bushfire&natural HAZARDSCRC

# AN EARTHQUAKE LOSS SCENARIO FOR ADELAIDE

## Part of the BNHCRC Scenario Project

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Risk Frontiers



An Australian Government Initiative

CRC AUSTRALIA

MACQUARIE University SYDNEY · AUSTRALIA

RISK FRONTIERS

# RISK FRONTIERS

## Natural Hazards Research Centre

An independent research capability created in 1994 to:

- Undertake research into natural hazards.
- Develop databases of natural hazards and their impacts on communities.
- Develop catastrophe loss models and software to improve the pricing of natural hazard risks.
- Develop an independent view of catastrophe risks.
- Undertake post-event reconnaissance of natural disasters.
- Encourage the responsible management of catastrophe risks.

# BNHCRC Scenario Project

## What if?

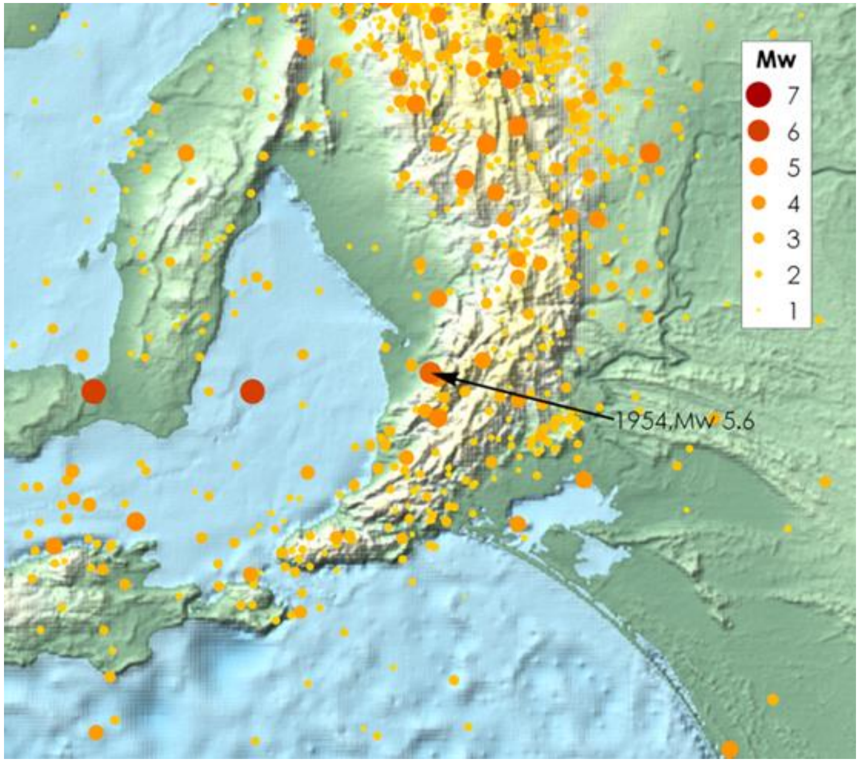
- One of Australia's major cities were hit by an **earthquake** similar to the Newcastle event?
- Six catchments in northern NSW **flood** contemporaneously?
- The Great **Flood** of 1954 occurred today? What would be the economic cost now that there are six times the number of exposed dwellings?
- A **tropical cyclone** hits Brisbane? What could we expect?
- We experience twenty **bushfires** in a week? It has happened in the past. What would it look like? Are we prepared?

# BNHCRC Scenario Project

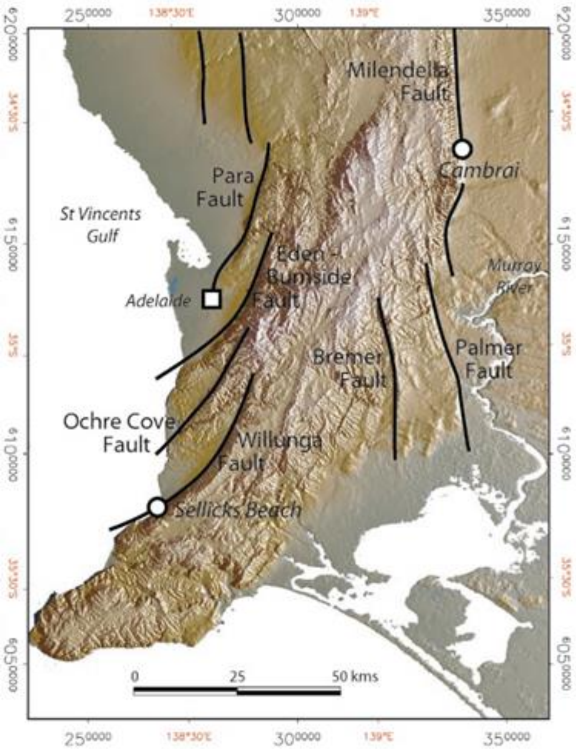
## Using realistic disaster scenario analysis to understand natural hazard impacts and emergency management requirements

- To deliver a suite of scenario simulations that allow the question of "what if?" to be answered.
- Purpose:
  - to visualise potential impacts before disasters happen,
  - to better understand the implications of catastrophic events beyond recent experience, and
  - to reveal blind spots and vulnerabilities in strategic planning.
- Hazards:
  - Earthquake
  - Tropical Cyclone
  - Bushfire
  - Flood
  - Heatwave
- Impacts:
  - Building damage (residential, emergency, commercial and industrial)
  - Infrastructure damage
  - Resultant death/injury and population displacement

# SCENARIO SELECTION Adelaide Seismicity



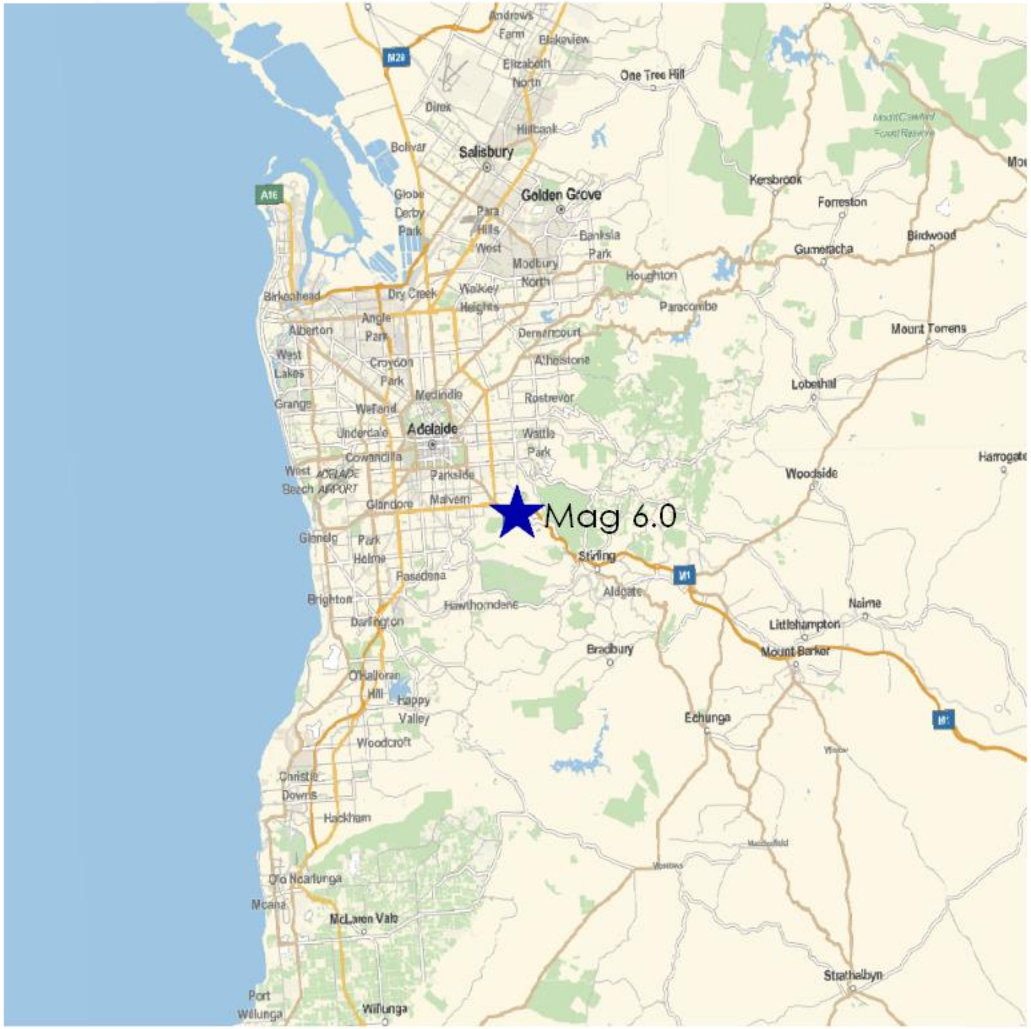

Historically recorded earthquakes (1840-present), source : Geoscience Australia.




Active Faults, from Sandiford (2003)

- M. Sandiford. *Neotectonics of southeastern Australia: linking the quaternary faulting record with seismicity and in situ stress*. In Evolution and Dynamics of the Australian Plate, volume 22 of Geological Society of Australia Special Publication, pages 101-113. Geological Society of Australia, 2003.

# SCENARIO SELECTION The Simulated Event



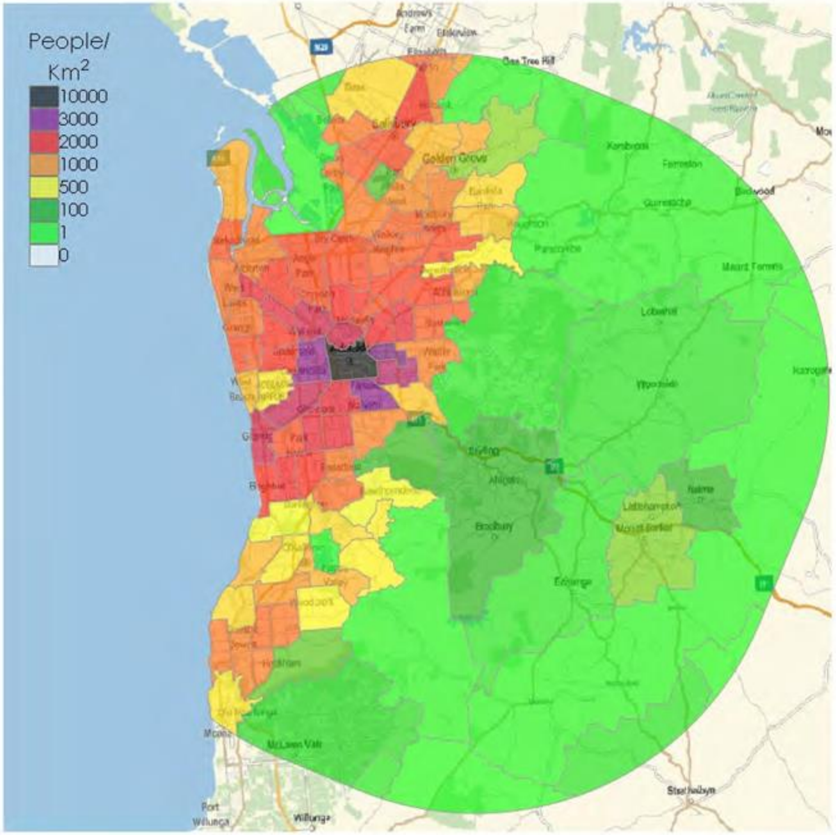

## Adelaide Region *

| ARP of Ground Motion | Mw of Typical Scenario |
|---|---|
| ARI > 10,000 | up to 7.0-7.5 |
| ARI ≈1000 | 6 |
| Building code, ARI ≈ 500 | 5.5 |

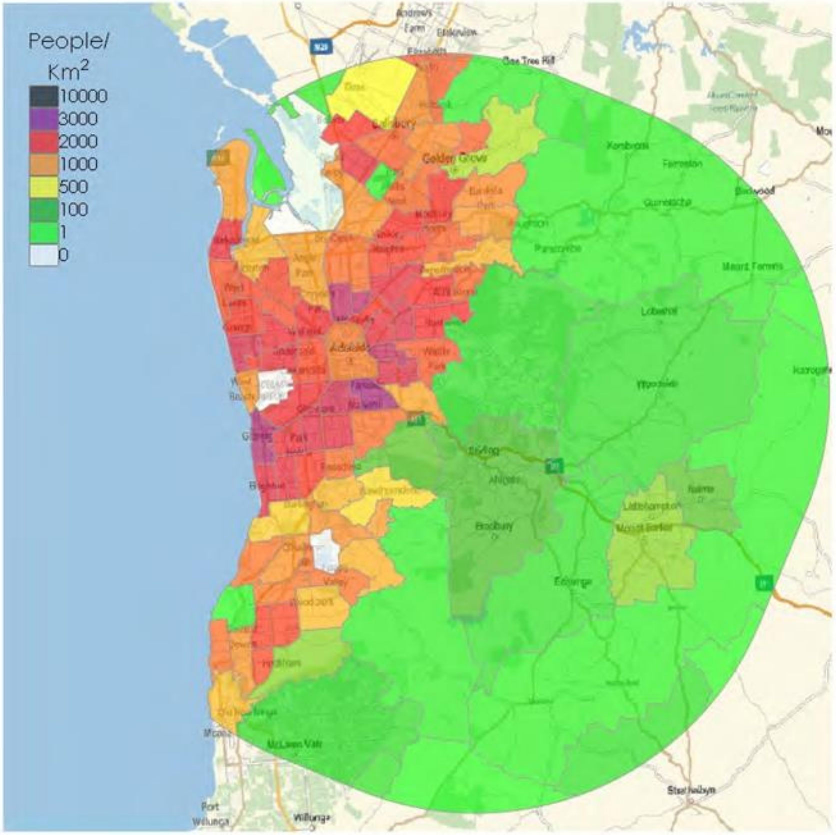
Smaller earthquakes also occur in a distributed manner throughout the region, not only on the identified active faults

* D. Clark and A. McPherson. *Large earthquake recurrence in the Adelaide region: a palaeoseismological perspective.* Australian Earthquake Engineering Society 2011 Conference,2011

# EXPOSURE Population




Day Time

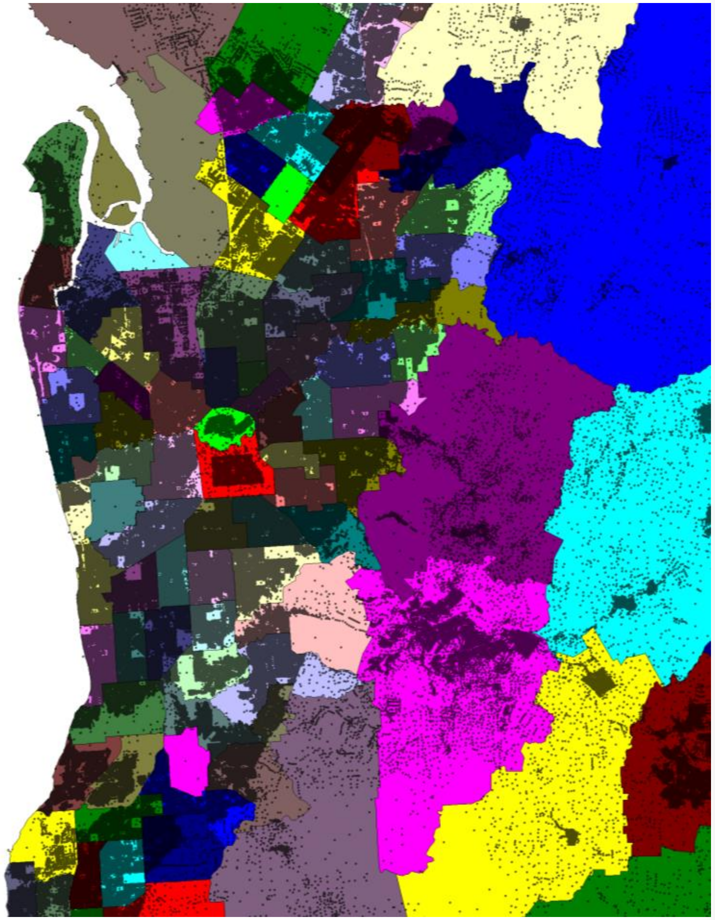



Night Time

**Sources:**

- 2011 Census
- Department of Higher Education

# EXPOSURE Buildings' stock



## What kinds of buildings are people in?

Different building construction types behave differently to seismic shaking

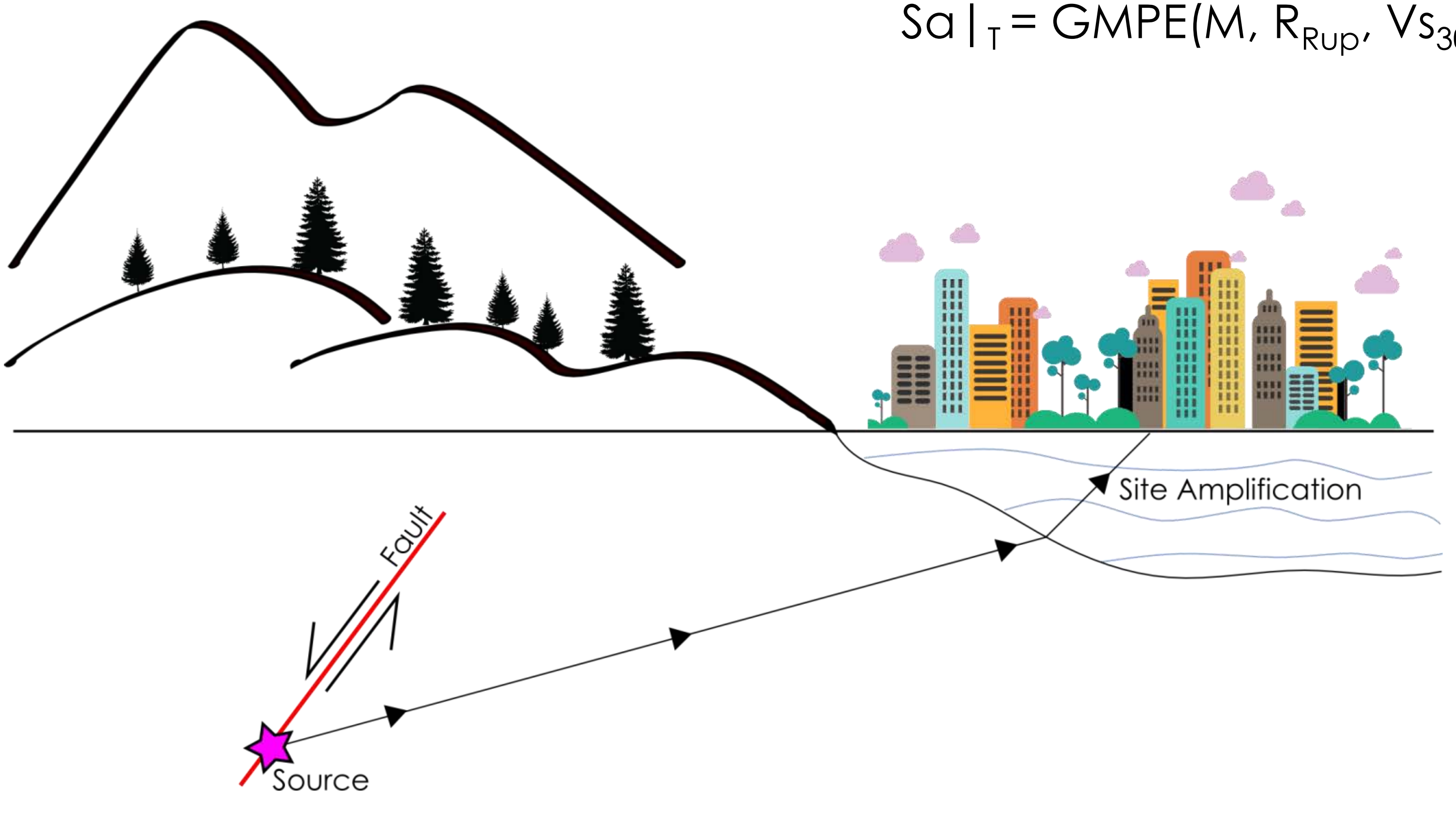
**Sources:**

- G-NAF (Geocoded National Address File) **Lat-Long**
- NEXIS (National Exposure Information System) **SA2**

# HAZARD Ground Shaking

Ground Motion Prediction Equations (GMPEs)

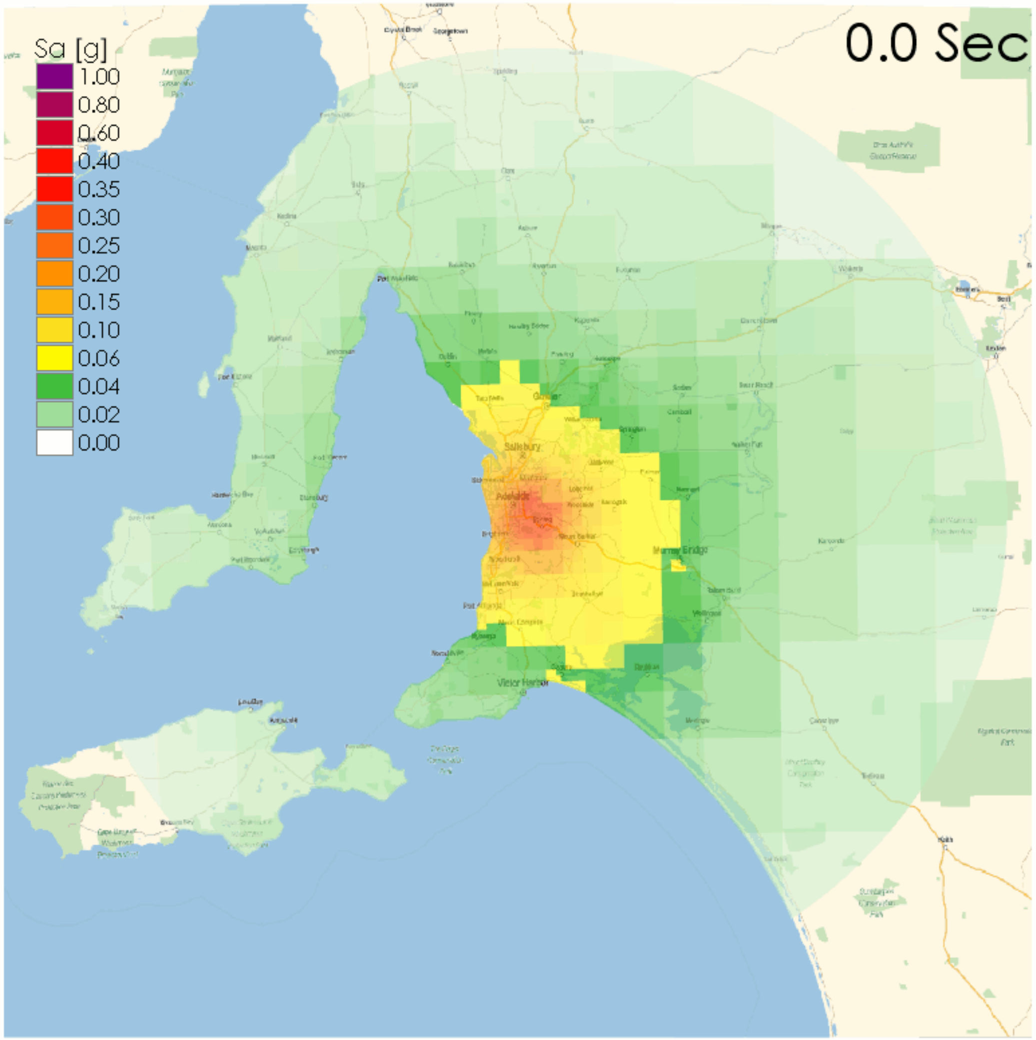
$$Sa|_T = GMPE(M, R_{Rup}, Vs_{30})$$

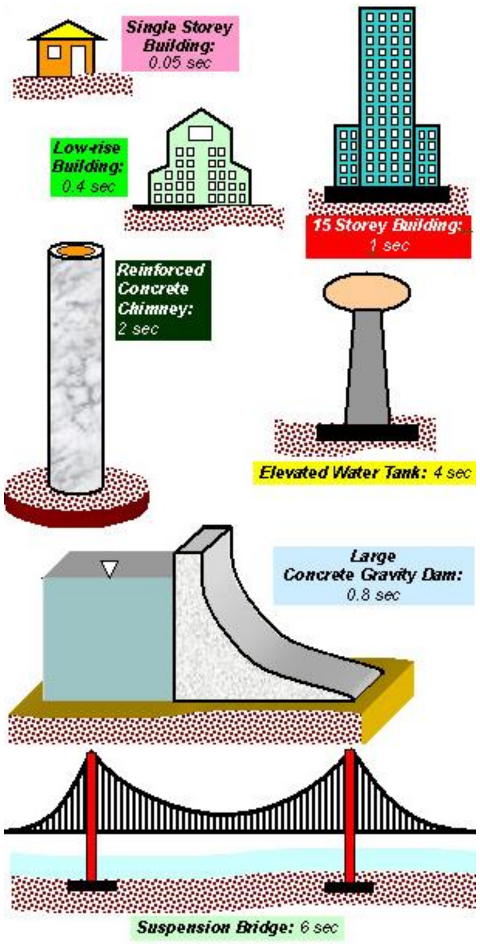




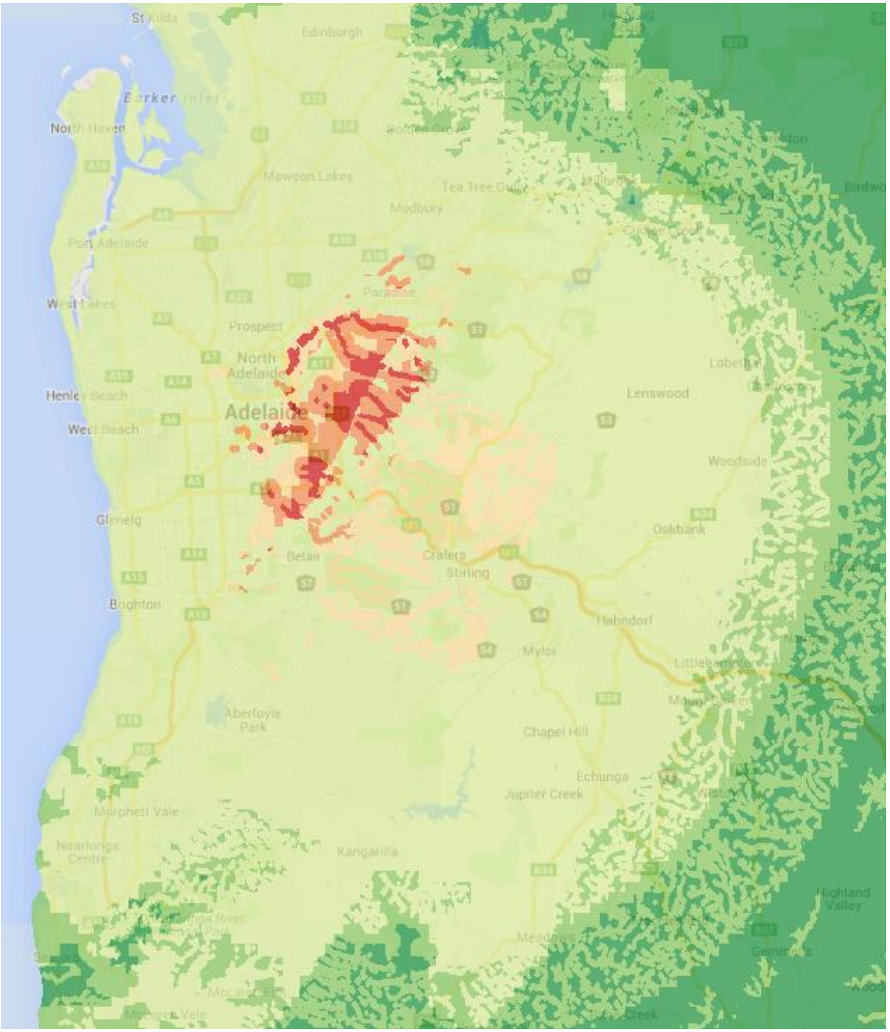
- P. Somerville, R. Graves, N. Collins, S. G. Song, S. Ni, and P. Cummins. Source and ground motion models for Australian earthquakes. In AEES Conference Papers, 2013.

# HAZARD Ground Shaking



# HAZARD Liquefaction




## Parameters

- Soil
- $Vs_{30}$
- Elevation
- Distance to water bodies
- **PGA**

## Features Affected by Liquefaction

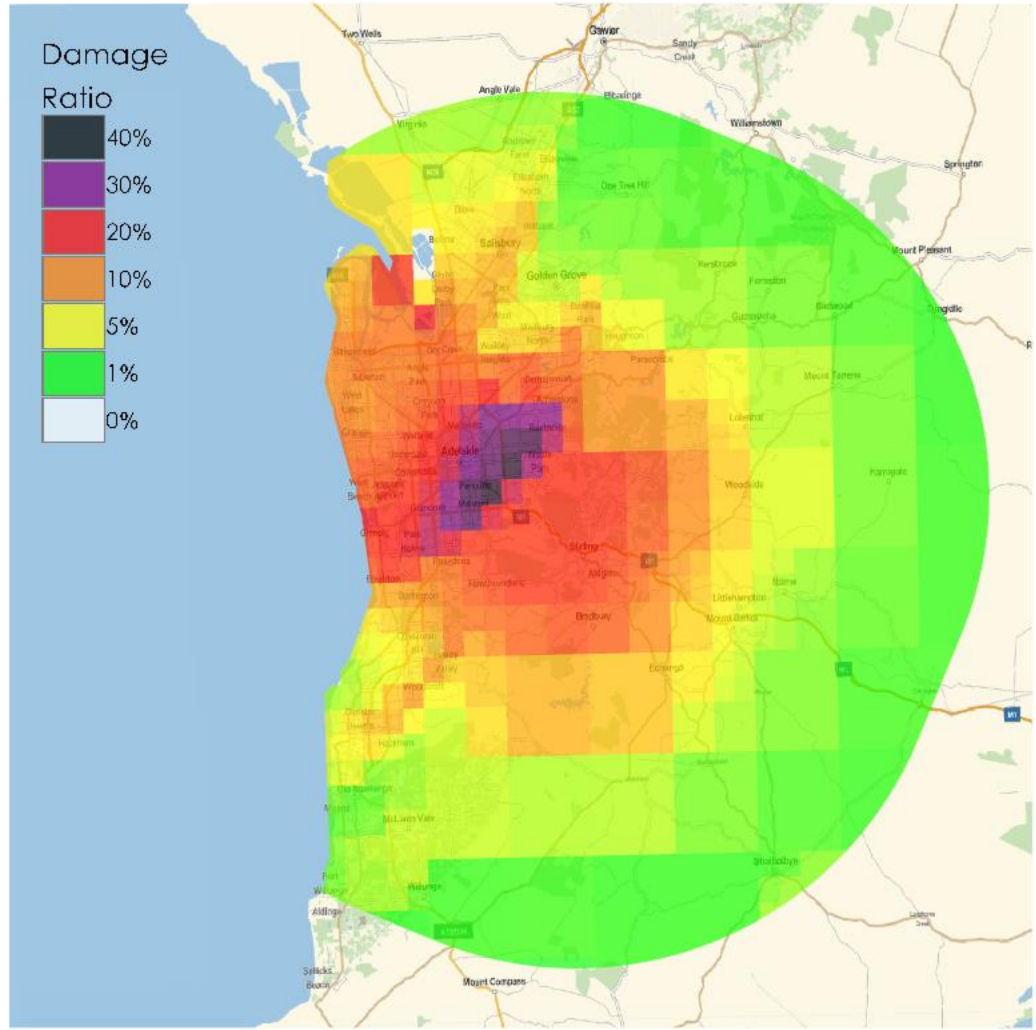
- Buildings
- Roads
- Rail
- Bridges
- Airports
- Pipelines


- K. L. Knudsen et al, Development of a liquefaction hazard screening tool for caltrans bridge sites. In TCLEE 2009: Lifeline Earthquake Engineering in a Multihazard Environment, pages 573-584, 2009.

# RESULTS Buildings

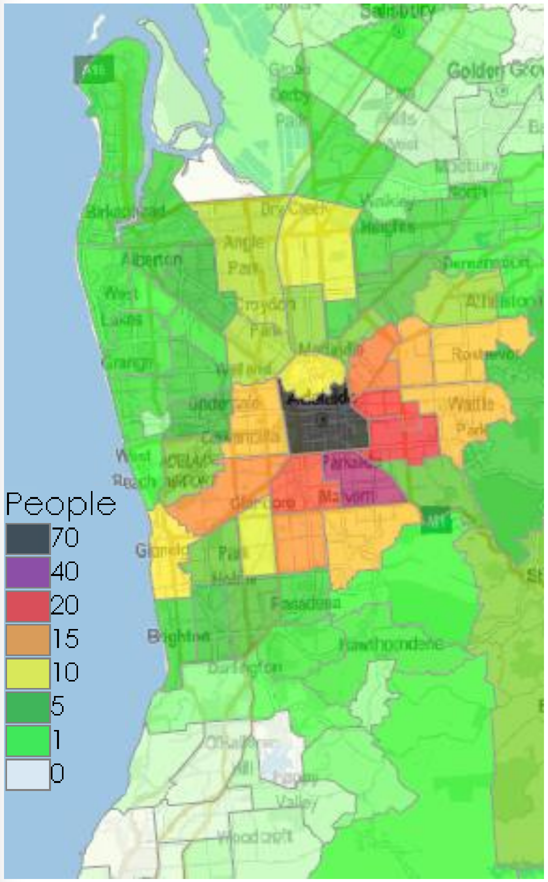
**Number of**
**Equivalent Addresses Destroyed**

| Line of Business | Number of Addresses |
|---|---|
| Residential | 88,440 |
| Commercial | 4,815 |
| Industrial | 1,650 |

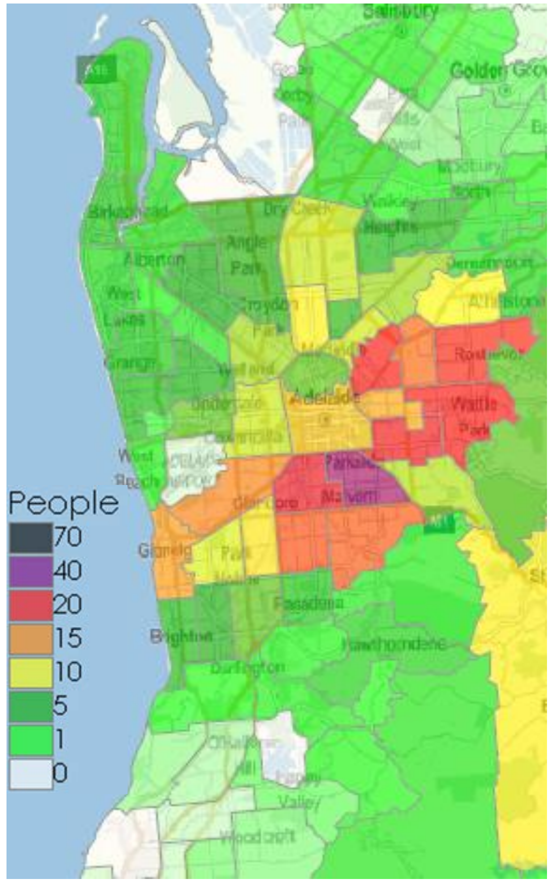



Residential Damage Percentage of Replacement Value of the local Buildings' Stock.

# RESULTS Casualties




Day Time




Night Time

**Severe Injuries and Deaths**

**Median total casualties by severity level and time of day (Number of People)**

| Severity | Day | Night |
|---|---|---|
| 1 | 4,988 | 5,324 |
| 2 | 1,532 | 1,650 |
| 3 | 170 | 167 |
| 4 | 322 | 327 |

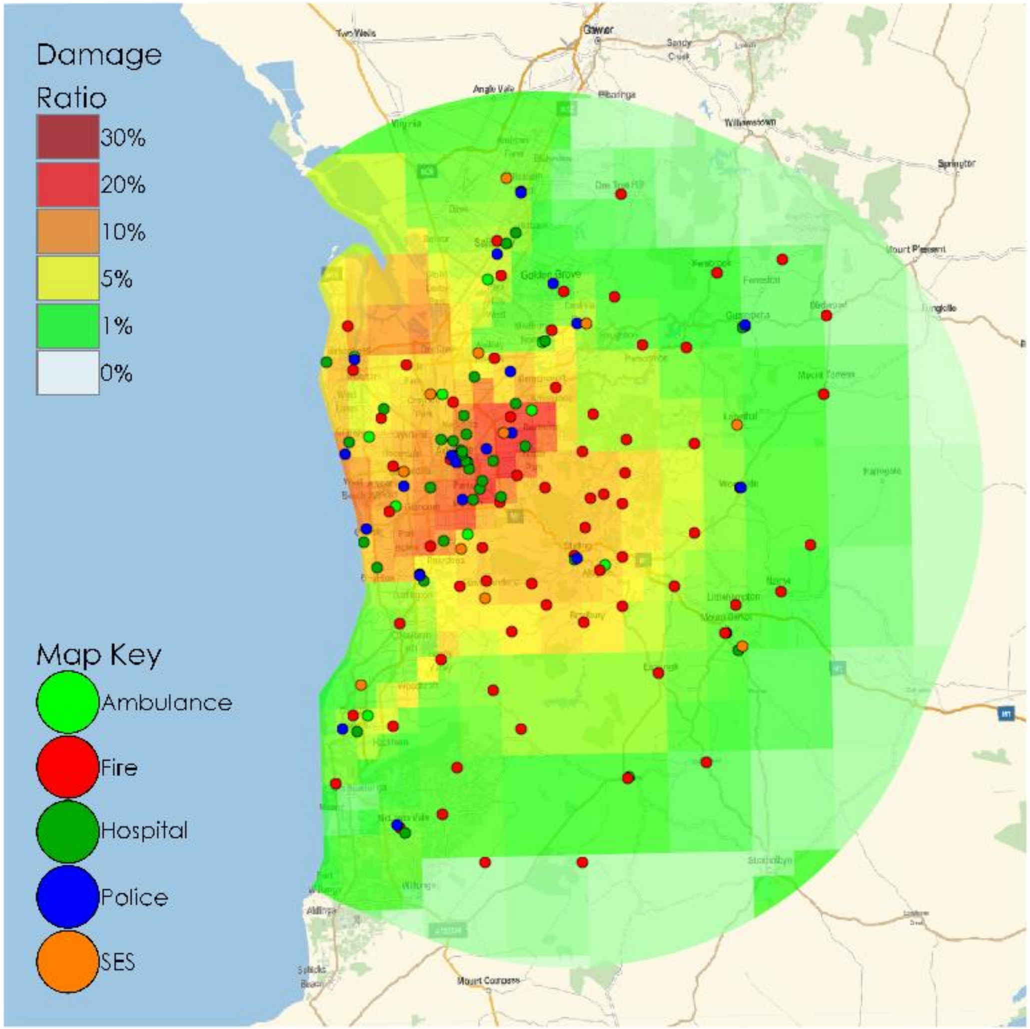
- **Severity 1:** Injuries requiring basic medical aid that could be administered by paramedics.
- **Severity 2:** Injuries requiring a greater medical care and medical technology or surgery, but not expected to be life threatening.
- **Severity 3:** Injuries that pose an immediate life threatening condition if not treated expeditiously.
- **Severity 4:** killed or mortally injured.

# **RESULTS** Essential Facilities

- Higher design standards than ordinary buildings.
- Hospitals should continue to operate even if power and water networks fail.
- Schools used as temporary shelters.
- Estimated loss of capacity:
  - near the epicentre: up to 22%
  - CBD: up to 14%

**Number of essential facilities expected to experience damage in excess of 10%**

| Facility | Number |
|---|---|
| Hospitals | 46 |
| Schools | 167 |
| Fire Stations | 5 |
| Police Stations | 5 |
| SES Stations | 1 |
| Ambulance Stations | 3 |

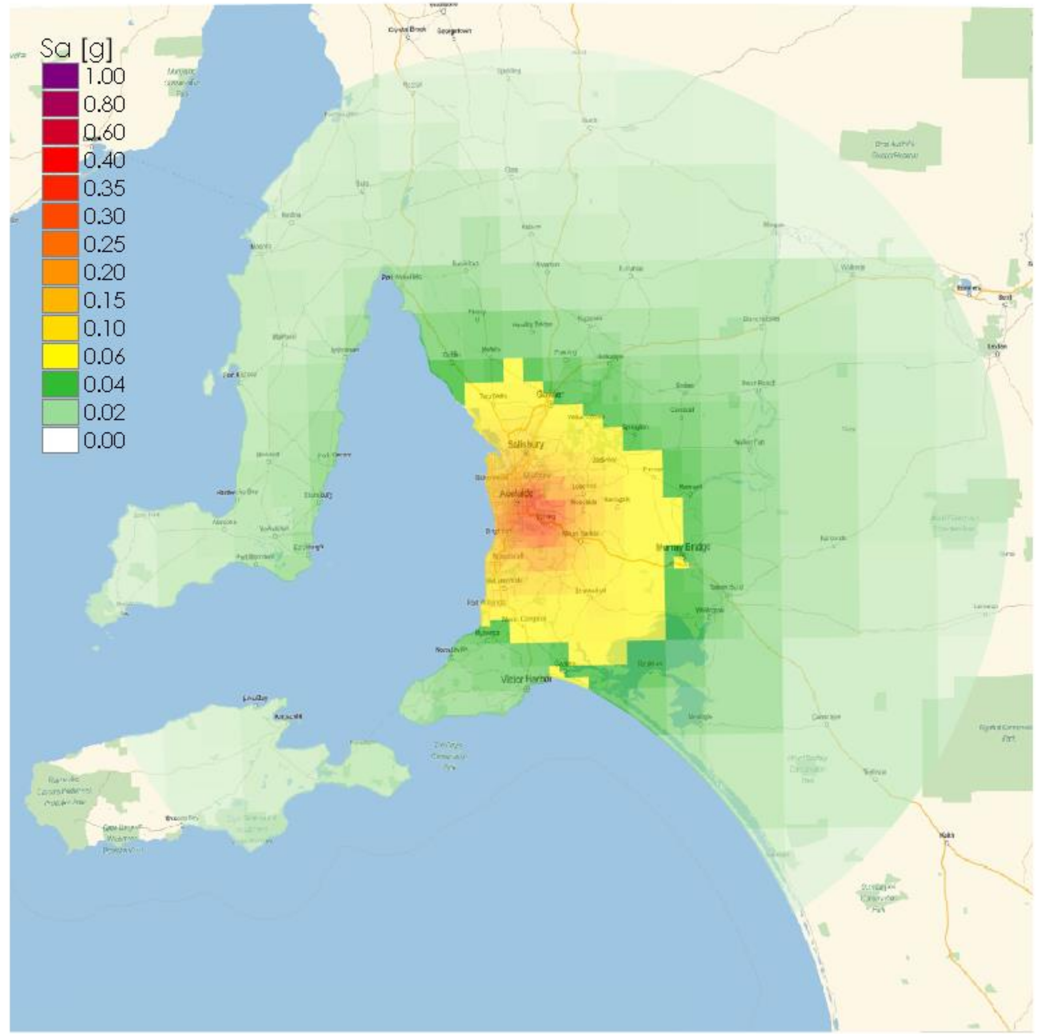



Damage Ratio to essential facilities.

# RESULTS Infrastructure

Modelled following
the HAZUS methodology
with considerations based
on the experience with past events.

- Damage estimated using peak ground acceleration and 1 second spectral acceleration as hazard parameters.
- Work and replacement materials shortage and inter-relationships between downtimes from different infrastructures not accounted for.




Peak Ground Acceleration (PGA) [g]

# RESULTS Infrastructure

## Transport

- **Roads** blocked from debris or preventively shut. Areas of the CBD may be cordoned off for a minimum of **7 days** following the event.
- **Bridges** may be closed for **a day to a week** for inspection and repairs of moderate damage. Near the epicentre, a small number of bridges could experience significant damage and take a minimum of **150 days** to be completely restored.
- Some **railway and tram lines** close to the epicentre will experience minor damage, which corresponds to a downtime of **2 to 7 days**. Few **rail and light rail bridges** close to the epicentre may be extensively damaged and take a minimum of **110 days** to be repaired. The **fuel and maintenance facilities** located in the proximity of the epicentre will mostly suffer minor to moderate damage, which may add **2 to 7 days** to the downtime. They will also have a 40% chance of suffering extensive damage, with associated downtimes of **up to 4 months**.
- Adelaide **airport** is situated 10 km from the epicentre of this scenario and is built on soft soil which is prone to liquefaction. The airport could be closed for a short period of time for damage assessment.

Union Street in Newcastle after the 1989 Earthquake (Source: The city of Newcastle)

Adelaide Airport

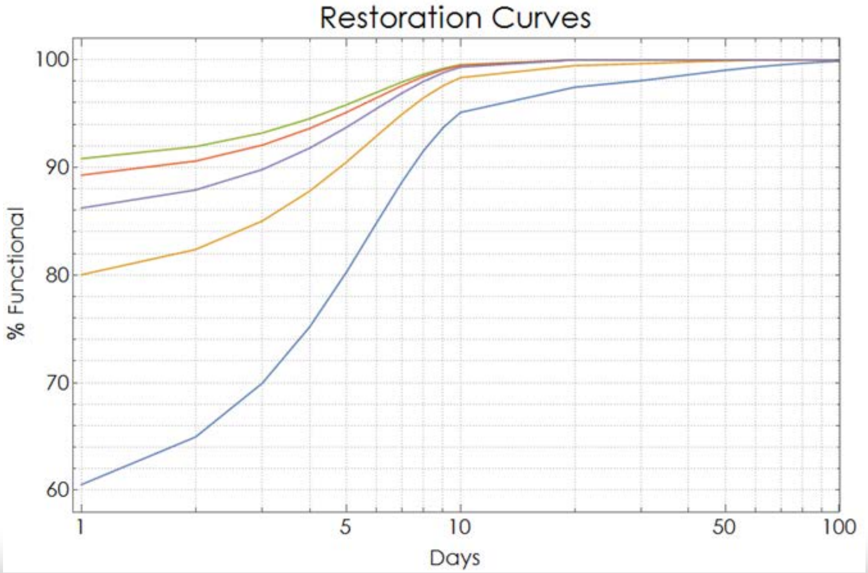
Liquefaction of soft soil on river banks causing damage to a bridge (Source: Risk Frontiers)

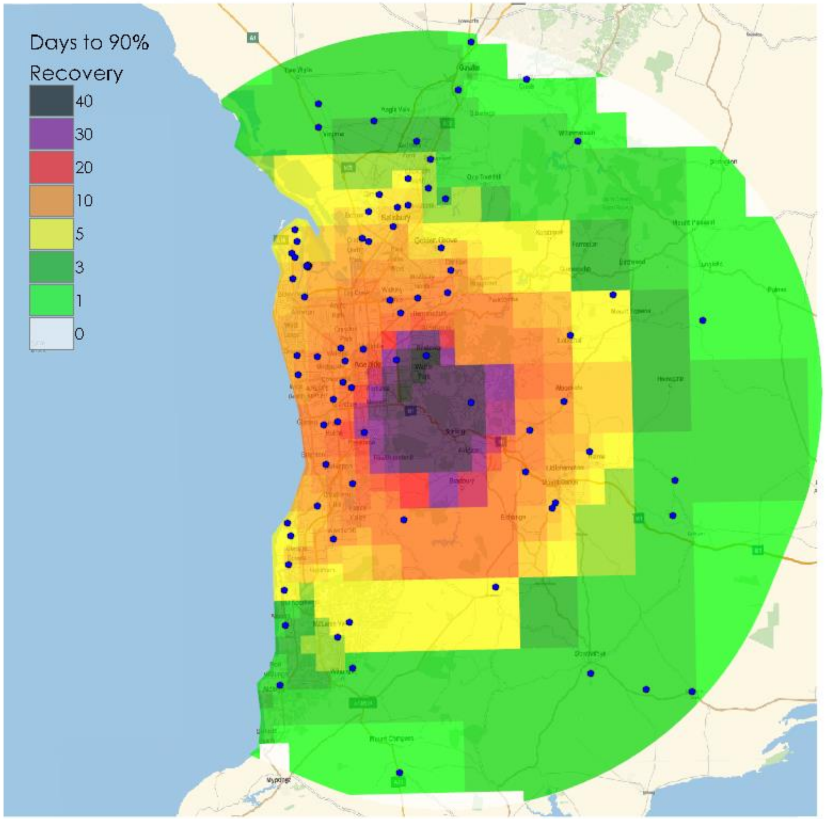
Railway damage in the Canterbury earthquake

# **RESULTS** Infrastructure

## Electricity

- 40% chance of complete failure of **large power components** in the proximity of the epicentre. Downtime of approximately **two months**.
- Almost all **addresses** close to the epicentre will experience at least minor power failures with downtimes of up to **3 days** (longer if nearby substations are severely damaged).
- **Power stations** close enough to the epicentre to sustain some slight or moderate damage will take **a month or longer** to fully recover.




Estimated number of days to reach 90% of the Substations' functionality. The blue dots indicate the substations' location.

Restoration curves for some of the power stations near the epicentre

# RESULTS Infrastructure

## Water Supply & Waste Water

### Water supply

- Major water facilities such as **pumping stations** and **reservoirs** may experience extensive damage with a probability of 15%, which implies a downtime of **40 days**.
- Minor damage may occur **across the network**, with a downtime of **3 days** (if no major system was completely damaged).
- In case of liquefaction, breakage of **pipes** is likely to be widespread in the high potential areas, and concerns over contamination may render the water not suitable to drinking.

### Waste water

- Extensive damage could occur in 25% of waste water systems near the epicentre even without the occurrence of liquefaction; addresses within this zone may be without sewage services for up to **150 days**.

## Communications

- The area near the epicentre could experience moderate damage with downtimes ranging from **less than 1day to a week**.
- About 30% of the major facilities (central offices and broadcast stations) located in the area near the epicentre will experience extensive damage with associated downtimes of **up to a month**.

# POTENTIAL UNFORESEEN IMPACTS

- **Chemical and high risk industrial plants**
  - Usually away from residential zones.
  - Service disruption (1998 Longford gas explosion, VIC).
  - Release of hazardous material.
- **Hazardous material release**
  - Not only from heavy industry but also from building collapse.
  - Release of carcinogenic or corrosive gases, poisonous liquids that contaminate the water table.
  - Asbestos: health risk, large clean-up costs, cordoning of many properties.
- **Fire following earthquake**
  - Caused extensive damage in the past (San Francisco 1906, Tokyo 1923).
  - Still common today (1995 Kobe, Japan). Likely localized to high risk sites (Cosmo Oil Company fire following the 2011 Tohoku earthquake in Chiba, Japan).
  - Gas pipe failure: large fire in the area affected by this scenario. The continued functioning of the water supply for fire fighting would become critical.
- **Long series of strong aftershocks**
  - Disruption of recovery activities.
  - Decrease in population and economic importance of the city as businesses migrates to safer areas.
  - Reconfiguration of the city: older suburbia will progressively close down as the aftershock sequence progresses.
  - Such a scenario would be devastating for Australia as it has been for New Zealand following the Canterbury earthquakes.

# SOCIAL IMPACT

**Short term**

- Death/ Injury.
- Isolation/separation.
- Loss of lifelines/services (water, sewage, gas, electricity).
- Building damage and loss of refuge (damage to home and possessions, access to home blocked off, etc.).
- Loss of communication.
- Strain on emergency services.
- Vandalism/crime.

**Long term**

- Long term injuries.
- Moving house/fixing house.
- Struggles with insurance or government pay-outs.
- Loss of income.
- Continual unrest.
- Increase in violence/drug and alcohol use.
- Economic loss in the area.

# QUESTIONS

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