Grey District Lifelines Plan

Communities and Council

Alpine Fault Earthquake Scenario &

Lifelines Vulnerability Assessment

Grey District Council

December 2007

IMPORTANT NOTES

Acknowledgements

We would like to thank Grey Council Councillors, staff and contractors, as well as staff from other lifeline providers including Telecom, Regional Council, Westland and Buller District Councils, Transpower, Electronet, Buller Electricity, and Transit, along with the emergency services and West Coast CDEM for their time and valuable inputs to this report.

Civil Defence and Emergency Management Act 2002

"The Civil Defence and Emergency Management Act 2002 allows, under Section 7, a precautionary approach in managing risks: All persons exercising functions in relation to the development and implementation of civil defence emergency management plans under this Act may be cautious in managing risks even if there is scientific and technical uncertainty about those risks."

This approach has been adopted in preparing the Life-Lines Plan.

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 practioners should assess the site-specific hazard potential, including the potential for damage, at a more detailed scale.

EXECUTIVE SUMMARY

Aim

The aim of this report is to raise awareness of the issues and to make recommendations as to what should be done to make the Grey District Council 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 - but insofar as the ability of a modern community to survive a disaster depends on more than the integrity of its physical assets, the report also makes more general comments and recommendations on such matters as communication and leadership.

Approach

The report uses an Alpine Fault earthquake scenario as a tool for, and as a means of, identifying important issues. The scenario is not a prediction of what would actually happen in an earthquake but rather, a speculation on what could happen in a major disaster. An actual earthquake might be worse, or less severe, or significantly different on some way. The reasons for using a scenario are:

1. As a means of producing a prioritised checklist of what needs to be done to improve community resilience,
2. To assist those responsible for infrastructure assets to perceive a broader picture allowing them to imagine how their particular system fits into a much wider setting, and to see how interdependencies between services might affect their own, and
3. To give concrete stories that people can relate to rather than stay with the abstraction of facts and figures.

The Alpine Fault earthquake is chosen because there is a high probability of it occurring within the next few decades, and because it would be the most devastating natural event likely to affect not just the Grey District, but the whole of the West Coast and adjoining regions. It is important, however, to note that most of the issues raised here relate to any major disaster, and not just to an earthquake. Although some of the things we say do indeed relate specifically to earthquakes, nevertheless the general points we make and also many of the detailed recommendations will apply to any large disaster.

The scenario is developed in three stages or levels, namely:

1. The physical nature and characteristics of an Alpine Fault earthquake, and
2. The damage the earthquake will cause, particularly to lifelines.

The Scenario

The Alpine Fault runs the entire length of the West Coast region, but for the purposes of this scenario, a rupture is assumed to run from north of the Matakitaki Valley in the north to Haast in the south. The whole of the Grey District, which all lies within 30 km of the fault, will be strongly shaken, and damage will be severe particularly as the earthquake is expected to be of long duration.

Direct effects of the earthquake include:

- Ground rupture destroying buildings, roads and railways on or crossing the fault, and
- Shaking damage to buildings, bridges and infrastructure.

Secondary effects from the shaking include:

- Landslides, which are expected to be extensive, particularly in the MM VIII and IX zones and in the mountains, with some of them likely to create dams across rivers. Landslides are not expected to impact directly on urban areas to any significant extent; there may be a small number of houses in Greymouth that have slips come into their back yards. Landslides will, however, cause major damage to roads and railways.
- Liquefaction in sandy areas within river valleys, in low swampy ground and in the coastal strip, particularly estuary and river margin areas.
- Seiches (water waves generated by seismic oscillations) in Lake Brunner and other lakes.

Indirect and longer-term impacts will result from the large volumes of landslide material entering rivers, particularly those with catchments close to the fault. The increased sediment load will result in high river water turbidity, river build-up, channel erosion and changes of course, with implications for drinking water quality, river control, stop banks, and bridges.

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

Transportation: All roads in the District are effectively closed immediately after the earthquake due to landslides, destruction of the road surface or damage to bridges. In particular access roads to the airport and the Grey Base Hospital are likely to be cut. The District remains isolated from other centres on the West Coast for the first 48 hours and it is about a week before the first land based transport can reach Greymouth, coming from Nelson. Direct road access to Canterbury through the Lewis Pass is not restored until at least 16 days after the earthquake. Fuel shortage becomes a concern particularly diesel for vehicles and heavy machinery and natural gas for domestic needs. The Greymouth airport is severely damaged by liquefaction and unusable by fixed wing aircraft although the runway could be made usable to Hercules aircraft in a relatively short time. The railway lines are damaged / destroyed in many places and the Tranzalpine train is derailed at Inchbonnie with 31 deaths. The rail connection to Christchurch is not resumed for 2 months.

Drainage: Large landslide dams develop in the district as a result of the earthquake. Rainfall in the following weeks causes breaches to some dams and the resulting flood waves cause flooding and further damage. The Greymouth flood wall sustains longitudinal fissure damage and the crest is lowered by a metre in two places. Aggradation (build-up) in all rivers is an ongoing problem, and for some there is avulsion (changes of course). The Inchbonnie stop bank requires immediate and regular attention to hold back the threat of the Taramakau River diverting into Lake Moana and the Grey River.

Water Supply: Liquefaction causes widespread damage to older asbestos cement (AC) and cast iron (CI) reticulation networks particularly in Greymouth and Runanga/Rapahoe. Reservoirs are damaged. Water supply is partially resumed via standpipes and tanker supply after 24 hours. However it is over a month before full reticulated supplies are resumed. Also of concern is the poor water quality due to the ongoing increased build-up of gravel in rivers and erosion causing rivers to remain turbid, particularly for the Greymouth, Dobson-Taylorville and Stillwater systems and declining system capacity due to fine sediment clogging the intakes for Greymouth and Dobson-Taylorville.

Sewerage: Sewers and oxidation ponds are affected in areas subject to liquefaction. Sewer and pump stations are affected in areas west of the railway line in Greymouth, in particular the main sewers and outlets. Pump stations tilt, and slumping of the Karoro oxidation pond causes the effluent to breach the pond bank. Rain exacerbates sewer damage causing isolated pockets of sewage flow on to the ground surface.

Power Supply: Power supply is lost throughout the district. Resumption from local generation is delayed both because it requires connection to the national grid for frequency control and because of damage to the distribution network that cannot easily be fixed due to poor access. A reduced power supply is reinstated from the north to the Grey Valley and Greymouth after 48 hours (this is a very optimistic expectation).

Communications: There is widespread network failure including the mobile phone network and all fibre optic cables out of the district which effectively isolates Grey District apart from some dedicated VHF radio links. Telecommunication services 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 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, although food in particular becomes a higher priority issue as local supplies run out before reliable transport routes can be established.

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 and through Civil Defence and Emergency Management Groups. Civil Defence and Emergency Management for this disaster scenario will need regional if not national input.

Greymouth is in a special position in that for some time after the earthquake all land transport into and out of the West Coast will be routed through it.

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 GDC lifelines and physical assets, and what GDC needs to address. The scenario is used as a means of identifying what the GDC should address to best prepare itself for an earthquake. In so doing it will 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 GDC lifelines after a major earthquake, such as the Alpine Fault earthquake described in the scenario, are as follows:

1. *Airport*. Immediately after the earthquake the airport is likely to be the main route for getting expertise and urgent supplies into Grey District and for getting the more severely injured people out for medical assistance. The airport runway is likely to have sustained damage due to liquefaction. Immediately after the earthquake the runway will be levelled to the minimum standard to allow fixed wing aircraft such as Hercules to land. This is anticipated to take 24hr to 48hrs.
2. *Roads*. After the Alpine Fault earthquake the highest priority road access for which GDC is responsible will be to CDEM co-ordination centres and to the airport. The next highest priorities will be access roads for rescue, to the Hospital and to emergency community centres and distribution points within each community. These will be followed by access between higher population centres including a link to Moana as one of the closest communities to the Alpine Fault. Road access will be required to important utilities such as power, communications and water supplies to get them functioning on an emergency basis. Transit will be responsible for road links that will be required between the district and other parts of the South Island. Road access between the district and Nelson is optimistically expected to be established in about six days.
3. *Urban Drainage*. It is likely that urban drainage and sewerage systems will be extensively damaged leading to surcharging and ponding of sewage in low areas. This problem will be compounded, particularly in Greymouth, if there is significant rainfall after the earthquake. No attempt will be made to repair damaged drainage systems immediately.

However provisions for drainage are expected to be required at critical facilities such as the airport, the hospital and emergency centres and to be in place within 24 hours.

4. *Water supply*. After the Alpine Fault earthquake water supplies are likely to have no power to drive pumps, and reticulation systems are likely to have excessive leakage due to damaged pipes. It is anticipated that an emergency supply will be established at all five community water supplies within 2 to 4 days. Return to a normal water supply level of service is anticipated to take more than a month.

5. *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 Moana, will suffer significant damage. Apart from dealing with the public health risk that may be caused by ponding of sewage (discussed above under urban drainage) not much will be done about sewerage systems immediately after the earthquake. Individual households will be expected to build pit latrines in their gardens while Portaloos or similar will be provided at community centres by CDEM. It is anticipated that some areas will not be given clearance to return to using the sewerage system for weeks and in many areas clearance will not be given for months. Reducing inflow/infiltration (II) to an acceptable level is likely to take more than a year as it is expected that much of the II will be from individual service connections.

6. *Greymouth Port.* The port is liable to be damaged. There are also limitations in terms of existing facilities that may reduce its usefulness. However it is anticipated that the port may be a key transport route for bringing bulk supplies such as fuel into the district. It is expected that the port will be at least partially operational within 24 hours.

Recommendations

To be more prepared for a large and devastating earthquake GDC should address the recommendations presented in this report. They are summarised as follows:

Communication is of paramount importance. It has many aspects and issues, but the main distinctions are between the channel, the form and the content. All are important. Controllers and Infrastructure/Network Utility Managers 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*.* Some failures 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 Grey District affecting the long-term sustainability of infrastructure and the Grey District economy in general. We recommend that careful attention be paid to identifying potential failures with compounding consequences.

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. Because the interdependencies can be subtle in their detail and will be very dependent on the actual situation on the ground, this report cannot give a fully 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:

- Road access requirements and constraints;
- 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;
- 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 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;
- Multiple demands on limited information channels; and
- Operation of one lifeline (e.g. water supply pumps) being dependent on another (e.g. power supply).

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 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.

A similar argument can be presented for food and other every day consumables e.g. disposable nappies. These too rely on a continuous uninterrupted supply chain as only small quantities are held in stock on the Coast at any time.

***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:
  - Greymouth Airport including access to the airport,
  - The Port of Greymouth;

  - Access via rivers; and
  - Roads and bridges managed by Transit and GDC 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 and water supply reservoirs. Equipment restraint in pump stations, treatment plants etc; should also be considered.
- 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 and power companies, railways and so on should 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 the recovery of Council lifelines after a significant earthquake or other disaster as well as for the Council's wider roles in the recovery process. With respect to this latter aspect, strong coordination, communication and information links need to be established with Civil Defence and Emergency Management functions/groups. In addition integrated planning should take place with Civil Defence and Emergency Management functions/groups in order that Council and the community are as best prepared as possible to respond to an Alpine Fault Earthquake. Aspects 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 GDC so that they can be mobilised to the district and effectively assist in the recovery effort allowing GDC 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 Greymouth and Runanga;
- 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,
    - Installing of burst control valves on water supply reservoirs,
    - Considering installing standby generators for the airport, and sewerage and storm schemes, and possibly some water supplies, and.
    - Reviewing critical network infrastructure and establishing a store of emergency spare parts, particularly for material and equipment that are likely to not be available locally, or are not normally “off the shelf” items.

Grey District Council Lifelines Study
Alpine Fault Earthquake Scenario & Lifelines Vulnerability Assessment

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Cover photograph:

Rotomanu-Inchbonnie Road with the Alpine Fault along the toe of the hillsides on the left of the valley

1 INTRODUCTION

Grey District Council (GDC) is responsible for managing key infrastructure assets including water supply, sewerage, storm water and district road assets. GDC has an essential role to play in reducing, being ready for, responding to and recovering from any disaster in the district. In 2004 GDC engaged consultants to help them identify priorities in terms of overall planning of the response to a major disaster. A first draft of the GDC Lifelines Study was released in May 2005. Copies of the draft were widely circulated on 26th May 2005 and comments on the draft were received until early August. A final draft of the GDC Lifelines Study was released in August 2005.

Lifeline studies have subsequently been completed for Buller and Westland Districts and for the West Coast Regional Council. In view of this, GDC engaged the consultants to update the first GDC Lifelines Report to incorporate lessons learnt from preparing the other Councils' lifeline reports. The present study responds to this requirement. GDC also wanted to widen its focus to include broader community issues in addition to the narrower and more technical matters relating to lifelines. These have been examined in the companion report: "Grey District Communities – An Alpine Fault Earthquake Scenario". In taking a broader approach the present report necessarily takes a more holistic view of the problem and expands the detail of the earthquake scenario.

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. The study examines lifelines; that is, the network services of water, sewage, transport, power, and communications which are essential to the functioning of a community.

The consultants have used an overarching 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. What would happen in an actual earthquake would be different in one way or another. Rather, the scenario gives a plausible and feasible picture of a possible major and widespread disaster in sufficient detail to enable the needs and priorities of the GDC 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 develops its specific recommendations for the GDC 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 in turn 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 greater impact on the District as a whole than any other potential earthquake,
- 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, and
- It is the same scenario as that used for the Buller District and Westland District Lifeline studies. An Alpine Fault earthquake will have a major 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 GDC 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 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 two workshops to discuss district lifeline assets. They were held in Greymouth on the 21st of October 2004 and at Punakaiki on the 20th & 21st of September 2005. Organisations invited to the workshops included:

Buller DC	Westland DC	Communications contractor	Buller Port
WCRC	Fuel companies	St Johns Ambulance	Greymouth Port
MCDEM	Helicopter pilots	Communication companies	NZ Fire Service
NZ Police	Rockgas	Toll Holdings/Trackco	Transit NZ/Opus
Grey DC	Hokitika airport	Regional & Local Controllers	Electricity Companies
Radio NZ	Supermarkets	Iveagh Bay Service Operator	TVNZ

A list of those who attended the workshops is presented in Appendix D.
The two workshops used the Alpine Fault earthquake 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 workshops 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 been included here.

The report develops the earthquake scenario in two stages. First, it discusses the earthquake itself and describes the resulting damage and effects, primarily focussing on physical effects and lifeline issues. It then considers the situations, reactions and needs of communities within the Grey District. In considering needs, reference is made to the companion report "Grey District Communities – An Alpine Fault Earthquake Scenario" along with the stories of four individuals after an Alpine Fault Earthquake. The stories of individuals were developed during the preparation of the Alpine Fault earthquake scenario lifelines studies completed for Buller District Council, Westland District Council, and the West Coast Regional Council in June, 2006.

Looking at the two stages in more detail, the development begins with Section 2 of the report. This 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.

The earthquake scenario is then developed and provides a description of the physical damage. This study uses a more damaging scenario than that presented in the August 2005 Study in order to highlight critical aspects that might not be as apparent from a less damaging scenario. The scenario is based on experience of earthquakes elsewhere in New Zealand and the world. As a "reality check", a description of the actual impacts of the 1929 Buller earthquake is given in Appendix C. This was a smaller earthquake with the major area of damage largely away from developed areas and with 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.

Section 3 explores the needs and priorities of individuals and communities, and the implications these could have on Council's response. Three categories of communities are defined and examples of communities in each category are provided.

Section 4 examines in detail GDC's main infrastructure assets and assets managed by others including rail, State Highways, telecommunications, power, fuel and regional flood protection assets. The affects of a major earthquake on GDC assets are looked at along with key principles for reinstatement of the assets and emergency levels of service for assets. Improvements are identified to allow recovery after the earthquake to proceed more effectively. The assets managed by others are described, significant risks are identified and improvements are suggested.

Finally, Section 5 concludes the study. 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.

2 EARTHQUAKE SCENARIO

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 snapshots 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 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 Grey District is shown in Figure 2.1. It can be seen that the fault runs roughly parallel to the Grey River about 30 km to the south east, and runs through Inchbonnie, Rotomanu and Haupiri.

Movement on the fault is 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. 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. The northern limits of these previous fault ruptures are indicated on Figure 2.1.

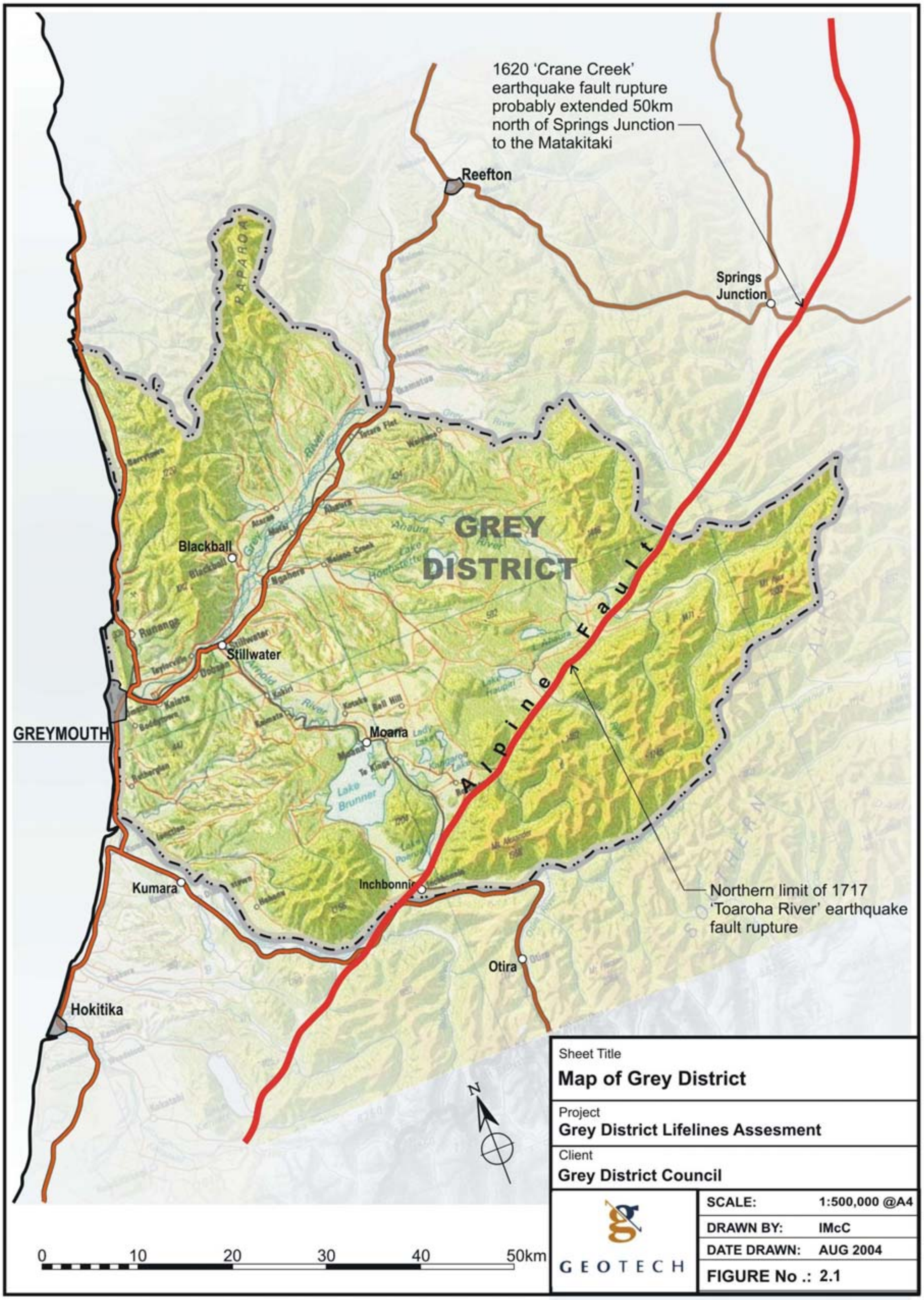


Figure 2.1 Location of Alpine Fault in Grey District

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 probabilities for 2007 would 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. The 1717 earthquake did not extend as far north as the 1620 event, but this may well be because it occurred only 100 years later and strains had not developed in the somewhat less active northern part. It is most likely that the next earthquake will include rupture north of Haupiri along all the fault length within the District (Yetton, pers. comm. 2004). 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 100 years or more.

Virtually the whole of the Grey District will experience strong shaking. It will be most intense closest to the Southern Alps and the fault trace. The settlements of Inchbonnie, Rotomanu and Haupiri are almost on the trace and can expect the most intense shaking, but Moana, Mitchells and Otira will all experience Modified Mercalli Intensity shaking of VIII - IX. Further west the towns of Greymouth and Kumara and the Grey Valley settlements of Dobson, Stillwater, Blackball, Ngahere, Ahaura and Ikamatua, as well as Runanga and Rapahoe and even Barrytown, will experience strong shaking of MM VII – VIII. This is likely to be the strongest shaking experienced in these towns since settlement of the district. Previous highest intensities for Greymouth were about MM VII in the 1929 Buller (Murchison) earthquake and MM VII in the 1968 Inangauha earthquake.

Direct effects of the earthquake will include:

- Ground rupture destroying buildings, road and railways on or crossing the fault, and
- Shaking damage to buildings and bridges, and to infrastructure such as water supplies, sewerage, power and telephone.

Secondary effects from earthquake shaking include;

- Liquefaction in sandy areas within river valleys, in low swampy ground near Lakes Brunner and Poerua and the coastal strip, particularly the estuary and river margin area of Greymouth.
- 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 damage to parts of Greymouth but few other towns and settlements in the main area of very strong shaking are close to slopes. Slips and landslides will cause considerable damage to roads and railways.
- Seiches (water waves generated by seismic oscillations) could be produced on Lake Brunner 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. 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 Grey 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 bridge piers and abutments for many years.

2.2 Ground Shaking Hazard

The lifelines are assessed at a general level in this report. However, when engineers look 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 epicentre 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 Grey District in Figure 2.3. This map is based on the synthetic isoseismals for the 1620 earthquake in Yetton *et al* (1998). The isoseismals have been modified in the north east to allow for the possibility of fault rupture in the next event extending north of Haupiri to the Matakitaki valley. The map shows a decrease in shaking across the District toward the northwest as distance increases from the Alpine Fault. Associated with shaking intensity is ground acceleration, and contours of possible peak ground acceleration are shown on Figure 2.4.

Both maps (Figures 2.3 and 2.4) 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 thicknesses and their depths. Areas underlain with deep 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. 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 (the delta area of the Crooked River at Lake Brunner) and the sea (mouth of the Grey River).

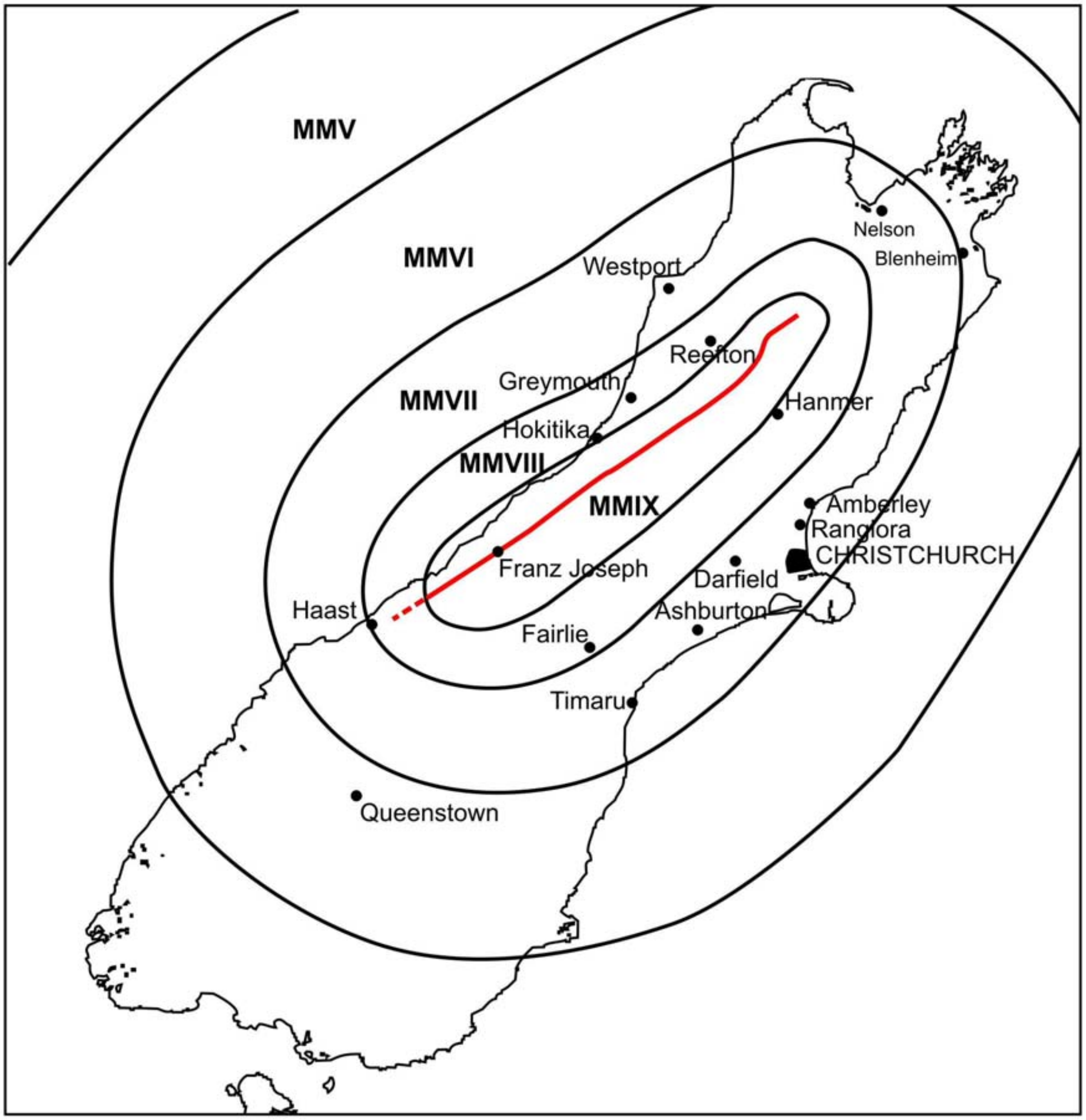


Figure 2.2: Estimated Modified Mercalli intensity isoseismals (lines defining equal shaking intensity) for the Alpine Fault earthquake scenario (adapted from Yetton et al. (1998) 1620 AD earthquake, modified for fault rupture further to the north).

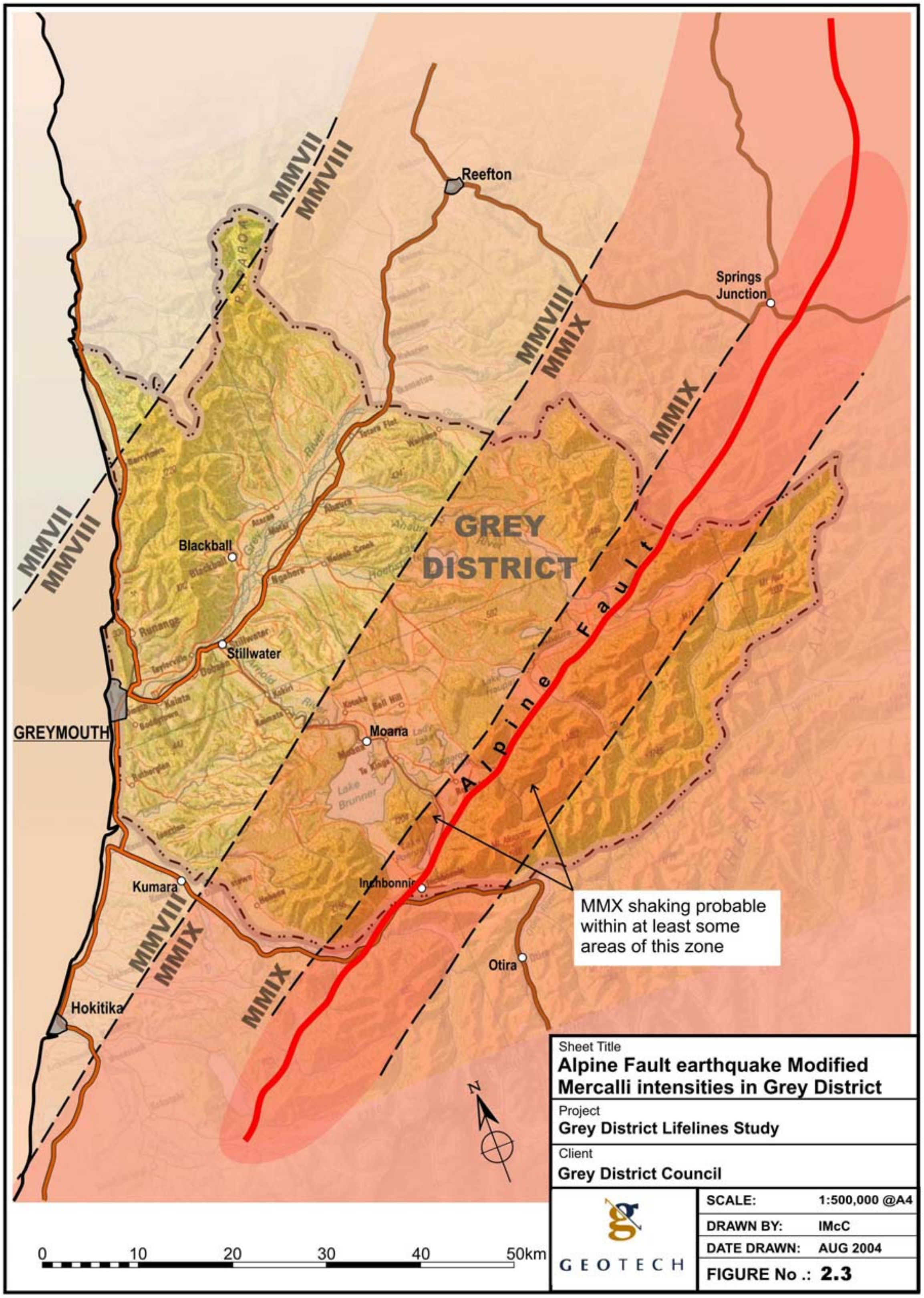


Figure 2.3: Alpine Fault Earthquake Modified Mercalli Intensity in Grey District

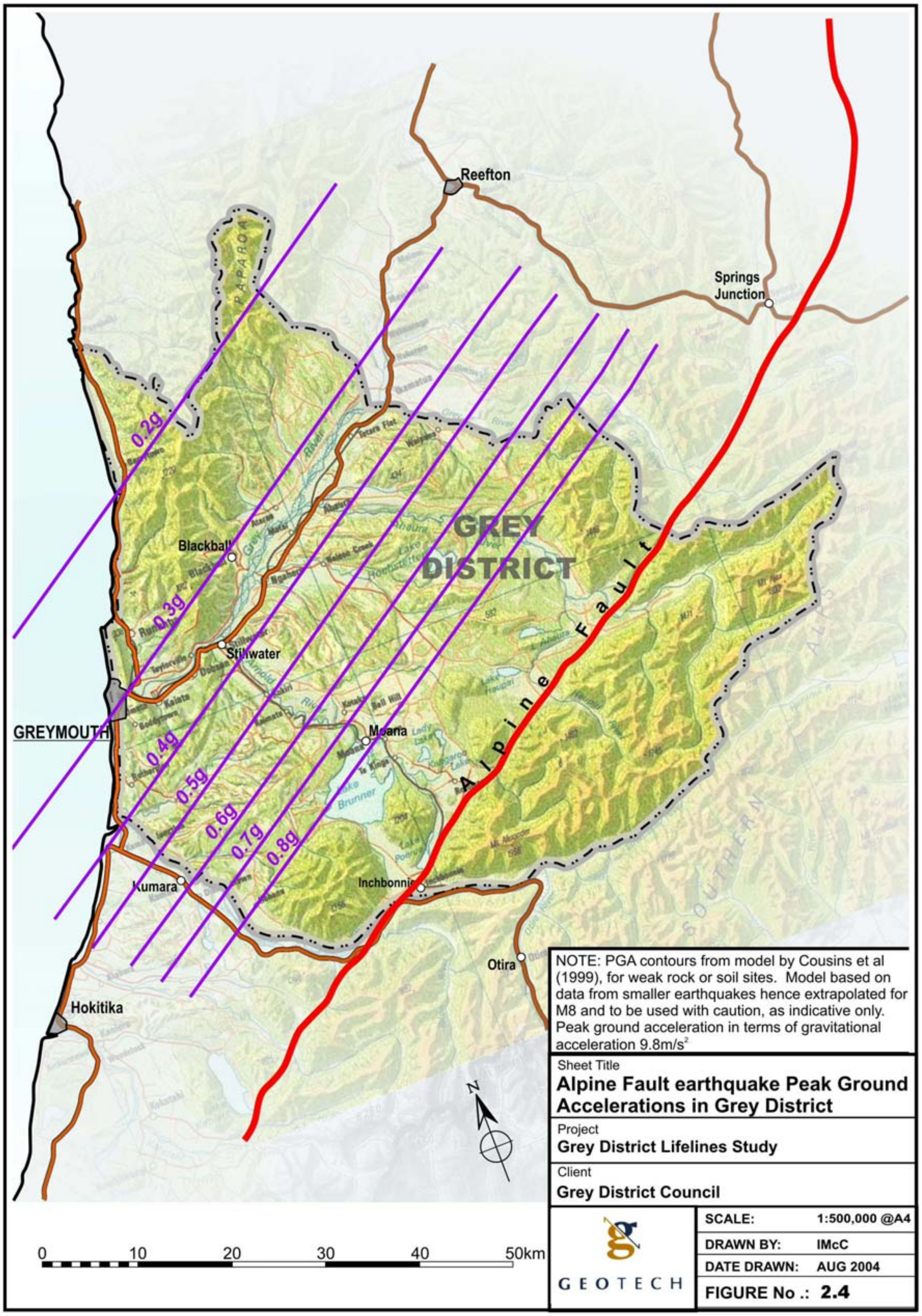


Figure 2.4: Alpine Fault Earthquake Peak Ground Accelerations in Grey District

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. The uncertainties in earthquake prediction and the lack of information on subsurface conditions make five classes unrealistic for a regional scale study such as this. The three zones are listed in Table 2.1, and shown for the District in Figure 2.5, the Greymouth urban area at a larger scale in Figure 2.6, and the South beach – Cameron area in Figure 2.7.

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

Figures 2.5 – 2.7 are based on simplified geological groupings i.e. areas underlain with strong rock at shallow depth, intermediate ground conditions with a shallow to moderate depth of soil overlying soft rock, and areas underlain with deep soils. In conjunction with Table 2.1, this zoning can be used to refine the shaking and peak ground accelerations in Figures 2.3 and 2.4, which assume average conditions. Any reduction of effects close to the epicentral area (defined here as being that area within 5 km of the fault rupture) should be made with caution.

The ground shaking zones have been derived directly from published geological maps (Nathan; 2002, Suggate, 1998). 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 Figure 2.5 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 to be indicative only, and it is recommended that any critical facility should have a site specific analysis.**

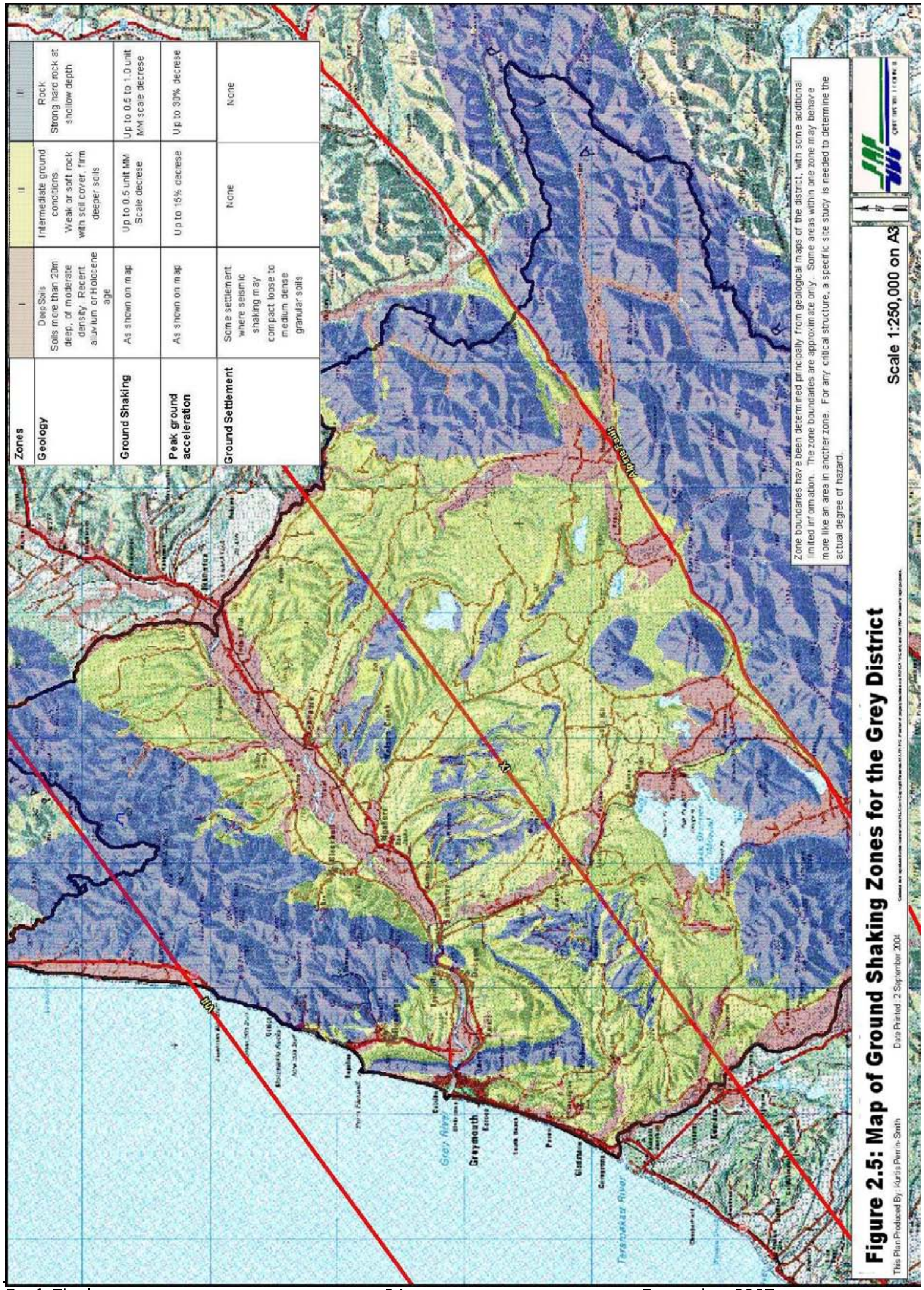
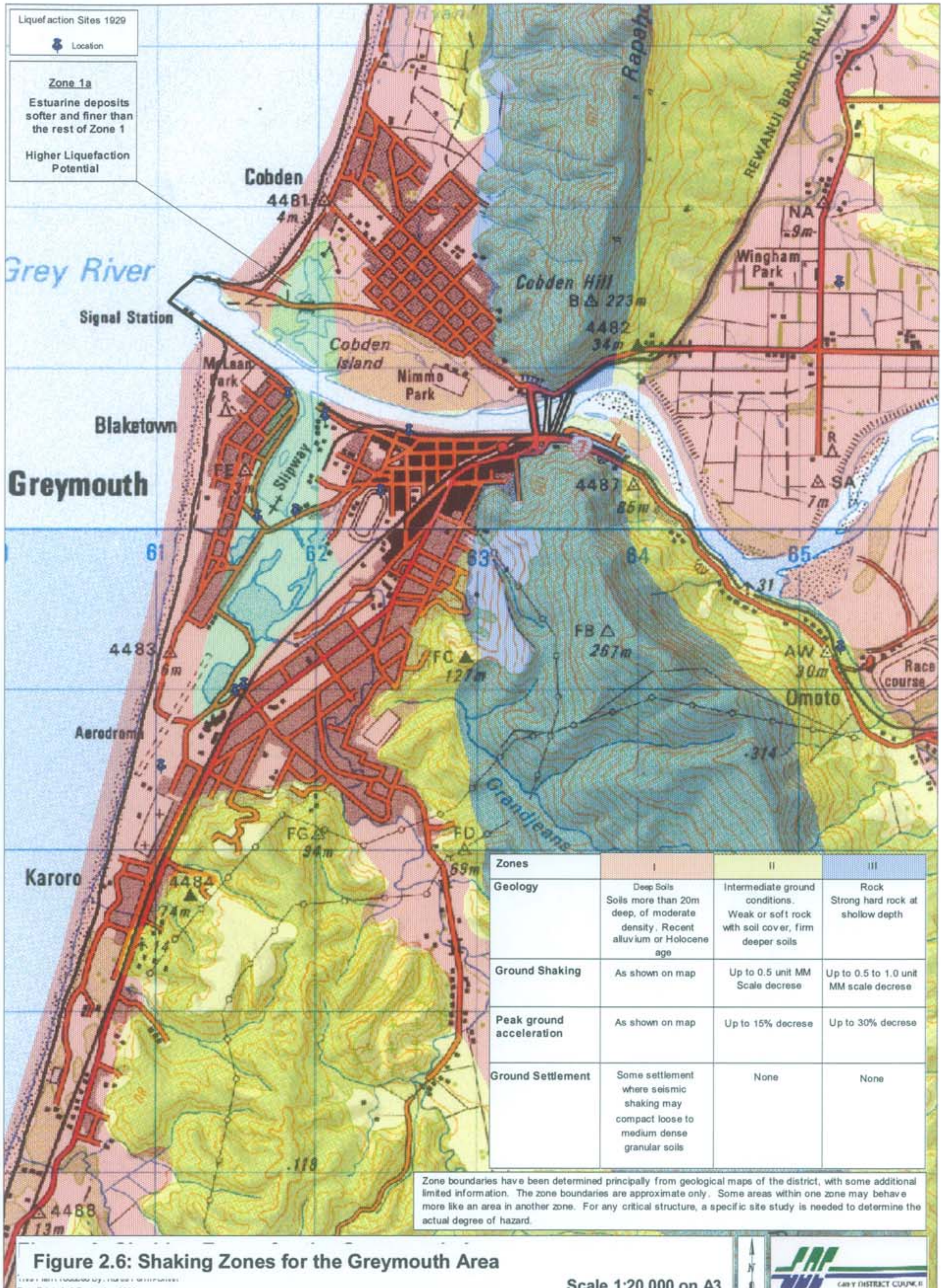


Figure 2.5: Map of Ground Shaking Zones for the Grey District



Zones	I	II	III
Geology	Deep Soils 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	Rock Strong hard rock at shallow depth
Ground Shaking	As shown on map	Up to 0.5 unit MM Scale decrese	Up to 0.5 to 1.0 unit MM scale decrese
Peak ground acceleration	As shown on map	Up to 15% decrese	Up to 30% decrese
Ground Settlement	Some settlement where seismic shaking may compact loose to medium dense granular soils	None	None

Figure 2.6: Shaking Zones for the Greymouth Area

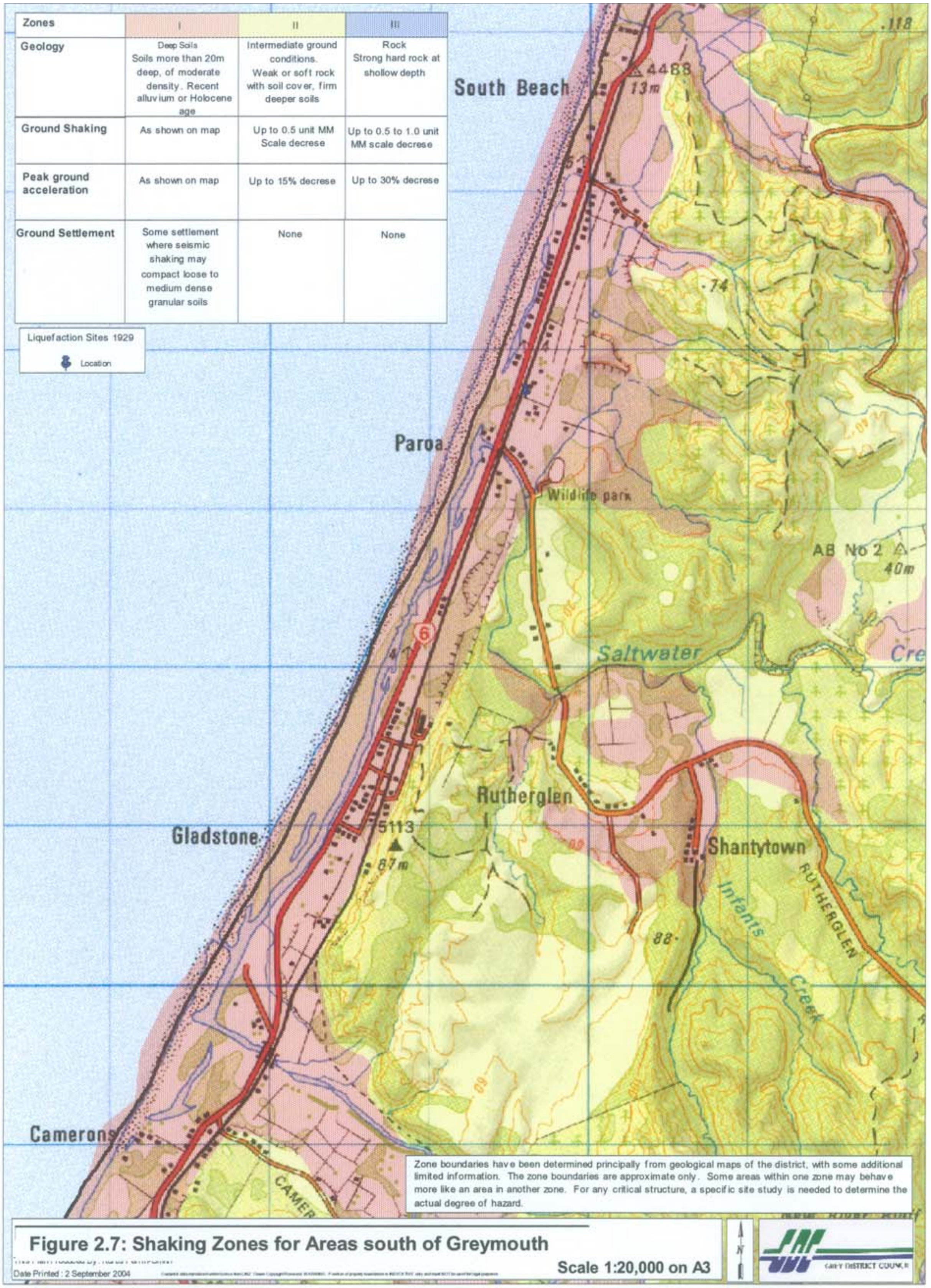


Figure 2.7: Shaking Zones for Areas south of Greymouth

In the larger scale map of Greymouth (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.

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 acceleration (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 and in liquefaction analysis.

Peak ground accelerations (PGA) from the earthquake have been estimated from the attenuation model of Cousins *et al* (1999). These are shown as PGA contours across the District on Figure 2.4, for weak rock or soil 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 the eastern half of Grey District, as it lies 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 increase or decrease in shaking intensity of 0.5MM unit, the equation has been used to calculate the corresponding change in PGA for zone 1 and 3 relative to zone 2, as shown in Table 2.1.

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 pipework 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. Thus the short duration of the Inangauha earthquake produced little liquefaction in the Grey District, although closer than the longer duration Buller earthquake of 1929. 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 gravelly 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.

The areas of geologically recent alluvium tend to be gravel dominated with only lenses of sand (except for some lake sediments in the high country). However, Carr (2004) records many localities on the West Coast that have experienced liquefaction historically, summarised in table 2.3.

Table 2.3: Historical Liquefaction on the West Coast

Earthquake	Year	Magnitude (Ms)	Number of sites with reported liquefaction	Range of epicentral distances (km)
Westport	1913	> 5	1	Unknown
Buller	1929	7.8	43	8 – 122
Westport	1962	5.9	2	18 – 20
Inangahua	1968	7.4	15	8 – 30
Hawkes Crag	1991	6.1	3	11 – 21

Of these sites, 12 were within the Grey District, and all occurred in the 1929 Buller earthquake, at distances from the epicentre of between 113 and 122 km. This earthquake produced moderate shaking throughout the District, with the MM VII isoseismal passing approximately through Lake Brunner and the coast a short distance south of Greymouth. In Greymouth, surface effects that are probably caused by liquefaction were reported in 7 locations, all west of the Hokitika rail line. Other sites were at Coal creek, opposite Wingham Park, the road into Omoto racecourse, Paroa and near the Greenstone River Bridge, east of Kumara. The liquefaction sites are shown on the ground shaking maps in Figures 2.6 and 2.7. It should be noted that liquefaction may also have occurred elsewhere in the District but was not reported, given the population and state of development at the time.

No reported liquefaction effects occurred in Greymouth during the 1968 Inangauha earthquake, although a number of pipes had to be replaced in the town, which may have been a result of lateral spreading. Although this earthquake did produce stronger shaking than the 1929 Buller earthquake, with the MM VIII isoseismal passing close to Blackball, Ngahere and south of Lake Hochstetter, and the MM VII isoseismal in the vicinity of Arthur's Pass and Hokitika, it was of shorter duration.

There is only limited potential for liquefaction in the Grey District on an area basis, but it is clear that liquefaction has occurred and can be expected to occur with shaking from an Alpine Fault earthquake. Of significance is the expected long duration of strong shaking with the Alpine Fault, which could cause liquefaction to occur at sites that were only marginally affected in historical events. 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, which also tend to have more development than elsewhere.

In particular, the area around Greymouth contains some estuarine deposits and at least some liquefaction is probable in the area between the town and Blaketown, including the airport. 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 lake sediments, 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 Moana and Iveagh Bay are also 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.

Liquefaction is expected to occur in susceptible soils at distances of up to 250 km from the earthquake epicenteral area. As the whole of the Grey District is within 40 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.

In conclusion, although the areas susceptible to liquefaction are limited within the GDC they tend to also be areas of greatest infrastructure development.

2.3.2 Liquefaction Zones

The Liquefaction zones correspond with the ground shaking zones on Figure 2.5. The boundaries between these zones are approximate only. The location of any site within one of these zones 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 between Blaketown and the main town, and where liquefaction is known to have occurred in 1929. The boundary to this zone is approximate only, as there is insufficient data to define this area.

Zone 2 covers areas of alluvium older than Holocene age. These 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.

Zone 3 is the remaining areas of the map, which are underlain with rock or hill soils that 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 this general zoning procedure, 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. The total number of landslides over an area comparable with Grey District (4,500 km^2) could have been about 10,000. Fourteen of the 17 deaths in the 1929 Buller earthquake were from landslides. Metcalf (1993) reports a rockslide in the Cobden Quarry triggered by this earthquake. It was estimated at 60,000 – 100,000 tonnes of rock, with some debris thrown up to 100 m from the source. The Buller earthquake occurred in a wetter than normal June, and the extent of landsliding will be somewhat dependent on the antecedent rainfall and climatic regime.

There is also evidence of landslides directly associated with the Alpine Fault in Westland. Wright 1998 has identified two debris lobes 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 (particularly Tertiary sedimentary rock types) 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.

Specific details about landslides within the Grey District are not readily available. Metcalf (1993) reports on five within Greymouth. One is a large 270m x 80m x 20-30m deep rock block slide in mudstone which has moved 20 – 30 m down slope towards Grandjeans creek behind the town. It is surmised that this was an earthquake triggered failure. Very close to it is debris from a rock avalanche extending 600 – 700 m down slope from trig FC. Of two slides Metcalf studied on State Highway 6 near Karoro, one was a 140m long by 60 m wide failure in the surficial colluvium, triggered by rainfall, and the other was a 350 m by 350m wide slide within mudstone, postulated to have been triggered by undercutting from marine erosion at least 4,800 years ago. The fifth slide is the Omoto landslide which has had documented movement since 1896, with failure within a deep colluvium that has accumulated down slope of the steep limestone and mudstone scarp of Peter Ridge. Most incidents of movement appear to have been rainfall triggered, but it is reported that "extensive" slips occurred at Omoto with the 1962 Westport earthquake.

There are a number of empirical methods to assess the extent of landsliding. 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. His conclusions are summarised in Table 2.4.

Table 2.4 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 Christchurch	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 map 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 River in South Westland. This landslide is thought to have occurred in 1717, during the last Alpine Fault 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 km2 in an area of 2,400 km2 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 Westland. 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 Brunner 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 Brunner with high steep hillsides rising directly from the lake within 7 to 10 km from the fault line, or on Lake Poerua within 2 km of the fault.

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 Grey District is regarded as low, but the coastal settlements, including lower parts of Greymouth and Cobden, 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 the New Zealand land mass 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 South Westland coastline, water depths increase rapidly from the coastline, and only little to moderate increase in tsunami height is expected, but the coastal shelf widens and shallows in a northerly direction past Grey District with an increasing potential for greater tsunami height. 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 west of the railway between Paroa and Karoro, Blaketown and the seaward parts of Cobden, parts of Rapahoe, and sections of the coastal road to Punakaiki. 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.

2.7 Earthquake Scenario for Grey District

This section outlines a possible Alpine Fault earthquake scenario for Grey District with particular regard to the potential impact of an earthquake on the lifelines systems. The emphasis is very much on the physical infrastructure and contains little reference to the social and logistical aspects of the disaster and subsequent recovery. These aspects are explored in the three community scenarios presented in “Grey District Communities – An Alpine Fault Earthquake Scenario” report..

It is important to realise that this earthquake would be much larger than anything we have experienced anywhere in New Zealand for a long time. It would devastate much of the West Coast and cause widespread damage over much of the South Island. There will be many deaths and a great number of injured. Transport and communication between the West Coast and the rest of New Zealand will be extremely limited for at least several days, with external assistance likely to be by air only. The Alpine Fault earthquake will be a regional disaster, affecting a much larger area than just Grey District, and this wider situation must be appreciated in considering the consequences for GDC. South Westland will be particularly badly affected, with SH6 severed by landslides and bridge collapses along its entire length south of Ross. Limited on-site supplies will mean an increasingly desperate situation in remote locations, together with the problem of evacuating some 3000 tourists. A major rescue and evacuation operation will be necessary for this area, which will deplete resources for response within Grey District, particularly as the distances are so large: Christchurch is nearer to Greymouth (170 km) than is Haast (250 km), yet there is a high chance that Greymouth will be involved in supporting the response needed for South Westland. Many evacuees will be brought into Hokitika and Greymouth for temporary accommodation.

There will be continuing aftershocks which will add damage to already damaged buildings and facilities and cause further landslips and other physical consequences. These aftershocks will go on for weeks if not months. Some, and perhaps many, deaths seem inevitable, particularly in outlying areas where medical help or rescue has not arrived in time. The social disruption would be on such a scale that local efforts in restoring services and lifelines would be hard, simply because the right personnel would not be available at the right times, for a variety of reasons. Accounts of major earthquakes all describe a chaotic situation after the shaking. Any underlying assumption of an orderly response is likely to be wildly optimistic.

This scenario, and the community scenarios following, are based on historical accounts of earthquakes translated into the Grey district. One problem with such a translation is how much the situation in Napier, 1931, Inangauha, 1968 or even Edgecumbe in 1986 is relevant to Grey District in 2007. There are the physical changes relating to improved aseismic construction materials which may reduce infrastructural damage, which should have reduced the vulnerability of more recently built structures, but offsetting these are socio-economic factors which may well make our society much more vulnerable. In 1931, people's lifestyle was much simpler. Our current dependence on telephones, computers, electricity and rapid transportation did not exist then. Many residents in suburban areas would have vegetable plots, for instance. Nowadays, many households are probably self sufficient for only about 3 days for food, water and fuel. Stocks held in supermarkets and stores are very limited. As this earthquake could easily cut all supply routes for a week, there could be a severe shortage of food and fuel for at least four days. Babies and the elderly would be especially vulnerable. Food supplies might have to be flown into Greymouth and Hokitika from Australia and elsewhere by Hercules aircraft; but then there would be the difficulty of distributing it in time to communities, even those as close in as Moana, and certainly those in South Westland. This could well be a disaster of almost unimaginable magnitude for New Zealand, especially in the light of our recent relatively benign history of natural events and the growth of a just-in-time style of operating which leaves little room for self-sufficiency. Issues of getting the sewage and telephone systems up and running again could fade into insignificance given the desperation of many people simply struggling to survive in the first few weeks.

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. The first version of this scenario, in 2005 was deliberately made optimistic in terms of damage and recovery. For this second edition of the study, the extent of damage and time for recovery have been increased to reduce the optimism, and highlight better some of the complexities and interdependencies that are likely to follow a large natural disaster.

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 lifeline 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 Grey District, the surrounding Districts and the remainder of the South Island. This is because impacts outside the District would have a direct and significant effect on the ability and speed with which Grey District could 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 themselves, this is not so significant, except that rainfall patterns both before and after the earthquake would impact on the number and nature of landslides both immediately and following the event, and the likelihood of damaging floods. In this second edition of the lifelines study the timing of the earthquake has been changed from mid morning in late winter to mid day, in mid February. This has been done to examine more closely the impact on recovery of lifelines when there is maximum demand on resources. In this scenario the timing of the earthquake is important. Visitor numbers at this time of year (mid summer) are much higher than in late winter. The initial response is significantly more complicated with large numbers of people trapped in South Westland and outlying areas of the District. At the time chosen a trainload of passengers is trapped in the epicentral area. The time of the earthquake sees the focus of resources during the early part of recovery directed towards the huge job of rescuing and evacuating visitors and locals from earthquake affected areas with particular urgency being given to a derailed train at Inchbonnie and to the tourist centres of Franz Josef and Fox Glacier. Although Franz Josef and Fox are well outside the Grey District, dealing with the disaster there would affect resources available in Grey and delay the re-instatement of lifeline services.

2.7.1 Time zero - 11:30am on a weekday morning in mid February

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 11:30am there is a very large earthquake (M_s 8) on the Alpine Fault with an epicentre near the Whitcombe Pass, approximately 10km east of the Alpine Fault trace.

The fault ruptures over a length from Haast in the south to north of the Matakitaki Valley in the north. The fault movement on the section through the Grey District is 8 m horizontally and 1 m vertically at the south boundary (Inchbonnie) decreasing to 6m horizontally and 0.5m vertically at the north boundary, (north of Haupiri). 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) but between 30 and 40 seconds towards the north west of the District.

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 Grey District at a larger scale. Shaking intensities for localities across the South Island are listed in Table 2.5.

Table 2.5: Shaking Intensities at Selected South Island Centres

Intensity	Localities within Grey District		Localities within South Island	
MM IX +	Inchbonnie	Haupiri	Franz Josef	Arthur's Pass
	Moana	Rotomanu	Mt Cook	Springs Junction
	Mitchells	Otira	Fox Glacier	
MM VIII	Kumara	Blackball	Hokitika	Culverden
	Paroa	Ngahere	Reefton	Springfield
	Greymouth	Ahaura	Inangahua	Fairlie
	Runanga	Ikamatua	Murchison	Twizel
	Dobson	Rapahoe	Nelson Lakes	Haast
	Stillwater	Barrytown	Hanmer Springs	
MM VII			Westport	Ashburton
			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 we note here the description of MM VIII and IX as defined by the Study Group (1992):

Table 2.6: 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.

An unknown number of people are without shelter. There is steady light rain. People are initially attending to their direct needs and the needs of those around them. As the reality of the situation starts to sink in and ongoing aftershocks continue people are becoming more frightened and traumatised. Some of the skilled personal (CD co-ordinators, contractors, police, emergency personal etc) have been injured and others are worried as they are unable to find out whether their families and loved ones are safe …

2.7.2 Time zero plus 5 minutes

Within **time zero plus 5 minutes** of the first shaking there is damage to lifelines in the epicentral and near epicentral areas as follows:

(a) Transport

Fault rupture severely damages the Jacksons – Inchbonnie road. The road is offset 8m horizontally and 1m vertically. The Inchbonnie – Rotomanu road is cut by the fault rupture close to where the road is closest to Lake Poerua and again close to Homestead Creek. Offsets are again 8m horizontally and 1m vertically, but the fault cuts the roads diagonally and about 50m of road at each location is destroyed. Fault rupture also severs and badly damages 0.5km of Wallace Road, inland from Kopara with 7m horizontal offset, and the Ahaura – Amuri Rd east of Haupiri, with 6.5m horizontal and 0.7m vertical offset.

Over 9km of the Inchbonnie – Rotomanu Road is within 500m of the fault and suffers distortion and fissuring over much of this length. A landslide buries 100m of road with debris up to 5m thick close to the railway crossing.

Two large landslides each bury about 100m of the Kumara – Inchbonnie Road near Camp point. A 200m long section of the Ahaura – Kopara Road is lost into the head of a landslide into the Ahaura River at Griffin Flat. Small landslips and rockfalls onto roads are common on virtually all the roads east of Moana. The Taylorville – Blackball Road is blocked by falls in three places east of Brunner.

Liquefaction affects a section of Cashmere Bay Road with severe distortion, fissuring and sand ejection. The foreshore road at Moana and short sections of the Arnold Valley Road in the Aratika area are similarly affected. Liquefaction affects a number of roads within Greymouth. A seiche in Lake Brunner submerges the foreshore, floods the basement to the yacht club and damages both the marina and yachts both in the water and parked on trailers and leaves the foreshore road covered with debris and boats. The marina banks are damaged by liquefaction.

All the bridges on the Inchbonnie - Rotomanu Road are damaged. All three bridges over the Crooked River are damaged to the extent of being impassable. The Moana – Rotomanu Rd is blocked by a small landslide close to the end of the Crooked River Bridge, which also suffers damage to the west abutment and settlement of the fill at the east abutment. The Cashmere Road Bridge loses two spans due to liquefaction damage to a pier, and the railway bridge is severely damaged with the north abutment and adjacent pier moving laterally towards the river, partially dropping the end span and effectively blocking the road under it. The Arnold valley road bridge across the Arnold River at Aratika has partially collapsed.

The Haupiri River Bridge at Kopara is badly damaged. The Taramakau River bridge at Jacksons is also damaged, with abutment slumping making it impassable. The rail overbridge at Stillwater has been damaged by deformation of the piers which act as retaining walls. The Rough River Bridge is badly distorted with one pier severely cracked. There is significant damage to the bridge over the Taramakau at Kumara. Slumping of fill at abutments is commonplace throughout the District, and almost universal east of Moana. Two people are killed when they drive into a bridge end near Ngahere.

There are many shallow slides in the hill areas of Greymouth. A slip on Milton Road isolates Arnott Heights. Slips and rockfalls have blocked the Taylorville - Blackball Road in several places, some with large trees across the road as well as soil and rock, and a dropout has taken out two-thirds of the road just south of Ruby Creek. There are also slips blocking the roads north of Blackball and between Blackball and Roa.

The Transit highways within the District are also affected. SH7 provides the main access up the Grey Valley. The bridge across the Grey River near Ikamatua is damaged and slumping occurs at both abutments. Similar damage occurs to the Ahaura River, Nelson Creek and Arnold River bridges. The road is completely blocked by a jack-knifed and overturned petrol tanker east of Ahaura. Fuel is spilling onto the road. A rockfall damages the west end of the Kiwi overbridge near Stillwater, which also suffers column damage. The rail overbridge to SH6 east of Stillwater suffers movement and cracking of both abutments, but remains standing. There are minor rock and gravel falls in cuttings between Dobson and Totara flat. The Omoto slip moves and disrupts the road but the road remains passable for high clearance vehicles.

SH6 north of Greymouth is affected by rockfalls at many places along the steep coastal section, as well as a large dropout 1km north of Rapahoe, and at the Cobden Bluff. There is minor liquefaction damage at Canoe Creek, and minor damage to Cobden Bluff overbridge and Camp overbridge. Liquefaction affects short sections of the road between Runanga and

Rapahoe and opposite Wingham Park. The Grey River Bridge suffers only minimal damage, with some settlement of the abutment fill. A rockfall blocks half the approach loop road from Mawhera Quay, and a large rockfall in the Cobden Quarry propels isolated boulders onto the north approaches.

SH6 south of Greymouth is disrupted by liquefaction damage in areas between Karoro and Camerons. The South Beach overbridge is damaged by liquefaction under its shallow foundations. Both the Saltwater Creek and the New River bridges are damaged but remain negotiable to light traffic. The Taramakau Bridge is only slightly damaged.

Outside the District, SH6 through Haast to Otago is severely damaged with fault rupture, bridge damage and several failures and widespread landslides. It is also cut by falls and landslides through the Upper Buller Gorge and as far north as Glenhope. SH7 is cut by a bridge collapse in Canterbury and large landslides on the west side of the Lewis Pass as well as fault rupture. SH 73 is cut by fault rupture at Rocky Point, bridge collapse at Taipo River and significant damage to the Turiwhate Creek, Big Wainihinihi and Otira River bridges. The road is severely damaged by landslides in the Rocky Point area, throughout the Otira and Bealey Valleys. Some of these slides are very large.

The Greymouth aerodrome has been damaged by liquefaction with the runway distorted and fissured and partially covered with ejected sand.

The Midland Railway is cut by the fault rupture near Homestead Creek and 100m of track is destroyed. The TranzAlpine passenger train is derailed and partially overturned between Inchbonnie and Lake Poerua and a coal train is also derailed between Ngahere and Ahaura. The bridge at Te Kinga is badly damaged by liquefaction failure around the piers. Further east the railway is badly affected with damage to embankments and bridges. There are small falls on cuttings to Greymouth and the line is distorted and damaged by movement on the Omoto slip. The Hokitika line is damaged by liquefaction effects in places near South Beach and some bridges are damaged. The Runanga branch line and the Westport line are also damaged with some embankment slumping, slips and distortion to bridges.

(b) Drainage

There are large landslide dams in the Crooked and Haupiri Rivers, Waikiti, Trent and Waiheke (all tributaries to the Ahaura River) and a small dam on the Ahaura River at Griffin Flat. The rivers are completely blocked at all these locations. A relatively small landslide near Brums Creek has blocked the Poerua River and the lake outlet. The light rain is not yet affecting the river or stream levels.

Liquefaction under some short lengths, in conjunction with dislodgement of rock on the steep batter, has damaged the river length of the Greymouth floodwall. Some lengths have longitudinal fissures and the crest has been lowered by a metre in two places. Large portions of the floodwall parallel to Packers Quay, Steer Avenue and around Preston Road are all damaged by liquefaction-induced lateral spreading and fissuring.
The stopbank to the Taramakau River at Inchbonnie is damaged by batter failures and is severed and offset 8m by fault rupture.

The suspension footbridge across the Lake Brunner outlet collapses when liquefaction removes the support of the west tower, and the bridge and cables act as a debris trap. The Arnold Power Station has been significantly damaged with partial failure of the dam, aqueduct and powerhouse. The failures have increased the flow in the river, but only to a medium flood size, as the dam impoundment drains.

(c) Sewerage

The oxidation pond at Moana is moderately damaged with distortion of the embankments and cracking of the concrete waveband. Liquefaction in sands under the site causes lateral spreading that damages the north west corner of the pond wall, and allows water ingress into ground fissures. The sewers are damaged. All pump stations are stopped due to power supply interruption, but have little significant damage, except for one on the foreshore that is flooded and suffers impact damage to the superstructure from the lake seiche.

There are a number of pipe failures in the Runanga reticulation, but only minor damage occurs to the oxidation ponds. The reno mattress waveband accommodates the small bank movements.

In Greymouth, there are many breaks in the pipework. The sewers are thrown out of line and level by liquefaction in Bright St between Hall and Clifford Streets, and the outlet pipe in Cobden, the landward side of Blaketown and the lower parts of the business area also suffer. The main sewer from Cowper St to Blaketown collapses in a number of places along its elevated section due to liquefaction damage and lateral spreading. The main outlet from the business area is disrupted by liquefaction damage and pipe breakage at the pump station. There is widespread damage to the Karoro – Paroa sewers both through pipe failure and liquefaction. The pumping station at South Beach is tilted and pipe connections severed, and liquefaction under a corner of the oxidation ponds causes the bank to breach and the pond half empties. The wave band is broken in a number of places.

(d) Water supply

All the water supply intakes are affected and all pumps stop. The intake wells for Runanga are damaged by liquefaction, as is the pump building and aerator. The supply main to Runanga is old AC pipe and is broken in many places, particularly between the intake and McLean's Pit Rd where liquefaction affects the line. There is widespread damage within the reticulation (AC pipe). The pipe to Rapahoe is severely damaged by ground distortion and liquefaction. The Runanga reservoir is cracked.

The supply main to Greymouth is undamaged until the Cobden Bridge, where abutment settlement has severed the pipe at the south end, and a join has pulled open part way across the bridge. Movement of the Omoto Slip is only about 0.5m but the suddenness of this has broken all the pipes (brittle AC and CI) into the reservoir. The reservoir itself is cracked, but remains operational. Within the Greymouth reticulation, there is widespread damage, particularly in the older AC and CI pipes, and in the lower areas around the lagoons in Cobden and Blaketown where liquefaction has affected some of the pipe routes. The Arnott pump station equipment falls over.

The Dobson system is damaged with breaks throughout the distribution system, but the intake and pipes across the river survive with only some distortion. The reservoir is undamaged.

Both the Blackball and Stillwater systems suffer a small number of breaks, and both the reservoirs are cracked.

(e) 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. The only generating station within the district, on the Arnold River, has suffered severe damage.

(f) Communications

Fixed line phones within parts of Greymouth 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 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.

2.7.3 Time zero plus 1 hour

(a) Transport

The situation in the epicentral zone between Inchbonnie and Haupiri and as far west as Moana is one of widespread devastation with all roads effectively blocked and most bridges damaged. Traffic movement is occurring elsewhere, but is greatly disrupted by debris on the roads and slumping at many bridge abutments. The rail overbridge at South Beach effectively stops traffic to the south. The Cobden Bridge over the Grey River at Greymouth has not been officially inspected, but is being used in any case, despite a small settlement at the south abutment.

All traffic on the railway has been suspended. The TranzAlpine train partially overturned when derailed with the strong earthquake and there are some dead and many injured. The driver was killed and the locomotive radio could not be found to alert Railway traffic control. There is no co-ordination with respect to aircraft and helicopters as yet.

(b) Drainage

There is no immediate issue, with priorities elsewhere. The rain is now heavy over most of the district, with increasing wind.

(c) Sewerage

Sewerage is flowing on the ground in numerous places in Greymouth. The seepage into the damaged bank at the Moana oxidation ponds causes a bank failure into the gully, and within a short time the pond has drained and effluent is effectively flowing directly into the Arnold River.

(d) Water supply

There is no water being pumped into any of the schemes. The breaks in the main pipes at the Cobden bridge and to the Omoto reservoir are discharging water and the whole system has no pressure. The Omoto reservoir is emptying, but the water is contained within a gully and is flowing through a culvert and not causing damage. Breaks in the system are also draining the Arnott Heights and Stanton Crescent reservoirs. Similar draining of reservoirs is occurring at Runanga and Dobson. The Scada control system is down with loss of links and battery stand failures.

A number of fires have broken out in Greymouth and Runanga. In one location in Blaketown, fire from one house has spread into a row of five old timber houses with minimal gaps between them. In the business area, a fire has started close to the Farmers store. The Greymouth fire crews are on site, but are having difficulty in positioning a portable pump to take water direct from the river.

(e) Power Supply

Power remains off throughout the whole District. Back up generators at the 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. There is limited land-line coverage within Greymouth only.

2.7.4 Time zero plus 3 hours

(a) Transport

The Cobden bridge has been officially re-opened for light traffic, with the abutment slumping filled and rocks cleared. At South Beach, a local contractor has cleared a route under the Mill Creek rail bridge behind Fuelquip that allows four wheel drive vehicles past the obstruction. There is little traffic other than people attempting to return to their homes. An excavator and front end loader are working east from Greymouth clearing debris from SH7 and smoothing the worst distortions in the Omoto slip. An excavator is doing a similar task on SH6 towards Runanga.

Locals at Inchbonnie have assisted the passengers at the train wreck, but no communication has been possible with the outside world. There are no helicopters available for reconnaissance of lifelines, because of the number of helicopters damaged and the priority given to rescue both within, but more particularly outside the district.

(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 Greymouth have been closed, but the flow out of the Omoto reservoir remains unchecked as there is no suitably positioned valve to stop it. All systems except Blackball and Stillwater are effectively inoperative with no water. The South Beach reservoir half drained before the valve was closed.

(e) Power Supply

No change

(f) Telecommunications

No change.

2.7.5 Time zero plus 9 hours

It is now getting dark. Rain continues. The train wreck was found by a search helicopter at 6pm. Two helicopters subsequently evacuated about 20 of the more seriously injured survivors and brought back some medical supplies, but a further 5 people have died from injuries to bring the total deaths to 31. The remaining passengers are either at the train, staying with those too injured to be moved, or sheltering in the damaged farm buildings nearby. There are 15 confirmed deaths in Greymouth, and 6 deaths from the rural areas.

(a) Transport

SH 6 is still blocked by rockfalls north of Rapahoe and is only negotiable by 4WD between Rapahoe and Greymouth, but SH6 south to Arahura has been reopened for essential 4WD drive traffic. The Arahura River bridge has been damaged in both piers and superstructure and remains closed. SH7 is closed at the Kiwi overbridge and by abutment damage at other bridges. The Stillwater bridge over the Grey is closed to all but pedestrian traffic pending inspection. Runanga, Taylorville and Dobson are all accessible for traffic from Greymouth, but Blackball is still isolated. The Arnold Valley Road is blocked by bridge damage east of Aratika, but an alternative route for 4WD is possible through Blair settlement. Road access east of Moana is still impossible. A tour operator has communicated that two tour buses are missing somewhere between Greymouth and Westport. It is likely that other buses en route are affected.

(b) Drainage

There is no immediate issue, with priorities elsewhere. The heavy rain continues. However, anxiety is rising about the condition of the Taramakau River and the Inchbonnie stopbank.

(c) Sewerage

No change.

(d) Water supply

The main Greymouth intake has been checked and pumps manually turned on with power supplied by a portable generator. A standpipe has been installed at the Cobden end of the Cobden Bridge and a water tanker is ferrying water to the Civil Defence posts at the schools and the hospital. 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.

2.7.6 Time zero plus 24 hours

There has been heavy rain throughout the night, but it has now eased to light showers. Confirmed deaths have now reached 73.

(a) Transport

The Stillwater Bridge over the Grey was reopened at 10 am and essential light traffic could reach Ngahere from Greymouth via Taylorville, with a detour through the Stillwater railway yards past the damaged overbridge. However, further debris at one of the slips, dislodged by rain and aftershocks, overwhelmed the loader working at the site half an hour later. Access to Reefton and the remaining settlements in the Grey Valley are expected to be accessible by essential four-wheel drive vehicles within a few hours. This requires filling some bridge approaches, pulling the overturned tanker clear and spreading grit over the spilled fuel. A road to Moana has been reopened for four-wheel drive traffic. Because of flooding in the Crooked River and damage to all bridges over it, vehicle access to Rotomanu is still impossible. The Arahura bridge remains closed, still severing Greymouth from Hokitika. The coastal route to Westport is still closed between Rapahoe and Barrytown The inland route through Reefton and Inangauha is expected to open within a few hours, but it appears that the Alpine SH links of SH6, 7 and 73 will all be closed for some days (if not weeks). The West Coast is effectively isolated.

A bulldozer has re-levelled the Greymouth airport and it is now open to Hercules and light aircraft.

(b) Drainage

The landslide dam on the Waikiti River overtopped at about 5 am. The resulting flood wave caused some damage in the upper Ahaura and then precipitated a breach of the landslide dam at Griffen Flat. The subsequent combined flood water laden with debris washed out one abutment and a pier on the SH7 Ahaura Bridge at about 8 am, but dissipated on the broader Grey River flood plain. High flows in the Taramakau have entered a flood channel adjacent to the Inchbonnie stopbank, and a small flow is passing through the ruptured bank and across farmland to McArthur Rd. The local farmer observed this at 10am, and has advised Greymouth via a train rescue helicopter pilot. Flows in the Grey River are moderate and do not appear to be worsening the damage to the Greymouth floodwalls as yet.

(c) Sewerage

No change.

(d) Water supply

Repairs have been made to the main distribution line in Greymouth and water is now available at standpipes at Sturge St in Cobden, and in the business area (this assumes that spares are on hand). A standpipe has been fitted at South Beach to distribute the 250m^3 of water remaining in the South Beach reservoir. The Dobson intake has been checked, and could be restarted as soon as a power supply is secured. The water is turbid and all water is to be boiled. Water tankers continue to take water to the Civil Emergency posts in Greymouth, and enough tankers are being procured by Civil Defence to take water to Runanga, Taylorville and Dobson by late in the afternoon.

(e) Power Supply

Trustpower have checked the Dillmans Hydro scheme and are planning to restart the Kumara power station. However, checks to transmission lines have to be completed first and without synchronisation from the grid to control the frequency, its output would be confined to about 1MW. The small stations in Westland District are similarly affected. The Arnold Station is inoperative. Repair to distribution lines is happening, but is constrained in part by road damage restricting access. Because there is no electrical power, barbecue units and gas cookers normally used for camping are being used to cook food and heat water at Civil Defence centres and in homes that are still habitable.

(f) Telecommunications

There is no change. Helicopters are still not available to check on damage, and there is little information on where the problems may be. Telecom is arranging for a helicopter and a team of cable specialists to fly in from the North Island to start locating and repairing breaks in the fibre optic cables. The fibre optic cable over the Ahaura Bridge was cut when part of the bridge was washed out.

2.7.7 Time zero plus 48 hours

The weather has cleared. Small aftershocks continue at frequent intervals, with occasional larger ones. Communication remains severely constrained and no contact has been made with many outlying areas. Conditions are grim with most buildings damaged to some degree, with the contents of all buildings in chaos, no power, no water in many areas, and over 30 hours of cool and wet weather. Most of the population is traumatised. Two house fires and one death occurred when the occupants used solid fuel burners without realising that flue and chimney damage had occurred. A major concern of CDEM is the large number of tourists trapped in South Westland, and this continues to divert helicopters and light aircraft from other activities.

(a) Transport

Clearing of roads continues. Progress is now faster with the improvement in the weather but fuel is running out and there less than a day's supply left. Some machines have already run out and been abandoned. The coastal road to Westport is still closed, as are both roads up the Grey Valley because of the bridge damage at the Rough and Ahaura Rivers. This damage would take time to repair, and CDEM have just decided to concentrate on reopening the coastal route. This follows a helicopter flyover of the road, both to ascertain damage and to locate trapped vehicles. One of the two missing buses is safe between two slips, but the second had overturned down a steep bank with three deaths. Traffic is confined to single lanes in many places on the roads that have been re-opened. 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.

With the clearing weather, most of the population of Rotomanu have walked out to Moana. A group of 60 of the least injured passengers from the train have walked out to Lake Brunner and been taken by boat to Moana. Efforts are being made to reinstate road access to Rotomanu, as heavy equipment is needed at the train wreck to allow body recovery. Radio contact with the community at Haupiri indicates that most of these people also intend to leave, but require to be met as far up the Haupiri Road as vehicles can get.

There are difficulties with fuel. Many vehicles have now used what petrol was in their tanks at the time of the earthquake, and CDEM have locked down all fuel supplies. Many people have to walk.

Four Hercules aircraft have come into Greymouth airport in the last 24hrs bringing in much needed emergency supplies, and search and rescue teams, and evacuating seriously injured people to Christchurch.

(b) Drainage

The landslide dam in the Crooked River has overtopped, but only limited scour of the dam occurred and no significant flood resulted downstream. The Taramakau River has dropped and water is no longer flowing through the stopbank breach. A WCRC engineer has just flown in to inspect the stopbank. The local farmer would fill the breach using a digger in the area as an interim measure.

(c) Sewerage

No change

(d) Water supply

The main pipe has been repaired as far as Cobden School and the end of Tainui Street in Greymouth. Lay flat hose has been used from hydrant to hydrant to bypass damaged lengths to get water to the hospital. Milk tankers in the district when the earthquake occurred have been commandeered by CDEM and continue to take water to the Civil Emergency posts. The Taylorville / Dobson intake pumps have been restarted and water is available at a standpipe in each settlement. The Stillwater and Blackball systems are operating, but with 10% of the areas cut off due to pipe damage.

(e) Power Supply

Transpower has reinstated supply from the north, and the Grey Valley settlements, Runanga and Greymouth are now all on reduced power. However most houses remain without power and continue to use alternative power sources (mostly gas) for cooking. Moana remains without power. Food stored in freezer units at shops and supermarkets has thawed and is being thrown out.

(f) Fuel

Fuel is of critical concern, and is available to essential vehicles and plant only. Underground fuel supplies initially could not be accessed, as there is no power to drive the fuel pumps. However, two contractors had their own pumps, a manual pump has been adapted to allow diesel to be pumped out via the measuring rod access point, and several service stations have been able to use portable generators to power their pumps.

(g) 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.

2.7.8 Time zero plus I 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. Fuel supplies effectively ran out on day 4. Despite attempts to get fuel in by barge, this could not be done in time. CDEM restricted remaining fuel to the highest priority tasks, including the clearing of SH6 north to Westport. Road clearance to Rotomanu had to be stopped, but had progressed sufficiently to allow 4WD access with a bypass to the Crooked River bridge across farmland and a ford in the river which has now gone down.

The first transport from Nelson reached Greymouth via Westport and the coastal road on day 6 after the earthquake. Supplies of food and fuel were among the first deliveries, but they barely began to address the problems of the 30,000 people still on the Coast. The road to Lake Haupiri was reopened to essential traffic the same day. SH7 over the Lewis Pass remains closed, but a repair team is at work erecting a temporary bridge in the Waiau Valley west of Hamner. No reinstatement has been attempted on the roads past Rotomanu and the Inchbonnie area remains isolated, as does Mitchells. Residents from these areas have been using boats on Lake Brunner to access Moana.

The Kiwi Overbridge has been temporally bypassed with a bulldozed track over the railway line suitable for four-wheel drive, partially reopening SH7 between Dobson and Stillwater. The railway embankment next to Mills Creek rail bridge has been cut to establish a two way route without height restriction past the South Beach Overbridge. Repair work to the Arahura Bridge has allowed heavy vehicles to move between Greymouth and Hokitika.

The emergency measures to reinstate road access at Kiwi and South Beach over bridges have effectively cut the railway line. The railways remain inoperative and no effort has been spent on repairing them as yet. The train wreck remains as it was, with several bodies remaining in the wreckage, as it has proved impossible to bring large enough equipment to site. Those bodies able to be moved have been taken to the Greymouth morgue by farm bike and 4WD.

(b) Drainage

A helicopter survey of the mountain catchments on day 4 has identified six landslide dams with the potential to breach and cause flooding downstream. It has started to rain heavily in the alpine areas again. The stopbank breach at Inchbonnie has been temporarily filled with earth, but the stopbank capacity is limited and its integrity remains a concern

(c) Sewerage

Temporary drains have been excavated in places to take sewerage into the Blaketown lagoon from the damaged pipes, and the discharge from the business area has been cleared to allow gravity drainage.

(d) Water supply

The strong aftershock on day 3 damaged the temporary repairs to the pipe at the Cobden Bridge abutment. 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. There have been delays due to insufficient spares and because for the first few days many staff were unavailable as they had to meet family needs. Water has been reinstated to 20% of Greymouth and Cobden at a reduced pressure. The Omoto reservoir remains out of operation. Dobson and Taylorville remain serviced with standpipes, as repairs to the distribution system have to wait until more urgent repairs are done. Runanga remains dependent on tankered water to temporary tanks and standpipes, as does Paroa and South Beach.

(e) Power Supply

Power supply is still unreliable. Aftershocks have damaged repair work and frustrated progress in reinstating power supply. Supplies of natural gas reached Greymouth on day 6 after the earthquake on the first trucks through from Nelson. Power was restored to Moana township on day 5, but most isolated farms are without power.

(f) 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.

2.7.9 Time zero plus 2 weeks

(a) Transport

Rain during the second week triggered a large number of slips within earthquake weakened ground, including six within Greymouth. Roads were closed for up to 2 days as a result of remobilised slips. Temporary repairs allowed the Rough River Bridge and access between Greymouth and Reefton to be reopened for light traffic on day 12. No repair work has started to road and bridge access to evacuated areas, such as Haupiri. Fuel is being brought into the West Coast Region and to Greymouth as one of the main distribution centres. However fuel is restricted to the clean up effort with little on none available for private use.

(b) Drainage

Intermittent heavy rain during the second week caused all the main rivers in the District to rise. A debris flow in the Rotomanu area destroyed a house and completely buried a road bridge. A new slip temporarily blocked the Evans River, and the resulting flood when it breached caused further damage to the Crooked River bridges. The landslide dam on the Trent River breached on day 13. The resulting flood wave caused flooding in the Haupiri flats, and caused local problems at Ahaura where it washed away fill being placed to infill the failed section of a bridge. The flood further downstream was large but not exceptional and did not threaten Greymouth, although more material was lost from the river side of the damaged floodwall. A bulldozer pulling a compacting roller negotiated the damaged road from Moana to Inchbonnie on day 10, and is at work carrying out proper repairs to the stopbank, in conjunction with an excavator that was already at Inchbonnie.

(c) Sewerage

The rain has exacerbated the effects of the sewer damage in Greymouth, with increased flows into the Blaketown lagoon and isolated pockets of sewage flow on the ground surface. The flood in the Grey 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 50% of Greymouth and Cobden, although at a reduced pressure. The Omoto reservoir remains out of operation. The outlying systems remain as they were at week 1.

(e) Telecommunications

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

2.7.10 Time zero plus I month

(a) Transport

The roading network within the District is largely functional again, although there are many areas with metalled surface, one way sections and weight and speed limitations on bridges. The Michells – Inchbonnie Rd remains blocked by the large landslide near Camp Point and the roads beyond Te Kinga are all negotiable by 4WD in dry weather only. The Ahaura-

Kopara Rd remains cut at Griffin Flat, although the locals have bulldozed a rough track through the bush around the top of the landslip head scarp. A Bailey bridge is being installed to allow the Ahaura Bridge on SH6 to be re-opened. Meanwhile all heavy traffic continues to use the coastal route through Westport, or a ford across Rough River when the river levels allow.

The Lewis Pass route was reopened 16 days after the earthquake to essential traffic only. The Arthur's Pass route remains closed between Turawhaiti and Arthur's Pass, with no immediate plans of repairing the remaining length, due to other priorities for resources. SH6 to the south has been reopened to essential traffic to Franz Josef, but it would be several months before the whole route through to Wanaka would be reopened.

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. The remaining bodies were removed from the train wreck three weeks after the earthquake.

(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 Inchbonnie and Haupiri, virtually all the local catchments are choked with landslide debris. During heavy rain, debris flows and 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 area, badly damaged by the earthquake, are being covered by debris, which has effectively buried the damaged bridges. Aggradation from debris on the local fans has combined with the landslide into the Poerua River and the level of Lake Poerua has risen by a metre. It is close to the road level at one point.

(c) Sewerage

The sewer reticulation is functioning although still damaged, with repairs to the obstructed points, but discharge is still to the lagoons and 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 Greymouth and Cobden, Dobson, Taylorville, and Blackball. Runanga has a restricted water supply with water being tankered in to a series of temporary tanks and standpipes. The problems are with the repair of the delivery main. The Omoto reservoir has been repaired and is back in operation.

(e) Power

Power has been restored to 90% of the district. The Haupiri and Rotomanu – Inchbonnie areas remain without power because of the extent of damage and the very small population remaining there.

(f) Telecommunications

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

2.7.11 Time zero plus I year

(a) Transport

The road network is essentially back to pre-earthquake condition, but with many speed and weight restrictions in place. Some key elements, such as the Arahura Bridge remain with weight restrictions, and can only be fully rectified with replacement structures. The Inchbonnie – Rotomanu Road has been relocated and rebuilt away from three of the more active fans and extensive bulldozing to control stream alignments has been necessary. This work might not have been carried out, and the road might have remained as a metalled access track, except that the rebuilding of the railway allowed a cost sharing for the work.

SH73 was reopened 7 months after the earthquake but is still subject to delays at several temporary bridges and sections still being worked on. The Haast Road was re-opened to Wanaka 4 months after the earthquake, but is subject to frequent closure due to instability and flooding at bridge sites. The South Beach overbridge has been demolished and replaced with a level crossing.

The railway was re-opened two months after the earthquake. Its operation was reduced to 75% of pre-earthquake capacity until nine months after the earthquake. The reduced capacity was due to ongoing repair of earthquake damage and three closures each caused by heavy rain bringing down debris flows that the blocked the track. After nine months the line capacity increased to 95% of normal as the earthquake repair work was completed and the track was only affected by debris flows.

The relatively short period to open the railway helped enormously with recovery as bulk construction materials could be brought in and exports of coal could resume again helping significantly to re-establish the Coast's economy.

(b) Drainage

Problems with aggradation are ongoing. The areas affected are close to the Alps between Inchbonnie and Haupiri. Major rivers are aggrading and flooding and depositing sediment over land that was previously hardly ever flooded. Smaller streams are disgorging large quantities of sediment over fans. The Taramakau River is also aggrading. The Alpine Fault rupture produced a 1 m step in the river bed diagonally across the river at Inchbonnie. The stopbank breach was repaired within a month of the earthquake, but subsequent bed level changes in combination with defects in the largely undesigned and unsupervised reconstruction work resulted in part of the river breaking out during a flood and flowing north to enter Lake Brunner. Fortunately, this flow was able to be stopped after the flood and the stopbank was subsequently rebuilt to keep the river in its present course. There are concerns that as aggradation continues, maintenance of the stopbank will become increasingly difficult and expensive.

There has been one flood event where parts of Greymouth were flooded through breaches and overtopping of weakened sections of the stop bank. Repair is continuing.

(c) Water supply

The turbidity in the Grey River has remained high affecting the quality for months although it is improving over time. Of more concern are the effects of high river sediment on intake capacity at Dobson (Dobson – Taylorville supply) and Coal Creek (Greymouth supply). At both intakes the capacity has been reduced due to the intake wells becoming clogged over time with river sediment load and at Coal Creek the river has changed course and is now 300m from the intake wells.

3 NEEDS AND PRIORITIES

3.1 Overview

This section provides information to help the Grey District Council establish general priorities for action both following an earthquake event and in working beforehand to mitigate its anticipated effects. The problem is approached by considering the primary needs of individuals and communities both immediately after the earthquake and also during the subsequent recovery period. Once these needs are established, they are then prioritised so that the Council can see the areas of greatest urgency.

Community and individual needs have been established in three ways:

1. By means of a workshop held at Punakaiki in September 2005, where thirteen generic needs were identified;
2. By means of the community scenarios or "stories" presented in the complementary report entitled "Grey District Communities – An Alpine Fault Earthquake Scenario". ; and
3. By means of a set of scenarios – "stories" – developed for four individual people as set out in Appendix E.

The resulting sets of needs are scored in terms of their relative importance at various times following the earthquake. Recommendations are then made with regard to Council priorities and actions.

A related issue is the relative importance of communities. Some are more important than others, not so much because of their size but because they are hubs, as it were, and provide vital services on which smaller communities depend. Section 3.4 categorises communities within the Grey District and the region into three levels of importance, again as a guide to Council prioritisation.

3.2 Individual and community needs

3.2.1 Listing the needs

The impact of the Alpine Fault scenario earthquake on the three typical GDC communities of Moana, Runanga and Greymouth, is examined in the "Grey District Communities – An Alpine Fault Earthquake Scenario" report using stories to develop an in-depth understanding of what would happen following the earthquake. This led to an understanding of the communities' needs. As a separate exercise, the stories of the lives of four individuals after an Alpine Fault earthquake were told in the lifelines studies completed for Buller District Council, Westland District Council, and the West Coast Regional Council in June, 2006. The arbitrarily chosen fictitious individuals were a Hokitika businessman, a Kokatahi dairy farmer, an international tourist at Franz Josef, and a Hokitika resident. Their stories are presented in Appendix E. The value of the stories of both the communities and the individuals does not so much lie in the accuracy of the events that unfold in the stories but rather in how they help us examine potential needs in detail, so gaining a deeper understanding of the issues.

Note that the community stories in the "Grey District Communities – An Alpine Fault Earthquake Scenario" report are based on the scenario presented in Section 2.7 while the scenarios given in Appendix E are based on the Alpine Fault scenario used in the June 2006 lifeline studies. The two scenarios are somewhat different, with the scenario in Section 2.7 outlining a more severe earthquake than that given in the earlier studies.

A workshop held Punakaiki in September 2005 also considered the matter and identified thirteen generic needs. These are presented in Table 3.1. The needs may be met by the individuals themselves or by the community. An individual's 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 places like CBDs. Communities on the other hand often use networks to meet a community's needs efficiently and effectively. Solutions for individuals may well be necessary early in the response, but expectations will be that these solutions will be temporary, and the community networks and systems will be restored quickly. For instance in Greymouth, water supply from rainwater collected in a basin would be acceptable to most individuals for a short time. However, there would be an expectation that within a short period of time water would be available at a standpipe within a convenient distance, and not too long after that the piped supply would be fully restored.

The needs given in Table 3.1 are listed without any consideration of their relative importance. This would change as time passed following the earthquake. The issue is considered in the next section.

Table 3.1: Generic Needs

Need for:	Means of Meeting Needs	
	By Individuals	Via Community Networks[1]
Leadership	Natural leaders locally	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 wells, springs, rain water tanks, streams etc	Community water supply, tankers. 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, emergency supplies	Supply point, transport[2], distribution points
Lighting & Heat (Cooking + Warmth)	Candles, gas cylinders, torches, 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. It 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.

3.2.2 Prioritising the needs

Based on the stories of the communities presented in the "Grey District Communities – An Alpine Fault Earthquake Scenario" report the relative importance of each of the thirteen needs of Table 3.1 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. Table 3.2 shows the grades used for level of need and reliance on networks.

Table 3.2: 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 three communities for three time intervals:

- The first three days after the earthquake,
- The end of the first month, and
- The end of the first year.

The 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 F and the summary results are shown in the radar graphs in Figure 3.1. The "importance scores" for each need for the three have been averaged and the results are presented graphically in Figure 3.2. The same results are presented in Table 3.3, with the addition of priority rankings for the different needs. 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 3.1: Community Needs – 3 day, 1 month & 1 year

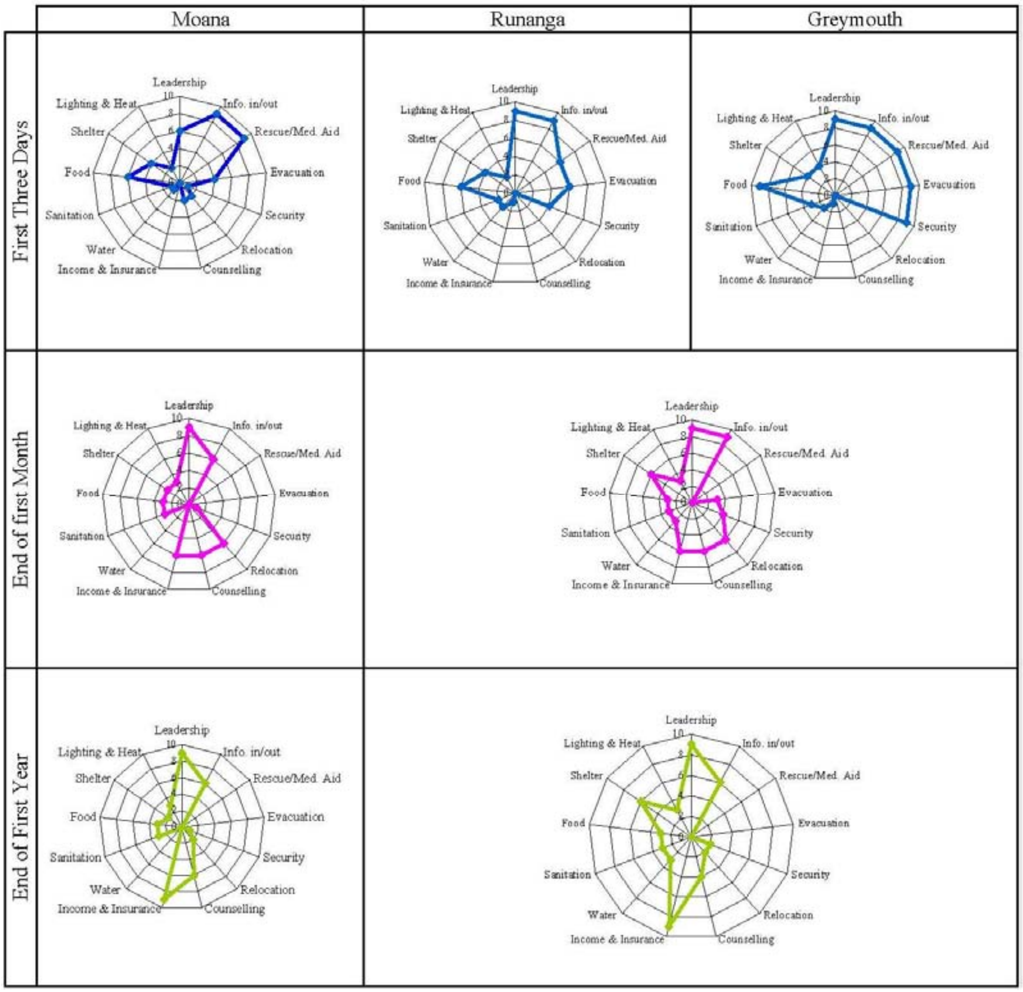


Figure 3.2: Bar Graph of Priority Needs for the Three Communities

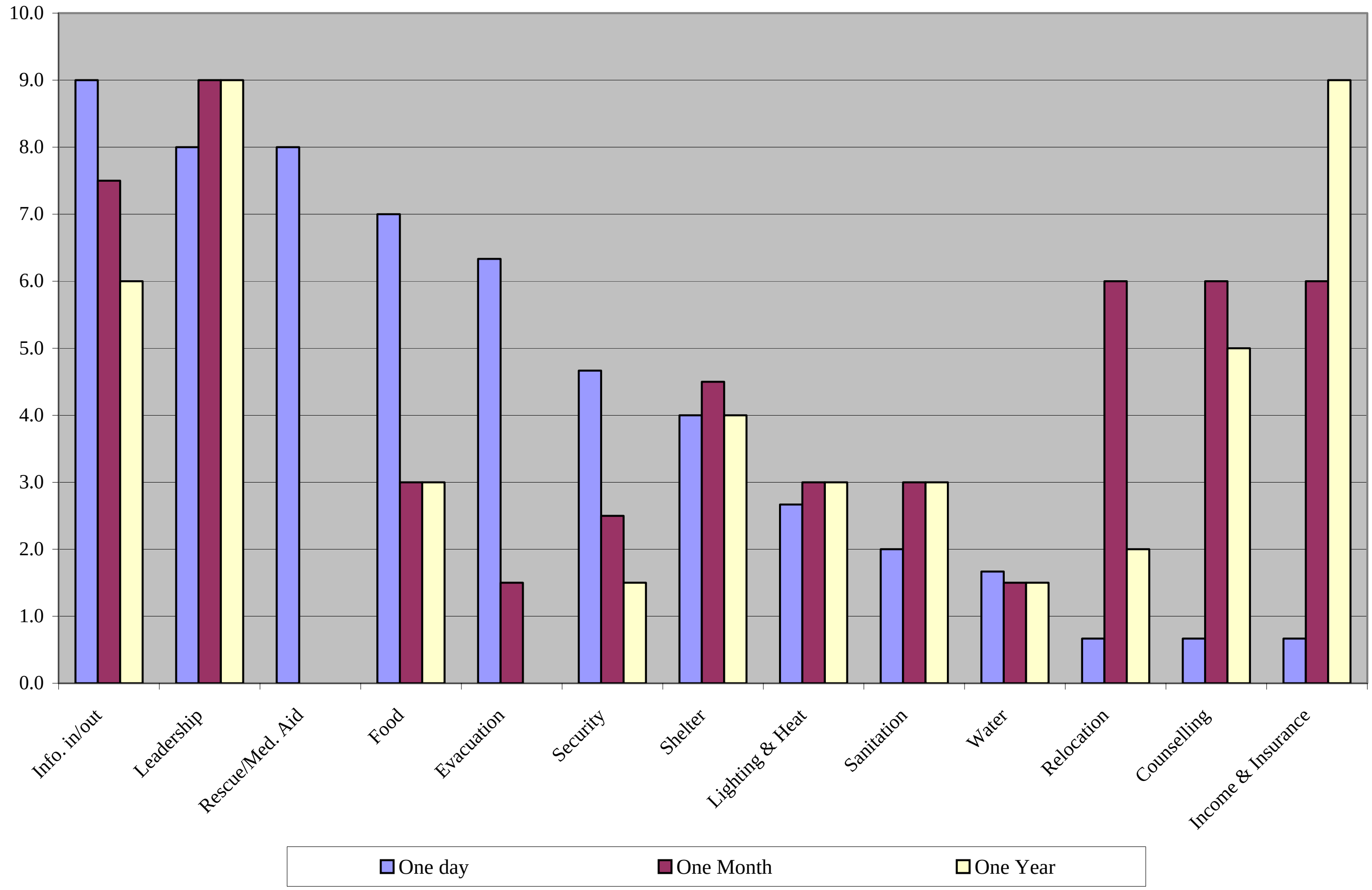


Table 3.3: Priority of Needs

Priority	One day	Mean	One Month	Mean	One Year	Mean
1	Info in/out	9.0	Leadership	9	Insurance & Income	9
2	Leadership	8.0	Information in/out	7.5	Leadership	9
3	Rescue/Med Aid	8.0	Relocation	6	Information in/out	6
4	Food	7.0	Insurance & Income	6	Counselling	5
5	Evacuation	6.3	Counselling	6	Shelter	4
6	Security	4.7	Shelter	4.5	Sanitation	3
7	Shelter	4.0	Food	3	Food	3
8	Lighting & Heat	2.7	Sanitation	3	Lighting & Heat (Cooking + Warmth)	3
9	Sanitation	2.0	Lighting & Heat (Cooking + Warmth)	3	Relocation	2
10	Water	1.7	Security	2.5	Security	1.5
11	Insurance & Income	0.7	Evacuation	1.5	Water	1.5
12	Relocation	0.7	Water	1.5	Rescue/Medical Aid	0
13	Counselling	0.7	Rescue/Medical Aid	0	Evacuation	0

3.2.3 Discussion

Three Days

From the assessment presented in Figure 3.1, Figure 3.2 and Table 3.3, it can be seen that for all three communities considered, the dominant needs in the first three days are leadership, information in and out, rescue and medical aid, food, and evacuation, while security is an additional important need in Greymouth. The dominant needs are important for the following reasons:

- *Leadership:* In the first few days after the quake, people will be in shock. As noted in the community stories above, people will be exhausted, tired, hungry and cold, and a good many will be hurt. To begin with no-one will know what is happening, what they should be doing, and what would be in store in the immediate future. It is almost certain that normal lines of communication will be down or only providing a marginal service. The primary role of leadership would be to help individuals and communities cope in as effective a way as possible, and here, encouragement is as important as practical advice. Anything that could help build morale and provide hope would be of great value. 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.
- *Information*: By "information" we mean both the information individuals and communities need to receive, and also their need to get information out as to what is happening to them. Information in both directions is going to be particularly important for isolated people (the Gloriavale Christian Community at Haupiri and even the Moana community). And although our primary focus here is the needs of individuals and communities, it will of course also be important for infrastructure managers and those who run networks on the Coast. 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 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. It is just as important for leaders and managers to receive good information as it is to give it.

- *Rescue and Medical Aid*: There will be injuries and deaths from the earthquake. Some people may be trapped under rubble or under plant. For those near the fault trace at the time of the quake, the need for professional rescuers and medical aid will be higher and they are likely to be totally reliant on outside support. Examples are those on the TranzAlpine train and communities in the Haupiri – Kopara area. The further from the fault trace the lower the likelihood of injuries, and so the less the need for rescue and medical aid, However in built up areas (CBD Greymouth) with older buildings that have not been strengthened against earthquakes there are also likely to be people trapped and injured in collapsed buildings;
- *Food:* Food is an issue not only because modern societies rely almost entirely on others to provide food for them, but also because very small stocks of food are held anywhere. Some households will have emergency food, and food is less likely to be an issue for those who live away from main centres and buy food in bulk, as part of their normal lifestyle. People may have only a limited amount of food because the earthquake damaged their food stocks, made their food inaccessible or because they only keep a limited amount of food with them anyway, e.g. tourists. Infants and the elderly are particularly vulnerable as they rely heavily on others to provide food for them; and
- *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. 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 aftershocks. Tourists are another group requiring evacuation.

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. And fundamental to all of these will be a reliable and adequate supply of fuel.

Shelter, lighting and heating, sanitation, water supply and security are likely to be the next most important needs to be met. These needs, some of which are essential for life such as shelter, heating and water, are relatively low in priority because of the likely availability of alternatives:

- *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. To begin with, considerable used will have to be made of emergency shelter in schools, pubs and churches.

- *Lighting and Heating*: Lighting and heating are 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. People who light fires in fireplaces or burners with damaged chimneys risk burning their houses down;
- *Sanitation and Water Supply:* Community sanitation and water supply facilities are likely to be more important in urban areas particularly in the Greymouth CBD. While people in country areas may have access to alternative water supplies and an area to dig a pit latrine, in urban areas there are minimal alternative water sources, many will be polluted, and in the CBD there is virtually nowhere to make alternative sanitation arrangements; and
- *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. The same can be said for fuel and building materials. Some people may also take advantage of the situation and loot valuables from damaged and vacant buildings;

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

End of First Month

There will have been a major crisis at the end of the first week, when food and fuel supplies will have all but run out, but at that stage the first road access will have been opened and bulk supplies will have begun flowing in from Nelson. Water supply and sanitation for those without good access to alternatives may also have become critical. However it is envisaged that the focus for restoration of at least emergency levels of service for water supply and sanitation will be to those with few alternatives.

By the end of the first month things will have been looking more hopeful. Table 3.3 shows that at the end of the first month the priority ranking of needs has changed. Tourists will have been evacuated and gone home. They will no longer have 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. Meanwhile, it is late March and the days are noticeably shorter:

- *Leadership*: Leadership remains important to provide direction and support as the recovery phase gets fully underway;
- *Information in/out*: Information required by individuals 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. Information flow has increased as the recovery effort is now well underway. Councils and in particular utility managers will need information and to communicate instructions. They will need almost continuous update on the status of lifeline assets as repairs are implemented and they will need to direct plant and manpower as the priority of tasks change. Leaders will need information so that information that they give out is up to date and accurate;
- *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. In addition, it would be helpful for Council to have someone available to talk to inquirers in a helpful and supportive way.

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 *shelter*, *lighting and heating*, *food*, *sanitation, security*, *water, and evacuation*:

- *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. It is likely in larger urban centres like Greymouth that temporary housing will be established to accommodate the influx of people to assist with the recovery and reconstruction. Housing sites for this temporary accommodation will be required along with services such as water, sewerage, power and telephone. Temporary shelter may also be required for people made homeless by the earthquake while they construct new homes;
- *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;
- *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.

End of First Year

For the three communities considered, 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 significantly 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.

3.2.4 Summary

For our three communities *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 and shelter are, however, always at the top of this group of needs: food because of the limited number of alternative complete food sources and a high reliance on transport networks to bring food in, and shelter because a number of families will have their houses destroyed and because many people will come into the area to assist. Both groups will require temporary accommodation. The period of one week to ten days is not examined in detail. It is possible that food, heating, water and sanitation could become very critical particular if bulk transport routes have not been effectively re-established.

3.3 Community Importance Categories

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 councils have allocated townships an importance category as shown in Table 3.4, where 4 represents highest importance.

Table 3.4: 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	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 3.4, emergency levels of service have been established for each lifeline and these are used to identify vulnerabilities and to determine improvements.

4 LIFELINES

4.1 Transport

4.1.1 Role of transport on the West Coast

The West Coast Region, including the Grey District, is heavily reliant on transport for survival. There are four modes of transport: road, rail, air and water. Road is the most significant transport route for goods into the Coast. Fuel, food, merchandise etc are all brought into the area by truck. Rail is the primary mode of transport for exporting coal and milk products from the West Coast with up to twelve 30 wagon trains crossing the Alps to Lyttelton each day. Two trains also bring goods into Greymouth daily. The airport at Greymouth is of moderate importance. There are daily flights to and from Wellington on week days and a number of private planes and a commercial helicopter service also operate from the airport The rescue helicopter uses Greymouth airport as its base. The Port of Greymouth is only of minor importance to the Grey district as a normal transport link.

After a major Alpine Fault earthquake air transport is likely to be the most important transport link into and out of the district for the first week at least and possibly longer. Air transport will be used to bring in all forms of supplies including fuel and food and be used to evacuate people, particularly those that are critically injured. The port has the potential to become an important bulk supply route after the earthquake provided the port is not seriously damaged, storage facilities are available, particularly for fuel, and vessels are available that can access the port. The Grey River can provide immediate access by jet boat up the Grey Valley to communities from Dobson to Ikamatua. The Arnold River can provide important access east towards the fault line as far as the Arnold Power Station. Road links to outside the West Coast region will not be possible until the major routes to Nelson and over the Lewis Pass can be opened to large trucks. This could be up to a week after a major Alpine Fault earthquake and the roads would be subject to frequent closures at least initially due to after shocks and/or rain leading to further landslide and dropouts. Rail, like road, will be subject to significant damage and could take up to 3 months to open after the earthquake. However once opened rail could provide a very valuable bulk transport route for bringing in materials and supplies to the district and the region.

As a result of improved roads and transport equipment in general over the years, there has been a significant increase in centralised production. An example of this is how most of the South Island's milk is now supplied from Christchurch, and some meat, most bread and general food etc is supplied via Christchurch.

While the above has no doubt led to cost efficiencies, it has also made the West Coast and the Grey District much more vulnerable if for some reason the transport system is disrupted. There is also a just-in-time approach to the supply of goods and fuel. Supermarkets for instance usually only have a few days' supply of high turnover goods and rely heavy on refrigeration for food preservation.

Some time ago the bulk fuel tank farm at Karoro was decommissioned resulting in the only fuel storage being that held in underground service station tanks.

Efficiency and disaster resilience are at odds with each other.

The Grey District 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 in the event of a major Alpine Fault seismic event, 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.

For the above reasons, it is important that mitigating potential disruption to the transport system be given careful consideration. There are two main mitigation options: to improve the resilience of the transportation system, and to improve the ability to function in the absence of availability of supplies. This may include increasing the inventory of critical items.

4.1.2 Transport Situation Following an Alpine Fault Earthquake

The following situation is likely to occur after a major Alpine Fault earthquake:

- 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, the road network east of Moana can be expected to have suffered significant damage by liquefaction and by destruction of bridges. The three mountain pass routes (Lewis, Arthur's and Haast Passes) 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 with the coastal area should suffer only moderate damage.
- The airport at Greymouth is likely to suffer damage from liquefaction but be made operable with 48 hours. This facility is likely to be central to the emergency period immediately following the earthquake.
- There will be an enormous demand on helicopters for rescue, reconnaissance, 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 maintenance 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.

4.1.3 Level of Service - Transportation

The minimum target levels of service to be provided to communities after the Alpine Fault earthquake are presented in Table 4.1.

Table 4.1: Levels of Service – Transport

Route	Emergency Level of Service		Interim Level of Service		Normal Level of Service
Roads					
Greymouth to Nelson via Westport	Four-wheel drive access, frequent road closures, very restricted speed, many sections of single lane.	6 days	Two-wheel drive access but surface still rough (no access to low clearance vehicles), many sections of single lane, some road closures.	4 wks	24 months
Lewis Pass		14 days		8 wks	24 months
Arthur's Pass		200 days		52 wks	48 months
Greymouth to Reefton		14 days		4 wks	12 months
Stillwater to Moana		7 days		2 wks	12 months
Other Roads		70 days		26 wks	36 months
Rail					
Greymouth - Westport	Severe speed restrictions, frequent rail closures.	28 days	Speed restrictions, some rail closures.	8 wks	12 months
Greymouth - Hokitika		28 days		8 wks	3 months
Greymouth - Lyttelton		60 days		36 wks	48 months
Greymouth Airport	Access to Hercules and light planes, limited navigational aids (airstrip lights).	2 days	Access to Hercules and light planes, normal full navigational aids.	1 week	4 weeks
Port of Greymouth	50m of port to birth against, no onshore crane facilities.	1 day	50m of port to birth against with onshore crane facilities.	1 week	4 weeks

4.1.4 Key Principles for reinstatement

Initially the key principles for re-establishing transport links are likely to be as follows:

- Access to critical emergency management co-ordination centres;
- Search and rescue and evacuation of injured people;
- Access to hospital and medical facilities;
- Access to the Greymouth airport;
- Access to repair critical communication infrastructure;
- Access to civil defence community centres and between communities starting with communities of highest population;
- Access 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 airport being of highest priority.

In general roads will be reinstated in the first instance, to a four-wheel drive level of service for access within the district.

There is a potential for boat access to some areas prior to roads being reopened. Access up the Grey River to Taylorville, Dobson, Stillwater and Ahaura should be straightforward, and boat access across Lake Brunner provides an alternative to the road into Iveagh Bay and the Mitchells area.

The port is important for bringing bulk supplies in the district during the recovery phase.

4.1.5 Airport

General Description

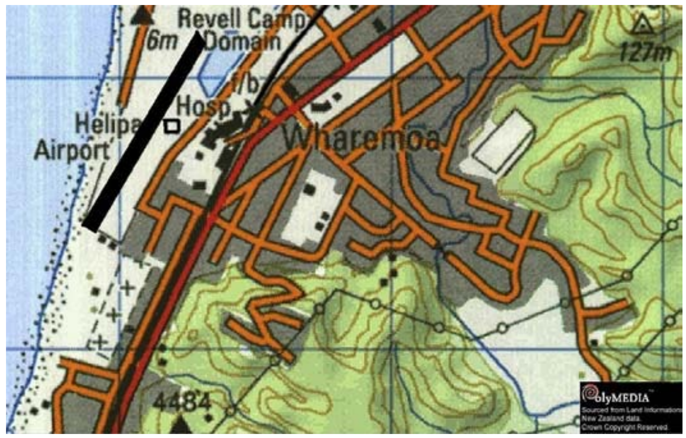


Figure 4.1: Location of Greymouth Airport

There is one aerodrome listed with the Civil Aviation Authority within the Grey district. This is the airport at Greymouth which is owned and operated by the GDC. It consists of a single 1090m by 32m paved runway that is normally used for light aircraft and helicopters, including regular commercial flights to Nelson and Wellington. An important use is the ferrying of patients to and from the adjacent Greymouth Hospital using an air ambulance. The airport is located near the coast and is in an area that is likely to be liquefiable.

The airport is an unmanned facility with only a part time flight control officer present on an as required basis. It has a basic ground to air radio facility with a battery powered hand held transmitter / receiver held at the Grey District offices. The emergency lighting is backed up by an emergency generator. The airport runway lighting can be activated by approaching planes prior to landing. There is a fuel facility. Emergency procedures at the airport are very limited with reliance on the CAA and the Fire Service.

The nearest alternative registered airport is at Hokitika with two sealed runways. There are also numerous smaller private grassed strips, and even straight sections of road, on the West Coast able to be used by light aircraft, that are not on the civil aviation register. These include the following sites in Grey District as shown on 1:50,000 maps.

- Nelson Creek Farm, Settlement
- Ahaura
- Coal Creek Farm Settlement
- Nelson Creek

Airport vulnerability

The most significant risk is from damage and differential settlement of the runway as a result of the liquefaction of the underlying soils.

Figure 4.2: Photo of Greymouth Airport from Arnott Heights

This may make the runway unsafe for use at a time of greatest potential demand, that is, when the use for medical support is likely to be most urgent.

Consideration could be given to testing the underlying soils for liquefaction potential using the cone penetrometer testing method. This way the relative potential for liquefaction would be known and alternative strategies put in place if required.

Reinstatement Strategy

The initial priority would be to reinstate the airport for helicopter use (if any reinstatement is necessary). This would be followed by reinstatement of the runway or surrounding area to allow access for fixed wing aircraft such as Hercules which may be used to bring in emergency medical and other supplies and evacuate seriously injured patients from the hospital. It is anticipated the airport could be reinstated to receive fixed wing aircraft within 24hr to 48 hours. **It is recommended that GDC ascertain the requirements for Hercules operation at the Airport and the time required to reinstate operating equipment such as lights and communications.**

GDC could also look at other locations for an alternative landing strip, although the location of the existing airport is ideal for servicing the largest urban area in the district.

4.1.6 Roads

Characteristics of the Road System

The Grey District road system is characterised by its 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 five links outside the district; three bridges across the Taramakau River into the Westland District, the coastal route to Westport, and the Grey Valley route to Reefton.

The Grey District Council maintains a significant network of roads and bridges within the district boundaries. State Highway 6, running the length of the district's coastline, and SH7 up the Grey Valley are administered by Transit New Zealand. 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.

Table 4.2: Grey District Road Statistics

	Transit (SH)	Grey District
Roads		
Total length	105	616
Urban sealed		126
Rural sealed		228
Rural gravel		262 (43%)
Bridges		
Number	70	220
Length (km)		3.5
Longer than 10m		87(40%)
Single lane		116 (53%)
Timber no.		52

Relative traffic volumes on the state highways in the district are indicated below.

Table 4.3: Annual Average Daily Traffic volumes (Transit for 2004)

SH	Location	AADT	SH	Location	AADT
7	Ahaura	1120	6	Greymouth Tainui St	12410
7	Kaiata	2590	6	Paroa	4830
6	Punakaiki	970	6	Taramakau Bridge	3200
6	Coal Creek	3580	73	Otira	1280
6	Greymouth Sth bridge	11940	73	Taipo River	990

The formal road network in the Grey District has some duplication, with two routes up the Grey Valley, and roads into Moana from Stillwater, Nelson Creek and Jacksons, for example. In addition there are many informal roads. The map below showing all known tracks and roads within the GDC demonstrates that in the case of an emergency there are a number of alternative routes to many locations. However, some are foot tracks only, and many may be poorly maintained and only useable by all terrain four wheel drive vehicles. And of course like main roads, some could be closed due to slips and structural damage. It does indicate that there is more redundancy in the road network than is apparent from the public road system only.

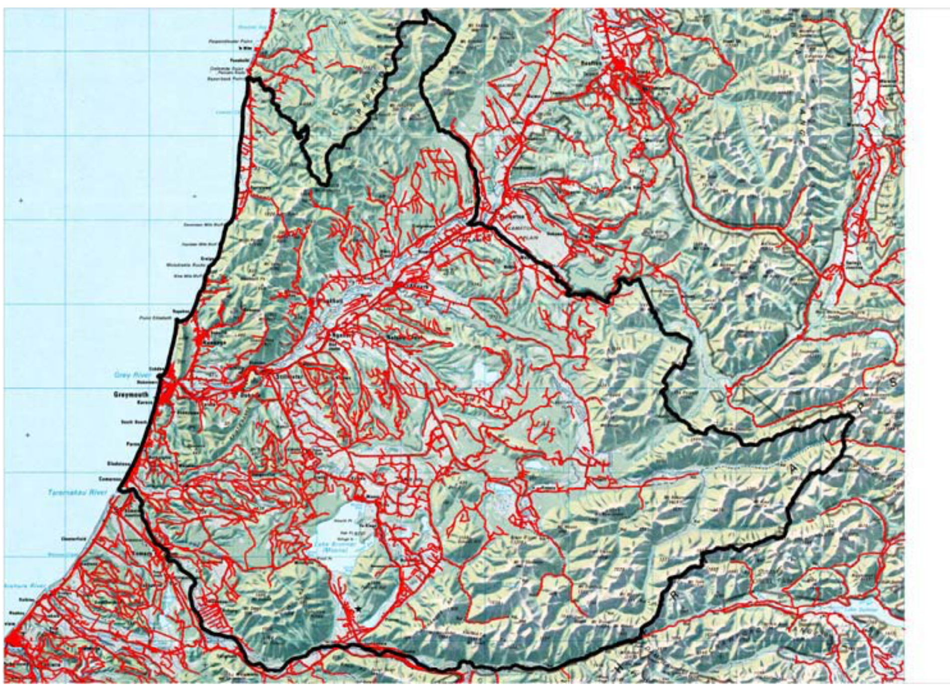


Figure 4.3: Grey District Road Map

Map of all roads and tracks in the Grey District to demonstrate alternative routes that may be available in an emergency (note some tracks may be unusable and others are walking tracks only)

In the event of a major emergency, for example a significant earthquake event, there are a number of GDC roads that become more important than others. For example, alternative routes to the State Highways that may be closed for some reason, access to the facilities at Sewell Peak and access to various potable water pump stations and reservoirs in the Grey District as well as key drainage structures such as the Regional stop bank and Inchbonnie.

The critical roads in Figure 4.4 represent alternative routes to the State Highway 73 between Jacksons, Kumara and Greymouth. In the past, the GDC road between Jacksons and Stillwater has been used when the Jacksons to Kumara Junction road has been close due to slips or accidents.

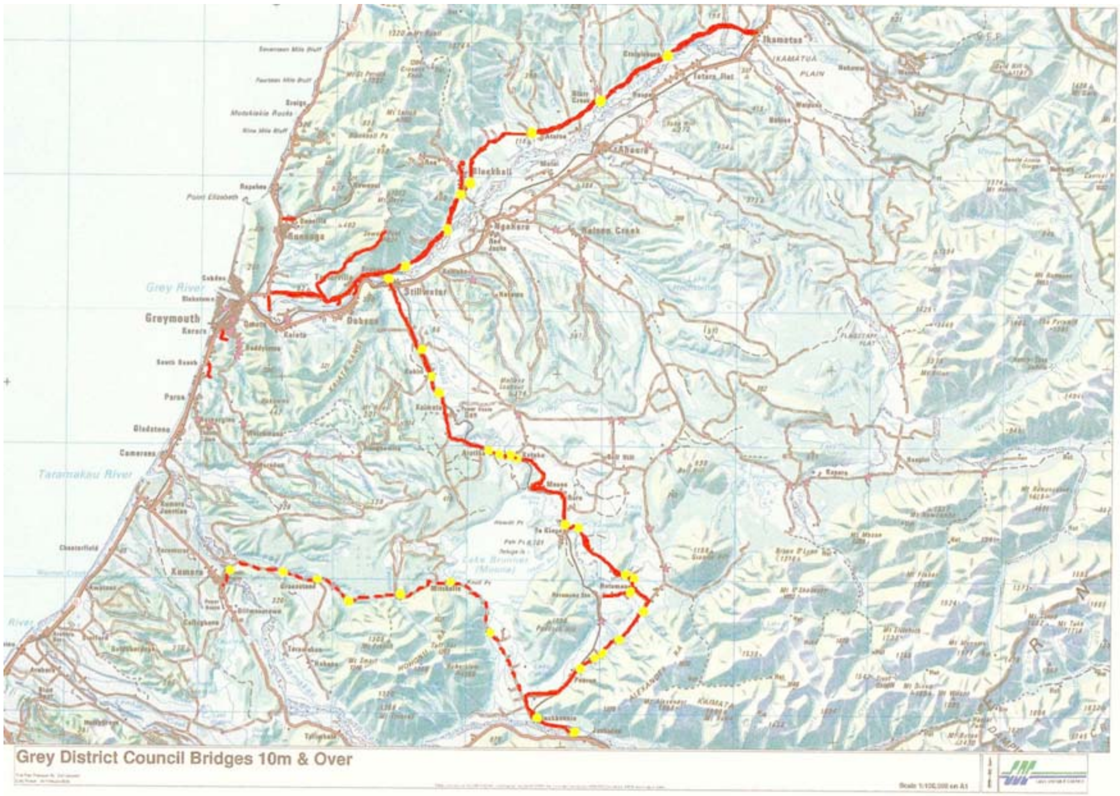


Figure 4.4: Critical GDC Roads

Critical GDC roads (red) with major bridges (yellow dots) providing alternative routes to State Highways and providing access to critical facilities such as potable water pump stations and reservoirs.

The actual nature of the Alpine Fault event may result in unexpected damage to routes that are thought to be more favourable and therefore it is not inconceivable that any of the above routes may become important for emergency / equipment access.

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.

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 GDC's responsibility, its performance will impact greatly on the district's resilience to an earthquake event as the state highways form the backbone of the road network in the district. It is imperative to see all roads within the district as a single network, regardless of who owns or manages individual routes.

The West Coast State Highway system and some key GDC roads are shown in Figure 4.5. The Grey District has four State Highway routes leading to and from the area, namely SH 6 north to Westport, SH 7 to Reefton, Inangahua and the Lewis Pass, SH 6 south to Hokitika, and SH 73 through Arthur's Pass. State Highway 73 can be accessed by using SH 7 to Stillwater then the GDC road from Stillwater to Jacksons, or from SH6 at Kumara. These state highways are managed by Transit New Zealand, who as part of normal operations has emergency procedures in place for the reinstatement of State Highways in the event of damage including that resulting from significant natural disasters.

Figure 4.5: West coast State Highway System

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 4.4) at risk of serious damage or collapse, requiring closure. Other bridges are at risk of damage, but have not been included in Table 4.4, and the table does not include the vast majority of bridges where little or no damage is expected.

Table 4.4: SH Bridges with Significant Seismic Risk – Transit Study

State Highway	Bridge	PGA EQ (1)	PGA cause (2)	Damage (3)	Likelihood (4)	Comments
6	***Westport – Greymouth***					
	Canoe Ck	0.2	0.4	3	C	Liquefaction abutment + pier movement
	Camp O/B	0.3	0.5	3	D	
	Coal Ck O/B	0.3	0.5	3	C	
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
7	***Reefton – Greymouth***					
	Big Grey	0.35	0.5	3	C	
	Nelson Ck	0.35	0.5	3	C	
	Kiwi O/B	0.35	0.5	3	C	

(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

It should be recognised that these bridges have been identified from a preliminary screening study, and detailed analysis may reduce (or increase) the relative risk. For instance, the Iron Bridge over the Buller River has been subject to MM IX shaking in 1929 and MM X in 1968, and survived with relatively minor damage, whereas the screening suggests that significant damage might have been expected.

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 the State Highway bridges in Grey District will escape serious damage. Outside the district, SH bridges in Buller District should similarly escape serious damage, but all the major bridges on SH73 to Arthur's Pass can be expected to be closed or destroyed, as will about 22 of the major bridges in South Westland.

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 road system has not been completed, (a model for such a study is outlined in Speed & Brabhaharan, 2006), but a preliminary review and common sense suggest the following is probable. Immediate links outside the district boundary are included as these also impact directly on the regional resilience.

1	***Link***	***SH 6 Westport – Greymouth – Coast Road***
	Importance	High: second of two roads from Westport.
	EQ Shaking	MM VII increasing to MM VIII south of Barrytown.
	Time to reopen	A few days.
	Damage	Rockfall, landslide, and some bridge damage.
2	***Link***	***SH 7 Reefton to Greymouth***
	Importance	Very High. Main route from Greymouth to both Nelson and Lewis Pass. Main access to Grey Valley communities. Fibre optic cable route in part.
	EQ Shaking	MM VIII
	Time to reopen	One – three days.
	Damage	Small slips, rockfall, and some bridge damage.
3	***Link***	***GDC Grey Valley right bank road***
	Importance	High: only access to Blackball, Taylorville, alternative to SH7, fibre optic cable route.
	EQ Shaking	MM VIII
	Time to reopen	One- three days.
	Damage	Landslides, rockfall, and bridge damage.

4	***Link***	***GDC Stillwater – Moana – Inchbonnie***
	Importance	Moderately high. Main access to Moana and hinterland, alternative access to SH73 from Jacksons, access to Inchbonnie stopbank, and fibre optic cable route.
	EQ Shaking	MM VIII at Stillwater to MM IX+
	Time to reopen	One – two days to Moana, weeks to Inchbonnie.
	Damage	Some slips, liquefaction, fault rupture near Inchbonnie, extensive bridge damage around Rotomanu compounded by ongoing debris and aggradation.
5	***Link***	***SH73 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 landsliding, possible rock avalanche, ongoing debris and aggradation issues at stream and rivers.
6	***Link***	***SH73 Turiwhate to Kumara Junction***
	Importance	Moderately 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, and minor bridge damage.
7	***Link***	***SH 6 Greymouth – Hokitika***
	Importance	Very high: main link to Greymouth, hospital, port, population centres.
	EQ Shaking	MM VIII
	Time to reopen	1 – 2 days.
	Damage	Possible bridge damage including Arahura, possible liquefaction in places.

In general, the times to reopen suggested above 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.

Grey District Roads

The GDC 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 GDC road network. At present GDC does not have a comprehensive data base on the condition of its 220 bridges. There are likely to be at least some bridges vulnerable to earthquake damage due to insufficient structural robustness. **It is therefore recommended that bridges on critical routes be structurally audited for robustness against seismic attack and flood damage potential.**

With reference to the above and the key principles outlined in Section 4.1.4, it is recommended that a number of key routes be given priority for reinstatement following a major catastrophic event. These include:

- **Access to Greymouth Airport, as this facility is essential in gathering information for damage assessment, rescue and evacuation, and emergency supplies into the district;**
- **Access to Hospitals and Community Emergency Centres firstly within each community then from outlying areas;**
- **Access south to Hokitika and the Hokitika airport;**
- **Links between population areas with centres of highest population (potential areas of greatest need) being given priority;**
- **A link between Greymouth and Moana as Moana is one of the closest communities to the Alpine Fault and therefore would probably need significant outside help;**
- **Access to critical lifeline installations including Sewell Peak (communications), major sub stations (electricity), telephone exchanges (communications), water pumping stations and reservoirs (potable water supply);**
- **Reinstatement of State Highway 7 in preference to SH 73 as the latter is likely to have sustained considerably more damage and therefore require more resources to reopen. It is anticipated that road access out of the district to Nelson via SH 6 could be established in about six days.**
- **Access to the Port of Greymouth to permit the unloading of supplies including fuel**
- **Access to Inchbonnie to maintain stop bank.**

While key roads managed by Grey District 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 Grey District must work closely together in coordinating the road recovery. While this will 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 Cobden Bridge. Although Transit seismic assessment of the bridges suggests that it would survive an Alpine Fault earthquake with little damage, their ranking includes a ranking of importance within the Transit system. This ranking may be quite different to the importance the Grey District may have for the bridge as not only is it a vital link to Cobden and the communities to the north, but it also carries the main Greymouth water supply along with electricity and 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.

The district roads that 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**. Priority roads are:

- Roads within the urban area providing access to the Greymouth airport and hospital. There is redundancy in access roads, but the area may well be affected by liquefaction. Liquefaction is unlikely to prevent four wheel drive access, except where lateral spread along creeks and lagoons causes extensive fissuring.
- Taylorville Road. This provides the only access to Taylorville, the Mt Seymour track, and the Greymouth water supply intake. It is vulnerable to liquefaction damage on the Coal Creek flats, slips on the section where it descends to Taylorville and rockfall between Taylorville and the Stillwater Bridge. It could become a key link if SH7 is blocked by movement of the Omoto Slip, severe damage to the Kiwi overbridge, or landslide in the Brunner Gorge.
- Stillwater Bridge could become a key link if SH7 is closed on either side of Stillwater. Apart from the bridge, this link contains some high embankments, which may suffer slumping, and a bridge over the railway, which may be seismically vulnerable, although it could reasonably easily be bypassed in an emergency.

- North Bank of the Grey Valley Roads. Blackball is accessed either by the Taylorville - Blackball Road or the longer Atarau Road to Ikamatua. The Taylorville Road is much shorter but traverses the toe of high steep hillsides for some kilometers, and is above the banks of the Grey River in places. It is therefore at some risk from landslide, dropouts and rockfall. The alternative Atarau Road generally traverses much more benign landforms, but crosses four significant bridges. The Atarau Road is not a key road unless the Taylorville Road is blocked, in which case it is the alternative access to Blackball, or if damage to SH7 between Ikamatua and Stillwater is such that it is quicker to reinstate access from the north along the north bank.
- Arnold Valley Road provides the main access to Moana. After the Alpine Fault earthquake, access to Moana through Inchbonnie and Jacksons will be effectively cut. Alternative routes exist via Bell Hill and Nelson Creek and to part of the Arnold Valley Road via Blairs Farm Settlement, but the initial intention should be to reinstate the Arnold Valley Road. For the most part the road is not significantly vulnerable. Some slips may occur in road cuttings, liquefaction damage is possible in the Aratika area, and bridge damage is also possible.
- Other district council roads off SH7 in the Grey Valley are not considered key routes, except for the six kilometers between Ngahere and Nelson Creek to access that small community.
- The roads east of Moana access the communities at Iveagh Bay and Rotomanu. The road to Iveagh Bay is vulnerable to possible liquefaction, which could also damage the Crooked River Bridge, and cause collapse of the rail bridge over the road. The roads to and beyond Rotomanu are very close to the fault trace and are within the area of strongest shaking. It is probable that all persons from this area should be evacuated (by helicopter) and road access is unlikely to be an immediate priority.
- The Rotomanu – Inchbonnie and Inchbonnie – Jacksons Roads will be impassable at the fault rupture, and given the proximity to the fault are also likely to suffer bridge damage and landslides. These roads will also be exposed to the expected large aggradation and debris flows over the months and years following the earthquake. It may be that it is impracticable to reinstate these roads for a considerable time following the earthquake. One consideration on this, however, is that the Regional Council stopbank on the Taramakau River at Inchbonnie will be breached by the fault rupture and then subjected to the expected aggradation in the river. It is likely to be essential to move earthmoving equipment to repair and heighten the stopbank in the months following the earthquake to reduce the risk of the Taramakau changing course into Lake Brunner.
- The alternative routes into Inchbonnie are SH73 and the Kumara – Inchbonnie Road. SH73 is expected to be closed for several months between Otira and Arthur's Pass, and between Jacksons and Wainihinihi it will be severely damaged as it virtually follows the fault trace (and the Council Bridge at Jacksons could well be damaged). This leaves the road from Kumara.

However, this road traverses steep hillsides for 3km around Lake Brunner and crosses several bridges. It is likely that some landslide and bridge damage will occur. The small population served by this road does not lead to ranking this road as a high priority to repair, unless it provides the best and easiest access to the Inchbonnie stopbank.

Boat access up the Grey River and on Lake Brunner would be an immediate alternative to damaged roads, and should allow early inspection of the Greymouth and Taylorville water intakes, any large landslide damage to the roads to Stillwater, and the Stillwater Bridge. Boats would also provide a way of evacuating injured people from communities close to the river. The dam on the Arnold River prevents through access to Moana, but two co-ordinated boats could effect a route between the Grey River and Lake Brunner. Boat access across Lake Brunner from Moana is likely to be the best access to Iveagh Bay and Mitchells for several or even many days.

A plan to ensure emergency access to suitable boats should be enacted, particularly for Greymouth and Lake Brunner.

4.1.7 Port of Greymouth

General Description

Figure 4.6: Port of Greymouth

Photo of the Port of Greymouth looking towards the mouth of the Grey River.

The Port of Greymouth is a relatively small facility near the mouth of the Grey River. Tip heads have been formed on both sides of the river mouth to extend the depth of the water over the sand bar at the river's confluence with the open sea.

The port is predominately used as a base for coastal fishing boats and for the transport of coal and aggregate by sea going barge.

It provides berths and mooring facilities, cargo storage and handling and a slipway.

Two ship loading cranes are routinely used during coal load out operations.

Significant Asset Risks

A significant risk to this facility is the ageing infrastructure and the potential damage to back walls and the wharf structure that could potentially occur as a result of a major earthquake and the possible resulting liquefaction and settlement. However, due to the extent of the port, it is unlikely that all of the port would be unusable.

In the event of an emergency, the port would be an alternative means of supply into the area if the State Highways are all closed. However, suitable barges would have to be mobilised for the carriage of fuel for instance. The two general cargo ships that serve the Chatham Islands from Timaru and Napier are likely to be the only ships available that are small enough to berth in the Port of Greymouth. The Royal New Zealand Navy has a sea transport capability that may be suitable to assist, but this would have to be investigated further.

At present the Port has no back up emergency power supply for navigation lighting. Therefore with no electricity, either port usage would be restricted to daylight hours or some type of temporary navigation lighting would have to be set up.

The existing two rail mounted cranes at the Port are electrically powered and therefore would not operate without power supplies. Shipboard cranes could be used if suitable shipping is available.

Upgrades and Improvements

A major priority for the Port would be to ensure that it would be possible to bring in and unload bulk fuel supplies from outside the area, most likely by barge.

It is recommended that consideration be given to setting up an agreement with the two shipping companies presently serving the Chatham Islands for providing assistance to the Grey areas via the Port of Greymouth in the event of an emergency and establishing what help could be provided by the Navy.

The Port has emergency procedures in place for Security / Anti Terrorism, and for Dangerous and Hazardous spillage but nothing specific for emergency handling of fuel and other essential supplies.

The handling of emergency supplies like fuel should be considered by the fuel companies in association with the Port of Greymouth.

The cranes are likely to become unusable after a major earthquake. Firstly it is very likely there will be no electricity from the national grid to power the cranes and there are no standby generators. Secondly, there is the possibility of the cranes jumping their tracks or overturning.

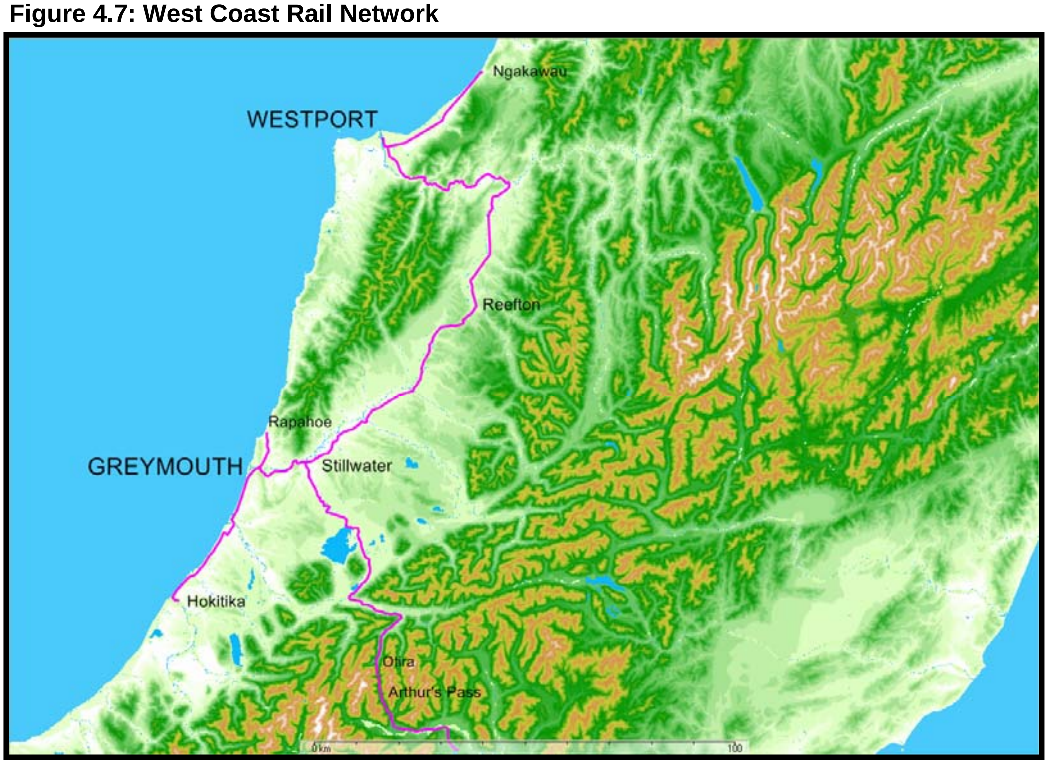
Consideration should also be given to the provision of emergency power for navigation lighting and perhaps even for one of the cranes. The emergency power could also be used for the adjacent storm water pumping station in Johnston Street.

After the Alpine Fault earthquake it is anticipated that the port will be at least partially operational within 24 hours.

4.1.8 Railways

General Description

Figure 4.7: West Coast Rail Network



The West Coast railway network is shown in Figure 4.7. 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

Reefton, Inangahua, Westport and Ngakawau. A south line leads to Greymouth, Rapahoe and Hokitika.

The 310km of railway on the West Coast traverses mountainous and hilly country using many bridges, embankments, cuttings and tunnels. 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 and thus the rail link has a significant input to the economies of the Grey and Buller Districts.

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.

Significant Asset Risks

The railway network to and from the Grey District, like the highways, passes through mountainous and in places unstable country. Although more significant damage might be assumed on first impressions, the railway line actually has very modest earthworks associated with it. From Avoca to Rotomanu, which is likely to be the area of greatest shaking in an Alpine Fault earthquake, the line essentially follows wide flat bottomed valleys right through the mountains. The formation was built by nineteenth century technology by constructing low embankments (generally less than 2m high) along one side of the valleys and thus avoiding excavation into the steep mountain sides. Usually the line is tens of metres from the toe of the mountains, and thus only large landslips are likely to impact directly onto the line. The structures on the Avoca to Rotomanu section are one 8.5 km long tunnel and numerous bridges. Again, the bridges are generally modest in height and length with significant bridges only across the main rivers (Waimakariri, Bealey, Rolleston, Taramakau and Crooked). Advice from ONTRACK is that railway bridges are designed to carry very heavy live loads (including inertial and braking forces) and are therefore capable of withstanding significant seismic loads. Only moderate bridge damage has therefore been included.

Earthquake effects on Railway

The railway will be cut by fault rupture near Lake Poerua. Extensive slip damage must be expected between Jacksons and Avoca but particularly in the Taramakau, Otira and Bealey Valleys. Many of the bridges date from construction of the line and are likely to suffer abutment damage. The Arahura River combined road-rail bridge, on the Hokitika line, has been identified as a seismic risk. Embankments will be damaged by slumping and the rail track thrown out of alignment particularly in the Poerua – Moana and upper Arnold Valley areas but also in Christchurch. Debris flows are likely to cause line closures east of Moana for a number of years after the earthquake with each closure lasting for a number of days.

It is expected that the railway line on the West Coast could be operating relatively quickly; within weeks, and over the Southern Alps within two months and perhaps less. However this will depend on the resources that are allocated to rail restoration work. It is quite likely that rail can be repaired quicker than road, certainly than SH 73, but where resources should be assigned must be assessed at the time with an open mind. What is important is that rail is included in CDEM's post-earthquake transport options and not dismissed out of hand.

4.1.9 Transport Improvement Schedule

Improvements identified in Sections 4.1.5 to 4.1.8 are summarised in Table 4.5. A more detailed improvement plan is presented in Appendix G.

Table 4.5: Improvement Schedule –Transport

Importance	Action	Completion Date	Responsible
	General		
High	Establish fast and flexible contract procedures with contractors	June '08	GDC
High	Establish availability of plant and equipment, in particular, but not limited to specialist plant and equipment.	June '08	GDC
High	Establish availability professional engineers.	June '08	GDC
	Greymouth Airport		
High	Assessment of Runway and access	June '08	GDC
High	Fuel storage seismic assessment	June '08	GDC fuel supply Co's
High	Power supply seismic assessment	June '08	GDC power & line supply Co's.
Low	Building and contents seismic assessment	June '08	GDC & Building Owners
High	Ascertain the requirements for Hercules operation at the Airport	June '08	GDC
Medium	Consider other locations for an alternative landing strip. Check on status of these strips	June '09	GDC
Medium	Based on information and findings for all the above develop an emergency Response Plan for the airport	June '09	GDC

Table 4.5: Improvement Schedule –Transport (Continued)

Importance	Action	Completion Date	Responsible
	Roads		
High	Confirm critical routes based on the Key Principles of Reinstatement (refer Section 4.1.4)		
Medium	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.	June '09	GDC,BDC, TDC,WDC , WCRC & Transit
Medium	In conjunction with Ontrack screen rail corridors from Greymouth to Christchurch, Greymouth to Westport and Greymouth to Hokitika for specific vulnerabilities and prioritise works that might reduce its risk to earthquake damage.	June '09	GDC,BDC, TDC,WDC , WCRC & Transit
High	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. A programme of progressive upgrading and improvements should be established and periodic inspections be formalised.	June '08	GDC
Medium	Liaise with Transit about key routes in the district and establish contacts for good co-operation after an earthquake.	June '09	GDC
High	In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify and prioritise immediate clearing and repairs.	June '08	GDC
Medium	Establish a database of the locations and owners of earthmoving resources that could be used in a major disaster for road and bridge repair.	June '09	GDC
	GDC Bridges		
Medium	Seismic assessment of all bridges on critical routes. Should include bridges carrying other services i.e. interdependencies.	June '09	GDC
Low	Seismic assessment of all bridges on other routes	June '10	GDC
Medium	A plan should be prepared based upon the above audit to progressively upgrade weak bridging over a reasonable but achievable period of time.	June '09	GDC

Table 4.5: Improvement Schedule –Transport (Continued)

Importance	Action	Completion Date	Responsible
	Port of Greymouth		
Medium	Continue to maintain port to an appropriate standard so that it would remain useable in the event of an emergency	June '09	GDC
Medium	Have the ground tested for liquefaction potential in the port area	June '09	GDC
High	Assess the likelihood of the cranes being operational after the major Alpine Earthquake and examine alternative (back-up) options	June '08	GDC
High	Set up an agreement with suitable shipping companies for use of appropriate vessels in an emergency (e.g. shipping companies serving the Chatham Island) and find out the capability of the Navy to help.	June '08	GDC
Medium	Consider forming an emergency plan with fuel companies for supply via the Port of Greymouth and Rail company. Plan should include handling/storage of the fuel at the port	June '09	GDC
High	Consider some form of emergency power for navigation system and a crane at the Port	June '08	GDC
	Railway		
Medium	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.	June '09	GDC & Ontrack
	River Transport		
	A plan to ensure emergency access to suitable boats should be enacted, particularly for Greymouth and Lake Brunner.		

4.2 Urban Drainage

Grey District Council manages eight communities with piped storm water systems:

- Cobden
- Blackball
- Greymouth/Blaketown
- Runanga including Dunollie
- Karoro/Paroa
- Dobson/Taylorville
- Moana
- Ahuara

The study does not consider any other community storm water systems, as they do not rely to any significant extent on pipe systems to convey storm water flows to prevent flooding. Flood protection systems managed by the West Coast Regional Council are discussed in Section 4.5.4.

4.2.1 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 4.6.

Table 4.6: Levels of Service – Storm Water Schemes

Service Description	Target period for Achieving Level of Service			
	Community Category (Refer Section 3.4)			
	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.

4.2.2 Key Principles

The key principles recommended for the management of urban drainage in the recovery after the earthquake are as follows:

- In the short term no attempt will be made repair storm water pipe networks. Provisions will be in place to safely manage and dispose of surface floodwater. These provisions should be in place around critical facilities such as the airport, the hospital, emergency centres within 24 hours;
- Continue with the current programme to separate storm water/sewerage schemes (Cobden, Blaketown and Greymouth);
- Continue replacement of system components following normal asset management principles; and
- Ensure that earthquake loads are adequately addressed in the development of new storm water pipe systems.

A preliminary assessment indicates that even if there was significant failure of the piped storm water systems in the six communities of Karoro/Paroa, Runanga, Dobson/Taylorville, Moana, Blackball and Ahuara it is unlikely that the failure would result in any flooding of significant concern. Repair of these storm water systems would proceed as resources allowed. For this reason these six storm water systems are not considered further in this lifelines study.

The two remaining piped storm water systems; Cobden and Greymouth/Blaketown, are examined in the following sections. Between 70% – 80% of these systems are combined sewage-storm water systems. Deficiencies are identified for these two systems in the face of a major Alpine Fault earthquake such as that described in Section 2.7. The West Coast has high antecedent rainfall and it is assumed that rain events will occur in the months required following the earthquake to reinstate the drainage systems. Upgrades and improvements are proposed to address these deficiencies based on the following recovery strategy:

- Areas where major flooding is likely to occur will be identified beforehand and flooding will be managed by constructing temporary channels to direct the water to flood basins and/or waterways or discharging the flood water by pumping. Adequate management of flood waters will be very important as the flood waters are likely to be mixed with sewage;
- After repairing higher priority lifeline assets damaged by the earthquake, repair requirements of the storm water pipe networks will be attended to. CCTV will be used to assess storm water pipe networks damage and contracts let to repair pipe networks; and
- Storm water will be separated from the combined storm water/sewerage system where it is cost effective to do so.

4.2.3 Generic Improvements

After an Alpine Fault earthquake the success in minimising flooding in the areas normally serviced by piped storm water systems will be improved by having the following measures in place beforehand:

- Confirm the location and extent of areas that are likely to flood;
- Establish an emergency flood mitigation plan that:
  - Identifies areas likely to be affected by flooding after the earthquake,
  - Provides contingency plans for flood affected areas,
  - Identifies those responsible for key tasks,
  - Identifies how damage will be assessed and repair priorities set, and
  - Identifies any training requirements.

A summary is presented in Table 4.9 of proposed upgrade works to address identified piped storm water system deficiencies.

4.2.4 Cobden Storm Water System

This section only considers the dedicated Cobden storm water pipe network; the combined sewerage/storm water pipe network is discussed in Section 4.4.

Description – Cobden

The Cobden storm water system can be described as follows:

- Storm water flows under gravity overland and via storm water pipes and combined storm water and sewerage pipes from the north of Cobden towards the Grey River. Some storm water discharges to Range Creek which in turn discharges to the lagoon adjacent to Hill Quay which in turn discharges into the Grey River mouth;
- Storm water that ponds on Nelson Quay behind the flood wall is pumped into the Grey River at the Newcastle Street storm water pump station;
- Details of the Cobden storm water network are presented in Table 4.7. The total length of pipe in the Cobden storm water network is almost 6,000m including almost 1,000m of open drains. The majority of the network is concrete pipe (43%) and most of the network is considered to be in fair to good condition (5,711m or 95% of the network).

Table 4.7: Summary Table - Cobden Storm Water Network

Pipe Type	Length (m)	Percentage	Condition[1] (m)	
			1 - 3	4 - 5
Open Drains	958	16%	958	0
AC	90	2%	90	0
Conc	2,568	43%	2,451	117
EW	1,505	25%	1,368	137
PVC	844	14%	844	0
Stone	33	1%	0	33
Total	**5997**	**100%**	**5,711**	**286**

1. Based on condition grading system in the GDC asset database (1 = best and 5 = worst)

Deficiencies - Cobden Storm Water

In the event of a major Alpine Fault earthquake such as that described in Section 2.7 Cobden is expected to experience strong intensity MM VIII shaking that will induce damage to the storm water network. Most of Cobden is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected in places. Liquefaction can be expected in areas of looser sandier soil, particularly around the lagoon (Te Aka Aka o Poutini) that is traversed by Hill Quay. Some pipe failures are likely and it is expected that the pipe capacity will be reduced resulting in increased overland flow. Pump stations, manholes and pipe alignment are likely to move particularly in areas where liquefaction occurs.

Figure 4.8: Assessed Flooding Risk - Cobden

A preliminary assessment of resultant flooding is presented in Figure 4.8. The flooding locations are described as follows:

- Storm water from the area between Fitzgerald Street and Firth Street will pond in the area at the western end of Ward Street and the Southern end of Hall Street. This storm water will drain slowly into the lagoon and then into the Grey River mouth;
- Storm water from the area of Cobden between Blackett Street and Stratford Street will drain to Nelson Quay. If the discharge pipes into the Grey River are damaged/blocked floodwater will pond on Nelson Quay. This water can be pumped into the Grey River at the Newcastle Street pump station provided electricity is available and the discharge pipe to the river is not damaged.

Upgrades & Improvements – Cobden

The risks identified in the previous section will be reduced by implementing the improvements outlined in Section 4.2.3 along with the following:

- Provide a generator set for the Newcastle Street pump station;
- Confirm that if the discharge pipe from the Newcastle Street pump station to the Grey River fails an alternative discharge pipe can be put in place quickly; and
- Identify how flooding in the Ward Street - Hall Street area can be minimised. This is likely to be by excavating a temporary sump and using mobile pumping equipment.

It is anticipated that recovery of the Cobden storm water system will proceed as follows after a major Alpine Fault earthquake:

- There will be significant joint failure resulting in reduced capacity of the storm water network. The extent of reduction of capacity will not be evident until after a rainfall event. Damage to all discharge pipes through the floodwall from the Cobden area will be investigated to establish their capacity to discharge storm water. Where damage can be repaired and repair is critical to prevent significant flooding, repair work will be undertaken as a matter of urgency;
- Damage to the Newcastle Street pump station will be assessed and made good to allow it to operate if flooding occurs. If the pump station is severely damaged or cannot operate for any other reason (no generator available) alternative arrangements will be made to pump anticipated flood water from the Nelson Quay area;

- A temporary drainage point will be dug and a portable pump set up in the Ward Street/Hall Street area where flooding is anticipated to be required if the storm water system fails;
- When a significant rainfall event occurs the two potential flooding areas will be monitored and pumps started as required; and
- As work priorities allow, the Cobden storm water system will be assessed more thoroughly (using CCTV in the pipe network) and contracts let to repair and/or replace damaged components of the system.

4.2.5 Greymouth/Blaketown Storm Water System

This section only considers the dedicated Greymouth/Blaketown storm water pipe network; the combined sewerage/storm water pipe network is discussed in Section 4.4.

Description - Greymouth/Blaketown

The Greymouth/Blaketown storm water system can be described as follows:

- The Greymouth/Blaketown storm water system is made up of three catchments:
  - Blaketown. Blaketown is bounded on the northern and eastern sides by floodwalls and on the western side by the Tasman Sea. Storm water is collected in the storm water pipe network and is discharged to catch pits or to the lagoon via discharge pipes through the floodwall. If ponding occurs storm water can also be discharged via the sewerage scheme pump stations at Steer Street, Collins Street and South Piphead;
  - Northern Greymouth. This is the area of Greymouth north of approximately Ngarimu Street. It is bounded by floodwalls along the Grey River to the north and around the lagoon on the west and south-western sides. Under normal operating conditions storm water is discharged as follows:
    - In the west storm water collected in storm pipes flows to the lagoon via a discharge pipe through the flood wall;
    - Storm water from the pipe network in the CBD and the area north of approximately Puketahi Street discharges through the floodwall at locations along the floodwall adjacent to the Grey River. In more extreme flood events storm water combines with sewage and is pumped through the flood wall at the Johnston Street pump station; and

    - Storm water from the pipe network in the area between approximately Puketahi Street and Ngarimu Street is discharged to Tarry Creek.

  - Southern Greymouth. This is the area south of approximately Ngarimu Street and north of approximately Miro Street. Storm water from storm water pipes draining the south-western part of this area discharges to a creek adjacent to Waterworks Road while the remainder of the area drains via storm water pipes and overland to Sawyer Creek.

- The total length of pipe in the Greymouth/Blaketown storm water network is 31,750m. The dominant pipe material is concrete. Around 12% of the pipe network is considered to be in poor or very poor condition (a "4" or "5" condition grade in the GDC database). Details of the storm water pipes in the Greymouth and Blaketown areas are presented in Table 4.8.

Table 4.8: Summary Table - Greymouth/Blaketown Storm Water Network

Area	Pipe Type	Length (m)	Percentage	Condition[1] (m)	
				1 - 3	4 - 5
Blaketown	AC	55	2%	55	0
	Conc	1,228	41%	1,182	47
	EW	1,034	35%	318	716
	Nova, PVC, Steel	644	22%	644	0
Total Blaketown		***2,961***	***100%***	***2,199***	***762***
Greymouth	Open Drain	393	1%	393	0
	AC	343	1%	343	0
	Brick, Stone	690	2%	0	690
	CI	21	0%	0	21
	Conc & RC	12,524	44%	11,420	1,104
	EW	6,376	22%	5,114	1,262
	Nova, PVC, St, Misc	8,438	29%	8,438	0
Total Greymouth		***28,785***	***100%***	***25,708***	***3,077***
Total Greymouth and Blaketown		**31,746**		**27,907**	**3,839**

1. Based on condition grading system in the GDC asset database 1 = best and 5 = worst

Deficiencies - Greymouth/Blaketown

In the event of a major Alpine Fault earthquake such as that described in Section 2.7, Greymouth and Blaketown are expected to experience strong intensity MM VIII shaking that will induce damage to the storm water pipe network. Most of the area is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected in places. Liquefaction can be expected in areas of looser sandier soil, particularly east of the railway line. Ten liquefaction sites from the 1929 earthquake are noted in the pipe network area (refer Figure 2.6 & 2.7). Rigid pipe systems (brick and stone and older concrete, earthenware and asbestos cement pipes with cement joints) are likely to suffer significant damage and may fail completely. Other less rigid pipe systems such as PVC with rubber ring joints are likely to suffer joint failures. Manholes and pipe alignment are likely to be affected in many areas particularly where liquefaction occurs. As a result of damage to and failure of the pipe network it is expected that the storm water pipe capacity will be reduced resulting in increased overland flow.

A preliminary assessment of anticipated flooding from a storm event is presented in Figure 4.9 (for Blaketown and Northern Greymouth) and Figure 4.10 (for Southern Greymouth). With pipe damage and failure there is likely to be an increase in overland flow during the storm event. Ponding is anticipated in the following areas (areas of ponding are shown as blue shaded areas in Figures 4.9 & 4.10):

- Steer Avenue in Blaketown (Refer Figure 4.9) due to failure of the discharge pipes through the flood wall and failure of the Steer Ave sewage pump station and related pipe network which would normally assist to pump the ponding water out of the area. Flood waters maybe over a meter deep rising until they either breach the flood wall (the flood wall is likely to be deformed due to liquefaction and the crest height reduced) or flow down Reid Street to the Packers Quay area;
- Packers Quay in Blaketown (Refer Figure 4.9) due to failure of the discharge pipes through the flood wall and failure of the Collins Ave sewage pump station and related sewer pipe network. Flood waters would reach more than a meter deep in places and eventually breach the flood wall;
- Murray Street in Greymouth (Refer Figure 4.9) due to storm water pipe failure and because this area is naturally prone to flooding. Floodwaters would rise and discharge down Murray Street;
- Elmer Lane in Greymouth (Refer Figure 4.9) due to storm water pipe failure and because this area is naturally prone to flooding. Floodwaters would rise and discharge into the Tarry Creek area;
- Tarry Creek in Greymouth (Refer Figure 4.9) due to general failure of the storm water pipe network preventing flood waters flowing to the Johnston Street pump station, failure of the discharge pipes through the flood wall and failure of the Tarry Creek pump station. The Tarry Creek pump station is likely to suffer structural damage and there will be no power to the site due to power supply grid failure. The floodwaters could potentially rise and flood much of the CBD (including the ambulance service and the police station) until the flood eventually breached the floodwall. The floodwall is likely to be deformed due to liquefaction and the crest height reduced in some locations; and

Figure 4.9: Assessed Flooding Risk - Northern Greymouth & Blaketown

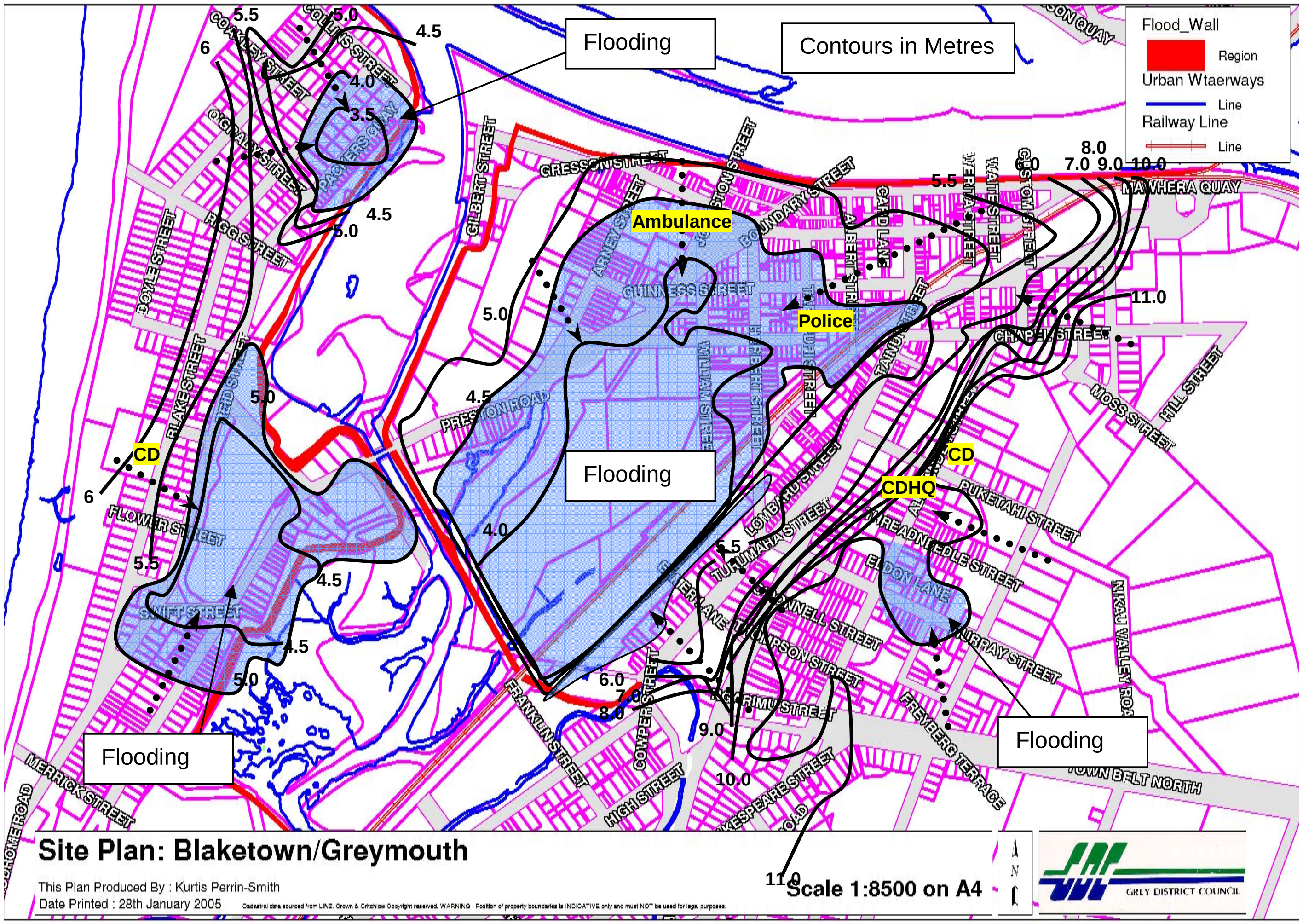
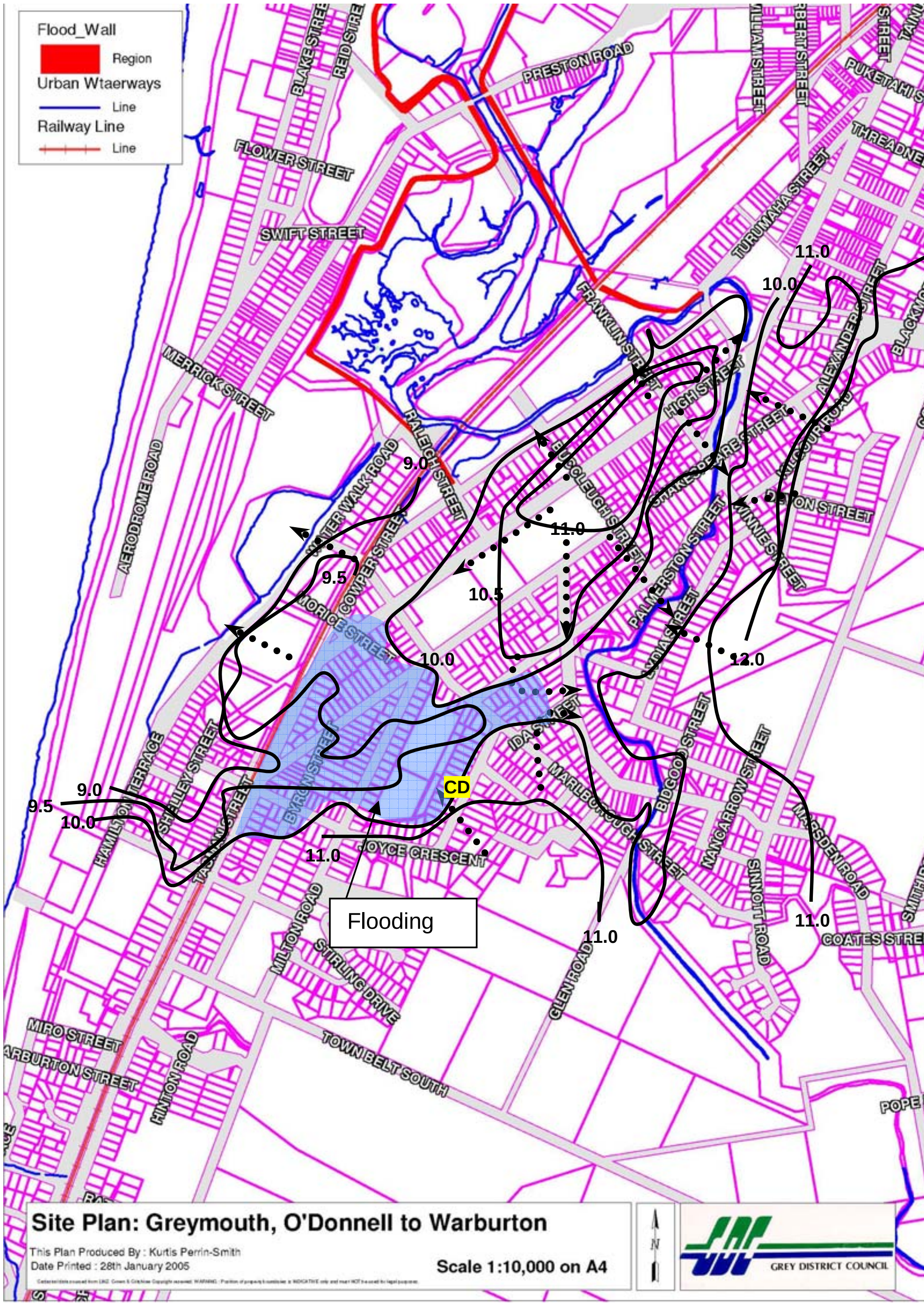


Figure 4.10: Assessed Flooding Risk - Southern Greymouth



- Milton Road/Shakespeare Street in Greymouth (Refer Figure 4.10) due to general failure of the storm water pipe network and because this area is naturally prone to flooding. The flood might extend as far as the CD post. Floodwaters would rise until they flowed into Sawyers Creek near Ida Street or flow out over the State Highway, the railway line and Tasman Street along Nelson Street and Felix Campbell Street to the creek adjacent to Water Walk Road.

Upgrades & Improvements - Greymouth/Blaketown

The risks identified in the previous section will be reduced by implementing the improvements outlined in Section 4.2.3 along with the following:

- Undertake a geotechnical and structural assessments of the Tarry Creek pump station along with all discharge pipes installed in the floodwall. Where appropriate these structures will be strengthened to reduce the likelihood of failure in an earthquake;
- Confirm the ponding areas and the depth and extent of flood waters based on the worst case storm water network failure; and
- Identify how the extent of flooding can be minimised. This is likely to be by identifying where temporary drainage channels can be excavated or where temporary sumps can be excavated and mobile pumping equipment used to discharge floodwaters to local waterways.

It is anticipated that recovery of the Greymouth/Blaketown storm water system will proceed as follows after a major Alpine Fault earthquake:

- There will be significant joint failure resulting in reduced capacity of the storm water network. The extent of reduction of capacity will not be evident until after a rainfall event. Damage to all discharge pipes through the floodwall in the Blaketown and Greymouth areas will be investigated to establish their capacity to discharge storm water. Where damage can be repaired and repair is critical to prevent significant flooding, repair work will be undertaken as a matter of urgency;
- Damage to the Tarry Creek pump station will be assessed and made good to allow it to operate if flooding occurs. If the pump station is severely damaged or cannot operate for some other reason (no generator available) alternative arrangements will be made to pump anticipated flood water from the Tarry Creek area. This may include breaching the flood wall at a predetermined location or mobilising large pumps to the Tarry Creek site to take over the function of the Tarry Creek pump station;
- Temporary drainage channels will be excavated or temporary drainage points will be dug and portable pumps set up in areas where flooding is anticipated if the storm water system has failed;

- When a significant rainfall event occurs the potential flooding areas will be monitored and pumps started as required;
- As work priorities allow the Blaketown/Greymouth storm water system will be assessed in detail (using CCTV in the pipe network) and contracts let to repair the system.

4.2.6 Urban Drainage Systems Improvements Schedule

Improvements identified in Sections 4.2.3 to 4.2.5 are summarised in priority order in Table 4.9. General improvements are presented first followed by improvements for each urban drainage system. Note a more detailed improvement plan is presented in Appendix G.

Table 4.9: Improvement Schedule – Urban Drainage

Importance	Action	Completion date	Responsible
	General		
High	Confirm the location and extent of areas that are likely to flood in all urban drainage communities.	June '08	GDC
High	Review the proposed level of service and strategy to ensure they are appropriate and achievable.	June '08	GDC
High	Establish a register of companies/contractors with useful plant such as mobile high volume pumps, excavators etc	June '08	GDC
Medium	Establish an earthquake emergency flood mitigation plan that: • Identifies areas likely to be affected by flooding after the earthquake, • Provides contingency plans for flood affected areas, • Identifies those responsible for key tasks, • Identifies how damage will be assessed and repair priorities set, and • Identifies any training requirements.	June '09	GDC
High	Ensure that all future storm water system structures are adequately designed for earthquake loads.	June '08	GDC
Low	Continue replacement of system components following normal asset replacement principles. However, give priority to replacement of downstream section then work upstream.	June '10	GDC
Low	Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding. Identify and implement appropriate emergency provisions.	June '10	GDC
	Greymouth/Blaketown and Cobden		
Low	Undertake geotechnical and structural assessments of the Tarry Creek and Nelson Quay pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks.	June '10	GDC
High	Determine optimal locations to breach the floodwall in the event that breaching is required.	June '08	GDC
Low	Continue the current programme of separating the storm water/sewerage schemes in Cobden, Greymouth and Blaketown	June '10	GDC
Medium	Consider purchasing a designated generator for the Nelson Quay Pump Station	June '09	GDC

4.3 Water Supply

Grey District Council manages five water supplies:

- Greymouth
- Runanga Rapahoe
- Dobson Taylorville
- Blackball
- Stillwater

This lifelines study does not attempt to consider community water supplies that are managed by others.

4.3.1 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 4.10.

Table 4.10: Levels of Service – Piped Community Water Supplies

Service Description	Target period for Achieving Level of Service			
	Community Category (Refer Section 3.4)			
	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.

GDC 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 a major 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 earthquake occurring.

4.3.2 Key Principles

The key principle in establishing emergency water supplies in each of the five communities is to establish water supply points using the following priority order:

Strategically located community standpipes;

Strategically located community emergency centres (e.g. schools and similar facilities that can cater for large groups of people, have a robust design and construction and are fitted or able to be fitted out with emergency heating and cooking facilities etc)[1]; and

Other emergency centres.

Each of the GDC water supplies is examined in the following sections and deficiencies of the supplies in the face of a major Alpine Fault earthquake are identified. Solutions and upgrades are proposed to address these deficiencies based on the following recovery strategy:

- After the earthquake it is proposed that an **emergency water supply** will be established in each of the five communities within two to four days. This level of service will be maintained while **normal supply** is progressively re-established. It is anticipated that service levels will be re-established in accordance with the timeframes presented in Table 4.10.

[1] CDEM may need to undertake an assessment of their emergency centres to confirm that they are adequate.

The success of the proposed emergency water supply and return to normal supply will depend on the following measures being in place before the 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 identified key mains between water sources and/or water storage and strategically located community standpipes, Civil Defence posts, and other emergency centres. 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 (e.g. referring to Figure 4.14 in Section 4.3.4 the proposed key main through the Runanga distribution is not a trunk main) the key main does not have to be sized to carry primary trunk main flows because emergency flows are likely to be significantly less than primary main flows;
- Installing burst control valves on all reservoirs to prevent water loss from the reservoirs after the earthquake. The burst control valves will be activated during the earthquake;
- Establishing reliable alternative power sources with adequate fuel supply. Consider purchasing a small mobile generator for small supplies and outfitting all supplies with a generator plug in point at the high lift pump stations;
- Review fire risks to establish an appropriate fire fighting resources for the period after the earthquake when the water supply is not available. This is probably the responsibility of the Fire Service;
- Establishing a formal response plan that identifies those responsible for key tasks, backup plans and training requirements. The plan should also include a thorough methodology for assessing damage and prioritising of repairs;
- 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 supply functions effectively. Repair of other pipelines back to normal supply status is likely to be undertaken after repair of higher priority lifeline assets damaged by the earthquake;
- Ensuring operation manuals are located on site at all supplies;
- Ensure all equipment is adequately restrained particularly at pump houses; 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[2].

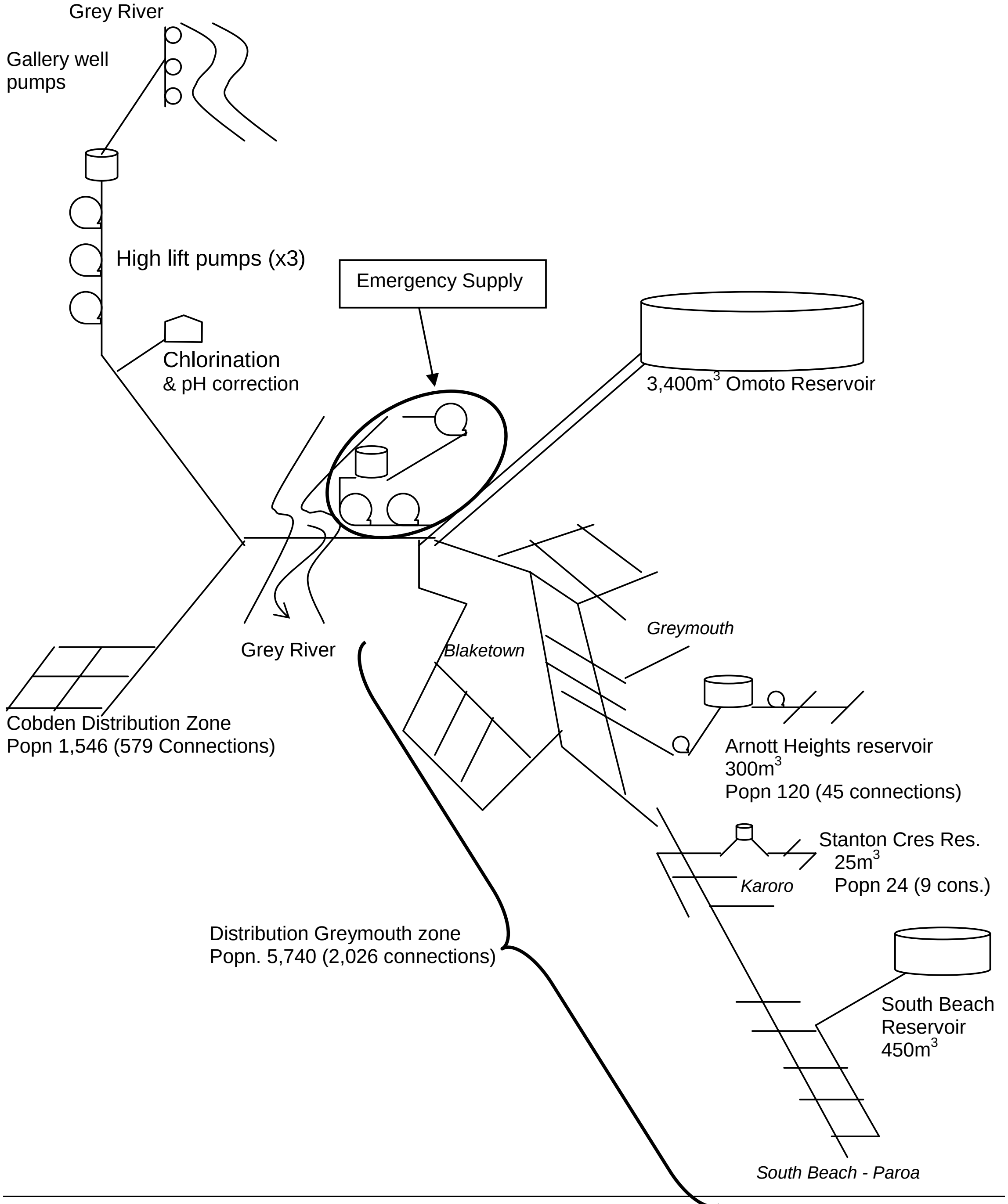
[2] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

A summary is presented in Section 4.3.8 of proposed upgrade works to address identified deficiencies in the supplies. Addressing these deficiencies will improve the ability of GDC to supply water under emergency conditions.

4.3.3 Greymouth Water Supply

Description – Greymouth

Figure 4.11: Greymouth Water Supply



The Greymouth water supply is shown in Figure 4.11 above and is described as follows:

- Water is drawn from an intake gallery at Coal Creek that consists of three shallow wells in a large gravel bank on the Grey River. A submersible pump in each well allows water to be pumped from any of the wells a short distance to the balance tank at the high lift pump station. As the water level is drawn down in the balance tank by the high lift pumps the gallery pumps are progressively started to meet demand. The gallery pumps shut down when the balance tank is full.
- The water is drawn from the balance tank and pumped by the highlift pumps via the transmission line to the Greymouth distribution system. The water is chlorinated with chlorine gas and the pH is corrected by dosing with lime. Chlorine contact time is achieved in the 375mm transmission line.
- The three high lift pumps at Coal Creek have variable speed control to maintain a constant delivery pressure to the transmission line downstream of the pumps. When the demand to be met by a single pump is greater than 100L/sec a second pump will start. The two pumps then synchronise to meet the total demand.
- The Omoto reservoir is located at the northern end of the distribution and the South Beach reservoir at the southern end. The distribution system demand can be met in three ways:
    - By the two reservoirs alone (gravity supply),
    - By the high lift pumps alone, or
    - By combined flow from the high lift pumps and the two reservoirs.

  When the demand is low excess water from the high lift pumps fills the reservoirs.
- The Greymouth water supply provides water to four distribution areas: Blaketown, Cobden, Greymouth and Karoro (including South Beach Paroa). Within the Greymouth area, houses in the elevated area of Arnold Heights are supplied from a separate reservoir and pump system. An in-line booster pump is used to supply water to this reservoir from the main reticulation system. Another smaller reservoir in the Greymouth area supplies a small number of houses in the Stanton Crescent area.
- The composition of the Greymouth distribution systems is presented in the following table.

Table 4.11: Composition of Pipes in the Greymouth Water Supply Reticulation

Location	Pipe Type	Length (m)	Percentage	Percentage	Year Installed
South Beach	Steel	254	2%	2%	1971
	PVC & PE	11,511	98%	98%	1971 – 2000
Karoro	AC	4,743	47%	51%	1950 – 1985
	Steel	376	4%		1971
	PVC & PE	4,995	49%	49%	1971 - 2003
Greymouth	AC	17,784	35%	58%	1930 - 1984
	CI	6,957	14%		1920 - 1961
	Steel	4,540	9%		1930 - 1975
	PVC & PE	21,319	42%	42%	1960 - 2003
Cobden	AC	3,760	25%	65%	1940 - 1972
	CI	1,906	13%		1940 - 1950
	Steel	3,978	27%		1940 - 1954
	PVC & PE	5,166	35%	35%	1954 - 2002
Blaketown	AC	2,866	37%	68%	1952 - 1962
	CI	2,404	31%		1945 - 1953
	PVC & PE	2,459	32%	32%	1987 - 1996

It can be seen from the data in the above table that the predominant pipe materials in Karoro, Greymouth, Cobden and Blaketown are AC, CI and older steel pipes. These materials represent 51% to 68% of the pipes. These pipes are likely to be more vulnerable in an earthquake and their vulnerability is increased because they are relatively old; in these areas 32% of the pipe network is more than 50 years old and 51% is more than 30 years old.

In contrast, 98% of the pipes in South Beach are PVC or PE. PVC & PE are more resilient under earthquake conditions than other pipe materials. The pipe network in South Beach is also younger with 95% of the pipe less than 10 years old.

- An emergency supply can be provided from the old intake and high lift pump station pump station at Omoto. At this intake water is drawn from the gravels on the southern bank of the Grey River via a horizontal infiltration gallery leading to a covered well. The water is pumped from this well using submersible pumps to a 250m³ contact reservoir. There are facilities for chlorine gas dosing before the water enters the contact reservoir. High lift pumps then pump the water from the contact reservoir into the Greymouth distribution system.

The Omoto site may provide a useful emergency supply even in the event that it is damaged e.g. when the infiltration gallery has failed in the past a temporary alternative intake structure (pump on pontoon) has been implemented to allow the supply source to continue functioning.

- Failure of the electricity supply to Greymouth for at least two days after the major earthquake is almost guaranteed; electricity supply failure may in fact last a lot longer than two days. A generator is located at the Coal Creek pump station to address this risk. However, this generator is also used for the pumps at the flood pump station.

Deficiencies – Greymouth

In the event of a major Alpine Fault earthquake such as that described in Section 2.7 Greymouth is expected to experience strong intensity MM VIII shaking which will induce damage to the water supply system. Most of Greymouth is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected in places. Liquefaction can be expected in areas of looser sandier soil, particularly east of the railway line. The intake is unlikely to suffer significant ground induced damage, but liquefaction is likely in places along the pumping mains between the intake and the high lift pumps to Cobden. The pipes to the Omoto reservoir cross part of the Omoto slip, which is likely to move. There is a significant risk that the Greymouth water supply may fail to maintain supply because of the following:

- The intake water turbidity may be elevated due to expected high turbidity in the Grey River caused by earthquake induced landslides in the catchment and prevalent West Coast rain;
- The generator is not available at the Coal Creek pump station or is required at the flood pump station;
- Insufficient reserve fuel storage on site at Coal Creek to keep the generator going (assuming the generator is available) until the electricity supply is reinstated;
- Major pipe failure. Ten liquefaction sites from the 1929 earthquake are noted in the Greymouth (refer Figure 2.6 & 2.7) distribution area. Based on the damage assessment chart in Appendix A and the MM values assigned in Figure 2.5, projections of entry and junction failures have been calculated for each distribution area based on pipe length and are presented Table 4.12;

Table 4.12: Estimate of Pipe Failure

Distribution Area	Pipe Material	Length (m)	Liquefaction Potential	Projection of entry and junction failure (m) [1]	
				Optimistic [2]	Pessimistic [3]
South Beach	Steel	254	East of the Railway	127	190
	PVC & PE	11,511		2,877	6,906
			Total	**3,004**	**7,097**
			Percentage	**26%**	**60%**
Karoro	AC	4,743	East of the Railway	2,371	3,557
	Steel	376		188	282
	PVC & PE	4,995		1,248	2,997
			Total	**3,808**	**6,836**
			Percentage	**38%**	**68%**
Greymouth	AC	17,784	East of railway and close to lagoon	8,892	13,338
	CI	6,957		3,478	5,217
	Steel	4,540		2,270	3,405
	PVC & PE	21,319		5,329	12,791
			Total	**19,970**	**34,752**
			Percentage	**39%**	**69%**
Cobden	AC	3,760	Some lower areas close to lagoon and beach	1,880	2,820
	CI	1,906		953	1,429
	Steel	3,978		1,989	2,983
	PVC & PE	5,166		1,291	3,099
			Total	**6,113**	**10,332**
			Percentage	**41%**	**70%**
Blaketown	AC	2,866	Some areas close to lagoon	1,433	2,149
	CI	2,404		1,202	1,803
	PVC & PE	2,459		614	1,475
			Total	**3,250**	**5,428**
			Percentage	**42%**	**70%**
Grand Total		**83,253**		**33,141**	**57,348**
Overall Percentage		**49,314**		**40%**	**70%**

1. Failure projections are based on length of pipe
2. Optimistic implies predominantly zone 1 type geology - no liquefaction occurs
3. Pessimistic implies significant liquefaction occurs throughout the distribution area

- The supply from Coal Creek to Greymouth and further south is entirely reliant on the pipeline across the Cobden Bridge and the integrity of Cobden Bridge itself. While a temporary pipeline can probably be put in place relatively quickly after the earthquake, if required, a bridge can not. The integrity of the Cobden Bridge is of paramount importance for maintaining a water supply to Greymouth;
- The Arnotts Height reservoir is likely to lose supply from the Greymouth distribution because of power failure, multiple failure of the distribution network and possible failure of the rising main to

the reservoir. It is also possible that the road to Arnott Heights will be impassable to a tanker for some time after the earthquake because of rockfalls/slips on the road;

- There are no automatic burst control valves on any of the four elevated storage reservoirs to prevent the reservoirs draining. Reservoirs are likely to drain after major failure of the distribution pipe network. In the case of the Omoto reservoir it is likely that the pipework to the reservoir will fail and that the reservoir may also be damaged structurally by the earthquake;
- Because of failure of the supply it may not be possible to control fires that break out after the earthquake;
- The emergency supply is old. In an earthquake the gallery, which required replacing, is likely to collapse. Also the gallery water quality is likely to be poor as the gallery is close to the river, which is very likely to be highly turbid;
- There is no operation manual located in the supply (e.g. at the high lift pump station) to assist someone who is unfamiliar with the supply and is required to operate the supply;
- Insufficient spare parts are in stock to repair widespread damage of pipelines; and
- Damage to inadequately restrained equipment at Coal Creek pump station (computer, screen, desk, phone, all spares, etc) and Omoto pump station (phone, spares, storage cabinets, etc).[3]

Upgrades & Improvements – Greymouth

As well as the generic improvements presented in Section 4.3.8, the following improvements specific to the Greymouth supply are proposed to address the deficiencies identified in the previous section:

- Continuous turbidity monitoring data collected by GDC suggests that even during prolonged high turbidity in the Grey River intake water turbidity remains low (less than 10 NTU). Treatment at the Coal Creek intake is to be provided to meet New Zealand Drinking Water Standards (DWSNZ) and it is expected that this treatment will be adequate to treat post Alpine Fault earthquake intake water quality to meet DWSNZ;
- Purchase a dedicated generator for the Greymouth water supply;
- Review reserve fuel storage capacity at Coal Creek to ensure there is adequate fuel for an earthquake event;
- Improve the security of supply throughout the Greymouth distribution system by reviewing the integrity of the key mains - ideally a section of these mains, including a joint, should be removed for analysis. Where replacement is considered appropriate consideration should be given to

[3] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

replacing with butt-welded HDPE or similar pipe material that is resistant to damage due to earthquake induced ground movement[4].

- The following key mains should be assessed (refer Figure 4.12):
  - The 250mm concrete lined steel pipe (installed in 1975) across the Cobden Bridge;
  - The existing 225mm CI pipeline (installed in 1930) on Tainui Street and High Street. Consideration should be given to shifting the function of main to Alexander Street and Shakespeare Street to avoid construction on the state highway (Tainui St – High Street). The existing Tainui Street and High Street 225mm CI pipeline may be retained but its function as a key main should be phased out;
  - The existing 200mm CI pipeline (installed in 1940) on Bright Street in Cobden from Cobden bridge to just past Sturge Street;
  - The Omoto reservoir structure and its foundations should be assessed in detail. If the reservoir is considered to be sound the trunk main/mains to the reservoir should be considered as a key mains and be assessed;
  - The Arnott Heights reservoir could provide valuable additional storage for the Greymouth water supply (Arnott Heights reservoir volume = 300m3). The Arnott Heights reservoir (elev 81.9m) is higher than the Omoto reservoir (elev. 80.5m) and the South Beach reservoir (elev 68.5m). Further assessment is required to define how the Arnott Heights reservoir can be best integrated as an additional supply reservoir for the Greymouth network along with the costs and benefits. If the assessment indicates that the Arnott Heights reservoir should be integrated to supply the Greymouth network the main to the reservoir should be considered as a key main.

    Incorporating the Arnott Heights reservoir with a key main to the reservoir would benefit the Arnott Heights community as they would then not be reliant on road access for tanker supply water during periods when there is no electricity;
  - Water supply lines to CD posts, the hospital and other emergency services building from the key mains should be checked to confirm they have a low risk of failure in an Alpine Fault earthquake event.

The two trunk mains from Greymouth into Blaketown (one via Boundary Road and the other via Raleigh Street) although important are not considered as key mains as both trunk mains are located in areas considered highly susceptible to liquefaction.

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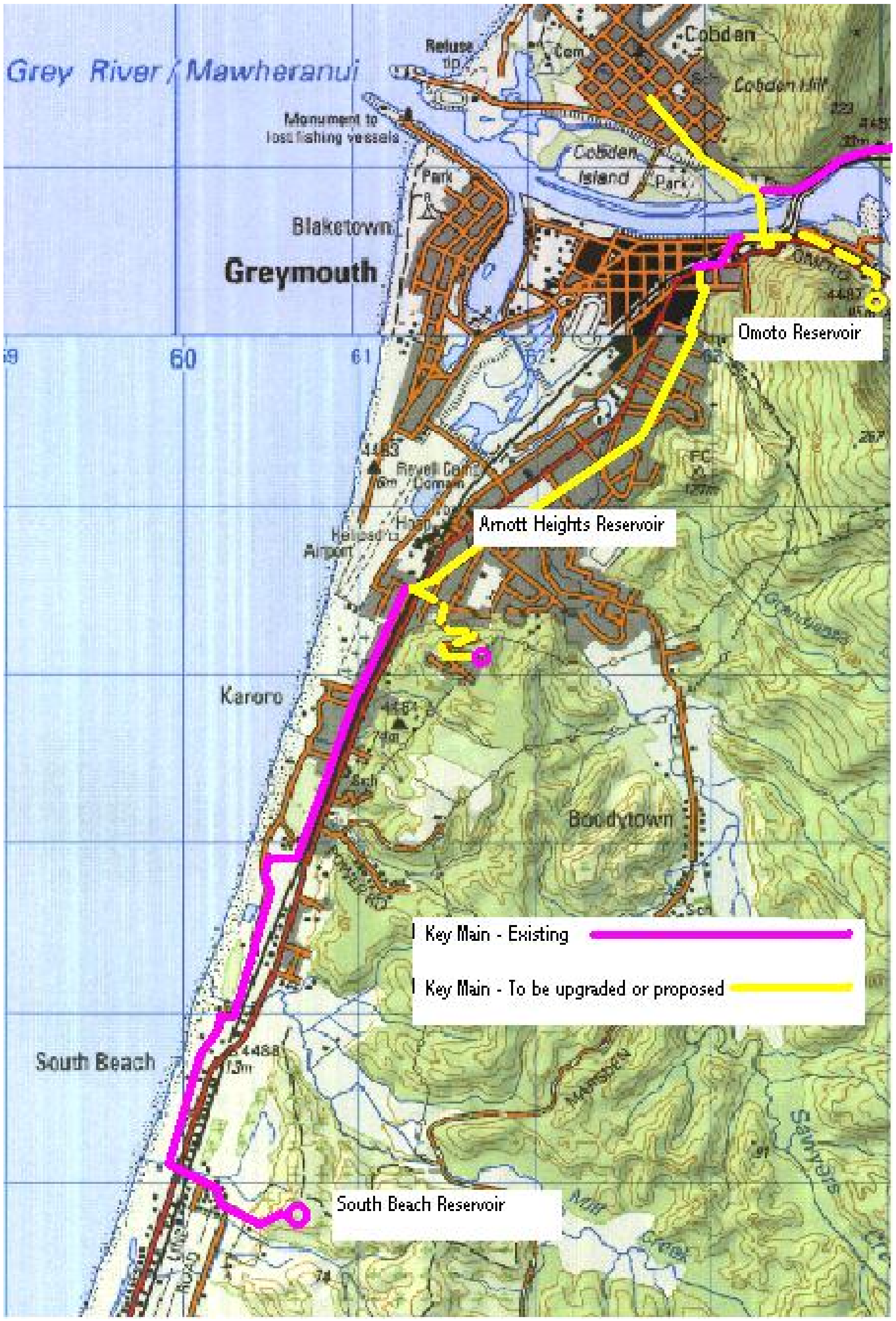
[4] HDPE is also more flexible axially resulting in cyclical expansion and contraction as the pressure in a pressurised pipeline fluctuates. This may be unacceptable beneath some roads because repeated expansion and contraction of the pipe may result

Figure 4.12: Greymouth Distribution - Proposed Pipe Replacement/Duplication



in depressions in the roadway surface above HDPE pipeline crossings. Also, the HDPE industry is still trying to develop a dependable tapping saddle and repair clamp that is able to expand and contract with the pipe wall and not eventually leak.

- Review the probability of the Cobden Bridge failing and consider supply alternatives if the risk of failure is considered too high;
- Install burst control valves on the four storage reservoirs; Omoto, Arnott Heights; Stanton Crescent and South Beach reservoirs;
- High fire risk areas need to be identified and alternative means of fire fighting (suction intakes into the Grey River, the Erua Moana Lagoon, or specially constructed reservoirs for fire fighting) put in place. This is probably the responsibility of the Fire Service;
- Reduce as far as possible reliance on the emergency supply after an earthquake as gallery water quality is likely to be turbid and the gallery is likely to fail during the earthquake anyway;

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

- Power to the Coal Creek pump station will fail at time zero; the time of the earthquake or very shortly afterwards;
- Between 40% to 70% of the Greymouth water supply network is likely to fail at the entries and junctions. Water will be lost from the mains at these failure points;
- The reservoir burst control valves will be actuated and prevent flow from the reservoirs;
- Water supply service staff will manually shut down all branch line valves off the key mains and start the generator to allow the Coal Creek pumps to be operated. Supply will be restored to the key mains from Coal Creek to Cobden Bridge and from Cobden Bridge to the South Beach reservoir, to the Omoto reservoir and to Codben (Sturge Street). Key mains will be filled by progressively opening mainline valves. Damage will be assessed and repairs made before subsequent key main valve are opened;
- Water will be supplied to multi-tap standpipes set up at strategic fire hydrants along the key mains. The supply of water to CD posts, the hospital and other emergency services building will also be checked. Every effort will be made to supply water where required for fire fighting;
- Arnott Heights will be supplied from the Arnott Heights reservoir to a multi-tap standpipe near the reservoir. The main to the reservoir will be out of service until power is restored as at this stage it is assumed that the Arnott Heights reservoir is not integrated as an additional supply reservoir for the Greymouth network. The reservoir will be filled by tanker if road access allows or supply will be provided from small (1000L) tank transported to Arnott Heights by light 4WD vehicle and trailer;
- This emergency water supply level of service will remain in place until a more permanent power supply is available; and

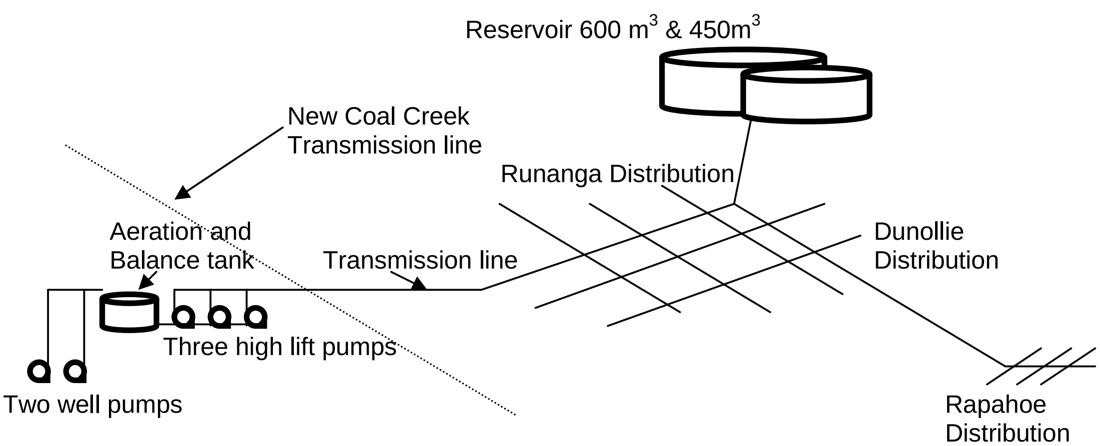
- Once power is restored pipelines will be tested and assessed. Where only minor pipe failures have occurred pipelines will be repaired and put back in service. Where there are major pipe failures the pipelines affected will remain out of service awaiting total replacement at a later date. A thorough methodology for assessing damage and prioritising of repairs should be established as part of an overall water supply earthquake response plan.

A summary of improvements that should be undertaken is presented in Table 4.13 in Section 4.3.8.

4.3.4 Runanga/Rapahoe Water Supply

Description - Runanga/Rapahoe

Figure 4.13: Runanga/Rapahoe Water Supply



The Runanga/Rapahoe system is shown in Figure 4.13 above and is described as follows:

- Water is drawn from two shallow wells on Sids Road and pumped to a balance tank via an aeration chamber.
- Water is drawn from the balance tank by up to three high lift pumps and pumped via a 150mm diameter transmission main to the Runanga community. Water is supplied to the Runanga, Dunollie and Rapahoe distribution systems and the reservoirs at Dunollie.
- The water is not chlorinated.
- The total length of pipe in the distribution network including the trunk mains is 27,700m. The length of pipe in the distribution network excluding rider mains and service connections is 20,340m which is made up of 19,690m of AC pipe (97%) and 650m of galvanised iron and PVC (3%). The AC pipe is 45 years old.

The Dunollie reservoirs, a 600m^3 timbertank reservoir and a 450m^3 concrete reservoir, maintain head on the system. When the reservoir water level falls to 3.75m depth a signal is sent via a Telecom cable to the Sids Road pump station to start one of the high lift pumps. If the water level continues to fall to 3.67m a second high lift pump starts. The high lift pumps shut down once the reservoir top water level of 4.22m is reached.

The well pumps are started by float switches in the balance tank in response to water being drawn off by the high-pressure pumps. When the water level falls in the balance tank the first well pump starts and if the level continues to fall the second well pump starts. Both well pumps shut down once the balance tank is full.

GDC had the structural integrity of the 450m^3 concrete reservoir examined in April 2002 and the concrete was found to be in sound condition although major leaks are evident at construction joints. To address these leaks GDC installed a liner in the concrete reservoir in 2005.

Significant Asset Risks - Runanga/Rapahoe

The Runanga/Rapahoe water supply intake is located on alluvial soils. In the event of a major Alpine Fault earthquake such as described in Section 2.7 intensity MM VIII shaking is expected that may cause liquefaction at a number of locations in the supply. Liquefaction caused by the 1929 Buller earthquake was recorded within 150m of the Sids Road transmission line. If liquefaction occurred at the intake, it is expected that the wells and pump house would be made inoperable. The supply pipe traverses potentially liquefiable soils for several kilometres and there may be zones of liquefiable soils in the lower parts of Runanga/Dunollie and on the route to Rapahoe. The Dunollie reservoir may be subject to stronger shaking due to its location on a narrow ridge.

There is a significant risk that the Runanga/Rapahoe water supply may fail for some or all of the following reasons:

- Failure of the AC pipe. Tests undertaken in 2002 of a 150mm dia section of AC pipe from the transmission main showed that the pipe had suffered moderate deterioration to the external surface in isolated areas and significant deterioration to the internal surface. Based on this information and the damage assessment chart in Appendix A (In ground pipe work) it is expected that between 40% to 80% of AC pipe entries and junctions will fail in the supply;
- There is no automatic burst control valve on the Dunollie reservoir to prevent the reservoir draining. The reservoir is likely to drain after major failure of the AC pipe network;

- There is no reservoir storage in Rapahoe. In the event that the single AC supply main from Dunollie failed there would be no water supply available in Rapahoe for potable or fire fighting needs;
- Because of likely general distribution system failure, the supply may not be available for fire fighting in Runanga/Dunollie area either after the earthquake;
- The condition of the Sids Road well casings is unknown. If they are in poor condition they may fail in an Alpine Fault earthquake event;
- Control of the supply is dependent on telecommunications and grid power. As both telecommunications and grid power are likely to be out of service for a period after the earthquake the water supply cannot be controlled automatically,
- Insufficient spare parts are in stock to repair widespread damage of pipelines; and
- Damage occurs to inadequately restrained equipment (spare submersible pump, phone, electrical power multi-plug) in the Sids Road pump house. The aeration chamber may also not be adequately restrained. [5]

Upgrades & Improvements - Runanga/Rapahoe

As well as the generic improvements presented in Section 4.3.2, the following improvements specific to the Runanga/Rapahoe supply are proposed to address the deficiencies identified in the previous section:

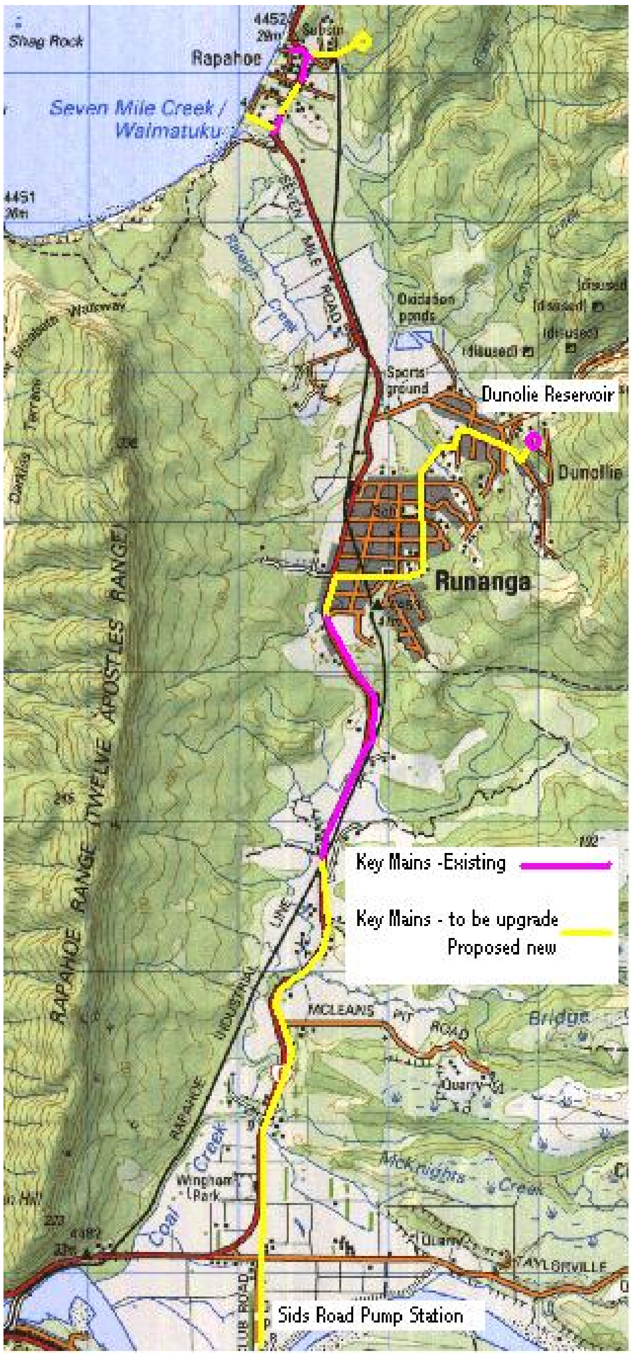
- Replace, upgrade and duplicate the key mains shown in Figure 4.14 (shown in yellow) between the Sids Road pump station to the Dunollie reservoirs and between the proposed new reservoir in Rapahoe and the Rapahoe CD Sector Post. Consideration should be given to using butt welded PE or similar pipe material that is resistant to damage due to earthquake induced ground movement[6];
- Install a burst control valve at the Dunollie reservoirs to prevent draining of reservoirs in the event of major pipe failure;
- Install a reservoir at Rapahoe with burst control valve;

[5] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

[6] HDPE is also more flexible axially resulting in cyclical expansion and contraction as the pressure in a pressurised pipeline fluctuates. This may be unacceptable beneath some roads because repeated expansion and contraction of the pipe may result in depressions in the roadway surface above HDPE pipeline crossings. Also, the HDPE industry is still trying to develop a dependable tapping saddle and repair clamp that is able to expand and contract with the pipe wall and not eventually leak.

- Install a standby supply connection from the Coal Creek source (Greymouth supply) to the Runanga/Rapahoe supply at Sids Road;
- Use CCTV or similar to inspect the condition of the well casings at Sids Road. Consider replacing casing or drilling a new well/wells if casings are in poor condition;

Figure 4.14: Pipe Replacement and Upgrade - Runanga/Rapahoe Water Supply



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

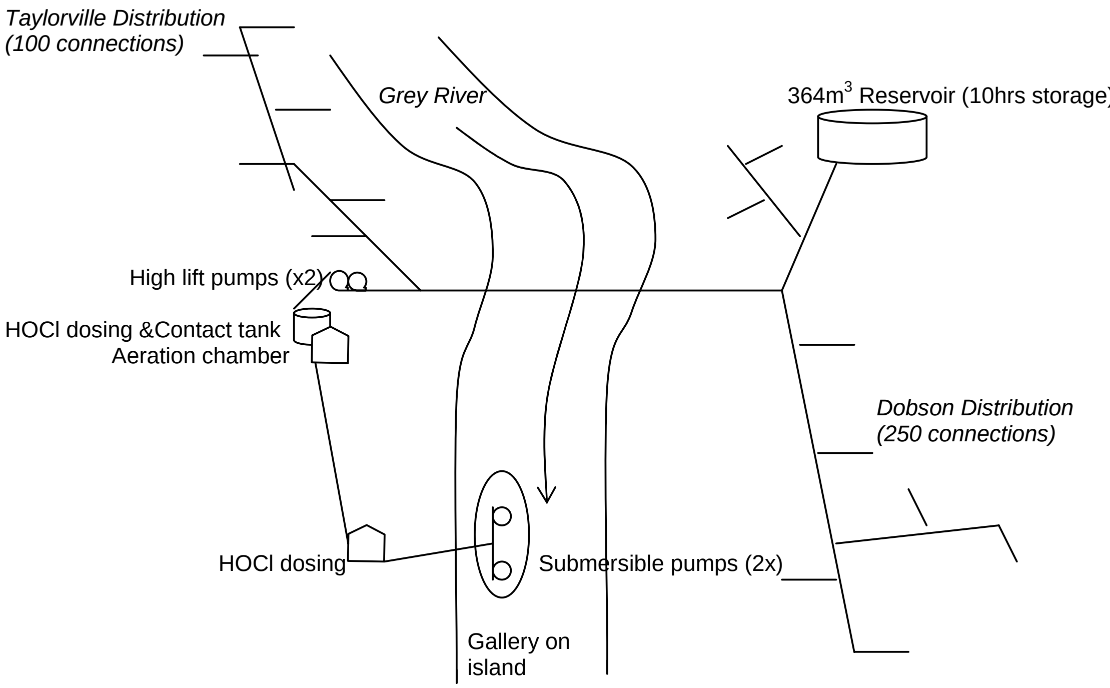
- Between 40% to 80% of the remaining AC pipes are expected to fail at the entries and junctions. Water in the network will flow out at failure points. The key mains are likely to remain mostly intact;
- Flow from the pumps will stop due to power failure and flow out of the reservoir will be prevented by the burst control valve;
- Branch lines from the key mains will be closed manually. The integrity of the key mains between Sids Road and Runanga will be checked by pressurising with water from the Dunollie reservoirs. The proposed new reservoir in Rapahoe will be used to pressurise and check the key mains in Rapahoe. Any breaks will be repaired with gibault joints before supplying water to the key mains;
- Supply into the civil defence posts (Runanga School and Rapahoe Sector Post) will be provided from the key mains and other public supplies will be provided from stand pipes installed at fire hydrants at strategic locations along the key mains;
- Water will be rationed. A generator, which will be moved between the Runanga water supply and the Dobson/Taylorville and Stillwater water supplies, will be used to power the Sids Road pumps to fill the Dunollie reservoirs. In the event that the generator is not available water could be supplied from the Coal Creek source (via the proposed connection at Sids Road) or be pumped into the reservoirs via a fire hydrant from a supply tanker. The Rapahoe reservoir will be filled via a fire hydrant from a supply tanker;
- Rationing and standpipe supply will remain in place until a more permanent power supply is available; and
- Once power is restored pipelines will be tested and assessed. Where only minor pipe failures have occurred pipelines will be repaired and put back in service. Where there are major pipe failures the pipeline will remain out of service for total replacement at a future date. A thorough methodology for assessing damage and prioritising of repairs should be established as part of an overall water supply earthquake response plan.

A summary of improvements that should be undertaken is presented in Table 4.13 in Section 4.3.8.

4.3.5 Taylorville/Dobson Water Supply

Description - Taylorville/Dobson

Figure 4.15: Taylorville/Dobson Water Supply



The Taylorville/Dobson system is shown in Figure 4.15 above and is described as follows:

- Water is drawn from an infiltration gallery on a gravel island in the Grey River. The gallery is made up of two shallow wells and water is pumped from the gallery to an aeration chamber and contact tank. The water is chlorinated on route to the aeration chamber.
- Water is drawn from the contact tank by up to two high lift pumps and pumped via a 150mm diameter transmission main to Taylorville and across the Grey River to Dobson and the storage reservoir.
- The gallery pumps are controlled by the water level in the contact tank and high lift pumps are controlled by the water level in the storage reservoir. Pump operation is controlled via “Pro link” radios.
- The total length of pipe in the distribution network including the trunk mains is 14,025m. The length of pipe in the distribution network excluding rider mains, service connections and the PE river crossings is 7,785m which is made up of 7,100m of AC pipe (91%) and 685m of PVC (9%). The AC pipe was installed in 1957.
- The storage reservoir maintains head on the distribution system.

Deficiencies - Taylorville/Dobson

In the event of a major Alpine Fault earthquake such as that described in Section 2.7 the water supply will be subject to intensity MM VIII shaking. The intake is on recent alluvial soils, and most of the township areas are on older alluvial terraces. The Dobson reservoir is on a hillside of shallow bedrock. There may be some liquefaction in the intake area, which could conceivably affect all or some of the intakes, pumps and pipelines and the west abutment of the pipe bridge. There is a significant risk that the Taylorville/Dobson water supply may fail to be maintain supply because of the following:

- The gallery water quality may deteriorate because of anticipated sustained high turbidity in the river water after the earthquake due to landslides in the Grey River catchment;
- Failure of the intake pump and/or pipe work;
- Failure of the AC pipe. The trunk main from the gallery to the aeration chamber is 150mm dia AC pipe and a preliminary soil assessment suggests liquefaction is likely in a major Alpine Fault earthquake. Based on the damage assessment chart in Appendix A (In ground pipe work) as much as 80% of AC pipe junctions will fail on the 150mm gallery trunk main and between 25% to 50% of entries and junctions will fail in AC pipes in Taylorville and Dobson;
- The condition of the pipe river crossing is unknown;
- The exposed galvanised steel pipe up a rock face to the Dobson reservoir is not well secured and likely to fail during the earthquake;
- There is no automatic burst control valve on the Dobson reservoir to prevent the reservoir draining. The reservoir is likely to drain after major failure of the distribution network;
- Control of the supply depends on a radio link between the reservoir and the high lift pump station and on signals from the level control in the contact tank. These dependent on grid power, which is likely to be out of service for a period after the earthquake. The water supply will not be able to be controlled automatically,
- Insufficient spare parts are in stock to repair widespread damage of pipelines; and
- Damage to inadequately restrained equipment (spare parts, phone, chlorine tank, Chlorine dosing shed restrained to concrete pad) at pump houses[7].

[7] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

Upgrades & Improvements - Taylorville/Dobson

As well as the generic improvements presented in Section 4.3.2, the following improvements specific to the Taylorville/Dobson supply are proposed to address the deficiencies identified in the previous section:

- Records of continuous monitoring of the gallery water quality indicate that turbidity is normally below 1 NTU even during turbid river water conditions. Treatment is to be provided to meet New Zealand Drinking Water Standards (DWSNZ) and it is expected that this treatment will be adequate to treat post Alpine Fault earthquake intake water quality;
- Improving the security of the distribution network by reviewing the integrity of the key mains - ideally a section of these mains should be removed, including a joint, for analyses. Consideration should be given to using butt welded PE or similar pipe material that is resistant to damage due to earthquake induced ground movement[8]. The following key mains should be assessed (key mains in yellow in Figure 4.16):
    - The 150mm AC pipe (installed in 1957) from the junction with the HDPE pipe from the island gallery to the high lift pumps;
    - The 150mm AC pipe (installed in 1957) from the high lift pumps to Taylorville Road;
    - The 150mm from the river crossing on the Dobson side to the Dobson reservoir. The section of AC pipe beside the railway has already been replaced with PE pipe. The section under the SH and up to the reservoir is to be upgraded;
    - The 150mm AC pipe (installed in 1957) along the State Highway in Dobson to Maori Street. If replacement is deemed necessary the section along the State Highway should be replaced and a new main laid along Maori Street to Omapere Street and along Omapere Street to the Civil Defence sector post at the school. This will avoid construction along the State Highway as much as possible;

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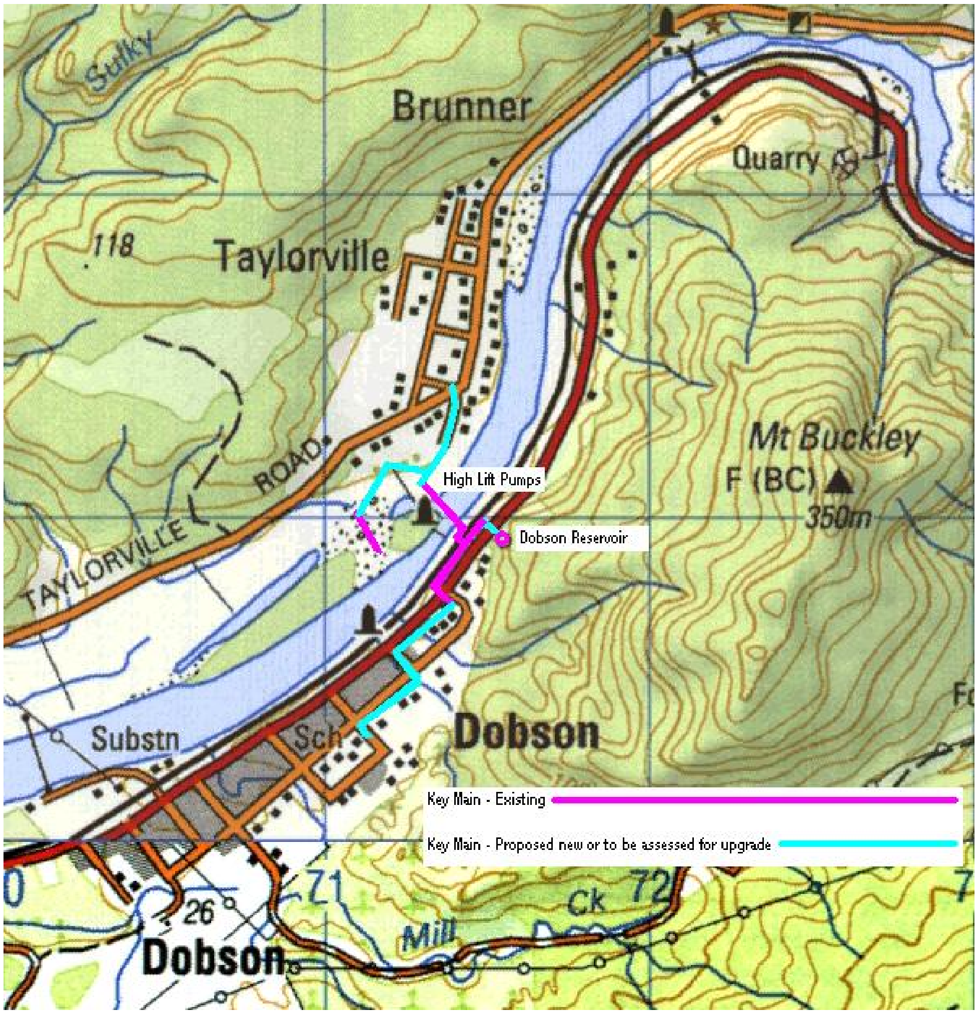
[8] HDPE is also more flexible axially resulting in cyclical expansion and contraction as the pressure in a pressurised pipeline fluctuates. This may be unacceptable beneath some roads because repeated expansion and contraction of the pipe may result in depressions in the roadway surface above HDPE pipeline crossings. Also, the HDPE industry is still trying to develop a dependable tapping saddle and repair clamp that is able to expand and contract with the pipe wall and not eventually leak.

Figure 4.16: Pipe Replacement and Upgrade - Taylorville/Dobson



- The exposed galvanised steel pipe up the rock face to the Dobson reservoir should be assessed and secured to the rock as required with rock bolts or similar;
- Install a burst control valve at the Dobson reservoir to prevent draining of the reservoir in the event of major pipe failure;
- Re-assess the pipe river crossing including bridge columns, pipe, cables and anchors; and
- The water supply will have to be operated manually until grid power is in service again and the supply radio control system can operate again.

After the improvements have been implemented it is anticipated that the recovery of the Dobson/Taylorville water supply after a major Alpine Fault earthquake will take place as follows:

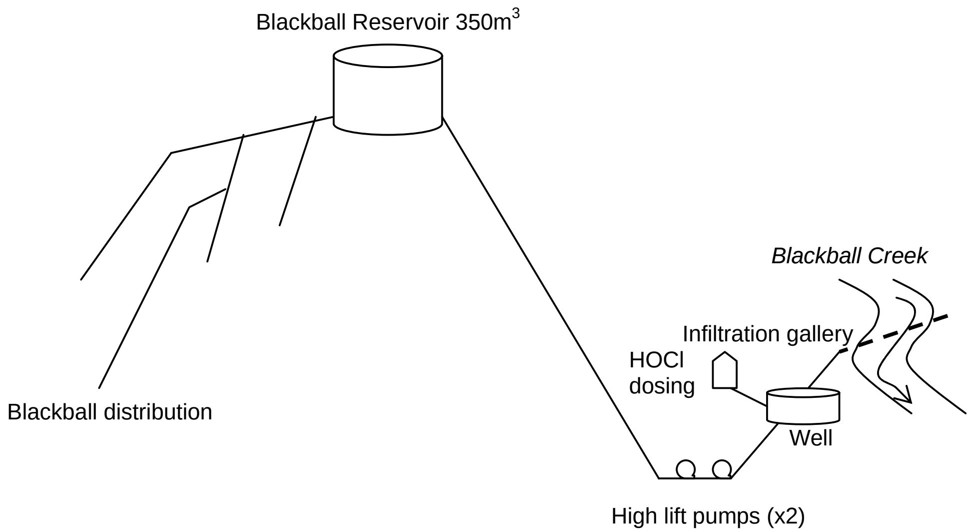
- Power to the Dobson pump stations will fail at time zero; the time of the earthquake or very shortly afterwards;
- The PE pipe river crossing pipe over the Grey River between Taylorville and Dobson and the pipe between the gallery on the island and the bank on the Taylorville side are likely to swing during the earthquake but not fail;
- Between 25% to 35% of the Taylorville/Dobson water supply network (excluding rider mains and service connections) is likely to fail at entries and junctions. Water will be lost from the mains at some of these failure points;
- The reservoir burst control valve will be actuated and prevent flow from the reservoir;
- Water supply service staff will manually shut down all branch line valves off the key mains. Water from the Dobson reservoir will be used to pressurise the key mains in stages to check their integrity. Breaks will be repaired with gibault joints;
- Supply into the Civil Defence posts (Dobson School) will be provided from the key mains along with stand pipes installed at fire hydrants at strategic locations along the key mains;
- Water will be rationed. A generator set will be moved around the smaller water supplies (Runanga/Rapahoe, Dobson/Taylorville and Stillwater) approximately once every three days to allow the pumps to fill the reservoir. In the event that a generator is not available the community will have to rely on a tanker supply in the street as access to fill the Dobson reservoir is likely to be very difficult;
- Rationing and standpipe supply will remain in place until a more permanent power supply is available; and
- Once power is restored pipelines will be tested and assessed. Where only minor pipe failures have occurred the pipeline will be repaired and put back in service. Where there are major pipe failures the pipeline will remain out of service awaiting total replacement at a later date. A thorough methodology for assessing damage and prioritising of repairs should be established as part of an overall water supply earthquake response plan.

A summary of improvements that should be undertaken is presented in Table 4.13 in section 4.3.8.

4.3.6 Blackball Water Supply

Description – Blackball

Figure 4.17: Blackball Water Supply



The Blackball system is shown in Figure 4.17 above and is described as follows:

- Water is drawn from an infiltration gallery in Blackball Creek. The water flows from the gallery to a covered well via a 150 mm (6") diameter PVC pipe.
- Water is drawn from the covered well by up to two high lift pumps and pumped via a 150mm diameter transmission main to the Blackball reservoir.
- The water is chlorinated with hypochlorite solution on the discharge side of the high lift pumps.
- The high lift pumps are controlled by the water level in the Blackball reservoir. A signal is sent via a cable from the reservoir to the high lift pump station.
- The total length of pipe in the distribution network including the trunk mains is 6,425m. Most of the network (95%) is PVC (4,700m = 73%) and PE pipe (1375m = 22%). The remaining pipe is 350m of AC and CI pipe, which is the trunk main from the Blackball reservoir to the distribution network. Most of the network (87%) was installed in 1965.
- The storage reservoir maintains head on the distribution system.

Deficiencies – Blackball

Blackball is located on an old alluvial terrace. The stiffer soil types are likely to result in less damage to the water supply than for the more recent alluvium in Greymouth. In the event of a major Alpine Fault earthquake such as that described in Section 2.7, shaking intensity MM VIII is expected and will produce some damage. There is a significant risk that the Blackball water supply may fail to be maintain supply because of the following:

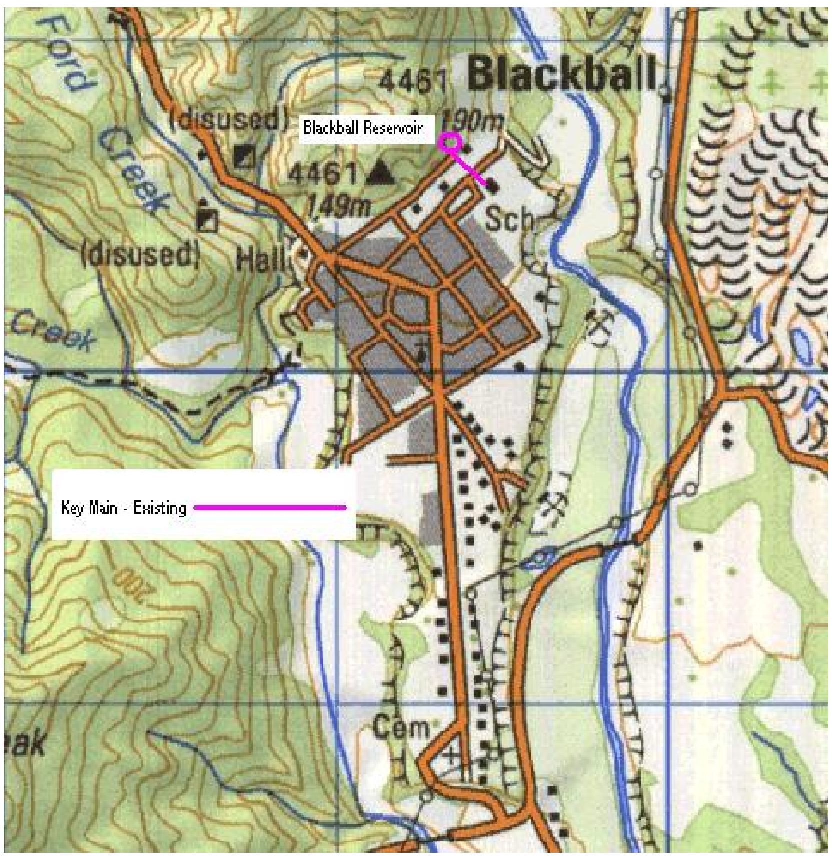
- The gallery is very shallow and the water quality will almost certainly deteriorate because of anticipated sustained high turbidity in the Blackball Creek water after the earthquake due to landslides in the Blackball Creek catchment;
- The pump house may not be reinforced and may therefore be quite susceptible to earthquake damage;
- Failure of the distribution pipe. There was only minimal supervision of installation of the distribution in 1965. The condition of the bedding and the quality of the pipe laying practice are unknown. Taking into consideration the less than ideal supervision at installation and the damage assessment chart in Appendix A (In ground pipe work) it is anticipated that between 25% to 50% of entries and junctions are likely to fail in the AC/CI trunk main and between 5% to 40% in the PVC pipes;
- There is no automatic burst control valve on the Blackball reservoir to prevent the reservoir draining. Failure of the distribution network will drain the reservoir;
- It is unclear whether there are adequate valves in the right locations to adequately isolate the key mains or adequate hydrants in the right locations for stand pipe supplies;
- Insufficient spare parts are in stock to repair wide spread damage of pipelines; and
- There would be damage to inadequately restrained equipment (spare parts, chlorine tank and support stand, chlorine dosing shed restrained to concrete pad) at pump houses.

Upgrades & Improvements - Blackball

As well as the generic improvements presented in Section 4.3.2, the following improvements specific to the Blackball supply are proposed to address the deficiencies identified in the previous section:

- As the water quality at source is likely to be poor and there is a possibility of the pump shed being damaged in the earthquake, the Blackball supply should probably be supplied by tanker in the short term after the earthquake;
- Distribution system failure is not critical as Blackball is small. Supply to the CD Sector post is important (shown in crimson in Figure 4.18) and this should be checked to ensure it will remain viable after an earthquake. Other public standpipe facilities can be set up on a temporary basis. Vehicle access to the reservoir will be important to allow it to be filled by tanker;

Figure 4.18: Pipe Replacement and Upgrade - Blackball



- Install a burst control valve at the Blackball reservoir to prevent draining of the reservoir;
- Check that there are adequate isolation valves and hydrants in strategic locations; and

- Training of emergency staff should be considered as it may be some time after the earthquake before technical staff can get to Blackball to make repairs.

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

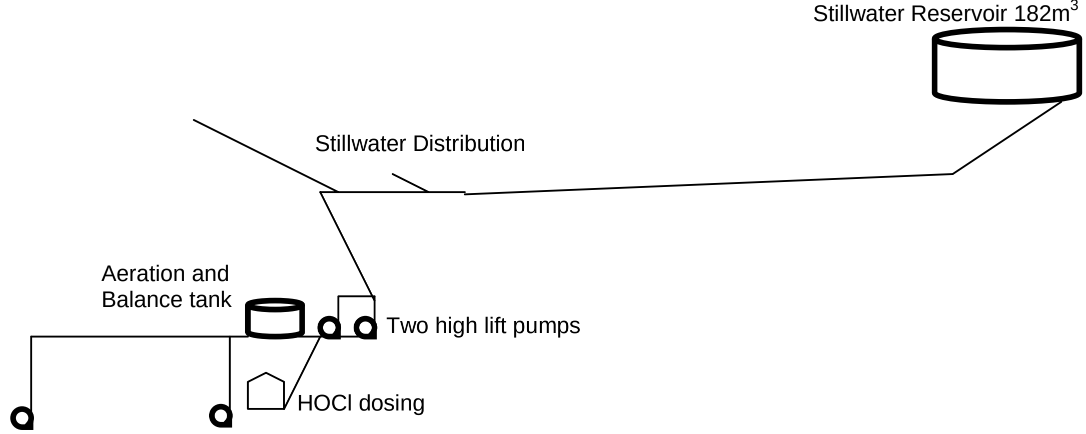
- Power to the Blackball pump station will fail at time zero; the time of the earthquake or very shortly afterwards;
- The pump house may have suffered structural damage due to lack of concrete reinforcing and be dangerous to work in. Pump operation, however, will not be a priority as it is very likely that the water quality will deteriorates significantly with each rainfall and remains turbid most of the time;
- Between 5% and 40% of the PVC pipe entries and junctions are likely to fail;
- The reservoir burst control valve will be actuated and prevent flow from the reservoirs;
- Water supply service staff or emergency staff appointed by GDC will manually shut down distribution system valves, open valves at the reservoir to direct a water supply into the civil defence posts (Blackball School) and set up a small number of stand pipes;
- Water will be rationed. The population of Blackball is small (330 people) and the storage reservoir is large (350m^3). Assuming that water quality is poor at the Blackball intake, getting the Blackball pump station operating again will be low priority. Water from one of the other supplies (probably Coal Creek source) will be taken by tankers to Blackball regularly and pumped into the reservoir;
- Rationing and standpipe supply will remain in place until the Blackball source stabilises sufficiently to allow pumping of the source to resume or if necessary an alternative source is established; and
- Once a satisfactory source is functioning and power is restored pipelines will be tested and assessed. Where only minor pipe failures occur pipelines will be repaired and put back in service. Where there are major pipe failures the pipeline will remain out of service for total replacement at a future date. A thorough methodology for assessing damage and prioritising of repairs should be established as part of an overall water supply earthquake response plan.

A summary of improvements that should be undertaken is presented in Table 4.13 in section 4.3.8.

4.3.7 Stillwater Water Supply

Description – Stillwater

Figure 4.19: Stillwater Water Supply



The Stillwater system is shown in Figure 4.19 above and is described as follows:

- Water is drawn from shallow wells on the south side of the Grey River approximately 300m from the river.
- The water is pumped from the wells using submersible pumps through an aerator and into a balance tank.
- From the balance tank high lift pumps pump the water through a bulk meter to the distribution.
- The water is chlorinated at the high lift pump station.
- A single distribution main supplies Stillwater township on the way from the high lift pumps to the elevated storage reservoir on a hill a short distance from Stillwater.
- The high lift pumps are controlled by the water level in the storage reservoir via a Telecom landline. The submersible pumps are controlled by float switches in the balance tank.
- The total length of pipe in the distribution network is 3,000m of which 2,380m is trunk main and 620m is rider main. The trunk is made up of:
    - 1,600m of AC pipe (67%) that was installed in 1967,
    - 530m of PVC (22%) that was installed between 1967 and 2004, and
    - 250m of other materials (11%): PE and galv. Steel installed in 2002.
- The storage reservoir maintains head on the distribution system.

Deficiencies – Stillwater

Stillwater is located on older alluvial and outwash surfaces. In the event of a major Alpine Fault earthquake such as that described in Section 2.7 this stiffer soil profile should result in less damage than experienced by Greymouth, but the shaking intensity of MM VIII will damage the water supply. The intake is on a lower terrace, with a low risk of liquefaction. There is a significant risk that the Stillwater water supply may fail to maintain supply for the following reasons:

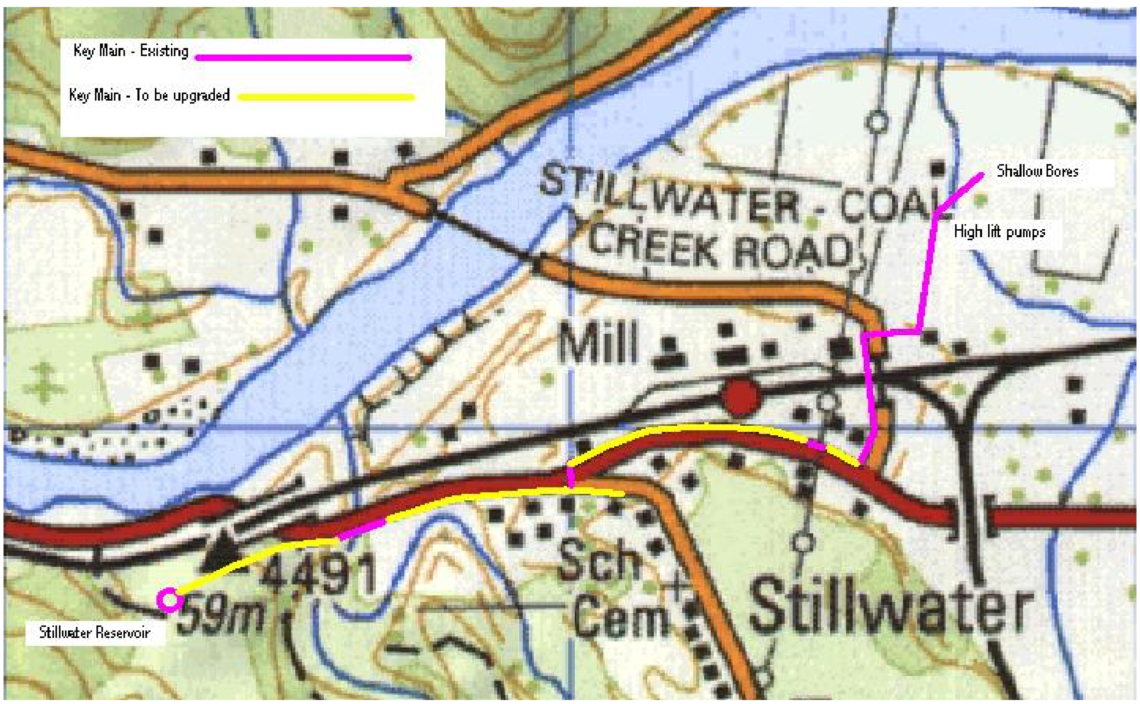
- Intake failure. The intake is unlikely to be damaged. However this needs to be confirmed with an appropriate investigation;
- Failure of the AC pipe. Based on the damage assessment chart in Appendix A (In ground pipe work) between 25% to 50% of entries and junctions will fail in the AC pipes and 5% to 30% of entries and junctions will fail in the PVC pipes;
- The aeration chamber is in poor condition;
- There is no automatic burst control valve on the Stillwater reservoir to prevent the reservoir draining;
- It is unclear whether there are adequate valves in the right locations to adequately isolate the key mains or adequate hydrants in the right locations for stand pipe supplies;
- Control of the supply is dependent on telecommunications and the grid power, which are likely to be out of service for a period after the earthquake. The water supply will not be able to be controlled automatically;
- There are insufficient spare parts in stock to repair widespread damage of pipelines;
- There is inadequately restrained equipment (chlorine dosing building restraints, monorail chain block, multiplug connection, phone, chlorine tank along with support stand and pipe work, spare parts) at pump houses;
- Granulated chlorine storage method is inadequate and chlorine may spill in an earthquake; and
- The reservoir structure is deteriorating (evidence of exposed reinforcing on the exterior).

Upgrades & Improvements – Stillwater

As well as the generic improvements presented in Section 4.3.2, the following improvements specific to the Stillwater supply are proposed to address the deficiencies identified in the previous section:

- Improve the security of the distribution network by replacing the sections of 150mm AC pipe in the key main from the shallow bores to the reservoir and to the CD post (shown in yellow in Figure 4.20). Consideration should be given to using butt welded PE or similar pipe material that is resistant to damage due to earthquake induced ground movement[9];

Figure 4.20: Pipe Replacement and Upgrade - Stillwater



- Use CCTV or similar to inspect the condition of casing of the two the Stillwater intake wells;
- Assess the Stillwater reservoir structure and foundations. Strengthen and improve as required so that the reservoir will function after an earthquake;

[9] HDPE is also more flexible axially resulting in cyclical expansion and contraction as the pressure in a pressurised pipeline fluctuates. This may be unacceptable beneath some roads because repeated expansion and contraction of the pipe may result in depressions in the roadway surface above HDPE pipeline crossings. Also, the HDPE industry is still trying to develop a dependable tapping saddle and repair clamp that is able to expand and contract with the pipe wall and not eventually leak.

- Install a burst control valve at the Stillwater reservoir to prevent draining of the reservoir in the event of major pipe failure; and
- Ensure that there are adequate isolation valves and hydrants at strategic locations in the distribution network.

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

- Power to the Stillwater pump (submersibles and high lift) will fail at time zero; the time of the earthquake or very shortly afterwards;
- It is expected that the upgraded key main from the Stillwater shallow bores to the reservoir and to the CD post at the school in Stillwater will remain largely intact;
- The reservoir burst control valves will be actuated and prevent flow from the reservoirs;
- Water supply service staff or emergency staff appointed by GDC will manually shut down all branch lines valves off the key main. Water from the Stillwater reservoir will be used to pressurise the key main to check the main's integrity;
- Water will be rationed. The population of Stillwater is small (120 people) and the storage reservoir is large (180m^3). Supply will be provided from the reservoir into the Civil Defence post (Stillwater School) and to a small number of standpipes installed at strategic locations on the key main. Water will be pumped from the Stillwater bore to the reservoir every few days using the small generator that will be moved between the small supplies. In the event that a generator is not available water will be taken regularly by tankers to the Stillwater CD post;
- Rationing and standpipe supply will remain in place until a permanent power supply is available.

Stillwater is a small supply. However, the intake and pump station are likely to be less vulnerable to damage than in other supplies. The reservoir is in a relatively secure position and the trunk mains are to be upgraded to key main status. This will make the Stillwater one of the more robust supplies and it may be able to augment water supplies to Taylorville and Dobson.

A summary of improvements that should be undertaken is presented in Table 4.13 in section 4.3.8.

4.3.8 Water Supply Improvement Schedule

Improvements identified in sections 4.3.3 to 4.3.7 are summarised in priority order in Table 4.13. General improvements are presented first followed by improvements for each supply. Note a more detailed improvement plan is presented in Appendix G.

Table 4.13: Improvement Schedule - Water Supply

Importance	Action	Completion Date	Responsible
	General		
High	Establish a formal response plan that identifies those responsible for key tasks, backup plans and training requirements. It will be important to identify local people in the four supplies outside Greymouth to be responsible for water supply operation under emergency conditions particularly when GDC staff or contractors are not available. Identify where necessary plant will be obtained from e.g. tankers. The plan should also include a thorough methodology for assessing damage and prioritising of repairs.	June '08	GDC
High	Review spare part requirements to establish emergency supply status at all water supplies.	June '08	GDC
Medium	Purchase a generator sets for small water supplies (Runanga, Dobson, Stillwater & Blackball)	June '09	GDC
Medium	Undertake an assessment of the key mains in all the water supplies including mains to CD posts and other emergency services	June '09	GDC
Medium	Ensure all equipment is adequately secured against movement in an earthquake at all water supply pump stations and treatment plants and ensure all water supply buildings and reservoirs have adequate earthquake strength.	June '09	GDC
Medium	Undertake a liquefaction assessment at locations of vulnerable components for all water supplies.	June '09	GDC
Low	Review options for multi-tap standpipes and assess the number required for each of the five GDC water supplies. Fabricate adequate multi-tap standpipes for all supplies and identify where the standpipes are to be stored.	June '10	GDC
Low	Establish priorities for initial re-instatement of water supplies	June '10	CDEM/ GDC
Medium	Define high fire risk/high value areas and identify appropriate secondary fire fighting options	June '09	GDC
Medium	Install burst control valves on reservoirs in all supplies	June '09	GDC
Medium	Prepare an Emergency Response Plan for Water Supplies and provide a copy at each water supply pump station for each of the community supplies	June '09	GDC
High	Review reserve fuel storage capacity requirements for the Coal Creek intake, Sids Road, Taylorville, Stillwater and Blackball high lift pump stations to ensure there is sufficient fuel available in the event of the Alpine Fault earthquake.	June '08	GDC

Table 4.13: Improvement Schedule - Water Supply (Continued)

Importance	Action	Completion Date	Responsible
	Greymouth		
Low	Provide treatment to DWSNZ 2005 standard. Treatment design should take into consider likely water quality after an Alpine Fault earthquake.	June '10	GDC
High	Purchase dedicated generator for Coal Creek intake	June '08	GDC
High	Replace 250mm Steel – Cobden Bridge & Mawhero Quay (500m)	June '08	GDC
Medium	225mm CI - Tainui & High Streets duplicated in Alexander & Shakespeare Streets (2,000m)	June '09	GDC
Medium	Replace 200mm CI – Cobden (900m)	June '09	GDC
Low	Replace 150mm AC & Steel - Nelson & Tasman Streets (300m)	June '10	GDC
Medium	Evaluate the Arnott Heights reservoir as a supply reservoir for Greymouth as well as Arnott Heights. If feasible assess main to reservoir and upgrade as required to key main status.	June '09	GDC
Medium	Inspect the Omoto reservoir structure and foundations to assess likely damage in an Alpine Fault earthquake. If reservoir considered likely to still function satisfactorily after an Alpine Fault earthquake, assess mains to reservoir and upgrade as required to key main status.	June '09	GDC
	Runanga		
Medium	Undertake inspection of the Sids Road well casings. Assess condition and if questionable consider options to replace well casings or install new bore/bores	June '09	GDC
High	Upgrade 150mm AC - Sids Road - Runanga to a 200mm pipe (3,000m)	June '08	GDC
Medium	Install 150mm PVC main through Runanga past the CD sector post to the Dunollie reservoir (3,000m)	June '09	GDC
Low	Install 100mm PVC main through Rapahoe between the CD sector post and the proposed Rapahoe reservoir (900m)	June '10	GDC
Low	Install a reservoir and supply main in Rapahoe with burst control valve	June '10	GDC
Medium	Install a supply connection at Sids Road between the Coal Creek intake transmission line and the Runanga water supply transmission line	June '09	GDC

Table 4.13: Improvement Schedule - Water Supply (Continued)

Importance	Action	Completion Date	Responsible
	Dobson Taylorville		
Low	Provide treatment to meet DWSNZ 2005. Treatment design should take into consider likely water quality after an Alpine Fault earthquake	June '10	GDC
Medium	Replace 150mm AC - intake to high lift pump station (500m)	June '09	GDC
Medium	Replace 150mm AC - high lift pump station to Taylorville CD Sector Post (700m)	June '09	GDC
Low	Replace 150mm AC - to the Dobson reservoir (200m)	June '10	GDC
Low	Replace 150mm AC - SH 7 (Dobson) to the Dobson CD Sector Post (600m)	June '10	GDC
High	Assess pipe river crossing including bridge columns, pipe, cables and anchors	June '08	GDC
High	Attach pipeline to Dobson reservoir firmly to the cliff face	June '08	GDC
	Blackball		
High	Confirm that the 150mm AC/Steel pipe from the Blackball reservoir to the CD Sector Post at the school is in good condition. Consider improvements particularly at the reservoir end where it taps into the mainline from the reservoir.	June '08	GDC
Medium	Review to ensure there are adequate isolation valves and hydrant is strategic location	June '09	GDC
	Stillwater		
Medium	Assess the Stillwater reservoir structure and foundations	June '09	GDC
Medium	Undertake inspection of the Stillwater well casings. Assess condition and if questionable consider options to replace well casings or install new bore/bores	June '09	GDC
Low	Replace 150mm AC – Reservoir to Stillwater CD Sector Post (1,600m)	June'10	GDC
Low	Review to ensure there are adequate isolation valves & hydrant is strategic location	June '10	GDC

4.4 Sewerage

Grey District Council manages five sewerage schemes:

- Greymouth (no treatment)
- Cobden (no treatment)
- Karoro/Paroa
- Runanga
- Moana

This lifelines study does not attempt to consider community sewerage systems in the district that are managed by others.

4.4.1 Level of Service – Sewerage Schemes

The minimum target levels of service to be provided to communities after a major Alpine Fault earthquake are presented in Table 4.14.

Table 4.14: Levels of Service – Community Sewerage Schemes

Service Description	Target period for Achieving Level of Service			
	Community Category (Refer Section 3.4)			
	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.

4.4.2 Strategy – Sewerage

The strategy for achieving effective recovery after a major earthquake is as follows:

Pre-earthquake

- Establishing an emergency sanitation 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,
    - Back up plans,
    - Discharge requirements of major waste water producers after a major earthquake;
    - 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;
- Reviewing the preliminary assessments of surcharging locations presented in the following sections (Section 4.4.3 to 4.4.7) to ensure ponded water can discharge to a nearby waterway. While an operative sewerage system needs a water supply to function, surcharging is still expected because of the combined storm water/sewerage schemes in Greymouth, Blaketown and Cobden and because of disrupted but still functioning sewer systems in areas where inflow and infiltration occur;
- Continuing to replace system components following normal asset replacement principles. Replacement of sewer pipes should start from the discharge point and proceed upstream

replacing trunk mains first. This will reduce the risk of surcharging at locations where new pipe work resistant to earthquake failure meets older rigid downstream pipes that completely fail in an earthquake. Upgrading sewer pipes from CD posts and areas where offices are likely to be established to assist in the recovery effort will also be a priority;

- Separation of the combined storm water/sewerage in Cobden and Greymouth/Blaketown will take place during the re-building of the systems;
- Undertaking geotechnical and structural assessments of all pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks; and
- Reviewing all pump stations and oxidation pond sites to ensure all equipment and plant is adequately secured against movement in the event of an earthquake[10]; and
- Designing new sewerage system structures adequately for earthquake loads;

Post-earthquake

- During the emergency level of service no attempt will be made to repair sewer networks. Surcharges from failed sewers will be directed to nearby waterways; temporary ditches will be constructed to waterways where ponding occurs or ponding sewage will be pumped to nearby waterways. Special arrangement may be required to dispose of sewage from the hospital;
- During the interim level of service period residents able to remain in their homes will make their own toilet arrangements (long drop or similar). Where CD posts and 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 or CDEM will provide toilet facilities. Where sewers must be made operable some repair may be required. Sewage will continue to be discharge to natural waterways.
- It is likely that industry will close down until a normal level of service can be established or they make their own arrangements to safely dispose of industrial wastewater;
- The sewerage system components will be inspected sequentially according to priority (GDC in consultation with others will assign priorities). CCTV will be used to assess damage in the sewer networks. As well as damage to the sewers themselves it is anticipated that many lateral connections to the sewers will fail. In the longer term, damage to individual laterals will also need to be addressed to prevent unacceptable levels of infiltration into the sewer. Pump stations will not be used until major breaks that may allow sediment into the sewer network have been repaired. Pumping sewage with a high sediment load may damage pumps and a high sediment load may cause blockages in low velocity sections of the sewer network;

- Contracts will be let to repair sewerage systems in a staged manner. It is likely that some areas will not be given clearance to use the sewerage system for weeks and in many areas clearance will not be given for months; this has significant implications for the tourist industry. Reducing inflow/infiltration to an acceptable level is likely to take over a year as it is expected that much of this will be from individual service connections; and
- Lateral connections will be progressively repaired to property boundaries. Property owners will be expected to make their own arrangements for repair/reinstatement on their own properties, as these matters will/should be covered by insurance.

Each of the GDC sewerage schemes is examined in the following sections and deficiencies of the schemes in the face of a major Alpine Fault earthquake are identified. Upgrades and improvements are proposed to address these deficiencies based on the strategy outlined above.

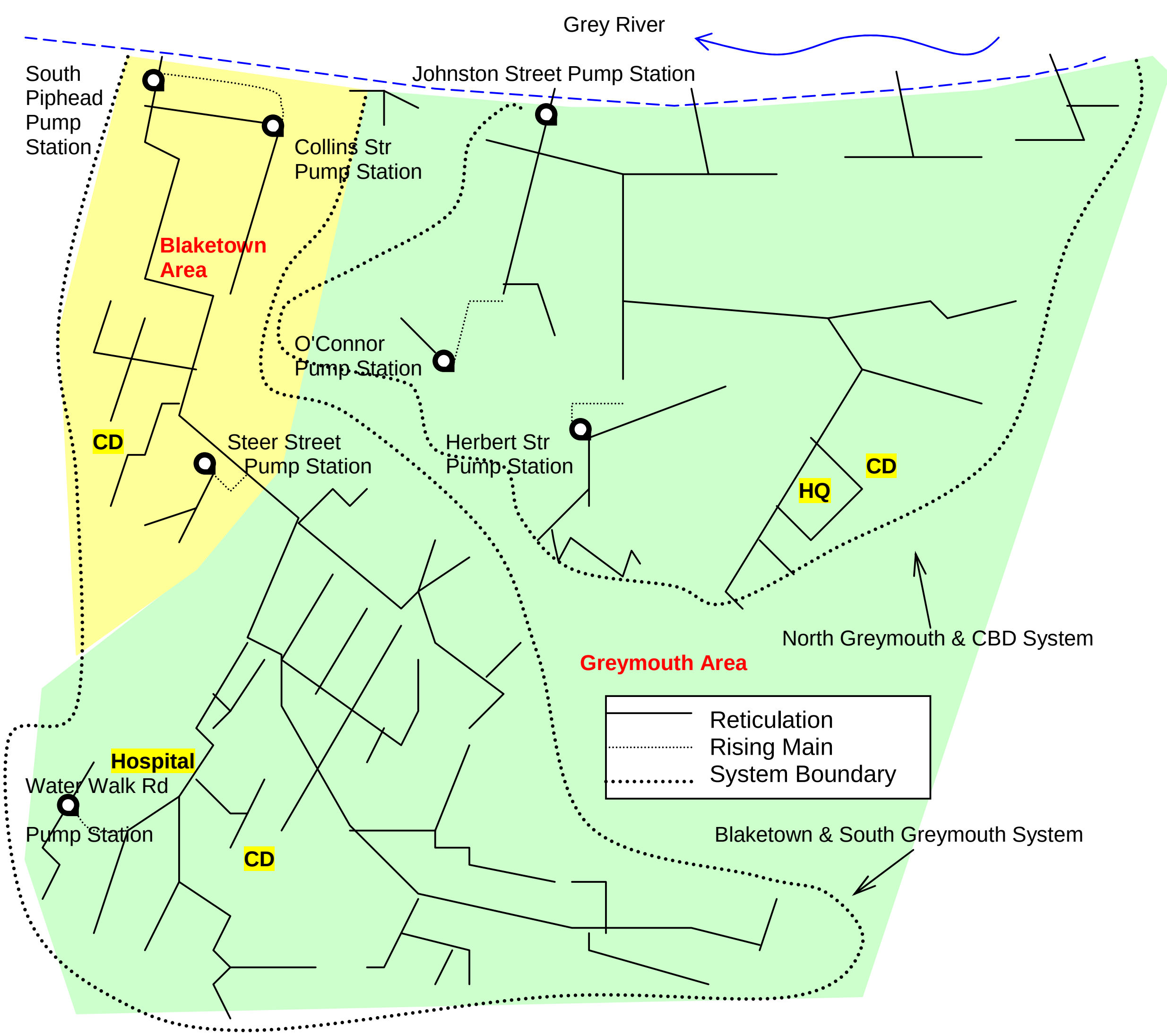
A summary is presented in Section 4.4.8 of proposed upgrade works to address identified sewerage system deficiencies.

[10] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

4.4.3 Greymouth Sewerage Scheme

Description – Greymouth

Figure 4.21: Greymouth Sewerage Reticulation



The Greymouth sewerage scheme is shown in Figure 4.21 above and can be described as follows:

- Sewage and some stormwater[11] from the Greymouth & Blaketown areas north of Two Mile Creek are collected in the Greymouth sewer network and discharge to the Grey River via five outfalls.
- The combined sewage and storm water stream is partially treated through screens and ultraviolet disinfection before discharge to the Grey River. Full treatment is planned by 2015;
- The Greymouth sewer network is made up of two independent systems;
    - North Greymouth and CBD: Includes all CBD and the area of Greymouth north of Ngarimu Street; and
    - Blaketown & South Greymouth: Includes all of Blaketown and the area of Greymouth between Ngarimu Street and Two Mile Creek.
- The North Greymouth & CBD system is made up of:
    - The Herbert Street subsystem that collects sewage and some storm water from the southern area of this system. The collected flow discharges to the Herbert Street pump station;
    - The O'Connor subsystem that collects sewage only from the western area of the Greymouth CBD. The flow discharges to the O'Connor pump station;
    - The flows from the Herbert Street pump station and the O'Connor pump station combine with the sewage and storm water flows collected in the reticulation north of Ngarimu Street and the CBD. Most of the flow is discharged into the Grey River via an outfall at Johnston Street and the remainder via an outfall at Boundary Street. When the combined flow is too great to be discharged via these two outfalls (high flows or high river water level) the Johnston Street pump station pumps the flow into the Grey River; and
    - Three other small reticulation systems collect sewage and storm water in the CBD and discharge them into the Grey River at outfalls at Tainui Street, Custom Street and the western end of Gresson Street.
- The Blaketown & South Greymouth system is made up of:
    - The Water Walk Road subsystem that collects sewage in the Water Walk Road area. The collected flow discharges to the Water Walk Rd pump station;
    - The Steer Street subsystem collects sewage and stormwater in south Blaketown area. The collected flow discharges to the Steer Street pump station;

[11] GDC is in the process of separating the combined sewage and stormwater system into separate sewage and stormwater systems.

- Stormwater and sewage collected in South Greymouth area and from Water Walk Rd and the Steer Street pump stations flow to Blaketown to combine with the Blaketown sewage and stormwater and flow on to the South Piphead pump station;
- The Collins Street subsystem collects stormwater and sewage in the lower north eastern area of Blaketown. The collected flow discharges to the Collins Street pump station and is pumped to the South Piphead pump station;
- The South Piphead pump station pumps all the flow into the Grey River.

- The total length of pipe in the reticulation network including the rising mains and river outfalls is 41,850m. As can be seen in the following table 69% of pipes in the Greymouth area and 97% of pipes in the Blaketown area are either AC, concrete or earthenware (EW). Over both areas 74% of pipes are either AC, concrete or EW.

Table 4.15: Summary Table - Greymouth Sewer Network

Area	Pipe Type	Length (m)	Percentage		Size Range Dia. (mm)	Year Installed
Blaketown	AC	1,016	12.8%	97%	100 - 150	1930 -1985
	Concrete	2,262	28.5%		150 - 1,000	1930
	Earthenware	4,420	55.7%		100 - 375	1930
	PVC	200	2.5%	3%	100 - 300	1930 - 2003
	PE & unknown	34	0.4%		150	2004
Greymouth	AC	2,813	8.3%	69%	150 - 300	1935 - 1976
	Concrete	7,280	21.5%		160 - 1,200	1920 - 1998
	Earthenware	13,146	38.8%		100 - 450	1910 - 1970
	PVC	10,250	30.2%	31%	100 - 300	1970 - 2004
	PE & unknown	425	1.3%		63 - 225	1950 - 2004
Total		41,847				

- The sewer network in the Greymouth area has developed steadily since 1910. Around 33% of the system was installed before 1930 and around 2000m was added every 10 years until the 1980s. In 1980 there was a move away from AC & EW pipes to PVC, and combined storm water/sewage flows were separated with new PVC pipes installed as dedicated sewers. The separation of the storm water and sewage has continued and now 35% of the reticulation pipes are dedicated sewer mains constructed of PVC (pipes less than 300mm) and concrete (pipes 300mm dia. and larger).
- Ninety six percent (96%) of the sewer network in the Blaketown area was installed before 1930.
- Backflow from the Grey River into the Storm water/Sewer network is prevented by flood flaps at the river outfalls and by internal flaps in manholes.

Deficiencies – Greymouth

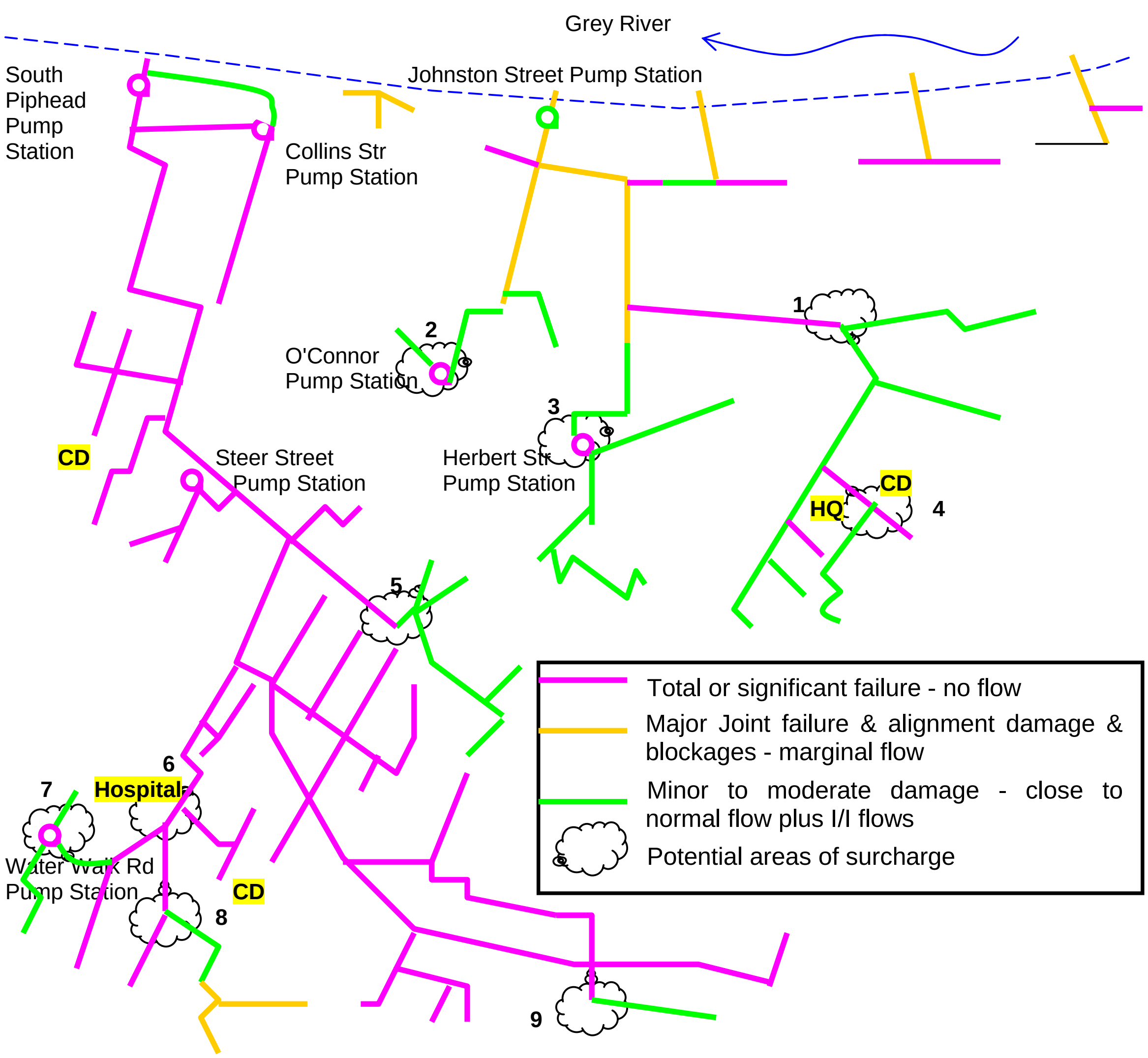
In the event of a major Alpine Fault earthquake such as that described in Section 2.7 Greymouth is expected to experience strong intensity MM VIII that will induce significant damage to the sewerage system. Most of Greymouth is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected in places. Liquefaction can be expected in areas of looser sandier soil, particularly east of the railway line. Ten liquefaction sites from the 1929 earthquake are noted in the distribution area (refer Figures 2.6 & 2.7). Older pipes (pre 1940), particularly asbestos cement, earthenware and concrete, may completely fail. Pump stations, manholes and pipe alignment are likely to be affected in many areas particularly where liquefaction occurs. There is a significant risk that the Greymouth reticulation system may fail to transport and discharge sewage due to the following:

- As it is almost certain that the power supply grid will fail and there will be no power to six of the seven pump stations, pumps will not operate and surcharging is likely to occur at or near pump stations. The Johnston Street pump station share a single portable generator with the Coal Creek highlift pump station. However these locations are on opposite sides of the Grey River and the generator may not be available for the Johnston Street pump station;
- Major pipe failures are expected as follows. Based on the damage assessment chart in Appendix A and the MM values assigned in Figure 2.5 (MM VIII to IX), it is expected that:
  - PVC - 25% of entries and junctions will fail generally, and between 50% to 70% in areas that are affected by liquefaction,
  - Earthenware and AC with rubber ring joints - 50% of entries and junctions will fail generally, and between 70% to 80% in areas that are affected by liquefaction, and
  - Non-ductile pipes with cement joints – there will be widespread damage and mains failure.

  Based on the above failure rates (and assuming that all EW, AC and concrete pipes laid before 1940 are cement jointed and all pipes laid after 1940 are rubber ring jointed) it is likely that:

  - Between 65% to 85% of the sewer network will fail at entries and junctions;
  - Between 88% to 99% of the sewer network in the Blaketown area will fail because most of the network (96%) was installed around 1930 and is constructed of EW, AC or concrete; and
  - Between 60% to 82% of the sewer network in the Greymouth area will fail at entries and junctions. Failure is lower in the Greymouth area because of the high percentage of new PVC pipe.
  - Flood flaps at outfalls and internal flaps in manholes may also be damaged.

Figure 4.22: Assessed Greymouth Sewerage Reticulation Failure and Surcharging



The assessed failure of scheme components and resultant surcharging of sewage (9 locations) are presented in Figure 4.22. Surcharging is likely to occur at manholes (due to inflow/infiltration and storm water) where upstream sewer pipes remain intact and sewage continues to flow while downstream sewer pipes fail and are unable to carry sewage away. A preliminary assessment indicates that this is likely to happen at the following locations:

- Surcharge 1: Whall St & Tainui St intersection - Surcharge will flow along the street and discharge to new storm water pipes;
- Surcharge 2: O'Connor Pump Station - Pump stops when electricity fails. Surcharge from pump station discharges via road way to lagoon;

- Surcharge 3: Herbert Street Pump station - Pump stops when electricity fails. Surcharge from pump station will flow along the street and discharge to new storm water pipes;
- Surcharge 4: Puketahi St & Alexander St intersection - Surcharge will flow along the street and discharge to new storm water pipes;
- Surcharge 5: Franklin St & Shakespeare St intersection - Surcharge will overflow to Sawyers Creek via old storm water system. If storm water pipes fail ponding may occur until a flow path develops to Sawyers Creek;
- Surcharge 6: Greymouth Hospital - All sewer pipes in the vicinity of the hospital are likely to fail. Sewage from the hospital will be directed to railway cut in and discharge to Sawyers Creek.

- Manholes and pump stations are likely to move, particularly manholes in areas affected by liquefaction where the structures are empty and/or have not been designed for earthquake lifting forces. This movement is likely to disrupt pipe alignment at entries and exits, especially where joints are rigid. This may allow surrounding soil material to be washed into the pipe and structure when pumps are started again;
- Sewer failure in the vicinity of the three CD posts will prevent sewage from the posts being transported away; and
- Damage will occur to inadequately restrained equipment at pump stations (restrain submersible pump in the dry well at Steer Street Pump station and electrical kiosk at Water Walk Road Pump station).[12]

Upgrades & Improvements – Greymouth

Along with the improvements outlined in the pre-earthquake section of Section 4.4.2 the following improvements are proposed to address the risks identified in the previous section:

- Consider purchasing a designated generator for the Johnston Street Pump Station as Johnston Street is a critical pump station; and
- Continue the sewage/storm water separation programme.

It is anticipated that recovery of the Greymouth sewerage system will proceed as follows after a major Alpine Fault earthquake:

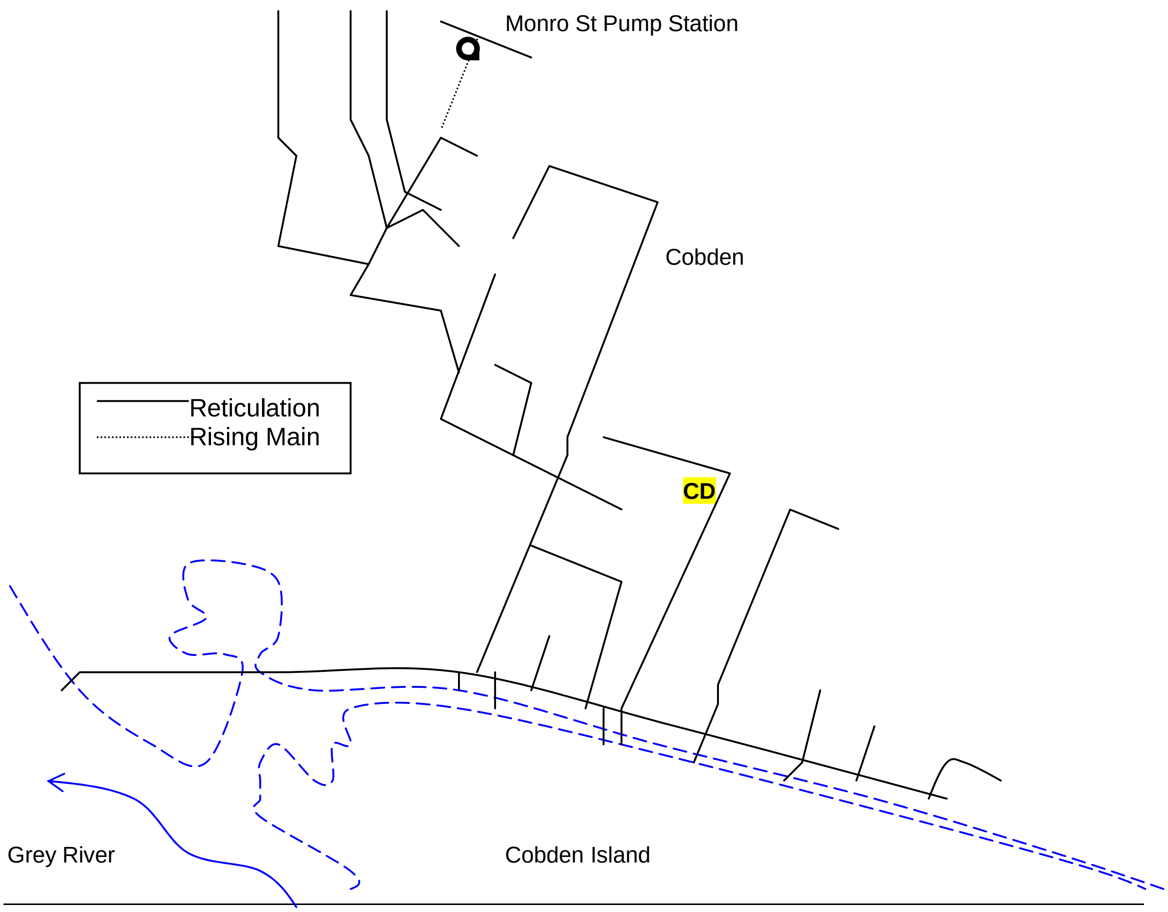
[12] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

- Power to the sewage pump station will fail at time zero; the time of the earthquake or very shortly afterwards;
- At the Johnston Street pump station pumps an operator will keep an eye on the combined sewage and storm water level and start the generator as required to manage the discharge;
- Major failure is expected in older sewer pipes that have not been replaced. Workmen will check for surcharging at known trouble spots and ensure that they are discharging safely away;
- The community will be informed not to discharge wastewater to the sewer and temporary sanitation measures e.g. Portaloo (where available), pit latrines, etc will be put in place at public locations. Private home owners will be expected to arrange their own toilet facilities; and
- The sewerage scheme will be assessed and contracts let to repair the scheme.

4.4.4 Cobden Sewerage Scheme

Description - Cobden

Figure 4.23: Cobden Sewerage Reticulation



The Cobden scheme is a combined sewage/storm water scheme. The scheme is shown in Figure 4.23 above and can be described as follows:

- Sewage and some storm water from the Cobden area is collected in the Cobden sewer network and discharges to the Grey River via seven outfalls. The combined sewage and storm water stream is partially treated through screens and ultraviolet disinfection before discharge. Full treatment is planned by 2015;
- The Cobden reticulation includes a small subsystem that collects sewage and stormwater on Monro Street. The combined stream flows to the Monro Street pump station where it is pumped into the main Cobden reticulation system;

The total length of pipe in the reticulation network including the rising main is approximately 14,000m. Details of the sewer reticulation pipe materials are provided in the following table.

Table 4.16: Summary Table - Cobden Sewer Network

Pipe Type	Length (m)	Percentage	Size Range Dia. (mm)	Year Installed
AC	693	5.0%	150 – 300	1920 –1978
Concrete	5,513	39.6%	300 - 1,500	1920 – 1984
Earthenware	7,217	51.8%	100 – 375	1920 – 1964
PVC	504	3.6%	100 – 250	1960 – 2003
PE & unknown	11	0.1%		2002
Total	13,938	100%		

- Around 4,000m of the Cobden sewer network was installed in 1920. The network was expanded to 13,000m around 1960 and small developments since then have brought the total length to the present 14,000m.
- Backflow from the Grey River into the sewage/storm water network is prevented by flood flaps at the river outfalls and by internal flaps in manholes.

Deficiencies – Cobden

In the event of a major Alpine Fault earthquake such as that described in Section 2.7, Cobden is expected to experience strong intensity MM VIII to MM IX shaking that will induce serious damage to the sewerage system. Most of Cobden is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected in places. Liquefaction can be expected in areas of looser sandier soil, particularly around the lagoon (Te Aka Aka o Poutini) that is traversed by Hill

Quay. Older pipes (pre 1940) particularly asbestos cement, earthenware and concrete may fail completely. Pump stations, manholes, and pipe alignment are likely to be affected in many areas particularly where liquefaction occurs.

There is a significant risk that the Cobden reticulation system may fail to transport and discharge sewage and storm water because of the following:

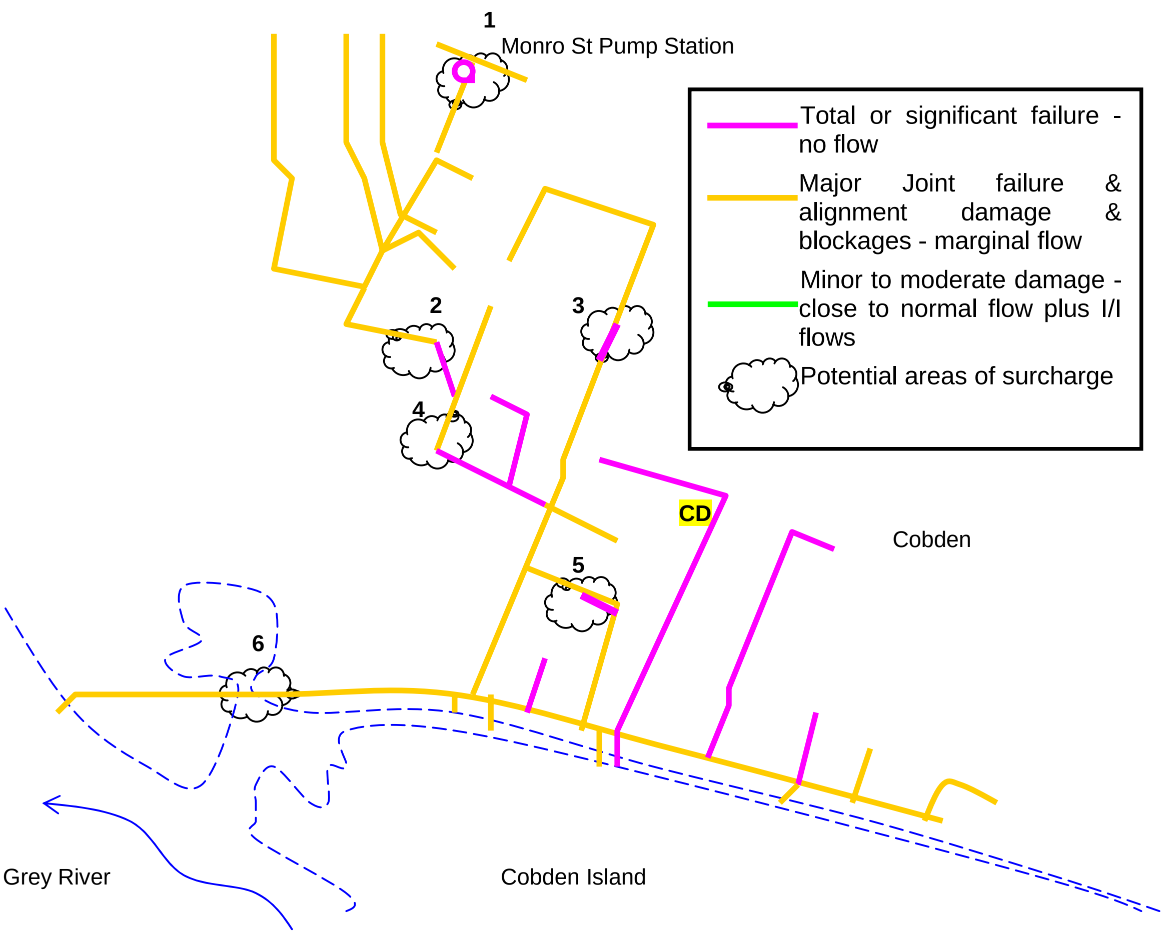
- Major pipe failures. Based on the damage assessment chart in Appendix A and the MM values assigned in Figure 2.5 (MM VIII to IX), it is expected that:
  - PVC - 25% of entries and junctions will fail and between 50% to 70% in areas that are affected by liquefaction,
  - Earthenware and AC with rubber ring joints - 50% of entries and junctions will fail and between 70% to 80% in areas that affected by liquefaction, and
  - Non-ductile pipes with cement joints - wide spread damage and main failure.

  Based on the above failure rates (and assuming that all pipes EW, AC and concrete pipes laid before 1940 are cement jointed and all pipes laid after 1940 are rubber ring jointed) it is likely that between 62% to 82% of the Cobden sewer network will fail.

  The assessed failure of scheme components and resultant surcharging of sewage (5 locations) are presented in Figure 4.24. Surcharging is likely to occur at manholes where upstream sewer pipes remain intact and sewage continues to flow (due to inflow/infiltration and storm water) while downstream sewer pipes or pump stations fail and are unable to carry sewage away. A preliminary assessment indicates that this is likely to happen at the following locations:
  - Surcharge 1: Monro Street Pump Station - As it is almost certain that power supply to the Monro Street pump station will be lost and surcharging will occur at the pump station. The surcharge will flow down the street and discharge to Range Creek;
  - Surcharge 2: Ward Street - Surcharge will pond;
  - Surcharge 3: Richmond Street near Baillie Place - Surcharge will flow down Richmond Street and discharge to Range Creek;
  - Surcharge 4: Fox St & Hall St intersection - Surcharge will pond;
  - Surcharge 5: Bright St & Blackett St intersection - Surcharge will flow down Blackett Street and pond on Nelson Quay behind the flood wall; and
  - Surcharge 6: Hill Quay in the lagoon area - Sewer failure likely due to liquefaction. Surcharge will discharge to the lagoon.

- Manholes and pump stations are likely to move particularly manholes in areas affected by liquefaction where the structures are empty and/or have not been designed for earthquake lifting forces. This movement is likely to disrupt pipe alignment at entries and exists, especially where joints are rigid; and
- Sewer failure in the vicinity of the CD post may prevent sewage at the post being transported away.

Figure 4.24: Assessed Cobden Sewerage Reticulation Failure and Surcharging



Upgrades & Improvements - Cobden

The risks identified in the previous section are to be addressed by undertaking the improvements outlined in Section 4.4.2 along with continuing the sewage/storm water separation programme.

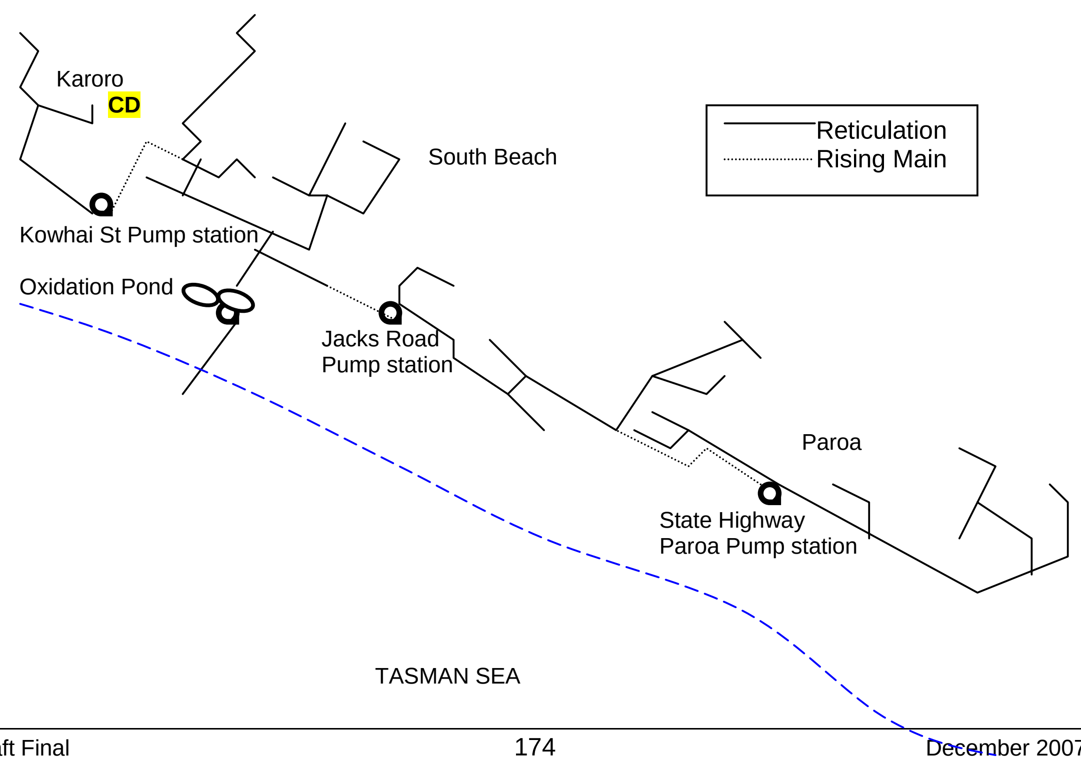
It is anticipated that recovery of the Cobden sewerage system will proceed as follows after a major Alpine Fault earthquake:

- Power to the sewage pump station will fail at time zero; the time of the earthquake or very shortly afterwards;
- Major failure is expected in older sewer pipes that have not been replaced. Workmen will check for surcharging at known trouble spots. Temporary drains will be constructed to nearby waterways where ponding occurs or periodically pumped out to a nearby waterway where temporary drains are not possible (Ward St & Hall St area and along Nelson Quay);
- The community will be informed not to discharge wastewater to the sewer and temporary sanitation measures e.g. Portaloo (where available), pit latrines, etc will be put in place; and
- The sewerage scheme will be assessed and contracts let to repair the scheme.

4.4.5 Karoro/Paroa Sewerage Scheme

Description - Karoro/Paroa

Figure 4.25: Karoro/Paroa Sewerage Scheme



The Karoro/Paroa sewerage scheme (not a combined sewerage/storm water scheme) is shown in Figure 4.25 above and is described as follows:

- The Karoro/Paroa sewer network collects sewage from Karoro, South Beach and Paroa.
- The reticulation is made up of four subsystems:
  - South Paroa: The South Paroa reticulation collects sewage from the southern end of Paroa between Rutherglen Road and just south of Clough Road. The sewage is discharged at the State Highway/Paroa pump station;
  - North Paroa: The North Paroa reticulation collects sewage from the State Highway/Paroa pump station and the area around Clough Road to Mill Creek. The sewage is discharged at the Jacks Road pump station;
  - Karoro: The Karoro reticulation collects sewage from the area between Two Mile Creek to Kowhai Drive. The sewage is discharged at the Kowhai Street pump station;
  - South Beach: Sewage from the Jacks Road pump station and the Kowhai Drive pump station is pumped via rising mains into the South Beach reticulation. The South Beach reticulation also collects sewage from all of South Beach from Stanton Crescent in the north to Jamieson Street in the south.
- All the sewage from the four sub-systems flows to two oxidation ponds;
- The effluent from the oxidation ponds either flows under gravity or is pumped from the ponds to an ocean outfall.
- The total length of pipe in the reticulation network including the rising mains and ocean outfall is 16,000m; approximately 60% of pipes are PVC and 40% are AC. Details of the pipe in the Karoro and South Beach/Paroa areas are presented in the following table.

Table 4.17: Summary Table - Karoro/Paroa Sewer Network

Area	Pipe Type	Length (m)	Percentage	Size Range Dia. (mm)	Year Installed
Karoro	AC	6,597	87.6%	100 - 150	1971 -1985
	Earthenware	63	0.8%	150	1971
	PVC	867	11.5%	100 - 300	1971 - 1999
Sth Beach Paroa	PVC	8,486	100%	100 - 300	1999 - 2003
Total		16,013			

Deficiencies - Karoro/Paroa

In the event of a major Alpine Fault earthquake such as that described in Section 2.7, the Karoro-South Beach-Paroa area is expected to experience strong intensity MM VIII to MM IX shaking that will induce severe damage to the sewerage system. Most of the area is located on geologically recent alluvial soils, with some ground settlement and distortion to be expected in places. Liquefaction can be expected in areas of looser sandier soil. The oxidation ponds, pump stations, manholes and pipe alignment are likely to be affected particularly where liquefaction occurs.
There is a significant risk that the Karoro-South Beach-Paroa sewerage scheme may fail to transport, treat and discharge sewage due to the following:

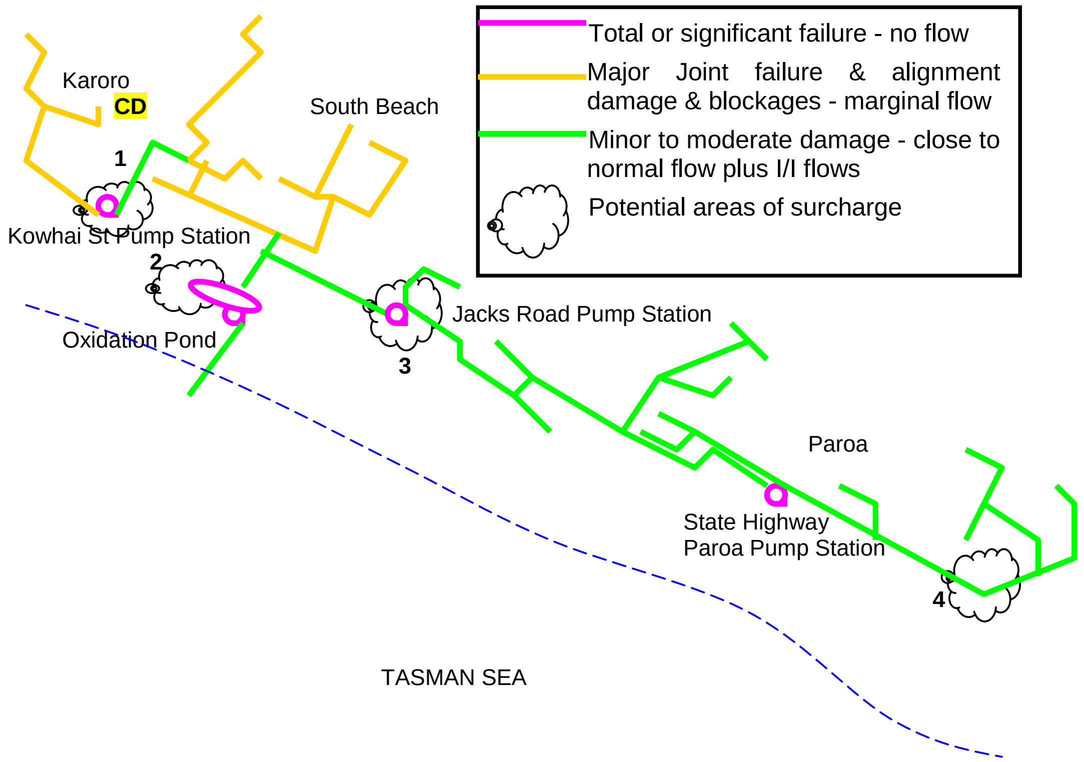
- Major pipe failures. Based on the damage assessment chart in Appendix A and the MM values assigned in Figure 2.5 (MM VIII to IX), it is expected that:
  - PVC pipes - 25% of entries and junctions will fail generally, and between 50% to 70% in areas that are affected by liquefaction, and
  - Earthenware and AC pipes with rubber ring joints - 50% of entries and junctions will fail generally, and between 70% to 80% in areas that affected by liquefaction.

  Based on the above failure rates it is likely that between 35% to 66% of entries and junctions in the sewer network will fail, with a higher rate of failure in the AC pipes in the Karoro area.
- As it is almost certain that the power supply grid will fail there will be no power to the four pump stations;
- Manholes and pump stations are likely to move particularly manhole structures that are empty and/or have not been designed for earthquake lifting forces. This movement is likely to disrupt pipe alignment at entries and exists, especially where joints are rigid. This may allow surrounding soil material to be washed into the pipes and structures when pumps are started again;
- Sewers may fail in the vicinity of the CD post (Karoro School) preventing sewage generated at the post from being transported away; and
- Damage is likely to occur to the oxidation pond resulting in sewage breaching the pond banks.

  The assessed failure of scheme components and resultant surcharging of sewage (4 locations) are presented in Figure 4.26 and described as follows:
  - Surcharge 1: Kowhai Street Pump Station - On loss of power supply the pump station will stop and surcharging will occur at the pump station. The surcharge will discharge to Watsons Creek;

- o Surcharge 2: Oxidation Ponds - The oxidation pond pump will stop on loss of power. Effluent from the pond will discharge at low tide (without the pump). The oxidation pond wall is likely to have subsided during the earthquake due to liquefaction. Effluent will breach the pond wall via the subsided section and will pond outside the oxidation pond before seeping into the surrounding sandy soil;
- o Surcharge 3: Jacks Road Pump Station - On loss of power supply the Jacks Road pump station will stop and surcharging will occur at the pump station. The surcharge will discharge to Mill Creek; and
- o Surcharge 4: State Highway/Paroa Pump Station - On loss of power supply the pump station will stop and surcharging will occur some distance away at Paroa School. The surcharge will discharge to Saltwater Creek.
- o Sewer failure in the vicinity of the CD post may prevent sewage at the post being transported away; and
- o Damage to inadequately restrained equipment at the oxidation ponds.13

Figure 4.26: Assessed Karoro/Paroa Sewerage Scheme Failure and Surcharging



[13] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

Upgrades & Improvements - Karoro/Paroa

The risks identified in the previous section will be reduced by implementing the improvements outlined in Section 4.4.2 along with undertaking a geotechnical and structural assessment of the oxidation ponds to quantify the earthquake risks at the site and recommend any structural improvements to address these risks.

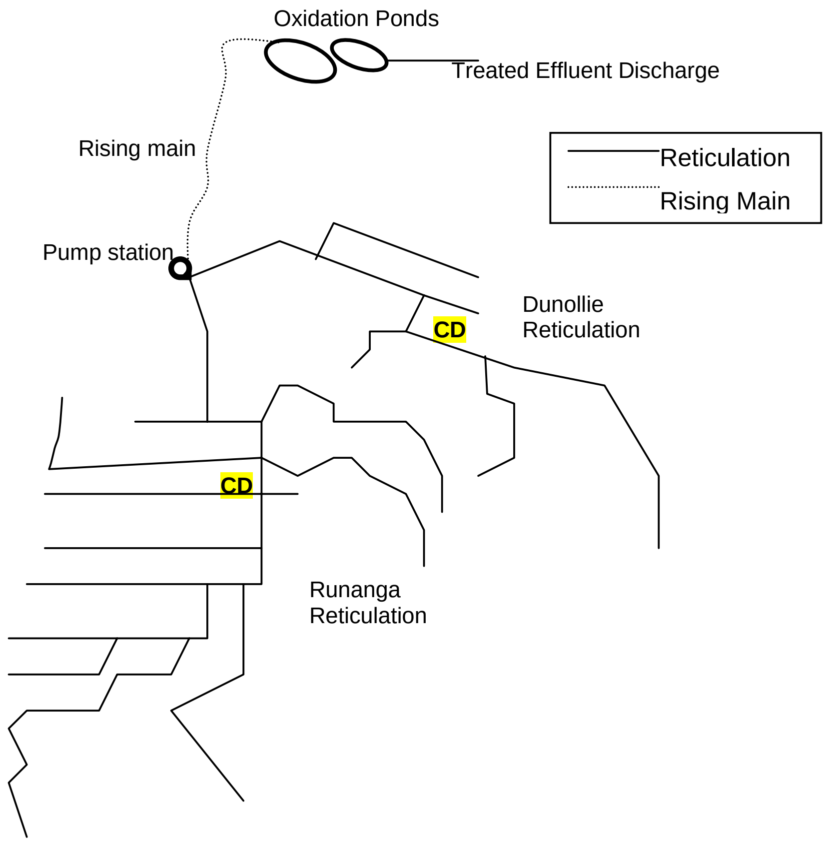
It is anticipated that recovery of the Karoro/Paroa sewerage system will proceed as follows after a major Alpine Fault earthquake:

- Power to the sewage pump stations will fail at time zero, the time of the earthquake, or very shortly afterwards;
- Significant joint failure is expected - more in Karoro than in South Beach and Paroa. Workmen will check for surcharging at known trouble spots and where sewage is ponding workmen will arrange temporary drains to nearby waterways;
- The community will be informed not to discharge wastewater to the sewer and temporary sanitation measures e.g. Portaloo (where available), pit latrines, etc will be put in place; and
- The sewerage scheme will be assessed and contracts let to repair the scheme.

4.4.6 Runanga Sewerage Scheme

Description – Runanga

Figure 4.27: Runanga Sewerage Scheme



The Runanga sewerage scheme is shown in Figure 4.27 above. The Runanga sewerage scheme is separate from the storm water scheme and can be described as follows:

- Sewage is collected via the Runanga and Dunollie reticulation systems and discharges at the Dunollie pump station on the western side of Dunollie;
- The sewage is pumped from the pump station via a 150 mm dia rising main to the Runanga oxidation ponds (2 ponds);
- The sewage is treated in the oxidation ponds and the effluent is discharged into Cavern Creek;
- The total length of pipe in the reticulation network including the rising main is 13,500m. Most of the pipes (95%) are AC. Details of the pipe are presented in the following table.

Table 4.18: Summary Table - Runanga Sewer Network

Pipe Type	Length (m)	Percentage	Size Range Dia. (mm)	Year Installed
AC	12,758	95%	100 – 225	1970 - 1989
Earthenware	246	2%	100	1973
PVC	495	4%	150	1993
Total	13,499			

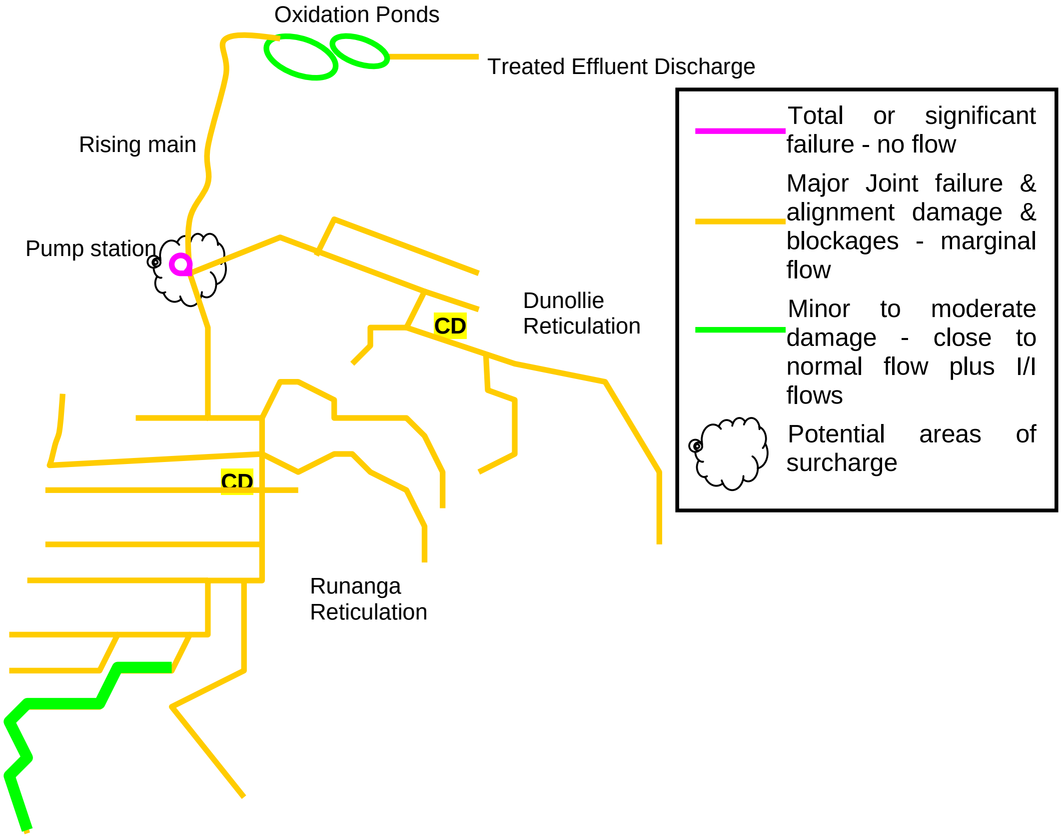
Deficiencies – Runanga

In the event of a major Alpine Fault earthquake such as that described in Section 2.7, the Runanga area is expected to experience strong intensity MM VIII to MM IX shaking that will induce serious damage to the sewerage system. There may be zones of liquefiable soils in the lower parts of Runanga/Dunollie. Intensity MM VIII shaking will cause some ground distortion in softer soils. There is a significant risk that the Runanga/Rapahoe sewerage system may fail to transport, treat and discharge sewage due to the following:

- Major pipe failures. Based on the damage assessment chart in Appendix A and the MM values assigned in Figure 2.5 (MM VIII to IX), it is expected that:
    - PVC pipe - 25% of entries and junctions will fail and between 50% to 70% in areas that are affected by liquefaction, and
    - Earthenware and AC pipes with rubber ring joints - 50% of entries and junctions will fail and between 70% to 80% in areas that are affected by liquefaction.

  Based on the above failure rates it is likely that between 50% to 75% of the sewer network will fail.
- It is almost certain that the power supply grid will fail and there will be no power to the pump station; and
- Manholes and pump station are likely to move, particularly manhole structures that are empty and/or have not been designed for earthquake forces. This movement is likely to disrupt pipe alignment at entries and exits, especially where joints are rigid. This may allow surrounding soil material to be washed into the pipes and structures when the pump station pump is started again.

Figure 4.28: Assessed Runanga Sewerage Scheme Failure and Surcharging



The assessed failure of scheme components and resultant surcharging of sewage (1 location) are presented in Figure 4.28. Surcharging is likely to occur at the Dunollie Pump Station when the power supply is lost and the pump stops. The surcharge will discharge to Raleigh Creek.

- Sewers may fail in the vicinity of the two CD posts (Runanga School & GDC Runanga office) preventing sewage from these posts being transported away; and
- There will be damage to inadequately restrained equipment (phone, telemetry cabinet and transformer on adjacent pole) at pump stations.[14]

[14] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

Upgrades & Improvements – Runanga

The risks identified in the previous section will be reduced by implementing the improvements outlined in Section 4.4.2 along with undertaking geotechnical and structural assessment of the oxidation ponds to quantify the earthquake risks at the site and recommend any structural improvements to address these risks.

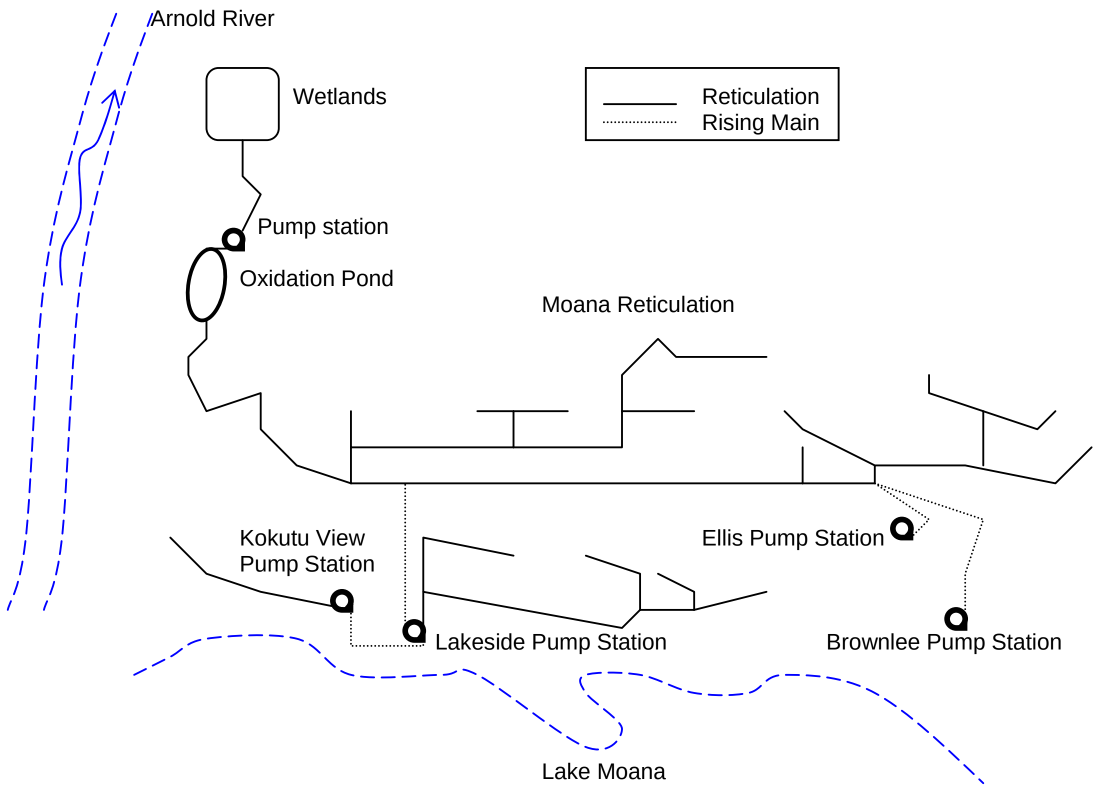
It is anticipated that recovery of the Runanga sewerage system will proceed as follows after a major Alpine Fault earthquake:

- Power to the sewage pump stations will fail at time zero; the time of the earthquake or very shortly afterwards;
- A high level of joint failures is expected throughout the sewer network. Workmen will check for surcharging and ensure that where ponding occurs temporary open drains are constructed to nearby waterways. Where this is not possible ponded sewage will be periodically pumped out to a nearby water way;
- The community will be informed not to discharge wastewater to the sewer and temporary sanitation measures e.g. Portaloo (where available), pit latrines, etc will be put in place; and
- The sewerage scheme will be assessed and contracts let to repair the scheme.

4.4.7 Moana Sewerage Scheme

Description – Moana

Figure 4.29: Moana Sewerage Scheme



The Moana sewerage scheme (not a combine sewerage/storm water scheme) is shown in Figure 4.29 above and is described as follows:

- The Moana sewer network collects sewage from Moana township and is made up of a gravity reticulation and four small reticulation subsystems.
- The four subsystems are:
  - The Bownlee subsystem that collects sewage from the Brownlee subdivision. The collected flow discharges to the Bownlee pump station;
  - The Ellis subsystem that collects sewage from the Ellis subdivision. The collected flow discharges to the Ellis pump station;

- o The Lakeside subsystem that collects sewage from the houses below Koe Street. The collected flow discharges to the Lakeside pump station;
- o The Kokutu View subsystem that collects sewage from the Kokutu View subdivision. The collected flow discharges to the Kokutu View pump station;

- Sewage is pumped from the four sub-systems into the gravity reticulation. The gravity reticulation discharges to the oxidation pond;
- Effluent from the oxidation pond is pumped into a wetland and the wetland effluent discharges into the Arnold River;
- The total length of pipe in the reticulation network including the rising main to the wetland is 6,600m. Details of the reticulation pipes are presented in the following table.

Table 4.19: Summary Table - Moana Sewer Network

Pipe Type	Length (m)	Percentage	Size Range Dia. (mm)	Year Installed
Concrete	3,995	60%	50 –150	1970 - 2003
PVC	1,369	21%	100 – 200	1970 - 2004
AC	807	12%	100 – 150	1970 - 1975
HDPE & Unknown	268	4%	80 – 200	1999 - 2003
Earthenware	174	3%	100	1970
Total	6,613	100%		

Deficiencies – Moana

In the event of a major Alpine Fault earthquake such as that described in Section 2.7, Moana township is expected to experience strong intensity MM IX shaking that will induce very serious damage to the sewerage system and to the whole community in general. There may be zones of liquefiable soils in the lower parts of Moana near the lake and Arnold River. Intensity MM IX shaking will cause ground distortion in softer soils. The earthquake is likely to generate a seiche (shake induced oscillation in the lake) that could damage structures along the lakeshore. There is a significant risk that the Moana sewerage system may fail to transport, treat and discharge sewage due to the following:

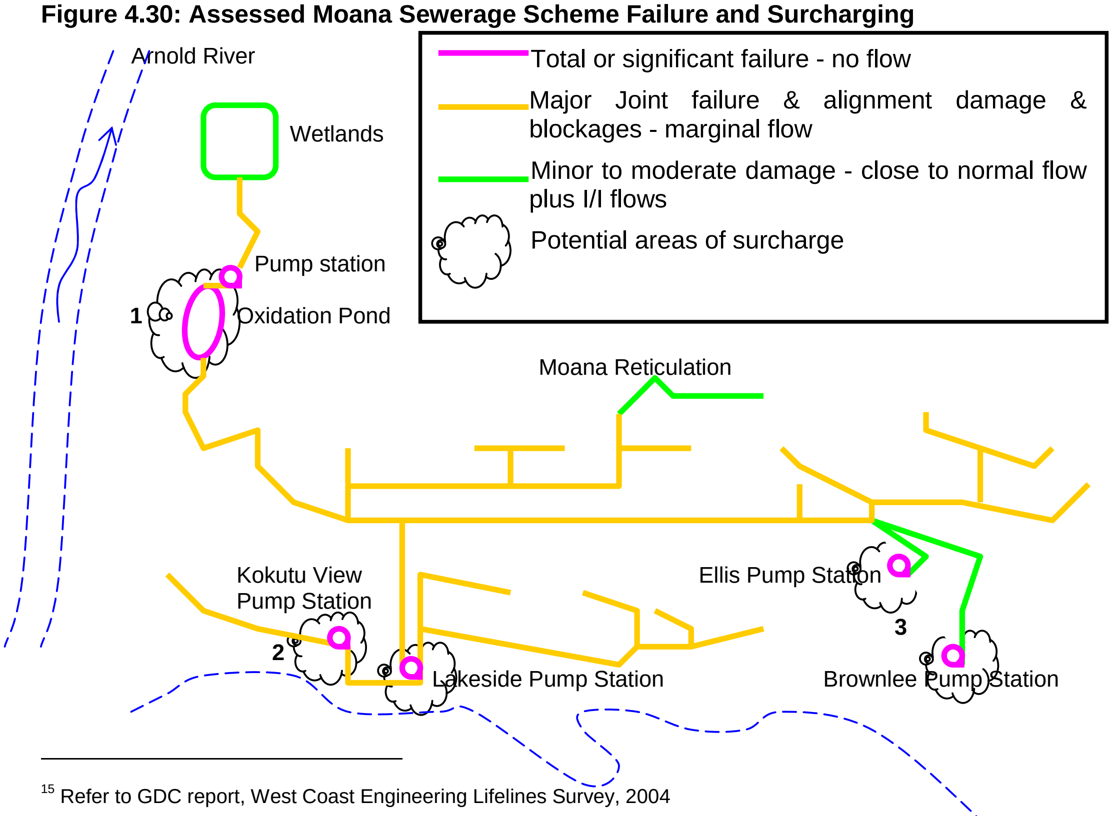
- Major pipe failures. Based on the damage assessment chart in Appendix A and the MM values assigned in Figure 2.5 (MM IX), it is expected that:

- o PVC pipes - 20% of entries and junctions will fail and more than 70% will fail in areas that are affected by liquefaction, and
- o Concrete, earthenware and AC pipes with rubber ring joints - 50% of entries and junctions will fail and more than 80% will fail in areas that are affected by liquefaction.

Based on the above failure rates it is likely that between 45% to 80% of entries and junctions in the sewer network will fail.

- It is almost certain that the power supply grid will fail and there will be no power to the pump stations;
- The Lakeside pump station is likely to be severely damaged by a lake seiche;
- Manholes and pump station are likely to move, particularly manhole structures that are empty and/or have not been designed for earthquake forces. This movement is likely to disrupt pipe alignment at entries and exits, especially where joints are rigid. This may allow surrounding soil material to be washed into the pipes and structures when the pump station pump is started again;
- Sewers may fail in the vicinity of the CD posts preventing sewage from these posts being transported away; and
- Damage may occur to inadequately restrained equipment (phone, telemetry cabinet and transformer on adjacent pole) at pump stations.[15]

Figure 4.30: Assessed Moana Sewerage Scheme Failure and Surcharging



[15] Refer to GDC report, West Coast Engineering Lifelines Survey, 2004

5 **4**

Lake Moana

The residents of Moana have individual water supplies. Assuming these are still intact and unless told otherwise the community can continue to discharge into the sewer system. Storm water and ground water may also enter the sewer through pipe breaks. The assessed failure of scheme components and resultant surcharging of sewage (5 locations) are presented in Figure 4.30 and described as follows:

- Surcharge 1: Oxidation Pond - It is likely that the pond embankment will become distorted and the wave band damaged. Liquefaction at the site may lead to damage to the pond wall and the resultant seepage through the wall could cause bank failure and complete draining of the pond into the Arnold River;
- Surcharges 2 to 4: Kokutu View, Ellis & Brownlee Pump Stations - On loss of power supply the pump stations will stop and surcharging will occur at the pump stations. The surcharges will discharge to Lake Moana; and
- Surcharge 5: Lakeside Pump Station - Pump will stop due to loss of power and the pump station is also likely to sustain damaged from a lake seiche. The surcharge will discharge to Lake Moana.

Upgrades & Improvements – Moana

The risks identified in the previous section will be reduced by implementing the improvements outlined in Section 4.4.2 along with undertaking geotechnical and structural assessment of the oxidation pond to quantify the earthquake risks at the site and recommend any structural improvements to address these risks.

It is anticipated that the recovery of the Moana sewerage system after a major Alpine Fault earthquake will proceed as follows:

- Power to the sewage pump stations will fail at time zero; the time of the earthquake or very shortly afterwards;
- A significant level of joint failures is expected throughout the sewer network. Workmen will check for surcharging at known trouble spots and where sewage is ponding workmen will arrange temporary drains to nearby waterways;

- The community will be informed not to discharge wastewater to the sewer and temporary sanitation measures e.g. Portaloo (where available), pit latrines, etc will be put in place; and
- The sewerage scheme will be assessed and contracts let to repair the scheme.

4.4.8 Sewerage Scheme Improvements Schedule

Improvements identified in Sections 4.4.3 to 4.4.7 are summarised in priority order in Table 4.20. General improvements are presented first followed by improvements for each sewerage scheme. Note a more detailed improvement plan is presented in Appendix G.

Table 4.20: Improvement Schedule – Sewerage

Importance	Action	Completion Date	Responsible
	General		
High	Develop a strategy for disposing of domestic and industrial sewage for the anticipated period of months before the sewerage service returns to normal. This may include public education so that communities are aware of and can be involved in developing the strategy.	June '08	GDC/ CDEM
High	Establish an emergency sanitation 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; • Back up plans; • Discharge requirements of major waste water producers after a major earthquake; • 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.	June '08	GDC
Medium	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.	June '09	GDC
High	Review the preliminary assessments of surcharging locations presented in sections 4.4.3 to 4.4.7 to ensure ponded water can discharge to a nearby water way.	June '08	GDC
Low	Undertake geotechnical and structural assessments of all pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks	June '10	GDC
High	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	June '08	GDC
High	Ensure that all future sewerage system structures and improvements are adequately designed for earthquake loads.	June '08	GDC
Low	Upgrade sewer pipes from CD posts or provide alternative sewage disposal facilities (standby septic tank facility) to ensure sewage can be disposed of from CD Posts after the Alpine Fault earthquake event.	June '10	GDC/ CDEM
High	Review all pump stations and oxidation pond sites to ensure all equipment and plant is adequately secured against movement in the event of an earthquake.	June '08	GDC
	Greymouth & Cobden		
High	Consider purchasing a designated generator for the Johnston Street Pump Station as Johnston Street is a critical pump station	June '08	GDC
Low	Continue the current programme of separating the storm water/sewerage schemes in Cobden, Greymouth and Blaketown	June '10	GDC
	Karoro/Paroa, Runanga & Moana		
Low	Undertake a geotechnical and structural assessment of oxidation ponds to quantify the earthquake risks at each site and recommend any structural improvements to address these risks.	June '10	GDC

4.5 Other Lifelines

Up to this point we have considered lifelines which are directly under the control of the Grey District Council. However, these are by no means the only lifelines essential to the functioning of the Grey District community and economy. The appropriate responses following a disaster and the prioritisation of actions to be taken beforehand to reduce the disaster's effects both need an understanding of the complete lifeline framework for the district. No one lifeline is independent of the others and it is because of the high degree of interaction between them that none can be considered in isolation. It is necessary to see the total picture. It follows that this report would not be complete without giving some consideration to the other lifelines, that is, those lifelines not directly controlled by the GDC. This section considers the other lifelines: telecommunications, electricity, fuel, and flood protection. However, because the GDC is not responsible for managing and upgrading them, they are necessarily not treated in the same degree of detail as those considered in earlier sections. State Highways and railways have already been addressed in the Transport section.

4.5.1 Telecommunications

General

(a) Landline and Cell phones

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 4.31 and are described as follows:

- Between Greymouth and Nelson: a fibre optic cable is routed from Greymouth to Stillwater crossing the Grey River at Cobden to the northern bank and crossing back over the river at Stillwater. The fibre is subsequently routed 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 Arthur's Pass (SH73), then via Moana and Stillwater progressing down the southern bank of the Grey River into Greymouth;

- Between Westport and Reefton: Digital Microwave Radio to Mt Rochfort, forwarded on to Reefton Radio and thence over fibre to the Reefton exchange and on via fibre to either Greymouth or Nelson exchanges.

Figure 4.31: Telecom Networks – West Coast

Cables follow the major roads to link all the other towns and smaller centres in the region.

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 with 3 to 5 days fuel supply and back up battery banks in smaller exchanges and cabinets that allow them to operate for up to 8 hours without an external power supply.
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. 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 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 in the Grey District area, which are similar for both Vodafone and Telecom, are Greymouth and the Grey Valley as far as Moana and Ikamatua.

(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 Grey District, there are G4 sites at Razorback (Punakaiki), Rapahoe, Dunollie and Blaketown, and G5 sites at Roa and Quarry Hill (near Inchbonnie). 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 in Grey District are at Sewell Peak (WCRC) and Mt Kakaria (GDC). Known black spots in VHF coverage occur in areas of the coast road north of Greymouth. Although Territorial Authorities have identified these areas as not having VHF coverage, the Department of Conservation Network does have coverage in 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.

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. Five private operators in Greymouth own satellite phones.

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, e.g. liquefaction, rock joint movement, 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. Moreover, 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 seismic performance of the telephone exchange building in Greymouth is not known.

Loss of electrical power for a long period of time will impact significantly on the telecommunications network. While key facilities have emergency generation, these are dependent on fuel supplies. The Telecom Greymouth exchange has a diesel generator and could operate without mains power for about 120 hours (assuming full diesel tanks).

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.

Effect of an Earthquake

The Alpine Fault earthquake is likely to significantly damage the telecommunications within the region. It appears highly likely that both 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

Fault rupture will sever the fibre optic link over Arthur's Pass near Inchbonnie where it crosses the fault line. Other damage may be sustained in the Rotomanu – Arthur's Pass area by bridge damage or landslide. The cable to Nelson does not pass over the fault, although it passes within 5km of the fault trace and it 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 immediate Greymouth 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. Thus 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.

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.

Thereafter the priority would be to restore minor exchanges and remote line units such as Paroa and Runanga, 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 and private operators. There may be others. Identifying the extent, resilience and redundant capacity of all these networks and opportunities to cross-link them 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 Section 3.2.3. CDEM members, including GDC, 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.

Upgrades and Improvements

Although telecommunications lie outside the direct influence of GDC, there are some issues that GDC should seek 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;

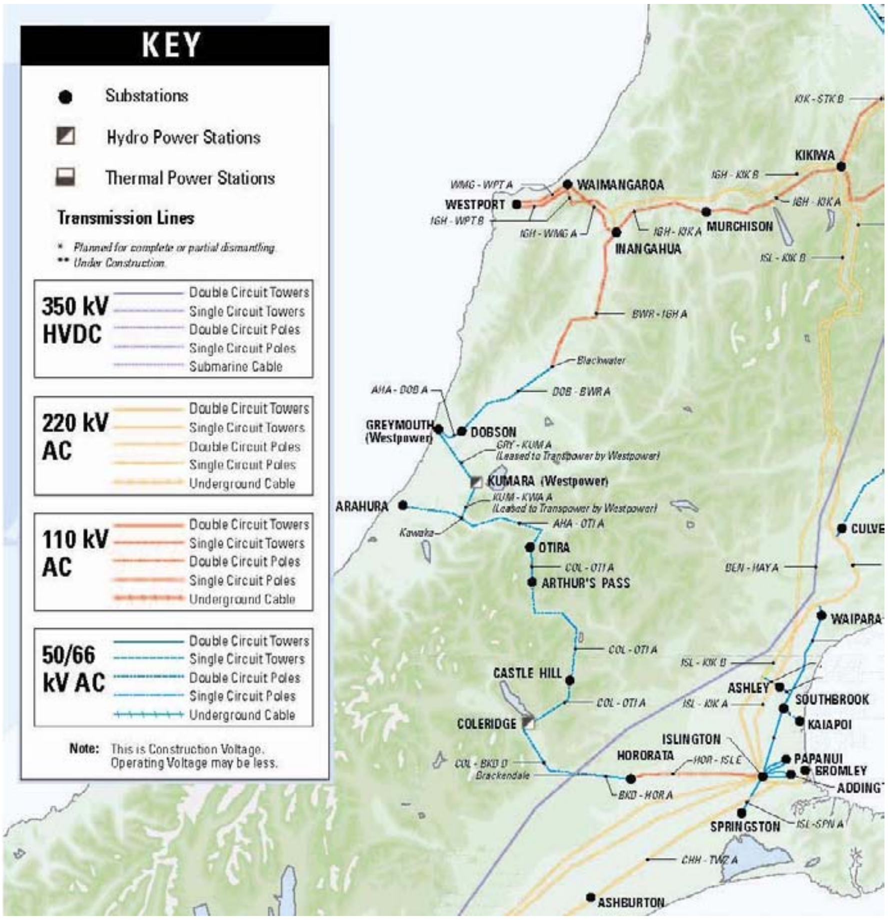
- Confirm that control equipment such as computers is properly restrained; and
- GDC to have access to satellite phones, and spare batteries or recharging facilities, as a link to outside the district in the event that all other links fail.

4.5.2 Energy – Electricity

General

The electrical power system in Grey District 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. Westpower's network extends over all of Grey District and into Buller and Westland Districts. This network is supplied from Transpower's Dobson (Grey District) and Arahura substations.

Figure 4.32: Transpower Network



Trustpower operates power stations in Grey and Westland districts that meet a portion of Grey District's power demand. Other power stations in New Zealand that supply the national grid meet the remainder of the demand.

Transpower supply into Grey District is from the north east down the Grey Valley from Inangahua to the Dobson 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 with a spur line from Kawaka to Kumara and Greymouth. 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: Kaniere Forks and McKays Creek), Dillmans (3 stations: Duffer, Dillmans and Kumara), and Arnold (1 station). On their own these stations can provide between 40% to 60% of the present electricity demand on the West Coast.

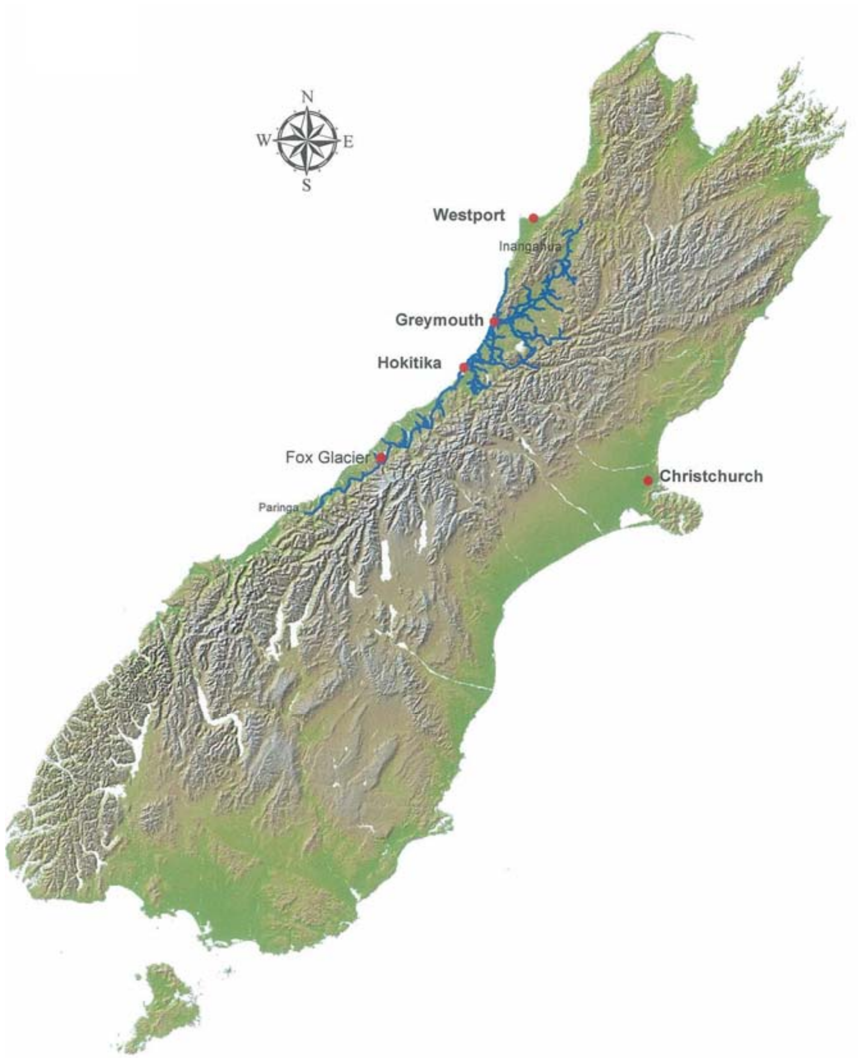
The Trustpower power stations feed power into the national grid. Under normal operating conditions the national grid provides synchronisation. Although the power station at Kumara has the capacity to produce 6.5 Megawatts, without national grid synchronisation it could only generate a small fraction of that amount, possibly as little as 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 peak load of 38MW. 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 owns 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 Westpower 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.

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. In the Grey area there are repeaters at Reefton and Paparoa on mains power.

Westpower's distribution lines vary greatly from urban overhead and underground lines to significant routes down to Franz Josef, Fox Glacier and beyond. In the Grey District the lines in the main are along valleys and within townships and are generally robust against earthquakes except possibly for poles with heavy transformers attached. In these cases, some damage may occur. Any pole route near potentially unstable hillsides may be vulnerable to earthquake induced land slips.

Figure 4.33: Westpower Network



With regard to substation buildings, there is a significant variation in age and type, with some older masonry buildings being more vulnerable than newer reinforced concrete or polystyrene sandwich panel types. In some cases there is some redundancy built in to networks that may help keep the network functional.

Westpower have a risk management section in their 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 been recently completed (2006) and remedial action on identified weaknesses is underway. 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.

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 the ground into or on to 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 by operating staff; and
- Damage to control equipment such as computers if not properly secured.

For a major Alpine Fault earthquake such as that described in the scenario in Section 2.7, the electricity system in Grey District will be significantly affected. Shaking of intensity MM VIII or greater will be experienced throughout the most of the district (only Barrytown and places north of Barrytown are outside the MM VIII isoseismals) 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 as both 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 in Christchurch. 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 to the Upper Waitaki generation and transmission facilities, and to the transmission lines and access roads 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 by 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 after some months following the earthquake.

Intensity MMIX shaking (or greater) will cause damage to the transmission system east of Moana. Damage can be expected to occur to poles from ground instability, liquefaction in susceptible areas and falling trees. Damage will occur elsewhere, but is likely to be less widespread. Much of the distribution network is single lines, and a single fault on these will cut power to the whole of the line beyond the fault.

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 normal capacity. It would be wise to assume that there will be no network power to any of Grey district for about a week.

The 6.5MW station at Kumara could well survive with minimal damage, but would not be able to generate anywhere 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 2.5MW Arnold station dates from the late 1920s and is likely to suffer sufficient damage to disable its generating capacity for a long time after an earthquake.

4.5.3 Energy – Fuels

The availability of an adequate liquid fuel supply for vehicles, generators and aircraft is a critical issue both immediately after an earthquake and in the longer term. The source of liquid fuels 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 liquid fuel stock is that within the service station tanks and tanks operated by private companies such as contractors and miners. There is no strategic liquid 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 liquid fuel from Nelson via the Grey Valley.

Supplies of gas fuels are similarly restricted with limited stocks held on the West Coast and supply by road.

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 District; and even then in limited quantities. This will place severe constraints on fuel availability.

Alternative supply methods could be by air, sea or rail. Air transport could bring in limited amounts to Hokitika, Greymouth and Westport. 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. It may be up to 2 months before the railway line to Christchurch is open. Sea or rail may very well be major routes for fuel and other supplies for some time after the earthquake. It will be important to be prepared to make the decision at the time following the event and depending on the damage to roads and rail, and the availability of sea vessels.

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 mine sites etc in the area.

In the absence of electric power, it will not be possible to remove fuel from existing underground fuel tanks at service stations. The ability to obtain aviation fuel from those stocks held at the various aerodromes may also be affected by 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 with accessibility to the fuel when there is no mains power available.

Effect on GDC

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 GDC 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. **It is recommended that CDEM/Regional Council carry out a survey of fuel held within the district in service stations and by organisations such as contractors or mining companies, and what would be needed to access it in an emergency.**

4.5.4 Regional Flood Protection

General Description

The West Coast Regional Council manages flood protection schemes in two areas, Greymouth and Inchbonnie. Flood banks to protect Greymouth are located in Greymouth along the Grey River (Greymouth Floodwall) and Sawyers Creek and immediately upstream of Greymouth in the Coal Creek and Kaiata area. There is a flood bank located at Inchbonnie to contain the Taramakau River and prevent it from flowing towards the Grey River via Lake Moana and the Arnold River. The Regional Council also manages other flood protection schemes in the Grey District at Red Jacks and Taramakau Settlement. However, they provide protection to local farm land and roads and are not considered to be strategically important from a lifelines perspective.

Significant Risks

The stopbank at Inchbonnie will be breached by the earthquake as it crosses over the fault rupture. The earthquake will also result in a step in the riverbed that will cause local bed steepening and erosion. There is therefore a risk immediately after the Alpine Fault earthquake that a flood in the river could result in at least some flood waters flowing into Lake Brunner. In the longer term, aggradation of the Taramakau riverbed is expected due to excessive sediment supply from landslides within its catchment. This could also reduce the effectiveness of the stopbank and increase the risk of the river changing course towards Lake Brunner. CDEM groups and lifeline utilities will need confirmation of the situation at Inchbonnie soon after the earthquake event and also into the future if riverbed build-up is an issue. Regional Council needs to have a strategy in place to address potential riverbed build up. **It is recommended that pre-earthquake mitigating measures to reduce the risk such as constructing secondary stop banks and stockpiling of materials should be considered for implementation.**

Portions of the Greymouth floodwall are built on areas that have a high probability of liquefaction and the batter on the floodwall is steep. In the event of a major Alpine Fault earthquake the floodwall is likely to suffer damage and its crest height may be reduced in parts. Undertaking tests of the underlying soil beneath the floodwall would be of minimal direct value as whatever the outcome of the test little can be done to improve the floodwall without major construction. Testing would however better define the extent and severity of the risk.

As with Inchbonnie, CDEM and lifeline utilities will need confirmation of the state of the flood protection structures around Greymouth immediately after the earthquake and on an on-going basis as floods occur. The river channel through Greymouth is controlled to a large extent by the river mouth conditions and aggradation of the bed is unlikely to occur to any degree that would affect the floodwall or flood levels.

4.5.5 Other Lifelines Improvement Schedule

Improvements identified in Sections 4.5.1 to 5.5.4 are summarised in Table 4.21. A more detailed improvement plan is presented in Appendix G.

Table 4.21: Improvement Schedule –Other Lifelines

Importance	Action	Completion Date	Responsible
	Telecommunications		
High	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.	June ‘08	Telecom/ BCL/DOC etc
Medium	Install a connection between the BCL tower and the Telecom transmitter / repeater on Sewell Peak to permit Telecom to use an alternative link to the rest of the country in the event of an emergency.	June ‘09	Telecom/ BCL
High	Place on record the length of time exchanges are expected to operate without outside electrical supply and / or communication in and out of the area.	June ‘08	Telecom
High	Confirm who have VHF facilities and establish a common channel for use in emergencies	June ‘08	GDC
Medium	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;	June ‘09	Telecom
High	Review access and fuel supplies to key facilities	June ‘08	Telecom
Medium	Determine GDC’s access to satellite phones and spare batteries as link to outside the district	June ‘09	GDC

Table 4.21: Improvement Schedule –Other Lifelines (Continued)

Importance	Action	Completion Date	Responsible
	Power		
High	Establish better communications between organisations and companies in the power sector on the West Coast, including power companies themselves (Transpower, Buller Electricity, Westpower) and organisations with communication capacity, Telecom, DOC and Regional Council. Also determine power supply interdependencies with other lifelines e.g. bridges, road access etc	June '08	Power companies/ Telecom/ DOC/ WCRC /Transit
Low	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower)	June '10	Power companies
	Fuel supply		
High	Consider alternative methods of supplying fuel to and within the GDC area including:	June '08	Fuel co's
Low	• Re-establishing a strategic fuel supply (tank farm) for the area,	June '10	
Medium	• Alternative supply methods e.g. barge and rail, and	June '09	
High	• A 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	June '08	
High	Consider forming database of available fuel storage tanks in the area that could be used in emergency e.g. to take fuel off barges	June '08	GDC / WCRC
High	Assess the quantity of fuel required for emergency generation, emergency services, earthmoving equipment and to keep basic services operational e.g. water supply	June '08	GDC / WCRC
Medium	Undertake a survey of fuel held within the district and what would be needed to access it in an emergency	June '08	CDEM / WCRC
	Flood Protection		
Medium	Develop strategies to address the expected earthquake damage and an anticipated issue of Taramakau riverbed build up at Inchbonnie and the potential failure of the floodwalls in Greymouth. The strategy should include early warning systems and strengthening flood banks.	June '09	WCRC / GDC (re access)
Medium	Consider pre-earthquake mitigating measures to reduce the flood risk such as the construction of secondary stop banks, stockpiling of materials, etc.	June '09	GDC / WCRC

5 SUMMARY OF RECOMMENDATIONS

5.1 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 three 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 communities and individuals and their likely responses and needs so as to further tease out needs and priorities and improve our understanding of them. Finally we look at the GDC and consider how they will respond.

This summary provides discusses general issues arising from the study, in particular those effecting GDC and provides a compilation of recommendation and improvements

5.2 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, resources, attitude and applicability.

5.3 Interdependence

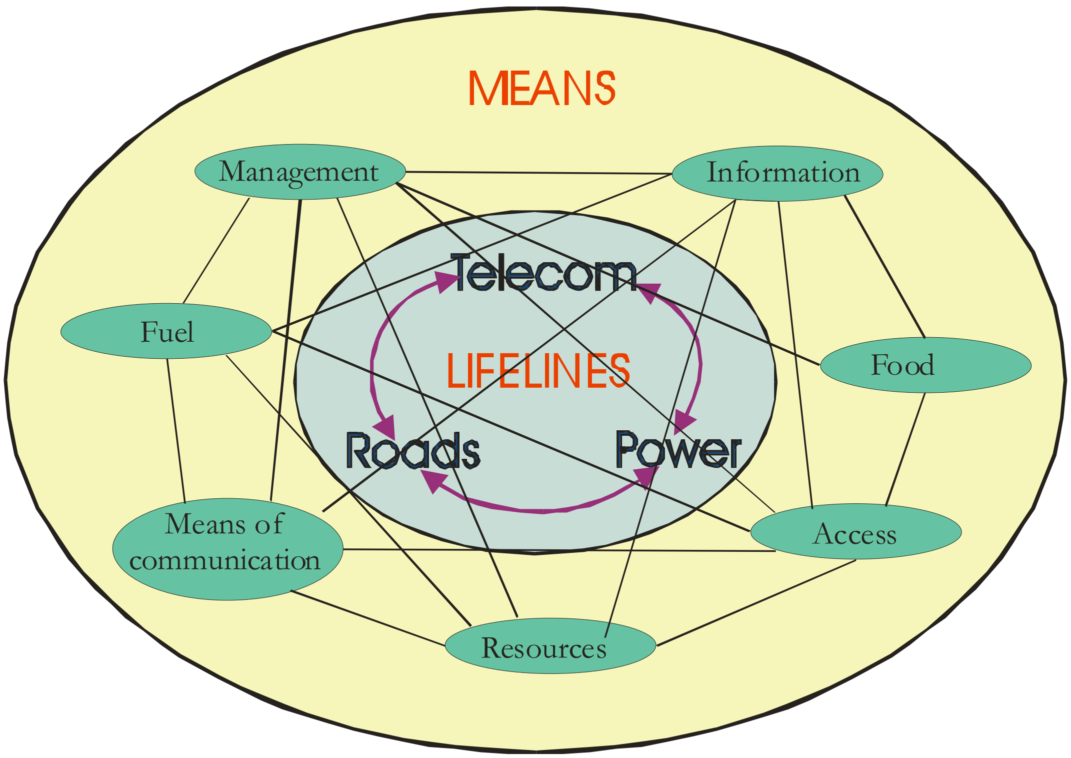
The various services and lifelines are not independent but are connected in various ways. Some connections are more obvious than others. It is important to take the interdependencies into account in the response and recovery stages of disaster management, and this requires that they are well understood beforehand. A good working relationship with other lifeline providers is essential to allow common protocols and linkages to be established. Because the interdependencies can be subtle in their detail and will be very dependent on the actual situation on the ground, this report cannot give a fully 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. Multiple demands on limited information channels; and
8. Operation of one lifeline (e.g. water supply pumps) being dependent on another (e.g. power supply).

It is useful to think of each lifeline as needing various means by which its ongoing maintenance is supported. This is illustrated in Figure 5.1, which shows an arbitrary three lifelines in the centre surrounded by “means”; that is, things which are necessary for ensuring the ongoing integrity of the lifelines. The point of the diagram is that the means are highly interdependent on each other as well as on the lifelines, so that the major interdependencies between lifelines are not so much direct interdependencies as those resulting from the interacting means. Note that in the diagram, the network of interconnections is deliberately drawn to seem confusing; this would be the reality in an earthquake. Some of the interconnections that have been identified in this plan are discussed in the following sections. Each disaster will, however be different and it will be important in a time of crisis to see the whole, and in a balanced way.

Figure 5.1: Lifelines require means by which they are supported, and the interactions between the lifelines are often through the means.



5.4 Ordering and prioritisation

There is likely, for each situation, to be a "stack" of things to be done in order of priority, for instance (Figure 5.2):

Figure 5.2 Priority Stack

The ordering 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 is recommended that CDEM and the Lifelines engineers group establish typical stack orderings beforehand.**

5.5 Leadership

The importance of leadership in a crisis was emphasised by participants at the Punakaiki workshop of September 2005. The terrorist attacks on the World Trade Centre showed the importance of leadership. New York resumed its basic functioning in a remarkably short space of time, and a major reason for this was the leadership shown by the Mayor, Robert Giuliani. He made strategic decisions and was seen to do so, while at the same time he did not become 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, firstly, sound co-ordination and direction of response and reconstruction efforts, and secondly, 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 5.6 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.

Implications for the District are:

1. Though many people have an innate capability for leadership, nevertheless there is much that can be learned about leading – knowing what to say, for instance, and – especially – how to say it.
2. Effective leaders are knowledgeable, part of which must involve good intelligence-gathering.
3. Leaders need to communicate with those they seek to lead, and they must also be able to listen.
4. Leadership must be integrated with and supported by effective management.

W**e strongly recommend that the requirements of strong post-disaster leadership be thoroughly explored by such means as workshops, exercises and, as noted below with regard to communication, the engagement of expert help.**

5.6 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 and 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. In the immediate aftermath of the quake, intelligence-gathering is all-important. Both information on the state and needs of communities and on damage to lifelines will be needed, as well as on the availability of resources;
2. At the same time, it is vital to get information out to communities and individuals as soon as possible;
3. The flow of information will be difficult when normal communication channels are not operating. Thus the means by which information can be carried requires careful consideration, especially for the early post-disaster stages.
4. Communication requires a sender, a receiver and a message. All three must be clearly understood;
5. 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;
6. It is easy for a message to be blocked or distorted by emotional factors, prejudice, preconceptions, lack of knowledge and so on; and
7. 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 elsewhere (e.g. ref. Tully, J. (ed),2007). However, we have not pursued the matter further 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.

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.**

5.7 Resources

Resource includes human resources, machinery and plant, fuel, food, and spare parts. A critical aspect that has been highlighted in this plan is that we rely extensively on centralised just-in-time supply of most commodities. While human resources, machinery, and plant will be available within days after a major disaster on the Coast the transport routes may not allow the supply of fuel, food and spare parts in the quantities required for a week or more. Stockpiles on these commodities may only last for a number of days. **It is recommended that GDC and CD raise this issue with food and fuel suppliers and GDC review there spare parts stocks and stock piles of aggregate.**

5.8 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.

People 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 vitally 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 and the preparation of Emergency Response Plans for the lifelines. The plans would cover such aspects as:

- Identifies how damage will be assessed and repair priorities set;

- 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;
- Back up plans and alternative arrangements if proposed methodologies not viable;
- Identifies areas likely to be affected after the earthquake and outlines what alternative arrangements will need to be put in place such as alternative drinking water supply; provisions to sanitise areas contaminated by sewage overflows e.g. quicklime for household spills; contingency plans for areas likely be affected by stormwater backup;
- The location of as-built drawings, backup copies and updating requirements; and
- Identifies any training requirements.

There remains the question of who should be involved in cooperative discussions. We believe that it is important to reach beyond lifelines asset managers and service providers and also involve major players in the community such as political representatives and major businesses – Solid Energy, for instance.

5.9 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.

5.10 Things to be Done

The following tables are a consolidation of improvement plans and recommendations made in this plan.

Importance	Action	Completion Date	Responsible
TRANSPORT			
	General		
High	Establish fast and flexible contract procedures with contractors	June '08	GDC
High	Establish availability of plant and equipment, in particular, but not limited to specialist plant and equipment.	June '08	GDC
High	Establish availability professional engineers.	June '08	GDC
	Greymouth Airport		
High	Assessment of Runway and access	June '08	GDC
High	Fuel storage seismic assessment	June '08	GDC fuel supply Co's
High	Power supply seismic assessment	June '08	GDC power & line supply Co's.
Low	Building and contents seismic assessment	June '08	GDC & Building Owners
High	Ascertain the requirements for Hercules operation at the Airport	June '08	GDC
Medium	Consider other locations for an alternative landing strip. Check on status of these strips	June '09	GDC
Medium	Based on information and findings for all the above develop an emergency Response Plan for the airport	June '09	GDC
	Roads		
High	Confirm critical routes based on the Key Principles of Reinstatement (refer Section 4.1.4)		
Medium	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.	June '09	GDC,BDC, TDC,WDC, WCRC & Transit
Medium	In conjunction with Ontrack screen rail corridors from Greymouth to Christchurch, Greymouth to Westport and Greymouth to Hokitika for specific vulnerabilities and prioritise works that might reduce its risk to earthquake damage.	June '09	GDC,BDC, WDC, & Ontrack
High	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. A programme of progressive upgrading and improvements should be established and periodic inspections be formalised.	June '08	GDC

Importance	Action	Completion Date	Responsible
Medium	Liaise with Transit about key routes in the district and establish contacts for good co-operation after an earthquake.	June '09	GDC
High	In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify and prioritise immediate clearing and repairs.	June '08	GDC
Medium	Establish a database of the locations and owners of earthmoving resources that could be used in a major disaster for road and bridge repair.	June '09	GDC
	GDC Bridges		
Medium	Seismic assessment of all bridges on critical routes. Should include bridges carrying other services i.e. interdependencies.	June '09	GDC
Low	Seismic assessment of all bridges on other routes	June '10	GDC
Medium	A plan should be prepared based upon the above audit to progressively upgrade weak bridging over a reasonable but achievable period of time.	June '09	GDC
	Port of Greymouth		
Medium	Continue to maintain port to an appropriate standard so that it would remain useable in the event of an emergency	June '09	GDC
Medium	Have the ground tested for liquefaction potential in the port area	June '09	GDC
High	Assess the likelihood of the cranes being operational after the major Alpine Earthquake and examine alternative (back-up) options	June '08	GDC
High	Set up an agreement with suitable shipping companies for use of appropriate vessels in an emergency (e.g. shipping companies serving the Chatham Island) and find out the capability of the Navy to help.	June '08	GDC
Medium	Consider forming an emergency plan with fuel companies for supply via the Port of Greymouth and Rail company. Plan should include handling/storage of the fuel at the port	June '09	GDC
High	Consider some form of emergency power for navigation system and a crane at the Port	June '08	GDC
	Railway		
Medium	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.	June '09	GDC & Ontrack
	River Transport		
	A plan to ensure emergency access to suitable boats should be enacted, particularly for Greymouth and Lake Brunner.		

Importance	Action	Completion Date	Responsible
DRAINAGE			
	General		
High	Confirm the location and extent of areas that are likely to flood in all urban drainage communities.	June '08	GDC
High	Review the proposed level of service and strategy to ensure they are appropriate and achievable.	June '08	GDC
High	Establish a register of companies/contractors with useful plant such as mobile high volume pumps, excavators etc	June '08	GDC
Medium	Establish an earthquake emergency flood mitigation plan that: • Identifies areas likely to be affected by flooding after the earthquake, • Provides contingency plans for flood affected areas, • Identifies those responsible for key tasks, • Identifies how damage will be assessed and repair priorities set, and • Identifies any training requirements.	June '09	GDC
High	Ensure that all future storm water system structures are adequately designed for earthquake loads.	June '08	GDC
Low	Continue replacement of system components following normal asset replacement principles. However, give priority to replacement of downstream section then work upstream.	June '10	GDC
Low	Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding. Identify and implement appropriate emergency provisions.	June '10	GDC
	Greymouth/Blaketown and Cobden		
Low	Undertake geotechnical and structural assessments of the Tarry Creek and Nelson Quay pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks.	June '10	GDC
High	Determine optimal locations to breach the floodwall in the event that breaching is required.	June '08	GDC
Low	Continue the current programme of separating the storm water/sewerage schemes in Cobden, Greymouth and Blaketown	June '10	GDC
Medium	Consider purchasing a designated generator for the Nelson Quay Pump Station	June '09	GDC

Importance	Action	Completion Date	Responsible
WATER SUPPLY			
	General		
High	Establish a formal response plan that identifies those responsible for key tasks, backup plans and training requirements. It will be important to identify local people in the four supplies outside Greymouth to be responsible for water supply operation under emergency conditions particularly when GDC staff or contractors are not available. Identify where necessary plant will be obtained from e.g. tankers. The plan should also include a thorough methodology for assessing damage and prioritising of repairs.	June '08	GDC
High	Review spare part requirements to establish emergency supply status at all water supplies.	June '08	GDC
Medium	Purchase a generator sets for small water supplies (Runanga, Dobson, Stillwater & Blackball)	June '09	GDC
Medium	Undertake an assessment of the key mains in all the water supplies including mains to CD posts and other emergency services	June '09	GDC
Medium	Ensure all equipment is adequately secured against movement in an earthquake at all water supply pump stations and treatment plants and ensure all water supply buildings and reservoirs have adequate earthquake strength.	June '09	GDC
Medium	Undertake a liquefaction assessment at locations of vulnerable components for all water supplies.	June '09	GDC
Low	Review options for multi-tap standpipes and assess the number required for each of the five GDC water supplies. Fabricate adequate multi-tap standpipes for all supplies and identify where the standpipes are to be stored.	June '10	GDC
Low	Establish priorities for initial re-instatement of water supplies	June '10	CDEM/ GDC
Medium	Define high fire risk/high value areas and identify appropriate secondary fire fighting options	June '09	GDC
Medium	Install burst control valves on reservoirs in all supplies	June '09	GDC
Medium	Prepare an Emergency Response Plan for Water Supplies and provide a copy at each water supply pump station for each of the community supplies	June '09	GDC
High	Review reserve fuel storage capacity requirements for the Coal Creek intake, Sids Road, Taylorville, Stillwater and Blackball high lift pump stations to ensure there is sufficient fuel available in the event of the Alpine Fault earthquake.	June '08	GDC
	Greymouth		
Low	Provide treatment to DWSNZ 2005 standard. Treatment design should take into consider likely water quality after an Alpine Fault earthquake.	June '10	GDC
High	Purchase dedicated generator for Coal Creek intake	June '08	GDC
High	Replace 250mm Steel – Cobden Bridge & Mawhero Quay (500m)	June '08	GDC
Medium	225mm CI - Tainui & High Streets duplicated in Alexander & Shakespeare Streets (2,000m)	June '09	GDC
Medium	Replace 200mm CI – Cobden (900m)	June '09	GDC
Low	Replace 150mm AC & Steel - Nelson & Tasman Streets (300m)	June '10	GDC

Importance	Action	Completion Date	Responsible
	Greymouth (Continued)		
Medium	Evaluate the Arnott Heights reservoir as a supply reservoir for Greymouth as well as Arnott Heights. If feasible assess main to reservoir and upgrade as required to key main status.	June '09	GDC
Medium	Inspect the Omoto reservoir structure and foundations to assess likely damage in an Alpine Fault earthquake. If reservoir considered likely to still function satisfactorily after an Alpine Fault earthquake, assess mains to reservoir and upgrade as required to key main status.	June '09	GDC
	Runanga		
Medium	Undertake inspection of the Sids Road well casings. Assess condition and if questionable consider options to replace well casings or install new bore/bores	June '09	GDC
High	Upgrade 150mm AC - Sids Road - Runanga to a 200mm pipe (3,000m)	June '08	GDC
Medium	Install 150mm PVC main through Runanga past the CD sector post to the Dunollie reservoir (3,000m)	June '09	GDC
Low	Install 100mm PVC main through Rapahoe between the CD sector post and the proposed Rapahoe reservoir (900m)	June '10	GDC
Low	Install a reservoir and supply main in Rapahoe with burst control valve	June '10	GDC
Medium	Install a supply connection at Sids Road between the Coal Creek intake transmission line and the Runanga water supply transmission line	June '09	GDC
	Dobson Taylorville		
Low	Provide treatment to meet DWSNZ 2005. Treatment design should take into consider likely water quality after an Alpine Fault earthquake	June '10	GDC
Medium	Replace 150mm AC - intake to high lift pump station (500m)	June '09	GDC
Medium	Replace 150mm AC - high lift pump station to Taylorville CD Sector Post (700m)	June '09	GDC
Low	Replace 150mm AC - to the Dobson reservoir (200m)	June '10	GDC
Low	Replace 150mm AC - SH 7 (Dobson) to the Dobson CD Sector Post (600m)	June '10	GDC
High	Assess pipe river crossing including bridge columns, pipe, cables and anchors	June '08	GDC
High	Attach pipeline to Dobson reservoir firmly to the cliff face	June '08	GDC
	Blackball		
High	Confirm that the 150mm AC/Steel pipe from the Blackball reservoir to the CD Sector Post at the school is in good condition. Consider improvements particularly at the reservoir end where it taps into the mainline from the reservoir.	June '08	GDC
Medium	Review to ensure there are adequate isolation valves and hydrant is strategic location	June '09	GDC
	Stillwater		
Medium	Assess the Stillwater reservoir structure and foundations	June '09	GDC
Medium	Undertake inspection of the Stillwater well casings. Assess condition and if questionable consider options to replace well casings or install new bore/bores	June '09	GDC
Low	Replace 150mm AC – Reservoir to Stillwater CD Sector Post (1,600m)	June'10	GDC
Low	Review to ensure there are adequate isolation valves & hydrant is strategic location	June '10	GDC

Importance	Action	Completion Date	Responsible
SEWERAGE			
	General		
High	Develop a strategy for disposing of domestic and industrial sewage for the anticipated period of months before the sewerage service returns to normal. This may include public education so that communities are aware of and can be involved in developing the strategy.	June '08	GDC/ CDEM
High	Establish an emergency sanitation 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; • Back up plans; • Discharge requirements of major waste water producers after a major earthquake; • 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.	June '08	GDC
Medium	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.	June '09	GDC
High	Review the preliminary assessments of surcharging locations presented in sections 4.4.3 to 4.4.7 to ensure ponded water can discharge to a nearby water way.	June '08	GDC
Low	Undertake geotechnical and structural assessments of all pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks	June '10	GDC
High	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.	June '08	GDC
High	Ensure that all future sewerage system structures and improvements are adequately designed for earthquake loads.	June '08	GDC
Low	Upgrade sewer pipes from CD posts or provide alternative sewage disposal facilities (standby septic tank facility) to ensure sewage can be disposed of from CD Posts after the Alpine Fault earthquake event.	June '10	GDC/ CDEM
High	Review all pump stations and oxidation pond sites to ensure all equipment and plant is adequately secured against movement in the event of an earthquake.	June '08	GDC
	Greymouth & Cobden		
High	Consider purchasing a designated generator for the Johnston Street Pump Station as Johnston Street is a critical pump station	June '08	GDC
Low	Continue the current programme of separating the storm water/sewerage schemes in Cobden, Greymouth and Blaketown	June '10	GDC
	Karoro/Paroa, Runanga & Moana		
Low	Undertake a geotechnical and structural assessment of oxidation ponds to quantify the earthquake risks at each site and recommend any structural improvements to address these risks.	June '10	GDC

Importance	Action	Completion Date	Responsible
OTHER LIFELINES			
	Telecommunications		
High	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.	June '08	Telecom/ BCL/DOC etc
Medium	Install a connection between the BCL tower and the Telecom transmitter / repeater on Sewell Peak to permit Telecom to use an alternative link to the rest of the country in the event of an emergency.	June '09	Telecom/ BCL
High	Place on record the length of time exchanges are expected to operate without outside electrical supply and / or communication in and out of the area.	June '08	Telecom
High	Confirm who have VHF facilities and establish a common channel for use in emergencies	June '08	GDC
Medium	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;	June '09	Telecom
High	Review access and fuel supplies to key facilities	June '08	Telecom
Medium	Determine GDC's access to satellite phones and spare batteries as link to outside the district	June '09	GDC
	Power		
High	Establish better communications between organisations and companies in the power sector on the West Coast, including power companies themselves (Transpower, Buller Electricity, Westpower) and organisations with communication capacity, Telecom, DOC and Regional Council. Also determine power supply interdependencies with other lifelines e.g. bridges, road access etc	June '08	Power companies/ Telecom/ DOC/ WCRC /Transit
Low	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower)	June '10	Power companies
	Fuel supply		
High Low Medium High	Consider alternative methods of supplying fuel to and within the GDC area including: • Re-establishing a strategic fuel supply (tank farm) for the area, • Alternative supply methods e.g. barge and rail, and • A 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	June '08 June '10 June '09 June '08	Fuel co's
High	Consider forming database of available fuel storage tanks in the area that could be used in emergency e.g. to take fuel off barges	June '08	GDC / WCRC
High	Assess the quantity of fuel required for emergency generation, emergency services, earthmoving equipment and to keep basic services operational e.g. water supply	June '08	GDC / WCRC
Medium	Undertake a survey of fuel held within the district and what would be needed to access it in an emergency	June '08	CDEM / WCRC

Importance	Action	Completion Date	Responsible
OTHER LIFELINES			
	Flood Protection		
Medium	Develop strategies to address the expected earthquake damage and an anticipated issue of Taramakau riverbed build up at Inchbonnie and the potential failure of the floodwalls in Greymouth. The strategy should include early warning systems and strengthening flood banks.	June '09	WCRC / GDC (re access)
Medium	Consider pre-earthquake mitigating measures to reduce the flood risk such as the construction of secondary stop banks, stockpiling of materials, etc.	June '09	GDC / WCRC
GENERAL			
High	*Improve understanding of leadership and communication issues* Consider how communication can best be achieved after a major earthquake. Consider running a seminar/workshop on leadership and communication issues.	Jun '07	CDEMG
High	*Improve understanding of how outside help will be co-ordinated, serviced and directed.* • 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	CDEMG
High	*Improve understanding of how lifeline services repair will be co-ordinated* • 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	CDEMG & Lifelines Group
Low	*Establish how building/housing repairs will be co-ordinated* • 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	CDEMG & Council regulatory Department
High	*Resources* Determine how supplies of food and fuel, for example are to be maintained the event of transport routes being seriously disrupted	Dec '10	CDEMG & Councils

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APPENDIX A

Damage Assessment Chart

Grey District Council Lifelines Study

Damage Assessment Chart

1 Reference Report

The Chart has been compiled for use with the Grey District Lifelines Study, November 2006. It should be read in conjunction with Section Two of that report. Section four 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.

Grey 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				

Grey District Council Lifelines Study - Damage Assessment Chart

B - In Ground Pipe work 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 ductility 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 Pipe work (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 ductility 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				

Grey District Council Lifelines Study - Damage Assessment Chart

C - Transport

IMPORTANT: Refer notes on the first page this Appendix

Zone	Shaking Intensity	Roads	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, Landslides 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 embankments*		*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	Roads	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	Rock fall and small slips on steep batters.	Minor damage to alignment		Minor slumping
	MM VIII	Rock fall and slips in steep batters	Distortion of rail lines, some spreading of embankments		Some slumping of abutment fill common
	MM IX	Landslides in steep slopes and batters, cracking of ground, large volume rock fall 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 ferro-concrete 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 III** 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. Landslides 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 III (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. 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 Grey District in 2007.

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 rock fall 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 rock fall, 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 between Haupiri and Wainihinihi. The damage to the upper Buller Gorge road was on a road at right angles to the fault rupture, whereas several district roads run 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.

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 residents 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 landslides might be different now, but a similar earthquake must be expected to cause widespread landslides 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.

APPENDIX D

Workshop Attendance Lists

Lifelines Workshop Attendance 21 October 2004

Lifelines

Ian Forsuth	BDC
Mel Sutherland	GDC
Peter McConnell	GDC
David Evans	GDC
Carl Jackson	GDC
Neil Campbell	New Zealand Rail Corporation
David Stapleton	Port of Greymouth
Rob Ruiter	Telecom
John McKenzie	Transpower
John Wilson	Transpower
Neville Higgs	Transit/Opus
Jim McDermott	Trustpower
Ian Lees	Trustpower
Mary Trays	WCRC - Hazards Analyst
Thomas O'Lauaghan	Westpower

Grey District

Martin Kennedy	GDC
A Rose	GDC

Buller District

Reg Barrell	BDC CDO

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)

Others

Chris Cowan	Coastwide Helicopters	(Day 1 weather dependent)

Apologies

Terry Archer – Annual leave

APPENDIX E

Effect on Individuals of an Alpine Fault Earthquake

Alpine Fault Earthquake Scenario –Effect on Individuals

In order to ensure the fullest understanding of the community'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.

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.

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.

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.

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.

APPENDIX F

Needs Assessment

Moana Community Needs

Needs	First Three Days			One Month			One Year			First Three Days	One Month	One Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	2	6	3	3	9	3	3	9	Strong need for leadership but provide in local 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 on 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 families now temporally 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	2	4	0	1	0	0	1	0	Only medical evacuees but high reliant on others because of difficulty of road access	Evacuation phase is over	Evacuation phase is over
Security	1	1	1	1	1	1	1	1	1	Security not an issue because of isolation of the area	Security is still not an issue because of isolation difficulty of access to the area.	Security not an issue
Relocation	2	1	2	3	2	6	1	2	2	Relocation locally. People living close to the fault whose house have been badly damaged relocate to Moana CD centre	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 insurances claims or planning how to recover	Very high need and high reliance. Not total reliance because of West Coast independence / entrepreneurial approach.	No income to speak of for Rotomanu farmers. High need and almost total reliance on outside agencies for income and capital to rebuild.
Water	1	1	1	1	0	0	1	0	0	Normal need but use own or neighbours drinking rainwater tank water	Household rainwater system re-established	Household rainwater system re-established
Sanitation	1	1	1	1	3	3	1	3	3	Spade and a patch in the back yard adequate	Sewerage scheme operating although sewage not treated	Sewerage scheme operating
Food	3	2	6	1	3	3	1	3	3	High need and in first three days mostly rely on own source. However baby food a problem.	Normal need for food with total reliance on others for supply	Normal need for food with total reliance on others for supply

Moana Community Needs

Needs	First Three Days			One Month			One Year			First Three Days	One Month	One Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Shelter	2	2	4	1	3	3	1	2	2	People who come in from outside Moana such as Rotomanu totally reliant on shelter in Moana. Moana residents mostly make do.	Starting to return to home. Total reliance on outside agencies for building materials	Returning to normal but repairs to homes still being completed
Lighting & Heat	2	1	2	1	3	3	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 (e.g. national grid, gas)	Normal need and return to total reliance on others (national grid + fuel suppliers)

Runanga community Needs

Needs	First Three Days			First Three Days
	Need	Reliance	Importance	
Leadership	3	3	9	Strong need for leadership to direct people and co-ordinate community effort
Info. in/out	3	3	9	Hugh need for information (in/out) but local word of mouth is working
Rescue/Med. Aid	2	3	6	High reliance on Greymouth for expert medical help
Evacuation	2	3	6	Only medical evacuees and totally reliant on air travel
Security	2	2	4	Need for security to guard against minor burglaries and looting attempts to get food, building materials and fuel.
Relocation	0	3	0	Relocation not important at this early stage
Counselling	3	0	0	No counselling at this stage. Rely on community support
Income & Insurance	1	1	1	Concern about immediate impact but not yet organising insurances claims or planning future income source
Water	1	2	2	Normal need for water and high reliance on Council. At CD posts almost total reliance on Council.
Sanitation	1	2	2	Spade and a patch in the back yard adequate
Food	2	3	6	High need for food and high to total reliance on others
Shelter	2	2	4	Normal need for shelter and moderate reliance on other because of unknown stability of home and continuing after shocks
Lighting & Heat	2	1	2	Higher need for lighting & heating because of emergency shelter conditions but low reliance at this stage on national grid - because can use gas bottles, wood & coal stores.

Greymouth Community Needs – Including Runanga's needs after 3 days

`Need	First 3 days			One Month			One Year			First 3 days	One Month	One Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Leadership	3	3	9	3	3	9	3	3	9	Community reliant on leadership to provide immediate direction	Very high need for leadership to show a way forward - give hope	As for "End of first month"
Info. in/out	3	3	9	3	3	9	2	3	6	Very High need to know status of family members, what is happening, how to get help etc	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	People that are trapped or seriously injury need immediate and urgent assistance	Rescue & med aid is over	Rescue & med aid is over
Evacuation	3	3	9	1	3	3	0	2	0	Assume evacuation of seriously injured people that can not be treated adequately at Greymouth hospital	Evacuation mostly over. Some evacuation of valuable items from areas near the fault destroy by the quake	Evacuation is over
Security	3	3	9	2	2	4	1	3	2	The community would have a high need for security (looters) and high reliance on others to provide	High need for security because huge demand for reconstruction materials	Normal security
Relocation	0	0	0	2	3	6	1	2	2	Not yet considering relocation - concerned about immediate impact	People & businesses have decided to leave the coast and require relocation out of the area	Families have moved away. Some new people mostly single move in.
Counselling	0	0	0	3	2	6	2	2	4	Minimal formal counselling at this stage. Support from family/friends/neighbours	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	2	3	6	3	3	9	Concern about immediate impact - not yet organising insurances claims and planning future income sources	Income required to retain people on the Coast. 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	Normal needs and higher reliance on GDC system	As for "End of first month"
Sanitation	1	3	3	1	3	3	1	3	3	While some resident may have a backyard to build a toilet, those in the CBD, motels, hotels etc will not.	Normal needs & increasing reliance on GDC sewerage system	As for "End of first month"

Greymouth Community Needs – Including Runanga's needs after 3 days (continued)

`Need	First 3 days			One Month			One Year			First 3 days	One Month	One Year
	Need	Reliance	Importance	Need	Reliance	Importance	Need	Reliance	Importance			
Food	3	3	9	1	3	3	1	3	3	Home supplies used initially. However by day 3 food supply is very limited because of large number of people, transportation limitations, and distribution difficulties.	High needs because of demand from additional outside support people, high reliance on others and continuing transportation difficulties	Normal needs and return to normal supermarket supply however more food now held in stock
Shelter	2	2	4	3	2	6	2	3	6	Potentially higher need. Depends to a certain extent on weather conditions at the time.	Because of damage to homes & accommodation and influx of homeless and outside support shelter need very high	Some still reliant on temporary housing while their homes are rebuilt - huge demand for builders and materials
Lighting & Heat	2	2	4	1	3	3	1	3	3	Higher need for lighting for security for fuel, food and building material outlets. However residential areas manage.	Normal needs and reliance restored power. Some still using small gensets.	Normal needs and returning to high reliance on normal supply (national grid). Lower demand because people & businesses have left the area

APPENDIX G

Detailed Lifelines Improvement Schedule

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
General	High	1. Fast & Flexible Contract Procedures	Done	Use Short Form Contract Agreements (one page document linked to NZS 3910) for contracts and use Purchase & Works Orders for Supply of Goods and Services. Both documents already in place	Short Form Contract Agreement (linked to NZS 3910) and Purchase and Order Books	Within 12 months	GDC
General	High	2. Establish availability of plant and equipment, in particular but not limited to specialist plant and equipment.		Review maintenance contracts and establish Memorandum of Understanding for Emergencies to confirm maintenance contractor will supply plant, equipment, materials and personnel. Confirm that Transit NZ and NZ Rail Corp (OnTrack) have similar agreements in place for their road and rail networks.	Transport Engineer (TE) for Transport including Airport, State Highways and Rail. Utilities Engineer (UE) for other Utilities Listed in this Study	Within 12 months	GDC
General	High	3. Professional Engineers		Establish preferred supplier agreements for emergencies with professional engineering regularly used by Council and/or based on the West Coast.	Manager, Assets & Engineering (MAE)	Within 12 months	GDC
General	High	4. Review communication systems between all Life Line Utilities and with Emergency Management (CDEM) Group.		Commenced review of the provision of radio telephone systems.	MAE	Within 12 months	GDC
Greymouth Airport	High	1. Runaway Seismic Assessment	Dec 06-Feb 07	CPT Tests and Report for Airport Runway. Geotechnical Report for Airport Runway	MAE to Include Copy of test results and geotech report with Life Line Study Documents as well as on the Greymouth Airport File.	Within 12 months	GDC
Greymouth Airport	High	2. Fuel Storage Seismic Assessment			TE	Within 12 months	GDC & Fuel Supply Co's

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Greymouth Airport	High	3. Power Supply Seismic Assessment			TE	Within 12 months	GDC & Power & Line Supply Co's
Greymouth Airport	Low	4. Buildings and contents Seismic Assessment		Council does not own any building on site. Existing airport terminal operates from Aeroclub Building. This is a light time frame and timber clad building. New Private Air Terminal about to be constructed.	MAE	Within 3 years	GDC & Building Owners
Greymouth Airport	High	Ascertain the requirements for Hercules operation at the Airport	Feb o7	Assistant Engineer has approached Airforce to confirm requirements	TE	Within 12 months	GDC
Greymouth Airport	Medium	Consider other locations for an alternative landing strip		Possibly use road, but need to check obstructions. Check topographic maps – forestry runway Nemona Forest?	TE	Within 2 years	GDC
Greymouth Airport	Medium	Based on information and findings for all the above develop an Emergency Response Plan for the Airport			MAE	Within 2 years	
Land Transport	Medium	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.		600Km of highway. Confirm what work each Road Controlling Authority has down and review reports for prioritising improvement works. If work not done, confirm what work is proposed and timeframes.	TE	Within 2 years	GDC,BDC, TDC,WDC, WCRC & Transit

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Land Transport	Medium	In conjunction with the OnTrack (NZRC) screen Rail Corridors from Greymouth to Christchurch, Greymouth to Westport and Greymouth to Hokitika for specific vulnerabilities and prioritise works that might reduce its risk to earthquake damage.		Confirm what work OnTrack (NZRC) has down and review reports for prioritising improvement works. If work not done, confirm what work is proposed and timeframes.	TE	Within 2 years	GDC & OnTrack
Land Transport	High	Prepare a route hazard map to identify which roads and railway lines may become damaged or impassable. Hazards should include slips on cuttings and embankments, landslide and rock fall potential, potential liquefaction areas and areas within those where lateral spreading of the roads or railway lines is possible. A programme of progressive upgrading and improvements should be established and periodic inspections be formalised.		Use GDC Geographic System to do initial desktop assessment and then verify by drive through survey. Once hazard map prepared prioritise improvement works based on Key Principles of Reinstatement (See Section 4.1.4). Consult with Transit and OnTrack regarding their networks.	TE	Within 12 months	GDC
Land Transport	Medium	Liaise with Transit about key routes in the district and establish contacts for good co-operation after an earthquake.		Confirm key positions can communication systems.	TE	Within 2 years	GDC
Land Transport	High	In conjunction with the bridge audit, below, prepare a damage assessment strategy to be followed after the earthquake to quickly identify and prioritise immediate clearing and repairs.		Review system used for Central NI Floods	TE	Within 12 months	GDC
Land Transport	Medium	Establish a database of the locations and owners of earthmoving resources that could be used in a major disaster for road and bridge repair.		See Telephone Directory as initial starting point. Find out if Contractor's Federation maintains a database.	TE	Within 2 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Bridges	High	1. Confirm critical routes based on Key Principles of Reinstatement (Section 4.1.4)			MAE	Within 12 months	GDC
Bridges	Medium	2. Seismic Assessment of all bridges on Critical Routes.	0.5	Initial Work has been carried out by John Mackenzie (ELMAC Consulting Ltd.) Need to review this work and decide what additional work is required.	Initial Seismic Assessment Report	Within 2 years	GDC
Bridges	Low	3. Seismic Assessment of all bridges on Other Routes.			MAE	Within 3 years	GDC
Bridges	Medium	A plan should be prepared based upon the above audit to progressively upgrade weak bridging over a reasonable but achievable period of time.			MAE	Within 2 years	GDC
Marine Port @ Greymouth	Medium	Continue to maintain port to an appropriate standard so that it would remain useable in the event of an emergency		Check management and ownership arrangements.	Port Westland & Terminal Co.	Within 2 years	GDC
Marine Port @ Greymouth	Medium	Have the ground tested for liquefaction potential in the port area			Port Westland & Terminal Co.	Within 2 years	GDC
Marine Port @ Greymouth	High	Assess the likelihood of the cranes being operational after the major Alpine Earthquake and examine alternative (back-up) options		Backup option is mobile cranes but this will depend on vehicle loading capacity of wharves.	Port Westland & Terminal Co.	Within 12 months	GDC
Marine Port @ Greymouth	High	Set up an agreement with suitable shipping companies for use of appropriate vessels in an emergency and find out the capability of the Navy to help.		Life Line utilities need to talk to Port Westland about potential supply arrangements from North Island	Port Westland & Terminal Co.	Within 12 months	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Marine Port @ Greymouth	Medium	Consider forming an emergency plan with fuel companies for supply via the Port of Greymouth and ONTRACK.		Line Lines utilities and Port of Westland need to talk to Fuel Companies and OnTrack about potential supply arrangements.	Port Westland & Terminal Co.	Within 2 years	GDC
Marine Port @ Greymouth	High	Consider some form of emergency power for navigation system and a crane at the Port		Confirm what arrangements in place if any. If none assess what is required	Port Westland & Terminal Co.	Within 12 months	GDC
Urban Storm water Drainage Systems - General	High	Confirm the location and extent of areas that are likely to flood in all urban drainage communities.	Done	See relevant section of Life Lines report.	UE	Within 12 months	GDC
Urban Storm water Drainage Systems - General	High	Review the proposed level of service and strategy to ensure they are appropriate and achievable.			UE	Within 12 months	GDC
Urban Storm water Drainage Systems - General	High	Establish a register of companies/contractors with useful plant such as mobile high volume pumps, excavators etc		See General Improvements above	UE	Within 12 months	GDC
Urban Storm water Drainage Systems - General	Medium	Establish an Emergency Response Plan for earthquake induced flooding to mitigate flooding effects. (See below for required details to include in the Plan)				Within 2 years	GDC
Urban Storm water Drainage Systems - General	High	Ensure that all future storm water system structures are adequately designed for earthquake loads.		Check requirements in NZS 4404:2004	MAE	Within 12 months	GDC
Urban Storm water Drainage Systems - General	Low	Continue replacement of system components following normal asset replacement principles. However, give priority to replacement of downstream section then work upstream.	Done	This is allocated a low priority as it is normal operational practice to commence replacements from lower lying area and work uphill.	UE	Within 3 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Urban Storm water Drainage Systems - General	Low	Undertake an assessment of public health risk posed by potential sewage surcharges combining with storm water and ponding. Identify and implement appropriate emergency provisions.		Include procedures to reduce health risks in the Emergency Response Plan (See relevant section of Life Line Study) Confirm Section of Study?	UE	Within 3 years	GDC
Urban Storm water Drainage Systems - Greymouth/Blaketown & Cobden	Low	Undertake geotechnical and structural assessments of the Tarry Creek, Johnston Street and Nelson Quay pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks.		Nelson Quay done. Geotechnical report done prior to design. Structure designed to withstand ground acceleration.	MAE	Within 3 years	GDC
Urban Storm water Drainage Systems - Greymouth/Blaketown & Cobden	High	Determine optimal locations to breach the floodwall in the event that breaching is required.		Obtain advice from West Coast Regional Council. Include details on the Emergency Response Plan	UE	Within 12 months	GDC
Urban Storm water Drainage Systems - Greymouth/Blaketown & Cobden	Low	Continue the current programme of separating the storm water/sewerage schemes in Cobden, Greymouth and Blaketown	Ongoing (Done 2014)	This is allocated low priority as the work is progressing automatically for other reasons.	UE	Within 3 years	GDC
Urban Storm water Drainage Systems - Greymouth/Blaketown & Cobden	Medium	Consider purchasing a designated generator for the Nelson Quay Pump Station	Done	Generator located in Council Yard - (Puketahi Street). Hot plugs currently being installed a Pump Station	UE	Within 2 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Water Supplies: General	High	Establish a formal response plan that identifies those responsible for key tasks, backup plans and training requirements. It will be important to identify local people in the four supplies outside Greymouth to be responsible for water supply operation under emergency conditions particularly when GDC staff or contractors are not available. Identify where necessary plant will be obtained from e.g. tankers. The plan should also include a thorough methodology for assessing damage and prioritising of repairs.			UE	Within 12 months	GDC
Water Supplies: General	High	Review spare part requirements to establish emergency supply status at all water supplies.			UE	Within 12 months	GDC
Water Supplies: General	Medium	Purchase a generator set for small water supplies (Runanga & Dobson)	Done	Generator in Council Yard - Puketahi Street. Hot Plugs currently being installed.	UE	Within 2 years	GDC
Water Supplies: General	Medium	Undertake an assessment of the key mains in all the water supplies including mains to CD posts and other emergency services	Done	Done as part of this Life Lines Study (see also other listed improvements below)	UE	Within 2 years	GDC
Water Supplies: General	High	Ensure all equipment is adequately secured against movement in an earthquake at all water supply pump stations and treatment plants and ensure all water supply buildings and reservoirs have adequate earthquake strength.	Done	Assessment carried out by ELMAC Consultants Limited. Confirm extent of recommendations implemented	UE	Within 12 months	GDC
Water Supplies: General	Medium	Undertake a liquefaction assessment at locations of vulnerable components for all water supplies.		Desk tip study using GIS, followed up be specific site inspections and Geotech investigations in required.	UE	Within 2 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Water Supplies: General	High	Provide supply operation manuals at a location (e.g. high lift pump station) in each supply.	Done	Supply operation manuals have been prepared and held at GDC office. Need to copy to Pump Stations	UE	Within 12 months	GDC
Water Supplies: General	Low	Review options for multi-tap standpipes and assess the number required for each of the five GDC water supplies. Fabricate adequate multi-tap standpipes for all supplies and identify where the standpipes are to be stored.			UE	Within 3 years	GDC
		Establish priorities for initial re-instatement					
Water Supplies: General	Medium	Define high fire risk/high value areas and identify appropriate secondary fire fighting options		Consult with and seek advice from NZFS	UE	Within 2 years	GDD
Water Supplies: General	Medium	Install burst control valves on reservoirs in all supplies	10%	Some valves purchase but yet to be installed.	UE	Within 2 years	GDC
Water Supplies: General	Medium	Prepare an Emergency Response Plan for Water Supplies and provide a copy in at each water supply pump station for each Community supply.		Include requirements for ensuring water is safe to drink if normal treatments systems are unavailable.	UE	Within 2 years	
Water Supplies: General	High	Review reserve fuel storage capacity requirements for the Coal Creek intake, Sids Road, Taylorville, Stillwater and Blackball high lift pump station to ensure there is sufficient fuel available in the event of the alpine fault earthquake.			UE	Within 12 months	GDC
Water Supplies: Greymouth	Low	Provide treatment to DWSNZ 2005 standard. Treatment design should take into consider likely water quality after an Alpine Fault earthquake.		Not mandatory at this stage. See requirements for to include alternative means of treatment in Emergency Response Plan	UE	Within 3 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Water Supplies: Greymouth	High	Purchase dedicated generator for Coal Creek intake	Done	While existing generator is transportable and can be used elsewhere it is permanently based at the Coal Creek intake site.	UE	Within 12 months	GDC
Water Supplies: Greymouth	High	Replace 250mm Steel – Cobden Bridge & Mawhero Quay (500m)			UE	Within 12 months	GDC
Water Supplies: Greymouth	Medium	225mm CI - Tainui & High Streets duplicated in Alexander & Shakespeare Streets (2,000m)			UE	Within 2 years	GDC
Water Supplies: Greymouth	Medium	Replace 200mm CI – Cobden (900m)			UE	Within 2 years	GDC
Water Supplies: Greymouth	Low	Replace 150mm AC & Steel - Nelson & Tasman Streets (300m)			UE	Within 3 years	GDC
Water Supplies: Greymouth	Medium	Evaluate the Arnott Heights reservoir as a supply reservoir for Greymouth as well as Arnott Heights. If feasible assess main to reservoir and upgrade as required to key main status.		Can additional reservoir be provided on the site?	UE	Within 2 years	GDC
Water Supplies: Greymouth	Medium	Inspect the Omoto reservoir structure and foundations to assess likely damage in an Alpine Fault earthquake. If reservoir considered likely to still function satisfactorily after an Alpine Fault earthquake, assess mains to reservoir and upgrade as required to key main status.			UE	Within 2 years	GDC
Water Supplies: Runanga	Medium	Undertake inspection of the Sids Road well casings. Assess condition and if questionable consider options to replace well casings or install new bore/bores			UE	Within 2 years	GDC
Water Supplies: Runanga	High	Upgrade 150mm AC - Sids Road - Runanga to a 200mm pipe (3,000m)	0.1	Contract Tendered	UE	Within 12 months	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Water Supplies: Runanga	Medium	Install 150mm PVC main through Runanga past the CD sector post to the Dunollie reservoir (3,000m)			UE	Within 2 years	GDC
Water Supplies: Runanga	Low	Install 100mm PVC main through Rapahoe between the CD sector post and the proposed Rapahoe reservoir (900m)			UE	Within 3 years	GDC
Water Supplies: Runanga	Low	Install a reservoir and supply main in Rapahoe with burst control valve			UE	Within 3 years	GDC
Water Supplies: Runanga	Medium	Install a supply connection at Sids Road between the Coal Creek intake transmission line and the Runanga water supply transmission line	0.25	Tee Junction in place on the Greymouth supply line.	UE	Within 2 years	GDC
Water Supplies: Dobson-Taylorville	Low	Provide treatment to new DWSNZ (anticipated for release in 2005). Treatment design should take into consider likely water quality after an alpine fault earthquake		Not mandatory at this stage. See requirements for to include alternative means of treatment in Emergency Response Plan	UE	Within 3 years	GDC
Water Supplies: Dobson-Taylorville	Medium	Replace 150mm AC - intake to high lift pump station (500m)			UE	Within 2 years	GDC
Water Supplies: Dobson-Taylorville	Medium	Replace 150mm AC - high lift pump station to Taylorville CD Sector Post (700m)		Is there still a CD Sector Post in Taylorville?	UE	Within 2 years	GDC
Water Supplies: Dobson-Taylorville	Low	Replace 150mm AC - to the Dobson reservoir (200m)			UE	Within 3 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Water Supplies: Dobson-Taylorville	Low	Replace 150mm AC - SH 7 (Dobson) to the Dobson CD Sector Post (600m)			UE	Within 3 years	GDC
Water Supplies: Dobson-Taylorville	High	Assess pipe river crossing including bridge columns, pipe, cables and anchors			UE	Within 12 months	GDC
Water Supplies: Dobson-Taylorville	High	Attach pipeline to Dobson reservoir firmly to the cliff face			UE	Within 12 months	GDC
Water Supplies: Dobson-Taylorville	High	Install a generator plug at the high lift pump station			UE	Within 12 months	GDC
Water Supplies: Blackball	High	Confirm that the 150mm AC/Steel pipe from the Blackball reservoir to the CD Sector Post at the school is in good condition. Consider improvements particularly at the reservoir end where it taps into the mainline from the reservoir.	Done	Currently being replaced as part of scheme upgrade	UE	Within 12 months	GDC
Water Supplies: Blackball	High	Install a generator plug at the high lift pump station			UE	Within 12 months	GDC
Water Supplies: Blackball	Medium	Review to ensure there are adequate isolation valves and hydrant is strategic location	Done	Currently being done as part of scheme upgrade	UE	Within 2 years	GDC
Water Supplies: Stillwater	Medium	Assess the Stillwater reservoir structure and foundations			UE	Within 2 years	GDC
Water Supplies: Stillwater	Medium	Undertake inspection of the Stillwater well casings. Assess condition and if questionable consider options to replace well casings or install new bore/bores	Done	Existing well abandoned, new well installed.	UE	Within 2 years	GDC
Water Supplies: Stillwater	Low	Replace 150mm AC – Reservoir to Stillwater CD Sector Post (1,600m)		Programmed for commencement from 2008/09 and likely to be done over 3 years to spread costs.	UE	Within 3 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Water Supplies: Stillwater	Medium	Install a generator plug at the high lift pump station	10%	Underway	UE	Within 2 years	GDC
Water Supplies: Stillwater	Low	Review to ensure there are adequate isolation valves & hydrant is strategic location			UE	Within 3 years	GDC
Sewerage Systems: General	High	Develop a strategy for disposing of domestic and industrial sewage for the anticipated period of months before the sewerage service returns to normal. This may include public education so that communities are aware of and can be involved in developing the strategy.			UE	Within 12 months	GDC/ CDEM/ C&PH
Sewerage Systems: General	High	Establish an Emergency Response Plan for Sanitation (See below for required details to include in the Plan).			UE	Within 12 months	GDC
Sewerage Systems: General	Medium	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.		Starting point will be decided on what level of spare parts will be adequate for each system. This will depend on a number of factors such as design, age, materials used, vulnerability to damage (proximity to fault, orientation of facilities to ground acceleration and ground/soil characteristics).	UE	Within 2 years	GDC

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Sewerage Systems: General	High	Review the preliminary assessments of surcharging locations presented in sections 11.3 to 11.7 to ensure ponded water can discharge to a nearby water way.			UE	Within 12 months	
Sewerage Systems: General	Low	Undertake geotechnical and structural assessments of all pump stations to quantify earthquake risks at each site and recommend any structural improvements to address these risks		Priority is actually "High" however likely to take some time to secure funding to do assessments. However commence with by using geological information on GIS to do an initial in-house assessment.	UE	Within 3 years	GDC
Sewerage Systems: General	High	Review the proposed levels of service and strategy to ensure they are appropriate and achievable.			UE	Within 12 months	GDC
Sewerage Systems: General	High	Ensure that all future sewerage system structures and improvements are adequately designed for earthquake loads.		Check NZS4404:2004. Check Building Act 2004 for requirements for Utility Buildings, facilities and pipe lines.	UE	Within 12 months	GDC
Sewerage Systems: General	Low	Upgrade sewer pipes from CD posts or provide alternative sewage disposal facilities (standby septic tank facility) to ensure sewage can be disposed of from CD Posts after the Alpine Fault earthquake event.			UE	Within 3 years	GDC/ CDEM

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Sewerage Systems: General	High	Review all pump stations and oxidation pond sites to ensure all equipment and plant is adequately secured against movement in the event of an earthquake.		Review ELMAC Consultancy Ltd report. Review if recommended work has been carried out.	UE	Within 12 months	GDC
Sewerage Systems: Greymouth & Cobden	High	Consider purchasing a designated generator for the Johnston Street Pump Station as Johnston Street is a critical pump station	Done	Generator Purchased, has been wired up and regularly tested.	UE	Within 12 months	GDC
Sewerage Systems: Greymouth & Cobden	Low	Continue the current programme of separating the storm water/sewerage schemes in Cobden, Greymouth and Blaketown	Ongoing (Done 2014)	This is allocated low priority as the work is progressing automatically for other reasons.	UE	Within 3 years	GDC
Sewerage Systems: Karoro/Paroa, Runanga & Moana	Low	Undertake a geotechnical and structural assessment of oxidation ponds to quantify the earthquake risks at each site and recommend any structural improvements to address these risks.		Priority is actually "High" however likely to take some time to secure funding to do assessments. However commence with by using geological information on GIS to do an initial in-house assessment.	UE	Within 3 years	GDC
TeleComms	High	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.		Review existing systems in place for CDED, Rural Fires, Emergency Services, DOC and WCRC and TA's. Establish/Review database of key personal and contact numbers.	MAE	Within 12 months	Telecom/ BCL/DOC etc

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
TeleComms	Medium	Install a connection between the BCL tower and the Telecom transmitter / repeater on Sewell Peak to permit Telecom to use an alternative link to the rest of the country in the event of an emergency.		BCL and Telecom need to agree to this proposal		Within 2 years	Telecom/ BCL
TeleComms	High	Place on record the length of time exchanges are expected to operate without outside electrical supply and / or communication in and out of the area.		Supply information and use to review Communication and Emergency Response Plans.		Within 12 months	Telecom
TeleComms	High	Confirm who have VHF facilities and establish a common channel for use in emergencies		See other tasks above.	MAE	Within 12 months	GDC
TeleComms	Medium	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;				Within 2 years	Telecom
TeleComms	High	Review access and fuel supplies to key telecommunication facilities and also facilities that rely on telecoms for warning/operating/monitoring systems.		Identify all key facilities first and then consider access and fuel requirements.	TE (Access) UE (Fuel Supplies)	Within 12 months	GDC
TeleComms	Medium	Determine GDC's access to satellite phones and spare batteries as link to outside the district		Review adequacy and vulnerability of radio telephone systems.	MAE	Within 2 years	GDC/CDEM

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Power	High	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		Review existing systems in place for CDED, Rural Fires, Emergency Services, DOC and WCRC and TA's. Establish/Review database of key personal and contact numbers.	MAE	Within 12 months	Transpower/ Trustpower/ Westpower/Tasman Energy /Transit etc
Power	Low	Continue programme of upgrading and renewing equipment, buildings and communications to minimise vulnerability to earthquake damage. (Transpower, Buller Electricity, Westpower, Tasman Energy)		Actually "High" priority however level of improvements will depend on policies and funding of Power and Line Companies.	Power Co's to report on progress.	Within 3 years	Power companies
Fuel Supply	High	Consider alternative methods of supplying fuel to and within the GDC area including:		Need to talk to OnTrack, Port Companies and Road Transport Association	TE	Within 12 months	Fuel Co's
Fuel Supply	Low	• Re-establishing a strategic fuel supply (tank farm) for the area,		Actually "High" priority however level of improvements will depend on policies and funding of Power and Line Companies.	Fuel Co's to consider	Within 3 years	Fuel Co's
Fuel Supply	Medium	• Alternative supply methods e.g. barge, and		Talk to Port Co's and Sea Transport Co's	TE	Within 2 years	Fuel Co's
Fuel Supply	High	• A 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			TE	Within 12 months	Fuel Co's

Life Line	Importance	Action	Progress	What has or is being done?	Actions being taken by who or what is in place?	Completion Date	Responsible
Fuel Supply	High	Consider forming database of available fuel storage tanks in the area that could be used in emergency			TE	Within 12 months	GDC / WCRC
Fuel Supply	High	Assess the quantity of fuel required for emergency generation, emergency services, earthmoving equipment and to keep basic services operational e.g. water supply			UE	Within 12 months	GDC / WCRC
Flood Protection	Medium	Develop strategies to address the expected earthquake damage and an anticipated issue of Taramakau riverbed builds up at Inchbonnie and the potential failure of the floodwalls in Greymouth. The strategy should include early warning systems and strengthening flood banks.				Within 2 years	WCRC