm water contaminated with sewage may occur. Storm water management is discussed in Section 9.
- Surcharge location No. 6 at the oxidation ponds will result if the north-east embankment fails. The sewage will flow over open pasture and what doesn't soak into the ground will flow to Houhou Creek.

Although the aerial outfall is likely to collapse the impact is unlikely to be significant. Effluent in the ponds will continue to flow to the break in the outfall and onto the beach sand where it will soak in or reach the sea. As there will be little or no sewage reaching the ponds the outfall flow will cease when the ponds are empty.

Figure 8.2: Assessment of Hokitika Sewerage Scheme Failure and Surcharging



8.2.3 Upgrades & Improvements – Hokitika Sewerage

The following improvements are proposed to address the vulnerabilities identified in the previous section:

- Undertake an assessment of public health risk posed by sewage surcharges at Sewell Street and Fitzherbert Street pump stations particularly if the surcharges combine with storm water (refer Section 9.2.2). Depending on the outcome of the assessment consideration may be given to a standby generator to discharge the effluent into the Hokitika River; and
- Undertake a geotechnical and structural assessment of all pump stations, the oxidation pond and the ocean outfall to confirm and quantify earthquake risks at each site and make recommendations on improvements to address these risks.

With the above improvements in place it is anticipated that recovery of the Hokitika sewerage scheme will proceed as follows after the Alpine Fault earthquake;

- Power to the sewage pump stations will fail shortly after the earthquake;
- Surcharging will occur at the six locations identified in Figure 8.2. Those in Kaniere and at the oxidation pond will discharge away to nearby waterways;
- Surcharging from the Sewell Street and Fitzherbert Street pump stations will discharge to the Hokitika River via the storm water system. Provisions will be in place e.g. portable storm water pumps or a standby generator, to drain any areas that are likely to pond;
- Some failures are expected in the sewer reticulation network particularly in older pipes in soils where liquefaction is more likely. Workmen will check the network for surcharging caused by sewer failures and ensure that they are discharged safely;
- The community will be notified not to use their WCs or discharge any other wastewater to the sewerage scheme. The community will be informed on setting up emergency toilet facilities e.g. pit latrines at CD centres and at their own homes;
- The sewer servicing offices/buildings established to assist in the recovery effort will be made operable within 2 weeks undertaking repairs where necessary. Sewage collected will be discharged to the Hokitika River;
- The sewerage pipe network will be progressively assessed using techniques such as CCTV assessment and contracts let to repair the scheme. Where repair is uneconomical, sewers will be replaced. The highest priority pipeline is likely to be the rising main from Fitzherbert Street to the oxidation pond followed by other trunk gravity and rising mains. Stocks of disinfection chemicals will be maintained for households pit latrines, and also for use following ponding or repair work.

8.3 Sewerage Scheme Improvement Schedule

Improvements identified in Section 1 are summarised in Table 8.4.

Table 8.4: Improvement Schedule - Sewerage

Improvement[1]	Action	Completed by	Responsible
	General		
H	Establish a formal response plan for sewage disposal after an Alpine Fault earthquake including: • Key tasks and those responsible for them. The plan should be flexible enough so that if some key personnel are not available the plan is still robust; • Backup plans; • Methodology for assessing damage and prioritising and managing repairs; • The location of as-built drawings, backup copies and updating requirements, and • Training requirements.	Dec '07	WDC/CD EM
H	Ensuring adequate spare parts are in stock to allow repairs to sewerage assets e.g. sewers from CD centres & CBD areas to be undertaken after the earthquake and means for disinfecting areas polluted by sewage.	Dec '06	WDC
M	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	Dec '08	WDC/CD EM
M	Assess the remaining sewerage schemes in the district including non-WDC schemes to determine vulnerabilities and improvements required.	Dec '08	WDC
M	Discharge requirements of major wastewater contributors will be assessed and any necessary provisions put in place to manage identified problems with sewage flows immediately after the Alpine Fault earthquake.	Dec '08	WDC & major wastewater contributors
L	Review planned sewer pipe replacement and give priority to replacement immediately upstream of discharge points.	Dec '10	WDC
	Hokitika		
H	Identify surcharge areas and assess the likely public health risk e.g. Sewell Street and Fitzherbert Street pump station areas. Appropriate emergency discharge arrangements will be identified and implemented as required.	Dec '07	WDC
L	Undertake a geotechnical and structural assessment of all pump stations, the oxidation pond and the ocean outfall to confirm and quantify earthquake risks at each site and make recommendations on improvements to address these risks.	Dec '12	WDC

1. H = High Priority; M= Medium Priority; L = Low Priority

9 STORM WATER

Westland District Council manages 15 separate storm water systems serving populations varying from 80 to 4,060. The nine larger piped systems are as follows:

- Kumara
- Hokitika
- Kaneire
- Ross
- Harihari
- Whataroa
- Franz Josef
- Fox Glacier
- Haast

Another six smaller storm water systems mainly comprise open channels.

9.1 Level of Service – Storm Water Schemes

The minimum target levels of service to be provided to communities after the Alpine Fault earthquake are presented in Table 9.1.

Table 9.1: Levels of Service – Storm Water Schemes

Service Description	**Target period for Achieving Level of Service**			
	Community Category (Refer Section 5.3)			
	1	**2**	**3**	**4**
Emergency Level of Service Surface flood water will be safely managed and disposed of in communities not evacuated	3 days	3 days	3 days	1 days
Normal Level of service	12 months	12 months	8 months	6 months

The implication of the emergency level of service is that although storm water pipe networks and/or pump stations may have failed due to the earthquake there will be adequate emergency provisions in place, or that can be put in place in the target time period, to safely manage and dispose of storm water.

The target periods for achieving these levels of service apply to communities that are not evacuated. The target periods are measured from the time of the Alpine Fault earthquake occurring.

9.2 Strategy – Storm Water

The strategy for achieving effective recovery of storm water systems after the earthquake is as follows:

- In the short term no attempt will be made to repair storm water pipe networks. Prior to the earthquake areas will be identified where flooding is likely to occur particularly where it may hamper access to vital facilities e.g. the police station, CD headquarters or medical centre. Provisions will be in place to safely manage and dispose of surface floodwater;
- Continue replacement of storm water system assets following normal asset management principles; and
- Ensure earthquake loads are adequately addressed in the development of new storm water systems.

In the following sections a description is provided of the Hokitika storm water system, its vulnerabilities in the face of the Alpine Fault earthquake and upgrades and improvements that can be made to address the vulnerabilities. No further details are provided for the remaining storm water in Westland District.

9.2.1 Description – Hokitika Storm Water System

The Hokitika storm water system can be described as follows:

- Although there are a small number pipes on the west side of Hokitika that discharge to the ocean, the majority of storm water in Hokitika flows from north to south under gravity overland or through storm water pipes to the Hokitika River. There are two systems divided approximately by Fitzherbert Street.
- Storm water east of Fitzherbert Street discharges to the Hokitika River via:
    - Twelve gravity outfalls into the Hokitika River ranging in size from 300mm to 750mm diameter
    - A pump station at Bealey Street, which discharges storm water via a 450mm diameter outfall, and
    - Other sundry gravity outfalls smaller than 300mm diameter, which drain relatively minor areas.
- Storm water east of Fitzherbert Street discharges to the Hokitika River via:
    - Two pump stations; one at Tancred Street and one at Sewell Street. Tancred Street pump station pumps storm water into the Hokitika River via a 750mm outfall and Sewell via a 1,050mm outfall;

- A 900mm diameter gravity outfall under the State Highway bridge; and
- Other sundry gravity outfalls smaller than 300mm diameter, which drain relatively minor areas.

The composition of the pipe network in the Hokitika storm water system is presented in Table 9.2.

Table 9.2: Composition of Pipes in the Hokitika Storm Water System

Pipe Material	Length	Percentage
Asbestos	375	1%
Concrete	9,750	26%
Cast Iron	375	1%
Earthenware	1,125	3%
PVC	1,500	4%
Other	3,750	10%
Unknown	20,625	55%
Total Reticulation	**37,500**	**100%**

According to the Council's current draft Activity Management Plans, the majority of the reticulation network is considered to be in good condition.

9.2.2 Vulnerabilities – Hokitika Storm Water System

In the event of the major Alpine Fault earthquake described in Part II it is expected that Hokitika will experience strong intensity MM VIII shaking. Much of Hokitika is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected. Liquefaction can be expected in the area bounded approximately by Revill Street, Tudor Street and Fitzherbert Street. The soils are firmer in the area north of approximately Stafford Street and east of Fitzherbert Street and structures are likely to sustain less damage than in other parts of Hokitka (refer Figure 2.6).

The alignment of pipes, pump stations and manholes is likely to be affected particularly in the area of expected liquefaction. An estimate of the likely percentage failure of pipe entries and junctions is presented in Table 9.3.

Table 9.3: Estimate of Reticulation Entry & Junction Failure – Hokitika Storm Water System

Pipe Material	Length (m)	Projection of entry and junction failure	
		Optimistic	Pessimistic
Asbestos	375	35%	52%
Concrete	9,750	35%	52%
Cast Iron	375	35%	52%
Earthenware	1,125	95%	95%
PVC	1,500	12%	31%
Unknown & other	24,375	22%	67%
Total	**37,500**	**27.6%**	**62.1%**

From Table 9.3 it can be seen that between 28% to 62% of entries and junctions may fail in the storm water system. It is noted that 55% of the pipe materials are unknown, which contributes significantly to the wide range of projected optimistic and pessimistic failures values.

Storm water normally discharges to the Hokitika River under gravity however pump stations are provided to assist with disposal of large volumes of storm water. In the event that there is heavy continuous rain soon after the Alpine Fault earthquake the storm water pump stations are likely to have failed due to loss of power and following will occur:

- ***Bealey Street Pump Station:*** Storm water will pond in the vicinity of the pump station;
- ***Tancred Street Pump Station:*** Storm water will surcharge at the pump station and flow to the Sewell Street pump station; and
- ***Sewell Street Pump Station:*** Storm water will pond in the vicinity of the pump station. Anecdotal information from Council staff suggests the resultant flooding may extend as far as Stafford Street on Sewell Street. This area encompasses the medical centre, police station and the CD Headquarters.

It should also be noted that storm water is likely to be contaminated with sewage because of surcharging at failed sewage pump stations (refer Section 1).

9.2.3 Upgrades & Improvements – Hokitika Storm Water

The following activities are proposed to address the vulnerabilities identified in the previous section:

- Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding where both storm water and sewage pump stations fail (refer Section 8.2.3). Identify and implement appropriate emergency provisions; and

- Undertake a geotechnical and structural assessment of all pump stations to quantify earthquake risks at each site and make recommendations on improvements to address these risks. Implement improvements.

With the above activities completed it is anticipated that recovery of the Hokitika storm water system will proceed as follows after the Alpine Fault earthquake;

- Power to the storm water (and sewage pump stations) will fail shortly after the earthquake;
- Emergency provision will be put in place or be permanently in place to ensure storm water can be safely discharged e.g. temporary diesel powered water pumps or standby generator for the storm water pumps. These will be operated until power is reinstated;
- The storm water pipe network will be progressively assessed using techniques such as CCTV and contracts will be let to repair the system. Where repair is uneconomical, pipelines will be replaced.

9.3 Storm Water System Activity Schedule

Activities identified in Section 9 are summarised in Table 9.4.

Table 9.4: Activity Schedule – Storm Water

Importance[1]	Action	Completed by	Responsible
M	Undertake a geotechnical and structural assessment of all pump stations to quantify earthquake risks at each site and implement improvements to address these risks.	Dec '08	WDC
L	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	Dec'12	WDC/CD EM
L	Establish a formal response plan for storm water disposal after an Alpine Fault earthquake including: • Key tasks and those responsible for them. The plan should be flexible enough so that if some key personnel are not available the plan is still robust; • Backup plans; • Methodology for assessing damage and prioritising of repairs; • The location of as-built drawings, backup copies and updating requirements; and • Training requirements.	Dec '12	WDC/CD EM
L	Review planned storm water pipe replacement and give priority to replacement immediately upstream of discharge points.	Dec '12	WDC
L	Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding. Identify and implement appropriate emergency provisions.	Dec '10	WDC

1. H = High Priority; M= Medium Priority; L = Low Priority

10 OTHER LIFELINES

10.1 Telecommunications

10.1.1 General

(a) Landline and Cellphones

Figure 10.1: Telecom Networks – West Coast

Telecom operates the largest landline system on the West Coast together with a cellular network and support services for other telecommunication companies. The integrity of the Telecom network, both landlines and mobile is managed from a centre in Hamilton. The West Coast area is connected to the national network by three principal core or transport network paths. These are shown in Figure 10.1 and are described as follows:

- Between Greymouth and Nelson: a fibre optic cable routed to Stillwater on the Southern bank of the Grey River and subsequently along the main road of the Grey Valley to Reefton (SH7) thence to Springs Junction over the Rahu Saddle (SH7)and North to Nelson via Murchison (SH65 & SH6);
- Between Greymouth and Christchurch: a fibre optic cable from Christchurch over the Arthur's Pass (SH73), then via Moana and Stillwater progressing down the northern bank of the Grey River and back over the Cobden Bridge into Greymouth;
- Between Westport and Reefton: Digital Microwave Radio to Mt Rochfort, repeatered to Reefton Radio and thence over fibre to the Reefton exchange where the capacity is derived to either Greymouth or Nelson.

Within Westland District, Telecom operates a fibre optic cable extending from Hokitika to Fox with a back-up Micro Wave link between Harihari and Franz Josef via repeater stations at Mt Hercules and Omoeroa. There is no back up between Hokitika and Harihari or between Franz Josef and Fox. Communities south of Fox as far as Jackson Bay are served by a series of UHF repeater stations that link back to Greymouth.

The three principal telephone exchange buildings on the West Coast are at Greymouth, Westport, and Hokitika. They are generally built to a high standard and the equipment within is restrained in accordance with national Telecom standards. Back up power generation is provided in larger exchanges and back up battery banks in smaller exchanges.

In the event of failures of both core cables out of the region, local calling will still work provided the exchange is operational, i.e. they don't need a link to the rest of the network to operate. The situation is similar with Fleetlink[6]. Fleetlink has good coverage, especially of tracts of the Lewis Pass and Arthur's Pass, and depends on the integrity of the landline network. However, the repeater sites will function in isolation from the network allowing emergency traffic locally in the event of a major earthquake.

Cellular and Paging are a different matter. These depend entirely on the survival of the fibre network to outside the region as each Cell Site requires a high capacity data link back to the Main switch centre in Christchurch to function. The normally survival time under battery operation without power supply of the twelve Cell Sites is about 5 hours, except for Mt Rochfort and Westport which both have generators.

Clear Communications and Telstra Saturn provide an alternative service to telecom, but having no physical assets on the West Coast, they access their customers through the Telecom network. Both

[6] Fleetlink is a combined radio and telecommunications system used in vehicle fleets

companies on-sell Vodafone mobile telephone services. Vodafone's use of GSM technology with its limited cell site coverage radius has required them to build many radio base station sites to achieve coverage. This has resulted in an extensive network of sites, connected with medium and low capacity back haul microwave links to carry the traffic to their cellular switch nodes.

Transpower operate a fibre-optic communication network over part of their power network. It is not known if this network extends into the West Coast region.

While landline coverage extends over the whole region, the cell phone coverage is limited to relatively small areas around the population centres. The coverage areas, which are similar to both Vodafone and Telecom, are: Franz Josef; Whataroa – Harihari; Hokitika and a small area inland; Greymouth and the Grey Valley as far as Moana and Ikamatua; Reefton and its immediate area; Springs Junction and the Maruia Valley; and the coastal area between Charleston and Granity, including Westport and extending inland to Stockton and Denniston.

(b) BCL

Broadcasting Communications limited (BCL) is a 100% owned subsidiary of Television New Zealand (TVNZ). BCL has a national transmission network, based principally on high capacity microwave radio between their high sites, with some fibre optic capacity.

Their many high sites with high power TV and FM radio transmitters and lower level transposer and translator sites provide geographic coverage to over 99% of the population in occupied dwellings. However, this coverage reach is principally for VHF television transmission (one way transmission from a high power transmitter to adequate external, fixed antennas). The range of UHF TV transmissions is reduced due to increased signal propagation loss at the higher frequency.

On the West Coast, BCL operate a Digital Microwave Radio (DMR) link from Sewell Peak, north east of Greymouth, to Nelson, plus 26 "high" sites. These high sites comprise towers and supporting infrastructure and are classified (G1-G5) by the level of population coverage, linking capacity, back-up power capacity and the type of infrastructure. On the West Coast there are three G3 sites (Mt Rochfort near Westport, Reefton and Sewell Peak near Greymouth), 10 G4 sites and 13 G5 sites. In Westland District, there are G4 sites at Harihari, Mt Hercules, Franz Josef, and Fox Glacier, and G5 sites at Otira, Kokatahi, Waitaha Valley, Jacobs Ridge and Bald Hill. Generally, the BCL infrastructure can be expected to be relatively robust in the face of a major earthquake.

We note, moreover, the increased use of direct satellite television broadcasting. As this trend develops, the ability of the local community to receive television broadcasts will become less dependent on land-based transmission infrastructure.

The BCL network could be utilised in an emergency for telecommunications if suitable linkages were made, for instance between the Telecom facilities and those of BCL on Sewell Peak. Up to this point such an arrangement has not been considered due to commercial sensitivity considerations.

(c) Radio

Radio communication can provide backup in the case of telecommunications disruption or failure, and provide mobile communication to areas that are not accessible by the telecommunications network. (refer to West Coast CDEM for more details on emergency communications).

There is wide coverage over the West Coast by a number of Very High Frequency (VHF) radio networks. The Department of Conservation and St John operate through the VHF ES Band. Users of the VHF E Band include the West Coast Regional Council, Territorial Authorities, Timberlands West Coast and Electronet. These organisations have both base and mobile sets, with 105 vehicle and 225 hand held units over the whole of the West Coast. Repeater stations for VHF are at Hokitika Airport (WCRC), Sewell Peak, Mt Bonar, Mt Deelaw, (WCRC and WDC) Simplex, Simplex CD, Omeoroa, Karangarua, Haast, (all WDC) and Bald Hill, (WDC, WCRC, and DOC). Known black spots in VHF coverage occur in areas between the Arahura River and Hokitika where shaded by the terrace, between Fox and Knights Point, and Haast. Although these areas have been identified as not having VHF coverage by the Territorial Authorities, the Department of Conservation Network does cover these areas.

The CDEM HF radio network on the West Coast is managed jointly between the Ministry of Civil Defence and Emergency Management and the West Coast CDEM Group. Within Westland District there are sets at Franz Josef, Fox and Haast.

Contact with offshore vessels has been identified as a potential means to access information or to get messages out of the region. The VHF marine frequency is compatible with new generation radios but only to the line of sight distance from repeaters. Once past line of sight, HF is required.

(d) Satellite Phones

Satellite phones are independent from terrestrial communication infrastructure and provide increased reliability for satellite phone to satellite phone use, provided that the phone location can sight the satellites. Satellite phones are operated by Electronet (Harihari), DOC (Fox Glacier), and the Police and five private operators in Haast.

10.1.2 Vulnerabilities

Local telephone service networks are mainly by underground cables using copper conductors. This type of reticulation is susceptible to damage, particularly to some types of cable that are now obsolete and more likely to give problems. Significant differential ground movement, which is common at bridge abutments, is likely to cause severe damage.

The core supply is via fibre optic cables installed in ducts, and microwave systems. The cables are vulnerable to fracture if there is significant ground movement i.e. liquefaction, in rock if movement occurs along rock joints, and at bridge abutments. Microwave systems may have support structure failure or antennae misalignment as well as equipment damage. Damage may also occur where cables and ducts enter buildings due to differential movement. Also, buried cables are particularly vulnerable to earthquake induced landslip or subsidence. The trunk cabling is often attached to highway bridging and is vulnerable to damage due to approach settlement or structural damage.

The loss of both fibre optic cables would result in a complete cessation of communication in and out of the West Coast Region and would also result in the Fleetlink system becoming inoperable. More over, once fuel for the back up generators and batteries run out, exchanges will become inoperable and again all communications including Fleetlink will be lost.

The telephone exchange is on the first floor of the building in Hokitika. It's seismic performance is not known.

Loss of electrical power for a long time will impact significantly on the telecommunications network. While key facilities have emergency generation, these are dependent on fuel supplies. Telecom exchanges with diesel generators and indicative survival times (assuming full diesel tanks) are as follows:

- Greymouth (120 hours),
- Hokitika (120 hours),
- Whataroa (240 hours),
- Westport (120 hours),
- Granity (240 hours), and
- Karamea (240 hours).

Alternative communication systems, including satellite phones, are reliant on batteries, and if power is cut for a prolonged period, it may not be possible to recharge batteries.

10.1.3 Effect of an Earthquake

The Alpine Fault earthquake is likely to significantly damage the telecommunications within the region. It appears highly likely that both the fibre optic cables will be cut and it could easily be several days before the link to Nelson is re-established. Most of Buller will remain operable, but damage will be widespread in Grey and Westland Districts , and it may be days and perhaps weeks before landline connections are restored south of Harihari.

Fault rupture will severe the fibre optic link over Arthur's Pass where it crosses the fault rupture. The cable to Nelson does not pass over the fault, but is still at risk from damage at bridge abutments and from landslide. If the fibre optic cable links are cut to Christchurch and Nelson, telephone connection to outside the region is lost. There may be a local service, perhaps only within the Hokitika town area but no cellphone service because of its reliance on a link to Christchurch.

In the past when there was only one fibre optic link into Greymouth, service was normally restored within approximately half a day following an unexpected damage. Repair kits each 300m long and sufficient for two breaks are held in Greymouth. Therefore one breakage could be repaired within a day providing the location of the breakage could be found, access obtained, and staff were available. Therefore time for restoration is dependant upon availability of staff, access, the number of and extent of breakages, and the number of repair kits available on the Coast.

Cable damage is expected elsewhere in the network, particularly at bridge abutments and locations where slips may carry off sections of cable. Cable links are particularly vulnerable in South Westland being so close to the fault and in some places crossing it.

Microwave links can be shaken out of alignment, requiring physical re-alignment. Back up batteries and generator fuel may be insufficient to last the period before mains supply can be re-instated, and exchanges and repeaters may fail through lack of power.

Telecom's priority would be to restore the "Core" routes as collectively they carry ALL of the communications to the West Coast. Specifically, as well as forming the backbone for the exchange networks, they carry Data (EFTPOS, Private Office Networks), Cellular (both Telecom and Vodafone) and other miscellaneous connections such as Paging and TeamTalk where those services require connection to a centralised server.

In parallel with restoring core routes Telecom would also be restoring the main exchanges at Greymouth, Hokitika, and Westport. Greymouth is the highest priority exchange as all of the minor exchanges rely on the survival of the Greymouth exchange for both connections outside of the West Coast and for inter-calling between themselves.

There after the priority would be to restore minor exchanges and remote line units such as Franz Josef, Whataroa, Paroa, Runanga, Reefton, Granity and Karamea would be stabilised, followed by the large number of electronic cabinets and distributed radio systems that are connected to these exchanges. Cellular restoration falls into this category.

A number of communications networks operate in the District; Telecom, BCL, satellite telephones, private operators and there may be others. Identifying the extent, resilience and redundant capacity of all these networks and opportunities to cross-link these networks is beyond the scope of this report. However, it is vital information that should be made available to members of CDEM. Communications is identified as a most important lifeline in Section5. CDEM members, including WDC, need to work with the communication networks to allow optimal emergency planning to be undertaken now to maximise the number of potential communication options available in the response and recovery periods after the Alpine Fault earthquake.

10.1.4 Upgrades and Improvements

Although telecommunications lie outside the direct influence of WDC, there are some issues that WDC should encourage to have addressed.

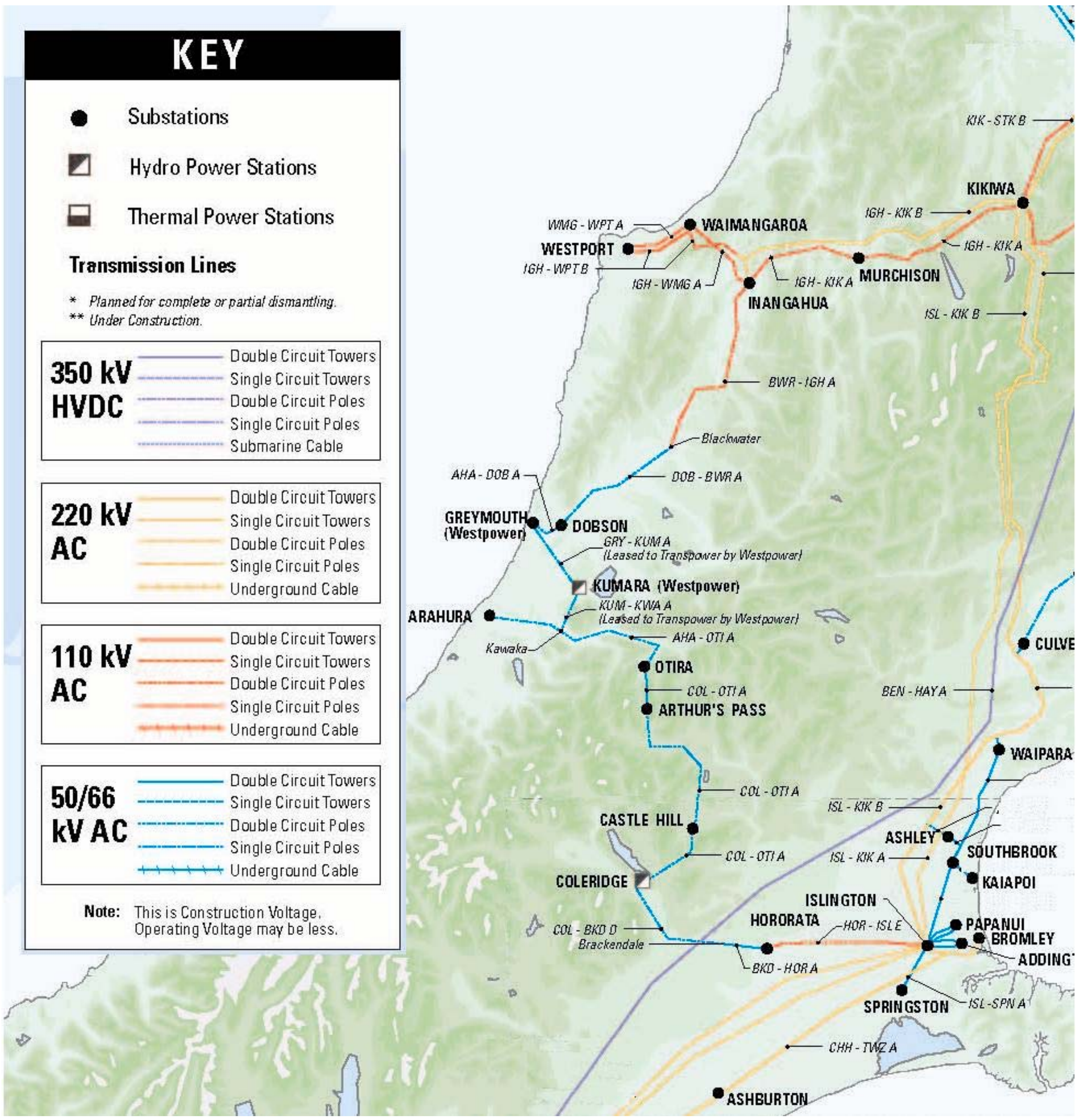
- Establish better communications between organisations and companies with communication services on the West Coast, including the power companies, Telecom and Regional Council. Advise who are contact personnel to establish relationships and co-operative effort before and after the earthquake;
- Establish who have VHF facilities and establish a common channel for use in emergencies;
- Telecom should ensure arrangements for a national level response, and train staff outside the West Coast on the nature of the West Coast network so that they can be effective in assisting recovery;
- Identify sites with interdependencies with other lifelines such as bridges. Also establish where access might be needed;
- Review access and fuel supplies to key facilities; and
- Confirm that control equipment such as computers are properly restrained; and
- WDC to have access to satellite phones, and spare batteries or recharging facilities, as link to outside the district in the event that all other links fail.

10.2 Energy – Electricity

10.2.1 General

The electrical power system in Westland consists of a regional supply from the national grid operated by Transpower, local generation supplying the national grid from Trustpower power stations, and a local distribution network operated by Westpower. Westpowers network extends over all of Grey District and into Buller District, as well as Westland District as far south as Paringa. This network is supplied from Transpowers Dobson (Grey District) and Arahura substations.

Figure 10.2: Transpower Network



The Haast area is isolated from the national grid and is supplied by a small hydro station on the Turnbull River together with a back-up diesel generator at Okuru operated by NZ Energy Ltd. Trustpower operates power stations in Grey and Westland districts that meet a portion of Westland

District's power demand. The remainder of the demand is met by other power stations in New Zealand that supply the national grid.

Transpower supply into Westland District is from the north east down the Grey valley from Inangahua to Greymouth and then to the Arahura Substation. The line to Greymouth is currently being upgraded from 66kV to 110kV, and a second 110kV line is planned. A second Transpower line comes over Arthur's Pass to Otira and Arahura. There is thus some redundancy in the system supply into the north of the District.

Trustpower owns and operates a number of power stations on the West Coast in Westland and Grey Districts at Wahapo (1 station), Kaniere (2 stations), Dillmans (3 stations), and Arnold (1 station). On their own these stations can provide between 40% to 60% of the present electricity demand on the West Coast.

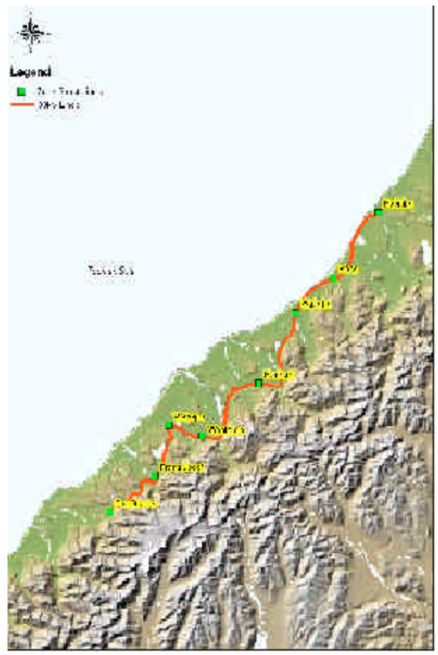
The Trustpower power stations feed power into the national grid. Under normal operating conditions the national grid provides synchronisation, however some stations are able to operate without synchronisation from the grid. Wahapo, for example, is often used to supply Franz Josef and Fox on its own when that network is isolated from the national grid. Although the power station at Kumara has capacity to produce 6 Megawatts, without national grid synchronisation, it could be made to provide some power, but significantly less than 6 Megawatts, and possibly only about 1MW.

Westpower network includes 1,978 km of high voltage transmission line, 15 zone substations and 1,853 distribution substations (5kVA – 1MVA), to deliver a current peak load of 38 MW. Supply from Transpower is at the three Westpower owned 66 kV substations of Greymouth, Hokitika and Kumara, and the Transpower substations at Dobson (33kV) and Otira (11kV). Westpower own 42 km of 66kV lines (Greymouth – Kumara – Kawhaka) which are leased to Transpower and operated as part of the national grid. One hundred and thirty three kilometres (133 km) of 33 kV lines, 1,434 km of 11 kV and 99 km of 400 V lines form the major part of the network.

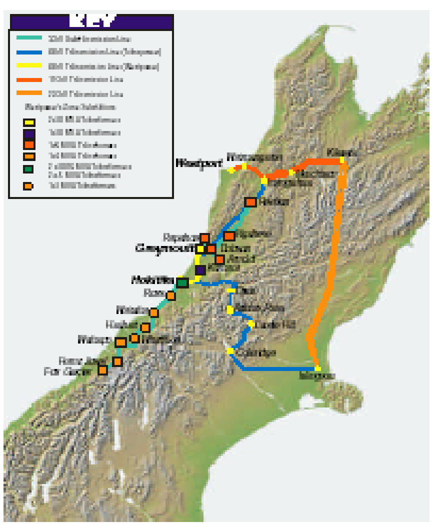
North of Hokitika, there is some redundancy in the network because of the number of lines feeding into the system and links within the system. However south of Hokitika, the network is essentially a single 33 kV transmission line to Harihari with 11 kV spur lines serving local areas, and a combined 33kV/11kV line between Harihari and Fox Glacier, again with 11kV spur lines including one from Fox Glacier to Paringa. A fault in the main transmission line can therefore cut power to a large area, although there is some local generation (3.1MW at Wahapo and a small old station at Fox) which can work independently of the main grid. Because of this vulnerability, Westpower endeavour to keep this line well maintained. The Arahura – Harihari line was built in the mid 1960s for 66kV by the NZED. It was leased in 1993 and then sold in 2001 to Westpower to carry 33kV. Westpower intend to upgrade this line to 66kV again in the near future.

Figure 10.3: Westpower Network

(a) 11kV feeder lines



(b) 33kV lines



(c) Zone substations

The Westpower communications system includes some aerial and fibre optic cable from the Greymouth substation to the control room in Greymouth, 16 UHF links and 36 mobile and 3 base VHF stations. There are repeaters at Reefton, Paparoa, Mt Hercules and Whataroa, all on mains power. The

UHF links are nearing the end of their life, and will be restricted to the South Westland area in the next few years.

Westpower have a risk management section in the Asset Management Plan. A seismic withstand report was prepared in 2004 for most zone substations and strengthening has started on identified weaknesses. A seismic assessment of the network has just been completed; action on identified weaknesses has not been started as yet. In the event of a transformer failure, the system can be reconfigured to allow a unit to be redeployed from elsewhere on the network. A mobile 33kV/11kV substation is also being constructed.

The Haast area is served by an isolated system with lines between Snapshot Creek, inland of Haast township, and Jackson Bay. Power is generated at the 800 kW hydro scheme on the Turnbull River, but there is also a 375kW backup diesel generator. The network is essentially a single line, with a spur into the power station, and is owned by NZ Energy Ltd, a small family company, which also owns the Fox power station. The maximum load currently is 700 kW. All the major consumers, such as the hotels, motor camp, and fishing services at Jackson Bay, have their own emergency generators.

10.2.2 Vulnerabilities

Vulnerabilities to electrical supply include:

- Damage to generation or transmission lines remote from the district;
- Damage to power stations within the district preventing generation;
- Damage to transformers from being unrestrained for seismic loads;
- Damage to substation buildings and their contents because of poor seismic performance;
- Failure of brittle components in substations such as bushings and insulators;
- Damage of switchgear and control panels because of inadequate supports;
- Cable damage at points where they pass from ground into or onto structures (such as buildings and bridges);
- Poles being carried away or pushed out of alignment by landslides;
- Poles carrying overhead wires moving out of alignment due to soft ground, which in turn could break insulators and lines;
- Pole mounted transformers exerting large seismic forces and breaking the supporting poles;
- Damage to emergency generators, loss of fuel supply or loss of access to them for refuelling or operating staff; and
- Damage to control equipment such as computers if not properly secured.

- The linear nature of the power supply in Westland increases the vulnerability, as one fault makes the whole system "downstream" inoperative.

For the Alpine Fault scenario, the electricity system in Westland will be significantly affected. Shaking of intensity MM VIII or greater will be experienced throughout the whole district and can be expected to result in damage to both overhead and underground reticulation with simultaneous faults in many areas.

A major vulnerability is the Transpower supply lines, as the Transpower network, and the major generating plants in the South Island will be affected. Transpower has comprehensive emergency management procedures to manage outages and restore service. It has a policy of diversification of equipment and spares storage and has temporary transmission towers available. The reinstatement goal is for at least partial service within five days following a major disaster. However in an Alpine Fault earthquake, Transpower resources are expected to be stretched with widespread damage around the Upper Waitaki generation and transmission facilities, and the transmission lines and access to them in the mountainous areas of Canterbury, Marlborough, Nelson and Westland. It is highly likely that the line from Coleridge to Arahura over Arthur's Pass will be cut with pylons and poles destroyed by landslides, and at the fault rupture at Rocky Point. Access for repair and reinstatement will be extremely restricted for weeks or even months afterwards. It is safe to assume that Transpower supply will only be possible via Kikiwa and Inangahua for some months following the earthquake.

Westland is at the end of the line from Canterbury through Marlborough and Nelson and Buller, and efforts to re-establish supply to larger populations on the way may delay supply to Westland. Local generation from the Trustpower hydro stations can provide some power to the region, however it is limited as most of the stations require synchronisation from the Transpower grid to operate at capacity. It would be wise to assume that there will be no network power to any of Westland district for in excess of a week. The exceptions are Haast, provided that the fault rupture does not extend through the Haast area, and parts of the Franz Josef – Whataroa area, which might be able to be supplied earlier from the Wahapo power station.

Intensity MMIX shaking (or greater) will cause damage to the transmission system south of Ross. Landslides are likely to cut the lines in many places, but particularly around Mt Hercules and the Cook Saddle. The line is also vulnerable at the east side of the Wanganui River near Harihari, at Franz Josef and at the Karangarua River where it crosses and then recrosses the fault trace. The large ground displacements are likely to strain the cables to the degree of failure of the cables or supporting poles. The line between Franz Josef and Fox follows close to the fault trace and is likely to cross the fault rupture in several places. Extensive damage to this section is almost certain and as the road will similarly be destroyed in places, reinstatement will be slow and could take several months. Fox Glacier and further south will therefore probably be without power for several months. The small hydro station is likely to suffer sufficient damage to prevent its operation, and lack of any road access for the supply of repair plant and material will prevent its repair before the transmission line can be repaired.

The Haast area supply may be able to be reinstated within a day or so of the earthquake after checking the lines and power station if the fault rupture does not extend south of Paringa as assumed for the scenario. If the fault rupture extends through the Haast area, widespread damage to both the hydro station and distribution lines is likely to prevent the power supply from being re-established for some months after the earthquake.

Of the power stations in Westland district, the 10.5MW Dillmans scheme at Kumara could well survive with minimal damage, but would not be able to generate anwhere close to capacity until the grid is re-energised because of synchronisation requirements. The smaller 1.5MW stations on the Kanieri River can be expected to be disabled for at least a few days. It is probable that these plants can operate independently of the grid. The 3.1MW Wahapo station should also survive the earthquake, and could be used to power the Whataroa – Okarito area once the lines have been checked and repaired.

10.3 Energy – Fuels

The availability of an adequate fuel supply for vehicles, generators and aircraft is a critical issue both immediately after an earthquake and in the longer term. The source of fuel supply varies with each of the five fuel companies operating in the region. The five companies presently operating in the area are Shell, Caltex, Mobil, BP and Challenge.

Supply is by road tanker on an as needed basis. The only fuel stock is that within the service station tanks and tanks operated by private companies such as contractors and miners at any one time. There is no strategic fuel supply held in the West Coast following the removal of the Caltex tank farm in Karoro. Some of the companies routinely supply the Grey District from Christchurch via Arthur's Pass or the Lewis Pass, while others supply fuel from Nelson via the Grey Valley.

The likely damage to the road network, both within the region and to the road links out of the region is such that it could well be up to a week before fuel can be supplied by road to Grey and Westland Districts. This will place severe constraints on fuel availability. In South Westland, the situation will be much more severe, with road access unlikely to be re-established to Harihari for perhaps a month, and Fox Glacier for perhaps over six months. The service station at Franz Josef is located on the fault, and it is very likely that any supplies there will be lost. Fuel supply for helicopters and light aircraft in South Westland is likely to become critical as damage to the roads will make huge demands on air transport for rescue, reconnaissance and evacuation.

Alternative supply methods could be by sea or air. It could take three days or longer for mobilization, loading and travel of a suitable barge and tug to enable fuel to be brought into the Ports of Greymouth or Westport, from New Plymouth for instance. Air transport could bring in limited amounts to Hokitika and Westport.

The storage of such fuel would have to be considered. There are service station holding tanks and there are also likely to be at least some road tankers that could be used for temporary storage. In addition to this, it may be possible to use other private storage such as transport firms or borrow some transportable type of above ground fuel storage tanks from mines sites etc in the area.

While the electricity supply is lost, it will not be possible to remove fuel from existing underground fuel tanks service stations. The ability to obtain aviation fuel from those stocks held at the various aerodromes may also be affected with loss of power. Alternative methods of retrieving fuel, such as portable generators, should be established before a major emergency. Security of fuel will be another issue, to ensure that remaining stocks are conserved and used for essential purposes and not removed by individuals. The volume and location of fuel storage tanks on the West Coast should be assessed along accessibility to the fuel when there is no power source to power fuel pumps.

10.3.1 Effect on WDC

Ideally, sufficient fuel would be stockpiled to enable the generators to function for a period of approximately five days under the required operational loading. The WDC should also ensure that an adequate supply of fuel is available following an earthquake in order to ensure that the necessary plant and equipment can be operated for up to one week. This may include provision of some means of extracting fuel from underground tanks in the absence of a mains electricity supply e.g. portable generators and the ability to connect them up.

10.4 Other Lifelines Improvement Schedule

Improvements identified in Section 10.1 to Section 10.3 are summarised in Table 10.1.

Table 10.1: Improvement Schedule –Other Lifelines

Importance[1]	Action	Completed by	Responsible
	Telecommunications		
H	Establish better communications between organisations and companies with communication services on the West Coast, including the power companies, Telecom, DOC and Regional Council. Also determine telecom interdependencies with other lifelines e.g. bridges.	Dec '06	Telecom/BCL/DOC etc
H	Confirm who have VHF facilities and establish a common channel for use in emergencies	Dec '06	WDC
H	Telecom to ensure arrangements for a national level response, and train staff outside the West Coast on the nature of the West Coast network so that they can be effective in assisting recovery;	Dec '07	Telecom
H	Review access and fuel supplies to key facilities	Dec '07	WDC
H	Determine WDC's access to satellite phones and spare batteries as link to outside the district	Dec '07	WDC
	Power		
H	Establish better communications between organisations and companies in the power sector on the West Coast, including the communication companies, Telecom, DOC and Regional Council. Also determine power supply interdependencies with other lifelines e.g. bridges, road access etc	On-going	Transpower/ Trustpower /Westpower/ Tasman Energy /Transit etc
M	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower, Tasman Energy)	On-going	
	Fuel supply		
H	Consider means of extracting fuel from service station tanks in the absence of mains power e.g. small petrol generator to drive fuel pumps, or manual pumps.	Dec '06	Fuel co's
M	Consider alternative methods of supplying fuel to and within the WDC area.	Dec '07	Fuel co's
L	Consider forming database of available fuel storage tanks in the area that could be used in emergency	Completed	WDC
L	Consider providing sufficient fuel for emergency generation to keep basic services operational	Completed	WDC

1. H = High Priority; M= Medium Priority; L = Low Priority

11 SUMMARY

11.1 Introduction

This report aims to raise issues and make recommendations as to what should be done to make the Council and hence the community better able to withstand the effects of a major earthquake disaster and to recover from it more effectively. It focuses primarily on lifelines; the network services of water, sewage, transport, power and communications which are essential to the functioning of a community. However, it also considers some broader issues such as leadership, which have been shown to have a major effect on the ability of a community to recover.

In order to help understand the likely effects of an earthquake and what can be done to reduce its effects, we have used a scenario approach. Thus, we have postulated a major earthquake on the Alpine Fault, and explored its consequences. It is important to realise that we are **not suggesting** that this is the earthquake that will actually occur. Any actual earthquake will be different from the scenario earthquake. However, there is no doubt that some day, a major earthquake will occur and the community must be as ready for it as possible.

Accordingly we have developed the Alpine Fault earthquake scenario as a means of, or tool for, exploring the issues and their relative importance. The scenario was developed in two stages. The first considers the physical effects of the earthquake and what it does to the lifelines. The second stage looks at the effects on people and their likely responses and needs with the aim of further teasing out the community needs and priorities and of improving our understanding of them.

This summary provides the following:

- Comments on general issues arising from the study,
- Summaries of our recommendations on things to be done of a generally concrete nature,
- A list of things that have to be determined, and
- Matters to be addressed; that is, to be considered and resolved, and where we ourselves cannot give a definitive recommendation as to what should be done.

11.2 General Issues

When considering lifelines and appropriate response to disaster, various issues need to be considered which are general and overarching, and are at a broader level than the individual lifelines. Most have been mentioned in passing in the report, but here we draw them together. They are discussed here under the headings of interdependence, ordering, leadership, communication, attitude and applicability.

11.2.1 Interdependence

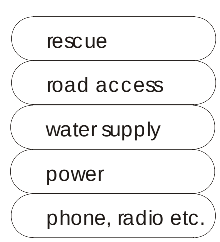
The various services and lifelines are not independent but are connected in various ways. Some are more obvious than others. It is important to take the interdependencies into account in the response and recovery stages of disaster management, and this requires that they are well understood beforehand. Protocols and linkages will have to be established in preparation. Because the interdependencies can be subtle in their detail and will be very dependent on the actual situation on the ground, we cannot, in this report, give a comprehensive review. Rather, we recommend that the matter be considered carefully by the groups and individuals concerned, possibly by means of a workshop.

Some possible interdependencies are, in no particular order:

1. Road access requirements and constraints;
2. Common causes of failure. For instance, a slip might take out telecommunications, water and other services as well as roads, or a bridge failure might do the same;
3. Failure of backup. For example, under normal conditions if sewer pumps or pipes fail surcharging sewage would flow over land and drain via the storm water system. However, in a strong earthquake the storm water system might also have failed;
4. Dependence on a common need for contractors, plant, personnel, equipment, materials, fuel, transport (surface and air) and so on;
5. Storage and accessibility of information;
6. Facilities which need several services to be up and running in order to function effectively – a hospital, for instance;
7. Information channels; and
8. Operation of one lifeline (eg water supply pumps) being dependent on another lifeline (eg power supply).

11.2.2 Ordering and prioritisation

There is likely, for each situation, to be a "stack" of things to be done in order of priority, for instance:



The order of the stack, and its components, will be different for different situations; and for any one location, it will change with time. The changing nature and order of priorities must be borne in mind as it could easily be forgotten in the stress of disaster response. It would be helpful to establish typical stack orderings beforehand.

11.2.3 Leadership

The importance of leadership in a crisis was emphasised by participants in the Punakaiki workshop. Following the September 11 terrorist attacks on the New York World Trade Centre, the city resumed its basic functioning in a remarkably short space of time. A major reason for this was the leadership shown by the Mayor, Robert Giuliani. He was able to make strategic decisions, and to be seen to do so, while at the same time not being involved in detailed direction of the response effort. This is in contrast to the situation in New Orleans following hurricane Katrina, where lack of leadership by the mayor, the governor of the state and at the national level by the Bush administration turned a serious disaster into a national catastrophe.

The two quite separate results of good leadership are sound co-ordination and direction of response and reconstruction efforts, and heightened morale among all stakeholders. Both are important, but their implications are different. A great deal of the effort in response, co-ordination, and direction lies in fairly technical issues and requires management and administrative skills. On the other hand, heightened morale can only come through good communication – see the points made in Section 11.2.4 below. In our view, sound administration and high morale are both equally important in achieving a good outcome following a disaster.

Clearly, there are two distinct leadership roles. There is an analogy here with leadership in a company, where the Chairman of the Board and the CEO have different and complementary parts to play. At the District level, the two roles could well be played by the mayor and the chief executive. In both cases, a thorough consideration must be given beforehand to the responsibilities and expectations of the roles, and the ways in which they must interact. The present report necessarily focuses more on the managerial and technical aspects of response and recovery. Nevertheless, we strongly recommend that the requirements of strong post-disaster leadership be thoroughly explored by such means as workshops, exercises and, noted below with regard to communication, the engagement of expert help.

11.2.4 Communication

Communication is of paramount importance. It has many aspects and issues. Controllers need to know what is happening, and so in fact do all stakeholders. Instructions, assessments, information, requests all need to be routed to the right recipient. Leaders need to be seen and heard to be leading. And those operating locally need to be aware of the overall extent of the disaster and the wider situation outside their own area. The three main aspects to be considered are:

1. WHO needs to communicate, and to WHOM?
2. WHAT needs to be communicated, and WHY?
3. HOW is the communication to be achieved?

Some other points to be considered are that:

1. Communication requires a sender, a receiver and a message. All three must be clearly understood;
2. Communication should ideally be in the form of a three-way loop. The sender sends the message. The sender then needs to know that the receiver has received the message. The receiver then needs acknowledgement that his or her response has been received. Of course, all three legs are not always possible or even expected;
3. It is easy for a message to be blocked or distorted by emotional factors, prejudice etc;
4. When communicating with the public, great care needs to be taken to use the right language, and to convey the right message. Facts are seldom sufficient. Considerable skill is needed here.

It should be noted that these points are only touched on briefly. They could be expanded at length as the issues are complex and much work has already been done on them by others. However, both because we see our role as identifying the issues rather than providing detailed and case-specific solutions, and also because we ourselves do not claim to be experts in the area, we have not pursued the matter further.

Nevertheless, because good communication is so centrally critical following a disaster, it is strongly recommended that;

- The above issues should be thoroughly explored where they relate to technical communication between personnel and organisations in the response and recovery periods; and
- Expert-led training sessions should be held regarding post-disaster communication with the public, with a particular emphasis on those who would be expected to provide community leadership.

11.2.5 Attitude

There are two particular attitudes, which are helpful if not vital for all those involved in disaster response and recovery. They are adaptability and co-operation.

Adaptability is necessary because every emergency is different and has aspects which have never before been encountered. Moreover, it is likely that key people will not be available, records will be missing and so on. The best approach is to expect the unexpected. We believe that the culture of the West Coast is such that people are used to adapting to the conditions they meet in creative ways, and this will stand them in good stead in a disaster.

They will also need to co-operate. Individuals will have to work together, and so will organisations. Co-operation does not always come naturally in today's competitive corporate world. In an emergency, of course, organisations will co-operate more fully. However, it is also important to co-operate beforehand in the preparatory stage. Information should be shared and joint plans of action worked out, together with protocols of what should be done. In this regard we would encourage joint civil defence workshops as well as one-to-one discussions.

11.2.6 Applicability

The final general point to be made is that the issues raised here relate to any major disaster, and not just the Alpine Fault earthquake, which is, as we have said, merely an arbitrary scenario to help identify what needs to be done to help respond to and recover from a disaster. Some of the things we have said do indeed relate specifically to earthquakes, and this must be so in that a major earthquake will certainly hit all or part of the West Coast at some stage. Nevertheless the general points we have made, and also many of the detailed recommendations, will apply to any disaster.

11.3 Things to be determined

Here we list recommendations for things that have to be found out or assessed, or where plans must be developed, together with suggested timeframes.

Priority[1]	Activity	Completed by	Reference
	Transportation		
	General		
H	Establish fast and flexible contract procedures with contractors, and establish availability of professional engineers where appropriate.	Dec '06	Table 6.4
	Hokitika Airport		
M	Hokitika Airport – Determine the seismic resilience of the airport, including building contents and power supply	Assess Dec '08 Implement Dec '11	Table 6.4
	South Westland Airstrips		
M	Check condition of airstrips and size of aircraft that could use them. In particular, airstrips at Okarito, Tatare (both possible alternatives to Franz Josef), Fox Glacier, Okuru and Neils Beach.	Dec '06	Table 6.4
	Franz Josef Airstrips		
M	Investigate possible alternative landing strips on the north side of the Waiho.	Dec '06	Table 6.4
L	Investigate possible alternative access means between the township and the aerodrome should SH 6 link become unusable.	Dec '10	Table 6.4
	Jackson Bay Wharf		
L	Review strength of structure and implement any measures to enhance its seismic resilience.	Dec '10	Table 6.4

1. H = High Priority; M= Medium Priority; L = Low Priority

Priority[1]	Activity	Completed by	Reference
	Roads		
M	Screen SH 6 between the West Coast and Nelson and over the Lewis Pass and Haast Pass for vulnerabilities and prioritise works that might reduce risk to earthquake damage. This work is ongoing with Opus.	Ongoing	Table 6.4
H	Determine key routes in the District with Transit.	Dec '06	Table 6.4
H	Undertake a structural audit of bridges and road structures on key routes and prepare a plan based on the audit to progressively upgrade bridges & road structures. Prioritising structures should proceed using critieria such as that suggested at the end of Section 6.2.5 and should include particular attention to multiple use bridges carrying other lifelines.	Dec '07	Table 6.4
	Water Supply		
M	Assess the remaining water supplies in the district to determine vulnerabilities and improvements required.	Dec '08	Table 7.6
	Hokitika Water Supply		
M	Define essential businesses and industry and strengthen pipe networks to them.	Dec '12	Table 7.6
L	Review the risk of loosing supply to the Hokitika community west of Fitzherbert Street due to failure of one of the three pipelines supplying this area.	Dec '13	Table 7.6
H	Determine spare parts requirements and strategic storage locations.	Dec '06	Table 7.6
	Sewerage		
H	Ensure adequate spare parts are in stock to allow repairs to sewerage assets and adequate means to disinfect areas polluted by sewage.	Dec '06	Table 8.4
M	Assess the remaining sewerage schemes in the district including non-WDC schemes to determine vulnerabilities and improvements required	Dec '06	Table 8.4
L	Review planned sewer replacement and give priority to replacement immediately upstream of discharge points	Dec '10	Table 8.4
	Hokitika Sewerage		
H	Identify surcharge areas and assess likely public health risk. Determine appropriate emergency discharge arrangements	Dec '07	Table 8.4
L	Undertake a geo-technical assessment of pumps stations and determine vulnerabilities in an earthquake and identify improvements	Dec '12	Table 8.4
	Storm Water		
M	Undertake a geotechnical and structural assessment of all pump stations to quantify earthquake risks at each site and implement improvements to address these risks.	Dec '08	Table 9.4
L	Review planned storm water pipe replacement and give priority to replacement immediately upstream of discharge points	Dec '12	Table 9.4
L	Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding.	Dec '10	Table 9.4

1. H = High Priority; M= Medium Priority; L = Low Priority

Priority[1]	Activity	Completed by	Reference
	Telecommunications		
H	Confirm who have VHF facilities and establish a common channel for use in emergencies	Dec '06	Table 10.1
H	Telecom to ensure arrangements for a national level response, and train staff outside the West Coast on the nature of the West Coast network so that they can be effective in assisting recovery;	Dec '07	Table 10.1
H	Determine WDC's access to satellite phones and spare batteries as link to outside the district	Dec '07	Table 10.1
	Fuel Supply		
M	Consider alternative methods of supplying fuel to and within the WDC area.	Dec '07	Table 10.1
H	Consider means of extracting fuel from service station tanks in the absence of mains power e.g. small petrol generator to drive fuel pumps or manual pumps.	Dec '06	Table 10.1

1. H = High Priority; M= Medium Priority; L = Low Priority

11.4 Things to be Done

This table lists recommended actions to be taken.

Priority[1]	Activity	Completed by	Reference
	Transportation		
H	Prepare a road and bridge damage assessment strategy to be followed after the earthquake to quickly identify, prioritise and manage immediate clearing and repairs.	Dec '06	Table 6.4
H	Liase with Transit and ONTRACK about key routes in the district.	Dec '06	Table 6.4
L	Prepare a route hazard map to determine roads which may become damaged or impassable	Dec '12	Table 6.4
H	Establish a database of owners and operators of earthmoving resources	Completed	Table 6.4
H	Undertake a structural seismic audit of all district bridges starting with bridges on critical routes. Undertake a survey of remaining significant structures from most to least important.	Dec '07	Table 6.4
	Water Supply		
H	Prepare a formal response plan for water supplies after a significant earthquake	Dec '07	Table 7.6
M	Investigate strategies for supporting these supplies for various earthquake scenarios.	Dec '08	Table 7.6

1. H = High Priority; M= Medium Priority; L = Low Priority

Priority[1]	Activity	Completed by	Reference
	Hokitika Water Supply		
H	Review equipment restraints at pump stations and the treatment plant	Dec '06	Table 7.6
M	Replace the remaining sections of AC pipe on the transmission main	Dec '09	Table 7.6
M	Install burst control valves at the raw water storage lakes and the treated water reservoir.	Dec '09	Table 7.6
M	Assess and modify where appropriate the pipe work at the Pine Tree Road and Cement Lead Road reservoirs.	Dec '08	Table 7.6
M	Replace the 200mm diameter AC pipeline from the Cement Lead Road reservoirs to Pine Tree Road.	Dec '12	Table 7.6
L	Replace the 150mm diameter AC pipeline from the airport to Whitcombe Terrace, Bonar Drive and on to Tudor Street.	Dec '12	Table 7.6
L	Progressively replace the 250mm diameter AC pipeline with a more earthquake resistant material from the Pine Tree Road reservoirs via Pine Tree Road and Kaniere Road to the Dairy factory.	Dec '13	Table 7.6
	Sewerage		
H	Prepare a formal response plan for sewage disposal after a significant earthquake	Dec '07	Table 8.4
	Storm Water		
L	Prepare a formal response plan for storm water management after a significant earthquake.	Dec '12	Table 9.4
	Telecommunications		
H	Establish better communications between organisations and companies with communication services on the West Coast, including the power companies, Telecom, DOC and Regional Council. Also determine telecom interdependencies with other lifelines e.g. bridges.	Dec '06	Table 11.2
	Power		
H	Establish better communications between organisations and companies in the power sector on the West Coast, including the communication companies, Telecom, DOC and Regional Council. Also determine power supply interdependencies with other lifelines e.g. bridges, road access etc	On-going	Table 10.2
M	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower, Tasman Energy)	On-going	Table 10.2

1. H = High Priority; M= Medium Priority; L = Low Priority

11.5 Things to be addressed

Priority[1]	Activity	Completed by	Reference
	General		
H	***Improve understanding of leadership and communication issues*** Responsible: CDEMG Consider how communication can best be achieved after a major earthquake. Consider running a seminar/workshop on leadership and communication issues.	Jun '07	Section 11
H	***Improve understanding of how outside help will be co-ordinated, serviced and directed.*** Responsible: CDEMG What are the priorities? How will outside help be accommodated and fed? What will be the best way to communicate? What requirements will they have for food transportation and fuel?	Jun '07	Section 11
M	***Improve understanding of how lifeline services repair will be co-ordinated*** Responsible: CDEMG with advice from Lifelines group Which lifelines should be repaired first? How will the Council get plant and manpower to where it is needed? How will plant and manpower be prioritised and managed? What assessment and monitoring strategies and means need to be put in place?	Dec '10	Section 11
L	***Establish how building/housing repairs will be co-ordinated*** Responsible: CDEMG and Council Regulatory Department How will material supplies (window glass, timber etc) along with plant, manpower and supplies be controlled and managed? Who will undertake inspections of buildings and what will be the priority? How activities that would normally require a consent be approved during the response and recovery periods?	Dec '12	Section 11
	Transportation		
L	Establish contacts with Transit and ONTRACK for good co-operation after an earthquake. This is mostly in place informally. Annual updating of contact lists is required as part of CDEM plan		Table 6.4
L	Establish a database for major cuttings and embankments so that a programme of progressive upgrading and improvements can be established and periodic inspections can be formalised.	Dec '10	Table 6.4
	Water Supply		
M	Review the proposed levels of service and strategies for after an earthquake for water supply systems to ensure they are appropriate and achievable	Dec '08	Table 7.6
H	Review options for standpipes and assess the number required	Dec '07	Table 7.6
H	Define remaining high fire risk/high value areasa and identify appropriate secondary fire fighting options.	Dec '06	Table 7.6

1. H = High Priority; M= Medium Priority; L = Low Priority

Priority[1]	Activity	Completed by	Reference
	Sewerage		
M	Review the proposed levels of service and strategy for sewage disposal after a major earthquake to ensure they are appropriate and achievable	Dec ‘08	Table 8.4
M	Consider discharge requirements of major waste water producers after a significant earthquake and determine any provisions necessary to manage these discharges	Dec ‘08	Table 8.4
	Storm Water		
L	Review the proposed levels of service and strategy for storm water management after a major earthquake to ensure they are appropriate and achievable	Dec ‘12	Table 9.4

1. H = High Priority; M= Medium Priority; L = Low Priority

12 REFERENCE

Brodie, J.W., Irwin, J., 1970, Morphology and Sedimentation in Lake Wakitipu, NZ, NZ Journal of Marine and Freshwater Research 4(4)

Butcher, G., Andrews, L., Cleland G., 1998, The Edgecumbe Earthquake. Report prepared for the Centre of Advanced Engineering, University of Canterbury.

Carr, K.M., 2004, Liquefaction Case Histories from the West Coast of the South Island, New Zealand, MSc thesis, Dept of civil engineering, University of Canterbury, Research report 2004-04

Cousins,W.J., Zhao,J.X., Perrin,N.D., 1999, A Model for the Attenuation of Peak Ground Acceleration in New Zealand Earthquakes based on Seismograph and Accelerograph Data, Bulletin of the NZ Society for Earthquake Engineering, Vol 32, No.4

Dowrick, D.J., Rhoades, D.A., Davenport, P.N., 2003, effects of microzoning and foundations on damage ratios for domestic property in the magnitude 7.2 1968 Inangahua, New Zealand Earthquake, Bulletin NZ Society for earthquake engineering, Vol 36, No.1

Gair, H.S., 1967 Sheet 20, Mt Cook, Geological Map of New Zealand 1:250,000 DSIR

Hancox, G.T., Perrin, N.D., Dellow, G.D., 2002, Recent studies of historical earthquake-induced landsliding, ground damage, and MM intensity in New Zealand, Bulletin of the NZ Society for Earthquake Engineering, Vol 35, No.2

Hancox. G.T., Cox, S., Turnbull, I.M., Crozier, M.J., 2003, reconnaissance studies of landslides and other ground damage caused by the Mw 7.2 Fiordland earthquake of 22 August 2003, Institute of Geological and Nuclear Sciences science report 2003/30

Henderson, J., 1937, The West Nelson Earthquakes of 1929, NZ Journal of Science & Technology, Vol XIX No.2, Department of Industrial and Scientific Research.

Korup, O., 2004, Geomorphic implications of fault zone weakening: slope instability along the Alpine Fault, South Westland to Fiordland, NZ Journal of Geology & Geophysics, Vol. 47, 257-267

Much, A.R., McKellar, I.C., 1964, Sheet 19, Haast, Geological Map of New Zealand 1:250,000 DSIR

Paterson, B.R., Bourne-Webb, P.J., 1994, Reconnaissance report on Highway Damage from the 18 June 1994, Arthur's Pass earthquake, Bulletin of the New Zealand National Society for Earthquake Engineering, Vol 27 no. 3.

Paterson, B.R., Berrill, J.B., 1995, Damage to SH 73 from the 29 May 1995 Arthur's Pass Earthquake, 1995, Bulletin of the New Zealand National Society for Earthquake Engineering, Vol 28 no. 4

Paterson, B.R. 1998, Effects and Mitigation of Rock-roll Hazard SH 73 Arthur's Pass highway, South Island, New Zealand, Proceedings NZ Geotechnical Society 1998 Symposium, Auckland

Rhoades, D.A. & Van Disson, R.J., 2003, Estimates of the time-varying hazard of rupture of the Alpine Fault, New Zealand, allowing for uncertainties, NZ Journal of Geology and Geophysics, Vol 46, p479-488

Saul, G.J. 2001, Geotechnical Aspcts – Candy's Bend Road Widening, Arthur's Pass, Proceedings NZ Geotechnical Society 2001 Symposium, Christchurch

Sindon, L., 2003, The Impact and recovery of the State Highway Network from a Major Alpine Fault Event, 3rd professional project report, Department of Civil Engineering, University of Canterbury

Stirling, M., Yetton, M., Pettinga, J., Berryman, K., Downes,G., 1999, Probabilistic Seismic Hazard Assessment and Earthquake Scenarios for the Canterbury Region, and Historic Earthquakes in Christchurch, Stage 1 (Part B) of Canterbury Regional Council's Earthquake Hazard and Risk Assessment Study, CRC Rport No. U99/18

Transit New Zealand, 2000, Manual for Seismic Screening of Bridges, Revision 2

Transit New Zealand, 2000,Seismic Screening of Bridges, Region 11, Canterbury

Transit New Zealand, 2000,Seismic Screening of Bridges, Region 12, West Coast

Watts, Duncan J., 2003, "Six Degrees – The Science of a Connected Age", W.W. Norton & Company

Warren, G., 1967 Sheet 17, Hokitika, Geological Map of New Zealand 1:250,000 DSIR

Wright, C.A., 1998, Geology and Paleoseismology of the Central Alpine Fault new Zealand, unpublished MSc Thesis, Department of Geological Sciences, University of Otago, Dunedin

Yetton, M.D., (2000) Probability and Consequences of the next Alpine Fault Earthquake, Unpublished PhD Thesis, Department of Geological Sciences, University of Canterbury, Christchurch

Yetton, M.D., Wells, A., Traylen, N.J., 1998, Probability and Consequences of the next Alpine Fault Earthquake, EQC Research report 95/193

APPENDIX A: DAMAGE ASSESSMENT CHART

Westland District Council Lifelines Study

Damage Assessment Chart

1 Reference Report

The Chart has been compiled for use with the Westland District Lifelines Study, June 2006. It should be read in conjunction with Section Two of that report. Section Three outlines an earthquake scenario, and it is recommended that this is also read to provide a perspective on the chart contents.

2 Chart Zones

The chart has been set out for each of the three Ground Shaking Zones as described in Table 2.1 of the above report. Because of the large area of the District, and the range of expected earthquake shaking intensities for any single earthquake event, indicative damage is shown for a range of shaking intensities for each zone. The damage is indicative only and a wide variation can be expected within each zone due to variations in sub-surface conditions, geology, terrain and orientation of the site with respect to the earthquake source.

3 Chart Limitation

The Damage Assessment Chart is an indicative guide only. The damage to structures should be read in conjunction with the description of damage in the Modified Mercalli Intensity Scale, Appendix B, and the description of building types, Appendix B, of the Report. There is little information on damage ratios for structures or infrastructure other than buildings, and the relative damage is necessarily somewhat subjective. It may be used for coarse screening of effects, but must not be used as the basis for any design. Any decision involving expenditure or engineering design requires a more detailed evaluation of the conditions pertaining at that particular site.

4 Liquefaction

The Damage Assessment Chart includes comments on possible liquefaction damage for Zone 1 only, as there is expected to be little liquefaction outside this zone. If liquefaction in zones 2 and 3 does occur, damage will be similar to that outlined for zone 1 in the corresponding shaking intensity.

Westland District Council Lifelines Study - Damage Assessment Chart

A - Structures IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Structures	Fixings designed for seismic loads	Equipment not fixed or fittings not designed for seismic loads	Liquefaction damage (where site is liquefiable and structure not specifically designed)
1	MM VI	Slight damage to Type I buildings	Little to no damage	Movement probable, 10% failure	Minimal
	MM VII	Minor damage except for poorly constructed weak material Type I buildings	Minor damage	Movement expected, 30% failure	Some damage with foundation tilting and settlement
	MM VIII	Well designed structures serviceable, but with at least minor damage. Many non seismically designed structures damaged and unserviceable.	Considerable damage, 25% failure	70% failure	Large settlement, tilting, damage to foundations
	MM IX	Damage and distortion to even modern, well designed structures, some may be unserviceable. Non seismically designed structures likely to be seriously damaged and poorly constructed weak material structures collapse.	Widespread damage 40% failure	90% failure	Large settlement (many cm)and foundation distortion to cause major damage to structure
2	MM VI	Intermediate between Zone 1 and 3			
	MM VII				
	MM VIII				
	MM IX				
3	MM VI	As for Zone 1, with some small reduction in severity possible			
	MM VII				
	MM VIII				
	MM IX				

Westland District Council Lifelines Study - Damage Assessment Chart

B - In Ground Pipework

IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Welded Steel polyethylene	Moderately ductile pipes Concrete with rubber joints Steel and cast iron with rubber joints	Low strength/ low ductiliity pipes Earthenware with rubber joints Asbestos cement Cast iron with lead joints	Non-ductile pipes Ceramic with cement joints Brick
1	MM VI	Should be OK	Should be OK	Occasional mains damage and entry and junction failure	Minor mains damage 5% entries and junctions fail
	Liquefiable site	Liquefaction unlikely at this level of shaking			
	MM VII	Should be OK	little mains damage, 5% entries and junctions fail	Little mains damage, 10% of entries and junctions fail	Mains damage possible 20% entries and junctions fail
	Liquefiable site	*Possible damage at entry to structures and at junctions*	*Mains damage possible, 15% of entries and junctions fail*	*Moderate mains damage, 40% of entries and junctions fail*	*Significant damage*
	MM VIII	Should be OK, minor damage	Some mains damage, 15% entries and junctions fail	Mains damage likely 40% entries and junctions fail	Mains damage widespread
	Liquefiable site	*Likely damage at entry to structures and at junctions*	*Mains damage likely,50% entries and junctions fail*	*Mains damage, 70% entries and junctions fail*	*Mains failure*
	MM IX	Damage possible at entry to structures and at junctions	Mains damage likely, 40% entries and junctions fail	Mains damage probable 60% entries and junctions fail	Mains damage
	Liquefiable site	*Likely damage at entry to structures and at junctions*	*Mains damage likely,70% entries and junctions fail*	*Mains damage, 80% entries and junctions fail*	*Mains failure*

B - In Ground Pipework (Continued) IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Welded Steel polyethylene	Moderately ductile pipes Concrete with rubber joints Steel and cast iron with rubber joints	Low strength/ low ductiliity pipes Earthenware with rubber joints Asbestos cement Cast iron with lead joints	Non-ductile pipes Ceramic with cement joints Brick
2	MM VI	As for Zone 1 but with 10 – 15% reduction in severity			
	MM VII				
	MM VIII				
	MM IX				
3	MM VI	As for Zone 1 but with 30% reduction in severity			
	MM VII				
	MM VIII				
	MM IX				

Westland District Council Lifelines Study - Damage Assessment Chart

C - Transport IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Roading	Railway	Bridge Structure	Bridge Abutments
1	MM VI	Little to no damage	Little to no damage	Refer Section A - Structures	Little to no damage
	Liquefiable sites	*Liquefaction unlikely at this level of shaking*			
	MM VII	Minor damage to kerbs and cracking of seal. Small slips on steep batters.	Minor damage to alignment		Minor slumping
	Liquefiable sites	*Some damage to kerbs and cracking of seal. Lateral spread of fill possible*	*Lateral spread of embankments possible*		*Lateral spread possible.*
	MM VIII	Some damage to kerbs. Some distortion and cracking of seal. Slips in batters	Distortion of rail lines, some spreading of embankments		Some slumping of abutment fill common
	Liquefiable sites	*Damage to kerbs. Sumps damaged. Widespread distortion and cracking of seal. Lateral spread of fills*	*Some distortion of rail lines. Spreading of embankments*		*Slumping and lateral spread of fill, abutment failures possible if not piled. Pile damage possible*
	MM IX	Damage to kerbs, distortion and cracking of seal, Landsliding in steep slopes and batters, cracking of ground	Distortion of rail lines, both horizontal and vertical, significant embankment damage		Slumping of abutment fill at most bridges, many of significant magnitude. Translational or rotational movement at some abutments.
	Liquefiable sites	*Extensive damage to kerbs. Sumps damaged. Extensive distortion and cracking of seal. Lateral spread*	*Distortion of rail lines. Spreading of embankmnets*		*Slumping and lateral spread of fill, abutment failures likely if not piled. Pile damage likely.*

C - Transport (Continued)

IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Roading	Railway	Bridge Structure	Bridge Abutments
2	MM VI	Intermediate between zones 1 and 3			
	MM VII				
	MM VIII				
	MM IX				
3	MM VI	Little to no damage	Little to no damage		Little to no damage
	MM VII	Rockfall and small slips on steep batters.	Minor damage to alignment		Minor slumping
	MM VIII	Rockfall and slips in steep batters	Distortion of rail lines, some spreading of embankments		Some slumping of abutment fill common
	MM IX	Landsliding in steep slopes and batters, cracking of ground, large volume rockfall possible	Distortion of rail lines, both horizontal and vertical, significant embankment damage		Significant slumping of abutment fill at most bridges. Translational or rotational movement at some abutments.

APPENDIX B: MODIFIED MERCALLI INTENSITY SCALE

Construction Categories for Damage Assessment

as Used in Modified Mercalli Intensity Scale

After Eiby (1966) Categories of non-Wooden Construction	After Study Group (1992) Categories of Construction
Masonry A Structure design to resist lateral forces of about 0.1g, such as those satisfying the New Zealand Model Building Bylaw, 1955. Typical buildings of this kind are well reinforced by means of steel or ferroconcrete bands, or are wholly of ferro-concrete construction. All mortar is good quality and the design and workmanship is good. Few buildings erected prior to 1935 can be regarded as in category A. **Masonry B** Reinforced buildings of good workmanship and with sound mortar, but not designed in detail to resist lateral forces. **Masonry C** Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the comers, but neither designed nor reinforced to resist lateral forces. **Masonry D** Buildings with low standard of workmanship, poor mortar, or constructed of weak materials like mud brick and rammed earth. Weak horizontally. **Windows** Window breakage depends greatly upon the nature of the frame and its orientation with respect to the earthquake source. Windows cracked at MM5 are usually either large display windows, or windows tightly fitted to metal frames. **Water Tanks** The "domestic water tanks" listed under MM7 are of the cylindrical corrugated-iron type common in New Zealand rural areas. If these are only partly full, movement of the water may burst soldered and riveted seams. Hot water cylinders constrained only by supply and delivery pipes may move sufficiently to break the pipes at about the same intensity.	**Buildings Type I** Weak materials such as mud brick and rammed earth; poor mortar; low standards of workmanship (Masonry D in other MM scales). **Buildings Type II** Average to good workmanship and materials, some including reinforcement but not designed to resist earthquakes (Masonry B and C in other MM scales). **Buildings Type Ill** Buildings designed and built to resist earthquakes to normal use standards, i.e. no special damage limiting measures taken (mid –1930's to c. 1970 for concrete and to c. 1980 for other materials). **Buildings and bridges Type IV** Since c. 1970 for concrete and c. 1980 for other materials, the loadings and materials codes have combined to ensure fewer collapses and less damage than in earlier structures. This arises from features such as "capacity design" procedure, use of elements (such as improved bracing or structural walls) which reduce racking (i.e. drift), high ductility, higher strength. **Windows** Type I – Large display windows, especially shop windows. Type II - Ordinary sash or casement windows. **Water Tanks** Type I - External, stand mounted, corrugated iron water tanks. Type II - Domestic hot-water cylinders unrestrained except by connecting pipes. **H - (Historical)** Important for historical events. Current application only to older houses, etc. **General Comment** “Some” or a “few” indicates that the threshold of a particular effect has just been reached at that intensity.

INTENSITY SCALES

MODIFIED MERCALLI (MM) INTENSITY SCALE
(Table from Downes, 1995)

	After Eiby (1966)	After Study Group (1992)
MM I	Not felt by humans, except in especially favourable circumstances, but birds and animals may be disturbed. Reported mainly from the upper floors of buildings more than 10 storeys high. Dizziness or nausea may be experienced. Branches of trees, chandeliers, doors, and other suspended systems of long natural period may be seen to move slowly. Water in ponds, lakes, reservoirs etc. may be set into seiche oscillation.	*People* Not felt except by a very few people under exceptionally favourable circumstances.
MM II	Felt by a few persons at rest indoors, especially by those on upper floors or otherwise favourably placed. The long-period effects listed under MM I may be more noticeable.	*People* Felt by persons at rest, on upper floors or favourably placed.
MM III	Felt indoors, but not identified as an earthquake by everyone. Vibration may be likened to the passing of light traffic. It may be possible to estimate the duration, but not the direction. Hanging objects may swing slightly. Standing motorcars may rock slightly.	*People* Felt indoors; hanging objects may swing, vibration similar to passing of light trucks, duration may be estimated, may not be recognised as an earthquake.
MM IV	Generally noticed indoors, but not outside. Very light sleepers may be wakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building. Walls and frame of buildings are heard to creak. Doors and windows rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock, and the shock can be felt by their occupants.	*People* Generally noticed indoors but not outside. Light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic or to the jolt of a heavy object falling or striking the building. *Fittings* Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock. *Structures* Walls and frame of buildings, and partitions and suspended ceilings in commercial buildings may be heard to creak.

	After Eiby (1966)	After Study Group (1992)
MM V	Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people frightened. Direction of motion can be estimated. Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Some windows cracked. A few earthenware toilet fixtures cracked. Hanging pictures move. Doors and shutters may swing. Pendulum clocks stop, start, or change rate.	*People* Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed. Direction of motion can be estimated. *Fittings.* Small unstable objects are displaced or upset Some glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing. Cupboard doors secured by magnetic catches may open. Pendulum clocks stop, start or change rate (H*). *Structures* Some window type I* cracked. A few earthenware toilet fixtures cracked (H)
MM VI	Felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. Slight damage to Masonry D. Some plaster cracks or falls. Isolated cases of chimney damage. Windows, glassware and crockery broken. Objects fall from shelves, and pictures from walls. Heavy furniture moved. Unstable furniture overturned. Small church and school bells ring. Trees and bushes shake, or are heard to rustle. Loose material may be dislodged from existing slips, talus slopes, or shingle slides.	*People* Felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. *Fittings* Objects fall from shelves. Pictures fall from walls (H*). Some furniture moved on smooth floors. Some unsecured free-standing fireplaces moved. Glassware and crockery broken. Unstable furniture overturned. Small church and school bells ring (H). Appliances move on bench or table tops. Filing cabinets or “easy glide" drawers May open (or shut). *Structures* Slight damage to Buildings Type I*. Some stucco or cement plaster falls. Suspended ceilings damaged. Windows Type I* broken. A few cases of chimney damage.

	After Eiby (1966)	After Study Group (1992)
MM VII	General alarm. Difficulty experience in standing. Noticed by drivers of motorcars. Trees and bushes strongly shaken. Large bells ring. Masonry D cracked and damaged. A few instances of damage to Masonry C. Loose brickwork and tiles dislodged. Unbraced parapets and architectural ornaments may fall. Stone walls cracked. Weak chimneys broken, usually at the roofline. Domestic water tanks burst. Concrete irrigation ditches damaged. Waves seen on ponds and lakes. Water made turbid by stirred-up mud. Small slips, and caving-in on sand and gravel banks.	*People* General alarm. Difficulty experienced in standing. Noticed by motorcar drivers who may stop. *Fittings* Large bells ring. Furniture moves on smooth floors, may move on carpeted floors. *Structures* Unreinforced stone and brick walls cracked. Buildings Type I cracked and damaged. A few instances of damage to Buildings Type II. Unbraced parapets and architectural ornaments tall. Roofing tiles, especially ridge tiles may be dislodged. Many unreinforced domestic chimneys broken. Water tanks Type I* burst. A few instances of damage to brick veneers and plaster or cement-based linings. Unrestrained water cylinders (Water Tanks Type II*) may move and leak. Some Windows Type 11* cracked. *Environment* Water made turbid by stirred up mud. Small slides such as falls of sand and gravel banks. Instances of differential settlement on poor or wet or unconsolidated ground. Some fine cracks appear in sloping ground. A few instances of liquefaction.

	After Eiby (1966)	After Study Group (1992)
MM VIII	Alarm may approach panic. Steering of motorcars affected. Masonry C damaged, with partial collapse. Masonry B damaged in some cases. Masonry A undamaged. Chimneys, factory stacks, monuments, towers and elevated tanks twisted or brought down. Panel walls thrown out of frame structures. Some brick veneers damaged. Decayed wooden piles broken. Frame houses not secured to the foundation may move. Cracks appear on steep slopes and in wet ground. Landslips in roadside cuttings and unsupported excavations. Some tree branches may be broken off. Changes in the flow or temperature of springs and wells may occur. Small earthquake fountains.	*People* Alarm may approach panic. Steering of motorcars greatly affected. *Structures* Buildings Type I heavily damaged, some collapse. Buildings Type II damaged, some seriously Buildings Type Ill damaged in some cases. Monuments and elevated tanks twisted or brought down. Some pre-1965 infill masonry panels damaged. A few post-1980 brick veneers damaged. Weak piles damaged. Houses not secured to foundations may move. *Environment* Cracks appear on steep slopes and in wet ground. Slides in roadside cuttings and unsupported excavations. Small earthquake fountains and other manifestations of liquefaction.

	After Eiby (1966)	After Study Group (1992)
MM IX	General panic. Masonry D destroyed. Masonry C heavily damaged, sometimes collapsing completely. Masonry B seriously damaged. Frame structures racked and distorted. Damage to foundations general. Frame houses not secured to the foundations shifted off. Brick veneers fall and expose frames. Cracking of the ground conspicuous. Minor damage to paths and roadways. Sand and mud ejected in alluviated areas, with the formation of earthquake fountains and sand craters. Underground pipes broken. Serious damage to reservoirs.	*Structures* Many buildings Type I destroyed. Very poor quality unreinforced masonry destroyed. Buildings Type II heavily damaged, some collapsing. Buildings Type III damaged, some seriously. Damage or permanent distortion to some buildings and bridges Type IV. Houses not secured to foundations shifted off. Brick veneers fall and expose frames. *Environment* Cracking of ground conspicuous. Landsliding general on steep slopes. Liquefaction effects intensified, with large earthquake fountains and sand crater.
MM X	Most masonry structures destroyed, together with their foundations. Some well built wooden buildings and bridges seriously damaged. Dams, dykes and embankments seriously damaged. Railway lines slightly bent. Cement and asphalt roads and pavements badly cracked or thrown into waves. Large landslides on river banks and steep coasts Sand and mud on beaches and flat land moved horizontally. Large and spectacular sand and mud fountains Water in rivers, lakes & canals thrown up the banks	*Structures* Most unreinforced masonry structures destroyed. Many Buildings Type II destroyed. Many Buildings Type Ill (and bridges of equivalent design) seriously damaged. Many Buildings and Bridges Type IV have moderate damage or permanent distortion.
MM XI	Wooden frame structures destroyed. Great damage to railway lines and underground pipes.	

	After Eiby (1966)	After Study Group (1992)
MM XII	Damage virtually total. Practically all works of construction destroyed or greatly damaged. Large rock masses displaced. Lines of sight and level distorted. Visible wave-motion of the ground surface reported. Objects thrown upwards into the air.	

APPENDIX C: 1929 BULLER EARTHQUAKE

1929 Buller Earthquake

This appendix outlines some of the major effects of the 1929 Buller earthquake. It was a M7.8 event, smaller than the M8 or larger postulated for an Alpine Fault earthquake. While the difference does not seem great, because of the log scale for earthquake magnitude, the Alpine fault earthquake could release eight times the energy of the 1929 earthquake. Although the effects in 1929 were minor within Westland District, it does provide a very useful basis for a damage scenario. The following is based on readily available source material and is not an exhaustive study. The principal sources are Henderson (1937) and newspaper reports in the Christchurch Press from June and July 1929. Some additional details have come from Carr (2004), Hancox et al (2002), MacDonald, (1973) and Rogers (1996). Details of the effects on infrastructure are given, followed by some comments on the relevance to Westland in 2005.

C.1 General

The 1929 Buller earthquake devastated the Murchison area, but also caused widespread damage throughout the Buller District, particularly in the Karamea area. It was a M7.8 event centred about 15km north west of Murchison, occurring at 10:20am on 17 June 1929.

Slight earthquakes were felt about 1:30 and 7:30 on the morning of the disaster, but caused no great alarm. The main shock at 10.17 am … is described as being violently up and down. Unwilling observers had difficulty in keeping their feet, they clung to anything with which they came into contact or found themselves on the ground. Thunderous reverberations from the rocking, heaving earth nearly drowned the creaking and groaning of the houses, the clattering of falling movables, and the crashing of chimneys on and through the roofs. Everyone made for out of doors, many were mentally numb, and some experienced a physical nausea akin to sea-sickness.

Strong shakes, often accompanied by loud detonations, continued throughout the afternoon and following night. The people would not enter their homes, but camped as best they could in sheds and hastily-erected tents; most of them collected at the school grounds, where an open-air kitchen was established. They saw the hills surrounding their fertile flats stripped to the bare rock and the great fissures along the river banks. The bridge across the Matakitaki was impassable, while the river had ceased to flow. Power and telegraph poles were down in all directions; there was no communication with the outside world except through a few wireless receiving sets, no lights, and the generator in the power house was wrenched on its bearings. Settlers struggling in from the neighbouring valleys told of relatives and friends buried and of homes overwhelmed beneath landslides; of miles of vanished roads; of lakes rising behind dams of debris across the Matakitaki, Matiri, Maruia and Buller rivers. Small wonder that all were terrified and oppressed with the imminence of further disaster."

(Description of the 17 June 1929 earthquake at Murchison, in Henderson, 1937)

I don't know where to start to explain the position as regards Karamea. We are isolated, and it looks as though we will be for some time to come. There is practically nothing left whole in Karamea. Every road in the district is closed, and nearly all bridges are down. The wharf is gone, and the roads are either opened up in all directions or are covered altogether. There is not a chimney left standing in Karamea, and nearly every tank is gone, and some houses were burnt down. We seem to have been the storm centre. It seems, at first sight, as though we are permanently cut off, as all the hills around us appear to be down. There are great openings you could drive a horse and cart into in the middle of the road. There are water geysers and boiling sulphur in the middle of the paddock, and worse than all, Karamea River is blocked – evidently a big slip in the Gorge.

(Unknown author as reported in newspapers, June 1929)

Of the 300 residents of Murchison, 167 left Murchison on the morning of 18 June and reached Nelson that night. By the next day, 289 refugees were in Nelson leaving only 40 – 50 men in the town. There were 17 deaths in this earthquake; 16 of them by landslide, and 4 within the Buller District north of Westport.

C.2 Roads

All the roads in the Murchison area were badly affected. Initially the road to Glenhope was cleared sufficiently to allow refugees to leave Murchison on day 2. The bridge across the Buller upstream of Murchison was intact, but parts of the roadway bordering the river closer to Murchison had fallen away and traffic had to take to the neighbouring paddocks. Heavy rain by day 3 caused further slips and hampered work in restoring roads, and some later evacuees travelled south to Reefton.

The road through the Upper Buller Gorge was severely damaged (MM IX – X), with "the complete destruction of parts of the road between Lyell and Newton Flat." The Upper Buller Gorge road was not reopened to wheeled traffic until 1 April 1931, but two days after re-opening, heavy rain brought down further slips and the road was closed for a further 4 weeks, more than 22 months after the earthquake.

A service car had just crossed the Iron Bridge over the Buller at the time of the earthquake. The car was trapped between a large slip, which took out most of the road in front, and a rockfall behind. It took over six hours for the car occupants to return about ½ mile to the nearest house, and 4- ½ months before the car was retrieved. The Iron Bridge spans shifted nearly 0.3m on their supports and the holding down bolts pulled out of the piers.

Bridges on the Matakitaki at Murchison and Lyell Creek had trusses displaced and distorted. The Newton River bridge was "much" damaged and later completely destroyed by flood and debris from the "vast" slips upstream. A number of small timber bridges were completely wrecked.

As the main Buller Gorge road was so damaged, an alternative route for transport between Nelson and the West Coast was needed. The road along the lower Matakitaki, upper Maruia and upper Inangahua was hastily improved and a temporary bridge built over the Maruia so that communication was re-established after about 3 weeks. In the Matakitaki, the road between six mile and eight mile was completely destroyed by slips in several places and when public motor transport between Nelson and Westport recommenced on 15 July (4 weeks after the earthquake), there was a 5 km break in the road here with a walking track linking the road ends.

In the Inangahua area (MM VIII), a large portion of the road from Cronadun to Three Channel Flat showed "lengthy cracks". At Rotokohu cracks were 0.5m wide and 40m long and the road sank several feet. The approaches to the Rotokohu bridge were damaged. At Oweta a road bridge had "sprung up in the middle and sunk at either end". From Westport (MM VIII), the roads to Seddonville, Reefton and Greymouth were reopened within a few days, although repair work in the Lower Buller Gorge took many months to complete. On the road north to Waimangaroa, large fissures appeared on the road ("cracks as wide as 0.2 – 0.3m and extending chains down the road"), and a pier on one bridge was lifted about 1.5m. Extensive fissures are reported on the road to Cape Foulwind, and one bridge was completely demolished and others badly damaged.

Hill roads suffered severely from slips. Two lorries were buried on the Stockton Road (MM VIII), and slips destroyed miles of road in the Denniston area. On July 18 (a month after the earthquake) Millerton and Stockton remained without any road access, as the large slips initiated by the earthquake were continuing to move. Clearing debris from the road only brought down more material and work was abandoned for some time. Access to the towns was by foot track or the inclined tramway to the mine. Two prospectors were killed by a landslide on the track into the upper Mokihinui.

The Karamea Road (MM IX) was so extensively damaged over a twenty mile length that it took over fifteen months to reinstate it for wheeled traffic. A length of over 1km on the Karamea Bluff was completely lost by landslide and rockfall, and the rest of the road to Corbyvale was destroyed by a series of slips. Residents from Corbyvale, isolated in the middle of this road, were evacuated on foot in mid July after it became apparent that access could not be re-instated readily. Karamea remained isolated by land and dependent on coastal ships into the river port. The first relief to Karamea was by a tiger Moth aeroplane landing on the beach 5 days after the EQ.

In Karamea (MM IX), the three bridges (Karamea, Quinlans and Oparapara) were all usable after the earthquake, despite subsidence of the abutments to Quinlan's bridge. All bridge approaches dropped 0.3 – 1m, Quinlans bridge had both end spans "let down" about 1 metre at the abutments. The Karamea bridge was damaged, with abutment fill slumped 0.6m at either end, and was removed following a large flood in 1931. On demolition, it was found that the piles had been broken, likely to have been earthquake damage. The roads within the Karamea flats were also affected by liquefaction and ground movement: " from here (Karamea) to the bridge used to be perfectly straight, but now it is in and out and up and down all the way. Likewise telegraph poles are leaning this way and that all the way".

As a general comment, Henderson reported "many road fillings across gullies spread at the base, fissured along their length, dropped and pulled away from the more solid ground at one or both ends. In some, one or both ends of the culverts were covered, in others the culverts wrenched apart or crushed. The slumping of bridge approaches caused considerable damage. The abutment walls tended to be forced toward the stream, in some cases allowing the bridge span to drop and in others thrusting the whole structure toward the opposite bank."

Restoration of the roads was continually hampered by aftershocks and rain bringing down further slips. One example illustrates this. About a week after the earthquake it was reported that the new concrete bridge across Doctors Creek is "down, the solid slab that formed the traffic way standing on end". The Doctors Creek bridge appears to have failed on 24 June as a report indicates that a team of linesman made it into Murchison by truck on the 23rd, but on their return to Glenhope the following day found the bridge tipped and impassable. At this time a debris flow also occurred at the Staircase, following a landslide damming a gully, and the resultant flood "was just like the Buller River itself in flood, but with big masses of timber being hurled about in all directions." The following day, "the huge trees which were there the previous night, blocking the road, had been shifted like matchwood right onto the bed of the Buller river, and leaving four times as much newly fallen timber and mud on the road. A temporary track and bridges of felled trees were erected to allow the evacuation of refugees over this area by foot. (Press June 28)

Comment: The impact of landslides on the roads in 1929 was clearly severe, and is indicative of the damage that could occur in South Westland. The damage to the upper Buller Gorge road was on a road at right angles to the fault rupture, whereas SH 6 in South Westland is parallel and close to the fault. Of particular note is the time needed to clear roads, and the ongoing problems with aftershocks and heavy rain remobilising the disturbed hillsides. The long times to restore some roads (22 months for the upper Buller Gorge, 15 months for the Karamea Road) might be expected to be greatly reduced with modern earthmoving equipment, but the much greater road widths and extent and height of cut batters may well increase the vulnerability of the current roads. In addition, the standard of road acceptable for re-opening is probably far different from 1929. It is clear that these roads would take at least months to re-establish today. South Westland has no alternative route to SH 6, unlike the ability to detour around the most damaged road in the Upper Buller gorge.

Also of note is that while many bridges were damaged, many appear to have been usable, at least for light traffic, but that some were subsequently destroyed by floods and debris. Given the very steep terrain along the Soyuth Westland range fron, the heavy rainfall the area is subject to, and the large *number of bridges and culverts on SH 6, damage to the road subsequent to the earthquake may be more severe than the direct damage.*

C.3 Drainage

Landslide dams formed lakes on the Matakitaki, Matiri, Maruia and Buller rivers. Warnings of possible floods from the breaching of these dams caused five ships to leave the port on day 2, and for many residenets of the town to camp out (in rain) on higher ground. Several large landslides blocked both the Mokihinui and Karamea Rivers. Landslides also dammed Glasseye and Tobin Creeks in the Karamea district.

The Matakitaki landslide of about 18 million cubic metres (which also buried two houses and killed four people) formed a lake 3 miles long and up to 25m deep, which took four days to fill. The lake apparently later silted up and became an area of willow trees, before washing out during a flood in the late 1930s, with no significant damage downstream. A slide in the Maruia also formed a 3 mile long lake, but the cone of debris was smaller and within 2 days the river had worked around its toe and cut a channel through terrace gravels and drained the lake. Rock falls from each side of the valley a little upstream of O'Sullivans bridge dammed the Buller River for 2 days.

The Mokihinui River was dammed about 1 mile below the forks (about 17km upstream of Seddonville), forming a lake about 20 m deep and extending several miles up the north branch. Two and a half weeks after the earthquake, part of the dam failed and the lake level fell about 8m. At Seddonville the river first rose at 2pm about 1.5m and stayed at that level until about 4:30 when it rose rapidly to peak at about 5pm, allowing little time for the residents to escape (if the flood had occurred at night it was thought that half of the 200 population would have died). Most of the township was flooded by up to 3m, forcing residents to flee or take refuge on their house roofs. Some houses were shifted off their foundations and a hall drifted about 100m before stopping against another building. The damage from the flood was much worse than the earthquake damage (Press July 6). The flood apparently choked in the narrow valley further downstream, with floodwaters passing through the Mokihinui railway tunnel, carrying away ballast and damaging the line. Most of the residents of Seddonville were evacuated following the flood. (Press July 12). On July 20, attempts were made to lower the remaining landslide dam in the Mokihinui, to prevent any re-occurrence of the flood.

The Karamea River was apparently blocked in several places, the lowest being near the junction of the Roaring Lion, and forming lakes up to 25m deep. Six months after the earthquake, one or more of these dams failed after heavy rain, and the low lying land around Karamea township was flooded. Aggradation in the Karamea raised the river bed by over 4m at the bridge, and later led to the closing of the port. There is also a report of flooding at Little Wanganui from a landslide dam failure.

Comment: The 1929 earthquake occurred in an unusually wet winter, and the extent of landsliding might be different now, but a similar earthquake must be expected to cause widespread landsliding with consequential problems of dammed river, debris flows and aggradation. For the Alpine fault earthquake, at least some landslides are a certainty with subsequent downstream effects.

C.4 Communications

Telegraph wires were broken south of Glenhope from the Nelson end and south of Reefton. Twelve hours (after the earthquake) a messenger from Murchison, who took nine hours to cover 30 miles, reported the first news to Glenhope. Restoration of lines started immediately with the dispatch of a party of linesmen. Connection to Murchison was made by midday on 19 June (day 3), but after 6 hours it was cut again by further slip movement and the falling of trees. Ongoing damage as the results of slips continued to break the line for well over a week after the earthquake.

Westport was isolated telegraphically, and news from that town was by wireless from one of the vessels in the harbour. Tiger Moth aeroplanes were sent on day 2 from Christchurch with wireless operators, landing on the beach. Communication was re-established between Westport and Granity to the north by using the railway telephone, Reefton to the east and Greymouth to the south within a few days. Communication was lost from Westport again on June 22 (day 6) when fresh slips severed the line through the Buller gorge. The mining towns remained cut off on June 24 (day 8).

The telephone system in Westport was badly affected by the collapse of part of the Post Office and its subsequent demolition. It was restored with the equipment being installed in a makeshift Post Office. Telephone services to the mining towns and Seddonville were working from about 26 June (day10).

By June 26, telegraph traffic was normal into Westport but Karamea was still isolated. The transport of an expert radio telegrapher and the necessary radio equipment to Karamea by air was delayed by poor weather until 1 July (day 15).

Comment: In this area, technology has changed most dramatically. However, land lines are still vulnerable, whether buried or on poles, both to initial damage and to subsequent landslide movement, debris flows and flooding.

C.5 Sewer

Ground fissuring ruptured pipes so that the sewer failed. In Derby St from Cobden to Gladstone Street, a distance of some 300m, the 9 inch main sewer was badly broken and some 30 house connections had to be renewed. In Romily St between Cobden and Bright Streets some 100m of the main and about 12 connections had to be renewed. (letter from Borough Engineer to mayor of Westport, August 1929.

C.6 Water

The water supply was cut in Westport (MM VIII). It appears that the main supply pipe was badly damaged over a considerable length in the Orowaiti River area. There was damage (cracked and "crumbling") to the reservoir dams, and within the town, inference that ground fissuring ruptured pipes, although the gas mains suffered little damage

On June 21 (day 5) it was reported "close to the railway station in Westport two men are pumping water for dear life. It is the town's only supply at present, for that in the river and creeks is too muddy to use. There is a constant stream of residents with containers…They have to keep the railway locomotives supplied as well. Fortunately the electric light has not failed and water may be obtained in the manner indicated, but sanitation is causing everybody a good deal of concern." (Press, 21 June) A day later a brewery and the railway department were arranging for water to be pumped from wells into the mains by steam power. Westport's water supply was partially restored by this means on 23 June (day7) to an area from the riverfront to Queen Street and from Brougham Street to Packington Street.

Elsewhere people were drawing water from whatever source was available. Dr Telford, Medical Officer of health, allowed only water from wells with a depth of 8m of more to be used. He placed a ban on a spring from which hundreds of people were drawing water, contaminating it with kerosene to make it non-potable, as it posed a potential health risk.

Meanwhile the Borough was working to reinstate the water mains. By the 29 June (day13) the smaller 8 inch main was in operation, although there was a shortage of 8 inch pipes, with just enough to complete repairs. "Had there been a more lengthy break the position would have been serious." The borough engineer reported "the 14 inch main would be unavailable until new pipes over a considerable distance were procured, as the pipes had been drawn apart, crunched by the earthquake and made quite unfit for further service." New pipes were to be ordered from the Wanganui Spiral Pipe Company for the earliest delivery. (Press 27 June). The services of the Railway Departments pumps were requisitioned to keep the mains full, and a steam fire engine was brought in from one of the outlying districts in case of any emergency.

A heavy aftershock on July 8 (day22) nearly brought down the bridge at Orawaiti carrying the water main to Westport. The work of straightening up and strengthening the bridge had just been completed, with the bridge being held up by the fastenings on to the railway bridge, which ran beside it.

Comment: Details are sketchy, but the vulnerability of Westport's water supply is clear. The details of the damage to the supply main are not known, but it may have been damage at pipe joints from ground distortion and possible liquefaction. It was clearly not an insignificant length of pipeline affected as it took nearly two weeks to repair the 8 inch line. Restoration of full supply had to wait until replacement pipe was made and delivered, and the 8 inch line was restored earlier only because *sufficient pipe was in stock in Westport. A well allowed a temporary supply, but there were areas without a water supply for a long time, with people resorting to potentially unsafe sources. There are clear parallels with the Hokitika water supply in that both towns are supplied with long gravity pipelines. The shaking intensity in Hokitika is expected to be greater than in Westport in 1929 (both MM VII, but Hokitika is closer to the MM IX isoseismal.*

APPENDIX D: NEEDS ASSESSMENT

Hokitika Business Person

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	3	3	9	3	2	6	Business totally reliant of other's leadership to look after his business/employees	Very high need for leadership in the business sector to see a way forward	As for "End of first month"
Info. in/out	3	3	9	2	3	6	2	3	6	Very high need to know what is happening to his company/staff and totally rilant on others	Less need for information in & out but still totally reliant on others	As for "End of first month"
Rescue/Med. Aid	3	3	9	0	3	0	0	3	0	ditto	Rescue & med aid is over	Rescue & med aid is over
Evacuation	3	3	9	1	3	3	0	2	0	Assume evacuation required as business at locations severely effected by EQ.	Evacuation of valuable equipment	Evacuation is over
Security	3	3	9	2	1	2	1	1	2	Vulnerability and Security of business as buildings will have been damaged	High need for security because operating on minimum staff but low reliance on others	Normal security
Relocation	0	0	0	3	2	6	1	2	2	Not yet considering relocation - concerned about immediate impact	Many staff & perhaps business require relocation to other centres for work/income	Relocation out is over. Not yet looking at relocating family of staff back to area
Counselling	0	0	0	3	2	6	2	2	4	No counselling at this stage	Business person needs support/advice to re-establish business. Staff need support	As for "End of first month"
Income & Insurance	0	3	0	3	3	9	3	3	9	Concern about immediate impact - not yet organising insurance claims and planning future income sources	Income required to retain staff. Insurance required to rebuild business	As for "End of first month"
Water	1	2	2	1	3	3	1	3	3	Normal need but high reliance on others for drinking quality water for employees	Normal needs and higher reliance in others	As for "End of first month"
Sanitation	1	1	1	1	3	3	1	3	3	Low reliance on others for sanitary system for employees	Normal needs & increasing need for reliance on formal sanitary system	As for "End of first month"
Food	2	3	6	1	3	3	1	3	3	Employee in EQ effected areas have high reliance on others for food	Normal needs and higher reliance in others	As for "End of first month"
Shelter	2	2	4	1	2	2	2	3	6	Potentially higher need. Depends on weather conditions	Assume business is not viable at this stage and only marginal in Westport. Premises demolished in Frans Josef (Health & safety issues) made safe but basically shut down in Hokitika	Re-building of business not yet underway because of small number of tourists. Businesses that are re-building have a high reliance on roads, trades people etc
Lighting & Heat	3	2	6	1	2	2	1	3	3	Higher need for lighting for security	Normal needs and less reliance on others because have small gensets	Normal needs and returning to high reliance on normal supply (national grid). Lower demand because people & businesses have left the area

Kokatahi Farmer

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	1	3	3	3	9	3	3	9	Strong need for leadership but provide in local farming community	Focus for leadership now outside the community as a clear regional path out of the emergency needs to be defined	Leadership still important as recovery is going to take years
Info. in/out	3	3	9	2	3	6	2	3	6	Feeling of isolation being cut off. High need for information from outside and total reliance others for the information	Less need although still high and now greater reliance on normal communication channels	Need still high because of future uncertainties and family now temporily relocated. Total reliance on normal communication channels
Rescue/Med . Aid	3	3	9	0	3	0	0	3	0	High need and total reliance on others	Rescue & med aid phase is over	Rescue & med aid is over
Evacuation	2	3	6	0	1	0	0	1	0	Only medical evacuees but totally reliant on others I.e. airlift	Evacuation phase is over	Evacuation phase is over
Security	1	1	1	1	1	1	1	1	1	Security not an issue	Security not an issue	Security not an issue
Relocation	0	0	0	3	2	6	1	2	2	Relocation not important at this early stage	Relocation of children with there mothers for schooling and because ongoing after shocks are frightening	Relocation out is over. Starting to relocating family members back to area as schools and others services are established again
Counselling	2	1	2	2	3	6	3	2	6	High need but rely on neighbours for support	Range of counselling required for trauma as well as advice on how to move forward/re-establish	Need still high but less reliance on professionals and more on family and neighbours etc
Income & Insurance	0	3	0	3	2	6	3	3	9	Concern about immediate impact - not yet organising insurance claims and planning how to recover	Very high need and high reliance. Not total reliance because of West Coast independence / entrepreneurial approach.	No farm income to speak of. High need and almost total on outside agency for income and capital to rebuild.
Water	1	0	0	1	0	0	1	0	0	Normal need and high but us own drinking water sources	Temporary and adequate supply established	Permanent private supply re-established.
Sanitation	1	0	0	1	0	0	1	0	0	Spade and a patch in the back yard adequate	Long drop facility established in back yard	Individual septic tank system operating again
Food	1	0	0	1	3	3	1	3	3	Self reliant	Normal need for food with some reliance on others for bread, cooking ingredient etc	Returned to normal needs and normal reliance on others
Shelter	2	1	2	1	2	2	1	1	1	Need for shelter but relatively self sufficient to arrange own temporary shelter	Starting to return to home however moderate reliance on outside agencies for building materials	Majority of repairs to home completed
Lighting & Heat	2	1	2	1	2	2	1	3	3	Higher need for lighting & heating because of emergency shelter conditions but low reliance on other	Normal need for lighting and heat with increasing reliance on others (national grid) as supply returns to normal	Normal need and return to total reliance on others (national grid + fuel suppliers)

Franz Josef Tourist

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	1	0	0	0	0	0	Foreign country, very high need and total reliance on others for leadership	Normal need but now in home country so no reliance on West Coast	Normal need but now in home country
Info. in/out	3	3	9	1	0	0	1	0	0	Very high need for information in and out and total reliance on others	ditto	ditto
Rescue/Med. Aid	3	3	9	0	0	0	1	0	0	Very high needs and total reliance on others	Now in home county	ditto
Evacuation	3	3	9	0	0	0	1	0	0	ditto	ditto	ditto
Security	3	2	6	2	0	0	1	0	0	Very high need and high reliance on others	Normal need but now in home country so no reliance on West Coast	ditto
Relocation	0	3	0	0	0	0	0	0	0	NA evacuation only	NA	ditto
Counselling	3	1	3	3	0	0	0	0	0	High need but rely on immediate community support	High need but now in home country so no reliance on West Coast	ditto
Income & Insurance	1	1	1	1	0	0	1	0	0	Very worried about this but insurance and income not a high need in first three days	Now in home county	ditto
Water	1	1	1	1	0	0	1	0	0	Normal need but natural water sources are found to be adequate	ditto	ditto
Sanitation	1	1	1	1	0	0	1	0	0	Normal need but forced to use a designated location	ditto	ditto
Food	2	3	6	1	0	0	1	0	0	High need and total reliance on other because don't have any food.	ditto	ditto
Shelter	2	3	6	1	0	0	1	0	0	High need because of likely poor weather and total reliance on other as most build are un-useable	ditto	ditto
Lighting & Heat	2	3	6	1	0	0	1	0	0	High need because of likely poor weather and total reliance on other as most build are un-useable	ditto	ditto

Hokitika Resident

Needs	First 3 days			End of 1st Month			End of 1st year			First 3 days	End of first month	End of first Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	3	3	9	3	3	9	Strong need for leadership to direct people and co-ord community effort	Still a high need and reliance on leadership for moral and to get things heading back to normal	Still a high need and high reliance on others to provide the leadership
Info. in/out	3	2	6	2	3	6	2	3	6	Hugh need for information (in/out) but local and word of mouth is working	Less need however greater reliance on normal communication channels	Still a high need for information and total reliance on normal communication channels
Rescue/Med. Aid	2	3	6	0	2	0	0	2	0	High reliance on expert help high need. Not as severe as Franz Josef as further from epicentre	Rescue & med aid phase is over	Rescue & med aid is over
Evacuation	2	3	6	0	3	0	0	3	0	Only medical evacuees but totally reliant on others I.e. airlift	Evacuation phase is over	Evacuation phase is over
Security	2	3	6	1	3	3	1	3	3	High need for security and high reliance on others to organise	Security returns to normal	Normal security
Relocation	0	3	0	2	3	6	1	3	3	Relocation not important at this early stage	Relocation of children with there mothers for schooling and because ongoing after shocks are frightening	Relocation out is over. Starting to relocating family members back to area
Counselling	0	3	0	2	3	6	2	3	6	No counselling at this stage	Range of counselling required for trauma as well as advice on how to move forward/re-establish	As for "End of first month"
Income & Insurance	1	1	1	3	2	6	2	2	4	Concern about immediate impact but not yet organising insurances claims or planning future income source	Very high need and high reliance. Not total reliance because of West Coast independence/entrepreneurial approach.	Less need but still high reliance.
Water	2	3	6	1	2	2	1	3	3	Normal need for water and high reliance on others. At CD posts almost total reliance on others.	As for 3 days but wanting to return to normal total reliance on other or drinking water	Return to normal need and total reliance on public water supply
Sanitation	2	2	4	1	1	1	1	3	3	Spade and a patch in the back yard adequate	Long drop facility established in back yard	Almost everyone has returned to using public sewerage scheme
Food	2	3	6	1	3	3	1	3	3	High need for food and high to total reliance on others	Normal need for food and total reliance on others	As for "End of first month"
Shelter	2	2	4	1	2	2	1	1	1	Normal need for shelter and high reliance on other because of unknown stability of home and continuing after shocks	People startig to return to their homes where habitable but still high reliance on others for shelter	Re-building of homes well underway. People have moved to their own temporary accomodation where required
Lighting & Heat	2	2	4	2	3	6	1	3	3	Higher need for lighting & heating because of emergency shelter conditions but low reliance on national grid - use gas bottles, wood & coal stores	Still higher than normal need however reliance on outside energy sources very high as locally available stock has been used up	Return to relatively normal demand as in better accomodation and now total reliance on other for energy souces

APPENDIX E: WORKSHOP ATTENDANCE LIST

Lifelines Workshop Attendance 20 & 21 September 2005

Lifelines

Peter Kingsbury	MCDEM	(2 days)
Simon Chambers	MCDEM	(2 days)
Steve Griffen	BDC	(2 days)
Rob Ruiter	Telecom	(2 days)
Mel Sutherland	GDC	(1 days)
Peter McConnell	GDC	(2 days)
Rob Daniel	WDC	(2 days)
John McKenzie	Transpower	(2 days)
Neville Higgs	Transit/Opus	(2 days)
Thomas O'Callaghan	Electronet	(2 days)
Rodger Griffiths	Electronet	(2 days)
	Buller Electricity	(2 days)
Chris Ingle	WCRC – Recovery Manager	(2 days)
Mary Trays	WCRC - Hazards Analyst	(2 days)
Nichola Costley	WCRC - EMO	(2 days)
	WCRC – Councillor	(Day 1)
Dave Brunsdon	National Lifelines Coordinator	(2 days)
Doug Truman	Regional Controller	(Day 1)

CEG

Brian Fancourt	St John	(morning day 1)
John Canning	Police	(Day 1)
Dave Hyde	NZFS	(Day 1)

Grey District

Mark Thomas	Councillor CD / NZFS	(2 days)
Allan Wilson	Controller GDC	(2 days)
Albie Rose	GDC CDO	(Day 1)

Buller District

Reg Barrell	BDC CDO	(2 days)

Luke Murphy	BDC Asset Engineer	(2 days)
Graham Crase		(Day 1)

<u>Others</u>

Chris Cowan	Coastwide Helicopters	(Day 1 weather dependent)

<u>Apologies</u>

Terry Archer – Annual leave