The 2009 New Zealand West Coast ShakeOut: Improving earthquake preparedness in a region of high seismic risk.

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Abstract

New Zealand is geologically active and has significant seismic potential resulting from its position astride the Pacific-Australian plate boundary. The Alpine Fault transects 495 km of the South Island, west of the Southern Alps. It produces large (ca. M8) earthquakes, and is late in its average seismic cycle. Recent studies have shown that the West Coast would suffer extensive damage and isolation in the event of a large earthquake. Current levels of organizational, business, and community awareness and preparedness for dealing with the outcomes of a future major earthquake are considered less than optimum, even following the recent Canterbury earthquake sequence (2010-2011). The 2009 ShakeOut exercise was an opportunity for West Coast Civil Defence organizations to assess the status quo and develop resilience in order to improve physical and economic recovery outcomes. The exercise was based on the Californian ShakeOut event, and despite many differences in geography and population density, comparisons between the West Coast ShakeOut and California ShakeOut registration data show very similar participation profiles.

Keywords: *earthquake hazard, ShakeOut, New Zealand, Alpine Fault, preparedness.*

Introduction

The South Island of New Zealand lies across the Australian and Pacific tectonic plate boundary. It forms part of the "Ring of Fire", the margins of the Pacific Plate that generate most of the world's seismic activity each year. The Alpine Fault makes up part of the plate boundary west of the Southern Alps in the South Island (Figure 1).

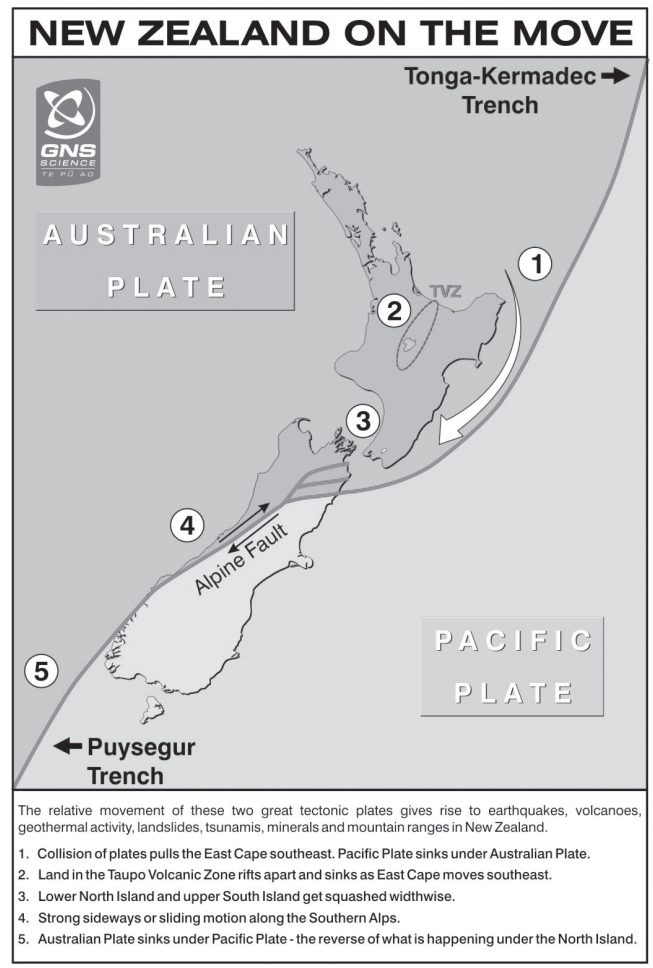

Figure 1. The Australian and Pacific tectonic plate boundary. Source: GNS Science

Most of New Zealand has a significant exposure to earthquake hazard, demonstrated by the recent Canterbury earthquake sequence (2010-2011). However, this study is concerned with the potential for rupture of the Alpine Fault. The Alpine Fault is a 495 km long mature dextral reverse fault that generates periodic earthquakes approximately every 300 years, with the

last known event taking place in 1717AD (Berryman, Cochran, Clark, Biasi, Langridge, & Villamor et al., 2012, Figure 2).

The West Coast region is situated to the west of the Southern Alps, and is at risk from significant ground shaking generated by a future large Alpine Fault earthquake. The population of 31,000 is widely dispersed throughout the region, with Greymouth (pop. 9,500) Westport (pop. 3,800) and Hokitika (pop. 3,500) the most significant centres and district capitals. The region is isolated as a result of its geographical situation, and linked to the east coast by only three alpine passes, all of which cross the Alpine Fault.

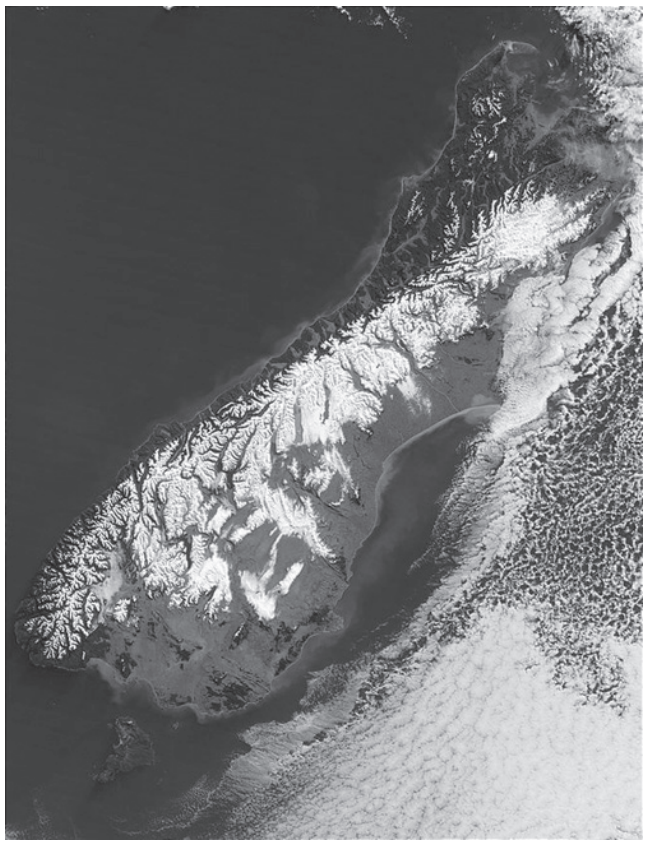

Figure 2. Snow lying on the Southern Alps, New Zealand revealing the straight line of the Alpine Fault. Source: NASA

The three local authorities (Buller, Grey and Westland District Councils) and the West Coast Regional Council are required to assess the risk posed by natural hazards, and have produced Lifelines scenario reports that describe the main natural hazard threat to roads, rail, electricity supply and water reticulation (McCahon, Dewhirst, & Elms, 2006a). The reports prioritize the risk posed by various natural hazards, with the Alpine Fault considered the highest risk regional hazard (McCahon et al., 2006a). The Canterbury earthquake sequence (2010-2011) confirmed the serious consequences of major earthquakes for New Zealand, and focused the national consciousness on seismic risk. This paper, however, reports on community-based efforts to improve local resilience and preparedness *before* the Canterbury earthquakes.

The consequences of a major Alpine Fault earthquake to the West Coast region are expected to be significant. Anticipated strong, Mercalli shaking intensities throughout the region will cause substantial damage to buildings, infrastructure and communities (Robinson & Davies, 2013; McCahon, Dewhirst, & Elms, 2006b). Building codes to ensure the construction of earthquake resistant buildings help reduce loss of life and lessen physical injury figures, but the isolation of the West Coast region would present significant long-term issues for a population whose economy is based upon a functioning transport infrastructure. The main transport link from the West Coast to Christchurch, the South Island's largest city, is through Arthur's Pass, a route that travels adjacent to the Alpine Fault for 10 km and then crosses a series of deep landslide prone valleys. It is anticipated that Arthur's Pass could be closed for more than 6 months after an Alpine Fault earthquake (Orchiston, 2012; McCahon et al., 2006a).

Christchurch is the largest city in the South Island, 200 km east of the Alpine Fault. Isoseismal modeling of a future Alpine Fault event indicates that Christchurch could experience intensities (MMVI+) sufficient to cause non-structural damage to buildings due to the underlying alluvial soils on which the city is largely built. Emergency managers gained significant experience in responding to major earthquakes during the Canterbury earthquake sequence. However, damage to airport and roading infrastructure in Christchurch under this scenario could potentially lead to a delay in the arrival of disaster response teams and deployment of resources to the West Coast region.

The economic future of the West Coast region following an Alpine Fault earthquake will depend to a large extent upon damage to roading infrastructure, and the resilience of West Coast businesses. The local economy is mainly based on farming and tourism, and prolonged closure of the roading network would cause a severe regional economic downturn. It could take up to six months to repair Arthur's Pass and Haast Pass highways to a single lane (Orchiston, 2012; McCahon et al., 2006b). A lack of road access would place a significant strain on West Coast businesses, both in

terms of delivery of supplies, and for the mobility of tourists. The popular tourist circuit of the West Coast from south or north would not be possible, and for tourism operators located in South Westland it may be many months until tourists return (Orchiston, 2012). Power outages and road damage would also impact the dairy industry, with farmers unable to milk their cows and transport milk products to factories.

This article reports on efforts by community leaders in the West Coast to build local preparedness and resilience for a future Alpine Fault earthquake by using the 2008 Californian ShakeOut exercise as a template. First, the Californian ShakeOut is described in terms of its nature and intent. The article then outlines the development of the West Coast ShakeOut and compares the two events in terms of participation data and community outcomes. Finally, official observations recorded in schools during the West Coast ShakeOut exercise are described.

The Californian ShakeOut

In November 2008 an earthquake exercise and drill event, entitled the Great Southern Californian ShakeOut was held in southern California (United States Geological Survey (USGS), 2013). The exercise and drill was developed by the USGS based on an earthquake scenario for the San Andreas Fault. The scenario took the form of a magnitude 7.8 earthquake, typical of an event that may strike southern California in future (Perry et al., 2008). The aim of the drill was build community resilience, and to create a sense of urgency to motivate preparedness in individuals, communities and organisations (Jones & Benthien, 2011). It utilized "lessons learned from decades of social science" to help improve preparedness in areas of high seismic risk (Jones & Benthien, 2011). Several New Zealand representatives visited California during the exercise to observe the events that took place (Becker, 2009).

The Californian ShakeOut capitalized on the widespread use of the Internet by developing a website to act as a portal for public involvement. It provided a countdown to the ShakeOut drill and a large number of links and resources available for download. Participants were encouraged to get prepared in the build-up to the event by making emergency plans, and reminded to "drop, cover and hold" during the drill to protect themselves during shaking. Following the drill itself, participants (particularly emergency management officials) could continue responding to the earthquake scenario for a period of time (e.g. evacuate buildings, check utilities, apply first aid, etc). This exercise continued for two days after the earthquake drill, and allowed responders to test their reaction to a large earthquake.

Communication to the public before the event was focussed on three key areas, designed to maximise levels of participation and generate as many positive outcomes as possible (Jones & Benthien, 2011). Earthquake scenarios and preparedness messages were presented to communities, repeatedly and consistently. Organisers provided visual images of people preparing for earthquakes to highlight the specific actions being undertaken. Organisers encouraged the "milling" principle whereby people talk about the drill and preparedness with the people they care about (e.g., families) and also with others who may have taken action (Becker, 2009).

In evaluating the effectiveness of the ShakeOut exercise, the event was seen to have generated a significant level of participation by Southern Californian communities. Organizations and local authorities participated in emergency management planning, the earthquake drill and other ShakeOut outreach activities. In total over 5.2 million people registered on the ShakeOut website to take part in the drill, with approximately 3.6 million of those school attendees or graduate students. Home Depot stores registered a 260% increase in sales of products used in earthquake preparedness during the weeks around the ShakeOut ((L. Jones, personal communication, 2009).

The Californian ShakeOut demonstrated that emergency exercises and drills have the potential to improve community awareness and involvement in preparedness and planning for future earthquakes. Traditionally, earthquake exercises have focused solely on planning from an emergency management perspective, but the ShakeOut effectively targeted the wider community, creating greater visibility of the problems and potential solutions in preparing for major earthquakes. Since 2008, the Californian ShakeOut participation has grown significantly, and other seismically active regions have developed their own ShakeOut events using the Californian template, including Japan, southern Italy, Puerto Rico and New Zealand. Globally more than 24 million participants have registered to take part in ShakeOut events since 2008.

The 2009 West Coast ShakeOut

Largely through the efforts of Chris Manuel, a local teacher and Royal Society teaching fellowship recipient, the Californian ShakeOut was brought to the West Coast of New Zealand in September 2009, the first event outside the United States. The event was constructed around the Ru Whenua Civil Defence exercise on September 18th 2009, which was based on an Alpine Fault earthquake scenario. As a result of collaboration with Mark Benthien, Director of the Southern California Earthquake Centre, a web-based public information portal for the West Coast ShakeOut was developed and hosted by the Californian ShakeOut administrators (ShakeOut, 2009). This gave the Californian team the opportunity to trial a global version of their product on a small scale compared with the design capability of the Californian ShakeOut. The budget for the West Coast ShakeOut was very limited, but allowed for some publicity material and visits to each significant settlement in the region to inform local stakeholders about the event. The design and implementation of the West Coast ShakeOut took five months.

The West Coast ShakeOut used the same procedures and formatting as the Californian event except for some significant simplifications because of limited timeframe and budget. For example, the number of registration categories was significantly reduced. The main categories were individuals and families, schools and education providers, organizations and businesses, and community groups. Sub-categories were used to identify types of schools, businesses and government agencies. Other simplifications included changing the weblinks to external resources on the website to reflect the New Zealand perspective and growing local information base, although some existing links were left if no equivalent source existed (e.g. disabled persons earthquake advice and business resiliency planning). No shaking propagation simulation maps were included because none existed for seismic scenarios based on the Alpine Fault at the time. No large rallies were planned because of the geographic isolation of the population. However, GNS Science hazard specialists Mauri McSaveney and Rob Langridge spoke at each of the three district centres about the nature of the Alpine Fault and the potential consequences of its rupture.

The West Coast ShakeOut exercise used a promotional video produced as an "Education for Enterprise" project by local Year 12 high school students as part of their media studies course. The script was an adapted version of the 2008 ShakeOut video, to maintain the character of the message. Information sources focused on explaining the nature of the risk in an accessible but scientific manner and included a description of the likely consequences for the region based upon previous events. The provision of information to participants was via a series of e-mails, using language that was generally less formal than the Californian material to reflect cultural differences and the smaller audience for the event.

The West Coast ShakeOut was promoted throughout the region, principally using schools as a conduit to the communities, but also targeting supermarkets and retailers to attract the widest audience. Information brochures were produced, again as an "Education for Enterprise" school project using a local education provider to produce the design from a predetermined script. Ten thousand brochures were printed, and distributed mainly through schools and supermarkets and also through health promoters and libraries. The brochures included a significant description of the risk profile and consequences so those without Internet access could still be informed. Significant media attention was encouraged by sending regular press releases. Local newspapers covered the stories thoroughly, and the ShakeOut exercise was reported in many other newspapers throughout the country. Radio coverage by the two main West Coast stations, and one local Hokitika station was an important aspect of the exercise. Both played the drill broadcast on the day and one followed the story with interest, interviewing the organizer live on three occasions over a period of a month.

The Californian ShakeOut was reported by Green & Petal (2010) to have had positive outcomes on improved school disaster planning. The event was found to improve dialogue on earthquake preparedness and offer students an opportunity to "rehearse frightening events in a less threatening environment." (Green & Petal, 2010, p.3). Westland High, Paroa and West South Schools used ShakeOut to reinforce key earthquake safety and preparedness messages by either developing a series of earthquake lessons preceding the ShakeOut event, or using ShakeOut to raise staff and student awareness. Involving schoolchildren in disaster education can prepare children both physically and psychologically for future disaster events (Ronan and Johnston, 2005). In addition, children act as a conduit to passing on the preparedness message to their families, and are a

valuable means of disseminating key preparedness messages into the community (Green & Petal, 2010).

The West Coast ShakeOut 2009 exercise was run concurrently with Operation Ru Whenua (West Coast CDEM exercise), from 6am till midnight on 18th September. Ru Whenua involved both volunteers and paid council staff operating in 6-hour shifts in the Westport Emergency Operations Centre (EOC). The scenario included setting up welfare centres, and in Greymouth approximately 50 people including Civil Defence and Emergency Management (CDEM) representatives, Red Cross, Child, Youth and Family (CYF), Victim Support, SPCA, Work and Income New Zealand (WINZ), Search and Rescue, and local residents took part in the exercise. School children and local residents presented with a range of "injuries" and disaster related needs (e.g. food, clothing, shelter) and new arrivals were registered and assessed as if in an actual event.

Emergency managers were unaware of the scripted scenario and were fed information minute by minute throughout the exercise. The scenario was designed to identify gaps and needs in current planning and highlighted the fact that issues or a lack of resources in one area could create problems in other areas. For example, the EOC compiled incoming disaster information using computers rather than traditional paper-based systems, which was found to be much more time-efficient. However, because of the increased power usage during the exercise the EOC generator required fuel supplies additional to those available in the town, demonstrating the need for careful planning of resources and storage facilities specifically dedicated to the EOC.

Comparison of ShakeOut participation rates

The implementation of the West Coast ShakeOut exercise was found to be successful, with more than 1 in 4 people in the West Coast region taking part (27.5% of the 2006 census population). Table 1 illustrates the participation figures for the region. Some registrations also came from neighbouring districts interested in being part of the process. Internet availability may have been a factor in limiting the potential success of ShakeOut with only 63% of New Zealand households reportedly having access to the Internet and 33% having broadband access in December 2006 (Statistics New Zealand, 2006).

In evaluating of the 2009 Californian ShakeOut three counties in California were chosen for comparison of participation data, shown in Table 2 alongside data for the West Coast event. The West Coast ShakeOut attracted very similar participation rates, both as a proportion of the population and as a distribution between the main registration categories. The similarity of participant distribution between the West Coast and California reflects the emphasis placed upon targeting schools and other education providers in the first instance. Schools represent not only a means of attracting large numbers of participants for a minimal input of resources, but also act as a conduit to both the wider community. The relatively poor involvement of government agencies in the West Coast region may well reflect the reduced presence of these agencies in the region and also fewer layers of governance in New Zealand compared to California (State and Federal Governance). The higher percentage of individuals, families and businesses in the West Coast ShakeOut is partially a reflection of the relatively small numbers in these categories, but may also reflect the ability of the local promoter to access the communities on a more personal level given the small population. Each district on the West Coast has a business forum that allows ready communication with small businesses without the need to make personal visits.

Table 1
The distribution of ShakeOut participants by main registration categories.

District	Participants	Individuals and families	Education	Business	Govt agency
Buller	1895	17	1739	51	80
Grey	3761	206	3124	126	166
Westland	1916	144	1350	186	127
Other	758	30	706	14	8
Combined (% of total participants)	8330	397 (4.8%)	6919 (83.1%)	317 (4.5%)	381 (4.6%)

Table 2
Comparison of ShakeOut participation between the 2009 West Coast region and three partially randomly selected counties in the 2008 Californian ShakeOut, shown as percentage of the total population.

County/Region	Total participants	Individuals and families	Education	Business	Govt. agency
San Diego	580,243 (19.3%)	717 (0.12%)	492,734 (84.9%)	11,980 (2.1%)	64,575 (11.1%)
Los Angeles	2,621,892 (26.6%)	1,611 (0.44%)	2,274,434 (86.7%)	80,258 (3.1%)	134,377 (5.1%)
Sacramento	112,005 (9.2%)	131 (0.12%)	98,161 (87.6%)	503 (0.4%)	12,080 (10.8%)
West Coast	8,330 (27.5%)	397 (4.8%)	6,919 (83.1%)	377 (4.5%)	381 (4.6%)

Review and evaluation of the West Coast ShakeOut

The West Coast ShakeOut was the largest ever earthquake drill in New Zealand at the time and most schools on the West Coast participated in the exercise. The process was subject to an internal review, presented to the communications executive group of the supporting district and regional councils, and forwarded to the Ministry of Civil Defence and Emergency Management (MCDEM) for consideration in any future events of this type in New Zealand. In addition, the organizer requested the support of an external review team, who followed the process and visited the region on the day of the exercise. The external review team formed part of the authorship for this paper. Thus, while attempts were made to review the process of developing and implementing the ShakeOut exercise, no evaluation in terms of measuring the effectiveness and lasting benefit of the event has been conducted.

The goal of the external review panel in visiting Westland High and Paroa and Westport South Primary Schools was to observe staff and children undertaking an emergency response drill, and to join discussions of earthquake related issues. The observers also visited the Greymouth Welfare Centre and Westport Emergency Operation Centre where CDEM personnel were coordinating the earthquake response during Operation Ru Whenua.

Observations of school student understanding, preparedness and awareness

At the ShakeOut time of 10.10am observers were in three classrooms at Westland High School, Hokitika (Year 7 – 15). The students were aware that the earthquake simulation was going to happen. “Drop, cover, hold” was written on blackboards, and all students and staff understood that they must get under the desks and hold on during the simulation (Coomer, Johnston, Wilson, Becker, Orchiston, & Page, 2009).

After the exercise observers joined a Year 12 class for a discussion of earthquake issues, and to discuss impacts or implications of a possible Alpine Fault rupture. Students showed some interest in the geomorphic response and were generally knowledgeable about physical earthquake processes and the likelihood that West Coast communities would be isolated from each other and from the rest of the South Island. They asked about the possible size and timing of the Alpine Fault rupture, about the extent of building damage, whether a tsunami could happen, and where outside help would come from. Students living out of town were concerned for their families and the possibility of being isolated from their homes for many days. They wondered what would happen to those trapped in Hokitika and if they would have to stay at school rather than make their own way home to be with their families. Communication with their families, friends, and with the outside world, was a major issue, particularly regarding access to cell phones. Students wanted to know about shelter, food and water supplies both at school and home. Only a few families had emergency supplies at home. Some students were concerned about post-event recovery and whether they would retain their part time jobs. Most students were realistic about an Alpine Fault earthquake happening, however only a minority thought it would take place during their lifetime.

Students at both Paroa and West South Primary Schools (Year 1-6) had been taught the “Drop, cover, hold” procedure, and learnt about safety at school and at home in preparation for ShakeOut. Around one third of children said they had an emergency kit at home with water, food, toilet paper/buckets and a first aid kit. Some children had experienced earthquakes and

knew what to expect, while some younger children were clearly anxious about what to do during a big shake, and questioned the safety of the school buildings. They discussed the local sandy soils and liquefaction and whether the school buildings would sink during an earthquake. One child spoke about the risk of fire and some mentioned the likelihood of tsunami and whether the earthquake would kill people "like on TV".

Some of the children asked when the next Alpine Fault rupture is likely to occur and if the lower South Island earthquake (Resolution Island, M7.8 July 2009) was 'the big one' we were worried about. There was concern about isolation following road damage but all seemed confident that they would be looked after whether at school or at home. The children talked about the earthquake information in the school newsletter, with some developing earthquake and fire escape plans at home as a consequence of the ShakeOut event.

Conclusions

The ShakeOut exercise and Operation Ru Whenua generated substantial community interest and involved large numbers of local participants. The publicity generated by the event raised awareness of future Alpine Fault earthquakes, the likelihood of such events taking place, and the need to prepare for such an event. For school children, the exercise provided an opportunity to ask questions and build their understanding of how a future earthquake will impact on themselves, their families and their communities.

Since 2008, the Californian ShakeOut has been applied in other seismic regions throughout the world, including New Zealand in 2012. The West Coast ShakeOut was the first outside California, and generated similar participation rates and registration profiles. Beyond earthquakes, the concept could be developed to include other hazard types such as tsunami, volcanic eruption, flooding and landslides. Initial costs of setting up such a system may be offset by the ongoing and multi-hazard applicability that it could deliver as a means of promoting community resilience. Events like this act to reduce post-disaster losses and improve the culture of earthquake preparedness in areas of high seismic risk.

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