A geomorphological analysis of the Aoraki/Mount Cook region, New Zealand

Alex Biddulph (230281882) | Henry Wilson (230086313) | Joseph Hopkinson (230317712) | Jack Clough (220223405)

Introduction:

Our expedition aimed to research mass-movement hazards, geomorphology, and hydrology in the Mount Cook region of New Zealand. We had a variety of projects which included spatial mapping and conducting grain size analysis on alluvial fans, comparing sediment characteristics between landslides and moraines, and measuring river regimes, velocity, sediment types and transport at different lengths downstream of a glacial and non-glacial river. This was completed using Emlid-Reach GPS units, Schmidt hammers, sediment logs and flow meters. We hope findings from our research will further develop: understanding of alluvial fan formation and debris flow and avalanche dynamics in the Aoraki/Mount Cook region, as well as hydrological differences between glacial and non-glacial rivers, and separate out climatic signals (from past glacial retreat) from mass movement generated landforms.

Objectives:

- Map outer extents of Kitchener and Wakefield alluvial fans using Emlid Flow GPS units
- Quantify surface grain size and roundness along vertical transects on three fans (Wakefield, Mueller Hut, Kitchener) using Wolman's (1954) intermediate (b-) axis (report D10/D50/D90, sorting, and Krumbein roundness).
- Analyse hydrology indicators in the Hooker and Twizel Rivers and the influence of suspended sediment transport
- Test the paleoclimatic reliability of different moraine ridges using Schmidt hammers, recording

Methods:

Alluvial fans:

Emlid GPS units were used to plot around the extent of Kitchener and Wakefield Fan, periodically recording elevation above sea level and X and Y coordinates to be mapped in QGIS. Numerous rocks were dated using Schmidt hammer techniques, aiming to characterise the fans. Collect 100 surface clast samples using Wolman's intermediate (b-) axis (D10/D50/D90 report) method along vertical transects at each fan.

Moraines:

Collected a large sample set of Schmidt hammer R-values for boulders across different moraine ridges in the Mueller Glacier foreland. Measured clast shape and clast roundness for numerous clasts across the moraine ridges using digital callipers.

Hydrological:

Hydrological indicators were taken using an ultrameter every 30 minutes and discharge every hour between 11am and 3pm across three days. 500ml samples were taken and tested through pre-weighed filter paper to calculate suspended sediment concentration.

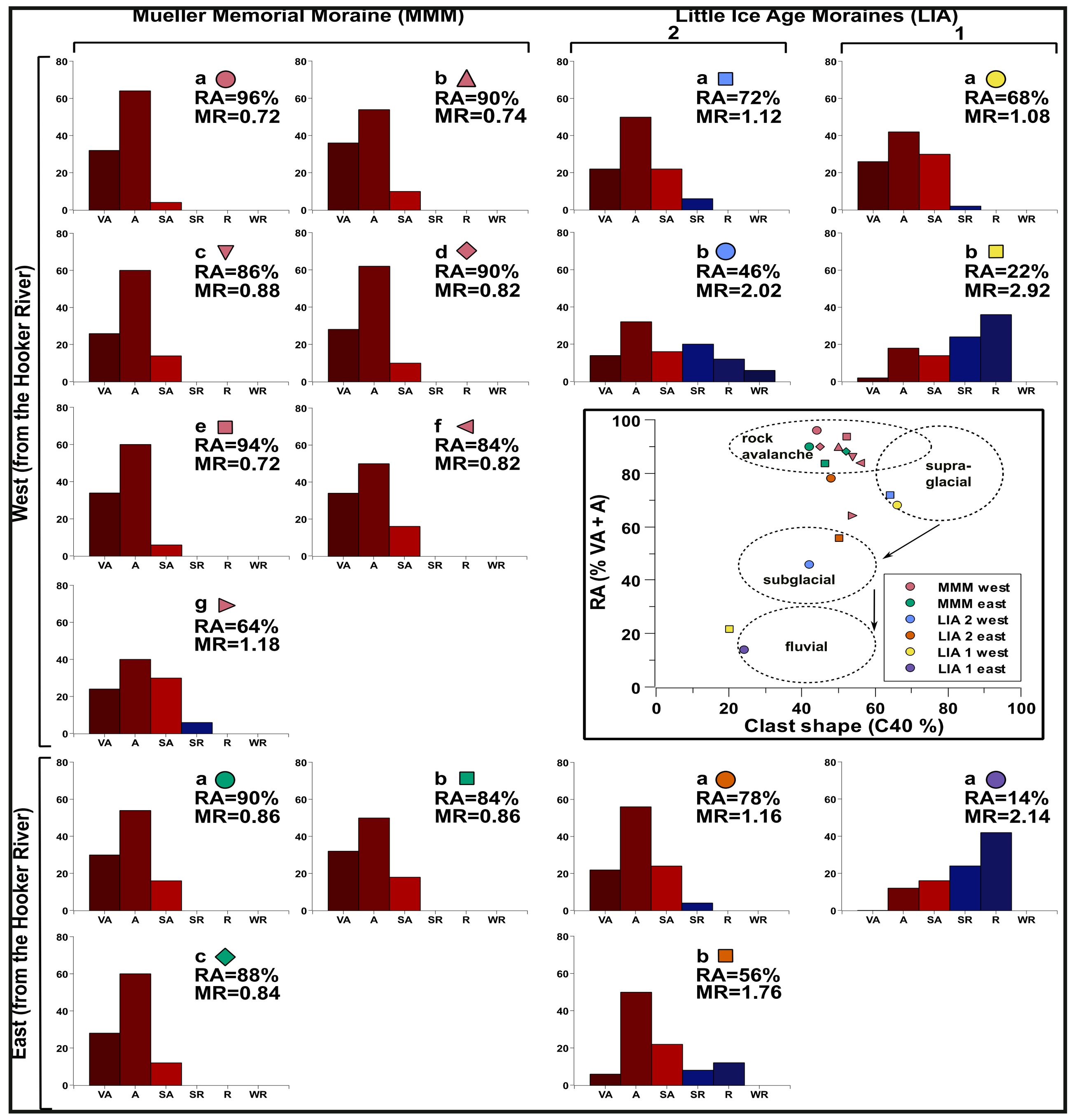

Figure 1. Clast roundness and angularity data for sample sites across different moraine ridges. RA= percentage of clasts identified as A and VA. MR= mean roundness, calculated using VA= 0, A=1, …, WR=5. A Co-variance analysis graph has been inset using control envelopes from Lukas et al., 2013.

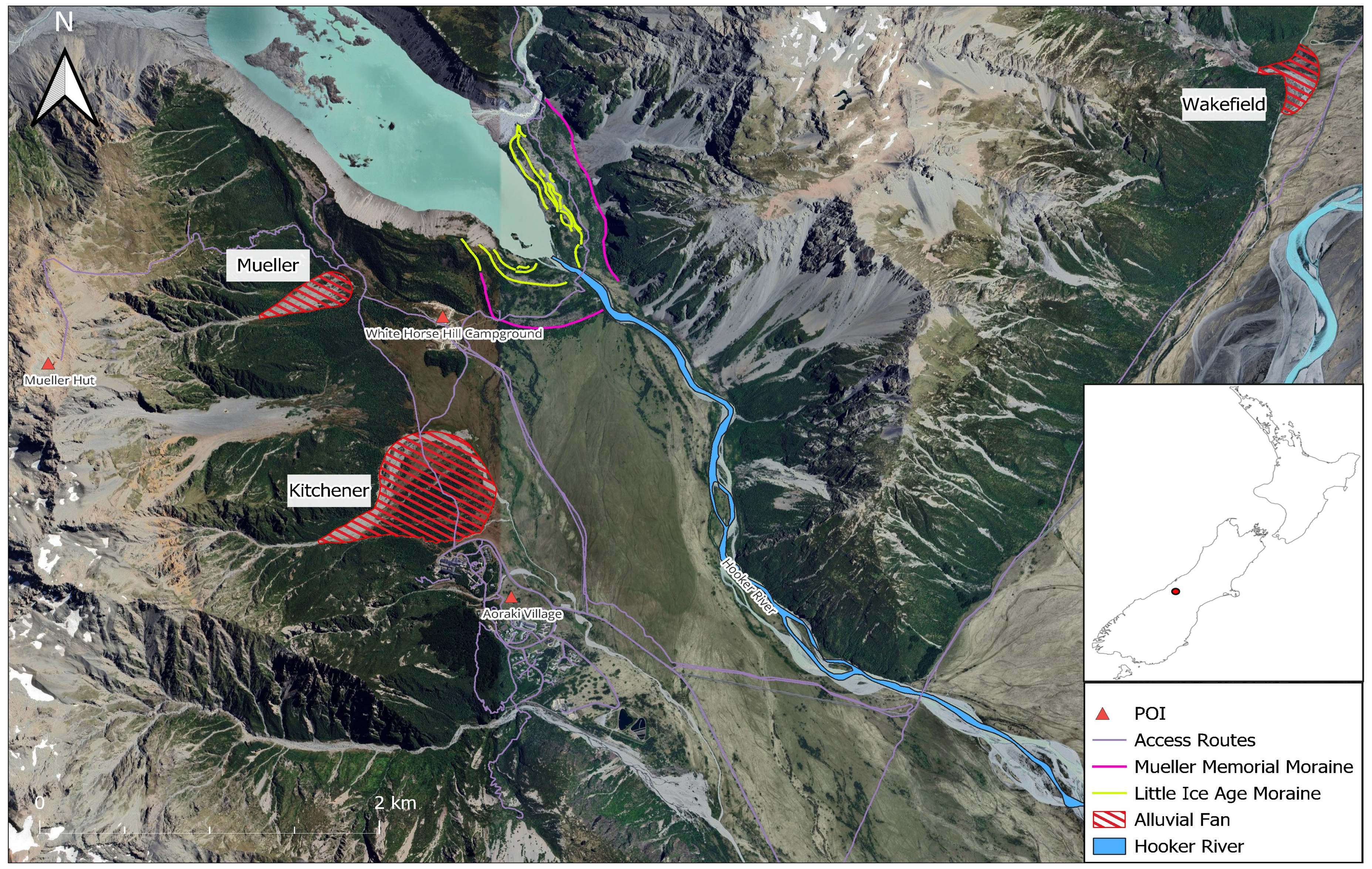

Figure 2. Map of Aoraki/Mount Cook village and surrounding area, annotated with preliminary mapping of moraines, alluvial fan sites, and the Hooker River.

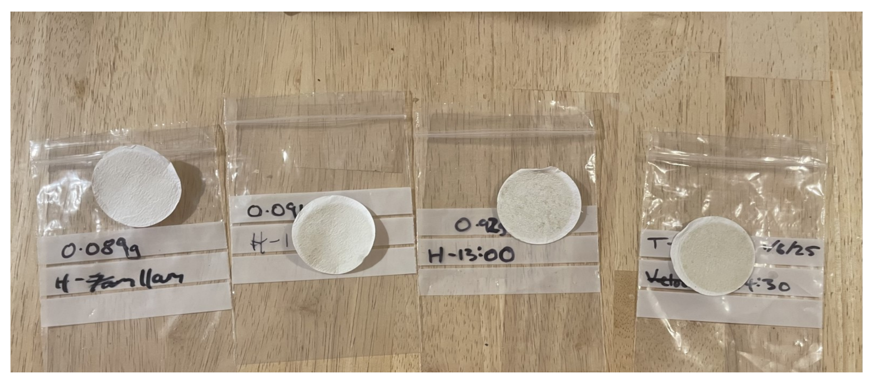

Figure 4. Suspended sediment captured in filter paper from Hooker River.

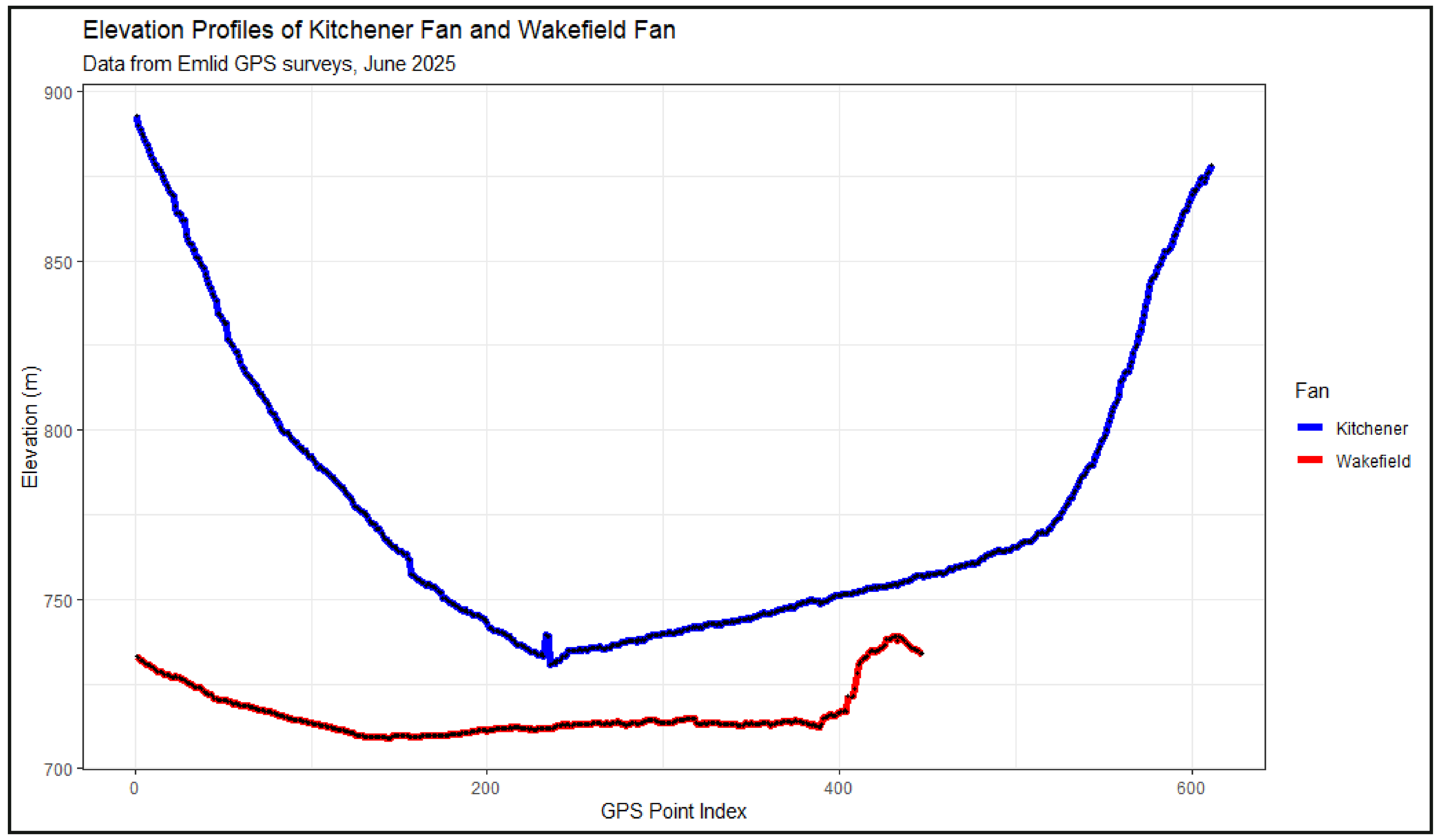

Figure 3. Elevation profiles of Kitchener and Wakefield fans using June 2025 Emlid-Flow GPS data

Findings:

Alluvial fans:

- Avalanche and debris flows are the predominant methods of formation for alluvial fans in the Aoraki Mount Cook National Park
- The debris flow-dominated fan (Wakefield Fan) has a much smaller area than the avalanche-dominated fan (Kitchener Fan)
- The avalanche-dominated fan (Kitchener Fan) has a much greater elevation range than the debris flow-dominated fan (Wakefield Fan):
- *Kitchener Fan: 892m asl (max. elevation) - 720m asl (min. elevation) (Figure 3)*
- *Wakefield Fan: 739m asl (max. elevation) - 708m asl (min. elevation) (Figure 3)*
- All three fans show significant differences in b-axis among transects and roundness among transects (Mueller fan having the largest D50 =13.0mm and most angular overall of 0.28).
- Coarse, angular surface clasts dominate active lobes and upper fans (Mueller, Wakefield); roundness increases only locally where fluvial reworking is evident.

Moraine:

- Consistent Schmidt Hammer R-values across the Mueller Memorial Moraine (MMM) suggest its ridges make up one complex formed as a result of a single glacial advance event, contrasting with some previous interpretations.
- The MMM displays significantly different clast roundness and angularity results to nearby moraines on the Mueller Glacier foreland (LIA moraines) *(Figure 1)* whilst evidencing similar results to other known supraglacial rock avalanche deposits, indicative of a mass-movement origin.

Hydrological:

- Electrical conductivity and TDS are the most differentiating hydrological indicator between the 2 rivers, being much higher in the Hooker River (means of 85.7 and 56.49 respectively) than the Twizel River (24.9 and 15.98), linking to the widely regarded positive correlation between these indicators (Walton, 1989).
- Change in filter paper weight was much greater in the Hooker River, which was also visibly more silty *(Figure 4)*, indicating a mean of 0.06g detectable suspended sediment per litre compared to just 0.0032g in the Twizel River.

References

Walton, N.R.G. (1989). Electrical Conductivity and Total Dissolved Solids—What is Their Precise Relationship? Desalination, 72(3), pp.275–292

Lukas, S., Benn, D.I., Boston, C.M., Brook, M., Coray, S., Evans, D.J.A., Graf, A., Kellerer-Pirklbauer, A., Kirkbride, M.P., Maarten Krabbendam, Lovell, H., Machiedo, M., Mills, S.C., Nye, K., Reinardy, B.T.I., Ross, F.H. and Signer, M. (2013). Clast shape analysis and clast transport paths in glacial environments: A critical review of methods and the role of lithology. *Earth-Science Reviews*, 121, pp.96–

Wolman, M. G. (1954). A method of sampling coarse river-bed material. Eos, Transactions American Geophysical Union, 35(6)

Contacts

Alex Biddulph—a.biddulph1@newcastle.ac.uk
Henry Wilson—h.wilson15@newcastle.ac.uk
Joe Hopkinson—j.hopkinson2@newcastle.ac.uk
Jack Clough—j.clough2@newcastle.ac.uk

Acknowledgements

This expedition was only made possible by the generous donations made by Newcastle University Expeditions Committee, Royal Geography Society (with IBG) and The Jeremy Willson Charitable Trust. We also want to thank Professor Rachel Carr who supported us right through until we got to New Zealand. Thanks also to the technical Geography department who lent us equipment to use during our time in New Zealand.

The Jeremy Willson Charitable Trust

Royal Geographical Society with IBG

Newcastle University