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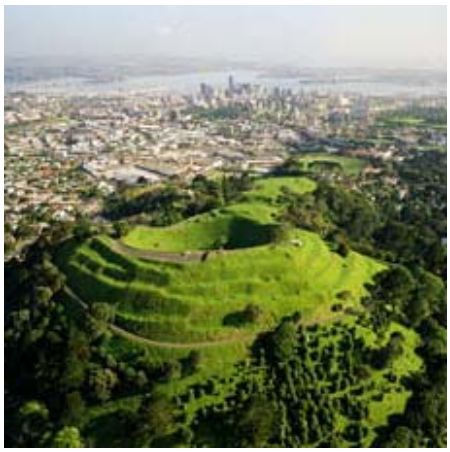
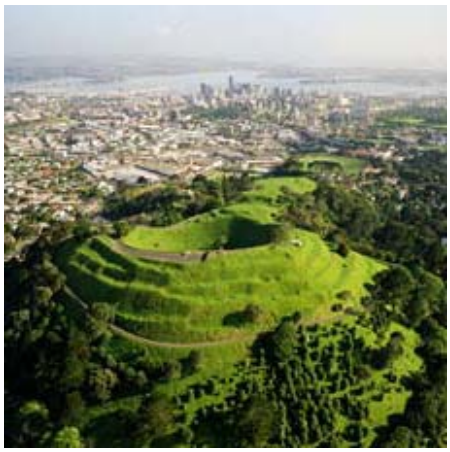


Synthesis of existing risk and social data for the Auckland Volcanic Field.

Michele Daly

IESE Technical Report 1-2009.05 | June 2009

ISBN [print]: 978-0-473-15414-1; ISBN [PDF]: 978-0-473-15415-8



Synthesis of existing risk and social data for the Auckland Volcanic Field.

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This report was prepared as part of the DEVORA Project, Theme 3, Objective 1.

ISBN [print]: 978-0-473-15414-1; ISBN [PDF]: 978-0-473-15415-8

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EXECUTIVE SUMMARY

The DEVORA[1] research programme is aimed at a much-improved assessment of volcanic hazard and risk in the Auckland metropolitan area, and will inform a strategy and rationale for appropriate risk mitigation. The key themes of the programme are:

Theme 1: Geological Model
Theme 2: Probabilistic Model
Theme 3: Risk and Social Model

To inform the overall programme and allow for a targeted approach over a number of years, the first stage has been a synthesis of information for each of the Themes. This report addresses Theme 3 and provides an overview of the current extent of risk and social data.

A literature search has been undertaken (Appendix 1) and as many of these reports and articles as possible have been summarised for the purposes of the DEVORA research team. A gap analysis has allowed for an assessment of where future research efforts could be best targeted in order to meet the DEVORA research objectives.

Over the years there has been a concerted effort to understand the consequences of an eruption at the Auckland Volcanic Field as well as from distal eruption centres. The early work was lead primarily by the Auckland Regional Council and the Auckland Engineering Lifelines Group in conjunction with the Auckland University and GNS Science. More recently, the national civil defence exercise *Exercise Ruaumoko* in 2008 has extended our understanding of social and economic consequences further.

Much of what we do know is qualitative and there needs to be research into how we incorporate existing and/or new social data into our risk models. Some

physical data inventories (building inventories; utility infrastructure) is also not well defined or in a format useful for risk modelling purposes.

Section 5 offers some suggestions for where the DEVORA programme and connected research programmes could focus efforts on over the next few years in order to move to a greater understanding of the risk to the Auckland region of a volcanic eruption. This will then enable much more focussed risk treatment strategies to be developed.

1. INTRODUCTION

Background

The DEVORA[1] research programme is aimed at a much-improved assessment of volcanic hazard and risk in the Auckland metropolitan area, and will inform a strategy and rationale for appropriate risk mitigation. The key themes of the programme are:

Theme 1: Geological Model
Theme 2: Probabilistic Model
Theme 3: Risk and Social Model

This report contributes to Theme 3 of the programme of work, which has the following objectives:

Theme 3: Risk and Social Model

- Objective 1: Synthesis of existing volcanic risk and social data (*this report*)
- Objective 2: Fragility of Auckland infrastructure
- Objective 3: Development of exposure database and model

[1] DEVORA = **De**termining **Vo**lcanic **R**isk in **A**uckland

Objective 4: Determining indirect and intangible impacts

Objective 5: Development of statistical risk assessment methods

Objective 6: Development of tools for improved societal response

Key questions that will be addressed in Theme 3 of the DEVORA programme are:

1. Who and what are exposed to volcanic hazards in Auckland?
2. How will each hazard affect people and infrastructure?
3. How will people and organisations cope in an eruption?
4. What are the flow-on effects nation-wide from an eruption affecting Auckland?
5. How can we calculate risk to people and infrastructure?
6. What are the risks to people and infrastructure?
7. How can these risks be reduced?
8. How can people and organisations prepare to respond effectively to warnings?

This report provides a synthesis of existing volcanic risk and social data to determine what information currently exists and to what extent the above questions have been addressed. Gaps in information will enable where the best effort of researchers can be directed.

Risk and Social Data

Definitions of risk and social science research and data as applied to this synthesis are as follows:

Risk = (probability of an event/hazard occurring) * (impact of event occurring)

= f (time, space) * f (exposure, vulnerability, damage)

This synthesis has concentrated on the impact side of the risk equation, with DEVORA Themes 1 and 2 developing a geological and probabilistic hazard model respectively.

Social science research = research on individual and community behaviour; hazard awareness and risk perception; community and organisational resilience; effective education programmes; psychological health issues

Social data = the data and information generated as result of the research above (e.g. survey information) and also that which has been generated for other purposes (inventories, indices and demographic information).

Annotated Bibliography

An annotated bibliography has been prepared as a resource for the rest of the programme and as the basis for the synthesis. Over 170 reports and publications have been identified and listed in a separate document (refer also Appendix 1). In undertaking searches through various bibliographic databases the emphasis has been on locating research and information specific to the Auckland Volcanic Field. Some social science research conducted on other volcanoes around the world and in New Zealand and/or other hazards in Auckland might also be applicable and selected reports have been included in the bibliography.

It is intended that the bibliography be a 'live' database which is added to over the course of the DEVORA programme.

Report Structure

This synthesis has been structured around the risk management process (AS/NZS 4360: 2004). This is followed by a section on the social data and social and physical inventories that currently exist that could form the basis of an exposure database. Gaps are discussed throughout and summarised in a separate section at the end.

2. RISK AND SOCIAL DATA SYNTHESIS

Hazard and Risk Assessments

Based on early descriptions of the hazards that could occur in the Auckland Volcanic Field (Allen, 1992; Smith and Allen, 1993; Allen and Smith, 1994), the Auckland Regional Council undertook a series of projects to update knowledge on what could happen, where and when (Johnston et al, 1997 a & b). These early reports developed 5 eruption scenarios and included a chronological description of what could happen (precursory activity, warning times, hazards etc) as well as a discussion of the likely impacts of each of the scenarios on key infrastructure (water, power, telecommunications etc) and the general population (evacuation and public health issues). The impacts were largely based on reported observations, both published and unpublished, of impacts to infrastructure and populations from overseas eruptions.

The Auckland Engineering Lifelines Group (AELG, 1997a and b) extended this work to a comprehensive (at the time) assessment of the impacts of a volcanic eruption on the major lifeline utilities and networks of the Auckland Region. In addition to the scenario approach, a uniform hazard approach was taken to illustrate the uniform spatial probability of an eruption. General descriptions of impacts in previous work were extended to include damage to specific network components, mitigation measures and interdependencies between lifeline utilities.

These early hazard and risk assessments formed the basis for all subsequent risk assessment, risk treatment and contingency planning work on the Auckland Volcanic Field. They currently remain the documents most organisations in the Auckland region base their volcanic risk assessment on. It is only within the last few years that new information about the Field (e.g. Magill and Blong, 2005) has generated a review of some of this early information.

The Auckland Engineering Lifelines Group is currently undertaking a review of the need to update hazard and network information in the light of advances made within the past few years. The assessment of need will be based on whether new information would change current practice around mitigation, asset management, contingency and response planning. There are currently few tools to guide lifeline utilities through this process.

Risk Evaluation

All early work around identifying the consequences of a volcanic eruption has been descriptive and qualitative. The only exceptions to this have been:

1. an attempt to get an indication of the minimum cost of a volcanic eruption by estimating ash clean up costs, building damage, business losses and costs of evacuation (Johnston et al, 1997; Paton et al, 1999),
2. an attempt to understand the economic losses as a result of the Auckland power crisis in 1998 (AELG, 1998; Newlove et al 2005), and more recently,
3. economic modelling done as part of Exercise Ruaumoko (AELG, 2008; Treasury, 2008).

The Auckland Regional Council (ARC) attempted to produce a volcanic risk model in 1999 (Paton et al, 1999), however, a lack of inventory, damage ratios and suitable proxies for some of the social information required placed the project on hold. Cost estimates for both direct (damage to buildings and properties) and indirect (loss of business, costs of evacuation, relocation) were developed as part of this work. The ARC attempted again in 2005 and 2006 to develop a more quantitative approach (ARC, 2005; 2006) but again a lack of inventory, cost and degree of complexity precluded its further development. The risk assessment tool RISKSCAPE being developed by GNS Science and NIWA (Bell and King, 2005; Kaye, 2007) has superceded these efforts. Organisations such as the ARC and AELG are looking at how best to interface with this model and contribute to its development.

At the same time as a volcanic hazard assessment for the Auckland Volcanic Field was being undertaken, other natural hazard assessments were being undertaken (earthquake, tsunami, cyclone etc) (ARC, 1994, 1995, 1996) and comparisons with other hazards were being made (e.g. ash from distant North Island eruptions, Alloway et al, 1998). Two more recent studies evaluate comparative risk in the Auckland region for several potential sources (Magill et al, 2004; 2005).

Arguably the first attempt to rank the risks across all hazards was the risk assessment undertaken for the development of the region's CDEM Group Plan (Akl Region CDEM Group Plan, 2005). The method used was a semi-quantitative tool called SMuG (or SMG) which was recommended by the Ministry of Civil Defence and Emergency Management (MCDEM, 2002). While qualitative and highly subjective for many reasons (Cunningham, 2005), the resultant output and consultative process elevated understanding of risk amongst agencies concerned and served to direct resources to higher ranked risks. An eruption at the Auckland Volcanic Field ranks in the highest priority group (Akl Region CDEM Group Plan, 2005).

The Ministry of Civil Defence and Emergency Management (MCDEM) are developing a guideline for the development of the second generation of CDEM Group Plans. In it they are recommending a modified version of the earlier SMG tool (MCDEM, in press).

The modified SMG model requires consequences to be described across four environments: **Social** (numbers of dead, injured, displaced; disruption to normal social function), **Built** (costs of damage to and indirect effects of loss of buildings, structures, utilities and other critical infrastructure), **Economic** (financial loss across all environments), and **Natural** (impact on environment, topography, natural resources). These are weighted, with Social assigned the highest

weighting (50%), Built (25%) and Economic and Natural 15% and 10% respectively.

A consequence rating (number from 1-5) is assigned to each of the four environments using the measures of consequence in Table 1.

Table 1: Consequence descriptors used in the SMG risk evaluation method (MCDEM, in press)

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 infrastructural failure, huge financial loss.

Consequences are still described in very basic qualitative terms and Social (the highest ranked of the four CDEM environments) is limited to an assessment of the likely numbers of deaths and injuries. The onus seems to be on the CDEM Groups to expand the descriptors. The previous HESIG[2] model used two categories to capture social impacts. Combining the two and not updating the consequence descriptors could delay a move to more comprehensive evaluation

[2] HESIG = Human (deaths, injuries), Economic (financial losses), Social (disruption to social function), Infrastructure (extent of damage to built environment), and Geography (extent of changes to natural environment)

of social impacts at this stage of the development of the CDEM Group's risk profile.

Table 2 summarises the extent of consequence information available for the Auckland Volcanic Field using the four CDEM environments (Human; Built; Economic and Natural).

While some quantitative information is available, there remains much more work to be done in this area. Little information is available in identifying and quantifying indirect impacts (e.g. network service outages). The human, infrastructure and recently the economic consequences have received more attention. Little information is available on the social impacts and how these could be incorporated into a risk model (see section on Social Data Inventories).

Social Research

Social research efforts in Auckland started with a focus on the evaluation of hazard education programmes through hazard and risk perception surveys (Ballantyne et al, 2000). As well as public education campaigns, evaluation of the effectiveness of school education campaigns was also undertaken (Ronan & Johnston, 1997; Ronan et al, 1998).

Hazard awareness, risk perception and preparedness surveys are regularly undertaken (yearly in some cases) by all the local authorities in the Auckland region. Hazard awareness and levels of preparedness are often used by local authorities as part of their *State of Environment* reporting requirements.

Poor effectiveness of hazard education programmes, as measured by low levels of hazard awareness and preparedness (Ballantyne et al, 2000), lead to research into defining, understanding and measuring community resilience (Paton, 2007, 2008). Initial piloting and testing of a resilience model was done in the context of a volcanic eruption at the AVF. This research has shifted the emphasis away

from conventional public education campaigns (though they still have a place) to effecting behaviour change through community development programmes and empowered community decision making. There remains a gap in the application of this research into practice although steps are currently being undertaken to address this, both regionally and nationally.

Table 2: Summary of Vulnerability, Damage and Consequence Information for an eruption at the Auckland Volcanic Field

Environment	Comment	Qualitative	Semi-Quant.	Quantitative
Social • in terms of numbers of dead, injured, displaced • disruption to normal social function **50%**[3]	• estimates of numbers needing to be evacuated given certain eruption scenarios - assumes low numbers of deaths as evacuation prior to eruption • some research into public health impacts (respiratory health) • some research into psychology and mental health (general) • some behavioural analysis around trust in public information and authorities and evacuation behaviour (during Exercise Ruaumoko) • community resilience indicators developed (all hazards) • organisational resilience (underway)	• • •	• • •	
Built Buildings, structures, utilities **25%**	• vulnerability and damage assessments undertaken for most critical infrastructure, although this is now out of date and some was completed in a haphazard manner. • the focus has been on direct damage, with only some emphasis on indirect and flow-on effects (service outage; business losses; interdependencies etc). • descriptions of damage and discussion of mitigation measures on lifelines – ash impacts on water, wastewater, roads, airports, electricity, broadcasting and communications. • little in the way of damage ratio or fragility functions available for lifelines – some overseas work (e.g. Spence, 1996). • Little in the way of information on buildings or other critical infrastructure (no class descriptions; fragility functions etc)	• • ? ?	•	
Economic Total dollar costs for all categories, human and infrastructure, includes	Micro-Economics (Exercise Ruaumoko) • regional and national GDP • *Economic Futures Model* (losses with and without business mitigation measures)		• •	• •

[3] Suggested weighting (MCDEM) – refer section on Risk Evaluation (this report)

Environment	Comment	Qualitative	Semi-Quant.	Quantitative
long-term recovery plus loss of business, includes direct and indirect costs **15%**	Macro-Economics (Treasury – Exercise Ruaumoko) • CPI inflation; tradeables and non-tradeables inflation; output; consumption; investment; exports; imports; unemployment; short and long term nominal interest rates; real exchange rate • Ash clean-up costs • Building damage and business interruption (some)		• •	• •
Natural impact on environment, topography, natural resources **10%**	Little information available.	•		

A parallel research programme on understanding and measuring organisational resilience is also being undertaken (Seville, 2009). An online survey tool is being tested among Canterbury and Auckland businesses based around a set of organisational indicators (McManus, 2007). The results of this work will provide an indication of the strengths and weaknesses of the business sector in terms of adaptive capacity and contribute to a better understanding of the indirect effects of a major hazard event on business.

The development of an evacuation plan and *Exercise Ruaumoko* provided an opportunity to undertake some behaviour analysis to test assumptions about how people might behave in an impending volcanic crisis. A focus group of 20 people met three times during Exercise Ruaumoko to gauge hazard awareness, risk perceptions and personal reactions to the scenario and exercise produced communications documents (Fougere, 2008). This was complemented by an online survey which again focused on hazard awareness, risk perception, evacuation behaviour, outcome expectancy, and preparedness (Horrocks, 2007).

This was the first time a focus group and online survey were used in Auckland to test assumptions in civil defence emergency management plans about community behaviour. The results of the focus group and online survey are still being evaluated, however preliminary results have proved to be very useful and some of the assumptions made during the planning stages (numbers of people likely to require temporary accommodation; ability to self evacuate; where people will evacuate to etc) will need to be updated with this new information.

The potential of these types of tools in the development of public information messages, development of plans, and public education programmes should be further developed.

Risk Treatment

Risk treatment for volcanic hazards has focused on:

- a volcano-seismic monitoring network (now operated by GEONET),
- a contingency plan for an eruption at the AVF (ARC, 2007),
- a generic mass evacuation plan (and supporting procedures) (ARC, 2007; Akl Region CDEM Group, 2007),
- public education awareness campaigns (Ballantyne, 2000); museum exhibits, and
- lifeline mitigation measures for volcanic ash (AELG, 2009).

3. SOCIAL DATA INVENTORIES

One of the issues with respect to developing a robust risk model has been the difficulty in incorporating social information (or suitable proxies) into a risk model. One of the most commonly used approximations of social vulnerability is the *social deprivation index* (Salmond and Crampton, 2007). Some of the social data inventories currently available are listed below. This list is not exhaustive. More work is required to determine how these datasets could:

1. contribute to building up a regional vulnerability or resilience profile, and
2. how this profile, or the individual datasets be adapted or modified or used as proxies as part of a risk model such as Riskscape.

At present, the sectors of interest have not been defined for specific natural hazards (e.g. housing, crime, income, health, employment, etc) and there is no model that connects these sectors of interest (except the *social deprivation index*). It would be useful and potentially an important precursor to the development of a Socio-Economic Model to identify and possibly construct a robust conceptual framework (or justify using the *social deprivation index*). Ideally the conceptual framework should be amenable to mathematical representation but also based on a sound theoretical understanding of the links between variables.

During the development of the Auckland Mass Evacuation Plan, social agencies were willing to participate in the development of a vulnerability profile for the region that could be used in emergency management planning.

Social Deprivation Index

The Social Deprivation Index is a measure of socio-economic status calculated for small geographic areas. It is mainly used as a tool to determine funding levels in certain areas for health and social services, but increasingly is used as a measure or proxy for other purposes (e.g. vulnerability for CDEM purposes). The calculation uses a range of variables from the Census of Population and Dwellings which represent nine dimensions of social deprivation. The Social Deprivation Index is calculated at meshblock level, and built up to the relevant geographic scale using weighted average census usually resident population counts. The nine variables (proportions in small areas) in decreasing weight in the index are:

1	Income	People aged 18–59 receiving a means tests benefit
2	Employment	People aged 18–59 years who are unemployed
3	Income	People living in equivalised[1] households with income below an income threshold
4	Communication	People with no access to a telephone
5	Transport	People with no access to a car
6	Support	People aged less than 60 years living in a single parent family
7	Qualifications	People aged 18–59 years without any qualifications
8	Living Space	People living in equivalised[4] households below a bedroom occupancy threshold
9	Owned Home	People not living in own home

[4] Equivalisation: method used to standardise household composition and size.

The Social Deprivation Index is provided in two forms, a continuous score and an ordinal scale. The first principle component score is the result of the calculation using the nine weighted census variables. The scores are scaled to have a mean 1000 index points and standard deviation 100 index points. The decile rating is derived from the first principle component score. The ordinal scale ranges from 1 to 10, where 1 represents the areas with the least deprived scores and 10 the areas with the most deprived scores.

Note that the deprivation index applies to areas rather than individuals who live in those areas.

Census (NZ Statistics)

The Social Deprivation Index utilises a number of factors derived from Census data. All these variables are independently available through Statistics NZ. A different index could be constructed with a different mix of variables.

Hazard awareness, risk perception survey data and state of environment reporting

All the local authorities in the Auckland Region collect hazard awareness and risk perception information as part of their regular *state of environment* reporting or other outcome surveys. The questions asked are not all consistent between authorities and survey frequency varies. Regional council hazard analysts and MCDEM have been working toward developing a set of indicators that councils could use as part of their *State of Environment* reporting and to measure the effectiveness of hazard mitigation and risk reduction policies. Many councils 'default' to indicators such as levels of preparedness in the absence of other measures (Daly, 2008).

Ministry of Social Development (Orange Pages)

The Orange Pages is a database of information the welfare sector has access to that may be useful in preparing for and during an emergency event. They include:

a. Beneficiary Population Data (MSD) – useful in identifying individuals or families who may be more vulnerable.
b. Children in Care (MSD) – useful in identifying the names and numbers of at risk children in a particular location.
c. Youth in Justice (MSD) – names and numbers of at risk youth in a particular location
d. Approved caregivers and alternative care providers (MSD)
e. Arrivals at International airports (who; intended length of stay; places visiting; reasons for visiting etc) (Min Tourism)
f. List of iwi and Maori organisations – may also include Marae (TPK)
g. Guests at Commercial Accommodation Providers (Min Tourism) – estimates the number of people currently in hotels, motels etc
h. HNZC property locations (HNZC) – owned and leased – by region, neighbourhood unit level, type, vacancy level etc)
i. Tax payer info (Inland Revenue)
j. Disability Service Clients (Min Health) – demographics; street address; service providers
k. Health Facilities (Min Health) – Healthcert holds info about all health facilities from rest homes to hospitals
l. School and student information (Min Ed) – contact details for all schools; names and numbers enrolled at each school
m. Early Childhood information (Mon Ed) – contact details for each Early Childhood service.
n. Persons evacuated (Red Cross) – Info on people evacuated and their needs
o. Telecare clients (St John) – Info on addresses and ph numbers of clients with medical alarms for infirmity/disability reasons
p. Caring caller clients (St John) – Info on addresses and ph numbers of clients contacted daily because of their social isolation and/or to remind them to take medication.
q. EQC Database (EQC) – location of claims
r. Victim Support – local and national contacts

Use of this information for emergency management planning purposes (e.g. and as part of DEVORA) would need to be carefully worked through with the Ministry of Social Development (MSD) and the other social development agencies, possibly through the National Welfare and Recovery Coordinating Group (NWRCG) and the Auckland Welfare Advisory Group (ARWAG).

4. PHYSICAL DATA INVENTORIES

Aside from basic location information of high level infrastructure (roads, larger buildings etc) there are limited critical infrastructure and building inventory data in the public domain in Auckland. Key organisations are local authorities (including the regional council), Terralink (property valuations) and LINZ (geographical information). The following is a brief summary.

Lifeline Utility Infrastructure

The Auckland Regional Council (ARC) holds on its GIS system key lifeline infrastructure developed for the Auckland Engineering Lifelines Project 12 years ago (AELG, 1997a). This includes roads, water and wastewater networks, gas, fuel, telecommunications, and electricity. Both line elements (cables, pipes) and nodes (substations, pump stations etc) were stored. Only infrastructure classed as 'critical' is included and there is very limited (if any) attribute information (e.g. pipe composition, depth of burial, age, condition etc). The definition of 'critical' used was variable across the sectors and would need revisiting. Although 12 years old, the inventory is a good starting point. It might not take much to assign attribute data to elements of the dataset to allow it to be incorporated into Riskscape. Currently the data is termed 'confidential' and was only able to be combined and used for the purposes of the Auckland Engineering Lifelines Project. Permission from the AELG and individual organisations would have to be sought, however this could be facilitated by the ARC or AELG. Given the age of the information and the relationships built up between organisations over the past several years, this might not be much of a problem.

The AELG is currently in the process of reviewing this information with a view to updating it and exploring its usefulness for Riskscape. Individual lifeline organisations are also interested in engaging with Riskscape and there are numerous opportunities emerging for improving inventory, attribute and other information.

Participation in a project by any one of the lifelines may hinge on being able to demonstrate to them how the additional information provided by Riskscape (in terms of damage and loss estimates) might change their current asset management, contingency and response planning.

Building Inventories

There is very little information available. Previous attempts at risk models (Johnston, 1999; ARC, 2005, 2006) have relied on valuation data as a proxy. The AELG (2008) has attempted to identify key community facilities that are a priority for service reinstatement following a disaster (e.g. hospitals, fire stations, welfare centres etc) although there were problems in how to classify the importance of various facilities. Recent classification systems in use (AELG, 2009) may assist in this process. No building attribute data has been collected as part of these projects, however individual facilities (e.g. Police North Comms centre) have previously had building vulnerability assessments undertaken (F. Stoks, pers. comm., 2009). Some of this information is likely to be confidential.

Environmental Inventories

The Auckland Regional Council holds databases of resources of value to the community such as:

- Sites of geological, archaeological and ecological significance (e.g. lava caves; stonefields; remaining stands of pre-European native forest etc)
- Sites of significance to Maori
- Aquifers (for water supply)

There are also other geo-referenced datasets such as parklands, open space, etc.

While typically included as a layer in previous risk models (to show what could be lost or damaged in certain scenarios), no value in terms of loss has been assigned to them.

5. GAPS AND RECOMMENDATIONS

The following is a summary of gaps and research ideas with linkages to the appropriate DEVORA Objective under Theme 3 (Risk and Social Model).

Table 3: Summary of Gaps and Research ideas relevant to the DEVORA Research Programme

Gap/ Required Research	DEVORA Objectives
1. More work is required to determine whether existing social datasets (e.g. social deprivation index) or other combination of data available is suitable as an input to a numerical risk model. Can this be achieved or is there another representation of social risk that can be used in parallel (to Riskscape)? ▪ How does the information we currently have contribute to building up a regional vulnerability or resilience profile? and ▪ How does this profile, or the individual datasets be adapted or modified or used as proxies as part of a risk model such as Riskscape? *(Note: as a result of the development of the ACDEMG Mass Evacuation Plan, several social development agencies expressed a desire to work with the local authorities to develop such a profile)*	2 and 4
2. Assess the level of business continuity preparedness of Auckland organisations and areas where government recovery effort would have most value, ▪ how long could they survive without operating? ▪ how long could they survive without infrastructure? ▪ how long could they survive with reduced number of customers in the region? *(Note: There is some organisational resilience research on Auckland organisations being undertaken by the Canterbury University in conjunction with the Akl CDEM Group)*	4
3. Extend the work the Economic Workgroup did during Exercise Ruaumoko. The workgroup outlined some impacts for the various sectors that were represented in the group. This work could be expanded to a greater level of detail and wider range of sectors. Output from this discussion could possibly be fed back into the Economic Futures model and/or Riskscape.	4
4. The Economic Futures model ran two scenarios during Exercise Ruaumoko –	

Gap/ Required Research	DEVORA Objectives
with and without a range of mitigation measures implemented by organisations. There was not a huge difference in the outcome, and more work is required to develop the range of mitigation measures possible and the economic impact they would have if introduced.	
5. Develop the different attributes (depth of burial, roof pitch) for each inventory class (e.g. buildings, pipes, roads, bridges etc) required for the relevant volcanic hazards (ash, pyroclastic flow etc).	2 and 3
6. Start creating a building inventory: ▪ Critical or essential facilities, working with civil defence emergency management to identify these and working with the facility owners to collect attribute information ▪ Other building inventory – residential, commercial, community etc – look at ways of collecting this information cost effectively (use of proxies; internet community; google earth etc)	3
7. Work towards building a utility network inventory by selecting one or more utilities (or sectors such as water) and facilitating the collection of attribute data. *(Note: this would best be done on an all hazards basis. The Auckland Engineering Lifelines Group look to be heading down this track and may use the existing dataset they have as a starting point.)*	3
8. Work towards a better understanding of the consequences of lifeline network service outages (e.g. prolonged (>12 hrs) power outage) to understand the downstream and indirect consequences better as these are generally always understated.	4
9. Consider the outputs of Economic Models such as the Economic Futures Model with a view to their incorporation into the social or socioeconomic model.	4
10. Develop the relevant fragility functions for the different attributes.	2
11. Look at how environmental inventories could be valued and incorporated into the risk model.	4
12. Exercise Ruaumoko provided an opportunity to look at individual and community behaviour in the context of an eruption at the Auckland Volcanic Field. Evacuation behaviour is very important for traffic management and welfare planning, and is dependent on the demographics of the evacuation	4 and 6

Gap/ Required Research	DEVORA Objectives
zone. The focus group and survey undertaken during Exercise Ruaumoko could be extended to include a wider range of issues, for example: ▪ When would people self evacuate? ▪ How long would it take for people to hear notification and be ready to leave? ▪ Levels of preparedness to evacuate i.e. have they prepared a grab bag? ▪ Where would evacuees go and how they would get there? ▪ How long would it take to ready agency resources, conduct evacuation and secure zone for very large evacuee numbers? ▪ How long would it take for evacuees to travel to their destination? i.e. traffic management modeling? ▪ How many would present at welfare centres and need accommodation? ▪ How long would it take to register evacuees? ▪ How long could they be without an income? ▪ Numbers of households with pets? ▪ Ability of neighbouring regions to house Auckland evacuees including number thresholds and length of time (this was partially done for Ruaumoko, but only at a generalised level and the research was not consolidated).	

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Auckland Regional Council (1995) Earthquake hazards in the Auckland region. Technical Publication No. 57, 1995.

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Auckland Regional Council (2005) Hazard Consequences Research. Unpublished client report. Opus Consultants.

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Johnston, D.M.; Ronan, K.R.; Houghton, B.F. (1997) Living with an erupting volcano : the physical and social impacts of the 1995-1996 Ruapehu eruption on New Zealand communities.p. 40 In: The New Zealand Psychological Society 1947-1997 celebrates 50 years of psychology in New Zealand : he tirohanga ki muri : looking back and moving forward : conference, Massey University, Palmerston North, August 30-September 4 1997.

Johnston, D.; Paton, D.; Gough, J.; Dowrick, D.; Daly, M.; Baddon, L.; Batistich, T.; Wood, I. (1999) Auckland volcanic risk project : gaining a better understanding of the implications of a volcanic eruption at the Auckland volcanic field.p. [40] In: New Zealand Geophysical Society Symposium 1999 : Natural Hazards and Climate Change : Victoria University of Wellington : abstracts. Wellington: New Zealand Geophysical Society.

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Appendix 1: Risk and Social Data Annotated Bibliography

DEVORA

Risk and Social Annotated Bibliography

Notes on use of Bibliography:
To search for publications that contain certain keywords, use the "Find" excel tool.

Ref.	Author	Year	Title/Publication/pages	Cat	Abstract/ Summary	Location	Type
1	Allen, S.R.	1991	Volcanic hazards from the Auckland Volcanic Field.p. 28 In: Stewart, R.B. (ed.); Palmer, A.S. (ed.); Todd, A. (ed.) Geological Society of New Zealand and New Zealand Society of Soil Science Joint Annual Conference, Palmerston North 1991, November 25-29 : programme and abstracts. [Lower Hutt]: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 59A	AKL			Conference Proceedings
2	Allen, S.R.	1992	Volcanic hazards in the Auckland volcanic field. MSc (Geology) thesis, University of Auckland	AKL		AU	Unpublished
3	Allen, S.R.; Smith, I.E.M.	1994	Eruption styles and volcanic hazard in the Auckland Volcanic Field, New Zealand.p. 5-14 In: Wada, H. Memorial volume to the late Professor Teruhiko Sameshima. Shizuoka, Japan: Institute of Geosciences. Geoscience reports of Shizuoka University 20	AKL			Book
4	Alloway, B.V.; Daly, M.; Johnston, D.M.; Smith, I.	1998	Preliminary assessment of the threat posed to New Zealand's largest urban centre by silicic volcanism originating from the central North Island.p. 20 In: Cities on volcanoes : international meeting, Rome and Naples (Italy), June 28 to July 4, 1998 : program and abstracts. [S.l.]: [s.n.].	AKL			Conference Proceedings
5	Auckland Civil Defence and Emergency Management Group (ACDEMG)	2005	ACDEMG Plan	AKL	The broad purpose of this Plan is to enable the effective and efficient management of regionally significant hazards and risks that may affect the Auckland Region. The Plan serves to document hazards and risks, agreed actions and the principles of operation within which agencies involved in civil defence emergency management cooperate. Planning outcomes (such as agreed targets and actions or operational arrangements) are committed to by incorporating them within the existing processes of respective Group members.		Plan
6	Auckland Civil Defence and Emergency Management Group (ACDEMG)	2008	ACDEMG Group Functional Plan P2 Mass Evacuation Plan	AKL	The aim of this Plan is to detail a range of considerations and actions for the mass evacuation of people from a hazardous environment to a place of relative safety. This Plan outlines the principles and strategic (high level) arrangements to be followed by the CDEM Group to ensure the conduct of an effective and coordinated process for the following stages of mass evacuation: Decision to evacuate, Public notification, Physical evacuation, Shelter and Return.		Plan
7	Auckland Engineering Lifelines Group (AELG)	1998	Risk Management: Looking forward from the Auckland power crisis	AKL	A seminar was held to identify the broader implications of the Auckland power crisis and lessons transferable to other communities. This report summarises the outcomes of the seminar.	ARC	Unpublished
8	Auckland Engineering Lifelines Group (AELG)	2008	Priority Emergency Sites and Routes in Auckland Region (AELG-5) (version 3.0)	AKL	Key Objectives of the project were to: - To ensure essential or emergency services are operational as soon as practicable; - To identify essential critical lifeline utility sites and priority safe routes; The key deliverables from this project were: - An agreed priority route network for road transport - Each lifelines organisation has a list of critical community and lifeline utility sites in Auckland, has an assessment of the need for their service at those critical sites, and is able to assess emergency management expectations in light of company priorities;	AELG Website (parts of report are confidential)	Report

9	Auckland Engineering Lifelines Group (AELG)	2001b	AELG Volcanic Ash Review - Part 1 - Impacts on Lifelines Services and Collection/ Disposal Issues (AELG-13)	AKL	This review looks at the impacts on Lifelines Services and Collection/Disposal Issues of Volcanic Ash. Key objectives include: - identify the likely quantity and properties of ash that may require removal and clean-up from the Auckland region, - identify methods of collecting and transporting ash, - identify health and safety and environmental issues - identify gaps in knowledge and further work and research that is required to fill these gaps, - discuss practical solutions for dealing with the issues identified above	AELG Website	Report
10	Auckland Engineering Lifelines Group (AELG)	2004	Volcanic Ash in Auckland's Water Supply (AELG-11)	AKL	Building on previous work and summarising a range of international case studies, we (a) evaluate the potential for physical and/or chemical contamination of water supplies from volcanic ashfall and (b) outline factors to consider in mitigation before, during and after an ashfall event. The relevant properties of volcanic ash are summarised, especially its abrasive, corrosive, leachate-forming and suspendable nature. We review reported impacts of volcanic eruptions on water supplies, drawing on case studies from New Zealand (1945, 1969 and 1995/96 eruptions of Mt Ruapehu) and overseas, with eight case studies.	AELG Website	Report
11	Auckland Engineering Lifelines Group (AELG)	2005	Volcanic Eruption: Recommended Actions for Airports (AELG-9)	Other	Poster developed for airport operational staff outlining actions to be taken pre, during and post eruption regarding managing volcanic ash.	AELG Website	Poster
12	Auckland Engineering Lifelines Group (AELG)	2006	Infrastructure Hotspots (AELG-3)	AKL	The objectives of this project were the identification of network areas where numerous services were co-located, and an assessment of the vulnerability of each site to external influences such as third party disruption, earthquakes, slips, and floods.	AELG Website	Report
13	Auckland Engineering Lifelines Group (AELG)	2007	Volcanic Eruption: Recommended Actions for Roads (AELG-18)	Other	Poster developed for roading operational staff outlining actions to be taken pre, during and post eruption regarding managing volcanic ash.	AELG Website	Poster
14	Auckland Engineering Lifelines Group (AELG)	2008	Volcanic Eruption: Recommended Actions for Water Supply Managers (AELG-9)	Other	Poster developed for airport operational staff outlining actions to be taken pre, during and post eruption regarding managing volcanic ash.	AELG Website	Poster
15	Auckland Engineering Lifelines Group (AELG)	1997a	Auckland Engineering Lifelines Project: Final Report Stage One Nov 97. TP 112.	AKL	This report summarises the results of three years work by several largely voluntary task groups into the risks posed by selected natural hazards to critical utility networks in the Auckland region. Its objective was to reduce the impact of hazards on lifeline infrastructure.	AELG Website	Report
16	Auckland Engineering Lifelines Group (AELG)	1997b	Auckland Engineering Lifelines Project:Stage One Report July 1997: Part 1 Hazard Information; Part 2: Network Utility Information 1997. TP 116.	AKL	This report contains the results of research performed during the AELG project on hazard risk assessments and Network utility information.	AELG Website	Report
17	Auckland Engineering Lifelines Group (AELG)	2008b	Exercise Ruaumoko: AELG Exercise Evaluation Report. P40-41 In AELG Agenda 4 June 2008; Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Unpublished
18	Auckland Engineering Lifelines Group (AELG) Website	2007	Exercise Ruaumoko: Potential Infrastructure Damage. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Partcipant Workshop 13 Nov 2007.	AKL		ARC	Unpublished
19	Auckland Regional Council (ARC)	2005	Hazard Consequences Research	AKL	Opus was commissioned to develop a risk assessment methodology for Auckland that will allowe consequences of hazards to be quantitatively assessed to determine levels of risks and allow comparison of risks against each other. This report presents the results of this research project and recommends a methodology for use in carrying out a multi-hazard risk assessment for Auckland.	ARC	Unpublished
20	Auckland Regional Council (ARC)	2006	ARC Hazards Consequences Assessment Methodology - Review Workshop Summary	AKL	Report of a workshop reviewing an ARC developed Hazards Consequences Assessment Methodology.	ARC	Unpublished

21	Auckland Regional Council (ARC)	2007	Contingency Plan for the Auckland Volcanic Field.	AKL	The purpose of the Plan is to establish a co-ordinated civil defence and emergency management framework to facilitate preparedness and response to, and recovery from, an eruption or hazard event from the AVF. The Plan will compliment existing civil defence and emergency management planning, targeting the management and co-ordination of response to a volcanic eruption. The Plan identifies roles, responsibilities and actions for many different 'stakeholder' organisations.		Plan
22	Ballantyne, M., Paton, D., Johnston, D., Kozuch, M., Daly, M.,	2000	Information on volcanic and earthquake hazards: The impact on awareness and preparation. Institute of Geological & Nuclear Sciences Limited, Lower Hutt. Science Report 2000/2.	AKL		GNS	GNS Report
23	Barnard, S.T.; Cole, J.W.; Johnston, D.M.	2007	Potential impacts of volcanic ash on wastewater systems and telecommunications infrastructure in New Zealand.p. 138 (abstract 22-O-14) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	AKL		GNS	Conference Proceedings
24	Barrata, A., Zuccaro, G., Binetti, A.	2004	Strength capacity of a non-tension portal arch-frame under combined seismic and ash loads. Journal of Volcanology and Geothermal Research 133, 369-376.	Other			Journal
25	Becker, J., Smith, R., Johnston, D.M., Munro, A.,	2001	Effects of the 1995–1996 Ruapehu eruptions on communities in central North Island, New Zealand, and people's perceptions of volcanic hazards after the event. The Australasian Journal of Disaster and Trauma Studies 2001 1 http://www.massey.ac.nz/~trauma/issues/2001-1/becker.htm.	Other			Journal
26	Becker, J.S.; Saunders, W.S.A.; Johnston, D.M.; Leonard, G.S.	2007	Issues and opportunities for land-use planning for volcanic hazards : a case study from New Zealand.p. 149-150 (abstract 23-P-02) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	Other			Conference Proceedings
27	Becker, J.S.; Smith, R.; Johnston, D.M.; Munro, A.	2001	Effects of the 1995-1996 Ruapehu eruptions on communities in central North Island, New Zealand, and people's perceptions of volcanic hazards after the event.Australasian journal of disaster and trauma studies, 2001-1: 23 p.	Other			Journal
28	Bell, R.; King, A.B.	2005a	Regional Riskscape Model : progress on developing a multi-hazard risk toolbox.p. 117-118 In: Townend, J.; Langridge, R.M.; Jones, A. (comps) The 1855 Wairarapa Earthquake Symposium : 150 years of thinking about magnitude 8+ earthquakes and seismic hazard in New Zealand : 8-10 September 2005 : proceedings volume. [Wellington, NZ]: Greater Wellington Regional Council.	Other	In June 2004, The New Zealand Foundation for Research, Science and Technology directed funding to the development of a Regional Riskscape Model. The main goal of the project is to produce a decision-support tool that converts existing hazard knowledge into likely consequences for a region, such as damage and replacement costs, casualties, disruption and number of people that could be affected. (auth/DG)		Conference Proceedings
29	Bell, R.; King, A.B.	2005b	Regional Riskscape Model : quantifying and comparing consequences of natural hazards.p. 13 In: Collen, J.; Bukarau, L. (eds) Abstracts of papers presented at the STAR Session 2005. Suva, Fiji: SOPAC. SOPAC miscellaneous report 603	Other			Conference Proceedings
30	Blong, R.J.,	1981	Some effects of tephra fall on buildings. In: Self, S., Sparks, R.S.J. (Eds.), Tephra Studies. D. Reidel Publishing Company, Dordrecht, pp. 405– 420.	Other			Book
31	Blong, R.J.,	1984	Volcanic Hazards: A Sourcebook on the Effects of Eruptions. Academic Press, Sydney. 424 pp..	Other			Book
32	Boshier, J.A.	1990	Public perception and response to risk assessment in New Zealand.p. 17-25 In: Proceedings IPENZ Conference 1990 : Engineering : Past, Present and Future: Building the Environment. Wellington, NZ: Institution of Professional Engineers NZ. Proceedings IPENZ annual conference 1990	Other	Risk assessment has been developed in industrialised countries to quantify the degree of hazard that might result from industrial activities. In New Zealand risk assessment has been used in both a formal quantitative way for some industrial activities and in an informal way for decisions on natural hazard mitigation. However, the public perception of risk is often at variance with the technical assessment and can influence the risk management decisions that are subsequently taken by developers or regulatory agencies.		Conference Proceedings

33	Brantley, S.R.; Johnston, D.M.; Adleman, J.	2003	Volcanic ash : what it can do and how to prevent damage.p. 15 In: Cities on Volcanoes 3, Hilo, Hawaii, July 14-18, 2003 : abstract volume. Hilo, Hawaii: The Conference.	Other	Information about volcanic ash and its effect and how to dispose of it is not widely available. Drawing from lessons around the world a new website has been put together which provides guidelines to help people learn what to expect during and after an ash event and how to effectively deal with it.		Conference Proceedings
34	Campbell, G.H.; Flaws, M.G.	2001	Protection of the Auckland volcanic cones : National Reserve status proposal.p. 15 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	AKL			Conference Proceedings
35	Chick, L.	2003	Case study : planning for a volcanic crisis in Auckland.61 p. In: Chick, L.; Houghton, B.F.; Johnston, D.M.; Scott, B.J. 7th volcanoes & society short course : Planning for a volcanic crisis, Wairakei Research Centre, Taupo, 13th-14th October 2003. Wairakei: Wairakei Research Centre.	AKL	Explores the disaster risk management process and how this process can be used to help manage a volcano problem (auth)		Course
36	Chick, L.; Houghton, B.F.; Johnston, D.M.; Scott, B.J.	2003	7th volcanoes & society short course : Planning for a volcanic crisis : course notes, Wairakei Research Centre, 13th-14th October 2003.89 p. In: Chick, L.; Houghton, B.F.; Johnston, D.M.; Scott, B.J. 7th volcanoes & society short course : Planning for a volcanic crisis, Wairakei Research Centre, Taupo, 13th-14th October 2003. Wairakei: Wairakei Research Centre.	AKL	The course presented an assessment of volcanic hazards in NZ, reviewed monitoring and warning systems, discussed community reslience and developing effective warning systems as well as discussing how organisations can better prepare for future volcanic events. A number of case study's are discussed including planning for a volcanic crisis in Auckland - HOW has Auckland assessed its volcanic risk and what planning has been undertaken.		Course
37	Chick, L.; Williams, A.; Linzey, A.; Williams, K.	2004	Cities on volcanoes : preparing for an eruption from the Auckland Volcanic Field.Tephra, 21: 32-37	AKL	This article summarises the planning involved around a volcanic eruption in the Auckland Volcanic Field, including location prediction difficulties, readiness mechanisms, and lifelines preparedness.		Serial
38	Clerc, G	2007	Exercise Ruaumoko: Auckland Region Health Service Impact Workshop Minutes. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Health Sector Workshop 29 Nov 2007.	AKL		ARC	Unpublished
39	Coetzee, D.	2004	National contingency plan for volcanic eruption.Tephra, 21: 24-25	Other	The National Contingency Plan for Volcanic Eruption is part of the National Civil Defence Plan (Annex B2 to Part 1). The plan outlines a framework of actions to be taken by Government, local authorities and other agencies with civil defence emergency management (CDEM) responsibilities, in preparation for and response to volcanic events. Because smaller events will occur with a greater frequency than large eruptions, the plan allows for appropriate response according to predicted scale or expected impact. (auth)		Journal
40	Cole, J.; Blumenthal, E.	2004	Evacuate! : what an evacuation order given because of a pending volcanic eruption could mean to residents of the Bay of Plenty.Tephra, 21: 46-52	Other	In about 1315 AD Tarawera volcano erupted with enormous force, depositing rhyolitic ash over much of the northern part of the North Island. This was the Kaharoa eruption. Columns of ash may have continued for days or weeks, and these were followed by slow extrusion of lava domes, with intermittent ash eruptions, which may have continued for four years. If such an event occurred today it would cause major disruption to the surrounding area. Evacuation of some areas will be inevitable. (auth)		Journal
41	Cole, J.W.; Sabel, C.E.; Blumenthal, E.; Finnis, K.; Dantas, A.; Barnard, S.; Johnston, D.M.	2005	GIS-based emergency and evacuation planning for volcanic hazards in New Zealand.Bulletin of the New Zealand Society for Earthquake Engineering, 38(3): 149-164	Other			Journal
42	Crimp, R.	2001	Mitigation strategies for telecommunications in New Zealand.p. 3:17-3:27 In: Proceedings of International Workshop, held at the Telstra Suite, Te Papa, Wellington, 16 & 17 October 2001 : defining best technical practice : planning the future direction of Lifelines. Wellington, N.Z.: Wellington Lifelines Group.	Other	This document briefly describes some of the physical hazard mitigation strategies and measures taken by Telecom New Zealand over the past 10 years to ensure high availability of its products and services to customers and the community. Earthquake risk is used as an example to illustrate some of the mitigation measures taken in more detail. (auth)		Conference Proceedings

43	Daly, M.; Holland, G.	2008	Risk reduction gap analysis for the Auckland region.p. 15 In: Stewart, C. (ed.) 2nd Australasian Natural Hazards Management Conference : from warnings to effective response and recovery, Te Papa, Wellington, New Zealand, 29-30 July 2008 : optional workshops 28 and 31 July 2008. Lower Hutt: GNS Science. GNS Science miscellaneous series 15	AKL			Conference Proceedings
44	Daly, M.; Johnston, D.M.	1997	Volcanic impact assessment for the Auckland Volcanic Field.p. 34 In: New Zealand Geophysical Society Inc Geophysical Symposium on the theme "Natural hazards in New Zealand", 28-29 August 1997 ... Victoria University of Wellington. Wellington: New Zealand Geophysical Society. New Zealand Geophysical Society Inc. ... Symposium, abstracts 1997	AKL			Conference Proceedings
45	Daly, M.; Johnston, D.M.; Houghton, B.; Manville, V.R.; Paton, D.; Scott, B.J.	2004	8th Volcanoes & Society short course : planning for a volcanic crisis : course notes, Wairakei Research Centre, 14th-15th October 2004.88 p. In: Daly, M.; Houghton, B.; Paton, D.; Johnston, D.M.; Manville, V.R.; Scott, B.J. 8th Volcanoes & Society short course : planning for a volcanic crisis, Wairakei Research Centre, Taupo, 14th-15th October 2004. Wairakei: Wairakei Research Centre.	AKL	The course presented an assessment of volcanic hazards in NZ, reviewed monitoring and warning systems, discussed community reslience and developing effective warning systems as well as discussing how organisations can better prepare for future volcanic events. A number of case study's are discussed including planning for a volcanic crisis in Auckland - HOW has Auckland assessed its volcanic risk and what planning has been undertaken.		Course
46	Daly, M.C.; Wilkie, D.; Johnston, D.M.	1998	Reducing the vulnerability of infrastructure to volcanic hazards in Auckland, New Zealand : the Auckland Engineering Lifelines Project.p. 45 In: Cities on volcanoes : international meeting, Rome and Naples (Italy), June 28 to July 4, 1998 : program and abstracts. [S.l.]: [s.n.].	AKL			Conference Proceedings
47	Davis, M	2007	Exercise Ruaumoko: Auckland Metro CWD Impact on Health Service Delivery. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Health Sector Workshop 29 Nov 2007.	AKL		ARC	Unpublished
48	Dirks, K.; Samaranayake, D.; Hope, V.	2004	Health impacts in Auckland of the Mt Ruapehu volcanic eruption of 1996.Eos, 85(28:supplement): WP10	AKL			Serial
49	Falconer, R.K.H.; Alloway, B.V.; Johnston, D.M.	2001	Gaps between public, business and scientific knowledge of volcanic risk.p. 38 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	Other			Conference Proceedings
50	Fenwick, T	2008a	Exercise Ruaumoko: Summary of Exercise Infrastrucure Impacts.	AKL		AELG	Unpublished
51	Finnis, K.; Johnston, D.M.; Paton, D.	2004	Volcanic hazard risk perceptions in New Zealand.Tephra, 21: 60-64	Other	Assessing risk by focusing purely on the physical processes that cause it does not fully accommodate the public's perception of risk. In the past this has led to problems in communicating hazard information and persuading the public to undertake appropriate mitigation measures. This paper provides a review and analysis of current findings.		Serial
52	Finnis, K.K.; Johnston, D.M.	2007	Vulnerability of populations around New Zealand's volcanic centres.p. 144 (abstract 22-P-19) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	AKL		GNS	Conference Proceedings
53	Fougere, D.	2008	Exercise Ruaumoko: Exercise Ruaumoko Phoenix Community Perception Focus Group Report. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Report
54	Gloyn, J.G.	1991	The impact of volcanic risk on agriculture and horticulture in New Zealand.p. 62 In: Stewart, R.B. (ed.); Palmer, A.S. (ed.); Todd, A. (ed.) Geological Society of New Zealand and New Zealand Society of Soil Science Joint Annual Conference, Palmerston North 1991, November 25-29 : programme and abstracts. [Lower Hutt]: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 59A	Other			Journal
55	Gordon, K.; Cole, J.; Johnston, D.M.	2003	Effects of volcanic ash on computers and air conditioning systems.p. 49 In: Cities on Volcanoes 3, Hilo, Hawaii, July 14-18, 2003 : abstract volume. Hilo, Hawaii: The Conference.	Other	This paper discusses a study undertaken to look at the effects of volcanic ash on computers and airconditioning which can be key parts of infrastructure networks. Testing was done a range of equipment and the results are discussed.		Conference Proceedings

56	Gregg, C.E.; Paton, D.; Houghton, B.F.; Swanson, D.A.; Johnston, D.M.	2004	Community preparedness for lava flow hazards : the role of knowledge, perception and history.p. 11 In: Johnston, D.M.; Tilyard, D. (comps) Proceedings of the 6th Natural Hazards Management Conference, Baycourt, Tauranga, 10-11 August 2004. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences information series 65	Other	This paper examines the implications of differential patterns of activity for public perceptions of lava flow hazards in Kona, Hawaii. Results of a questionnaire survey adminstered t 462 high school students and adults in Kona are discussed.		Conference Proceedings
57	Hayward, B.	2001	Protection for two more of Auckland's volcanoes.Newsletter / Geological Society of New Zealand, 125: 5-6	AKL	Hector Day 2001 was marked by members of the Auckland Branch with a tour of Auckland's newest reserve (Otuataua Stonefields Reserve), which contains two of the 48 centres of Auckland's young basalt volcanic field (Puketaapapa and Otuataua) (DG)		Newsletter
58	Horrocks, J	2007a	Exercise Ruaumoko: Auckland Public Perception Volcano Survey Template. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Unpublished
59	Horrocks, J	2007b	Exercise Ruaumoko: Community Behaviour-Based Communication Framework.In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	Other		ARC	Unpublished
60	Horrocks, J.; Leonard, G.S.; Wood, P.; Johnston, D.M.; Smith, R.	2007	New Zealand's all-hazard civil defence emergency management structure : cooperation and mutual support for volcanic crisis management.p. 153 (abstract 31-O-07) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	Other			Conference Proceedings
61	Hoskin, K	2007	Exercise Ruaumoko: US Mass Evacuation Behavioural Experience References. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	Other		ARC	Unpublished
62	Houghton, B.; Paton, D.; Johnston, D.M.; Alloway, B.V.; Scott, B.J.	2001	Volcanoes and society : planning for a volcanic crisis in New Zealand : short course notes, 15th-16th October 2001, Wairakei Research Centre.Taupo, NZ: Institute of Geological & Nuclear Sciences Limited.. . 1 v. (loose-leaf)	AKL	The course presented an assessment of volcanic hazards in NZ, reviewed monitoring and warning systems, discussed community reslience and developing effective warning systems as well as discussing how organisations can better prepare for future volcanic events. A number of case study's are discussed including planning for a volcanic crisis in Auckland - HOW has Auckland assessed its volcanic risk and what planning has been undertaken.		Course
63	Houghton, B.F.; Bonadonna, C.; Gregg, C.E.; Johnston, D.M.; Cousins, W.J.; Cole, J.W.; Del Carlo, P.	2006	Proximal tephra hazards : recent eruption studies applied to volcanic risk in the Auckland volcanic field, New Zealand.Journal of volcanology and geothermal research, 155(1-2): 138-149		Despite the small size and intensity of Auckland eruptions, the risk from tephra fall is high because of the high density of buildings and lifelines. The nature of this threat can be evaluated by comparisons with historical Strombolian and Hawaiian eruptions, which have occurred in nonpopulated areas. Rapid cone growth during future eruptions will define a region of some 30 to 100 ha where complete destruction will occur on a time scale of hours. The cost of this destruction is likely to range between NZ$200M and NZ$1.4B (ca. US$130M to US$900M). Beyond this, we have modeled the cumulative long-term effect of the build-up of a downwind blanket of lapilli and ash by estimating accumulation rates for three phases of the 1959 Kīlauea Iki eruption in Hawai‘i.		
64	Hughes, N.M.; Leonard, G.S.; Keys, H.; Johnston, D.M.; Paton, D.; Carter, G.	2008	The challenge of turning public education into improved action : awareness and warning effectiveness before/after the 2007 Ruapehu eruption, NZ.1 p. In: IAVCEI 2008 General Assembly, Reykjavik, Iceland : programme and abstracts. Reykjavik, Iceland: IAVCEI.	Other			Conference Proceedings
65	Hurst, A.W.	2001	Key issues in monitoring an Auckland volcanic crisis.p. 59 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	Other			Conference Proceedings

66	Johnson, D.M.; Houghton, B.F.	1997	Changing perceptions of volcanic hazards in two different communities before and after the 1995 Ruapehu eruption, New Zealand.p. 35 In: The New Zealand Psychological Society 1947-1997 celebrates 50 years of psychology in New Zealand : he tirohanga ki muri : looking back and moving forward : conference, Massey University, Palmerston North, August 30-September 4 1997. : .	Other			Journal
67	Johnson, D.M.; Ronan, K.R.; Houghton, B.F.	1997	Living with an erupting volcano : the physical and social impacts of the 1995-1996 Ruapehu eruption on New Zealand communities.p. 40 In: The New Zealand Psychological Society 1947-1997 celebrates 50 years of psychology in New Zealand : he tirohanga ki muri : looking back and moving forward : conference, Massey University, Palmerston North, August 30-September 4 1997. : .	Other			Journal
68	Johnston DM	1998	Modelling ash distribution for Auckland scenarios. Institute of Geological and Nuclear Sciences Client Report 71770D.10A. Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand, pp 1–12	AKL		GNS	GNS Report
69	Johnston, D.,	2004	Cities coping with volcanic ash. Volcanoes and Society Workshop, Wairakei Research Centre, Taupo, New Zealand. October.	Other			Course
70	Johnston, D.; Daly, M.	1997	Auckland erupts!!!.New Zealand science monthly, 8(10): 6-7	AKL	It's just a matter of time before the Auckland Volcanic Field lets loose, and researchers are already assessing the likely impacts. (auth)		Serial
71	Johnston, D.; Houghton, B.F.	1995	Living with volcanoes.Tephra, 14(2): 22-28	Other			Serial
72	Johnston, D.; Paton, D.; Gough, J.; Dowrick, D.; Daly, M.; Baddon, L.; Baitistch, T.; Wood, I.	1999	Auckland volcanic risk project : gaining a better understanding of the implications of a volcanic eruption at the Auckland volcanic field.p. [40] In: New Zealand Geophysical Society Symposium 1999 : Natural Hazards and Climate Change : Victoria University of Wellington : abstracts. Wellington: New Zealand Geophysical Society.	akl	Research was initiated in Auckland, NZ in 1995 in order to provide a bsisi for developing a framework for the comprehensive mangaement of a wide range of risks associated with volcanic hazards. It consisted of two phases, the first looking at qualitative scenario modelling of the impacts on infrastructure, population and the environment and the second on quantitative GIS risk assessment.		Conference Proceedings
73	Johnston, D.; Paton, D.; Houghton, B.F.	1999	Volcanic hazard management : promoting integration and communication.p. 243-245 In: Ingleton, J. (ed.) Natural disaster management : a presentation to commemorate the International Decade for Natural Disaster Reduction (IDNR) 1990-2000. [s.l.]: Tudor Rose.	Other			Journal
74	Johnston, D.M.	1997	Mitigation measures for volcanic ash falls.p. 211-222 In: Auckland engineering lifelines project : stage one report. [Auckland, NZ]: Auckland Regional Council.	AKL	This report summarises the results of three years work into the risks posed by selected natural hazards to critical utility networks in the Auckland region. Its objective was to reduce the impact of hazards on lifeline infrastructure. This report: * Examines the effects of direct damage by major natural hazards to lifeline services * Assesses the vulnerability of lifeline services to damage from natural hazards * Identifies interdependencies between the lifeline services and strategies for reducing risk * Helps project participants identify and implement mitigation and response strategies for their own networks	ARC	Report
75	Johnston, D.M.	1994	Contamination of potable water supplies by volcanic ash.Water & wastes in NZ, November: 18-21	AKL			Journal
76	Johnston, D.M.	1995	Community perceptions of risk.p. 51-53 In: Hull, A.G.; Coory, R. Proceedings of the Natural Hazards Management Workshop '95, Auckland, 28-29 November 1995. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 38	Other	The public's perception of risk is often found to be biased. Environmental, social and psychological factors shape perceptions of risk and there is empirical evidence that risk perception is related to hazard awareness and hazard knowledge, and influences planning behaviour and warning compliance. Understanding a community's perceptions of risk is therefore an important part of the decision making process and should be used as an input into natural hazard management. (auth)		Conference Proceedings
77	Johnston, D.M.	1997a	Physical and social impacts of past and future volcanic eruptions in New Zealand. PhD thesis, Massey University	Other			Unpublished

78	Johnston, D.M.	1997b	The Impact of recent falls of volcanic ash on public utilities in two communities in the United States of America.Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences science report 97/05. iii, 19 p.	Other			GNS Report
79	Johnston, D.M.	1997c	Review of impacts of historic eruptions on lifelines.p. 193-209 In: Auckland engineering lifelines project : stage one report. [Auckland, NZ]: Auckland Regional Council.	Other	This report summarises the results of three years work into the risks posed by selected natural hazards to critical utility networks in the Auckland region. Its objective was to reduce the impact of hazards on lifeline infrastructure. This report: * Examines the effects of direct damage by major natural hazards to lifeline services * Assesses the vulnerability of lifeline services to damage from natural hazards * Identifies interdependencies between the lifeline services and strategies for reducing risk * Helps project participants identify and implement mitigation and response strategies for their own networks	ARC	Report
80	Johnston, D.M.	1998	Changing perceptions of volcanic risk following the 1995 Ruapheu eruptions, New Zealand.1 p. In: 23rd Annual Hazards Research and Applications Workshop. [S.l.]: [s.n.].	Other			Conference Proceedings
81	Johnston, D.M., Houghton, B.F., Neall, V.E., Ronan, K.R., Paton, D.	2000	Impacts of the 1945 and 1995-1996 Ruaupehu eruptions, New Zealand: an example of increasing social vulnerability. Geological Society of America Bulletin 112(5), 720-726	Other			Serial
82	Johnston, D.M.; Bebbington, M.S.; Lai, C.-D.; Hougthon, B.F.; Paton, D.	1999	Volcanic hazard perceptions : comparative shifts in knowledge and risk.Disaster prevention and management, 8(2): 118-126	Other			Journal
83	Johnston, D.M.; Cole, J.W.; Nairn, I.A.; Houghton, B.F.	2001	The vulnerability of urban infrastructure to volcanic ash falls.p. 63 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	Other			Conference Proceedings
84	Johnston, D.M.; Daly, M.; Nairn, I.A.; Thordarson, T.; Alloway, B.V.; Smith, I.E.	1998	Assessing the impacts of an eruption from the Auckland Volcanic Field, New Zealand.p. 74 In: Cities on volcanoes : international meeting, Rome and Naples (Italy), June 28 to July 4, 1998 : program and abstracts. [S.l.]: [s.n.].	AKL			Conference Proceedings
85	Johnston, D.M.; Daly, M.; Paton, D.	2000	Planning for Auckland volcanic eruption.The Authority : local body news, 8(5): 12	AKL	Auckland is New Zealand's largest and fastest growing city. The metropolitan centre of Auckland has developed across a potentially active basaltic volcanic field. It faces a hazard from several large central North Island volcanic centres. (auth)		Serial
86	Johnston, D.M.; Kerr, J.E.; Paton, D.; Ronan, K.; Houghton, B.F.	2003	Improving societies' preparedness for future volcanic eruptions.p. 68 In: Cities on Volcanoes 3, Hilo, Hawaii, July 14-18, 2003 : abstract volume. Hilo, Hawaii: The Conference.	Other	Promoting resilience to volcanic hazards through encouraging individual and community preparedness is a complex processs. A major challenge is ensuring that information is meaningful, motivates risk acceptance and the adoption and maintenance of risk reduction behaviour. This paper investigates this.		Conference Proceedings
87	Johnston, D.M.; Leonard, G.S.; Saunders, W.S.A.; Becker, J.S.; Paton, D.; Walton, M.	2006	Understanding and managing social and economic consequences of natural hazards.Abstracts / Geological Society of Australia, 82: 151-152	Other			Journal
88	Johnston, D.M.; Nairn, I.A.; Thordarson, T.; Daly, M.	1997a	Volcanic impact assessment for the Auckland Volcanic Field : a report.Auckland: Auckland Regional Council. Technical publication / ARC Environment 79. x, 208 p.	AKL	This report aims to identify the likely impacts within the Auckland region of future volcanic eruptions from the Auckland Volcanic Field, a monogenetic volcanic field covering an area of 360 square km in which activity has occurred from scattered vents during the past 140000 years. The effects of such eruptions on the buildings, main infrastructure, critical facilities, population, economic activities and natural features are considered. Five possible eruption scenarios are developed, vulnerabilities examined, and possible impacts assessed. (auth/ARC)	ARC	Journal

89	Johnston, D.M.; Nairn, I.A.; Thordarson, T.; Daly, M.	1997b	Volcanic impact assessment for the Auckland Volcanic Field.p. 111-169 In: Auckland engineering lifelines project : stage one report. [Auckland, NZ]: Auckland Regional Council.	AKL	This report aims to identify the likely impacts within the Auckland region of future volcanic eruptions from the Auckland Volcanic Field. The effects of such eruptions on the buildings, main infrastructure, critical facilities, population, economic activities and natural features are considered. Five different eruption scenarios have been developed. Their purpose is not to predict what the next eruption at Auckland will be like, but to identify some of the processes and effects that could be expected in a likely eruption. However, a future Auckland eruption will not necessarily be similar to any of the scenario events, in sequence, size, duration, or vent location. A full discussion of each of the scenarios can be found in ARC Technical Report 79. A summary of one of these scenarios (scenario 3) is presented in this report. (auth/EB)	ARC	Report
90	Johnston, D.M.; Paton, D.; Gough, J.; Dowrick, D.; Daly. M.; Baddon, L.; Batistich, T.; Wood, I.	2001	Understanding of the implications of a volcanic eruption at the Auckland Volcanic Field.p. 66 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	AKL			Conference Proceedings
91	Johnston, D.M.; Paton, D.; Gough, J.; Dowrick, D.J.; Daly, M.; Baddon, L.; Batistich, T.; Wood, I.	2000	Auckland volcanic risk project : gaining a better understanding of the implications of a volcanic eruption at the Auckland Volcanic Field.p. 66 In: Johnston, D.M. (comp.) Proceedings of the Natural Hazards Management Conference, Napier, 16-17 August 2000. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 48	AKL	Research was initiated in Auckland, NZ in 1995 in order to provide a bsisi for developing a framework for the comprehensive mangaement of a wide range of risks associated with volcanic hazards. It consisted of two phases, the first looking at qualitative scenario modelling of the impacts on infrastructure, population and the environment and the second on quantitative GIS risk assessment.		Conference Proceedings
92	Johnston, D.M.; Ronan, K.R.; Gowan, M.; Paton, D.; Leonard, G.S.; Houghton, B.F.	2008	Multi-agency approaches for improving mental health outcomes during a volcanic crisis : lessons from eruptions in New Zealand.1 p. In: IAVCEI 2008 General Assembly, Reykjavik, Iceland : programme and abstracts. Reykjavik, Iceland: IAVCEI.	Other			Conference Proceedings
93	Johnston, D.M.; Saunders, W.S.A.; Becker, J.S.; Leonard, G.S.	2007	Reducing volcanic risk through land-use planning : is it an option?.p. 148 (abstract 23-O-03) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	Other			Conference Proceedings
94	Johnston, D.M.; Stewart, C.; Leonard, G.S.; Hoverd, J.L.; Thordarsson, T.; Cronin, S.	2004	Impacts of volcanic ash on water supplies in Auckland. Part I.Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences science report 2004/25. 83 p.	AKL	Auckland lies on the active Auckland Volcanic Field and during some climatic conditions is downwind of the active Taupo Volcanic Zone. Over the past few years a number of reports have evaluated volcanic risk to Auckland's infrastructure. Building on this previous work, and summarising a range of international case studies, we (a) evaluate the potential for physical and/or chemical contamination of water supplies from volcanic ashfall and (b) outline factors to consider in mitigation before, during and after an ashfall event. The relevant properties of volcanic ash are summarised, especially its abrasive, corrosive, leachate-forming and suspendable nature. (auth)		GNS Report
95	Kaye, G.; Cole, J.W.; King, A.B.; Johnston, D.M.	2007	Riskscape : a new tool for volcanic hazard risk assessment in New Zealand.p. 142 (abstract 22-P-14) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	Other			Conference Proceedings
96	Kaye, G.; Wilson, T.; Cole, J.; King, A.B.; Johnston, D.M.	2006	Volcanic hazard risk assessment in the Riskscape Program : review of existing inventory fragility models and test application in the Rotorua district, New Zealand.p. 32 In: Conference proceedings : 7th New Zealand Natural Hazards Management Conference, Christchurch, 23-24 August 2006. Lower Hutt: GNS Science. GNS Science miscellaneous series 8	Other	The Riskscape program provides a means to assess risk from natural hazards in NZ. IT combines hazard modules and inventory database in a GIS like software environment enable the user to tailor their specific analysis to their particular needs. This is going to be tested in the Rotorua District and and potentially the US.		Conference Proceedings

97	Kaye, G.D.	2007	RiskScape Volcano : a volcanic hazard risk assessment model for RiskScape.Lower Hutt: GNS Science. GNS Science report 2007/38. 176 p.	Other	This document outlines the volcanic risk assessment model “RiskScape Volcano” developed for the RiskScape software. The model was tested by conducting multi-hazard volcanic risk assessments of population, agriculture, and infrastructure in Rotorua, New Zealand, and critical infrastructure in Mammoth Lakes, California, USA. The primary focus of this science report is to outline the design, implementation methods used to build RiskScape Volcano and undertake the risk assessments in Rotorua and Mammoth Lakes, so that RiskScape Volcano can eventually be incorporated into RiskScape.		Journal
98	Kerr, J.E.; Johnston, D.M.	2003	Land use planning as a tool for managing volcanic hazards, New Zealand.p. 71 In: Cities on Volcanoes 3, Hilo, Hawaii, July 14-18, 2003 : abstract volume. Hilo, Hawaii: The Conference.	Other	70% of New Zealanders within 200km of an active volcano. Through considering the role of legislation, policy and land use planning, the paper addresses two key themes that present challenges to planners when developing and implementing land use policies to address volcanic hazards, 1) their low probability/high impact nature and 2) a complex land use regulatory regime.		Conference Proceedings
99	Kidd, A.L.	2007	Exercise Ruaumoko: Potential Economic Impacts. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Economic Sector Workshop 19 Sep 2007.	AKL		ARC	Unpublished
100	Kidd, A.L.	2008a	Exercise Ruaumoko: Exercise Ruaumoko Potential Electricity Transmission Impact. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Transpower Interview.	AKL		ARC	Unpublished
101	Kidd, A.L.	2008b	Exercise Ruaumoko: Evacuation Progression Script Assumptions Basis. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Unpublished
102	Lauder, W.R.	1965	Volcanic risk at Auckland : letter to the editor.New Zealand journal of geology and geophysics, 8(3): 565-566	AKL			Journal
103	Lecointre, J.	2007	Managing volcanic risk in densely populated coastal areas : an international perspective.p. 85 In: Mortimer, N.; Wallace, L.M. (eds) Geological Society of New Zealand & New Zealand Geophysical Society Joint Annual Conference : launching International Year of Planet Earth, 26-29 November 2007, Tauranga : programme and abstracts. Lower Hutt?: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 123A	Other			Journal
104	Leonard, G.S.; Johnston, D.M.; Paton, D.	2006	Effective all-hazard warning system development and community resilience : results from ongoing multi-hazard research in New Zealand, USA and Australia.2 p. In: Third International Conference on Early Warning : from concept to action, 27-29 March 2006, Bonn, Germany : abstracts. Bonn, Germany: Third International Conference on Early Warning.				Conference Proceedings
105	Leonard, G.S.; Johnston, D.M.; Saunders, W. and Paton, D.	2006	Assessment of Auckland Civil Defence and Emergency Management Group warning system options, GNS Science Report 2006/002 79p.	AKL	This report recommends priority options for public notification of warnings for the short (1 year), medium (1 to 5 years) and long (5 to 10+ years) term for the Auckland CDEM Group, based on a review of 26 options under the broad headings of ‘natural warnings’, ‘via institutional staff to those in their care’, ‘via community/organisation networks to the public’, ‘via third-party hardware and/or staff’ and ‘via dedicated hardware’.		Report
106	Leonard, G.S.; Richards, J.; Olsen, J.; Stephens, J.; Lindsay, J.; Johnston, D.M.; Cowan, H.A.	2007	A case study of cooperation : the New Zealand 'Auckland it's our volcano' initiative.p. 159-160 (abstract 31-P-15) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	AKL			Conference Proceedings
107	Lindsay, J	2008	Exercise Ruaumoko: Post Eruption Outbreak Scenario. P47-50 In Auckland Engineering Lifelines Group (AELG) Agenda 4 June 2008; Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Unpublished

108	Lindsay, J and Peace, C	2005	Health and Safety Issues in a Volcanic Ash Environment. Auckland Engineering Lifelines Group, Project Report AELG/7. 44pp.	AKL	The specific objectives of this report are to provide AELG members with information that: * Allows them to understand the health and safety issues for their staff working in a volcanic ash environment * Provides advice on steps employers and staff can take to keep themselves safe in varying levels of ash exposure (e.g. what safety equipment is needed; what safety procedures need to be followed) * Explains these issues in the context of New Zealand's health and safety legislation, and * Identifies any gaps in knowledge or in preparedness for safely carrying out activities in an ash environment, and makes recommendations for further work and research to fill these gaps.	AELG website;	Report
109	Lindsay, J.; Leonard, G.S.	2007	Volcanic hazard assessment for the Auckland Volcanic Field : state of the play.p. 88 In: Mortimer, N.; Wallace, L.M. (eds) Geological Society of New Zealand & New Zealand Geophysical Society Joint Annual Conference : launching International Year of Planet Earth, 26-29 November 2007, Tauranga : programme and abstracts. Lower Hutt?: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 123A	AKL			Conference Proceedings
110	Lindsay, J.M.; Molloy, C.; Shane, P.	2007	Assessing long-term volcanic hazard and risk in Auckland, New Zealand.p. 124 (abstract 21b-O-13) In: Abstracts volume : Cities on Volcanoes 5 conference : Shimabara, Japan, November 19-23, 2007. Shimabara, Japan: Volcanological Society of Japan.	AKL			Conference Proceedings
111	Loasby, K.	2007	Exercise Ruaumoko: Ex Ruaumoko Lifelines and Health Workshop. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Auckland Engineering Lifelines Group (AELG) and Health Workshop 271107.	AKL		ARC	Unpublished
112	Lodge, J	2007	Exercise Ruaumoko: Auckland Mass Evacuation Welfare Plan. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Plan
113	Lodge, J	2008	Exercise Ruaumoko: Exercise Ruaumoko Welfare Demand Tool. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Unpublished
114	Lorden, Rob	2001	Report on Volcanic Field Visit Kagoshima	AKL	In June 2001 the Auckland Engineering Lifelines Group (AELG) Chair Rob Lorden participated in a field visit to Kagoshima, Japan to enable learning from their volcanic eruption to be built into NZ Emergency Management procedures. Rob's particular interest (on behalf of the Auckland Engineering Lifelines Group (AELG)) was the impact on utilities/ lifelines organisations and tips to assist recovery of these services.	AELG Website	Report
115	Magill, C.	2007	Reply to comments on "Probabilistic tephra fall simulation for the Auckland region, New Zealand by Magill et al. (2006)".Journal of volcanology and geothermal research, 159(4): 423-424; doi:10.1016/j.jvolgeores.2006.09.001	AKL			Journal
116	Magill, C.; Blong, R.	2005a	Volcanic risk ranking for Auckland, New Zealand. I, Methodology and hazard investigation.Bulletin of volcanology, 67(4): 331-339	AKL	Volcanic eruptions typically produce a number of hazards, and many regions are at risk from more than one volcano or volcanic field. So that detailed risk assessments can be carried out, it is necessary to rank potential volcanic hazards and events in terms of risk. As it is often difficult to make accurate predictions regarding the characteristics of future eruptions, a method for ranking hazards and events has been developed that does not rely on precise values. This method was used to rank volcanic hazards and events that may impact the Auckland Region, New Zealand. Multiple events and outcomes are considered. Relative probabilities were determined for each event the AVF is at risk of, with the highest given to Mt. Taranaki. Multiple hazards were considered.		Journal

117	Magill, C.; Blong, R.	2005b	Volcanic risk ranking for Auckland, New Zealand. II, Hazard consequences and risk calculation.Bulletin of volcanology, 67(4): 340-349	AKL	In this paper, the effects of each hazard are considered and the risk ranking from a companion paper completed. Values for effect are proportions of total loss and, as with likelihood and extent, are based on order of magnitude. Two outcomes were considered – building damage and loss of human life.		Journal
118	Magill, C.; Blong, R.; McAneney, J.	2004	Probabilistic risk assessment for the Auckland Volcanic Field, New Zealand.p. 29 In: McPhie, J.; McGoldrick, P. (eds) Dynamic earth : past, present and future : 17th Australian Geological Convention, 8-13 February 2004, Hobart, Tasmania, Australia. Sydney: Geological Society of Australia. Abstracts / Geological Society of Australia 73	AKL			Conference Proceedings
119	Magill, C.; Blong, R.; McAneney, J.	2006	VolcaNZ : a volcanic loss model for Auckland, New Zealand.Journal of volcanology and geothermal research, 149(3/4): 329-345	AKL	VolcaNZ is a probabilistic volcanic loss model developed for the Auckland Region in New Zealand that currently considers tephra fall hazards from the Auckland Volcanic Field (AVF), Tuhua volcano, Okataina volcanic centre, Taupo volcano, Tongariro volcanic centre and Egmont volcano. In this first version of the model, structural and non-structural damage to residential building envelopes and associated cleanup costs are calculated using Monte Carlo simulation.		Journal
120	Magill, C.; Blong, R.; McAneney, J.; Smith, I.; Hurst, A.W.	2004	Volcanic loss modelling for the Auckland region.p. 20 In: Johnston, D.M.; Tilyard, D. (comps) Proceedings of the 6th Natural Hazards Management Conference, Baycourt, Tauranga, 10-11 August 2004. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences information series 65	AKL	This paper presents a probablisitc volcanic loss model to assess risk from relatively frequent, small thickness tephra falls impacting the Auckland region., A survey was conducted to examine the vulnerability of Auckland's building stock to tephra fall. In a GIS framework, simulated tephra dispersal events are combined with this building information and assumptions regarding expected damage to determine a distribution of likely losses.		Conference Proceedings
121	Magill, C.R.; Hurst, A.W.; Hunter, L.J.; Blong, R.J.	2006	Probabilistic tephra fall simulation for the Auckland region, New Zealand.Journal of volcanology and geothermal research, 153(3-4): 370-386	AKL	The Auckland Region, New Zealand is at significant risk from tephra falls originating both from the local Auckland Volcanic Field (AVF) and several distant, large-volume centres. We use geological data and observations of historical eruptions to develop a catalogue of simulated tephra dispersal patterns for the Auckland Region, using the ASHFALL model.		Journal
122	Magill, C.R.; McAneney, K.J.; Smith, I.E.	2005	Probabilistic assessment of vent locations for the next Auckland volcanic field event.Mathematical geology, 37(3): 227-242	AKL	Auckland, New Zealand's most populous Region is centred on the Auckland volcanic field (AVF), which contains an estimated 49 small-volume basaltic volcanoes. Although these volcanoes are considered monogenetic, a number of centres may have been active either simultaneously or within a short period of time. After reviewing the characteristics of the field, known vent locations and a provisional eruption sequence were used to estimate likely eruption locations for the next event.		Journal
123	Mamula-Stojnic, L.	2001	A conceptual model for integrated volcanic risk management in Auckland.p. 90 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	AKL			Conference Proceedings
124	Millar, M., Paton, D., and Johnston, D,	1999	Community vulnerability to volcanic hazard consequences. Disaster Prevention and Management, 8, in press.	Other			Journal
125	Miller, C,D.	2001	Long-term strategy for mitigating volcanic risk in cities.p. 97 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	Other			Conference Proceedings
126	Ministry of Civil Defence and Emergency Management (MCDEM)	2008	Exercise Ruaumoko '08 Final Exercise Report	AKL	Exercise Ruaumoko was the second of two national disaster exercises directed by Cabinet. Exercise Ruaumoko commenced in November 2007 and culminated with an operational phase in March 2008. The exercise was led by the Department of the Prime Minister and Cabinet, the Ministry of Civil Defence & Emergency Management, and the Auckland Civil Defence Emergency	MCDEM website	Report

					Management (CDEM) Group. This report summarises the outcomes and learnings of the exercise.		
127	Ministry of Social Development	2008	Exercise Ruaumoko: Volcanic Eruption Guidelines for the welfare cluster. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Unpublished
128	Molloy, C.M.; Shane, P.	2007	Volcanic ash fall frequencies and hazards based on new Auckland maar sediment records.p. 103 In: Mortimer, N.; Wallace, L.M. (eds) Geological Society of New Zealand & New Zealand Geophysical Society Joint Annual Conference : launching International Year of Planet Earth, 26-29 November 2007, Tauranga : programme and abstracts. Lower Hutt?: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 123A	AKL			Conference Proceedings
129	Murdoch, G.	2001	Human historical and cultural associations with Auckland's volcanic field.p. 104 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	AKL			Conference Proceedings
130	Newnham, R.M.; Lowe, D.J.; Alloway, B.V.	1999	Volcanic hazards in Auckland, New Zealand : a preliminary assessment of the threat posed by central North Island silicic volcanism based on the Quaternary tephrostratigraphic record.p. 27-45 In: Firth, C.R. (ed.); McGuire, W.J. (ed.) Volcanoes in the Quaternary. London: Geological Society. Geological Society special publication 161	AKL	The City of Auckland, built on an active basaltic volcanic field active, faces an additional volcanic threat: that from several large and productive rhyolitic and andesitic eruptive centres of the central North Island. Non-basaltic tephra fallout layers originating from these distal eruptive centres are numerous and widespread in the Auckland region. This paper reviews the Quaternary records of distal volcanism affecting Auckland and outlines current investigations into the assessment of environmental impacts of past eruptions. Our preliminary results indicate that the potential threat to Auckland from the distal volcanic sources has been underestimated and that further research into the impacts of Quaternary volcanism of Auckland's environment and infrastructure is essential.		Journal
131	Nichol, R.	1986	"I think I'll put some mountains ... here": volcanic risk in Auckland.Tane, 31: 133-138	AKL	The question of the timing and location of the next eruption in the Auckland area has received a good deal of attention in the last few years. The Auckland field has seen at least 50 eruptions in the last 60,000 years and this activity may well persist for anohter 60,000 years		Journal
132	Park, B.	2007	Exercise Ruaumoko: Exercise Ruaumoko Potential Water Network Impact. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Report
133	Parkes, B	2007	Exercise Ruaumoko: Auckland Metro Potential Health Service Impacts. In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council, Health Sector Workshop 29 Nov 2007.	AKL		ARC	Unpublished
134	Paton, D.,	2007	Measuring and monitoring resilience in Auckland.Lower Hutt: GNS Science. GNS Science report 2007/18. 79 p.	AKL	Recognition that some people and groups adapt better than others to the loss and destruction associated with disaster has stimulated a need to develop this resilient capability. To do so, emergency planners must be able to identify the individual and community characteristics that predict resilience. The goal of this project was to identify from the large number and diversity of factors that could be implicated, a parsimonious and cost-effective resilience model. A generic model that comprised personal, community and institutional indicators was proposed.		Report

135	Paton, D.,	2008	Modelling societal resilience to pandemic hazards in Auckland, GNS Science Report 2008/13 23 p.	AKL	Because a pandemic will affect people and communities and societal functions, any model of resilience must accommodate the interdependencies between people, communities and societal institutions. Consequently, a generic multi-level model that accommodated the interrelationship between these levels was developed to examine resilience to volcanic hazard consequences. The validity of the model was demonstrated when assessed using the volcanic impact scenario (Paton, 2007). This provided support for the utility of the model to act as a mechanism capable of assisting several aspects of natural hazard planning.		Report
136	Paton, D., Johnston, D., Gough, J., Dowrick, D., Daly, M., Baddon, L., Batistich, T., Wood, I.,	1999	Auckland Volcanic Risk Project: Report 1. Auckland Regional Council (New Zealand), Technical Publication 126.	AKL	Research was initiated in Auckland, NZ in 1995 in order to provide a bsisi for developing a framework for the comprehensive mangaement of a wide range of risks associated with volcanic hazards. It consisted of two phases, the first looking at qualitative scenario modelling of the impacts on infrastructure, population and the environment and the second on quantitative GIS risk assessment.	ARC	Report
137	Paton, D., Johnston, D.M., Gough, J., Dowrick, D., Manville, V.,Daly, M., Batistich, T., Baddon, L.,	1999	Auckland volcanic risk project: stage 2. Auckland Regional Council, Auckland. 99 pp.	AKL	Research was initiated in Auckland, NZ in 1995 in order to provide a bsisi for developing a framework for the comprehensive mangaement of a wide range of risks associated with volcanic hazards. It consisted of two phases, the first looking at qualitative scenario modelling of the impacts on infrastructure, population and the environment and the second on quantitative GIS risk assessment.		Report
138	Paton, D.; Daly, M.; Parkes, B.; Myburgh, D.	2006	Measuring community resilience in Auckland, New Zealand.p. 137 In: Fourth Conference, Cities on Volcanoes, IAVCEI, Quito-Ecuador 23 - 27 January 2006, Abstracts volume. Quito, Ecuador: Instituto Geofisico de la Escuela Politecnica Nacional.		Developing a capacity to adapt to the extrelemly disruptive impact of natural hazards on peoples live is central to emergency management. This paper discusses the development of a generic model comprising personal, community and institutional indicators. A survey has been undertaken using these measures which provides a snapshot of Auckland's resilience at a point in time.		Conference Proceedings
139	Paton, D.; Daly, M.; Williams, S.	2006	Measuring community resilience.p. 47-48 In: Conference proceedings : 7th New Zealand Natural Hazards Management Conference, Christchurch, 23-24 August 2006. Lower Hutt: GNS Science. GNS Science miscellaneous series 8		Developing a capacity to adapt to the extrelemly disruptive impact of natural hazards on peoples live is central to emergency management. After defining adaptive capacity this paper discusses the development of a generic model comprising personal, community and institutional indicators.		Conference Proceedings
140	Paton, D.; Johnston, D.M.	2004	Volcanic hazards : understanding risk and promoting community preparedness.p. 36 In: McPhie, J.; McGoldrick, P. (eds) Dynamic earth : past, present and future : 17th Australian Geological Convention, 8-13 February 2004, Hobart, Tasmania, Australia. Sydney: Geological Society of Australia. Abstracts / Geological Society of Australia 73	Other			Conference Proceedings
141	Paton, D.; Johnston, D.M.; Bebbington, M.S.; Lai, C.-D.; Houghton, B.F.	2001	Direct and vicarious experience of volcanic hazards : implications for risk perception and adjustment adoption.Australian journal of emergency management, 16(1): 58-63	Other			Journal
142	Paton, D.; Johnston, D.M.; Houghton, B.F.	1998a	Organisational response to a volcanic eruption in New Zealand : dynamics of integrated emergency management.p. 113 In: Johnston, D.M.; Kingsbury, P.A. Proceedings of the Natural Hazards Management Workshop : Christchurch, 4-5 November 1998. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 45	Other			Conference Proceedings
143	Paton, D.; Johnston, D.M.; Houghton, B.F.	1998a	Organisational response to a volcanic eruption in New Zealand : organisational dynamics of integrated emergency management.p. 111 In: Cities on volcanoes : international meeting, Rome and Naples (Italy), June 28 to July 4, 1998 : program and abstracts. [S.l.]: [s.n.].	Other			Conference Proceedings
144	Paton, D.; Johnston, D.M.; Houghton, B.F.	1998b	Organisational response to a volcanic eruption.Disaster prevention and management, 7(1): 5-13	Other			Journal

145	Paton, D.; Johnston, D.M.; Houghton, B.F.	2001	Organisational response to a volcanic eruption : observations and implications for integrated emergency management.p. 120 In: Stewart, C. (ed.) Cities on Volcanoes 2, Auckland, New Zealand, 12th - 16th February 2001 : abstracts. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 49	Other			Conference Proceedings
146	Paton, D.; Johnston, D.M.; Houghton, B.F.; Smith, L.M.	1998	Managing the effects of a volcanic eruption : psychological perspectives on integrated emergency management.Journal of the American Society of Professional Emergency Planners, 5: 59-69	Other			Journal
147	Paton, D.; Millar, M.; Johnston, D.M.	2001	Community resilience to volcanic hazard consequences.Natural hazards, 24: 157-169		This paper describes the role of self-efficacy, problem-focused coping, sense of community and age in predicting resilience to the social consequences of volcanic hazard activity following the 1995 and 1996 eruptions at Ruapehu volcano, New Zealand. The nature of the relationships observed suggest that resilience should be conceptualised and managed in a contingent rather than a prescriptive manner. The implications of the findings for community risk perception, predicting resilience within an all-hazards management framework, community hazard reduction planning, resilience assessment and evaluation, and risk communication is discussed.		Journal
148	Paton, D.; Smith, L.; Daly, M.; Johnston, D.M.	2008	Risk perception and volcanic hazard mitigation : individual and social perspectives.Journal of volcanology and geothermal research, 172(3/4): 179-188; doi: 10.1016/j.jvolgeores.2007.12.026	AKL	This paper discusses how people's interpretation of their experience of volcanic hazards and public volcanic hazard education programs influences their risk perception and whether or not they adopt measures that can mitigate their risk. Drawing on four studies of volcanic risk perception and preparedness, the paper first examines why experiencing volcanic hazards need not necessarily motivate people to prepare for future volcanic crises.Next, the findings of a study evaluating the effectiveness of a public volcanic hazard education program introduce the important role that social interaction amongst community members plays in risk management. Building on the conclusions of these studies, a model that depicts preparing as a social process is developed and tested.		Journal
149	Paton, D.; Smith, L.; Johnston, D.M.	2000	Volcanic hazards : risk perceptions and preparedness.New Zealand journal of psychology, 29 (2): 84-88	Other			Journal
150	Peters, V.; Johnston, D.M.; Wilson, C.; Leonard, G.S.; Cole, J.; Paton, D.	2006	Volcanic risk management and evacuation planning for Auckland Volcanic Field, New Zealand.p. 137-138 In: Fourth Conference, Cities on Volcanoes, IAVCEI, Quito-Ecuador 23 - 27 January 2006, Abstracts volume. Quito, Ecuador: Instituto Geofisico de la Escuela Politecnica Nacional.	AKL	Research was initiated in Auckland, NZ in 1995 in order to provide a bsisi for developing a framework for the comprehensive mangaement of a wide range of risks associated with volcanic hazards. It consisted of two phases, the first looking at qualitative scenario modelling of the impacts on infrastructure, population and the environment and the second on quantitative GIS risk assessment.		Conference Proceedings
151	Pomonis, A.,	1997	Soufriere Hills volcanic eruption: a risk assessment to buildings from volcanic block impacts and tephra fall loading. Cambridge Architectural Research Ltd Internal Report, 21 pp.	Other			Report
152	Pomonis, A., Spence, R., Baxter, P.,	1995	Risk assessment of building structures for an eruption in Furnas Volcano, Sa˜o Miguel, The Ac¸ores. Part of the UK contribution to the Furnas European Laboratory Volcano Project. Center of Volcanology, University of the Azores. 56 pp.	Other			Journal
153	Reserve Bank of New Zealand	2008	Exercise Ruaumoko 2008: Auckland Volcanic Field Eruption – FPS Simulation	AKL	This briefing report provides you with details of the Auckland volcanic field eruption simulation run in FPS as part of exercise Ruaumoko 2008. The FPS simulation is designed to build on the analysis already completed by Market Economics and offer an insight into how a volcanic eruption in Auckland might impact the New Zealand economy as a whole.		Unpublished
154	Ronan, K.R.; Johnston, D.J.	1996	The impact of volcanic eruptions on childhood emotional functioning.4 p. In: Pan Pacific Hazards '96 : July 29 to August 2 1996, Vancouver, B.C. Canada. Vancouver: [Disaster Preparedness Resource Center].	Other			Conference Proceedings

155	Ronan, K.R.; Johnston, D.M.	1997	Children's risk perceptions and preparedness : a hazards education survey.Auckland, NZ: Auckland City Council. . 50 p.	AKL	This paper outlines a study that investigated the risk perceptions and preparedness in a sample of 440 Auckland area school children using a risk perceptions and preparedness-based survey		Report
156	Ronan, K.R.; Johnston, D.M.	1999	Behaviourally-based interventions for children following volcanic eruptions : an evaluation of effectiveness.Disaster prevention and management, 8(3): 169-176	Other			Journal
157	Ronan, K.R.; Johnston, D.M.; Fairlie, R.; McCarthy, T.; Daly, M.	1998	Children's understanding of hazards in the Auckland Volcanic Field, New Zealand.p. 117 In: Cities on volcanoes : international meeting, Rome and Naples (Italy), June 28 to July 4, 1998 : program and abstracts. [S.l.]: [s.n.].	AKL			Conference Proceedings
158	Ronan, K.R.; Paton, D.; Johnston, D.M.; Houghton, B.F.	2000	Managing societal uncertainty in volcanic hazards : a multidisciplinary approach.Disaster prevention and management, 9(5): 33-348	Other			Journal
159	Salmond C, Crampton P, Atkinson J.	2007	NZDep2006 Index of Deprivation. Wellington: Department of Public Health, University of Otago Wellington	Other			Report
160	Sanders, A.	2006	Volcanic Activity: Health risks and implications for emergency management in New Zealand. Auckland Case Study. Department of Public Health Summer Studentship. University of Otago.	AKL			Unpublished
161	Sanders, A.; Johnston, D.M.; McIntyre, M.; Horwell, C.; Williams, S.	2006	Providing health information to the public during a volcanic crisis in New Zealand.p. 165 In: Fourth Conference, Cities on Volcanoes, IAVCEI, Quito-Ecuador 23 - 27 January 2006, Abstracts volume. Quito, Ecuador: Instituto Geofisico de la Escuela Politecnica Nacional.	Other	This paper presents the results of a project initiated to contribute to the development of "an analysis and information protocol for volcanic" ash and to review NZ's emergency management arrangements for health advice during a volcanic event.		Conference Proceedings
162	Shane, P.	2007	Comment on "Probabilistic tephra fall simulation for the Auckland region, New Zealand by Magill et al. (2006)".Journal of volcanology and geothermal research, 159(4): 421-422; doi:10.1016/j.jvolgeores.2006.08.010	AKL			Journal
163	Shearer, C	2008	Exercise Ruaumoko: Report of the Economic Workgroup: Assessment of the Impacts of a Volcanic Eruption on the Auckland Economy . In Civil Defence Emergency Management: Exercise Ruaumoko. Auckland : Auckland Regional Council.	AKL		ARC	Report
164	Smith, I.; Allen, S.	1993	Volcanic Hazards at the Auckland Volcanic Field. In: Ministry of Civil Defence and Emegency Management, Volcanic Hazards Information Series No. 5.	AKL			Serial
165	Smith, I.; Alloway, B.V.; Johnston, D.M.; Daly, M.	1998	The nature of the Auckland Volcanic Field.p. 126 In: Cities on volcanoes : international meeting, Rome and Naples (Italy), June 28 to July 4, 1998 : program and abstracts. [S.l.]: [s.n.].	AKL			Conference Proceedings
166	Spence, J.S., Pomonis, A., Baxter, P.J., Cobrun, A.W., White, M., Dayrit, M. And Field Epidemiology Training Program Team	1996	Building damage caused by Mount Pinatubo eruption of June 15, 1991. In: Newhall, C.G. And Punongbayan, R.S., (eds.) 1996, Fire and Mud: eruptions and lahars of Mount Pinatubo, Philippines. Philippine Institute of Volcanology and Seismology and University of Washington Press, p. 1055-1061.	Other			Journal
167	Stewart, C.; Johnston, D.M.; Leonard, G.S.; Thordarrson, T.; Cronin, S.	2006	Modelling contamination of water supplies by volcanic ash fall in Auckland, New Zealand.p. 28 In: Fourth Conference, Cities on Volcanoes, IAVCEI, Quito-Ecuador 23 - 27 January 2006, Abstracts volume. Quito, Ecuador: Instituto Geofisico de la Escuela Politecnica Nacional.	AKL	This study considered for the first time the impacts of a volcanic eruption on Aucklands water supplies. Reported impacts from historic eruptions were reviewed both domestic and international. A model was developed to predict chemical contamination of water suppliese by volcanic ash.		Conference Proceedings
168	Stewart, C.; Johnston, D.M.; Leonard, G.S.; Thordarsson, T.; Cronin, S.	2005	Modelling contamination of water supplies by volcanic ashfall in Auckland, New Zealand.p. 133 In: Abstracts : SETAC Europe 15th annual meeting, 22-26 May 2005. Brussels: Society of Environmental Toxicology and Chemistry.	AKL			Conference Proceedings
169	Volcanic Impacts Study Group (VISG)	2004	VISG Annual Breakfast Seminar 2004.	Other	Towards achieving community sustainability in the face of natural hazards: - integrated lahar warning system design on Mt Ruapehu, New Zealand	AELG website	Conference Proceedings
170	Volcanic Impacts Study Group (VISG)	2005	VISG Annual Breakfast Seminar 2005.	Other	Proceedings of the 2005 Annual Breakfast Seminar. Presentations included: - Occupational Health and Safety in a Volcanic Ash Environment. - Community Preparedness for Volcanic Hazards an emergency manager's perspective on community response to Volcanic threat in Ecuador. 3.3 Health hazards of Volcanic Gases – What we know from studies of humans. - Providing health information to the public during a volcanic crisis in New Zealand - Assessing and improving the effectiveness of staff training and	AELG website	Conference Proceedings

					warning system response at Whakapapa and Turoa ski fields, Mt. Ruapehu - Volcanic Ash and Aviation: Mitigation and Response		
171	Volcanic Impacts Study Group (VISG)	2006	VISG Annual Breakfast Seminar 2006.	Other	Proceedings of the 2006 Annual Breakfast Seminar. Presentations included: - An Auckland volcanic eruption and Transit New Zealand's preparedness - Impacts of volcanic ash on Auckland's water supply and wastewater systems -Discussion: Utility needs and possible future research directions	AELG website	Conference Proceedings
172	Volcanic Impacts Study Group (VISG)	2008	VISG Annual Breakfast Seminar 2008.	Other	Proceedings of the 2008 Annual Breakfast Seminar. Presentations included: - VISG activities - GeoNet news: status update on the Auckland monitoring network (Brad Scott) - Exercise Ruaumoko summary and key EM findings, social science surveys and work performed. - Exercise Ruaumoko Archive - what's available and how to access it - Overview of the DEVORA Programme - AELG/19 ash impacts workshop	AELG website	Conference Proceedings
173	von Veh, M.W.	2006	Vent alignments in the Auckland Volcanic Field and their significance for volcanic risk assessment.p. 91-92 In: Stewart, B.; Wallace, C.; Lecointre, J.; Reyners, M.E. (eds) Geological Society of New Zealand, New Zealand Geophysical Society Joint Conference : geosciences '06 - our planet, our future : Massey University, Palmerston North, 4-7 December 2006 : programme and abstracts. Lower Hutt: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 122A	AKL			Conference Proceedings
174	Williams, S.; Johnston, D.M.; Stuart-Black, S.	2006	Planning for welfare issues in a large-scale long-term evacuation in response to a volcanic threat - the challenges to New Zealand.p. 156 In: Fourth Conference, Cities on Volcanoes, IAVCEI, Quito-Ecuador 23 - 27 January 2006, Abstracts volume. Quito, Ecuador: Instituto Geofisico de la Escuela Politecnica Nacional.	AKL	The national welfare recovery group performed a research project to ascertain using modelling and situation information provided from background research, the kind of effects tht would be produced from their worst case scenario - the reawakening of the Okaitana volcanic field.		Conference Proceedings
175	Wilson CJN, Stirling MW	2002	Towards a probabilistic volcano hazard analysis model for New Zealand. In: Johnston DM, Tilyard D (eds) Proc 5th Natural Hazards Management Conf. Te Papa, Wellington, 14–15 August 2002. Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand, pp 73–81	Other			Conference Proceedings