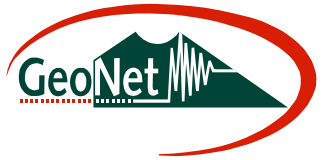
Why should we worry about landslides in New Zealand

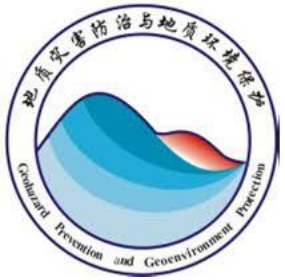
50 years of landslide research by GNS Science (and its former agencies) and our collaborators

The GNS Science landslide team: G. Archibald, Z. Bruce, M-A. Brideau, J. Carey, S. Dellow, S. de Vilder, K. Jones, B. Lukovic, B. Lyndsell, C. Massey, R. Morgenstern, B. Rosser, D. Townsend, M. McSaveney, M. Page, N. Perrin, S. Read

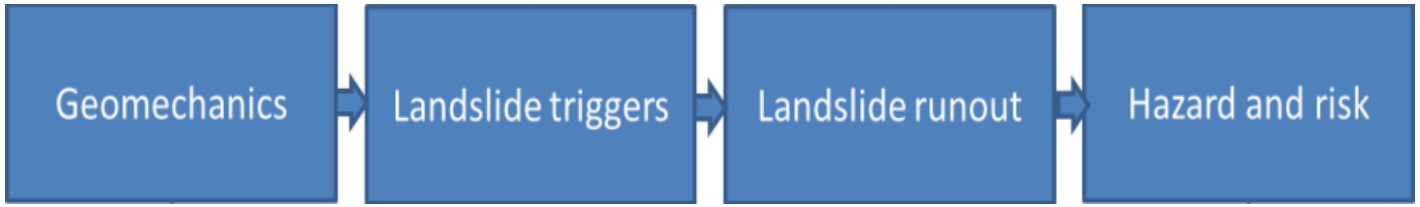
And many other GNS Science and external collaborators

Thanks to our collaborators



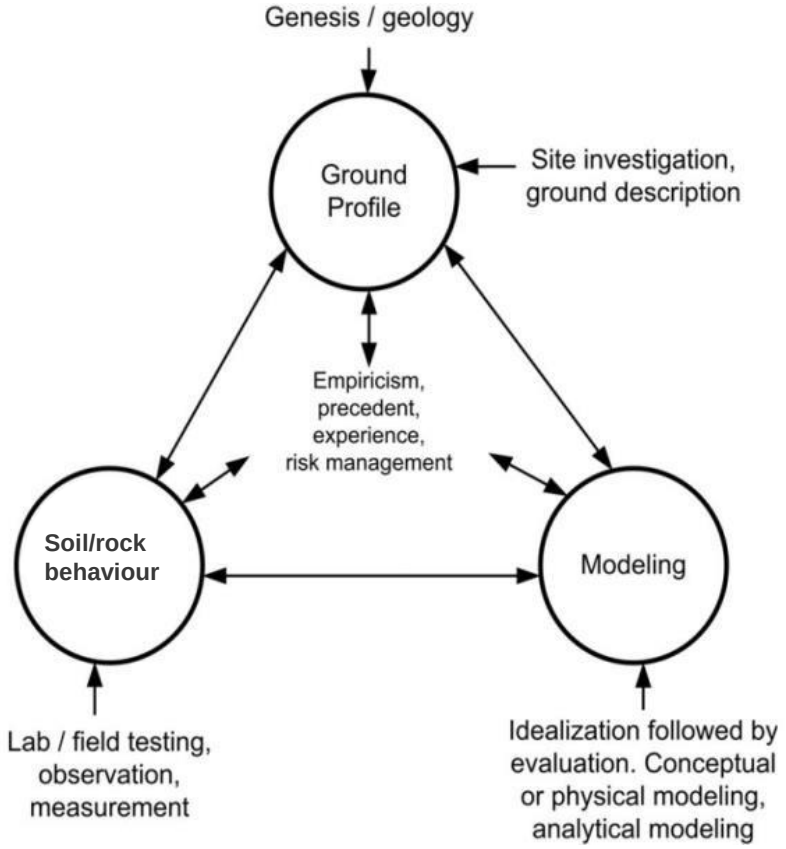


What we have and continue to do



- **Our research is based on the four principles of Engineering Geology**
  1. Ground profiles (e.g. geology, geomorphology maps, x-sections, geospatial datasets: optical Imagery, INSAR, LIDAR)
  2. Soil/rock behaviour (e.g. from testing, observation and measurement);
  3. Modelling – landslide initiation and movement processes, site-specific and regional-scale forecasting;
  4. Empiricism – consulting work is fundamentally linked to our research, it provides the “empiricism, precedent and well winnowed experience”

- **These combine to help us assess how the ground is likely to respond to a given trigger or change in conditions such as engineering works.**



Adapted from Burland (2000)

Our aim

- **To reduce the risk from landslides by understanding their triggers, mechanisms and consequences.**

  To achieve this we study the factors that trigger landslides (earthquake, rain and temporal change); their properties and mechanisms of development, rates and processes of movement and their probability and social and economic impact of occurrence. We've done this for the last 50 years

- **Started with the Inangahua M7.1 earthquake 24 May 1968**

Before

After

The demand for this research (relevance)

- **Landslides >800 deaths since 1780, on average 3.5 deaths/year (but are event driven),** (source: GNS Science landslide catalogue)
- **Earthquakes = 474 deaths (including those from EQ-triggered landslides)**
- **Volcanic activity = 126 deaths (excludes Tangiwai – 151 deaths), which was a landslide (debris flow/flood)**
- **2010/11 Canterbury earthquakes: About $210M losses from landslide impacts on homes only** (source: treasury), **5 deaths from landslides**
- **October 2011: $200M losses when a landslide ruptured the Maui gas pipeline** (source: MBIE)
- **1988 Cyclone Bola losses: $270M losses related to landslides** (source: Page, M., 2015. GNS Science report)
- **2016 Kaikoura EQ:** $1.3B cost to reinstate SH1 due to landslides (source: NCTIR)
- **EQC:** main hazard claimed for (source EQC)
- **Landslides cost New Zealand a minimum of $250M/year. Individual landslide "event" costs can range from $3.5M to $1.3B.** (source: Page, M., 2015. GNS Science report and NCTIR)

Maui gas pipeline being destressed from landslide movement (2014)

For example, in Hong Kong, improved slope management practices have reduced landslide risk by around 50% between 1977 and 2000. (Wong and Ko, 2005)

Significant milestones in landslide research

- 1979 to 1984: Abbotsford Landslide
- 1985 to 1995: Clyde Dam work
- 1988: Cyclone Bola
- 1991: Mount Cook rock avalanche
- 1992 CRI's formed: National-scale large landslide mapping and database started and appearing on Qmap for the first time
- 1996: Landslide catalogue started
- 1997: Summary of EQ-induced landslides in NZ
- 1998: Poerua landslide and dam breach
- 2001: GeoNet established – landslide duty officers, 32 responses to date


Mount Cook (L. Homer)


Abbotsford (G Hancox)

Significant milestones in landslide research

- 2004: Manawatu floods and landslides
- 2005: Matata Debris flow/flood
- 2006 to 2011: Wet winters, central north Island, Utiku, Taihape (SH1 and NIMT rail) and Waikorora landslide (Maui pipeline) monitoring,
- 2007 Young River Landslide and dam monitoring
- 2007 Ruapehu dam breach and Lahar monitoring

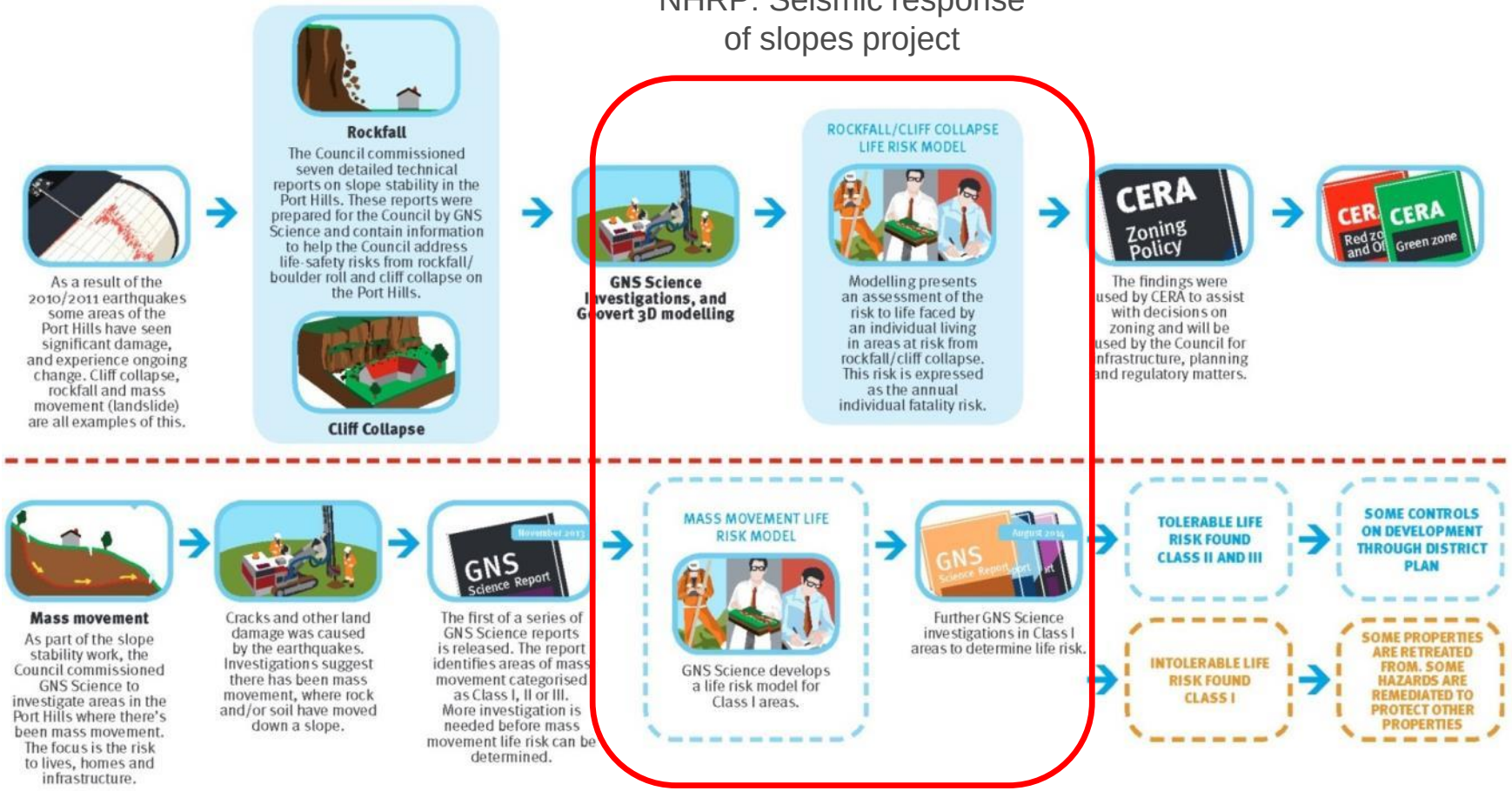
- **2009 NHRP established**
- 2010 to 2016: Canterbury EQ sequence
- 2011: Pukearuhe landslide and Maui pipeline rupture
- 2014 onwards: Submarine landslide mechanisms
- 2015 to 2019: SLIDE Wellington
- 2016 to 2023 Kaikoura EQ

Impact: Successful implementation and outreach achieved through interaction with policy makers

Port Hills Land Damage (produced by CCC & CERA as part of their outreach)

Here are the steps the Council and Canterbury Earthquake Recovery Authority (CERA) have taken to investigate and address changes to slope stability in the Port Hills since the 2010/2011 Canterbury Earthquakes.

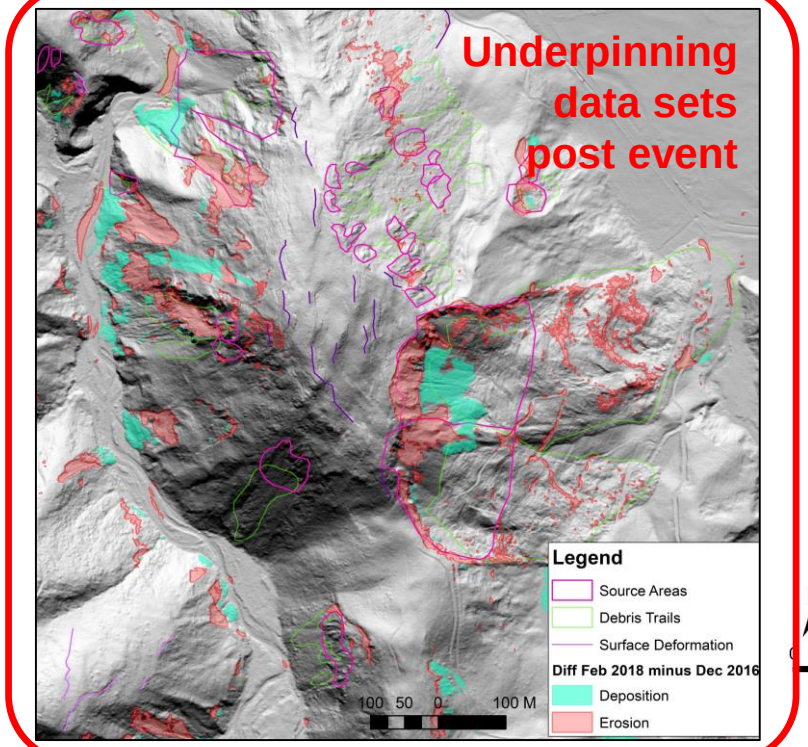
NHRP: Seismic response of slopes project



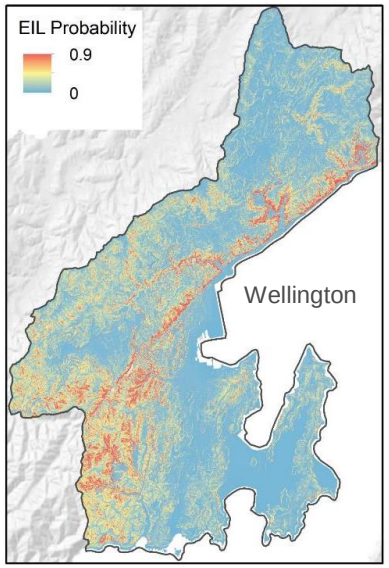

Rapaki rockfall 2011 (D. Barrel)

Now and the Future: EQ and Rain Landslide Forecast tools

NHRP: Kaikoura EQ
landslide and dams project

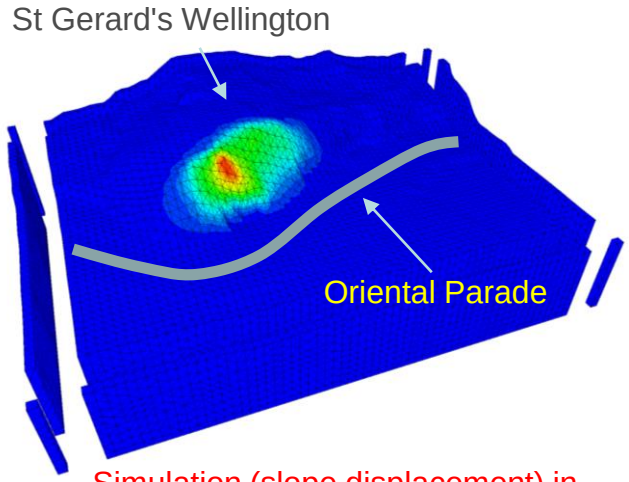


Statistical landslide susceptibility models



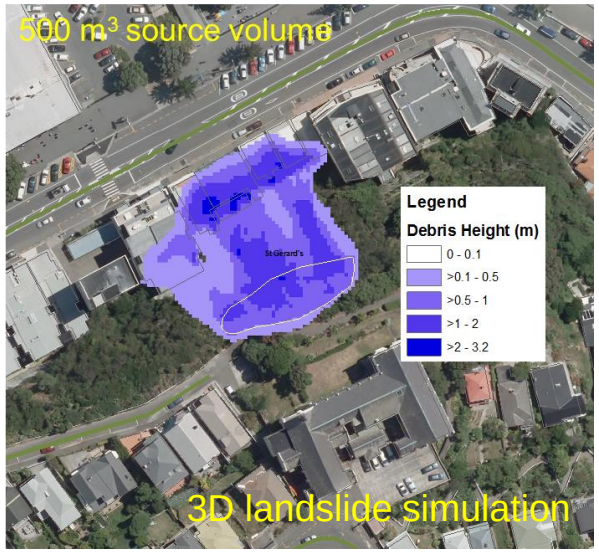
EIL: EQ-induced landslide

2D and 3D physics based simulations



Simulation (slope displacement) in response to EQ shaking

Geospatial landslide debris runout models



- **Provide landslide forecast tools – incl. cascading hazard models e.g., landslide dams – to rapidly identify potential landslide hazards and at risk people/infrastructure immediately after an event**
- **Provide landslide models for insurance, risk and infrastructure resilience modelling and landuse planning**
- **Provide input data to establish vulnerability functions for asset types impacted by landslides**

Thanks from the team

Questions/contact: c.massey@gns.cri.nz or s.dellow@gns.cri.nz