Life-safety risk from cliff collapse on the Port Hills

(Summary Series 2/3)

The Christchurch City Council commissioned GNS Science to assess and report on slope-instability risk in the Port Hills following the earthquakes of 22 February 2011. This brochure summarises information contained in two technical reports and should be read in conjunction with *Understanding life-safety risk concepts for rockfall and cliff collapse in the Port Hills (Summary Series 1/3)*. The GNS Science reports focus on selected areas where damage occurred from cliff top collapse, and where rock material was deposited at the bottom of cliffs during earthquakes. It specifically presents assessments of the risk of death (life safety) faced by an individual living directly above or below some of the major cliffs in the Port Hills, such as the sites in the photographs in this brochure.

GNS SCIENCE
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Why were these technical reports needed?

Following the 4 September 2010 Darfield Earthquake, seismic activity in the Christchurch region has been considerably higher than the future long-term average for the region, and is likely to remain high for several decades. As a result, the risk of death from cliff collapse in the Port Hills is now higher than it was before 4 September 2010. However, the risk of death is expected to decrease over the coming decades as the seismic hazard decreases. The risks presented in these reports relate to the annual individual fatality risk (risk of death) from debris avalanches and cliff-top recession (see following photographs and Terminology section) triggered by earthquakes or by any other non-earthquake causes.

What areas do the technical reports cover?

The areas included in the GNS Science technical reports are those immediately above or below the cliffs in the areas shown in the map below. This includes parts of Redcliffs, Shag Rock Reserve (Kinsey Terrace and the non-residential Shag Rock Reserve), Sumner (Wakefield Avenue and Nayland Street) and Whitewash Head (Scarborough). In these areas, lives are threatened by the hazards of cliff-top recession and debris avalanche.

▼ Location map showing Ports Hills areas covered by these reports.

Cashmere

Sumner

Lyttelton

2 Km

■ Cliff collapse risk zones
□ Cliff collapse study areas
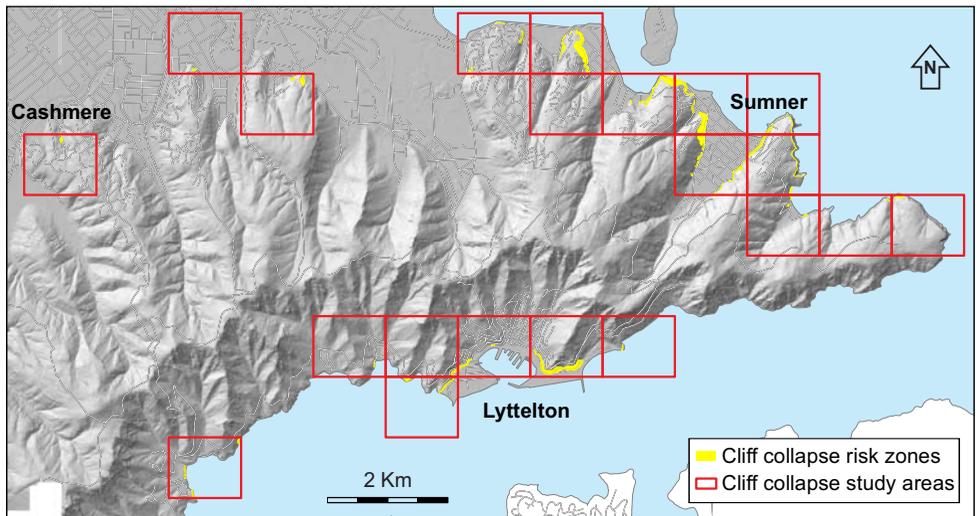
▲ Debris avalanche caused by cliff collapse (Raekura Place, Redcliffs) This landslide occurred in the main 22 February 2011 earthquake.

▲ Rock and debris falls on an approximately 50 m high cliff behind houses at the north end of Wakefield Avenue, Sumner.

Terminology

"Cliff-top recession" is used to describe the loss of land from the cliff top and consequent change in the cliff edge upslope.
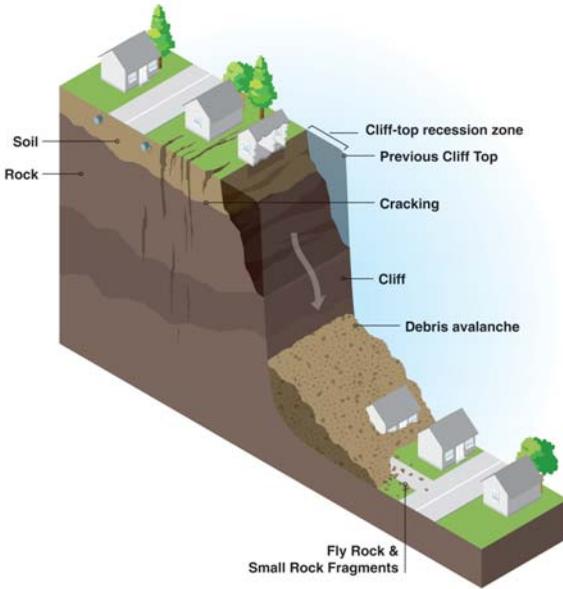
Cliff-top recession mainly occurs during earthquakes as witnessed during the 2010/2011 Canterbury earthquakes. In the next decade further recession of the cliff edge may continue as a result of earthquakes. Each time the cliff edge fails it moves further upslope, so too will the risk zones by an amount equal to that lost.

"Debris avalanche" is used to describe falling debris from the cliff face, many boulders falling simultaneously from a slope.

The two terms are collectively referred to as cliff collapse.

◄ Cliff collapse features referred to in the technical reports.

Annual individual fatality risk

In the technical reports risk is expressed as the annual individual fatality risk (risk of death). This is the probability (likelihood) that a particular individual occupying a dwelling will be killed by a cliff collapse in any year. This risk is expressed as logarithmic numbers such as 10^{-4} ("10 to the power minus 4") per year. Table 1 shows how some of these numbers translate into more familiar terms. For example, 10^{-4} is the same as one person in every 10,000 at risk of being killed each year.

Table 1. Different ways of expressing risk probabilities.

Probability 1 in... (per year)	Is the same as (per year)	Is the same as (per year)	Is the same as
1,000	10^{-3}	0.001 or 0.1%	8% per lifetime*
10,000	10^{-4}	0.0001 or 0.01%	0.8% per lifetime
100,000	10^{-5}	0.00001 or 0.001%	0.08% per lifetime
1,000,000	10^{-6}	0.000001 or 0.0001%	0.008% per lifetime

*Based on average New Zealand life expectancy of about 80 years, from 2008 mortality and population data

For more information on understanding risk concepts, see *Understanding life-safety risk concepts for rockfall and cliff collapse in the Port Hills (Summary Series 1/3)*.

What is the chance of being killed by cliff collapse?

Risk maps provided in the technical GNS Science reports show there are a number of dwellings located in the debris avalanche and cliff recession life-safety risk zones. Of these, a considerable number expose people to risk of greater than 1 in 1,000 per year under current seismic conditions. Refer to *Summary Series 1/3* for a comparison of risks across New Zealand.

The technical reports recognise that cracks at the cliff top might become cliff collapses at a later date, and that associated landslides might become more mobile. If these were to occur in some locations, such cracking could lead to failure of large areas of the cliff top and cause large debris avalanches to fall. While it is not possible at present to determine the likelihood of such failures, or indeed that they can occur, the Council is continuing to monitor and assess the risk. This will lead to an increased understanding of future potential instability.

▲ Shag Rock Reserve, Clifton Hill, Sumner.

How was the chance of being killed from cliff collapse determined?

The probability of a person being killed from cliff-top recession or debris avalanches was determined by:

1. Consideration of the possible range of cliff-collapse triggering events, including earthquake and non-earthquake events (e.g. rain);

2. Selection of a set of representative events for each type of trigger spanning the range of events from small to large; and

3. For each representative event, consideration of the following factors:

   For debris avalanche:

   a) the annual likelihood of an event occurring and the volume of material produced;

   b) the proportion of debris reaching/passing a given distance out from the bottom of the cliff and the probability of at least one of the boulders in the debris passing through a particular location;

   c) the probability that a person is present at that location when the debris moves through it; and

   d) the probability that a person will be killed if hit by at least one boulder as the debris passes.

   For cliff-top recession:

   a) the annual likelihood of an event causing an area of cliff top to be lost;

   b) the probability that a person is on the cliff top when it falls; and

   c) the probability that a person will be killed, if they fall.