Case Study Report: 2010 Canterbury and 2011 Christchurch Earthquakes – Demolition and Disaster Waste Management

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Executive Summary

On 4 September 2010, the Canterbury region of New Zealand was struck by a 7.1 magnitude earthquake. The event caused significant damage but no loss of lives. The earthquake, however, triggered a sequence of more deadly and damaging aftershocks that are continuing at the time of writing. In particular, on 22 February 2011, Christchurch was struck by a magnitude 6.3 earthquake, centred within 10km of the central city. 182 people died and 164 were seriously injured (GeoNet, 2011). The central city was significantly damaged and there was widespread liquefaction in the eastern suburbs of the city. At the time of writing an estimated 1,400 commercial properties and a minimum of 7,500 homes are facing demolition. It is estimated that approximately four million tonnes of building debris will be generated from the demolition and building repair work and up to four million tonnes from the horizontal infrastructure repair. In addition, in excess of 500,000 tonnes of liquefaction silt was generated by the earthquake.

New Zealand's Civil Defence and Emergency Management (CDEM) Act provides the legislative framework for managing emergency responses. It also established the organisational structures and planning requirements for Civil Emergency personnel. The Act is comprehensive for enabling emergency response; however, it is weak in terms of enabling recovery. As a result, the Canterbury Earthquake Recovery Act was passed two months after the earthquake (April 2011). The Act gives authority to Ministers to amend almost any piece of legislation (through an Order in Council) to facilitate earthquake recovery. The CER Act provides liability protection for actions taken under the Act.

In line with the legal framework described above, the initial emergency response (up to the end of April 2011) was managed by New Zealand's emergency management authority Civil Defence. The recovery is being managed by the Canterbury Earthquake Recovery Authority (CERA) as allowed for in the CER Act.

There appeared to be no role developed for strategic management and coordination of the overall waste management process. Debris and waste management issues were divided between CERA and the Christchurch City Council such that no organisation appeared to be overseeing the whole waste management system, from cradle to grave. Thus, no entity was actively identifying bottlenecks & capacity limitations and determining protocols & strategy was ad-hoc. Some planning work was carried out during the initial stages of response and recovery but it did not appear to be institutionalised.

Perhaps as a result, public communication and consultation appeared reactionary during the response and recovery.

Emergency works such as silt clearance and demolition for urban search and rescue, were paid for through Civil Defence / national government funds. Demolition and debris management activities in the recovery phase are generally being paid for by insurance companies. Commercial properties are generally insured privately and residential properties have joint cover between the national insurer, the Earthquake Commission (EQC), and private insurers[1].

The dual EQC / private insurance system created some organisational and logistical complexities for residential properties with land damage. In many cases the damage was above $100,000 and the property would need to be handed between EQC and the private insurer depending on the stage of demolition, land remediation or rebuilding. The decision to retreat from large affected areas (rather than remediate) has considerably reduced this organisational problem, but as introduced complexities around cost share arrangements.

Overall, there were significant organisational and logistical deficiencies with the private funding mechanisms. While some ex-ante organisational changes post-earthquake mitigated the complexities of the dual and private funding system, a more considered analysis of operational implications or a completely transformed funding system is needed.

Despite the individually oriented funding mechanisms, and due to a desire to protect public health and safety and to open the city centre as quickly as possible, a centralised demolition and waste management approach was adopted by most insurance companies (residential property repair and demolition) and CERA (commercial and residential red zone property demolition). For commercial buildings, building owners had the opportunity to carry out their own demolition as long as they did so within the allocated time. Approximately one third of commercial properties (classified as dangerous under the CER Act) were managed by CERA.

CERA developed a selective demolition procurement strategy. It allowed for simple, low risk jobs to be carried out quickly and efficiently using cost reimbursement contracts. This allowed a greater opportunity to efficiently share resources across the city. The higher risk jobs (e.g. tall building demolition) were justifiably tendered to ensure prices were competitive and risk of cost overrun rested primarily with the contractor.

Waste is predominantly being handled at existing, privately owned, waste handling facilities. Several new facilities have been established to specifically manage the earthquake waste: Lyttelton Port reclamation; Burwood Resource Recovery Park (BRRP); Burwood disposal facility; and several private waste sorting facilities operated by demolition contractors (both legal and illegal).

[1] EQC covers the first $100,000 of any structural damage insurance claim on a residential property and the first $20,000 for contents. Private insurers cover the balance, up to the policy value.

Initially, no on site separation was carried out post-earthquake. All mixed waste was taken to BRRP for separation. Following completion of search and rescue type activities, a 'quick pick and go' demolition model was established. This enabled 'clean' debris that could be easily and quickly removed from the buildings to be directed straight to end-use market while the remaining mixed waste could be sent to BRRP or other for separation, processing, recycling and onward disposal. The aim of this approach was to maximise speed of demolition but also to balance costs and environmental impacts. Full building strip-outs (as is practiced in peace-time) were often not possible due to the continuing aftershocks and subsequent danger to workers, therefore waste often included building contents and fittings. It was acknowledged that the 'quick pick and go' approach may be marginally more expensive on a site by site basis but the economic benefits of the faster recovery would outweigh the additional costs. As the recovery progressed, the buildings being demolished became more stable, and lump sum contracts were issued, more and more recycling was carried out on site.

Liquefaction silt was largely collected from private properties by an army of volunteers and placed on the kerbside for collection. Council roading contractors collected the silt and deposited at one of two designated disposal sites.

As well as the authority to change existing laws, the CER Act established quite specific provisions controlling demolition of damaged structures. Most importantly the Act gave CERA the authority to require buildings to be demolished or made safe and to intervene if works were too slow and to seek compensation for works carried out on behalf of building owners.

Several disaster waste management contracts were let without the full 'peace-time' procurement procedures being followed. These were let during the emergency phase but extended into the recovery phase. The CDEM Act has allowances for expedited procurement procedures; however the CER Act does not.

The CER Act was used to establish several disaster waste handling facilities (as above). Apart from these specific facilities, generally, new facilities were expected to go through the 'peace-time' Resource Management Act approval process. Some discretionary powers were used where existing facilities wanted to modify their operation parameters in aid of earthquake recovery.

Health and safety regulations remained largely unchanged. The Department of Labour provided some earthquake specific guidance and flexibility in regulation interpretation for asbestos management; however, the law (or regulations) was not changed.

At the time of writing the demolition and debris management programme is continuing. The demolition works continue in parallel with a number of other recovery issues, including establishing new planning and building regulations and securing insurance cover within New Zealand. At this stage the demolition and waste management works have neither facilitated nor hindered the overall recovery.

Contents

Acronyms

BRRP	Burwood Resource Recovery Park
CCC	Christchurch City Council
CDEM	Civil Defence and Emergency Management
CER Act	Canterbury Earthquake Recover Act
CERA	Canterbury Earthquake Recovery Authority
CPH	Community and Public Health
DOL	Department of Labour
ECan	Environment Canterbury
EQC	Earthquake Commission
IPENZ	Institute of Professional Engineers of New Zealand
LPC	Lyttelton Port of Christchurch
MfE	Ministry for the Environment
MOH	Ministry of Health
OIC	Order in Council
PMO	Project Management Office
RMA	Resource Management Act
SDC	Selwyn District Council
USAR	Urban Search and Rescue
USEPA	United States Environmental Protection Agency
WDC	Waimakariri District Council

1 Introduction

1.1 Disaster Waste Management

Disasters can create large volumes of inert and hazardous debris. The amount and composition of the waste depends on the type and severity of the disaster, and the nature of the built environment. Recent natural disasters such as the 2010 Haiti earthquake (Booth, 2010; Johnson and Correa, 2010; Kahn, 2010), Victorian Bushfires 2009 (Brown et al., 2010a), Hurricane Katrina 2005 (Luther, 2008; USEPA, 2008) and the 2004 Indian Ocean tsunami (Basnayake et al., 2005; Petersen, 2006) have all generated volumes of waste which overwhelmed existing solid waste capacities and required extraordinary management approaches.

Disaster debris can impede rescuers and emergency services reaching survivors, inhibit provision of lifeline support, pose a public and environmental health hazard, and hinder the social and economic recovery of the affected area. Poor management of a clean-up effort can result in a slow and costly recovery which is potentially risky to public and environmental health in both the short and long term.

The first and most comprehensive national guidance on disaster debris management was the USEPA's "Planning for Disaster Debris" (USEPA, 1995) which was updated in 2008 (USEPA, 2008). Most US local government authorities now have plans due to recovery cost incentives provided by the Federal Emergency Management Agency (USEPA, 2008). Outside the US, understanding of the need to plan for debris management is growing (Johnston et al., 2009; UNOCHA, 2011).

There are limited studies existing specifically on earthquake waste management. Waste issues following the 1995 Kobe earthquake have been well fairly well documented (Kuramoto, 1995; Lauritzen, 1995; Lauritzen, 1998; Reinhart and McCreanor, 1999; Baycan and Petersen, 2002; Inoue et al., 2007; Hirayama et al., 2009; Hirayama et al., 2010). Other earthquake events where waste issues have been explored include: 1995 Northridge earthquake, US (USEPA, 1995; Jones, 1996; State of California, 1997; USEPA, 2008); 1999 Marmara earthquake, Turkey (Baycan and Petersen, 2002; Baycan, 2004). There are minor reports on: 1989 Loma Prieta earthquake, US, 1990 Luzon earthquake Philippines, 1992 Erzoncan Earthquake, Turkey (Lauritzen, 1996/1997); 1992 Humboldt County Earthquake, US State of California, 1997); and 2003 Algiers-Boumerdes, Algeria Earthquake (Benouar, accessed 2009).

Earthquake waste managers in the past have faced many challenges, including: insufficient landfill space; highly mixed waste; heavy waste; shortage of machinery and personnel; overwhelmed recycling and disposal facilities; and asbestos.

1.2 Christchurch Earthquake

At 12:51 pm on 22 February 2011, Christchurch, New Zealand, was struck by a magnitude 6.3 earthquake, centred within 10km of the central city and just 5km deep. The earthquake generated large horizontal and unprecedented vertical ground accelerations causing widespread building and infrastructure damage. The timing of the earthquake, in the middle of the day contributed to a high casualty rate: 181 people died and 164 were seriously injured (GeoNet, 2011). The central city was significantly damaged and there was widespread liquefaction in the eastern suburbs of the city.

The February earthquake was an aftershock of a larger 7.1 magnitude earthquake located 20km west of Christchurch in September 2010. No-one was killed in this earthquake; however, this event has led to an aftershock sequence with more than 3000 earthquakes above magnitude 3 (Greenhill, 2011b) in the 500 days following the earthquake, including 13 magnitude 5 (and above) earthquakes (GeoNet, 2012). The recovery process, as will be discussed later, has significantly impacted by the continuing seismic activity.

Immediately after the February earthquake, the central city was cordoned off to restrict access, and named the "red zone". The cordon was due to the imminent threat from dangerous buildings and for the protection of personal property in a large number of unsecured premises. At the time of writing an estimated 1200 commercial properties and another 10,000 homes are likely to be demolished. 120,000 properties require repairs. Many of the buildings are too unsafe to enter. In June 2011, the New Zealand Government announced that they would purchase approximately 5000 homes because the land was deemed unsuitable without significant remediation. It is anticipated that more land will be abandoned.

The earthquake caused severe damage to lifelines (critical infrastructure) such as electricity, water, and sewer. Emergency water supplies were trucked in for many. Piped water supply was returned to 95% of households within a month and 84% of households had could flush their toilets. Boil water notices remained in place for four months (Christchurch City Council, 2011a). Sewage systems in some places will never be replaced. Some homes will rely on portaloos and chemical toilets until they move out of the area. Power was lost in some areas for several days and new overhead cables had to be constructed to replace damaged underground cables to service some areas.

It has been estimated that the demolition of buildings and rebuilding process associated with the Canterbury earthquakes will generate approximately four million tonnes of debris. This roughly equates to 20 years' worth of municipal waste from Christchurch. It is estimated there may also be up to four million tonnes of debris from infrastructure repairs. Approximately 40 significant buildings are likely to be demolished or made safe. The time taken to remove or repair these tall buildings will largely determine the time required to open the inner-city 'Red Zone.' Approximately half of the listed heritage buildings in Christchurch sustained damage. In addition, in excess of 500,000 tonnes of liquefaction silt was generated and largely collected by an army of volunteers and Council trucks.

The debris from some buildings requires special handling. Debris from buildings where fatalities occurred needed to be retained for possible Coronial Inquiries. Specific features of some heritage buildings are to be retained. Many commercial buildings built prior to the mid-1980s contained asbestos and therefore required special management. Some buildings contained other hazardous substances or were built on contaminated land. Prolonged power outages in the CBD generated large volumes of putrescible waste, particularly in food handling premises, posing a potential health nuisance.

While costs from the Christchurch Earthquakes waste management are yet unknown, the total cost of the earthquakes was estimated at $18 billion in May 2011 (English, 2011). This value is constantly being revised. Waste management costs will largely be carried by insurance companies, the national insurer (Earthquake Commission) and the government.

1.3 Report Scope

This report includes (1) a brief overview of the response and the initial stages of the recovery from the 2011 Christchurch Earthquake and (2) details of the disaster waste recovery process – including demolition works, collection and disposal. The final section of the report is an analysis of the strengths and weaknesses of the key waste management decisions. The report focuses on Christchurch City.

The report forms a case study of a modern disaster waste management system. It will be used, by the authors, as part of a wider study on disaster waste management systems and will in time be compared with other case studies to try and develop a strategic and integrated approach to planning for and responding to disaster waste.

It should be noted that the focus of the report is on the recovery phase, therefore waste management during the emergency phase is commented on but not analysed in any detail.

The definition of waste here includes all waste types except for animal and human remains and wastewater.

2 Methodology

2.1 Active Participatory Approach

The lead researcher was actively involved in the Christchurch earthquake response and recovery. The researcher was employed by ECan and seconded to Civil Defence and then CERA as part of a waste management team. Her duties involved the design and initial stages of implementation of the demolition and debris management process.

The case study data was largely gathered through observations and participation in the recovery process. As this event occurred in the researchers' home town, much of the contextual information is assumed

knowledge; however, references are given where appropriate. Documents cited for contextual information include websites and laws. Some post disaster literature includes websites, public information announcements, government reports and newspaper articles.

2.2 Methodology strengths and limitations

Participation in the recovery efforts has allowed for the lead researcher to understand better the decision-making processes in the management of demolition and disaster waste. The lead researcher could observe real and perceived decision drivers and constraints which are often absent in written or first-hand moderated accounts of a situation. The researcher also observed in real time, meaning a greater level of detail could be recorded. Previous case studies have only allowed for gathering of data in a snap-shot of time. The accounts or data have been often moderated by the author / orator and primarily only the outcome has been presented, as opposed to the decision-making process. This 'fly-on-the-wall' aspect of the methodology is a particular strength.

However, the objectivity of the research may be called in to question. Because of the closeness to the design of the waste management process, the lead researcher may not be able to critically analyse the actions taken and outcomes achieved. Bias, for example, towards the organisation the researcher was working for would be a natural tendency. In the interest of future learning, the researcher attempts to dissociate herself from the process to allow for a critical analysis. The co-author on the paper, whom was not directly involved in the recovery process, has identified where analysis has not been sufficient or critical enough.

Another limitation of the research methodology is that the analysis was been carried out mid-way through the demolition process. Some of the effects (environmental, economic and social) may not have been fully realised at the time of writing. In some cases the authors have projected future effects based on evidence available at the time of writing. It has been noted wherever projections have been made.

Lastly, no community based data collection was carried out. This presents a significant limitation when attempting to analyse social effects of the demolition programme. In lieu of this information, social impacts have largely been based on observations and the media's portrayal of community response. References are given where possible. It is noted that the media does not always present information that is representative of the whole community.

3 Christchurch Earthquake waste management

3.1 Waste

3.1.1 General Composition

Primarily the earthquake waste consists of construction and demolition materials, some rocks, and vehicles. For demolition of unsafe or already collapsed buildings this includes building contents as well, including furnishings, household hazardous substances, food, and whiteware. In addition the widespread liquefaction led to significant volumes of silt, some potentially hazardous (refer below).

In response to the earthquake in Christchurch, the waste types were categorised to match the likely composition of different waste streams from the demolition site and the waste handling facilities the waste would go to. In particular, there was a need to distinguish a waste stream not usually seen in business as usual practices – building debris complete with contents. Therefore the following definitions were used (CERA, 2011a):

Mixed earthquake material is waste resulting from full or partial building demolition where very limited or no site salvage was carried out.

Cleanfill material: cleanfill material is mixed inert materials. According to the MfE guidelines (Ministry for the Environment, 2002) cleanfill material includes any material that when buried will have no adverse effect on the environment (or does not undergo any physical, chemical, or biological transformations that will cause adverse environmental effects or health effects once it is placed in a cleanfill. For example:

- Asphalt
- Bricks
- Ceramics
- Concrete (clean and unreinforced)
- Fibre cement building products
- Glass
- Road Sub-base
- Soils, rock, gravel, sand, clay etc.
- Tiles (clay, concrete or ceramic)

Sorted materials: materials separated into individual material components ready for on selling to their recycling or end-use market. These included:

- Metal
- Timber (treated and untreated)
- Concrete
- Bricks
- Plasterboard
- Reuse items (doors, windows, toilets etc.)

Hazardous materials: Some hazardous materials are expected in the waste matrix. These include asbestos, toxic chemicals, fuel, etc. Prolonged power outages also produced significant volumes of rotten food waste.

3.1.2 Special Waste Types

Some waste required specific treatment as detailed below:

Buildings linked to fatalities

Building materials from buildings linked to fatalities had to be treated separately in the event of future investigations by the Royal Commission or the Coroner's Office.

Heritage materials

Many heritage buildings were damaged. Where the whole building could not be saved, building elements that should be retained if possible were identified by authorities or the building owner. These materials had special storage and handling requirements.

Asbestos

Any building built before the mid-1980's was likely to have asbestos in it. Asbestos handling guidelines were established (refer Section 3.5.7).

Silt

Large quantities of silt were generated through liquefaction. The primary hazard associated with the silts was as an irritant when dried (indicated by a spike in respiratory illnesses post-earthquake). In addition sewage was present in some of the silts (due to broken pipes) and E Coli was detected in some areas. The flooding generated in liquefied areas also led to damp living conditions with associated health risks.

Personal and business property

A large number of properties were unsafe to enter prior to demolition. However, many building tenants and owners outlined personal items that they wished to salvage if possible. Also a number of affected businesses identified essential documents / equipment they required to run their business. Intellectual property and confidential documents also had to be treated appropriately.

3.2 Organisation

3.2.1 Strategy

In response to the 22 February earthquake, a State of National Emergency was declared by the Minister of Civil Defence on 23 February 2011. This enabled the New Zealand Civil Defence and Emergency Management (CDEM) Act 2002 to be enabled in full. This act gives authority to the National Controller (the Director of the Ministry of Civil Defence and Emergency Management) almost full power to act in whatever way is necessary to respond to the disaster. The CDEM Act, Section 9 (2) (a) states that the National Controller has responsibility for:

(i) the provision of transport:
(ii) the removal of endangered persons and casualties from any area affected by the emergency to areas of safety or to hospitals:
(iii) medical care and attention to casualties:
(iv) the relief of distress and suffering:
(v) the accommodation, feeding, care, and protection of persons:
(vi) the provision of other services necessary to restore community services and provide for the welfare of the public:

A team of people from volunteer groups, City Council, Regional Council and Civil Defence Groups gathered at an Emergency Operations Centre, established in the city Art Gallery, to meet the needs of the affected population. With no specific plans in place to manage demolition and debris wastes, a small team was established to design and implement processes. The team consisted of representatives from CCC, ECan and the lead author of this paper. Immediately after the earthquake, there was an urgent need to provide coordinated demolition assistance to the Urban Search and Rescue teams to allow them to complete their searches.

A waste management policy and plan was established in early March but as far as the author is aware it was never formally adopted, largely because there was no apparent process to do so. The plan was continually updated until handover to CERA in late June 2011. The policy had seven objectives:

- Protection of public and worker health and safety.
- Rapid and affordable recovery of Christchurch.
- Avoidance or mitigation of the environmental and social effects of waste removal, transportation, processing and disposal.
- Efficient use of natural and physical resources.
- Sensitivity in the handling of buildings, vehicles and their contents.
- Protection of heritage items.
- Transparent and equitable processes.

The State of National Emergency expired on 30 April 2011 (Carter, 2011).

The CDEM Act has some provision for management of recovery post disaster, including an organisational structure that divides the response effort into four environments: built, natural, economic and social. However, the provisions within this Act were deemed insufficient to respond to this event. As a result, prior to the expiration of the state of emergency a new piece of legislation was passed and the Canterbury Earthquake Recovery Authority (CERA) was established.

The CERA structure has seven groups:

- Strategy and Planning (including legal and contracts)
- Community well-being
- Infrastructure
- Economic Recovery
- Demolition (later termed 'Operations')

- Communication and relationships
- Corporate services

Initially the entire team responsible for demolition and debris management under Civil Defence were transferred to the demolition team in CERA. Debris management largely remained within this operational team.

3.2.2 Operations

CERA was responsible for the demolition of 1) all buildings defined as dangerous under the Building Act (where the building owners did not demolish in an appropriate amount of time) and 2) all buildings in the residential red zone where property owners opted for the full government pay-out. As discussed above, a demolition team was established under CERA. The demolition team was made up of a range of project managers, contractors, engineers and quantity surveyors. Contractors were contracted to complete packages of works. This is explained in detail in Section 3.5.6.

The major insurance companies established Project Management Offices (PMOs) to look after the demolition and reconstruction for all their insurable interests. Typically the PMOs were run by Contracting Companies, Engineering Consultancies or Project Management Companies.

Some individuals elected to manage demolition works independently. Typically these were people who were not insured, under-insured or who had accepted a cash pay-out from their insurance company.

3.2.3 Disaster debris management plans

Typically waste has not been included in Civil Defence training and planning in New Zealand. There were no existing plans for disaster waste management in Christchurch. In 2008 Wellington Region Civil Defence Management Group produced some generic debris disposal guidelines (Wellington Region Civil Defence Emergency Management Group, 2008); however, these (or any other guidelines) had not been adopted in Christchurch.

3.3 Legislation

Below is an outline of the various legislative frameworks that affected the earthquake demolition and debris management.

For a detailed discussion on the regulatory provision for managing waste following disasters in New Zealand (written prior to the September 2010 earthquake) please refer to a separate article by the authors, “Legislative Implications of Managing Disaster Waste in New Zealand”(Brown et al., 2010b).

3.3.1 Civil Defence and Emergency Management Act

As discussed above, the Civil Defence and Emergency Management Act is the law that governs emergency response in New Zealand. With the appointment

of the National Controller in a State of National Emergency, the legislation gives the National Controller all the powers necessary to preserve life and property (as described above).

3.3.2 Canterbury Earthquake Recovery Act

The Canterbury Earthquake Recovery (CER) Act was passed on 18 April 2011, superseding the Canterbury Earthquake Response and Recovery Act 2010, which had been passed following the 4 September 2010 earthquake.

The purposes of the CER Act are outlined below. The CER Act enables the establishment of a new government authority to direct recovery (Canterbury Earthquake Recovery Authority (CERA)), gives provisions for demolition of structures and allows for 'Orders in Council' to be made to change other pieces of legislation where necessary to facilitate the recovery.

3. The purposes of this Act are—

(a) to provide appropriate measures to ensure that greater Christchurch and the councils and their communities respond to, and recover from, the impacts of the Canterbury earthquakes:

(b) to enable community participation in the planning of the recovery of affected communities without impeding a focused, timely, and expedited recovery:

(c) to provide for the Minister and CERA to ensure that recovery:

(d) to enable a focused, timely, and expedited recovery:

(e) to enable information to be gathered about any land, structure, or infrastructure affected by the Canterbury earthquakes:

(f) to facilitate, co-ordinate, and direct the planning, rebuilding, and recovery of affected communities, including the repair and rebuilding of land, infrastructure, and other property:

(g) to restore the social, economic, cultural, and environmental well-being of greater Christchurch communities:

(h) to provide adequate statutory power for the purposes stated in paragraphs (a) to (g):

(i) to repeal and replace the Canterbury Earthquake Response and Recovery Act 2010.

The CERA Act includes a 12 week transition period where all orders made under the National Controller remain in place until CERA has established systems and/or policies to overrule the Civil Defence orders.

Public consultation on recovery decisions was a major component of the CER Act.

Specific clauses related to demolition in the CER Act include:

Section 38 – allows for CERA to order demolition of buildings giving 10 days for the owners to provide a satisfactory demolition plan before CERA carried out demolition on the owners behalf. This includes the right to recover cost.

Section 39 – allows for CERA to order demolitions of buildings that pose an immediate threat to life or property without notice.

The CER Act also gives powers to enable recovery such as land requisition.

At the time of writing 27 Orders in Council had been issued in total, seven of which relate specifically to demolition and waste. Those relating to waste were:

Name	Purpose	Expiry date
Canterbury Earthquake (Resource Management Act Port of Lyttelton Recovery) Order 2011 (SR 2011/148) 23 May 2011	Disposal of cleanfill material in land reclamation at the Lyttelton Port of Christchurch	18 April 2016
Canterbury Earthquake (Resource Management Act Permitted Activities) Order 2011 (SR 2011/36) 19 April 2011	Designation of storage of materials associated with construction works	18 April 2016
Canterbury Earthquake (Resource Management Act – Burwood Resource Recovery Park) Order 2011 (SR 2011/254) 18 July 2011	Provisions for the processing operations at Burwood Resource Recovery Park.	18 April 2016
Canterbury Earthquake (Transport Legislation) Order 2011 (SR 2011/39) (as at 27 May 2011)	Allowing overloading of vehicles provided written approval is gained.	31 October 2011
Canterbury Earthquake (Historic Places Act) Order 2011 (SR 2011/231) 27 June 2011	Provisions for the expedient management of archaeological sites including appointment of a Canterbury archaeological officer.	18 April 2016
Canterbury Earthquake (Resource Management Act) Amendment Order 2011	Allows Kate Valley Landfill to operate outside the provision of its resource consent	31 March 2012
Canterbury Earthquake (Building Act) Order 2011 (SR2011/311). 5 September 2011	Amendment to the Building Act to include for demolition of a property to avoid immediate danger or to fix insanitary conditions.	16 September 2013

3.3.3 Resource Management Act

The Resource Management Act (RMA) governs the management of natural resources in New Zealand. Both ECan and CCC have responsibilities under the RMA. The RMA guides the development of city and regional plans. Within these plans certain activities are either, depending on where the activity will take place, permitted, controlled, restricted discretionary, discretionary, non-complying or prohibited. Unless an activity is permitted, a resource consent application is required. In terms of waste the plans often restrict discharge to air, water or land, and so require consents. Noise, light, visual and other community impacts are also relevant and also lead to a need for consents.

Section 330 of the RMA allows for emergency actions to be taken to respond to or to mitigate the effects of an emergency situation without requirement for consent. To the authors' knowledge, no actions were taken following the earthquakes under Section 330.

3.3.4 Building Act

The Building Act 2004 regulates the building industry to ensure that appropriate standards are maintained. Prior to December 2010, all buildings being demolished required a building consent. However, in response to the September 2010 earthquake and the concern over the volume of consents required, a suite of proposed Building Act changes (in plan prior to the earthquake) were expediently approved in the Building (Exempt Building Work) Order 2010. One change included the provision that any detached building less than three storeys high could be demolished without prior council approval. Demolition consents for other buildings are still required and generally the council requires safety, waste management and traffic management plans.

3.3.5 Waste Minimisation Act

The Waste Minimisation Act 2008 aims to reduce waste going to landfill by encouraging waste reduction. One mechanism to achieve this used in the Act is a levy for waste disposal to landfill. The waste levy is attracted when material is stored for more than six months.

For the purposes of the recovery, the waste levy was waived after the 4 September 2010 earthquake until the 'clean-up is complete' (Smith, 2010). It is unknown when this will be reinstated.

3.3.6 Health and Safety in Employment Act 1992

This act is in place to prevent harm to people in or near places of work. The Act is governed by the Department of Labour. However, the Act puts the onus of workplace safety on the employer.

The Health and Safety in Employment (asbestos) Regulations 1998 specifically governs the management of asbestos.

3.3.7 Land Transport Act 1998

This Act aims to enhance New Zealand's land transport planning and funding and to promote safe driver behaviour. This includes weight restrictions, licensing requirements, driver hours etc.

3.3.8 Local Bylaws

In addition to national laws and regulations, there were several local bylaws that were influential in the demolition and waste management process.

- The Christchurch City Cleanfill Bylaw regulates the type of materials that can be deposited in Christchurch City cleanfills to encourage recycling and, as a by-product, to mitigate environmental issues and gather data through reporting requirements.
- The Licensed Waste Handling Facilities Bylaw 2007 regulates the operation of waste handling facilities (defined as a facility that produces 50 Tonnes of waste per annum).

3.4 Funding

In New Zealand, the primary post-disaster funding source for demolition and debris management is insurance. Generally the following insurances are held:

- Commercial buildings - private insurance
- Residential buildings – the national insurer, Earthquake Commission, covers land damage and up to $100,000 building damage, private insurance covers the balance
- Infrastructure – local authority specific insurance

Insurers in general will carry out demolition and debris management works on behalf of residential building owners. However, private insurers have the option to give a pay-out to the building's owners and allow them to manage the works. A significant trend was observed in Christchurch where building owners opted to receive a cash pay-out and to manage their own demolitions (particularly on under-insured commercial properties).

While the exact level of insurance cover was unknown at the time of writing, early estimates indicated that a large number of commercial properties were under insured for demolition (either the insurance policy did not include for demolition or the allocated sum within the policy was insufficient). It is unknown how insurance companies calculated the demolition costs for their insurance policies.

Emergency related costs are generally covered by regional civil defence groups, local council and, above a certain threshold, central government. Following the earthquake, some costs associated with clearing the streets in the centre city to allow for emergency vehicle access and for search and rescue purposes, were claimed through this process. However, wherever possible, costs were charged back to the building owner. It is unknown what mechanism was used to do this as there is no explicit clause in the Civil Defence and Emergency Management Act which allows for cost recovery.

For the land areas that the government elected to retreat from, property owners were bought out by the Government with contributions from insurance companies. The Government, therefore, essentially funded the residential red zone demolition.

3.5 Waste management process

The basic organisation of waste management is shown in a waste flow diagram (developed by the author in June 2011), Figure 3-1. Note that the proportion of wastes being managed by the different agencies has changed since the diagram was prepared. CERA managed less commercial building demolitions than originally estimated. Residential demolitions are being managed by both the insurance PMOs and CERA. To the authors' knowledge, the PMO offices have not set up localised waste sorting and processing sites and instead many contractors have set-up private (legal and illegal) waste handling facilities. The diagram also does not include the 500,000 tonnes of silt that were collected during a kerbside collection and taken to a disposal area at Burwood landfill.

2011 Christchurch Earthquake Waste Management Strategy

14 June 2011

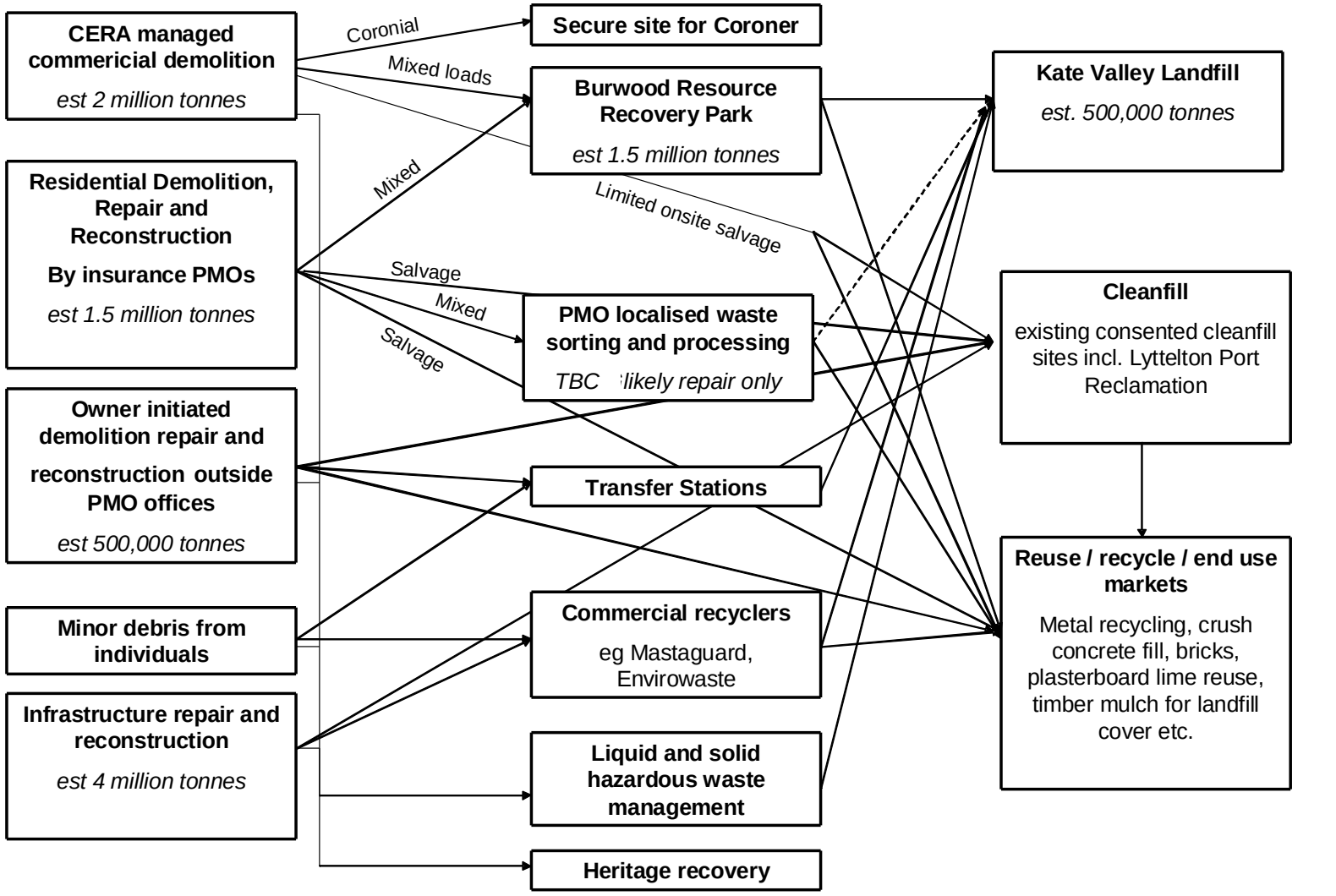

Figure 3-1 2011 Christchurch Earthquake Waste Flow Diagram (CERA, 2011a)

3.5.1 Emergency response

Immediately following the earthquake, numerous contractors descended on the central city to assist in the search and rescue. Many of the contractors worked for free and initially there was little coordination in place. The contractors coordinated in an ad hoc basis with the Urban Search and Rescue operations. Within a week a contractor had been appointed to coordinate the contracting resources and a demolition contractor base was established on a vacant site in town. A week later, an independent project management company, RCP, had been engaged to oversee the demolition operations. Contractors were engaged to carry out works on a time and cost basis. The contractor unit rates were "Blue Book" rates which are the industry accepted benchmark for contracting services. To the authors' knowledge there were no formal contracts in place.

As part of the response a resource recovery site was established at the closed Burwood Landfill. The site is discussed further in Section 3.5.9.

3.5.2 Liquefaction silt

The eastern suburbs of Christchurch were covered in a thick layer of wet silt material caused by liquefaction. The silt material bubbled up onto property, inside houses and into broken infrastructure. Approximately 6000 volunteers assisted in the removal of silt, amongst other recovery activities such as delivering chemical toilets and pamphlets. 500 were mobilised through the student volunteer army at University of Canterbury (Christchurch City Council, 2011b).

Silt was collected by city council roading maintenance crews – City Care and Fulton Hogan. Trucks were sourced from all over the country. Silt was transported to two pre-identified disposal sites – at Burwood landfill and the Fulton Hogan cleanfill site. No specific stormwater, groundwater or dust suppression measures were put in place at the sites. Residents near the Burwood site expressed concern over the dust, in particular due to wet silt being tracked on the roads into the landfill which later dried and was mobilised by the wind.

3.5.3 Minor debris

For small amounts of debris at individual properties (predominately broken crockery, glassware, electronics, chimneys etc.), property owners were advised to take material to one of three transfer stations around the city. The transfer stations are already established facilities that accept waste from individuals. The waste is then taken to the regional landfill at Kate Valley. Dumping costs in general could be reimbursed by insurance companies or EQC.

3.5.4 Repair and Rebuild waste

The contract for repair work by EQC (where damage is valued between $10,000 and $100,000) was awarded to Fletcher Construction. Fletcher Construction is the managing contractor who is coordinating subcontractors to complete these repair works. Generally it is understood that contractors are responsible for managing their own waste streams.

Other repair works and rebuild works are primarily being carried out by insurance PMOs and by individuals. The CCC Target Sustainability group have encouraged the PMOs to sign Memorandums of Understanding to allow CCC to offer consultants advice on appropriate waste management choices. Waste management choices by individuals are expected to largely be driven by contractor experience, practices and the lowest cost option.

3.5.5 Infrastructure repairs

Generally infrastructure repairs will be carried out over a much longer period. The repairs are being managed in an alliance between CERA, CCC, Fulton Hogan, Downer Construction, Fletcher Construction, MacDow New Zealand and City Care. The contractors will work together to repair and replace horizontal infrastructure including water, stormwater, wastewater and roads (CERA, 2011a). To minimise costs, roading material will be reused at the site wherever possible.

Some roads in the city have been identified as having coal tar in them. A design for encapsulating the contaminants when the material is replaced in the road repair has been designed.

3.5.6 Demolition

Building assessment process

In Christchurch a recently trialled post disaster placard system for building evaluations was adopted. The system provides a "triage' system to determine where buildings pose a public health and safety risk. The system relies on three coloured placards – green, yellow and red. Green is safe, yellow is 'restricted use' and red is unsafe. There are two levels of assessment – Level 1 and Level 2. Level 1 is an external assessment. When it is safe to do so, a Level 2 (internal) assessment is conducted. The system gives the public awareness of the safety risks and it also gives a snapshot of the state of the building stock (IPENZ, 2011).

Commercial properties

Under Section 38 of the CER Act, CERA could order the demolition or make safe works to any property which is a dangerous building. The definition of dangerous building is taken from Section 121 and 122 of the Building Act and the subsequent amendments in Section 7(1) 0f the Canterbury Earthquake (Building Act) Order 2010 (SR 2010/315). The definition includes:

> *"7(1)(c) there is a risk that the building could collapse or otherwise cause injury or death to any person in the building as a result of an earthquake that generates shaking that is less than a moderate earthquake; or "*

Based on the Level 2 engineering assessment in the building assessment process described above, CERA decided whether or not to issue a Section 38. A Section 38 letter would notify that the owner had 10 days to notify CERA of

their plans to demolish or make safe the building concerned or they must agree to CERA carrying out demolition or make safe works on their behalf.

Under the Building Act, buildings above three storeys or attached to other properties, require building consent prior to demolition. However, CCC agreed that any buildings approved for demolition by CERA would not require building consent

Approximately one third of property owners elected to have CERA manage the works. The high percentage was largely due to an agreement between the insurance companies and CERA that it was most efficient for CERA to manage all the CERA instructed works.

All property owners who elected to carry out the works themselves had to submit a work plan for approval. The plans included

a. Health & Safety plan
b. Traffic management plan
c. Demolition methodology & contractor name & start/finish dates
    i. Sites services capping plan
    ii. Treatment proposal for basements and piles
    iii. Treatment for footpaths and kerbs
    iv. Treatment of ground service – topsoil and seeding
d. Archaeological authority
e. Hazard Management plan
f. Waste Management plan

The work plans were approved by CERA and had to fit within the timeframes identified by CERA. If the plans were insufficient or the works were not carried out as specified, CERA could take over the works.

All building owners had to sign an agreement with CERA.

The CERA demolition PMO, signed a number of accredited contractors on under Framework Agreements. Contractors had to apply for accreditation by submitting information outlining their experience, expertise and equipment availability. Contractors were accredited to carry out certain activities (e.g. asbestos removal, buildings over six stories). The contracts included standard conditions of engagement. The conditions included a number of things including waste ownership. The agreement stated that unless otherwise stated in the works schedule (e.g. identified personal items property owners wished to recover), waste ownership would lie with the contractor if the works were as a lump sum. Otherwise if the works were carried out on time & cost basis, ownership remained with CERA.

Building owners were given cost estimates prior to work commencing. The estimates were calculated based on a value per square metre.

Generally works were carried out under either time & cost or lump sum contracts. In general smaller, less technical jobs were carried out on a time & cost basis. Day-works dockets (work records) were filled in by contractors on a daily basis. Larger more complex jobs (for example significant buildings

over five stories) or where buildings contained high value material (e.g. historic buildings) were carried out as lump sum contracts. Lump sum contracts were awarded based on a closed tender process. It should be noted that as time passed, more and more contracts were awarded as lump sum contracts due to pressure from insurance companies.

To ensure that the tight time frames for reopening the city were met, and to minimise worker exposure to the unstable working environment in the centre city, sorting on site was initially limited to a 'quick pick and go' method. Essentially this meant that any material that came cleanly off the building was taken direct to the appropriate market / end-use. For time and cost works under CERA, disposal locations were pre-identified. Three sites were identified for four different waste streams:

1. Burwood Resource Recovery Park: mixed materials and wood
2. Lyttelton Port: Cleanfill material (brick, concrete, aggregate etc.)
3. Sims Metal: Ferrous and non-ferrous metals

In addition a closed tender system was established for sale of 'significant building items'. This primarily consisted of large native timber and other unique items (such as stained glass windows, stonework).

For lump sum contracts, contractors were able to manage the waste as they saw fit as long as it was within the time frame allocated and they complied with all laws and regulations.

Works within commercial districts were prioritised in a number of ways. The major driver was to reduce the cordon area and to remove restrictions on roads and footpaths. Generally the significant buildings were the critical path on the plan for the centre city.

Historic buildings had to have special consideration. In the early stages of the process, approval to demolish or make safe heritage buildings was a bottleneck in the demolition approval process. Eventually the CCC heritage team in consultation with Heritage Places Trust compiled a list of 40 top heritage sites which would have detailed investigations while decisions on other heritage buildings would primarily be driven by the building owner and their insurer. Typically resource consents are required for demolition of heritage properties. However, this was waived for CERA approved demolitions.

Prior to demolition, a cursory analysis on potential site hazards was carried out, based on external visual inspections and desktop data analysis. Typically the study identified asbestos, fuels, gases, contaminated soils, paints, and varnishes.

The majority of the CBD is an archaeological site (generally properties built pre-1900). CERA and the New Zealand Historic Places Trust developed a stream-lined process by which archaeological sites were managed. Consents to carry out demolition works were granted within three days and an

archaeologist was present on site during below ground demolition work (that is, foundation removal).

Residential properties in residential red zone

At the time of writing the residential demolition programme was still being established. Essentially there were two streams of work based on the compensation method, that is:

1. Crown offer (rateable value of land and house)
2. Combined offer: Crown (value of the land) and insurer (value of property)

It is CERA's responsibility to undertake demolition works for Option 1. It is the insurer's responsibility to undertake demolition works for Option 2. At the time of writing while over 3000 property owners had selected their preferred option, only 200 houses, under Option 2, had been demolished. Primarily, the reason for this was the need for EQC, private insurers and the Crown to determine cost share arrangements for each property. Loss adjusters for EQC and private insurers have differing opinions on a) the total value of the damage and b) which event the damage occurred in[2]. In addition to that, the Crown and insurers have to agree on the payment for outhouses, garages and fences. Generally insurers pay for anything damaged and the Crown pays for anything undamaged. Demolition cannot commence until agreement on payment is made.

It should be noted that demolition is not the only option being considered. Relocation of houses is also being advocated. There are constraints on this option, namely the cost of relocating properties and the availability of land which allows relocated houses. Determining whether houses can be relocated, or not, also contributes to the delays.

For Option 2, CERA is acting as a works coordinator. CERA is liaising with insurance project management offices and attempting to bundle demolition works together. This effort is made to manage traffic, health and safety, streamline monitoring and, importantly, to enable effective community engagement and liaison. Due to the slow and random release of works for demolition, this coordination process has not been successfully achieved to date.

Insurance companies and their contractors are facilitating salvage where economically viable. Newer properties have more material salvaged that other properties (for example, double glazing, insulation, vanities). Some seemingly valuable material such as rimu floorboards in older houses cannot be salvaged in re-useable condition. Some gib-board in newer houses cannot be removed because they are glued in place. It is estimated that 75% of a house is separated on site and that of the 25% that is taken to a mixed waste facility (e.g. BRRP) a further 60-70% will be recycled. This leads to a total of approximately 90% of the waste from a house is diverted from landfill. On average there are 10-12 trucks of debris removed from each house site.

[2] EQC defines significant aftershocks as new events. For each new event they are obligated to pay the first $100,000.

In general community engagement exercises regarding demolition in the red zone have uncovered that communities are eager for materials to be recycled or reused.

Contractors have to be conscious of a number of hazards at residential properties: swimming pools (fall hazard), household hazardous wastes, and stability issues.

Other residential properties

The majority of affected properties were insured and were therefore managed by insurance PMOs. As noted in Section 3.4, however, some properties were under-insured for demolition and some owners accepted cash payouts from insurance companies. Consequently, some residential non-red zone demolitions have been and will be carried out by individual owners.

The PMOs and the insurance loss adjustors determine whether or not it is economical to repair the building. If not, the PMOs engaged independent contractors to carry out demolition works. It is unknown what procurement method was used to carry out demolitions (for example, tendering lump sum contracts; and/or whether works jobs were carried out on an individual house basis or clusters of works were assigned). The PMOs had monitoring systems in place to ensure waste was handled correctly.

For individuals managing their own demolition work, generally, due to the insurance reasons above, the primary driver for individuals was to maintain lowest cost. In some cases, this may have contributed to improper waste handling: several illegal dumpsites were identified by ECan and CCC (Sachdeva, 2011b; The Press, 2011b; Williams, 2011b) and the waste was believed to have originated from residential demolitions.

Currently, CERA are considering debris management options for cliff top houses which cannot be safely access with large machinery.

3.5.7 Asbestos

Asbestos has been and will continue to be one of the primary hazards for demolition workers in demolition and repair of earthquake damaged structures. In New Zealand, buildings built prior to the mid-1980's are likely to contain asbestos products including, textured ceilings, asbestos cement roofing, lino backing, pipe insulation, spray on fire retardant.

Asbestos management is governed by a number of laws and regulations in New Zealand (Ministry of Transport, 2009). Generally asbestos is considered a hazardous substance under the Hazardous Substances and New Organisms Act 1996 (HSNO). Primarily asbestos management is a workplace safety issue governed by the Department of Labour (DOL), under the Health and Safety in Employment (Asbestos) Regulations 1998. The regulations stipulate that any person carrying out restricted work (that is working with friable asbestos), must hold a certificate of competence. DOL have also introduced a requirement for notification of any restricted work 24 hours before commencement. Removal of non-friable asbestos does not require any certification. Guidelines for the management of asbestos have been produced

by DOL "New Zealand Guidelines for the Management and Removal of Asbestos". These guidelines outline the best practice for management of asbestos. The guidelines include requirements for dust suppression, appropriate Personal Protective Equipment, testing, transportation, disposal and air monitoring. In addition, for friable asbestos removal encapsulation of the removal area is required. Ministry of Health is concerned with impact on public health.

Transportation of asbestos may or may not be governed by the Dangerous Goods Rule New Zealand Land Transport Authority, depending on the form of asbestos. Disposal is governed by local authorities. The only authorised asbestos disposal site in Canterbury is Kate Valley Landfill. Kate Valley has specific transportation requirements for asbestos including the plastic lining of vehicle and covering of loads to minimise risk at the landfill site. All waste possibly contaminated with asbestos was required to go to Kate Valley. There is a surcharge at the landfill for receipt of asbestos, as the material is buried in a separate area and requires more handling.

Shortly after the February 2011 earthquake, DOL recognised that the guidelines could not be applied in all circumstances – in particular where work had to be carried out quickly and/or where a building was structurally unsound. The DOL issued a Christchurch Recovery – Asbestos Management factsheet (Department of Labour, 2011). The factsheet identified three categories of work and the minimum standards required for each category:

1. Critical action: to preserve life. Personal protection (dust mask) is recommended.
2. Urgent work: make structures safe or remove earthquake generated rubble. Visual assessments are sufficient and basic risk mitigation measures
3. Non-urgent work: demolishing or clearing stable sites. Full application of guidelines is required.

An asbestos management flow diagram was prepared by the lead author during her work with Civil Defence / CERA and is included in Appendix A.

For the CERA managed demolitions, an environmental consultant carried out a hazard assessment, identifying any hazardous substances including asbestos. Generally due to the instability of the buildings the investigation was based on an external assessment and an interrogation of available council databases. If asbestos was identified, specialist contractors would be sent in, regardless of whether the asbestos was friable of not. For demolition and repair work outside the CERA process, asbestos removal prior to demolition, where practical, is a requirement under law. However, it is unknown how vigilant individual contractors or insurance PMOs have been. The Department of Labour monitored some sites for compliance; however, they had limited resources and were not able to visit all workplaces.

At the time of writing no issues affecting the recovery (in terms of time, cost, health effects etc.) had arisen because of asbestos. Although there were several cases reported of illegal dumping (some explicitly including asbestos) (Sachdeva, 2011b; Williams, 2011b; Wright, 2011) and one case where a CERA

demolition contractor did not identify asbestos and disposed of it unknowingly at BRRP and Sims metal recycling (Greenhill, 2011a). The author is aware of one building containing asbestos which will take five months to clear before demolition can begin.

It is interesting to note that asbestos removal compensation is usually excluded from insurance policies.

Air Monitoring
As a requirement of the DOL Asbestos Management Guidelines, all work sites involving asbestos must have air monitoring to ensure contaminant emissions do not exceed maximum levels for workplace exposure. The 'relaxed' guidance in the factsheet did not require monitoring for critical action or urgent works.

MOH also has guidelines on asbestos fibre exposure. However, early advice from MOH was that air monitoring was a workplace matter handled by DOL.

A number of concerns about potential exposure were raised by the public; however, no public space air monitoring has been carried out as authorities doubted whether this would be beneficial (i.e. if asbestos was detected it would be difficult to identify the source and mode of emission to inform policy / practice changes).

3.5.8 Transportation

As noted in Section 3.5.2, silt was transported in a wide range of vehicles. To the author's knowledge, trucks were paid on an hourly rate. Many of the trucks did not have sealed tailgates and the wet silt material would frequently drip from the truck as it travelled.

Transportation was primarily determined by the contractors. Contractors would supply their own trucks for jobs that they were responsible for. Some contractors would cooperate with others to share the fleet to gain efficiencies. Initially it was envisaged that the CERA truck fleet would be managed as a centralised fleet to share between jobs, such that transportation was independent of demolition. However, due to the number of trucks changing between owner initiated jobs and CERA managed jobs this was not considered possible (see Section 4.3.3).

Demolition material was also transported in a variety of trucks. There were insufficient specialist demolition trucks available to carry out the works therefore a range of other trucks were employed. The result of this, unfortunately, was that the truck fleet was not as efficient as possible as small trucks filled before weight limits were met. In addition the truck payments were based on a per trip basis, which did not necessarily incentivise optimum truck loading.

Initially a job number system was put in place to identify trucks transporting CERA managed waste. The identifier was printed on a piece of paper and placed in the truck window. This system was very open to abuse by

contractors potentially adding private job waste loads to CERA accounts or by diverting high value loads such as metal. It is unknown what, if any, misuse occurred. After about four months a carbon copy weigh docket system was implemented after consideration and discounting of GPS and barcode system options.

Requiring trucks to be covered was considered to reduce dust generation. Some requests were made by the public regarding this also. While covering trucks is possible and was carried out for all material linked to fatalities, it was considered impractical and posed a high worker health and safety hazard – both at the demolition site and at the landfill. Either truck drivers would have to climb on the trucks to place the cover on or scaffolding would have to be erected to enable this. Neither option was practical. Dust suppression by centrally located overhead spray units or wetting loads by hoses before leaving the site was practiced instead. As much of the central city demolition was carried out over winter and a moderately cold and wet summer, drying of loads in transit was not likely.

3.5.9 Burwood Resource Recovery Park (BRRP)

An intermediate waste management facility was created during the initial stages of the response to provide an easily accessible disposal site for unsorted demolition waste. As described in Section 3.5.14, Christchurch's nearest landfill is a 180km return trip and the site has limitations on what type of trucks it can receive. Therefore a staging area closer to the affected areas was required to avoid bottlenecks in the limited truck fleet or at the disposal site. In addition, the existing facilities in Christchurch that manage mixed demolition waste are limited in capacity. To facilitate the 'quick pick and go' methodology, and to minimise final disposal costs, a large scale facility was required to extract maximum possible recyclables from the mixed waste.

The old Christchurch landfill site at Burwood forest was identified as an ideal site. The site was chosen because:

- The site was within 10km of the city centre
- The site is 77 hectares
- The site is bordered by trees
- The geology and groundwater of the area is well known and is not over the drinking water aquifer.
- The site already had infrastructure such as a weigh bridge
- The site is owned by CCC.
- The site had been being used for liquefaction silt disposal since September 2010.

A joint venture was established to operate the site as a resource recovery site. The site was operated as an independent commercial operation. Other sites were considered but the commercial model of BRRP relied on a large volume of material and splitting the market would have driven up the gate price at the facility. In addition there were limited other sites available which did not sit over the drinking water aquifer or recharge zone.

BRRP initially stockpiled mixed demolition waste while sorting equipment was sourced and assembled. Sorting is due to commence during this month (April 2012). The facility will use a combination of a manual sort line and a mechanical separator comprising screens, magnets, density separators etc. The primary recovered materials will be metal, untreated timber, treated timber and cleanfill (concrete / bricks / tiles). The residual material, estimated to be 65% of the materials received (given that some clean material has been removed at the demolition site) will be disposed of at Kate Valley Landfill.

BRRP was also initially intended as a quantity control mechanism for waste going to Kate Valley. The transfer stations and Kate Valley itself currently cannot reasonably accept more than an additional 500T/day. If BRRP did not exist it is believed that the transfer stations and/or Kate Valley would not be able to handle the increase in waste. BBRP allowed for the residual waste to be slowly taken to Kate Valley. As will be discussed in Section 3.5.15, this benefit was partly negated when a decision was made to create a disposal facility at the Burwood site. BRRP became a temporary storage facility while the new landfill cell was constructed.

BRRP was established under Civil Defence authority. The temporary storage OIC (see Section 3.5.11) was used to temporarily consent the facility after the expiration of the Civil Defence / CER Act transition while a full resource consent was sought.

3.5.10 Other recycling facilities

Several private operators in Christchurch run small operations for recycling of construction and demolition waste. In particular the sites are run by demolition contractors or container waste operators. The sites generally have small capacities. In the past some of these facilities have been abandoned due to the financially unsustainable operations. Some contractors post-earthquake applied for consents to increase their operations and some contractors increased operations without appropriate notification or environmental controls. One such site was served an abatement notice 5 months after the earthquake.

3.5.11 Temporary storage areas

On the 8th of March 2011, an Order in Council (OIC) was issued under the CER Act permitting the establishment of temporary depots and storage facilities "reasonably incidental to any construction work". The intent behind the OIC was to allow for stockpiling of materials to assist during the rebuilding and recovery – in particular storage of materials specific to a particular site. The intent was not to allow for contractors to set up facilities for the duration of the recovery efforts. There was a general concern that there were limited controls on these temporary storage sites to prevent them being abandoned in the future (see Section 3.5.10).

While the activities were permitted, the councils had the opportunity to impose conditions on the activities. CCC established standard conditions and an approval process for these sites fairly rapidly. ECan did not do the same. Approvals issued by CCC advised applications that they required ECan approval as well, however ECan did not receive all the applications. CCC and ECan agreed to share information regarding future applications in order to jointly consider applications and create a united front for applicants.

3.5.12Recycling and reuse

Between the separation of materials at the building site and the operations at the various recovery facilities, it is envisaged that at least 75% recovery will be achieved. This target has not been mandated but will be largely driven by the high disposal costs at Kate Valley Landfill.

Metals

Metals are a high value item and contractors endeavour to separate as much metal from the mixed waste as possible prior to disposal in order to reduce the overall cost or maximise their own profit (lump-sum contracts). Metals are collected, separated and crushed and then exported. Prices are based on world market value so were not impacted by the influx of earthquake generated materials.

Concrete and cleanfill

There was an existing market for crushed concrete and cleanfill material. A number of quarry operators accept cleanfill material in order to rehabilitate quarry pits. In addition there was a market for crushed concrete for subdivisions, land rehabilitation (for future development) and for roading projects. Pre-earthquake, crushing concrete was cash negative due to the low cost of clean aggregate in Christchurch. The establishment of the Lyttelton reclamation (see Section 3.5.14) with zero disposal costs impacted this recycling market. As at April 2012, demolition concrete can be sold for $2 / Tonne (as opposed to paying to dispose of it at $20/Tonne).

Native timber

Native timber in New Zealand is a highly sought after and valued commodity. Wherever possible, large native timber beams were salvaged during demolition and sent to market. The high value of the material will also offset demolition costs. It is understood, however, that some of the timbers are hard to remove in re-useable lengths and quality. Storage of large volumes of materials is also likely to become a problem.

Reuse items

Pre-demolition, salvage for re-use is economically a suitable option in peace-time. However, the market for second-hand building items (e.g. toilets, kitchen sinks, joinery, light fittings) is unlikely to absorb the influx of materials from the demolition of at least 7,500 homes and 1,400 commercial buildings. The national market is also unlikely to be able to absorb the quantity of material available. At the time of writing it is unclear what will happen to the reusable materials, however, it is likely the level of salvage will decline as the market is flooded and the prices reduce. Exportation of materials has been considered, however, it is likely the logistics of moving

bulky material from isolated New Zealand as well as the low value of the materials may make this unfeasible.

3.5.13Hazardous and special waste

It has been the contractors' responsibility to remove hazardous substances prior to demolition. As noted in Section 3.5.7, this was controlled for CERA managed works but it is unknown how effectively this was achieved for independently managed jobs. The following practices were generally applied.

Material linked to fatalities

Buildings and vehicles where fatalities occurred had to be taken to a secure storage area. The building materials had to be loaded - unsorted, without salvage and with minimal damage to building elements – into covered trucks. The waste was then taken to a secure site established at Burwood Landfill, specifically established post-earthquake, until investigations by the Coroner or the Commission of Inquiry were completed. The material would be finally disposed of at Kate Valley Landfill. In line with Maori protocol, the site where any material with human remains present a *karakia* or blessing was carried out to free the spirits of the deceased.

Putrescible wastes

A programme was established under Civil Defence to remove putrescible foods from premises within the red zone. Food premises within the red zone which were either green or yellow stickered were contacted and asked if they would be willing to clean their premises. The cleaning contractor was supplied but the owner needed to be present and would be required to pay for the cleaning via insurance or other. Putrescible waste is handled as a hazardous waste. Almost 100 premises were cleaned, out of a possible 145 (green or yellow stickered) premises. A further 100 premises were in red stickered buildings. Putrescible waste was too rotten to send to compost so waste was sent to Kate Valley.

Putrescible waste from red stickered buildings had to be removed during the demolition process. Any material contaminated with putrescible waste had to be sent to Kate Valley (likely via the transfer station or a hazardous waste handler) as opposed to BRRP.

The major concern regarding the putrescible waste in the abandoned buildings was the smell and the potential for vector proliferation (rodents and flies predominantly). Prior to the putrescible waste removal programme, a poison laying campaign was run around the red zone to try and kill rodents and/or prevent them from leaving the red zone. The author is not aware of any reported rodent or other vector problems.

Treated timber

Treated timber is an environmentally hazardous component of the waste stream. This is due to the heavy metal components of many of the treatment methods in addition to lead paint coatings on some pieces. At the time of writing there was no economically and environmentally suitable disposal method for the timber. Disposal at Kate Valley was not necessary for the risk associated with the material. Disposal at an unlined cleanfill material was too

high a risk. Technologies to treat or reduce the volume, such as pyrolysis or gasification had not been fully developed for treated timbers. Investigations to find a solution were under way at the time of writing. It is understood that treated timber will be separated from the others wastes and stored in a separate (low-engineered) cell at the Burwood disposal site.

Personal property

Under CERA, prior to any demolition, an agreement was signed between the property owner, insurer and contractor regarding the ownership of personal effects. Generally all personal belongings removed from buildings or uncovered during demolition remained the property of the building owner, tenant or insurer. Best endeavours were made to recover and return personal belongings provided it was safe to do so.

During the civil defence response, a project was carried out by USAR personnel to sweep any building being demolished or made safe to recover personal belongings. If contactable, property owners or tenants could advise of any particular items that were essential to recover. Property was collected in bins corresponding to the building and floor number and guarded by Security Personnel. Tenants and property owners were advised if items had been recovered and could be collected.

Some property owners reported that contractors had taken personal property during demolition works (NZPA, 2011a; b). One example in particular was Community House demolished in late September, early October 2011. Tenants files, computers and other personal items were found in a demolition salvage yard after tenants were allegedly told the building was not safe to enter and retrieve these items (Van Beyen, 2011b; Van Beyen, 2011a). It is understood that there was miscommunication between contractors, building owners and tenants. This building was demolished by contractors engaged by the building owner.

Household hazardous waste

The government (Ministry for the Environment) provided approximately $500,000 towards a household hazardous wastes removal programme. The programme was aimed at encouraging residents leaving residential red-zone properties to dispose of household hazardous wastes safely prior to demolition. The funds also allowed for hazardous substance sweeps of the area to be made prior to demolition (Smith, 2012).

Heritage material

CERA demolition instructions identified handling requirements for heritage buildings and materials. Heritage items that had to be removed (under Heritage instructions) were either recovered by the building owner (in agreement with the insurance company) or were recovered by the CCC Heritage Team. Either way, the items had to be catalogued and taken to the location instructed. The CCC Heritage Team had several secure locations for storage of heritage building elements such as stonework, stained glass windows, and woodwork.

3.5.14 Lyttelton Port Reclamation

During the Civil Defence response the Lyttelton Port of Christchurch (LPC) requested permission, from the National Controller, to dispose of 'clean' debris in a proposed (pre-earthquake) reclamation area in Te Awaparhi Bay. After some confusion, it was agreed that the National Controller would only permit the disposal of debris from the port repair work as opposed to debris from Christchurch as a whole, as requested by the Port.

LPC was keen to take advantage of the large volume of inert material available from building demolitions and appealed to national government, for assistance. The Ministry for the Environment, in consultation with the CCC and ECan, issued an Order In Council (under provisions in the CER Act) making the 10 hectare reclamation a non-notifiable, controlled activity on 23 May 2011 (Office of the Governor-General, 2011b). This allowed ECan and CCC to approve the application quickly and to apply consent conditions on the activity. One of the conditions of the consent was that the key stakeholders identified were consulted prior to approval.

LPC allowed the material to be disposed of for free. This compared to a gate price of $20-25 for other cleanfill sites / concrete crushers around Christchurch. LPC would assume the costs for the handling and placement of the material. The cost savings for LPC were the diminished need to source raw aggregate. As discusses in Section 3.5.12, the market altered drastically and by April 2012, concrete crushing operators were paying to receive demolition concrete.

The material accepted at the reclamation included stone, bricks, tiles, aggregates, reinforced and un-reinforced concrete, cured asphalt and glass. Prohibited materials included asbestos cement products, fine grained material (including soils, sands and clays), organics, liquids or semi solids, chemicals, material that would generate hazardous dust during dumping, sheets of metal cladding, other cladding material, contaminated soil or dredging material, material associated with fatalities. Contamination levels for gib/plaster board, timber, all metals, carpet, plastics, and electrical cables was allowed up to 5% per volume per load (Lyttelton Port of Christchurch, 2011b).
.
The reclamation was consented to take 2.2 million tonnes. Much of the material is required for a 3 m surcharge of the loose marine deposits. All sizes of material were accepted. LPC needed both large and small material for different parts of the reclamation. The reclamation is expected to take 2 years to complete (LPC, 2011).

Figure 3-2 Te Awaparhi Reclamation (Lyttelton Port of Christchurch, 2011a)

3.5.15 Disposal

All residual, unrecyclable wastes were disposed of at Christchurch's only regional landfill – Kate Valley landfill. The landfill is a public private partnership between the six district councils and Canterbury Waste Services. The landfill is a regulated monopoly, that is, it is the only municipal waste management landfill in the region.

Kate Valley is located approximately 80 km from Christchurch, translating to a transport cost of approximately $25 / Tonne. Restrictions on truck travel, in terms of truck type, truck speed and numbers of trucks per day, are enforced. In peace-time the landfill accepts approximately 250,000 Tonnes per year (average 17,000 tonnes per month). Under the existing operating process (existing consents and using the existing hooklift truck system), the landfill only had additional capacity to take 300-500 Tonnes per day. Hence it was unable to accept the residual waste volumes that would be generated directly from the demolition works. Figure 3-3 shows the daily waste quantities, in tonnes per day, between July 2010 and August 2011. The graph shows the waste peaks received after the September and February earthquakes. Note that the February peak was of a lower magnitude but a longer duration.

Most of the waste destined for Kate Valley goes via one of three council transfer stations so that waste can be loaded into appropriate trucks and compacted efficiently. The transfer stations also have limited extra capacity. However, the transfer stations played a key role by providing a buffer in the waste flows and helping to manage bottlenecks at Kate Valley and in the transportation system (bin availability).

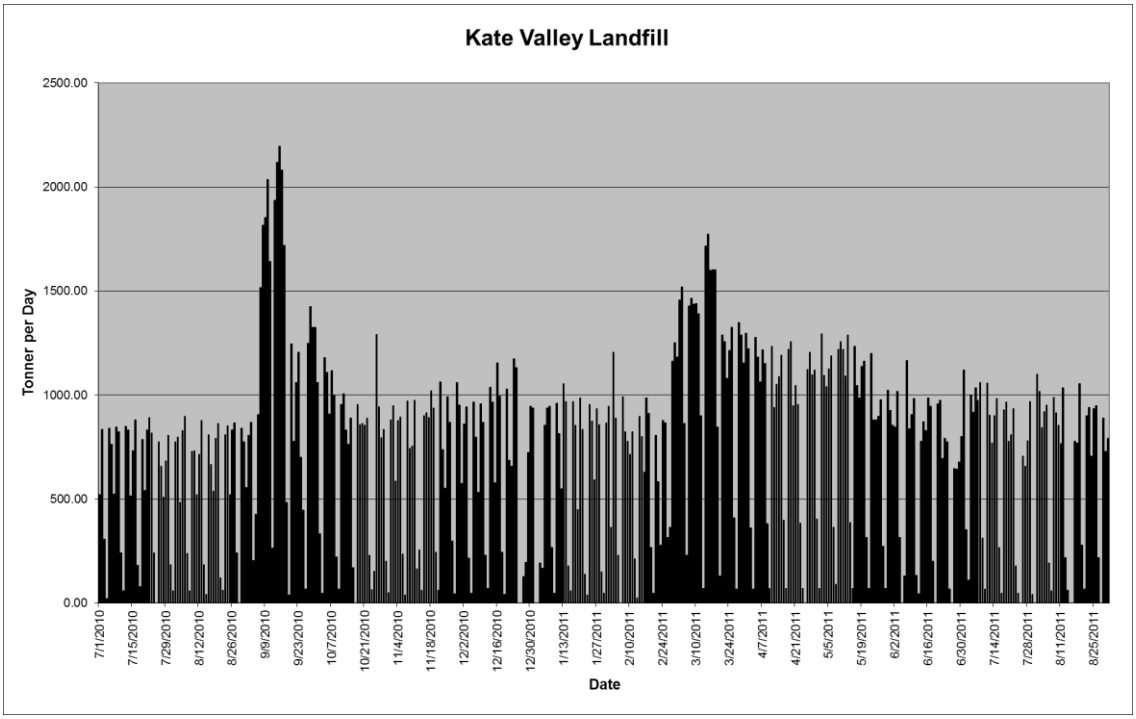

Figure 3-3 Kate Valley landfill daily waste quantities from July 2010 to August 2011 (source: Canterbury Waste Services)

In November 2011, the government announced that the low engineered disposal option at Burwood would be constructed for materials which could not be 'economically recycled'. The operation is being managed as a 50/50 joint venture between the five Canterbury councils and Transpacific: 'spreading commercial risk to ratepayers (Heather, 2011a). Disposal at Burwood will reduce the overall cost of waste management as well as reducing carbon emissions from truck transport to Kate Valley.

3.5.16 Health and Safety

As discussed in Section 3.5.7 asbestos was a significant health and safety concern during the demolition works.

Another major concern was the number and quality of contractors working in confined spaces within the centre city. The CERA demolition PMO monitored all works in the centre city alongside DOL to ensure that safe practices were being carried out. In particular CERA liaised with lifelines utilities to ensure services had been identified and isolated, managed traffic and monitored health and safety risks from workers operating on neighbouring sites.

At the time of writing there had only been one death (by electrocution) related to the repair and demolition works.

3.5.17 Monitoring and record keeping

The demolition and waste industry in New Zealand is largely unregulated. Apart from health and safety in employment regulations and resource management processes around disposal, there is little requirement for

contractors to monitor and report details of the demolition process such as waste volumes, disposal locations etc.

As discussed, CERA managed demolition and debris management were monitored and reported for transparency and accountability. Insurance PMOs generally had reporting systems in place. For example, in terms of waste some PMOs required contractors to following the BRANZ REBRI guidelines. Private property owners and contractors had varying reporting and monitoring systems and if they did were largely internal only.

Prior to 2010, all buildings being demolished required a building consent. This allowed CCC to gather data on demolition methodology, traffic management plans, waste management plans etc., and to (if desired) require reports on completion of the demolition. In 2010, in response to the September 4 earthquake in Christchurch, planned changes to the Building Act were rushed through on 23 December 2010 (Building (Exempt Building Work) Order 2010 (SR 2010/431)) to state that

"Schedule 1
A building consent is not required for the following building work:
(l) the demolition of all or part of a damaged building that is detached (stand-alone) and is no more than 3 storeys high:"

The change allowed demolitions to go ahead without delay. However, they limited the knowledge CCC had over demolitions, and made gathering data about waste production and management difficult.

Pre-earthquake the CCC had some rudimentary data collection systems for cleanfills and waste handling facilities but the data were difficult to analyse and manipulate. CERA attempted to, firstly, make the available information more accessible / user friendly and second to develop (through MfE) a more sophisticated waste tracking system that would endeavour to track waste from cradle to grave. However, with limited regulatory means to require information, it was unlikely this would progress. At the time of writing it is unknown whether either system will become operational.

In November 2011, DOL commenced a dust monitoring programme around demolition sites to address worker and public health risks prior to summer water restrictions and summer winds taking effect (The Press, 2011a).

3.5.18 Public information

External communications were established under Civil Defence and were then continued on by CERA. A communications team was established separate from the operations teams under both Civil Defence and CERA. Under Civil Defence, the communications team would feed media requests to the various operational teams for comment before passing the responses on to the media. Generally this approach appeared reactive. Under Civil Defence all media statements were checked by the National Controller or delegate prior to

release. Daily media briefings were held during the initial stages of the response.

3.5.19 Other waste collection

Municipal waste collections were reinstated almost immediately after the earthquake, with the exception of the cordoned central city. No waste collection service was provided for the cordon area as it was assumed no-one was living in the area. Some roads were impassable due to rockfall, land subsidence etc. making collection at gate not always possible. Initially recycle materials were comingled with mixed garbage to streamline collection process. It is likely this was due to heavy congestion on the roads. Some municipal waste collections and to be rerouted and others were increased due to the need for some residence to dispose of solid excreta in their wheelie bins (where long drops could not be dug due to higher water levels).

Damage to the composting facility meant that while green waste was collected separately it was ultimately sent to landfill with the regular waste. Damage to the compost plant was not publicised as the CCC did not want people to think it was no longer necessary to separate wastes.

4 Analysis

The case study analysis follows the principles set out by Yin (2009) in *Case Study Research, Design and Methods*.

The authors' research into disaster waste management has identified five key factors that influence a disaster waste management system - these will form the unit of analysis. These factors are:

- The overall coordination of disaster waste management activities
- The funding mechanism for demolition and waste management
- The organisation and execution of the physical works
- The environmental standards used
- The public health and safety standards used.

It is these factors that determine the path and in turn overall success of the process. In order for lessons to be learnt that can help position communities to respond better in the future, it is important to understand these factors and anticipate how they may influence the success of a waste management programme.

To assess the impact of each of the above factors in the Christchurch Earthquake case, the analysis focuses on: the related decision-making; the associated delays; the organisational aspects; the legal constraints; and the environmental, economic and social effects (both positive and negative). With limited data available from the waste management process (for example, data on waste composition, costs and social assessments), it is difficult to quantitatively assess the environmental, economic and social impact of the waste management processes. However qualitative assessments of the strengths and weaknesses within each key factor have been made.

For the purposes of this report and in line with New Zealand Ministry of Civil Defence and Emergency Recovery guidelines (MCDEM, 2005), environmental effects include direct effects on the natural environment including: natural resource degradation and/or depletion; waste pollution; amenity values; biodiversity and ecosystems. The environmental effects may have secondary effects on human health through contamination of waterways, soil etc. Social effects look at direct effects on human safety and wellbeing, health and welfare. In terms of waste this will largely include direct disease or health threat from the waste, and health and safety issues related to handling of the waste.

4.1 Factor 1: Overall coordination

4.1.1 Approach and rationale

Following the 4 September 2010 earthquake, an independent group called the Canterbury Earthquake Recovery Commission was established to oversee the recovery and to consult with Ministers regarding any potential legislative change under the Canterbury Earthquake Response and Recovery Act 2010. The group had no decision-making authority and was considered by many to be largely ineffective. Major delays were observed in the recovery, in particular, the slow demolition of buildings posing a public health and safety hazard and in some cases blocking roads and preventing others from accessing their buildings.

The CER Act and CERA were born out of the experiences of September. An organisation with decision-making authority was deemed necessary.

The demolition and debris management team evolved during the emergency response phase. Representatives from the CCC, ECan, Civil Defence, project management consultants and contractors were brought together to develop and implement the demolition and debris management system. During the National Emergency this team operated under the Civil Defence Transition and Planning directors. Largely the team was responsible for waste management operations (as opposed to strategic management), and systems were developed largely through a process of constant refinement. The team concentrated on demolition and debris management primarily from dangerous buildings. This operational team moved fluidly from Civil Defence to CERA with the agreement of the organisations who had provided the necessary staff. This carry-over occurred out of necessity as much as with a strategic intent for continuity.

4.1.2 Delays

The CER Act and consequently CERA was established on 18 April 2011, just under 8 weeks after the 22 February earthquake. The State of National Emergency ended on 30 April 2011 almost 10 weeks after the February earthquake. The transition period before all civil defence directives were replaced by CERA directives was 12 weeks from the commencement of the CER Act. Thus it was not until 12 July 2011, 21 weeks after the 22 February earthquake that CERA was effectively fully functional. During this time new

operational and organisational systems had to be established – diverting resources from implementation to system establishment and negatively impacting the recovery timeline. By 12 July the Chief Executive, Roger Sutton had been appointed, however, the senior management team were not appointed until late August. Staff seconded from, primarily, central government were temporarily filling those senior management roles.

If legislation and appropriate organisational structures had been formulated pre-disaster, the recovery authority would have undoubtedly been activated sooner and there would have been less reliance on the broad powers under CDEM Act for such a considerable period of time. However, given that no such legislation or organisational structure was in place it is understandable that the timeframes were so long.

4.1.3 Organisational aspects

The widespread impact of the February 2011 earthquake necessitated a central authority to direct the overall recovery. With such a large number of organisations and individuals involved, an authority was necessary to ensure everyone was working towards a common goal. A piece of legislation to enable an authority to do this was also vital. Without CERA and the CER Act, Christchurch would be facing a slow and piecemeal recovery dictated by individuals. The centre city for example may have remained closed for years as building owners, tenants, banks and insurers negotiate demolitions of buildings.

Within CERA, however, there was no clear responsibility for oversight of waste long term. According to the roles and responsibilities outlined on cera.govt.nz, 'water and waste' is the responsibility of the CCC and 'debris management – demolition' is a CERA responsibility. The CERA role appears to focus primarily on the waste from demolitions being managed by CERA – which may include up to three quarters of the total waste demolition stream (primarily in the commercial and residential red zones). It was also unclear whether CERA's interest extended to waste handling facilities used for handling demolition debris or not. At the time of writing there was no one person or authority taking the lead role for the broader waste issues and planning. This is no doubt a by-product of the new and developing CERA organisation. A number of ad hoc groups and inter-organisational relationships have developed but there did not appear to be a defined structure and responsibility for this overview.

One ad-hoc group established early in the response was a solid waste working group with representatives from CERA / Civil Defence, CCC and ECan. The intent of the group was to share information and to try and solve any emerging issues. The group has representatives from enforcement, consenting, operations and strategy and planning. It is unknown if this group has continued, and if so, how effective it is.

In the author's opinion, one of the largest challenges was the balancing and matching of 'peace-time' mandates, roles and responsibilities and post-disaster roles. Some individuals and organisations maintained their peace-

time roles and mandates and were inflexible when approaches needed to be streamlined to facility recovery activities. On the other hand some individuals and organisations were very accommodating and willing to changes processes and procedures to facility recovery. In some cases this flexibility meant that processes and standards were arguably changed unnecessarily in a bid to 'help' the recovery.

The division between regional and city council was also slightly disabling. The enforcement arms of the councils do not appear to routinely share information or coordinate inspections. While the councils have different mandates, waste management problems generally intersect. For example, if the neighbours are complaining to the CCC about a site because of dust and odour, it is likely that there are significant problems regarding discharges to air and stormwater, which is ECan's responsibility.

The authors believe that clear direction will be needed from CERA to lead the waste management issues as an integral part of the wider recovery activities. Unless this direction is given, the local authorities are likely to continue working under their own 'peace-time' mandates which could work against the recovery objectives.

Many of the persons involved in the recovery were working in an unfamiliar environment. Many local, regional and national government staff were unfamiliar with the Civil Defence arrangements (and later the new CERA structure), so there was a lot of confusion over roles and responsibilities and protocols etc. The author herself had no experience working in the civil defence framework. In addition the author, having not worked as a professional in Christchurch, found it difficult to adjust and learn the systems of the respective councils. With an influx of external resources, this is inevitable in a disaster and must be planned for.

As discussed in Section 4.1.1 the largely operational demolition arm of CERA was staffed by local council and civil defence staff who had been involved from, in some cases, the day of the earthquake. The CERA management staff, however, was predominantly sourced from central government and were coming into the earthquake response without much understanding for the issues. The length of transition and time taken to establish roles and responsibilities could be largely attributed to this factor. It took a long time for the CERA personnel to understand the issues involved, what had already been done and what needed to be done. While it is understandable that new staff needed to be brought into these roles (as resources were severely limited), communication channels between those already involved in the process and those arriving could have been improved.

Communications or public information teams were involved in both Civil Defence and CERA. The teams primarily operated as a separate team, outside the operational groups. In the initial stages of the response, due to the high volume of media inquiries, public information management was quite reactive. Generally media enquiries were received and the public information representatives would seek answers to the media questions. There were several occasions where waste management information was poorly

communicated to the public. This was likely due to misinterpretation of the information and the limited scope of questioning (thus the responses did not draw out all the relevant details). This reactive situation meant that important public communication messaging regarding waste, particularly around risk management (e.g. asbestos) was not effectively disseminated.

Ideally, a communications team member should be imbedded in the various arms of the organisation. This would enable the person to fully understand the issues involved and to be able to identify the emerging issues before they become a problem. This is in contrast to reacting when the media believes there is a problem. This would also enable more 'good news stories' to be told which will have positive effects on both the community and the staff of the organisation.

4.1.4 Legal implications

The extent of power and authority given to 2010 Canterbury Earthquake Response and Recovery Act caused significant concern among the legal fraternity in New Zealand. On the 28th of September a letter signed by 27 legal scholars from New Zealand and overseas, outlining concerns over the legislation, was sent to Parliament. The primary concerns of the legal experts were (as quoted in the letter) (Geddis, 2010):

- Individual government ministers, through "Orders in Council", may change virtually every part of NZ's statute book in order to achieve very broadly defined ends, thereby effectively handing to the executive branch Parliament's power to make law;
- The legislation forbids courts from examining the reasons a minister has for thinking an Order in Council is needed, as well as the process followed in reaching that decision;
- Orders in Council are deemed to have full legislative force, such that they prevail over any inconsistent parliamentary enactment;
- Persons acting under the authority of an Order in Council have protection from legal liability, with no right to compensation should their actions cause harm to another person.

While some concerns have been raised, there appeared to be less resistance to the CER Act. It is unclear whether this is due to the greater perceived need for legislative flexibility or whether lessons from the drafting of the CERRA legislation were incorporated successfully into the CER Act.

The legislation does give immense authority to elected persons; however, in terms of RMA issues, it could be argued that this is no more than the Ministerial Call-in powers under the RMA. Given that no legislation was in place, and there was no time to fully consider all the legal avenues necessary to successfully facilitate the recovery, flexible legislation was necessary. The legislation relies on government officials to implement the legislation appropriately and not abuse their powers.

The haste with which the legislation was written and accepted has also introduced problems in implementation. There are several inconsistencies in the CER Act. Poorly written parts of the legislation have at times made it difficult to carry out CERA's duties, particularly in respect of demolitions. Section 39 of the CER Act outlines a number of interested parties that must be notified of the impending demolition 'if practicable'. This requirement puts the onus of responsibility on CERA as opposed to the building owner and has slowed down the demolition approval process significantly as councils do not routinely have information on the other interested parties (particularly where there are complicated financial arrangements). Legal challenge is of constant concern and is factored into every decision.

The lack of clarity around roles and responsibilities, particularly during the transition between Civil Defence and CERA, in the author's opinion, contributed to at least one ill-considered legislative change: the temporary accommodation and storage permitted activity Order in Council. This Order in Council contained a clause permitting temporary storage of materials incidental to construction work. This opened up a lot of opportunities for waste management sites to be established which could potential become legacy issues for the city if managed incorrectly. Perhaps if organisational structures and roles and been more defined, a more comprehensive review of the proposed legislative change could have been made such that potential for negative consequences could have been mitigated.

Two new waste handling facilities were approved to assist in the recovery using OICs: Burwood Resource Recovery Park (BRRP) and Lyttelton Port of Christchurch (LPC) reclamation. BRRP was established under Civil Defence and considered a vital part of the recovery effort. Civil Defence approached several organisations to establish a joint venture to operate the facility. During the transition period, CERA and the MfE liaised with ECan and CCC to ensure they were satisfied with the operation and that an OIC could be passed to allow the operation to continue. LPC reclamation, however, was initiated via a request from the LPC CEO to the Minister for Earthquake Recovery and Minister for the Environment. The LPC drove the initiative. While operational CERA staff supported the initiative, due to the wider economic benefits the port brings and the free disposal being offered, there were no channels within Civil Defence or CERA to advocate for this. Council staff could advocate through their elected officials but at the time, CERA had no channels established.

4.1.5 Environmental

As discussed in the previous section, the lack of oversight across the whole of the waste management system introduced some potential for negative environmental effects. The roles and responsibilities within CERA and with local environmental authorities were not established in a timely manner.

The extent of powers under the Civil Defence Act, with respect to environmental issues, was drawn into question. As described in Section 3.5.14, LPC requested that debris be disposed of in a planned port reclamation. The National Controller approved the request under the

understanding that it would be just debris from the LPC itself, however, the LPC understood they were approved to accept any clean debris and started accepting clean debris from all over Christchurch. The National Controller is limited to act under Section 9(2)(a) of the MCDEM Act (see Section 3.2.1). In the author's opinion, it is questionable whether waste disposal fits into any of these criteria, particularly where the LPC may have had alternative places (such as in their quarry or at a cleanfill site) to store or dispose of the debris. Unless the waste was stopping them from operating as a port (that is a lifeline utility) then this approval should arguably not have been granted under the CDEM Act. It is unknown whether there was any consultation with environmental officials regarding this emergency approval. While the reclamation was eventually approved under the CER Act, without proper processes and environmental controls in place, adverse environmental effects may have arisen.

4.1.6 Economic

There were some community-wide economic recovery issues relating to the waste strategy which were not given sufficient attention. For example, the decision to recycle or not had significant financial implications. Recycling was a peace time accepted practice and the natural default. Existing recycling facilities were not sufficient to manage the volume of waste generated so a centralised facility, BRRP, was established. The cost to dispose of mixed material at this facility was $90/T at the start of the operation (it was increased to $120/T after volumes received were smaller than expected and of lower recyclable value). This was initially a cost saving of about $45/T compared to disposal direct to Kate Valley Landfill. There was, however, another waste management option – creating a low cost disposal site for the relatively inert material. As discussed in Section 3.5.15, this option was eventually accepted in November 2011 after it was deemed economically unviable to transport the materials to Kate Valley. If this decision had been made earlier, possible savings would have been made for building owners / insurers. In some cases this would led to increased capital to spend on rebuilding activities. Without a solid organisational structure in place and clear roles and responsibilities, the issues around total cost of waste management possible options for cost savings were not fully considered.

4.1.7 Social

The responsibility for public health protection and information dissemination was unclear. For example, a number of complaints were received regarding asbestos related risks and management. The complaints were directed to a number of parties including DOL, CCC, CERA and Community and Public Health (CPH). The number of complaints or concerns raised at each organisation was not significant; however, on aggregate, they demonstrated a general lack of confidence from the community. The health concerns were essentially a by-product of the recovery; therefore, in the author's opinion, the natural responsibility lay with CERA to facilitate public information dissemination. However, CERA did not have operational capacity or the necessary expertise to carry out monitoring and to advise the public on the

risks. CERA endeavoured to liaise with all the other authorities to contribute to a public health risk awareness campaign and to identify an appropriate authority to carry out air monitoring. The authorities all had varying opinions of the risks and the most appropriate approach for managing the risk and managing public information. Approaches ranged from air monitoring, to leaflet drops, to mitigation measures (such as dust suppression), to doing nothing.

A public information campaign would have had a number of benefits, including allaying community fears, developing a community wide understanding of the demolition process and likely risks, providing information for people to protect themselves if necessary and also to provide a united front of all organisations and identifying a single point of contact for future queries, concerns or complaints.

4.1.8 Summary

An organisation established in haste, such as CERA, is undoubtedly going to have problems in the initial stages. While this report has highlighted a number of weaknesses, it is with a view to improve for future response events, rather than to criticise the response.

Overall the opportunity to establish a strategic management and coordination role for waste management was overlooked. The roles defined under the CERA structure divided waste management under two organisations and this appeared to leave some gaps in the overall strategic management. No organisation appeared to oversee the waste management system including identification of bottlenecks, capacity limitations and determining protocols. Some ad hoc planning and oversight work was carried out initially but it was not institutionalised. Organisations primarily operated in their peace-time roles and responsibilities.

Table 4-1 summarises the strengths and weaknesses of the overall coordination of demolition and waste management works.

Table 4-1 Christchurch Earthquake overall coordination of demolition and waste management works assessment summary

	Strengths	Weaknesses
Organisational	• Central organisation was essential to best serve the recovery. • Ad-hoc working groups formed.	• No clear long term strategic responsibility for waste. • Silos within existing organisations impeded strategic management and creative decision-making • Discontinuity between organisations led to double-ups and inconsistencies • Slow transition between Civil Defence and CERA since CERA management staff had not been involved in response or early recovery. • Public information teams sat outside operational teams and often did not fully understand issues. • Public information was very reactive during the response.
Legal	• Flexible legislation was essential	• Hastily written CER Act led to inconsistencies and implementation difficulties. • Unclear organisational roles and responsibilities led to some potentially unnecessary legislative changes.
Environmental		• Unclear roles and responsibilities led to questionable environmental decisions • Extent of Civil Defence Act powers on environmental issues was unclear.
Economic		• No oversight or directive on overall system costs in particular the costs of waste management options
Social		• Public health information poorly communicated.

4.2 Factor 2: Funding mechanism

4.2.1 Approach and rationale

Funding for natural disaster responses in New Zealand are divided into two time frames – the emergency response efforts and the recovery efforts. The emergency response efforts are those primarily to support life and prevent further loss in accordance with the *CDEM Act 9(2)(a):*.

> *(i) the provision of transport:*
> *(ii) the removal of endangered persons and casualties from any area affected by the emergency to areas of safety or to hospitals:*
> *(iii) medical care and attention to casualties:*
> *(iv) the relief of distress and suffering:*
> *(v) the accommodation, feeding, care, and protection of persons:*
> *(vi) the provision of other services necessary to restore community services and provide for the welfare of the public*

Demolition and debris management works are not explicitly included in any of these areas, however, could be included in (vi) has a support service for restoring community services and welfare. For any activities carried out for these purposes, the Regional Civil Defence and Emergency Management Groups can recover costs incurred from the Crown.

In terms of recovery, New Zealand has an insurance culture. Business and home owners generally understand it is their responsibility to ensure that their losses are minimised in an adverse event affecting their property. Most choose insurance to minimise this risk. The New Zealand government has reinforced the insurance culture through the establishment of the Earthquake Commission to cover all insured residential properties for natural disasters.

In the wake of the 2010 and 2011 Christchurch Earthquakes, insurance remained the primary funding source for all recovery activities – including waste and debris removal. Donations have been raised and the government has allocated budget for the recovery works; however, to date, no money from the central budget has been allocated to demolition or debris removal works.

4.2.2 Delays

The insurance sector was established pre-earthquake. Post-earthquake the challenge was to develop systems which would ensure that the recovery would progress in the most efficient ways possible given the existing funding sources. The majority of the delays, therefore, resulted from establishing new operational systems and creating new organisational structures (such as CERA) to coordinate and prioritise the efforts made by those funding the recovery. Considering the scale of the task and the number of organisations involved new systems and regulations were established relatively quickly. However, the constant need to consult with the funding organisations throughout the course of the recovery introduced many efficiencies and delays. These are discussed in the relevant sections below.

4.2.3 Organisational aspects

Demolition and debris management work required during the emergency works included: partial or full demolition works to enable search and rescue to be completed; clearing roads for emergency and construction vehicles; and partial or full demolitions to minimise risk to persons. There was some confusion over whether this was considered an emergency action, and therefore paid for by Civil Defence funds, or whether these works were the financial responsibility of individual property owners. Generally it was assumed by Civil Defence that wherever possible costs would be recovered. However, recovering costs proved difficult for several organisational reasons and legislative reasons (see Section 4.2.4).

With no systems established pre-earthquake, initially these emergency works were carried out with rudimentary record keeping. Within a week of the earthquake Civil Defence and USAR had established a job number system to attempt to link all works to a property for future financial recovery. While this aided cost recovery and reduced the cost to the Crown, there were lost efficiencies in the emergency works. While the hours charged to each building could be easily assigned, the debris from the buildings had to be carried separately to the disposal point to ensure that weights of debris were recorded accurately. This resulted in some part loads travelling to disposal locations. This caused inefficiencies and great resource demands. Some of the initial works, in particular the road clearing where it was difficult to determine the origin of the materials collected, was eventually added to the Civil Defence emergency work costs. It is worthwhile noting that if the disaster event had been a tsunami the amount of 'un-allocatable' work would have increased substantially.

During the recovery period, it was recognised that due to the number of individual insurance interests and companies, coordination of demolition and debris management works would be needed in the central city red zone. This was later extended to the residential red zone. Insurance companies agreed that in order to achieve the maximum coordination and resource efficiencies CERA should manage the demolition works. This decision was, in the author's opinion a very positive move and the pace of demolition is significantly better than in September 2010[3]. Resources were also able to be prioritised such that particular areas in the red zone could be opened progressively. For example, Cashel Street Mall was identified as a landmark area for reopening. CERA was able to coordinate all property owners and their insurance companies to ensure that this was the first area of the city to be cleared and in turn reopened.

As for emergency works, the need to bill each insurable interest separately during the recovery period remained. Some efficiencies of using the pooled approach were lost by maintaining this transparency and accountability at a property level, however, they were minor. Given that an insurance funding system was in place, this was a satisfactory compromise.

[3] Note that this is based on anecdotal evidence. As of November 2010 (Building (Exempt Building Work) Order 2010) demolitions of buildings of 3 storeys and less can be carried out without local authority consent. Therefore no full records of demolitions are available.

The centralised demolition programme managed by CERA was voluntary. As long as they met CERA's demolition programme, property owners could opt to carry out their own works. Approximately two thirds of property owners elected to carry out the works on their own behalf. This statistic was so high largely because many buildings owners were opting to be paid out by their insurance company and therefore were no longer obliged to take recommendations from the insurance company to use the CERA PMO. Owner initiated jobs were inevitably less efficiently managed and generally ran over programme. While CERA were monitoring these works and had the legislative authority to take over the works, the reality was that seizing a site after works had begun and completing the works was less efficient than letting the contract run its course. If insurance companies had refused to pay customers out, or if the CER Act had required property owners to use the centralised process (see Section 4.3.4), or if funding had come from a central government source without cash settlement options, then these inefficiencies might have been avoided.

Despite this agreement, the insurance companies were concerned about being charged overheads to cover the services of the CERA PMO. Overheads included engineers, project managers, site managers, disbursements etc. were continually questioned. Eventually a percentage overhead was agreed on.

The dual EQC / private insurer funding scheme, however, has created a complicated coordination task for some residential properties. For properties with greater than $100,000 damage, the buildings must first be demolished by private insurance companies / householder, then the property handed to EQC for land repair (if necessary) then handed back to the private insurance company / householder for rebuilding. The low level of tenant displacement (due to a large number of heavily damage but still habitable properties) increased this complexity as demolition works had to be integrated with land remediation and reconstruction activities to minimise disruption to property owners. The level of land remediation and the number of houses in this category are unknown at the time of writing; however, the large land area being retreated from has reduced this complexity significantly. If the government / EQC held insurance for the full value of each property, this complexity would be eliminated. If EQC had increased its $100,000[4] threshold to reflect increased house prices, the number of houses in this category would be reduced.

The estimate by some that a large number of commercial buildings were under insured for demolition, is particularly concerning. It was believed by some that this was due to higher labour and disposal costs post-earthquake. However, the authors believe that, apart from the decision to increase the speed of demolition (which naturally incurs costs), demolition costs had not increased substantially in Christchurch. Demolition costs in Christchurch, are however, notably higher than in other parts of New Zealand[5]. It is believed

[4] The $100,000 cap was set based on average house prices in 1992 and has not been adjusted since.
[5] Higher demolition costs are largely due to the environmental protection measures necessary to protect the sensitive groundwater aquifers underlying Christchurch and the availability of gravels (reducing the value of recycled concrete).

(unconfirmed) that, insurance policies may have been valued based on demolition costs from other centres. The effect of this under valuing was a stronger desire for business owners to manage their own demolition and to save costs, with the resultant effects on recovery of reducing the positive effects of the centralised process.

One notable omission to most insurance policies is compensation for asbestos removal. This exclusion is not surprising as the extent of asbestos in most properties is unknown and removal costs are very expensive. However, in terms of impact on the recovery progress, as for the dual insurance coverage discussed above, this omission creates organisational complexities. Asbestos removal will often, particularly when the building is structurally damaged, have to be carried out in conjunction with demolition works. Technically it is the building owner's responsibility to organise the asbestos removal but in practice the insurance PMOs and the CERA PMO are generally arranging for asbestos removal and are on-charging the building owner. Cost recovery for this work is likely to be problematic.

4.2.4 Legal implications

The Civil Defence-led emergency works were carried out under the authority of the National Controller under powers delegated from the CDEM Act. As discussed in the previous section the works were carried out with the intent of cost recovery, however, under the CDEM Act there appears to be no legislative ability for the Crown to recover costs from private property. Civil Defence began gaining agreement from building owners prior to works commencing (within a week of the earthquake) that they would be liable for costs incurred. It is unknown how much money has been recovered and whether any legal challenge has arisen from this process.

As discussed in the previous section, to enable an efficient and coordinated recovery, and to avoid all the insurance companies and individuals funding their own demolition works, a centralised approach was preferred. The CER Act gave CERA the authority to carry out works on behalf of building owners and recover costs. CERA needed to be able to direct operations and seek compensation. The CER Act specifically included a clause (Section 40) to allow the Crown to recover costs for works to demolish or repair a building deemed dangerous. If costs could not be covered then a covenant would be put on the land title so costs could be recovered when selling. The dangerous building definition is that used in the Building Act and includes buildings that would collapse in a moderate earthquake.

In addition the CER Act recognised the potential for conflict of interest between individual and community wide interest. In particular, the individual focussed nature of insurance systems magnified this potential. To mitigate this conflict and ensure recovery continued towards a community focussed end-point Section 38 of the CER Act allowed for CERA to intervene where demolition works were progressing too slowly. However, from a practical point of view the time restrictions were very hard to enforce. Despite best efforts owner driven projects were, in the majority, slower and less effective than CERA managed jobs.

4.2.5 Environmental

In terms of the emergency response, the demolition and debris management works which were carried out adhered to the environmental standards set by the relevant authorities (see Section 4.4). Therefore the funding mechanisms had no direct environmental impacts.

During the recovery phase, the high level of insurance theoretically provided adequate cover to demolish and dispose of buildings in line with current environmental regulations. Insurers pay any costs incurred to meet existing environmental standards. Also most buildings demolished on behalf of insurance companies were managed by their respective PMOs. The PMOs in general are large reputable companies with environmental quality assurance mandates, therefore local environmental standards were generally adhered to. However, as discussed in the previous section, a number of buildings were under-insured. It is these buildings, particularly where the owner has been paid out and the building owner is managing their own demolition, where instances of improper waste management may occur. Illegal dumping was reported in several locations across Canterbury (Sachdeva, 2011b; The Press, 2011b).

The example of illegal dumping illustrates the reduction in quality control that arises when the funds and subsequently works are not centrally managed. As soon as the funds are held outside an authority or an environmentally responsible organisation, then the level of quality control reduces and negative environmental effects occur. This is discussed further in Section 4.3.5.

The division of work between EQC and the private insurer, as described in Section 4.2.3, had the potential to reduce local reuse and recycle options. For example following the September 2010 event, crushed concrete from demolished properties was considered for underground dam structures as part of land remediation. However, the logistics would have been very cumbersome as each house's demolition was carried out by its respective private insurer, and EQC would then carry out land remediation. After the February earthquake, the retreat from many areas and the undertaking by CERA to demolish all affected properties has reduced the potential for onsite or local reuse and recycling of materials.

The provision that insurance companies will only pay for one shift of waste has the potential to create future environmental issues. BRRP for example has a five year operating window. BRRP anticipates they will receive all the waste within two years. Thus, BRRP has to anticipate the waste composition and potential separation it will achieve after five years in order to set the gate price for the first two years. This is very challenging to estimate meaning that site operators carry a considerable risk. If waste facility operators underestimate their initial costs, they have no opportunity to recover the money from insurers. This potentially will cause an environmental legacy issue where a number of waste piles are left after the demolitions are complete. If the recovery funds were pooled and actual costs were covered as at the end of the operations, potential environmental issues could be avoided.

However, that does introduce the possibility of contractors inflating costs unnecessarily.

4.2.6 Economic

A consequence of the individual focussed insurance system was that initially insurers wanted to save as much money as possible on each building demolition. In order to save money, insurers wanted to take the lowest cost demolition option. This often included sorting waste materials on site and increasing the time for demolition. While the increased time is not necessarily of consequence at an individual building level (particularly where the building is in the inaccessible red zone), on a city-wide scale when there are resource shortages, this has impacts on the overall recovery timeframe and economic impact. Insurers soon realised that slower demolitions on individual sites meant slower reopening of neighbouring businesses. While the business next door might not be their financial interest, on a macro scale they realised the importance of expedited demolitions. Insurers wanted faster demolitions to reduce business interruption or temporary accommodation costs.

Unfortunately, property owners who were managing their own demolitions (generally through under insurance as described), were solely focussed on reducing costs at a site level. The property owner would not necessarily benefit from, for example, reducing demolition time to allow access for a neighbouring building owner. Again, as demonstrated in the previous section, as soon as the financial control over the property owners is lost, the quality control, this time in terms of time, is lost.

The level of under-insurance for demolition also had an economic impact on the recovery. Demolition costs over and above those specified in the insurance policy would have to be paid for. Depending on the insurance policy this would either result in a reduced value for rebuilding, or would require the building owner to contribute directly towards the demolition. Either way this results in reduced available capital for rebuilding of Christchurch. In future demolition costs for insurance policies need to be valued to match the local market. They also need to be regularly revised to ensure they reflect the costs near to the time of the disaster.

During a large scale demolition project such as this, there are many opportunities for economies of scale to be gained. Efforts were made to centralise the demolitions as much as possible (see Section 4.3), however, the funding mechanisms thwarted a number of opportunities to reduce overall (community wide) demolition costs. For example, true economies of scale could not be met because of the need to attribute exact costs to each building. In some cases there were up to eight different insurance companies involved in one building (including insurance for contents). As far as practicable, wastes associated with each insurable interest had to be handled separately. As a result, the only practicable way of handling this, in a timely manner, was to transport the material to a central facility for recycling and charge for the waste on a per tonne basis. Loads from different buildings would have to be transported in separate trucks also.

Because the demolitions were being paid for by a number of entities (insurers and individuals, as opposed to say a government or central financial pool), the resource recovery park essentially had to be run as a private operation with an upfront charge. TPI took a large financial risk on the operation and that is reflected in their price. There is a potential that TPI could make a large profit which will be lost to the recovery efforts. Alternatively TPI could make a large loss and insurers and individuals will save significant amounts of money. If upfront costs were not required and costs did not have to be allocated to each individual building, then the resource recovery park could have been run as an 'at cost' facility by government or local authority to potentially save valuable rebuild money.

The attempt to 'bundle' properties in the residential red-zone may allow for some opportunities for economies of scale. However, it should be noted that due to concern about looting and vandalism in empty houses, and the delays in approving houses for demolition (following insurance settlements between EQC, Crown and private insurers) demolitions may be carried out in a more ad-hoc fashion. This would mean a patchwork demolition with houses being demolished on a site by site basis. Economies of scale for sorting, reuse, recovery of recycling materials, and use of crushed concrete for site filling, as examples, may be reduced.

At the time of writing it was uncertain how uninsured property owners would be managed. While the CER Act allowed for demolition costs to be recovered via land covenants, it is unclear whether the government will actually pursue this money and how successful they will be in acquiring it. No doubt the approach will be different for residential and commercial properties. It is feared that if uninsured property owners are financially assisted then that might undermine the insurance culture in New Zealand.

Organisational complexities arising from different organisations funding different components of the recovery, discussed in Section 4.2.3, will undoubtedly increase both the management and the implementation costs: in particular the EQC / private insurer relationship. Every time a site is taken over by another contractor there are establishment and disestablishment costs. Management time will also be required to coordinate the handing over the site between different agencies. The centralised management adopted by CERA for the residential red zone will help to reduce these additional costs.

4.2.7 Social

Some properties were allegedly demolished without owner or insurer notification and without opportunity to salvage personal property. Buildings were demolished in the interest of search and rescue and public safety, however some building owners challenged the need to demolish their buildings. The absence of a clause in the CDEM Act to allow for cost recovery for works carried out actually contributed to a greater effort to consult with building owners prior to building demolition and in most cases ensuring that all parties agreed on the proposed works prior to demolition. Consultation was also driven by public pressure and a desire to preserve property rights as far as practicable.

For insurance purposes buildings are generally considered individually and without consideration for the impact of neighbouring buildings and the wider community. For example, there were several property owners that approached CERA to request works on neighbouring properties to allow then access to their property. Under normal circumstances affected persons would be left to negotiate with the property owner and their insurance company and wait for their action. Alternatively they could approach the CCC and use provisions of the Building Act. The provisions under the Building Act generally include long notification periods before work can commence. Fortunately under Section 52 of the CER Act, CERA had been given the authority to act to mitigate any danger to neighbouring properties. In other words CERA could counter the individual view of insurance to ensure the funding decisions being made benefitted the wider community recovery.

It is interesting to note that at a high level the insurance companies also understood the collective impacts of the recovery. For example, the insurers were consulted when determining in what order to open areas of the red zone. The insurance companies agreed that it was largely irrelevant for them in which order it was reopened because they had properties across the area. Savings made from early reopening in one area would be negated by delays in reopening another area.

The existence of EQC also offset the negative impacts of individual insurance on community recovery. Having a national natural disaster insurance meant that-- across all residential insurance policies – a minimum coverage was assured[6]. This meant that property owners and the community at large would be less vulnerable to variations in individual policies. In addition EQC had the foresight of providing insurance for land – something which no other insurance company in New Zealand offers. Having one insurance company for land issues, in particular a Government entity, was hugely beneficial for the community recovery in Christchurch. The EQC in conjunction with local authorities, other Crown departments and insurers could assess, relatively quickly, the viability of land rehabilitation for liquefied areas as a whole, including for council infrastructure (roads, water, sewer etc). If each property was dealt with by different insurers the decision making could have been considerably more cumbersome and slow. Unfortunately, as discussed in Section 4.2.3, the complexity of having multiple insurers dealing with one property meant that while the decisions on the land could be made centrally with a community focus, payment settlements for the properties were still up to individual insurers. Insurance companies would still only compensate property owners for damage sustained during the earthquake. The government had to pay for additional costs resulting in land retirement.

As discussed in the previous sections, a number of building owners opted to manage their own demolition, often due to inadequate insurance cover and a desire to save money. As building owners tried to save money, it is believed that, in some instances, public and worker health a safety may have been

[6] Historically this minimum cover of $100,000 +GST was the price of an average house when the policy was introduced in 1992. However, this value was not changed to match rising house prices.

compromised. For example, several instances of illegal dumping of asbestos were reported (Wright, 2011). Building owners were clearly trying to save money on demolition by minimising disposal costs. The result was a public health and safety hazard. There were also instances where contractors had been instructed by CERA engineers not to strip building contents prior to demolition but had ignored these instructions despite on-going and significant aftershocks. Stripping out buildings increases material recovery and lowers disposal costs, but slows recovery as well as increasing safety risks.

4.2.8 Summary

There were primarily two funding mechanisms relating to demolition and debris removal – central emergency funding for emergency works and an individual property level insurance system for recovery.

The emergency funding from the national government provided funds for activities primarily to support life and prevent further loss in accordance with the CDEM Act. It was unclear what demolition and debris management works were included in this funding. The CDEM Act did not include for cost recovery from building owners.

For recovery works, the majority of properties were covered by insurance. Insurance coverage theoretically ensured that building owners would eventually recover most of their losses (both direct capital and indirect business loss). While this is overwhelmingly positive there were some major drawbacks to the insurance system:
1. Insurance settlements take time;
2. insurance considerations are based on an individual building level and do not generally consider community recovery (generally cost driven, not time driven);
3. left unmanaged there is no prioritisation or coordination of limited resources;
4. potential economies of scale, time and resource efficiencies are lost amongst the multiple insurance organisations patchwork spread across the city;
5. many insurance valuations for demolitions were undervalued; and
6. asbestos is excluded from policy cover.
The establishment of CERA and their respective coordination efforts aimed to mitigate many of these negative effects. The efforts were largely successful.

The dual EQC / private insurance system created some organisational and logistical complexities for residential properties with land damage. In many cases the damage was above $100,000 and the property would need to be handed between EQC and the private insurer depending on the stage of demolition, land remediation or rebuilding. The decision to retreat from large affected areas has considerably reduced this organisational problem, as CERA now becomes responsible for demolition without needing to coordinate with insurers or EQC.

Overall, there were significant organisational and logistical deficiencies with the funding mechanisms pre-disaster. While some organisational changes post-earthquake mitigated the effects, more robust regulation or a completely

transformed funding system is needed. Table 4-2 summarises the strengths and weaknesses of the funding decisions.

Table 4-2 Christchurch Earthquake funding mechanism assessment summary

	Strengths	Weaknesses
Organisational	• Insurers agreed to a centrally facilitated demolition and debris management effort which greatly enhanced efficiencies and resource prioritisation. • Insurers agreed to pay an overhead to CERA PMO. • Most insurance demolition PMOs are arranging for asbestos removal as part of demolition works.	• Lack of clarity over what demolition and debris management works were paid for by civil defence or private building owners. • Delays and efficiency losses in emergency and recovery works due to need to carry out works on each building separately (for cost recovery). • Difficulty in allocating some emergency works (such as road clearing) to individual buildings. • Insurance cash settlements increased the number of owner initiated jobs which were predominantly less efficient. • EQC, private insurer coverage combination creates organisational complexities. • Asbestos not included in most insurance policies and creates complexities during demolition works. • Under-valued insurance policies for demolition increased the number of owner-implemented works.
Legal	• CER Act included provision for demolition and make-safe works to be carried out and for cost recovery to be sought.	• CDEM Act did not include provision for cost recovery for works carried out. • CER Act provisions to allow intervention when demolition works were progressing too slowly were impractical.

	Strengths	Weaknesses
Environmental	• Emergency operations funding paid for works carried out within local environmental standards.	• Under-valued insurance policies for demolition increased prevalence of improper waste management practices (e.g. illegal dumping). • EQC / private insurer split reduced opportunities for onsite or local material reuse and recycling. • The 'oneshift' payment policy for waste may cause future environmental issues if funds collected during demolition are insufficient to manage the waste.
Economic	• Insurers realised that on a macro-scale faster but more expensive demolitions were more advantageous. • Commitment by CERA to demolish all residential red zone properties increases opportunities for savings and economies of scale. • Commitment by CERA to demolish all residential red zone properties will reduce organisational costs associated with coordinating EQC and private insurers.	• Insurers initially wanted cheapest demolition strategies – this would slow demolition and overall economic recovery. • Under-valued insurance policies for demolition increased prevalence of slow demolitions (impacting neighbouring businesses and infrastructure). • Insurance companies required 'upfront' and measured disposal costs, therefore, the resource recovery park had to be operated as a private enterprise with associated risk / profit margins – potentially increasing disposal costs. • EQC and private insurer organisational complexities will increase demolition costs.

	Strengths	Weaknesses
Social	• Emergency funding provision allowed for public safety and community welfare needs to be met. • The absence of a cost recovery clause in the CDEM Act contributed to improved effort to gain approval from property owners. • CER Act provisions enabled CERA to direct insurers to act with a wider community recovery in mind. • EQC provided minimum cover for all insured parties which benefits community recovery. • EQC was able to address land issues from a community wide perspective.	• Insurance decisions are made on an individual building basis and do not consider wider recovery. • Under-valued insurance policies for demolition increased prevalence of slow demolitions (impacting community recovery programme). • Insurance excludes asbestos which has led to some instances of illegal dumping (public health hazard).

4.3 Factor 3: Implementation strategy

4.3.1 Approach and rationale

As described in the previous sections, the key to the implementations strategy was to try and coordinate all the diverse stakeholders (building owners, insurers, contractors etc.) so that they were all working towards a common goal – that being the efficient and expedient recovery of Christchurch. With limited resources available for demolition works, a centralised approach to demolition and debris management became the best option.

Organisation

Demolition

The decision to centralise processes and coordinate demolition resources was made on many levels and by different organisations:

- CERA was established (refer Section 4.1).
- CCC's road maintenance contractors City Care and Fulton Hogan coordinated all volunteer and professional services to clean up liquefaction silt.
- The private insurers each engaged companies to manage all repair, demolition and rebuild works.
- EQC engaged Fletchers to manage all repair works and Fletchers in turn engaged a pool of skilled trades-people to carry out the works.
- Civil Defence / CERA Demolition team engaged a project management company, who in turn established a pool of demolition contractors.

In terms of the Civil Defence / CERA approach, the centralised process for commercial buildings essentially evolved out of necessity. Immediately after the earthquake a number of demolition companies came to the city to assist in search and rescue. This valuable resource needed to be coordinated so that it effectively helped and didn't hinder the search and rescue effort and to deal with administration such as timesheets, approvals, liaison with USAR, CCC, Civil Defence etc. A contractor was nominated to coordinate the efforts. The contractor was replaced by a project management company. A system for accreditation of contractors was established and standing contracts were rolled out for demolition works. The structure seemed to be effective and was built on and improved.

The CER Act was developed to allow CERA to step in when works were not progressing fast enough. However, it generally did not give mandate for the works to be centrally organised. Therefore many individual building owners opted to manage their own works.

Waste Management
BRRP was established as a private operation because authorities wanted to transfer the risk of waste operations. Consequently this opened up the market for contractors to establish other, competing, facilities.

Procurement
Management
Generally, large value contracts let by government authorities have to follow strict procurement guidelines. However, due to the perceived urgency of the necessary works, some contracts were let to established and known entities without a full tender process. This included the demolition project management role by project management consultants RCP, the operation of BRRP, and the initial selection of contractors for demolition works.

Demolition
Contractor services were procured in a number of different ways. It is understood that private insurers predominantly tendered demolition projects (including debris management); EQC/Fletchers appointed contractors at approved hourly rates and approved quotes prior to work commencing; Civil Defence /CERA carried out works on a time and cost basis (using tendered rates) for small / non-technical / low risk demolitions, and tendered large technical demolitions.

CERA's 'selective procurement process' for demolition (where jobs were carried out as time and cost or were tendered depending on complexity) was based on a desire to: minimise front-end contract administration time and cost; maintain maximum control on programme of works; maximise control of work quality (including waste management); ensure that project risks sat with the most appropriate organisation; maximise economies of scale; maximise use of resources; and keep costs to a minimum.

Waste management
Payment for waste deposited at BRRP had to be charged (pre-treatment) at a per tonne basis because the private insurers insisted on only paying for one movement of waste.

4.3.2 Delays

Many of the demolition delays were not associated with physical works, but on approvals for demolitions to commence. These delays were due to a variety of reasons including slow insurance settlements, heritage approvals, building owner demolition refusals, and determination of building condition (and repair costs). These causes are noted but are not explicitly analysed here. Delays considered in this section are those occurring after buildings have been approved for demolition.

One of the major delays expected in the central city was a demolition contractor resource (human and equipment) shortage. However, this did not really eventuate. The major constraints on the programme were those described above and the physical constraints of working on multiple jobs in the confined CBD.

There were a number of delays observed on owner implemented jobs – primarily due to separation of waste materials on site and generally poor site management (particularly where buildings owners were project managing the works).

The establishment of a central waste receipt facility (BRRP) was remarkably quick; however, development of the full processing facility was comparatively slow. This had minimal effect on the recovery programme as material could be quickly movement to the facility. However, the delay, between receipt of materials and processing the material, introduced environmental and health and safety risks.

Overall, the demolition works have progressed at an impressive speed compared to other events studied by the author. The prohibition of material sorting on site for CERA jobs, and the directive hand taken by CERA on progressing demolitions, were two key components in this.

It is interesting to notes that a Fairfax Media poll showed that 60% of the people polled believed the demolition process in the CBD was as fast as could be expected (Hartevelt, 2011).

4.3.3 Organisational aspects

Organisation
General
Clearly different approaches were required for the demolitions and waste, compared to the management of the liquefaction silts.

The widespread nature of the silt deposits and the fact that the material was not ‘owned’ by the property owner, meant that a kerbside collection was the

only reasonable option for the materials. The assistance of thousands of volunteers eased the issue of who was to pay or carry out removal of the material from each property and the council could effectively implement a silt kerbside collection service.

The demolitions, however, do not lend themselves to a centralised kerbside collection approach. The payment structure (largely through individual insurance) and the volume of wastes generated, require waste management approaches specific to buildings.

Demolition
From an organisational perspective, the concurrent decisions by insurance companies, EQC and CERA, to centrally manage their respective workloads, were positive. First, cross organisational communication was simplified. If CERA or another party needed to disseminate or gather information regarding the recovery process the number of parties to be consulted was greatly reduced. For example, when the waste management team needed to map and forecast the waste management system, there were only 7 major organisations to contact. This improved works coordination, timing and prioritisation.

Second, these large organisations were, in general, more aware of the aggregate effect of certain actions. For example, the insurance PMOs appreciated the safety, cost (direct and indirect), and efficiency benefits of CERA managing all demolitions in the central city.

Third, resources (and the larger supply chain) could be more efficiently managed. Any shortages or problems would be more quickly identified on an aggregated scale in these few, large organisations. Smaller organisations would be slower to foresee potential problems as the resources would be spread thinly across a larger number of organisations.

Fourth, quality assurance of works was better affected using a centralised approach. It was alleged that immediately following the 2010 Canterbury earthquake some demolition operators were under-quoting demolition jobs and illegally dumping debris. In 2011, there were several instances where contractors, working outside CERA management were operating in unsafe working conditions (e.g. salvaging inside unstable buildings). The CERA process oversaw and monitored health and safety in conjunction with relevant regulatory authorities (predominantly Department of Labour).

There were also some negatives from a central process. One aspect that was difficult to manage was the cost incurred by the CERA demolition management office. Some insurers did not believe that this cost should be borne by them, or they were concerned by the value of the overhead – particularly when all insurance companies had already engaged contractors to oversee the demolition works. The value of the oversight is of benefit to the wider recovery and not necessarily to the individuals involved, so therefore they did not expect to have to pay.

The central approach was undermined by the ability for building owners to elect to carry out works independently. As discussed in Section 4.2.3,

approximately two thirds of property owners elected to carry out the works on their own behalf for financial reasons. This, of course, created a parallel demand for the resources. CERA had a clearly communicated demolition works plan. The plan aimed to systematically clear dangerous buildings in the centre city to sequentially reduce cordons and allow people back into the area. From a purely theoretical point of view it shouldn't matter who is doing the works – 'x' number of buildings should take 'y' number of days if there are 'z' number of contractors. However, private contractors were tendering for and signing legally binding contracts for volumes of works which sometimes they could not meet in the required time frames, thus concurrently reducing the pool of available resources for priority works, and also potentially causing delays on the particular buildings they tendered for. CERA had the ability to step in if delays arose, however, as discussed in Section 4.2.4 this was not practical in most cases. If CERA had been more assertive and definitive and managed demolition start times (and not just completion times) for particular buildings, this effect could have been managed.

In addition, this disaggregation of the simple centralised management approach meant that there was an increasing number of individual entities to communicate with, manage and gather data from. Rather than the 7 major organisations, there were an additional dozen contractors / project managers, building owners to deal with. For example, the CERA waste team consistently attempted to gather waste generation figures to assist in their forward forecasting. However, with no contractual or legal mandate to gather this data, individual contractors were far less willing (and less able in terms of record keeping systems and administrative resources) than the larger organisations.

The decentralisation also affected the transportation options. Initially it was envisaged that the transport fleet could be operated 'independent' of the demolition contractors. That is, a logistics company or manager would provide trucks to sites as requested, therefore allowing for greater efficiencies in the limited truck stock. Transportation of demolition materials was identified early on as a potential bottleneck (at the time of writing this had not been realised). Pooling of trucking resources also would have had the benefit of allowing greater visibility of the trucks – with trucks ideally linked into a GPS tracking system, loads would not be diverted (particularly high value loads like metal) and speeds could be monitored. Traffic light phasing and dedicated truck routes could also have been implemented to reduce travel times.

However, due to CERA's stance of allowing owner initiated works, and the reality of contractors switching between CERA managed and owner initiated jobs, a logistics managed fleet and a GPS system were not possible. As a result it is feared that some contractors took advantage of the systems by diverting high value loads such as metal and adding private disposal truck loads to CERA managed works. Ultimately, if CERA had managed all demolitions, a system would have been able to have been implemented with greater efficiencies and economies of scale. CERA could have considered signing the contractors into an exclusive contract, similar to Fletchers EQR. However, this would have either created public and political opposition by essentially

eliminating the possibility of owner initiated works and a free market; or no contractor would have signed and the demolition works would have been left to a market that would have potentially cannibalised itself or spiralled out of control (see Section 4.3.6).

Centralised management is an important tool in ensuring debris removal completeness. CERA established completion standards in the CBD which contractors had to adhere to. These included excavating basements and backfilling with gravel. A collection of individual contractors and property owners carrying out demolition works has the potential to leave sites in an array of different stages of completeness. The standards established were generally adhered to.

Waste management facilities
Operating a disaster specific waste management facility such as BRRP as an independent commercial facility meant that all the financial risk was borne by the operator. Consequently, the success of the earthquake recovery – which is dependent on an operational resource recovery facility - depended on an independent commercial entity. In the authors' view, a facility of such significance to the recovery of Christchurch and operating under such high risk and changeable conditions (in terms of volume and nature of waste received) should be managed publically to minimise risk of operation failure and resultant impacts of the wider community.

In fact in November 2011, the facility operation was transferred to the public / private entity Canterbury Waste Services Ltd. CWS is jointly owned between TPI and the five Canterbury Councils. This indicates that authorities realised the extent of the risks and that the facility needed to be closely managed to ensure the facility was available for the good of the recovery and the risks shared appropriately.

Significant risk to the BRRP operation was generated because it was operating independently of the demolition works. BRRP, therefore, had limited control or visibility over what materials it was receiving and was very vulnerable to changes in demolition practices. BRRP's original cost model included for 15% of the waste (by weight) to be metal which has a high recovery value. However, much of the metal was being separated at the demolition site and going straight to the metal salvage companies. Thus, BRRP had to revise its cost model for a reduced metal component (5%). This resulted in a need to increase the gate fee on the facility. BRRP was also dependent on receiving large volumes of waste. Subsequently, the increase in gate fee would likely reduce waste volumes received and negatively affect the cost model. A number of contractors established waste management facilities to support their operations. The planning and costs for these could be better managed because they could forecast waste quantities and quality.

Two possible actions could have mitigated this risk to BRRP. First, if CERA had achieved a wholly centrally managed process, waste quantity and quality would have been better controlled. This would have stabilised BRRP's gate fee and quite possibly reduced the gate fee as the risk of waste quantity and quality fluctuations would have reduced. Second, BRRP could not have

accepted waste from works not carried out by CERA engaged contractors. Thus, the quality of the material would have been more consistent. Quantity estimates may still have been hard to achieve. This second approach would also likely have caused downstream effects such as an increase in illegal dumping, increased pressure on peace-time waste facilities and more onsite recycling (which would slow down the demolition works and recovery).

With waste management activities spread over a large number of sites, waste forecasting and planning was difficult. BRRP was established to manage the entire waste stream, so capacity concerns were not critical in this case. However, determining if recycling markets were adequate was difficult. Treated timber, for example, was a waste stream without a pre-earthquake market. It was challenging for authorities to determine an appropriate management option without knowing the total volume of treated timber expected, where the sources would be (i.e. BRRP, contractor waste management facilities, direct from building sites) and what value disposal could be valued at to mitigate illegal dumping or disposal at Kate Valley landfill (not desired by authorities).

Procurement

Management

Some Christchurch City councillors expressed misgivings over the appointment of a number of contracts following the February Earthquake. Included in the contracts of concern was the selection of Transpacific Industries to operate the Burwoood Resource Recovery Park (BRRP) facility without a tendering process (Gorman, 2011). BRRP was originally established as an independent Joint Venture with two other companies. The only contract was for the lease of the land. The standard procurement requirements for leasehold selection are unknown. Regardless of the legal requirements, there was discontentment that a single entity had been given the opportunity to make a profit from the venture.

There are several reasons which, in the author's opinion, ameliorate the decision not to tender this particular (the BRRP) contract. First, a facility was urgently needed post event to take waste from the city centre to assist in search and rescue. In addition, a secure area was necessary to take building materials which may have been required for coronial or other investigations. The urgency did not allow for a tender process to be carried out. Second, the waste industry is small in NZ and TPI was arguably the only company with sufficient expertise and financial means to establish and operate a facility of this scale. This is demonstrated by the two original partners in the joint ventures withdrawing from the joint venture because the financial risks were too great. TPI was able to quickly make investment in plant and equipment to establish the required sorting facility.

Given waste was largely being stockpiled for over a year, it may have been possible to engage the contractors on a temporary basis before a formal tender process could be carried out for the long term operation. Once TPI made the large capital investment required, it became difficult for other contractors to buy TPI out. However, it is important to note that there may have been

difficulties in establishing a price for waste disposal if the long the long term waste recycling process had not been designed and costed.

When appointing contractors quickly in uncertain environments, risk management is very important. With limited time to make decisions and assess tenders, the value of existing relationships and work records become invaluable as a method of managing risk. If unknown operators were appointed, even at a 'lower cost' the potential negative (potentially financial as well as environmental and social) effects may outweigh the savings.

Demolition

To carry out the central city demolition works, a pool of contractors was gathered. The accreditation process established by Civil Defence / CERA was an effective, efficient and transparent way of organising and managing the contractor work force. It set a quality baseline for which contractors could be selected for various demolition jobs in the central city.

In the initial stages of the response, under Civil Defence, a time and cost approach was adopted due to the constantly changing extent and nature of the works. This approach meant that the demolition management office could move resources easily between jobs to ensure maximum efficiency. This was particularly important during the search and rescue phase where it was essential to make use of valuable international USAR teams.

From an administration and management perspective, time and cost contracts create more work than tendered contracts, particularly in terms of on-site supervision and contractor payments. However, this added administration and supervision also contributes to the quality control of the project. Greater control can be gained on works programme, methodology and quality. In peace-time time and cost contracts are often discounted because of the additional administrative effort required and fear that contractors will not work efficiently. However, in a post-disaster environment where resources are pooled and have to be maximised, the authors believe that this fear is not justified. It is beneficial to contractors to work efficiently so that they are given more work. The work for the contractors is then high volume and low risk. Contractors were generally happy with a time and cost approach. However, there were some who insisted on marketing their services, on a lump sum tender basis, outside the CERA process to building owners. This option, offers them potentially greater return but at a higher risk. And in turn, it creates greater risk to the CERA recovery programme, in particular by contractors trying to reduce costs (on their lump sum contracts) by salvaging more on site and slowing the demolitions. As the process progressed, the majority of contracts were let as lump sum contracts.

It is important to note here that some believe that the demolition workforce was not maximised due to the slow release of buildings for demolition (by insurance companies and building owners) and therefore contractors were not necessarily compelled to work efficiently on time and cost contracts.

Efforts were made to combine neighbouring buildings into one demolition contract to increase economies of scale. The slow and unordered nature of the

demolition approvals being received (due to the large number of stakeholders involved in approving each demolition) meant that this was difficult to achieve. Larger work packages would have lent themselves more to a tender process. However, because of this piecemeal and slow demolition approval process, there were a lot of small building demolitions contracts. The constant stream of small jobs was better suited to time and cost contracts as resources could be deployed quickly on rolling contracts and additional delays from preparation and award of tender packages could be avoided.

Some large demolition projects, such as the Hotel Grand Chancellor, were carried out as a lump sum contract because of the risks. In the authors' opinion this was justified. Methodologies applied to large scale demolition are largely contractor dependent based on the expertise, skill and equipment they have. It is difficult for a third party, such as CERA, to direct methodology and take the risk of cost overruns as well as health and safety risks.

The nature and cost of waste management also depends on the demolition methodology so a lump sum contract allows for contractors to consider their methodology in light of waste management costs. For example, explosives will generate very mixed waste particularly where buildings have not been stripped, whereas crane methods can pick some elements cleanly off the building. Therefore, the financial risks associated with debris disposal need to be tied into complex projects. While from an environmental point of view, guaranteed payment (via a time and cost contract) for waste disposal mitigates the risk of improper disposal, the financial risks associated with dealing with waste from a complex project are quite significant. Clear contract terms and good contract monitoring in a lump sum contract should mitigate potential for inappropriate waste management.

In the authors' opinion, risks during a recovery process should be held by persons or an authority with the overall recovery in mind, in this case, CERA. The collective risk of failure of the demolition programme in Christchurch is far greater than the risks considered by a series of independent contractors. Time and cost contracts removed the majority of risk from the contractors and placed it with CERA.

Cashflow

Cashflow became a problem for many contractors participating in recovery works. In particular there was considerable media coverage over the delays in paying contractors who carried out 'emergency repairs'. Any property owner could authorise "emergency repairs' to be carried out if the works were valued under $2000. Contractors could later claim this from EQC. However, a number of contractors' claims were not paid expediently due to investigations into the validity of the claims. Under CERA, a process was established several months into the recovery effort whereby contractors were paid directly from a revolving credit provided by the government. The contractor would charge CERA, the Crown would pay and the costs would then be recovered from the property owner who would have to submit the claim to the insurer for validation and payment. This ensured that contractors could continue operating without lengthy claim settlement delays.

One of the benefits of the time and cost model was that the contractor did not receive the invoice for the disposal fees. This reduced one link in the payment chain. The dedicated disposal facilities would charge CERA directly meaning payments could be made within a month of invoice. If contractors had received the invoice and charged the invoice on to CERA, payments would likely have been delayed a further one to two months. Contractors carrying out tendered projects, however, included waste disposal in their tendered price and therefore would have to pay the disposal costs, charge CERA and then wait for reimbursement.

4.3.4 Legal implications

Organisation

Demolition

The CER Act, very importantly, included a mandate for CERA to monitor works and ensure that demolition works were carried out within CERA's recovery timeline. This was essential to ensure all the various stakeholders, with different objectives, were working towards a common recovery goal.

While the CER Act included for CERA to monitor works, it only allowed for CERA to manage works if building owners were not meeting CERA timelines. Thus, potential efficiencies from central works management (as discussed throughout this section) could not be realised. It is believed that there was not political will to remove property owner rights within the legislation and order CERA management of all works. If central management of demolition works is desired in future events, adequate legislative structures would need to be in place.

Waste management

As discussed in Section 3.3.4, there were changes made in the Building Act following the September 2010 earthquake. In particular, the requirement for demolition consents for detached buildings three stories or under was removed. While this reduced the administration demands and potential bottlenecks, as desired, there were unexpected consequences. This, in effect, removed regulatory visibility and control on the demolition works, in terms of methodology, traffic management and waste management. While there are overarching regulatory controls in place, such as the Health and Safety in Employment Act and the Resource Management Act to regulate contractor activities, without a consent or approval process, authorities do not know which works are taking place, and so cannot efficiently deploy resources to monitor the works. In particular, there was concern within Civil Defence and CERA that demolitions were taking place and waste from the demolitions were not being disposed of at approved facilities. The increased level of illegal dumping observed by ECan (Sachdeva, 2011b) supports this concern. Without visibility at the front end, authorities are put in a reactive position, essentially acting when negative actions are taken, such as illegal dumping. A consent or approval process would likely act as a deterrent for improper practices.

The centralised approach developed by the insurance companies and CERA were an effective way to establish controls where regulatory controls were inadequate. CERA and some of the insurance project management offices

established standard operating procedures for waste management that met or exceeded regulatory requirements. CCC and ECan worked with the project management offices to ensure proper practices were being met. Independent contractors, on the other hand, had neither regulatory nor organisational controls.

In addition to this, CERA chose to use the monitoring powers in the CER Act for works in the red zone to require demolition documentation, which included a traffic management plan, demolition methodology and waste management plan (CERA, 2011b). Therefore, even independent contractors working in this area could be monitored as would be the case if demolition consents had still been required.

Procurement

Management

Clause 94 of the CDEM Act allows certain delegated persons to enter into contracts for the purposes of the Act without regard to the Public Contracts Act 1959. The appointment of RCP as the project manager for the central city demolitions was carried out during the civil defence emergency period. Despite this the appointment was publically criticised and the additional costs required were questioned (Williams, 2011a).

The CER Act does not include any powers that supersede the requirement of the Public Contracts Act, other than Clause 28. This clause allows the CERA Chief Executive to specify Council contracts which it must approve.

Demolition

Consideration of waste ownership issues was extremely important. Immediately after the earthquake, under Civil Defence directive, all salvage rights for contractors were frozen. This was a very important and publically well received initiative. However, there was concern contractors were flouting this rule and were taking and selling personal material salvaged from buildings (NZPA, 2011a; b). Damaged buildings contained personal items, intellectual policy, confidential information etc. which had to be carefully managed, and where possible returned to the owners. There are also insurance implications which generally include that where contents can be salvaged, these items will be removed from the insurance pay-out.

As the Civil Defence / CERA demolition process matured, in May 2011, waste ownership issues were written into the demolition contracts. The different contract types (time & cost and lump sum) required different approaches to waste ownership. As outlined in Section 3.5.6, for time and cost contracts, the waste was essentially owned by CERA. CERA assumed the risk (Section 4.3.3) and the responsibility for ensuring appropriate management of all the waste components. Contractors were instructed where and how to manage each component of the waste.

Under the lump sum contracts however, the ownership of the waste, and therefore any profits gained from the waste, belonged to the contractor (unless some or part of the waste was excluded in the contract documents). Thus

there was much less control on management of any personal items that were found during the demolition process.

With the high tangible and intangible value associated with contents of earthquake damaged goods, waste ownership is an important consideration. The time and cost contracts had a significant advantage in the clarity around ownership of valuable personal items uncovered during demolition. By having standard contractual clauses, and by having an expected standard of behaviour established before an event, instances of improper waste salvage would be mitigated.

The ownership of the waste and therefore legal responsibility for it also had environmental impacts. These are discussed in Section 4.3.5.

Waste management facilities
There was some concern expressed within the CERA demolition team that the centralised process might be challenged for being anti-competitive: in particular, the directive that for time & cost contracts, during the initial stages of the response, all waste should be directed to one of four locations:

- all mixed waste should go to BRRP
- all scrap metal to Sims Pacific Metals
- all concrete and brick material should go to Lyttelton
- all asbestos contaminated waste to Kate Valley

No formal process had been carried out to select these sites. This was because there was no time to carry out a formal procurement process and the scope of the works was very unclear (such that contract quantities would be hard to define). If no sites had been identified (or there was a delay in waiting for sites to be identified) then there would have been far higher consequences to the recovery (i.e. stalled recovery, illegal dumping etc.).

The above sites were chosen simply because they were the most appropriate and seemingly cost- effective destinations for the waste streams. Burwood was the only site capable of taking the volume of mixed wastes anticipated; Sims is the only commercial exporter of scrap metal in Christchurch and had the equipment and space to handle the materials; Lyttelton was the only free disposal location for concrete and brick at the time; and Kate Valley was the only facility authorised to accept asbestos waste in Canterbury. Best endeavours were made to ensure that contractor rates and waste management costs were reasonable for all these facilities. For example the cost model for Burwood was reviewed by a representative from the Auditor General's office. To date there has been no legal action on these grounds.

In addition to the lack of regulatory means to collect data and monitor waste management activities of demolition contracts described above, there was insufficient regulatory means to gather data from the diverse range of waste management facilities in operation. As described above, this lack of access to data made planning and identification of potential bottlenecks difficult. In the future it would be highly beneficial to have data collection systems in place and operational pre-disaster. A consultants study carried out to investigate

the potential for gathering this data post-earthquake concluded that while the data would be useful, it would be difficult to get full participation from all waste handlers (from demolition contractors to recyclers to disposal facilities) without regulatory means. And even if regulatory controls were in place, the reliability of operators to supply appropriate and accurate data in a timely manner may be difficult to achieve.

4.3.5 Environmental Organisation

Demolition

In general, the centralised approach was very positive from an environmental point of view. As discussed in the previous section, where regulatory controls were insufficient and/or there were inadequate resources to monitor every contractor and every worksite, the centralised management structure offered a pseudo control mechanism. The insurance PMOs and CERA had established environmental procedures and all contractors working under these umbrella organisations were expected to adhere to them. In many cases the project management offices liaised with the relevant authorities to ensure their procedures were adequate and in turn monitored their contractors for compliance. This significantly reduced the requirements on the under resourced regulatory authorities who were faced with monitoring significantly more demolitions than in peace-time.

Waste management facilities

The decision to make BRRP an independent commercial venture had some potential environmental impacts. Within the waste stream there were several components that did not have existing recycling markets. In particular, the large volume of treated timber waste caused significant concern. There were no existing markets for treated timber and disposal at Kate Valley landfill was expensive, impractical and not necessary from an environmental point of view. As an independent commercial operation, BRRP sought independently to solve their own disposal / recycling solution for treated timber. While the operators, TPI, worked with local environmental authorities to determine a solution, the solution was largely driven by economics. Opportunities for benefit to the wider community, for example, through development of waste to energy technologies or other, may not have been realised.

The decentralisation of the demolition process and subsequent establishment of multiple waste facilities, added to this problem. Each individual contractor had a portion of these challenging waste streams. First it was hard to estimate total quantities of each waste component. Second it was unknown what "cost" each contractor had allocated for disposal of the component (necessary when comparing recycling options). Third there were commercial sensitivities among contractors as each tried to find disposal / recycling options. All of these factors made assessment and comparison of alternative options difficult, particularly where options were dependent on economies of scale. Each contractor owned the risk of their own waste but no one officially owned the risk of the disposal on a city wide scale. ECan and CCC of course could authorise certain activities to be undertaken but no-one was developing the

overall strategy. This seemingly fell outside CERA's brief and the opportunity to drive sustainable waste management practices was lost.

Procurement

Management

The absence of a tendering process likely had a fairly neutral effect on the environment. The contractors were selected based on their capabilities. If a contractor had a poor environmental record they would not have been selected. If a tendering process had been in place, contractors would have been assessed for their environmental capabilities, thus the absence of a tendering process had likely minimal environmental impact.

Demolition

The decentralisation of the demolition works and the gradual shift to lump sum contracts created an incentive for contractors to establish their own debris management sites. Subsequently a number of debris management sites emerged across the city, established by contractors trying to minimise waste management costs on their lump sum tender contracts. Many of these facilities were not legal and posed potential environmental and public health hazards (Williams, 2011b). There was concern that some contractors had underestimated the costs involved in handling the waste and would not be able to pay for the residual waste to be disposed and the site to be remediated. Christchurch has a history of mismanaged waste management sites. At the time of writing most sites were still in the early stages of operation and it is unknown if there will be any legacy issues.

The time and cost model, on the other hand, reduced incentives to 'cut environmental corners'. Contractors were directed what to recycle, when and how and were directed which environmentally approved facilities to take material to. Contractors had a guaranteed profit margin.

Waste management

As discussed in Section 4.2.5 and above, the 'oneshift' policy by insurance companies for waste management does potentially introduce some environmental issues. There is a possibility that contractors may not have adequately calculated waste management costs. Legacy issues may be left.

4.3.6 Economic

Organisation

Demolition

The centralised process provided many opportunities for direct costs to be reduced. Economy of scale benefits through coordination of works, synergy of waste transportation, and negotiation of high volume goods and services contracts, were possible. However, generally, it is believed that true economies of scale were not realised in the CBD due to the disaggregation of the centralised process. As discussed elsewhere in this report, contractor trucks spread across both CERA managed and individually managed sites meant that transportation efficiencies were not always possible. Negotiation opportunities for goods and services contracts were lost because the market was spread across CERA and over 200 other contractors.

For example, during the development of the Civil Defence / CERA managed demolition process, the waste management team endeavoured to establish bulk supply contracts with waste handling facilities, in particular, scrap metal dealers, concrete crushers and native timber dealers. The aim was to reduce the overall cost of demolition by securing high resale or low deposition values. However, due to the unknown scope of the CERA demolitions (due to private building owners opting to demolish their own buildings and the lack of information held about the composition of the building stock), a reliable estimate for expected material volumes was not available. Tenders, therefore were difficult, if not impossible, to establish. If CERA had assumed full management of all the CBD, the expected quantities would have been easier to estimate and bulk supply deals could have been arranged. Thus while competition was introduced, opportunities were lost for economies of scale. The relative scale of these effects is not known.

The centralised management provided an opportunity to informally regulate the demolition market to avoid price gouging. CERA, for example, asked all contractors to tender their labour and plant rates. CERA ensured that rates were appropriate, and if they were not CERA had the organisational influence to ask for prices to be reviewed. Those that provided lower rates received more work. The owner implemented projects called for individual tenders. Individual building owners are generally not in a position to negotiate lower prices where price escalation has occurred. If work is plentiful and resources are scarce, price escalation is a real possibility[7]. The authors were not able to gather sufficient data from individual demolition projects to ascertain whether price gouging was occurring on owner implemented jobs following this event.

The time savings made through efficient use of resources and greater quality control on programme (both prioritisation of projects and project duration) had significant indirect economic benefits to insurers and Christchurch. Business loss insurance payments were reduced as areas of the city could be progressively reopened, and as areas were reopened economic activity was revitalised.

Overall it was anticipated that the centralised process would reduce overall demolition costs.

Waste management facilities

The main reason that BRRP was established as an independent operation was to transfer the risk of the operation from government authorities. However, in accepting the risk, BRRP in turn transfers their financial risk to the customer by charging a premium on the disposal fees. If the operation exceeds its profit forecasts then that represents money that has effectively been diverted from the rebuilding efforts (where insurance policies are for fixed values).

If the operation is unsuccessful, and the contractor cannot afford to remediate the site, they may walk away from the operation, leaving a legacy issue and a financial burden for local or central government.

[7] Note that this is based on anecdotal evidence and at the time of writing, we do not have any data or analysis of the costs of tendered vs time and cost projects.

Some believed that the independent commercial operation of BRRP allowed for competition to develop and to keep prices competitive. However, the actual result of maintaining BRRP as an independent operation, and open to competition was that the gate price at BRRP went up. Contractors set up, what became, pre-sorting sites and started taking only their hard to separate, low-value waste to BRRP. The reduced the quality and volume of waste at BRRP – both affect the economic viability of the operation. The reality was the BRRP was performing a function which no other operation in Christchurch could achieve – large-scale, manual and mechanical waste separation and processing. The allowance of multiple waste management sites to be established significantly affected the economics of BRRP. Savings were seemingly made at the demolition, however, costs may be later incurred if BRRP cannot complete its clean-up operation or if BRRP closes and that waste has to go to Kate Valley without the high level separation possible at BRRP. This is a financial risk to local, regional and national government.

Procurement

Demolition

Some stakeholders, in particular insurers, were concerned that time and cost contracts did not generate sufficient competition and as a result were advocating for lump sum tender processes to be carried out. Initially time and cost rates were established using the Bluebook (industry-accepted, standard, contracting rates). However, as soon as practical, contractors in the Civil Defence / CERA pool were required to submit tendered rates to introduce competition and reduce rates. Contractors were advised that those that submitted lower rates would be given preference when allocating jobs, provided they had the required skills. This approach introduced competition without requiring a tender process.

In terms of the CBD demolition, without access to sufficient data and with the difficulty in assessing the indirect costs (such as business loss, social disruption, future environmental remediation costs), it is hard to ascertain whether the lump sum or time and cost projects were the most cost effective. Typically lump sum contracts were used on buildings where more salvage was possible and thus disposal costs were lower.

Generally however, the authors observed that individuals and organisations involved insisted on business as usual practices, without recognising the different demands and constraints of a post-disaster situation. 'Free market' principles were applied to the demolition despite the context being significantly different to 'peace-time'. When demolition contracts were slowly released to the market there was stiff competition between contactors trying to secure jobs. Contract prices were driven so low that authorities knew that the work would not be possible to achieve in the time desired and within expected environmental and public health standards. Rather than taking a financial loss, works tended to slow down to allow for cost savings (demolition time stats). On the other hand, when there was an oversupply of work, contractors were able to inflate prices. Generally this latter scenario led to a timely clearance of the city but at a higher price. Contractors wanted to finish the job quickly in order to move on to the next one before the contracts dried up again. This shows that in a disaster the market doesn't have time to adjust. A

free market works when there is time for the market to adjust to the new conditions – in this case a desire to move quickly and minimise social disruption.

Waste management
Because of the lack of control on the waste received at BRRP, the operators were taking on a high risk and this was reflected in their price (Williams, 2011c). As a consequence, the higher price caused contractors to sort more on site before taking to BRRP. As the quality of waste deteriorated at BRRP, the price was forced to rise again. If a cradle to grave type approach was utilised demolition contractors and BRRP would have shared both the risk and the reward. In particular benefits from any valuable material recovered, no matter where in the process it was recovered, would have been shared. Thus contractors would have been able to more easily determine when salvaging onsite or offsite was better value. Many individual contractors essentially had cradle to grave systems in their business as usual – where contractors would operate their own waste sorting sites. The scale of this event, concern over environmental issues and lack of appropriate sorting sites meant that relying on small contractor-run sites would not meet the demand. A central facility offered far greater economies of scale and reduced environmental risk. The economic risk, however, was not as carefully considered as it could have been.

There was some concern that the time and cost model, where waste was directed to four specific locations, might disrupt the local waste management and recycling market. At the time of writing there had been no evidence of that occurring, other than a slight shift in economies of some markets. The concrete crushing market for example was initially unable to compete with the free disposal at Lyttelton. However, the concrete crushing industry was able to evolve, primarily driven by partnerships with demolition companies, so that it could continue and at the time of writing had actually out-priced the free disposal at Lyttelton. Some splitting of the market between the Lyttelton reclamation and concrete crushing operations was considered; however, due to implementation difficulties (particularly given the markets had different prices) this was not possible. Overall, given that the time and cost contracts in the CBD were only a proportion of the total demolition works, the effect on existing markets was minimal.

4.3.7 Social

Organisation

Demolition
Centralised management of the demolition works in the CBD was essential to mitigate health and safety risks for workers. In the CBD there were a large number of demolitions being carried out in close quarters. CERA maintained oversight of all demolitions in this area. Dedicated transport routes were established, contractors were aware of works in close proximity, and the location of all contractors was known in the event of an earthquake. For owner implemented projects CERA had no legal or contractual mandate to perform this role, however, CERA did this out of necessity. Should any problems arise, CERA was in close communication with DOL. A fully

centralised approach would have allowed CERA to more fully control, rather than just monitor, health and safety in the central city.

The disaggregation of the centralised process gave an opportunity for some contractors to engage in behaviour that was risky to worker and public health and safety. For example, there were several instances noted where contractors, working outside the CERA management were operating in unsafe working conditions. In one instance, on the same day as a sizeable aftershock, contractors were found salvaging building contents inside a building deemed too unstable to enter by CERA engineers. There was also concern from the public and CERA that some contractors would not handle hazardous materials properly. In particular release of asbestos particles presented a major concern. While DOL was present in the CBD, it was impossible to monitor every worksite due to the volume of demolitions being carried out. Thus, it is not possible to say whether the fear of asbestos and other hazardous material was well founded or not. However, given the discovery of illegal dumping of asbestos (Wright, 2011), it is reasonable to assume that the fear was justified. A fully centralised management approach would have mitigated this effect.

Many disaster affected communities identify the use, or lack of use, of local labour as an important contributor to community recovery. In Christchurch however, contractors and the community generally appeared content with the demographic of demolition contractors. In some cases international assistance was welcomed for complex demolition work and the increased numbers of competent contractors. Very few instances were noted where overseas help was unwelcome. In other areas of the recovery, such as insurance claims assessments and skilled tradespeople for rebuilding work, international assistance was portrayed negatively in the media.

The improved efficiencies, resulting from centralised management, discussed in previous subsections of Section 4.3 clearly reduced the time for demolition. Public pressure was high for the CBD to reopen, both in terms of contributing to the grieving process and to restart the rebuilding process (Sachdeva, 2010).

Waste management facilities

Operating the waste facilities as private entities, as discussed in Section 4.3.3, places at risk not only the waste management site's success, but also potentially the overall recovery. One of the elements of risk the waste facility operators must manage is public and worker health and safety. The proliferation of independent waste management sites certainly raised concerns from the public. Many residents neighbouring the various waste management sites expressed concerns over risk to public safety. At the time of writing there was no evidence of adverse public health effects from these sites, nor were there any instances where the public complaints led to closure of any sites. However, evidence following other disasters (such as Hurricane Katrina (Luther, 2008)) suggests that public health concerns can lead to facility closure, which in turn reduces waste management options available to the recovery process. Managed centrally by an organisation that has wider recovery objectives in mind, management of these public health risks and perception issues may be better achieved.

Procurement

Management

The decision not to tender several of the contracts involved in the demolition and debris management works had a negative social impact. There was some negative media indicating that the absence of tendering was unacceptable, which influenced public opinion. However, these issues were in parallel with a number of other recovery issues. Therefore, it is difficult to determine the degree to which contract management for demolition and debris management had a negative social impact. In the authors' opinions, the affect was minor, particularly due to the fact that the absence of tendering would not directly impact the majority of people.

Demolition

The time and cost model adopted, as discussed in the environmental impact (Section 4.3.5), introduced greater quality control. In terms of health and safety effects, if contractors were directed by CERA to meet certain standards under a time and cost model, contractors had no incentive to not follow the directions given: the Contractors' profit margins were guaranteed. This is as opposed to lump sum contracts, where contractors stand to increase their profit anywhere they reduce works required. Health and safety is one area which can be neglected as it does not generally affect the project deliverables, and therefore payment. As identified earlier in this section, there was evidence to suggest that contractors were in fact opting to reduce standards: by disposing asbestos illegally and sending staff into buildings that were unsafe. However, it is believed that these instances were outside the managed process, and were more a result of poor oversight rather than contract type. CERA monitored all CERA managed contracts (lump sum or time and cost) to ensure health and safety standards were met.

The sensitive issues around personal property within damaged buildings can be controlled through appropriate contracts and/or organisational controls. Personal property was salvaged from several buildings in the CBD without owner permission. Tenants, in fact, had been told no salvage was possible. Despite this, personal materials were found in demolition and salvage yards. It is likely that demolition contractors were salvaging goods to reduce cost of demolition as well as for individual gain. As discussed above, contractors have incentive to reduce costs if lump sum contracts are used.

Waste management facilities

The social effects due to the payment mechanism for waste facilities are largely economics driven. These have been discussed in the previous section.

Residential red zone

The central coordination of the demolition works has enabled communication and consultation with affected communities to be more effectively managed. Prior to an effective coordination structure being put in place, properties were being demolished without the owners being notified. The attempt to bundle works together geographically (to managed health and safety and traffic management issues) has the potential to reduce the impact of the demolitions on the remaining population. Concentrated consultation and engagement can

be carried out prior to demolition and health and safety and traffic management issues can be better managed.

4.3.8 Summary

The central management approach adopted by most insurance companies and CERA introduced opportunities for efficiencies and quality control. Unfortunately, in the CBD, CERA's centralised management was not compulsory. Disaggregation meant that a lot of control of the recovery programme was lost and as a consequence the demolition times increased.

CERA's selective demolition procurement strategy was effective. It allowed for simple, low risk jobs to be carried out quickly and efficiently with little administrative time and cost and with greater opportunity to efficiently share resources across the city. The higher risk jobs were justifiably tendered out to ensure prices were competitive and risk of cost overrun rested primarily with the contractor.

The BRRP model, however, was not ideal: the large amount of risk borne by the operator, largely due to the unknowns in the waste matrix, considerably increased prices and project risk.

Table 4-3 summarises the strengths and weaknesses of the organisations of the physical works.

Table 4-3 Christchurch Earthquake implementation strategy assessment summary

	Strengths	Weaknesses
Organisational	• Centralised management simplified cross organisational communication. • Centralised management was cognisant of global impacts of activities. • Smaller number of larger organisations was better able to manage and forecast resource demands and shortages. • Centralised management provided good quality control. • By selecting known contractors, potential environmental, social and financial risks were reduced. • Centralised management ensured completeness of works and consistency between worksites. • Time and cost contracts allowed for resources to be maximised and deployed quickly for simple jobs. • Time and cost contracts placed demolition (recovery) risk on CERA for simple jobs. • Large, complicated jobs were tendered and risk rested with the contractor.	• Benefits of the centralised approach was undermined by the ability for individuals to manage their own works. • Data collection from a large number of organisations was difficult, which affected forward recovery planning. • Some efficiencies, e.g. transportation fleet management, were lost due to disaggregation of the centralised process. • Some contracts were not tendered. • Time and cost contracts generated more on-going administration. • In lump sum jobs, waste management costs were sometimes included as an extra. This adds considerable financial risk to the Principal.

	Strengths	Weaknesses
Legal	• CER Act allowed for monitoring of works to ensure CERA recovery timelines were met. • Centralised management structures created organisational controls in the absence of adequate regulatory controls. • Salvage rights freeze for contractors mitigated improper ownership of waste. • Time and cost contracts mitigated improper ownership of waste.	• CER Act did not allow for CERA to manage all works. • 2010 Building Act changes removed requirement for demolition consent and therefore visibility on demolition activities. • Waste ownership issues for lump sum contracts were more difficult to control. • Concern expressed that centralised process was anti-competitive. • Insufficient regulatory means for data collection from contractors and waste management facilities
Environmental	• Centralised PMOs generally monitored contractors for environmental compliance, reducing the demands on under resourced regulatory groups. • The time and cost model reduced incentives for contractors to 'cut environmental corners'	• Recycling decisions by privately owned waste facilities were largely influenced by economic drivers. Social or environmental benefits may have been missed. • The large number of private waste facilities reduced opportunities for recycling options where economies of scale were required. • Lump sum contracts created an incentive for contractors to establish their own waste management facilities – some of which were illegal and/or poorly managed.

	Strengths	Weaknesses
Economic	• Centralised management systems acted as informal market regulators to reduce potential for price gouging. • Centralised management reduced indirect costs to insurance and Christchurch through efficient use of resources and programme control. • Contract time and cost rates were tendered to introduce competition and reduce cost. • Time and cost contracts reduced risk of environmental remediation costs in future. • Time and cost model had little impact on existing recycling markets.	• Disaggregation of the centralised process in the CBD meant economies of scale could not be fully realised. • The financial risk transfer of the operation of BRRP was ineffective: if the operators have over or under estimated the gate price, the community will end of paying in the rebuild or in the environmental clean-up. • The commercial independent operation of BRRP opened it up to competition which in turn reduced economies of scale and increased the price of the operation. • The financial risk for BRRP could have been reduced by coupling the operation with demolitions to secure quality and quantity of waste. • Many organisations insisted on business as usual practices and expected the free market to respond as usual.
Social	• CERA maintained oversight of the congested work environment in the CBD to mitigate health and safety risks. • Limited contract tendering had a minor social impact. • Both local and international contractors were used as and when necessary. • Time and cost contracts reduced incentives for contractors to reduce health and safety standards. • Coordination of demolition works in the residential red zone allowed for opportunities for better community engagement.	• The disaggregation of the centralised project led to concerns of improper handling of hazardous material and subsequently public and worker health and safety concerns.

4.4 Factor 4: Environmental standards

4.4.1 Approach and rationale

In general, environmental standards pre-disaster were maintained during the earthquake recovery. There were some exceptions and these are discussed in this section.

Recycling

Recycling was included in the debris management plan for many reasons:

- To reduce waste going to landfill and therefore disposal costs[8]
- To avoid bottlenecks in the transportation of waste to Christchurch's regional landfill.
- To optimise cost recovery and the environmental benefit of beneficial reuse and recycling.
- Maintain Christchurch's 'green image'.

Recycling could either be carried out at the point of demolition (site separation) or offsite at a recycling facility. To ensure a fast demolition a 'quick pick and go' model was established. This enabled 'clean' debris that could be easily and quickly removed from the buildings to be directed straight to market while the remaining mixed waste could be sent to a recycling facility for separation, processing, recycling and disposal. The aim of this approach was to maximise speed of demolition but also to balance costs and environmental impacts. While this was initially implemented, as the recovery progressed, the buildings being demolished were more stable, buildings were slower to be 'released' for demolition and resources were not at a premium, more and more recycling was carried out.

There were no existing facilities in Christchurch that could recycle the quantity of waste expected over the duration of the recovery works. Therefore an additional site or sites were required to function as resource recovery parks. Due to the drinking water aquifers that lie under Christchurch, there were limited sites suitable for medium term storage and processing of materials within feasible distances. It was decided that one or two large sites would be best. The former Christchurch landfill site in Burwood forest was identified as the most suitable location for a facility: located 10km from the CBD, on the east side of Christchurch (close to the worst affected suburbs) and with an underlying aquifer that discharges toward the coast.

Temporary storage

As discussed in Section 4.3, because of the decentralisation of the demolition works and the tendency toward lump sum contracts, a number of contractors also established recycling facilities. A number of these were established using an Order in Council established under the CER Act to enable temporary storage of materials incidental to construction works. It is believed the order was issued and written without due consideration of the potential interpretation of 'temporary storage' 'reasonably incidental to any

[8] Waste disposal at Christchurch's regional landfill is, generally, the most expensive waste management option, partly due to the distance from Christchurch (80??km) and the requirement to use specialist trucks (requiring double handling between demolition trucks and closed landfill trucks).

construction work undertaken'. This is understandable given the short time the legislation was written in.

Disposal
Approximately one week after the earthquake, the LPC began advocating for approval to receive inert materials (concrete, brick and rubble) to reclaim land at its port facility. LPC had already designed the reclamation and had an application pending at the Environment Court at the time of the earthquake. Lyttelton Port Company claimed the reclamation would save an estimated $90million (due to free disposal fees) and would ensure the Port could continue economic activity given the damage sustained in the earthquakes. An Order in Council permitting the reclamation activities was granted on 23 May 2011. The Earthquake and Environment Ministers justified the OIC for the following reasons (Brownlee and Smith, 2011):

- To ensure continuing economic activity of the port to avoid the fate of Kobe after the 1995 earthquake in Japan: Kobe port declined from 15th to 30th most productive port in Japan following the earthquake.
- The need to manage building supplies for the rebuild through the port.
- To allow LPC to carry out extensive repairs on its existing wharfs.
- To provide additional space at the port.

Due to the high cost of disposal at Kate Valley, and logistical difficulties in transporting the waste, a decision was made to allow for disposal of residual construction and demolition wastes (after sorting) in a low-engineered landfill cell at the closed Burwood landfill site.

Waste levy
In New Zealand a waste levy is imposed on all waste going to landfill, on a per tonne basis. Following the 2010 September earthquake, the Minister for the Environment, Nick Smith, announced that the waste minimisation levy would be waived for all earthquake generated waste to reduce the cost of the clean-up. The levy will not be reinstated until the clean-up is complete (Smith, 2010). [Note it is unclear how it will be determined whether waste is earthquake generated or not and when the clean-up will be 'complete'].

4.4.2 Delays

The degree to which recycling was carried out potentially had a direct impact on the speed of the demolitions. That is why the 'quick pick and go' method was initially implemented. When resources were maximised in the early stages of the demolition, this initiative definitely reduced delays in the demolition process. At the time of writing however, the limiting factor on the speed of the demolitions was not the degree of recycling carried out but the speed at which agreements were reached between building owners and insurers regarding demolition. Therefore no delays could be directly attributed to the level of recycling being carried out.

LPC experienced delays in the approval of the reclamation and issuing of the OIC. However, it must be noted that this was a delay to a private operation and this did not impact the wider recovery works and alternative disposal and

recycling sites for concrete were available (with marginally higher costs). The delay in processing the OIC is considered reasonable given that the reclamation did not immediately affect the recovery works and the complex social and environmental issues that needed to be considered prior to approval.

BRRP also experienced delays in getting consent to operate. However, because the operation was deemed essential to the recovery efforts under the CDEM Act, BRRP could operate immediately.

The operations at BRRP on the other hand took some time to be established. Because the facility had never been planned or considered before the disaster, there was a lag time for the recycling plant to be designed and/or sourced from overseas. As a result, waste materials were stockpiled for approximately 14 months before any recycling commenced. As for the LPC reclamation, this delay did not directly affect the recovery, however it did increase the possibility of adverse environmental effects (see Section 4.4.5).

It took several months to decide whether or not to construct a low-engineered disposal cell at Burwood landfill. As there was also a delay in established the BRRP processing facility (above), there was not effect on the overall waste management process. The delay in approving this facility primarily affected BRRP, as they were unable to accurately forecast the costs to operate BRRP (if costs for residual waste disposal were unknown). This delay also, consequently, affected contractors and their ability to accurately price for demolition works.

Generally there were no significant recovery delays caused by environmental factors.

4.4.3 Organisational aspects

Recycling

As discussed in Section 4.3, the implementation strategy largely influenced the environmental approach taken during the recovery. Where central organisations were controlling demolition works, recycling strategies and standards could be set. For demolitions carried out independently, contractors were able to make their own choices with respect to recycling. Primarily this was driven by economics. With high disposal fees in Christchurch, recycling is economically favoured. If fees were not so high, the regional landfill may have been overwhelmed with material and the recovery could have been significantly affected. At no stage was a mandate requiring recycling considered.

The permitting of concrete crushing in the CBD had some organisational benefits. While the time to clear the demolition site was inevitably longer, the pressure on truck resources was reduced. Because materials were required to fill basements of demolished buildings (for safety and stability reasons), there was no longer a need to cart away concrete materials to the south of the city and import gravels from the north and west of the city.

Temporary storage
Generally environmental standards were set by the local and regional authorities, CCC and ECan respectively. A collaborative working group was established between Civil Defence / CERA and key representatives from the all councils (also discussed in Section 4.1.3). This group aimed to address environmental issues affecting, or caused by, the recovery. For example legislation that was preventing necessary waste management actions to be carried out or negative environmental effects (eg illegal dumping) resulting from recovery related policy. Collaboration efforts would have been greatly assisted if the councils had established relationships pre-earthquake.

Many contractors expressed confusion over the need to gain consent from both councils for certain activities. While this is accepted in peace-time, it appeared to be more confusing and cumbersome post-disaster when contractors wanted to proceed quickly with their activities. For example, temporary storage site OIC applications were generally made to CCC as they had a clear application system established (ECan was slower to establish an assessment system). Initially CCC would grant consent with a note (amongst others) that stated ECan approval may also be required. A number of applicants either ignored or did not see this provision and established sites without the required ECan approval. This situation could potentially lead to negative environmental effects. To mitigate this, the above working group ensured that applications received by CCC were shared with ECan and a joint approach to application assessment could be made. In future events, a single application process, with joint council approval may be more efficient and clearer in a post-disaster environment. In the author's opinion this role should sit within the recovery authority (CERA) with direct lines of communication to the council environmental authorities. This would also enable environmental decisions to be balanced against the recovery needs.

Disposal
Some environmental decisions were made at national level, with limited consultation with the operational teams working for Civil Defence or CERA. The LPC reclamation was an example directly related to waste management where there were decisions made at national level with little consultation with operational staff. The initial appeal by LPC to construct a reclamation using earthquake debris went directly to national level decision makers. The Civil Defence waste management team only became aware of the proposal by chance. It is noted that the reasons for granting the OIC stated by Brownlee and Smith (2011) (Section 4.4.1) focussed on the benefits of ensuring the Port remained active rather than as a solution for waste management activities, however, the introduction of a new disposal facility has implications on the waste management process.

The decision to dispose of material in a low-engineered cell at Burwood landfill was largely driven by a private entity advocating a public good. That is, TPI was operating BRRP and could see that cost savings could be made to them and subsequently building owners / insurers if a low cost disposal facility was provided for.

4.4.4 Legal implications

Recycling

As discussed in the previous section, there was no legal mandate on what level of recycling should be achieved. Thus, primarily the decision to recycle was driven by economics.

Regulatory measures were required to enable some recycling facilities to extend their operation's size to meet demand. In particular a number of consents to crush concrete were received – both on demolition sites and at waste handling facilities. It is understood that these consents were generally managed under the discretionary powers within the RMA. For example, in the CBD, ECan elected to take a non-enforcement position on the use of concrete crushers in the CBD and did not require consents for concrete crushing in the cordoned area. The basis for this decision was that noise and dust effects (generally the primary concern from concrete crushing activities) were not of a concern within, what was essentially, a construction zone. CERA developed some concrete crushing guidelines, in consultation with ECan and CCC, which contractors had to meet in lieu of obtaining consent. The effects based and discretionary elements of the RMA enabled recovery needs to be met.

The discretionary approach of the RMA, however, meant that the market / private contractors were at the whim of the persons or authorities implementing the RMA. And as discussed in the previous section, sometimes the implementation of the RMA was independent of the CERA recovery process. This may have made it difficult for contractors to plan and implement recovery associated activities if they did not know the stance authorities would take on a particular environmental compliance issue.

In general, as the examples in Section 4.4.3 show, the approach taken to the resource recovery was very much market driven. The establishment of additional waste management facilities, for example, was not driven by CERA assessing there was a need, but by contractors seeing a market opportunity. This was symptomatic of the recovery as a whole. Government was reluctant to step in where they believed market forces could prevail. This put the regulatory authorities in a very difficult, reactive position. Under the RMA authorities are limited to assessing the environmental and social effects and are not able to assess the economic viability of a facility. This is potentially problematic: first if contractors have undervalued the cost of managing the waste; and second when numerous waste handling facilities establish themselves in a short time assuming they will get a certain portion of the market to make their ventures feasible. If the waste market gets saturated then there is the potential for contractors to walk away from sites before the waste is removed. This leaves a legacy for local authorities to manage. The RMA does have capacity to require bonds from site operators, however, this was not considered by authorities in this circumstance. At the time of writing it was too early to say whether legacy issues will be a problem following the earthquake. In the authors' opinion, however, regulatory power were needed such that the need for additional waste facilities could be assessed – to avoid market saturation and potential legacy issues. A concept such as this may be challenged for being anti-competitive.

The CDEM Act allowed for BRRP to be established within a week of the earthquake. BRRP was essential to the response and early recovery works, particularly in the CBD. If the CDEM Act had not been in place there would not have been a mechanism to allow for BRRP to be established. There would likely have been no suitable place, within proximity to the CBD, to store coronial material. Mixed waste would also have been forced to transfer stations, destined for landfill. This would have likely overwhelmed the transfer stations, consumed valuable landfill space and been expensive.

The long term operation of BRRP was facilitated by a CER Act OIC: Canterbury Earthquake (Resource Management Act—Burwood Resource Recovery Park) Order 2011 (Office of the Governor-General, 2011a). Given the scale and nature of the operations at BRRP, it is unlikely that, even given the discretionary and flexible nature of the RMA, any regulatory body would have allowed the facility without a full consent process. The OIC provided the regulatory means to fast-track a facility which was essential to the earthquake recovery and for which there were no suitable alternatives available. What the OIC was essentially facilitating was the community wide needs of the recovery to be prioritised over the immediate effects of the facility itself. The fast-tracked consent process at local and regional authority level ensured that, given the facility would go ahead, the social and environmental effects had to be minimised. This was a successful effort in balancing the global needs of the recovery with the local effects of the facility and ensuring quality control.

Temporary storage

The temporary storage OIC was issued just two weeks after the earthquake. As with the decision to reclaim at LPC, the decision to produce the OIC was made without, as far as the author is aware, consultation with the waste management operations and planning team of Civil Defence. It is understood that the intention of the OIC was to facilitate construction of temporary homes (therefore storage of building materials) and perhaps medium-term storage of building rubble which could be used in the rebuild works. The OIC defined temporary storage works as "reasonably incidental to construction works". The intention was not necessarily to allow temporary waste storage facilities up to 20km from the demolition site to be established. Nevertheless this is how it was interpreted. In terms of a waste management solution, the OIC did not solve waste management issues – it merely transferred it. Temporary storage sites were permitted only as temporary storage sites and not processing facilities. Mixed wastes would have to be double handled and moved to a waste processing facility or disposal site later. However, a lot of contractors applied for temporary storage permits with the belief that either they could process the material at the site or they would be able to use the site as leverage to gain consent to process the materials and budgeted their operations accordingly. Thus if processing was not permitted in the future, contractors may have insufficient funds to remove the material and remediate the site. The OIC, in short, did not consider the waste management problem from cradle to grave and did not meet any pressing recovery need. Instead it created additional problems for the future.

It was also unclear how the temporary storage OIC impacted on existing legislation. In particular, the OIC had implications under two Christchurch

City bylaws: the Cleanfill Licensing Bylaw 2008; and the Waste Handling Bylaw 2007. At least one of the temporary storage facilities permitted under the OIC was also licensed under the City's Cleanfill Licensing Bylaw 2008. The material this facility is allowed to accept under the City's standards, "mixed demolition material and waste", may not be in compliance with the Cleanfill Licensing Bylaw, which allows only natural hardfill, cover material and other hardfill, and strictly limits the allowable contamination (1% or 2% depending on the contaminant9). It should be noted that the cleanfill bylaw prohibits the 'disposal' of this material, therefore, temporary storage may not be an issue. However, disposal is not defined in the legislation.

Despite the applicability of the Licensed Waste Handling Facilities Bylaw, there was no requirement for temporary storage facilities to gain a waste handling facility permit and adhere to the conditions of the bylaw. The Bylaw seems to apply to any facility that handles more than 50 tonnes of waste per year, which undoubtedly would apply to the facilities being established. Clause 4.1 of the Bylaw states:

> "No person shall carry on or permit or suffer any land or facility owned or controlled by that person to be used for a waste operation unless:
>
> (a) The Council has granted a licence to a person in relation to that waste operation; and
>
> (b) That waste operation is carried on in accordance with the terms and conditions of the relevant licence."

If the waste levy had not been removed post-earthquake, the Waste Minimisation Act 2008 may also have applied to the temporary storage facilities. Under the Act, waste disposal levy is applied for the deposit of waste on land for greater than 6 months (Waste Minimisation Act section 26(3)).

Written in haste, it is unsurprising that the OIC has some misleading elements and ill-considered implications. Preparing similar legislation in advance of an event would have allowed for a more thorough analysis of the potential issues arising from a law such as this. Some have argued that given the flexibility and discretionary powers of the RMA discussed above and the permissive City Plan, that a separate and quite specific law was not needed. The RMA could also potentially be moulded and applied to allow for facilities like this to be permitted if required and there was a will by the implementing authority.

Disposal

The LPC reclamation was granted using an OIC under the CER Act 2011: Canterbury Earthquake (Resource Management Act Port of Lyttelton Recovery) Order 2011" (Office of the Governor-General, 2011b). Similar to the BRRP OIC discussed above, this OIC enabled the wider benefits of the operations to be considered above the local effects of the facility. It is interesting to note that prior to the earthquake a reclamation was proposed and was scheduled to be heard at the Environment Court. The OIC enabled

[9] The waste streams allowed in cleanfills within Christchurch can be found in Schedule A of the Cleanfill Licensing Bylaw 2008, http://resources.ccc.govt.nz/files/CleanfillLicensingBylaw2008-bylaws.pdf.

the reclamation to be fast tracked with minimal consultation. There was some negative reaction from the community (as discussed in Section 4.4.7).

It is interesting to compare the two facility-specific applications of the CER Act (LPC and BRRP) with the more general application of the OIC for the temporary storage facilities. The facility specific applications were generally well considered in terms of benefit to recovery / need and overall environmental, social and economic impact. The temporary storage facilities, however, have opened up an opportunity for some to take commercial advantage of relaxed regulation with marginal benefit to the overall recovery. Given the broad powers of the CER Act, there was always potential for misuse (both intentional and unintentional) of the regulation. Foreseeing potential effects of new regulations is always difficult, but especially when written in haste and in broad terms. Facility specific OICs were likely more easily and completely analysed, and consequences of operation more easily identified, as opposed to new rules permitting a type of facility or operation where legislative freedom could be taken advantage of and quality control reduced, even when the facility was not strictly needed to facilitate the recovery. In the authors opinion, standards should only be reduced where implications of standards reduction are understood, mitigation measures are in place and the changes are absolutely necessary for the wider recovery.

4.4.5 Environmental

Recycling

The decision to allow concrete crushing in the CBD (e.g. to fill basements with demolition material etc.) provided considerable cost savings. The time to clear the demolition site increased, but from an environmental perspective, less transportation was required and no raw materials were needed.

The nature of the operation at BRRP has the potential to have adverse environmental effects. The operation consisted of long term stockpiling of mixed wastes (as discussed in Section 4.4.2). The waste included a wide variety of materials, including in some cases, building contents such as computers, fridges and furnishings. The operators of BRRP estimated they would collect all the waste over a period of two years and process / recycle them over five years. This means that some waste may be stockpiled for up to three years. The stockpiles, at the time of writing, were open and were formed directly on the ground without a liner or leachate collection system. The waste could potentially leach over this period and potentially contaminate surface or ground water. Due to the relatively inert nature of the waste the risk of leaching was considered low. The Burwood site was chosen because the ground water aquifer was known to flow away from the city's drinking water aquifers and to the sea.

Temporary storage

As discussed in the previous section, there was concern that temporary storage facilities did not consider the full waste management cycle and there was potential for legacy issues due to contractor mismanagement.

Disposal
It was unclear how the environmental assessment of effects was carried out for the LPC reclamation approval. The fill composition, for example, allowed for 5% contamination by volume as opposed to the 2% allowable in the Christchurch City Cleanfill Bylaw. It could be argued that the marine environment is more sensitive than a landfill site and therefore the level of acceptable contamination would be the same or less. However, the consequences of contamination in the landfills situated over the drinking water aquifer is much greater.

There were some complaints received that debris from the reclamation was floating across the harbour (Sachdeva, 2011a). LPC implemented mitigation measures to prevent floating debris. In particular loads were inspected before and as they were unloaded and a boom was put in place to catch any floating debris. LPC believed that the debris found on neighbouring beaches was due primarily to illegal dumping and not the reclamation activities. However, LPC took responsibility for this material and regularly sent clean-up crews to remove debris from these beaches. The long term environmental effects were considered minimal from this floating debris.

In terms of the Burwood disposal site, it is unknown what environmental effects are anticipated by environmental authorities. In the author's opinion, the waste stream will be largely inert. In most cases hazardous materials will have been removed either during the demolition process or will have been identified during the sorting process. The residual material being disposed should be relatively inert. The exception to this is the leachate potential of treated timber. Currently there is very little research internationally into the environmental effects of landfilling treated timber.

Indirectly it is possible that the likely reduction in disposal costs to BRRP (as a result of the reduced residual disposal fees) will encourage more contractors to use BRRP rather than their own waste facilities (both legal and illegal). This will hopefully reduce to proliferation of waste disposal sites across the city.

4.4.6 Economic

Recycling
Within the CERA CBD demolition programme the 'quick pick and go' approach was not driven by environmental objectives but with the speed of recovery in mind. The decision was consciously made, with the acknowledgement that the direct costs for demolition would increase with indirect benefits from a faster demolition enabling the expedient return of economic activity, reduced business loss and potentially preventing the 'donut' effect (where a city regenerates around the original city centre). The intention was still to recycle as much material as possible – but to do so offsite so that demolitions were not slowed down. However, as previously stated, the slow release of buildings for demolition meant that there was no backlog of jobs and contractors had time to recycle on site without adverse effects on the recovery programme.

Generally the economics of recycling drove the level of recycling, rather than any environmental goals being enforced. In some cases, such as concrete crushing and gypsum recycling, the large quantities improved the feasibility of recycling. In other instances, such as second hand doors and toilets, the large quantities of materials overwhelmed the market and the feasibility of reuse dramatically decreased. As with peace-time environmental laws there were no recycling targets set. From an economic point of view – this ensured a financially sustainable situation.

Temporary disposal
Many of the contractors establishing temporary storage sites (and other waste handling facilities) stated that the operations would save demolition costs (Sachdeva and Mathewson, 2011). However, the authors believe that the decentralisation of the waste processing system reduced the economies of scale. In addition, the possible negative environmental effects presented a potential future liability and cost for environmental remediation. It will be some years before any remediation costs are identified.

Disposal
As stated by Brownlee and Smith (2011) it was believed that the LPC would have both direct benefits on the cost of the recovery and indirect benefits from the economic activity associated with port activities. It is interesting to note that the free disposal at LPC caused the demolition concrete market to change from a cash negative ($20/Tonne disposal) to a cash positive recycle market ($2/Tonne) for demolition contractors.

As mentioned above, the Burwood landfill cell for the residual material offers a lesser cost solution (compared to transportation to and disposal at Kate Valley). This cost saving will be passed on to insurers and building owners through reduce disposal fees at BRRP.

Waste levy
The removal of the waste levy decreased the cost of demolition significantly. However, it should also be noted that the recovery costs were being paid for by, generally, the insurance companies. If the levy had been retained, the levy revenue could have been used to assist in some of the post-earthquake waste management issues. One area which requires development is the technological development of a waste treatment method for treated timber. Large quantities of treated timber were generated post-earthquake and there is no existing market for treated timber. A beneficial use is needed to meet peace-time as well as post-earthquake needs.

4.4.7 Social

Recycling
The general expectation of the community was that recycling should be practiced. In the early stages of the recovery where no or limited salvage was being carried out there were a number of media reports expressing concern over the waste of valuable materials or alternatively hailing the effective reuse or recycling of materials. For example, the loss of valuable native timbers

(Heather, 2011c); and the use of reclamation rather than landfill (Greenhill and Wood, 2011).

Temporary disposal
Under the temporary storage OIC, several debris management sites were established. Due to the limited consultation requirements of the OIC, some communities were not consulted about proposed facilities. It is understood that CCC representatives consulted with the community board of the host community only. One community however, received word that a facility was planned and publically opposed the move before consent was granted (Mathewson, 2011; Sachdeva and Mathewson, 2011). The company proposing the facility withdrew its application. Given that these temporary facility permits were valid for five years, some better form of consultation should have been carried out, particularly with respect to these facilities which were not , arguably, essential elements of the recovery process (in other words the recovery process would not be halted without them).

Public health issues, in particular resulting from asbestos exposure, were a concern for neighbours of these temporary disposal sites. While legally contractors are required to remove asbestos at the demolition site, there is valid concern that some contactors may not (intentionally or unintentionally) remove the asbestos before taking to a temporary storage facility. In the authors opinion the approval process for the temporary storage sites does not adequately address these potential public health issues.

Disposal
Some Lyttelton residents were unhappy about the lack of consultation carried out prior to the OIC and consents being granted for the LPC reclamation. LPC carried out consultation with identified stakeholders for its Assessment of Environmental Effects. These stakeholders had been previously identified during the original reclamation consent application. ECan and CCC were officially given only five-days to issue consents for the reclamation after the OIC were issued, which gave only limited time to assess effects and consult with affected parties. However, ECan and CCC representatives had been involved in the OIC preparation so had the opportunity to prepare for consent approval. There were some complaints from residents regarding the lack of consultation, concern over truck movements and fear over environmental contamination and damage (Greenhill and Wood, 2011; Heather, 2011b; Wood, 2011). However, some resident and business group spokespeople said that despite the insufficient consultation, they generally thought the reclamation was a good idea.

The author is unaware of the public reaction to permanent material disposal at Burwood.

Waste levy
The authors do not know of any public reaction to the waste levy removal.

4.4.8 Summary

Generally there were very limited changes made to peace-time environmental standards in this earthquake response. Decisions on recycling were largely left to market forces to decide. The CERA Act was used to approve two site specific waste management facilities which directly aided the recovery efforts. The environmental and social effects were balanced with the overall recovery needs. The CER Act was also used to authorise more generally 'temporary storage' facilities. This use of an OIC opened up opportunity for contractors to gain commercial advantage at the expense of some environmental and social quality, even in instances where the facility was not strictly 'needed' to facilitate the recovery.

Table 4-4 summarises the strengths and weaknesses of the approach to environmental standards taken.

Table 4-4 Christchurch Earthquake environmental standards assessment summary

	Strengths	Weaknesses
Organisational	• Civil Defence, CERA, ECan and CCC formed a collaborative working group to address environmental issues affecting and caused by the recovery. • Existing landfill disposal costs encourage recycling. • Concrete crushing in CBD reduced pressure on truck resources.	• The dual council system for environmental approval (particularly with respect to the temporary storage OIC) was confusing and some contractors considered approval from one council sufficient. • Inadequate organisational structures were in place for environmental decisions to be balanced with recovery needs. • Disjoint between national environmental decisions concerning recovery and operational teams. • Degree of recycling dependent on individual contractor's decisions generally based on economics – no recovery mandate issued.

	Strengths	Weaknesses
Legal	• Discretionary elements of the RMA were successfully used to allow concrete crushing activities which aided recovery efforts. • CDEM Act allowed for the expedient establishment of BRRP – essential to initial recovery efforts in CBD. • Site specific BRRP and LPC OICs enabled the global needs of the recovery to be balanced against the local effects of the facilities / operations.	• Discretionary elements of the RMA made it difficult for individual contractors to plan waste management activities and made them vulnerable to unpredictable rulings. • The temporary storage OIC did not consider cradle to grave implications of temporary storage sites. • The temporary storage OIC had some confusing elements including unclear relationship to existing laws. • The temporary storage OIC did not, arguably, facilitate anything that the discretionary, effects based RMA could not have. • OIC was applied inconsistently – to both site specific approvals and general facility type approvals.
Environmental	• Concrete crushing in CBD reduced demand on raw materials and reduced transportation costs for basement filling.	• Opportunities for reuse of materials were lost due to market approach to recycling. • Stockpiling of waste and long duration of recycling at BRRP posed potential environmental risks. • Potential for environmental legacy issues due to contractor mismanagement of temporary storage sites.
Economic	• The direct cost savings possible from recycling on site were balanced with indirect costs to recovery as a whole. • Environmental approaches were driven by their economic feasibility not environmental ideology. • LPC reclamation will have positive direct and indirect economic benefits to the region.	• The quick pick and go approach increased the direct cost of recovery. • Costs may be incurred if temporary storage sites require site remediation in the future.

	Strengths	Weaknesses
Social	• Community generally supportive of recycling efforts.	• Inadequate consultation was carried out for siting of the temporary (5 year) storage facilities. • Temporary storage facility siting did not adequately address public health issues. • Inadequate consultation was carried out prior to OIC and subsequent consent approval.

4.5 Factor 5: Public health and safety standards

4.5.1 Approach and rationale

In general, peace-time public health and safety laws and regulations were maintained throughout the earthquake response and recovery.

Two main public and worker health and safety issues are considered in this section:

- The approach to asbestos management
- The practice of strip-outs in damaged buildings.

Asbestos

In terms of asbestos management, there was some concern by the primary author that management of asbestos would become a bottleneck in the recovery. DOL did not share the same concerns and elected to take a pragmatic and reactive approach to asbestos management. DOL issued a factsheet on how to manage asbestos after the earthquake (Department of Labour, 2011). The advice acknowledged that some of the standard asbestos management practices might have to be adapted to allow for unstable buildings. For example, removal of asbestos pre-demolition was not possible where the building is unstable. However, no provisions were made to formally reduce standards or management practices to ensure a fast recovery. Asbestos quantities were unknown.

Building strip-outs

Strip-outs of buildings were largely carried out for cost reduction and recycling maximisation purposes. However, in the early stages of the demolition, there were a large number of buildings which were very unstable. Given the large and significant aftershock sequence in Christchurch, CERA engineers notified building owners and contractors whether or not building strip-outs should be carried out prior to demolition. However, a number of contractors did not heed CERA's advice.

4.5.2 Delays

Asbestos

Friable asbestos in particular is very time consuming to remove and there are limited qualified contractors available to do the work. At the time of writing, however, no delays had been caused by asbestos removal and the volume of asbestos was less than anticipated.

Building strip-outs

Building strip-outs potentially increase the demolition time. If a building is deemed too unsafe to enter but the owners want to remove contents and strip-out the interior, extensive works may need to be carried out. Clarendon Towers is an example where the building owner is keen to recover their tenants' contents prior to demolition. Most of the tenants are lawyers and only hold one paper copy of documents for confidentiality reasons. The loss of these documents has potentially serious consequences for the companies involved and their clients. This will significantly increase the demolition time. The building itself poses a risk to a number of surrounding buildings and will prevent their reopening.

4.5.3 Organisational aspects

Asbestos

While the DOL factsheet was a good first step it was written in isolation and did not fully align with the recovery constraints. On the factsheet the formulation of the categories showed that as the immediate risk to life decreased, the tolerance to long term health risks (ie asbestos exposure) also decreased. While this is perfectly understandable, the deficiency in the categorisation is that risk to life is the only consideration. There is no allowance for the effect (social, environmental or economic) of slow demolition on the recovery effort. It was also unclear exactly what buildings would fall into each category and who would make that decision. Impact on recovery, in terms of additional costs and/or time taken was also not considered. Understandably, DOL does not have a mandate to address recovery issues. It is here that CERA perhaps should have more actively engaged with DOL to determine a process where if the recovery progress was threatened due to asbestos related demolition requirements, a risk mitigation strategy could have been jointly developed which meet both organisations requirements.

Operationally, DOL worked quite closely with the CERA demolition operations office, to address any issues. The authors are unaware of any significant delays or financial impacts that have arisen from asbestos management, other than one building which will take 5 months to remove the asbestos. The strong relationship with the CERA demolition team aided in the monitoring of works in the CBD. CERA could advise DOL of any worksites which did not appear appropriately managed. This was an effective way of prioritising and utilising effectively the limited regulatory resources available.

Many concerns were received from the public regarding potential exposure to asbestos. As discussed in Section 4.1.7, the concerns were directed to a number of different bodies and it was very unclear to the public which organisation was responsible for protecting them. Additionally when the lead author attempted to provide some public information regarding the risk around asbestos exposure, the organisations contacted were not confident of who should lead public information dissemination regarding asbestos. They also had varying opinions on the risks associated with asbestos resulting from the demolition and debris management works which made it difficult to establish a common message.

Because there was not a truly centralised management process for demolition (see Section 4.3) and the majority of waste management facilities were privately operated, separate from demolition works, disposal sites faced large risks when accepting waste. Disposal sites accepted waste from contractors they may not have known from sites they didn't know the nature of. There is a risk that demolition contractors could intentionally or unintentionally include asbestos in their loads. If the disposal sites are run independently as they were here, some form of accreditation procedure for customers would be one way of mitigating the risk of asbestos exposure.

Building strip-outs
As a rule, employers are responsible for their employees' safety as per the Health and Safety in Employment Act administered by DOL. Contractors should only have asked their staff to enter a building if the building was safe. However, 'safe' is subjective. As was observed in many stages over the course of the recovery, people have different risk tolerances and understanding of the risk of future earthquakes and building safety. If a building owner or contractor was not sure about the safety they should engage someone who has that expertise. Generally within the CBD, CERA elected to provide a risk assessment and advise contractors of the risks involved to minimise risks to all worksites. In addition they required methodologies to be provided for demolition to ensure unsafe buildings were not being entered. However, where contractors were not contracted directly to CERA, they would not always heed this advice or follow their approved demolition plan. As discussed in Section 4.3.7 some contractors were caught inside unstable buildings when significant aftershocks occurred. As for asbestos monitoring DOL did not have the resources to monitor all sites and CERA did not have the legal authority to act on matters of health and safety. Within the CBD CERA (in collaboration with DOL) aimed to mitigate the risks to workers as much as possible but ultimately, and legally, it was the contractor's responsibility.

General
Access to buildings for business access, personal property removal, pre-demolition strip outs or asbestos removal was a continual point of contention. While CERA ultimately decided whether buildings were safe enough to carry out these activities, many building owners obtained independent advice and felt that it was not CERA's role to make a safety assessment. Building owners and insurers generally wanted to reduce costs by: recovering critical business information; removing asbestos pre-demolition (to minimise volume of contaminated waste and therefore cost); and to carry out strip outs to

maximise value of recoverable materials. Independent engineers contracted to CERA were not willing to accept the same level of risk. The difference being that the CERA engineers did not have a financial gain to make. The question is – does a potential financial gain alter the acceptable risk?

4.5.4 Legal implications

Asbestos

As discussed above, no legal changes were made regarding health and safety matters. However, DOL did offer quite 'open' advice on their post-earthquake factsheet. The advice was open to interpretation. The authors have concern that this might be open to legal challenge in the future if any adverse health effects are attributed to the earthquake recovery. Previous disaster events, internationally, have led to prosecutions because of poor health and safety practices.

4.5.5 Environmental

Asbestos

Asbestos is relatively inert, therefore as long as the material is covered and does not pose a public health risk, there is no environmental risk. However, it is worth noting here that illegal dumping of asbestos did occur because of the expense of management of asbestos (refer Section 4.2.7) and this poses an environmental effect from an aesthetic point of view.

Building strip-outs

The prohibition of building strip-outs for unstable buildings obviously impacts the amount of recycling achieved. However, as discussed in Section 4.4, the desire to recycle was balanced against the desire for a fast recovery.

4.5.6 Economic

Asbestos

The relaxed or more flexible asbestos guidance provided by DOL provided opportunities for both demolition cost inflation and cost reduction depending on how the guidance was applied. For example, if a building is known to contain asbestos but the asbestos can't be removed pre-demolition then the entire waste stream has to be considered to be contaminated. No material can be recycled and all must be disposed of at the regional landfill which is the most expensive waste management option. Therefore the cost to demolish is increased. However, where previously the property had to be sealed to remove asbestos, but this can no longer be carried out due to building instability – some savings may be made.

Generally speaking, maintaining peace-time health and safety standards as far as practicable will undoubtedly have indirect savings in the future through fewer people being exposed to hazards.

Building strip-out

Economic implications of building strip-outs are discussed in Section 4.4.6. Generally strip-outs reduce the cost of demolition, but the longer demolition

has indirect costs for the recovery. Building strip-outs in high risk buildings, however, pose a significant financial risk for contractors in the event of loss of life. Stabilisation of unsafe buildings to allow strip-outs also increases demolition costs.

4.5.7 Social

Asbestos

As discussed in Section 4.5.3 there was a general lack of responsibility for managing public health and safety risks. It was not until November 2011 that DOL announced an air monitoring programme was going to be carried out for mitigation of worker and public health threats. Better efforts could have been made to monitor works from a public health and safety point of view earlier on and provide information for public peace of mind.

In general, as discussed in Section 4.1.7, public communication (regarding waste) was not well executed. Particularly during the response phase, communication tended to be reactive rather than proactive.

4.5.8 Summary

Overall health and safety standards were maintained. It was fortunate that the quantities of asbestos did not significantly affect the programme of the demolition. Despite constant communication and advice about risks involved with unstable buildings and on-going aftershocks, building owners and contractors continued to ignore the risks and place workers and themselves in danger.

Table 4-5 summarises the strengths and weaknesses of the approach to public health and safety standards taken.

Table 4-5 Christchurch Earthquake public health and safety standards summary

	Strengths	Weaknesses
Organisational	• DOL and CERA had a strong informal relationship regarding asbestos and general workplace health and safety issues affecting the recovery. • CERA mitigate risk to all worker in CBD by providing advice on building stability and approving methods of demolition.	• No one organisation was designated to respond to public health issues post-earthquake. • Independent disposal sites did not have adequate procedures in place to mitigate risk of asbestos exposure. • Some contractors acted irresponsibly when ordering staff to perform building strip-outs on unstable buildings. • Building owners, contractors and CERA had different risk tolerances and therefore there was contention over CERA advising on safety risk.
Legal		• Guidance documents provided by DOL were open to interpretation and may be the basis for future liability investigations.
Environmental		• Some illegal asbestos dumping occurred. • Prohibition of building strip-outs reduced recycling percentages.
Economic	• Maintaining peace time public health and safety standards will undoubtedly reduce future costs resulting from exposure to workplace health risks.	• Depending on interpretation the DOL post-earthquake asbestos guidelines could save or cost money for the building owner. • Building strip-out in unsafe buildings has high financial risk (in the event of loss of life).
Social		• More effort should have been made to monitor public health and safety and provide public information.

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Appendix A

- **Asbestos Management flow diagram**

Asbestos management post Christchurch Earthquake 2011