Waikato Regional Council Technical Report 2014/04

An overview of natural hazards for the Hamilton City Council

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Te Kaunihera ā Rohe o Waikato

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Executive Summary

The purpose of this report is to provide an overview of natural hazards in Hamilton City as a basis for guiding and prioritising work activities for the Hamilton City Council (HCC) and Waikato Regional Council (WRC) for 2014/15 and beyond. This report also provides a useful insight into the district's natural hazard risks as part of the scheduled review of the Hamilton City District Plan.

Both agencies have responsibilities for the management of natural hazards in accordance to a complex set of statutory responsibilities, but primarily the Resource Management Act (RMA) 1991.

Known natural hazards in the Hamilton City district are identified and explained. A qualitative risk analysis is then undertaken, and an evaluation of the risk from each natural hazard is made as a basis for prioritising risks.

Earthquakes pose the greatest risk in terms of potential loss of human life, social disruption, economic cost and infrastructure damage. Severe wind is the second highest risk, followed by drought. The report also identifies various factors/considerations that are likely to affect natural hazard planning such as climate change and sea level rise.

Hazard Scenario	Total Score	Priority
Earthquake	14.3	1
Severe wind	14.1	2
Drought	12.1	3
Volcanic ashfall	11.8	4
Landslide	10.0	5
Rural fire	8.5	6
Flooding (river and drainage)	8.2	7

1 Introduction

1.1 Purpose

This report provides an overview of the significant natural hazards currently affecting and likely to affect the area administered HCC:

- An initial assessment of the range of existing and potential natural hazard risks that affect the district and how these may change over time.
- An initial qualitative risk assessment which identifies the risk to life and property in broad terms
- An identification of gaps and priorities
- A basis for developing effective District Plan provisions regarding natural hazards.

Both HCC and WRC have ongoing natural hazards commitments in the area. This report presents an initial analysis for the key natural hazards and provides guidance to HCC and WRC for the prioritisation of natural hazards work programmes within HCC.

The key drivers for the preparation of this assessment are:

- The review of the Hamilton City District Plan (including the identification of future district growth priorities)
- The need to document/review the suite of natural hazards relevant to the HCC area.
- To pre-empt proposed changes to the RMA which is likely to raise the importance of natural hazards as a matter of national priority.
- To outline existing natural hazard information (and its status) held by WRC, including maps and other spatial information.
- To identify any (research) gaps.
- To outline and identify options for addressing risk in the future.
- Form a basis for guiding and informing strategic policy formulation and implementation.
- Undertake a qualitative (desk top) risk assessment exercise as a basis for determining future priorities (short and long term).

1.2 Statutory and legal framework

The Local Government agencies primarily charged with managing the natural hazards that affect the Hamilton City District are HCC and WRC. This responsibility includes the development of policy and the implementation of strategies and mechanisms to avoid or mitigate the effects of hazards on people, property and the environment. Further details in regard to these responsibilities are presented in Appendix 2.

The statutory framework guiding WRC and HCC is primarily determined by the Resource Management Act 1991. Other relevant statutes include the Local Government Act 2002, the Soil Conservation and Rivers Control Act 1941, the Land Drainage Act 1908, the Building Act 2004, the Public Works Act 1981, the Civil

Defence Emergency Management Act 2002, and the Hauraki Gulf Marine Park Act 2000. Further discussion around the relevant provisions of these statutes is provided in Appendix 1.

The Ministry of Civil Defence and Emergency Management has a role in hazard management through its enabling legislation.

1.3 National drivers for hazard management

There are several key drivers which impact the way in which natural hazards are managed in New Zealand. These include:

- The emergency management focus on hazard risk reduction, the treatment of residual risk and an all hazards approach.
- The recent review of the Resource Management Act which places more importance on natural hazards and their associated risk in planning and development processes.
- Local Government New Zealand through the development of a Natural Hazards Guidance note.
- Insurance Council through the release of their discussion paper on how natural hazards are currently and likely to affect the insurance sector.
- Increasing community expectations for natural hazard management to be linked with other community outcomes.
- The impact of predicted future climate change on natural hazards, including the need to adapt existing risk reduction measures (e.g. flood protection schemes).
- Increasing development pressure on land that is affected by natural hazards.
- The damage that continues to be sustained by numerous New Zealand communities due to natural hazards.

1.4 Key hazard planning considerations for Hamilton City Council

In addition to the statutory framework and national drivers, there are a number of other considerations that are or will affect the management of natural hazards in the Hamilton City District, including:

- Continuing population growth in known natural hazard risk areas.
- The proximity of existing development to land affected by natural hazards.
- The growing number of Resource Consent applications covering the development and encroachment of marginal land.
- The incorporation of predicted future climate change into research, planning and operations.
- Increasing property values, particularly in areas that are affected by one or more natural hazards.

- Translating Central Government risk management guidelines into effective policies using the Regional and District planning framework.

- The increasing demand from Central and Regional Government for land use planning controls to be incorporated into a risk reduction strategy.

- The Increasing awareness of the importance of lifelines infrastructure (e.g. roading, electricity and potable water).

- The existing reliance of some communities on physical works that are unlikely to provide the unconditional protection that is often sought.

- The importance of maintaining public awareness and understanding regarding the management of natural hazards.

A crucial role for the Council in areas affected by natural hazards is raising public awareness and ensuring that the public is prepared for emergencies, to reduce the risk to lives and property.

2 Profile of the Hamilton City District

2.1 General Description

Hamilton City encompasses a land area of approximately 98km^2 on the banks of the Waikato River, and is home to 141,615 people (2013 Census Data), making it New Zealand's fourth most-populous city. The city is split up into suburbs, each with varying population densities (Figure 1)

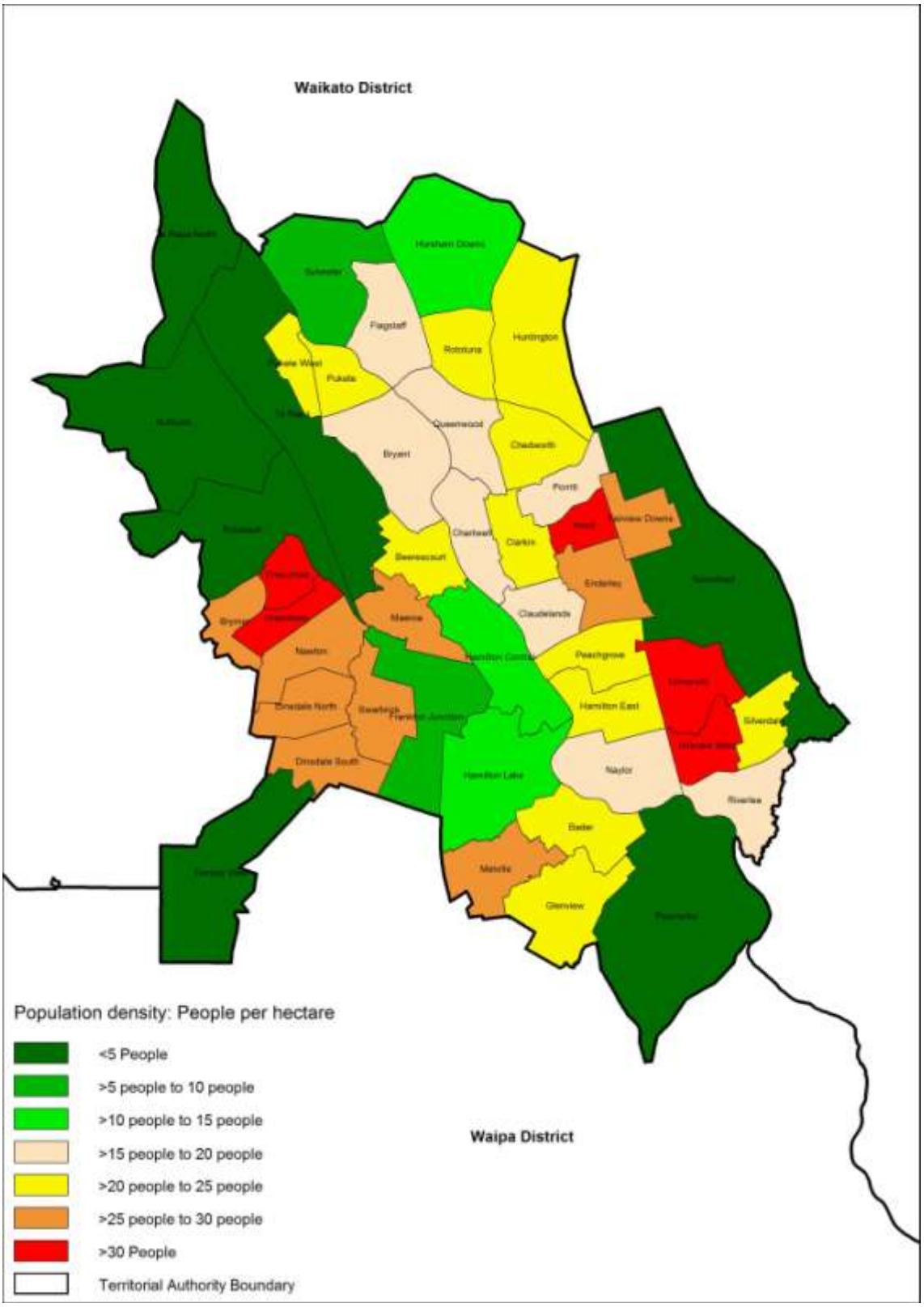

Figure 1: Population density in Hamilton City by suburb

The city has some major transport links, including the primary rail transport corridor which links Auckland, Tauranga and Wellington. Five other State Highways run through Hamilton City, including SH1, SH3, SH23 and a small section of SH26 and SH3 (
Figure 2).

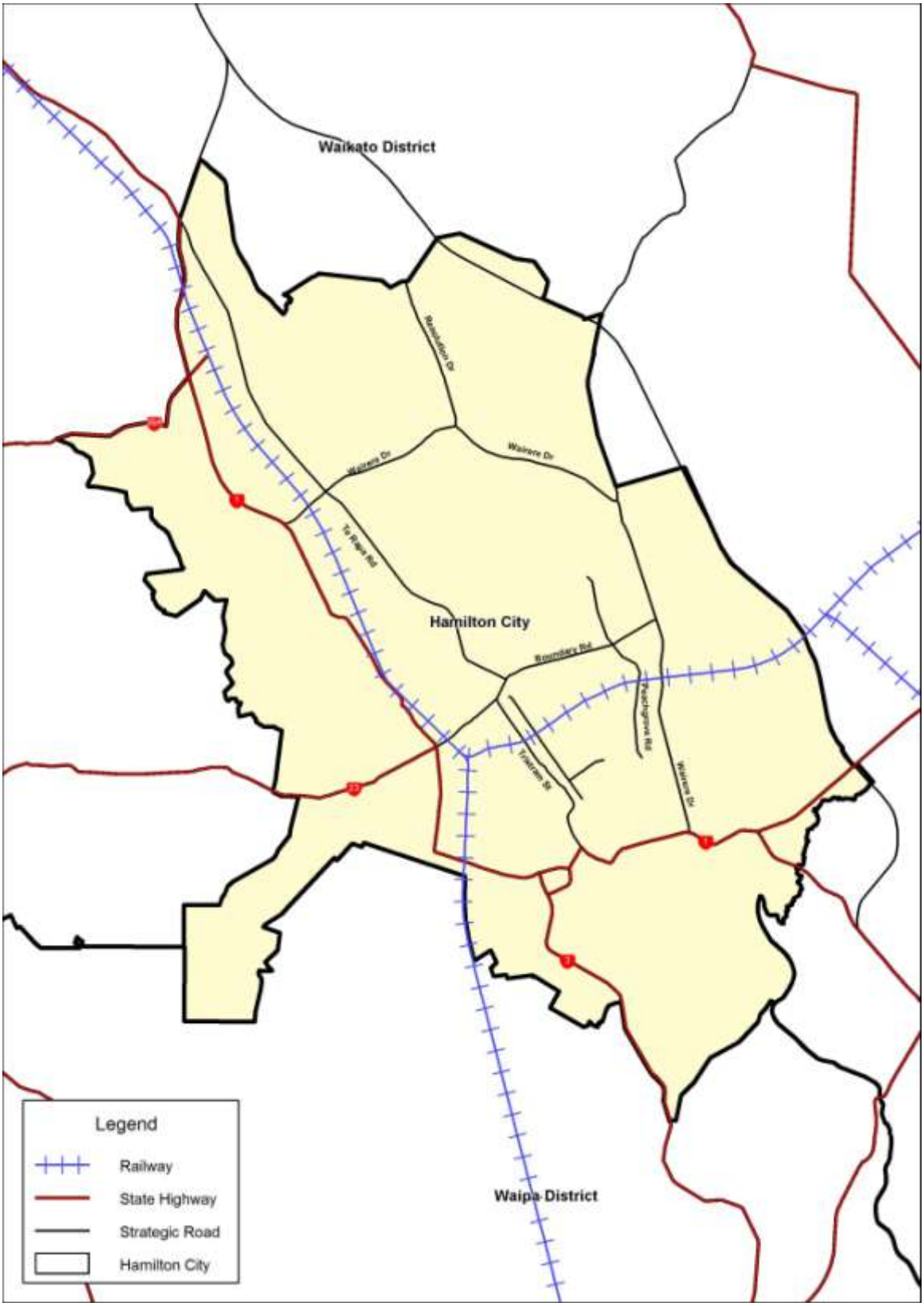

Figure 2: Hamilton City main transport routes

3 Physical Setting

3.1 Geology

The Hamilton Basin area is characterised by four main landforms (Figure 3):

A. Low rolling hills which are commonly known as the ‘Hamilton hills’

B. Flattish alluvial plains with micro - relief of low mounds (bars) and swales (depressions)

C. Low terraces adjacent to the modern Waikato River

D. Gullies cut into the alluvial plain o r low terraces and draining to the Waikato River

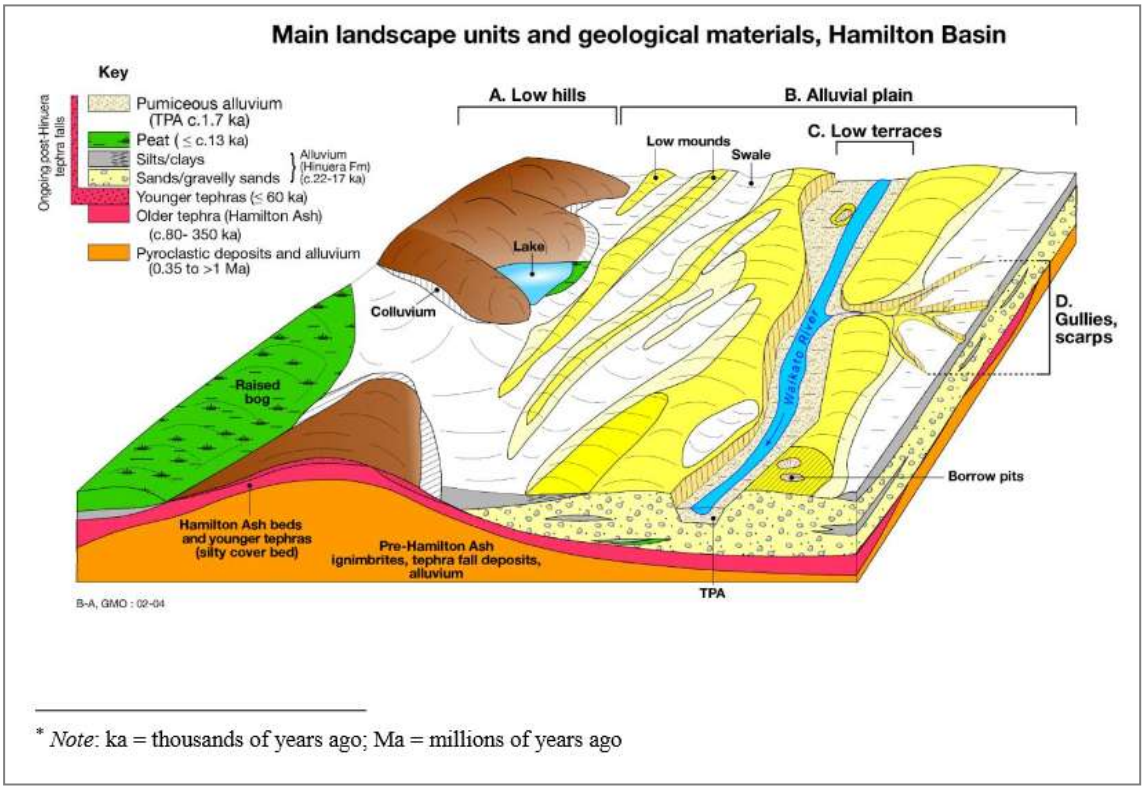

Figure 3: Hamilton Basin landforms (http://sci.waikato.ac.nz/farm/content/soils.html)

The low rolling hills represent the remnants of a landscape dating back to more than a million years. The plains represent alluvium derived ultimately from the mainly volcanic catchments of the central North Island and deposited by the ancestral Waipa and Waikato River systems in a series of depositional episodes over the past 100,000 years. These deposits swept around and over the pre-existing hilly landscape in the Waikato, partly burying it so that today we find just remnants of the hills protruding through the flat-lying alluvial surface.

The lowermost terraces adjacent to the Waikato River mark deposition from a dramatic break-out flood event about 250 AD ago following the latest eruption of Taupo Volcano (in 2325 AD). Large quantities of pumiceous deposits were carried down the Waikato River, which rose several metres to tens of metres, and left stranded as terrace deposits adjacent to the main river channel and up tributary valleys or gullies that drained into it. The deposits are up to 30 m thick Soils which have developed on these materials are weakly formed because of their young age.

With regard to the management of natural hazards, the following geological features are relevant to Hamilton City:

- Much of the lower lying geological units include a significant portion of material derived from volcanic activity – in particular pumiceous deposits from the Waikato River.

- The peat bogs on the Western side of the city (see Figure 4) are particularly relevant to the management of natural hazards, as these areas have the potential to result in localised subsidence.

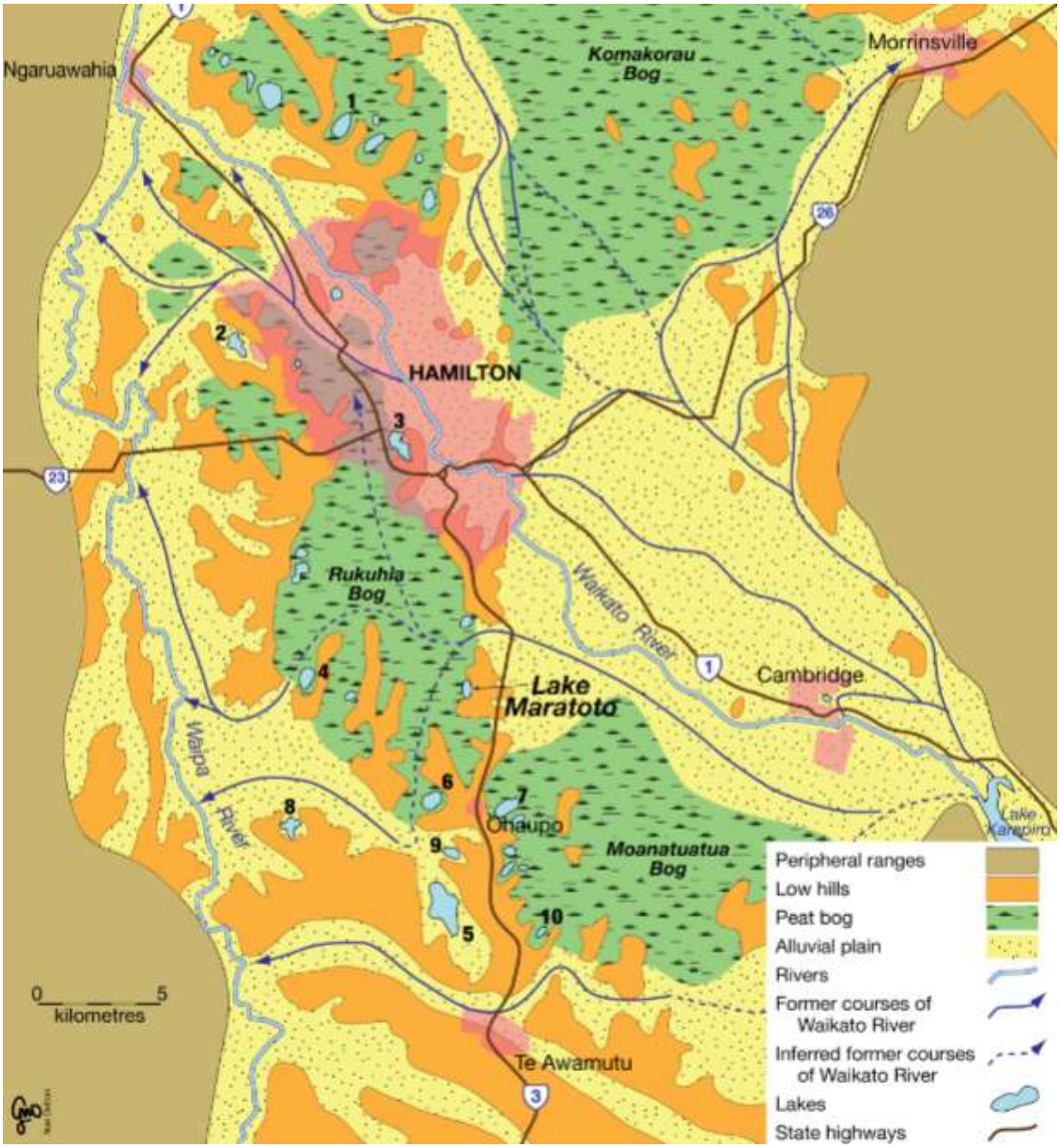

Figure 4: Modern landscape features of the Hamilton Basin (Lowe, D.J. 2010)

3.2 Climate

Hamilton City has typical weather patterns of the Waikato Region; warm, humid summers and mild winters, with prevailing west and southwest winds.

The Kaimai Range has a large influence on the variable weather patterns of the area. The Range lies in the northern climatic region and separates two weather districts. To the west, the Waikato Region is largely influenced by the predominant easterly movement of frontal systems onto New Zealand, while in the Bay of Plenty Region, to

the east, most of the summer rainfall arises from tropical storms which originate north of New Zealand (Jane & Green, 1984).

Rainfall is also influenced by the Kaimai Ranges as there is a steep altitudinal gradient in rainfall on the western face of the Range.

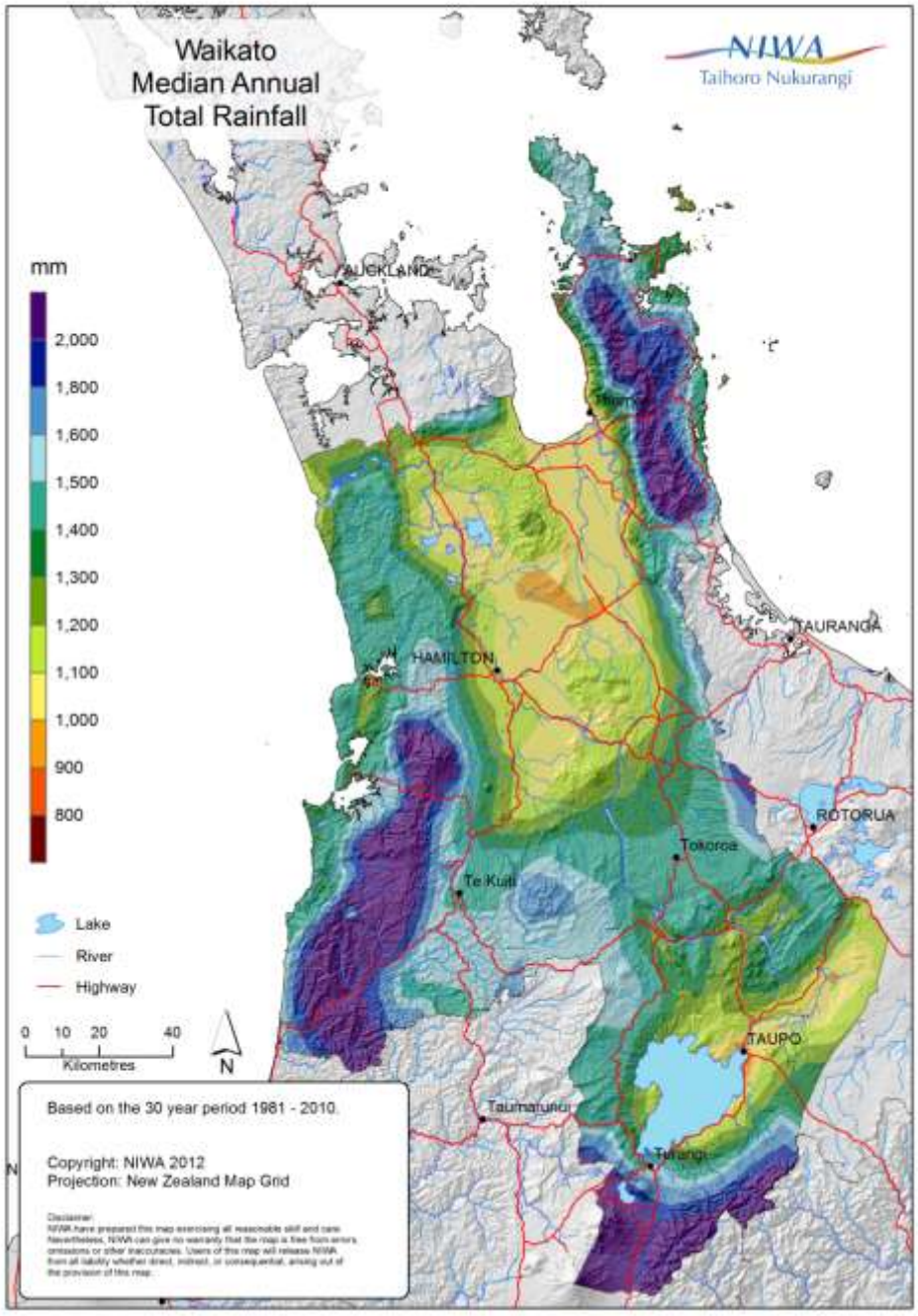

Figure 5: Annual rainfall averages of the Waikato Region (https://www.niwa.co.nz/climate/national-and-regional-climate-maps/waikato).

4 Natural Hazards in the Hamilton City District

4.1 Introduction

The Hamilton City district is similar to many areas of New Zealand in that it is subject to a number of natural hazards. Our present understanding of natural hazards within the district stem from a number of sources including:

- Local knowledge and experience, particularly with river flooding, coastal flooding, and severe storm events.
- Detailed investigations of specific hazards.
- River flood engineering, mapping and surveying work
- General hazard studies such as earthquake risks
- The regional hazard risk analysis completed as part of the Civil Defence Emergency Management Group Plan.

Hamilton City is particularly at risk from geological and meteorological based natural hazards. An assessment of the probability and the effects of natural hazard events can be based on knowledge of the history of past occurrences as well as a comprehensive hazard analysis. The following natural hazards have been identified as particularly relevant for Hamilton City.

- Earthquake
- Severe Wind
- Drought
- Volcanic ash fall
- Landslides and erosion
- Rural fire
- Flooding (river and drainage)

In addition to the above natural hazards, it is also noted that New Zealand in general is subject to tectonic (earthquake), volcanic, and severe weather.

4.2 Current and previous research

Several research projects have been identified to improve the understanding of the Hamilton City District.

Table 1: Natural hazard research undertaken to date: Hamilton City

Research Project	Researcher	Year	Hazard
Earthquake Hazard Assessment for the Waikato Region	IGNS	1996	Earthquake
Volcanic Hazard Assessment for the Waikato Region	IGNS	1997	Volcanic
Land Susceptibility Mapping and Risk Assessment for the Waikato Region	University of Waikato	1999	Landslides

4.3 Earthquake hazards

New Zealand experiences large numbers of small earthquakes, in a well-defined belt stretching from Fiordland to East Cape and the Bay of Plenty. This pattern is part of the 'Ring of Fire', the almost continuous belt of volcanoes and earthquakes rimming the Pacific Ocean. The shallow earthquakes (less than 40 km deep) are spread in a wide belt through the country (See Figure 6).

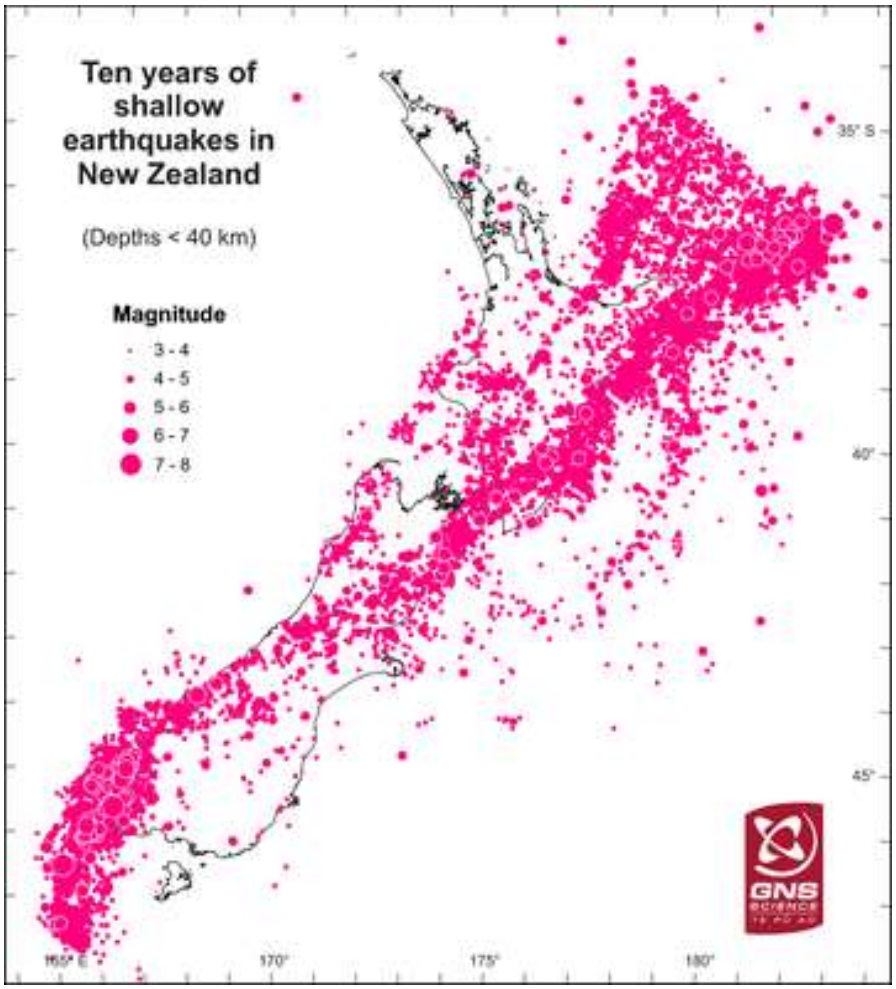

Figure 6: Shallow earthquakes in New Zealand over the past 10 years (http://www.gns.cri.nz/Home/Learning/Science-Topics/Earthquakes/New-Zealand-Earthquakes/Where-do-earthquakes-happen-in-NZ)

The Waikato region has many active fault lines that increase the chance of earthquakes. About 20 per cent of the region's population live on soils prone to movement during earthquakes. Figure 7 shows where earthquake fault lines are in the Waikato region and which areas are most at risk. Hamilton City has areas of A and B risk classification.

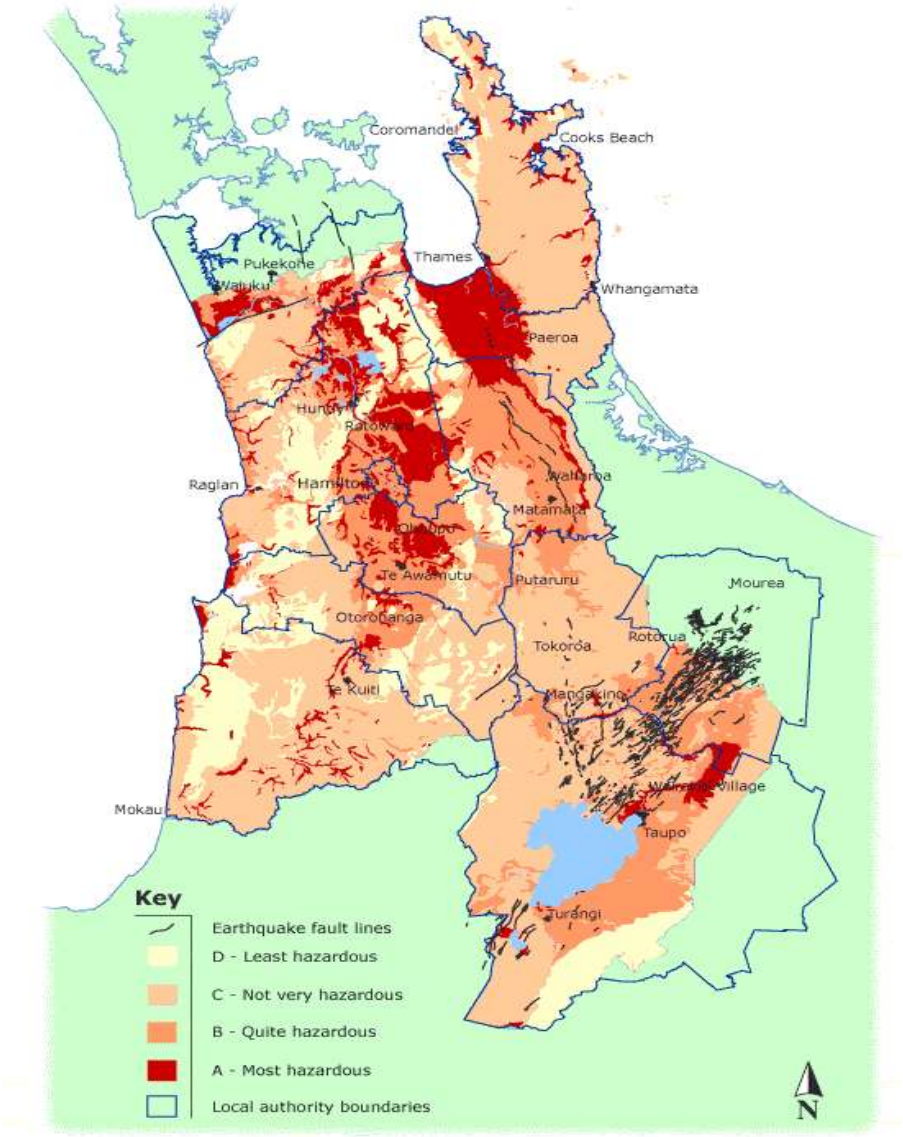

Figure 7: Regional Ground Shaking Risk Zones and Active Fault Lines (http://www.waikatoregion.govt.nz/Services/Regional-services/Regional-hazards-and-emergency-management/Earthquakes/Earthquake-hazard-zones/)

Map Key for Figure 7:

A) The most hazardous materials were formed less than 10,000 years ago. These have high volcanic ash content, mixed with peat, clay, silt, ash, sand and gravel. They may include layers that are easily saturated with water and are liquefiable.
B) Materials that are quite hazardous were formed less than 2.5 million years ago.These include river and marine terrace deposits, lignite, dune sand, pumice, gravel and ignimbrite (volcanic rock) flows.
C) Not very hazardous materials formed between 75 and 2.5 million years ago and include sandstone, siltstone, mudstone, coal measures, limestone and conglomerate.
D) The least hazardous materials are basement rocks formed more than 75 million years ago.

4.3.1 Liquefaction

Hamilton City has recent unconsolidated material (one of the three factors for liquefaction - broad scale) in 17% of the urban area and 19% of the total area. See Figure 7 for an overview of the earthquake and liquefaction hazards in the Waikato region.

For liquefaction to occur, it is likely that the following three factors are present:

- Soil characteristics such as un-consolidated sands and silts, typically of Holocene Age (<10,000 years)
- A high water table
- Earthquakes large and long enough to trigger liquefaction

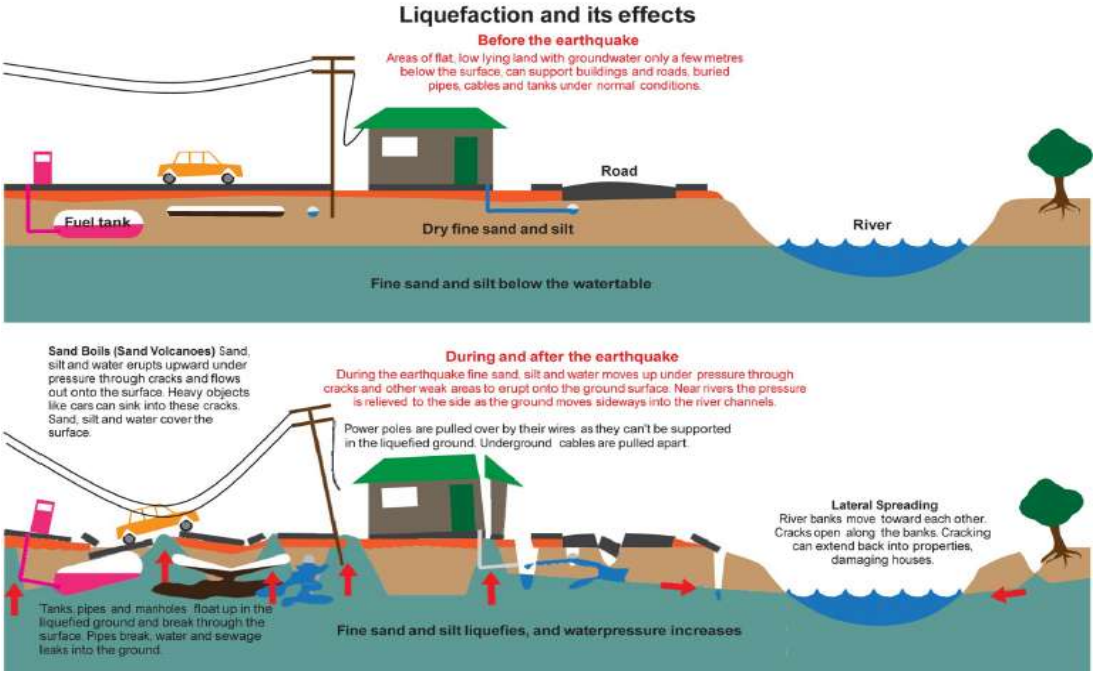

Figure 8: Liquefaction and its effects (WRC internal presentation)

The estimated Modified Mercalli Intensity (MMI) in Hamilton using the NZ national seismic hazard model - which uses all known active faults plus background seismicity with earthquakes up to ~ Magnitude 7. Note the model does not predict earthquakes triggering MMI 9 or 10 in Hamilton. Liquefaction commences at MM7

Table 2: Hamilton MMI and return period

Hamilton (-37.787, 175.279)				
MMI	5	6	7	8
Return Period (yrs)	18	55	288	2857

Earthquakes strong enough to cause liquefaction are “predicted” approximately every 300 years in Hamilton (GNS Science, 2011 (DOC # 1964902))

4.3.2 Recent research on the Hamilton Fault identification

There has been a recent discovery of a fault in Hamilton by Vicki Moon and Willem de Lange (University of Waikato). Geomorphic evidence suggests this fault and other potential faults extend SW – NE through Hamilton (See Figure 9).

Figure 9: Approximate location of the Hamilton Fault (dotted yellow line) and other possible faults within Hamilton City (dotted blue lines). Source: University of Waikato

It is clear that liquefaction has occurred in the Hamilton Basin before, and therefore can be expected again, however, we do not yet know age or extent of liquefaction or the earthquake source (Kerepehi or local). There is also evidence of faulting at one site; with best estimates dating it to < 250,000 years.

Geomorphic evidence suggests this fault, and possibly more faults extend SW – NE through Hamilton.

- Age of fault, size of earthquakes and their frequency are key aspects of understanding and quantifying the hazard.
- We do not know this information yet, and will need some time to answer these questions – anticipate 2 or 3 years.

4.4 Severe wind

New Zealand is a windy country due to its small size and position within a belt of strong winds in the Southern Hemisphere, which generally occur between the latitudes of 40 and 49 degrees. Hamilton is relatively sheltered from strong coastal winds (see Figure 10) due to its inland location, however is vulnerable to large complex low pressure systems which can bring strong winds and heavy rain.

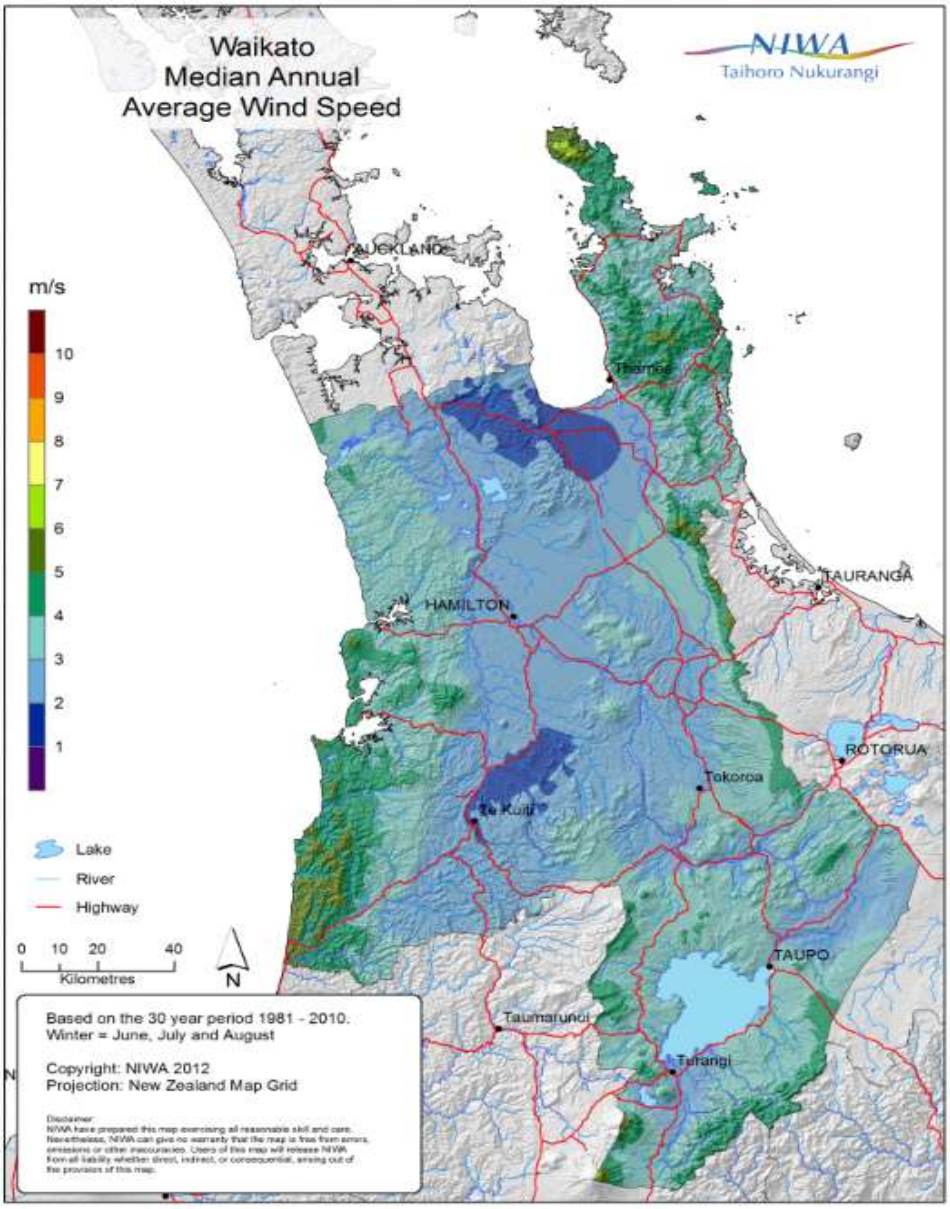

Figure 10: Waikato median annual average wind speed (https://www.niwa.co.nz/climate/national-and-regional-climate-maps/waikato)

Tornadoes can occur in New Zealand but these are neither as common nor as destructive as those that occur over the plains of the United States. Tornadoes in New Zealand typically last for a few minutes, track across the land for two to five kilometres, and are 20 to 100 metres wide. Wind speeds are around 115 to 180km/h. Tornadoes are localised and their damage is usually confined to the path of the tornado itself.

New Zealand's most damaging and lethal tornado occurred in Hamilton City on 25 August 1948. Debris from some buildings was carried as far as Bruntwood and Hautapu. There were three casualties, five seriously injured people and 163 buildings and 50 businesses damaged or destroyed. The damage was estimated at £1,000,000 (about $60 million in 2014 dollars). This information has been sourced from the Historic Weather Events Catalog provided on the National Institute of Water and Atmospheric Research website.

4.5 Drought

Historically, water shortage and drought within the Waikato region has not been as severe as in other regions of New Zealand, such as Otago, Marlborough, and Hawke's Bay. However, drought events have impacted communities and the Waikato region's economy in the past few years, with the most recent declared drought in 2013. Areas typically most affected by water shortage and drought conditions are the Hauraki Plains, lower Waikato Basin, Thames-Coromandel, and Pukekohe.

A summary of the Waikato Regions recent droughts are summarised in Table 3

Table 3: Recent drought in the Waikato Region

Year	Effects
2007- 2008	This drought event lasted from November 2007 to April 2008, during which the Waikato experienced its driest January in a century. A shortage of feed caused by the drought increased the price of silage to four times its normal rate. The cost of the drought was believed to be $1.5 billion to the Dairy sector alone. The economic effect of the drought was one of the factors that threw New Zealand's economy into recession by mid 2008.
2009	The Waikato experienced a dry spring, the effects of which were compounded by the previous drought of 2007-2008.
2010	Waikato had two dry springs, which resulted in a double drought. The drought led to the owners of the Waikato River hydro scheme, Mighty River Power, announcing a 10 per cent drop in hydro production for the December quarter. Dairy farmers were estimated to have lost an average $100,000- $150,000 in income over the previous three years due to consecutive drought events.
2013	This drought affected more of New Zealand than any other drought in the past 40 years. See Section 4.5.1.
2014/15	The Waikato continues to experience below normal rainfall and the cumulative effects of previous dry spells and lower winter rainfall is being felt more widely across the region. This is also evidenced by very low water flows.

NIWA has undertaken some specific research on how the frequency of drought might change over the coming century. The resulting report (NIWA, 2005) developed drought risk projections for a range of climate change scenarios, corresponding to approximately the middle 75% of the IPCC (Intergovernmental Panel on Climate Change) global temperature change projection range. Under both the "low-medium" and the "medium-high" scenarios (which bracketed this 75% range), the drought risk was projected to increase in frequency during the coming century for all areas that are currently drought prone.

Since drought affects are generally felt over a wide area, the Hamilton City District would be affected if a drought event was declared in the Waikato Region. The city is totally reliant on water extraction from the Waikato River to provide municipal potable water supplies to residents and businesses.

4.5.1 2013 Drought

The 2013 drought was a severe event and the impacts on farming and growth may continue for years. NIWA has confirmed that for parts of Waikato the 2013 drought was the worst in terms of soil deficit in 40 years or, in some areas, as many as 70 years (as far back as records go). See Figure 11 for the soil moisture deficit maps of New Zealand on March 1 2013. These record breaking levels were high enough for the entire North Island to be declared in drought on March 15 2013. The cost of the drought for New Zealand was estimated at $2 billion.

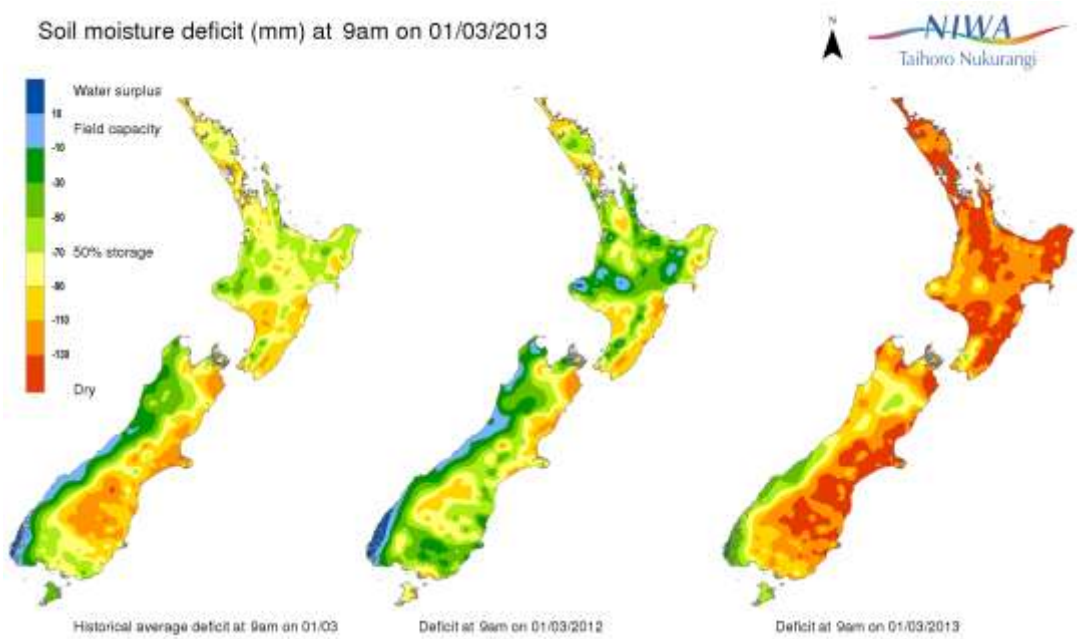

Figure 11: Soil moisture deficit maps for New Zealand on 1 March 2013 (https://www.niwa.co.nz/climate/nz-drought-monitor/2012-2013-drought).

Currently, changes in weather patterns can affect the likelihood of drought in the Waikato region. Both El Niño and La Niña phases of the Southern Oscillation weather pattern can cause droughts around the country; however an El Niño pattern is more likely to cause droughts in the Waikato Region. It has also been predicted that climate change will increase the frequency, severity and length of droughts. However, the 2013 drought was not caused by either El Niño or La Niña patterns. NIWA found it was due to slow-moving high pressure systems over the Tasman Sea and New Zealand during summer. These effectively blocked any other sorts of weather systems approaching the country (NIWA 2013).

4.6 Volcanic ash fall

The Waikato Region, including Hamilton City, faces threat from future activity in the Taupo Volcanic Zone (TVZ), Mayor Island, White Island, Rotorua volcanic field, Auckland Volcanic Field and Taranaki volcano in the southwest. Rhyolitic and andesitic volcanic centres in the TVZ have been active during most of the Quaternary (approximately 1.6 million years ago), depositing large volumes of volcanic material across the Waikato Region.

The violence of an eruption could vary between those of the TVZ, and the relatively quiet, largely ash eruptions of Ngauruhoe and Ruapehu. While the amount of ash produced by an eruption and the extent of fallout is variable and difficult to predict, it is likely that large areas of farmland and forest, some urban areas and many rivers could seriously be affected by ash and mud during a major eruption. Even relatively small thickness of ash fall can have a significant impact on the environment and human activity.

Ash rarely causes direct damage, but instead accumulates and causes structures to collapse, especially if the ash becomes wet and heavy. Ash particles may carry a film of corrosive acid and this causes corrosion on metallic surfaces. Ash is abrasive, and can be conductive, especially when wet. A finer grain size of ash may represent a greater hazard than coarser grain sizes since finer grain sizes will penetrate machinery and other human structures more readily (Environment Waikato 1999. Volcanic Risk Mitigation Plan. Hamilton, Environment Waikato). See Table 4 for some of the effects of volcanic ashfall.

Table 4: Some effects of volcanic ash fall (Adapted from Edbrooke, 2005)

Less than 1mm ash thickness • Irritant to lungs and eyes • Possible contamination of water supplies • Minor damage to houses, vehicles and equipment caused by abrasive ash
1-5mm ash thickness *Effects that occur with <1mm of ash will be amplified plus:* • Possible crop damage • Some minor effects of livestock (lack of feed, wear on teeth, possible water contamination) • Water supplies may be cut or limited due to electricity failure • Roads may needs to be cleared to reduce dust nuisance and prevent storm water systems becoming blocked
5-100mm ash thickness *Effects that occur with <5mm of ash will be amplified plus:* • Burial of pasture and low plants. Foliage may be stripped but most trees should survive • Most pastures killed over 50mm of ash • Major ash removal operations in urban areas • Weaker roof structures may collapse at 100mm ash thickness • Road transport may be halted due to ash build up
100-300mm ash thickness *Effects that occur with <100mm of ash will be amplified plus:* • Buildings that are not cleared of ash will run the risk of roof collapse (particularly if the ash becomes wet) • Severe damage to trees • Loss of electrical reticulation
>300mm ash thickness *Effects that occur with <300mm of ash will be amplified plus:* • Heavy kill of vegetation • Complete burial of soil horizon • Livestock or animals killed or heavily distressed • Kill of aquatic life in lakes and rivers • Roads unusable until cleared

Figure 12: Ash from Mount Ruapehu carried by south easterly winds over ake Taupo during the 1995-1996 Ruapehu eruptions. (Environment Waikato 1999. Volcanic Risk Mitigation Plan. Hamilton, Environment Waikato)

4.7 Landslides

Hamilton has a number of areas vulnerable to land instability including gullies, river banks and steep slopes. Stemming from the Waikato River in Hamilton, a network of gullies extend, occupying approximately 750 hectares or 8% of the city area (Downs et al. 2000). Four main systems (Kirikiriroa, Mangakotukutuku, Mangonua and Waitawhiriwhiri) exist as a result of the Waikato River channelling through the

geological foundations of sand, silt, peat and gravel, known as the Hinuera formation (Clarkson et al. 2004). As the river channel deepened, springs became exposed and eventually undermined the banks, causing slips and streams into the river. This process has continued over time, resulting in the steep-sided gullies that presently adjoin the river (Refer to Figure 13).

The somewhat non cohesive nature of the Hinuera formation results in entrainment of materials by flow of water. This increases the susceptibility of sediment to erosion when it is exposed to surface runoff (Bird 1985). If soils are not protected, gully extension via erosion can occur due to surface runoff produced from just a few hours of rainfall. Erosion can also occur from disturbance to watercourses on or near slopes consisting of these sediments (Bird 1985).

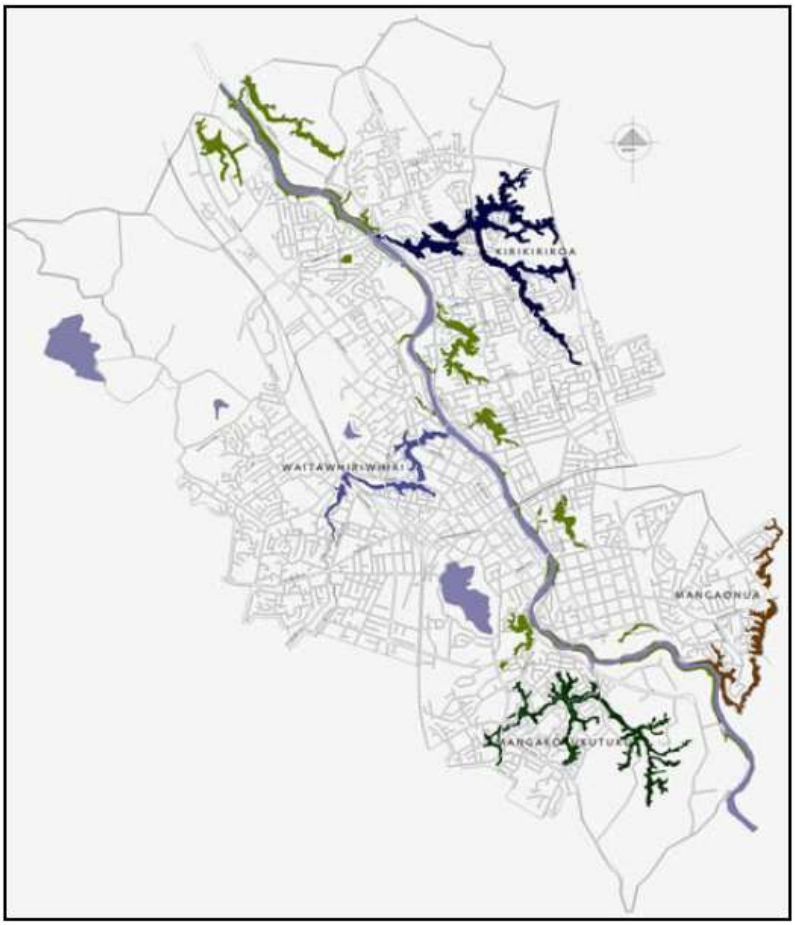

Figure 13: Hamilton's gully systems (Clarkson B and McQueen J 2004)

4.8 River flood hazards

The most common (equal with drought) natural threat to the Hamilton district is river flooding. Flooding is and has been a historical threat to the area with the Waikato River posing the greatest potential flood hazard. The Waikato Hydro system can play a relatively minor role in reducing the effects of floodwaters on certain parts of the Waikato River, however, these reductions in floodwaters are usually minimal and with heavy rain, there will still be flooding issues around Hamilton City. Anne Street and Grantham Street are well known areas where flooding from the Waikato River occurs.

Hamilton City Council has received flood hazard mapping for parts of the city. This information was used in the Proposed District Plan to identify flood hazard areas and the information can be found on their website. The flood modelling work has identified 28,000 properties that are at high, medium or low risk of flooding in Hamilton in a significant storm. The flood modelling work maps the depth and speed of flooding

during a big storm that has a 1% chance of occurring in any given year. Two types of flood modelling have been carried out. One maps some areas in detail and the other is more indicative. The modelling has enabled Council to determine three categories of risk to properties: high, medium and low. Technical reports supporting the new flood hazard mapping and modelling are also available from Hamilton City Council.

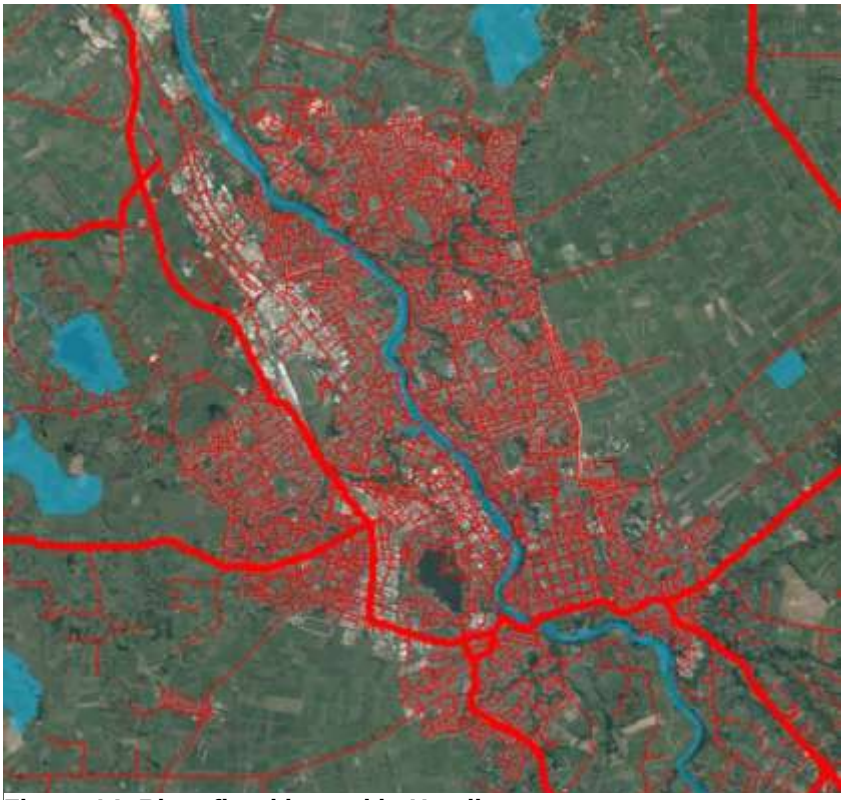

Figure 14: River flood hazard in Hamilton

4.9 Climate change

Normal climate changes are being affected by a gradual increase in the levels of greenhouse gases around the earth's atmosphere. This could see a rise in sea levels and changes in climate patterns, increasing the number of storms, rain, coastal flooding and erosion in the region.

The Waikato region tends to have warm, humid summers and mild winters, with prevailing west and south-west winds from the Tasman Sea. While no part of the region is more than 80 km from the sea, extreme hot and cold temperatures can occur in some sheltered and elevated areas inland. The average rainfall is 1,250 mm, however rain is generally heavier in the Coromandel Peninsula, Waitomo/Kawhia and the alpine area of Tongariro National Park. Rainfall is generally less in the lower Waikato lowlands, Hauraki Plains, Taupo behind the Hauhungaroa Range and Reporoa Valley behind the Paeroa Range.

The Ministry for the Environment has provided future climate change projections for the Waikato region. According to this information, Waikato temperatures are likely to increase by around 0.9°C by 2040 and 2.1° by 2090 (compared to 1990). Towards the end of this century, it is expected that the Waikato may have around 30-60 days per year where maximum temperatures exceed 25°C.

Rainfall is expected to vary within the region but higher annual rainfall is more likely in south and west parts of Waikato and lower annual rainfall is more likely in Coromandel. Heavy rainfall events may become more frequent in the Waikato.

Storms crossing the Tasman Sea are expected to increase in summer and reduce in winter by the end of the century. Extreme winds over this century may increase

between 2 and 5 per cent in almost all regions of New Zealand during winter and decrease similarly in summer (Ministry for the Environment 2012).

The potential effects of climate change on the Waikato Region include:

- Changes in weather patterns – differences in rainfall, temperature and microclimates could affect agriculture and horticulture. The location of some industries, agriculture, horticulture and tourism may change.
- More turbulent weather - extreme weather can increase flooding, erosion, droughts and damage ecosystems.
- Sea level rise - higher sea levels will affect coastal communities increasing coastal flooding and erosion.
- Threats to biodiversity - species that are already under threat or at the limit of their climatic range may not be able to survive.
- New diseases and pests may take hold. Tropical pests and tropical diseases like malaria may become established in areas where they currently do not exist.

An increase in the amount and frequency of rainfall could cause more river flooding in some areas of the Hamilton City District, while decreases may result in drought. Land use, such as cropping and forestry may need to change to suit new weather patterns, affecting runoff, hillside and valley drainage as well as increasing fire risks due to vegetation changes. The location of some industries, agriculture, horticulture and tourism may also need to change.

Landslides may be triggered by heavy rain, as much of the soil through the Waikato region is volcanic and prone to erosion. People relocating inland to avoid coastal hazards such as flooding and erosion may face an increased risk of large scale rock and/or soil slips in marginal areas, due to the effects of changes in rainfall, drainage patterns and land use on hill slopes.

These events also threaten ‘lifeline’ services such as water, power, telecommunication and transportation networks.

It is also important to realise that climate change is not just in the future. The best available evidence, and the consensus of international experts, indicates that it is already happening, although this trend is within the “noise” of natural climate variability.

Adaptation to the effects of climate change should be viewed as a process that does not necessarily require high costs in the short-term. Depending on the specific issue in question there might be a range of adaptation measures, of varying cost, that require implementation over time and which should be integrated within the wider context of resource management (Warrick et al 2001).

5 Risk Assessment

5.1 Introduction

Having determined the most common and significant natural hazards in Hamilton City District, it is necessary to analyse and evaluate the level of risk associated with each hazard. This will allow a comparison between different hazards in order to guide prioritisation for the level of work effort. One important precursor to this exercise is determining what the outcome or goal of the hazard mitigation work should be. Suggested goals for both HCC and WRC are:

- To work towards the resolution of natural hazard issues in the district.

- To minimise risks from natural hazards to people and infrastructure in the district.

- To determine natural hazard management priorities for the purposes of long term planning.

Work actions should be determined using the combination of agency goals, current work commitments and level of risk associated with the hazard.

5.2 Description of scenarios

The assessment of risk can involve a broad range of approaches and processes, including:

- Checklists.
- Judgements based on experience and records.
- Brainstorming.
- Flow charts and scenario analysis.

One of the most intuitive ways to describe risk is in the form of scenarios, and this approach has been adopted for this risk assessment.

Based on the natural hazard commentary provided, a scenario has been developed for each natural hazard that represents the 'maximum credible event'. These scenarios are outlined as follows:

- River flood involving the 1 % AEP year flood event, resulting in widespread inundation, as indicated by the existing flood hazard information.
- Land instability following a 1 % AEP rainfall event, resulting in numerous landslides on land that is identified as being highly or very highly susceptible
- Volcanic activity involving a 0.1 % AEP event from the Taupo Volcanic Zone, resulting in most of the district being covered in ash to a depth of 2 mm (weather conditions permitting).

5.3 Risk assessment methodology

Risk analysis and evaluation typically involves determining the likelihood of a hazard event occurring and the consequences of the hazard event. A commonly accepted standard for risk management in New Zealand is the AS/NZS 4360: Risk Management Standard. This standard is used as the basis for this report in order to:

- Establish the context (Section 4)
- Identify risks (Section 3)
- Analyse risks (Section 4.4)
- Evaluate risks (Section 4.4)
- Treat risks.

5.4 Analysis and evaluation

Problematic to any risk analysis is the level of detail and characterisation of the importance rankings. Table 5 shows a two stage approach to analysing and evaluating risks. Stage 1 involves the evaluation of risk based on likelihood and consequences of

each scenario. Stage 2 involves a more detailed analysis based on the Risk Profile Template (detailed in the CDEM Group Plan Review), which allows the evaluation of risk based on these factors:

1. Seriousness: The measure of the potential impact, based on five areas that may be impacted (i.e. human, social, economic, infrastructure and geographic).

2. Manageability: The measure of the ability to manage either the hazard or the potential impacts on the community.

3. Growth rating: The measure of the potential for the risk to grow (e.g. the hazard may occur more frequently or the community exposure to the hazard may increase).

The 2 stage approach to risk evaluation is necessary to allow the prioritisation of risks that receive the same evaluation during Stage 1 (e.g. ‘high’).

Hazard Scenario	Likelihood	Consequence	Risk Evaluation											Total	Priority
			Seriousness					Manageability					Growth		
			Social	Built	Economic	Natural	*Sub-total*	Reduction	Readiness	Response	Recovery	*Sub-total*	*Sub-total*		
Earthquake	*C*	*4*	4	4	4	4	**8**	3 MM	2 MH	4 HM	4 HM	**3.25**	**3 LH**	**14.3**	1
Drought	*A*	*3*	3	3	4	3	**6.3**	2 MH	2 MH	2 MH	1 LH	**1.75**	**4 MH**	**12.1**	3
Flooding (river and drainage)	*A*	*3*	2	2	2	3	**4.2**	1 LH	1 LH	1 LH	1 LH	**1**	**3 MM**	**8.2**	7
Volcanic ashfall	*C*	*3*	3	3	2	2	**5.5**	3 MM	3 MM	4 ML	3 MM	**3.25**	**3 LH**	**11.8**	4
Severe wind	*C*	*4*	4	4	3	2	**7.3**	5 HL	4 ML	3 MM	3 MM	**3.75**	**3 LH**	**14.1**	2
Landslide - bank instability	*B*	*3*	3	4	2	3	**6.2**	3 HH	2 MH	1 LH	1 LH	**1.75**	**2 LM**	**10.0**	5
Rural fire	*E*	*2*	2	1	2	2	**3.5**	4 ML	4 ML	2 MH	2 LM	**3**	**2 LM**	**8.5**	6

Table 5: Risk analysis and evaluation

Note: An outline of the terms and scales used in Table 5 are presented in Appendix 6: Key to Table 2 (risk analysis evaluation key).

- The hazards listed under “Hazard Scenario” have been identified as being most relevant to the Hamilton City District based on the discussion in Section 4.

- These natural hazards are all identified as creating a significant risk to the Hamilton City District, with earthquake and drought being identified as being particularly significant.

- Further analysis of these natural hazards using the Risk Profile model confirms that earthquake and severe wind are most significant, followed by drought, volcanic ashfall and landslide – bank instability.

- The priority assigned to earthquake is driven by the seriousness of the hazard, along with the potential for the risk associated with the hazard to escalate due to both increased development and increased awareness of the hazard type due to the 2011 Christchurch Earthquake.

- River flooding is assigned a lower priority than earthquake or drought due to a lower manageability and growth rating. However, it is important to note that this priority is based on the current environment, and that there is a significant potential for the risk associated with this hazard to escalate due to inappropriate development and medium to long term changes in the natural environment (e.g. sea level rise and the natural dynamics of the coastal environment).

5.5 Residual risks

Residual risk is the term used to define those risks that cannot be defined in more detail after elimination or inclusion of all conceivable quantified risks have been addressed. Residual risk can also be described in terms of “the bigger than event”. For example, if planning and operational measures are only implemented against the 1 % AEP event scenario, then anything larger (e.g. 0.2 % or 0.1 % AEP events) would be considered a residual risk.

WRC aims to address the residual risk component through the proposed regional flood risk management strategy. Residual risk is also a key consideration within the proposed national and regional flood risk management strategies.

5.6 Conclusion

As a result of the above assessment/evaluation, it is concluded that earthquake, severe wind, drought and volcanic ash fall are the highest priority natural hazards currently facing the Hamilton City district.

6 Summary, discussion and recommendations

6.1 Summary of natural hazard risks

6.2 Discussion

The following discussion is relevant to natural hazards in the Hamilton City District:

- The proposed prioritisation of natural hazards in the Hamilton City District is based on a variety of considerations. It is however important to note that the relative significance of a natural hazard is generally dependant on the nature of development on susceptible land. It is therefore important that all possible natural hazards continue to be considered when planning for future growth, including those hazards that are currently assessed as being less significant.

- The characteristics of most natural hazards are dependent on the natural environment. Therefore, a natural hazard that is currently relatively insignificant may become significant following changes in the environment (e.g. climate change that is currently predicted due to global warming or a change in the coastal environment accelerating in coastal erosion).

- This assessment is at a District Scale and is intended to assist with the identification of issues that may need to be considered. This may include a trigger for a more site specific assessment to confirm/discount any specific natural hazard threats.

6.3 Recommendations

As a result of this qualitative risk assessment, the following recommendations are proposed for the Hamilton City District with regard to the management of natural hazards:

- It is recommended that earthquake risk be considered the highest priority natural hazard affecting the Hamilton City District. This is because of the existing level of risk, along with the potential for the risk to escalate due to future development (and the unknown risk associated with liquefaction).

- It is also recommended that the approach to the management of earthquake risks is developed to be consistent with the Regional and National approaches (e.g. Earthquake Risk Mitigation Plan, Building Act 2004).

- It is also recommended that the Hamilton City District Plan be adopted as a key tool to reduce the risk and potential impact of natural hazards, particularly those identified as having a priority in the Hamilton City District (e.g. earthquake, severe wind, drought and volcanic ashfall).

- The significance of various natural hazards in the Hamilton City District is partially dependant on the appropriate development of susceptible land. It is therefore recommended that the full range of natural hazards continue to be considered when planning for future growth, even those that have been identified as relatively insignificant by this assessment.

- That WRC and HCC continue to address the natural hazard risks jointly through sharing of information and sound policy and strategy formulation and implementation.

7 Bibliography

Bird G 1985. Hinuera formation material slope stability problems and the subdivision of small blocks of land near gullies. Waikato Valley Authority Technical Report 1985/10. Hamilton, Waikato Valley Authority

Building Act, 2005

Civil Defence Emergency Management Act, 2002

Clarkson B, McQueen J 2004. Ecological restoration in Hamilton City, North Island, New Zealand. Paper from the 16th International Conference, Society for Ecological Restoration, August 24-26, 2004, Victoria, Canada

Downs TM, Clarkson BD. Beard CM 2000. Key ecological sites of Hamilton City. Report prepared for Hamilton City Council, CBER Contract Report No. 5. Hamilton, Centre for Biodiversity and Ecology Research, Department of Biological Sciences, University of Waikato

Beanland S, Drummond G, Huber P, Hull A, Townsend T 1996. Earthquake hazard analysis Environment Waikato (Regional Council) area. Environment Waikato Technical Report 1996/17. Hamilton, Waikato Regional Council (Environment Waikato)

Land Drainage Act, 1908

Local Government Act, 2002

Local Government Official Information and Meetings Act, 1987

Ministry for the Environment 2012. Climate change projections for the Waikato region. http://www.mfe.govt.nz/issues/climate/about/climate-change-affect-regions/waikato.html [Accessed 9 January 2014]

National Institute of Water and Atmospheric Research 2013. Soil moisture deficit (SMD) maps. http://www.niwa.co.nz/sites/niwa.co.nz/files/October%202012%20to%20May%202013%20soil%20moisture%20deficit.pdf [Accessed 13 March 2015]

National Institute of Water and Atmospheric Research 2013. http://hwe.niwa.co.nz/event/August_1948_Waikato_Tornado [Accessed 13 March 2015]

Public Works Act, 1981

Reserves Act 1977

Resource Management Act, 1991

Soil Conservation and Rivers Control Act, 1941

Standards Australia/Standards New Zealand. AS/NZS 4360:2004. Risk management : Australian/New Zealand standard. 3rd ed. Wellington, Standards Australia and Standards New Zealand

Waikato Regional Council 2003: Volcanic Ashfall Zones. http://www.waikatoregion.govt.nz/Services/Regional-services/Regional-

hazards-and-emergency-management/Volcanic-activity/Volcanic-ashfall-zones/#Bookmark_PDF [Accessed March 2015]

8 Appendix 1: Statutory and legal framework

8.1 The Resource Management Act (RMA) 1991

8.1.1 Introduction

The RMA sets in place a planning framework with respect to hazard management. The Act defines the role of central government agencies, such as the Department of Conservation, and regional and district councils such as WRC and HCC respectively. The mechanisms to achieve this include a hierarchy of linked interrelated policy statements supported by non-statutory documents such as action plans developed to address individual (river flooding) or a suite of related hazards (coastal erosion and flooding).

The RMA assigns to regional councils responsibility for the integrated management of natural and physical resources within their region. Regional councils are required to control the use of land, the taking and use of water, and the planting of plants in water bodies for soil conservation, the quality of water, the quantity of water, and the avoidance or mitigation of natural hazards. Regional and district functions are specified by the Act and are outlined in Appendix 2.

8.1.2 Long-term management strategies

The RMA provides for the long-term management of hazards through various policy mechanisms, some of which are discussed above. These include, in the case of coastal hazards, the New Zealand Coastal Policy Statement and regional coastal plans, and for other hazards regional policy statements, and district plans. Policy implementation is given effect through various methods and can include non-statutory mechanisms such as education programmes, advocacy and community consultation and engagement; or statutory mechanisms such as the application of rules and standards in respect of defined zones. Monitoring strategies provide feedback on the effectiveness of the various methods employed to mitigate or avoid the adverse effects of hazards.

8.1.3 Short-term management strategies

Section 330 of the RMA builds on powers presently available to Council pursuant to the Public Works Act 1981 (s.234) and the Local Government Act 1974 (s.708A(3)). The section permits activities in an emergency situation that might otherwise contravene the Act. The section empowers employees and agents of councils to enter upon land and take action in an emergency situation. Section 331 of the Act requires that the appropriate consent authority must be advised when emergency works have been undertaken. Resource consents must be sought where adverse effects of the activity continue. The provisions and a discussion of section 330 are outlined in *Appendix 3*.

8.2 Resource management policy statements

8.2.1 Introduction

The RMA requires that a hierarchy of policy documents is prepared by central, regional and local government bodies with respect to resource management issues generally including the management of natural hazards. The documents are interrelated (to achieve integrated management) and the Act requires that subordinate regional and district documents are not inconsistent with each other or any national policy statement.

8.2.2 Regional Policy Statement (RPS)

WRC's RPS incorporates policy on natural hazards. The statement indicates the dual role of the region and district in managing hazards, but that the district council is likely to take a lead role in managing responses to localised hazard events.
The RPS identifies implementation methods for the management of natural hazards relating to both the region and the district. Those relating to district councils, in summary, refer to:

- The development of objectives, policies, rules and methods in district plans to control the use of land;
- The delivery of environmental education programmes;
- The implementation of hazard mitigation plans;
- To provide information on natural hazards through land information memoranda;
- To work in partnership with the regional council.
- Similarly, those implementation methods relating to the regional council include:
- The development of specific objectives, policies, rules and/or other methods in regional plans for the avoidance or mitigation of coastal hazards;
- To take a lead role in the collection, analysis, storage and communication of coastal hazard information to territorial authorities;
- The development, in conjunction with territorial authorities and the wider community, hazard mitigation plans for managing the risks associated with coastal hazards**;**
- To support the development and implementation of environmental education programmes related to coastal hazards.
- The text on the "Management of Natural Hazards" contained in the Regional Policy Statement is attached as *Appendix 4*.

8.2.3 Hamilton City District Plan

The Hamilton City District Plan includes a section on "Natural Hazards". This section identifies the relevant issues, objectives, policies, methods, principle reasons, environmental results and monitoring.

8.3 Other hazard management statutes

8.3.1 Introduction

This section will examine in greater detail the legal obligations for WRC and the HCC and the organisations' staff and elected members in terms of other relevant legislation including the Civil Defence Emergency Management Act 2003, Building Act 1991, Soil Conservation and Rivers Control Act 1941 and the Local Government Official Information and Meetings Act 1987.

8.3.2 Civil Defence Emergency Management (CDEM) Act 2002

This Act establishes a framework for CDEM aimed at building resilient New Zealand communities. Its purpose is to improve and promote the sustainable management of hazards in a way that contributes to the social, economic, cultural, and environmental well-being and safety of the public and also to the protection of property. It also provides for the planning and preparation for an emergency and for response and recovery in the event of an emergency.

Under the Act, HCC is a member of the Waikato CDEM Group (a consortia of local authorities working with emergency services and lifeline utilities to reduce risk across the region). It is also one of the councils that make up the Waikato Valley Emergency Operating Area (EOA).

8.3.3 Soil Conservation and Rivers Control Act 1941

The provisions of the Soil Conservation & Rivers Control Act 1941 apply only to regional councils and determine their role for river and catchment management and include the following responsibilities:

- To minimise and prevent damage by floods and erosion;
- To construct, reconstruct, alter, repair, and maintain all such works it considers necessary;
- To exercise a general supervision over local authorities of any powers they exercise as to river and drainage matters;
- To give directions for the guidance of local authorities with regard to the above matters.

WRC also has responsibility for land drainage in terms of the provisions of the Land Drainage Act 1908, primarily within the specified drainage areas scheduled in 1989.

8.3.4 Local Government Act 2002

Section 551 of the Local Government Act outlines the river clearance powers available to territorial local authorities. At present, responsibilities for these functions are generally shared.

8.3.5 Local Government Official Information and Meetings Act 1987 (LGOIMA)

Section 44A of LGOIMA deals with Land Information Memoranda (LIM). Any person may apply to council for a LIM in respect of any property in the district. Among the matters that must be included in a LIM is information relating to natural hazards that is known to council.

Unless there is proof to the contrary hazard information contained in a LIM shall be sufficient evidence of the correctness, as at the date of issue, of any hazard information. There is no opportunity or grounds that allow council to withhold hazard information.

These latter provisions of the Act have implications generally for council when receiving information such as reports that apply to a property or group of properties and more specifically when that information relates to hazards.

8.3.6 Building Act 1991

8.3.6.1 Project Information Memoranda (PIM)

A similar mechanism as land information memoranda is contained at Part V of the Building Act. Sections 30 and 31 of the Act makes provision for persons wishing to proceed with building works to first obtain a Project Information Memorandum (PIM) in respect of the works and the land upon which the works are to be established. As with the provisions of LGOIMA every PIM shall include information on "special features" of the land likely to be relevant to the proposed building work identifying, amongst other things, potential hazard information that falls within council's current knowledge-base. This requirement places a great deal of responsibility on council to get it right. One of the challenges will be to ascertain the "special features" of the land that do fall within council's knowledge. The section intends a considered response by council that will involve some research and investigation.

8.3.6.2 Building Consents

Council must refuse to issue a building consent in respect of any application for building works on land that is subject to, amongst other things, flooding or erosion or the building work itself is likely to worsen the effects of or cause erosion or flooding. If council is satisfied that adequate provision has been made to protect the hazard prone land a building consent will be issued.

Where council considers that the building works will not increase losses arising from an extreme natural event then a building consent may issue in terms of s74 of the Building Act, 2004 provided a notice to such effect is registered against the Certificate of Title of the land upon which the building works stand. The section absolves Council, its officers and elected representatives of any liability if the building works are subsequently damaged by an extreme event.

8.3.7 Reserves Act 1977

The Reserves Act guides district councils such as the HCC in how they manage reserve lands that fall within their jurisdiction. It provides for the acquisition, control, management, maintenance, preservation (including the protection of the natural environment), development, and use, and to make provision for public access to the coastline and the countryside.

If applicable, the relevant district body must prepare a management plan for coastal reserve land. Such plans must provide for and ensure the use, enjoyment, maintenance, protection, preservation, and, where resources permit, the development of the reserve.

Plans must be submitted to the Minister of Conservation for approval within 5 years after the date of appointment of the administering body, although this time may be extended. In preparing a management plan public notice must be given, and all submissions received must be considered.

Local authorities must also keep management plans under continuous review so that they are adapted to changing circumstances or in accordance with increased knowledge.

9 Appendix 2: HCC/WRC RMA Functions

The functions, powers and duties of local authorities with respect to hazards as defined by the Resource Management Act 1991 are outlined below.

Section 30(1)(d)(v):

Functions of regional councils under this Act:

Every regional council shall have the following functions for the purpose of giving effect to this Act in its region:

> *…(d) In respect of any coastal marine area in the region, the control (in conjunction with the Minister of Conservation) of—*
>
> *…(v) Any actual or potential effects of the use, development, or protection of land, including the avoidance or mitigation of natural hazards …*

And section 31(b):

Functions of territorial authorities under this Act—

Every territorial authority shall have the following functions for the purpose of giving effect to this Act in its district:

> *…(b) The control of any actual or potential effects of the use, development, or protection of land, including for the purpose of the avoidance or mitigation of natural hazards…*

Section 62(ha) requires that a regional council in its regional policy statement defines:

For the region or any part of the region, which local authority shall have responsibility within its own area for developing objectives, policies, and rules relating to the control of the use of land for—

The avoidance or mitigation of natural hazards … and may state particular responsibilities for particular hazards … or group of hazards …; but if no responsibilities for a hazard … are identified in the policy statement, the regional council shall retain primary responsibility for the hazard …

10 Appendix 3: RMA Section 330

10.1 Provisions and discussion of Section 330 of the Resource Management Act 1991

Section 330 provides (emphasis added):

Emergency works and power to take preventive or remedial action—

Where—

Any public work for which any person has financial responsibility; or
Any natural and physical resource or area for which a local authority or consent authority has jurisdiction under this Act; or
Is, in the opinion of the person or the authority…, affected by or likely to be affected by—

An adverse effect on the environment which requires immediate preventive measures; or
An adverse effect on the environment which requires immediate remedial measures; or
Any sudden event causing or likely to cause loss of life, injury, or serious damage to property—

the provisions of sections 9, 12, 13, 14, and 15 shall not apply to any activity undertaken by or on behalf of that person, authority, … or mitigate any actual or likely adverse effect of, the emergency.

Where a local authority or consent authority—

Has financial responsibility for any public work; or
Has jurisdiction under this Act in respect of any natural and physical resource or area—which is, in the reasonable opinion of that local authority or consent authority, likely to be affected by any of the conditions described in paragraphs (d) to (f) of subsection (1), the local authority or consent authority by its employees or agents may, without prior notice, enter any place (including a dwellinghouse when accompanied by a constable) and may take such action, or direct the occupier to take such action, as is immediately necessary and sufficient to remove the cause of, or mitigate any actual or likely adverse effect of, the emergency.

As soon as practicable after entering any place under this section, every person must identify himself or herself and inform the occupier of the place of the entry and the reasons for it.

11 Appendix 4: RPS & natural hazards

11.1 Policy One: Consistent Management of Natural Hazards

Ensure that natural hazards are managed in a consistent manner throughout the Waikato Region and roles and responsibilities of agencies are defined.

Implementation Methods:

1. The Waikato Regional Council (WRC) will:

    i. develop specific objectives, policies, rules and/or other methods in regional plans for the avoidance or mitigation of natural hazards in the coastal marine area and in the beds of rivers and lakes
    ii. take a lead role in the collection, analysis, storage and communication of natural hazard information to territorial authorities
    iii. prioritise risks from natural hazards across the Region for further investigation, in consultation with territorial authorities and the Region's community
    iv. develop, in conjunction with territorial authorities and the wider community, hazard specific mitigation plans for managing the risks associated with natural hazards
    v. implement those aspects of mitigation plans that are relevant to WRC's functions
    vi. coordinate responses to regionally significant natural hazard events with those of territorial authorities, network utility operators, government departments and other relevant agencies
    vii. support the development and implementation of environmental education programmes related to specific natural hazards

2. Territorial authorities will:

    i. develop specific objectives, policies, rules and/or other methods in district plans that control the use of land (except for in the beds of lakes and rivers and the coastal marine area) for the avoidance or mitigation of natural hazards
    ii. deliver environmental education programmes on local natural hazards to their communities
    iii. implement relevant hazard specific mitigation plans through building consents and other regulatory and non-regulatory methods
    iv. provide information on the presence of natural hazards at specific sites through land information memoranda and project information memoranda where such information is known by the territorial authority
    v. work in partnership with the Waikato Regional Council (WRC) and their communities to ensure efficient and effective response and recovery to natural hazard events including planning for emergencies

3. Local authorities will advocate that other agencies such as network utility operators and neighbouring regional councils work with territorial authorities and the Waikato Regional Council (WRC) for the management of natural hazards through the development of partnership agreements and memoranda of understanding.

4. Local authorities will advocate that all the roles and responsibilities identified above are implemented through strategic plans, annual plans, district and regional plans, civil defence plans and partnership agreements within three years of this Regional Policy Statement becoming operative.

12 Appendix 5: Other work

12.1 Hydraulic modelling

WRC has developed a comprehensive/dedicated hydraulic modeling program in response a rapid increase in resource consent applications and river management issues. Hydraulic modeling is carried out on a priority basis and includes both one dimensional (Mike 11) and two dimensional (Mike 21) outputs. It is seen as being one of the most crucial elements of our flood risk management approach

WRC's modeling program aims to achieve the following:

- Outputs are based on best practice and methodology and includes all available information such as hydro-met data, climate change allowances, sea level rise, and land information
- Models provide a robust and sound basis for assessing/determining likely extents of flooding from a given-sized event (or across a range of scenarios)
- Flood hazard risk maps are produced that as accurately as possible depict the flood extent, velocity, and depth of floodwaters

District Plans use the assessed flood hazards/levels and employ a sound planning framework as a basis for reducing risks.

12.2 Categorisation of flood risk

To assess flood risks, it is necessary to consider the nature and degree of the potential impacts of flooding, which are dependent on the magnitude of specific hazard parameters within the overall flood hazard. During flooding, the primary hazard parameters in terms of potential impacts are:

- Flood depth: The potential impacts directly related to this parameter include:
  - Drowning (flood waters rising higher than waist level)
  - Damage (flood waters damaging property and contents as they rise)
  - Isolation (deep flood waters preventing escape by flood victims or access by emergency services)
- Flood flow velocity: The potential impacts directly related to this parameter include:
  - Drowning (flood waters flowing too fast for people to maintain balance or washing away occupied vehicles)
  - Damage (the force of fast flowing flood waters damaging structures)
  - Isolation (the force of fast flowing waters and/or debris transport preventing escape by flood victims or access by emergency services

The severity of flooding is largely governed on the magnitude of these two primary hazard parameters. For example, the higher the combined depth and velocity, greater are the risks to people and property.

13 Appendix 6: Key to Table 2 (risk analysis evaluation key)

13.1 Measure of likelihood

Table 6: Measure of likelihood - generic table

Level	Descriptor	Description
A	Almost certain	Expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur at some time
D	Unlikely	Could occur at some time
E	Rare	May only occur in exceptional circumstances

13.2 Manageability and Growth ratings

Table 7: Manageability table rating

Management difficulty	**Current effort (4Rs)**	**Rating**
Low	High	1
Low	Medium	2
Medium	High	
Medium	Medium	3
High	High	
Low	Low	4
Medium	Low	
High	Medium	
High	Low	5

For manageability, a rating is developed from 1 to 5 based on the combination of management difficulty and current level of effort being applied. The rating is developed and entered on the table (Table 5) for each of the 4Rs – Reduction, Readiness, Response, and Recovery.

Growth is the rate at which the risk will increase through time – either through an increase in the probability of the event occurring, an increase in the exposure to the community, or both. For growth, a rating is developed from 1 to 5 based on the combination of the probability of occurrence of the event arising and the changes in community exposure to the event.

Once all the ratings have been completed, the table will provide a risk total for each hazard identified. The hazards can then be ranked by risk and can assist in the approach to risk management.

13.3 Measure of consequence of impact and seriousness

Table 8: Measure of consequence of impact and seriousness

Level	Descriptor	Detail description
1	Insignificant	No injuries, little or no damage, low financial loss
2	Minor	First aid treatment, minor building damage, medium financial loss
3	Moderate	Medical treatment required, moderate building and infrastructure damage, high financial loss
4	Major	Extensive injuries, high level of building and infrastructure damage, major financial loss
5	Catastrophic	Deaths, most buildings extensively damaged and major infrastructure failure, huge financial loss

The seriousness criteria should be amended to reflect the relative importance of the four factors – social, built, economic and natural environments. The following definitions and weighting were followed:

- Social – population, social structures, vulnerable groups, ethnic diversity and tangata whenua. 50% of the total value, due to the high priority of protection of human life and safety.
- Built – residential, commercial, key lifelines, utilities and industrial and agricultural infrastructure. 25% of the total value, due to the importance of protecting lifelines and other critical infrastructure in relation to social concerns.
- Economic – regional economy, growth, employment, income, tourism and resources. 15% of the total value, reflecting a secondary priority and the fact that the built environment will normally account for most of the economic damage.
- Natural – geography, geology, and climate .10% of the total value, reflecting the relatively low level of concern.

Once complete, the seriousness value is completed. The minimum value is 2 and the maximum possible value is 10. Each environment is automatically weighed per the assumptions in Table 8: Measure of consequence of impact and seriousness, and the subtotal represents half the total maximum possible value of 20. Measure of consequence of impact and seriousness

13.4 Qualitative risk matrix

Table 9: Modified qualitative risk analysis matrix

	Consequences				
Likelihood	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A Almost certain	High	High	Extreme	Extreme	Extreme
B Likely	Moderate	High	High	Extreme	Extreme
C Possible	Low	Moderate	High	Extreme	Extreme
D Unlikely	Low	Low	Moderate	High	Extreme
E Rare	Low	Low	Moderate	High	High

This matrix has six rating levels. The process for risk analysis is a collaborative effort involving key stakeholders who can draw upon previous risk analyses, new hazard and

information and experience. The result of the analysis will rate each hazard risk as either very low, low, moderate, high, very high or extreme.