PLANNING FOR DISASTER DEBRIS MANAGEMENT

Charlotte Brown & Mark Milke
University of Canterbury, Department of Civil & Natural Resources Engineering, Private Bag 4800, Christchurch 8140, cob15@student.canterbury.ac.nz

Abstract
Disasters can generate large volumes of debris. Disaster debris can severely impact emergency response and recovery efforts; overwhelm local solid waste management facilities and personnel; and can be potentially harmful to public and environmental health.

Framed around a case study of the debris management following Hurricane Katrina, US, 2005, this paper provides an overview of eight key issues involved in disaster debris management: debris management goals, prioritization and timing, environmental impact, economics, social factors, organisational and coordination structures, legislative issues, and financial aspects / funding mechanisms. The key components of a typical debris management plan are presented and the paper concludes with a brief look at the way forward for disaster debris management in New Zealand.

1.0 Introduction
Depending on their nature and severity, disasters can create large volumes of debris. In some cases the equivalent of many years worth of waste can be generated in a single event often overwhelming existing solid waste management facilities and personnel. The presence of disaster debris also impacts almost every aspect of an emergency response and recovery effort. 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 exacerbate these problems, and can result in a slow and costly recovery which is potentially risky to public and environmental health in both the short and long term.

Establishing a solid waste management system in ‘peace’ time is a complex challenge – balancing stakeholder desires, community needs, environmental factors and political will. Adding a disaster to the equation adds another level of complexity by introducing time pressures and a shocked community.

The aim of this research is to understand the role of debris in disaster management and how to effectively plan for and integrate debris management into both the emergency response/recovery and solid waste management systems. This paper is a presented around a case study of the debris management following Hurricane Katrina, 2005, US, with examples drawn in from other disaster events.

Table 1.1 gives a list of some disaster events within the last 15 years that required major debris management.

Table 1.1 – Debris Quantities in Past Events

Year	Event	Debris Volume	Data Source
2005	Hurricane Katrina, USA	76 mill cubic metres	(Luther 2008)
2004	Indian Ocean Tsunami	10 mill cubic metres (Indonesia alone)	(Bjerregaard)
2004	Hurricane Charley, USA	2 mill cubic metres	(MSW 2006)
1999	Marmara Earthquake, Turkey	13 mill tonnes	(Baycan 2004)
1995	Great Hanshin-Awaji Earthquake (also known as Kobe Earthquake), Japan	15 mill cubic metres	(Baycan and Petersen)

2.0 Case Study: Hurricane Katrina

On 29 August 2005 the States of Louisiana and Mississippi, USA, were hit by a Category 3 storm called Hurricane Katrina. The hurricane itself caused widespread property damage. In addition, heavy rain caused a flood levee breach in New Orleans that sent tonnes of water and toxic sediment (from historic petro-chemical industrial activity) down into New Orleans. In total 76 million cubic metres of debris was generated at a projected clean-up cost in excess of US$4.2 billion. The debris management contributed to a plethora of social and environmental and economic issues, including:

- Looting and rioting allegedly partly due to slow road clearance
- Public health concerns over toxic sediment handling
- Slow residential rebuild and repatriation
- Illegal waste dumping by residents frustrated by slow clean-up
- Slow home demolition processes due to the presence of asbestos
- Environmental concerns and public complaints over inappropriate land disposal
- Significant volumes of rotting food due to prolonged power outages
- Delicate debris removal from sensitive marsh areas

Chuck Brown, the assistant secretary of the Office of Environmental Services was charged with responsibility for disposing all the debris from Hurricane Katrina. At a press conference just under two weeks after the event, Brown summed up the urgency of the task ahead '"once we get [authorization]," he said, "we are going to move very fast." (King 2005).

3.0 The issues

Hurricane Katrina is a recent example of an extremely complex debris management problem. Hurricane Katrina highlights a number of issues associated with the management of disaster debris and illustrates the links between disaster debris and the social, environmental and economic concerns of both the response and recovery phases of an emergency operation. These issues are discussed in the 8 sections below.

3.1 Goals

In many cases, the goals for disaster debris management appear to be ill- (if at all) defined and can often be difficult, conflicting, or unrealistic to achieve. Typical goals for debris management have been stated as:

- Remove debris as quickly as possible and protect human health and the environment (EPA 2008)
- To protect life, public health, and safety, and to ensure economic recovery of the affected community (FEMA) (EPA 2008).
- Reduce public health risk and timely return to normalcy (Waste Management in Emergencies Group 2004) (on sub-Saharan Africa)
- (Short term) Debris clearance and creation of immediate temporary employment. (Long term) Build capacity in government and develop sustainable waste management systems and related livelihoods (UNDP 2006) (on 2004 Indian Ocean Boxing Day Tsunami in Thailand).

Following Hurricane Katrina, the Solid Waste Association of North America (SWANA), recommended that debris managers select a debris removal programme that was quick to implement, with the least amount of exposure to any hazardous or toxic materials (SWANA 2005). The presence of large quantities of asbestos in the debris, however, presented a conflict in achieving this goal as standard asbestos handling and disposal procedures were identified as a contributing factor to the slow debris removal process: "[US Environmental Protection Agency] EPA…is providing debris management guidance to ensure minimization of exposures while expediting cleanup." (Luther 2008). In Louisiana, the USEPA granted 'No Action Assurance' letters (LDEQ 2006) which allowed a relaxation in some standard (NESHAP [National Emission Standards for Hazardous Air Pollutants] regulations) asbestos demolition and disposal procedures (LDEQ 2007). This regulatory relaxation is an example of a trade-off between a health and safety risk, and a desire to clean up quickly and return to normalcy.

3.2 Prioritisation and timing

Typically disaster debris management is described in 2 or 3 phases[1]:

1. Emergency response (preservation of life, provision of emergency services, stabilising buildings, clearing roads etc)
2. Recovery (restoring lifelines, debris removal, building demolition)
3. Rebuild (construction of major structures and houses).

The inevitable strain on financial, personnel and equipment resources following a disaster means emergency managers need to prioritise debris management and other relief / recovery activities in each of these phases.

The debris management options chosen will affect how long the overall clean-up period is. According to USEPA, communities generally want the debris removed as quickly as possible (EPA 2008). However, there is a trade-off between speed of clean-up, degree of diversion, recycling of waste/ debris, waste treatment and disposal options. The Louisiana Department of Environmental Quality's (LDEQ) Hurricane Katrina Debris Management Plan prioritised debris management practices 'to the extent they are "appropriate, practical, efficient, timely and have available funding: recycling and composting; weight reduction; volume reduction; incineration or co-generation; and land disposal."' (LDEQ 2006).

[1] The third phase is often not included, or considered, as it is not seen as a directly related to the disaster response effort. However, it is included here as it forms part of the overall disaster debris management cycle from emergency to recovery to rebuilding.

Social and political pressure for a fast and economic recovery can elevate levels of risk taking as speed of recovery reigns over environmentally sustainable and accepted solid waste management practices. External influences, such as funding mechanisms (refer Section 3.8) can also restrict/determine clean-up programmes (State of California 1997).

3.3 Environmental impacts

In terms of debris management, the handling, treatment and disposal options selected will all have an impact on the environment. In general terms solid waste management practices follow this typical management hierarchy (EPA 1995):

1. Source reduction
2. Recycling
3. Waste combustion and landfilling

As discussed in Section 3.2, timing and desired speed of recovery (and at times, cost) often leads debris managers to alter the standard waste management hierarchy. Source reduction is generally not possible, recycling can be slow and cumbersome and is dependent on market availability for cost effectiveness and so by default waste combustion and landfilling are often the favoured management options. However, landfill space is often insufficient for the volume of debris generated and combustion is not socially acceptable in many communities. Temporary or sub-standard debris treatment methods and disposal sites are often employed with varying environmental effects. Following Hurricane Katrina, some construction and demolition landfills expanded their waste acceptance criteria (Luther 2008). In Sri Lanka and Thailand, following the Boxing Day tsunami, waste was dumped in temporary dump sites in schools, low-lying marsh area, rice paddies and coastal areas (Basanayake, Chiemchaisri et al. 2006) resulting in a lengthy environmental remediation process (UNDP 2006).

The waste stream also undoubtedly includes materials which are hazardous to environmental and public health and require special treatment and handling. This includes: human and animal corpses and wastes; medical wastes; asbestos; heavy metals; oils; toxic chemical; drywall/gypsum; and unexploded ordinances. In previous events, generally accepted hazardous material handling practices have been sacrificed or 'stream-lined' in favour of speed. As mentioned earlier the asbestos after Hurricane Katrina is an example of this.

3.4 Economics

The cost of disaster debris management itself includes the direct costs of management, collection, treatment and disposal. It also includes indirect costs - for example, through disruption of lifelines like transportation, which hinders rebuilding processes and impacts on local industry such as tourism etc.

In response to the Tsunami in Thailand, Thai officials prioritised the clean-up and recovery of the Coastal areas to encourage the rejuvenation of the lucrative tourist industry (Basnayake, Chiemchaisri et al. 2005).

As discussed in Section 3.8, current funding mechanisms only consider direct costs and do not consider the longer term, indirect costs, of certain debris management options, such as reduction in landfill space use, environmental impact remediation resulting from inappropriate and/or illegal dumping, limited resource recovery etc.

3.5 Social factors

Disaster debris can serve as a reminder to communities of the losses they have endured and equally the removal of debris can be a sign of community/national recovery and resilience.

The slow clean-up after Hurricane Katrina caused several problems. After the disaster it took a week to clear the roads, which, according to Rhodes Yepsen resulted in looting and rioting (Yepsen 2008). Slow residential and public debris clearance led to many occurrences of illegal dumping in public places including road median strips (Jackson 2008). And in a vicious cycle, toxic sediments washed through private properties led to retarded resettlement of the affected areas which in turn slowed the clean-up of private properties further with right of entry issues for clean-up crews (Luther 2008).

In contrast, the meticulously fast debris management process following the Wenchuan Earthquake, Sichuan, China, 2008, drew criticism from some Chinese. Parents of children that perished in collapsed school buildings have accused the government of covering up a corrupt building sector. In some cases, bodies of some children have still not been formally identified a year after the event and some parents believe many were never recovered from the rubble (Demick 2009). This example challenges the conventional view discussed earlier that speed is the primary component in a debris removal plan.

Public perception, understanding and involvement has long been recognised as the key to successful solid waste management programmes (EPA 1995). Achieving this community engagement in a disaster situation is a huge challenge for debris managers but according to authorities after Hurricanes Frances and Jeanne, Palm Beach, US, 2004, communication was the key to their successful and efficient debris removal programme (EPA 2008).

3.6 Organisational and coordination structures

In past events, disaster debris has been managed almost independently, with little or no coordination with other recovery efforts. Roles and responsibilities even within debris management operations seem ill-defined despite (or perhaps because of) complex and varied stakeholders with differing social, economic and environmental agendas.

After the Great Hanshin-Awaji earthquake in 1995, Kobe, Japan, disaster debris management was split between private and public entities (Kuamoto 1995). After Typhoon Tokage 2004 (Japan) the Ministry for the Environment and Ministry of Health, Labour and Welfare were responsible for environmental disaster debris and debris from collapsed buildings and infrastructure respectively (UNEP 2005). In Turkey following the 1999 Marmara earthquake no department was allegedly assigned coordinative responsibility for debris (Baycan 2004).

There are a plethora of organisational structures to manage the large number of stakeholders and contexts faced in disaster debris management. However a community or governing body decides to manage its emergency and disaster debris programme, clear roles and responsibilities and overall objectives need to be defined for effective response.

3.7 Legislative issues

Solid waste management, in developed countries, is governed by a variety of environmental and operational legislations. When a state of emergency is declared in a disaster in many countries, emergency legislation is activated which has the power to delegate emergency operational decision-making to a central person or body, who in turn can waive various environmental (and other) legislation to facilitate an emergency response. Many disaster debris management plans or guides highlight the availability of emergency waivers on environmental regulations but it is often unclear to what degree and in what circumstances this relaxation is acceptable (Solis, Hightower et al. 1995; WRCDEMG 2008).

In some cases, however, environmental legislation waivers have led to community disaffection and potential environmental degradation. After Hurricane Katrina, acceptance of mixed waste at several Construction and Demolition (cleanfill) landfills resulted in a lawsuit being filed against the US Federal Emergency Management Agency (FEMA) by an environmental lobby group concerned about the inappropriate disposal of mixed waste in a cleanfill (Luther 2008).

The use of air-curtain incinerators (ACI) in Miami Florida after Hurricane Andrew, 1992, drew public and environmental activist complaints. Despite the requirement to meet all the State and Federal requirements for incineration, some sites did not meet these standards (partly due to the nature of the waste). As a result of the complaints and concern over the disposal of the potentially hazardous ash waste, State officials shut down all debris burning operations (EPA 1995). Even if there is no or little environmental damage, the perception of the legislative relaxation or shift from standard environmental practices can be controversial.

In a disaster there is a tendency, as discussed in Sections 3.1 and 3.2, to opt for the quickest debris collection, treatment and disposal options, even if these are not consistent with ‘peace’ time laws and regulations. However, as demonstrated in the examples above, both the actual and perceived impacts of these legislative relaxations need to be considered before such decisions are made.

3.8 Financial aspects / funding mechanisms

Disaster response and recovery funding mechanisms vary from country to country. Funding mechanisms or strategies vary in their reliance on insurance, emergency funding, local authority financing, donations, public and private contributions. The nature of the funding mechanism, scope and delegated responsibility for clean-up activities can significantly affect the speed and efficiency of the debris removal (and consequently recovery) programme.

Invariably funding mechanisms stipulate lowest cost options. For example, in the US, FEMA's funding policy, stipulates that only lowest cost debris management options will be eligible for reimbursement (FEMA 2008). This, it seems is independent of the debris management strategies and environmental, economic or social benefits of the options. In some cases this criteria does not allow disaster debris managers to meet the goals of long-term (or even current) waste management strategies (Lauritzen 1995) as they are considered too costly (in terms of time and money) in a disaster response situation.

For example, in Los Angeles (LA), following the Northridge earthquake, FEMA originally denied funding for LA officials to establish a recycling system to supplement its insufficient landfill space, on the grounds that it was more expensive than landfilling. The State of LA was forced to prove that recycling was part of their long-term waste management strategy and the additional cost to start up recycling facilities was justified (State of California 1997).

Following the 2009 Victorian Bushfires, the Australian government elected to provide a free demolition and debris removal service to all bushfire victims to expediate the recovery process and minimise the potential for detrimental public health and environmental effects. Ordinarily, insurance would pay for this service on private properties and public funding (shared between emergency funding mechanisms and local authorities) would facilitate collection, treatment and disposal.

4.0 Debris management plans

The need to plan for disaster debris has only really been recognised within the past 15 years or so. Planning documents prepared by governments are generally built from the experience of previous events in the country and are framed around existing legislation, organisational structures and funding mechanisms. The first and most comprehensive national guidance on disaster debris management was by USEPA's "Planning for Disaster Debris" (EPA 1995). Recently, in an effort to increase preparedness and reduce costs and disruptions of disasters, FEMA introduced incentives, by way of increased cost share, for local authorities that prepared debris management plans (EPA 2008). Other developed countries are slowly following suit but the plans are often based on the USEPA's guidelines.

The key elements identified in the USEPA's "Planning for Disaster Debris" (EPA 2008) for pre-event planning are:

1. Pre-planning activities
2. Ancillary activities
    a. Identify likely debris types and forecast amounts
    b. List applicable federal, state, and local environmental regulations
    c. Inventory current capacity for debris management and determine debris tracking mechanisms
    d. Pre-select temporary debris storage sites
    e. Identify equipment and administrative needs (including pre-negotiated contracts)
    f. Develop communication plan
    g. Create a disaster debris prevention strategy

3. Create a debris removal strategy
4. Harmful materials identification and handling recommendations
5. Recycling options
6. Waste-to-energy options
7. Disposal options
8. Open burning options

5.0 The way forward in New Zealand

Despite New Zealand's high risk of natural disasters, disaster debris management is a near virgin topic – both in terms of research and in terms of policy. In 2008, Wellington Region Civil Defence and Emergency Group prepared the first debris disposal guidelines in the country for Greater Wellington (WRCDEMG 2008). The Joint Centre for Disaster Research has recently lead a small EQC funded report on issues specific to urban earthquake debris management in Wellington (Johnston, Dolan et al. 2009).

New Zealand's sometimes cumbersome environmental regulation and consultative RMA processes will be difficult, if not impossible, to administer in a disaster situation. With existing solid waste management facilities likely to be far exceeded in a large scale event some pre-planning and fore-thought into potential debris management options needs to be carried out. If New Zealand is to maintain its clean green image then this is yet another string that needs to be added to our environmental and disaster preparedness bows.

As solid waste and environmental managers and practitioners in New Zealand we need to start planning for disaster debris management. We need to start preparing and positioning ourselves for the inevitable by:

- considering alternate disposal options
- assessing possible environmental impacts and risks
- investigating recycling options
- establishing MOU's between localities and contractors
- establishing operational roles and responsibilities with civil defence, ministry groups and local authorities
- sensitising the community and preparing post-event communication strategies
- investigating funding mechanisms and capacities.

As researchers we need to learn lessons from overseas experiences. We need to more fully understand the role that debris management plays in disaster recovery and what the best strategy is for preparing for and responding to a high debris volume disaster event.

7.0 Conclusion

Effective disaster debris management has far wider implications in disaster response and recovery than is currently recognised. There is real social, economic and environmental value in planning for the management of disaster debris. It is not just a logistical exercise – it is an integral part of the disaster recovery process.

References

Basanayake, B. F. A., C. Chiemchaisri, et al. (2006). "Wastelands: Clearing up after the tsunami in Sri Lanka and Thailand." Waste Management World **March-April 2006**: pp 31-38.

Basnayake, B. F. A., C. Chiemchaisri, et al. (2005). Solid wastes arise from the Asian Tsunami Disaster and their Rehabilitation Activities: Case Study of Affected Coastal Belts in Sri Lanka and Thailand. Tenth International Waste Management and Landfill Symposium. Sardinia.

Baycan, F. (2004). Emergency Planning for Disaster Waste: A Proposal based on the experience of the Marmara Earthquake in Turkey. 2004 International Conference and Student Competition on post-disaster reconstruction "Planning for reconstruction" Coventry, UK, April 22-23, 2004

Baycan, F. and M. Petersen "Disaster Waste Management - C&D Waste."

Bjerregaard, M. MSB/UNDP Debris Management Guidelines, Disaster Waste Recovery.

Demick, B. (2009). China quake survivors still wait for word. LA Times.

EPA (1995). Decision-Makers' Guide to Solid Waste Management, Volume II. Office of Solid Waste and Emergency Response. **Vol. II**.

EPA (1995). Planning for Disaster Debris. Wastes Department.

EPA (2008). Planning for Natural Disaster Debris Office of Solid Waste and Emergency Response and Office of Solid Waste.

FEMA (2008). Public Assistance Policy Digest. US Department of Homeland Security.

Jackson, N. M. (2008). "Cleaning up after Mother Nature." Waste Age(July 2008): 3.

Johnston, D., L. Dolan, et al. (2009). Disposal of debris following urban earthquakes: guiding the development of comprehensive pre-event plans Wellington, GNS.

King, P. H. (2005). The Long, Hard Road Back. Los Angeles Times. Los Angeles.

Kuamoto, N. (1995). The Actual State of Damage and Measures Undertaken in Hyogo Prefecture. Earthquake Waste Symposium, Osaka.

Lauritzen, E. K. (1995). Solving Disaster Waste Problems. Earthquake Waste Symposium. Osaka. **Technical Publication Series - 2**.

LDEQ (2006). Comprehensive Plan for Disaster Clean-up and Debris Management. Department of Environmental Quality. Louisiana.

LDEQ (2007). Louisiana Katrina/Rita NESHAP Matrix

Luther, L. (2008). Disaster Debris Removal After Hurricane Katrina: Status and Associated Issues, Congressional Research Service.

MSW (2006). MSW Management **September/October**: 36.

Solis, G. Y., H. C. Hightower, et al. (1995). Disaster Debris Management. British Columbia, The Disaster Preparedness Resources Centre, The University of British Columbia for Emergency Preparedness Canada.

State of California (1997). Integrated Waste Management Disaster Plan: Guidance for local government on disaster debris management. Integrated Waste Management Board.

SWANA (2005). Hurricane Katrina Disaster Debris Management: Lessons Learned from State and Local Governments.

UNDP (2006). Tsunami Recovery Waste Management Programme. Multi Donor Fund for Aceh and Nias, UNDP.

UNEP (2005). Lessons Learnt from the Tokage Typhoon (Typhoon 23 of 2004) in Japan.

Waste Management in Emergencies Group. (2004). "Solid Waste Management in Sub-Sahara African Emergencies." Retrieved 2006, from old url www.redr.org/wmine/index.htm.

WRCDEMG (2008). Group Debris Disposal Guidelines. Wellington Region Civil Defence Emergency Management Group. Wellington.

Yepsen, R. (2008). "Generating Biomass fuel from disaster debris." Biocycle **49**(No.7): 51.