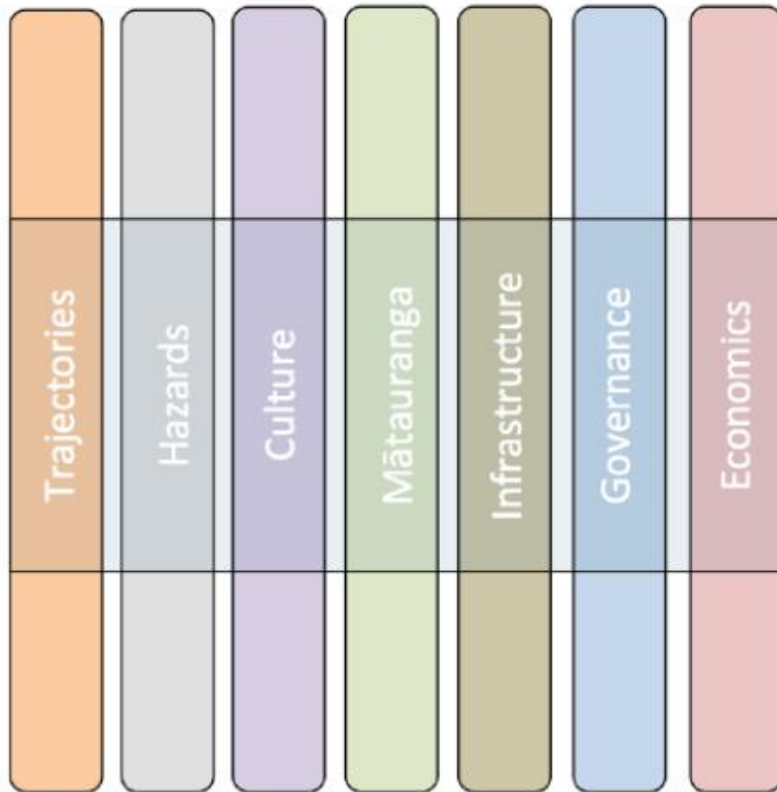# Resilience of Distributed Infrastructure 2015-2019

- Infrastructure Advisory Group Meeting

- Feb 2019

- More Info:

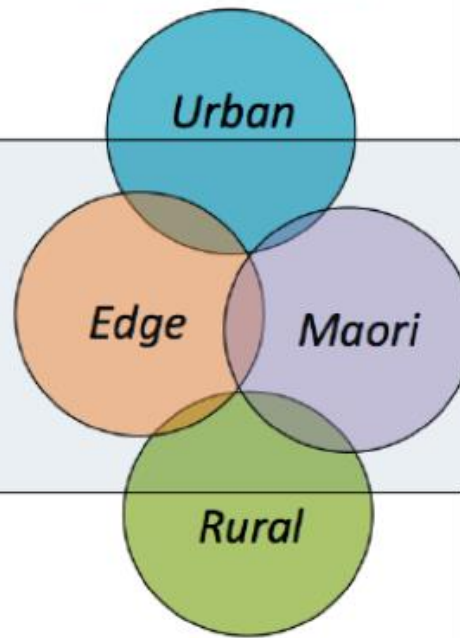- https://wiki.canterbury.ac.nz/display/QuakeCore/Special+Project+1%3A+Spatially-distributed+Infrastructure

RNC1 Old Structure

Research Strategy – Resilience to Nature's Challenges

Underpinning Resilience Disciplines

Trajectories | Hazards | Culture | Mātauranga | Infrastructure | Governance | Economics

Co-creation Labs

Urban

Edge

Maori
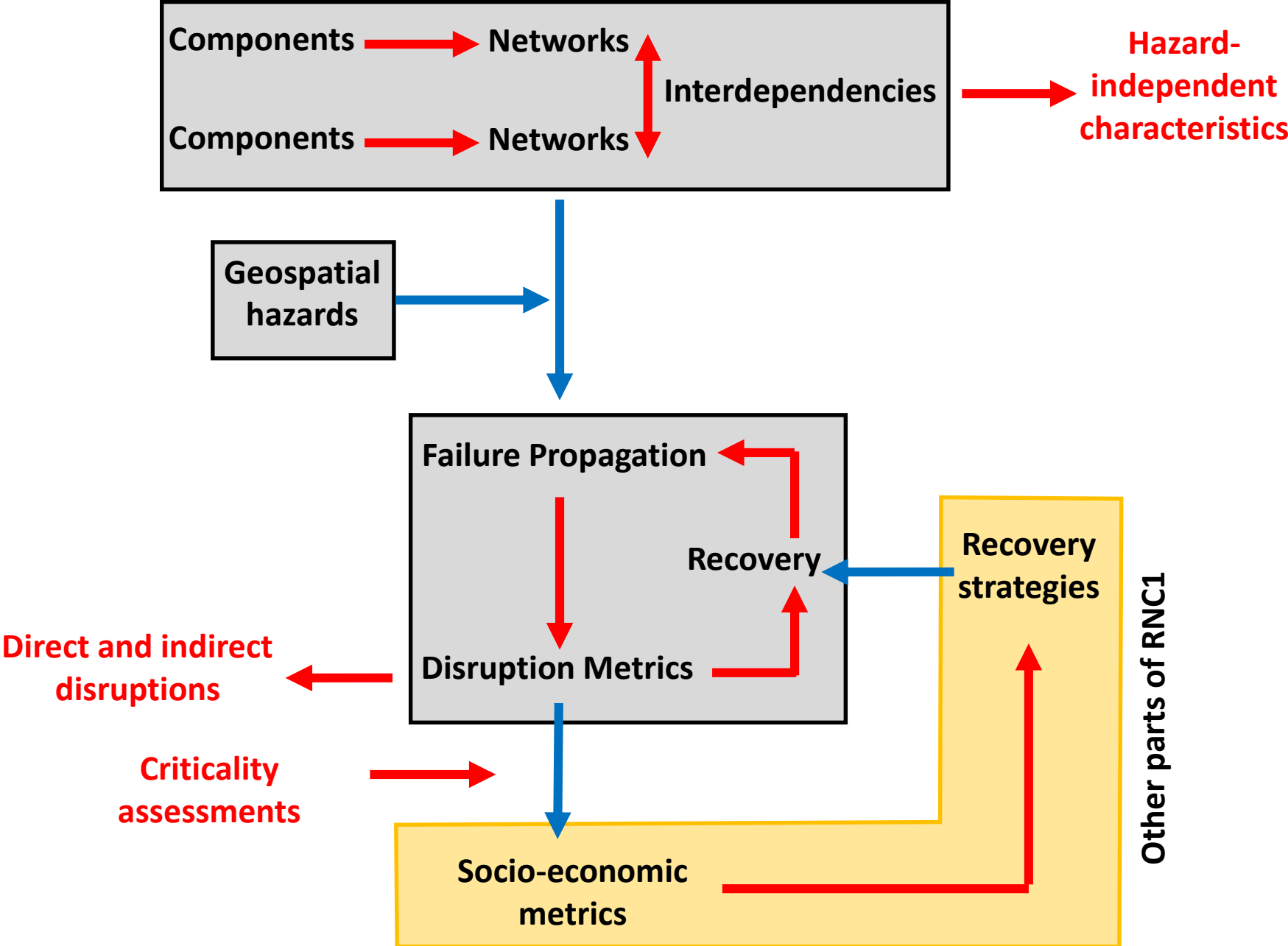
Rural

Resilience Pipeline

A Resilient New Zealand

Priority Partnerships

Innovative Enabling Technologies

Distributed Infrastructure Structure

Immediate Team

- Wotherspoon, Costello, Ranjitkar, Nair, Shamseldin, Whittaker, Chowdhury, Austin (UoA)

- Bradley, Hughes, Blake, Giovinazzi, M. Wilson, T. Wilson (UoC)

- Ivory (WSP-Opus)

- Stevenson (Res Orgs)

- Crawford-Flett (QC)

- Paulik, Popovich (NIWA)

- Uma (GNS)

- Fairclough (Neoleaf)

- Strong collaborations with QuakeCoRE, AF8, NIWA throughout and with wider ground of reseachers

Infrastructure Statistics to Date

- Students (direct)
  - 10 PhD
  - 6 Masters
  - 2 Post-Doc
  - 25+ undergraduate projects
- Over $1 million co-funding
- Over 50 partner meetings
- Over 50 presentations
- 20+ publications/reports
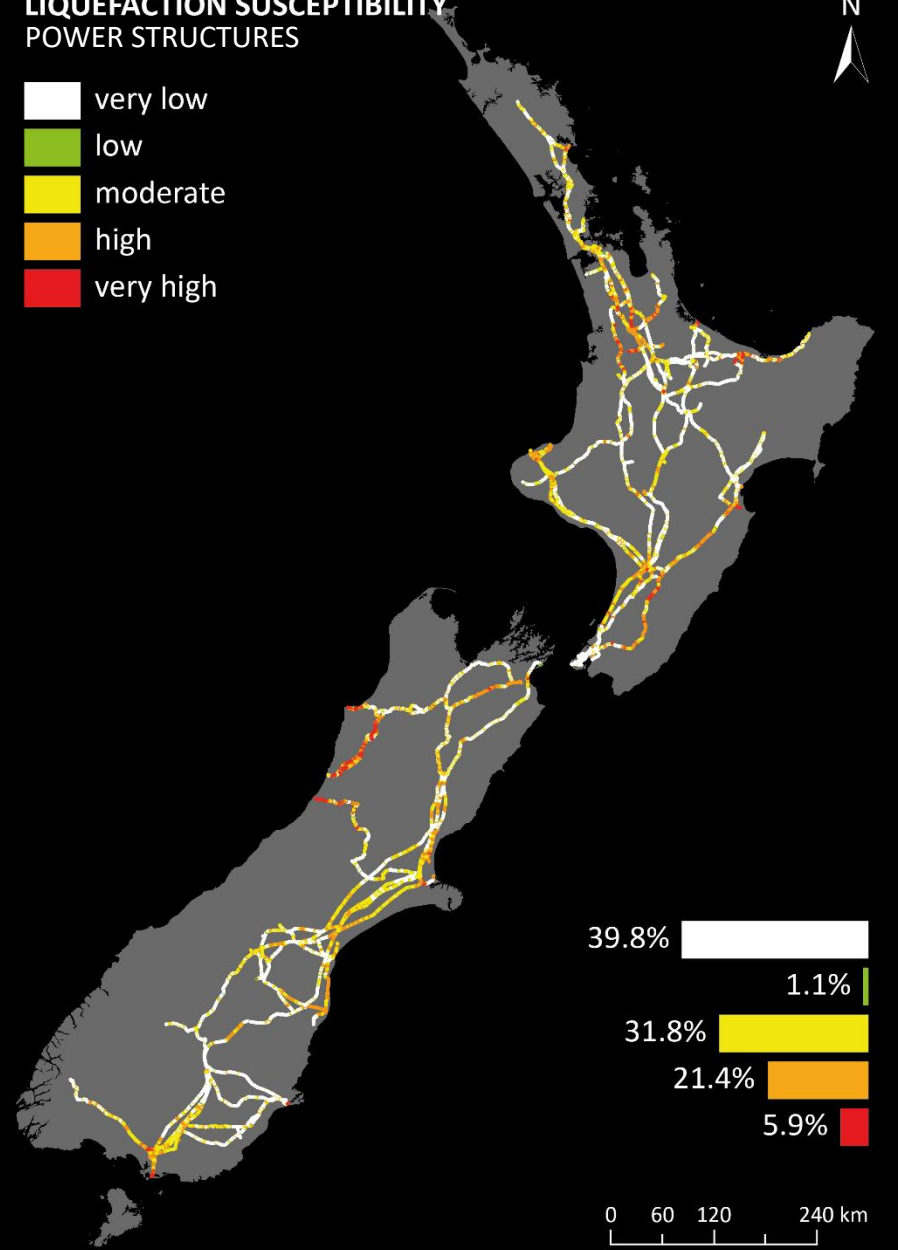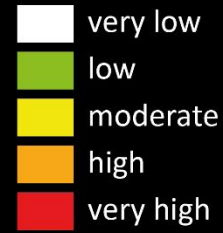
Geospatial Hazards

- National/regional geospatial hazard simulation – ground shaking, liquefaction, landslides
  - Automated mapping onto infrastructure networks for scenarios/return period shaking **Mid 2019**

LIQUEFACTION SUSCEPTIBILITY
STATE HIGHWAYS

- very low
- low
- moderate
- high
- very high

N

24.6%
1.1%
36.1%
29.5%
8.7%

0   60   120   240 km
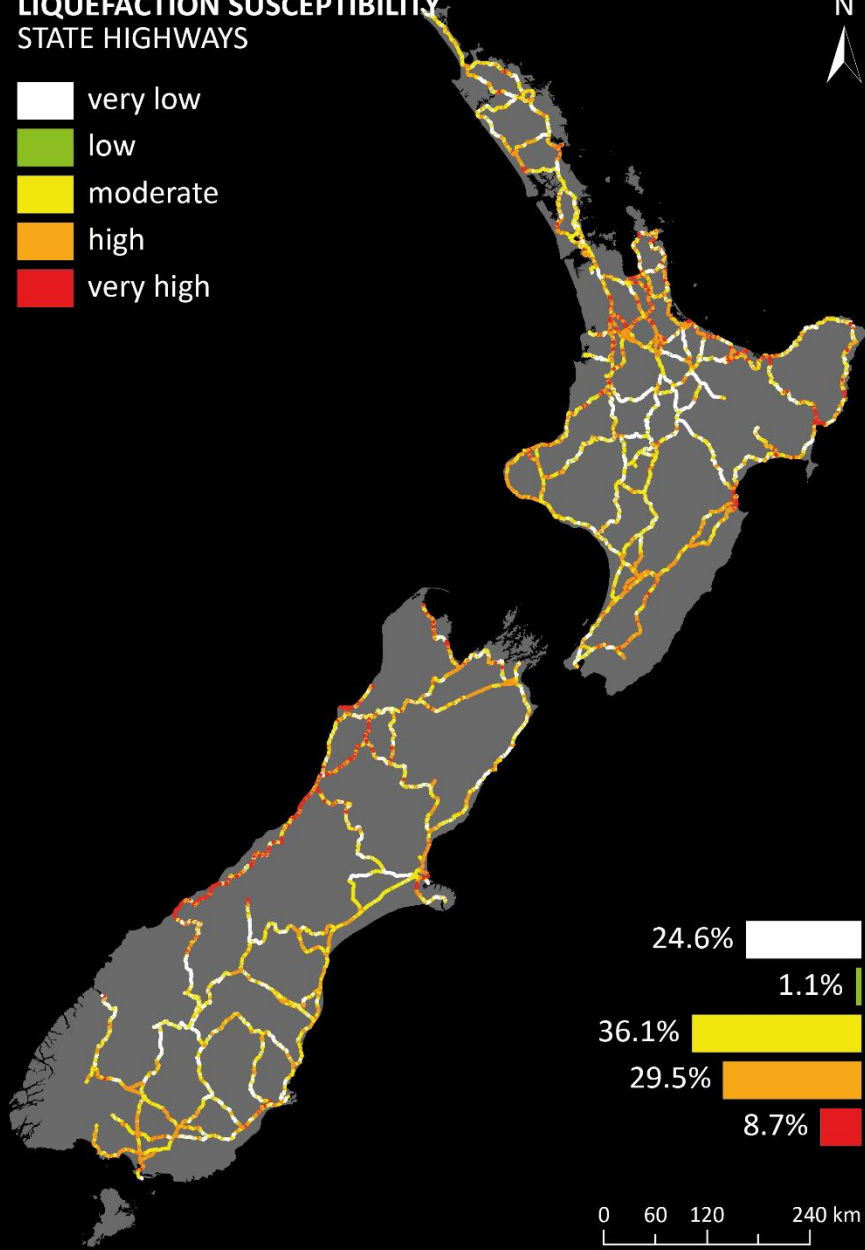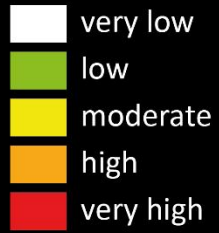
LIQUEFACTION SUSCEPTIBILITY
POWER STRUCTURES

- very low
- low
- moderate
- high
- very high

N

39.8%
1.1%
31.8%
21.4%
5.9%

0   60   120   240 km

PGV (cm/s)

Liquefaction Probability
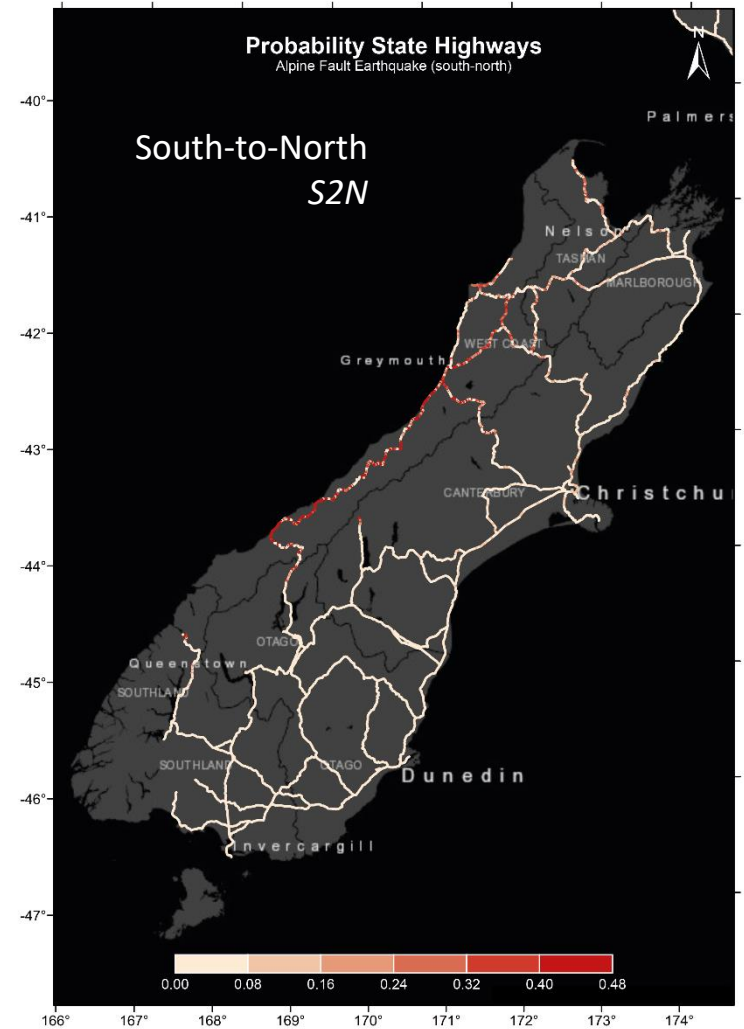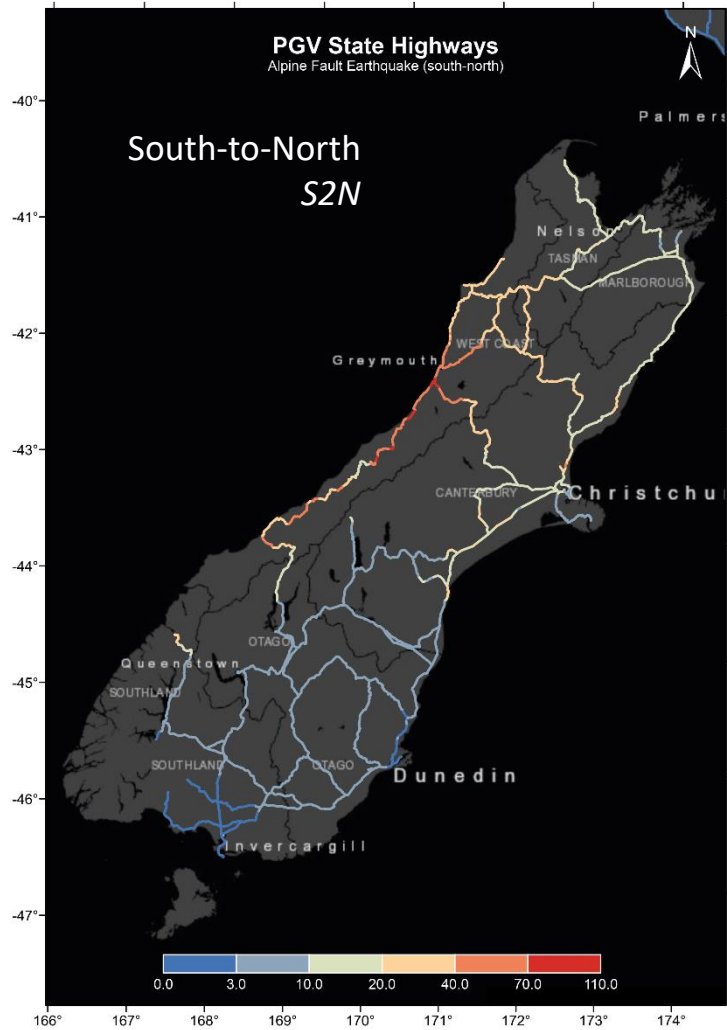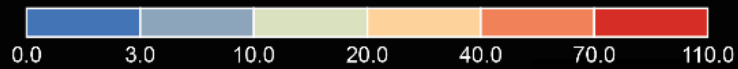
Transport

- MoT Kaikōura project   **COMPLETE**
  - An evaluation of transport sector responses to the Kaikōura earthquake, New Zealand
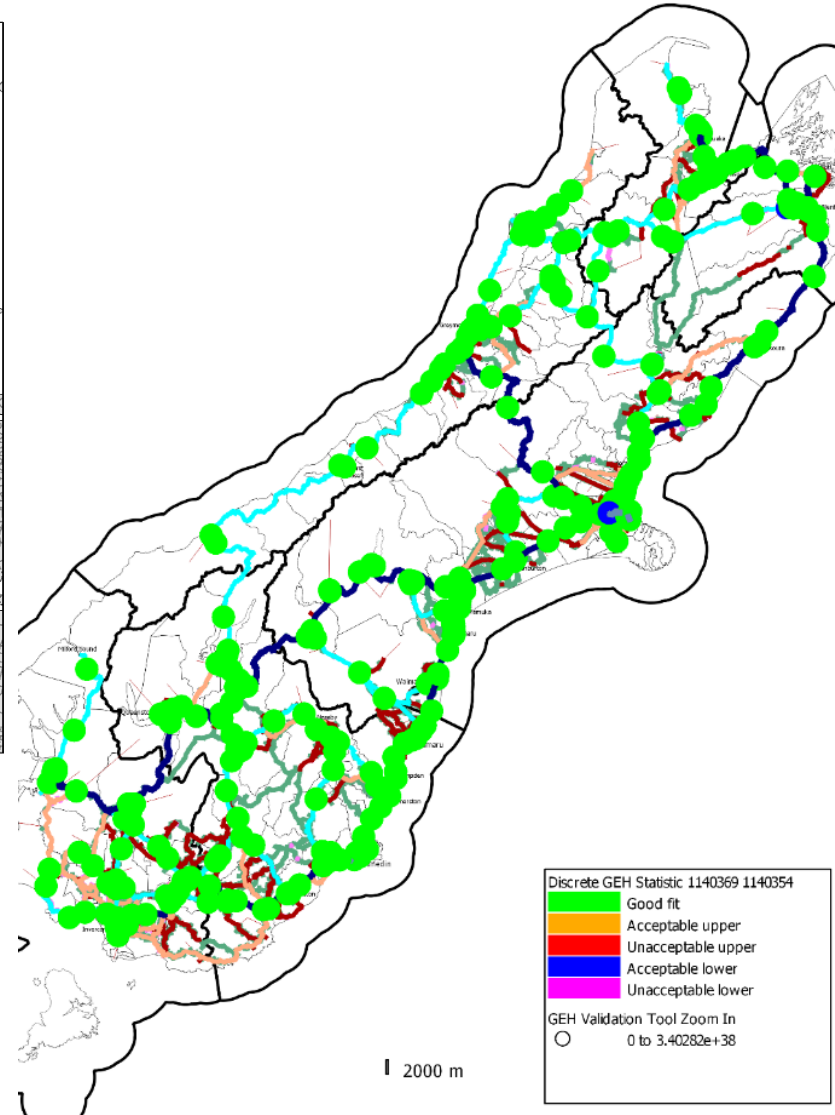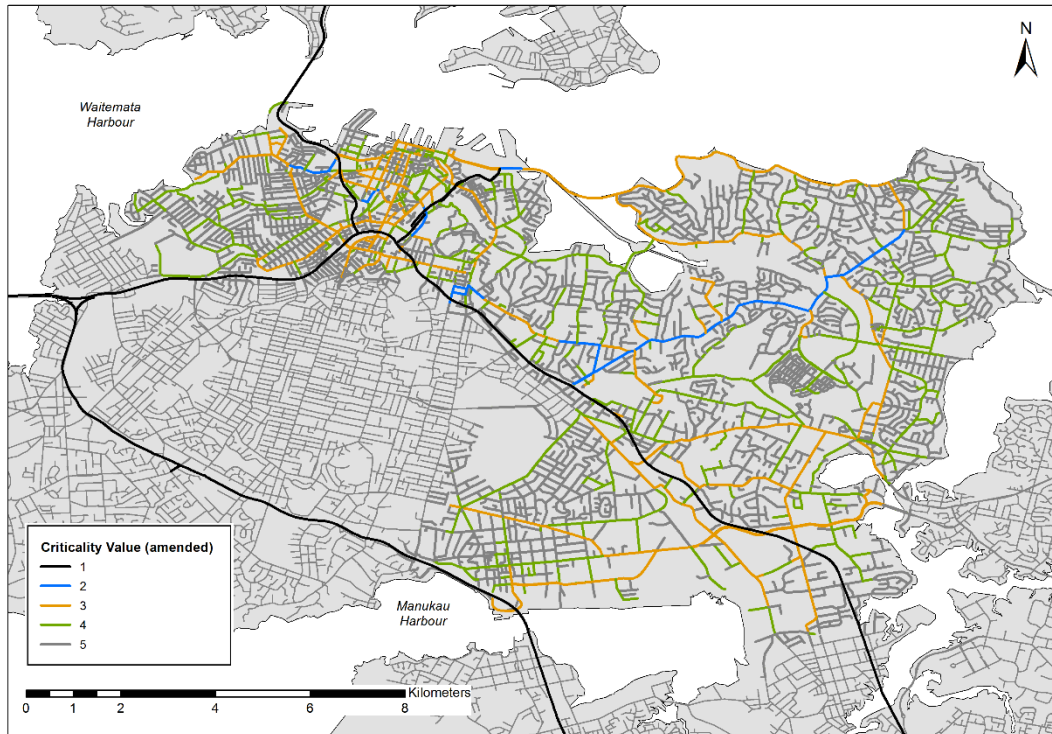
- Urban Road Criticality Framework (AT)   **COMPLETE**
  - Update of existing framework to account for critical facility access

- Operational Resilience Assessment of a Rural Road Network (NZ Transport Agency)
                                                          End 2019
  - South Island Transport Model Complete
  - Kaikoura EQ and Alpine Fault

- Auckland Transport Model (AT, NZ Police)
  - Model Complete   **End 2019**
  - Volcanic eruption evacuation

Transport

- NZ specific bridge fragility models (NZ Transport Agency)
  - Historic seismic performance   **COMPLETE**
  - Seismic and tsunami loading   **End 2019**

- Port Tsunami Exposure (Port Companies)
  - Scenario Propagation Modelling
  - Component Mapping

    COMPLETE

Transport

Criticality Value (amended)
— 1
— 2
— 3
— 4
— 5

Kilometers
0 1 2 4 6 8

Waitemata Harbour

Manukau Harbour

Discrete GEH Statistic 1140369 1140354
- Good fit
- Acceptable upper
- Unacceptable upper
- Acceptable lower
- Unacceptable lower

GEH Validation Tool Zoom In
○ 0 to 3.40282e+38

2000 m

Electricity

- Electric power distribution system resilience modelling toolbox (Westpower and Transpower)

- A Framework for Islanded Microgrid Operation after Hazard Events (Westpower)

- Effective Power Restoration Practices following extreme natural hazards (Westpower)

Electricity

- Seismic fragility of buried HV cables (with Orion) **End 2019**
  - Development of performance dataset from Canterbury earthquake sequence

- Electric power criticality and resilience (EEA) **Mid 2019**
  - Build on Transport and other frameworks

- Tsunami impacts (Orion)
  - Component fragility modelling - electricity **Mid 2019**
  - Electricity network and recovery **2020**

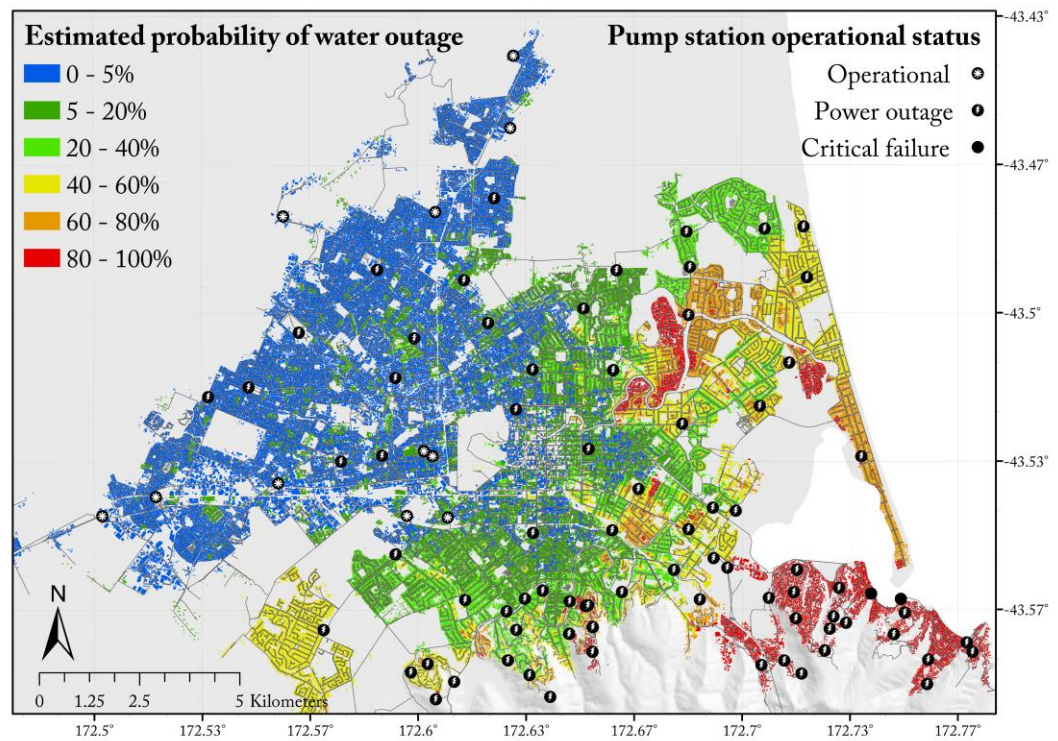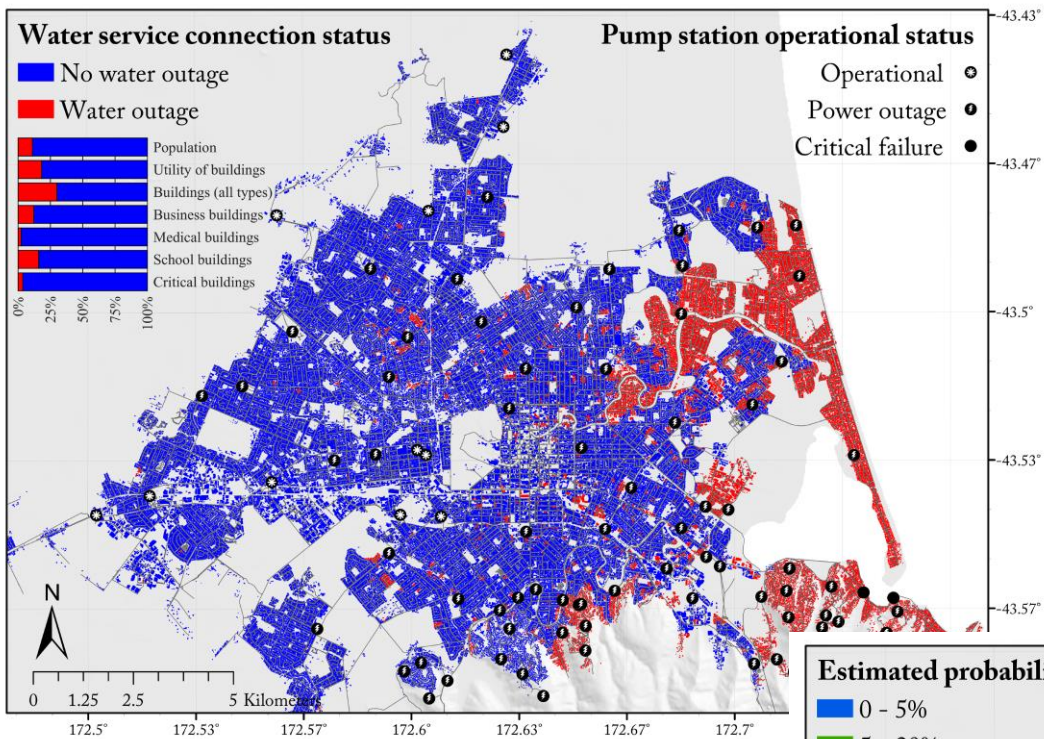- Wind farm hazard assessment (initial) **COMPLETE**

Electricity
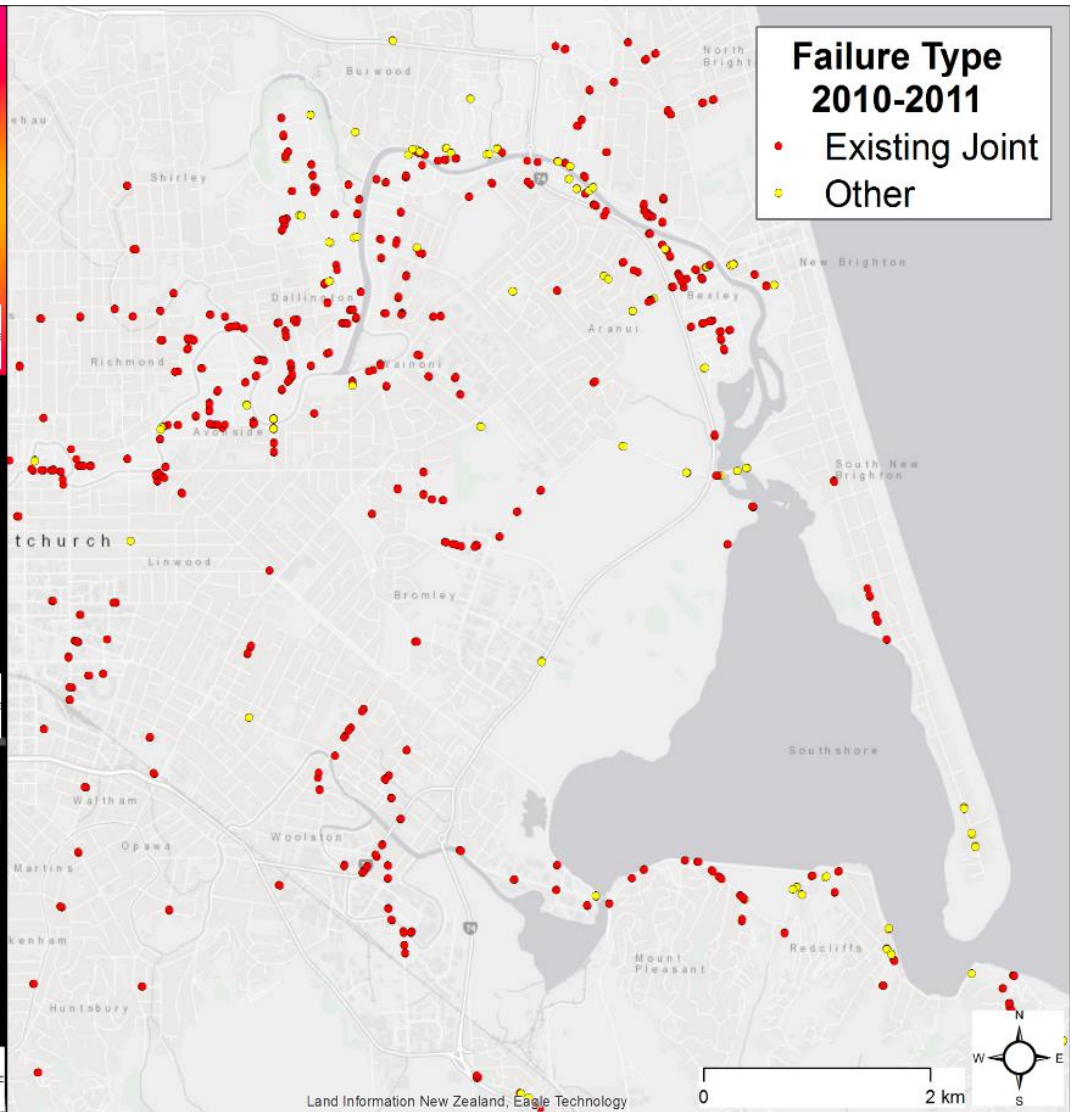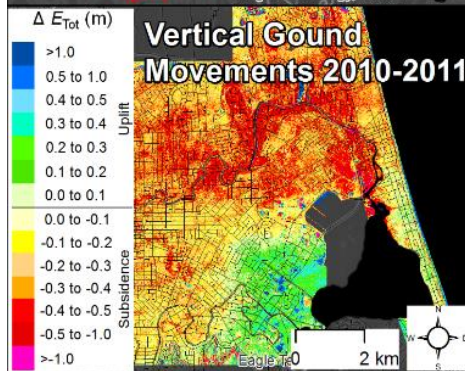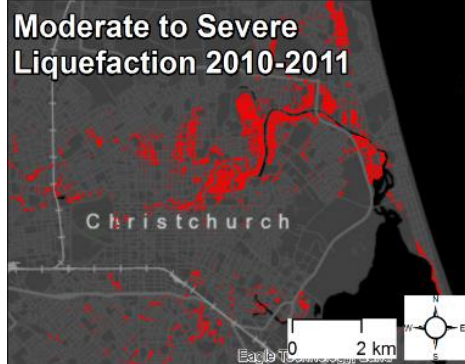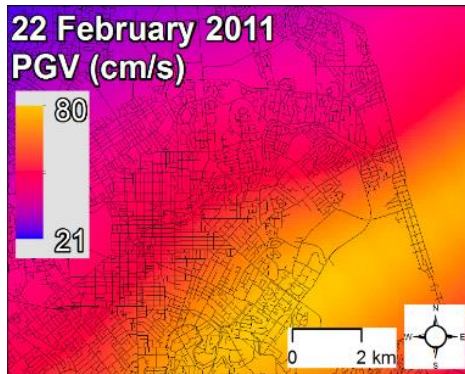
3 Waters

- Potable water (with CCC)
  - Development of seismic fragility models from Canterbury earthquake sequence dataset **Complete**
  - Development of system recovery tool for Christchurch network **Complete**

- Wastewater (with CCC)
  - Dataset collation from Canterbury earthquake sequence and fragility model development **Early 2019**

- Stormwater Resilience (with AC)
  - Technical resilience framework for pipe networks **Complete**
  - Resilience indicators for network structure **Complete**

Water service connection status

Pump station operational status

- Operational
- Power outage
- Critical failure

No water outage
Water outage

Population
Utility of buildings
Buildings (all types)
Business buildings
Medical buildings
School buildings
Critical buildings

0% 25% 50% 75% 100%

N

0 1.25 2.5 5 Kilometers

172.5° 172.53° 172.57° 172.6° 172.63° 172.67° 172.7°

-43.43°
-43.47°
-43.5°
-43.53°
-43.57°

Estimated probability of water outage

Pump station operational status

- Operational
- Power outage
- Critical failure

0 - 5%
5 - 20%
20 - 40%
40 - 60%
60 - 80%
80 - 100%

N

0 1.25 2.5 5 Kilometers

172.5° 172.53° 172.57° 172.6° 172.63° 172.67° 172.7° 172.73° 172.77°
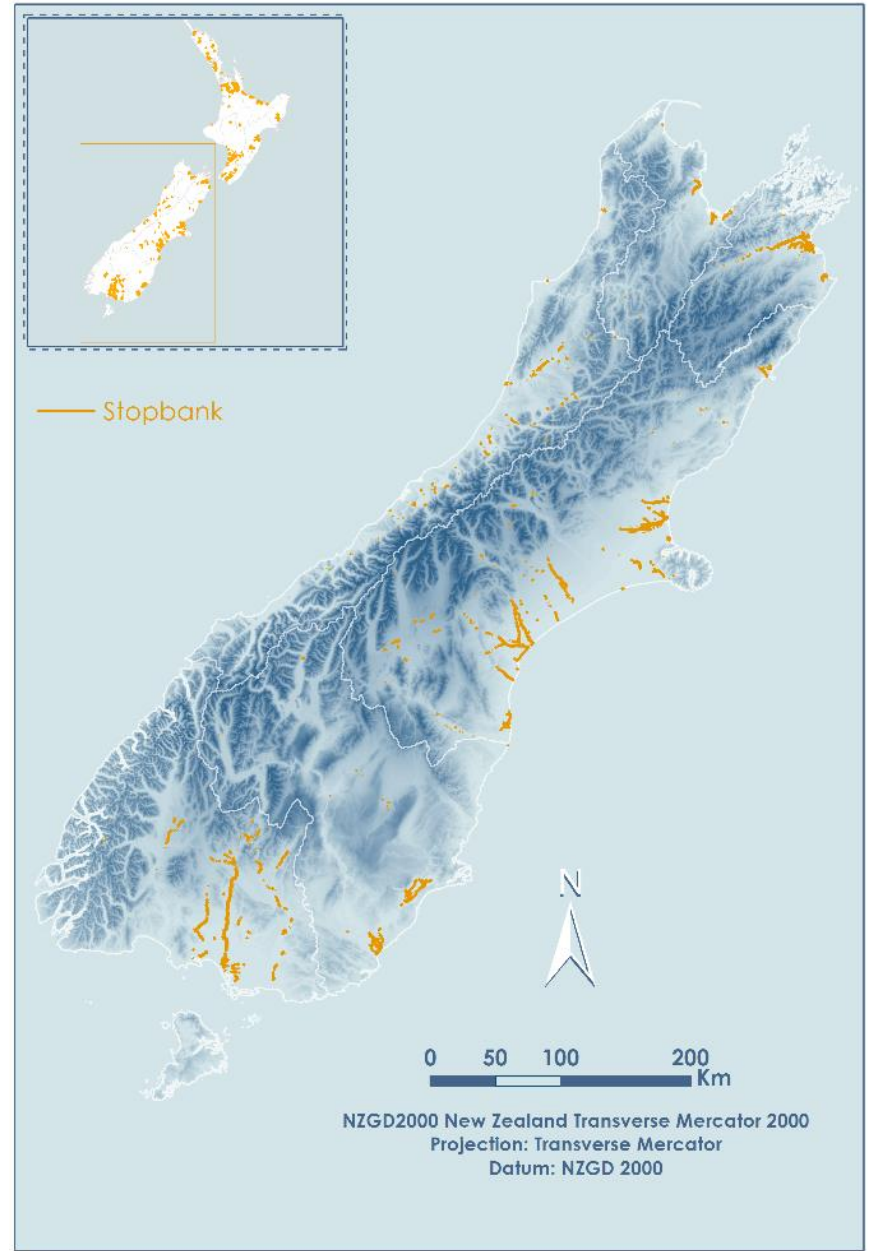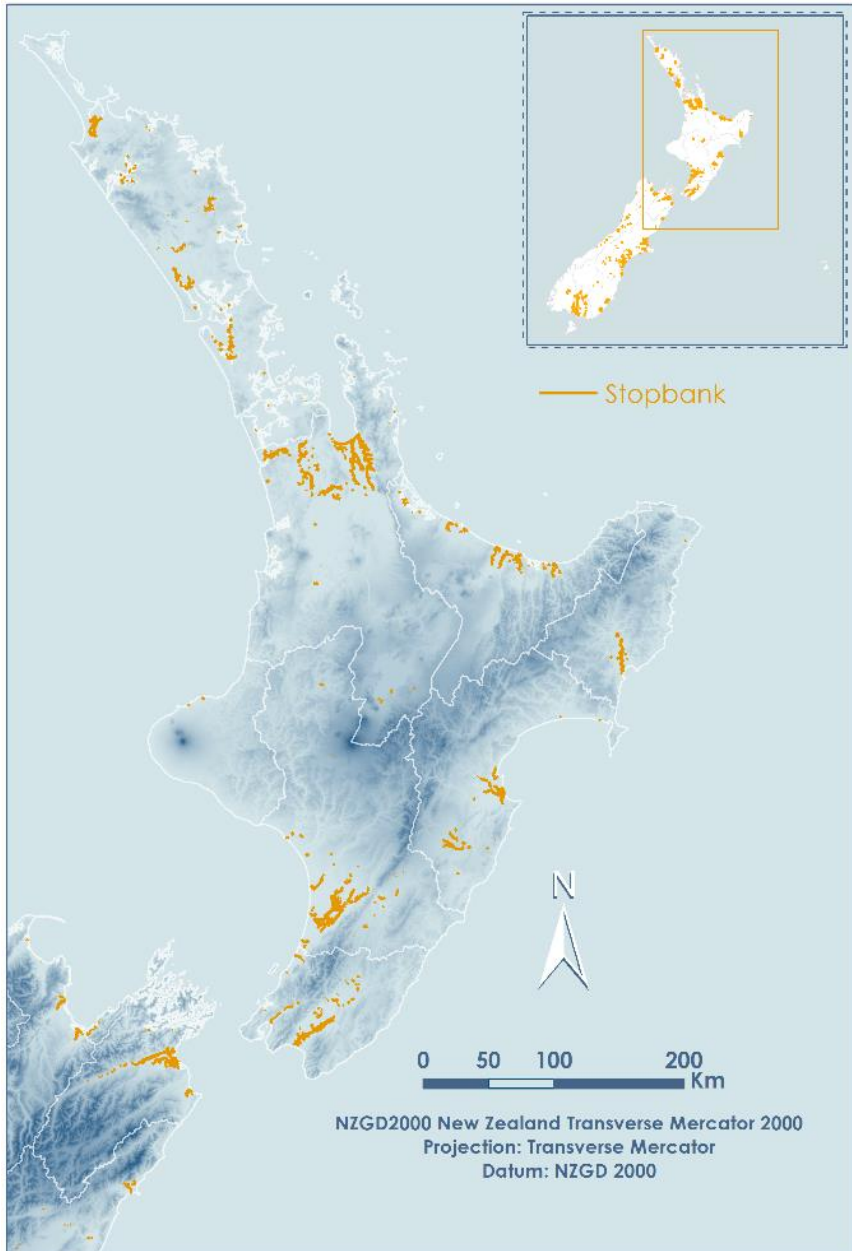
-43.43°
-43.47°
-43.5°
-43.53°
-43.57°

Flood + Flood Defence

- Flood Defence (River Managers and Tasman DC)
  - NZ Inventory of Stopbanks (NZIS) v1 **Complete**

  - NZIS Geotechnical data and incident database **End 2019**

  - Influence of undocumented stopbanks on flood routing and catchment performance **Early 2019**

  - Stopbank failure mode modelling **2020**

- Infrastructure flood vulnerability models **1st stage COMPLETE**

Stopbank

NZGD2000 New Zealand Transverse Mercator 2000
Projection: Transverse Mercator
Datum: NZGD 2000

0   50   100   200
Km

Stopbank

NZGD2000 New Zealand Transverse Mercator 2000
Projection: Transverse Mercator
Datum: NZGD 2000

0   50   100   200
Km

Telecommunications

- Telecommunications performance in Canterbury and Kaikōura EQs (Chorus)

- Framework for dynamic reconfiguration of wired and wireless communication systems   **2019-2020**

End-to-End Simulation

- National Scale Interdependent Infrastructure Model

    COMPLETE

- Incorporation of electric power network process models into interdependency models
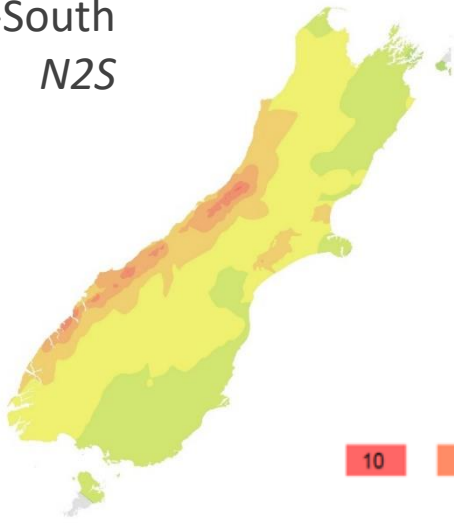
    Mid 2019

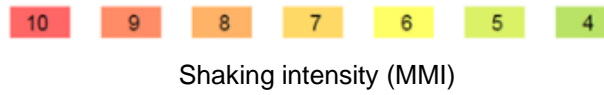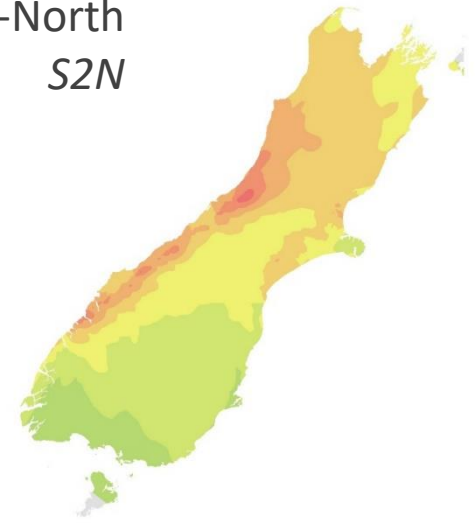- Linkage of model outputs into MERIT

    Test Case – Corridor Forums

- City scale interdependency modelling

    End 2019

North-to-South
N2S

South-to-North
S2N

Shaking intensity (MMI)

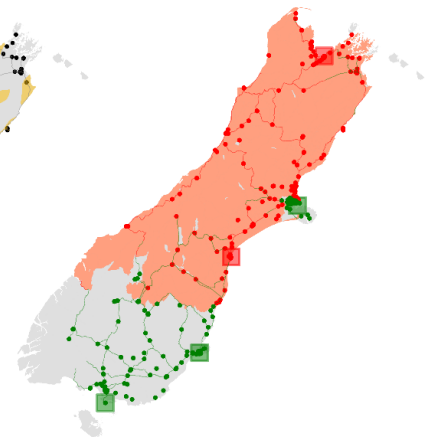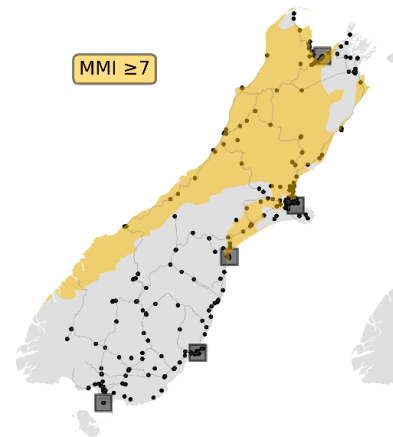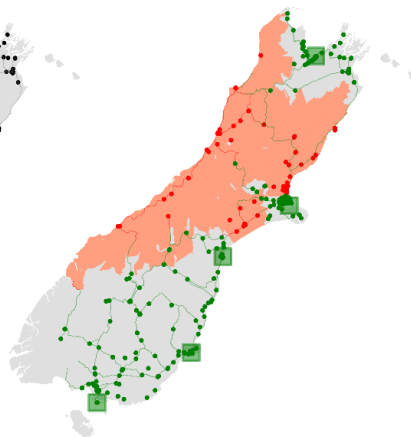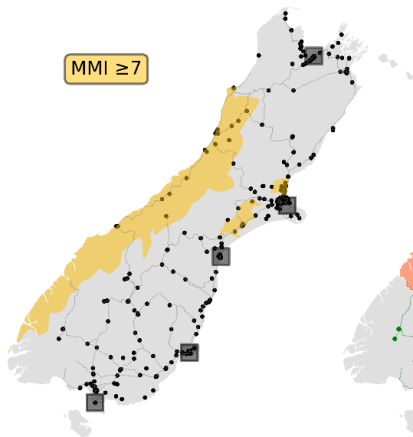| 10 | 9 | 8 | 7 | 6 | 5 | 4 |

Asset Exposure

Extent of Disruption

Asset Exposure

Extent of Disruption

MMI ≥7

MMI ≥7

Socio-economic

COMPLETE

- Critical infrastructure impacts & adaptations in small towns (CDEM SI, CELG)
  - Kaikoura earthquake

- Evacuation behaviour in Auckland (AC)   **2019-2020**

- Transient Population Model (CDEM SI)   **Mid 2019**

- Marae adaptations following infrastructure outages (various iwi)   **Mid 2019**