

The Crater Lake issue - a management dilemma

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Introduction

Tongariro is New Zealand's oldest National Park and the fourth oldest Park in the world. It was established in 1887 when Horonuku Te Heuheu Tukino, the paramount chief of Ngati Tuwharetoa, gifted the central portion of the Park to the nation. The outstanding natural values of Tongariro were officially recognised in 1990 when it was awarded World Heritage status. The area's important Maori cultural associations were also accorded the same status in 1993. The Park is currently managed by the Department of Conservation.

Situated within Tongariro National Park, the volcanoes of Ruapehu, Tongariro and Ngauruhoe and their surrounding lahar ring plains comprise major landscape features in the central North Island. The Whangaehu Valley is the major lahar path from the volcanoes and is almost certainly the most active lahar (volcanic mud flow) path in the world. The Whangaehu outwash fan and lahar deposits further downstream preserve records of previous lahar activity over thousands of years. This is the most dynamic natural landscape in New Zealand.

Mt Ruapehu and Crater Lake represent one of the world's most active and distinctive examples of volcanism. Ruapehu is one of the most frequently active composite volcanoes in the world erupting every 1-3 years on average. Volcanic processes can be seen in action and studied as a 'natural laboratory'. Crater Lake is one of two crater lakes (together with Kelut in Java) regarded as classic case studies of interaction between magmatic fluids and lake water which often produce lahars. The Crater Lake, located over the actual vent of the volcano, is especially important. The Lake is partly surrounded by permanent snow and ice and is the most accessible and by far most active of only two or three such active crater lakes on Earth.

Twice last century Crater Lake was completely emptied during eruptive episodes. On both occasions, 1945 and 1995, bridges were destroyed and damaged. When the Lake partially emptied on the 24th December 1953 the lahar washed away a rail bridge at Tangiwai killing 151 of the 285 passengers and crew aboard an express train. This was one of New Zealand's worst tragedies, and preventing a recurrence of it has been a major focus of railway authorities and more recently Ministers and government agencies.

Despite this activity, and in fact because of it, the volcanoes and Ruapehu in particular

are major areas of outdoor recreation in New Zealand. Past volcanic activity has created a fantastic varied alpine landscape, the largest close to the bulk of the country's population. Statistics show that TNP is amongst the most visited national parks in the country. Crater Lake is second only to the well-known Tongariro Crossing as a focus of visitation to active volcanic features. Domestic skiers, snowboarders, climbers, trampers, sightseers and others enjoy this park and increasing numbers of overseas people do too, especially backpackers. The active volcanic nature clearly adds to the attraction for many of the people who come to the park.

The Tongariro National Park Management Plan documents the objectives of park management. Currently nearing the end of its fourth review, it outlines the ways the park, including natural hazards and human impacts, are managed. In a national park it is imperative that some very significant areas receive a very high degree of protection from human intervention. This is reinforced by the World Heritage cultural and landscape status of the park which creates global obligations for protection and monitoring of the park's exceptional values. On Ruapehu the area above 2250 m except within the ski area boundaries (up to 2320m) is designated a Pristine Area to avoid human intervention or development and to offset more intensive development in the Amenity areas around the ski areas below. This area reinforces the original Gift Area, and is essential for retaining and enhancing the pervading aspects of wildness, quietness and outstanding visual features in the Crater Lake area, plus its very significant cultural, historic and conservation values.

The national park/world heritage status, popularity, values, dynamic volcanic nature, and destructive potential including the 1953 disaster all help focus a great deal of public, media and political attention on the issue we have today.

The present situation

Tongariro National Park is currently facing its most testing management dilemma in its 116 year history.

The eruptions of 1995 and 1996 built up a deposit about 7 metres thick of tephra (ash, scoria and rocks) on the crater rim at the former lake outlet. (The deposits were over 15 metres thick near Pyramid Peak but there pose only a minor and less direct hazard due to potential slumping). Therefore on refilling the Lake will encounter a barrier or dam of tephra and rise above what would otherwise be the normal overflow level (2529.5 m) at which the lake becomes 100% full. Seepage through the permeable tephra will then occur and subsequently sudden collapse of the tephra dam is likely given the permeable and weak nature of the material: such collapse has been judged as most likely to occur at a lake level approaching or above 2536m (115% full). The impounded water could burst out in a way similar to the 1953 event producing a lahar with a peak discharge at Tangiwai considerably larger than the 1953 event. Whatever volume is released the majority of the lahar will travel down the normal Whangaehu lahar path but an extreme event would be large enough to spill over into the Waikato Stream and enter the Tongariro catchment and Lake Taupo.

Close monitoring and extrapolation indicate Crater Lake will become full probably sometime in the late spring or early summer of 2004. The Lake is currently (mid July 2004) 94% full after almost eight years of refilling. This is significantly different from

the situation in January 1953, seven years after the 1945 eruption ended, when the Lake was almost at the level it was when the 1953 lahar occurred 11 months later.

The striking difference is due to the crater being larger now than post 1945, fewer and possibly smaller meltwater streams flowing into it now due to glacial recession, and probably other factors affecting input and output of water, including volcanic activity. It appears the volcano was more active after the 1945 eruption than it was after 1996 but there have been several cycles of heating and enhanced activity since 1996 (most recently in February 2004). The temperature of the lake water five years after each eruption was similar (21°C).

Infrastructure at risk from the potential dam-break is mainly down the Whangaehu Valley. There is no housing at risk. The main assets are transmission pylons of the national grid near the aqueduct site and bridges of the main trunk railway and State Highway 49 at Tangiwai. Also at Tangiwai are some power poles and fibre optic cables across the bridges, the Tangiwai memorial and toilets. Downstream one small farm-bridge (Strachan's) and a small rural bridge (near Tirorangi marae) are also at high risk plus some sections of the Whangaehu Valley Road. Some distance below the marae the lahar will become similar in size to normal rain floods and much smaller than the devastating rain floods of February 2004. Other assets at risk include DoC's Whangaehu foot-bridge and some pine trees beside the river in Karioi Forest and downstream. Most of these structures and other assets have been built in the knowledge, thanks partly to the 1953 event, that the Whangaehu is an active and major lahar path.

In the Tongariro catchment State Highway 1 is at risk from potential spill-over and Rangipo power station might need to cease production until spill-over lahar sediment cleared. The freshwater environment of the Tongariro River would also be at risk but apart from blue ducks its ecology rapidly recovers after lahars as seen in 1975 and 1995-1996.

In terms of natural hazard management the current situation is unusual for two main reasons:

- It is predictable well in advance of the significant risks it raises;
- The 1953 disaster created sad memories and raises strong feelings some of which conflict with strongly held environmental and cultural values.

Assessment

The Minister of Conservation is responsible for the management of national parks in New Zealand. Clause 4(1) of the National Park Act 1980 states "...shall have effect for the purpose of preserving in perpetuity as National Parks, for their intrinsic worth and for the benefit use and enjoyment of the public, areas of New Zealand that contain scenery of such distinctive quality, ecological systems or natural features so beautiful, unique or scientifically important that their preservation is in the national interest."

The Department of Conservation produced an 'Environmental and Risk Assessment for mitigation of the hazard from Ruapehu Crater Lake' in April 1999. This followed a draft Assessment of Environmental Effects (AEE) in October 1998 based on scientific information and consultation. It was released for public comment and forty-

six submissions from local government agencies, State Owned Enterprises, environmental and recreation groups, iwi, private citizens, as well as unsolicited letters and other input were received and taken into account in preparing the final AEE. The biggest single group of submissions was from recreational interests including NZAC, FMC, tramping clubs and ski clubs. The Minister requested that the Department's final AEE be scientifically peer reviewed in addition to the public review.

The AEE presented 24 options in six categories that included:

- Allow lahar to occur: develop alarm and response system, improve land use planning but no engineering intervention at crater or in lahar flood zones.
- Allow lahar to occur but intervene in lahar flood zones to reduce its size and/or confine it.
- Prevent or reduce lahar by hardening or perforating tephra barrier at the crater. Prevent or reduce lahar by excavating a trench through the 1995-1996 tephra barrier at the crater.
- Prevent lahar and reduce lake volume by excavating trench into underlying lava at outlet.
- Defer, prevent or reduce lahar by other options e.g. siphoning, barrier truss.

Other agencies have carried out their own assessments, using data and information provided by DOC and their own knowledge of their assets and their operating environment. Horizons Regional Council assessed effects on the Whangaehu River below the bridge at Tiorangi marae and concluded that, while there may be risks to people at the river's edge if they are not forewarned, there will be no damage downstream as the lahar will not leave the channel on a fine day. A heavy rain scenario would not add significantly to the risks posed by normal rain-induced floods, which do leave the river channel, although sediment deposition would be worse. Transpower made a detailed assessment of topography in the area of their pylons and concluded that two of the 10 were at some risk. Genesis Power and Transit New Zealand carried out very extensive assessments.

Mitigation

ERLAWS and planned responses

In May 2000 the Minister decided to action the installation of an alarm warning system and formalisation of emergency management response and contingency plans. Following discussions with scientists, technicians, computer and radio specialists, Genesis Power Ltd and a technical design review the Eastern Ruapehu Lahar Alarm and Warning System (ERLAWS) was installed during the 2001/2002 spring and summer along with radio repeaters at Dome Shelter, Taiping and Tukino Road.

ERLAWS consists of three types of sensors at three sites down the upper Whangaehu Valley:

- Site 1 (Crater Lake outlet) - three geophones to detect the vibration of the collapse and from lahars, a buried tripwire to detect collapse of the dam and

water level sensors (first one installed in the 02/03 summer) to detect a sudden drop in Lake level

- Site 2 (NZ Alpine Club hut) - two geophones to detect the vibration from passing lahars
- Site 3 (near Tukino skifield) - two geophones to detect the vibration from passing lahars.

Data from these sensors are telemetered through dual pathways to the Genesis control room at Tokaanu power station. There the data are monitored on an independent computer (and backup), mirrored on the Genesis SCADA system, sent to an external server and displayed on a special ERLAWS website. Data from Genesis sensors will soon be added. When incoming data exceed pre-set thresholds an alarm will automatically be sent via pagers to police, district council staff, Transit, Toll Rail and duty scientists who will then respond following predetermined plans. This will be up to two hours before the lahar reaches Tangiwai.

Two years after commissioning ERLAWS is proving very reliable. Over the past six months it has been operating very close to 100% of the time. Individual aspects such as the ability to detect lahars, base computer and paging system, and 24/7 website support are all fully operational. The site at the crater is operating at about 97% (greater than predicted) but planned lake level sensors are not in operation at present. All 22 planned or unplanned tests where detectors reacted to vibrations leading to alarm paging have all been successful and in May 2003 a natural rain-induced flood showed that the detectors will be very sensitive to lahars in the Whangaehu Valley.

ERLAWS will also trigger systems installed by Transit to warn road users. These include automatic barrier arms at the State Highway 49 bridge plus flashing lights and signs there and on State Highway 1. Automatic connectivity with the police is planned.

District councils and the police are developing the primary response plans. Ruapehu District Council is responsible for the southern plan centred on Tangiwai and the upper Whangaehu Valley while Taupo District Council is responsible for Tongariro River planning. The Ministry of Civil Defence and Emergency Management is assisting with this planning. The plans will be integrated with each other and with individual agency plans including those of Genesis, Toll Rail (who have their own alarm system for stopping trains), Transit, Transpower, the Army, police, Winstones Pulp International and DOC.

Exercises and training are being held so that plans are complete before the Crater lake reaches 100% full although Ruapehu and Taupo district councils, the police and DOC already have plans in place. On 28 April this year the most comprehensive exercise yet proved the connectivity between ERLAWS and the Transit systems, and showed that planning was proceeding very well with agencies working together successfully.

Embankment

In December 2000 the Minister of Conservation requested that the Tongariro National Park Management Plan be amended to permit the construction of a 'bund' or embankment to prevent overflow from the Whangaehu River into the Tongariro

catchment. This embankment is located just inside the National Park boundary near the head of the Whangaehu outwash fan. This site is important but not as sensitive as that at the Crater Lake itself.

The structure was completed in February 2002. It is almost 300 metres long, up to 4.6 metres high and about 20 metres wide composed of gravel, ash and boulders bulldozed from the lahar flood plain. The core material was compacted then armoured in front and on top with a layer up to 2 metres thick of well-graded boulders up to 1.5 metres in diameter. The bund was designed to withstand and have 1.5 metres of freeboard above the extreme lahar possible from a sudden collapse of the tephra dam.

The primary aim of the bund is to increase public safety. It will greatly reduce risks to people crossing the Waikato Stream bridge and culvert section of State Highway 1 as well protect public safety in the Tongariro River. Its secondary purpose is to protect the aquatic environment of the Tongariro River and Lake Taupo. It will have a negligible effect on the main part of the lahar down the Whangaehu River. According to lahar hydrological modelling the maximum spill over prevented by the bund is only about 7% which is very small compared to the non-spilling portion and much smaller than uncertainties in calculated lahar parameters. For example it would increase the depth of the worst-case lahar at Tangiwai by about three centimetres which is much less than the expected heights of waves on the lahar surface.

Long –term protection

Protecting infrastructure and other assets against future lahars is clearly a key to keeping communities and businesses resilient in the face of severe and ongoing lahar hazards. Lahars are recurring and severe natural hazards. There have been at least 15 eruption episodes in European times that have produced lahars on Ruapehu and heavy rain has also been known to cause further hazardous lahars after eruptions. The largest historic eruption lahar was a unpredictable event in April 1975 when about 20% of Crater Lake water was permanently ejected and a lahar in the Whangaehu Valley almost killed eight construction workers in a Tongariro Power Development tunnel. Volcanologists do not believe that was the largest such unpredictable volcanic explosion Ruapehu can produce.

Recent scientific research by Massey University has shown that there have been several lahars 10 to 50 times larger than the 1953 event in the last 2000 years, the most recent of which occurred as recently as 400-450 years ago. The six largest volume lahars (2 to 10 times larger than the current predicted event) occurred at an average frequency of 1 every 315 years. Such large lahars were caused by collapses of the geologically young eastern to southern rim of Crater Lake. Recurrence of this sized lahar would result in inundation of distant populated areas and destruction of infrastructure.

Such severe hazards and far-reaching consequences have been under-estimated by engineers and authorities who have based infrastructure design and land use zoning on the limited 150 year long written record at Ruapehu. A 1939 aerial photo suggests that construction of the rail embankment at Tangiwai halved the width of the lahar flood channel at the river crossing there which would have made the 1953 disaster more likely to occur.

Lahar hazards from Ruapehu, and the ephemeral nature of Crater Lake over the last 2000 years have become much clearer over the last eight years thanks to the current focus. To paraphrase a director of emergency management in a US county threatened by lahars from Mr Ranier, we have entered a window of major lahar threat that is about 300 years long on average but the last lahar occurred at least 400 years ago. Monitoring and geological assessment of the crater rim (which changed significantly during the 1995-1996 eruption) do not indicate major problems are imminent. But we need to use the predicted lahar risk with its short term, small residual risks to prepare for the far less predictable, larger lahars in the longer term which pose significantly greater residual risks.

Genesis Power and more recently Transit New Zealand have been most active in planning for the long term. Genesis has extended and upgraded its communication, control and lahar detection systems and are putting in place further safeguards for Wahianoa Aqueduct and the Rangipo Power Station. Transit has determined that long term protection of bridges at State highways 49 and 1 are feasible and are currently raising and strengthening the SH49 bridge at Tangiwai. The Ministry of Civil Defence and Emergency Management has made it clear that overall residual risk to public safety will be reduced significantly to appropriate levels when the highway crossing at Tangiwai is made safer. The bund offers protection to State Highway 1 where it crosses the Waikato-iti Stream and its southern tributary.

Further action and decisions

The former Minister ruled out intervention at Crater Lake in December 2001 and the present Minister of Conservation, in association with the Minister of Police/Civil Defence, the Attorney-General and Cabinet reiterated that position in May 2003 and again in March 2004. Ministers are monitoring progress with the alarm system, response planning and long term protection at Tangiwai. DoC at the request of the former Minister of Conservation convened a scientific and technical advisory panel of geologists (including lahar specialists) and civil engineers to provide independent advice including an oversight role of ongoing work monitoring the refilling of Crater Lake. More information is also being made available to the public as the Lake becomes full, including warnings at vulnerable places. Signs have started being erected at key locations.

A fundamental question the Minister had to address was whether interference with natural, cultural and scientific values of a World Heritage site should proceed simply because there are 'residual' risks. The risk to life is low because of the warning and response system including those of Transit and Toll Rail, plus the construction of a bund, but cannot be absolutely mitigated. Carrying out engineering work at Crater Lake would not be without risk either due to the high altitude alpine volcanic nature of the site (as was underscored by medivacs of workers at the tephra barrier in 2003 and the Army tragedy in winter 1990). Such work would also create precedents for further direct interference with other volcanic risks in the National Park as well as more common natural hazards elsewhere.

We believe a more appropriate management action is to use the knowledge of lahars to be prepared for such hazards and where necessary place infrastructure such as

roads, rail and power lines at sites less likely to be at risk or to design them in ways to make them safe. This is what Ruapehu Alpine Lifts has done at Whakapapa Ski Area and what Genesis and Transit are doing. This is a 999more sustainable course of action. In concert with warning and response systems this will reduce risks to a low level, even for larger lahar hazards that the recent geological record tells us will no doubt occur sometime in the future.