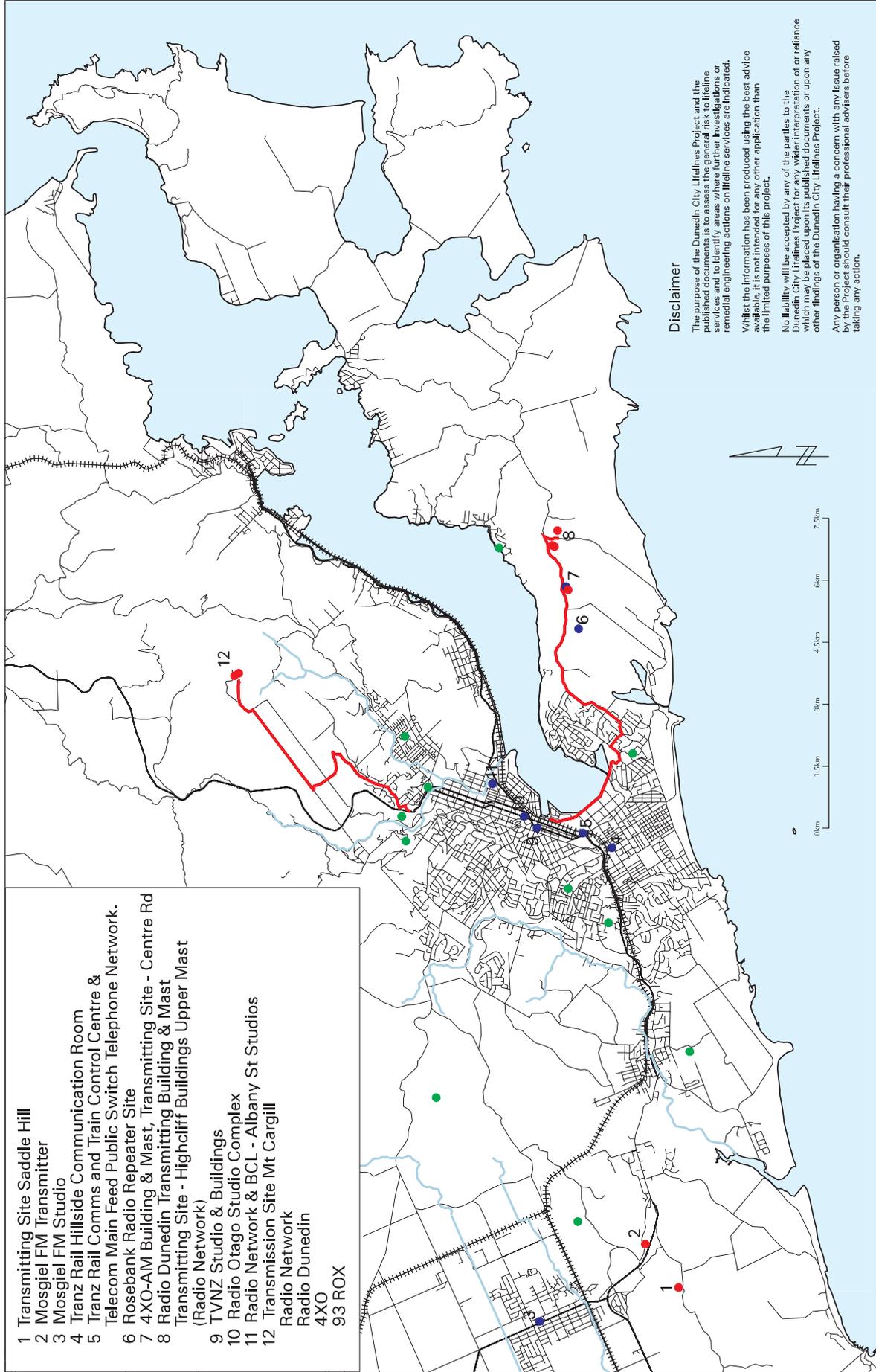


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Telecommunications and Broadcasting



TELECOMMUNICATIONS - DESCRIPTION OF SERVICE

General Description

All participants provide telecommunication services to the greater Dunedin area, including telephone traffic, computer based data traffic, television and radio signals. Some provide access to public networks while others are private. These networks consist of both copper-cable and fibre-optic cable landlines and, to a more limited degree, radio systems which utilise the most up-to-date technologies and are extremely robust. Some have such diversity that on the failure of one system they can be switched to an alternative system with little apparent interruption to the user.

Generic description of this highly complex technology has been prepared to cover the broad spectrum of communications in the Dunedin/Otago area and relies upon contributions from:

- Telecom New Zealand.
- Tranz Rail Ltd.
- Broadcast Communications Limited.
- Clear Communications Ltd.

Technologies

The technologies and methods employed to connect the various assets of each service provider are:

Fibre Optic Cable

High capacity underground fibre optic cables carry the majority of telephone and data traffic to and from Dunedin. Within the city this cabling is used to link service providers with high speed interconnection.

Copper Cable

This older technology is used to provide the majority of urban and suburban telephone / data links. There is still some overhead cabling but underground cable more common and is used extensively throughout the city. Modern electronic circuitry allows copper cabling to be used beyond its original range and capacity.

Microwave Radio

Microwave systems utilise radio waves to provide interconnection between two locations and a number of systems are used within the city and to the north, central and south. Most of these systems are used as a back-up to fibre optic cable for telephone and data traffic. Microwave is also used where cabling is uneconomic to install.

Mt Cargill and Swampy Summit are the primary microwave transmission sites, providing connection to sites to the north and south for telephone, data, television and radio. A number of other sites are used for local linking within a participant's system and to one or more of the major transmission sites. An extensive microwave network carries television transmissions from the Mt Cargill site north to Mt Studholme, south to Kuriwao and Hedgehope and central to Obelisk as well as linking sites within Dunedin.

VHF/UHF Radio

These technologies include cellphones, land mobile despatch services, trunk-dispatch radiotelephones and radio-paging systems. Minor uses include cordless telephones and wireless private in-house telephone exchanges.

Cellular

There are many cell-sites within Dunedin City and its surrounds which provide cellphone coverage. Sites vary from hilltops to building faces, which allows tailoring of the coverage area to be served by each site. All these sites are linked, either by microwave radio or cable to the telephone network. If the link to the telephone network is broken, the cellphone transmitter / receiver cannot operate. The density of cellphone sites is determined on the basis of expected usage for the area.

Dispatch Service

This service provides for mobile radio communication which is effected by transmission through a repeater station located on a hilltop, either to another mobile radio or to a base radio. This service can be connected to the telephone network but more commonly stands alone or is connected to another repeater by a radio link.

Trunk Dispatch

This service is provided at several sites in Dunedin and is similar to the dispatch service except that the channel used is allocated by the repeater currently being used. It is a dynamic process and allows better use of mobile radio frequencies. The repeaters can operate in 'stand-alone' mode if linking to the telephone network fails, allowing limited operation.

Radio Paging

To provide a calling and messaging service to customers, paging transmitters are located on hilltops and tall buildings and each must be connected to the telephone network to function.

Safety Radio Services

The MSA (Maritime Safety Authority) operates a VHF marine safety service on the marine channels 16 and 71 from Mt Cargill. This is available for public use and is connected via a telephone network to a Maritime Operations centre at Avalon. The Otago Maritime VHF Association also operates a Marine Repeater at Hautai Hill.

Port Otago operates an HF (High Frequency) and VHF radiotelephone service from the marine station at Tairaroa Heads.

Airways Corporation operates a VOR (VHF Omnidirectional Radio) and DME (Distance Measuring Equipment) at Swampy Summit and NDB's (Non-directional beacons) at Swampy Summit and Henley. This equipment can operate independent of the telephone network.

Systems

The public switched telephone network (PSTN), with its computer controlled exchanges, provides customer connection, through the various technologies described above, to other customers locally, nationally and internationally. Exchange types include:

- Remote line units (RLU)
- Local exchanges (LX)
- Tandem exchanges (TX)

Telephone exchanges are located at strategic points in the networks and when failures occur, rapid reconnection or restoration of service can be made depending on the severity of the failure. Failures or network problems are able to be diagnosed quickly and telephone traffic control measures can be implemented rapidly

The PSTN is structured to provide alternate routing of traffic should failure of certain exchanges, trunks or junctions occur. Excepting customers connected to the affected exchange, any such failure would result in impaired service, not total loss. Total loss of network access generally requires the simultaneous loss of several exchanges trunks, junction routes and links which are not duplicated.

Since the introduction of stored programme control exchanges, service providers have been able to monitor customer behaviour on a real-time basis and experience has shown that small scale local events can considerably increase calling rates, resulting in network congestion in a local area. This causes difficulties for the affected customers when originating and completing calls but leaves the rest of the network operating normally. More widespread events can cause a general network blockage, with a collapse of the network's ability to function through overloading. Traffic management systems are used to control these situations by restricting the ability to originate calls. It is vital that public broadcast by radio and television be made to discourage unnecessary use of the telephone network following a major disaster. Failure to do so means that load shedding will have to be activated with a resulting risk of disallowing emergency calls.

The cellular network could suffer even greater overloading if many of its cells are out of service, as occurred during the Edgecumbe earthquake where, because of high levels of calls coming into the area, it was necessary to apply 100% restriction to calls from selected exchanges such as international and Auckland for several days after the event. This method of control can be expected in any civil emergency.

Cable Networks

Each participant uses one or more of the above technologies in providing links to their fixed assets. The telephone network consists of:

Local Access Networks

Typically these consist of multi-paired copper cables connecting customers to the exchange. To extend the range or capacity of copper cables, various technologies are employed, usually involving electronic circuitry of some kind. This can be powered over the cable itself or by a remote power feed. Rural subscribers may be connected via a radio system to the cable network.

Junction Links

These are circuits or links provided between exchanges within the Dunedin area.

Trunk Links

These are circuits which extend beyond the Dunedin area. They consist of high-capacity fibre optic cables or digital radio systems.

To the north and south, fibre optic cables are laid alongside the railway line and State Highway One; to Mosgiel, the cables follow both the railway line and State Highway to Mosgiel junction.

A fibre optic cable provides the link between the Dunedin BCL base in Albany Street to the BCL communications facility in Dowling Street. It will ultimately be used to provide interconnection between a telephone/data service provider and a digital microwave network.

Microwave Networks

A communications centre at Strathallan Street utilises a microwave link to Cargill House to provide interconnection between service providers.

Swampy Summit and Mt Cargill are the major microwave sites to and from the city and both sites have fibre optic cables connecting them to the local Dunedin networks. Mt Cargill also has local circuits to the TVNZ facility in Dowling Street to carry television programming. There is a further link to the BCL base in Albany Street carrying telephone and data traffic for the Maritime Safety Service, which has facilities located at Mt Cargill.



Microwave Transmission Site, Swampy Summit

- Telecom

Radio Networks

Cellphone sites vary from hilltop sites to various buildings and structures in the urban area and all require connection to the cellphone switch via trunk links to remain operational.

There are dispatch repeaters and trunk dispatch repeaters at many sites in and around Dunedin. Swampy Summit is the main site for these repeaters, some of which are linked to other sites within Dunedin, including Rudd Road, Signal Hill, Corstorphine, Rotary Park, Saddle Hill, Mt Cargill, Heywards Point and Mt Hyde.

Paging transmitters are located at four sites in Dunedin.

Transmission Buildings and Exchanges

There are a number of local and tandem exchanges in the Dunedin area, each housed in its own building. One service provider operates a digital exchange at its communications centre in Strathallan Street and another at the Hillside Workshops.

New cell site structures are continually being added to the cellular network to provide additional coverage.

All land mobile radio and microwave transmission sites have purpose-built buildings and masts or towers. Because of their exposed locations, these masts and towers are built to stringent requirements to enable directional antennae to remain in position in periods of abnormal conditions.

Power Supplies

The primary source of power for all service providers is the Dunedin Electricity network but all telecommunication sites have some degree of standby power.

The Mt Cargill facility operates from a three phase 11kV overhead line up Cowan Road to the carpark where it terminates and is fed underground to a transformer outside the rear of the building. The site also has two standby diesel generators which together are capable of running the entire site and all its equipment or individually can be configured to run most services, but at a reduced level. Essential services such as analogue and digital linking equipment and the communication equipment have battery back-up to provide uninterrupted service and to allow some continuation of service should the standby generators fail.

Most trunk dispatch repeaters and dispatch repeaters have either limited battery back-up to provide a few hours operation or are located at sites where standby generators are provided.

The communications centre in Strathallan Street uses a 6.6kV feed from Andersons Bay Road with back-up provided by a standby generator and UPS (Uninterruptable Power Supply).

Clear Communication's John Wickliffe House site has 24 hour battery back-up and the Dowling Street site has 20 hour battery back-up.

Access Routes

Access to all telecommunication sites, via public and private roads, is possible using two-wheel drive vehicles in dry conditions but 4WD is usually necessary in wet conditions. Many sites are of sufficient size to allow helicopter access if necessary.

TELECOMMUNICATIONS - ASSESSMENT OF VULNERABILITY

Telecom New Zealand Ltd

Landlines

Vulnerability to Earthquake

Local reticulation (exchange to customer) is mainly by underground cables using copper conductors. By its widespread nature this reticulation is susceptible to damage, with certain types of cables (now obsolescent) more likely to give problems. Any cables affected by significant differential ground movement caused by changes in soil types or liquefaction, are likely to be severely damaged and bridge crossings would be especially vulnerable. Widespread damage to copper cables between the customers and the exchange may result from water penetration through cracks in the sheathes of lead sheathed cables.

Cabling between exchanges (junctions and trunks) is by a combination of fibre optic cables installed in ducts and microwave radio systems. Cables are vulnerable in areas subject to significant ground movement, eg. crossing a fault, in areas subject to liquefaction, or where a landslide carries both ducts and cables with it. Little damage is expected (except at some bridge crossings) to the route-diverse fibre optic junction cable system, and hence there will be low loss of junction links although there may be some reduction in junction capacity.

Radio systems may be subjected to support structure failure or antennae misalignment. Where ducts and cables enter buildings in areas subject to liquefaction or settlement damage may occur due to differential movement between the surrounding ground and the building. Aerial systems for microwave radio could become misaligned even if the supporting structures remain intact, although modern systems are reasonably tolerant of movement.

Restoration of lead sheathed cables may extend over many months, but virtually all other elements of the PSTN may be restored to full capacity within one week.

Vulnerability to Flood

Buried cables are designed to function in wet environments, so flood effects on them should be minimal. Higher surface water levels will increase the static water pressures on cable sheaths, in some cases resulting in water penetration causing faults within one to two days of the flood. These will be randomly distributed in flooded areas and should only affect a small proportion of customers.

Cabinets are almost always located in the road reserve at the fenceline and flood levels up to 200mm in the cabinet will have no affect. Beyond this, customers will lose service progressively.

Pillars are located in the road reserve at the fenceline and typically only contain 1 to 4 customer lines. Flood levels up to 400mm will normally have no affect but beyond this level, faults may occur.

Roadside equipment enclosures may be flooded and water penetration of critical components will cause total failure of the installation.

Any connectors in pillars, connection blocks in cabinets, telephone sockets in houses, and internal house wiring that have been immersed will probably have to be replaced. Associated cabling and mounting hardware will have to be hosed down to remove silt, sand etc. and then dried.

Repair of cables broken due to scouring of roadways and bridge abutments may have to wait until repair of the road is sufficiently advanced. Customers' service affected by either immersion of plant or cable breaks should be progressively restored over a period of two days to two months after the flooding subsides.

Vulnerability to Landslip

Buried cables are particularly vulnerable to landslip or subsidence. Cables are installed using a number of different methods.

Major urban cables are often installed in duct systems. Early installations comprised earthenware ducts, laid in sections approximately 1m in length and are particularly vulnerable to collapse in the event of ground movement. Newer installations are in PVC ducts, either glued or rubber-ring jointed. A mixture of other duct materials has been employed, including asbestos cement and cast iron. The cables conveyed in these duct systems generally have either a lead or plastic sheath. Plastic sheathed cables are more tolerant of minor displacement than lead sheathed cables which are susceptible to sheath cracking in the event of any movement.

Minor urban and rural cables are generally direct buried with the two predominant cables being lead and plastic sheathed.

The effect of cable damage will vary from small numbers of isolated customers without service, to widespread loss of service affecting many or all Telecom services. Major routes have diversity, so the failure of any one will precipitate the rapid restoration of services onto other routes.

Vulnerability to Snow Storm / Wind Storm

Overhead wires (aerial service leads) to many customers will be lost through the weight of snow or tree branches overloaded with snow falling and breaking wires, or telephone poles being broken. These customers will be scattered in pockets around the city but as the programme to convert to underground leads progresses this will become less of a problem.

Although aerial service leads are relatively easy to repair, it will take some time to repair all connections if damage is widespread. Most telephone poles support power service leads from the opposite side of the road, as well as telephone service leads. The priority that the replacement of broken telephone poles is given may be dictated by the need to restore power to houses, rather than the need to restore telephone service.

Exchanges and Radio Installations

Vulnerability to Earthquake

All telecommunications equipment is critically reliant on power supply so standby power generation equipment (to provide an essential supply) is installed at most locations. The adequacy of fuel reserves at individual sites is being reviewed, giving consideration to the possibility of a prolonged power outage and likely difficulties in obtaining access to the sites for refuelling. This underlines the interdependence of lifelines and the need for mutual understanding of both resilience and expectations.

Switching equipment is reliant on air conditioning to ensure the temperature does not exceed certain levels. While air conditioning equipment is not operating, temperatures need to be monitored to ensure they do not rise to damaging levels. Air conditioning equipment is reliant upon power and, in some cases, water supply (for replenishment only), and requires adequate seismic restraint of all fans, ducting, pipework and chillers.

The telecommunications network makes good use of diversity by means of alternative physical routes and alternative media but there are still some parts of the network where improvements can be made.

All exchanges in the Dunedin area are stored program control, which has resulted in some centralisation of switching operations, with remote lines units being dependent upon their hosts for switching of calls. The operation of some telephone exchanges may be unstable due to congestion caused by repeated re-dialling attempts. Dial tone may be slow to appear.

The majority of exchange buildings and equipment is expected to suffer little damage and, due to diversity, disruption to customer services from any damage that is incurred should be minimal.

Vulnerability to Flood

Exchange equipment will be at risk as soon as flood levels rise more than 50mm above the exchange floor level and five Telecom exchanges are at risk. If the equipment is powered up at the time, irreversible damage could occur, requiring replacement of the immersed equipment and possibly other equipment as well. If the equipment is powered down before immersion, it is expected that once the flood levels have subsided the immersed equipment can be successfully salvaged and restored to full service within days.

Exchange cable wells will be affected by high water levels in Telecom ductlines/ manholes causing exchange cable wells to fill with water at a rate faster than the permanently installed sump pumps can handle. In many cases, the sump pump outlet pipe discharges into a gully trap below the potentially highest flood level and will be ineffective. If the water level rises to within one metre of floor level in many of the exchanges this could result in unfilled, unpressurised plastic cables, installed between the air dams in the cable well and the main distribution frame on the floor above, becoming partially submerged. Faults affecting many customers could result.

Vulnerability to Landslip

The vulnerability of exchange and radio buildings to landslip is considered low, although smaller installations serving pockets of customers may fail as a result of land instability.

Vulnerability to Snow Storm/Wind Storm

Many windows would be blown in or be broken by flying objects, then rain or snow would be able to enter buildings through the broken windows and damage equipment. Broken glass would have to be extricated from equipment during the clean-up after a windstorm. This would pose a risk to the availability of the network as, during the work, equipment could be accidentally disturbed. Most critical network sites either do not have windows or windows have been filled in.

Traffic overloading frequently results during a windstorm or snowstorm. It is expected that the telephone network will be very busy, but shouldn't be catastrophically overloaded. Some exchanges may experience minor load shedding. Loss of some cell sites may increase traffic on other cells, but since most of the PSTN will still be functional, this should not be a problem.

Toll links north may be lost or only partially available and many customers with aerial service connections will lose service. They will be relatively easy to repair once the winds have died down but it will take some time to repair these connections if damage is widespread.

The roofs at all Telecom sites are expected to carry snow loadings, although the strength of those at some radio station buildings need to be reviewed.

Mobile Radio Services

Vulnerability to Earthquake

The cellular and paging networks for most of the South Island are completely dependent on the central switch and failure of this switch or the links to it would completely disable these services.

The Fleetlink trunked dispatch service is normally dependent on a central switch but failure of this switch or the links to it would merely disable the linking between repeater sites and many users would be unaware of such a switch failure. Loss of all physical links to the radio stations would result in the loss of access to the PSTN for Fleetlink users. Congestion may occur on Fleetlink channels, but can be overcome by installing extra shared channels (within say two days).

There is likely to be significant cellular network congestion for the first two hours after an earthquake with some relief after three to six hours (as service demands are reduced through individual cellphone batteries depleting and the probable lack of mains power for re-charging). Disruption of service will result at some cell sites due to the depletion of battery reserve following the loss of mains power to sites and others will be disrupted by the loss of their fibre optic cable links to the cellular switch. Little effect is expected on the equipment and masts at the cell sites or on the connection of the cellular network to the PSTN or the trunk network, and the cellular network should be restored to virtually full capacity within four days.

In recent major international disasters cellphones have proven to be an extremely useful and speedy way for utilities to augment their communications systems and accordingly the management of Cellular network congestion by Telecom should be in favour of utility and emergency organisations. Restriction of other Dunedin cellular customers should be considered, to establish that preference.

Mobile radio services can expect up to 10% loss of service providing the timber masts at hilltop radio stations do not fail. There will be little effect on the land mobile radio equipment at these stations and little disruption due to traffic congestion.

Loss of the entire Otago radio paging network could result from all trunk links north being lost, or loss of valuable cable links between the paging switch and the hilltop radio stations. The paging network should be fully restored within 2-4 days by using temporary radio links.

Vulnerability to Flood

Two of the Dunedin cellular network cell sites could suffer from flood immersion to varying extents, but loss of both these sites would only have a minimal effect on the coverage and service level of the surviving cellular network.

Land mobile radio, Fleetlink and paging networks should be completely unaffected. Since all paging signals are broadcast from all the transmitters, loss of one landline access will only result in the Dunedin paging coverage being slightly decreased.

In common with all of the scenarios, some initial congestion on the telephone, cellular and Fleetlink networks is expected. During a flood it is expected that the telephone network will be very busy but shouldn't be catastrophically overloaded. Some exchanges may be subject to minor load shedding and loss of some cell sites may increase traffic on other cells, but since most of the PSTN will still be functional this is not expected to be a problem.

If it is assumed that all Telecom sites in, or near the flood plains lose mains power, the only sites affected are those that do not have their own engine alternator set mains back-up.

Road access to some sites may be impassable for virtually all vehicles and others may only be accessible by high wheel base vehicles such as 4WD's or trucks. This should not present any great difficulties to the Telecom repair effort, so long as there remains access across rivers.

Vulnerability to Landslip

Some radio based services rely on landlines for interconnection with the central switch (cellular, paging, etc) and services may be interrupted due to landslip but diverse routes are available to most critical sites. Restoration of services is dependant on access to failed sites and is therefore reliant on road access being available.

Vulnerability to Snow Storm / Wind Storm

Towers and masts are expected to survive the storm because of their combined snow and wind rating, but some dipoles and other antennas on these masts could be damaged. This means that the land mobile, paging, and trunked dispatch networks may be partially disrupted.

Most cell sites do not have standby generators and many could lose their mains power supply. Those that do will fail completely after the battery reserve has been used, unless a portable engine alternator is connected to the cell site. As Telecom has a number of portable engine alternator sets in Dunedin it should be possible to keep most cell sites functional unless road access is blocked by snow drifts.

Tolls

Vulnerability to Earthquake

Toll links out of Dunedin comprise a combination of fibre optic and radio technologies, with all links vulnerable to the effects of earthquake. Cable routes may fail as supporting structures fail and radio systems are vulnerable to building and support structure failure. Toll failure will initially cause widespread disruption to services until priority traffic is re-routed. Some services will automatically restore almost immediately.

Vulnerability to Flood

Toll services will be minimally impacted by flooding. Where supporting structures fail, services will be lost until traffic can be restored using alternative routes.

Vulnerability to Landslip

Cables carrying toll services which traverse unstable ground will be vulnerable to failure although complete failure of a cable will not necessarily result in the complete loss of services. Alternative routes will be employed for service restoration.

Vulnerability to Snow Storm/Wind Storm

Toll links carried on radio bearers could be affected by a windstorm but there will be little impact if only one link is lost.

Area Vulnerability to Disaster Events

For the purposes of describing Telecom's asset vulnerability to various events, the area has been subdivided into the following geographic zones:

- Harbour Basin and low lying areas, comprising the Leith Valley and North East Valley, harbour periphery, reclaimed land areas and South Dunedin/St Clair/St Kilda. This zone extends along the south coast to Taieri Mouth.
- Hill suburbs, comprising Maori Hill to Mornington and Corstorphine, Halfway Bush, Brockville and the Peninsula.
- Taieri Plains, comprising the entire plain.
- Northern approach, comprising the area north of the Leith Valley.

Harbour Basin and Low Lying Area Vulnerability

Landlines in this zone are vulnerable to earthquake shaking effects, particularly to lead sheathed cables and to flooding where water levels reach about 400mm above ground level.

Exchanges are vulnerable to flooding and, to a lesser extent, to earthquake shaking.

Mobile radio installations are built to new building codes and are not considered particularly vulnerable to shaking. Flooding may become an issue if water levels reach approximately 1m about ground level.

Cellular coverage in this area is provided by several transmitters with overlapping service areas but localised congestion may result if any one site is unusable.

Hill Suburbs Vulnerability

Landlines are vulnerable to localised land slumping, with effects ranging from inter-exchange lines being lost to small pockets of customers without service.

Exchanges are not particularly vulnerable to any event as all equipment is secured to adequate seismic standards and the majority of buildings are of recent construction.

Cellular services are housed in modern containerised structures although towers and masts may fail from shaking.

Taieri Plains Vulnerability

The major effect on the Taieri Plain is flooding, when exchanges will fail if water levels reach approximately 500mm above ground level and area isolation may occur as roadside equipment cabinets become inundated.

Landlines will fail randomly throughout the area, with the failure profile based generally on age and cables will eventually fail if left immersed in water, particularly at higher than normal static pressures. Fault location and repair will extend over some months.

Exchanges and landlines on the Taieri will be subjected to the effects of enhanced shaking.

Northern Approaches Vulnerability

The northern approach is characterised by land instability and any cables traversing unstable ground will be subjected to a variety of failure mechanisms ranging from sheath cracking due to land creepage, through to catastrophic failure due to large scale landslip.

Exchanges and radio sites are minimally exposed to landslip but mains power supply vulnerability and dependability is of primary concern. Most sites (excepting cellular service) have back-up AC and DC power sources.

Landlines in low lying coastal areas, including Blueskin Bay and the Waikouaiti River estuary, may be subject to the effects of tsunami.

High level radio sites will be subjected to the effects of snow and wind storms, although they are self-contained and essential services will survive for some period. Access during such events will be restricted, and may be for days afterwards.

Clear Communications Limited

Landlines

Clear Communications Limited provides a telecommunications service via microwave and fibre optic circuits from Dunedin, northwards. The fibre optic follows the railway line.

Dunedin to Ravensbourne

This landline is a fibre optic and is vulnerable to earthquake shaking, liquefaction and from flooding and tsunami in the lower Leith area. The probable cause of failure from earthquake is derangement or severance of the fibre at bridge crossings due to lateral movement.

Ravensbourne to Purakanui

Earthquake and landslip may lead to severance or derangement of the fibre, with the sections most vulnerable to earthquake shaking being bridge crossings.

Purakanui to Warrington

Earthquake is less of a risk here but the fibre optic is more exposed to the effects of a tsunami. If little movement occurs the optical fibre is less susceptible to water ingress than is conventional copper cable.

Microwave

Mt Cargill

See the Broadcasting section for detail.

Tranz Rail Limited

Landlines

Tranz Rail's telecommunication network is very dependent on local cabling and the supply of its network services by Telecom in the form of three 2Mbit/sec links. These are supplied by landline to the communications centre in Strathallan Street, which is Tranz Rail's most vulnerable site because of its fault line proximity and possibility of flooding. The cause of failure under earthquake conditions is likely to be severance of cables at jointing and derangement of switchgear within the building. Flooding is likely to cause cable faulting and probably presents a more frequent hazard impact though of less severity to the system. The mains power supply to this area is equally vulnerable.

Exchanges

Tranz Rail has two digital switches in Dunedin. The main switch is located on the ground floor of the communications centre in Strathallan Street, which is a building approximately 17 years old and of timber construction. Derangement of switchgear is likely to cause interruption of service in earthquake conditions and flooding damage to the exchange will be similar to that occurring to cable junctions etc.

The building itself is likely to suffer severe damage due to enhanced shaking and the liquefiable nature of the land upon which it is built. As a consequence, equipment located within the building is considered to be highly vulnerable.

Mobile Radio and Telephone Communication

Tranz Rail links its train control from its Network Centre in Wellington to repeaters in the Otago and Southland areas through its building in Strathallan Street.

Access to hilltop and remote trackside repeaters appears to be reasonably good.

Tranz Rail is also dependent on mobile radio and cellular telephone services from Telecom.

Train Signalling

A centralised traffic control (CTC) signalling system is used in the Dunedin area for the safe and efficient running of trains. The Dunedin rail yard and five remote sites are controlled from the Train Control Centre in Strathallan Street using data circuits provided by Telecom as well as Tranz Rail landline circuits. In addition to this, a computerised track warrant system is used to ensure the safe running of trains between these remote sites. This information is conveyed to the locomotive engineer by radio communication.

In the event of a CTC system failure, set procedures are put into place and information authorising train movements is conveyed to the engineer by radio.

Signalling systems are particularly susceptible to disruption of trackside circuitry which is expected to be deranged or cut in many locations following a credible earthquake. In particular areas such as those immediately surrounding the Dunedin City shoreline to Port Chalmers and through the South Dunedin area, both track and communication lines will be most seriously displaced.

TELECOMMUNICATIONS - MITIGATION STRATEGIES

Introductory Note

A number of participating organisations in this study have no staff in the Dunedin district, making the defining of mitigation strategies difficult. Of those participants who have been able to provide information most do not have direct control over expenditure on this important feature. Some participants have already taken part in Lifeline studies in other locations and have mitigation strategies in place, while others explain their reason for limited strategies in their introductions.

All telecommunications service providers have similar strategies as the technologies used are similar.

Telecom New Zealand Limited

Introduction

The mitigation strategies outlined in this study draw heavily on the experiences of other areas, in particular Wellington and Christchurch, where lifelines studies have been completed and appropriate mitigation strategies developed.

Many strategies identified in these studies are already being implemented in other areas including Dunedin. The result is a series of strategies which may seem to be common sense, but which contribute to the survivability of the telecommunications networks.

Mitigation Strategies Common to all Areas

The following strategies are common to all geographic areas and some are already commonly practiced:

- All new or reworked installations to conform to company seismic control standards.

- All building refurbishment to conform to appropriate controls, particularly fire protection and hazard mitigation policies (internal).
- Back-up copies of critical network databases to be held off-site, and where possible, in electronic media.
- Good housekeeping policies and practices in key sites, including proper restraint of movable objects (desks, computer terminals, bookcases, etc) and removal of rubbish and packaging immediately to reduce the risk of fire.
- Enhanced security.
- Pressurisation of critical cables to prevent the ingress of water.
- Identify cables at higher risk of sheath fracture.
- Provide diverse network feeds to key installations where appropriate.
- Provide robust back-up systems at key sites.
- Enhance survivability of engine alternator sets and associated fuel systems.
- Analyse long term power outage probabilities and assess fuel requirements.
- Analyse battery back-up performance and robustness.
- Analyse key support systems such as air conditioning plant.
- General robustness designed into new and reworked networks.

Mitigation Strategies Relating to Specific Geographic Areas

Harbour Basin Low Lying Areas and Taieri Plains

Analyse the general preparedness for flooding events, including the provision of sand-bag materials and develop strategies to eliminate water ingress to key sites for extended periods. The main problem with this type of event is the disposal of unwanted water and silts.

In extreme events, power will be removed from key elements to enhance their survivability and hence lessen restoration times.

Hill Suburbs and Northern Approach

Mitigation strategies for this area revolve around expeditious route selection. In general, cable routes closely follow road alignments.

Tranz Rail Limited

Mitigation Strategies Policy Statement

The following strategies are common to all areas:

- All sites conform to company seismic standards.
- All major buildings conform to local building requirements.
- Good housekeeping and safety practices are actively encouraged within the company.

Provision of Back-up and Alternative Circuits

Where possible back up circuits are provided by use of:

- Standby generators and UPS for power requirements.
- Dial-up circuits for data and signalling.
- Dial-in back-up equipment to intercept radio links in the event of a network failure.
- Dial-out via dedicated lines in the event of a Telecom 2Mbit/sec link failure.
- Dial-out back-up using cellular link units.

BROADCASTING - DESCRIPTION OF SERVICE

Participants

Participants in this section were:

Broadcast Communications Ltd (BCL)

BCL is a wholly owned subsidiary of TVNZ which, in the context of this report, operates one broadcast site in Dunedin as well as maintaining other sites in the Dunedin area. Much of the technical information relating to the Mt Cargill site was provided by BCL.

The Radio Network (TRN)

TRN is a private sound broadcaster which operates what was previously the Radio New Zealand Commercial Division.

Radio New Zealand (RNZ)

RNZ is a SOE operating the non-commercial divisions of the previous Radio New Zealand.

Radio Otago

A private sound broadcaster owned by Radio Otago Ltd.

Television 1 and 2

TV1 and TV2 are owned by Television New Zealand, a State Owned Enterprise (SOE).

Television 3 and 4

TV3 and TV4 are owned by a private broadcaster, Global Television NZ Ltd.

Channel 9

A private television broadcaster owned by Allied Press Ltd

General Description

Each participant provides either 'information communications' in the form of broadcasting or, in the case of BCL, a technical service function to the broadcaster.

The broadcasting spectrum can be split into three distinct areas, each of which provides differing coverage:

- Sound radio - AM broadcasting
- Sound radio - FM broadcasting
- Television broadcasting

Owing to the nature of broadcasting spectrum licensing, the number and ownership of both sound and television broadcasting stations depends on market forces. Broadcasting spectrum is allocated by an auction process in which the highest bidder obtains the right to use a frequency. These frequencies can then be used, held, leased or sold. This has resulted in a continuously evolving industry and changing technologies which makes description difficult.

Television Broadcasting

There are eleven television channels available in Dunedin City, with six of these being free-to-air.

Both terrestrial and satellite technologies are available in Dunedin, although the majority of viewers receive their signals from terrestrial sites. The main television transmission site is located at Mt Cargill.

Currently analogue transmission only is used, with video information using AM (amplitude modulation) and sound information using FM (frequency modulation). Transmitted power levels vary from less than one watt from some translators to 300 kW from primary sites.

Sound Radio Broadcasting

Presently there are nine AM broadcast and ten FM broadcast transmitters as well as three FM repeaters. Of these, three are government owned (a SOE), with the balance being private stations.

The AM broadcast band covers the frequency range 550kHz to 1,600kHz and provides a generally larger coverage area than FM transmissions of the same power. The FM broadcast band presently covers 89MHz to 100MHz.

The AM frequencies currently used in Dunedin are:

621 kHz	Radio Rhema	}	Three Mile Hill site
693 kHz	Radio Sport Network		Highcliff site
810 kHz	National Radio		
900 kHz	Parliamentary broadcasts		
1044kHz	Newstalk ZB		
1125kHz	Classic Hits (re-transmits 89.4FM)		TRN Centre Road site
1206kHz	4XO-AM		Highcliff site

1305kHz	Radio Dunedin 4XD	Centre Road site
1575kHz	Hills AM (Access radio)	TRN Centre Road site

The FM frequencies currently used in Dunedin are:

89.4 MHz	Classic Hits	}	Mt Cargill site
90.2 MHz	Light FM		
91.0 MHz	Radio One		
92.6 MHz	Concert FM (+ 2 repeaters)		
93.4 MHz	C93		
95.4 MHz	Mosgiel FM		Chain Hills site
95.8 MHz	96ZM		RNZ Highcliff site
96.6 MHz	Radio Pacific	}	Mt Cargill site
97.4 MHz	4XO-FM		
98.2 MHz	More FM		

Microwave Networks

The services provided in Dunedin are both network programmed and locally programmed. Programme is brought to Dunedin by all types of telecommunications networks.

Three bi-directional analogue bearers in a 2+1 configuration provide programme links from Mt Studholme in the north which are used for incoming TVNZ and RNZ Concert FM programme distribution and contribution. One outgoing analogue link carries TV3 programme to Mt Studholme for re-broadcast in the Timaru and Waimate areas.

Further links are provided to Kuriwao in South Otago and to Obelisk in Central Otago. These are analogue bearers in a 2+0 configuration and carry television and RNZ Concert FM programme to Invercargill, Alexandra, Wanaka and Queenstown. There is also a digital 34 Mbit bearer to Kuriwao.

Within the city there are two bi-directional digital links from Mt Cargill to the TVNZ facility in Dowling Street. A passive reflector on Consultancy House is installed to reflect the signal to Dowling Street which is not in line-of-sight to Mt Cargill. Two further digital bearers link Mt Cargill to the BCL maintenance base in Albany Street carrying mainly data and telephone traffic.

There is an unidirectional microwave link from the Allied Press building in Stuart Street to their television transmission facility at Cowan Road.

A 9 metre satellite receiving antenna located adjacent to the Mt Cargill building receives the BBC news signal for HPTV which is routed to the Dowling Street studio by one of the analogue microwave links.

Television Repeaters

There are many television translators which repeat the TVNZ and TV3 transmissions to pockets within Dunedin where primary coverage is poor.

Landline Networks

Apart from those described in the Telecommunication - Description of Service section there are a number of Telecom provided landlines from studios to transmission sites. They are:

- Albany Street studio to Highcliff, 2 circuits - Radio Dunedin, 4YC.
- Telecom to Highcliff, 1 circuit - 4YA.
- Prince Albert Road to Centre Road, 1 circuit - Access Radio.
- The TV3 and SKY television programmes are received by fibre optic cable from the north.

VHF/UHF Networks

All FM transmitters at the Mt Cargill site are provided with programme via VHF or UHF Studio to Transmitter Links (STL's) which are radio links relying on directional antennae at each end. Some of these are dual-mono (to provide a stereo broadcast) and thus provide a degree of redundancy. STL transmitters are located at Radio Otago's Cumberland Street studio, The Radio Network studio in Albany Street, the University of Otago Student Union building and the BCL Maintenance base in Albany Street. UHF links provide programme to the Peninsula sites.

Transmission Facilities

Mt Cargill Site

All transmitters are contained within one building and all antennae are on the one lattice tower.

Building

The building at the summit of Mt Cargill is a poured concrete, partially cantilevered, single storied, flat roof structure divided into four operational areas:

- FM transmitters.
- Television transmitters.
- Antenna combiner.
- Service area.

The building has its own water and sewerage systems so is not reliant on external services.

Transmission Mast

The transmission mast is a self supporting steel lattice structure 105m high which carries the majority of the microwave and radio linking antennae as well as the radio and television antennae.

Antennae

Antennae consist of a single FM band antenna for all FM transmitters and three separate antennae for television transmission. These comprise a band 1, band 2 and a UHF antenna. These are divided into upper and lower stacks and fed with separate feeder cables and while normally operated as a combined antenna, each stack can operate independently. The antennae are connected to their transmitters by coaxial cables which are carried in two covered trenches.

Maintenance Access

Access is via Pine Hill Road and Cowan Road. Cowan Road is particularly subject to harsh weather during winter and may be closed for days and 4WD vehicles are usually required. A sealed carpark adjacent to the building may be used as a helipad.

Power Supply Systems

Power is provided by Dunedin Electricity through an 11kV 3 phase overhead line terminating at the carpark, with the final 200m underground. A transformer is located outside the rear of the building. Two standby diesel generators are available.

Highcliff Site

Buildings

The principal building is of 1930's era, constructed in concrete, and houses five AM transmitters, service areas and limited workshop facilities. Three small huts at the base of the masts house the antenna coupling units and two FM transmitters.

Transmission Masts

There are two lattice type stayed masts which, an earlier study has indicated, are more likely to survive an earthquake than the self supporting type. The 155 metre tall mast is substantially constructed, with a 3 metre wide plinth base, and the 125 metre tall mast has an equally substantial cross-section with a wide footing. Neither is likely to collapse. These masts are in themselves the antennae or radiators, with the antenna coupling units located in huts at the base of the masts. An FM antenna is also located on the upper mast.

Maintenance Access

Access to the masts and buildings is from Highcliff Road and Karetai Road, both of which are public roads and 2WD vehicles normally suffice, winter or summer.

Power Supplies

Power is provided by Dunedin Electricity from an 11kV 3 phase overhead line terminated at a transformer inside the main building. Power is reticulated underground from the building to both transmission masts and the FM hut. An automatic diesel generator provides standby power to all facilities on site and has a fuel tank above ground holding sufficient capacity for 3 days' operation.

Centre Road sites (Radio Network / Radio Otago)

There are three AM transmitters at these sites.

Buildings

There are two relatively small buildings of concrete block construction.

Transmission Masts

There are two stayed masts of steel lattice construction and a coupling unit which allows three AM transmissions on one mast.

Maintenance Access

Access is either from Highcliff Road to Centre Road or Tomahawk Road to Centre Road. As Centre Road is difficult in wet weather, 4WD is often necessary.

Power Supplies

An 11kV overhead line brings power to a pole transformer in Centre Road. An automatic back-up diesel generator is on each site, with sufficient fuel for 1 week stored in a tank above ground.

Chain Hills Site

This site and Saddle Hill are FM repeater sites only. Equipment is cabinet mounted at Saddle Hill and in a building at Chain Hills. Power is supplied by the normal 230V reticulation and access to both sites is by public road.

Studio Buildings

There are radio studio facilities for Radio New Zealand and The Radio Network at Albany Street; Radio Otago Ltd has three studios at its Cumberland Street building and one at Mosgiel; Hills AM studio is in South Dunedin; and Radio One is in the University Union building, Castle Street. Channel 9 has television studio facilities in the Allied Press building in Stuart Street.

Power Supplies

All studios are dependent on reticulated power supply, but the Albany Street studio has an automatic back-up generator which can provide power for up to 1 week. .

Transmission Equipment

Each studio has STL facilities to its transmitters at Mt Cargill, Highcliff or Centre Road and Radio Otago has an STL from its Mosgiel studio to the Chain Hills transmitter.

BROADCASTING - ASSESSMENT OF VULNERABILITY

Sound Radio Broadcasting

Studio Buildings**Albany Street Studios (Radio Network/Radio New Zealand)**

This is a single level reinforced concrete and concrete block building, structurally very strong but on unstable, partly reclaimed land with one corner of the building on solid ground. Its proximity to the Leith and relatively low level makes it vulnerable to flooding and possibly to tsunami.

Cumberland Street Studios (Radio Otago)

This is a relatively modern building on reclaimed land with its basement and access vulnerable to tsunami and possible liquefaction from shaking.

Mosgiel Studios (Radio Otago)

Subject only to extreme flooding.

Prince Albert Road (Southern Community Broadcasters)

The studio occupies the ground floor of an older two storey concrete building which is at risk from earthquake shaking and possible liquefaction. There is also some risk from flooding.

Transmission Buildings

Highcliff (Radio New Zealand)

This is an old reinforced concrete building, with substantial light-weight roofing spans. Earthquake may cause severe damage to its roof and walls with subsequent damage to transmitting equipment.

Centre Road (Radio Network)

This is a concrete block building, subject to possible cracking of walls and with a light-weight roof likely to collapse during an earthquake.

Centre Road (Radio Otago)

Constructed in concrete block, this building will probably suffer cracking to walls during earthquake.

Saddle Hill (Radio New Zealand)

This is simply a steel cabinet on a concrete plinth and is unlikely to be damaged during an earthquake but the land upon which it stands is vulnerable to slipping.

Chain Hills (Radio Otago)

This is a concrete block building with light-weight roof, built upon land susceptible to slip.

Mt Cargill

See the section in Broadcasting which describes this buildings' vulnerability.

Transmission Equipment and Masts

Highcliff (RNZ)

This site has two separate transmission masts with FM transmission antennae on the larger mast.

The smaller mast is the most likely to survive an earthquake although the coaxial feeder cables could be vulnerable to derangement or severance.

The multi-coupling networks at the base of both masts are highly vulnerable to damage if either of the coupling buildings, located at the base of each mast, is damaged. The lower mast coupling building is timber framed and hence likely to survive an earthquake but the upper mast coupling building is concrete block and will be vulnerable to cracking.

The FM transmitters are in a small concrete block building which is vulnerable to cracking from earthquake and severe damage or destruction if the upper mast falls on it. The FM aerials are located on this mast which is vulnerable to high winds and severe earthquake shaking which may cause lateral displacement at the base insulators. The transmitters themselves are small and mounted in a strong rack.

Centre Road (Radio Otago)

This is a light-weight stayed mast, with the FM antenna mounted at the top of the AM mast. It is vulnerable to severe earthquake shaking.

Centre Road (Radio Network)

This is a lightweight mast that will be vulnerable to shaking and high winds although damage is likely to be minimal. There are three transmitters located at the base of the mast.

Saddle Hill (Radio New Zealand)

This wooden self-supporting pole and steel cabinet is at risk only from severe earthquake or slip.

Chain Hills (Radio Otago)

This is a stayed timber pole at risk only from severe earthquake or slip.

Mt Cargill

See Broadcasting section for details of transmission facilities.

Landlines

Albany Street to Highcliff

This Telecom line is vulnerable to earthquake, flooding and landslip at various locations. Derangement or cutting of the cable may occur along its length.

Telecom to Highcliff

This Telecom service is vulnerable to earthquake, flooding and landslip at various locations by a derangement or cutting of the cable, which may occur along its length.

Cumberland Street to Centre Road

This is another service provided by Telecom and is vulnerable to earthquake, flooding and landslip at various locations with derangement or cutting of the cable possible along its length.

Microwave and UHF

The following UHF radio links are vulnerable to misalignment of their aerial and co-axial feeder systems by earthquake shaking and possible damage to building structures:

- Cumberland Street to Centre Road
- Albany Street to Mount Cargill
- Cumberland Street to Mount Cargill
- Cumberland Street to Highcliff
- Mosgiel to Chain Hills
- Albany Street to Highcliff

Power Supplies

Centre Road and Highcliff

Mains power supply for the three AM transmission sites on the Peninsula is fed from the Andersons Bay Substation on the same feeder at 6.6kV. Supply runs from Silvertown Street via Tomahawk Road to Centre Road. An alternative supply running along the harbour side of the Peninsula can be tied in at Marion Street, Macandrew Bay but this feeder crosses unstable land. All services are vulnerable to flooding, earthquake and landslip at various locations.

Saddle Hill Transmissions

This site is supplied by 11kV overhead lines with some vulnerability from weather, earthquake and landslip but easily repaired.

Mt Cargill

See the Broadcasting section which covers supply to this facility.

Standby Power Supplies

At the following sites, automatic starting diesel generators have been installed. The greatest risk to all of these is building failure or loss of the fuel tanks due to earthquake shaking:

- Highcliff.
- Centre Road (Radio Otago).
- Centre Road (Radio Network).
- Albany Street (Radio Network).

Television Broadcasting

Studio Buildings

Dowling Street Studio

This building is solidly constructed of bluestone but has an extensively modified interior. It is vulnerable to shaking from earthquake, although the risk is low due to founding on basement rock. There is a minor risk from tsunami

Albany Street Maintenance Centre

This is a modern single storey building built on a concrete pad but the site is on low lying reclaimed land close to the Water of Leith. Consequently it has a risk from flooding, shaking, liquefaction and tsunami.

Many radio and landline services pass through the site with few redundancy options and hence the building and contents are at high risk. Typical damage will involve settlement of foundations, wall cracking and roof derangement, with cable input to the building and underground ducts severely damaged and the building possibly rendered unoccupiable. Overall the loss of this building would represent a major impact on broadcasting systems.

Allied Press Stuart Street

This is an old multi-storey building of brick construction and is at risk from shaking, liquefaction and tsunami. The building houses the Channel 9 Studio and transmission equipment and typical damage will be cracking of walls and settlement of foundations. Though damage may occur to services entering and leaving the building, the impact is reduced by the availability of standby power.

Transmission Buildings

Mt Cargill Transmission Building

This is a poured concrete cantilevered building at approximately 600 metres above sea level and is at only moderate risk during earthquake due to foundation on bed-rock and there is no risk of flooding or liquefaction. The highest risk to this building is the weather as the site is subject to high winds and snow storms. Although there is no alternative to this building, many of the services within it could be restored relatively quickly using temporary accommodation.

Cowan Road

This is a steel framed, iron clad building with frames set in a concrete foundation. The greatest risk to this structure is from windstorm.

Transmission Equipment and Masts

Mt Cargill

The most vulnerable part of the transmission equipment is the tower and associated antenna system. The tower is a self supporting lattice structure and is subject to the severe weather conditions at this site. The primary risks are high winds, and snow and ice loading. There is a lesser risk due to shaking during an earthquake. The tower is engineered to withstand expected weather conditions but individual antennas can have a lower resistance. Earthquake shaking may damage the base of the structure which, whilst not damaging the building to any great extent, may cause failure of the tower base hold-down bolts. This may result in severe lateral force when combined with weather impact. There is a measure of redundancy within the antenna system but if the tower fails so will most transmission services. The equipment within the building is less vulnerable as long as the integrity of the building is maintained.

Cowan Road

Weather is the factor which will have the greatest effect on service from this site. High winds could cause misalignment of the microwave antenna of the linking transmitter, rendering the service temporarily unusable.

Landlines

The Albany Street to Dowling Street landline is situated in low lying land, much of it reclaimed and subject to liquefaction and settlement due to earthquake. Cable junctions may fail due to the ingress of water exacerbated by earthquake shaking fracturing cable covers. This fracturing may also take place at building inlet and exit connections. The cable is also subject to the effects of flooding and tsunami.

Some alternate landlines are available, but these are subject to the same risks. Given the loss of this landline, alternative equipment could be obtained at short notice to restore at least some services but it should be noted that the Albany Street Maintenance Centre is subject to similar risks and that loss of these facilities together would extend the risk significantly.

Microwave and UHF

Albany Street to Mt Cargill

The Albany Street end of the circuit is on low-lying reclaimed land and is at risk from shaking, liquefaction, tsunami and flooding while the Mt Cargill end is at approximately 600m above seal level and at risk from severe weather conditions. The greatest risk is to the antenna system and supporting tower. There are some redundancy options and alternative equipment could be obtained at short notice to restore most services.

Dowling Street to Mt Cargill

These circuits face similar risks to those at the Dowling Street studio and the Mt Cargill transmission building.

Allied Press Building to Cowan Road

The main risk to this circuit is from earthquake shaking at the Stuart Street end and from extreme weather at Cowan Road. The most vulnerable equipment would be the antennae which could be misaligned.

Telecom Central Automatic Exchange to Mt Cargill

Refer to the vulnerability of exchanges and radio installations.

Power Supplies**Mt Cargill/Cowan Road**

The upper sections of this 11kV line are primarily affected by severe weather conditions and isolated sections are vulnerable to landslip and shaking failure. Damage is likely to be relatively minor and easily repaired.

There are emergency power supply systems at Mt Cargill in the event of a failure but there is no standby power supply at Cowan Road where complete reliance is placed on the 11kV overhead line to the transmission site.

Standby Power supplies**Mt Cargill**

The standby power source consists of two diesel generators each of which is able to supply at least part of the site services. The building housing them is robust and to be at low risk from all but extremes of weather and earthquake.

Allied Press Building

There is a standby generator available in this building to maintain supply in the event of a mains failure. Whether this would serve the transmission equipment in the event of an earthquake or tsunami would depend on the degree of damage suffered by the building.

Access Routes**Mt Cargill (Cowan Road)**

This road rises to a height of approximately 600 metres above seal level and the most serious risk to access is due to weather conditions. In the past the road has been closed for several weeks at a time due to snow. Many of the functions at this site are remotely controlled and are therefore less affected by road closure but fault maintenance may become difficult.

BROADCASTING - MITIGATION STRATEGIES

Sound Radio Broadcasting

Studio Buildings

The modern computer based technology is easily transferred to an alternative site and if the digital equipment is destroyed, alternative or replacement equipment is readily available.

No measures other than secure installation of the technical equipment is taken to preserve the integrity of the existing studios.

Because of network programming and providing the toll network remains available, normal programme can be sourced from outside the local area.

Transmission Buildings

The following locations have been examined in respect of damage anticipated in the vulnerability analysis and consideration given to minor mitigatory measures:

- Highcliff
- Centre Road
- Saddle Hill
- Chain Hills
- Cowan Road

Due to the age and nature of construction of all buildings, little can economically be done to mitigate construction weaknesses and no current programme of upgrading is proposed. As most buildings currently have adequate room for future service additions, there is little likelihood of building upgrades being required for expansion.

Highcliff and Centre Road require the standby fuel supply storage tanks to be additionally braced for seismic security.

All RNZ and TRN sites have been undergoing a programme to remove surplus/redundant equipment and any additional equipment is being securely seismically mounted.

Transmission equipment and masts

Consideration has been given to possible mitigation work associated with the transmission sites at Highcliff, Centre Road, Saddle Hill, Chain Hills and Cowan Road.

The AM masts are all primarily vulnerable to earthquake damage or destruction. They are required to sit on fragile insulators at ground level and because of the varying base mounting systems, some masts are more vulnerable than others. In the short term, there are unlikely to be any economically feasible upgrades that can be carried out.

Any FM radiators on AM masts are robustly mounted and FM feeders and radiators, which are vulnerable, are easily and quickly substituted.

Transmission equipment is generally securely bolted to the structural floor and any further mitigation to protect equipment is dependant on building design or upgrades.

Microwave and UHF Linking

UHF links are easily replaced by alternative or spare equipment from redundant or low priority services and lower quality communication gear is readily available for emergency replacement links should the primary system be lost. A low power linking or FM transmitter can be located at some suitable central location and be received at most transmission sites to provide a common programme on most AM/FM transmitters.

Television Broadcasting

Introduction

BCL owns and operates a number of broadcast and communication sites consisting of buildings, towers, antennas and support facilities such as standby power generator sets and ventilation systems etc. BCL also owns a number of microwave and fibre optic linking circuits in and out of these sites but does not own the individual transmission equipment within the building which belongs to client operators such as TVNZ, TV3 and Radio Otago.

The majority of BCL's mitigation strategies are already in place or part of an ongoing policy, centred on the assets it owns and not on the client owned equipment, although obviously the continued operation of this equipment relies heavily on the integrity of BCL's infrastructure.

Mitigation Strategies Common to all Areas

BCL has three principal parts to its mitigation strategies:

- Measures to preserve the integrity of the equipment and its services.
- The provision of back-up or alternative means to continue service.
- A disaster recovery plan.

Each site and service has a mix of the above strategies depending on the nature of the equipment and the risks to which it is exposed.

Measures taken to ensure the integrity of equipment:

- Where physically possible, BCL has opted for total compliance with the appropriate current NZ standards.
- All equipment, including non-fixed equipment, is seismically secured to NZ standards.
- Regular building and infrastructure inspections are undertaken by qualified inspectors, using the current standards and data available. All major installations are upgraded where there are shortcomings due to changed hazard data or improved standards.
- All installation and alteration work must conform to rigorous BCL standards and the appropriate current NZ controls. Every change or addition passes through a BCL control process.
- All sites are routinely checked and required to conform to BCL's rigorous "image" standard with emphasis on storage, cleanliness and other health and safety issues.

The provision of back-up or alternative systems includes:

- Where possible, all critical on-site equipment and equipment subject to potential failure is duplicated. This includes such at-risk equipment as antennas and feeders as well as the provision of duplicate back-up power supply generators.
- The provision of physically and environmentally secure fuel supplies.
- Where duplication of critical equipment is not appropriate, alternatives are used, i.e. the provision of alternative network feeds to critical sites.

Mitigation Strategies for Specific Sites or Systems

Mt Cargill (including building, tower and antennas etc.)

This site is subject to severe weather which can result in physical damage to site infrastructure, loss of conventional power to the site and restricted access. The general strategies detailed above apply with an emphasis on preserving the integrity of the equipment. Specific mitigation strategies are:

- Considerable weather data has been gathered and continues to be gathered for the site and the building and external infrastructure are engineered to withstand the expected conditions.
- All changes or additions are subject to a BCL change process and take into account the above data.
- Ongoing engineering consultancy to ensure building integrity against wind, water and snow damage.
- Dual standby generators are provided, each of which can maintain all of the services in the event of a power failure.
- Dual fuel storage and delivery systems are installed.
- Full remote control and supervision of all systems if access is impossible.
- Duplication of critical elements such as antennas and feeders.
- Critical equipment has a no-break battery back-up power supply.
- External equipment subject to the ingress of water is pressurised with dry air.
- Alternative network feeds to the site for those services which require it.
- An extensive disaster recovery plan is being developed.

Dowling Street Studio

This building has a low risk from flooding and shaking. Since the study began the studio complex and the building have been sold and are now no longer owned by TVNZ. There is still a network distribution node within the building and BCL general mitigation strategies apply only to the node. Specific (BCL) mitigation strategies are:

- The provision of alternative routes for critical services.
- The provision of no-break battery power for critical equipment.

Albany Street Maintenance Centre

This building is at risk from shaking and tsunami and BCL's general mitigation strategies apply. Specific mitigation strategies concentrate on:

- Providing alternative network feeds.
- The provision of alternative routes for critical services.
- The provision of no-break battery power for critical equipment.
- Generator standby power which can run all services in the event of a power failure.

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BUILDINGS - INTRODUCTION



University of Otago

Selection of Buildings for Study

Buildings identified for this part of the study were limited to those considered to be critical in the period immediately following a disaster for emergency relief, continuing avoidance of risk to health, and for assembly and shelter, and also in the intermediate period for risk abatement. A few key industrial buildings were identified as important economic recovery.

The list was originally longer than that adopted, but the time required to individually survey each building was constrained. The list should also have included residential complexes, including halls of residence, buildings important to the image of Dunedin, such as its heritage buildings, and

additional buildings that are important to the ongoing economic viability of the city. Expansion of the range of buildings examined is a worthwhile objective in continuation of the project.

Earthquake Assessment Adopted

For vulnerability assessments, it was decided that the only issue that need be specifically addressed was earthquake. Landslide and storm damage, including flooding, are likely to be common to an area, and any buildings within that area would be readily identified from the vulnerability studies of other groups and directly from the hazard analyses. Earthquake damage to a building, on the other hand, will depend on its structural form, materials, design standards, construction standards, and on siting and foundations.

Seismic Event Selection

The seismic event chosen for this study was one with an intensity measured on the Modified Mercalli (MM) scale at a level of MM IX on firm ground, or up to MM X on the softer ground in parts of the city. The MM intensity isoseismals for firm ground that were adopted were those estimated by Professor Richard Norris which are described and mapped in the chapter on hazards. The estimated recurrence interval of the event that produces these intensities is about 7,000 years (5,000 - 10,000 years) according to the assessment made there. They are associated with the maximum credible event of a Richter Magnitude 7.0 on the Akatore Fault or parallel fault. Other estimates are for at least 2,000 years recurrence interval for a MM IX intensity on firm ground when all sources, including remote events, are considered.

Smaller recurrence intervals were considered but dismissed. Elsewhere in New Zealand, recurrence intervals as short as 150 years have been used for similar studies. However, Dunedin is located in one of the more tectonically stable parts of the country and such an event, approximated by MM VII intensity would have little effect on most of the identified buildings. A recurrence interval of 150 years is likely to form the basis of intended modifications to the provisions in the Building Act relating to "earthquake prone" buildings. Collapse under such an event is likely to be defined by the relative vertical separation of adjacent levels.

An event with a recurrence interval of 450 years would have significant effect, consistent with MM VIII intensity. It is the event used for basic strength assignment for new structures. The longer period was adopted because it is associated with the maximum credible event identified in the hazards chapter and because it tests in a meaningful way the vulnerability of the infrastructure and support facilities of Dunedin.

Assessment Method Discussion

It has become customary to assess building response through an acceleration response spectrum, which is then scaled to account for building form and ductility and for risk. Approximate assessments for the effects of softer sites are also made. While this may be suitable for the design of new buildings, use of an acceleration spectrum is not necessarily suitable for the assessment of existing ones. Even for the assessment of the response of building parts and services, the spectrum must be modified in some way to account for resonant effects and the direct participation of ground accelerations, not directly modelled in the spectrum which is therefore not a true indicator of maximum likely accelerations.

Current international trends are towards a displacement-based approach which is likely to be included in the next generation of structural design standards. It produces more consistent results and has the beneficial effect of focusing attention onto the key issues that are related to building distress and collapse i.e. the strains in the materials, and the influence of deflection on the stability under displaced gravity loads (the so-called P-delta effect).

Traditional static analyses do not provide an accurate picture of the likely effects of earthquakes. More detailed analyses, while providing better assessments, can not usually be applied with confidence to older buildings because of difficulties in modelling the structure and material properties and uncertainties about ground interaction. However, where the maximum relative displacement can be estimated and the resulting effects determined, then an adequate picture of the effects of the earthquake can be gauged.

This study has primarily used a more heuristic approach based on the known performance of various types of buildings in past earthquakes. Indeed, it is as well to recall that the majority of data used for the seismic risk assessment produced by the New Zealand National Society for Earthquake Engineering was drawn from historic reports of MM Intensity and the attenuation relationships that were implied.

The Modified Mercalli Intensity Scale itself is defined in part by the effects of seismic events on buildings of various loosely defined types. Assignment of a type to a building should therefore provide a measure of the vulnerability of the building to an event that produces a chosen intensity level. Although rather tautological, this is essentially the method used in this vulnerability assessment. It is similar to, but cruder than, the "attribute score" or "penalty score" method often used for roughly assessing vulnerability from a visual survey.

Building Standard Used

For this purpose, the definitions proposed by Andrews et al were used. These were partially reported in the chapter on hazards, but the types mentioned in the MM definitions were not reported in the papers. For completeness, these are:

- | | |
|-----------|--|
| Type I: | Weak materials such as mud brick and rammed earth; poor mortar; low standards of workmanship. |
| Type II: | Average to good workmanship and materials, some including reinforcement, but not designed to resist earthquakes. |
| 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 or c 1980 for other materials) |
| Type IV: | Since c 1970 for concrete and since c 1980 for other materials, the loading 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. |

Anticipated Effects Based on Modified Mercalli Intensities

The effect of a MM IX earthquake is likely to be:

- Very poor quality 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.

The effect of a MM X earthquake (the same event as before, but the effects determined for soft sites) is likely to be:

- 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 of Type IV have moderate damage or permanent distortion.

Method of Assessing Vulnerability

Each identified building was assigned a type, taking into account mitigating factors (such as greater depth and thickness of masonry). The likely effects on the buildings were at first assessed from this type assignment, and then tempered by knowledge drawn from experience of more detailed assessments of similar buildings. Not all buildings have been analysed mathematically or surveyed in any detail, but many have been. Several have been analysed by the displacement-based approach described above. The willingness of those who have undertaken those past assessments to share the resulting information is appreciated. Considerable effort was required to correlate these assessments and the preliminary assessments of the identified buildings with actual numerical calculation.

A building was assessed as vulnerable if it would suffer loss of essential function due to damage to the building fabric. This does not necessarily imply collapse. Damage to services in buildings may also lead to loss of function, and it is thought that this cause is likely to be that most commonly leading to loss of function of facilities when the services are reviewed at a later time.

BUILDINGS - DESCRIPTION AND VULNERABILITY

Infrastructure Owners' Buildings

Water

Mount Grand Treatment Plant (Mixed Vulnerability)

The building was constructed in 1974. The reinforced masonry treatment building and mixer tanks support the chlorine/drum store. Filter tanks are reinforced concrete as are the pipes used as retention loops. The contact tank was built in 1969 using precast post-tensioned prestressed concrete wall panels and reinforced masonry inner walls.

Southern Reservoir Treatment Plant (Mixed Vulnerability)

The chlorination building was constructed in 1954 using reinforced concrete frames with cavity masonry panels (250 mm). The micro-strainer building is of similar construction and was completed in 1969. Neither structure is vulnerable.

The Number One contact tank, constructed in reinforced concrete in 1954 is vulnerable. The Number Two tank, built in 1969 using post-tensioned precast concrete wall panels and reinforced masonry inner walls is marginally vulnerable.

Booth Road Treatment Plant (Not Vulnerable)

This building was constructed in 1963 of reinforced concrete frames with cavity masonry walls. The reservoir and micro-strainer tanks are of reinforced concrete. The reservoir has post-tensioned concrete roof units.

Mosgiel Bores and Treatment Plant (Not Vulnerable)

The reinforced masonry buildings were upgraded in 1995. Aeration towers are of reinforced concrete pipes.

Midland Street Yard (Not Vulnerable)

These buildings were constructed in 1965. The heavy store has steel portals, encased to crane rail height, and masonry infill panels. End wall frames are of reinforced concrete. Other buildings have reinforced concrete frames with masonry infill wall panels.

Sewerage and Stormwater

Tahuna Waste Water Treatment Plant (Not Vulnerable)

Constructed in 1977, the building has reinforced concrete walls and frames, and precast prestressed roof units and cladding.

Musselburgh Pumping Station (Generally Not Vulnerable)

This building was constructed in 1958 and extended in 1997. The original building has steel portal frames with brick infill panels on the street, and precast reinforced concrete roof units. This roof has the potential to collapse in a severe earthquake. The building configuration is compact. The extension has steel portal frames, metal roof and cladding, with brick cladding on the street.

Portobello Road Stormwater Pumping Station (Not Vulnerable)

Built in 1962, the building has reinforced concrete frames with brick cavity walls (275mm) and precast reinforced concrete roof units post-tensioned after placing.

Electricity

Transpower Substations (Not Vulnerable)

Halfway Bush substation building is sited on clays and silts overlying volcanic rock. It was built in the 1950's and was upgraded in the 1960's. Except for the north wall of the crane building, which may be prone to earthquake damage, the building is unlikely to be vulnerable.

The South Dunedin substation building is more recent and designed to provisions of PW 81/10/1, and therefore effectively meets present-day requirements. It is piled. Settlement in the foreshore is evident around it.

The Three Mile Hill substation building is also designed as for the South Dunedin building to PW 81/10/1.

The small Berwick switchyard building is of light timber frame construction. Piles below floors are well braced.

Dunedin Electricity Ltd Headquarters (Not Vulnerable)

Vulnerable parts of this complex were secured when it was recently remodelled. This work included construction of an intermediate reinforced concrete floor within the previous double-height spaces. Other buildings, though not detailed to contemporary standards, are dominated by design criteria other than earthquake (wind, crane surge), leading to a high inherent strength.

Major Dunedin Electricity Ltd Substations (Vulnerability varies)

All substations are subject to a current seismic assessment study with some seismic strengthening to be constructed as a result. At present seven of the substations have been assessed with various degrees of strengthening recommended. All transformers and important switching gear is likely to be on shallow reasonably stiff raft-type foundations.

Substation buildings are as follows:

- Andersons Bay. Pitched reinforced concrete roof on a combination of reinforced concrete walls and frame with concrete masonry infill. Shallow foundations on deep soils. Constructed 1960.
- Berwick. Lightweight timber truss roof on single storey reinforced concrete masonry walls. Shallow foundations on deep soils. Constructed 1987.
- Corstorphine. Lightweight roof on structural steel portal frames. Concrete masonry cavity walls with the internal 150mm wythe reinforced and solid filled. Shallow foundations on intermediate depth soils. Constructed 1972.
- East Taieri. Lightweight roof on parallel chord rafters. Cavity concrete masonry walls with bond beam at top and reinforced pilasters. Shallow foundations on deep soils. Constructed 1973.
- Green Island. A reinforced concrete roof on reinforced concrete walls in transverse direction. Nominal frame action in longitudinal direction. This building is to be strengthened with the addition of some buttress walls in the longitudinal direction. Shallow foundations on deep soils. Constructed 1957.
- Halfway Bush. Lightweight roof on single storey reinforced concrete walls in both directions. Shallow foundations on intermediate depth soils. Constructed 1986
- Kaikorai Valley. Lightweight roof on truss construction. Reinforced concrete columns with cavity concrete block infill. Internal wythe of block appears to be reinforced and solid filled. Shallow foundations on deep soils. Constructed 1977.
- Mosgiel. Office building is constructed of lightweight timber framing with brick veneer. Light roof on timber framed roof structure. Continuous concrete perimeter foundation wall with internal piles. The substation is constructed with a light roof on cavity concrete block walls. There is likely to be a bond beam to the top of the walls with several reinforced pilasters. Shallow foundations on deep soils. Constructed 1964
- Neville Street. Reinforced concrete roof on a combination of reinforced concrete walls and frame. The structure is two storeys high with high stud heights. Foundation construction consists of a shallow stiff raft slab on deep soils. Constructed 1951
- North city. Light roof on single storey reinforced concrete block walls. Shallow foundations on deep soils. Constructed 1975.
- North East Valley. Light truss roof on reinforced concrete block walls. Shallow foundations on deep soils. Constructed 1994.

- Outram. Heavy tile roof on a combination of single storey reinforced concrete walls and frame. Shallow foundations on deep soils. Constructed 1964.
- Port Chalmers. Reinforced concrete roof on single storey reinforced concrete walls. Shallow foundations on deep soils. Constructed 1953.
- Smith Street. Pitched reinforced concrete roof on reinforced concrete walls in the transverse direction and a reinforced concrete frame in the longitudinal direction. Brick infill to the reinforced concrete frame. Shallow foundations on deep soils. Constructed 1958.
- South City. Partial two storey building with a light roof to the upper storey sections. There is a combination of reinforced concrete walls and structural frame in both directions. There is a large internal blast screen constructed from cavity brick with the cavity solid filled and reinforced. The foundation is a tapered compensating type raft foundation used as a basement. The building is constructed on reclaimed ground. Constructed 1971.
- St. Kilda. Light roof on single storey concrete block walls. Shallow foundations on deep soft soils. Constructed 1979.
- Ward Street. Light roof on structural steel trusses. Two-storey high reinforced concrete frames with solid in-situ concrete infill. Reinforcement consists of individual bars and rolled steel sections. Deep piled foundations through reclaimed harbour land. Constructed 1937.
- Willowbank. Reinforced concrete roof on cavity brick construction. There is likely to be a bond beam at the top of the walls and reinforced pilasters distributed around the structure. Concrete raft type foundation on deep soils. Constructed 1963.
- Halfway Bush Supply. Light roof on timber framing. Reinforced concrete block walls. Shallow foundations on intermediate depth soil. Constructed 1988.
- South Dunedin Supply. Light roof structure on 100mm cavity concrete block walls. There is a bond beam at the top of the walls and reinforced pilasters at mid point of each longitudinal wall. Shallow foundations on deep soft soils (reclaimed harbour). Constructed 1972.

Gas Production

Gas Production Plant (Not Vulnerable)

The main production building is a two storeyed reinforced concrete building with unreinforced brick veneer. It is compact in configuration and should respond well even though it has not been designed to current standards.

Roading

Ward Street Yard (Marginal Vulnerability)

Built in 1962, the building has reinforced concrete frames and cavity masonry infill walls. Some structures have precast reinforced concrete frames.

Communications

Telecom Central Exchange (Critical Parts Not Vulnerable)

This five-storey reinforced concrete building, completed in 1975, was designed as a ductile frame using the draft code provisions of the time. Security of engineering systems has been subsequently improved to the provisions of NZS 4219.

Telecom Maintenance Depot (Vulnerable)

All buildings on this site are reasonably new. The main buildings are constructed from structural steel portal frames with reinforced concrete block infill to windowsill level. These buildings are essentially lightweight in construction on shallow strip foundations. There are several secondary buildings, which are not currently in service. The remainder of the site consists of a large chip seal paved yard for parking of maintenance vehicles. The assigned vulnerability has been assessed from the location and the limited access that would be available after a major seismic event.

Dunedin Postal Centre, Strathallan Street (Possibly Vulnerable)

These buildings consist of three large portal frame structures with light cladding and a two-storey steel and timber framed office building. All foundations are shallow strip foundations on previously existing hard fill. The site has very soft deep soils (reclaimed harbour) and a major storm water drain passing under the building. Constructed in 1997.

Radio

Albany Street (Generally Not Vulnerable)

This building is of well detailed reinforced concrete and masonry construction with steel framing for roofs however, part of the floor is built on reclaimed land and may be subject to differential settlement.

Transmission Towers (Generally Not Vulnerable)

Included in this group are the Peninsula towers and the Mount Cargill tower. They are well anchored, adequately detailed and are well maintained.

Television

Forsyth Barr House (Not Vulnerable)

Although not well proportioned for ductile response, the building possesses high lateral resistance. Recent alterations removing several structural walls have not diminished the intrinsic overall strength.

Broadcasting House, Dowling Street (Part Vulnerable)

The principal building, though of unreinforced masonry, is only mildly vulnerable. Most deficiencies are related to past inappropriate remodelling and interior alterations. The adjacent building, however, is vulnerable, particularly in the studio area.

Administration

Civic Centre (Not Vulnerable)

This block excludes the Municipal Chambers, and the conference and entertainment facilities of the Town Hall complex. It houses the central administration of the City Council. Constructed in reinforced concrete to present day standards, it is well founded on a rafted system on sound clays. Weaker subsoil areas near the Moray Place Post Office (now ANZ Postbank) were backfilled with concrete.

Contractors' Facilities

Fulton Hogan, Fairfield (Low Vulnerability)

The Fulton Hogan main office building is constructed with post tensioned reinforced concrete frames with precast floor systems and some concrete block infill. This building was built within the last 25 years and will have been designed for a reasonable level of earthquake load. There are further single and two storey office buildings of light timber frame construction that should be designed to the non-specific design codes of the period. The latest timber frame office building is designed to be portable and has been constructed to modern standards. The remaining buildings are generally single storey, high stud buildings constructed from structural steel portal frames or timber with light-weight cladding. All foundations are expected to be shallow strip type. There are old underground coal mine shafts in the vicinity of Fairfield which will result in various levels of vulnerability to ground stability during a major earthquake. The remainder of the site consists of yard space for vehicles and plant. The main area of vulnerability stems from the possibility of the yard becoming isolated due infrastructure failure.

Works Civil Construction (Critical Parts Not Vulnerable)

The depot comprises a number of single storey buildings, developed since around 1975, that house office and workshop facilities. Construction is a mix of light timber framing, steel portals and reinforced concrete masonry.

Naylor Love (Vulnerable)

All Naylor Love subsidiaries (Construction, Structural Steel, Aluminium, Building Services) are housed in buildings with unreinforced masonry walls and unreinforced partitions between the building parts. Roof construction is often of timber trusses only notionally tied into the walls. The administration building (completed 1997) would remain functional, but the critical support facilities would be severely damaged, some collapsing. Recovery of large timbers from the yards and storage areas for shoring and the like would be possible, but the facility as a whole would be inoperable.

Critical Facilities Buildings

Civil Defence

Headquarters (Not Vulnerable)

This is housed in the lower parts of a car parking building that is of substantial reinforced concrete construction in good repair. The building has a high intrinsic strength, and has been detailed in a way that should provide ductile response. Column dimensions are substantial, inhibiting instability even if materials fracture. Some improvement to access paths is desirable for security of access.

Hospitals

Dunedin Hospital (Critical Areas Not Vulnerable)

Critical facilities are housed in buildings of reasonably modern construction. Although not all are detailed for ductile response, they possess large strength. These buildings include the main Ward Block (including lecture theatres), Oncology and Clinical Services.

Vulnerable areas include Psychological Services (part of the original hospital), Children's Pavilion (four storey reinforced concrete building of frame-like proportions) and the complex housing Physiotherapy, Prosthetics, Orthotics and Occupational Therapy. These buildings are more particularly vulnerable due to the widespread use of single wythe unreinforced masonry partitions along main interior access routes.

Wakari (Major Use Areas Not Vulnerable)

Buildings that were remodelled when Psycho-Geriatric and other psychological services were recently moved to the site are not vulnerable. These include the Forensic (Safe Care) Unit (new building), Long Stay (former nurses home), and Intellectually Handicapped Unit (former radiotherapy building).

The main part of the original building is vulnerable. It includes single wythe unreinforced clay tile, brick and coke breeze masonry partitions, and the frames are not well detailed. Principal shear walls are not well positioned (lack of gravity stabilising loads, and dubious connections to floors). The kitchen is housed in the part-basement of this block, but it may escape serious damage and is accessible from the exterior.

The two wings that extend to the north from this block are, however, likely to be satisfactory and are seismically separated from the main block.

Mercy and Marinoto Clinic (Not Vulnerable)

Except for the original homestead building, which is classed as non-essential, all buildings are of recent construction and are well proportioned and detailed.

Fire Stations

Central (Vulnerable)

This building, although including reinforced and steel elements, is essentially of unreinforced masonry. It is likely to suffer severe damage appliances housed within the building may be damaged or trapped. There is also a risk to personnel.



Dunedin Central Fire Station - Civil Defence

Though the vulnerability of the building is recognised by the NZ Fire Service and there are contingency plans for control of emergencies from elsewhere (St John Ambulance, Central Police Station), the security of this facility itself is nevertheless critical.

Suburban (Not Vulnerable)

Several buildings (St Kilda, Roslyn, and Willowbank) are of a similar design using timber framing (glue laminated timber frames to the roof) and split block veneers. Some veneers may fail, but this is unlikely to prevent rapid use of the facilities and appliances.

Lookout Point station has substantial reinforced concrete frames and floors. Some infilled unreinforced masonry walls may fail, but the station should remain operational.

Police Stations & Prison

Central (Not Vulnerable)

The five-storey reinforced concrete building completed in 1994 was designed to remain fully operational following a 500-year seismic event. A risk factor of 1.3 was applied and the foundations were piled to firm gravels for the main building. Systems are designed to be operational for isolation from utilities for a period of three days.

Suburban (Not Vulnerable)

Dunedin South and Dunedin North Community Police Stations are recently constructed.

Prison (Vulnerable)

The three storey brick building was constructed before the turn of the century and although in good condition for this age and type of building, it is nevertheless vulnerable.

Ambulance

Order of St John Regional Headquarters (not vulnerable)

The operational sections of this building were substantially upgraded to a higher standard of seismic resistance in 1995. The building is piled and the overhanging ground immediately behind the garage is considered stable in view of the bedrock exposed.

Community Buildings

Halls, Stadiums and Raceways

Dunedin Town Hall Complex (Not Vulnerable)

Although appearing to be constructed of unreinforced masonry, this building is well framed with steel and reinforced concrete. It may suffer damage, but would be useful for shelter and similar uses.

The Glenroy Auditorium, including the Harrop Street Link was substantially rebuilt in the recent redevelopment.

The Municipal Chambers were secured and largely strengthened (though not to contemporary standards) when it was upgraded. It may be damaged, but the substantial thickness of the masonry walls should ensure its stability. The building houses non-essential facilities.

Edgar Stadium (Vulnerable)

The building is well constructed, with steel framing and precast concrete walls well connected to the frames, though the support to the end walls is questionable (ineffective bracing elements). The roof is lightweight. The site has suffered considerable settlement (not related to usage) and is prone to liquefaction. While damage is likely, the building would remain useful for storage of materials not requiring shelter from the weather. Reliance for shelter for persons might be imprudent in view of the likely difficulties of access to the site, and probable poor weatherproofness.

Dunedin Stadium (Not Vulnerable)

Like the Edgar Stadium, this building is well built and robust. Any liquefaction of the underlying uniform sands is unlikely to render the building unusable. Blocking of surface soils brought about by liquefaction of sands at depth may present access difficulties, but the building is likely to remain operational and suitable for shelter for persons and as an assembly point (subject to access).

Badminton Hall (Not Vulnerable)

The limited amount of masonry is well contained by encased columns. Remarks for the Dunedin Stadium are applicable here.

Forbury Park (Members Stand Not Vulnerable; Rest Vulnerable)

The main (members) stand is framed in reinforced concrete and steel, and is piled to firm strata. Flexibility of the ground may produce resonant effect from remote earthquakes, and ground settlement may impair usability, but the facility should remain operational and suitable for personal shelter or assembly.

Other buildings on the site (Stewards, including administration area, and Public stands) are substantially of unreinforced masonry in poor repair, with settlement damage and are likely to be severely damaged or collapse. Debris is unlikely to impair access, however.

Schools

Schools were not separately surveyed. However, integrated schools have a programme of improvement that is a condition of their integration agreement. Most (all in the case of Catholic schools, the majority of integrated schools) have completed this upgrading. All public non-integrated schools are the subject of a nation-wide survey to be conducted for the Ministry of Education. A pilot study is being undertaken in Wellington, and this will be followed for the rest of the country, probably in 1998. The information will be reviewed when available.

Commercial Buildings

University of Otago (Mainly Not Vulnerable)

Most critical facilities are in new buildings, well designed, built, and maintained. Those designed even before the advent of modern codes of practice (c 1976) were required to comply with PW 81/10/1 which is roughly equivalent to the later codes.

Buildings which are exceptions are those identified in a recent survey as vulnerable and listed in their order of priority for strengthening work suggested by the survey: Geology, Registry, Allen Hall, Former Mining School (Computer Sciences), Lindo-Ferguson, Staff Club, Home Science, Marama Hall, Professorial Houses, Scott Building, St Margaret's College, Selwyn College, Zoology, Union Court, Works and Services, Botany Annex. The survey excluded Knox College Halls of Residence, School of Physical Education, and the Survey School and Botany Department Building.

The Survey School (original Queen Mary maternity hospital) was checked under "change of use" provisions of the Building Act and found to be adequate. Hazardous elements (for example unreinforced single wythe partitions) were removed.

Cadbury Confectionery (Mixed Vulnerability)

The bulk store was constructed in the early 1990's to present-day standards. In the 1960's, two levels were added to a 1940's building immediately to the south of the bulk store. That original building has been assessed by the designers of the additions as having reasonable seismic resistance. Other buildings, dating from before and about the Second World War, and are constructed in a fashion typical of that period. Although some have frames of substantial wall-like proportions and have floors tied in to walls, they are assessed as somewhat vulnerable, with, perhaps, one-quarter of them losing function in a MM IX event.

Transtec (Railway Workshops) (Not Vulnerable)

Except for some non-essential facilities constructed from unreinforced brick (eg original foundry), all buildings are of lightweight construction. Principal framing to the industrial use spaces is steel and/or timber with properly engineered connections. Foundation conditions consist of indifferent overburden overlying sound strata at 8-10 m depth, and critical items such as presses and mills are piled to these strata. There may be some damage to weatherproofing, especially to the large glazed areas of some walls, but the buildings would remain functional. The administration areas are also largely of timber framed construction and would remain functional.

Scott Technology (Not Vulnerable)

This is a structural steel building with only lightly reinforced blockwork infill walls. Infills should survive. Other blockwork (end walls) may be distressed, with minor failure although the building as a whole should remain functional.

Farra-Dunedin Engineering (Vulnerable)

There are three main areas, the foundry, the steel fabrication shop and the sheet-metal/pattern shops. The street walls of the foundry are of reinforced concrete in a poor state. The concrete is permeable and reinforcement is rusting. Past concerns about this have led to duplicate steel columns for support of the

roof. The roof structure is of both steel trusses and portals tied to the walls. Extensive damage is probable but collapse unlikely.

The steel shop is of similar construction but with unreinforced masonry walls. Columns, probably sufficient to prevent collapse, buttress these. The main transformer is in a vulnerable, otherwise disused part, failure of which may render the building inoperable.

The sheet metal building is largely vacant. Pattern store has unreinforced hollow core cavity concrete walls and indefinite structure and is likely to collapse. The sheet metal shop may survive, but may not be functional. The whole site is on firmly compacted fill which may aggravate the problem.

Wickliffe Press (Low to Moderate Vulnerability)

The Wickliffe press plant is made up of several different buildings added to and altered as the plant expanded. The buildings adjacent to Albany Street are constructed from a reinforced concrete frame with Oamaru stone infill and large windows. These buildings are over 40 years old and as such will not be designed for any significant earthquake loads. A majority of the remaining buildings are structural steel high stud portal frame buildings with lightweight roof cladding and precast concrete exterior walls. These are relatively recent buildings constructed over the last 15 years. The main office building is of structural steel frame and concrete floors and was constructed around 1993. All foundations are likely to be shallow strip foundations on deep soils.

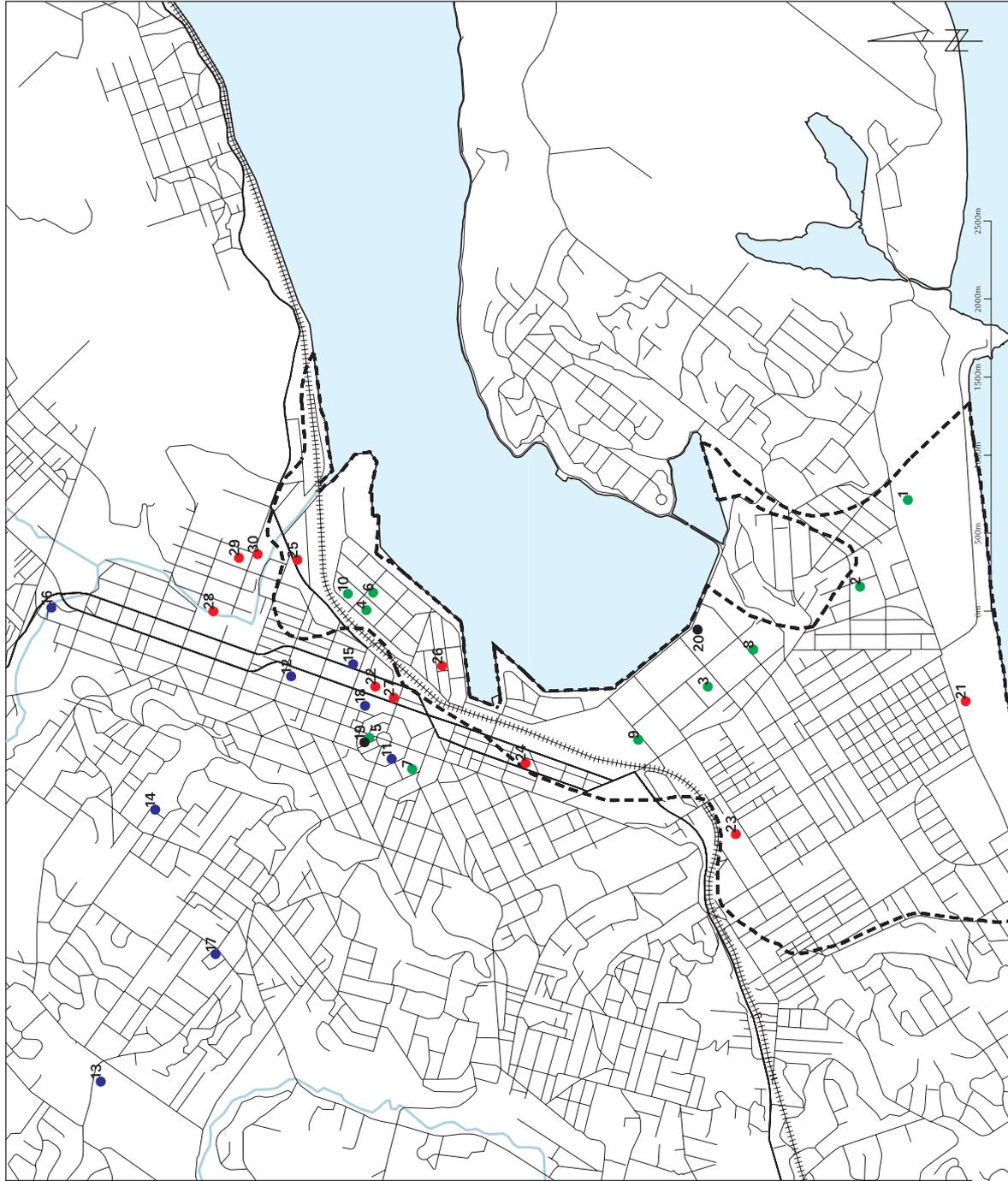
Allied Press, Cumberland and Stuart Streets (Moderate Vulnerability)

The Allied Press buildings consist of several buildings of varying construction. The main wings (Evening Star Building) on Cumberland and Stuart streets are four storey reinforced concrete buildings constructed over 30 years ago. The design will have allowed for only nominal earthquake effects. These buildings have been subject to concrete repairs within the last 10 years. They generally house the offices and editorial departments and also the local television network. The press building is currently under construction and has been designed to modern standards. The distribution and old press hall are of modern construction, structural steel and lightweight cladding. There are several unreinforced masonry buildings on the site but these are not critical to the operation of the newspaper or television. The new press building is constructed on piles. All major items of plant have been constructed on deep raft type or pile foundations.

Fisher & Paykel, Taieri (Not Vulnerable)

The whole facility on the Taieri industrial estate is relatively new. It is built on ground that is known locally as "Milners Pit", which is less prone to the large deformation or slumping likely to characterise sites further south. Construction is structural steel in the main, with the older administration building of in-situ reinforced concrete panel construction. The building would survive even an extreme event.

Buildings



Disclaimer

The purpose of the Dunedin City Lifelines Project and the publication of this map is to provide information on lifelines services and to identify areas where further investigations or remedial engineering actions on lifeline services are indicated. Whilst the information has been produced using the best advice available, it is not intended for any other application than the limited purposes of this project.

No liability will be accepted by any of the parties to the Dunedin City Lifelines Project for any wider interpretation or reliance which may be placed upon its published documents or upon any other findings of the Dunedin City Lifelines Project.

Any person or organization having a concern with any issue raised by the Project should consult their professional advisers before taking any action.

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- 2 Musselburgh Pump Station
- 3 Midland Street Yard
- 4 Ward Street Yard
- 5 Civic Centre
- 6 Dunedin Electricity Ltd
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Rivers

--- Boundary of Soil Types Susceptible to Liquefaction

● Infrastructure Owners ● Community Facilities

● Critical Facilities ● Commercial

City Consultants
 September 18, 1998

BUILDINGS - MITIGATION STRATEGIES

Owners' Involvement

In this part of the report, some suggestions are made for mitigating the effects of earthquakes on the buildings reported upon under the preceding section. General suggestions are made that are relevant to all buildings, but specific suggestions are made only for those buildings identified as possibly vulnerable.

It is recognised that this report does not include all important structures and that it adopts a “broad brush” approach to statements made on vulnerable elements of buildings.

The requirement to mitigate the effects of a major disaster event will fall on the building owner. This may be driven from several influences:

- Legislative.
- Territorial Authority encouragement for improvement of building stock.
- Insurance—and the inability to secure finance for buildings construed as earthquake risks.

It is noted that the cost to building owners of forced mitigation may prove prohibitive in the current economic climate. Nevertheless owners are advised to consider the impact of hazard damage on their building assets and further investigate vulnerability on a voluntary basis.

The Building Act and Proposed Changes.

A proactive approach by the Territorial Authority to identify earthquake risk structures and to formulate a strategy for their management is considered the most prudent approach. This will enable gradual improvement of the building stock to a given standard to be achieved over a controlled period of time. This is notwithstanding any legislative change that might require upgrading in a programmed way.

The vulnerability of a building can be measured in both the probable effects to the structure of the building and also to the contents of the building. This also applies to modern “earthquake proof” non-vulnerable buildings. Significant improvement to the recovery times after a disaster event can be made by prudent investigation and securing of critical items of plant, equipment and stocks of spare parts.

There should be an awareness, especially among building owners, that the provisions of the Building Act that relate to “earthquake prone” buildings are likely to be amended. Existing provisions are contained in section 66 of the Act.

In section 66, an earthquake prone building is defined as one that would suffer catastrophic collapse in a moderate earthquake and thereby present a risk to persons through death or injury or cause damage to adjoining property. For this purpose, a “moderate” earthquake is defined as one that would subject the building to forces one-half as great as those specified in NZS 1900, Chapter 8:1965. This definition uses NZS 1900, even though that Standard has been revoked for the design of new buildings and replaced with NZS 4203:1992. The provisions apply to all unreinforced concrete or unreinforced masonry buildings other than those used for some forms of domestic accommodation.

If a building is determined by the Territorial Authority to be earthquake prone, the Authority may serve notice on the owner of the building to remove the danger, either by demolition or by strengthening.

Present proposals for amendment of the Act suggested by the Building Industry Authority include redefining a moderate earthquake as one with a return period of 150 years. The notion of collapse is, however, preserved. All buildings, of whatever construction, would be covered by the amendments, although some forms of domestic buildings may yet be exempt. Territorial Authorities would be required to survey all affected buildings within a specified period and may (i.e. optionally) then serve notice on owners of buildings found to be earthquake prone (though the use of that term seems likely to be discontinued).

An earthquake with a return period of 150 years in Dunedin is only slightly greater in intensity than Modified Mercalli Intensity VII. Peak ground acceleration from such an earthquake could be expected to be about one-half that applicable to the design of new buildings. An average value of this fraction for the whole country is about two-thirds. As the presently used notion of collapse is to be retained, conventional design methods may not be directly applicable. Designers may therefore wish to derive reduced peak ground acceleration for which conventional design methods could be used. This is roughly equivalent for many buildings to a return period of 50 years, and implies a further reduction from the levels used for new buildings of some 30%, typically.

It is possible that a two-tier approach may be introduced. A threshold level would be used for assessment of vulnerability and another level would be used for the design of strengthening methods. A suggestion has been made that the return period for the threshold level is set at 50 years, and the return period for strengthening is set at 150 years. Both would be used against the criterion of collapse.

The levels of strength associated with the likely revisions to the Building Act are significantly above those presently used for the definition of earthquake proneness. The actual ratio depends on the form of the building and its materials of construction and detailing. For buildings expected to remain elastic, present strength criteria for determining earthquake proneness are roughly 1/8 of those applicable to new buildings, whereas the proposed criteria increase this to about 1/3–1/2.

Recommendation to Owners

With these amendments in mind, owners of buildings contemplating renovations or other remodelling should consider upgrading their buildings for earthquake resistance at the same time. This would effect a progressive improvement of the building stock without the sort of disruption that would inevitably arise from compulsory improvement.

In many cases, considerable improvement of the response of the buildings in earthquakes can be achieved with minimal cost and intervention. Mostly, improvement of inter-connection will suffice to radically improve performance of the building and securing of contents will also mitigate against loss.

Experience shows that damage to buildings in earthquakes is greater where maintenance has been improper or inadequate. Well maintained, unstrengthened buildings have survived large earthquakes better than fully strengthened buildings in poor condition. A maintenance schedule is therefore a necessary part of proper building management. It should be prepared regardless of whether or not restoration or redevelopment work is being carried out.

It is highly desirable that owners form contingency plans for rapid assessment of damage to buildings and for appropriate security measures in the event of a damaging earthquake. In the event of isolation, alternative access routes should be identified and back-up communication installed.

Infrastructure Owners' Buildings

Water

Mount Grand Treatment Plant (Mixed Vulnerability)

A detailed survey of this facility should be undertaken during current upgrading activity, particularly with respect to contact and dosing structures.

Southern Reservoir Treatment Plant (Mixed Vulnerability)

The contact tank structures should be examined and upgraded as part of the general Dunedin City Council water improvement strategy.

Sewerage and Stormwater

There are a number of relatively minor items mentioned in the Civil Services section of the study which should be tackled under general maintenance provisions. Amongst these is the precast roofing at Musselburgh Pumping Station.

Roading

The Ward Street Yard has marginal vulnerability and the building as a whole, but particularly the cavity masonry infill walls should be reviewed and secured. Use of steel stiffener posts for the walls would be effective.

Electricity

Transpower Substations (Not Vulnerable)

Dunedin Electricity Ltd Headquarters (Not Vulnerable)

Major Dunedin Electricity Ltd Substations (Vulnerability Varies)

Dunedin Electricity has taken reasonable mitigation measures for their buildings. This has involved the assessment of the seismic performance, and upgrading as recommended by the engineering consultants involved.

In addition to mitigation measures for buildings, further measures may be required to mitigate the effects of a major disaster event by securing building contents and equipment, such as stock items of switching and isolating gear. The lead time to procure these items is significant and any breakage due to poor securing would have a large impact on the ability of this organisation to function after a major event. There are several items of equipment found in typical switching yards that require securing, such as electronic switching gear and back-up battery banks. The securing of these items is simple and inexpensive.

Communications

Telecom Central Exchange (Critical Parts Not Vulnerable)

Telecom Maintenance Depot (Vulnerable)

The major hazard relates to isolation in the event of a major emergency and it would be prudent to survey the facilities to determine measures to secure the building contents and any specialist stock and plant.

Dunedin Postal Centre, Strathallan Street (Possibly Vulnerable)

The location would suggest that the area might become isolated in a major event with disruption to the infrastructure elements in the area. Securing of the contents would be prudent.

Television

Broadcasting House is vulnerable. A change of ownership of the company has presented the opportunity to review the building and its functions and a general strategy for improvement has been adopted which will be worked through as opportunities present themselves.

Contractors Facilities

Fulton Hogan, Fairfield (Low Vulnerability)

The worst effect is that this contractor might be isolated from the Dunedin area due to the location of base operations their securing of basic facilities such as communications systems would be a major mitigating factor.

Works Civil Construction (Critical Parts Not Vulnerable)

Naylor Love (Vulnerable)

The continued function of these buildings after a major seismic event and the ability to recover shortly afterwards needs examination. A program of replacement and upgrading of most of the buildings on the site should be considered.

Critical Facilities Buildings

Hospitals

Dunedin Hospital (Critical Areas Not Vulnerable)

Wakari (Major Use Areas Not Vulnerable)

Fire Stations

Central (Vulnerable)

Though the vulnerability of the building is recognised by the NZ Fire Service and there are contingent plans for control of emergencies elsewhere (St John Ambulance, Central Police Station), the security of this facility itself is nevertheless critical. Recent removal of the control room to Christchurch may have eased one problem but not necessarily improved the ability to respond effectively to a major disaster in Dunedin.

It is suggested that the main front vehicle bay be secured to prevent collapse of the overlying structure into it and onto the street.

Suburban (not vulnerable)

Police Stations & Prison

Central (not vulnerable)

Suburban (not vulnerable)

Prison (Vulnerable)

The suitability of this building for continued use as a prison should be reviewed.

Ambulance

Order of St. John Regional HQ (not vulnerable)

All operational parts of the building have recently been strengthened and no further work appears necessary at this time.

Community Buildings

Halls, Stadiums and Raceways

Edgar Stadium (Vulnerable)

If there is low reliance on the facility for relief work then little need be done. Upgrading work should address the identified weaknesses in the structure and identify alternative routes to and from the facility should be undertaken.

Forbury Park (Members Stand Not Vulnerable; Rest Vulnerable)

As high reliance on this facility is unlikely, progressive structural upgrading as part of other works should be sufficient mitigation.

Schools

Vulnerability and mitigation strategies are part of a national study being undertaken by the Ministry of Education. The study is due for completion in October 1998. In general, except for isolated buildings, not part of the main blocks, most schools are not vulnerable. Nothing further need be recommended to accelerate the mitigation of risk.

Commercial Buildings

University of Otago (Mainly Not Vulnerable)

Establishment of the vulnerability of buildings not included in this study, and a program for their improvement should be progressed. These include selected buildings from the following list: Geology, Registry, Allen Hall, Former Mining School (Computer Sciences), Lindo-Ferguson, Staff Club, Home Science, Marama Hall, Professorial Houses, Scott Building, St Margaret's College, Selwyn College, Zoology, Union Court, Works and Services, Botany Annex, and all Halls of Residence.

Cadbury Confectionery (Mixed Vulnerability)

Older buildings should be reviewed. It is likely that improvement of building inter-connection would be effective in reducing vulnerability to acceptably low levels. Security of plant, equipment and building services should be reviewed.

Farry-Dunedin Engineering (Vulnerable)

All buildings should be reviewed. Continuation of buttressing of walls with steel columns is encouraged, at least as an interim measure. Consideration should be given to protection of critical plant, particularly main transformer and switch areas.

Wickliffe Press (Low to Moderate Vulnerability)

The most likely difficulty will be distributing product to customers and receiving incoming supplies. To ensure that business can be re-established at the earliest time, mitigation measures should include the securing of critical plant and stocking of sufficient spare parts and stock.

Allied Press, Cumberland and Stuart Streets (Moderate Vulnerability)

Basic mitigation measures are securing critical items of equipment such as computer and communication systems.

Assessment and strengthening is advocated because the local television network is housed in the buildings this may become a vital link in the communications systems immediately after a major event.

BUILDING SERVICES & CONTENTS - DESCRIPTION

Introduction

Building services and contents have not been extensively surveyed as part of the Dunedin Lifelines Project partially because of the considerable resource required to make subjective assessments on the widely varying content and the belief that this and building structural surveys are essentially the owner's direct responsibility, best handled by the engagement of qualified persons.

Traditionally, most attention has been placed upon the building itself which is either constructed to the appropriate standard of seismic resistance or strengthened to achieve this. While this is crucial to minimising human and material losses from a major disaster, the building function otherwise is solely to keep personnel and contents productive and protected from the elements .

Should the services and equipment become inoperable during and/or following a major disaster, the building is no longer able to carry out the function(s) it was intended for. Examination in previous studies has found that much damage has been done within seismically adequate buildings and they therefore become totally unusable due to the complete upheaval caused by the contents of the buildings being dislodged and rendered inoperable.

In the past, once the structure of the building has been completed, mechanical and electrical contractors have often installed the building services with little input from suitably qualified engineers and as a result have failed to ensure an appropriate level of seismic resistance being incorporated.

If consideration had been given to seismic effect, this would often be at a level of 0.1g (0.1 times the acceleration due to gravity). This compares with accelerations in excess of ten times this being experienced at the top of some buildings during moderate to severe earthquakes.

Seismic Standards

The services and contents of more recently constructed buildings should comply with the current New Zealand Standards, NZS 4219 "Seismic Resistance of Engineering Systems in Buildings" and NZS 4104 "Seismic Restraint of Building Contents". However, it has been observed that this is not always the case.

BUILDING SERVICES & CONTENTS - MITIGATION STRATEGIES

Building Services

Service failures during earthquake may be many and varied in so many different ways that examination on a property to property basis is the best way to generate practical mitigation options.

It is recommended consideration be given to the following service systems within buildings:

- Heating and Ventilation Fans, motors, ducting, pipework and vents.
- Electrical Emergency batteries, switchboards, light fittings and fans.
- Fire Protection Header tanks, pipework, batteries and control boxes.
- Plumbing and Drainage Water storage, pipework, hot water cylinders.
- Lifts Hoist motors, controls.
- Security Systems Controls, video cameras etc.
- Communications PABX racks, controls generally, speakers etc.
- Refrigeration Compressors, cabinets, pipework.

Many of these more sophisticated building services are now incorporated in private homes and should similarly be considered by home owners.

Building Contents

Building contents are frequently given even less consideration than services, with various owners and tenants installing all manner of equipment and furniture without any concern for the effects of an earthquake.

Examples of frequently seen loose standing contents in commercial buildings and private homes which should be restrained are:

- Tall bookshelves (and contents if important).
- Key communication equipment ie PABX, fax, etc.
- Key computing/ data access equipment.
- Large partitions.
- Drawings and file storage.
- Hot water cylinders (good supply of emergency water).
- Emergency generators, header tanks, fuel tanks, supply lines, start batteries and cabinets.

Conclusions

While structural retrofitting of a building may be a costly though vital operation, mitigating the risk of injury to people and loss of function of a building due to unrestrained building services and contents can often be easily carried out at relatively little cost.

The payback in both instances can be substantial, resulting in little or no loss of function allowing the service, utility or business to continue operating and providing a commercial benefit to owners, operators, service providers, businesses and the wider community.

Recommendations

It is strongly recommended that building owners and managers examine the services and contents of their buildings to assess the potential loss due to natural hazard and consider mitigatory actions which might be taken now to increase survival of these assets. Systems have been developed that enable a broad-brush but methodical risk assessment to be undertaken economically.

Standby power may be a crucial element in the operation of certain critical buildings and particular attention should be given to protection of existing systems, with installation of standby power as an alternative supply in some cases.

Compiling a register of potentially vulnerable system assets, commencing seismic restraint work and preparing recovery plans for use after events are highly desirable mitigatory actions which may be started now.