

Debris flow risk management in practice: A New Zealand case study

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Abstract

In 2005 the settlement of Matatā on Awatarariki fan, Bay of Plenty, North Island, New Zealand was devastated by a $>3 \times 10^5 \text{ m}^3$ debris flow; several dwellings were destroyed and many damaged, but no fatalities occurred. In the 7 years following the event, design options for a debris-flow containment structure in the catchment were developed. Following a formal determination by the Government's building control agency in 2006, building consents were granted for a number of replacement dwellings on the fan. In 2012, the previously chosen containment structure project was cancelled due to effectiveness and cost concerns. Subsequent investigations confirmed there were no viable engineering solutions to manage debris-flow risk from this catchment, and risk analyses have demonstrated that no debris-flow management systems, warning and evacuation systems, or individual dwelling protection mitigation measures, independently or in combination, could deliver a residential environment with tolerable risk-to-life levels. Since 2013, Whakatāne District Council (the Council) has been working towards a non-legislated managed voluntary retreat from the area where the risk to life is greater than about 10^{-4} a^{-1} , which is also the area of boulder deposition in the 2005 event. This has involved many meetings with affected landowners, including legal counsel and experts, but the currently 13-year delay in resolving uncertainty about landowners' futures has generated considerable stress and even hostility. A parallel legislation-based workstream the Council has undertaken to fulfil its statutory responsibilities has exacerbated tension between the Council and some property owners. From a technical perspective, this study emphasises the danger of lay officials and consultants placing too much confidence in immature technologies to reliably modify debris-flow occurrence. From a public management perspective, it highlights the immaturity of New Zealand's natural hazard management policy framework, in particular the significant disconnect between policy intent and policy implementation and its polarising effects on a small provincial community.

Keywords: Debris-flow risk-to-life; risk reduction; national and local government responsibilities; engineered risk reduction; managed voluntary retreat; New Zealand.

1. Introduction

Although New Zealand is exposed to a wide range of natural hazards, use of formal risk management practices for low-frequency, high-consequence natural hazards is still an emerging field. New Zealand is one of 187 signatories to the 2015 Sendai Framework for Disaster Risk Reduction which refocused international policy direction for disaster reduction from disaster management to disaster risk management. In 2017, changes to New Zealand's Resource Management Act formally recognized the Sendai philosophy of proactively managing risks from natural hazards. However, the Act was changed with minimal consideration of how it might be applied in practice. And therein lies the problem. Some local authorities, in response to events, have identified situations where significant risk from natural hazards exists and for which no pragmatic and affordable engineering solution exists. In such cases, retreat from the high hazard area is the only option. For these scenarios, the legislative provisions of the Resource Management Act are proving to be not only woefully inadequate, but also polarizing to communities, driving a wedge between the

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affected residents and the local authorities endeavoring to apply the legislation. We demonstrate the challenges involved in implementing a disaster risk reduction framework through a case study involving Matatā, a small rural township in the eastern Bay of Plenty of New Zealand that experienced debris flows in 5 catchments in and around the township in 2005. Matatā is part of the Whakatāne district which has a land area of 4,442 km² and a population of 32,691 (2013 Census). The Whakatāne District Council (the Council) is the governing territorial authority.

2. The Natural Hazard Event

In May 2005, extremely heavy rainfall in the steep catchments behind Matatā caused many slope failures that initiated debris flows and debris floods, devastating much of the coastal township (McSaveney et al, 2005). Twenty-seven homes were destroyed, 87 other properties damaged and major transport links cut, resulting in an estimated NZ\$20 million in damage. About 700,000 m³ of debris was deposited from 5 catchments. The most destructive debris flow was from the Awatarariki Stream, where about 300,000 m³ of debris was deposited throughout the fan. Boulders up to 7 metres diameter were mobilised in this debris flow. While there were no deaths or injuries, the nature of this event was such that deaths could easily have occurred.

The closest automatic rain gauge was at Awakaponga, 5km SSE of Matatā. This recorded 367.5 mm for the period 17-19 May, with a peak 1- and 24-hr rainfalls of 94.5 mm and 307.5 mm respectively. These are between 200-500 year recurrence intervals based on extreme value statistics – but may be more frequent. Blackwood (2005) regards them as ~20 percent greater than the 1% AEP estimated rainfall intensities. Morphological evidence at Matatā and the adjacent Manawahe area indicated that rainfall intensities in the storm centre were even higher (Ibid). Peak debris and water discharges in the streams flowing into Matatā are estimated to have been between five and twenty times the theoretical 100-year flood discharges, with water flows up to twice the estimated 100-year floods (Tonkin and Taylor Ltd, 2005). For the Awatarariki catchment, the subject of this case study, the 100-year design flow is 44 m³/s whereas the estimated peak debris-flow discharge for the May 2005 event was 700 m³/s (Tonkin and Taylor Ltd, 2015).

There is evidence that equally large and larger, debris flows have occurred many times over the last 7,000 years, with four smaller flows occurring since 1860 (McSaveney et al, 2005).

3. An Engineering Solution?

Following the 2005 debris flows, the Council engaged external experts to advise what options were available to manage the risk to the Matatā community from future debris-flow events. Considerable community engagement informed option selections. For all of the five catchments, cost-benefit analyses ranked engineering solutions higher than managed retreat (Walton and Clough, 2005).

The Awatarariki fan community wished to re-establish the residential environment through an engineered solution that reduced the risk from future debris flows to acceptable levels. The Council considered a range of mitigation options and settled on a debris dam to achieve this. Subsequent consultation with the community, however, identified that any option involving large scale earthworks would not be supported by tangata whenua (local people of Māori descent who exercise customary authority in an identified area) due to the presence of highly-valued burial caves in the planned location of the dam. The Council then investigated alternative, less intrusive options. A combination of active marketing and an appetite for innovation by key Council officers and Council advisors resulted in adoption of a flexible ring-net proposal as the preferred solution. As the detailed design process proceeded and the requirement to contain >3 x 10⁵ m³ of debris was established, significant design and construction challenges were identified, in particular the unprecedented 14 m high by 39 m wide size of the barrier required as well as the ability of the local bedrock to withstand the anchor forces involved. Ongoing maintenance costs were a separate community concern.

As a consequence of better understanding the design and maintenance parameters, external engineering experts eventually advised the Council that an engineered debris detention structure in the catchment was not viable. The Council then investigated engineering options for a fan solution. Despite a range of options being considered, no viable solution could be identified.

In December 2012 the Council resolved to not proceed with an engineered solution, and to investigate and develop a planning framework to manage the risk. This was a pivotal decision by the Council, not just for the affected landowners but also for the Council itself in its regulatory roles of building consent authority and resource consent authority. The Council decision formally recognised that the properties known to be at risk from the debris-flow hazard from the Awatarariki Stream catchment would continue to be exposed to that risk in the future.

4. Policy Framework for Natural Hazard Risk Management

In 2014 the New Zealand Insurance Council estimated that natural disasters can be expected to cost New Zealand just under 1% of its GDP (about NZ\$1.6B) in any year (Insurance Council of New Zealand, 2014). This ranked New Zealand as having the third most vulnerable economy in the world to the impact of natural disasters. However, a lot of natural hazard damage is uninsured and many of the consequences are difficult to monetize; a Government agency recently estimated the total annual cost of natural hazard events in New Zealand to be between NZ\$12B and NZ\$18B. Annual costs of this magnitude are not sustainable for a country with a population approaching 4.9 million (Stats NZ, 2018). Thus a policy shift away from disaster response to disaster risk management has wide-ranging support within New Zealand. Proactive risk reduction, strengthened community resilience, and reduced expenditure on disaster response are anticipated outcomes of the new policy direction. Current policies and legislation relevant to natural hazard management in New Zealand are summarised in the following table.

Table 1 Key legislation and policies relevant to natural hazard management in New Zealand

Strategic document	Description/Purpose	Relevance
Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR)	SFDRR increases emphasis on disaster risk management and makes reduction of disaster risk a primary responsibility of signatory governments.	New Zealand is a signatory to the SFDRR. The nation has committed to reduce levels of risk that have been identified as being unacceptably high.
Civil Defence Emergency Management Act 2002 (CDEM)	To improve the sustainable management of hazards. Achieves acceptable levels of risk by identifying, assessing, and managing risks, consulting and communicating about risks, and identifying and implementing cost-effective risk reduction.	Both the Bay of Plenty Regional Council (BOPRC) and Council are part of the Bay of Plenty CDEM (Civil Defence Emergency Management) Group and contribute to the CDEM Group Plan. The Plan provides a framework for civil defence and emergency management decisions to be made across the Bay of Plenty. The Plan is linked to the Regional Policy Statement (RPS) which cascades to regional and district plans.
Local Government Act 2002 (LGA)	To meet the needs of communities for local infrastructure, local public services, and performance of regulatory functions in a way that is most cost-effective for households and businesses.	Section 11A(d) states that a core public service to be considered is the avoidance or mitigation of natural hazards
Resource Management Act 1991 (RMA)	Sets out how we should manage our environment, including the integrated management of natural and physical resources.	Natural hazard risk management is now a matter of national importance. Every RMA decision must take natural hazard risk into account. In this context regional authorities can extinguish existing use rights, without compensation.
Land Drainage Act 1908 and Soil Conservation and Rivers Control Act 1941	Provide for the conservation of soil resources, the prevention of damage by erosion and to make better provision for the protection of property from damage by floods.	Enable the regional council to undertake or maintain works to minimise flooding and damage in a catchment. Some mitigation measures have been carried out at Matatā under these Acts following the 2005 debris-flow event.
Local Government Official Meetings and Information Act (s 44A) 1987 (LGOIA)	Provides for Land Information Memoranda (LIM) - Council reports about a particular property or section or special features of the land, including hazard information. Their most common application is during the sale and purchase of properties.	Debris-flow risks within the hazard areas on the Awatarariki Stream fanhead are identified in Land Information Memorandum (LIM) reports.

Building Act 2004	<p>Provides for Property Information Memoranda (PIM) - Council reports about a particular property or section or special features of the land, including hazard information that may impact upon a new development. Typically applied for before lodging a building consent application. Sections 71-74 relate to limitations and restrictions for the construction of buildings on land subject to natural hazards.</p> <p>The NZ Building Code includes functional requirements and performance criteria for buildings. Code Clause B1 – Structure, includes requirements relating to building failure and references annual exceedance probabilities for some natural hazards that vary depending on occupancy and nature of activity undertaken.</p>	<p>The Council applied to the Ministry of Business, Innovation and Employment (MBIE) for two determination under this Act during the Matatā process</p>
Bay of Plenty Regional Policy Statement (RPS)	<p>Provides overarching policy for the Bay of Plenty which is given effect through regional and district plans. The RPS draws on long term plans, national policy statements and standards, and CDEM Group Plans (the latter being influenced by the National Civil Defence Emergency Management Strategy and National Civil Defence and Emergency Plan).</p>	<p>In 2016, BOPRC introduced a risk management approach to natural hazards (Plan Change 2 – Natural Hazards). The RPS now requires both the Regional Council and District Council to take steps to reduce high natural hazard risk.</p>
Whakatāne District Plan	<p>Identifies the important resource management issues in the District, and guides development in the district. Helps ensure Whakatāne is developing the way the community wants it to.</p>	<p>Currently, the District Plan zones the Awatarariki Stream fanhead as Residential. The Council has commenced a process to re-zone the land to manage the debris flow and debris-flood risk to property and people. This will also fulfil the Council's responsibilities under the new natural hazard provisions of the RPS for the debris-flow hazard from the Awatarariki Stream catchment.</p>

The NZ Government's adoption of the SFDRR signals the need for Government involvement in the development of national natural hazard risk management policies and frameworks, and in mitigation of risk from future (inevitable and foreseeable) high-impact natural hazard events that are beyond individual or community means to address.

Recognising the SFDRR commitment, recent changes to the Resource Management Act (RMA) have elevated the importance of managing natural hazard risk to now be a matter of national importance when statutory decisions are made. Additionally, the RMA provides for regional councils, under certain circumstances, to remove existing uses without payment of compensation; however, this contentious provision has yet to be tested through the judicial system.

A risk management approach to disaster reduction requires individual risks to be identified, quantified, and then managed according to priority. This introduces challenges for communities and regulatory decision-makers, including:

- developing an understanding of multiple (interacting and cascading) natural hazards;
- identifying the impacts associated with each hazard (alone and in combination with others);
- establishing a reasonable likelihood of the hazard event occurring;
- comparative analysis of different hazard impacts together with the levels of risk they present; and
- development and funding of risk reduction interventions.

It is already clear that these are formidable challenges. Firstly, the level of risk for many natural hazard events is being established on an ad-hoc basis with no guidance, support, or oversight by central Government. Second, risk quantification has proven costly and problematic due to the complex and uncertain nature and frequency of natural hazard events, particularly those of low probability where there are limited (if any) robust data from historical events. Also, and more importantly, no national framework has been established to guide communities on when risk reduction intervention is appropriate. Similarly, no national or regional funding framework exists to support risk reduction interventions. These challenges reflect the immature state of policy development for natural hazard risk management within New Zealand at the time this paper is authored.

The new risk management approach means management of natural hazards is prioritised by the risk they present. The policy intent of the recently introduced Bay of Plenty Regional Policy Statement (RPS) is to ensure that the consequences of natural hazard events, when they do occur, are as low as practicable. This recognises that under-acknowledgement of hazard risk in historical land use planning decisions has contributed to the high level of natural hazard vulnerability of many New Zealand communities.

Whereas the RMA focuses on environmental management, the Building Act (BA) focuses on building performance standards to ensure that buildings are safe for people to use. Specific provisions of the BA cover new building work on land that is potentially subject to natural hazards. In such cases, a building consent may be refused, or may be granted where the building construction won't accelerate or worsen the natural hazard on the site or other property; the owner is prepared to accept the risk from the unmitigated hazard; and the building consent authority can reasonably grant a waiver or modification of the building code. The BA requires the consenting authority to record this information on the property title at time of granting of the building consent. Building consent decisions can be challenged to the Ministry of Business of Business, Innovation and Employment (MBIE) through a determination application.

5. Application of the Policy Framework to Management of Debris-Flow Risk on the Awatarariki Fan

In 2006, the year following the Matatā disaster, the Council applied for a BA determination from MBIE around whether it could issue dangerous building notices to prevent the Awatarariki fan properties being reoccupied. At the time it was considered that the 2005 debris flows were initiated by a rainfall event with a 0.005 to 0.002 AEP, and that if the event was replicated at any time in the future, similar consequences could be expected. The Council's position was that the area should not be reoccupied, however, MBIE concluded otherwise and determined that the Council should allow residents to reoccupy their homes (Department of Building and Housing, 2006). The decision was subsequently extended to those wishing to rebuild homes destroyed by the 2005 debris flow. As well as repairs to existing dwellings, six replacement dwellings were also constructed between 2007 and 2011.

Engineering works were completed on four of the five catchments affected by the 2005 event. The December 2012 Council resolution to not proceed with engineering works for the Awatarariki catchment, and to move to a planning solution instead, caused the Awatarariki residents to be (understandably) very upset.

In 2012, there was (and there still is) no national guidance on natural hazard risk management assessment methodologies, interpretation of assessments, or on tolerable/intolerable risk levels. The Council sought expert external advice to assist its decision-making processes. The Australian Geomechanics Society Landslide Risk Management Guidelines (AGS, 2007) were identified as an internationally well-respected framework. Debris flows can be considered a subset of landslides, providing justification for the use of the Guidelines for the Awatarariki debris-flow risk assessment. These assessments generated an annualised loss-of-life risk distribution across the fan that ranged from 10^{-2} to 10^{-6} (Tonkin and Taylor, 2013). International comparisons indicated that an annual loss-of-life risk greater than 10^{-4} for an existing environment was unacceptable for residential use. This criterion was also adopted for rockfall risk assessments on the Christchurch Port Hills following the 2010-2011 earthquakes (Massey et al., 2014). Similarly, societal risk plotted on a F-N chart presented in AGS (2007) confirmed the risk to be unacceptable.

Awatarariki fan residents were provided with the risk assessments conducted by Tonkin and Taylor Ltd and supporting information. A representative group of residents was invited to participate in a decision-making exercise to develop a way forward for the residents and the Council. A Consensus Development Group was subsequently established, including residents, a senior manager from the regional council, an elected representative and senior staff from the Council, expert technical and planning advisors, and independent facilitators. The Group met for four days over a two month period and explored a wide range of potential solutions. However not everything was agreed upon; for example, there was a significant gap between the Council and the landowners' views on where the line of tolerable/intolerable risk should be drawn or whether a line should be drawn at all. The group agreed that a high risk exists but individuals varied widely in their personal tolerance of this risk, with many prepared to take individual responsibility for accepting the risk. The group agreed that engineering options were likely to be unaffordable and accepted that the Council had legal responsibilities to manage natural hazard risk to all people in society including the young, the elderly, and visitors. At the end of the process, there was agreement on a roadmap to move things forward. This roadmap included a further review of the quantitative risk assessment; investigation of early warning systems; consideration of on-site mitigation options; and development of a settlement agreement for voluntary managed retreat, with funding provided by a number of agencies, if on-site mitigation of the risk is not possible.

A peer review of the risk assessment suggested that the modelled risk understated, by an order of magnitude, the risk-to-life during the 2005 debris-flow event, and consequently the area with loss-of-life risk greater than $10^{-4} a^{-1}$ was increased. The reviewers concluded that the risk in the expanded area (the "high risk area" hereafter) made residential use unsafe (McSaveney and Davies, 2015). This area includes 34 private properties of which 16 have dwellings, the rest being vacant sections. The other 11 publically-owned properties include transport infrastructure and reserves.

Early warning systems were investigated by GNS Science Ltd, a New Zealand Crown Research Institute, and it was concluded that they were unlikely to be effective due to the short time between event initiation in the catchment and impact on the fan. An escalating alert and warning system was also considered but discounted due to the lack of data on which to base reliable triggering, and the inevitable false warnings the system would produce. Capital and operational costs were additional factors, as was operational liability for system performance (Litchfield, 2015).

On-site mitigation options were explored through a second Building Act determination. Two property owners lodged building consent applications to build dwellings within the high risk area. With knowledge of the high level of natural hazard risk and the lack of any suitable risk mitigation option, the Council's building consent authority declined to issue a waiver or modification of the requirements of the New Zealand building code, and thereby declined to grant the building consents. The Council tested this decision by applying to MBIE for a determination. Two years after the application was lodged, the determination decision was finalised (Determination 2016/034). The decision confirmed that vacant sites in the high risk area should not be developed for residential use.

6. Voluntary Managed Retreat

Elimination of other possible solutions led to the final option identified by the Consensus Development Group, that of voluntary managed retreat; this would provide for acquisition of properties by the Government, BOPRC or the Council, on a 'willing buyer – willing seller' basis. One of the Government's responses to the devastating 2010 - 2011 Canterbury earthquake sequence was to enact special legislation which enabled large areas of badly-damaged land and buildings to be acquired and people relocated. Most of the acquisitions involved land that had been damaged in the earthquakes, whose loss-of-life risk was low. In a policy environment promoting disaster risk management, and where a high loss-of-life risk had been proven with no viable risk reduction mitigation intervention available, Awatarariki fan residents and the Council looked to the Government in the first instance, and BOPRC in the second instance, to support an outcome consistent with that provided to property owners in Canterbury.

To inform discussions with the Government and BOPRC an Acquisition Strategy was developed that would incentivise property owners to relocate away from the high risk area. Legal advice to the Council indicated that owners of all of the 34 properties in the high risk zone (i.e. vacant sites as well as sites with houses) needed to be offered the same process; final offers would reflect the difference in value of the land and assets obtained through a formal valuation process.

The Acquisition Strategy recognized the "chicken and egg" dilemma for the Council: it needed to establish financial parameters for meaningful engagement with potential funding partners through identifying indicative settlement offers, without confirmed funding arrangements being in place. Legislative provision exists in New Zealand for compulsory acquisition of private land under the Public Works Act, however voluntary managed retreat is not a public work and therefore these provisions do not apply. Experience of managed retreat in the United States indicated that unless residents were incentivized to relocate, take-up of a retreat package would be low (Freudenberg et al., 2016). Accepting that a significant proportion of property owners in the high risk area had limited capacity to repay additional debt, voluntary retreat proposals were developed to incentivise owners to relocate. The proposals were based on the current market value ignoring the natural hazard risk at the time of a formal offer, plus contributions towards legal expenses and relocation where the fan property was the primary residence of the owner. A valuation appeal procedure was also proposed. In sum, these provisions largely mirrored the acquisition provisions of the Public Works Act.

Individual property valuations were needed to establish the financial envelope for managed retreat of the 34 properties in the high risk zone. All but two owners gave consent for property valuers to visit their property. The valuation process assessed the potential cost of property purchases and clean-ups at NZ\$15M. Indicative voluntary retreat proposals were provided to individual property owners who were then asked to register their interest in exploring the managed retreat process further. Two property owners declined to participate, one of whom was a Maori family group who owned a large parcel of land on the fan and had plans to register that land as a Maori reservation with a reserve status to avoid further development; this group supported retreat from the area and wished to integrate the development of the reservation with the Council's broader plans for a coastal reserve for all of the high risk area. For a range of reasons including distrust of and lack of confidence in the Council, misunderstanding of the process, misunderstanding of the indicative offer, and different expectations of property values, 11 property owners did not return registrations of interest. The remaining 21 property owners wished to see the process continue.

Despite the shift in national policy direction towards DRR, little support for managed retreat from Government ministers, BOPRC elected representatives, and officials has been forthcoming. Feedback from the Minister of Local Government in mid-2017 included a statement that Government wished to see a more definite expression of intent by

the Council to pursue the formal legislative provisions of the Resource Management Act as provided for by Parliament, and to apply the recent changes to the RPS. The RMA provisions required a District Plan change to alter the zoning of the high risk area from 'Residential' to 'Coastal Reserve', and a change to a Regional Plan that would remove the occupancy rights of the 16 property owners with houses on their land, with no compensation. Whereas the change to the District Plan reflected the status quo arrived at following the 2016 BA determination, the change to the Regional Plan removed the 'voluntary' component of the Council's managed retreat strategy. This drastic change created a moral dilemma for several councilors who considered it one step too far. The subsequent Council resolution to progress along the RMA route was based on a majority vote rather than by consensus.

BOPRC introduced a risk management framework to the Bay of Plenty region through its change to the RPS. It will also be responsible for implementing and enforcing the change to the Regional Plan. The Council asked BOPRC to develop the Plan Change to the Regional Plan. This request was declined by BOPRC. As a consequence, the Council developed both plan changes. BOPRC was then asked to adopt the prepared Regional Plan Change, but again this request was rejected.

The lack of support from BOPRC and Central Government, combined with an absence of national and regional policy implementation direction and guidance, has required the Council, a provincial territorial authority with only 34,500 residents, to chart a course through unexplored and incomplete national and regional natural hazard risk management frameworks with relevant key public sector actors observing from the sidelines.

And what of the fan property owners, those most affected? The Council has maintained regular communication with all property owners throughout the process. For owners of vacant sites, the 2016 BA determination confirmed their inability to obtain a building consent to build on the land and their expectations largely reflected an acceptance of this. Unsurprisingly, a number of the owners of properties containing houses reacted angrily to the Council's decision to proceed with a Regional Plan Change that could see them forcibly removed from their homes without compensation. Their concerns were appropriately picked up by a sympathetic national media which resulted in Government Ministers taking a more active interest in engaging with the Council to pursue a managed retreat solution that is separate from the legislative RMA processes.

A change in Government in October 2017 has seen an holistic approach to public governance that includes wellbeing of citizens. The willingness by the current Government to engage with the Council over a managed retreat solution for the Awatarariki fan has had a moderating influence on BOPRC.

Now, 13 years after the event, and 6 years after a decision to not pursue an engineered solution, the level of risk is understood, and meaningful dialogue is occurring. This may not only lead to a solution for Awatarariki fan residents, but also result in a policy implementation template for managed retreat within New Zealand where unacceptable risk has been identified, no viable alternate solution to retreat exists, and the scale is such that local communities cannot afford to fund retreat on their own.

7. Conclusion

An initial proposal for an earth containment dam in the upper catchment reflected a traditional 'build back better' approach to management of debris-flow risk from the Awatarariki Stream and its tributaries. Community consultation resulted in an alternative construction proposal that was attractive to professionals and local authority officials for its innovation and cost. Unfortunately, the risk inherent in innovation went unrecognised and it wasn't until the detailed design phase that the inadequacies of the innovative design became apparent. Engineered fan solutions were also investigated and rejected.

Since all engineering options had been exhausted, a disaster risk management approach was adopted. Loss of life and property damage risks have been quantitatively assessed, with annualised loss-of-life risk ranging from 10^{-2} to $10^{-6}a^{-1}$ across the fan. 34 properties with an annual loss-of-life risk of $>10^{-4}a^{-1}$ were classified as being unsafe for residential use. Several risk reduction options were investigated including provision of early warning systems and active catchment management, but none proved to be viable. Having discounted all other risk reduction options, retreat from the risk was the only remaining option.

The journey the Council and property owners have gone through over the last six years has demonstrated significant failings in the national policy framework for disaster risk management.

- Although the policy vision is clear, the means to achieve it are lacking.
- No advice exists on how natural hazard risk should be assessed or what levels of risk require intervention.
- Intervention options are not enabled through supportive legislation, nor access to appropriate funding to implement risk reduction interventions.

- This lack of national policy guidance and support creates high levels of uncertainty, placing an unreasonable burden on local authorities and adversely influencing their ability to reduce natural hazard risk at the local level.
- Affected communities are seriously demoralised and polarised in the process.

Until these deficiencies are corrected, risk reduction initiatives will be resisted, inefficient practices will persist, and the New Zealand Government's natural hazard risk reduction objectives will not be realised – leaving people at unacceptable risk and personal hardship.

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