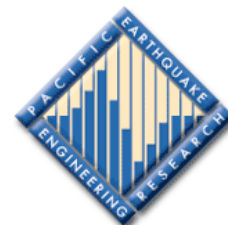


Nonstructural Damage

William T. Holmes

Rutherford & Chekene



Overview

- Little damage in publicly accessible areas;
- Anecdotal evidence of typical office damage but access was difficult;
- Newspaper accounts suggest cases of significant nonstructural damage in certain sectors;
- Universities (Canterbury and Lincoln)
 - Labs
 - Libraries



Canterbury Hospital

- EERI team tour indicated only minor damage but Newspaper suggest otherwise



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Darfield Earthquake of
September 4, 2010



Westpac Office Building

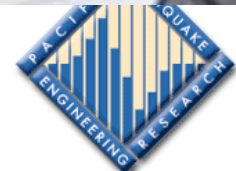
- Building red tagged, primarily for falling hazard from spalled concrete, then green tagged.
- Newspaper suggest “cosmetic” repairs will keep building closed for 6 months.





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September 4, 2010



New civic building gets all clear

By DAVID WILLIAMS - The Press Last updated 05:00 17/09/2010

Christchurch's new civic building, which suffered about \$2.5 million damage in the earthquake, has been declared safe after engineering checks.

Mayor Bob Parker said the \$113m building was strong, and engineering reports had confirmed its "structural integrity".

"I'm very proud of the way the new council building behaved. It did what it was designed to do and any people inside would have been completely safe," he said.

"If you go around a number of the other high-rises in the city, you'll find a number of them making exactly the same repairs."

Opened only last month, it was shut for a week after the earthquake and scaffolding was still in place around staircases when The Press visited yesterday.



Council Building

Shoring of long “monumental stair” with connection damage at 2nd Floor



Tao Lai photo

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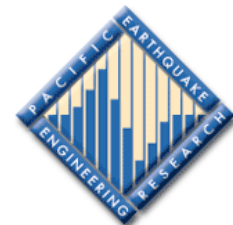
Council Building

Repair of gyp board partitions at upper floors



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Brand new \$ 113 M Council building suffered \$2.5 M in damage and was closed for a week, with interior repairs ongoing.

Questions asked why an important building needed to be closed.

According to newspaper reports, the building was designed as an "ordinary" building, but this may not completely explain the nonstructural damage that caused closure.

Bill for destroyed food could nudge \$200m

Ben Heather

At least \$95 million worth of food was destroyed in the earthquake, but the total bill will be closer to \$200m, the Food and Grocery Council says.

A survey of 160 council members showed the food industry suffered about \$95m in lost stock, as well as damage to buildings.

The survey did not include the two big supermarket chains, which both suffered heavy damage to buildings and stock.

Council chief executive Catherine Rich said the survey had revealed only "the tip

of the iceberg. A lot of this comes from power being turned off. That's a lot of melted icecream and defrosted peas."

Council chairman and New Zealand Coca-Cola Amatil managing director George Adams said including supermarkets would double the bill for the food industry.

Food and drink lost in the quake represented what would normally be sold over four weeks in Canterbury, he said.

About 1200 pallets of drinks were destroyed at Coca-Cola's two Christchurch factories - a third of the total stock.

Coca-Cola distributed

90,000 bottles of water to emergency services the day after the September 4 quake, but yesterday its warehouses were relatively empty as pallets continued to be shipped from the North Island.

Sanitarium Health Food general manager Pierre van Heerden said the company's Papanui factory, which makes Marmite and Weet-Bix, had lost \$750,000 worth of food.

"We have Weet-Bix stacked three pallets high. Things just collapsed," he said.

Foodstuffs chief executive Steve Anderson said the council's estimate for the cost to supermarkets was too high, and he estimated Foodstuffs

had lost between \$20m and \$30m of stock.

Among Foodstuffs' three distribution centres, which supply New World and Pak 'n Save supermarkets, one was running normally and another at 70 per cent capacity.

The Hornby centre had suffered substantial damage and would not be back to full capacity for at least two months. The company's Dunedin distribution centre had been turned into a 24/7 operation, Anderson said.

Progressive Enterprises would not comment on how much the quake had cost the company.



Typical local damage. New World supermarket in Kaiapoi is not reopening for at least a year



The Press



Michael Rowe, NZ Herald

Warehouse Storage of Energy Drinks

Food Distribution Center in Hornsby

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Storage on energy drinks





Other Miscellaneous Rack Damage



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Michael Rowe, NZ Herald

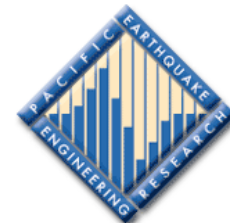


Conclusions

- No surprises
 - Having Standards for Seismic Resistance of *Engineered Systems* since 1983 and Seismic Restraint of *Contents* since 1994, nonstructural damage was not widespread as in Chile
 - Some disruption from nonstructural damage, but in non code complying buildings,
 - Companies and institutions must consider the damage potential and decide how much repairable damage is acceptable in their situation.
 - Heavy overhead items (e.g. Heavy ceilings, light fixtures, tall storage) can be life safety risks.

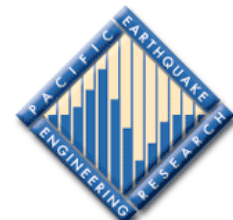


Issues from permanent soil deformation



Permanent Soil Deformation (grade changes)

- Liquefaction
 - In addition to immediate damage to structures and infrastructure due to differential settlements, permanent ground deformations
 - Changed local and storm drainage patterns





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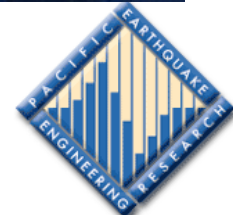
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Adequacy of surface storm drainage after settlement is unknown in many areas



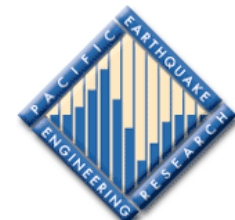
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September 4, 2010



Permanent Soil Deformation (grade changes)

- Liquefaction
 - In addition to immediate damage to structures and infrastructure due to differential settlements, permanent ground deformations
 - Changed local and storm drainage patterns
 - Some gravity sanitary sewer lines lost their fall

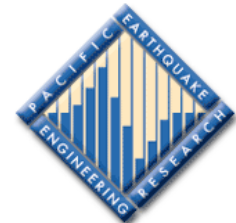


Kaiapoi
Pumping
sewage to
river, even
after breaks
were
repaired



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September 4, 2010



Permanent Soil Deformation (grade changes)

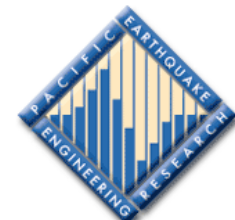
■ Liquefaction

- In addition to immediate damage to structures and infrastructure due to differential settlements, permanent ground deformations

- Can change local and storm drainage patterns
- Gravity sanitary sewer lines may lose their fall

■ Vertical fault Movement

- Dried up some small streams and created new ones
- Caused flood by uplifting stream bed



NEW SPRINGS, WELLS AFTER QUAKE

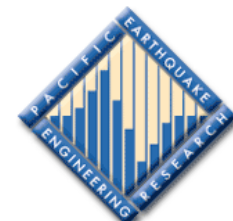
Saturday's massive earthquake has resulted in changes to the groundwater beneath the Canterbury Plains, Environment Canterbury says.

"New springs have been observed, wells have shown marked increases in water level, spring-fed streams such as the Halswell River have risen markedly and increased turbidity (cloudiness) has been seen in some wells," spokesman Dr Tim Davie said.

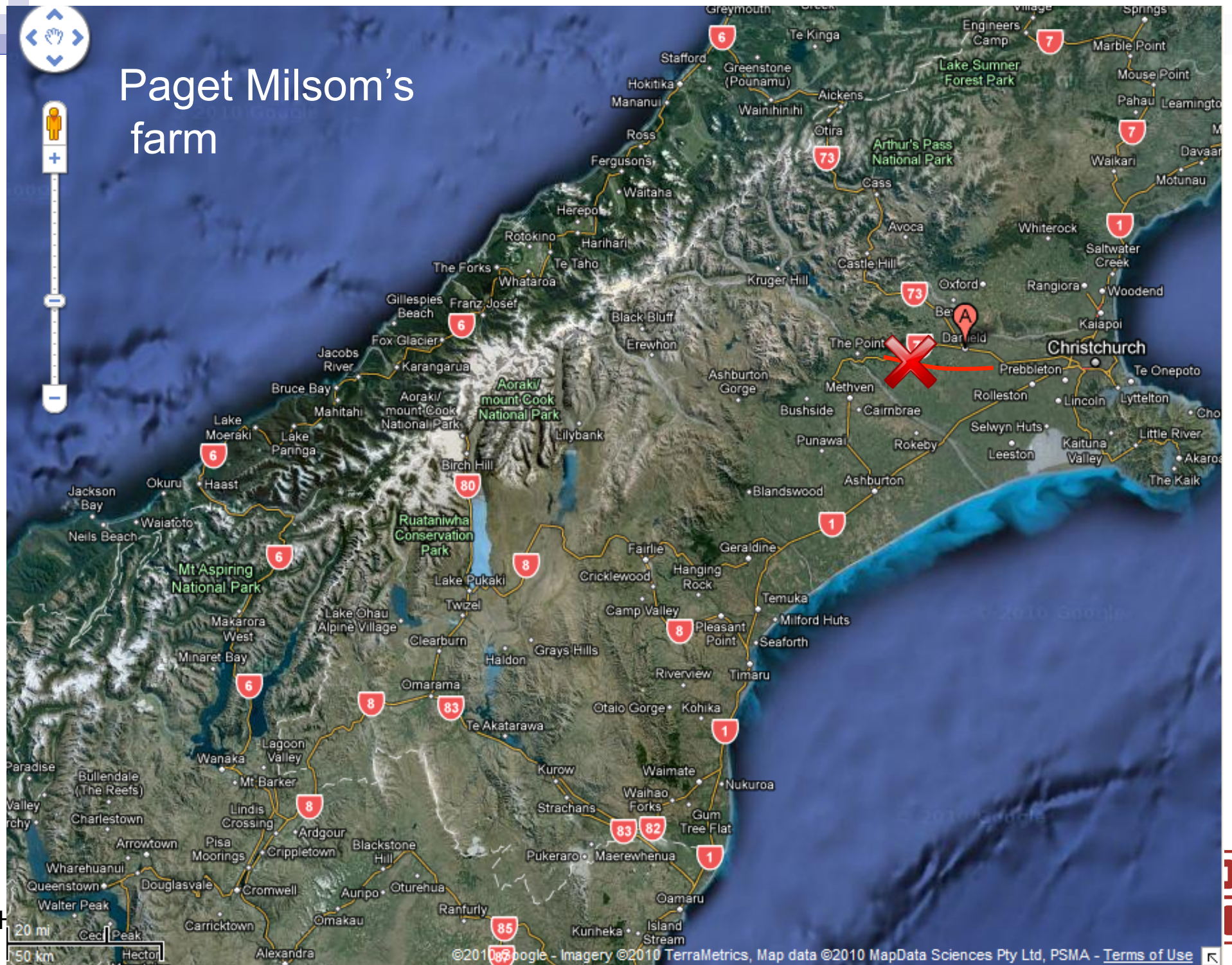
"It is well known by scientists that earthquakes can, and frequently do, induce a response in groundwater that can be observed up to several hundred kilometres from the earthquake epicentre."

Scientists from GNS Science and Environment Canterbury were measuring the changes to get a better idea of what was permanent.

The Press

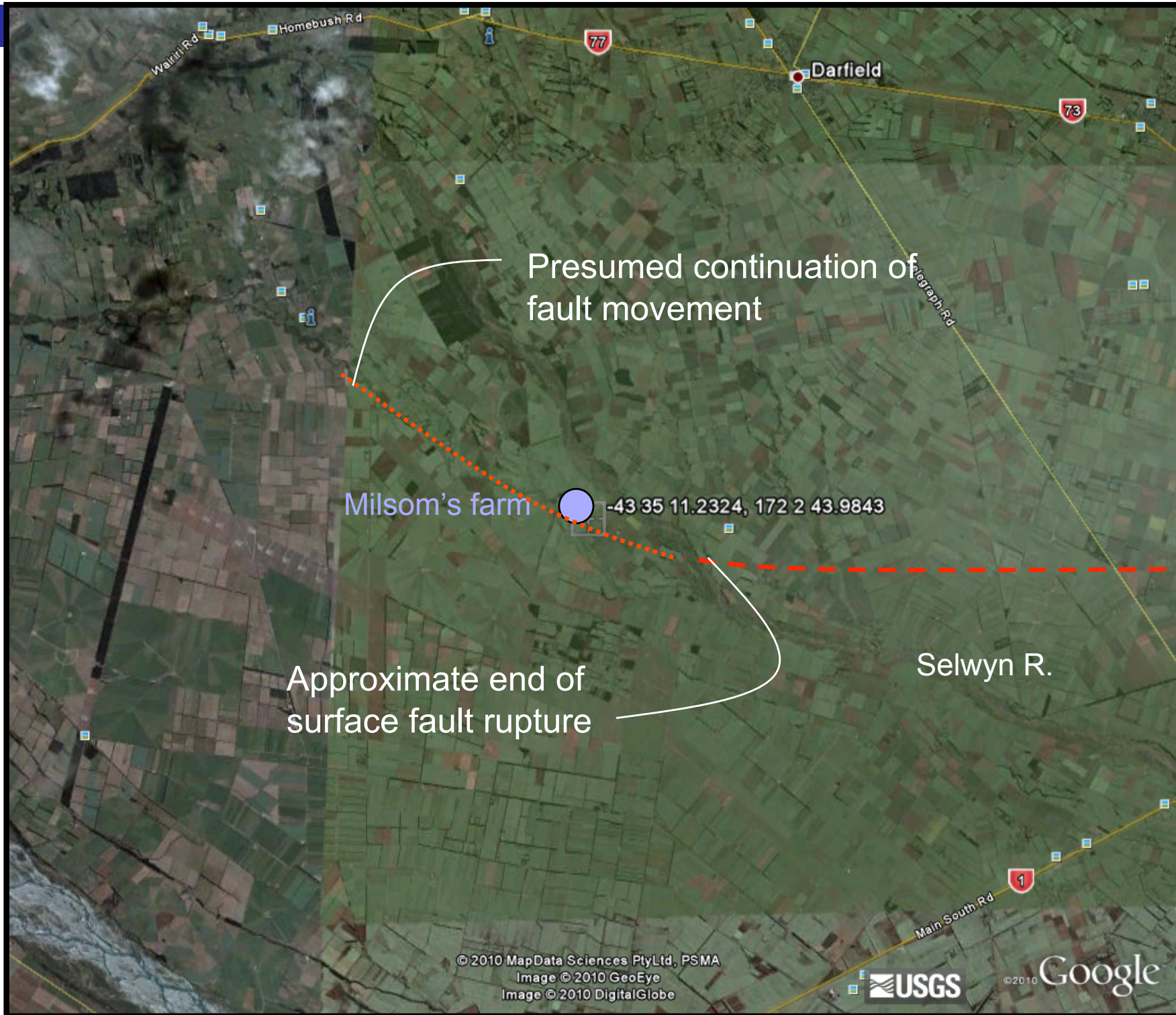


Paget Milsom's farm



Milsom's Flood

Location Map



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Milsom's Flood

Photo at Milsom's (new creek)

Apparent depression

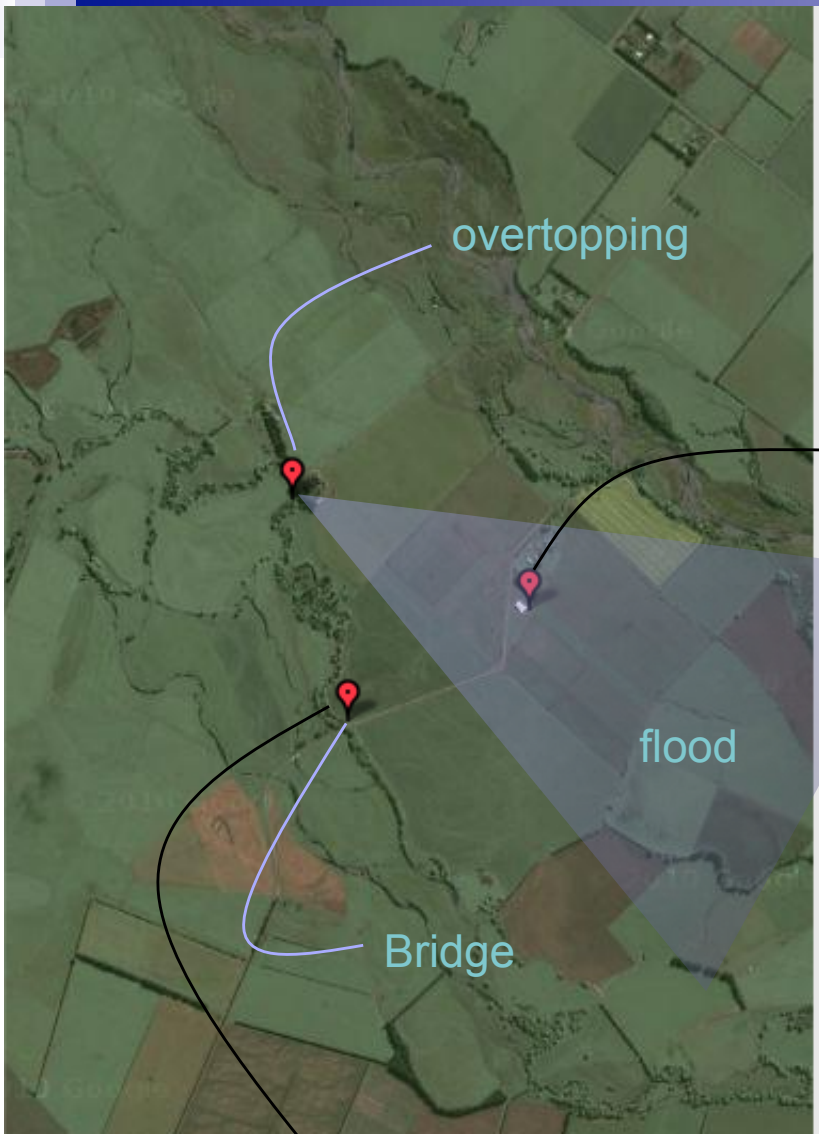
Apparent uplift

Photos along fault rupture

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Background maps from Google maps



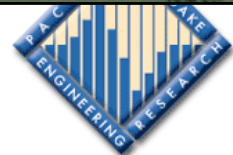


Geo-coded photos

Background maps from Google maps

Milsom's Flood

Darfield Earthquake of September 4, 2010





Original stream bed



New tributary due to drop in elevation and high water table

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Morning of
September 4
during flood



Morning of
September 4
during flood

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Looking over NE bank at overflow location



The "Digger"

Looking downstream from overflow at start of excavation



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Looking
downstream of
excavated river bed



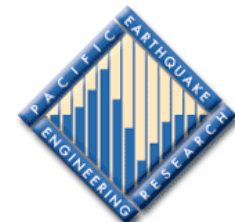
Lower end of excavated
river bed, at bridge

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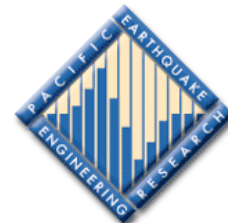
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Conclusions

- Mr. Molson is concerned about changes in flood plain locations not only on his stream but on the nearby larger Selwyn River.
- Similar phenomena in the April, Baja California event:
 - “topographic warping of the previously flat farmland, and damage to irrigation canals due to settlement and lateral spreading...Many fields of wheat and hay became submerged due to subsidence and the high ground water table...” (EERI Newsletter)
- The potential for this kind of damage should be added to loss studies in certain areas of the US.



Quick review of damage to unreinforced masonry bearings wall construction (URM)





Darfield Earthquake of September 4, 2010

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September 4, 2010

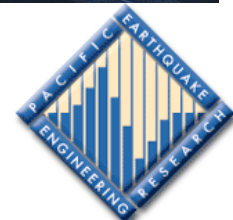


Sidewalk Cafe



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September 4, 2010



Adjacent Building



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September 4, 2010





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Darfield Earthquake of
September 4, 2010



These damage patterns are applicable in the US.

- Many pre-1940 URMs in regions across the U. S. (New England, South Carolina, New Madrid, Wasatch, Puget Sound, California/Nevada) are the same as those in Christchurch.¹
 - Exterior multi-wythe unreinforced masonry bearing walls
 - Wood floor and roof with seismically inadequate ties to walls
- At the Christchurch level of shaking (0.2-0.25g, Intensity VII-VIII), URMs were about the only building type systematically damaged from shaking.
- At a majority of locations of significant damage (150+), a risk to life safety was created—but no one was there (4:30 am)
- In 1994, Bruneau² confirmed the URM risk, particularly in eastern North America with “extensive...published ... reconnaissance..”:
 - (Scholl and Stratta 1984; Shah et al. 1984; Reitherman et al. 1984; Kariotis 1984; Adham 1985; Reitherman 1985; Swan et al. 1985; Esteva 1988; Hart et al. 1988; Deppe 1988; Moore et al. 1989; Muria-Vila and Meli 1989; Meli 1989; “Armenia” 1989; Mitchell et al. 1989; “Loma” 1990; Bruneau 1990; Cross and Jones 1991; Rutherford and Chekene 1991; Kariotis et al. 1991.)
- Add your own zinger here

1. **ABK, 1981**, *Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Categorization of Buildings.*
2. **Bruneau, 1994**, *State-of-the-Art Report on Seismic Performance Unreinforced Masonry Buildings*, J. of Struct. Eng., January, 1994, ASCE.



Questions

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Darfield Earthquake of
September 4, 2010

