Executive Summary

This report is a 2nd version of the original report produced in July 2007 and is a complementary document that helps put the Stage 3 Report, "Otago Alluvial Fans Project: Supplementary maps and information on fans in selected areas of Otago" into context. This report provides information on what was completed in Stage 1 of the project including background information regarding alluvial fans within Otago and their associated hazards.

An alluvial fan is an accumulation of river or stream (alluvial) sediments that form a sloping landform, shaped like an open fan or a segment of a cone. Alluvial fans typically occur near the boundary between hillslopes and valleys. They owe their origin to changes in the slope of natural drainage systems, for example where a steep gully merges onto a flatter valley floor. The gradient decrease and widening of the flood path where a gully meets a valley floor encourages the deposition of sediment. Over time, sediment accumulates to form a fan-shaped landform, with its apex at the gully mouth. Alluvial fans form on all scales, from a few tens of metres across, to several kilometres across.

Alluvial fans evolve and change through time, at time scales ranging from the geological (i.e. thousands of years) to the historical (years to centuries). The prime factors controlling the evolution are topographic (landscape) setting, climate, the size and geology of the catchment, and sometimes vegetation changes within catchments. Alluvial fans may evolve rapidly in short periods, with sediment deposition and the lateral displacement of streams during flooding, or may remain dormant or only intermittently active for long periods.

Alluvial fan flooding is a type of flood hazard that occurs only on fans and is characterised by flow-path uncertainty so great that the unpredictability must be considered in realistic assessments of flood risk or in the reliable mitigation of the hazard. Flooding on alluvial fans can be more damaging than other types of flooding because alluvial fans have steeper gradients than river floodplains. Water and entrained debris on alluvial fans can flow faster, and has a greater density, than is the case in river floodplains. A considerable amount of sedimentation may also occur in conjunction with alluvial fan floods. The principal hazards on alluvial fans are inundation by flood water, debris flow and debris flood deposits, channel migration, deposition and erosion. In terms of threat to life and destructive potential, debris flows are the greatest concern, however, depending on the characteristics and extent of development on an individual alluvial fan, the economic costs of each hazard will vary.

The Otago Regional Council commissioned Opus International Consultants and GNS Science to assess and report on the risk that alluvial fans pose to Otago communities. A regional assessment was carried out at 1:50,000 scale utilising previous geological mapping, aerial photo and map observations, and the combined local knowledge of the GNS Science-Opus project team. This report explains what alluvial fans are, exemplifies the different types of alluvial fan that occur in Otago, shows how alluvial fans can be identified, discusses the hazards posed to Otago communities from alluvial fans and outlines some of the ways that the risk can be mitigated. A Geographic Information System (GIS) map database was compiled, with 2197 separate fan areas identified and classified. There are 1970 km^2 of significant alluvial fan landforms in the Otago landscape, amounting to approximately 6% of the Otago land area.

The alluvial fans in Otago have been classified according to the type and activity of deposition processes that have formed a particular fan, because these criteria have the greatest bearing on the hazards present. The categories used are based on dominant processes interpreted on the fan, being either debris-dominated, floodwater-dominated or composite. A generalised map of these fans accompanies this report, using this classification scheme, but more detail can be obtained from the GIS dataset. The classification scheme is illustrated in this report with seven examples of alluvial fans from throughout Otago. The debris-dominated examples are the Pipson Creek fan and Mill Flat fan, in the Queenstown Lakes District area. The floodwater-dominated examples are the Milton fan in the Tokomairiro plain and the Pukeuri fan complex in North Otago. Composite fan examples where there is a combination of debris flow and floodwater flow processes include the North Roxburgh fan complex and the Stoney Creek fan in Wanaka. The Waikerikeri fan is introduced as an example of a large fan whose surface is for the most part old and inactive, but has been cut into by young active stream channels.

Much infrastructure and development is found on alluvial fans in Otago. These landforms form attractive places for development because they are elevated, scenic and have good drainage. Flooding processes including debris flows, sudden channelised flow, channel migration, and sheet flow will occur on a number of these fans and will not only be a threat to life but will also affect infrastructure. This could have significant consequences for Otago communities and steps are required to mitigate these hazards.

The first step to mitigating the hazards has been addressed by this assessment. Presently the public awareness of alluvial fan hazards is very low. Education is needed because fans are only intermittently active, and hazard definition and mitigation can be difficult. The identification of Otago's alluvial fans and the problems associated with them is the first stage of raising public awareness of the issues. This study provides a provisional classification of alluvial fan activity. Rather than defining site-specific hazards, the accompanying GIS dataset defines locations where alluvial fan-related hazards may exist, together with a prediction as to the nature of that hazard. The assessment is appropriate for regional scale planning and development purposes but should not be used as a substitute for site specific investigations and/or geotechnical engineering assessment for any project.

The next step in mitigation is to evaluate the risk on each fan. Site specific investigations and fieldwork are required to provide qualitative hazard evaluation, and identify the risk posed by alluvial fan hazards to infrastructure and human life. Where there is a low risk it may be appropriate for no further mitigation other than to be aware of the hazards. In high risk areas mitigation measures may include such steps as increasing public awareness, implementing a hazard warning system or a hazard management plan, better land use management, modifying infrastructure, installing engineering works, or hazard zoning.

Alluvial fans are going to continue to evolve, in response to natural processes including climate and earthquakes, with modulation by human factors such as changes in land-use and vegetation. For the present time we can expect increased human development on alluvial fans within the next 100 years. Human-induced changes are likely to be the most important influence on alluvial fan processes in the relatively short timescale of importance for land-use planning and management.