5. EARTHQUAKE

5.1 Summary

In September 2010 and February 2011, Canterbury experienced significant earthquakes affecting the city and outlying rural areas. This has provided a live test in New Zealand on the infrastructure and its ability to withstand such an event. Many of the assumptions and expected effects described in this section have been based on the Canterbury experience, however it is also recognised that the unique geological conditions mean that the expected impact of an Auckland earthquake cannot be entirely predicated on Canterbury experience.

This level of ground shaking is the level at which liquefaction of vulnerable soil types starts to occur. It can be expected that damage to non-ductile pipes and older, unreinforced structures will occur in all areas, with the most significant damage in areas of steep slopes and liquefiable soils. The impacts by sector are further discussed below.

Earthquake Hazard

Auckland is one of New Zealand's least seismically active regions, however the hazard to the region should not be discounted as the effects of a damaging earthquake would be significant due to the city's concentrated population.

For this project, a uniform hazard scenario has been assessed where ground shaking occurs uniformly across the region, with shaking equating to an earthquake with a return period of around 2,500 years. The scenario results in Peak Ground Accelerations (PGA) of 0.17g to 0.27g (depending on soil type) for the central Auckland area.

Infrastructure Impacts from Uniform Hazard Scenario

Electricity

- Overhead lines are less susceptible to damage causing outages than underground lines. The earthquake intensities considered are within standard design for electricity infrastructure although some localised outages could occur from damage to substations. The bulk transmission network is expected to be repaired relatively quickly.

Fuel and Gas

- Potential damage to the petroleum and gas networks could result from damage to underground pipes through liquefaction or critical infrastructure such as the Densitometer site for petroleum or the Westfield Gate Station for the gas network. Full service recovery is expected within 24 hours.

Telecommunications

- Copper landline networks are the most non-ductile of the telecommunications infrastructure and at the greatest risk of impact, particularly in areas that are on a single path access.
- Cellular networks have considerable redundancy built in to them to ensure the capacity meets the demand, particularly in high density areas such as the Auckland CBD. However, any outages of the cellular network will reduce capacity and increase the likelihood of congestion.
- The telecommunications sector is reliant on electricity to operate although all networks have built in back up supply or generators readily available for deployment. The sector also needs cooling water for some equipment. However both the electricity and water sector anticipate quick recovery times.
- Recovery of most of the telecommunications sector is expected to occur within a week, although there will be increased congestion in the beginning and some customers may experience longer term problems with their individual land line connection supplied by the copper networks.

Water Supply

- Water sources, treatment and trunk transmission systems are not expected to incur damage that would result in widespread supply disruption. Some damage is expected to transmission and networks distribution systems comprising non-ductile pipe systems, in particular the Auckland CBD, Takanini and rural Helensville, due to liquefaction. There may be challenges treating water contaminated with slip debris and silt. Full recovery is expected to take in excess of three months and possibly years.

Wastewater and Stormwater

- It is likely the wastewater network will suffer damage across the network systems comprising non-ductile pipe systems due to ground shaking and acceleration and liquefaction. The stormwater network will be similarly affected. Full recovery is expected to take in excess of three months and possibly years.

Transport

- Transport relies heavily on fixed infrastructure like roads, rail lines, wharves and runways. All of these solid, inflexible structures are at risk of fracture from ground shaking, acceleration and especially liquefaction. The failure of bridges could cause blockages to entire routes and although many bridges are designed for earthquake capacity, the approaches may be affected.
- There is expected to be minimal impact on the airport.
- A portion of the wharves are built on reclaimed land and are at risk of liquefaction so may become inoperable.
- Transport access for assessment and repair of infrastructure will be the main issue for all utilities and will require careful prioritisation.

Coordination of the response is critical due to the dependency of lifeline utilities on each other.

5.2 Earthquake Hazard

General Risk Overview

Auckland is one of New Zealand's least seismically active regions. It is some 300km from the major north-east/south-west oriented seismically active zone underlying the east coast of the North Island that marks the boundary between the Australian and Pacific tectonic plates. Despite seismic activity being lower than much of the rest of New Zealand, earthquake hazards in Auckland should not be discounted as the effects of a large earthquake would be significant due to the city's concentrated population.

Only one active fault, the Wairoa North Fault, has been identified in Auckland. Faults outside of Auckland, such as the Kerepehi Fault in Waikato, also have the potential to generate damaging earthquakes within the Auckland region.

Historical earthquakes and their effects, together with known potentially active faults are further described in the Auckland Regional Council's Technical Report No. 2009/010 February 2009.

Areas at higher risk of liquefaction include mostly low lying coastal areas including the reclaimed land of the central business district as well as patches of highly populated areas such as Te Atatu South, Wairau Valley, Auckland Airport and Takanini.

The NZ National Seismic Hazard Model, reviewed and updated in 2012 indicates that Auckland's earthquake risk is lower than previously thought (refer Figure 5-2).

Scenario Development for AELP-2

The Auckland Engineering Lifelines Project, Phase 1 (AELP-1) assessed the region's geology in terms of its ground shaking and liquefaction potential. In AELP-1, two scenarios were modelled:

1. A uniform hazard scenario where ground shaking occurs uniformly across the region, with shaking equating to an earthquake with a return period of 2,000 years. The model uses two seismic source regions around the greater Auckland area:
    - New Zealand based PGA and MM intensity attenuation functions and inclusion of large earthquakes from the Kerepehi Fault
    - an estimated PGA of 0.17g to 0.27g (depending on the soil type) for the central Auckland area

    When applied uniformly to the whole of the Auckland Region, this model allows an assessment of the earthquake - induced slope instability hazard and liquefaction susceptibility within 20km of a 'potential earthquake epicentre anywhere in the Region.

2. A specific scenario with a point source magnitude 6.0 earthquake at 10km depth with an epicentre 20km east of central Auckland.

For AELP-2, only the uniform hazard scenario has been assessed. Critical assets were overlaid on liquefiable-prone soil types and damage assessment undertaken assuming PGA of 0.2g to 0.3g across the region. Given the seismic model shown in Figure 3-3, this represents an earthquake hazard greater than a 1:2,500 event.

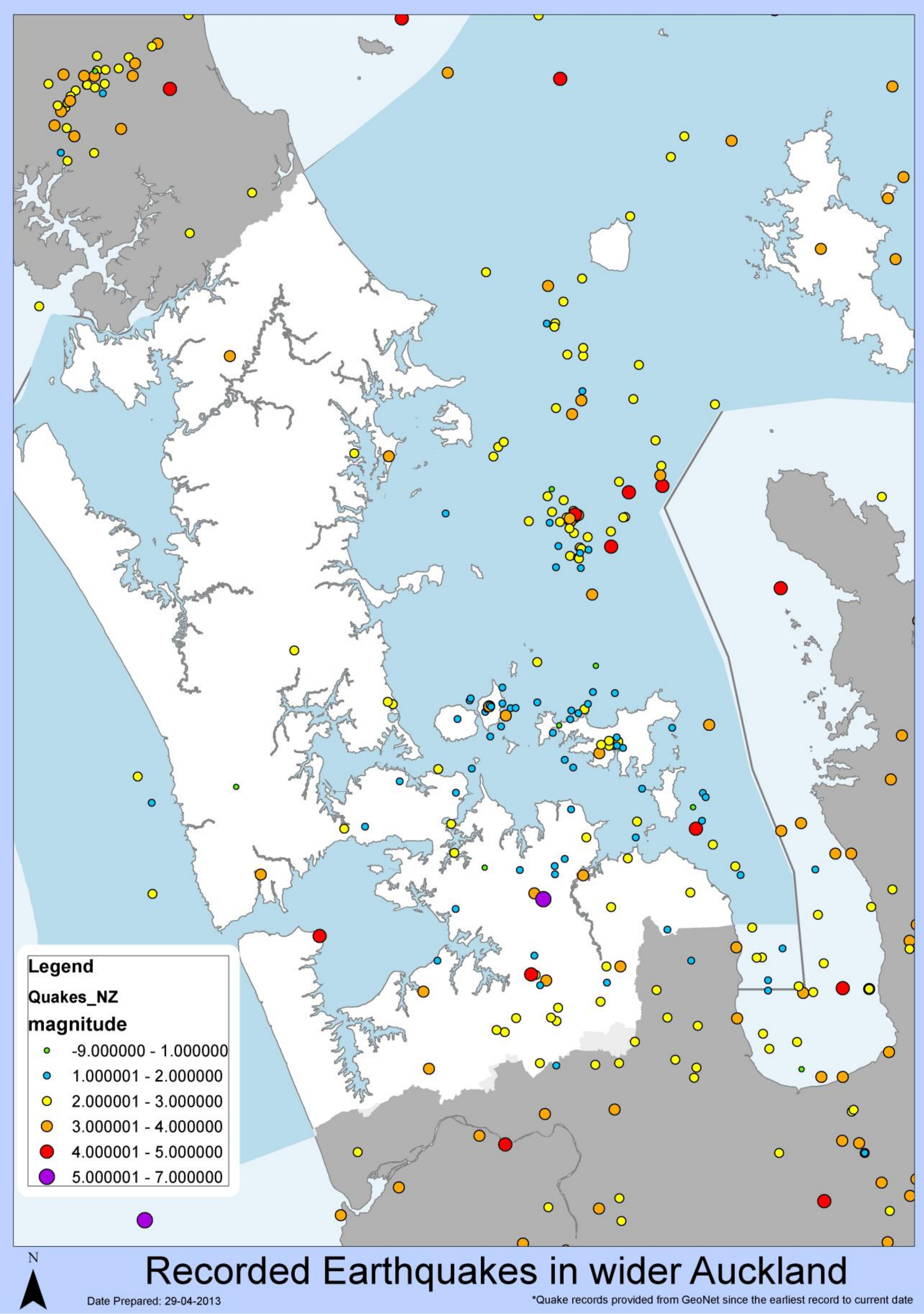


Figure 5-1: Recorded Earthquakes in Wider Auckland

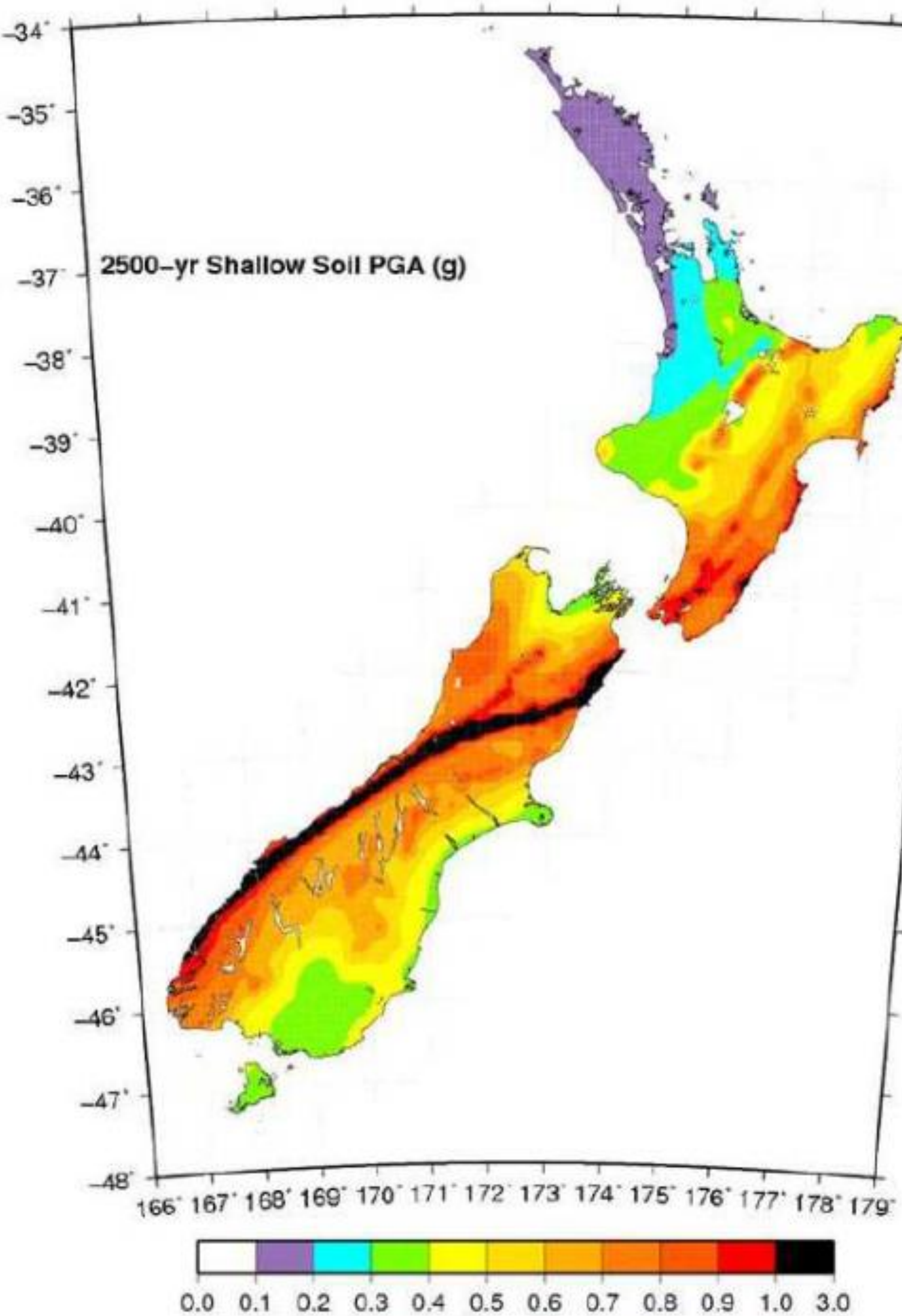


Figure 5-2: NZ Seismic Model[1]

[1] Stirling et al (2012)

5.3 Overview of Infrastructure Impacts

Liquefaction or liquefiable soils pose one of the biggest risks to infrastructure during an earthquake. Some parts of Auckland are on reclaimed and unconsolidated land making these areas more susceptible to the effects of liquefaction. The table in Attachment 1 outlines the specific risk to lifeline utilities from liquefaction during the uniform scenario hazard. The matrix addresses earthquake induced damage in broad terms based on:

- the likely design factors of safety for each type of structure
- earthquake hazard models developed for recent engineering projects in Auckland City
- observed performance of similar structures in other recent earthquakes
- the Modified Mercalli Intensity scale as presented by the Study Group of the New Zealand Society for Earthquake Engineering 1992 in the Bulletin of the New Zealand National Society for Earthquake Engineering 25: 345 – 357

The following sections summarise:

- expected network and service impacts under the uniform hazard scenario (which was described in Section 3.3).
- response and recovery activities following an earthquake
- future work that could be undertaken to improve the response or resilience to an earthquake in Auckland.

The analysis was initiated during workshops held in November 2011 to:

- consolidate the learnings from the Canterbury Earthquakes to identify future improvements; and
- mobilise the assessment of the infrastructure impacts using hazard maps overlaid on critical assets.

5.4 Energy

The Canterbury earthquakes in 2010 and 2011 showed that overhead lines are less susceptible to damage causing outages than underground lines. The earthquake intensities considered in the Auckland scenario are within standard design for electricity infrastructure although some localised outages could occur from damage to substations. These are expected to be repaired relatively quickly. Underground cables in liquefiable soils are expected to take the longest for restoration.

Potential damage to the petroleum and gas networks would be due to damage to underground pipes through liquefaction or critical infrastructure such as the Densitometer site for petroleum or the Westfield Gate Station for the gas network. Full service recovery is expected within 24 hours.

Infrastructure Impacts

Electricity

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
Local network ▪ Substation buildings classified as earthquake prone including The Drive, Spur Rd, Wellsford and Brickworks. ▪ 2 sections of sub transmission systems pass through liquefiable soils. ▪ Power supplies to CBD may be threatened since Quay Street Substation is on reclaimed land which is vulnerable to liquefaction. ▪ Other nodes at risk due to possible liquefaction are Greenmount, Mangere West, Mt Wellington, Newmarket, Ngataringa Bay, Takanini, Waimauku, Wairau Rd and Wiri. **Transpower Transmission network** ▪ By 2013 there will be ten high voltage transmission circuits into Auckland via at least two diverse geographical routes. ▪ One or two of the eight high voltage transmission circuits currently conveying up to 95% of Auckland's power could be lost. However as there are just one or two pockets of susceptible ground, any damage or disruption is likely to be confined to relatively small sections of circuits. These would probably be repaired very quickly by Transpower, with minimal interruption to supply. These weaknesses will be largely mitigated on completion of the NIGUP works. ▪ By 2014 Transpower will have installed over 60km of transmission cable circuit length across Auckland, predominately to supply the Auckland CBD area via Vector. Much of this cable route has been specifically engineered to withstand a greater level of event than envisioned in this report. ▪ By 2014 Transpower will have three new indoor gas insulated switchgear (GIS) buildings, all of which have been specifically engineered to withstand a greater level of event than envisioned in this report. Otahuhu and Wairau Rd GIS buildings are known to have been construction in areas prone to liquefaction	▪ The CBD is vulnerable if all three substations supplying it are affected and there may be damage elsewhere in the network. ▪ Loss of some zone substations possible causing localised outages. ▪ Some power outages or shortages may result from damage at nodes, but restoration of power to meet demand is not expected to take very long in most, if not all, cases. The earthquake intensities involved are well within the design capabilities of high voltage transmission and sub - transmission systems, so damage is only expected where abnormal amplification occurs. ▪ Canterbury Earthquakes have highlighted that underground cables are vulnerable if subjected to uneven settlement of the ground. ▪ Transpower has mitigated the effected of ground movement on it's cables and will also maintain overhead lines and towers as a mitigation against subsequent cable failures. ▪ While a failure of Transpower cable may not result in a loss of supply, the extended and complex nature of effecting a repair or replacement would reduce overall system security. This combined with other problems on the lines (or Vector's sub-transmission system) could result in extended periods without supply. ▪ On completion of Transpower NIGUP & NAaN works, the loss of a double circuit line is likely to affect only the "teed" sites of Takanini and Wiri

Table 5-1 Electricity Network: Vulnerability to Earthquake Hazard

Petroleum

The petroleum pipeline could be unsupported or under stress in liquefiable soil types but if intact, dispensation could be provided by lowering the Maximum Operating Pressure (MOP) as the pressure at the refinery is far lower than the MOP for its operation. To assess how much it may have moved would take a full in-line survey using GPS.

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Freemans Bay terminal ▪ Wynyard Wharf ▪ 2 sections of petroleum pipework ▪ Possible loss of Densitometer site due to liquefiable soil ▪ Loss of or damage to Freemans Bay would not constitute a major problem. Some damage to tanks from ground movement is possible because the facility stands on reclaimed land, but no motor spirit is held there. ▪ Some possible damage to the petroleum pipeline, but spares are not at risk.	▪ Loss of or damage to Freemans Bay could affect availability of Avgas fuels for light aircraft and helicopters, the latter possibly being needed to help other lifelines organisations restore their services. ▪ Possible reduction in MOP of pipeline until survey completed regarding integrity of line. Delay between 1 week and 1 month ▪ Densitometer site is required for assessing interface of differing fuel types. Expect 2 days to 1 week to assess and manage manual alternatives.

Table 5-2: Petroleum Network: Vulnerability to Earthquake Hazard

Gas

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Orion's Beaumont Street gas spares store was the gas node most at risk from a uniform hazard, because the store, on reclaimed land, is likely to experience liquefaction ▪ The main gas transmission pipeline passes through liquefiable soils in the area of Takanini. The 1987 Edgecumbe experience indicates that pipeline damage cannot be assumed, even where the pipeline crosses poor ground conditions ▪ The Westfield Gate Station, which supplies 60% of Auckland's gas, is next to liquefiable land and may suffer some damage.	▪ Repairs to damaged gas pipeline would be relatively quick ▪ Damage to the gas spare parts store in Beaumont St may delay any gas recovery should Westfield be damaged. Damage is not foreseen at the other major gate station, at Pakuranga

Table 5-3: Gas Network: Vulnerability to Earthquake Hazard

Recovery Times

	Day 1	Week 1	Full Recovery
Electricity	Some power outages or shortages may result from damage at nodes or to networks, but any restoration of power to meet demand is not expected to take long. Underground cables in liquefiable soils will take the longest for restoration.	Pylons replaced, substations and other nodes operational	7 days (longer for CBD) with some localised outages still remaining.
Petroleum Fuels	Little damage expected to Wiri Oil Services from the scenario event – pipeline also expected to be undamaged. Freemans Bay is on the edge of the destruction zone. Possible loss of region's Avgas fuels	100%	24 hours or longer
Gas	Gas volumes available after the event may be reduced, but so too would demand. The region's main gas spare parts store may be destroyed	100%	24 hours or longer

Table 5-4: Energy Network: Recovery Times

Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
Transpower	▪ TP.GG 61.02 Seismic Policy ▪ Emergency Response Plan (Specific event– Earthquakes) ▪ Transpower System Operator Contingency Plans for Supply Restoration ▪ Transpower Emergency Management Plans, including possible rolling blackouts to manage load ▪ Transpower Business Continuity Plan	▪ All newly designed assets must comply with this policy, which is intended to increase resilience. ▪ Systematic assessment of impacts and resources available to address them ▪ In the event of large scale supply loss, an approved plan for restoring supplies will begin depending on equipment availability. ▪ In the event of demand exceeding capacity to supply, then an approved plan to manage load will be implemented. ▪ Should Auckland based facilities put personnel and operations at risk, functions will relocate to pre-agreed fallback sites. ▪ Where an extended loss of supplies results from Transpower's network, the National Communications manager will handle all responses to the media, usually via Senior Transpower Management.
Vector-Electricity	▪ Emergency Response Plan (Specific event guide – Earthquakes) ▪ Zone substation contingency plans if necessary	▪ Systematic assessment of impacts and resources available to address them
Counties Power	▪ Civil Defence Emergency Management Plan	▪ Situation assessment and where safe conditions allow; prioritise repairs on critical infrastructure
Vector-Gas	▪ Emergency Response Plans ▪ Critical Contingency Management Plan ▪ Crisis Management Plan ▪ Critical Contingency Operator Plans ▪ Specific event guide for earthquake deployed	▪ Isolation of any damaged sections of pipeline to make situation safe. ▪ Curtailment of demand to attempt to secure long term security of supply. ▪ Mobilisation of resources and emergency spares. ▪ Use of alternative emergency management facilities if required
NZRC (Pipeline)	▪ Pipeline has been designed for earthquake. Liquefaction is still a threat	▪ Assess damage if any and maintain flow at reduced pressure until integrity confirmed ▪ Look at alternative distribution through liaison with C.O.L.L ▪ Consider 'floating storage' at Ports of Auckland
WOSL	▪ Wiri-Auckland Pipeline has been designed for earthquake.	▪ Assess damage if any. Call for use of road tanker use whilst pipeline assess/repair is carried out.

Table 5-5: Response and Recovery Activities, Energy Sector

Figure 5-3: Energy Network Overlaid on Liquefiable Soils

5.5 Telecommunications

The main impacts are expected to be to the copper cable network, mainly the older paper insulated lead sheathed cables where water ingress due to cracking and distortion takes the network down very quickly. Fibre reticulation is strong and robust even for moderate ground displacement especially where this is placed in duct-lines.

The main impacts to the telecommunications network would be due to power loss as there is a high penetration of “active” cabinets that rely on battery back-up lasting anywhere between 4 and 8 hours before generation is required to sustain the services. There may be significant access issues to plant for supplying diesel to generators, especially in the areas of gross liquefaction. However any electricity network outages are expected to be restored quickly.

Another issue potentially affecting telecommunications installations is the requirement for cold water to feed the evaporative chillers that provide chilled water to the equipment room process coolers. Absence of water may require the exchange to be shut down to prevent overheating and equipment destruction.

Recovery of the telecommunications sector is expected to be relatively quick although there will be increased congestion in the beginning and some customers may experience problems with individual land line connections.

Infrastructure Impacts

Copper Network

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
Chorus ▪ Feeder and distribution copper cables that are of lead and paper construction. ▪ Distribution cabinets (active and passive) inundated with liquefaction ▪ Some fibre failures where there is gross lateral movement at a boundary with a non liquefied zone Vodafone ▪ Vodafone fixed-line customers will be affected by issues at Chorus exchanges	▪ Isolation to areas on single path access ▪ Full or partial outage in the Devonport, Whitford, Te Atatu North and Glendowie if a failure (gross ground displacement) on the major routes of some duct lines ▪ Major localised service disruption. ▪ Loss of nodes or network segments does not necessarily mean loss of the network due to redundancies in place

Table 5-6: Telecommunication Copper Network: Vulnerability to Earthquake Hazard

Cellular Network

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Core network nodes not at risk. Some cell sites will be in areas of liquefiable soils – rooftop sites most vulnerable in this case (mainly rooftop access issues where the building is not safe to enter). But most are likely to remain operational and accessible at the stated PGAs. ▪ Dependency on Chorus for interconnect between landline networks ▪ Communication node buildings; particularly for roof damage causing collapse or water damage. Fire a possibility but not assessed. ▪ Only minor impacts beyond immediate network congestion are expected. ▪ Generator deployment may be required where mains power to cellsites is lost, however at the stated PGAs, widespread power outages of significant duration are not expected.	▪ Congestion of all networks due to increased use and reduced capacity ▪ Short term network congestion can be expected. Minimal risk of long term congestion. ▪ Loss of nodes or network segments does not necessarily mean the loss of the network due to redundancies in place.

Table 5-7: Telecommunication Cellular Network: Vulnerability to Earthquake Hazard

Fibre Network

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
Chorus ▪ Three southern fibre-optic transmission routes Vodafone ▪ Damage to both sides of the fibre-optic rings ▪ Vulnerable sites: - Orakei Basin - Harbour Bridge - Upper Harbour Bridge - Rail bridges ▪ Dependency on Telecom, Vector Communications and FX Networks for fibre transmission.	▪ Unlikely to be impacted except if bridges that hold the fibre network fail.

Table 5-8: Telecommunication Fibre Network: Vulnerability to Earthquake Hazard

Broadcasting

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ No assets at risk	▪ No impact expected

Table 5-9: Broadcasting: Vulnerability to Earthquake Hazard

Recovery Times

	Day 1	Week 1	Full Service Restoration
Land lines	No expectation of any physical repairs	60 – 90% dependent also on the availability of power to cabinets.	Service to cabinets within 7 days but many customers will still be affected by gross damage to older era distribution cables.
Cellular Networks	Loss of some coverage. Extreme congestion where coverage is available.	100%	Within 3 days (with electricity)

Table 5-10: Telecommunication Network: Recovery Times

Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
Broadcasting	▪ Activate TEPF.	▪ *Information not available*
Copper Telco Network	▪ Activate Chorus Crisis Management Plan	▪ Priority restorations achieved to key customers such as CDEM and Lifelines contributors ▪ Impact assessment of ducted network and distribution cables.
Mobile/Cellular Network	▪ Activate Emergency Management framework. ▪ Earthquake Response Plan. ▪ Activate TEPF.	At the stated PGAs, the need for a large-scale response is not anticipated, however the following options are available if needed: ▪ Generator deployment to cell sites where mains power is lost. Based on priority of site and limited by accessibility. ▪ Structural assessment of affected sites. ▪ Deployment of temporary coverage (CoWs) – would look to CDEM for guidance on where best deployed. ▪ Possible activation of congestion control methods. ▪ Free calling, phone charging at retail stores that are able to operate – possible deployment of mobile store (truck trailer).
Fibre Telco Network	▪ Activate Chorus Crisis Management Plan.	▪ Analyse indicators from communications terminal equipment as to the viability of Fibre Linking Establish priorities to restore essential transport linkages.

Table 5-11: Response and Recovery Activities, Telecommunications

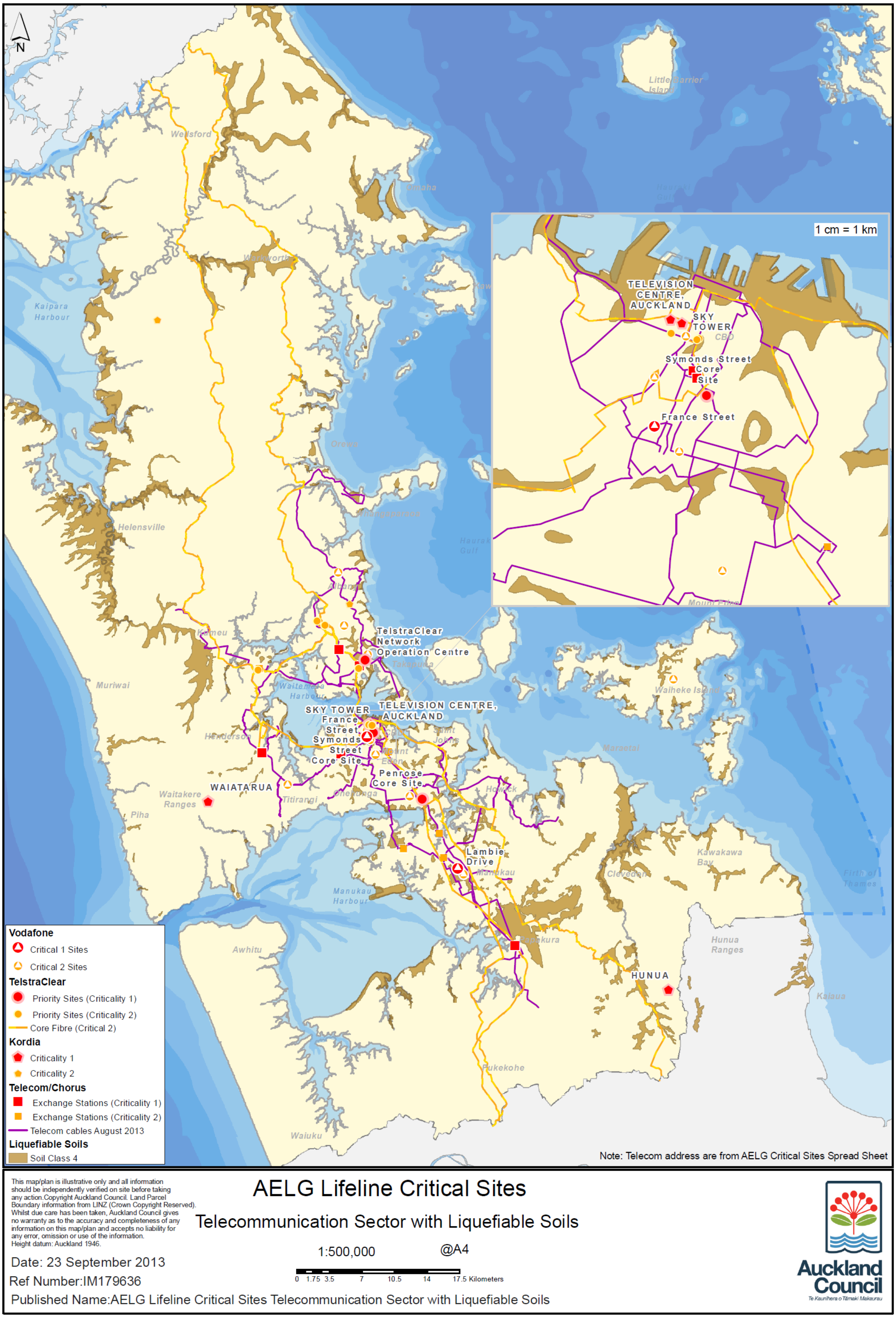


Figure 5-4: Telecommunication Network Overlaid on Liquefiable Soils

5.6 Transport

Transport relies heavily on fixed infrastructure like roads, rail lines, wharves and runways. All of these solid, inflexible structures are at risk of fracture from ground shaking, acceleration and especially liquefaction. The failure of bridges could cause blockages to entire routes and although many bridges are designed for earthquake capacity, the approaches may be affected. There is expected to be minimal impact on the airport. A portion of the wharves are built on reclaimed land and are at risk of liquefaction so may become inoperable.

Access for assessment and repairs will be the main issue for all utilities. A typical recovery profile of a vulnerable section of road following an earthquake scenario would be closure immediately after the event and recovery 10-50% capacity in the week after the event. Some roads could close but some could be unaffected. Most roads would be back to near fully capacity within a month, although some with larger bridge structures could take up to six months.

Infrastructure Impacts

Road

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Bridges and their abutments most vulnerable to ground movement. Large number of bridges along the motorway, especially older multi-span bridges and abutments eg spaghetti junction area and some on the southern and south western motorways. ▪ Roads on liquefiable soils and unstable land, especially reclaimed land, also at risk. Extreme effects likely on local roads due to lower construction standards. ▪ Under/overslips affecting access to utilities and communities. ▪ Joint Transport Operations Centre (JTOC) in liquefaction zone. ▪ Slips in cut areas blocking the road where the ground is unstable	▪ Failure of bridges reduces capacity at only a few key points, but blocks the entire route ▪ Possible flooding and physical damage from rupture and unsecured pipes ▪ Many non-strategic arterial roads likely to be closed by collapsed buildings ▪ Earth movement creating gaps and uneven levels in the carriageway, especially in hilly areas ▪ Any access to non-strategic arterials will be at a much reduced capacity, meaning long delays to traffic using operational sections of road and a complete loss of access to some areas ▪ Harbour Bridge likely to be unaffected but approaches on both sides likely to be impassable ▪ Causeway section of NW Motorway likely to be impassable. (this is the back up to the Harbour Bridge) ▪ Non-strategic arterials should have more passable sections than the motorway (which has more bridges) ▪ Even minor embankments on local roads are likely to collapse, blocking or undermining roads ▪ Hilly areas and reclaimed land likely to be worst affected by liquefiable soils, but many alternative routes likely in areas with good redundancy ▪ Periods of wet weather prior to an event may exacerbate slip damage

Table 5-12: Road Network: Vulnerability to Earthquake Hazard

Rail

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Rail is probably the most vulnerable of all modes to earthquakes because tracks are sensitive even to minor ground movement. Misaligned tracks totally impede capacity because of no detours ▪ High risk of slope failure and liquefaction completely destroying vulnerable sections on reclaimed land such as by Orakei Basin or in hilly areas like the Waitakere Ranges.	▪ Rail engines may not be able to get back to the station ▪ Serious damage could affect regional recovery by loss of bulk rail transport of supplies

Table 5-13: Rail Network: Vulnerability to Earthquake Hazard

Ports

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Both the Waitemata and Onehunga ports are built on reclaimed land, placing them at higher risk from earthquakes. ▪ Port operations may also be indirectly affected by impacts on rail and road connections. As a number of bridges and roads near both ports are also built on reclaimed land, they are likely to lose capacity and reduce the ports' ability to distribute cargo.	▪ Damage to the port facilities could be severe enough to require an alternative, as existing piles, wharves and container storage faciilties become misaligned and thus unusable as docking facilities ▪ In the long term, loss of port functions could have a very serious effect on the region's recovery ▪ It would take years to rebuild another port on the Waitemata Harbour following total destruction. Diversion to other ports such as Whangarei, Tauranga and Wellington could mitigate some of the adverse effects on the national, and to some extent, the Auckland economy

Table 5-14: Ports: Vulnerability to Earthquake Hazard

Airports

Network Assets at Risk in Liquefiable Soils	Expected Service Impacts
▪ Minor displacement of the runway would not significantly affect operations, although runway length maybe reduced until repaired ▪ Recent reconstruction of the central portion of the runway and taxiways is expected to provide resistance to earthquakes. Further investigation of possible liquefaction on Airport is to be sought in 2012. Nine buildings currently undergoing a seismic review. In light of Christchurch experience it is not expected to be an issue. ▪ Whenuapai Airbase is likely to be the least vulnerable of Auckland's airports and may cater for some transferred air traffic, but it does not have the capacity of the International Airport	▪ It is expected minor internal damage to airport buildings and equipment may affect operations ▪ Two main access routes to the Airport should provide one route for operations to continue in the event of damage to local roading. Access to the airport maybe reduced because of damage to roads and roadside services

Table 5-15: Airports: Vulnerability to Earthquake Hazard

Recovery Times

	Day 1	Week 1	Full Recovery
Road	Complete closure of some key roads; some local redundancy	10 – 50% capacity	1 month (roads) 6 months (big bridges)
Rail	Zero capacity	0 – 50% capacity	6 months
Ports	10% capacity	50% capacity	3 months
Airport	10% capacity if runway is damaged. Terminals are expected to be open, road access maybe the bigger issue.	100% capacity	1 – 2 days depending on road access.

Table 5-16: Transport Network: Recovery Times

Response and Recovery Plans

Sector	Planning undertaken	Specific Response Activities
AT (Roads)	▪ No specific earthquake contingency plan at this stage ▪ AELG Safe Routes Maps ▪ Auckland Transport Emergency Response Plan ▪ Contractor Emergency Response Plan	▪ Operations staff will carry out inspections and close out unsafe roads, bridges and structures. ▪ Detour routes will be created ▪ Contractors will provide assistance in terms of traffic management to emergency services ▪ Removal of blockages on safe routes will be given priority ▪ Repairs works will be carried to temporary restore roads to a functional state, though they may not be fully operational for some time
AT (public transport)	▪ No specific earthquake contingency plan at this stage ▪ Auckland Transport Emergency Response Plan ▪ Contractor Emergency Response Plan ▪ Public Transport Emergency Response Plan (to be developed)	▪ Operations staff will carry out inspections and close out unsafe roads, train stations and railway lines, bridges and structures. ▪ Detour routes will be created. Unfortunately not for rail. ▪ Contractors will provide assistance in terms of traffic management to emergency services ▪ Removal of blockages on safe routes will be given priority ▪ Repairs works will be carried to temporary restore roads to a functional state, though they may not be fully operational for some time
NZTA (Road)	▪ Response plan to manage access and network closure ▪ Inspection plan for structures to identify structural capacity	▪ Inspection will be carried out to identify extent of damage and network to be closed ▪ Media information issued to identify location of closure ▪ Structural inspection to identify bridge/retaining wall structural failures and capacity ▪ Implement traffic management and open network as condition confirmed. ▪ Develop plan for restoration
Auckland Airport	▪ No specific earthquake contingency plan at this stage. ▪ Insurance company do not consider Airport at risk of an earthquake. ▪ Generic Airport Emergency Plan for natural hazards.	▪ Operations staff on duty 24/7 would undertake immediate runway inspections. Buildings would follow. Emergency Operations centre opened at one of two sites. Crisis management teams would be implemented for response and recovery.
Ports of Auckland	▪ Earthquake Emergency Plan ▪ Major Incident Management Plan	▪ Initial visual inspection of damage sustained and threats to safety (eg, wharves, cranes, ships, buildings, dangerous goods cargo & container stacks) ▪ Commission detailed survey of all buildings, wharves & cranes ASAP
KiwiRail	*Information not available.*	▪ *Information not available.*

Table 5-17: Response and Recovery Activities, Transport

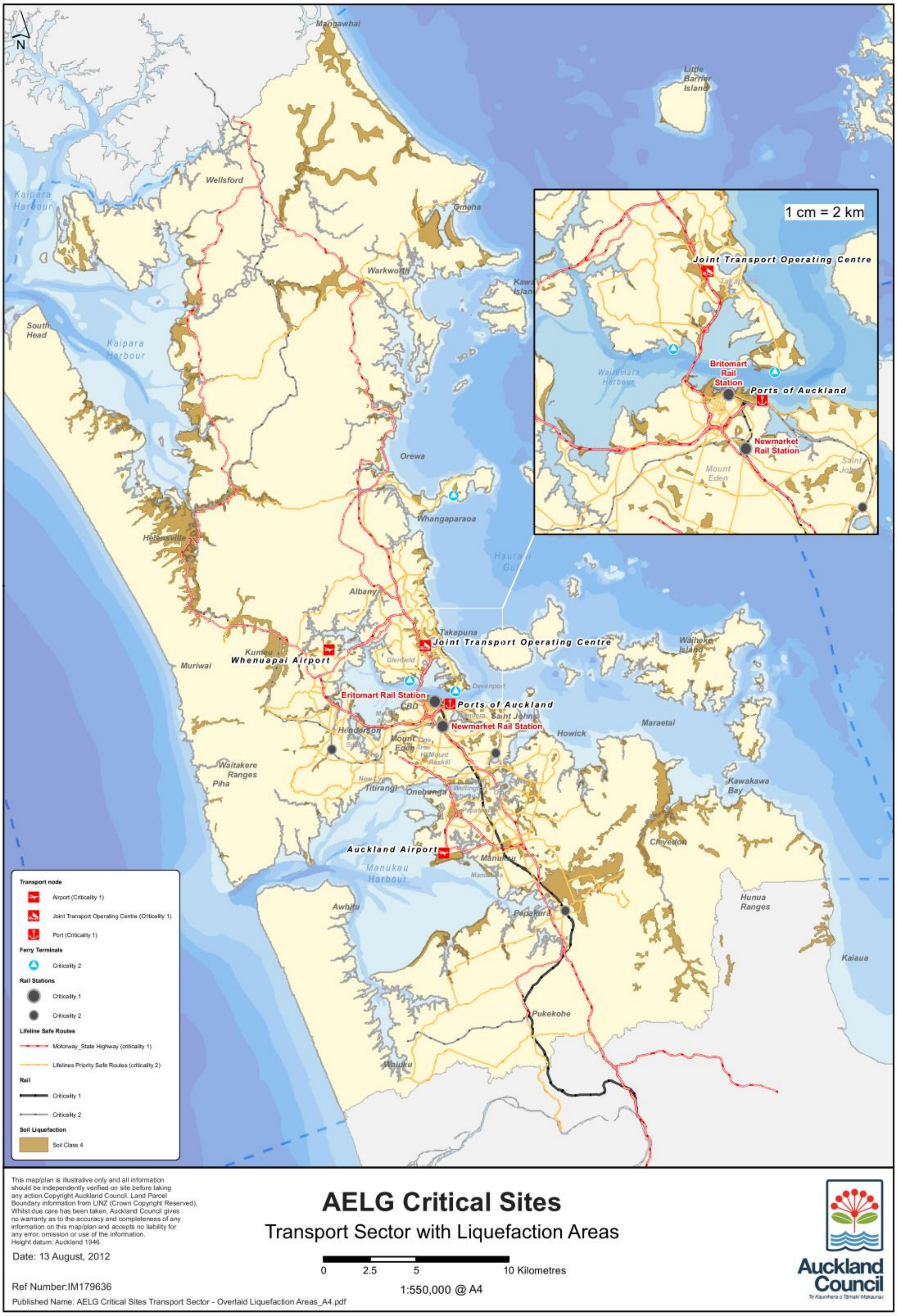


Figure 5-5: Transport Sector Overlaid Liquefaction Areas

5.7 Water and Waste

Water sources, treatment and trunk transmission systems are not expected to incur damage that would result in widespread supply disruption. Damage is expected to both water and wastewater transmission, distribution and collection systems comprising non-ductile pipe systems (Cast iron, asbestos cement and PVC) due to ground shaking and acceleration, liquefaction and landslip causing joint and pipe failure. Greatest risk areas due to potential for liquefaction are the Auckland CBD, Takanini and rural Helensville and landslip in the Waitakere's. There may be challenges treating water contaminated with slip debris and silt. The stormwater network will be similarly affected. Full recovery of water, wastewater and stormwater systems would be expected to take at in excess of three months and up to 5-10 years.

Infrastructure Impacts

Water

<table>
<tr><th>Network Vulnerabilities</th><th>Expected Service Impacts</th></tr>
<tr><td>
▪ Failure of the Hunua (5) and/or Waitakere (5) water supply dams and appurtenant structures unlikely. (Compliant with NZSOLD & Building Act: MCE and 1 in 2,500yr return period events respectively).
▪ High likelihood of failure to less ductile (cast iron and asbestos cement) watermains in both trunk (75km of 530km) and local network (majority of 7,000km) systems, particularly:
- Auckland CBD
- Takanini
- Rural Helensville
▪ The majority of major trunk watermains (≈530km) are continuous ductile welded steel and will remain intact and serviceable.
▪ Landslides in water supply catchments may contaminate impounded waters
▪ Treatment plants, reservoirs, pump stations & pipebridges at risk of damage due to ground acceleration.
▪ Possible loss of reservoir storage due to watermains breaks.
▪ Disruption due to failure/damage of third party bridge structures which carry watermains
- Greenhithe
- Panmure
▪ Watermains on Auckland Harbour & MHX bridges can sustain 1 in 2,500 yr events.
▪ Hunua No 4 watermain (under construction) designed for seismic resilience (specifically ground acceleration, liquefaction and lateral spread).
▪ WSL trunk systems SCADA and communications systems; independent of telco's, monitoring remote sites reliant on mains power and battery back-up systems. Generators installed at repeater sites, Sky Tower & Ruatawhenua (CAA).
▪ Disruption of power supplies to treatment & pumping facilities.
▪ Disruption to transport networks may cause access issues to critical facilities.
</td><td>
▪ Trunk water supply should remain available at average day demand service level target due to redundancies built into the network.
▪ Impounded waters contaminated with slip debris and silt resulting in difficult treatment conditions and possible restriction of source(s) availability or capacity.
▪ Potential loss of 2 sources; Waitakere & Nihotupu dams due to Cast iron watermains failures caused by landslip and/or displacement. Not an issue if other sources available.
▪ Loss of water supply or restricted availability in suburbs impacted by watermains failures or capacity constraint.
▪ Auckland CBD, Takanini & rural Helensville areas expected to suffer severe extended duration disruption due to cast iron and AC pipe jointing and pipe failures as a result of liquefaction of soils. Helensville has three days of reservoir storage.
▪ Impacts on water supply following an earthquake will be amplified by:
- increased demand resulting from water loss through damaged pipes
- people initially trying to store water
- high fire fighting demand
▪ Standby generation built-in at most WTP's (not at Waikato or Onehunga). Generators required at trunk system pump stations – potential for supply disruption after 24 - 48hrs. Generator resources and re-fuelling will become an issue.
▪ Flood damage to public & private property caused by watermains breaks.
▪ Public Health issue potential for contamination of water supplies due to failures of water and wastewater piped systems. Disinfection protocols required to be in place (sampling & testing) and mobile chlorination units. Loss of power supply significant issue.
</td></tr>
</table>

Table 5-18: Water Network: Vulnerability to Earthquake Hazard

Wastewater

Network Vulnerabilities	Expected Service Impacts
▪ Damage and extensive breakages of sewer lines, rising mains, pump stations, pipe bridges, connections and structures throughout network due to ground acceleration and displacement. ▪ Trunk sewers and networks sewage reticulation particularly vulnerable in Takanini area due to liquefaction of peat soils and AC pipe. ▪ Mangere WWTP – adjacent to foreshore of Manukau Harbour – potential for liquefaction/lateral spread. ▪ WSL SCADA and communications systems, independent of telco's, monitoring remote sites reliant on mains power and battery back-up systems (24hrs). Generators installed at repeater sites Sky Tower & Rautawhenua (CAA). ▪ Disruption due to failure/damage of third party bridge structures which carry sewers - Panmure Bridge ▪ Rosedale effluent detention dam/lagoons unlikely to fail - compliant with NZSOLD MCE. ▪ Army Bay, Omaha, Snells, Helensville WWTP's effluent dams vulnerable due to liquefaction or geotech issues. ▪ Disruption to transport networks may cause access issues to critical facilities.	▪ Long term disruption to wastewater collection systems due to failure of sewers (pipe and manholes) and loss of gradient in gravity systems and blockages due to liquefaction material. ▪ Liquefaction material transported to WWTP's causing blockage and disruption of treatment processes leading to in-flow by-pass to environment. ▪ Failed WWTP processes, pumping stations and sewers including high capacity facilities and local collector sewers, are a source of wastewater overflows to water courses, estuarine, harbour receiving waters. ▪ Gravity interceptor sewers into the Mangere WTP. If all the power sources fail, the plant by-pass flow can gravitate into the Manukau Hbr. ▪ Standby generation built-in at major WWTP's. Plant by-pass at small WTP's. However, generators required at trunk system and network pump stations. Overflows to environment within hours. Generator resources and re-fuelling will be an issue. ▪ Mangere & Rosedale WWTP's able to meet energy requirements provided natural gas (Mangere - NOVA) and digester biogas is available. If not, then dependent upon mains power electricity ▪ Public health risk due to disruption/failure of wastewater collection systems. ▪ Pollution of water courses, estuarine and marine environment. Water quality monitoring and ban on collection of seafood and recreational activities. ▪ Loss of power supply significant issue

Table 5-19: Wastewater Network: Vulnerability to Earthquake Hazard

Stormwater

Network Vulnerabilities	Expected Service Impacts
▪ Extensive breakages of stormwater lines and pipe connections throughout the catchments due to ground acceleration relative displacements and landslips. ▪ Landslip may block or severely restrict watercourses and rivers. ▪ Rivers and watercourses in liquefiable soils may lose significant conveyance capacity. Eg Kumeu River. ▪ Stopbanks and tidal gates protecting low lying urban areas (eg Parakai) are vulnerable to failure. ▪ Land settlement may cause permanent drainage problems. ▪ Blockage of both inlets and pipes due to ingress of liquefied soils. ▪ Culvert collapse. ▪ Stormwater dam failure. ▪ Stormwater Pump Stations	▪ Large diameter brick barrel pipes, ceramic pipes and culverts are particularly vulnerable to collapse. Most of these are in the CBD and will particularly affect the port area with flooding and disruption to transport. Many are buried very deep and under buildings. Recovery will be difficult. ▪ General loss of function of stormwater systems may take years to recover. ▪ If followed by heavy rain upstream flooding may result. Landslip blockages also bring risk of sudden and severe flooding to downstream properties in the overland flow path and flood plains. Evacuation may be necessary. ▪ More frequent and severe flooding of surrounding land. ▪ Frequent inundation of affected areas at high tides and during storms likely. E.g. Parakai, if affected, may be considered locally significant. ▪ Gravity fall for stormwater drainage may be permanently lost leading to inundation. ▪ Flooding of local area of damage, but damage and

Network Vulnerabilities	Expected Service Impacts
	flooding may be widespread in some parts of the region. ▪ Collapse of a culvert under a regionally significant road would potentially lead to some flooding as well as road damage. Both will potentially disrupt road transport. ▪ Dams are vulnerable to damage and rupture. Possible large flood downstream with no warning. Need to assess each for potential hazard. ▪ Local flooding may occur if there is long duration power outage or if structural damage occurs. Back-up power supply (large generator)may be required.

Table 5-20: Stormwater Network: Vulnerability to Earthquake Hazard

Solid Waste

Network Vulnerabilities	Expected Service Impacts
▪ Failure of Transfer Stations and Land fills ▪ Wellsford Waste Transfer Station and Resource Recovery Centre ▪ Snells Beach Waste Transfer Station and Resource Recovery Centre ▪ Snells Beach Transfer Station and Resource Recovery Centre ▪ Silverdale Transfer Station ▪ Helensville Transfer Station ▪ Rosedale Transfer Station ▪ Devonport Transfer Station ▪ Constellation Drive Refuse Transfer Station ▪ Waitakere Refuse and Recycling Station ▪ East Tamaki Transfer Station ▪ Papkura Transfer Station ▪ Waiheke Waste Transfer Station ▪ Pukekohe Transfer Station ▪ Waiuku Transfer Station ▪ Redvale Landfill ▪ Patiki Road ▪ Pikes Point ▪ .Whitford Landfill ▪ Envirofert ▪ Hampton Downs Landfill.	▪ Landfill and transfer station are vulnerable to flooding . ▪ Discharges of contaminants to air and or water ▪ Noise, dust and odours ▪ Hours of operations ▪ Vehicle movements ▪ Daily handling of tonnages

Table 5-21: Solid Waste Network: Vulnerability to Earthquake Hazard

Recovery Times

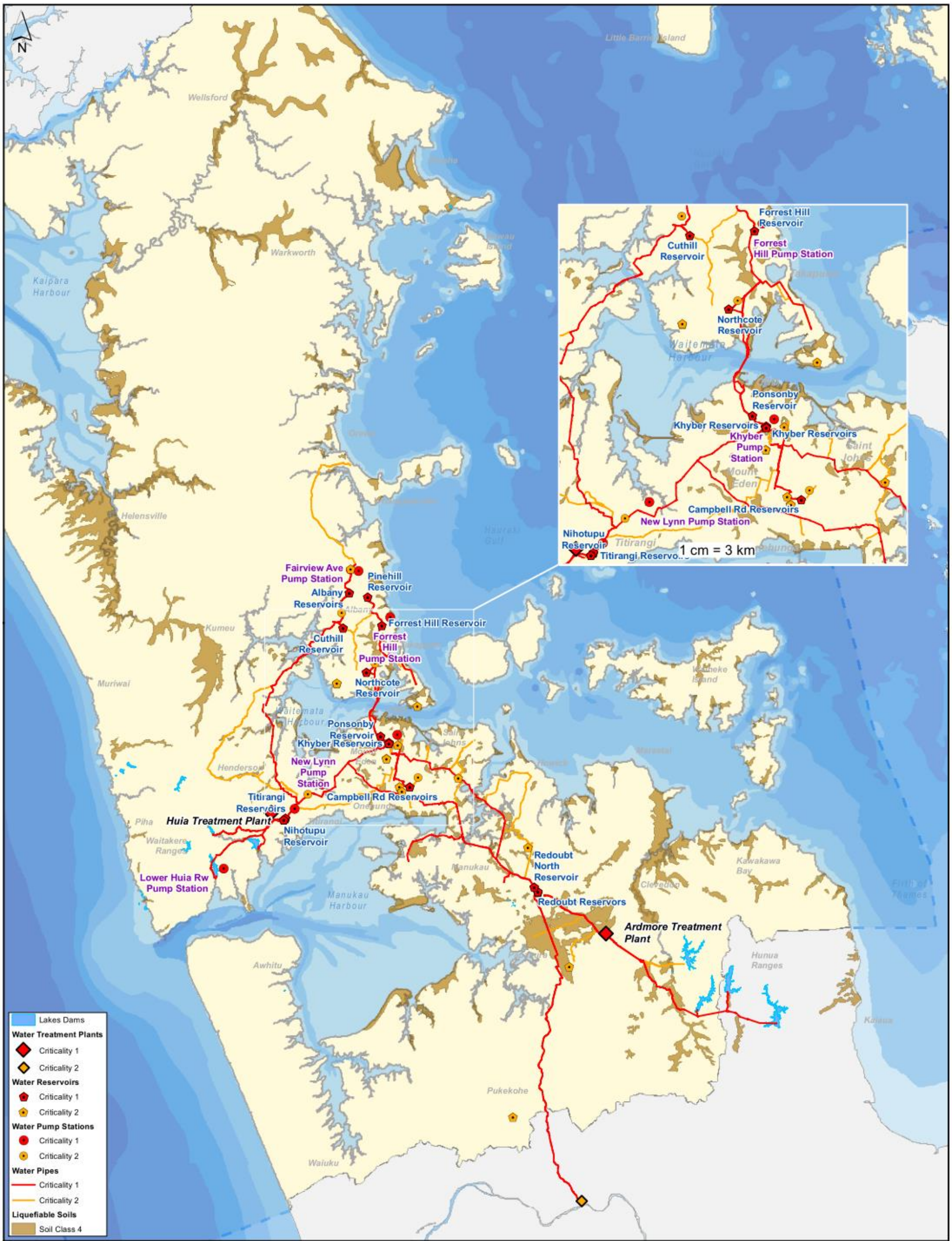
	Day 1	Week 1	Full Recovery
Water supply	▪ Initial situation assessment of critical facilities & process areas complete and significant issues identified. ▪ Security of supply issues identified. ▪ Targeted NZDWS Public Health compliance programmes in place. ▪ Boil water notice in place. ▪ Burst watermains isolated where possible. ▪ Resource requirements assessments on going – pipes; fittings; generators, personnel ▪ Staff resources assessed and resources gaps identified.	▪ Supply system reconfigured where possible. ▪ Water supply in place to serviceable areas sufficient to meet average day demand. ▪ Major watermains failures repaired or under repair dependent upon scale of damage. 1 week to 1 month. ▪ Temporary water supplies in place where possible. Might be tanker supply only. ▪ Resources management (human, plant equipment, fuel, etc) plans in place. ▪ Long term impact assessment understood.	▪ 3 months to years where assets impacted by structural damage, liquefaction or landslide. ▪ Supply restriction may remain in place for sometime in some zones. ▪ Dependent upon availability of materials (pipes) and accessibility for reinstatement.
Wastewater	▪ Initial situation assessment of critical facilities & process areas complete and significant issues identified. ▪ Sewer overflows identified. ▪ Resource requirements assessments on going – pipes; fittings; generators ▪ Staff resources assessed and resources gaps identified.	▪ Significant overflows channelled to waterways, harbours or stormwater systems. 1 week to 1 month. ▪ Major impacts identified and under repair. ▪ Requirements for temporary systems being assessed.	▪ Not expected within 3 months and may take years where assets impacted by structural damage, liquefaction or landslide. ▪ Dependent upon availability of materials (pipes) and accessibility for reinstatement. ▪ 1-2 months temporary systems in place
Stormwater	Inspection of key culverts, dams, pump stations and major critical assets. Emergency recovery where possible initiated.	Full preliminary inspection and priority assessment of all major visible assets complete. Assigning specific priority recovery works to contractors	May be necessary to clear overland flow paths where rehab or replacement of pipes are not possible in short term. Full recovery of all systems may take 5 to 10 years as wastewater and water supply will have priority for funding.
Solid Waste	*Information not available.*	*Information not available.*	3 months
Note: all recovery profiles assume unlimited resources and unrestricted access			

Table 5-22: Water Network: Recovery Times

Response and Recovery Activities

Sector	Planning undertaken	Specific Response Activities
Auckland Council (stormwater)	▪ The Stormwater Unit has no earthquake specific plans in place.	▪ Prioritised earthquake response inspection schedules to be activated. (These will be based on identified earthquake event critical assets.) ▪ From daily inspection reports, determine the most urgent, achievable with available resources in the short term, recovery actions. These will be prioritised by risk of flooding/inundation due to earthquake damage. ▪ As extent of damage becomes apparent develop a strategy for effecting full recovery.
Watercare	▪ Activate Operations Incident Management Plan ▪ Assess public health risk	▪ Situation assessment and systems reconfiguration to maintain security of services to maximum extent possible. ▪ Generator deployment to critical sites where mains power is lost. ▪ Implement public health risk management plan. ▪ Structural assessment of affected sites. ▪ Imposition of water supply restrictions may be required either locally or regionally dependent upon specific scenario to conserve resource. ▪ An issue will be use of potable water for Fire fighting – use seawater!

Table 5-23: Response and Recovery Activities: Water and Waste



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Date: 13 August, 2012

Ref Number:IM179636

Published Name: AELG Lifeline Critical Sites Water Sector - Liquefiable Soils_A4.pdf

AELG Lifeline Critical Sites

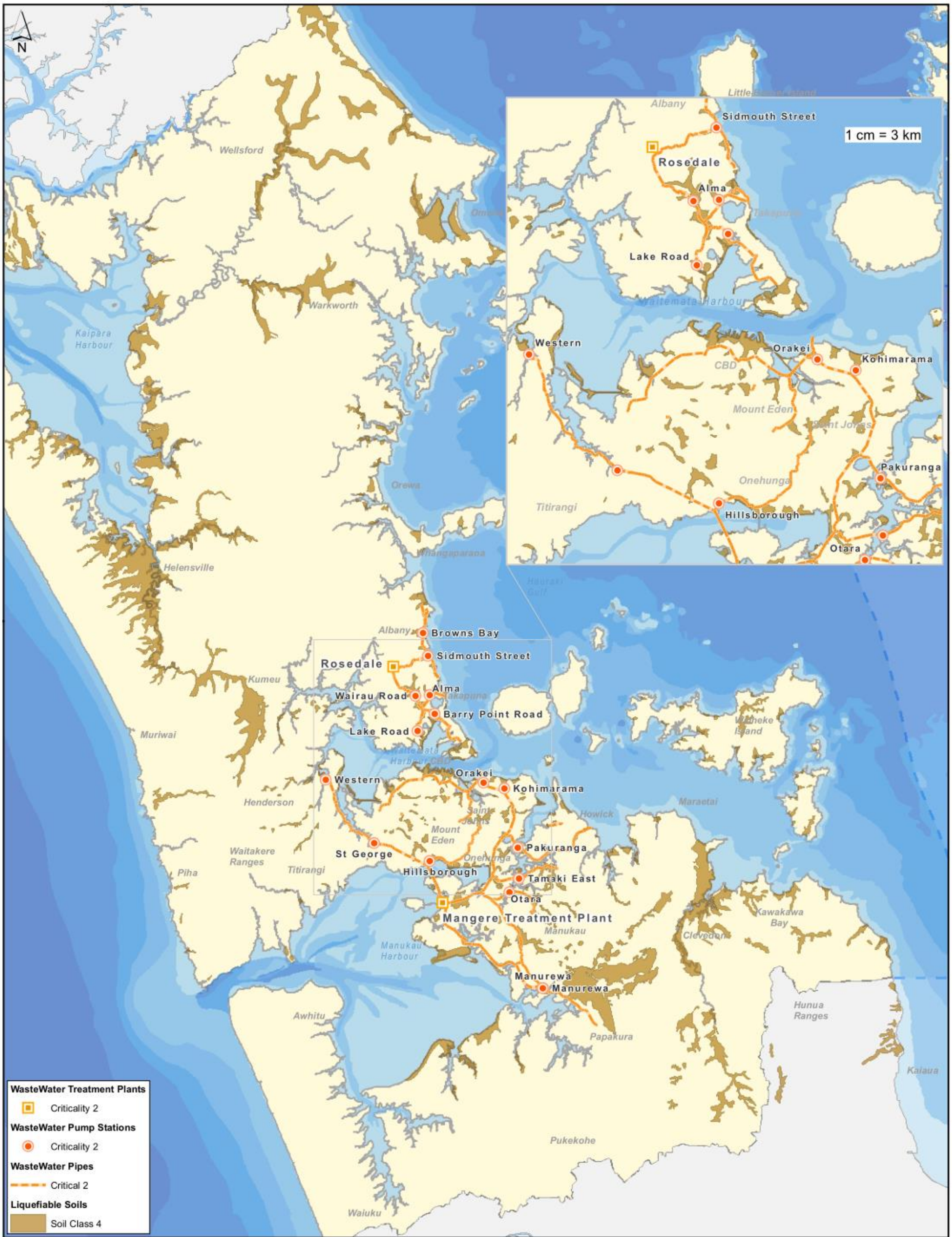
Water Sector with Liquefiable Soils

0 5 10 20 Kilometres

1:500,000@A4

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Figure 5-6: Water Supply Network Overlaid on Liquefiable Soils



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Date: 23 Aug 2012

Ref Number:IM179636

Published Name:AELG Lifeline Critical Sites Wastewater Sector with Liquefiable Soils

AELG Lifeline Critical Sites

Wastewater Sector with Liquefiable Soils

1:500,000 @A4

0 2 4 8 12 16 20 Kilometers

Auckland Council

Te Kaunihera o Tāmaki Makaurau

Figure 5-7: Wastewater Network Overlaid on Liquefiable Soils

5.8 Other Critical Community Sectors

As illustrated in Figure 6-5, only one key bank site is located in an area of liquefiable soils (downtown Auckland), with the Auckland Hospital in close proximity.

However, all the critical community sectors would be impacted by any failure of lifeline utility networks. These interdependences are discussed in Section 2.2.

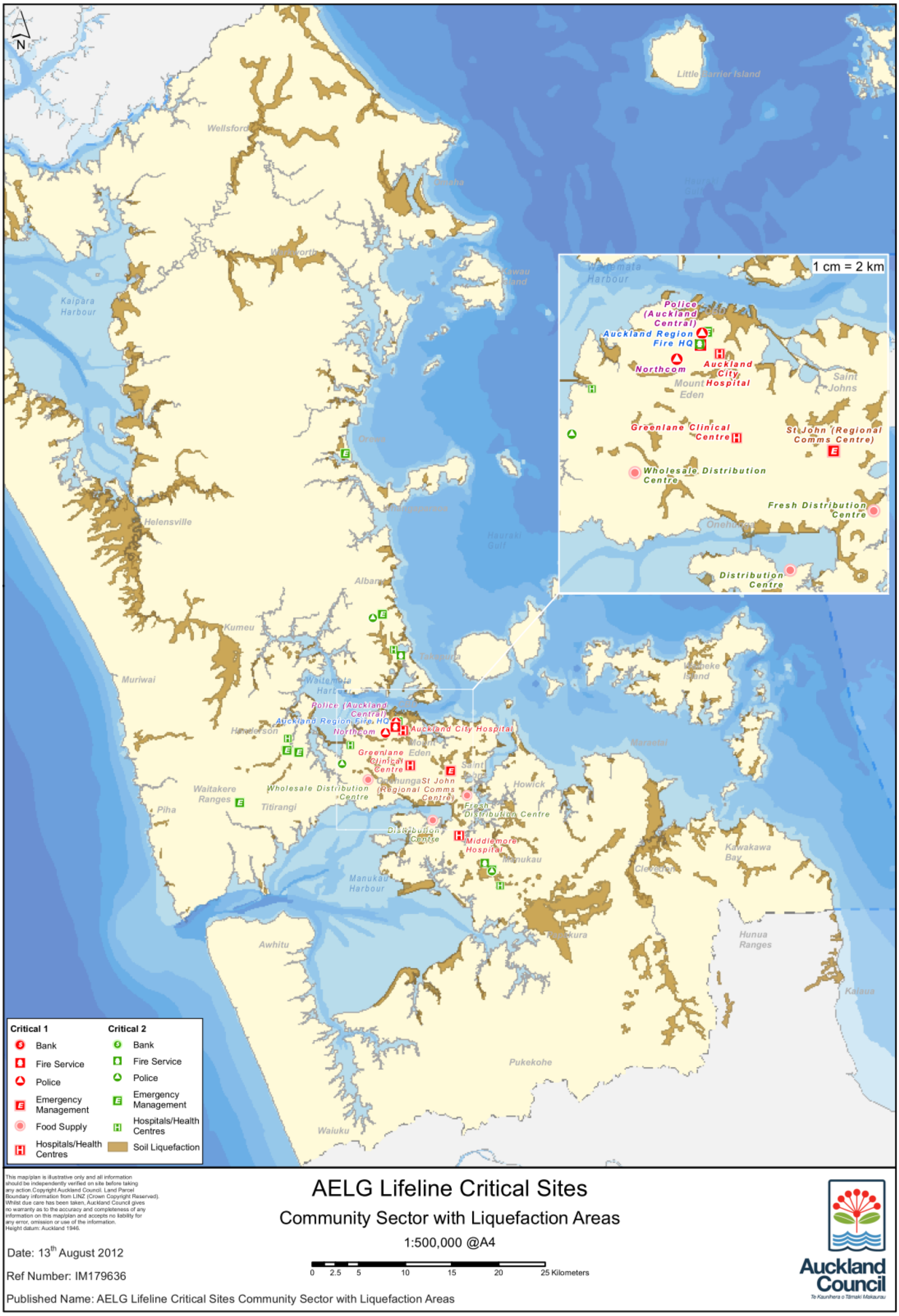

Figure 5-8: Critical Community Sites Overlaid Tsunami Hazard Data