An aerial photograph showing a road construction site. A red excavator is working on a dirt embankment next to a road. A road sign with a red arrow is visible. The surrounding area is green and hilly.

The Potential Impacts of Earthquakes, Floods and Volcanoes in the Waikato Region

Environment Waikato Technical Report 1998/02

The Potential Impacts of Earthquakes, Floods and Volcanoes in the Waikato Region

August 1998



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Cover photograph

State Highway 3, Mahoenui

Landslide triggered by heavy rainfall 9/10 July 1998

Overview

This report examines the major natural hazards impacting on the Waikato Region and reassesses the priorities for the natural hazards programme. A targeted approach is recommended for each major hazard.

Major Natural Hazards

Volcanic

The Waikato Region is the most hazardous in New Zealand from volcanic activity.

“Three active or potentially active volcanic centres lie within the Region at Tongariro, Taupo and Maroa. Five other volcanic centres (Auckland, Mayor Island, White Island, Okataina and Taranaki) lie outside the Region but large eruptions in any of these centres could also create a hazard in the Waikato.”

Table 1. Impact of a Tongariro / White Island type eruption – the most likely 1 in 100 risk scenario.

Attribute	Scale of Impact	% of Region Impacted
Area of land	10,485 square kilometres	42%
Number of people	76 590	21%
Capital value affected	\$9 875M	25%

An analysis of volcanic events over the last 150 years shows that the estimated average annual damage figure from Ruapehu (Tongariro volcanic centre) alone is \$4.75M based on actual eruptions.

The natural hazard programme has six priority products in progress for completion between July 1998 and March 1999.

Hazard Identification

- Loading of IGNS volcanic hazard maps in digital format into Environment Waikato Geographical Information System.
- Digitising of Lahar Risk Map for Ruapehu and entering as a GIS sub-layer of the IGNS volcanic hazard maps.
- Phase II (detailed investigation) of the Ruapehu “Crater Lake Study” due June 1998 - (DOC publication). EW will also be involved (as a stakeholder) in Phase III – examination of mitigation options in the 1998/99 financial year.

Risk Analysis and Mitigation

- Regional Volcanic Risk Mitigation Plan

Emergency Management

- Regional Volcanic Contingency Plan – subset of National Volcanic Contingency Plan

Environmental Information

- State of Environment Report – Natural Hazards Sub-Chapter – Volcanic Activity

Comment

The above products will enable Environment Waikato to: publish information and raise public awareness about the volcanic hazard; inform people of the precautionary steps they can take to protect themselves during an eruption; and assist asset and emergency managers with risk management.

The information and products will be most useful for those district councils that lie within the Taupo Volcanic Zone (Taupo, Rotorua, and South Waikato) and the Regional Lifeline Study.

Earthquake

The Environment Waikato region contains the Taupo Volcanic Zone, seismically one of the most active parts of New Zealand, and the Kerepehi fault. The Region is also subjected to strong ground shaking from earthquake sources outside the Region.

Seismic activity in the Region is concentrated in the Taupo Volcanic Zone. There have been seven significant historical earthquakes within the region, ranging in magnitude from M5.0 to M5.9. (Richter Scale). Estimated return periods (frequency) for shaking intensities of ≥ 7 (Modified Mercalli scale) range from 32 to 180 years at different urban centres around the Region. Exhibit 1.

Table 2. Impacts from a magnitude 6.3 earthquake centred on the Kerepehi fault based on a likely 100-year scenario.

Attribute	Impact	% Of Region Impacted
Area of land	5 350 square kilometres	21%
Number of people	147,000	41%
Capital value affected	\$14 397M	37%

An analysis of potential damage from earthquake activity in the region based on annual Earthquake Commission figures and transposing an Edgcumbe type event onto the Hauraki Plains gave an estimated average annual damage figure of \$9.90M.

At this point it is worth noting the ratio of earthquake damage to volcanic damage is **\$9.9M / \$4.75M = 2.08**

This ratio figure of around two is similar to the exposure assessed for the Earthquake Commission. It is believed that the chances of a volcanic eruption are much less than those for a major earthquake. Marsh and McLennan estimated the EQC loss by an eruption at significantly less than that for an earthquake (less than \$3 billion compared with over \$6 billion). However volcanic events last longer and economic recovery might also take significantly longer. Hence the potential scale of the economic effect is much greater.

However the ratio gives some confidence that the damage assessment for the two main “geohazards” are in the right order of magnitude.

The following two prioritised products are in progress and due to be completed between February 1999 and March 2000.

Hazard Identification

- Landslide Hazard Assessment

Risk Analysis and Mitigation

- Waikato Region Lifeline Study – Information gathering milestone June 1998. Mapping milestone December 1998. Vulnerability Analysis milestone June 1999. Draft lifelines report December 1999. Final product published March 2000.

Comment

The Landslide Hazard Assessment and Waikato Region Lifeline Study are sub-sets of the Earthquake Hazard Analysis. The Earthquake Commission has agreed to financially support the lifeline study with \$12,000 in 1998 and \$12,000 in 1999.

The above products will enable Environment Waikato to publish information and raise public awareness about the risks from earthquake and related hazards; especially the risks of business interruption. Individual businesses need to be aware of the precautionary steps that can be taken to protect themselves during natural hazard events. The information will also assist asset and emergency managers with risk management.

The information and products will be most useful for those district councils that have the highest ranked ground-shaking hazard in their Districts (Franklin, Waikato, Hauraki and Matamata/Piako) and the Regional Lifeline Study.

Flooding

The flooding hazard includes river flooding, coastal flooding and cyclones, which can impact both river and coastal flooding.

For this hazard due recognition also needs to be given that, the river-flooding hazard has been substantially modified by the construction of major flood alleviation schemes. The justification for those schemes relied, heavily, on the annual value of saved flood damages. The Capital investment in flood alleviation schemes represents an annual investment of about \$38M in economic terms. This is made up of two main elements, productivity improvement and saved annual damage costs. Saved annual damage costs are equivalent to \$12.6M.

Ongoing expenditure on asset management and maintenance now running (from 1998/99) at over \$8M per annum including catchment and land drainage schemes will minimise the risk of structural failure and over-topping.

Table 3. Impacts of flooding based on a likely 100-year scenario

Attribute	Impact	% Of Region Impacted
Area of land	11,400 square kilometres	46%
Number of people	79,800	22%
Capital value affected	\$12 982M	34%

If all types of flooding events that might occur in a 100-year period are considered the estimated average annual damage figure is \$4.75. This damage figure may increase due to overtopping of schemes especially those parts of schemes built to less than a 1 in 100 year standard. The potential damage from overtopping is assessed at \$1.9M which would have the effect of reducing saved damages from \$12.6M to \$10.7M.

The following six prioritised products are in progress and due to be completed between June 1998 and November 1998.

Hazard Identification

- Regional Coastal Flood Hazard Report
- Regional Coastal Erosion Hazard Report

Risk Analysis and Mitigation

- Plan - Lower Tongariro River Management Plan
- Coastal Flooding Risk Mitigation Strategy – Draft due November 1998
- Coastal Erosion Risk Mitigation Strategy – Draft July 1997. Final Product due September 1998.

Emergency Management

- Flood Warning Manual

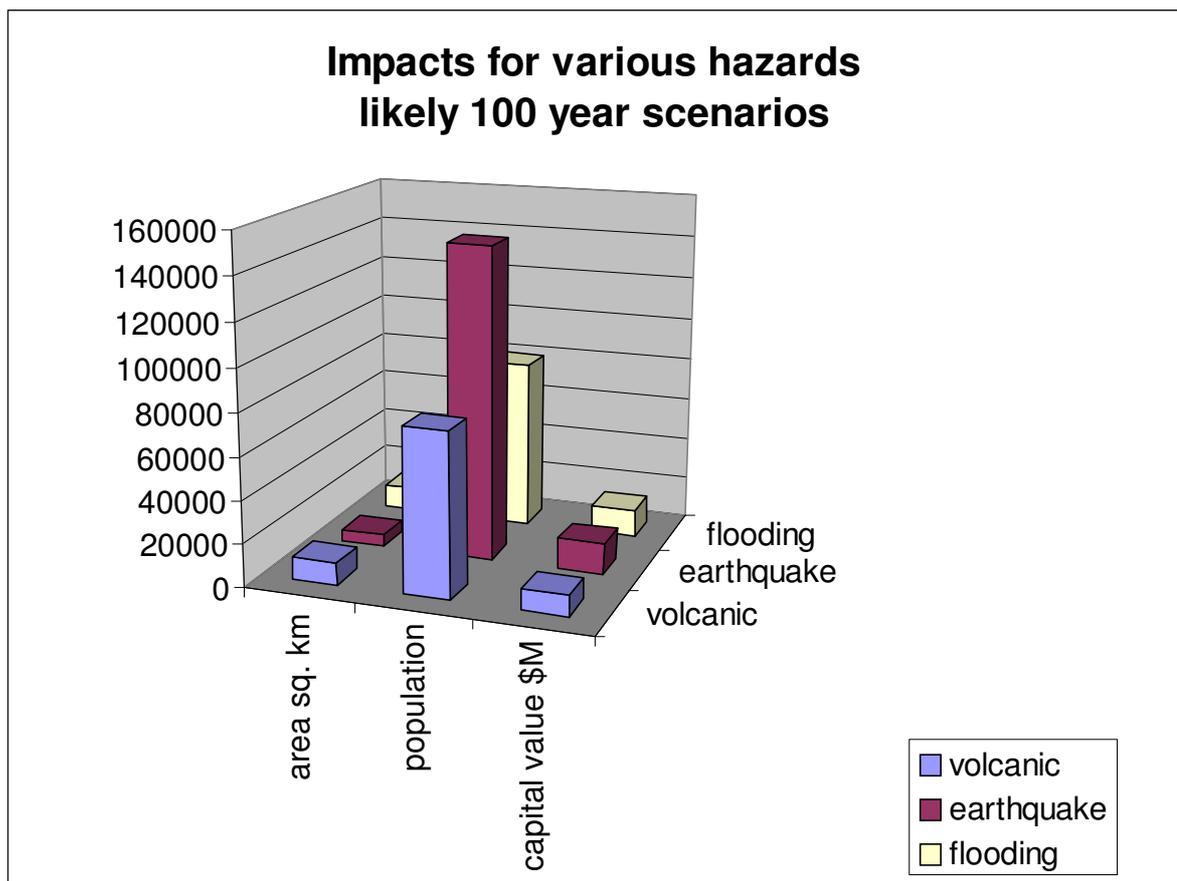
The following three products are proposed in priority order

Hazard Identification

- Reports - Assessment of flood hazard at 1:50 000 scale district by district - three year programme – two districts per annum 1998 to 2001
- Maps – Flood Hazard Map at 1:50 000 scale into Environment Waikato Geographical Information System - three year programme – two districts per annum 1998 to 2001
- Maps – Coastal Erosion and Flooding at appropriate scales into Environment Waikato Geographical Information System 1998/99.

Products will be most useful to district councils with major floodplains – Waikato, Franklin, Matamata/Piako, Hauraki and coastal hazards - Thames Coromandel and the Regional Lifeline Study.

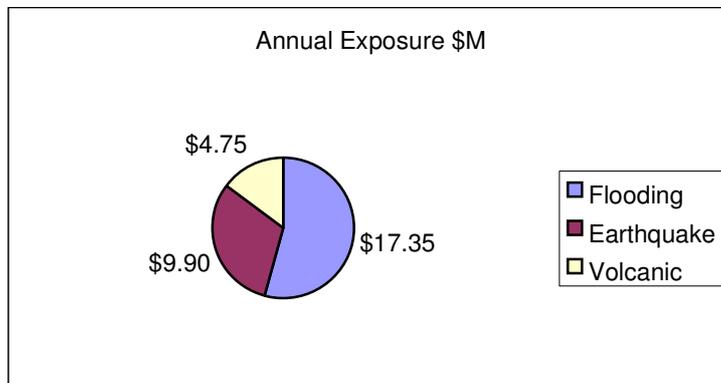
Summary - Total exposure of the Waikato Region to major natural hazards



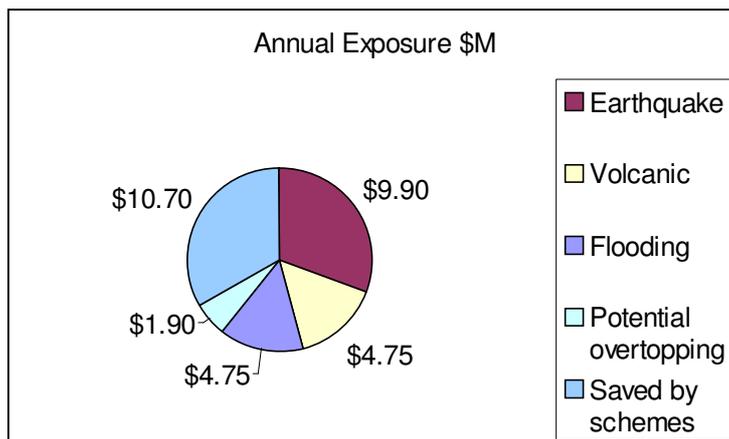
natural hazard	area of land sq. km	Number of people	capital value affected \$M
volcanic	10485	76590	9875
earthquake	5350	147000	14397
flooding	11400	79800	12982

Summary – Total exposure – Annual average damage basis

Assuming no flood schemes in place.



With Flood Schemes in place – Pie Charts read clockwise from 12 o'clock



Impact - Summary and Conclusions

From this analysis it is concluded that the earthquake hazard presents the Region's greatest exposure to natural hazards. This is a similar result to that derived by other agencies (EQC) and the same conclusion reached by the Auckland Regional Council for its region. Given the predominant urban status of Auckland and the predominant rural face of the Waikato the result is significant. After earthquake the greatest exposure of the Region is equally volcanic and flooding. However the flooding figure will increase by a loss of saved damages if over-topping occurs. Other hazards warrant mention but are likely to be at least one order of magnitude lower in impact at a regional level. For comparison purposes the prolonged dry weather prior to June 1998 became a drought hazard and preliminary information from the Ministry of Agriculture suggests a loss of \$30M (at farm gate) for the Waikato Region alone for the recent El Nino event. For the Waikato Region the generation of power from

Huntly was threatened for a short time. Peat fires have been very expensive to extinguish. More relevant regional information will result from our own drought study.

How is Environment Waikato making a difference?

With the **earthquake hazard** the key to making a difference is to get economic activity back to normal as quickly as possible after the event. Environment Waikato will use its products such as the Earthquake Risk Mitigation Plan as a basis for reducing business interruption. The recent Auckland electricity crisis demonstrated how few companies have contingency plans in place to counter the effects of technological or natural hazards. Hence those businesses have a high risk of failure and may not survive a major hazard event. The other product EW will use is the Waikato Region Lifeline Study to mitigate the loss of utility services and ensure quick recovery for the inevitable temporary loss of some services and the downstream (multiplier) effects of loss of service.

In the Bay of Plenty Edgecumbe event business interruption was about half the total damage costs. However the costs of business interruption have been growing exponentially since 1987 and will be a major factor in the cost of future events.

With the **volcanic hazard** the key to making a difference is to raise public awareness and give out factual information. This is because the event will go on longer, at least a few months. Research already carried out by IGNS and Massey University shows that a highly aware public that has good factual information is better able to cope with the trauma and disruption of a natural hazard such as a geohazard, which can go on for many months.

Environment Waikato will use its products such as the Volcanic Risk Mitigation Plan and its Civil Defence Regional Volcanic Contingency Plan to get information into the public arena.

With **flooding** the key activity for making a difference is good land use control to avoid and mitigate the flood hazard in vulnerable areas. This includes floodplains protected by river schemes. From research carried out in 1986 and published under the heading of “Creating Flood Disasters” it was evident that the reason for escalating flood damage despite investment in flood protection schemes was a direct result of intensifying development in “protected areas”. This was demonstrated during cyclone Bola when horticultural trees and vines on floodplains behind stopbanks were buried in silt.

In partnership with district councils EW will use its products of GIS flood mapping and Flood Risk Mitigation Plan to control land use. District councils in particular will need to be very much more circumspect in preventing development in hazardous areas. Recent case law puts the onus for unwise development in hazardous areas squarely with local government and its technical advisors. Floodplains in particular are subject to a double risk as explained below. Similar land use control strategies will be required in coastal areas subject to flooding and erosion risks.

Multiple Hazards

From the hazard identification work completed to date a number of geographic areas are subject to more than one natural hazard. An example is the Hauraki Plains, which has a major hazard of river flooding plus coastal flooding in areas adjacent to the Firth of Thames. The Plains also have the highest ranked ground-shaking hazard from earthquakes. Hence the use of the Resource Management Act to control land use and new development here becomes absolutely critical. A second example is the Lower Tongariro River, which is subject to both river flooding and extreme risk from the impact of lahars from Mt. Ruapehu. A hazard management plan is in preparation for the Lower Tongariro.

Other Products Making a Difference

Another EW product is its flood warning service. Originally purely for flood warning the service is now an important node in a broad regional warning service for other hazards such as cyclones, Tsunamis and geo-hazards through IGNS. Exhibit 3.

Complimentary Activities

A number of other activities both within an outside the natural hazard programme for example the **Regional Policy Statement Variation** are being monitored and influenced to ensure that products developed by the programme are maximised for effectiveness and making a difference to exposure from natural hazards.

Other Agencies

To maximise the difference Environment Waikato can make to the impact of natural hazards, the programme is integrated with the work of other agencies. For example IGNS is improving its monitoring and warning systems for geohazards and the Earthquake Society has published industry guidelines for the post earthquake inspection of buildings. Further details of the future programmes of IGNS are at Exhibit 2.

Appropriate letters of support have been forwarded to IGNS for its PGSF bid on the understanding that the programme recognises the work already undertaken in this field by Environment Waikato.

Natural Hazards programme staff are also involved with the MoRST foresight project which is looking at revised priorities for the natural hazards sector for PGSF to be implemented from 1 July 2000.

Emergency Management Groups and Lifeline Co-ordination Centres

Given the implementation stage of the review of Emergency Services it is timely for EW to initiate discussion with Territorial Local Authorities for the purpose of establishing Emergency Management Group(s) in the Waikato Region.

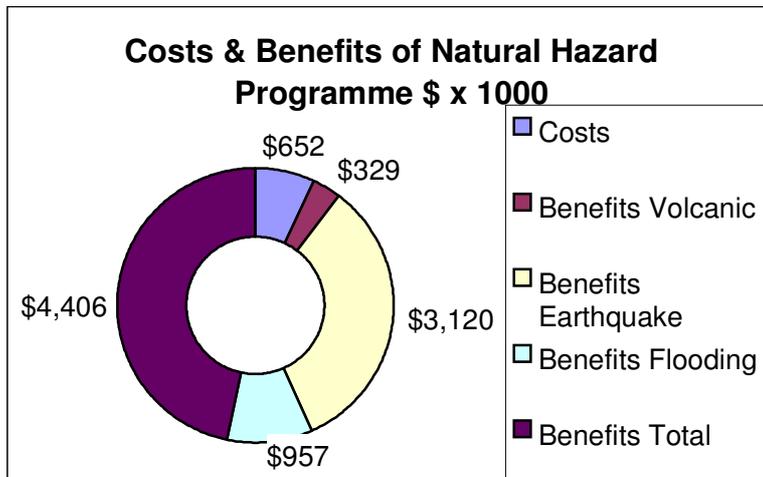
EW has generally supported the principles of the review because the objectives of the review are consistent with the Strategic Plan, especially in drawing the avoidance and mitigation responsibilities of the Resource Management Act closer to the preparation and readiness parts of the Civil Defence Act. The raising of public awareness and providing factual information about natural hazards through the natural hazard and environmental education programmes is beginning to make a difference. People are more aware and hence are becoming both better prepared and better able to cope.

The Council's progress with the Regional Information Bank concept and the use of Geographical Information Systems and its general role of information broker places the Council in an advantageous position as a provider of information under emergency conditions. The technology upgrade of the flood warning system and the accessing of information directly by the public are an example of a major operational improvement towards getting information into the public arena.

Consistent with the Partnership Project, there are now opportunities to agree on a new approach to emergency management with the district councils, but recognising we have yet to fully define the "all hazards approach" advocated in the review.

As part of emergency management development the importance of lifelines (roads, rail, utilities, hospitals, water reservoirs etc.) has been highlighted. A recent concept developed in Wellington is a Lifelines Co-ordination Centre. This has been defined, as a physical location specifically developed to enable the post-disaster co-ordination of lifelines. The model developed for Wellington has value as a template for other centres in New Zealand. For a large rural region like the Waikato the reinstatement of lifelines after a major natural hazard event will be critical especially as they will cross normal administrative boundaries. The Lifelines Centre would only become operational under conditions of major disruption. Current interface mechanisms for utility and emergency management agencies are not sufficiently focused for regional scale events involving numerous utility organisations. Environment Waikato is seen as having the capability to be a Lifelines Co-ordination Centre for regional scale events. This can be addressed as part of the final reporting for the Lifeline study.

Costs and Benefits



The benefits of the natural hazards programme will exceed costs provided annual average damage costs are reduced by 3%, a worst case scenario. A best case scenario reduces damage by 38%. A likely case scenario shown above is for average annual damage costs to be reduced by 20%.

Programme – Summary and Conclusions

The initial broad objectives of the Natural Hazard Programme as set out in the first Strategic Plan have been achieved but some review and refinement is now required. The timing for this is right, with the review of the Strategic Plan and matters such as the Emergency Services Review now complete.

It is considered particularly important to push ahead quickly with getting more information into the public arena, especially publication of hazard information, mitigation plans and GIS mapping. This is achievable as thirteen major products are due for completion in the next 10 months. A major weakness identified is the poor recording of post event reconnaissance and damage assessment.

A major challenge will be balancing the allocation of resources across the main four elements of the programme shown below. Some flexibility will be critical depending on which events actually occur.

Recommendations and Priorities

- Hazard identification
 - Publication of technical reports
 - Refinement and mapping including GIS layers
 - Information exchange and integration with other agencies especially District Councils
- Risk analysis and mitigation
 - Writing and publishing mitigation plans
 - Lifeline study
 - Ongoing advocacy and environmental education, i.e. reducing risk of business interruption
- Warning systems
 - Operation of flood warning service
 - Support for the development of other warning systems
 - Integration with other agencies
- Emergency management
 - Active participation in EMG development and operation
 - Post event reconnaissance and damage assessment

The priorities have been set out in a logical sequence over the next 30 months consistent with the draft Strategic and draft 1998/99 Annual Plans and this report. It is recommended that EW does not initiate any new major hazard studies at this stage but rather focuses on getting information already gathered and researched into the public arena. This is consistent with the RMA, which is very empowering of individuals to participate effectively under the Act. It is also consistent with current thinking about emergency management and response to target individual responsibility. The recent problems with electricity supply in Auckland have highlighted the importance of business continuance planning. This had already been identified as a high priority in the Earthquake Risk Mitigation Plan. The lifelines study is seen as a vital project that will help to bring closure more quickly to some elements of the programme and identify priority areas for further investigation and analysis.

Exhibit 1

The table shows *calculated* average return periods for strong to very strong intensity shaking (modified Mercalli (MM) scale) at main centres within districts of the Waikato region. *Bracketed values record observed* return periods for the last 100 years.

Location	Average Return Period in Years			
	MM > or = 5	MM > or = 6	MM > or = 7	MM > or = 8
Paeroa	4 (33)	14 (>100)	55 (>100)	240 (>100)
Thames	45 (25)	18 (>100)	73 (>100)	320 (>100)
Hamilton	5 (20)	23 (100)	90 (>100)	430 (>100)
Pukekohe	11 (33)	45 (100)	180 (>100)	1000 (>1000)
Ngaruawahia	6 (33)	27 (100)	110 (>100)	530 (>100)
Te Awamutu	5 (17)	22 (>100)	90 (>100)	420 (>100)
Otorohanga	5 (20)	25 (>100)	100 (>100)	470 (>100)
Te Aroha	4 (33)	15 (100)	60 (>100)	270 (>100)
Tokoroa	2 (25)	8 (>100)	32 (>100)	130 (>100)
Taupo	2 (8)	5 (100)	45 (>100)	210 (>100)
Te Kuiti	5 (25)	24 (>100)	96 (>100)	450 (>100)

In the above table *calculated* values are lower than *observed* (bracketed) values up to intensity 7. The more conservative observed values have been used to calculate average annual damage figures.

Exhibit 2

In reviewing the position of Environment Waikato in natural hazard management it is instructive to review what other organisations are doing. As an example the Institute of Geological and Nuclear Sciences (IGNS) is moving from pure scientific research into social and educational areas. The Institute is also developing more effective warning systems for earthquakes, volcanic eruptions and landslides. This involves substantially improving its seismograph network so that all instruments provide real-time measurements. Developments in Geographical Positioning Systems (GPS) with satellite surveying and mathematical modelling will have an impact on earthquake hazard assessment.

The Institute of Geological and Nuclear Sciences has developed a four-stage programme to help local government meet the requirements of the RMA with respect to geohazards. This programme includes:

- Scoping the needs of a particular regional or local authority
- Assessing relevant hazards, such as earthquakes and related effects, volcanoes, landslides and tsunami
- Recommending hazard mitigation measures and emergency preparedness planning through community lifelines work groups and education programming.
- Working with community groups to improve the transfer of knowledge to affected areas

The IGNS has also made application to the Foundation for Research, Science and Technology (FoRST) for Public Good Science Fund (PGSF) assistance for the first two years of a six-year programme on geological hazards. The programme represents a significant realignment between pure science and end product. The focus is a growing partnership with end-users. The programme objective has three themes, shown below, which emphasise elements of society at risk from natural hazards rather than hazard types.

- Hazards and people
- Hazards and management
- Hazards and infrastructure

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Exhibit 3 Environment Waikato involvement in, and ready access to global, regional, national and local warning systems and broad dissemination of warnings

