Newcastle earthquake essay

PART I INTRODUCTION AIM The aim of this report is to describe the Newcastle earthquake and identify its social, physical and economic effects on the community. The event in detail, major effects, how the event was caused, the effects on the communities property, people, infrastructure and economy, will all be addressed in this report. Also the long term planning implications, preventative measures, preparedness, response implications, and well as recovery implications will covered and described. OBJECTIVESThe objectives of this report on the Newcastle Earthquake are as follows: 1.

To define the terms emergency, and show what makes this event an emergency, 2. To identify in detail the nature of the event, in terms of how and why this event occurred, 3. To identify and discus who and what were affected by this event, 4. To identify the long term implications of this emergency, including details of preventative and preparedness implications, as well as response and recovery implications. PART II WHAT WAS THE EVENT? THE EVENTThe event was Australia’s most damaging earthquake which hit Newcastle city. WHERE AND WHEN THE EVENT OCCURRED AND IT’S DURATION The earthquake struck Newcastle city at 10.

28am on the 28th December 1989. The epicentre of the earthquake was 15kms west south west of Newcastle’s CBD, and registered at 5. 6 on the Richter scale. The initial earthquake only lasted 5 to 6 seconds, but two after shocks followed.

(Geoscience Australia 2004) The first aftershock was around ten minutes later but was not felt by many Novocastrians. The second was felt the day

after at 7: 08am the 29th December, measuring 2. 1 on the Richter scale (Newcastle Library n. d).

This after shock was strongly felt, especially in the suburb of Hamilton. The city is located on the east coast of New South Wales Australia, with a population of around 300 000 people (Geoscience Australia 2004). It was settled early in the 19th century, initially for the mining and exportation of coal. Most of Newcastle's business is based around this coal extraction. The CBD is located between the beach on the east and the busy port on the north. Many of the original buildings are still operating in the CBD (Geoscience Australia 2004).

This combination contributed to the damaged caused. MAJOR EFFECTS The earthquake was not a large compared to earthquakes that other countries have experienced, but extensive damage and fatalities were caused. There was a total of 13 deaths caused by the earthquake and another 162 people where hospitalised. Over 50 000 buildings where damaged, both homes and commercial properties (Newcastle Library n.). In a wider perspective, the shaking effects were felt from Albury, Cooma and Bermagui in the south, Temora and Narromine in the west, to Coonabarabran, Armidale and Coffs Harbour, which are 550 kilometres north of Newcastle.

Damage was recorded from Liverpool 138 kilometres south, Scone 145 kilometres west, and Gladstone 320 kilometres north (Australian Government 2003). The further effects that were felt by this earthquake will be explained in detail further down in the report. WHY WAS THIS EVENT AN EMERGENCY An emergency from an emergency services perspective A

serious disruption to community life which threatens or causes death or injury in that community and/or damage to property which is beyond the day-today capacity of the prescribed statutory authorities and which requires special mobilisation and organisation of resources other than those normally available to those authorities. (csu) Emergency definition from the New South Wales Disaster PlanAn emergency due to the actual or imminent occurrence (such as fire, flood, storm, earthquake, explosion, accident, epidemic or warlike action) which: (a)endangers, or threatens to endanger, the safety or health of persons or animals in the Sate; or (b)destroys or damages, or threatens to destroy or damage, any property in the State, being an emergency which requires a significant and co-ordinated response.

(New South Wales Government 2001) To determine why the Newcastle earthquake was classified as an emergency, the definition of emergency must be addressed. The two above definitions of the word emergency are different but do come to the same conclusion. It can be identified that the Newcastle earthquake did indeed endanger, or threaten to endanger, the safety of persons in the community. Also, the event did destroy or damage property in the affected area. The event also required the special mobilisation of organisation of authorities. From this it can been seen that the Newcastle earthquake can be classified as an emergency.

From here, the event can be classified into specific type of emergency. This event, an earthquake, is classified as a natural disaster. A natural disaster is one that occurs naturally in the environment with out any interference from man. These can include earthquakes, volcanic eruptions, tsunamis, cyclones, floods, landslides, some bushfires, and droughts (Carter 1991). Most of these

disasters cannot be avoided but some can be predicted or detected, providing significant warning time to prepare affected areas.

Natural diasters are part of the earth’s environment, and need to be accepted and expected in our societies. PART III HOW AND WHY DID IT HAPPEN? HOW AN EARTHQUAKE IS CAUSED The earth’s surface is made up of many separate pieces called tectonic plates. These tectonic plates are in constant movement. This movement and pressure of this movement, build up tension which needs to be released.

This tension is released in the form of an earthquake. Australia is situated on the Indian-Australian plate; this plate is moving north and colliding with the Eurasian, Philippine and Pacific plates. This movement and pressure is what causes Australia’s earthquakes. Tectonic plates can interact in three different ways. Where plates move apart, they are named Divergent plate boundaries. This movement allows magma to come to the surface, cool and fill the space formed by the movement.

The second type of plate movement is where plates are forced directly towards one and other, resulting in one plate being pushed under neath the other. This is called a convergent plate boundary. Transform boundaries, is where two plates slide along each other in opposite directions. Where these boundaries meet, fault lines are formed. It is at these fault lines where earthquakes are most likely to occur.

Earthquake’s need a particular science to detect and measure there presence. Equipment called a seismograph is what is used to measure the size of an earthquake. A seismograph records the vibrations that are caused

by an earthquake and produces a recording called a seismogram. Earthquake sizes are compared and measured by the Richter scale.

This scale is constructed by measuring the maximum height of the seismic waves caused by the earthquake. This measurement is taken at a distance of 100 kilometres away from the epicentre of the earthquake. The epicentre of an earthquake is also pinpointed by the use of three or more seismographs in different locations. This equipment is essential in researching and monitoring earthquake activity. This monitoring may help in the eventual prediction and warnings or earthquakes (Geoscience 2004).

THE CAUSE OF THIS PARTICULAR EVENT The Newcastle earthquake was caused in by the movement of the earth’s tectonic plates. The fault line responsible for the Newcastle earthquake is around 40 kilometres long, starting off the coast of Newcastle and travelling under Lake Macquarie. This fault line is an intra plate fault line, that is, a fault line in a tectonic plate, rather then where separate tectonic plates meet. (Lawson 2000) Another unique property of the Newcastle earthquake is the material underlying the surface the Newcastle CBD is built upon.

This material, known as alluvium is sediment deposited by flowing water. The alluvium amplified the ground motion of the earthquake, almost like a city sitting on top of jelly (Geoscience Australia 2004). Ground surface velocities were measured, where the city was built on basement rock the surface velocity was 50 millimetres per second. Where the city has this underlying layer of alluvium the ground surface velocities were measured at

200 millimetres per second. This is the reason that so much damaged was caused by this size of earthquake.

Generally an earthquake with a magnitude ranging from 5. 5 – 6. 1 only causes ‘ slight building damage with plaster cracking, and bricks falling’ (Geoscience Australia 2004). As the Newcastle earthquake was measured at only 5. 6 on the Richter scale, the amount of damage caused was unforseen and unexpected. The damaged caused would usually be associated with an earthquake of a magnitude of 7.

0 to 7. . The difference of the underlying earth, must be taken into account when assessing the risk of damage in other cities, and brought to attention when planning for the effects of an earthquake (Geoscience Australia 2004). THE EFFECTS ON NEWCASTLE’S PEOPLE The effects that the earthquake had on Newcastle’s citizens are very broad. It starts with the most obvious physical effects, but includes the psychological effects, economic effects, and lifestyle effects. Over all 300 000 people were directly affected by this earthquake, and approximately 1 000 persons were made homeless (Newcastle Library n.

) The first and most obvious effect of the Newcastle earthquake would have to be the physical injuries sustained. A total of 13 deaths occurred, 12 were because of structural collapse and the other was from earthquake induced shock. Another 162 people were hospitalized for injuries (Newcastle Library n. d).

These figures could have been much higher if the earthquake had happen during school hours or at a time when a major event was planned. The

psychological effects of such a major event usually begin immediately (with in 24 – 48 hours) this includes general distress. Numbness and shock occur usually as a defence mechanism, this distress and shock impairs normal functioning. The long term psychological effects are more serious, which sometimes do not present until six months later.

These can include a general distress and anxiety, post traumatic stress disorder, depression, phobias, substance abuse, sleep disturbance, hostility, somatization, disruption of family relationships, decreased capacity to work, increased presentation to health care services, increased use of medication, and a general decrease in physical health. The earthquake counselling service set up in Hamilton, a suburb of Newcastle, in February till the end of April diagnosed 46 people with server depression and 37 people with post traumatic stress disorder. Details of these effects are as follows: Depression, the symptoms can include loss of sexual interest, low energy levels, suicidal thoughts, crying easily, feelings of being trapped or caught, loneliness, excessive worrying, loss of interest in life, and a feeling of hopelessness. Anxiety can include feelings of nervousness, trembling, feeling scared for no apparent reason, and feeling tense.

Signs of hostility include feeling easily annoyed, temper, having urges to hurt or injure others, and frequent arguments. Somatization symptoms can include headaches, dizziness, pains in the heart or chest, pain in the lower back, nausea, shortness of breath, hot or cold spells, general feeling of weakness, and a heavy feeling in your arms and legs. Phobias can include feeling afraid of open spaces, afraid of being alone, avoiding certain places because of memories. There are four major stressors which produce

psychological distress in adults, resulting in the conditions previously outlined.

1. Death encounter – A threat to someone’s life or witnessing gruesome or massive death of others. 2. Loss – Loss of loved ones, home, property, community, familiar environment, or social network. 3. Dislocation – From home, community, familiar environment.

4. Responsibility – perceived or actual responsibility in terms of the disaster, especially when involving the deaths of others. There is a different outcome for children after a disaster, there is no normal reaction varies from child to child. These can include: 1. Fear and anxiety – When the child becomes frightened of things that before the event never bothered them.

Examples may include frightened of being alone, going to bed, or things that remind them of the event such as thunder. 2. Regression – The child regresses to a younger stage of development. Examples clinging to parents, thumb sucking, temper tantrums, baby talk, loss of toilet training, and wanting things that have been previously discarded, like bottles or toys. 3.

Sadness and withdrawal – The child becomes sad and withdrawn, losing interest in normal activities, loss of appetite, and a general lack of enjoyment of life. 4. Acting out – excessive naughty behaviour for attention. 5. Over reaction to minor stress – Reacting to things that would usually not cause them stress.

The general effect on the community was one of a heighten sense of vulnerability, mortality, and sense of community, but with the city damaged

there was no focus for the community (Bland 1996) THE EFFECTS ON NEWCASTLE'S PROPERTY There was devastating effects on Newcastle's structures and buildings, in total around 35 000 homes, 3000 commercial buildings, and 42 schools suffered serious damage. Minor damage was also experienced as far away as Scone, Gladstone and Sydney. These collapsing buildings caused extensive damage in its self, destroying significant property such as cars, roads and infrastructure, and even causing the most of the fatalities. The fatal collapses include the collapse of the Newcastle Workers club, and the Kent Hotel, both very popular businesses in Newcastle. (Australian Government 2003) The most unstable buildings during an earthquake are un-reinforced masonry buildings. Unfortunately these buildings are very common in the older parts of Newcastle.

This type of building was constructed up until the 1960s, and includes a wide range of constructions, including houses, terraced houses, shops, schools, churches, and hospitals. The reason of this type of building performing so poorly in an event of an earthquake is due to a lack of construction ties between the double brick walls. This leaves the construction inflexible, brittle, with weak spots and when added with age and corrosion makes them inadequate to withstand horizontal shaking (Geoscience Australia 2004). Another form of construction that is used widely in Newcastle is timber frame buildings. This type of building was popular from the 1960s onwards. This type of construction and perform better then the un-reinforced structures in an earthquake, although this does have weak spots especially were the masonry foundations are used.

This can lead to substantial damage to these areas (Geoscience Australia 2004). A more modern form of construction used in the Newcastle area is reinforced and pre-stressed concrete buildings. This type of construction form a significant percentage of large buildings, and used for various purposes such as commercial, car parking, industrial, residential, educational, and government purposes. These buildings will perform well in an earthquake as long as construction has been performed to ensure continuity and irregularities are avoided (Geoscience Australia 2004).

The last form of construction that will be addressed is steel framed buildings. This type of construction is again used for large buildings, mostly in areas of industrial and recreational. If construction is not undertaken carefully, connections between steel members can be brittle and cause problems in the event of an earthquake. Geoscience Australian 2004) As can been seen by figure 1.

0 shown below, timber frame structures are the most popular through the Newcastle city, with a large concentration of un-reinforced masonry structures in the older section of the CBD. From this map it can been seen where the most of the damage from different structural type would have occurred. In figure 1. 1 it is shown that the two most unstable structural types, timber frames and un-reinforced masonry, suffered the greatest amount of loss and structural damaged.

These two figures can be used together to show where the greatest amount of loss had occurred. Most of these modern structures did not experience major damage during the earthquake. Except in the case of the Newcastle

workers club, where nine of the thirteen fatalities occurred. In this situation there was a combination of two sections built in different styles, an older un-reinforced masonry section, and a newer concrete frame section. The problems arose in the newer section, which was four stories in height with underground parking directly beneath it. The earthquake caused a collapse from the top storey, trapping all people with in the lower stories and in the underground car park (Newcastle Council 2001).

Another significant structural collapse was The Kent Hotel, situation on Newcastle Beaumont St. This un-reinforced masonry buildings collapse was responsible for 3 fatalities. This mix of old vulnerable buildings on poor foundations, inadequate maintenance and brittle materials was the combination that led to the extent of damage experienced in the Newcastle earthquake. Geoscience Australia 2004).

Figure 1. 0 Placement of structural types in Newcastle according to frame type. (Geoscience Australia 2004) Figure 1. 1: Annualised loss for a selection of building types in the Newcastle region. The annualised loss for a specific building type is described as a percentage of the total value of that building type. (Dhu 2002) THE EFFECTS ON NEWCASTLE’S ESSENTIAL SERVICES Essential services play a very important role in emergency response and the recovery after such an event as an earthquake.

With out these essential services the emergency response teams are greatly impaired, especially when the only transport available is by road. The structural effects from the Newcastle earthquake were quite extensive, yet essential services such as gas and water were not affected. Electrical power

is very vulnerable to earthquake, the height and structure of power poles that carry the electrical power lines as well as the brittle ceramic insulators found in substations are the weak points of electrical systems during an earthquake. The electrical power infrastructure was damaged during the Newcastle earthquake (Geoscience Australia 2004).

Telephone services were also damaged and road transport was seriously impaired from collapsed buildings and debris. This occlusion of roads would have affected the emergency response the greatest, as if directly blocked the emergency services access to the sick, injured, trapped, and other emergencies such as fires (Geoscience Australia 2004). ENVIROMENTAL EFFECTS OF THE NEWCASTLE EARTHQUAKEEarthquakes are considered a natural disaster, and occur in response to the natural movement of the earth’s tectonic plates. Unless earthquake occur in a populated area there is little to none lasting environmental effects. In the case of the Newcastle earthquake structural collapse caused most of the environmental impact in the way of debris. This debris was effectively eliminated through the recovery and rebuilding procedures put in place after the earthquake.

So from this disaster there were no long term effects on the surrounding environment (Geoscience Australia 2004). SOCIAL AND COMMUNITY EFFECTS OF THE NEWCASTLE EARTHQUAKE There are many lasting effects on the community of Newcastle city. These include long term effects such as damage to social and cultural structures, loss of life/life style, and economic effects. Short term effects include fear, distress, and confusion.

Damage to social and cultural structures can have a large affect on a community and these structures often act as a focal point of the community, structures such as churches, museums, libraries, recreational venues, schools, and conservatoriums. Damage or collapse to this type of structures can have a depressive effect on a community, and cause a community to lose its sense of focus and identity (Geoscience Australia 2004). Short term effects include emotional distress and confusion immediately after the event. This effect also rendered around 1 000 people homeless, leaving them vulnerable and displaced (Newcastle Library n.

d). From a different perspective a emergency such as this can bring out a sense of community in a society, with people offering help to those in need. THE EFFECTS ON NEWCASTLE’S INFASTRUCTURE Every community relies on infrastructure to function. Infrastructure includes road networks, rail networks, primary and secondary schools, pre-school centres, TAFE campuses, University campuses, churches, government services, and recreational centres. The predominant section of infrastructure to experience the most damage was Newcastle’s schools.

A total of 147 schools in the city were damaged, of this three were deemed unsuitable for occupation and were demolished, another 42 experienced serious structural damage. There is a large concentration of primary schools in the area of Newcastle’s CBD and close suburbs. Many of these schools are old historic sites that are still being used today. This old un-reinforced masonry type of construction, and general erosion left these constructions very exposed to damage from an earthquake (Geoscience Australia 2004).

Another prominent structure in Newcastle that suffered significant damage was the Newcastle workers club, this falls under the heading of recreational facility. The damage experienced by this building was outlined under the heading THE EFFECTS ON NEWCASTLE'S PROPERTY. This articular building's collapse and demolition had a substantial detrimental effect on Newcastle's infrastructure. Many other important building through Newcastle suffered substantial damage, but all were successfully repaired or stabilised. THE EFFECTS ON NEWCASTLES ECONOMY Costs incurred by an earthquake included direct costs from damage as well as indirect costs, such as loss of business.

The estimated value of the damage done by the earthquake was estimated at 1. 124 billion dollars, this measured by the total insurance claims pay out in 1996. The total financial cost has now amounted to an estimate of 4 billion dollars. There were a total of 69, 564 insurance claims made for earthquake damage, 63, 756 of these were households, and 5, 808 were commercial buildings (Insurance Disaster Response Organisation 2002). Until the Sydney hailstorm the Newcastle earthquake was the worst event for the Australian insurance industry (Walker 1999). From the figure 1.

2 shown below, we can seen the areas of Newcastle that suffered the greatest economic loss and damage too their property and structures. Even though this event had a detrimental effect on the unprepared insurance industry, events such as these can often have some positive effect on a society's economy. Extensive rebuilding, use of supplies, equipment, and skills would have a helpful effect on the economy after such a set back (Geoscience Australia 2004). Figure 1. 2: Annualised loss by suburb. The

annualised loss in each suburb has been calculated as a percentage of the total value of all the buildings and their contents within the suburb.

(Dhu 2002) PART IV LONG TERM PLANNING IMPLICATIONS PREVENTATIVE / MITIGATORY IMPLICATIONS As this event is an unavoidable natural function of the earth, nothing can be done to avoid this type of event. What can be done in this situation is to reduce the amount of effect an earthquake has on a society. Ways that this can be done is through researching past events, collecting data, reviewing current building codes, protecting emergency facilities, and providing adequate insurance against earthquakes. Research of past earthquakes and the effect they had on the communities they affected, should provide societies at risk with a clear idea of what to expect. From this emergency plans can be implemented. Reviewing past earthquakes can give a clear idea on the direct effects on structures and buildings.

Just from this one incident it can been seen that certain types on structures need extra attention and reinforcement when it comes to decreasing the risk of damage that can be caused. This can be directly addressed through the use of building codes and earthquake codes. Since the Newcastle earthquake had little effect on the current building codes, the risk of another earthquake with in Australia needs to be address, and codes and preparation put in to place before that risk occurs (Walker 1999). Another method of reducing the impact in the event of an earthquake is to ensure that all emergency services would be able to cope. Emergency services such as Police, Fire and Ambulance stations, as well as hospitals, and other emergency services such

as the State Emergency Service, need to be structurally protected and enforced.

All stations and structures should be earthquake proofed by suitably qualified structural engineers, and changes made if need be. The emergency services also need to be well equipped for such an emergency in training, strategic planning, and equipment. Since most of these services main access is by road, suitable planning to avoid this needs to be enforced. Households and commercial operations need to ensure they hold adequate insurance policies against earthquake damage. This will not decrease the damage caused by an earthquake, but will help the recovery and rebuilding of the community after the event (Walker 1999).

PREPAREDNESS IMPLICATIONS To be suitably prepared for an earthquake incorporates similar principals as what was outlined in the section above. Additional research and emphasis should also be placed on investigating the earthquake risk in specific areas, and education of the public. The combination of these two ideas, as well as the points outlined in the section above, will prepare the community for the event of an earthquake and facilitate a decrease in fatalities and damage. An earthquake hazard in a specific area can be described as the level of ground shaking that has a certain chance of being exceeded in a given amount of time. For example an earthquake hazard can be described in terms of the level of ground shaking that has a 10% chance of being exceeded in 50 years.

With this calculated earthquake hazard, a earthquake risk can then be calculated. An earthquake risk is a combination of the earthquake hazard,

the elements at risk and the vulnerability of those elements to earthquakes (Dhu 2002). Shown below in figure 1. 3 it be been seen the areas of the greatest risk in the Newcastle area. Figure 1.

4 shows the greatest risk areas across the country, and figure 1. 5 shows the hazard areas across the country. All these calculated risk and hazard areas need to be addressed with earthquake plans put in place to reduce the damage of an earthquake when the event occurs. Figure 1.

3 Earthquake hazard map with a 10% chance of being exceeded in 50 years. Hazard is defined by the response of idealised low- to medium-rise buildings with a natural period of 0. 3 s. (Dhu 2002) Figure 1.

4 Australian earthquake risk areas (Newcastle Library n. d) Figure 1. 5 Australian earthquake hazard areas (Newcastle Library n. d) Another method of preparing a community for the event of an earthquake is educating the public of the correct procedures on the correct steps to carry out before, during, and after the event of an earthquake. Examples of correct procedures to be carried out in these situations supplied by the Newcastle Council (n. d) are as follows: What can you do before an earthquake occurs? •Follow earthquake building codes for new and existing buildings.

•Check your home for and secure earthquake hazards such as bookcases and other tall furniture. •Be aware of the location of electricity, gas and water main switches or valves and how to turn them off with the appropriate tools. •Keep the following items ready for use at all times -a first aid kit -a multi-purpose dry chemical extinguisher -a portable radio with extra batteries -a torch •Learn first aid and encourage family members to do the

same •Organise occasional home earthquake drills. This will provide your family with knowledge of how to avoid injury and panic during an earthquake.

What can you do during an earthquake? Remain calm, think clearly before moving, provide reassurance to others and then work through the consequences of any action you may take. If you are in a house •Take cover under a table or other sturdy furniture •Kneel, sit or stay close to the floor •Be prepared to move with your cover •You could kneel, sit or stay close to the floor, an interior wall or corner. Stay away from large windows, bookcases and unsecured objects. If you are in a shop, office or theatre •Do not rush for an exit Move away from windows, glass display cases or other obvious hazards •If you must leave the building, choose your exit carefully as possible If you are in a high rise building •Take cover under a desk or table; do not rush for exits •Stay in the building until shaking sops and until directed to evacuate. If you are outside •Avoid high buildings, walls, power lines and other objects that could fall •Do not run through streets •If possible move to an open ear away from all hazards If you are in a vehicle •Stop in safest place available, preferably in an open space •Avoid bridges, overpasses and overhead power linesWhat can you do after an earthquake? Check for serious injury to your families and other around you.

Do not attempt to move a seriously injured person unless they are in immediate danger of further injury. If you are inside a building •Only use the telephone for emergency use •Remain in a safe position until shaking stops •Check electricity, gas, water services and turn off if necessary •Check food storage and first aid supplies •Listen to your radio for information and advice

If you are outside •Check for fires or fire hazards •Avoid fallen power lines •Wear shoes to protect your feet •Do not attempt to drive. Leave roads clear for emergency vehicles •Check building for structural damage RESPONSE IMPLICATIONS The emergency services response to an emergency such as an earthquake largely depends on the plans and procedures put into place before the fact. The services that play a part in the response to such an event are the Fire brigade, Health services, Police services, public information services, rural fire services, state emergencies services, transport services, volunteer rescue associations, and welfare services. These services range from immediate response teams such as the Fire, Police, and Health services, o longer term response teams such as welfare services.

Without these essential response organisations, any emergency would end in a great more tragedy (New South Wales Government 2001). RECOVERY IMPLICATIONS Recovery from a disaster can be defined as “ the coordinated process of supporting disaster affected communities in the reconstruction of the physical infrastructure and restoration of emotional, social, economic and physical well being. ” (O’Mara 2004). After an event such as the Newcastle earthquake all of these points need to be addressed and much effort and coordination put into returning the community back to its former state.

There are long term recovery plans such as re building, and restoration of emotional and physical wellness. In response to the Newcastle earthquake an Emergency Reception Centre was set up. This centre treated 14, 800 clients, of these 1, 500 were in need of temporary or long term

accommodation. Centres like this prove vital in the recovery of a community after such an event. CONCLUSION In conclusion, it is known that the Newcastle earthquake caused extensive damage in physical, emotional, and economic ways.

It is also known that some of this damage could have been avoided or diminished with correct planning, preparedness and response actions. An event such as this should be used for education and future planning purposes to protect other communities from similar effects. REFERNCE LIST Australian Government 2003, Newcastle Earthquake, Australian Government, viewed 2 March 2006 ; www. ema. gov. au; Australian Government Geoscience Australia 2004, Earthquake Risk in Newcastle and Lake Macquarie: The Elements at Risk in Newcastle and Lake Macquarie, updated July 2004, Australian Government, also available in pdf format, viewed 11 March 2006 ; http://www.

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