Natural hazards in the Cardrona Valley

Summary Report November 2011

Introduction

The Cardrona Valley, located between Wanaka and Queenstown (Figure1), was first settled in 1882. Initially two settlements were established to service the mining industry in the upper valley township, located at the present-day Cardrona village and the lower township, next to Tuohys Creek.

The region-wide flood in September 1878 devastated the lower township, ruining houses, mines, and roads. This event heightened awareness of the flood hazard in the Cardrona Valley.

Today the valley is dominated by pastoral farming and tourism, with ski fields on either side of the valley. Cardrona Valley Rd follows the length of the valley and is an important link between Queenstown and Wanaka.

Development in the Queenstown-Lakes District has seen the number of lifestyle blocks in the valley also increase. The area's growing population and the accompanying demand for development increases people's exposure to natural hazards.

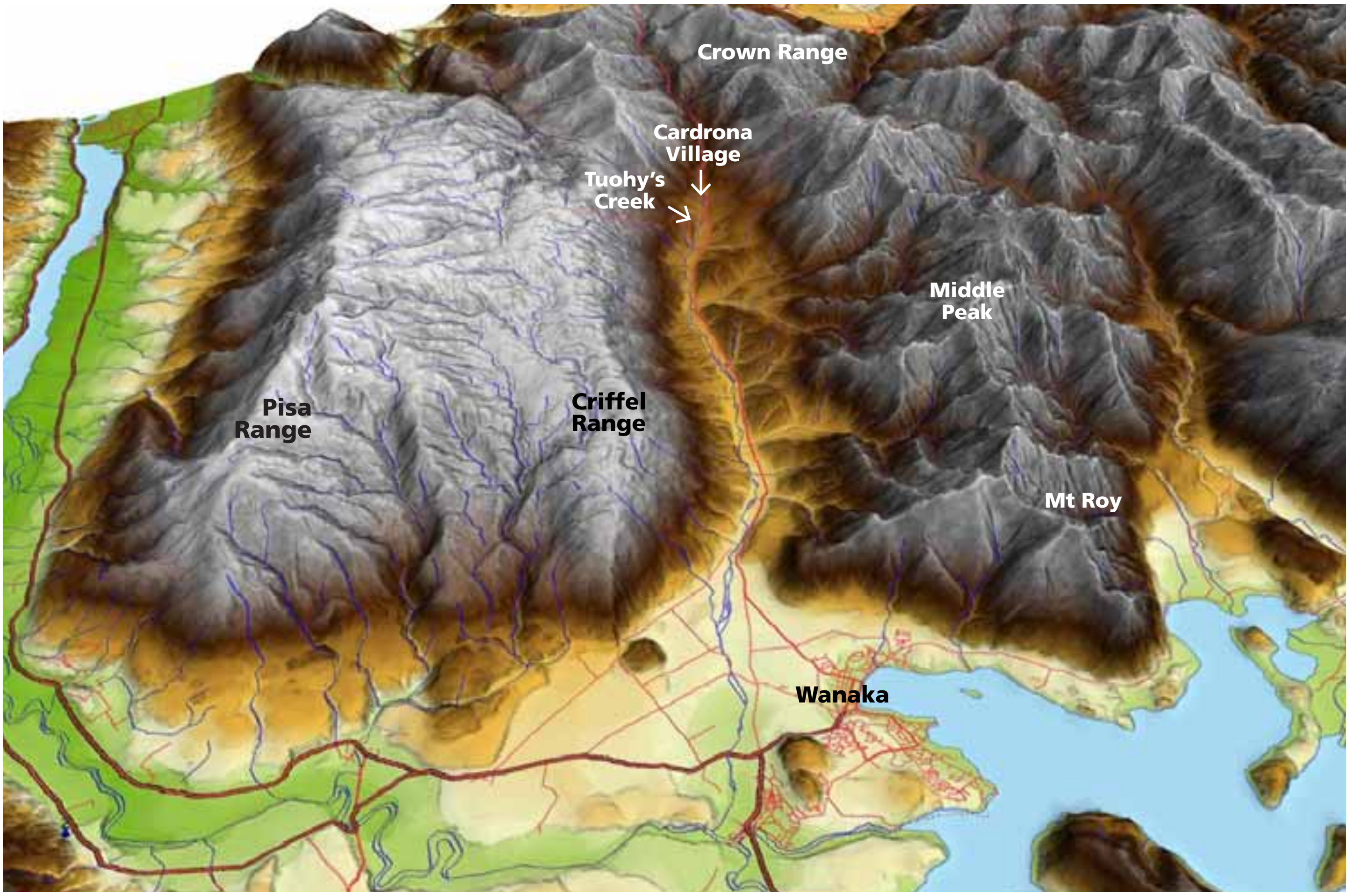


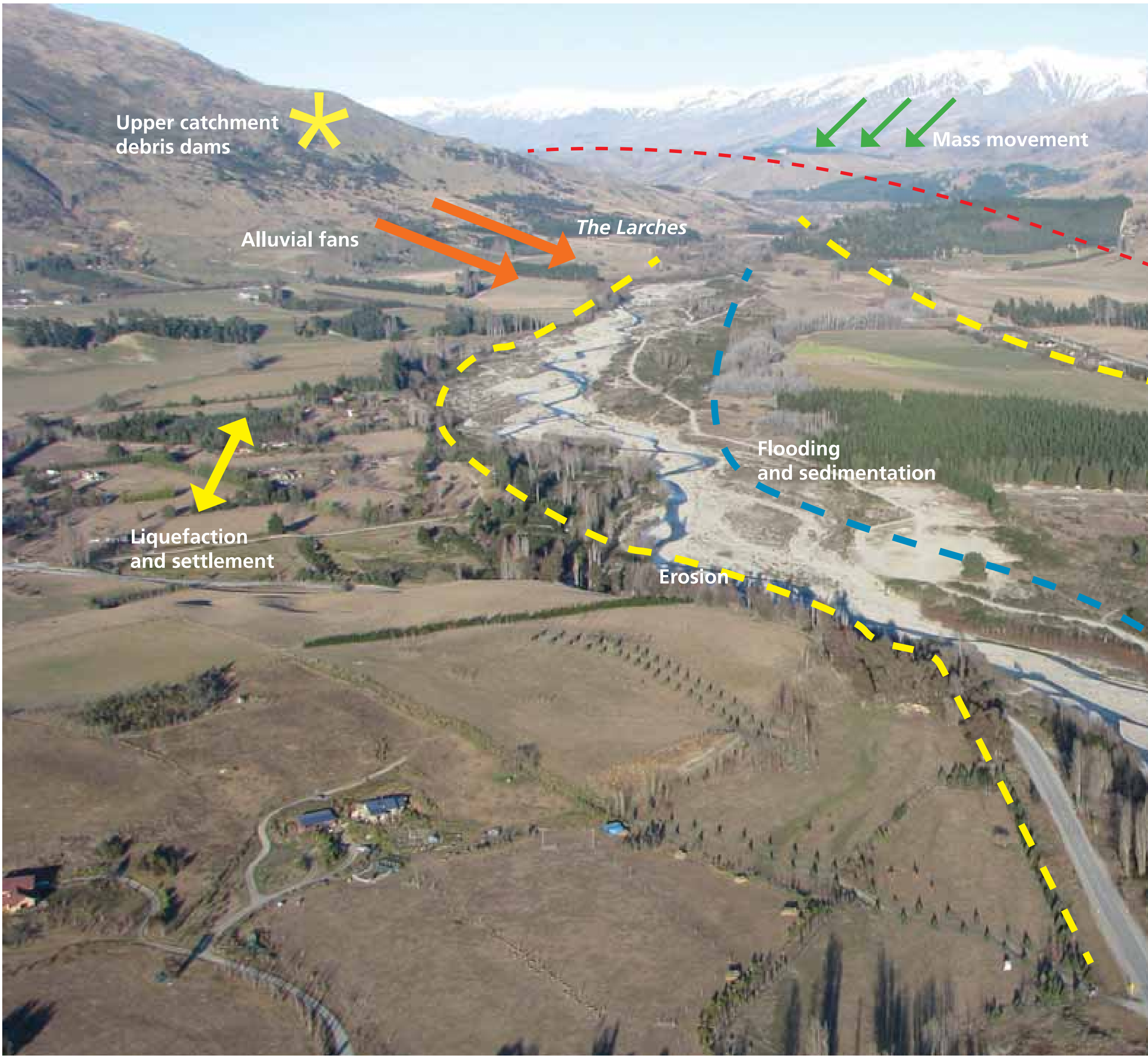
Figure 1. Cardrona Valley and surrounding landforms

Environment setting

The Cardrona River catchment, bound by the Crown Range to the south and west and the Criffel and Pisa Ranges to the east, drains an area of approximately 337km^2. The river flows northeast from its headwaters at the crest of the Crown Range to its confluence with the Clutha River/Mata-Au adjacent to Albert Town.

The flanking ranges rise to an altitude of just under 2000m and are composed of highly erodible schist (see glossary). These ranges have been uplifted by the active northwest and southeast Cardrona Faults (Figure 10). The Cardrona River and its tributaries have eroded into the basement schist. On the valley's lower slopes, fluvial terraces are eroding and contribute sediment to the river. Alluvial fans have formed at the base of these terraces, and at the confluence of many of the tributaries.

The Cardrona River form varies between a steep confined channel incised into bedrock in the upper valley through to a braided riverbed in the mid-lower reaches. Over recent decades, commercial gravel extraction between The Larches and the State Highway bridge has removed the complexity of the braided channel form.



The Cardrona Valley hazardscape

The Cardrona Valley has a complex hazard setting (Figure 2). Various parts of the valley are exposed to varying levels of flood hazard, alluvial fan hazard, debris flows, mass movement, and seismic hazards generated by earthquakes. Inundation, erosion, and sedimentation are all associated with flood hazard and can affect areas within the Cardrona River floodplain or its tributaries.

There are numerous large-scale landslides throughout the valley which can reactivate during periods of extended heavy rain when the ground becomes saturated, or when triggered by seismic events.

Increased demand for development in the valley raises the area's risk profile. Further intensification or spread of development may increase this risk unless suitably mitigated. The increased demand for development, as well as the dynamic environmental setting, has prompted this report to raise awareness of the area's vulnerability and to inform decision-making.

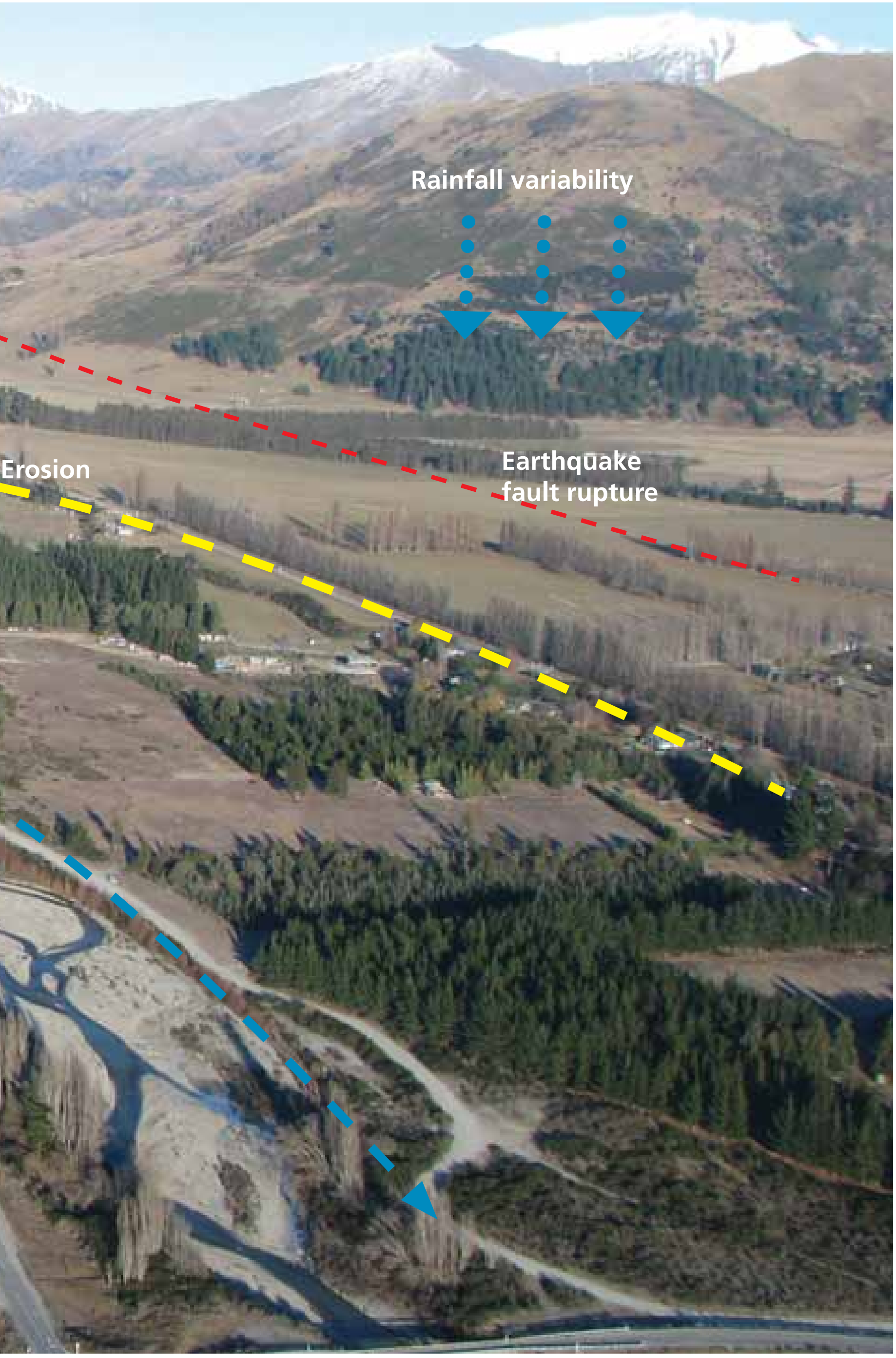


Figure 2. Natural hazards in the Lower Cardrona Valley. Photo taken looking upstream with the Ballantyne Rd bridge visible in the bottom right.

Flood hazard area

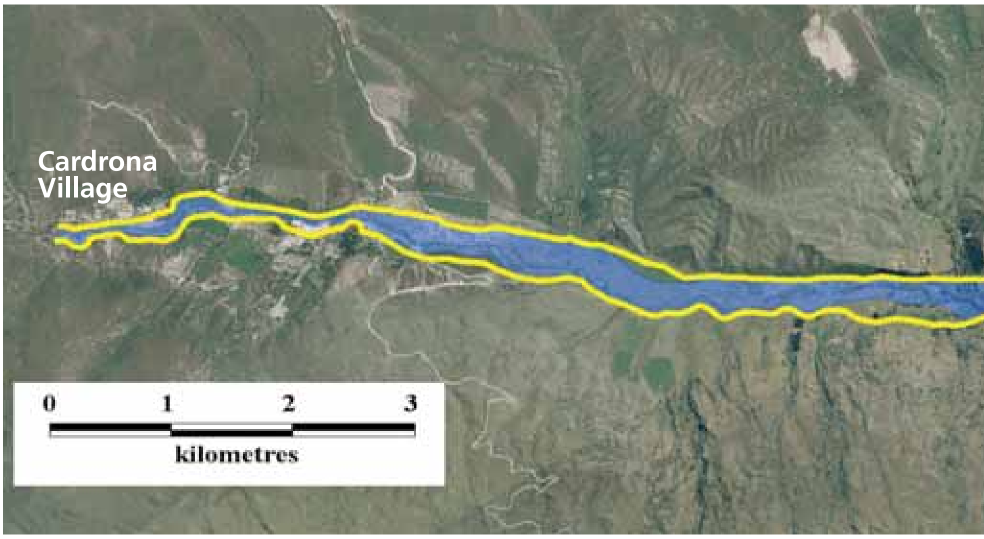
Erosion hazard

High

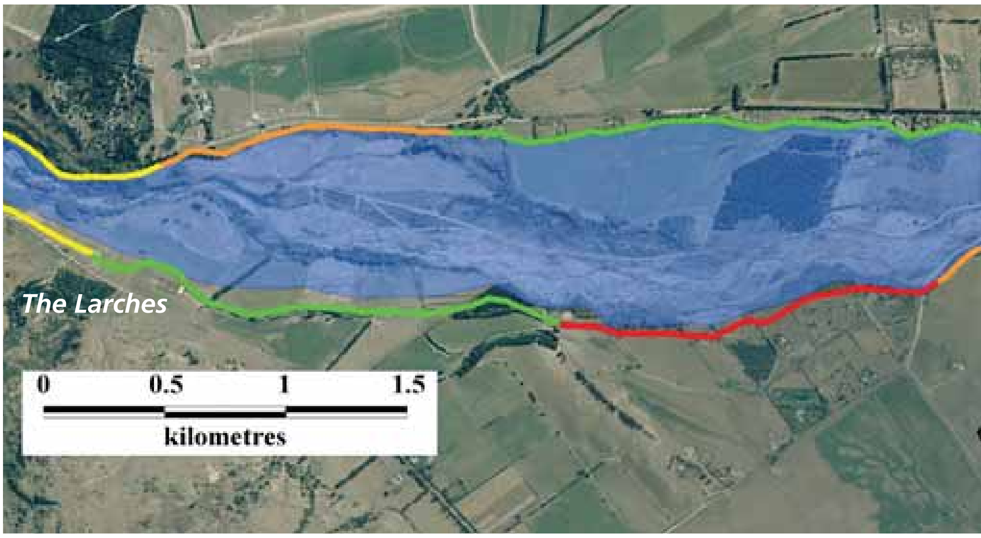
Moderate

Low

Indicative
(not categorised)



Joins to Figure 3



Flooding

Flood hazard includes inundation, erosion, and sedimentation. The extent of flood hazard can vary considerably during each flood event due to variations in flow, sediment supply, and the changing geomorphology (physical features) of the surrounding environment.

The area subject to flood hazard and erosion has been identified along the length of the Cardrona River and represents locations that may be subject to flood inundation, sedimentation, and erosion during a flood event (Figures 3 and 4).

In the upper catchment above Cardrona village, the confined nature of the channel and rapid sedimentation from tributary streams can result in channel blockage and debris dam formation (Figure 5).

In the mid reaches of the river between the village and The Larches, the valley widens and has a lower gradient therefore flood flows can move unpredictably across the floodplain, depositing sediment and debris (Figure 6).

Sediment input from the tributaries in this reach can cause in-channel sedimentation resulting in elevated flood levels, and causing flood water to move across the floodplain.

At The Larches the river is confined, so that during floods high water velocities can cause significant bank erosion.

Downstream of The Larches the river form adopts a braided channel which moves easily across the floodplain, causing both sedimentation and bank erosion (Figure 7). The frequency and magnitude of flood events is directly related to the rainfall events which cause them.

Climate scientists predict that average annual rainfall in western Otago will increase during the coming century (MfE, 2008[1]). Heavy rainfall events are also projected to become more frequent, and may become more intense.

1 Ministry for the Environment 2008. Preparing for climate change: A guide for local government

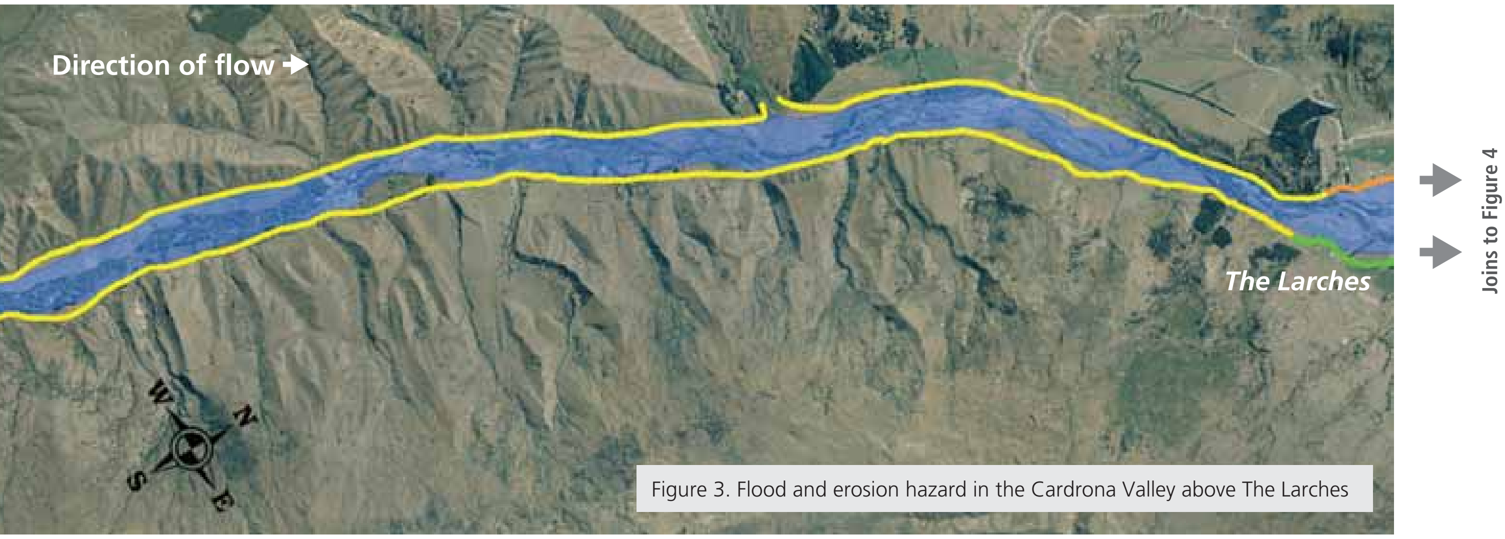


Figure 3. Flood and erosion hazard in the Cardrona Valley above The Larches

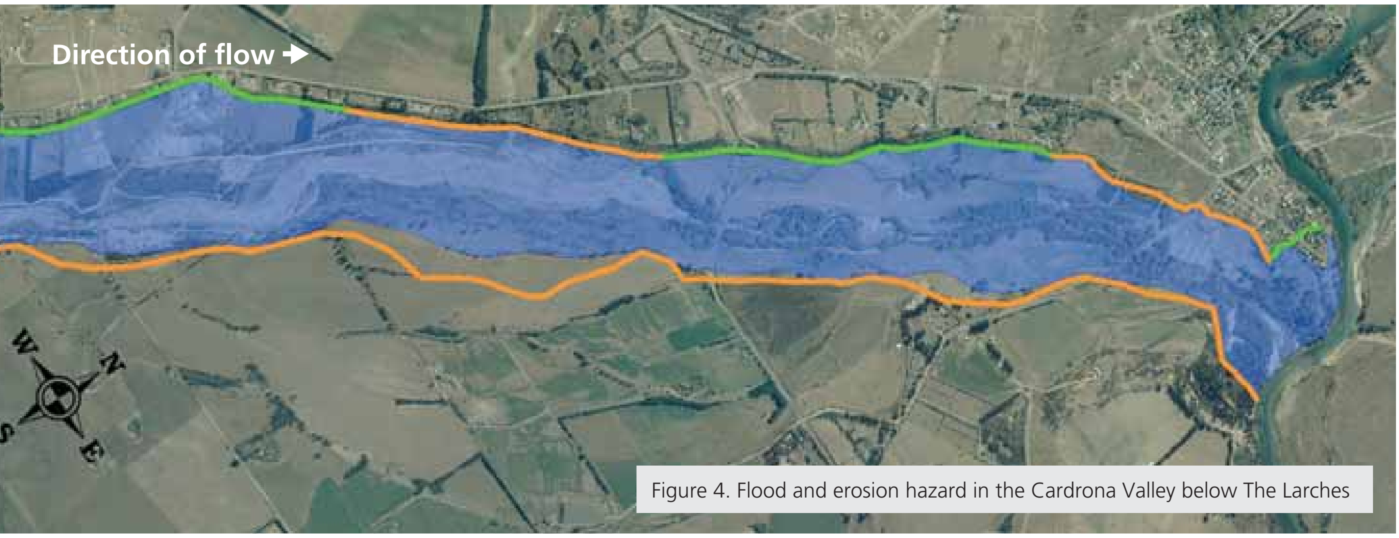


Figure 4. Flood and erosion hazard in the Cardrona Valley below The Larches

Erosion

Areas subject to erosion hazard adjacent to the Cardrona River are shown in Figures 3 and 4. Bank erosion has been categorised as high, moderate, and low based on channel morphology, on-site investigations and aerial photographs.

Erosion classifications are:

High – Erosion risk is mapped where the channel is adjacent to the river bank resulting in active erosion

Moderate – Erosion risk is mapped near the river bank or where it is considered that channels have the potential to move laterally towards the river bank.

Low – River bank erosion risk is low in these areas and is associated with sections of river bank that are unlikely to be exposed to lateral movement of the channel in the near future. These are typically higher-level floodplains which separate the river bank from the active channel.

Indicative – Erosion risk has not been categorised upstream of The Larches as damage resulting from lateral movement of the river is likely to be restricted to roads and bridges in this area.

The extent and likelihood of erosion depends on the nature and magnitude of the flood event and can change over time.

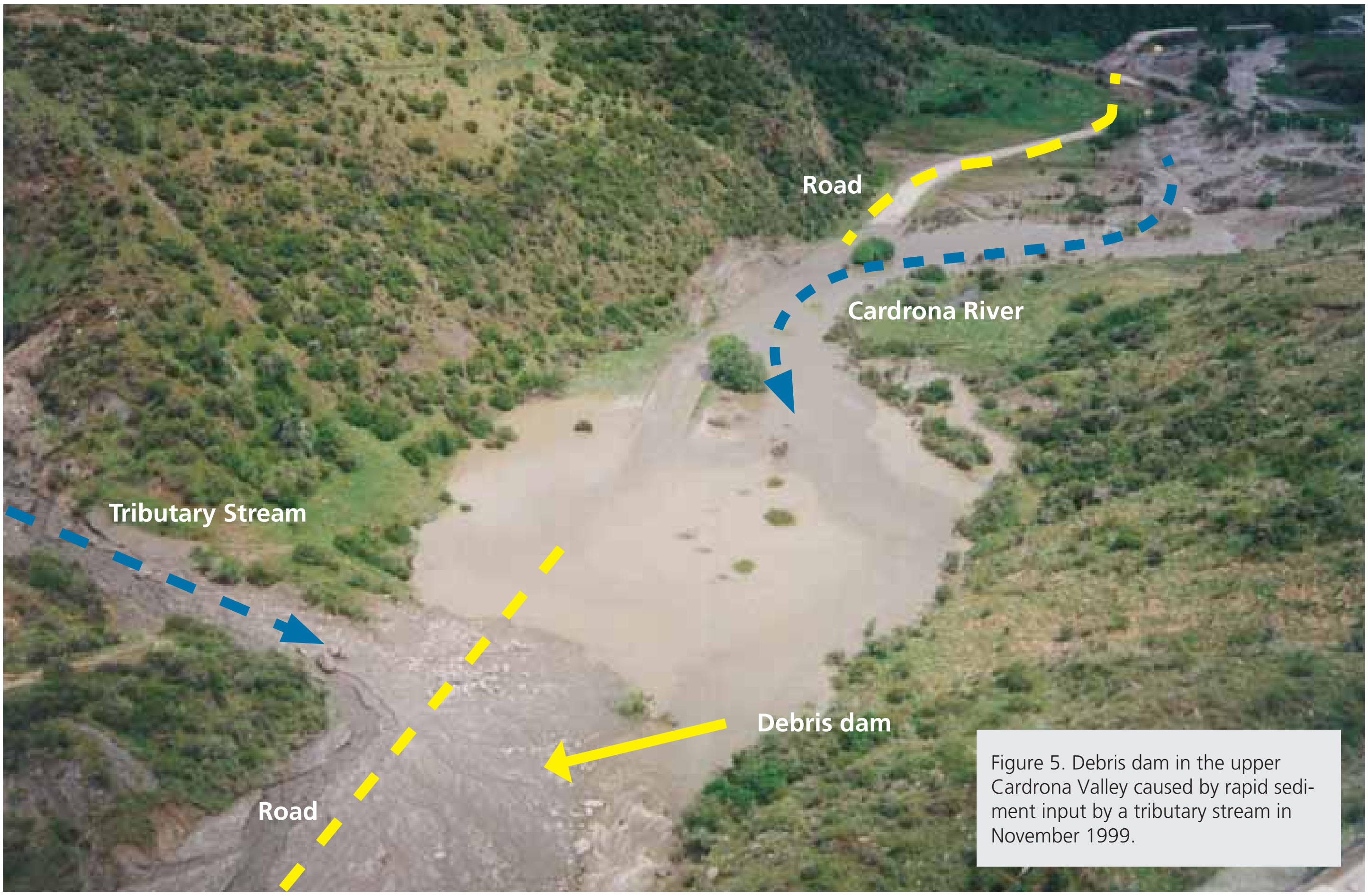


Figure 5. Debris dam in the upper Cardrona Valley caused by rapid sediment input by a tributary stream in November 1999.

Figure 6. Flood flows and sedimentation across the floodplain in November 1999.

Figure 7. Bank erosion on the east bank of the Cardrona River between The Larches and Ballantyne Rd (November 1999).

Alluvial fans

An alluvial fan is an accumulation of river (alluvial) sediments which typically forms in the shape of an open fan or cone. It occurs where a stream leaves the confines of a valley, loses energy, and deposits sediment (Figure 8). Alluvial fans are usually elevated above the valley floor and have good drainage. While this makes them attractive places for development people often fail to fully appreciate the potential alluvial fan hazard.

Flood and debris flows on alluvial fans are infrequent, but can occur without warning and be destructive. Flood and debris flows can leave the channel (avulse) and affect any part of the fan surface. Alluvial fans are common in the Cardrona Valley where tributary streams enter the main valley, supplying sediment to the floodplain.

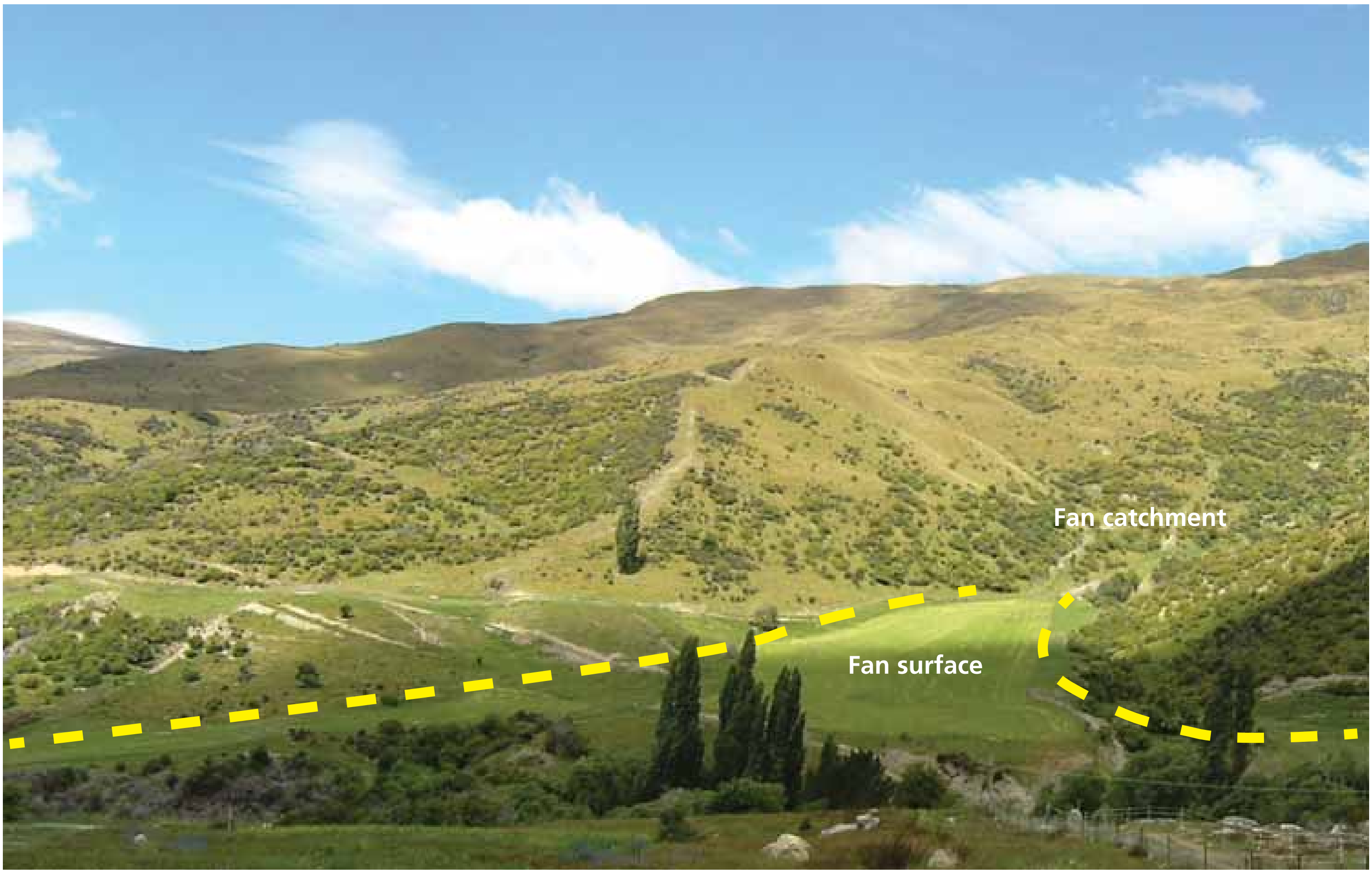


Figure 8. Alluvial fan in the lower Cardrona Valley

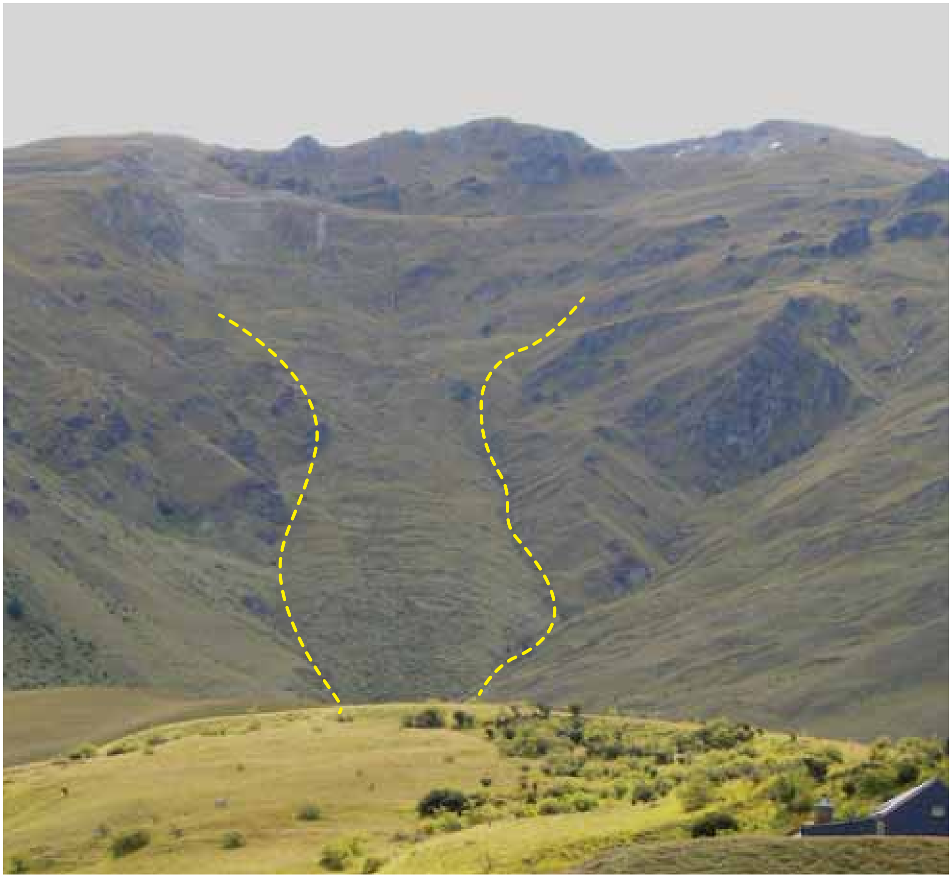


Figure 9. Large landslide deposit, formed by periodic failure and progressive erosion of active slopes in a tributary of the Cardrona River, Crown Range.

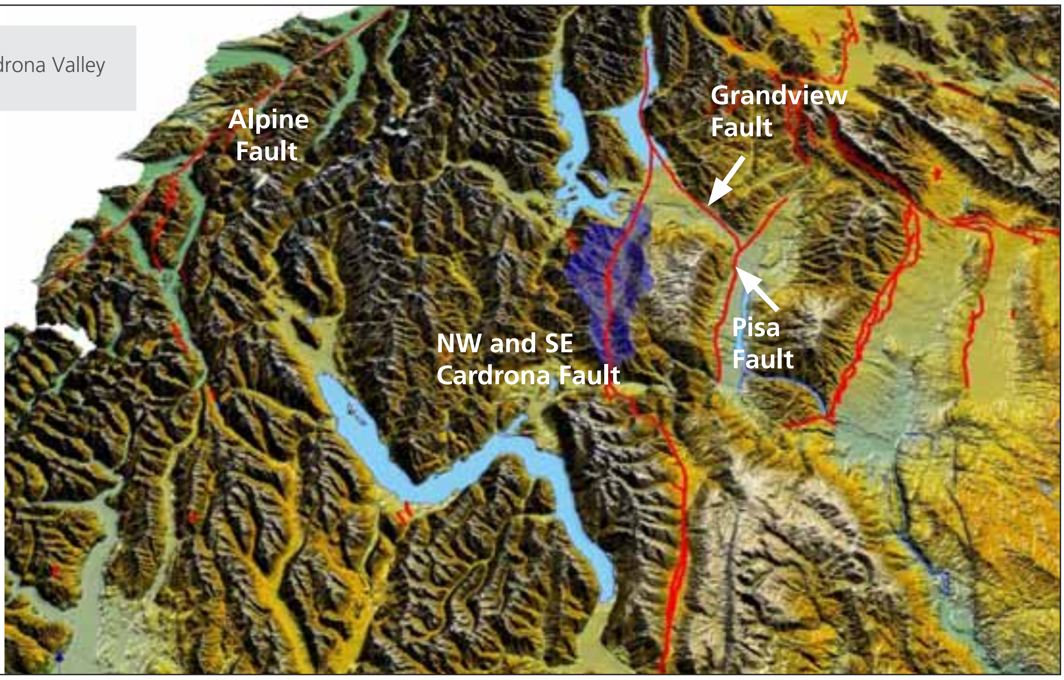
Mass movement

Mass movement is widespread throughout the valley. Large schist landslides flank the valley sides (Figure 9), which have been formed through geological activity and incision of the Cardrona River and its tributaries.

Landslides are usually triggered by seismic events or failure of saturated ground during periods of extended heavy rainfall, or sometimes due to a combination of both. Landslides can contribute large volumes of sediment to the valley floor and waterways.

The landslide risk to people and property in the valley is variable and needs to be determined on a site-specific basis.

Figure 10. Active faults near the Cardrona Valley



Earthquakes and seismic activity

Seismic activity affecting the valley is most likely to originate from the Alpine fault or the northwest and southeast Cardrona faults (Figure 10). The level of risk depends on the magnitude, location, depth, and type of earthquake as well as the underlying ground. Earthquake hazard includes fault surface rupture, landslides, liquefaction, ground shaking and rockfall.

The Alpine fault can produce large magnitude 8 earthquakes every 200-300 years. The NW and SE Cardrona faults have an estimated recurrence interval of about 7,500 years for magnitude 7.1 events. An event of this magnitude is estimated to cause up to 2m of displacement along the fault.

Summary

The Cardrona Valley is subject to a range of natural hazards including flood inundation, sedimentation and erosion, alluvial fan hazard, mass movement, and seismic hazards. The report "*Natural Hazards in the Cardrona Valley*" (December 2010) describes these in more detail and discusses their variable and dynamic nature. While many of these hazards are known, factors such as climate change will alter the nature and frequency of these hazards.

Glossary

Fluvial: Produced by the action of a river or stream

Liquefaction: The process by which sediments and soils collapse from a sudden loss of cohesion. Deposits lose strength after being transformed to a fluid mass often by seismic shaking.

Mass movement: The downhill movement of surface materials under the influence of gravity often induced or assisted by saturation of the slope.

Schist: Medium to coarse grained metamorphic rock composed of laminated, often flaky parallel layers.

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