

Christchurch Earthquake Hazard Analysis and Risk Mitigation

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Summary:

In September 2010, Christchurch, New Zealand was subject to a M_W 7.1 earthquake. Following a further ~5,000 aftershocks it was hit by another M_W 6.2 earthquake in February 2011. As part of the Civil Defence response team, Christchurch City Council required unstable boulders in the Port Hills to be identified and secured before further tremors could dislodge them. This paper describes the process of applied GIS to capture locations of rockfall hazards, collate appropriate levels of spatial data, map the hazardous locations for rapid distribution to field teams and identify at risk areas for prioritised stabilisation.

KEYWORDS:

Christchurch Earthquake, Rockfall Hazard, Risk Identification, Create Steepest Path, ArcScene



1. Introduction

Following the 10 Km deep M_W 7.1 earthquake on a previously unknown fault line in September 2010, Christchurch was thrown into turmoil with initial response teams deploying practiced procedures to rescue people trapped in buildings and to restore critical services. With limited access to infrastructure information that was also trapped in council offices, maintenance teams restored what was understood as critical access ways and pumping stations for potable water and wastewater. These services, although being restored, were found to require a more strategic approach to restoring single catchments at a time to ensure connectivity of networks.

The aftershock of M_W 6.2 struck six months later in February 2011. It was centered at only 5 Km deep, much closer to the city and was during the busy midday lunch hour. Beyond the death toll, the aftermath had, again, left many without services and landowners unsure if their sites could ever be built on again. This was then followed by a third devastating aftershock of M_W 6.0 in June 2011. The figure below supplied by GNS Science (2011) illustrates the ongoing tremors that had to be endured whilst response teams carried out their work.

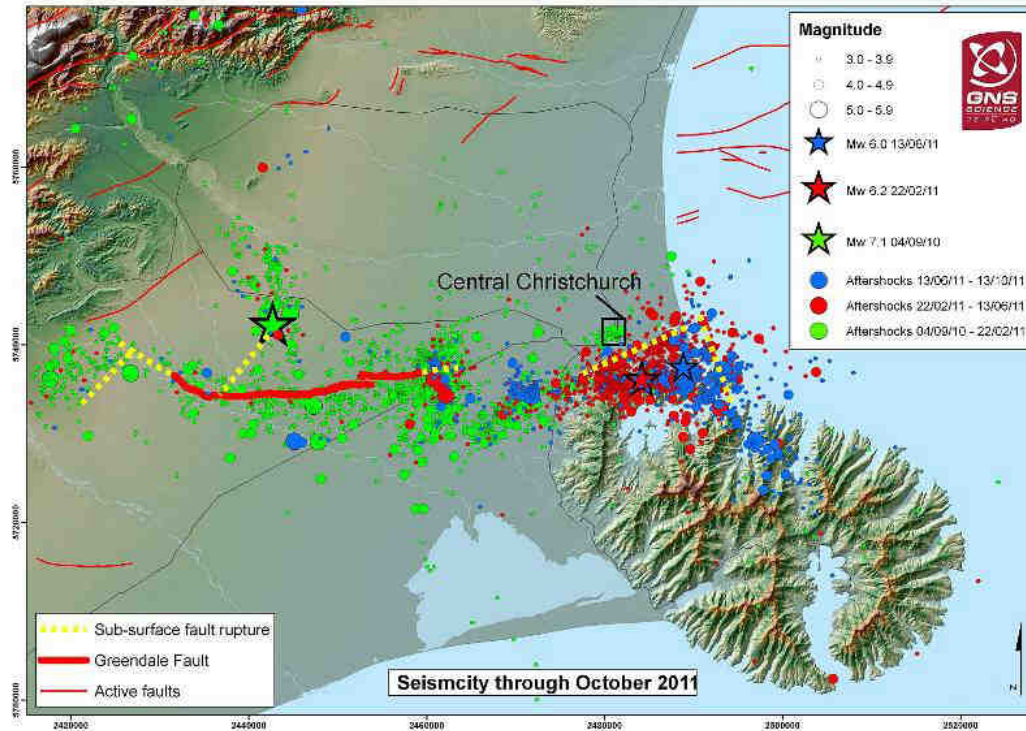


Figure 1. Illustration of Initial Earthquake and Major Aftershocks

Although these aftershocks were expected, the location and severity was not. Having recently dealt with similar procedures, response teams employed strategic techniques to restore essential services. This included checking residential properties to ensure their stability inside and security from surrounding hazards.

2 Hazard Identification Process with supporting Maps

The remedial work described in this paper takes place between the February 2011 and June 2011 aftershocks.

2.1 Rockfall Hazard Identification

The first major aftershock had sent dislodged boulders rolling down cliff faces and through houses. Building inspectors were sent to review the safeness of houses and capture locations of properties at risk. This did not include the potential for the continuing aftershocks causing further damage. Therefore as an immediate requirement, geotech teams were sent to survey the surrounding hillsides and capture the GPS locations of potential hazards.

2.2 Equipment Utilised

Geotech teams were under tight timeframes to identify hazard locations as it was unknown when another significant aftershock may occur. The teams used Garmin GPS units and a TG-810 Olympus Digital Camera with built-in GPS chip to provide waypoints as GPX files and geotagged Exchangeable image file format (EXIF) photos. A process was quickly established to convert these formats into useable geodatabases and shapefiles for mapping in ESRI ArcGIS.

2.3 Initial Base Maps

Using a mixture of historic and newly provided data, the author delivered base maps, off-site from over 1,000 Km away, of the catchment scope to provide an overview for further prioritisation as seen

below.

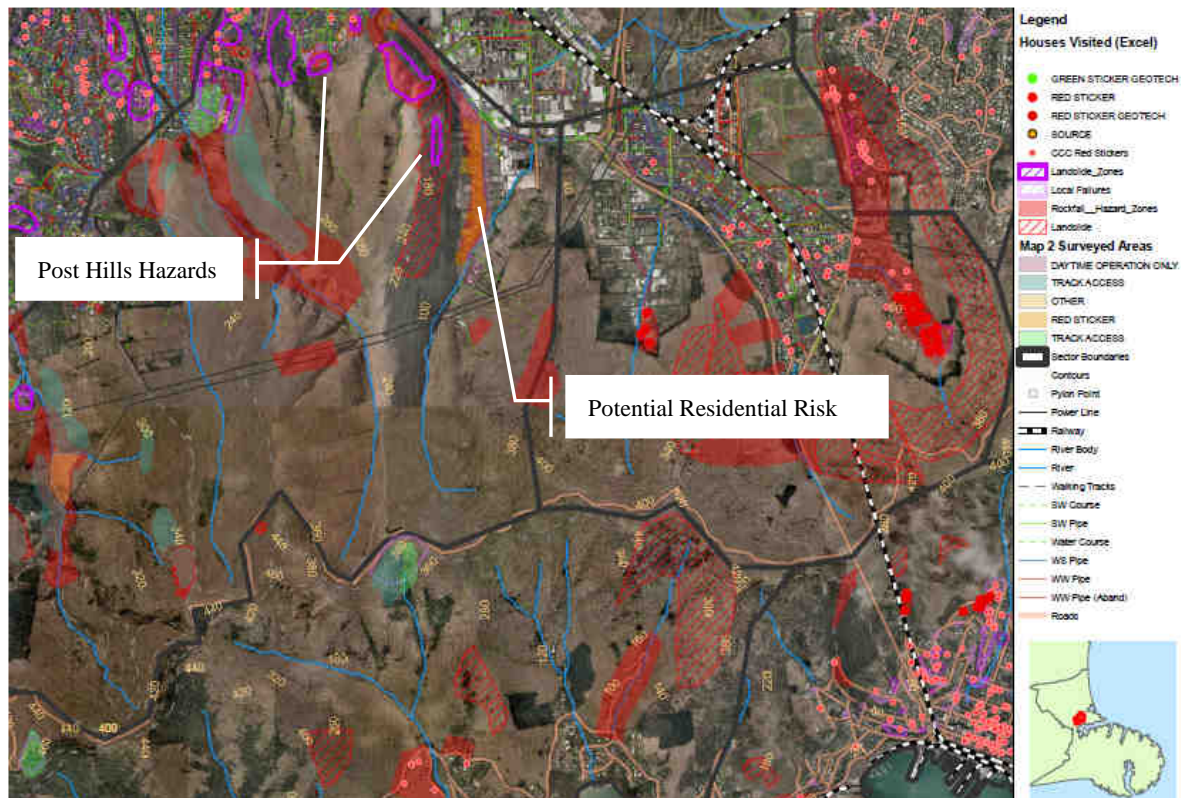


Figure 2. Sector 7 Rockfalls and Landslide Hazards Base Map of the Port Hills

Zones and areas within zones were identified to help prioritise work. Potential rockfall hazards were identified for stabilisation or to be blasted into manageable pieces. With this information, easily transportable maps were generated in Google Earth and delivered through Google Maps to teams at different locations. These provided field teams with locations of site works including blast sites, as shown below.

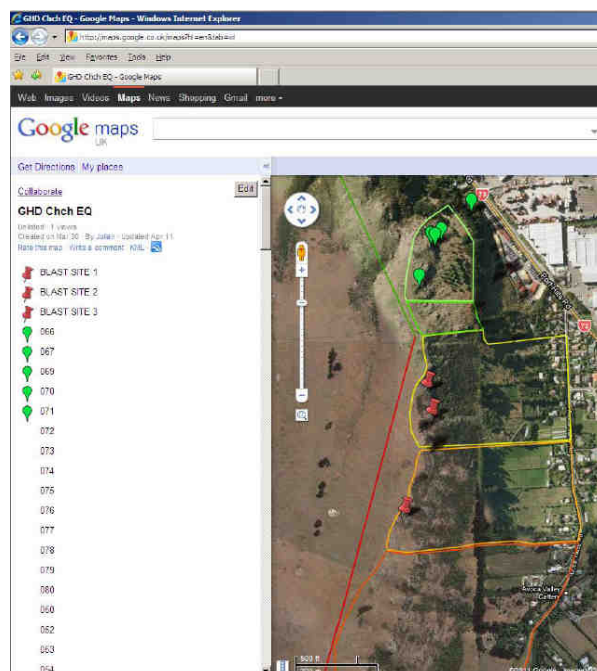


Figure 3. Google Maps showing areas within zones and possible blast sites

2.4 The Need to be On-Site

As further maps were required in quick succession, the author travelled to Christchurch to assist with forming a procedure to collate hazard areas and deliver maps for use in the field and for presentations to Civil Defence to ensure consistency with other response teams.

The temporary Civil Defence headquarters had set up servers for GIS data with a dedicated team of GIS Analysts and database administrators producing maps on demand as seen in the following photos.



Figure 4. Civil Defence Temporary Headquarters GIS Team

With access to relevant spatial data, appropriate feature-sets were utilised to further enhance spatial analysis to support the team. High resolution Digital Elevation Models (DEMs) had been captured to show the differences in ground elevations between LiDAR taken after the September 2010 earthquake and after the February 2011 earthquake. These were also used to create contours for tin models to show the severity of the Port Hills area. Further feature-sets were also captured of rockfall locations, landslides, pipe infrastructure, road infrastructure, rivers, tracks, pylons. Residential houses were being allocated with a green / yellow / red sticker to indicate the level of existing damage. These were being continuously updated and provided an indication of the worst liquefaction affected areas.

2.5 Improving the Hazard Capture Process

While on-site the author had the chance to streamline the process of converting field captured notes, waypoints and photos into useable maps. A form was also provided by the council to assist capturing all relevant information and ensure a consistent level of detail between teams, as seen below. This also assisted in standardising the information and format of field data.

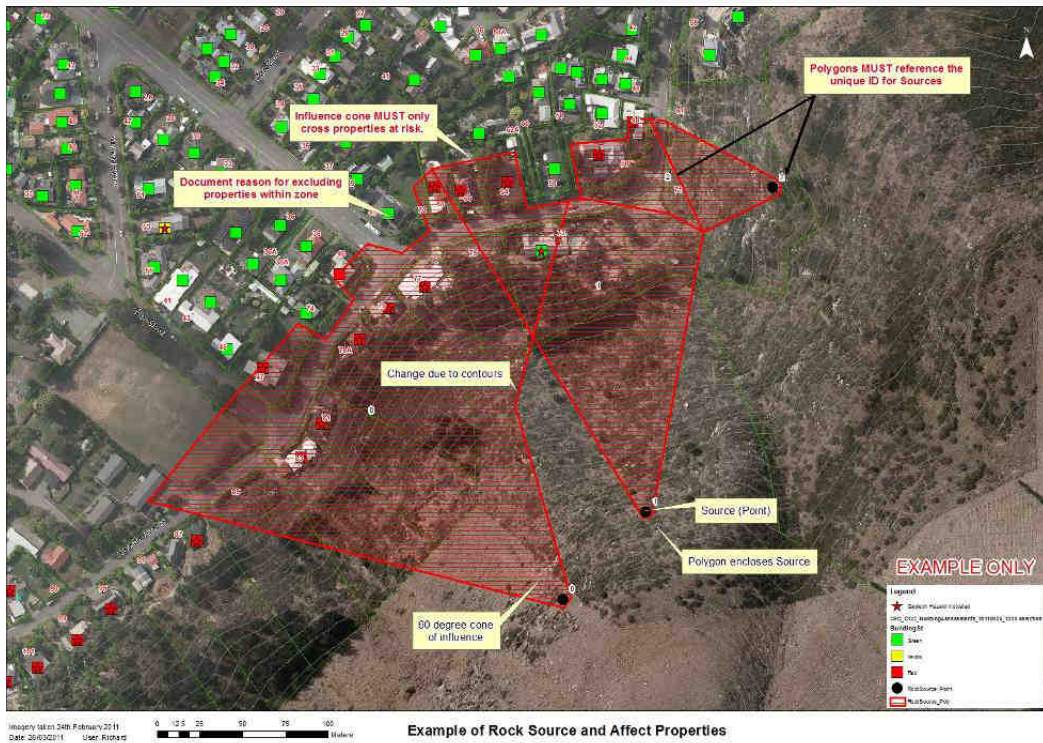


Figure 6. Cones of Risk Example Output

With data supplied that provided a hillside contour, it was possible to use the Create Steepest Path tool in ArcScene to find the likely path a boulder would take if it rolled down the Port Hills. The features were draped over a tin created using the contour data. The output produced below was able to be run for all scenarios of identified rockfall hazards.

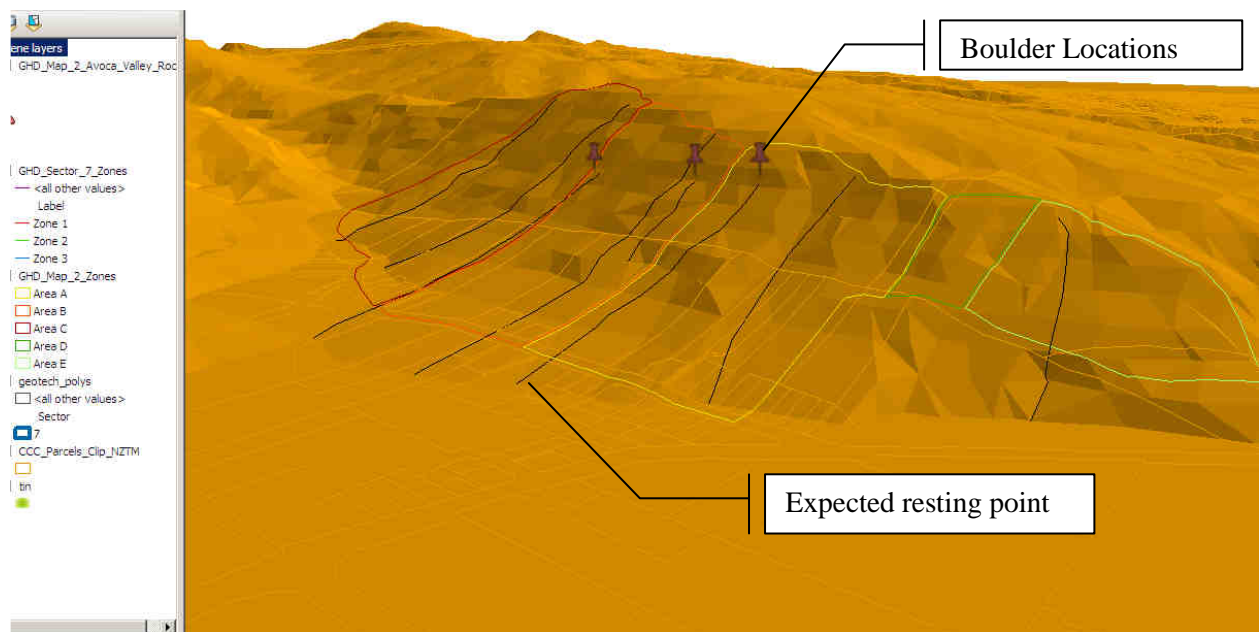


Figure 7. 3D Model of Port Hills with Steepest Path of each Boulder

With an indicative resting point identified, the 60° Cone of Risk could be placed in the middle of the resting point. This enabled the use of the Intersection tool to identify all address parcels that the Cones of Risk breached. These addresses were then reported as higher risk areas.

3. Summary

As with all emergency response situations, the best and most appropriate data and resources is not always available at ground zero. Through the use of remote resources, available equipment and dedicated response teams, the GIS analysts were able to produce useable outputs to keep emergency teams mobile and on-task. Each emergency situation has different lead times and requirements that change with time as the risk subsides.

Further potential improvements in field capture techniques were identified through the use of Microdot technology where field teams, that do not prefer to use to tablets and PDAs, can use hard copy forms to capture field information and send digitised electronic data back to base via a mobile phone connection. Another improvement identified was the requirement to have multiple off-site backups of information to reduce the risk of limited access to vital and timely data.

The use of GIS to support emergency response efforts in Christchurch has been recognised as a vital tool in ensuring accurate and real time spatial data could be turned around and delivered to emergency services to assist and improve critical decision making. It is believed that the remedial work to secure boulders between the February 2011 and June 2011 aftershocks was critical in avoiding further damage to properties and their occupants.

4. Acknowledgements

The author would like to thank Christchurch City Council and Environment Canterbury Regional Council for supplying timely spatial data that enabled these results to be realised. Also recognised is the Civil Defence, emergency services and all the volunteers for the support and action to minimise the impacts to the community.

5. References (data sources)

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GNS Science. *Seismicity through October 2011*. <http://www.gns.cri.nz>

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6. Biography

Julian moved to the UK from GHD New Zealand with 10 years spatial sciences experience and eight years focused on holistic asset management across multiple portfolios. Julian's emphasis is on improvement planning to link strategy to people, knowledge, data and system enablers, optimising service delivery processes and cross-network geospatial modelling.