11TH IAG INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY

FIELDTRIP GUIDE

ENGINEERING GEOMORPHOLOGY AND ALPINE HAZARDS AROUND ARTHUR’S PASS, SOUTHERN ALPS

2026

IAG GEOMORPHOLOGY · ANZGG Australian & New Zealand Geomorphology Group · manatiaki kōawa rivers GROUP

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Cover Photos: Wairongomai-Mangarara (Credit: Ian Fuller), Aoraki Mt. Cook National Park (Credit: Sam McColl), and Waikato at Taupo (Credit: Sarah McSweeney).

Mid-conference fieldtrip: Engineering geomorphology and alpine hazards around Arthur's Pass, Southern Alps.

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View of mountains west of Arthur's Pass, showing steep alpine slopes and evidence of active erosion processes typical of the area.

Introduction

The field trip will take participants along State Highway 73, one of the three main road passes for the Southern Alps (Figure 1). In doing so, the trip covers a diversity of landscapes and features of geomorphic interest. We will begin by driving across the dry and flat eastern Canterbury plains, then wind our way through the foothills and cross the main range at Arthur's Pass, to eventually cross the Alpine Fault plate boundary, and enter the hyper-humid West Coast front range. The landscapes covered include the outwash plains of the Canterbury hinterland, the Southern Alps foothills, tectonic basins and karst landscapes, glaciated landscapes, alluvial fans, and a transit through steep, mountainous relief. The focus will be on the natural hazards and consequent risk affecting the highway and small settlements, produced by the combination of active tectonics, high erosion, and high rainfall landscapes, particularly earthquakes, rockfall, rock avalanche, and debris flow hazards.

1.1 Itinerary

The table below provides indicative timings for the trip. The main stops (of geomorphic interest) are denoted by bold numbers and can be read in conjunction with the map in Figure 1.

Stop	Arrive	Depart	Activities/sights
Pick up at Te Pae		0740	
Springfield	0850	0900	Quick stop for those needing toilet.
(1) Porter's Pass	0920	0940	Porters Pass fault and EQ hazards.
(2) Kura Tawhiti Conservation Area	0955	1030	5-minute walk. Castle Hill basin tectonics and geology, and tor formation. Toilet available.
(3) Lake Pearson	1045	1110	Discuss alluvial fan formation and hazards. Toilet available.
(4) Waimakariri River Bridge	1130	1150	Glacial history, fluvial / braided river processes and flood hazard.
Arthur's Pass	1200	1215	Toilet stop.
(5) Moana, Lake Brunner	1320	1420	Picnic lunch at Lake Brunner. Toilet available. Lake formation and EQs.
(6) Lake Poerua	1440	1500	Alpine Fault scarp
(7) Otira Viaduct Lookout	1535	1610	5-minute steep walk. Overview of Otira landslide and viaduct.
Arthur's Pass	1630	1640	Toilet stop.
Te Pae, Christchurch	1845		Drop off at Te Pae. Option for brief stop at Springfield for toilet.

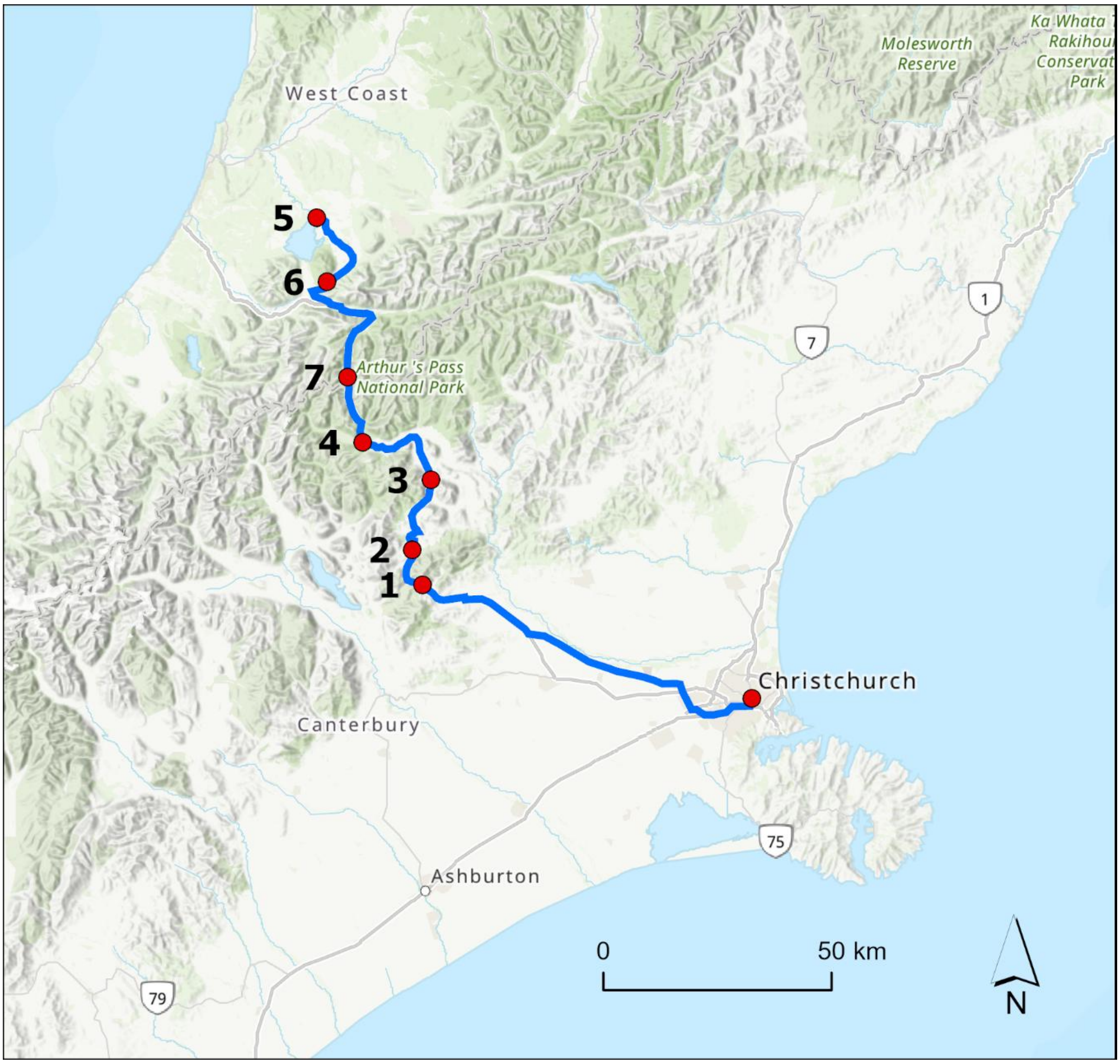

Figure 1 Overview map showing the route taken and main stops. 1 = Porter's Pass; 2 = Kura Tawhiti; 3 = Lake Pearson; 4 = Waimakariri Bridge; 5 = Lake Brunner; 6 = Lake Poerua; 7 = Otira Viaduct.

1.2 Overview of geological setting

The field area is a landscape where tectonics, climate, and glacial history converge to create one of New Zealand's most dynamic alpine environments, well accessible along State Highway 73. The bedrock comprising the mountains of the main divide is dominated by the Torlesse Terrane, a Late Triassic assemblage of indurated marine sandstone and argillite of deep sea turbiditic origin, commonly referred to as greywacke. These progressively give way to more metamorphosed semischists and schists heading west towards the Alpine Fault plate boundary. West of the plate boundary (on the Australian plate) the basement rocks include older sedimentary, metamorphic, and plutonic rocks. The greywacke rocks, in particular, are often steeply dipping, intensely fractured and with shear zones that make the slopes highly susceptible to erosion and slope failures (Paterson, 1996).

East of the main divide, the Castle Hill Basin presents a striking geological contrast to the surrounding mountains. Here, Oligocene carbonate sediments were deposited around 30–40 million years ago, when much of New Zealand lay beneath a shallow sea. These limestones overlie the greywacke basement and in this location are located within a structurally-controlled basin, which has preserved them from uplift and erosion. Castle Hill limestone has been sculpted by karst processes—chemical dissolution, cavern development, and block collapse—into the distinctive tors, pavements, and solution features that define the landscape today. The basin is not only a geological showcase but also a cultural site of significance to Ngāi Tahu, known as Kura Tāwhiti, with rock art and traditional travel routes preserved among the outcrops.

This landscape and associated hazards are strongly influenced by the region's tectonic setting immediately east of the plate boundary. Several active faults cross or pass close to the area, including major structures like the Alpine Fault (plate boundary), Hope Fault, and Porter's Pass Fault. These, and several other active faults, accommodate the high tectonic strain rates across the Southern Alps. The Alpine Fault, in particular, accommodates around 70% of the strain, accumulating an average of 30 mm per year of dextral slip and 6–10 millimetres per year of uplift. This uplift is matched by rapid erosion (Van Dissen & Yeats, 1991; Adams, 1980), producing steep, high relief slopes, and a very dynamic landscape.

The faults also contribute to the high seismic hazard of the area, and major historical earthquakes include the 1929 M_W 7.0 and 1994 M_W 6.7 Arthur's Pass earthquakes. These earthquakes triggered widespread landslides, including the ~60 million cubic metre Falling Mountain Rock Avalanche triggered in the 1929 earthquake (Figure 2). The rock avalanche occurred some 10 km northeast of Arthur's Pass village and had a 4 km long runout (Dunning, 2004).

Figure 2: Falling Mountain Rock Avalanche, triggered during the 1929 Arthur's Pass Earthquake. The rock avalanche is some 10 km northeast of Arthur's Pass village. Photo: LD Homer.

The geomorphology of the area today reflects both its tectonic activity and its glacial legacy. Te Waipounamu | South Island, New Zealand was heavily glaciated during mid- to late Pleistocene ice ages. At the peak of the last ice age about 1/3 of South Island was glaciated (e.g. Barrell, 2011). The most famous glaciers are those of the West Coast (Franz Josef and Fox) and of the Mackenzie District (Pukaki, Tekapo, Ohau) but there were large glaciers in each of the Canterbury braided valleys. In all cases, the glaciers reached the edge of the Canterbury Plains during the last glaciation maximum at about 26 ka (Rother et al., 2015) and pre-last-glaciation advances extended many kilometres on to the plains.

Several of the catchments seen along SH 73 were extensively glaciated during the last (Otiran; 74-14 ka) glaciation with the local higher peaks protruding above the ice as a series of nunataks. During the Pleistocene, ice carved broad parabolic-shaped valleys in the main catchments, leaving cirques, moraines, and oversteepened valley walls. Holocene advances left morainic ridges in Bealey Valley (Barrell et al., 2011), which we will see from the road. Since deglaciation, fluvial incision, frost shattering, scree accumulation, and debris flows have reshaped the slopes. Few small glaciers remain in the high alpine catchments, and winter snowfalls can affect the entire highway. High precipitation—exceeding 7000 mm annually west of the divide—drives landslides and debris flows creating a hazard along the highway and for the local settlements. Winter snow avalanches and freeze–thaw cycles add further instability and sediment generation, and additional mass movement hazards in the winter.

High sediment loads create active alluvial fans and dynamic gravel-bed and braided rivers, with potential for major flood and aggradation events. For example, the 1957 flood when the Otira River bed rose several metres in a matter of hours (Whitehouse & McSaveney, 1992). The high sediment loads of the major eastward draining Waimakariri River, has contributed to the construction of the Canterbury outwash plains between Christchurch and the foothills, and continues to require active management against flooding.

1.3 Overview of natural hazard risk setting

State Highway 73 through Arthur's Pass is one of just three routes across the Southern Alps, and, along with the adjacent Midland rail line, connects the isolated West Coast Region to the rest of South Island and the main urban centre of Christchurch (Figure 3). This connection is essential to support and maintain key industries on the West Coast, most notably tourism, dairy, and mining, which in 2024 contributed over $800 million to the regional economy and employed ~4000 people (Infometrics, 2025). A lack of safe deepwater ports and international airports on the West Coast mean these industries rely heavily on the road and rail routes through Arthur's Pass to enable national and international exports of dairy and mining products from Port Lyttelton and Christchurch International Airport. State Highway 73 also forms the important tourist loop connecting Christchurch, the West Coast Region and Queenstown.

Figure 3: Critical transport infrastructure across New Zealand. The lack of redundancy in routes across the Southern Alps makes the road and rail links through Arthur's Pass critical pinch points.

The numerous potential hazards through Arthur's Pass present a key risk for the West Coast Region and the whole of South Island. In particular, a major earthquake on any of the numerous faults in the area has the potential to block transport routes and isolate large numbers of people, both in the West Coast Region and through the pass itself. Most work has focussed on the potential consequences of a future earthquake on the plate boundary Alpine Fault, for which there is a 75% chance in the next 50 years (Howarth et al., 2021). Modelling suggests a combination of fault surface rupture, strong ground shaking and landslides could cause direct damage to road and rail infrastructure throughout the pass (Robinson et al., 2015), with expectations that the pass itself will be closed for >6 months before repair work can begin.

Field trip sites of interest

Stop 1: Porter's Pass Fault

At Porter's Pass, we will travel alongside the trace of the Porter's Pass Fault, one of the larger active faults in the area (Figure 4). It is believed to have last ruptured about 500-600 years ago with a likely recurrence interval of about 1500 years (Howard et al., 2005). Earthquakes on this fault are significant (estimated to be M > 7). The slip rate for the fault is estimated at 3.2-4.1 $mm.yr^{-1}$. With the overall southern propagation of the plate boundary (due to oblique convergence), it is expected that the Porter's Pass Fault will become more active over time, transferring slip from the Hope Fault (currently the dominant transform fault in the Marlborough Fault system).

Here, the road climbs steeply from the Canterbury Plains into the foothills of the Southern Alps, crossing the fault and cutting through active slopes. Concrete retaining walls protect the road from active scree slopes, but provide little protection from larger earthquake- or rainfall-triggered slope failures. This section of SH73 presents a major bottleneck with any closure resulting in a >500 km detour via SH7 and the Lewis Pass to the north.

Figure 4. Trace of the Porters Pass Fault from Porter's Pass. This fault has been trenched and its recurrence interval (c. 1500 years) and magnitude of ruptures (> M 7.0) determined (Photo: J Shulmeister).

Lake Lyndon at the bottom of the hill beyond Porter's Pass is a shallow alluvial fan constrained lake. The Lyndon valley was definitely glaciated at its western (Rakaia) end, but the area around Lake Lyndon was either never glaciated or the glaciations were so long ago that we cannot see any obvious evidence of their existence. A series of small hummocky deposits north of Lake Lyndon just before the turnoff to Porter's Pass ski field are indicative of either moraine or landslide deposit, with the later a more likely source.

As we continue towards the Castle Hill area we will observe numerous mass movement landforms. There are some excellent examples of debris flows with well developed levees. These erosional features start as deep gullies high on the hill side with the debris provided by the very friable Torlesse rocks. Alluvial fans are also noteworthy but the most spectacular examples of these are closer to Cass. From a risk perspective, here the road is joined by a 66 kV electrical transmission line, one of only two supplying the West Coast Region, with support pylons often placed on highly active alluvial and debris flow fans suggesting the potential for power loss as well as isolation.

Stop 2: Kura Tawhiti Conservation Area

A short walk here takes us to view some spectacular karst landforms, within Castle Hill Basin. While not a ‘natural hazards’ focussed stop, this location is scenically interesting and a chance to see some quite different geomorphology to the rest of the trip. The Castle Hill Basin is a tectonic depression bounded by several fault-controlled ranges, and has allowed the sediments in this area to escape the uplift and erosion that has removed the cover rocks from most other places of the South Island. The majority of the South Island (and remainder of New Zealand) was almost fully submerged during the Oligocene, during which marine clastic and carbonate sediments accumulated over the basement rocks. Following the onset of the Kaikōura orogeny, uplift and erosion has removed most of these cover rocks, but in about 15% of the South Island these cover rock still can be seen, where uplift has been relatively more benign. Here, the tectonic downfaulting of the basin has allowed the preservation of the limestones that form this karst landscape.

Deformation of the rocks in the basin from faulting and folding is indicated by the visibly tilted strata, which we will gain nice views of farther along the road (Figure 5). This tilting, in combination with weathering, has created some spectacular karstic landforms in the basin area, including tors, disappearing streams, and caves. The tors in this area, likely produced from preferential subsurface weathering of joints and subsequent exhumation, are numerous and the diversity of shapes have created a popular tourist destination (Figure 6). They are also popular for bouldering (rock climbing); there is said to be more than 20,000 ‘boulder problems’ in this area making it a world-class destination for rock climbers. Closer inspection of the tors reveals a variety of karst weathering features.

Figure 5: Castle Hill Basin (just east of Stop 2), showing the folded and faulted sedimentary cover rocks and more recent Quaternary deposits, dissected by streams. The snow-covered Cragieburn Range creates the backdrop. State Highway 73 can be seen in the centre of the photo. Photo: D. L. Homer.

Figure 6: Example of tors formed within the limestone rock of Castle Hill basin. Photo: D. L. Homer.

Farther along SH 73, we pass several actively retrogressing landslides that have developed as a result of toe erosion, either from stream incision or quarrying (Figure 7). The initial trigger and age of initiation of these landslides is unknown, but geomorphologically, they appear to be relatively recent, and have potential to retrogress farther upslope in the future.

Also visible, as we reach the other side of the hill approaching Cave Stream, there are an impressive series of river terraces with a distinctly underfit stream (Cave Stream) in the valley (Figure 5 and Figure 8). Karst processes have resulted in Cave Stream entering a cave, making Cave Stream Valley a blind valley. Nevertheless, the underfit nature of the stream relates neither to the tectonics nor karst processes. It is because this valley used to carry glacial melt-water from Craigieburn (River) during the peak of the last ice age. At that time, ice from the Waimakariri Glacier (specifically the Winding Creek Lobe) occupied the area of the Craigieburn Cutting (which we will travel through shortly) and diverted the Craigieburn that currently flows down the cutting, into Cave Stream. The combination of outflow from the glacier and the flow of the Craigieburn created a high aggradation terrace. There is a lower intermediate terrace, still likely related to higher flows. Even the modern valley floor suggests higher than modern flows with the cave stream meandering within its current valley.

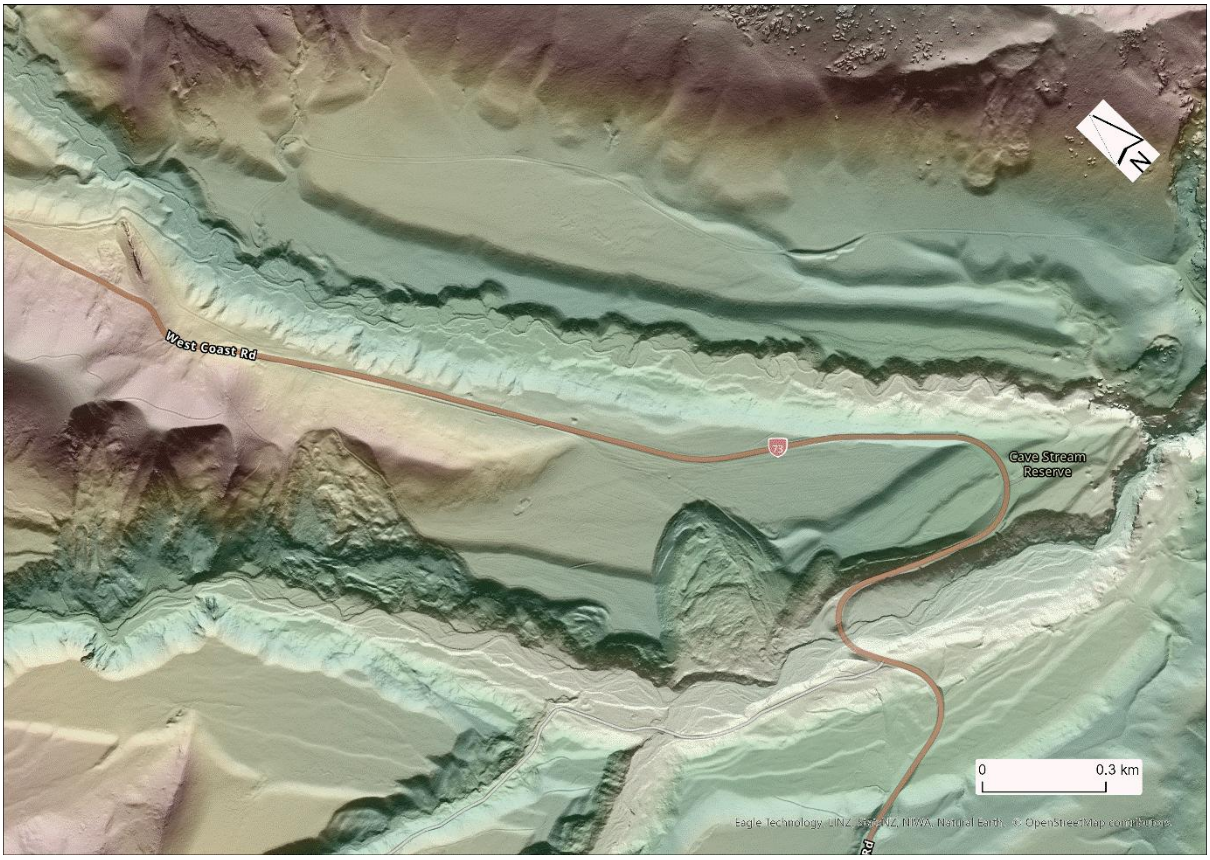

Figure 7. Examples of landslides developed within Broken River valley, along with the underfit Cave Stream in the upper part of the map. The map is produced using regional lidar from Land Information New Zealand.

Figure 8. The terrace sequence on Cave Stream. The two higher terraces were formed when meltwater from the Waimakariri Glacier was diverted into this stream. The river now has a limited catchment in the Craigieburn Range Photo: J. Shulmeister.

Stop 3: Lake Pearson

As we continue north-west we will pass through the Craigieburn Cutting, a steep road cut section of SH73 that forms another potential bottleneck. Small landslides commonly close this section of road and it is expected to be closed for a significant period of time in a future large earthquake. Combined with potential blockages at Porter's Pass, there is potential here for large numbers of road users to be trapped in a mountain 'island' between these road sections. Castle Hill Village, which we passed just before Cave Stream, provides the only settlement on this section of the highway, but mostly comprises holiday homes with few permanent inhabitants and zero resources such as health centres and grocery stores. In peak summer tourism and winter ski seasons, there could be several hundred vehicles trapped between Porter's Pass and the Craigieburn Cutting. We'll see several more examples of these potential 'mountain island' sites as we continue through the pass.

Beyond the Craigieburn Cutting, the road crosses and provides views of several great examples of alluvial fans. The fans have been the subject of geomorphic enquiry in this region due to their high diversity, from very low-gradient smooth fans of likely fluvial origin (Newtonian flow) through to fans of intermediate angle (likely involving debris floods), though to high-angle fans likely dominated by high-energy non-Newtonian flows (i.e. debris flows). The fans have been studied for their morphology and sedimentology and used to develop morphometric alluvial fan classifications (e.g. Figure 9; De Scally and Owens, 2004). A motivation for this is to be able to diagnose and recognise the processes that dominate fan construction and therefore the hazard that these different processes present. Later on, we will pass through Arthur's Pass Village, where parts of the village have been constructed on alluvial fans, and debris flows pose a hazard to both the buildings and the road and rail infrastructure. At other locations we will point out some of the mitigation works to protect the state highway.

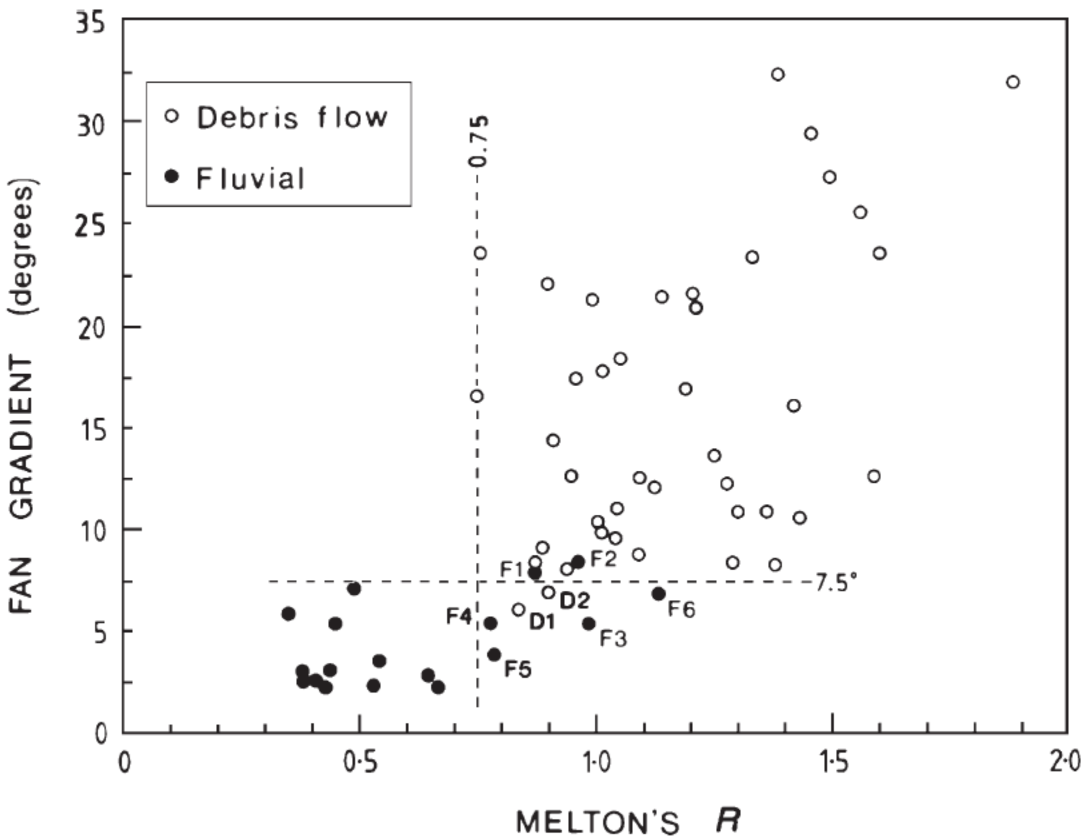

Figure 9: The relationship between fan gradient and Melton's ratio, which was developed based on several fans in the Arthur's Pass and Cass areas. This figure has been reproduced from De Scally and Owens (2004).

Lake Pearson is a nice example of where several fans can be seen in close proximity, and the shape of the lake has clearly been influenced by fan development (Figure 10). Five alluvial fans enter the small lake. Two of these enter from opposite sides and have created an 'hour-glass' shaped lake, and have very nearly dissected the lake. Three of the fans are steep, with rough micromorphology, with levees and lobes, and with coarse sediments. These are likely dominated by debris flows, and recent debris flow activity is often visible here, especially following heavy rainfall. At the southern end of the lake a much gentler alluvial fan is produced by Cragieburn and is likely dominated by fluvial deposition. At the northern end, the Ribbonwood Stream fan, which our stop is located on, has in the past flowed into the lake and is an example of an intermediate type of fan, likely dominated by debris flood processes (along with occasional higher energy flows and Newtonian flows). Also visible on the fan on the eastern side of the lake is a hummocky deposit that likely originates from a small rock avalanche.

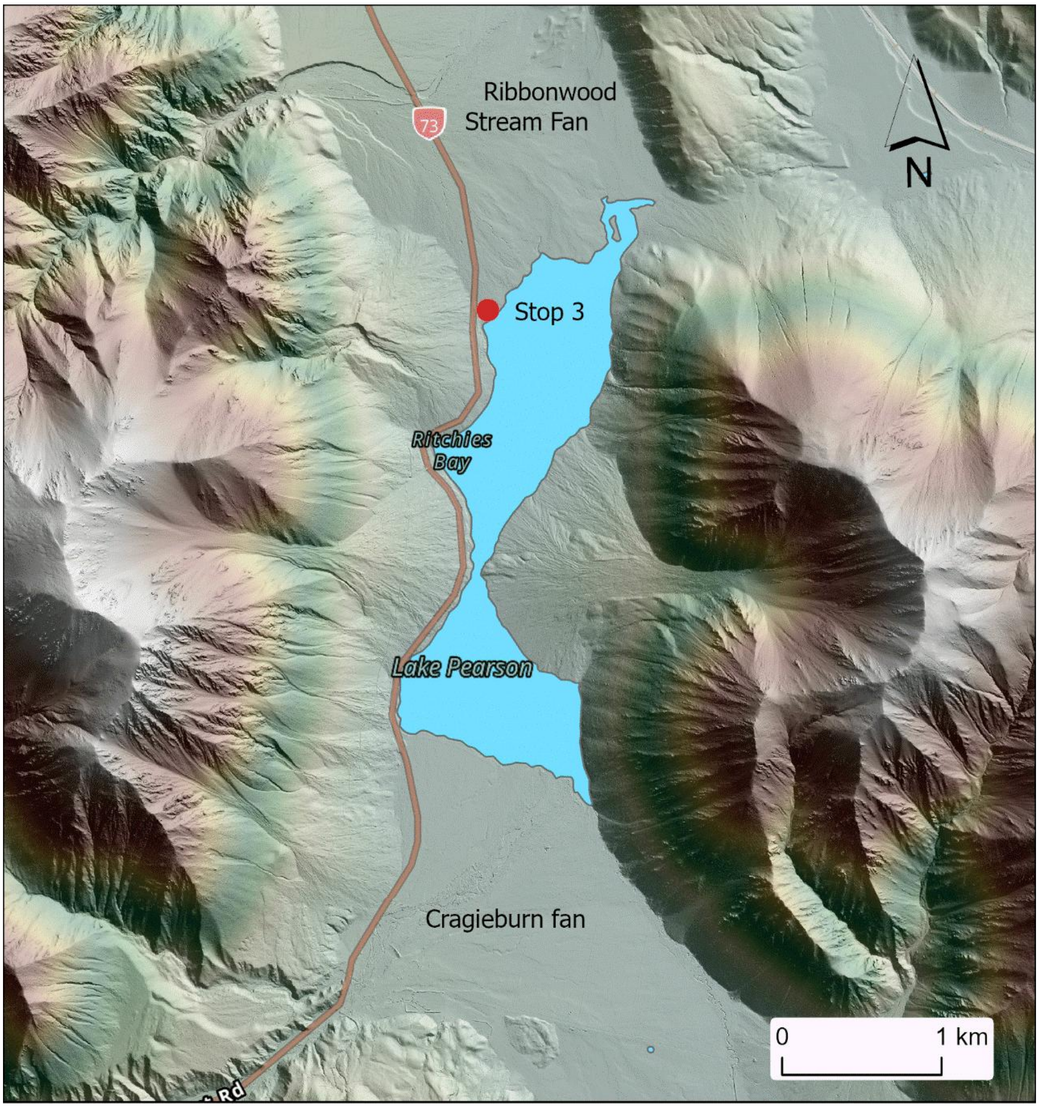

Figure 10: Diversity of alluvial fans at Lake Pearson. Background graphics are based on the 1-m lidar available for Canterbury from Land Information New Zealand.

Stop 4: Waimakariri Bridge

The Waimakariri is one of the largest rivers in Canterbury, with headwaters in the Southern Alps and discharging some 125 km downstream into the Pacific Ocean just north of Christchurch. For much of the river length, it is a classic braided river with a spectacular braid plain. The braiding is a result of the high sediment loads, steep gradient, and high and variable discharge. Near the mouth, the river has a mean daily flow of about 120 cumecs, and a mean annual flood of 1489 cumecs, but flows of about 4000 cumecs have been recorded historically. The Waimakariri River presents a major flood hazard to Christchurch (400,000 people), which has developed on the southern floodplain, and to Kaiapoi (5,000 people), which has developed to the north. An extensive system of flood protection works has been developed along both banks of the lower river, with primary stopbanks capable of retaining flows of 5500 cumecs and secondary stopbanks designed for flows of 6500 cumecs.

From this vantage we can also get a sense of the size of the valley, which was glaciated during the last (Otiran; 74-14 ka) glaciation (Figure 11). During the Pleistocene, ice carved broad parabolic-shaped valleys in the Waimakariri Catchment, leaving cirques, oversteepened valley walls, ice-sculpted bedrock, moraines, and former proglacial lakes (Figure 12). From here we can also see some of the truncated spurs and higher ice surfaces.

From a transport route perspective, this site presents yet another bottleneck. The bridge barely spans the narrowest section of the currently main active channel(s) of the Waimakariri, which has been forced into its current position on the true right by the Bealey River flowing from true left. Clear evidence of former Waimakariri river braids on the true left indicate older positions of the river, which if reoccupied would route the Waimakariri away from the current bridge and across the road (Figure 13). In high flow, the Waimakariri is eroding the true-left bridge abutments, where previous mitigation structures can be seen partially submerged in the channel.

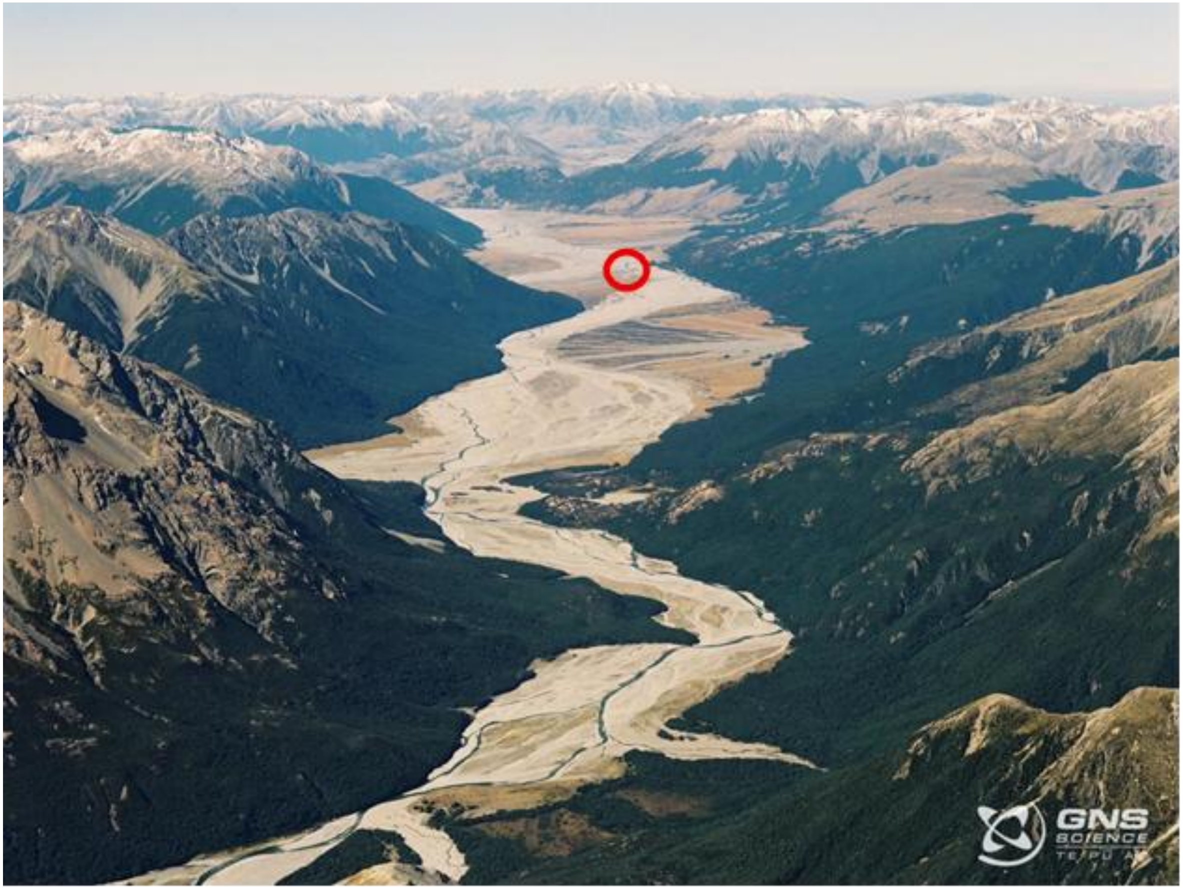

Figure 11: Waimakariri Valley, looking downstream (east). Stop 4 is marked by the red circle (approximate). Photo: L Homer.

Figure 12: Waimakariri River, looking northwards, some 18 km downstream of Stop 4. Evidence of moraine can be seen at the downstream end of the large alluvial fan. The fan is also etched by former lake shorelines, possibly related to landslide-damming of the valley. Photo: L Homer.

Figure 13. Aerial view of Stop 4 at the Waimakariri River State Highway 73 Bridge. Evidence of older braided channels from the Waimakariri River to the north of its current position indicate previous positions of the river. If the river were to reoccupy these channels it would bypass the current bridge (bottom left of image) and inundate the road (centre of image) making it impassible and likely requiring either new bridge infrastructure or significant work to re-route the river back into its present position. Image: Google Earth.

Arthur's Pass Toilet stop & commentary for the road:

We will have a brief toilet stop in Arthur's Pass village, before crossing the divide and travelling to our lunch stop at Lake Brunner.

After crossing the main divide of the Southern Alps, we will have traversed the Otira Viaduct (which we will return to at Stop 7 later today) and wound our way along the Otira River to its meeting point with the Taramakau River. Here, the valley widens out as it follows the Hope Fault, the southern and most active fault in the Marlborough Fault System. The Hope Fault is the second fastest slipping onshore fault in New Zealand, with dextral slip rates of 8-13 mm/yr (Langridge et al., 2005). It is the major carrier of plate tectonic strain between the Alpine Fault and Hikurangi Subduction zone, essentially marking the plate boundary between the Pacific and Australian plates. Recurrence intervals between earthquakes on the Hope Fault are estimated to be 300-500 years but the date of the most recent surface rupturing earthquake is unknown.

At Jacksons, we turn off SH73 and cross the Taramakau River and the Hope Fault. Shortly afterwards we leave the frontal ranges of the Southern Alps, with the road passing over a notable scarp in the landscape at Inchbonnie (and then again at Stop 6 near Lake Poerua after lunch). This scarp marks the location of the plate boundary Alpine Fault, New Zealand's fastest slipping onshore fault.

Stop 5: Lake Brunner (lunch stop)

Lake Brunner is a moraine dammed lake formed c. 11,000-14,000 years ago as a result of retreat of the northern lobe of the Taramakau Glacier, which separated from the main glacier and flowed north between Mt Te Kinga in the east and the Hohonu Range in the west (Figure 14). The lake covers an area of ~40 square kilometres and has a maximum depth of 109 m. The outlet is via the Arnold River to the north, which is artificially dammed downstream for hydroelectric power generation.

Given its proximity to the Alpine and Hope faults, Lake Brunner has been subjected to numerous large earthquakes, with recent work showing that records of these events are preserved in the sedimentary record from the lakebed. Much of this evidence is in the form of lacustrine mass movements, with ~35% of the lake bed covered by such deposits (Hughes et al., 2024). However, there is little evidence of sub-aerial mass movements from the surrounding Mt Kinga and the Hohonu Range entering the lake, indicating that these deposits are primarily submarine derived. The largest of these is a c. 800,000 cubic metre deltaic mass movement that appears to have runout for nearly 2 km across the lakebed.

The tsunamigenic potential of these and future mass movements in the lake has been explored. Based on empirical evidence, it's thought a minimum submarine mass movement volume of 450,000 cubic metres is required to trigger tsunami heights in excess of 5 m. Three of the identified deposits in Lake Brunner are of sufficient volume, suggesting that large lake tsunamis may have previously occurred on multiple occasions. Historical reports appear to corroborate this. Following the 1929 Murchison earthquake, multiple different observers reported seeing the centre of the lake '*fall in rapidly*' before a large vertical column of water was ejected, followed by large waves that reached the lake shore.

Similar geomorphic and observational evidence for tsunami in many of the lakes and fiords across the Southern Alps have been noted. Despite this, research to understand the hazard and risk posed by such events is limited (with a notable exception of Milford Sound), but the hazard posed is of growing concern from both the researchers and local communities.

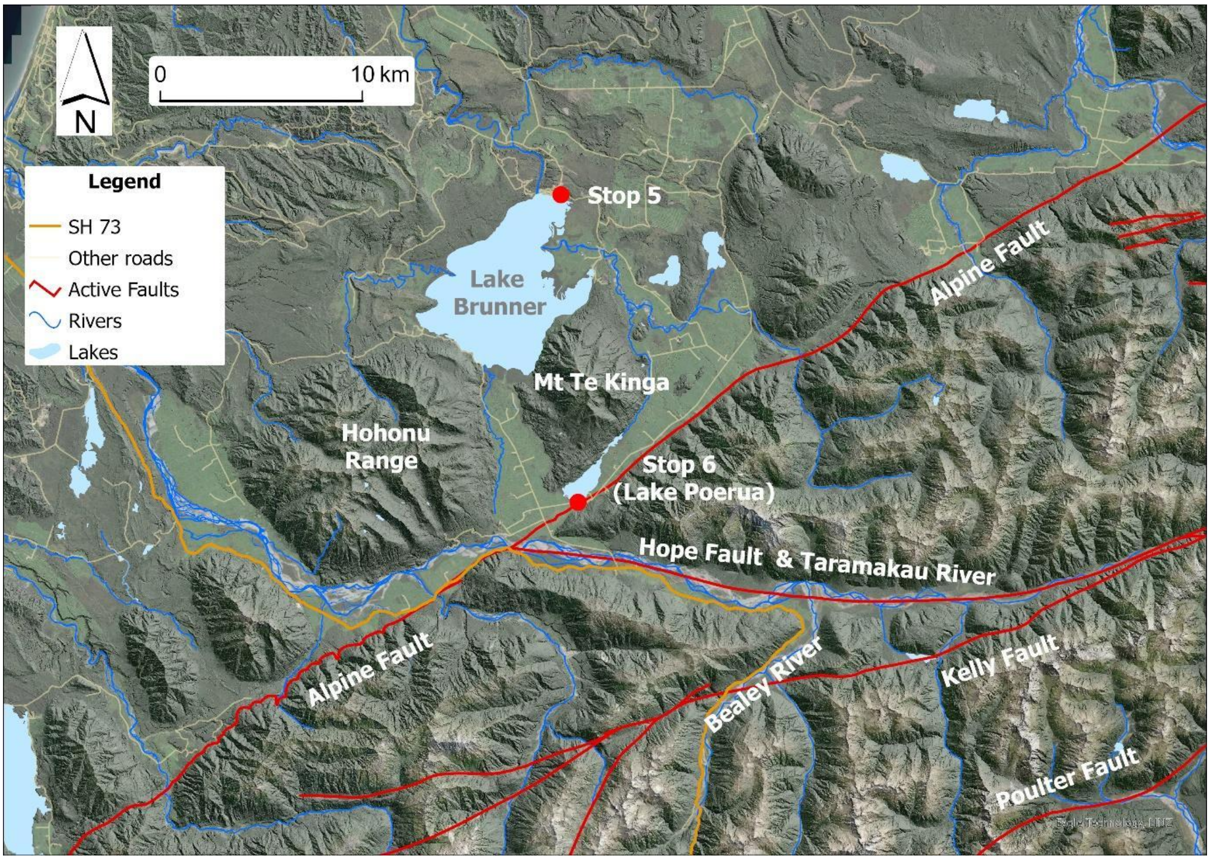

Figure 14. Context for Lake Brunner, located west of the plate boundary Alpine Fault.

Stop 6: Lake Poerua - Alpine Fault

This stop is right alongside the Alpine Fault plate boundary, affording us a view of the fault scarp (also visible from the bus, but we cannot stop on the road). The fault has offset a number of surfaces and landforms, often clearly visible in lidar data (Figure 14), which has helped earthquake geologists to reconstruct the rupture history of the fault. The Alpine Fault has been extensively researched, with the last 27 surface rupturing earthquakes over the last 8000 years being dated (Berryman et al., 2012). These dates show a highly regular timing pattern, with average recurrence intervals of ~300 years (Figure 15). The most recent surface rupturing event has been dated to c. 1717 giving a 75% chance of an earthquake on the Alpine Fault in the next 50 years (Howarth et al., 2021). Given current slip rates and previous single event displacement estimates of 2-3 m vertical and 8-9 m horizontal, it's thought likely such an earthquake will have M8+.

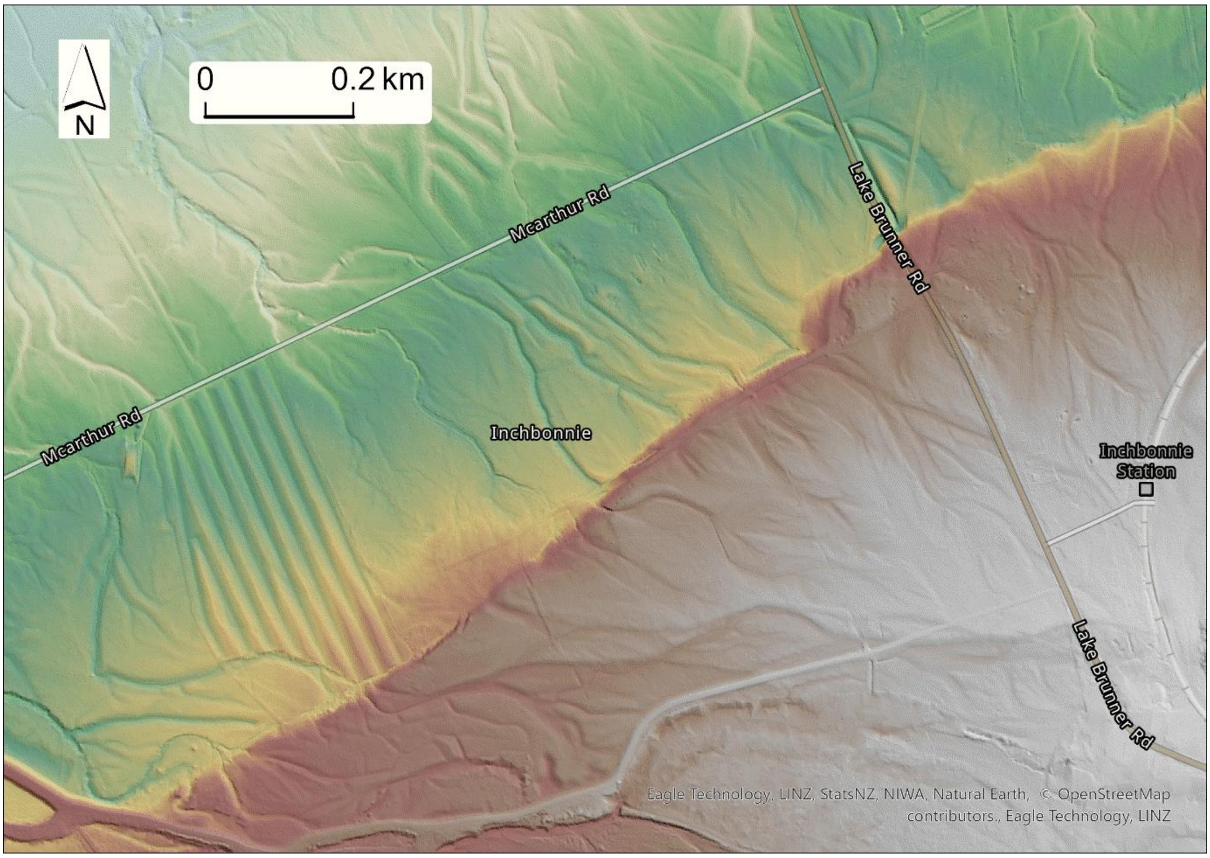

Figure 14. The Alpine Fault where it causes right-lateral and vertical displacement of a former outwash surface of the Taramakau River, just west of Stop 6. The discontinuity of the paleo channels across the fault is visible and the hanging wall side of the fault (south east) is about 5 metres higher than the footwall. We will cross the fault as we drive along Lake Brunner Road.

As a result of the very high seismic hazard, the AF8 programme (www.af8.org.nz) was developed and has been running since 2016. This is an interdisciplinary partnership between research, policy and practice designed to support, build and coordinate readiness and response capability for the next Alpine Fault earthquake. The programme was established and continues to be led by the six South Island Emergency Management (EM) Groups and key science groups from each of New Zealand's Universities and Public Research Organisations.

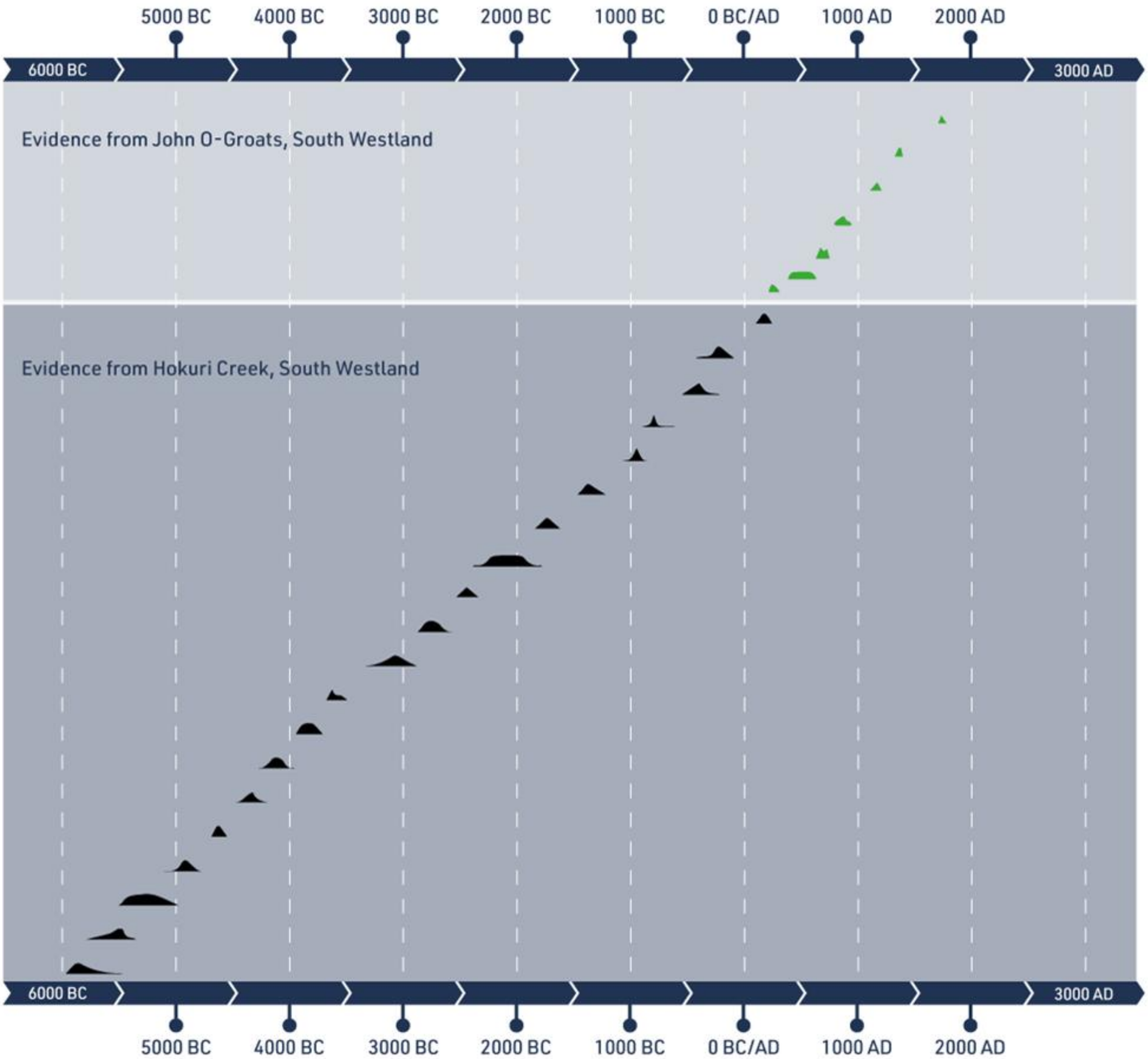

Figure 15. Probability density functions for the timings of the previous 27 Alpine Fault earthquakes from south Westland. The regularity of previous earthquakes on this fault gives a 75% probability of an earthquake in the next 50 years. Source: Cochran et al (2012).

After our stop at Lake Poerua, we will return towards Christchurch, back along SH 73. Whilst less impressive than the Otira Viaduct (our next stop), the Cockayne Bridge over Kelly River is a notable pinch point on SH73. During heavy rain (this area receives 7-8 m of rainfall annually) the deceptively large Kelly River has experienced numerous large debris flows that have previously destroyed the bridge and blocked access for several days. Lobes from previous debris flows as well as engineering works around the bridge are clearly visible in lidar data (Figure 16).

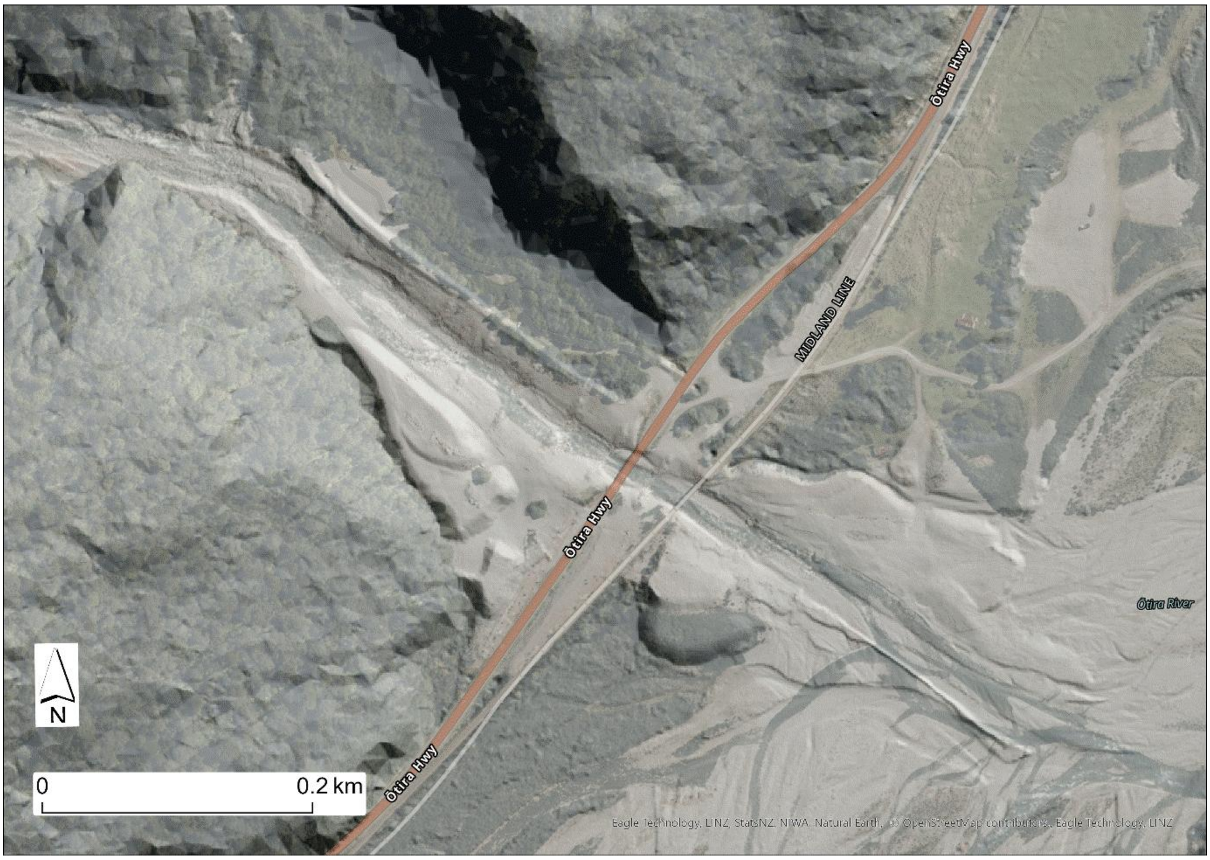

Figure 16. Engineering works at Kelly River at the confluence with the main Otira River valley.

Stop 7: Otira Viaduct

Having crossed it twice today, at this final stop we will walk up to a lookout over the Otira Viaduct, a 445-metre bridge that spans a section of the Otira Gorge (Figure 17). The viaduct was built in 1999 to replace the previous road alignment that took a high route above the lookout, over the scree slopes on the true right of the river (Figure 18). The previous route had steep sections and several switch-backs, and was subject to rockfall onto the road, and washouts / collapse of the road, making it both hazardous and prone to closures and regular realignments. A notable collapse occurred in the 1929 Arthur's Pass Earthquake.

The viaduct helped to provide a longer-term solution to the problem but was faced with several challenges. This included dealing with the alpine weather and approximately 5 metres of annual rainfall in this area. There is a shallow water table with high underground flow, and artesian conditions in places. Given the risk of rockfall or smaller debris avalanches affecting the viaduct structure, the viaduct piers had to be designed to withstand impact forces, and for some piers deflection structures were constructed. Being in a very seismically active area, the viaduct required several design features to accommodate strong earthquake shaking, including ductile piers and hinges, base isolation at the abutments, and shear keys. Completing the project within a National Park required environmentally sensitive design and construction, and consideration had to be given to avoiding damage to natural features of cultural significance to local Māori. The project has won several international awards (Billings, 2004).

The steep scree above the viaduct and the sediment upon which the previous road was aligned, originates from a large rock slope failure (Figure 18) that occurred about 2000 years ago (Whitehouse and Griffiths, 1983). The failure no doubt blocked the river at that time, but has since carved through the toe of the deposit. However, the bridge piers are embedded 25 metres fully within landslide debris, suggesting there is still some tens of metres of landslide debris lining the bottom of the valley – pilot holes were drilled to 40 metres without reaching bedrock.

Figure 17 – The Otira Viaduct, looking up valley. Note the large boulders in the stream bed, and the exposure on the left of the rock avalanche debris. Photo: D. L. Homer.

Figure 17– View of the original road alignment, and planned alignment of the viaduct at Otira Gorge. The source area of the major rock slope failure is demarked, along with other key features. Annotated photo reproduced from Billings (2004), photo originally taken by D. L. Homer.

We will now continue our journey back to Christchurch, stopping briefly for toilet breaks as needed. The return journey will go back the same way we came, affording some further views of the features we have visited today, or you can enjoy a bit of peace and sleep on the return journey...

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