Impacts of the Kaikoura Earthquake on Three Waters Systems in Wellington, Marlborough and Kaikoura

Preliminary Observations

Mostafa Nayyerloo I Risk Engineer I GNS Science
m.nayyerloo@gns.cri.nz
Matthew W. Hughes, Xavier Bellagamba, Jonathan Morris, Pathmanathan Brabhaharan
Stephen Rooney, Erica Hobbs, Keith Wooley and Steve Hutchison

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
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Wellington Water

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Study Area Overview

Greater Wellington – Three Waters

Water Supply

SURFACE WATER CATCHMENTS	BULK WATER STORAGE (UNTREATED)	WATER TREATMENT PLANTS
3	3,674 (million litres)	4

PIPELINES	PUMPING STATIONS	RESERVOIRS
2,379km	88	139

Note: excludes the public component of laterals

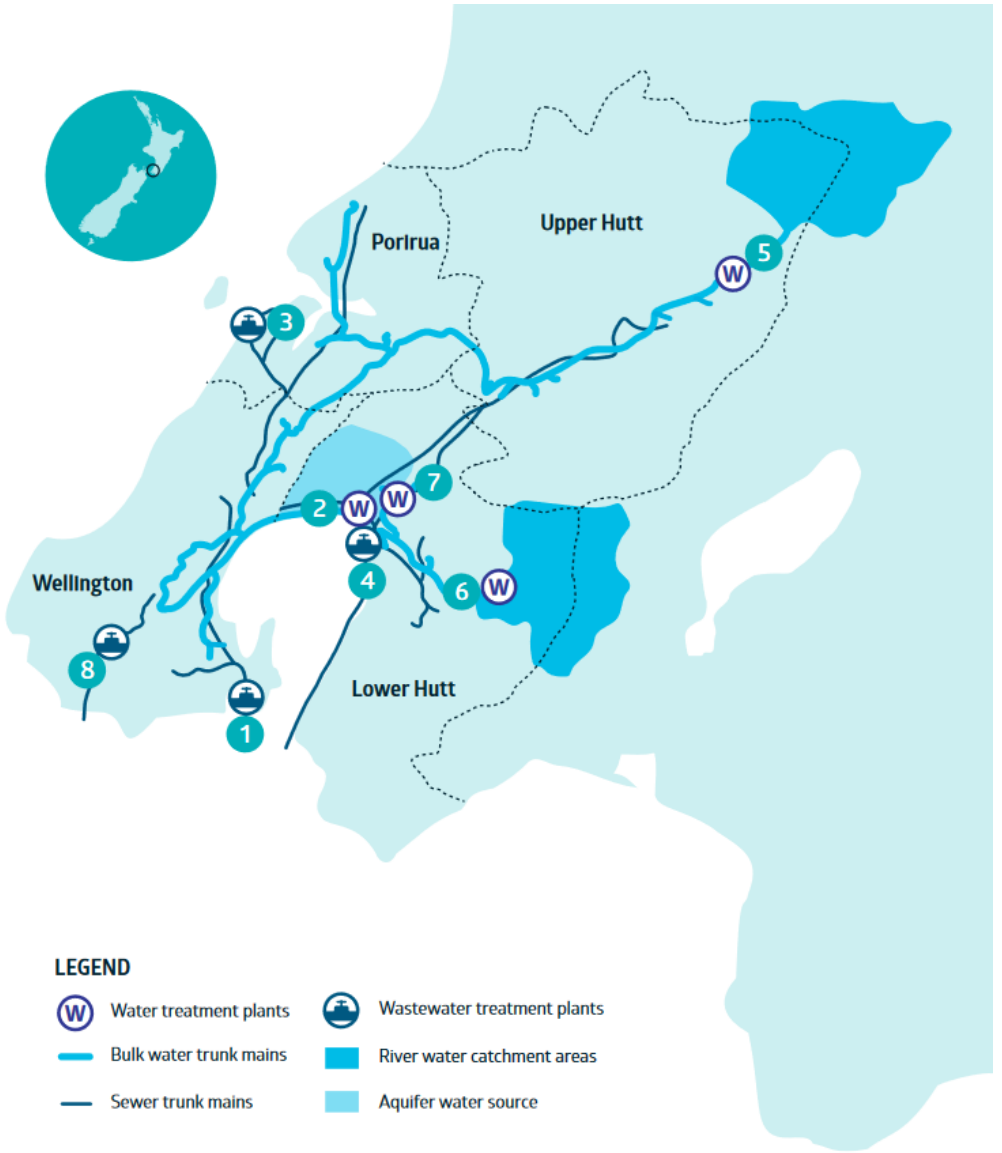
Note: Includes two bulk water storage lakes, two treated water reservoirs at water treatment plants and three bulk water balancing reservoirs

Wastewater

WASTEWATER TREATMENT PLANTS	PIPELINES	PUMPING STATIONS
4	2,367km	191

Stormwater

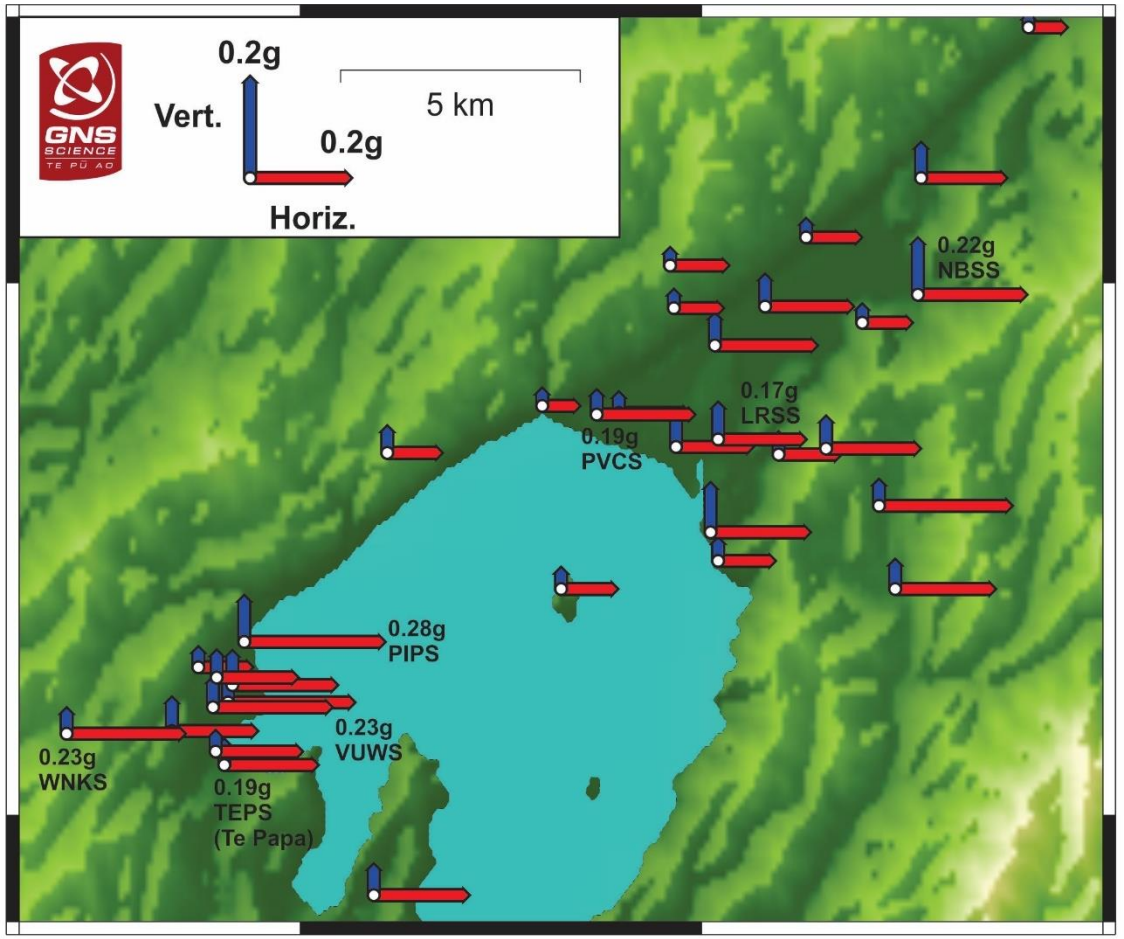
RETENTION DAMS	PIPELINES	PUMPING STATIONS
7	1,639km	21



Wellington Water

Study Area Overview

Greater Wellington – Seismic Demand



Anna Kaiser, GNS Science

- Duration of ground shaking significantly longer than 2013 Cook Strait sequence (~4 times)
- PGA 0.16 – 0.28 g (similar to Cook Strait sequence)
- PGV 20 – 35 cm/s

Three Waters Impacts

Greater Wellington – Support Services

- **Wellington Water offices within the IBM House in Petone, Lower Hutt were damaged that led to staff having to operate from temporary offices or their homes for ~2 months.**

Three Waters Impacts

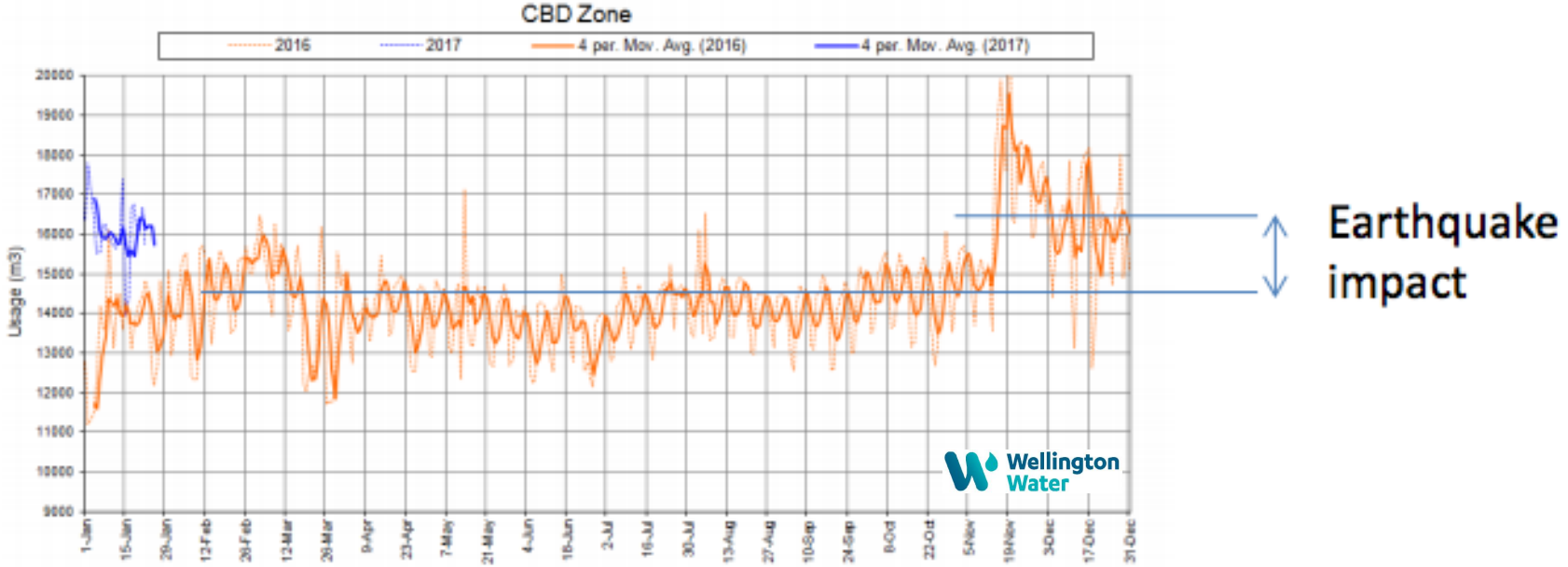
Greater Wellington – Potable Water

- **Increased turbidity (returned to normal within 24-30 hours).**
- **Slight increase in E. Coli (returned to normal within 2 days).**
- **Surface expression of liquefaction was observed around the Gear Island wellfield in Petone, Wellington, with damage to the concrete well aprons.**
- **Tawa Reservoir suffered minor non-structural cracking (~50 years old and was empty due to strengthening work).**

Three Waters Impacts

Greater Wellington – Potable Water

- Up to 15 breaks across the distribution network excluding the port area
- Major bursts and other minor pipe failures resulted in increased leakage.



- With damage to pipes in the port area due to ground deformation ~14,000 m3 of water was lost within the first two days.

Three Waters Impacts

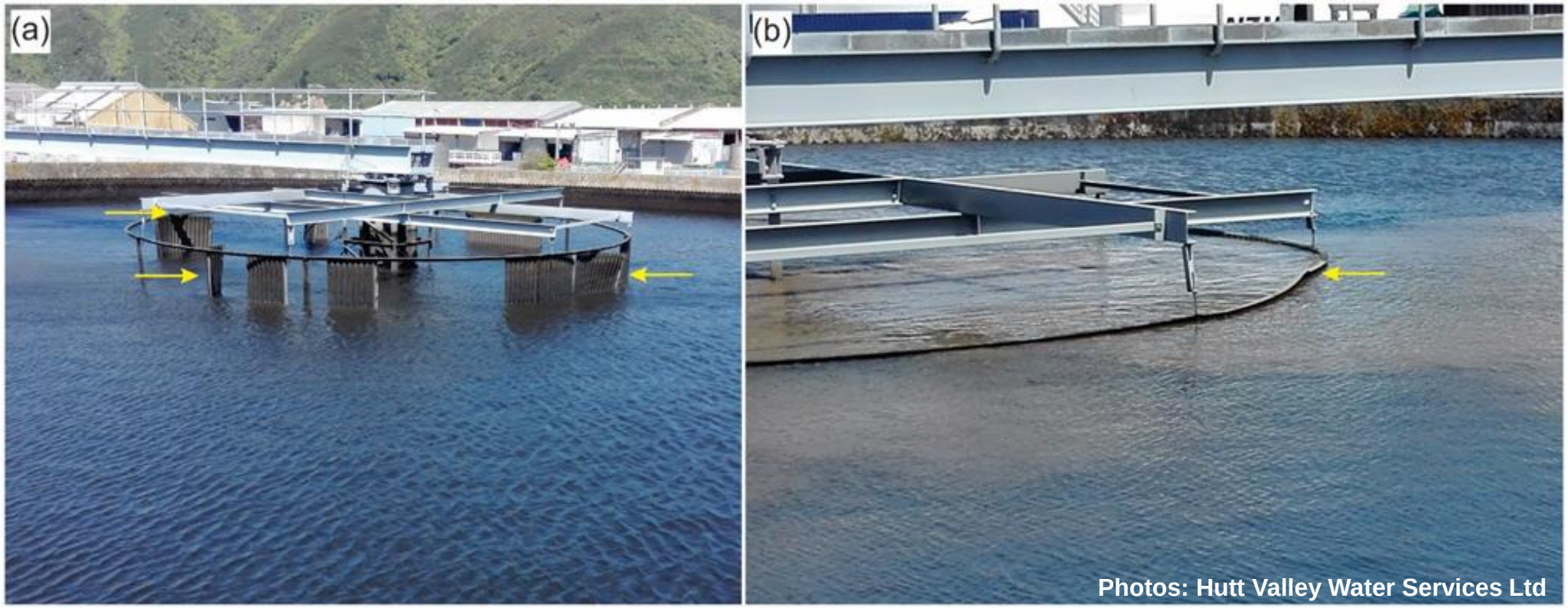
Greater Wellington – Potable Water

- **Flooding the day after the earthquake closed some of the state highways and isolated parts of the potable water network and created problems with regard to mobilizing repair crews and equipment.**

Three Waters Impacts

Greater Wellington – Wastewater

- **No major structural damage to any of the four treatment plants**
- **In the Seaview and Porirua treatment plants, water sloshing in the secondary clarifier tanks damaged the stilling well curtains and their holding rings.**



Three Waters Impacts

Greater Wellington – Wastewater

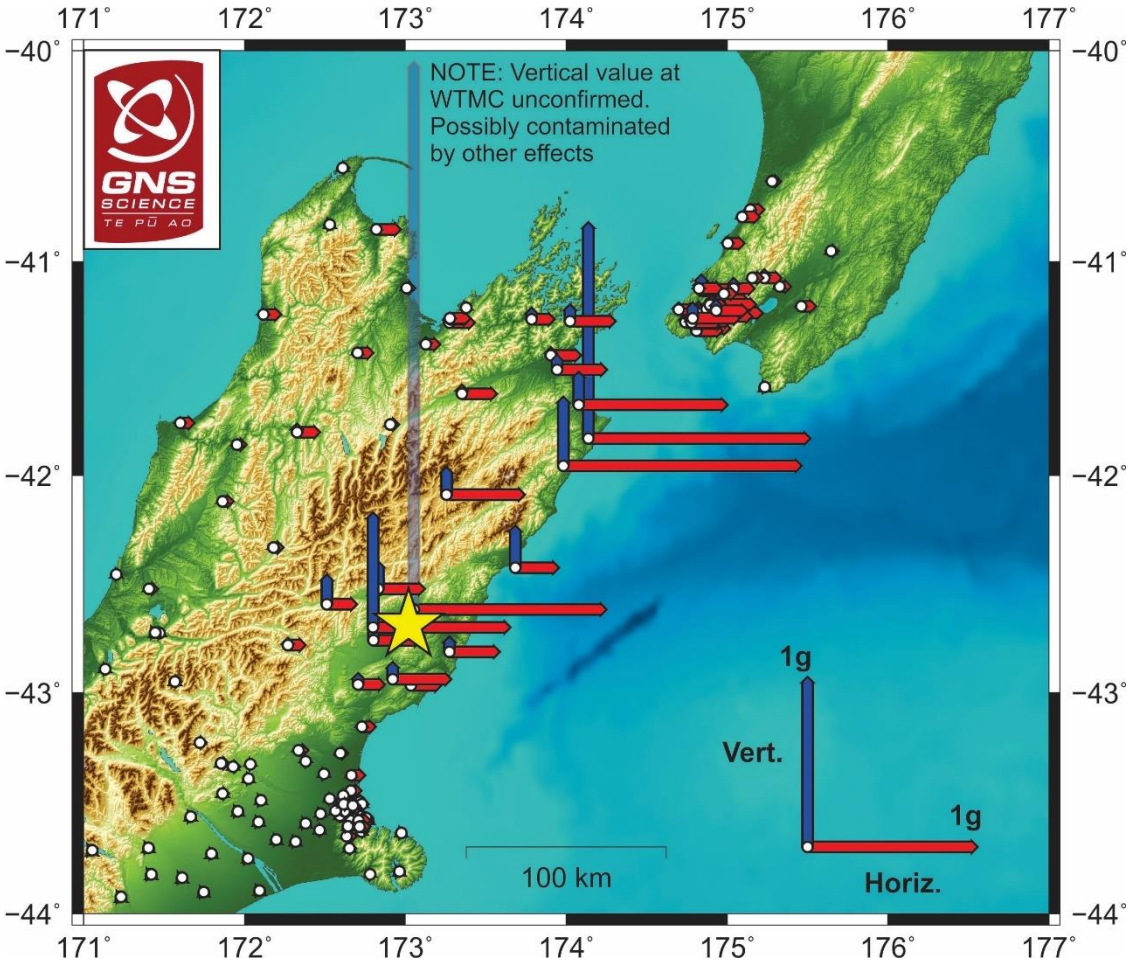
- **Power was cut from the Seaview treatment plant for ~3 hours, ~8 pump stations also lost mains power.**
- **Mobilizing portable generators was not possible due to the tsunami inundation warning.**
- **Inspecting assets such as outfalls in the coastal areas was also not possible due to the tsunami warning.**
- **There was noticeable in-flow increase at the Moa Point treatment plant to 50-70 litres/s above the normal flow of 770 litres/s.**
- **With the demolition of the Molesworth building in Wellington, the wastewater inceptor that passes beneath the building had to be protected.**

Study Area Overview

Marlborough – Three Waters

Study Area Overview

Marlborough & Kaikoura – Seismic Demand



Anna Kaiser, GNS Science

- Horizontal PGAs were ~0.25 g in Blenheim, ~0.75 g in Seddon and ~1.3 g in Ward.
- Ward also experienced high vertical PGAs of ~1.3 g.
- These shaking levels are ~2 times stronger than what was experienced during the 2013 Lake Grassmere event.
- PGVs for Blenheim were 15-50 cm/s, for Seddon 60-75 cm/s and for Ward 115-160 cm/s.
- PGVs for Kaikoura ranged from 50-140 cm/s.

Three Waters Impacts

Marlborough – Potable Water

- Systems replaced after the 2013 earthquakes generally performed well.
- Increased turbidity rendered boreholes temporarily unusable and required flushing for ~1 hour.
- Across Blenheim, Ward and Seddon there were many failures in AC pipelines and relatively few in more modern systems.
- System redundancy (dual pipelines, ring mains) and the ability to isolate damaged parts of the system helped manage the system after the events.

Three Waters Impacts

Marlborough – Potable Water

- Damage occurred at several pipe service bridges across the region.

Needles Creek Bridge north of Ward on SH1

Three Waters Impacts

Marlborough – Potable Water

- **At the Elizabeth Street footbridge in Blenheim, ground failure around the abutments resulted in complete failure of the AC pipeline suspended from the bridge.**

Photo: Mostafa Nayyerloo


Photo: Jonathan Morris

Three Waters Impacts

Marlborough – Potable Water

- Newer concrete tanks appeared to have performed well with only some hairline cracks and connecting pipework failure due to excessive movement.

Photo: Marlborough DC

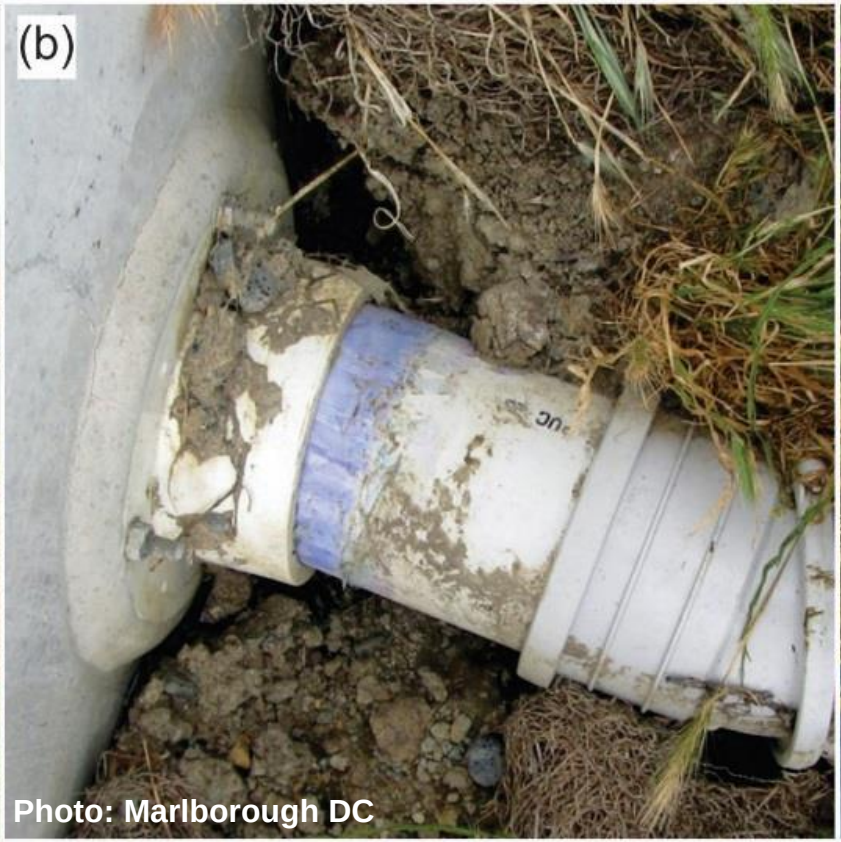


Photo: Marlborough DC

Photo: Mostafa Nayyerloo


Photo: Mostafa Nayyerloo


(a)
(b)
(c)
(d)
Photo: Marlborough DC

Three Waters Impacts

Marlborough – Potable Water

- **Earthquake emergency shut-off valves were set to trigger at 0.2 g, but the maximum reported PGA at valves was 0.18 g, so they did not trigger.**
- **Older ferrocrete tanks in Ward had suffered structural damage although one of the tanks remained partly operational.**

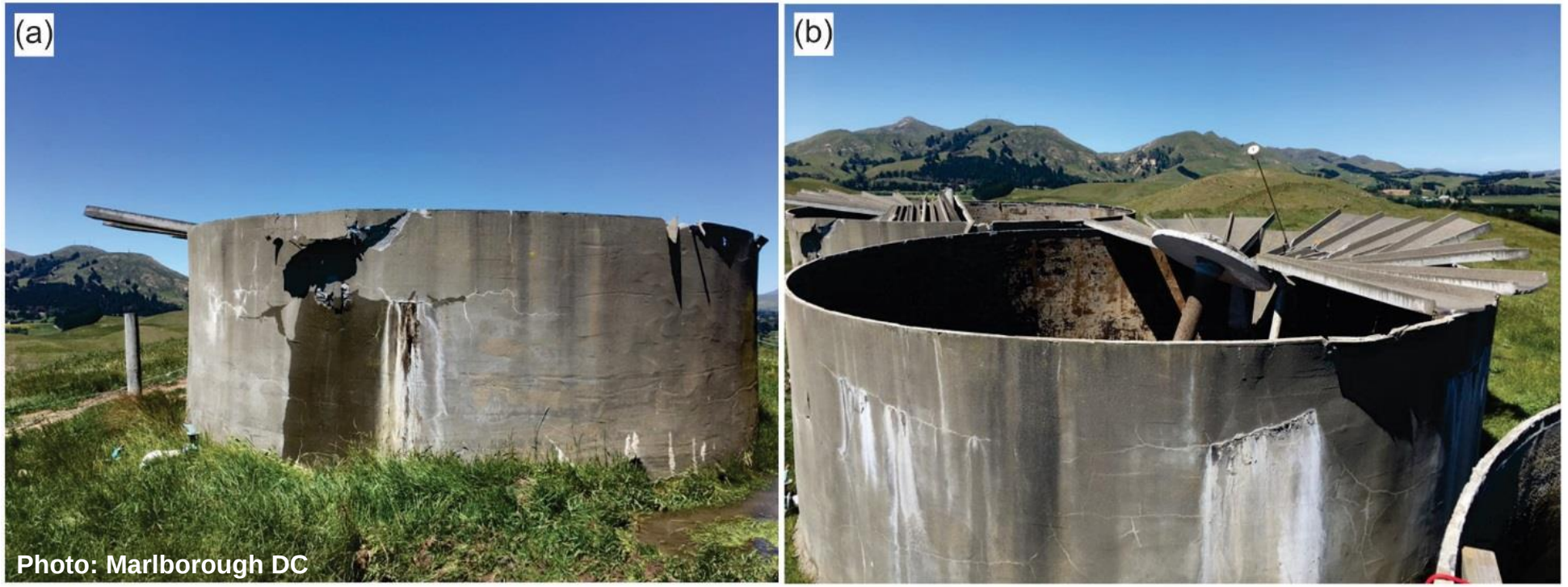


Photo: Marlborough DC

Three Waters Impacts

Marlborough – Potable Water

- As the hillside slopes were generally gentle and the tanks were set back from the hillside slopes, the tanks were not affected by slope instability.
- Concrete stave tanks suffered some damage but remained serviceable with some additional leakage through cracks, some of which were caused by the 2013 events and opened up a bit more during the Kaikoura earthquake.


Photo: Mostafa Nayyerloo


Photo: Mostafa Nayyerloo

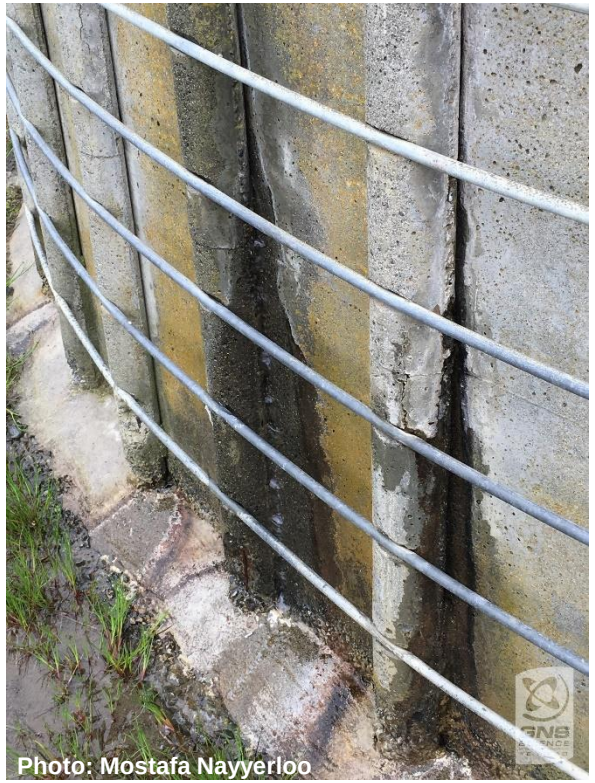


Photo: Mostafa Nayyerloo

Three Waters Impacts

Marlborough – Potable Water

- **The Taimate bore pump in Ward failed when movement of the borehole relative to the nearby pump house resulted in the hold down bolts pulling out of the concrete base and displacement of the pump, despite the presence of a rubber bellow joints.**

Photo: Mostafa Nayyerloo


Photo: Mostafa Nayyerloo

Three Waters Impacts

Marlborough – Wastewater

- **Many lines had been inspected with CCTV since 2013, and repeat surveys showed new damage in the majority of pipelines surveyed since 14th November 2016.**

Study Area Overview

Kaikoura

Three Waters Impacts

Kaikoura – Potable Water

- The earthquake stopped the reticulated supply.
- The council was able to inform residents within a day which streets had supply.
- By 19th November, some water stations an a mobile public shower were set up by the Defence Force.
- Residents were instructed to minimise all water usage due to system supply shortages.
- By 25th November, supply had been sufficiently restored in the township to enable use of flush toilets and showers, although the community was asked to still limit water usage.

Three Waters Impacts

Kaikoura – Potable Water

- The boil water notice was lifted for most of Kaikoura township, suburbs and outlying supply schemes on 23rd December.

- People returning to houses unoccupied since the earthquake were urged to conduct inspections of pipes and tanks on their properties and undertake the necessary repairs.

Three Waters Impacts

Kaikoura – Potable Water

- **The only full hilltop reservoir was inaccessible and there was only one water tanker available for fire fighting, so a total fire ban was issued across the area (loss of power and warm weather helped to minimise fire risk).**

Three Waters Impacts

Kaikoura – Wastewater

- Significant damage to pipes compromised most of the system.
- Residents were advised to use portaloos, buckets or holes dug in gardens to dispose human waste.
- On November 18th, chemical toilets were delivered by the Defence Force to be distributed to all households (the necessary supply of chemical solution was delayed by 2-3 days).
- By November 24th, there was a portaloo within 250 m of every property.

Photo: Matthew W. Hughes

Three Waters Impacts

Kaikoura – Wastewater

- Due to the inability of the waste water pipes to function from the 14th to 24th November, residents were urged not to flush toilets despite the return of reticulated portable water supply over this time.
- Restrictions on water use were also aimed at reducing environmental contamination.
- Environmental contamination by wastewater was recognised as a significant issue from 14th November, with attendant restrictions on entering waterways or swimming in the sea.

Photo: Matthew W. Hughes

Three Waters Impacts

Kaikoura – Wastewater

- **Through December 2016, repairs on the wastewater system continued and wider functionality returned.**
- **Pipe condition assessments via CCTV were occurring from the days after the event, supported by experience and expertise gained from condition assessments conducted in Christchurch.**

Acknowledgements

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  - GNS Science through the RiskScape and Post Disaster Cities research programmes

Questions

Mostafa Nayyerloo I Risk Engineer I GNS Science
m.nayyerloo@gns.cri.nz