Information requirements in the immediate aftermath of a major natural disaster

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ABSTRACT

Extensive damage to residential land occurred in Christchurch and neighbouring suburbs as a result of the devastating Canterbury Earthquakes of 2010 and 2011. The primary cause of the land damage on the Canterbury plains was liquefaction, manifested as sand ejection, differential settlements and lateral spreading. In the Port Hills, land damage from intense ground shaking resulted in rockfall, cliff collapse and landslides. The land damage resulted in damage to buildings and infrastructure with such severity and extent that many residents experienced considerable and prolonged hardship. A rapid emergency response was therefore imperative, requiring first a detailed assessment of the damage from the multiple events and then collating all available technical information to support the recovery planning and decision making process. The information could then be used in a broader context to assist central and local government in the task of moving the affected communities into housing that has an acceptable level of risk from similar earthquake events, in the shortest possible time and at a cost that is acceptable. This paper describes the overall process that Tonkin & Taylor Limited used to manage the process using a wide team of local and international experts to obtain reliable technical information and observations in the aftermath of one of New Zealand worst major natural disasters.

Keywords: Canterbury earthquakes, information, natural disasters, communication

1 INTRODUCTION

The 7.1 magnitude Darfield earthquake in Canterbury at 4:36am on 4 September 2010 started a chain of events that has changed both the landscape of the region, the New Zealand natural disaster community and the lives of the Canterbury residents forever.

During the daylight hours immediately following the Darfield earthquake, geotechnical engineers from Tonkin & Taylor Limited (T&T), assisted by researchers, government agencies, territorial authorities, the insurance industry and the community, began the process of establishing the nature and extent of the residential land damage arising from the earthquake, including liquefaction related settlement and lateral spreading. T&T provides land damage assessments of individual properties and advice (Leeves and Williams, 2011) to assist the crown owned entity the Earthquake Commission (EQC) in assessing specific residential insurance claims following natural disasters. A characterisation system to compile land damage observations was established to map the effects of liquefaction and lateral spreading in affected residential areas (Jacka and Murahidy 2011). This information was used to guide the recovery, land remediation and public information efforts of EQC and the New Zealand Government.

Within a few days the full extent of the residential land, and consequential building, damage became apparent. Most of the land damage was in the eastern suburbs of Christchurch City, however the eastern suburbs of the Waimakariri District to the north also sustained considerable damage. Selwyn District, south of Christchurch, where the earthquake was centred and where the fault ruptured at the ground surface extended for almost 30 kilometres, sustained comparatively little damage to residential land.

Although the Darfield earthquake would eventually realise some 180,000 residential insurance claims by the cut off date at the beginning of December 2010, by 8 September 2010 it was already very clear that there was a great need to establish a reliable technical information source to aid in the decision making and recovery process.

Still feeling the effects from the damage caused on 4 September 2010, a second and much more direct hit on the city of Christchurch came on the 22 February 2011 (Williams, 2011). There were 182 people killed and the 6.2 magnitude earthquake decimated the city's central business district. The land damage from liquefaction was 10 times that caused by the September 2010 earthquake (Williams, 2011). The Port Hills also sustained extensive land damage in this earthquake including rock fall, large-scale landslides and retaining walls failures. There were further damaging earthquakes on 13 June 2011 (5.6 and 6.0 magnitude) and 5.8 and 6.0 magnitude earthquakes on 23 December 2011 (Figure 1). In addition to these major earthquakes, there have been more than 9,500 aftershocks since the sequence began. All major earthquakes and the subsequent damage arising from them have been mapped for land damage using the characterisation system established following the initial earthquake.

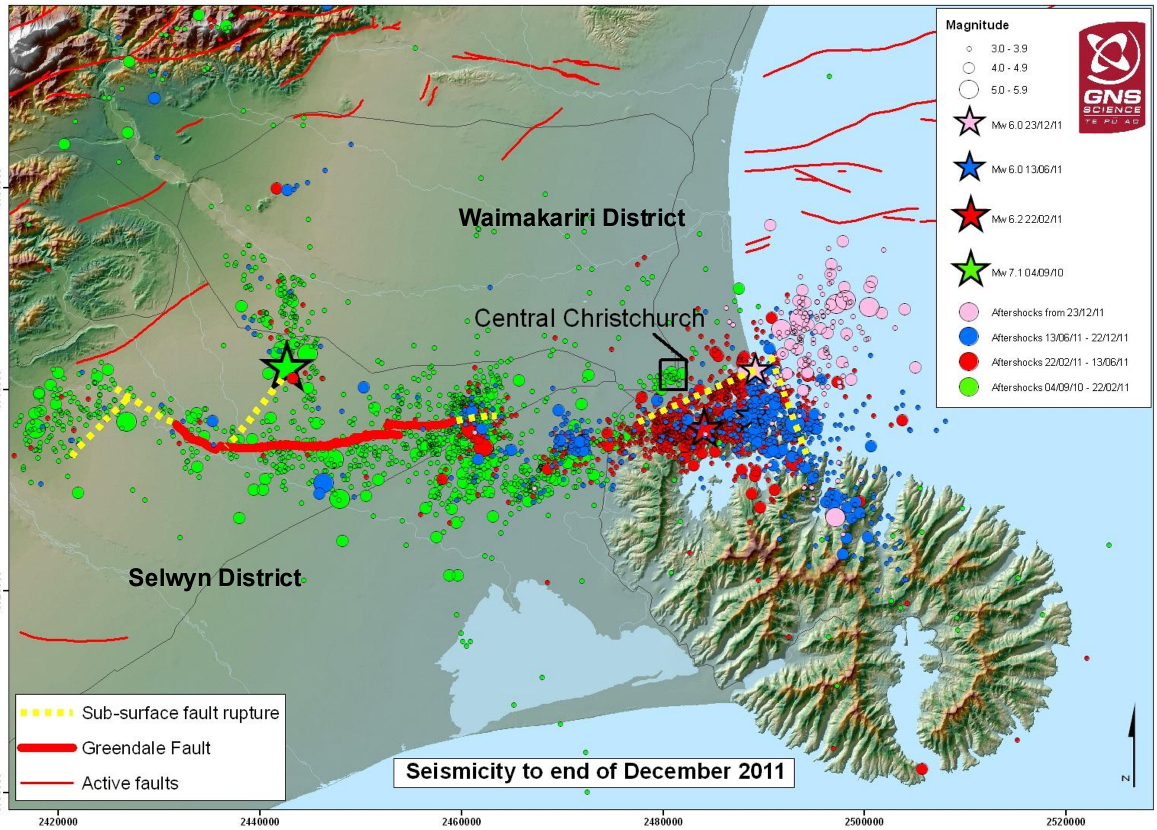

Figure 1. Canterbury earthquake sequence (image courtesy of Geonet, 2012)

This high level of seismic activity affects the recovery process significantly and will influence rebuilding with new engineering design standards being developed to match the increased seismicity of the region and new planning considerations for communities. The sheer scale of the damage assessment data management, with inputs from many organisations, has required the implementation of GIS and web-based data management systems for the information available (Leeves and Williams, 2011).

2 INFORMATION REQUIREMENTS

Immediately following each major earthquake within the Canterbury earthquake sequence, generally classified as an aftershock greater than 5.5 magnitude and or causing major land damage, various agencies require technically reliable, up to date information, in the first instance to keep the government, public and media informed of the situation. Open, clear and concise communication in natural disaster recovery is a vital key to ensuring the appropriate information is presented in a timely manner.

Particular information needs in the first few hours through to the longer term requirements relies on the following questions to be answered.

- What has happened?
- What has been damaged and where?

- Is coordination required?
- What is the frequency of the natural disaster?
- What is the full extent of the damage?
- How can the damage be repaired?
- When and where can repairs start?

T&T's Canterbury Earthquake Recovery Team has been advising the New Zealand Government since September 2010 and its new agency the Canterbury Earthquake Recovery Authority (CERA) since April 2011 on the land damage resulting from the Canterbury earthquake sequence. This logical step in information sharing came out of the ability for a single point contact source, to provide advice and information due to the wealth of data collected and collated on behalf of EQC. EQC was prepared to share the damage data obtained that was required by so many agencies involved to assist the recovery process (Williams, 2011). It is important to ensure that decision makers have the best possible information to progress the recovery.

2.1 Information data acquisition

In undertaking this work, T&T has engaged with and relied on the observations and inputs from a wide team of local and international experts. These include: GNS Science, the Natural Hazards Platform, New Zealand Aerial Mapping, local authority recovery teams, universities, the Earthquake Commission, Land Information New Zealand, Department of Building and Housing, Civil Defence and Emergency Management, New Zealand and overseas research teams (USA, Japan and Australia), councils, the insurance industry, other New Zealand experienced consultants, DHI water and Environmental Ltd, AAM Pty Ltd Group, the New Zealand government and the Canterbury community. The information collected includes both general data such as aerial photography images, land damage mapping (land cracking and observed liquefaction), building and infrastructure damage observations, ground movement and motion data and geotechnical investigations information across affected areas of Canterbury. Specific geotechnical information from investigations and instrumentation on the Plains includes 1344 Cone Penetrometer Tests, 162 boreholes with SPT's, over 12 kilometres of geophysical testing (MASW) and 656 piezometers, and in the Port Hills over 40 test pits and boreholes, with 17 inclinometers.

The data has been received and input into a database portal (Project Orbit) which can be interrogated to produce maps and information to assist in the Canterbury Recovery process. Table 1 provides a sample indication of some of the information that has been acquired and from which responsible agency that has assisted in the recovery process. The land damage maps provided Government, EQC, the respective councils and insurance companies with a clear picture of the extent of where damage had occurred (Leeves and van Ballegooy, 2011). This data in turn with other considerations (e.g. economics, social factors) was relevant to recovery decisions and land categorisation i.e. land recovery zones and residential foundation technical categories.

Table 1: Selected examples of information data acquisition

Information		Source agency responsible	Data available
Observed land damage	Cumulative Liquefaction Map	T&T EQC	Cumulative land damage using both aerial photographs and visual observations severity due to liquefaction and lateral spreading after the 4 Sept 2011, 22 Feb 2011 and 13 June 2011 earthquakes
	Land damage observations	T&T	Liquefaction and lateral spreading observed in properties following the 4 Sept 2010 and 22 Feb 2011 earthquakes. Data was collated from on-foot property by property mapping of individual properties.
	Liquefaction Observed on Roads - 22 Feb and 13 Jun 2011	T&T	Preliminary liquefaction map based on the observed severity of liquefaction on the roads
	Observed Liquefaction Aerial Detail	T&T	Extent of liquefaction following the 22 Feb 2011 and 13 June 2011 earthquakes based on aerial photography interpretation

	Information	Source agency responsible	Data available
Aerial photography		New Zealand Aerial Mapping (NZAM)	High resolution aerial photographs taken 4 Sept 2010, 23-24 Feb 2011, 14-15 June 2011 and 16 June 2011, 24 Dec 2011
Ground movement	LiDAR Areal Strains and Vectors	Imagin' Labs Corp. - California Institute of Technology, GNS Science	Colour banded areal strains and horizontal movement vectors for single and multiple earthquake events
	LiDAR and Digital Elevation Models and Movement	LiDAR acquired by AAM Brisbane NZAM	Digital Elevation Model (DEM) levels and elevation changes created from LiDAR
	LiDAR Verification March 2011	March 2011 LiDAR DEM Model (NZAM), Land Information New Zealand (LINZ) geodetic database point surveys	March 2011 LIDAR Levels relative to LINZ Reference Benchmarks
	Survey point movements	Fox Surveyors - commissioned by T&T using points established after the 4 Sept 2010, LINZ survey information from their geodetic database points, Waimakariri District Council (WDC), Environment Canterbury (ECAN), Christchurch City Council (CCC)	Movements during 4 Sep 2010 and 22 Feb 2011 earthquakes and cumulative movements (to Mar 2011) This map shows survey point movements for the two main earthquake events surveyed by five different organisations. A GNS Science regional movement model was used to estimate the relative movement at each survey point, by subtracting the regional movement from the observed movement.
Ground motion	MM Intensity Maps	Eagle Technology Group Ltd based on data supplied by GeoNet/GNS Science	Modified Mercalli Earthquake Intensity (MMI) Maps for 4 Sept 2010, 22 Feb and 13 June 2011
	Strong Motion Recording Stations	GeoNet/GNS Science	Canterbury Strong Motion Recording Stations
Recovery	Land Recovery Zones	Canterbury Earthquake Recovery Authority (CERA)	Zones were identified from engineering assessments of residential land, building and infrastructure damage. The zone boundaries were adjusted using the recovery criteria set by the NZ Government on the basis of whether it was practical to repair properties in a timely and cost effective way.
	Residential Foundation Technical Categories	Department of Building and Housing (DBH)	New technical categories only apply to residential properties in the green (rebuild) zone with foundations that are required to be repaired or rebuilt due to earthquake damage or for future major renovations or new builds.

Additional data such as full site specific suburb wide geotechnical investigations information from a range of agencies along with building damage insurance data is also available though this portal.

2.2 Information distribution

The ability to portray the areas of most significant damage visually using GIS-based maps proved a powerful tool and easy to understand compared to data-based methods (Leeves and van Ballegooy, 2011). Prioritisation of recovery efforts to those most in need of help were easily observed from the GIS-based land damage mapping exercise. It soon became apparent that the collation of information from all key parties would further help to rationalise and speed up the recovery process.

Customized maps and other electronic resources were published on the Project Obit website (Figure 2) that was developed to securely share those resources amongst the agencies and organisations involved in the Christchurch Recovery; https://canterburyrecovery.projectorbit.com. This website provides a collaboration portal, with controlled access to the published map layers and other documents. Agencies could post data as well retrieve it, effectively providing a secure inter-agency file server that could be accessed from anywhere via the Internet.

At this stage this is a restricted access site and only for use by specific users that have generated the data and/or can use the data for recovery purposes such as emergency responses, recovery planning or decision making. These agencies include NZ Government, CERA, EQC, local authorities, GNS Science, insurance industry, DBH engineering advisory group and universities to name a few. Data access is controlled according to its ownership and sensitivity. The maps are published in the standard KML file format that can be displayed using software such as Google Earth (Google, 2010). Map layer descriptions displayed on the website include the layer file names, map descriptions, earthquake event, data origin and version numbers.

It is noted that as earthquakes and damage continues to be recorded throughout Canterbury and more data is received the maps and information will periodically be updated. This therefore remains a one stop access point for the most current up to date and best available information for recovery decision making agencies, such as NZ Government, CERA, EQC and local authorities.

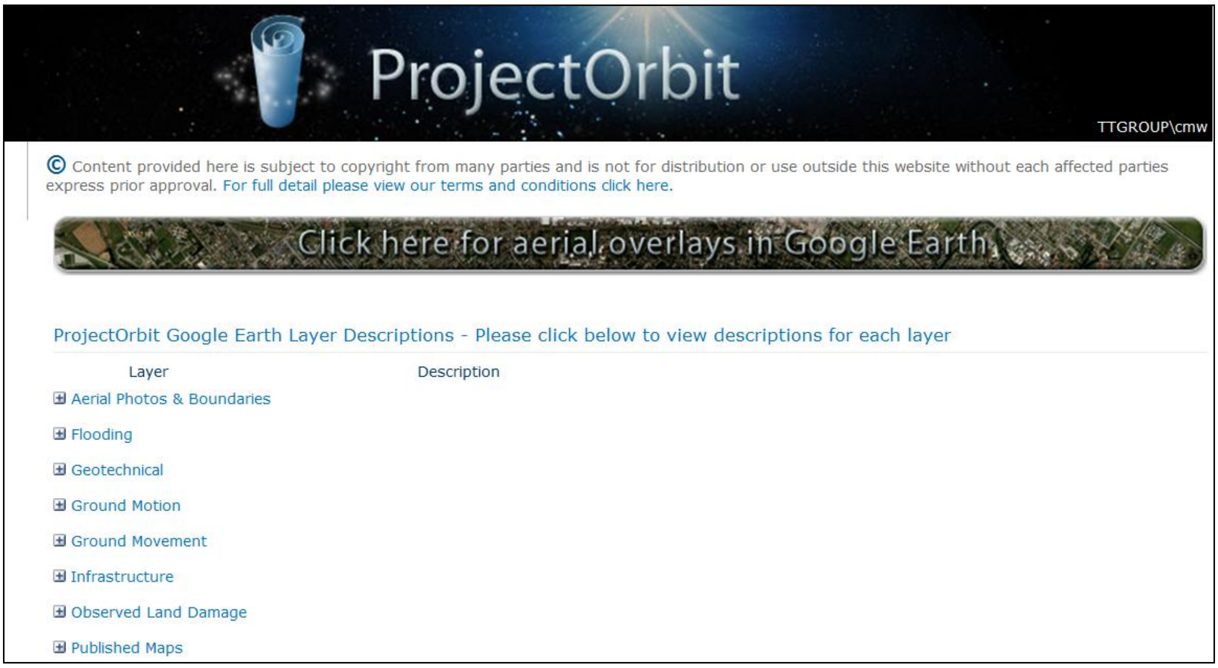

Figure 2. Canterbury recovery information website https://canterburyrecovery.projectorbit.com

2.3 Public information and communication

These technical data management systems have proved highly effective for recovery agencies, councils, insurers etc and their advisors, however it was noted that public information dissemination was established as also being a priority for community well being recovery. An initial document titled 'Darfield Earthquake 4 September 2010 Geotechnical Land Damage Assessment Report Stage 1' (Tonkin & Taylor, 2010a), was presented to the public on 20 October 2010 providing an introductory presentation of the categorisation of the land damage. A further 'Stage 2' public report released in November 2010 (Tonkin & Taylor, 2010b) was based on a detailed suburb-by-suburb engineering assessment into the nature and extent of the land damage and also identified land repair strategies.

The information presented has since been superseded by ongoing damage from major earthquakes however the engineering mapping categorisation and land remediation/ repair strategies provide a basis for the engineering work and advice continuing throughout Canterbury. In addition extensive and large scale site investigations around the most severely affected suburbs of Canterbury have been undertaken and reported on following the 22 February 2011 earthquake. Factual geotechnical reports have been prepared to facilitate the speedy response to the disaster. These reports are made freely available (http://canterbury.eqc.govt.nz/news/reports) to the public, researchers and engineers to ultimately be used to formulate remedial and reinstatements works where appropriate (Leeves and Williams, 2011).

Ongoing public dissemination of information has taken the form of public meetings, media briefings, public notices, website downloads such as factsheets, direct mail out letters to affected residents and newspaper press releases.

3 CONCLUSION

The collation and aggregation of available information has enabled visual representation, in relation to one and other, the location of ground movement, land damage, residential properties that are uninsured, properties that can be repaired or need to be fully rebuilt, undamaged properties and infrastructure damage. This information has facilitated respective parties to collaborate, make decisions, establish recovery zones and undertake co-ordinated repair and reconstruction works in parallel to minimise disruptions to the affected individuals and communities of Canterbury.

There is still more work to be done and data to be collated with the continued ongoing seismic activity slowing the recovery reconstruction phase for the communities that are to be rebuilt. However with continued best possible information and data being made available across many inter-agency networks decision makers can progress the recovery planning in a timely manner.

The processes and systems used here in the aftermath of one of New Zealand's worst major natural disasters, to manage a wide team of local and international experts, to obtain reliable technical information and observations could be applied across other world disasters.

4 ACKNOWLEDGEMENTS

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