CHAPTER 9. HEALTH & EMERGENCY SERVICES - CONTENTS

HEALTH & EMERGENCY SERVICES - INTRODUCTION

Approach Taken

Some city lifelines are primarily service providers rather than owners and operators of infrastructure networks. Their critical assets tend to be their expert staff, supported by specialist buildings and plant.

In many cases these lifeline providers are dependent upon the continued availability of the infrastructure of other lifeline services to enable them to carry out their full operational functions.
Lifelines considered in this chapter are:

- Medical Health - Dunedin Hospital, Mercy Hospital, The After Hours Doctors, General Practitioners, Civil Defence Emergency Medical Units and Ambulance Services.
- Public Health - Dunedin City Council Environmental Health Unit and Healthcare Otago Public Health Unit.
- Emergency Services - NZ Fire Service, NZ Police and Dunedin City Civil Defence.

As these services are not primarily owners and operators of infrastructural services, the main focus of this study was on the effect of the loss of other lifeline services on their essential functions. Vulnerability is therefore considered against the loss of each lifeline service.

HEALTH & EMERGENCY SERVICES - DESCRIPTION & VULNERABILITY

Water

Medical Health
Dunedin Hospital uses around 300,000 litres of water a day for drinking, sanitation and production of steam for heating. This is fed in to the hospital through a number of supply points. The boilerhouse has storage for 20 days of essential operation, while other areas hold 200,000 litres, which is less than one day at normal consumption rates and not all of the stored water is potable. In the event of rupture of water mains near to or within the hospital premises, flooding of the lower basement could threaten the power distribution controls, emergency generators and PABX equipment.

Mercy hospital has water storage on site for 24 hours of operation.

The After Hours Doctors centre has only four hours supply of stored water, while general practitioners and emergency medical units are all dependent upon continued mains water supply but could continue to function for a limited period without mains supply.

Ambulance operators are not dependent upon water supply for their primary functions.

Public Health
The primary impact on public health services would be the need to monitor and advise on hygiene measures in the absence of water or if water could not be properly treated.

Emergency Services
The NZ Fire Service places a high reliance on the availability of water mains for fire fighting water supplies, although untreated water is suitable and some other sources can be used for fire fighting.

The Central Police Station has sufficient stored potable water for at least 72 hours and also has a 200,000 litre static supply suitable for fire fighting.

The Civil Defence Headquarters has only limited stored water and ward headquarter sites are reliant on mains water supply, although the lack of water does not critically inhibit the essential functions of these sites.

Sewage Disposal

Medical Health
Dunedin Hospital discharges its sewage directly to the reticulated sewerage system, apart from that from the lower ground floor which is at a lower elevation than the sewers and relies on pumped discharge.

Mercy hospital and most emergency medical unit sites are elevated and so are unlikely to be affected by sewer discharges but will be restricted in how they dispose of their wastes.

General practitioners would expect to have patients presenting with illnesses from those who may become exposed to sewage contamination.

Public Health
Public health authorities would be involved in assessing risks from sewage discharges, with advice to the public on hygienic disposal methods and to engineers on alternative treatment and disposal options. If sewage is discharged to the harbour or waterways, there will need to be careful monitoring and warnings to the public to avoid recreational activities in these areas.

Emergency Services
The Fire Service may be limited in their use of alternative sources of fire fighting water where there is possible contamination from sewage discharges.

The Central Police Station has sewage holding tanks sufficient for three days of normal use.

All civil defence sites are fully reliant on reticulated sewage disposal.

Stormwater Disposal

Medical Health
Dunedin Hospital could experience flooding of its below-ground levels if stormwater reticulation is inoperative.

Mercy Hospital and other medical treatment sites should not be unduly affected but the Ambulance Service may experience access difficulties due to flooded roads and scouring caused by water flows.

Public Health
Advising people not to come into contact with potentially contaminated flood waters would be the main issue arising from damage to the stormwater system.

Emergency Services
The primary concern for all emergency services would be restrictions on access through surface flooding and road scouring.

Refuse Disposal

Medical Health
Dunedin Hospital fills a refuse skip in two days. Some of the waste generated is medical waste requiring special disposal procedures.

Mercy Hospital, general practitioners and emergency medical units and the Ambulance Service also generate medical wastes.

Public Health
The main public health concern is over difficulties in disposing of contaminated (flood water) or spoiled (refrigeration failure) foods from the 700 food outlets in the City and from domestic fridges and freezers. If collection and disposal at the landfill is not possible severe health effects could result.

Emergency Services
None of the emergency services generates refuse of a nature or quantity to cause problems.

Electricity Supply

Medical Health
Hospitals are highly reliant on electricity supplies and both Dunedin and Mercy hospitals have back-up generator capability.

The Dunedin Hospital generator will supply critical areas and minimal lighting in other areas and has fuel for thirty hours, while the boilerhouse generator has fuel for four days.

The Mercy Hospital generator provides 80% of the hospital's requirements.

General practitioners and emergency medical units can operate at about half their normal level during daylight without electricity. Some medical centres have wiring to enable a portable generator to supply their needs but don't have dedicated generators.

St John Ambulance has a generator with around 100 hours of fuel. This supplies operational but not administrative parts of their premises.

Public Health
Loss of access to computer records would be the only direct effect on public health authorities, but loss of refrigeration for foodstuffs could have serious public health consequences.

Emergency Services
Fire alarm systems are supposed to be fitted with 12 hour back-up batteries but after these run down alarms will not work. The Fire Service has a number of portable generators and a generator for the central Fire Station. Failure of power to their radio repeater sites will affect communications once back-up batteries become exhausted.

The Central Police Station has 72 hours of fuel for its back-up generator and the North Dunedin and South Dunedin stations each have around 12 hours of generator fuel.

The Civil Defence Headquarters has a generator with 72 hours of fuel and all vital equipment has battery back-up. The Civil Defence Emergency Communications Unit has full battery back-up and a portable generator. Ward headquarters sites have full back-up battery for their radio communication systems, which can also operate from car batteries. The premises themselves have no back-up power but basic battery and chemical lights are available for use at these sites.

Gas Supply (Fuel and Medical Gases)

Medical Health
Neither hospital is fully reliant on reticulated gas and Dunedin Hospital holds seven to nine days of LPG gas.

Both hospitals, general practicioners and the Ambulance Service use medical gases and supplies of bottled medical gases could easily be transported to Dunedin under all but the most severe circumstances.

Emergency Services
The primary concern with the reticulated gas supply would be getting it shut down rapidly to prevent fires or explosions from gas leaks.

Liquid & Solid Fuels

Medical Health
Dunedin Hospital uses steam from the coal-fired boilers for heating and cooking. Stored coal is sufficient for eight days of operation in summer but only three to four days in winter.

Mercy Hospital holds seven to ten days of boiler fuel.

St John Ambulance has a 10,000 litre underground tank of fuel for its ambulance fleet. The fuel pump runs from the generator but fuel can be pumped by hand in the last resort.

Emergency Services
The primary requirement is for vehicle fuels and all services rely on refuelling at normal service station facilities.

Transportation

Medical Health
The primary issues for all medical treatment sites is isolation from staff, patients and medical supplies. While the Ambulance Service has some four wheel drive ambulances and access to helicopters for moving patients where access is difficult, the number able to be moved this way would be relatively limited. Dunedin Hospital has a helipad and Mercy has large grounds which would provide landing space for helicopters.

Air transport is relied on for just-in-time delivery of many medical supplies so the operation of and access to the airport is critical.

Sea transport of medical supplies and medical evacuees would depend on the port being operational and the harbour navigable.

Loss of road and rail links into the city could create difficulty for delivery of medical gases and other supplies as well as for the medical evacuation of patients.

Public Health
The majority of public health functions require health personnel to operate in the field and restricted movement would hinder operations.

Emergency Services
Most emergency services rely on vehicular movement around the city to carry out their functions and any limitations on road transport would hinder this. While the Police and Civil Defence have access to four wheel drive vehicles, the Fire Service is reliant on its fire appliances which are not suited to off-road operation.

Loss of transport links into the city would limit the movement of supporting personnel and resources from other areas.

Communications

Medical Health
The Dunedin Hospital PABX is considered to be vulnerable, but fifty lines are hard-wired to default telephone positions in the hospital. The telepaging system operates on the generator power supply and the hospital is linked to the Ambulance Service radio-telephone system.

Mercy Hospital has hand-held radio equipment for communications on their own site but are reliant for all other communications on the public telephone system, as are general practitioners.

St John Ambulance has a full radio-telephone system which has a number of back-up operating modes and power supply options.

Public Health
Public health agencies have no communications other than the public telephone system.

Emergency Services
Police, Fire Service and Civil Defence all have full radio-telephone systems connecting their key sites and mobile vehicles as well as quantities of portable radio equipment including portable repeaters. The primary repeaters for all services have back-up power systems.

The Civil Defence Headquarters telephone exchange has tie-lines to the Police, Dunedin Hospital, St John Ambulance and a number of other organisations. If the public exchange is unable to switch calls between these organisations, the civil defence telephone exchange is capable of doing so if the lines remain intact.

The Civil Defence Emergency Communications Unit has radio communications equipment for all emergency agencies and is fully self-contained for field operations. The Police and Fire Service also have dedicated mobile command and communication units.

A remote radio broadcast facility at Civil Defence Headquarters enables simultaneous public information broadcasts to be made over the main Dunedin radio stations.

The 111 system is reliant on the public telephone system and any disruption to this has severe implications.

Emergency services place little reliance on cellular telephone networks due to their dependence on toll circuits and the ease with which the systems can be overloaded.

Buildings & Services

Medical Health
The Dunedin Hospital ward block is built to withstand over 2 metres of sway in an earthquake but the equipment and chemicals in the building are generally not seismically secured. The boilerhouse chimney may be vulnerable to earthquake, leading to a loss of steam production.

Mercy Hospital was built in the 1960's and has been extended over the years to prevailing seismic codes.

The After Hours Doctors Centre is in a relatively modern building but their equipment is not secured to withstand earthquake shaking and the wide spread of general practitioners' facilities throughout the city spreads the risk of major losses.

The operational part of the St John Ambulance building is of recent construction and of a seismically resistant design.

Public Health
Apart from access to equipment, health authorities are not particularly reliant on their buildings.

Emergency Services
The Central Fire Station is likely to suffer structural damage in an earthquake but other fire stations are more robust. Apart from access to fire appliances, the buildings themselves are not critical.

The Central Police Station is of recent seismically resistant construction.

The Civil Defence Headquarters was designed to withstand earthquake shaking. Many of the ward headquarters sites are in school buildings which have been assessed as being relatively safe.

HEALTH & EMERGENCY SERVICES - MITIGATION STRATEGIES

Water

Medical Health
Dunedin Hospital is supplied from a number of supply points, reducing the risk of complete water loss. Tankered water can be pumped into the main Dunedin Hospital tanks and from there pumped to other parts of the hospital.

Hospitals and medical treatment sites will have high priority for re-instatement of water supply through mains supply or temporary supply systems but all would have to implement water conservation procedures.

Public Health
Civil Defence Headquarters is equipped with a remote broadcast facility for local radio stations and this would be critical in getting public health information messages broadcast, but is dependent on the radio stations themselves remaining operational (see the chapter on Communications for details).

Emergency Services
The NZ Fire Service has identified a number of alternative fire fighting water supply sources, including Moana Pool and Speights Brewery (water supply). In the re-development of the Moana Pool complex, the desirability of a fire connection point for easy access to the pool water has been requested to be included in the design. In the event that water sources are scarce, fire control methods other than bulk water may have to be used. If all fires are brought under control, Fire Service resources will be available to assist with temporary water distribution.

Civil Defence Headquarters can be served by a rural fire trailer tanker brought into the carpark building. As this will not be immediately available and may not be potable water, a stored water supply is being investigated to serve the initial period of an emergency.

Sewage Disposal

Medical Health
The sump pump for the lower ground areas of Dunedin Hospital could be used to pump effluent from the hospital system into tankers for disposal, so long as road access is available and there is power to run the pump.

Mercy Hospital and the majority of other medical treatment sites are elevated and if necessary would have to continue discharging waste into damaged sewers.

Emergency Services
Alternative waste disposal for Civil Defence Headquarters is being investigated.

Stormwater Disposal

Medical Health
Protection of the Dunedin Hospital from excess stormwater entering lower areas will be a priority task, as a number of critical hospital systems are threatened by this. It is not practical to consider moving the large generators from this area, but future changes to the PABX system and electrical control systems should review their current vulnerable locations.

Emergency Servic es
The Civil Defence Headquarters has a raised floor to protect against excess stormwater affecting operations.

Refuse Disposal

Medical Health
Dunedin Hospital will establish a secure refuse disposal area and store waste until normal disposal is available again.

The After Hours Doctors centre will also use this facility and other medical health agencies will hold their own refuse in as secure a manner as possible.

Public Health
To reduce the volumes of foodstuffs perishing and needing to be disposed of, plans are in place to provide refrigerated containers for food storage and public health authorities will supervise disposal of unsafe foodstuffs.

Electricity

Medical Health and Emergency Services
The primary mitigation measure is ensuring ongoing fuel supplies for generators and refrigerated container units (see the chapter on Fuels).

Liquid & Solid Fuels

Medical Health
The Dunedin Hospital boiler can be run on coals other than those normally used although the resource consent does not allow for this. Steam will be limited to essential uses to conserve fuel.

Emergency Services
Emergency services, other than Ambulance, are totally reliant on the petroleum industry for the supply of vehicle fuels and will be among priority users if fuel stocks are limited. Petroleum supply companies are taking action to ensure that fuel from their bulk tanks can be accessed for this type of use.

Transportation

Medical Health
Rapid reinstatement of primary road and air transport links will be critical for medical health agencies for both access for staff and patients and supply of medical stores. Use of four wheel drive vehicles or stretcher teams may be the only way of transporting patients to other areas.

Communications

Priority re-instatement of telephone services to medical and emergency services sites is planned through the civil defence telephone re-connection priority lists.

Emergency services radio telephone systems are engineered and maintained to high standards and portable equipment is held to augment the main systems.

Buildings & Services

All health and emergency services are encouraged to survey their premises and secure critical stores and equipment against earthquake shaking.

The NZ Fire Service has plans to construct a new Central Fire Station.

CHAPTER 10. INTERDEPENDENCE OF LIFELINE SERVICES AND RECOVERY TIME ESTIMATES- CONTENTS

INTRODUCTION

No lifeline service can function wholly independently of one or more other lifelines.

While the primary focus of the vulnerability assessment phase of this project was on each group of lifeline services and the individual assets within it, the effects of interdependence can have a critical impact on service provisions and on recovery times.

The levels of interdependence are increased by the trend towards the use of contracted services for maintenance and recovery of damaged assets. In many cases, several lifeline services may rely on the same contractor.

Thus an assessment of the level of interdependence of lifelines became a key component of the vulnerability phase of the project.

To ensure that appropriate consideration was given by each individual service to dependence upon other services for reinstatement, recovery or ongoing daily operation, members were asked to identify the dependence of their particular service on others.

RESULTS OF INTERDEPENDENCE ASSESSMENT

In the assessment of interdependence, no attempt was made to define the extent of damage other than to state that it was widespread, random and disabling to all systems in some way. The dependence of each service on other lifelines is summarised in the tables appended to this section of Chapter 10.

When considering the interdependence of all lifelines, including fire, ambulance and police, the dependence of all services on each other was assessed to be:

- Roading (access)
- Fuels
- Communications
- Electricity Supply
- Buildings & Structures
- Water
- Stormwater
- Sewerage
- Airport
- Rail
- Harbour

Greatest dependence of services on this lifeline

Least dependence of services on this lifeline

When, however, the results are analysed further, the priorities are somewhat different. For example dependence of infrastructure services such as water, sewerage, and stormwater on other lifelines becomes:

- Electricity
- Roading (Access)
- Fuels
- Communications
- Buildings

Greatest dependence of services on this lifeline

Least dependence of services on this lifeline

For services such as police, fire and ambulance which are dependent on access and movement, the priority changes to primary dependence being on roading, fuels and communications, with some dependence on their buildings and water supply.

Individual agencies need to concentrate in the areas defined as of greatest dependence to them to ensure that their particular network and operation is protected against loss of these services for what could be lengthy periods. Conversely those services identified as being of greatest dependence for others need to review their networks and operations to ensure that a robust system is offered and the likelihood of loss of services to others who depend on them is minimised.

LIFELINES INTERDEPENDENCIES SCORING TABLE

AFFECTED LIFELINE	DEPENDENT LIFELINE															
	Water	Sewer-age	Storm-water	Elec-tricity	Fuels	Roading	Rail	Airport	Har-bour	Comm's	Build-ings	Police	Fire	Ambu-lance	Hos-pital	TOTAL
Water	-	1	1	1	4	1	1	1	3	1	4	4	4	2	4	32
Sewerage	1	-	1	1	4	1	1	1	2	1	4	1	1	4	4	27
Stormwater	2	3	-	1	2	3	1	2	1	3	2	2	2	4	3	31
Electicity	4	4	4	-	4	1	2	2	4	4	3	2	2	4	4	44
Fuels	2	3	3	4	-	4	4	3	4	1	3	4	4	4	4	47
Roading	3	3	3	3	4	-	3	3	4	2	4	4	4	4	4	48
Rail	1	1	1	1	1	1	-	1	4	1	1	1	1	3	3	21
Airport	1	1	1	1	4	1	1	-	1	1	1	2	3	3	3	24
Harbour	1	1	1	1	3	1	2	1	-	1	1	1	1	3	1	19
Comm's	2	2	2	2	4	3	3	4	4	-	4	4	4	4	4	46
Buildings	4	2	2	1	1	2	3	2	3	4	-	1	4	2	4	35
Police	3	2	3	3	4	1	4	4	1	2	4	-	-	-	-	31
Fire	3	2	3	3	4	1	4	4	1	2	4	-	-	-	-	31
Ambulance	1	1	1	1	1	1	1	1	1	3	3	-	-	-	-	15
Hospital	1	1	1	1	1	1	1	1	1	3	3	-	-	-	-	15
TOTAL	29	27	27	24	41	22	31	30	34	29	41	26	30	37	38	-

INTERDEPENDENCE RATING

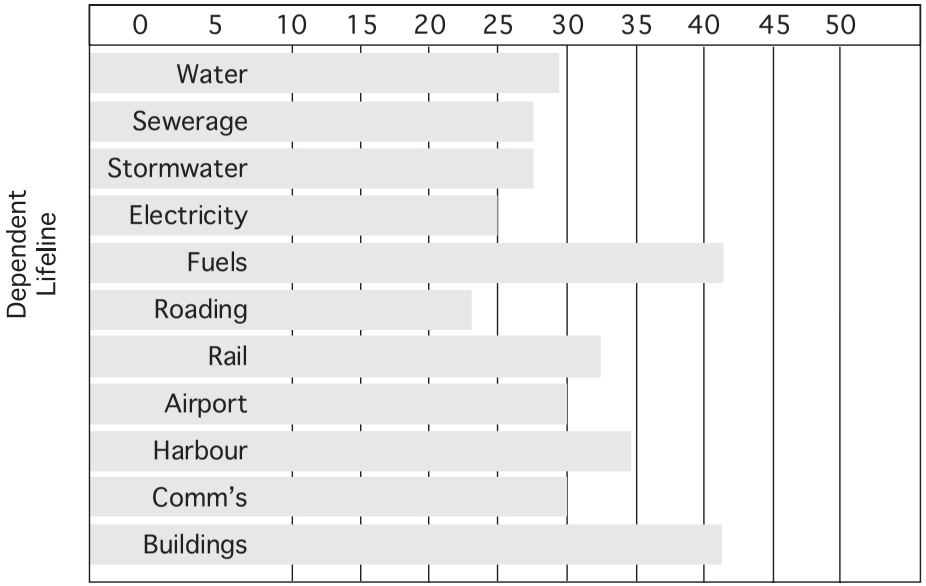
Significant Minor

4 3 2 1

LIFELINE INTERDEPENDENCIES

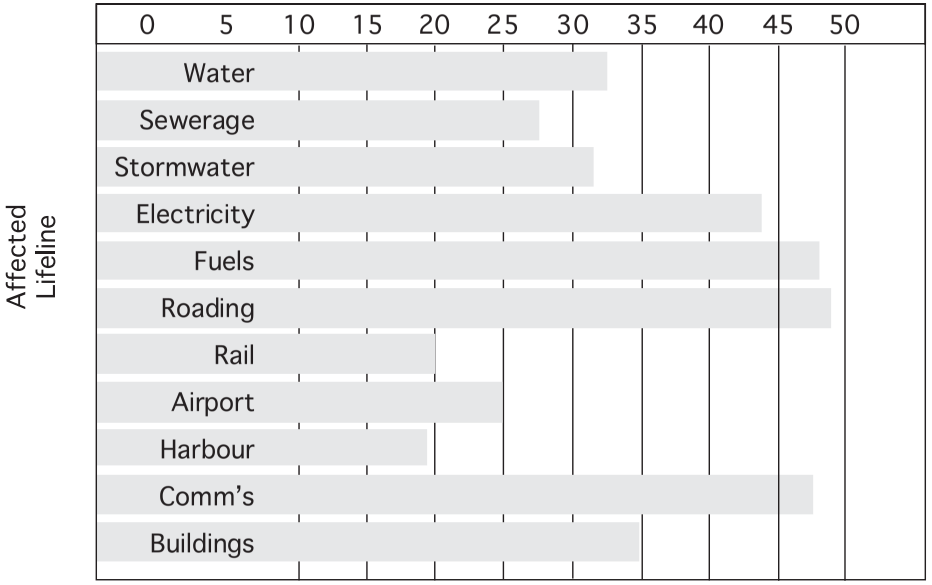
Comparative Dependence on Other Lifelines

Level of Dependence on all other Lifelines



Impact of Loss on Other Lifelines

Impact of loss of affected lifeline on other lifelines



Health & Emergency Services

Dependence on Lifelines

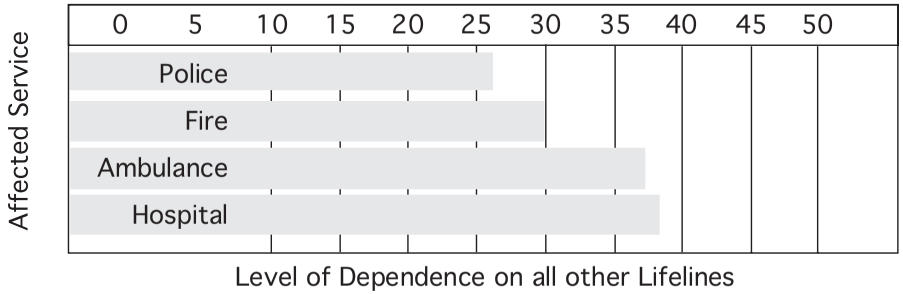


Table Here

THE RECOVERY PERIOD

Introduction

A scenario-based review of typically expected loss of lifeline services throughout the greater city area from seismic events (including liquefaction and earthquake induced landslip), flooding, tsunami, meteorological and technological events was produced to approximate the likely services losses and recovery times which may be expected.

Because of the uncertain nature of hazard impacts, detailed and accurate losses and recovery times cannot be determined.

The purpose of producing these assessments is to provide a simple measure against which other agencies may develop planning to operate without the lifeline concerned, or implement mitigation strategies to provide alternative service.

Water Supply Scenario

Seismic Events

- Raw water intake will be reduced by 60% and restoration of supply will take between 30 and 120 days.
- Treatment of water is likely to be disrupted for between 7 and 14 days with 40% loss of capacity if Mt Grand is disabled and up to 120 days if the Taieri Bridge is out of commission.
- Reticulation will be damaged in numerous places with restricted supply for 3 to 4 weeks over 20% of the city. Worst affected areas are likely to be South Dunedin, St Kilda, Kaikorai Valley, Mosgiel, Peninsula. However supply tothe Central Business District is likely to be satisfactory.
- Storage capacity will be critical in some areas which are serviced by isolated installations such as Montecillo, Fairfield and at Southern reservoir where a 15% loss of city supply may take 2 to 4 weeks to restore. The Peninsula storage is likely to be disrupted for a slightly longer period.
- There will be negligible damage to the water supply depots. Restricted supply (particularly to hill suburbs) may be needed to facilitate work repair to pipeline fractures or reservoir damage. This may continue for several weeks.

Flooding, Tsunami, Meteorological or Technological Events

- Raw water supply pipes damaged by flood and settlement or landslip:
    - Deep Creek and Deep Stream 20% disability estimated for 1 to 3 weeks.
    - Taieri Plain pipelines only 5% disability for 3 to 10 days.
    - Taieri Bores could be 100% unserviceable for 28 days.
- Treatment and storage facilities will have limited damage due to meteorological conditions causing operating difficulties but no significant functional loss.
- City reticulation could be damaged in numerous localities due to pipe settlement or wash aways, slips etc but generally only 10% system loss of function with reinstatement in a 1 to 3 week period. Principal localities at risk are South Dunedin, St Kilda, Kaikorai Valley and North East Valley, the Peninsula and Fairfield.
- Water supply depots will generally be unaffected.
- There is always a possibility of vandalism and more serious deliberate tampering with the water supply function and product. In the light of historical record, it is not possible to offer a calculable probability of disability to the system.

Sewage Scenario

Seismic Events (including liquefaction and induced landslip)

- Damage to pumping stations could result in the loss of 60% of capacity to drain the city area, and dependent upon the extent of damage to pumps and screens, will take from 8 to 26 weeks to repair (the latter time if damage occurs to the rising main).
- General reticulation damage will occur in the lower lying areas of the city with many collar breaks in Andersons Bay, South Dunedin, St Kilda and around the University and lower Central Business

District. It is estimated that 25% loss of service to city reticulation will take from 3 to 8 weeks to repair.
- Treatment plant and ocean outfalls are expected to suffer a 20% disability and require 2 to 8 weeks to reinstate.
- During the immediate and short term recovery period there is likely to be a need for discharge of untreated sewage to the harbour which will pose a health risk.

Flooding, Tsunami, Meteorological or Technological Events
- Expected damage to main sewers is caused by settlement, landslip and considerable infiltration placing a strain upon the reticulation and pumping system within the city area. There is likely to be a 10% loss of overall function which will require 7 to 14 days to reinstate. Localities principally at risk are in lower lying areas of South Dunedin and St Kilda.
- In the outlying districts the major pipeline and pumping mains associated with Mosgiel and Green Island sewage treatment plants are at risk from settlement, landslip and surcharge of lines as within the central city area. The loss of function is likely to be about 10% of the overall system but repair may take slightly longer due to access difficulties and take say 1 to 3 weeks to recover.

Stormwater Scenario

Seismic Events
- It is estimated that there will be an overall disability of disposal service of the order of 15% with an estimated repair period of between 4 and 8 weeks. This lengthy time will be the result of prioritising work.
- Damage is likely to be wide-spread with surface run-off carried to natural water courses and this may cause damage to underground services (power, telecommunications, gas etc) from infiltration and scour.
- Roading is certain to be damaged and open channels will suffer from blockage due to landslip.
- Pumping stations are expected to suffer minimal damage but service disruption will occur owing to power losses and pipework damage. An estimated 15% overall loss of service for a period of 7 to 14 days is possible.

Flooding, Tsunami, Meteorological or Technological Events
- Trunk stormwater pipework, pumping stations and open channel watercourses are likely to suffer damage through landslip, overcharged pipework, settlement and collar breakages, debris transmission and wash-outs. It is estimated that 7.5 to 10% of the city system will be affected and recovery will take 1 to 3 weeks.
- Outlying districts will suffer less from flooding with the exception of Mosgiel which tends to flood in lower areas of Owhiro Stream.

Refuse Disposal Scenario

Seismic Events
- There is expected to be little loss of function on the various landfill sites around the city. Possible damage may occur to the leachate pumping system at Green Island, but the overall disability to all sites is likely to be negligible and any repair work will be carried out as a non-urgent activity within 3 to 7 days.
- Roading damage will cause disruption to domestic rubbish collection.

Flooding, Tsunami, Meteorological or Technological Events
- Little damage should occur to the refuse disposal system apart from accessibility. The advent of tsunami may (in extreme conditions) cause more prolonged inundation of the Green Island disposal area and possibly damage to the leachate system but damage is expected to be minimal and recovery will take 3 to 7 days at worst.

Electricity Scenario

Seismic Events
- Because of extensive diversity it is expected that there will be no major loss of power supply, but

intermittent power outages will occur over the entire area for a period of between 1 to 3 weeks after the event.
- The principal cause of outage will be failure at sub-stations, due to building and equipment damage, and loss of pole mounted transformers throughout the city. (Some 75% of supply is overhead.)
- Load-shedding and repair outages will be commonplace at this time and it is anticipated that some 30% of the area supply system will be affected in some way.
- South Dunedin and the harbour commercial areas are likely to be the worst affected.

Flooding, Tsunami, Meteorological or Technological Events
- Periodic, but short term loss of high voltage supply due to weather conditions is generally unpredictable and not preventable. It is assessed as a 10% loss of service of not greater than 24 hours.
- Physical damage by weather to high voltage lines and towers, transformers and sub-stations is perceived as being minimal with 10% loss of service function on a broadly based and well diversified system, with reduction of supply being recovered within 3 to 7 days in all cases.
- Flooding and landslip are likely to be damaging to underground cables particularly in areas of South Dunedin, St Kilda, Kaikorai Valley and North East Valley, with some damage from washout. A general loss of 5-10% of systems in these areas, with restoration within 1-3 days is the anticipated worst case.
- Landslip causing damage to lines, transformers and pole mounted units will result in 5% losses of service for 1-3 days.

Gas Scenario

Seismic Events
- Total shut-down of the network for safety reasons may take 6 weeks to restore.
- Damage to the gas holder at Kensington will cause major disruption.
- Damage due to water infiltration may result in considerable delays in restoring supply.
- Fracture to pipes will cause pockets of explosive gas with considerable danger of serious fire damage.

Flooding, Tsunami, Meteorological or Technological Events
- Flooding, weather and technological hazards will cause serious loss of service for several reasons:
  - Full loss of gas production at the landfill site for 1-3 weeks.
  - Infiltration of water to gas lines following landslip, requiring replacement and purging, may cause 100% loss of service for 1-3 weeks.
  - Damage to the system by vandalism could require whole or partial close down of the system for purging, taking up to a week to reinstate.

Liquid and Solid Fuels Scenario

Seismic Events
- Distribution of stock in bulk delivery should not pose a problem if road transport and road surfaces permit. Tankage is likely to survive, but some delivery pipes may be damaged and cause a 10% disability of service for a period of 7 days.
- Delivery of new stock (both liquid and solid fuels) will be inhibited by damaged road access (particularly from the north) and any disruption to the harbour channel and berthing facilities. An estimated 50% loss of the oil wharf facility may extend for up to 6 weeks, requiring road transport servicing of bulk fuel supplies if road access is available.
- Loss of the oil wharf facility will necessitate rationing, as road transport supply can only transfer limited quantities of fuel. This would impact upon services dramatically if the hazard event was close to the time of a tankship call when stocks were at low level.

Flooding, Tsunami, Meteorological or Technological Events
- Re-supply of fuel stocks from north and south may be delayed. This disruption does not appear to be too serious, provided that adequate stocks of liquid fuel and coal are maintained in the city.
- In extreme conditions, solid fuels may be delivered by sea.
- Distribution may be inhibited by flooding and general road conditions but generally such events will be of short duration, affecting supply for 3 to 7 days at worst.

Roading Scenario

Seismic Events

- State Highway 1 to the north could be closed from between 3 to 7 days with damage to bridges, landslip and road surface heave. Particular areas of damage are expected at Tumai Overpass, Kilmog and Northern Motorway.
- State Highway 1 southwards is expected to remain open with some loss of function due to surface heave. Repairs are likely to be extended up to 30 days as non-priority activity.
- State Highway 88 to Port Chalmers will be unusable for 3 to 7 days and may severely inhibit port operations.
- Major city roads will be affected by surface heave, debris and surface flooding from burst water mains. Disruption to major city roads such as Portsmouth Drive and Kaikorai Valley Road may involve 20% of the routes and may not be fully restored for up to 30 days.
- Approximately 20% of all secondary and general roading will be disabled due to surface damage, collapsed structures, burst pipework damage, fallen trees etc and prioritising will be necessary to secure recovery of certain essential service roads, ie communications, power access. Full recovery may take up to 30 days.
- Bridges, both on the state highway system and throughout the city, are likely to be disabled by failure at the abutments and in some instances slipping of deck structure. The probable order of loss of function of city bridges is placed at 15% of stock, with an extended repair period of between 4 and 5 weeks.

Flooding, Tsunami, Meteorological or Technological Events

- State Highway 1 north may be closed for 1 to 3 days by major landslip, generated by weather or flooding/tsunami, involving 100% loss of service during reinstatement.
- State Highway 1 south may be closed for 1 to 3 days by major flooding and damage to bridges, with 100% loss of service.
- State Highway 88 to Port Chalmers may be disabled by weather causing slips or by tsunami damage and may be closed for 1 to 3 days pending repair.
- Major city roads will not be significantly damaged except for the following which are likely to experience 100% loss of service for the periods stated:
    - Portsmouth Drive - tsunami wash-away 3-7 days
    - Kaikorai Valley Road - flood from Kaikorai Stream 1-2 days
    - North East Valley Road - flood from Lindsay Creek 1-2 days
    - Kaikorai Estuary - tsunami and flood (bridge damaged) 3-7 days
- Secondary roads and access routes will be disabled by flood or slip for relatively short periods assessed at 3-7 days, depending upon priority of re-working. Generally only 10% of all stock will be affected in this way.
- Bridges are not expected to be significantly damaged, except for that over the Kaikorai Estuary and some minor structures in low-lying areas. These represent 5% of bridges, which could be closed for 2-3 days.

Harbour Scenario

Seismic Events

- Damage to the entrance channel from Taiaroa Head to Port Chalmers and onward to the Upper Harbour is likely to be in the form of collapse of the sides of the dredged channel and loss of navigation beacons. This may restrict berthing of larger vessels at both locations.
- Channel dredging will be needed and service restricted by 30%:
    - Taiaroa Head - Port Chalmers 14-30 days.
    - Port Chalmers - Upper Harbour 30-120 days.
- Smaller vessels are likely to be able to operate in daylight within 3 days, berthing at both locations. There will be uncertainty about LPG bulk supplies arriving by sea for up to 4 weeks because of vessel size.
- Port Chalmers facilities, craneage and general port operations are likely to suffer a 30% disability for a period of between 30-120 days depending upon severity of damage to non-redundant equipment.
- Some service pipework and electrical services will be damaged and hard standing areas will become

unsafe for container operations.

Flooding, Tsunami, Meteorological or Technological Events

- No serious damage is expected, but tsunami is likely to damage wharf protection works and weather may cause landslip damage. This damage is unlikely to cause significant loss of service and should be in effect for no more than 3 days.

Rail Systems Scenario

Seismic Events

- Track to the north is likely to be disabled 100% for a period of 3-10 weeks, dependant upon slip damage and bridge/tunnel conditions.
- Track to the south will be subject to reduced service, pending repair to anticipated track settlement. There will be bridge abutment damage and minor tunnel damage, but this will only represent 30% disability for a period of 1-3 weeks.
- The Dunedin to Port Chalmers line is expected to be affected in the same way as the track to the south and in roughly the same range of disability, possibly 50%.

Flooding, Tsunami, Meteorological or Technological Events

- Track to the north may be disabled 100% by slips and is subject to tsunami damage at several locations. The period of closure will vary greatly, but probably lies at 3-10 weeks.
- Track to the south could well be disabled 100% by flooding which could also damage bridge abutments and embankments. Slips may also occur. The period of reinstatement may vary from 1 to 3 weeks.
- The Dunedin to Port Chalmers line will probably close due to grade slipping but for a relatively short period of 3 to 7 days.

Air Transport Scenario

Seismic Events

- Dunedin Airport is expected to suffer minimum disruption at 15% disability on normal service. The runway is expected to remain operational for daylight operations only for a period of 3 to 7 days, pending re-calibration and restoration of navigational systems. The buildings will be damaged and suffer a greater loss of function, probably 25% disability, for 4 to 6 weeks, but will remain operational.
- At Taieri Airport and Dunedin Hospital Helipad no disruption is expected.

Flooding, Tsunami, Meteorological or Technological Events

- Historically, the most serious event which may recur is flooding. Any flooding of the runway will effectively stop aircraft movements at Dunedin Airport, but access to the airport may become difficult even if the runway is operational. Probably 100% loss of service will occur for a period of 2-3 weeks if the runway is covered and 3-7 days in localised flooding of airport access.
- Taieri Airport may be rendered 100% non-operational by extended bad weather for 3-7 days.
- The Hospital Helipad may experience shut-down for short periods due to weather condition (particularly strong winds), usually not exceeding 3 days.

Road Passenger Transport / Heavy Haulage Scenario

Seismic Events

- Some loss of vehicle stock is expected due to building collapse, with loss of maintenance facilities. The expected overall stock/maintenance loss of 10% will be recoverable in 7 to 10 days.
- There will be disruption of city services due to road conditions and possibly fuel shortages for a period of 7 to 10 days.
- Heavy demand will be placed upon heavy haulage vehicles for repair work and these may be subject to travel restrictions due to road damage.
- Haulage of goods from the north will require substantial deviations of route for 3 to 7 days.

Flooding, Tsunami, Meteorological or Technological Events

- Vehicle losses will be negligible, although there will be some loss of operating efficiency and choice of routes.
- Some service centres could be affected by flooding or tsunami effect, with general loss of service of no more than 5% for a period not exceeding 5 days.

Communications Scenario

Seismic Events

Telecommunications

- There will be severe disruption of service with a 25% disability on all services for the first 3 days and overloading of circuits in particularly badly affected areas. Exchange buildings will suffer minimal damage but microwave systems will require re-calibration, which should be readily achieved. Damage will be caused to landline cables by ingress of water from burst mains. The railway signal system will require re-calibration but should be readily restored.
- Toll links will offer limited service for 3-7 days.
- Local calls will be disrupted for 7-14 days.
- The Cellular network will be disrupted for 3-7 days.
- Full service restoration expected to take up to 3 weeks.

Broadcasting

- Only 10% loss of overall function is anticipated, with principal disability occurring on the first day and full service reinstatement will take up to 3 weeks, dependent upon availability of spare equipment and technicians.
- Loss of power supply, landline cable connections, and damage to buildings will be responsible for major service disruption.

Flooding, Tsunami, Meteorological or Technological Events

Telecommunications

- General meteorological conditions may cause some operational difficulties in normal circumstances but extreme conditions will cause service disabilities of the following orders and for similar reasons to the seismic events:
  - Toll links with limited service for 1-2 days.
  - Local calls disrupted 1-3 days.
  - Cellular net disrupted 1-2 days.
- Overall service disruption due to cable damage, winds, snow etc is estimated to affect only 15% of the system and in many instances alternative routing may be available.
- Railway landlines may be more severely damaged by slips and might need additional repair times of 1-3 weeks, depending upon severity.

Broadcasting

- Services are estimated to suffer 10% loss of function and be repaired in 1-3 days.
- The most significant problem will be power supply loss, but generally this outage will affect the system for no more than 24 hours.
- Full service restoration is dependent upon the availability of technicians and replacement equipment.

Buildings and Services Scenario

Seismic Events

Structures

- Modern commercial buildings will generally survive with only minor damage to glazing and peripheral structures.
- Pre 1960 (or thereabouts) commercial buildings will suffer more damage, with an anticipated 5% loss of function on the building stock. Typical failures will be due to collapse of retaining walls, infill panels, brickwork, canopies and glazing. Street access may be impeded by debris and, while some buildings may warrant demolition, most will be suitable for repair and upgrade. The period for recovery of building damage is difficult to assess but is likely to lie between 3-12 weeks before re-occupancy.
- It is estimated that there will be damage to 30% of domestic housing stock, but probably only 5% will be unsuitable for occupancy and then only for 3-12 weeks. Structural performance of buildings is

strongly related to age, with more modern buildings offering better security against damage.

Internal Services and Fittings

- Connections of water supply, waste services and power may be severed, with probably 20% of building stock damaged in this way. Header tank leakage, hot water tanks being shifted and connections broken, misalignment of lifts and activation of fire sprinkler systems will cause internal damage.
- Internal fittings and cabling will be damaged, including suspended ceilings, doors, security systems and furnishings will be broken and computer equipment may be damaged.
- Items on open shelves will fall.
- Up to 5% of commercial buildings may be unoccupiable for a period 3-4 weeks.

Flooding, Tsunami, Meteorological or Technological Events

Structures

- Generally there will be no loss of buildings other than from wind damage. Some glazing damage will occur from time to time and roofing will be blown away. Anticipated loss of service from events in this category is likely to be below 5% of all types of buildings, with unsuitability for occupancy being of the same order. Repair periods will naturally vary but will usually average 1-3 weeks.

Internal Services and Fittings

- Almost always the most susceptible element is content damage from meteorological conditions with approximately 5% of buildings suffering services and fittings damaged in worst events.
- It is particularly difficult to assess the degree of service loss and the time required for repair or reinstatement but it is clear that certain areas of the city such as South Dunedin and St Kilda are particularly vulnerable and reinstatement from the effects of flood could be lengthy.

Summary of Recovery Periods

A summary of indicative anticipated recovery periods from serious hazard impacts is presented in the table below.

Summary of Recovery Periods

Utility	Basic Service	Full Service
Water	2-3 weeks	4 months
Sewage	3-6 weeks	4-6 months
Stormwater	2-3 weeks	2-3 months
Refuse Disposal	3-5 days	5-7 days
Electricity	1 week	3-4 weeks
Gas	1-3 weeks	6 weeks
Liquid/Solid Fuels	1-2 weeks	5-6 weeks
Roading	3-7 days	5-6 weeks
Harbour	1-2 weeks	4-6 months
Rail Systems	1-3 weeks	3 months
Air Transport	1-2 days	3-4 weeks
Road/Passenger Transport	3-5 days	2-4 weeks
Communications	1-3 days	3 weeks

The times indicated assume that the resources needed to restore a particular service will be available as required, although the reality in a major event will be that priorities will have to be established and the

periods in the table will be the minimum likely to be experienced.

Should major hazard impact extend to other cities or districts, the periods of recovery may extend beyond those given, due to loss of availability of skilled personnel, equipment and materials normally expected to be supplied from outside Dunedin.

Basic service means service for shortened hours or where considerable inconvenience is experienced by users, or where rationing of the service commodity is needed. Safety considerations may involve total closure.

Full Service is when supply or service is largely restored to pre-event condition, although some general work of a non-essential nature may be ongoing.

REDUCING THE LEVEL OF DEPENDENCE

Actions need to be considered which will make each lifeline more robust. The following factors need to be considered:

Reduction of Dependence on Other Lifelines for Basic Services

In the initial response period the ability to get about and get to facilities is likely to be critical, and this is recognised in the priority of dependence identified earlier in this chapter. Road access and availability of fuels will be critical for most lifelines and resources are likely to be concentrated on addressing these issues initially.

With resources to reinstate lifelines being scarce or limited for some period, each lifeline operator needs to consider what they can do to protect their lifeline from dependence on potentially disrupted services. For example:

- Water, sewerage and stormwater need to consider the use of emergency generators for critical facilities, the structural integrity of their buildings and the services mounted within them and their communication systems so that they are functional and available following a hazard event.
- Police, fire and ambulance need to ensure that they have access to sufficient fuel and that their communications networks are robust and functional without the need for extensive restoration effort. They should also consider the need for 4WD vehicles for movement on damaged roads.

Robustness of Services to Critical Facilities

Some critical facilities are highly dependent on other lifelines. For example:

- Dunedin Hospital depends on water, sewerage, electricity, fuels for heating, road access, communications and their specialised buildings.
- The sewerage system relies on power supply to pumping stations and treatment plants (although the main installations at Musselburgh, Tahuna and Green Island have, or soon will have, emergency generators).
- The water system depends on power supply to pumping stations, treatment plants and control valves.
- The electricity supply companies require the availability of fuel to enable restoration works to be facilitated.

As part of their mitigation measures, each lifeline should review the dependence others have on their service at critical facilities and address how the supply of this service can be made more robust, avoid hazards or provide for alternative supply sources. Conversely, each lifeline should address how it will cope with failure of services on which it depends and, where possible, have appropriate mitigation strategies in place such as provision of emergency generators, adequate emergency storage of water, access to fuel and alternative communication facilities.

Coping With Limited and Rationed Resources

Dunedin is a small city and, in the case of a significant event causing widespread damage, a lot of work will be required to restore lifelines to even basic operation. Over the initial period resources will be limited and it is likely to be some days before significant resources (in terms of materials, equipment and skilled labour)

will be available from outside the City.

Any shortage of resources will result in conflicts, particularly where those resources are provided by contractors with commitments to a number of different lifeline operators, including those outside Dunedin in a wider emergency event.

As asset managers develop their mitigation and response strategies, it will be essential that material and parts requirements are assessed and either adequate stocks held or able to be accessed at short notice. Appropriately skilled personnel need to be provided for through contracts, mutual support agreements or other arrangements.

Civil Defence should facilitate pre-planning with regard to identifying the priority to be afforded to particular facilities and services under emergency conditions.

Flexibility in Planning and Mitigation Strategies

Inevitably there will be a need to establish priorities appropriate to any emergency or event but there will always be some uncertainty as to the actual form, scope and impact of a particular hazard event. Arrangements must therefore be flexible and allow for some fluidity as to what may need to be done and when. Mitigation strategies need to reflect the possible delay in access to resources - perhaps through more physical mitigation measures at key facilities which will provide a higher level of security in the event of an emergency. Planning could provide for shut-down in a fail-safe way to conserve what could be a scarce resource. Earthquake-activated shut-down valves on reservoirs are an example of this approach.

CONCLUSIONS

All lifelines depend on others and each operator must not only address how they can make their own service more robust and able to be restored as soon as possible, but must also address how they can contribute to making other lifelines which depend on their service more robust, particularly the critical facilities.

With resources likely to be limited in the event of a significant impact, consideration needs to be given to planning for such an event with a view to establishing the priority for reinstatement of facilities and services. Civil Defence is probably the best agency to facilitate such planning since the earliest decisions needed in an event are likely to be in their hands.

CHAPTER 11. PROJECT CONTINUATION- CONTENTS