GeoNet Landslide Response: Nelson Tasman District, 16–19 August 2022

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DISCLAIMER

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ABSTRACT

During 16–19 August 2022, an extreme rainfall event affected much of New Zealand. The National Institute of Water & Atmospheric Research (NIWA) refer to this event as the "strongest August atmospheric river (AR) on record" and classified it as a 1-in-120-year rain event for Nelson. The National Emergency Management Agency (NEMA) classified the event as 'N1', which elicits a minor national-level response. The rain event triggered many hundreds of landslides and flooding across the Nelson Tasman and Marlborough regions. In Nelson Tasman, NEMA reported that up to 570 properties were damaged and many roads, along with state highways SH 6 and SH 63, were closed, mainly from landslides and flooding. The main water supply pipeline to Nelson also failed, as it was hit by a landslide.

The GNS Science Landslide Duty Officer, in consultation with the Engineering Geology Team and others at GNS Science, activated a landslide rapid response (LRR) for this event on 19 August 2022 under the GeoNet programme, as several of the criteria for activating a GeoNet LRR were met. These criteria were: direct damage of greater than NZ$1 million, economic losses of greater than NZ$10 million, threats to public health (such as contaminated water supplies) and significant research interest. The purpose of this LRR is to ensure that appropriate advice is available to maximise public safety, as well as to acquire and collect reliable and consistent landslide information and data. The aim of this report is to document the activities and results from the LRR carried out for the Nelson Tasman region during the LRR period (19/08/2022 to 2/09/2022).

The GeoNet LRR for Nelson Tasman comprised the following steps: 19–21 August: Collate information on landslides reported in the media and on social media; 22–23 August: Carry out helicopter reconnaissance of the main areas affected; and 23–24 August: Carry out a walkover (field reconnaissance) of the Tāhunanui landslide in Nelson.

The data presented in this report was made available to Nelson City Council on the day of collection to support them, and their representative contractors, in responding to this event. It is intended that additional data collection will continue through the recovery phase of the event. This perishable data acquired in the field will help train rainfall-induced landslide forecast models being developed by GNS Science and NIWA to forecast the location and severity of landslides in future rain events across all of Aotearoa.

KEYWORDS

Landslides, Nelson landslides, Nelson rain event, Tāhunanui landslide, rainfall-induced landslides

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1.0 INTRODUCTION

In August 2022, an extreme rainfall event affected much of New Zealand (Rosser et al., forthcoming 2022). The National Institute of Water & Atmospheric Research (NIWA) are referring to this event as the “strongest August atmospheric river (AR) on record”. NIWA classified the event as a 1-in-120-year rain event for Nelson.[1] The National Emergency Management Agency (NEMA) classified the event as ‘N1’ = a minor national level response.

States of emergency were declared for the:

- West Coast region on 16 August 2022
- Nelson Tasman region on 17 August 2022, and
- Marlborough region on 19 August 2022.

The rain caused widespread flooding across Nelson City and Richmond and triggered many hundreds of landslides, with most concentrated around Nelson City, Hira, Cable Bay and the Rai and Maitai valleys. Many landslides were triggered in the Marlborough Sounds, impacting roads and buildings. Landslides, although less in number, were also triggered around the Abel Tasman National Park and the Takaka region.

The GNS Science Landslide Duty Officer, in consultation with the Engineering Geology Team and others at GNS Science, activated a GeoNet landslide rapid response (LRR) for this event on 19 August 2022, as several of the criteria for activating a rapid response were met. As a result, the GNS Science Incident Management Team (IMT) was set up and a Controller was established.

A report by Rosser et al. (forthcoming 2022) contains an overview of the larger event, which affected a large part of the country. The aim of this report is to document the activities and results from the GeoNet landslide rapid response carried out for the Nelson Tasman region only. It is not the intent of this report to summarise the day-to-day functions of the IMT during the response.

1.1 GeoNet Landslide Rapid Response Criteria

GeoNet maintains a rapid response capability for landslides in New Zealand.[2] The rapid response team consists mainly of engineering geologists and geotechnical engineers. The aim is to have team members mobilised within 24 hours of a major event. The criteria for activating a rapid response are landslides that cause any of the following:

1. Death or serious injury.
2. Subsequent catastrophic events (such as the breach of a landslide dam).
3. Direct damage of greater than NZ$1 million.
4. Economic losses of greater than NZ$10 million.
5. Threats to public health (such as contaminated water supplies).
6. Significant research interest.

1 https://twitter.com/NiwaWeather/status/1562674407650500608?t=h1kFxxeDQjHmgttYihgRdg&s=19
2 https://www.geonet.org.nz/landslide/how

Criterion 3–6 were met for this event, and the LRR was initiated to ensure that appropriate advice was available to maximise public safety, as well as to acquire and collect reliable and consistent landslide information and data.

1.2 Nelson Tasman Event Details

Between the 16th and 19th of August 2022, the maximum 24-hour rain recorded for Nelson City was 273.6 mm (Figure 1.1), and the maximum cumulative amount of rain over the four days was 749 mm (Figure 1.2). These rainfalls were recorded at the Third House rain gauge, located approximately 8 km southeast of Nelson City.

NIWA's High Intensity Rainfall Design System (HIRDS) can estimate high-intensity design rainfall heights at any point in New Zealand, and it is routinely used for assessing storm rarity.[3] The output of HIRDS is a set of tables containing either rainfall heights or rainfall intensities for given storm durations and annual recurrence intervals (ARI). The ARI's for selected sites in the Nelson Tasman region are shown in Figure 1.3 for the cumulative four-day rain heights (shown in Figure 1.2). Although NIWA classified the overall event as being a 1-in-120-year rain event for Nelson, the cumulative rainfalls at individual rain gauges had ARI's >250 years, indicating that the rainfall was rare and severe.

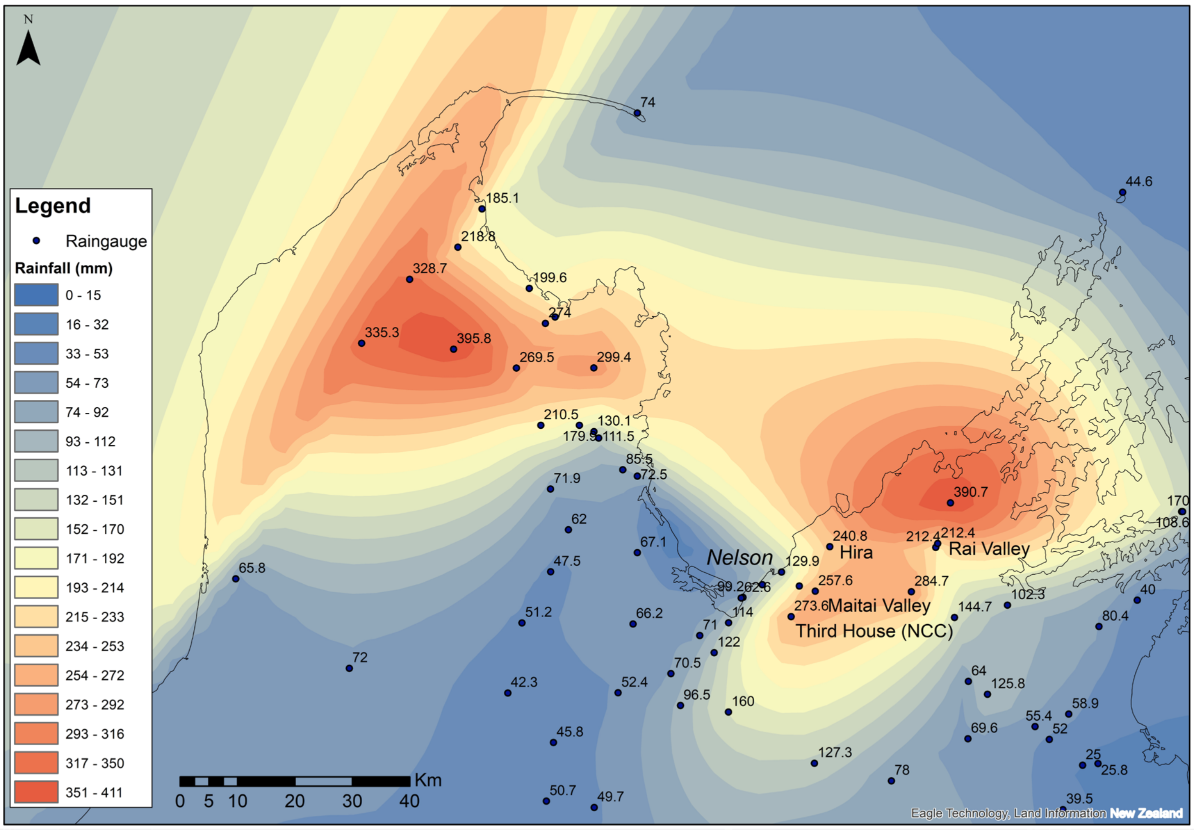

Figure 1.1 Maximum 24-hour rain (depth in millimetres) recorded at the given stations across the Nelson Tasman region within the period 16–19 August 2022.

3 https://www.niwa.co.nz/software/hirds

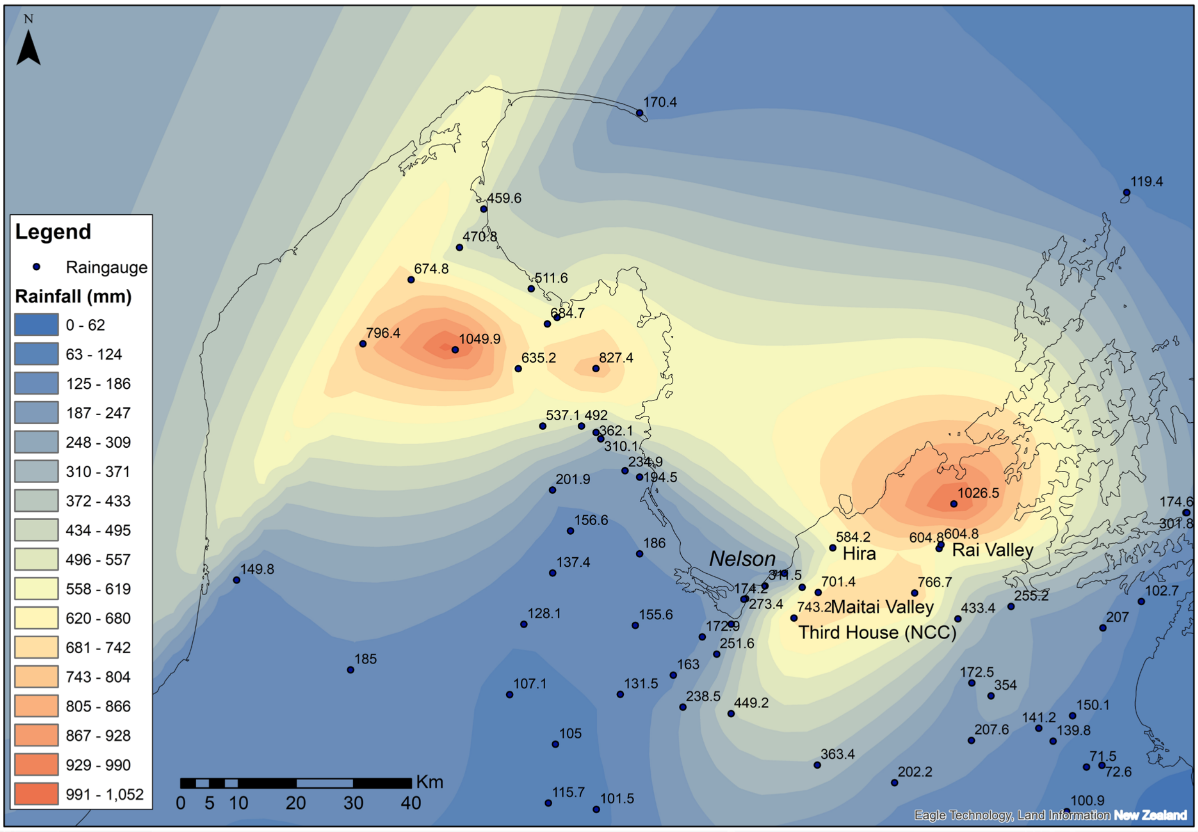

Figure 1.2 Cumulative rain (depth in millimetres) recorded at the given stations across the Nelson Tasman region for the period 16–19 August 2022.

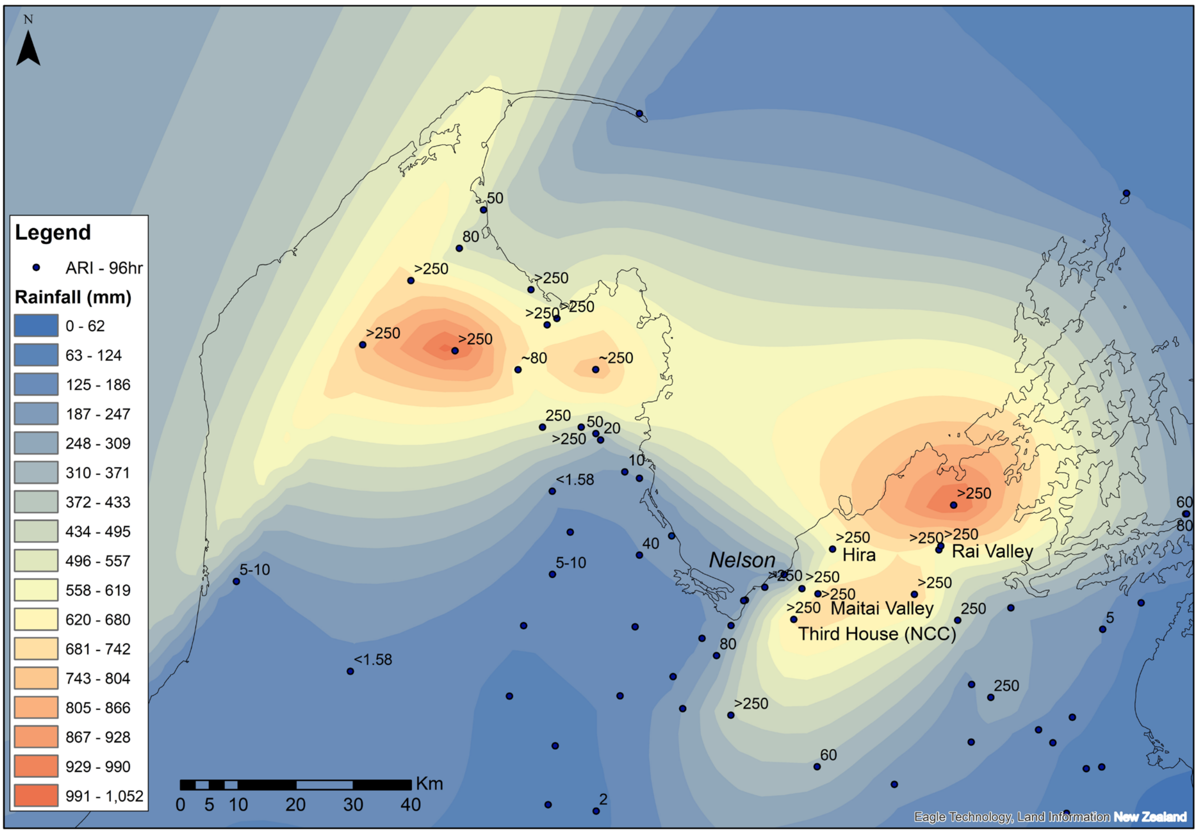

Figure 1.3 Cumulative rainfall (depth in millimetres) across the Nelson Tasman region over the period 16–19 August 2022 and the estimated annual recurrence intervals (black labels) for selected rain gauges, estimated from NIWA's High Intensity Rainfall Design System.

On 17 August 2022, NEMA reported that approximately 289 properties in the Nelson region had been evacuated. This increased to 570 properties on 21 August 2022. Many of these evacuations were due to damage from land instability. In Nelson, the main water supply pipeline from the Maitai Reservoir to Nelson City failed on 17 August 2022 as it was impacted by landslide debris, resulting in a reduced flow rate of drinking water to the city. Many of the region's roads were closed due to landslides and flooding, including State Highways (SH) 6 and 63. For several days, the only route between Nelson and Blenheim was via Lewis Pass (SH 7), which added approximately seven hours to the travel time.

2.0 LANDSLIDE RESPONSE

The GeoNet LRR for Nelson Tasman comprised the following steps:

1. 19–21 August: Collate information on landslides reported in national media, on social media, to local/regional authorities and to infrastructure providers. This was undertaken to identify their locations and plot them geospatially; and provided initial information on the location, number and severity of landslides caused by the rain event.
2. 22–23 August: Carry out aerial reconnaissance of the main areas affected using the locations identified in Step 1. This allowed the field team to:
   a. Systematically document (photograph) the extents and types of landslides and ground deformation caused by the rain.
   b. Verify the landslide locations, and identify any additional areas of landslides and ground deformation and potential impacts on buildings and infrastructure.
   c. Provide rapid information on landslides and areas of ground deformation to Toitū Te Whenua Land Information New Zealand (LINZ) to help plan their aerial photograph and LiDAR survey of the area most affected, as well as to the geotechnical engineers / engineering geologists working on the ground inspecting the damage to buildings and infrastructure on behalf of Nelson City Council (NCC) and others.
3. 23–24 August: Carry out a walkover (field reconnaissance) of the Tāhunanui landslide in Nelson with the Tonkin & Taylor (T&T) field team working on behalf of NCC to manage the hazard and risk that the landslide might pose to people, buildings and infrastructure.

3.0 LANDSLIDE SEVERITY/IMPACT ASSESSMENT RESULTS AND OBSERVATIONS

A summary of the findings from the helicopter reconnaissance is in Table 3.1 and Figure 3.1. The number of landslide photographs and media reports can be used as proxies to indicate the number/density of landslides and their impacts on buildings and infrastructure at the given locality. The photographs listed in the observations column of Table 3.1 are contained in Appendix 1. These photographs were selected to provide a representative overview of the types of landslides and ground damage caused by the event. The number of selected aerial photographs covering the complete region are listed in Table 3.1; the helicopter flight lines and GoogleEarth KMZ files with thumbnail photographs can be downloaded from the OSF.io repository[4] (Appendix 2). The photographs contained in the repository are medium resolution, i.e. scaled by half. Full-resolution photographs are available on request.

Table 3.1 A summary of the findings from the helicopter reconnaissance carried out on 22–23 August 2022. The rainfall given here is the maximum modelled from the gauges within the given locality. The observations that adopt landslide-specific terminology follow the scheme of Hungr et al. (2014), which are summarised in Table 5 of that paper.

Locality	No. of Landslide Photos	No. of Media Reports	Four-Day Total Precipitation (mm)	Max. 24-Hour Precipitation (mm)	Max. 1-Hour Precipitation (mm/h)	Observations
Kahurangi National Park	4	1	717	386	23	Generally no landslide damage (Figure A1.1). Existing landslides appear stable. Some small activations of scree slopes.
Kotinga	8	2	573	273	20	Landslides onto the road appear to have cut the community off.
Motupipi	17	4	481	237	22	Several debris flows in close proximity to dwellings and roading. Arcuate tension cracks in hillslopes indicate incipient movement (Figure A1.2).
Ligar Bay	62	14	466	228	20	Many landslides on roading (Figure A1.3), at least one located immediately downslope of dwelling. Deeper landslides and tension cracks are visible on steeper hillslopes. Notable slumping of a valley fill in farmland.
Mārahau – Totoranui	26	13	446	221	19	Many coastal cliff collapses (Figure A1.4). Several debris flows extend down to the waterfront. One minor landslide in close proximity to a dwelling noted.

4 https://osf.io/3q25w/

Locality	No. of Landslide Photos	No. of Media Reports	Four-Day Total Precipitation (mm)	Max. 24-Hour Precipitation (mm)	Max. 1-Hour Precipitation (mm/h)	Observations
Kaiteriteri	36	6	437	216	17	Several landslides onto roading and a debris flow extending down to the beach. Shallow slides in forestry, and a larger landslide from regenerating forest has crossed a road and blocked a small stream (Figure A1.5).
Takaka hill	6	3	306	146	11	Re-activated scree slopes common. Two river bank collapses have since been washed away. Small failure above a quarry and a few cut-slope failures onto roading.
Ruby Bay	36	4	154	13	1.3	Numerous landslides from cliffs onto the beach. Approximately one dwelling has been inundated (impacted) by debris. Gully erosion from cliffs has generated debris cones on the beach (Figure A1.6).
Richmond	10	5	142	105	12	Multiple landslides on roading and in close proximity to dwellings. Several slopes appear to have newly formed tension cracks. Notably long debris runouts (Figure A1.7).
Nelson/Stoke	253	35	250	130	23	Widespread landsliding, predominantly associated with new subdivisions (Figure A1.8), farmland (Figure A1.9), riverbank erosion and roading (Figure A1.10). Many dwellings and infrastructure affected, particularly in the region of Tāhunanui Slump (Figures A1.11 and A1.12). A landslide originating in forestry land in the Maitai Valley damaged a water supply pipeline (Figure A1.13).
Wakapuaka – Pepin Island	167	34	461	253	24	Generally steep slopes and tall cliffs have generated larger, deeper failures than observed elsewhere. Many landslides and debris flows and incipient landslides behind buildings (Figures A1.14 and A1.15), in farmland and in forestry. Large cliff failures have deposited debris cones on the waterfront (Figure A1.16). Pepin Island has been particularly hard hit (Figures A1.17 and A1.18).

Locality	No. of Landslide Photos	No. of Media Reports	Four-Day Total Precipitation (mm)	Max. 24-Hour Precipitation (mm)	Max. 1-Hour Precipitation (mm/h)	Observations
Delaware Bay	54	4	587	307	27	Many earth flows, debris flows and shallow landslides in both gullies and open slopes throughout the region (Figure A1.19).
Whangamoa River	30	8	657	336	28	Small landslides adjacent to the coast and on river banks. A couple of debris flows from vegetated gullies (Figure A1.20).
Southern Rai Valley	3	0	513	252	22	Isolated debris flows and landslides in forestry land.
Northern Rai Valley	53	16	604	285	24	Extensive debris flows, originating from moderate gradient hillslopes, extend down to the valley floor (Figure A1.21). Dwellings, roading and river channels affected (Figure A1.22). Most appear to originate in forestry and farmland.

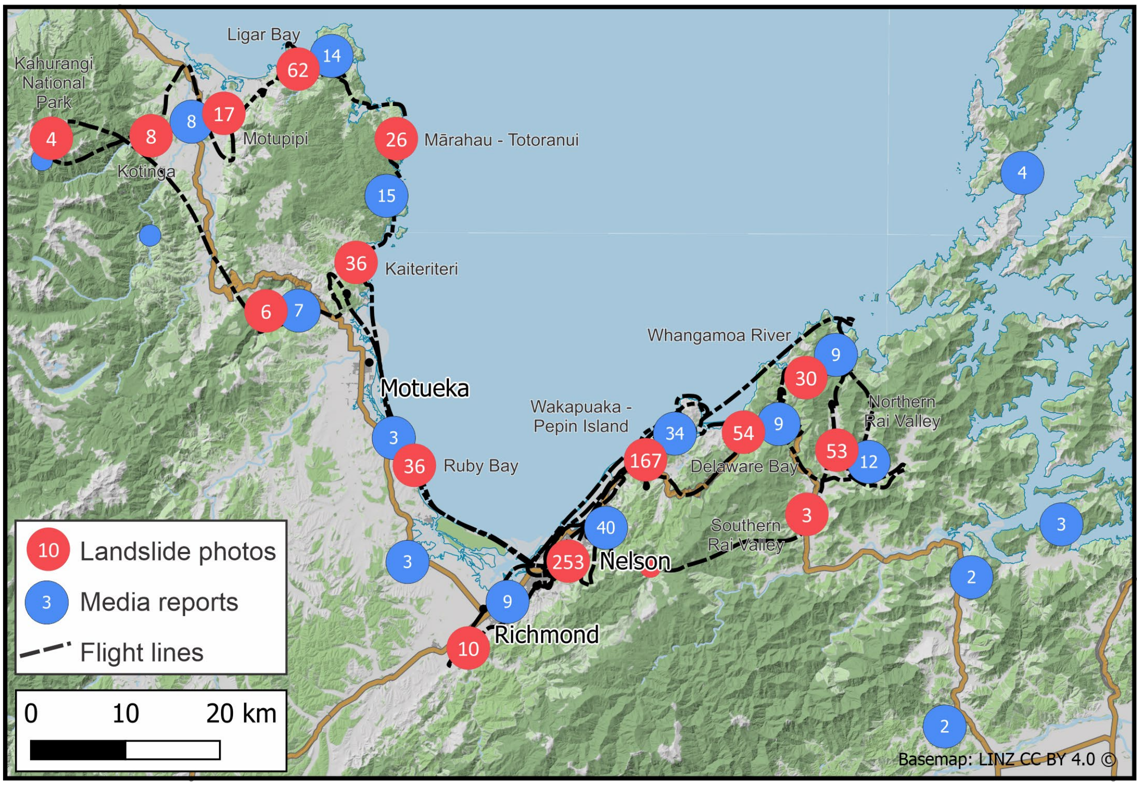

Figure 3.1 Summary of the helicopter reconnaissance carried out on 22–23 August 2022. The numbers in the blue circles relate to the number of media reports that were able to be located, and those in the red circles relate to the number of landslide photos selected to provide coverage at the given location – these can be used as a proxy for the number/density of landslides and their impacts on buildings and infrastructure. Photograph locations have been automatically clustered using the QGIS Cluster Renderer.[5] The black dashed line shows the flight path of the aerial survey.

5 https://www.qgis.org/en/site/forusers/visualchangelog30/index.html?highlight=cluster%20renderer#feature-point-cluster-renderer

4.0 SUMMARY

In August 2022, an extreme rainfall event affected much of New Zealand. NIWA refer to this event as the “strongest August atmospheric river (AR) on record” and classified it as a 1-in-120-year rain event for Nelson. NEMA classified the event as ‘N1’, thus requiring a minor national-level response. The rain event triggered many hundreds of landslides and caused incipient landslides and cracking of hillslopes. NEMA reported that up to 570 properties were damaged and that many roads, along with SH 6 and SH 63, were closed, mainly from landslides and flooding. The main water supply pipeline to Nelson also failed, as it was hit by a landslide.

The data presented in this report was used by the teams working for NCC on the ground to respond to this event. This work will continue to be used during the intermediate and longer-term phases of the recovery, as the data collected in the field will help train rainfall-induced landslide forecast models. Such models are being developed by GNS Science and NIWA to forecast the location and severity of landslides in future rain events across all of Aotearoa.

5.0 ACKNOWLEDGMENTS

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APPENDICES

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APPENDIX 1 SELECTED PHOTOGRAPHS

Selected photos showing typical landslide damage observed during helicopter reconnaissance flights on 22–23 August 2022.

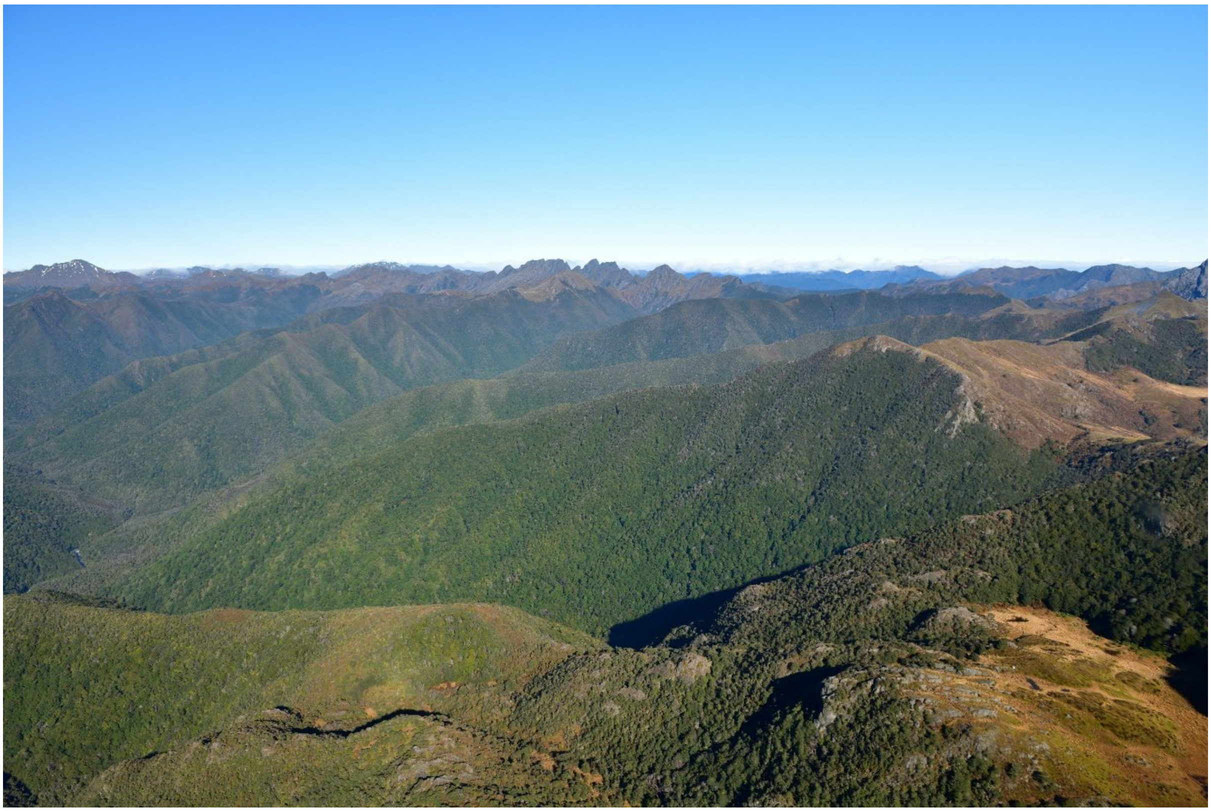

Figure A1.1 Photo 855_8398: Kahurangi (Haupiri Range).

Figure A1.2 Photo 855_8635: Motupipi (Pohara-Clifton).

Figure A1.3 Photo 855_8573: Ligar Bay (Wainui Bay).

Figure A1.4 Photo 855_8409: Mārahau-Totaranui (Torrent Bay / The Anchorage).

Figure A1.5 Photo 855_8757: Kaiteriteri (Holyoake Stream valley).

Figure A1.6 Photo 855_8323: Ruby Bay (Tasman Cliffs).

Figure A1.7 Photo 855_8232: Richmond (Aniseed Hill).

Figure A1.8 Photo 855_9176: Nelson/Stoke (Atawhai).

Figure A1.9 Photo 855_8176: Nelson/Stoke (Stoke).

Figure A1.10 Photo 855_7491: Nelson/Stoke (Bishopdale).

Figure A1.11 Photo 855_7383: Nelson/Stoke (Tāhunanui).

Figure A1.12 Photo 855_9206: Nelson/Stoke (Tāhunanui).

Figure A1.13 Photo 855_7740: Nelson/Stoke (Maitai Valley).

Figure A1.14 Photo 855_8780: Wakapuaka – Pepin Island (Glenduan).

Figure A1.15 Photo 855_7544: Wakapuaka – Pepin Island (Marybank).

Figure A1.16 Photo 855_8847: Wakapuaka – Pepin Island (Glenduan).

Figure A1.17 Photo 855_8895: Wakapuaka – Pepin Island (Pepin Island).

Figure A1.18 Photo 855_9123: Wakapuaka – Pepin Island (Okiwi bay).

Figure A1.19 Photo 855_9111: Delaware Bay.

Figure A1.20 Photo 855_8027: Delaware Bay (Whangamoa).

Figure A1.21 Photo 855_7804: Northern Rai Valley (Ronga River valley).

Figure A1.22 Photo 855_7835: Northern Rai Valley (Ronga River valley).

APPENDIX 2 CONTENTS OF THE ONLINE REPOSITORY

A2.1 Data Availability

Data presented in this report is available online at https://osf.io/3q25w/ (Massey et al. 2022). This includes:

1. Aerial survey.
2. GIS data.
3. Flight lines (Flight_lines.zip).

Garmin GPS logs recording the path of aerial surveys undertaken on 22–23 August 2022 are included in 'Track logs.zip'. This file contains raw GPS records stored as points in ESRI .shp file format, as well as processed polylines in ESRI .shp file format derived from the point data.

A2.2 Selected Photograph Locations (Photograph_locations.zip)

The location and orientation of photographs selected for inclusion in this report are provided in an ESRI .shp file. Attributes include:

- File name.
- Altitude – metres above sea level.
- Direction – degrees relative to true north.
- Latitude – decimal degrees WGS84 (EPSG4326).
- Longitude – decimal degrees WGS84 (EPSG4326).
- Timestamp – NZST.

A2.3 Selected Photograph Summary (Photograph_summary.kmz)

A summary of photographs selected for inclusion in this report is provided in a Google .kmz file for viewing in the Google Earth application. Included images have been down-sampled to 2 MP .jpg files in order to optimise file size. Attributes include:

- File name.
- Direction – degrees relative to true north.

A2.4 Selected Photographs (Selected_photographs.zip)

A selection of processed oblique aerial photographs from aerial surveys undertaken on 22–23 August 2022 are included in 'Selected_photographs.zip'. Original photographs have been down-sampled from 45 MP raw format to 10 MP .jpg for inclusion with this report.

www.gns.cri.nz

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