

Our Ref. 3071
22 February 2006

Tauranga City Council
Willow Street
Private Bag 12-022
TAURANGA

Attention: s 7(2)(f)(ii)

Dear s 7(2)(f)(ii)

MAUAO ROCKFALL HAZARD - PEER REVIEW REPORT

1.0 INTRODUCTION

This report provides a summary of a peer review of the rockfall risk assessment for Mauao undertaken by Avalon Industrial Services Ltd.

The scope of review included the following:

- Review of relevant reports prepared by Avalon Industrial Services Ltd (Avalon);
- Inspection of key locations on the mountain, in conjunction with Avalon and parks staff;
- Inspection of the rockfall incidents such as 22nd June 2005.

Key comments and conclusions are given in the following sections. In overall summary, the risk assessment methodology is considered to have been reasonable and the results give a realistic assessment of what level of risk is posed by rockfall to visitors to the mountain. The remedial/preventative work undertaken by Avalon appears to have been undertaken in a sound manner. Aspects of the assessment and management of the rockfall risk are discussed.

2.0 SCOPE

The following reports have been prepared for Tauranga City Council by Avalon:

“Mauao Rock Slopes & Rockfall Hazards”, dated July 2003, ref. 0314.

“Mauao Rockfall Hazards - Risk Assessment and Management”, dated June 2004, ref. 0405.

“Mauao Slopes Earthquake Damage & Revised Risk Assessment”, dated July 2004, ref. 0453.

“Mauao Slopes 2005: Zone 6 - Southern campground and hot pools - Rockfall hazard and risk assessment”, dated July 2005, ref. 0534A.

The Avalon reports were preceded by two reports on rockfall risk by Dr Laurie Richards, a specialist consultant to Tauranga District Council;

“Stability Assessment, Mount Maunganui, Tauranga”, report to TDC, dated 31 May 1999.

“Mauao Rockfall Review”, letter report to TDC, dated 20 Feb 2003.

These reports were not included in this peer review, given the additional information and event precedents that have since become available.

The scope of this peer review did not include the assessment and remedial design of the landslips that occurred as a result of the May 2005 storm, which were reported in the Avalon report:

“Mauao Slopes - May 2005 Flood damage and Slope remedial works”, dated August 2005, ref. 0534B.

3.0 ROCKFALL RISK ASSESSMENT

The quantitative risk assessment (QRA) given in the Avalon reports appear to be generally reasonable. We would note the following:

- The QRA includes a number of assumptions. It is important to appreciate that several of the factors used in the analysis are subjective. The two factors which appear to have the greater subjectivity are (1) exposure distances and (2) the vulnerability to fatality;
- Vulnerability (the probability of death if directly in the path of a boulder) for persons within the campground was assessed as being 0.5. This could be slightly low given that it relates to the 12 hours per day that a site was occupied;
- For the Waikorere and Oruahine tracks, the total length of each track appears correct, however there does not appear to be allowance for concentration of boulders within gullies/rock clefts. While the frequency of rock falls would increase for these sections, the reduction in risk over the majority of the track segment would be likely to reduce the calculated probability of a fatality;
- The threshold of considering only boulders at least 1m³ size appears reasonable;
- Based on the boulder run-out paths resulting from the blasting of 2004, the 50 m distance for penetration into the campground could be considered to be somewhat on the high side, but probably not worth specifically changing;
- The acceptability by society of a multiple fatality event is lower than for a single fatality event. The very large boulder that moved in June 2005 would have been sufficient to put at risk more than one person occupying a tent site;
- The QRA analysis correctly includes rockfalls generated by humans. The scaling of obviously loose boulders would have significantly reduced the proportion of risk originating from deliberate (vandal) action;

- Assessment of the recurrence frequency of events is not an exact science and some factors may be subject to revision in the future. A good example of this is the recent revision of rainfall storm intensities within Tauranga City, where recent revision of rainfall events in Tauranga (including five years of rainfall data and including the May 2005 storm event) resulted in rainfall of 280 mm within a 48 hour period previously categorised as a 100 year return period event is now considered to be a 35 year event¹.

The Avalon report for Zone 6 concluded that the overall level of risk appeared to be marginal (page 24). It is not clear whether this included or excluded the risk posed by the approximately seven highest-risk boulders which were subsequently stabilised.

A sensitivity QRA analysis varying the factors mentioned above and other parameters confirmed that a range of outcomes/levels of risk can be conceived. However, given the inherent uncertainties within the QRA, this would be unlikely to shed any more clarity on the issue.

Overall, the conclusion given in the Avalon reports that the level of rockfall risk at Mauao is towards the upper end of what would generally be considered acceptable in terms of landslide risk², appears to be slightly on the high side, but it is definitely within the range that requires Council to carefully assess and then manage the risk on an ongoing basis.

4.0 POINTS OF DISCUSSION

4.1 Management of Future Rockfall Risk

Natural weathering processes will continue to generate potential rockfall events.

The scaling work undertaken to date is a reasonable management tool.

It is important to appreciate that periodic inspections and scaling work will reduce but not eliminate the risk of future rockfall events.

A key question is what level of risk of injury or fatality is considered to be acceptable. We concur with the Avalon conclusion that the level of risk of a fatality due a rockfall is within normally accepted levels (annual exceedance probability less than 10^{-6} and preferably less than 10^{-7}).

The work undertaken by the management team over the last 8 years or so has significantly reduced the level of rockfall risk (regular inspections, rock scaling, rodent control, restrictions on access to unstable areas, etc).

If the current level of risk is judged to be unacceptably high, then (1) the risk of dangerous rockfalls must be reduced and/or (2) protection measures must be put in place to reduce the risk to people.

Techniques such as rock netting and bolting could be used to reduce the magnitude of the hazard, but would be very unlikely to be acceptable.

There is a significant difference in the vulnerability and exposure time of people walking along tracks and those within the camp ground. Accordingly, if a material reduction in the overall rockfall risk was deemed to be necessary, then the logical approach would be to concentrate on the eastern slopes.

¹ "Tauranga City High Intensity Rainfall Update October 2005", report prepared for Tauranga City Council by Opus International Consultants Ltd, 10 October 2005.

² Based on published guidelines such as "Landslide Risk Management" by Fells & Hartford; Geomechanics News 1999; etc.

Given requirements such as visual effects, the best approach would be to install rockfall fencing along the upslope fence line of the campground.

Given the iconic status of Mauao it would be essential that any protection system be discrete and have no irreversible impact.

A preliminary scoping is as follows:

- Specialist energy-absorbing design (Geobrugge, Maccaferri or similar);
- Nominally 2.0 m high;
- Minimum length would be within the gullies, where there is higher rockfall concentration. Extending over all of the gullies and ridges could be a longer term objective;
- The extent as per the attached Figure 1.

A preliminary cost estimate is as follows:

Preparatory works

Rockfall fence - 280 m long at s 7(2)(h) – Com per metre length

Landscaping, etc

Engineering design and certification

SUBTOTAL

Contingency - approx. s 7(2)(h)

TOTAL (exclusive of GST)



While not cheap, construction of the protection fence can be staged, with the highest risk corridors installed first.

We would expect this approach would give a significant reduction in the level of the rockfall risk.

4.2 Rock Scaling Programme

The latest Avalon report (for Zone 6) recommends that rock scaling be undertaken on an annual basis as part of the risk management programme. The scaling work undertaken up until now has certainly removed many of the highest risk situations. However:

- the work undertaken to date has included a “historical catch-up”;
- removal of rocks can lead to increased soil erosion and loosening of adjacent rocks;
- the rate of weathering the Mauao rhyolite is slower than (say) greywacke; and
- no matter how extensive, rock scaling can only reduce - but not eliminate - the risk of sudden rockfalls.

Accordingly, we have reservations about the benefit of an annual rock scaling programme for Mauao. It is perhaps a question of phraseology rather than intent. The periodic inspections by TCC staff and Avalon should be continued. It is important that as much continuity is achieved as possible.

4.3 Soil Slide/Flow Failures (“Mass Slips”)

There are several very large, vacated landslip scarps within the lower parts of the colluvial fan around the mountain. They are referred to as “mass slips” in the Zone 6 report by Avalon, which also raises the question as to whether these features represent an additional slope stability hazard to that posed by rockfall.

To our knowledge there is little or no substantive data on these features. Judging by their size and location we would interpret that they are pre-historic features (c.f. Avalon’s description as historic slips) and probably related to sea level fluctuations - that is, thousands to tens-of-thousands of years old.

Overall the risk posed by this type of failure appears to be low to very low and somewhat less than indicated by the Avalon report. Notwithstanding this, it is appropriate for them to be considered further. The engineering geological assessment should include geomorphic mapping, assessment of topsoil/subsoil development within the landslip scarps, stability analysis, and radiometric dating if suitable samples were obtained.

5.0 SUMMARY OF KEY RECOMMENDATIONS

- (a) Continue the current programme of periodic visual inspections, by both parks staff and geotechnical consultants (Avalon).
- (b) Confirm the level of risk deemed to be acceptable within the campground sector.
- (c) Assess the viability of a rockfall fence on the upslope side of the campground. A staged approach would reduce costs.
- (d) Review the regime for periodic rock scaling - better to be on an “as required” basis than consistently annually?
- (e) “Mass slips”: undertake an engineering geological investigation to better assess the age of these relic soil slide/flow failures. This should include consideration of post-event development of the topsoil/subsoil profile, radio-metric dating (if possible), etc.
- (f) Confirm the methodology, cost etc, for rapid installation of a telemetered monitoring network, should this become necessary at short notice in the future.
- (g) Eradication of pests who burrow under/behind the boulders has distinct benefits to the mitigation of the rockfall risk. Although unlikely to occur, any decrease to the current (intensive) programme should be considered in the rockfall risk assessment.

6.0 CLOSURE

This report has been prepared for Tauranga City Council with respect to the brief given to us. Conclusions and recommendations provided herein shall not be used in any other context without our prior review and agreement. As discussed in the report, the assessment of rockfall hazard at Mauao is subject to ongoing assessment.

Please contact the undersigned on ph [REDACTED] or mobile [REDACTED] if there are any queries arising.

Yours faithfully
TERRANE CONSULTANTS LTD

[REDACTED]
s 7(2)(a) Privacy

TCC CATEGORY 1 GEOTECHNICAL ENGINEER & GEOLOGIST

Attachment:

Figure 1 - Plan

3071.Mauao.revrep

