Otago Regional Council

Joint ORC, CODC, & Teviot Valley Community Board Presentation

Roxburgh Area Debris Flood Hazard: New Technical Findings

ORC and WSP | 11 February 2026

Otago Regional Council

Presentation Objectives

- Provide ORC, CODC, and Teviot Valley Community board with the latest technical findings
- Opportunity for questions with the consultants (WSP) and staff before results are presented to community

Coal Creek flat alluvial fans (north of Roxburgh) with Slaughterhouse Creek in the foreground

Teviot Valley looking across the Clutha River towards Dumbarton and the Old Man Range

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Agenda

1. Programme introduction and context – ORC presenter – 30 mins
2. Roxburgh Debris Flood Hazard and Risk Assessment – WSP presenter – 30 mins
3. Questions – 30 mins

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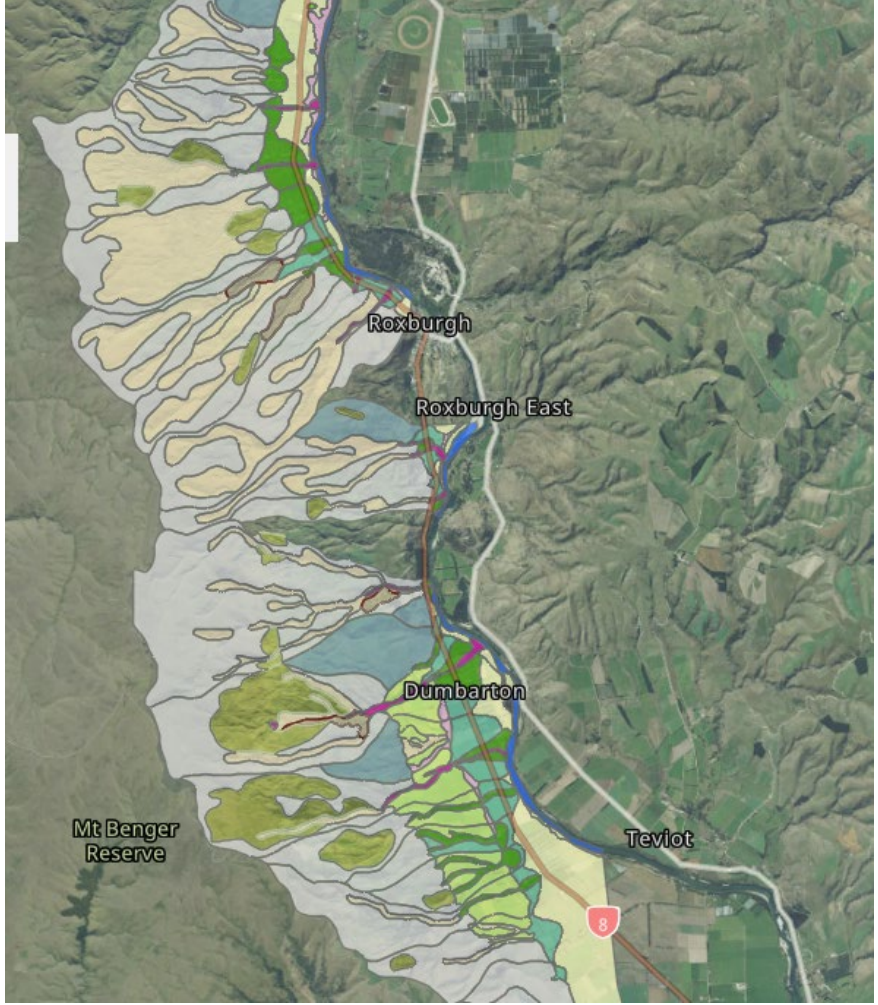
Regional Context

- GNS (2009) and Woods (2011)
- Potential alluvial fan hazard areas in Otago, including Teviot Valley
- Fan and catchment landform mapping
- Available on the Natural Hazards Database: [Alluvial Fans | ORC AGOL Natural Hazards Portal]
- Alluvial fans in Otago can have a range of hazards from clear water flooding to debris flows



Teviot Valley alluvial fan landform mapping (GNS, 2009)

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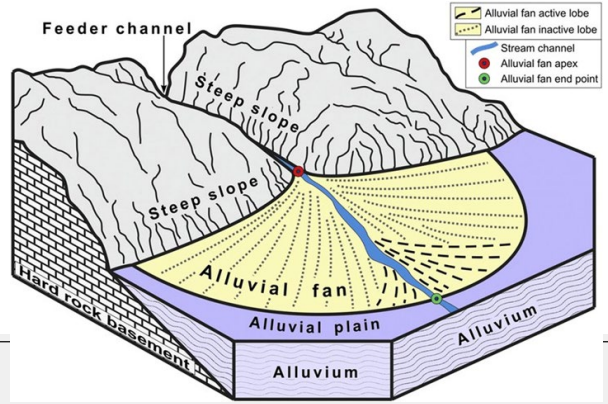
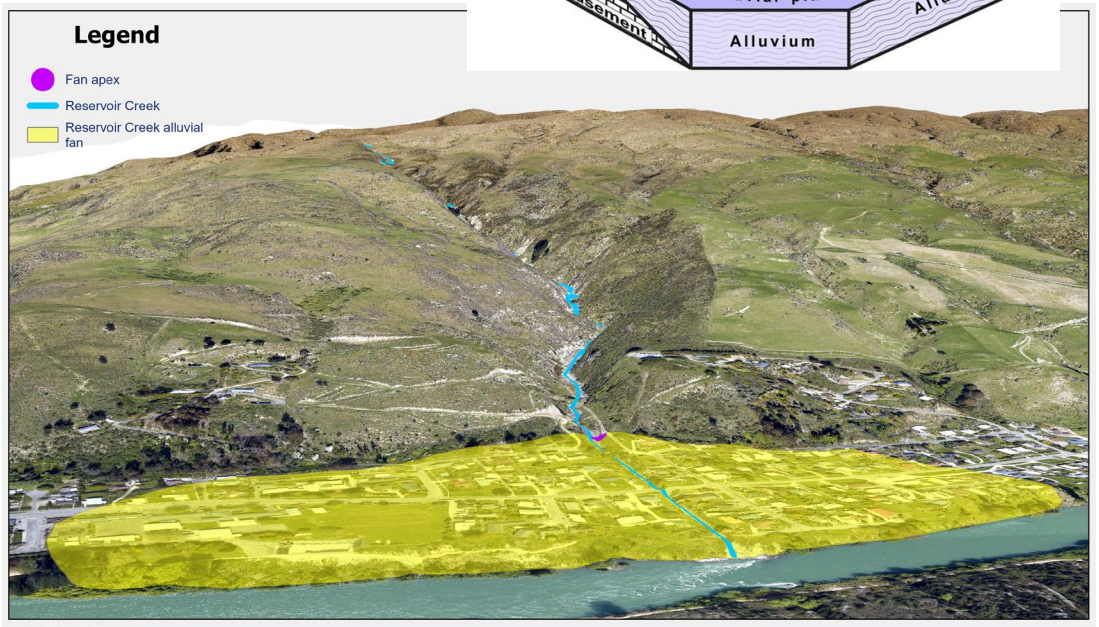
Alluvial Fan Hazards

- The Teviot Valley is exposed to alluvial fan hazards
- Alluvial fans are dynamic depositional landforms at the base of the Old Man Range where debris floods can occur
- Debris floods are a slurry of water, rock, debris that are dense and rapid
- Triggered by high-intensity rainfall
- Damaging and difficult to predict





Reservoir Creek alluvial fan

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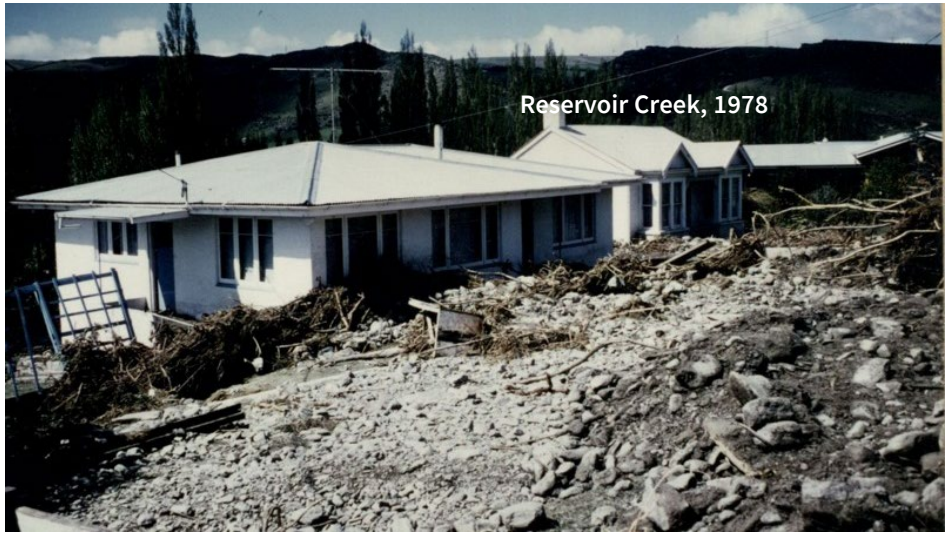
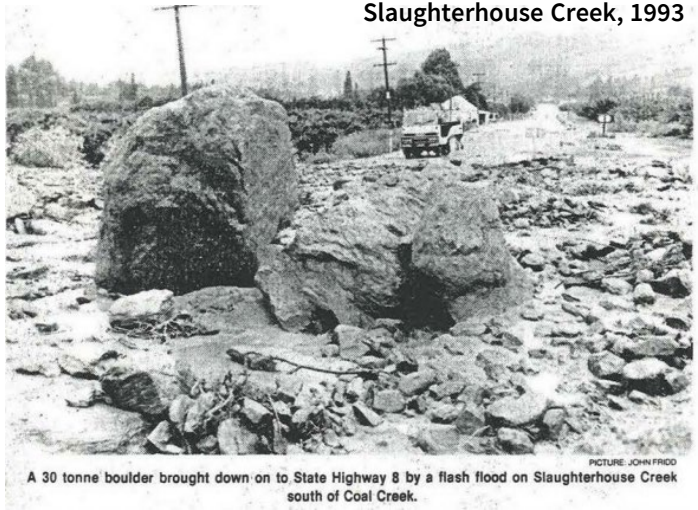
Past Events

- Large events in 1938, 1978, 1993, 2017
- As well as other smaller events
- Multiple events on different alluvial fans


Pumpstation Creek, 2017


Reservoir Creek, 1978

Slaughterhouse Creek, 1993


PICTURE: JOHN FRIDD

A 30 tonne boulder brought down on to State Highway 8 by a flash flood on Slaughterhouse Creek south of Coal Creek.

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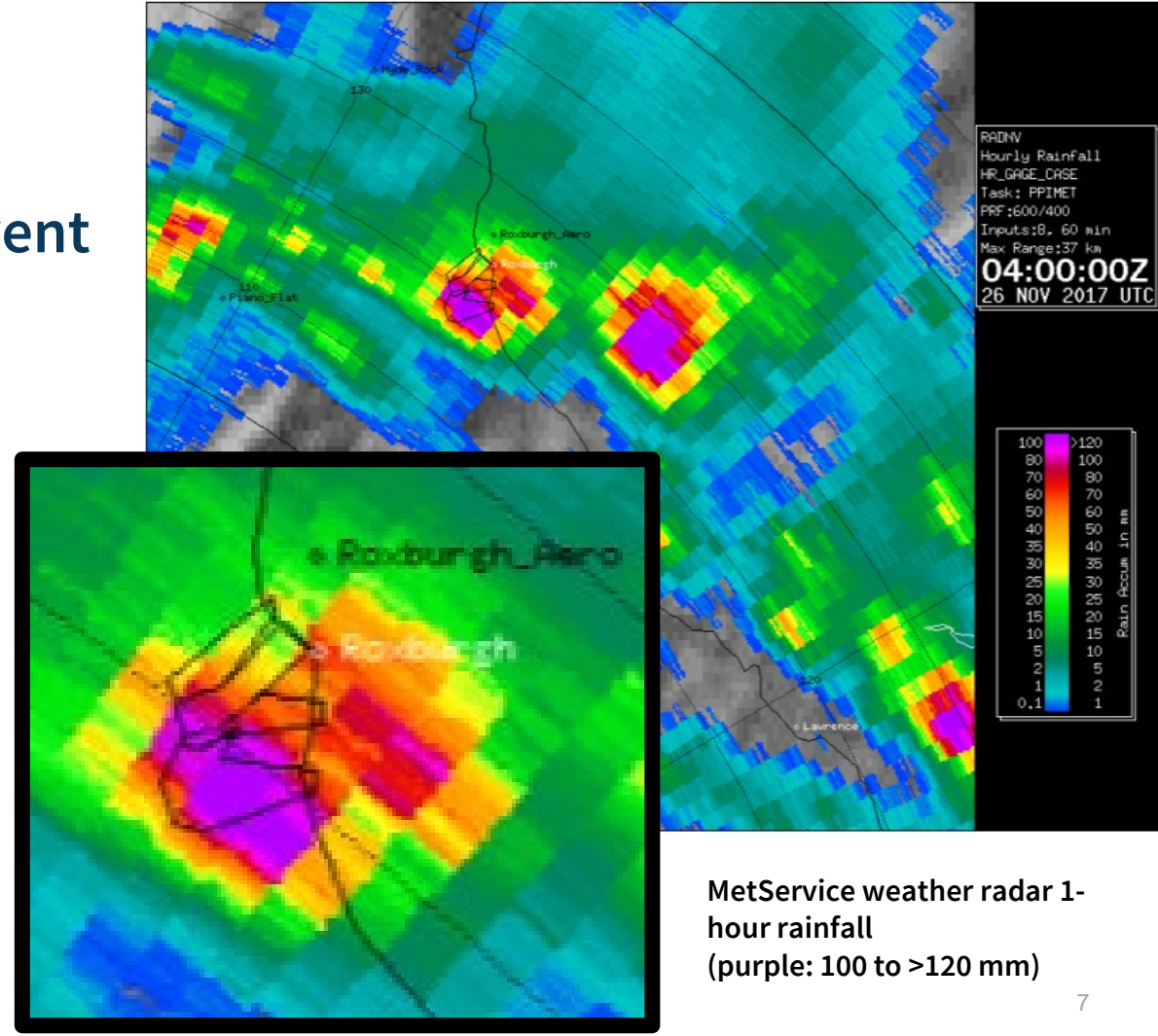
November 26th 2017 Event

- Triggered by localised severe thunderstorm cell
- Rainfall intensities > 1% Annual Exceedance Probability (AEP)
- Spatially variable rainfall
- Debris floods triggered in 5 creeks: Pumpstation, Reservoir, Golfcourse, Blackjacks, and Stevensons (flow within channel)



MetService weather radar 1-hour rainfall
(purple: 100 to >120 mm)

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November 2017 Impacts

- Overwhelmed SH8 crossings
- Deposited debris out of channels, on roads and properties
- Concrete chute contained large debris (Reservoir Creek)
- Localised flooding, water and silt damage
- Critical infrastructure damaged

Golfcourse Creek, 2017

Reservoir Creek, 2017

Post-2017 work completed

- ORC, NZTA, and CODC cooperated on recovery
- NZTA replaced SH8 culverts affected to increase capacity
- CODC increased resilience of pump station
- ORC conducted follow-up investigations:
  - Assessment of flood and erosion hazards in the Clutha River post 2017 events (Damwatch Engineering, 2017)
  - Hazard event assessment of the 2017 debris floods (GNS, 2018)
  - Management and reduction of debris flow risk in Roxburgh – first high-level risk assessment and management approaches for 2017 fans (Golder, 2019, 2 reports) – *identified the risk to life as potentially significant*

GOLDER

REPORT

Management and Reduction of Debris Flow Risk in Roxburgh, Otago

Geomorphological Assessment Report

Submitted to:

Otago Regional Council
70 Stafford Street
Private Bag 1954
Dunedin 9054

Submitted by:

Golder Associates (NZ) Limited
Level 1, 214 Durham Street, Christchurch 8011, New Zealand

+64 3 377 5696

18113634_7407-003-R-Rev0

August 2019

Current and Ongoing Hazard Management Approaches

PARA Framework – Protect / Accommodate / Retreat / Avoid

Protect

☑ Existing concrete chute for Reservoir Creek

☑ Existing SH8 road crossings structures

Accommodate

☑ Readiness, response, recovery, reduction

☑ Monitoring, forecasting and early warning

☑ Existing resilience of infrastructure

☑ Channel maintenance for 5 creeks (gravel and vegetation) and reactive delta gravel maintenance

☑ Chute maintenance for Reservoir Creek

☑ Individual and business insurance cover

☑ SH8 road crossings maintenance and repair

Retreat

Avoid

☑ Existing development rules and land use plans

Whose area of responsibility

Otago Regional Council (ORC)
Central Otago District Council (CODC)
NZ Transport Agency Waka Kotahi (NZTA)
Individual property owner
Multiple (some or all) - CODC, ORC, CDEM, NZTA, agencies, providers, community, individuals

Current Roxburgh Natural Hazards Management Programme

Objective: identify, assess, and potentially implement, natural hazard risk management responses for debris flow hazards in the Roxburgh area.

Two concurrent technical projects by ORC

1. **Interim creek monitoring and maintenance plan (ongoing)**
2. **Roxburgh Debris Flood Detailed Hazard and Risk Assessment (NEW)**
   - in collaboration with CODC and NZTA

Supported by a community engagement plan

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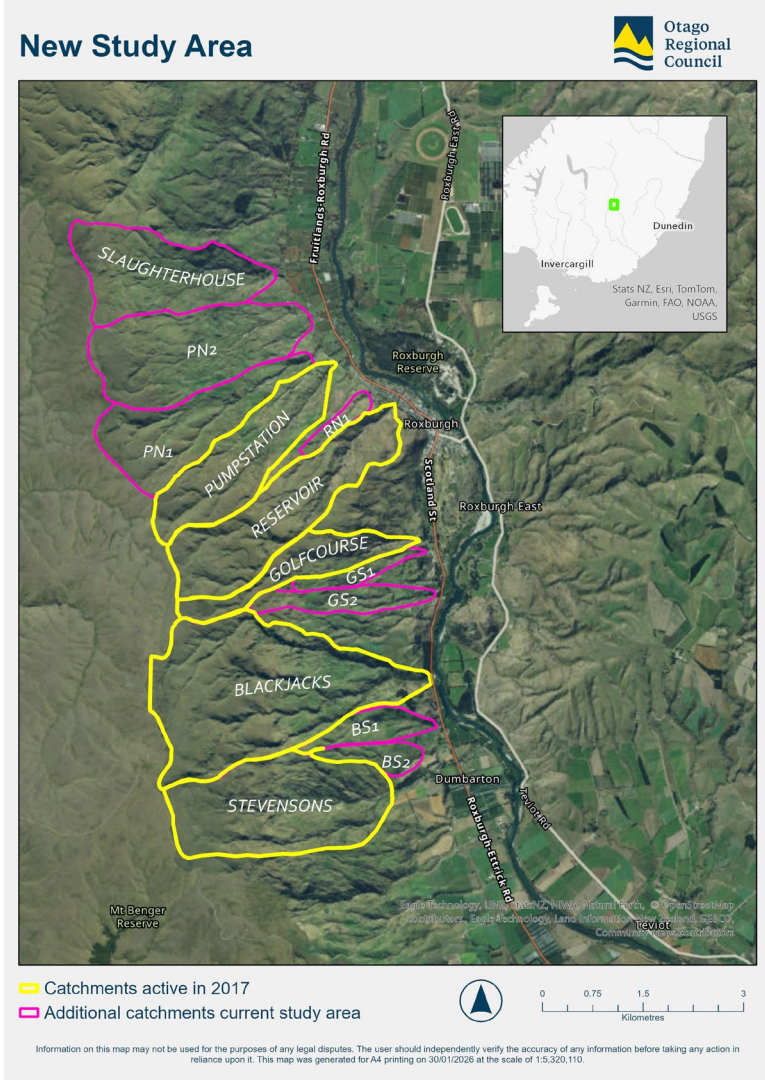
New Study Area

- 13 catchments/fans (yellow and pink)
- Catchments in yellow were active during the Nov 2017 events
- Catchments were included in the study area based on a prioritisation process
- Local names were not available for some creeks – these are identified by short labels (e.g. BS1)



New Results - Roxburgh Debris Flood Detailed Hazard and Risk Assessment

- **Follows-up on a recommendation of the Golder (2019) reports**
- **For 13 alluvial fans (including those active in 2017 event):**
  - new detailed mapping is complementary to and refines the regional data (2009)
  - identifies areas where debris floods are more likely to occur
  - improves detail and spatial resolution of hazard and risk information
  - multi-purpose, useful background for many types further management work
  - milestone study - provides the technical basis for all further work

Sharing New Results - Key Activities in February

4 to 13 February – community event promotion

- Teviot Weekly Bulletin (x 2 weeks), digital ads, letterbox flyers, posters

11 February - Joint presentation ORC and CODC councillors and Teviot Valley community board members

- end of day – go live of public information & media release

12 February - Hui with Aukaha, TAMI and rūnaka representatives

18 February - Community Drop-in and Presentation at Roxburgh Golf Club

- Drop-in anytime (3pm to 6pm)
- Presentation with Q&A (6:30pm-9pm)

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What's Next?

- **Early March - loop back to community with any follow-up (e.g. Teviot Bulletin)**

- **Consider councillor feedback, community and mana whenua concerns, and carry forward into planning**

- **Consider ways to align existing hazard management responses and planned work programmes with the new risk findings**
  - Develop short-term action plan (within current budgets and existing constraints)
  - Integrate into long-term decision-making and funding processes (e.g. Long Term Plans)

- **Additional community engagement activities in 2026 (if needed)**

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Consultant Presentation - WSP

ROXBURGH DEBRIS FLOOD AND DEBRIS FLOW STUDY

ORC AND CODC COUNCILLOR PRESENTATION

Prepared for Otago Regional Council | February 2026

ORC Debris Flood and Debris Flow Study

Project Background and Methodology

Roxburgh has been historically inundated by debris floods and flows. Debris flood modelling and risk assessment required for ORC future planning. This presentation overviews the WSP risk assessment.

Debris Flood Modelling

An overview of the methodology for the risk assessment.

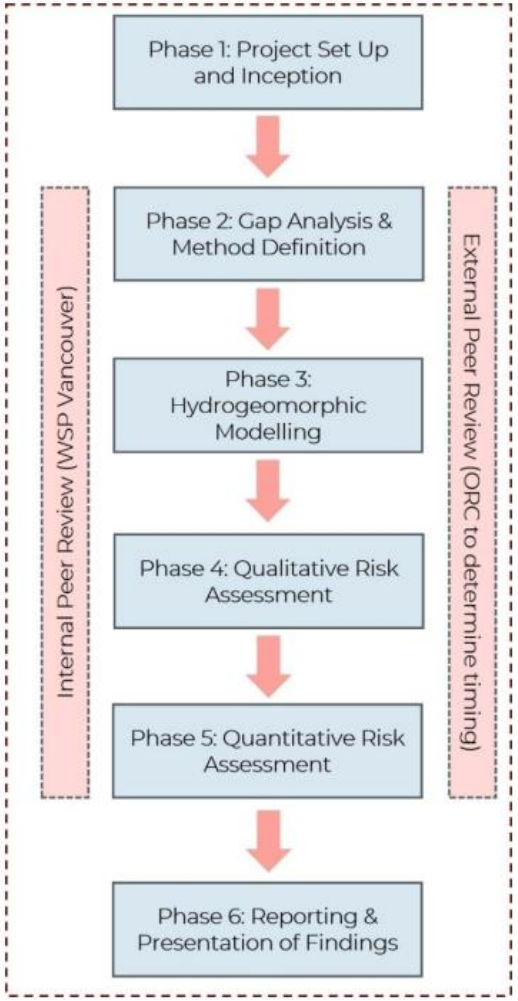
Risk Assessment Results

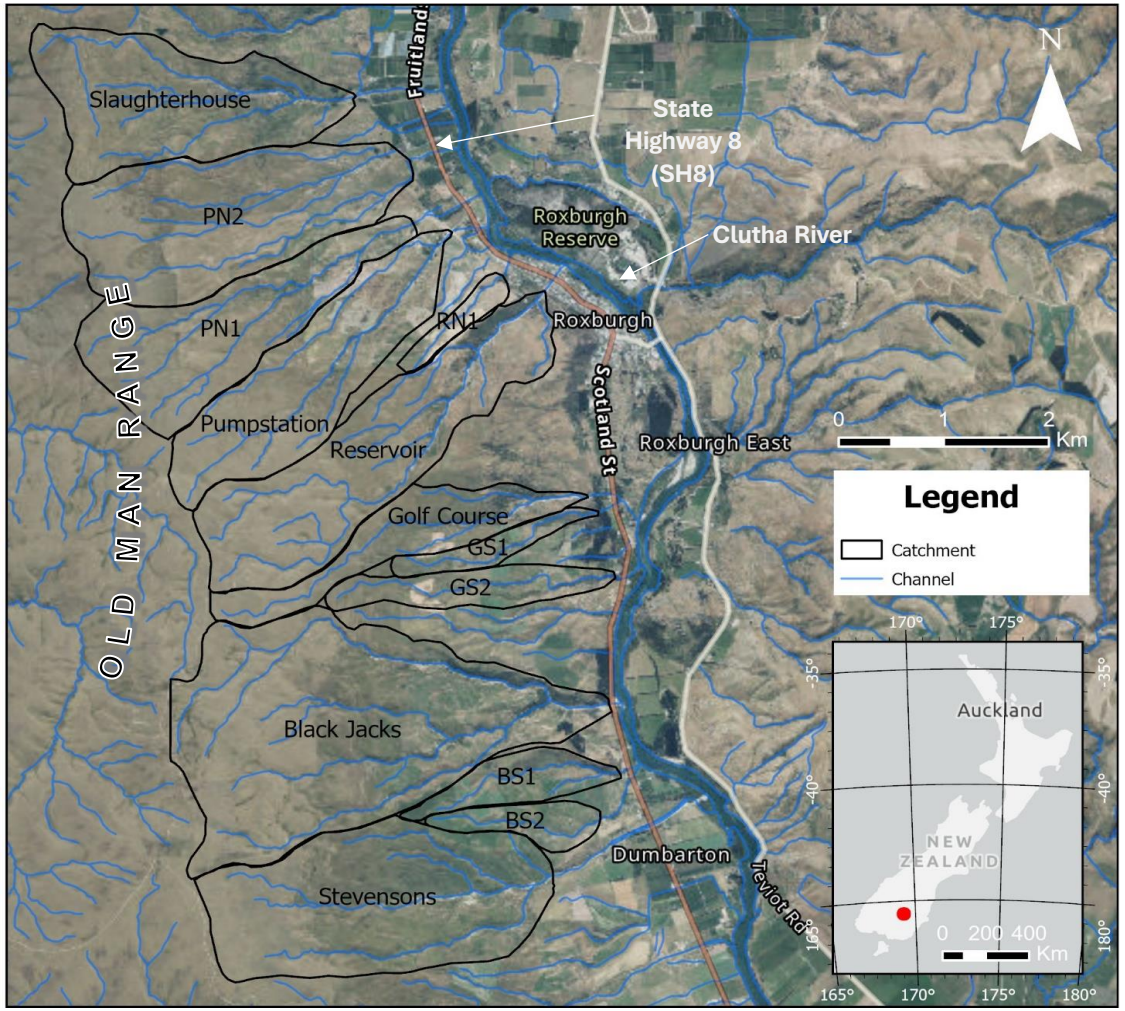
Overview of the risk assessment results including key observations and recommendations.

Implications

What did we find and what does this mean?

Background

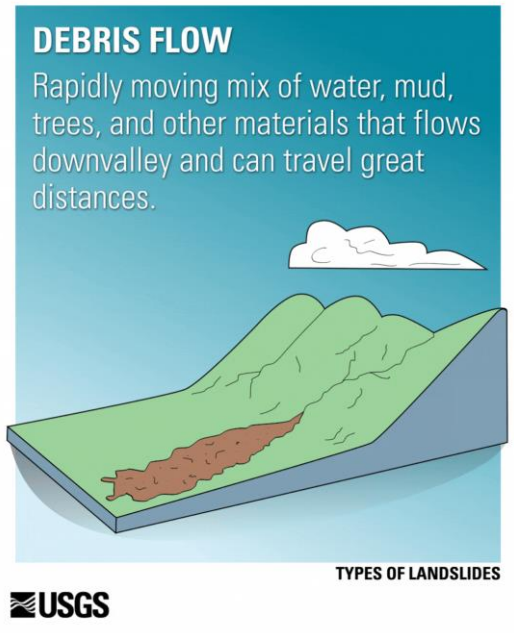

Phase 1: Project Set Up and Inception
Phase 2: Gap Analysis & Method Definition
Phase 3: Hydrogeomorphic Modelling
Phase 4: Qualitative Risk Assessment
Phase 5: Quantitative Risk Assessment
Phase 6: Reporting & Presentation of Findings
Internal Peer Review (WSP Vancouver)
External Peer Review (ORC to determine timing)

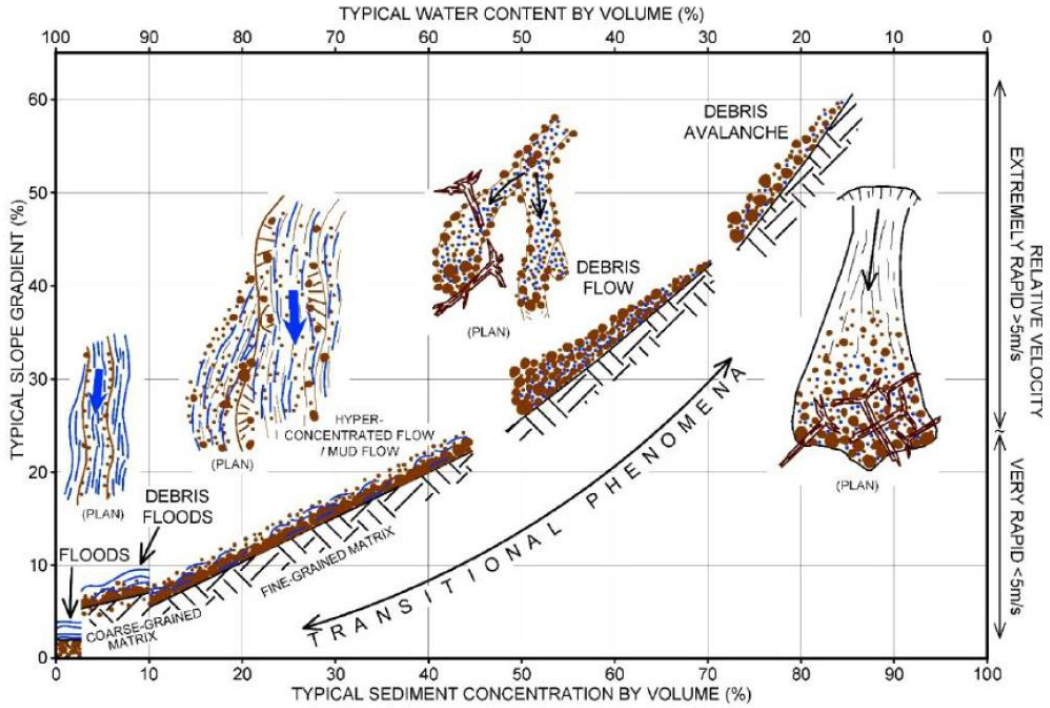

Slaughterhouse
Fruitland
State Highway 8 (SH8)
PN2
Roxburgh Reserve
Clutha River
OLD MAN RANGE
PN1
RN1
Roxburgh
Scotland St
Pumpstation
Reservoir
Roxburgh East
Golf Course
GS1
GS2
Black Jacks
BS1
BS2
Dumbarton
Stevensons
Teviot Rd
N
0 1 2 Km
Legend
Catchment
Channel
Auckland
NEW ZEALAND
0 200 400 Km
165°
170°
175°
180°
-35°
-40°

What are we looking at?

Hydrogeomorphic hazards refer to slope processes involving water and sediment that can have severe and wide-ranging impacts on both the human and natural environment.

They include **debris floods** (fluid-dominated) and debris flows (sediment-dominated) which are the key focus of this study.





Hydrogeomorphic hazards in Roxburgh

Why is Roxburgh and the Teviot Valley vulnerable to hydrogeomorphic hazards including debris floods and debris flows?

Hydrogeomorphic hazards in Roxburgh

What has happened in the past?

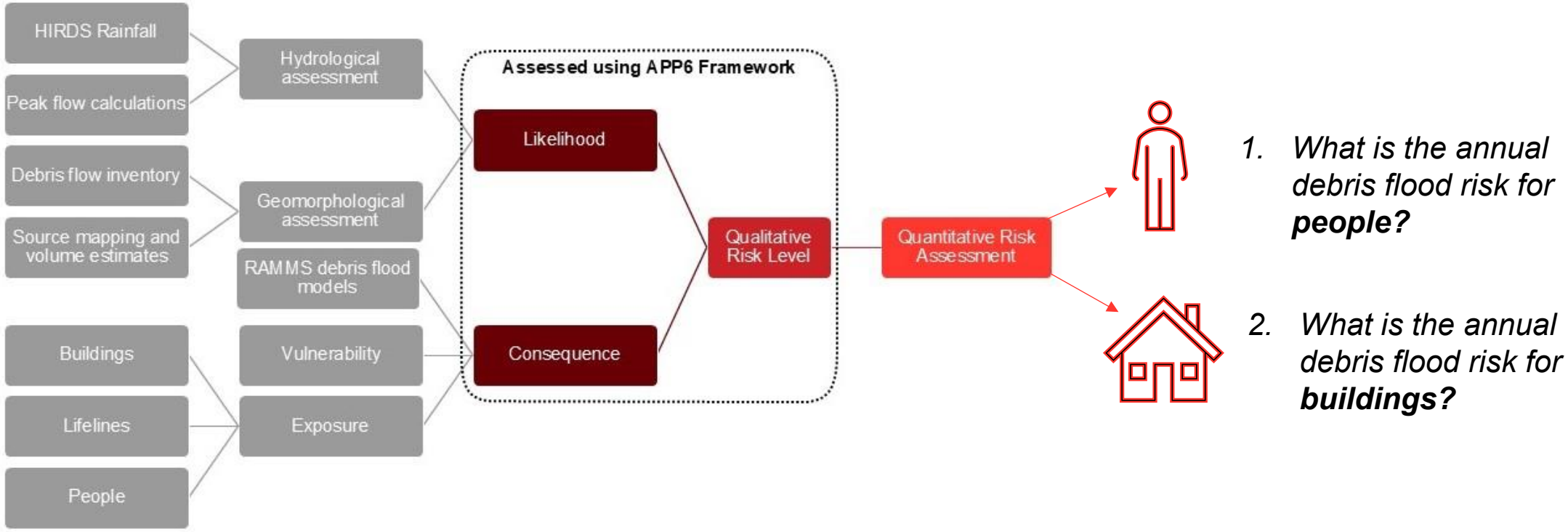
Historical records

- Seven documented events since 1938.
- 1978 and 2017 the most recent and notable events.

October 1978 Debris Flood Reservoir Creek

November 2017 Debris Flood Reservoir Creek

Our Study



1. *What is the annual debris flood risk for **people?***

2. *What is the annual debris flood risk for **buildings?***

DEBRIS FLOOD MODELLING

ORC AND CODC COUNCILLOR PRESENTATION

Prepared for Otago Regional Council | February 2026

Debris flood modelling

INPUTS

Topographical data

Where are the flow paths and debris source areas?

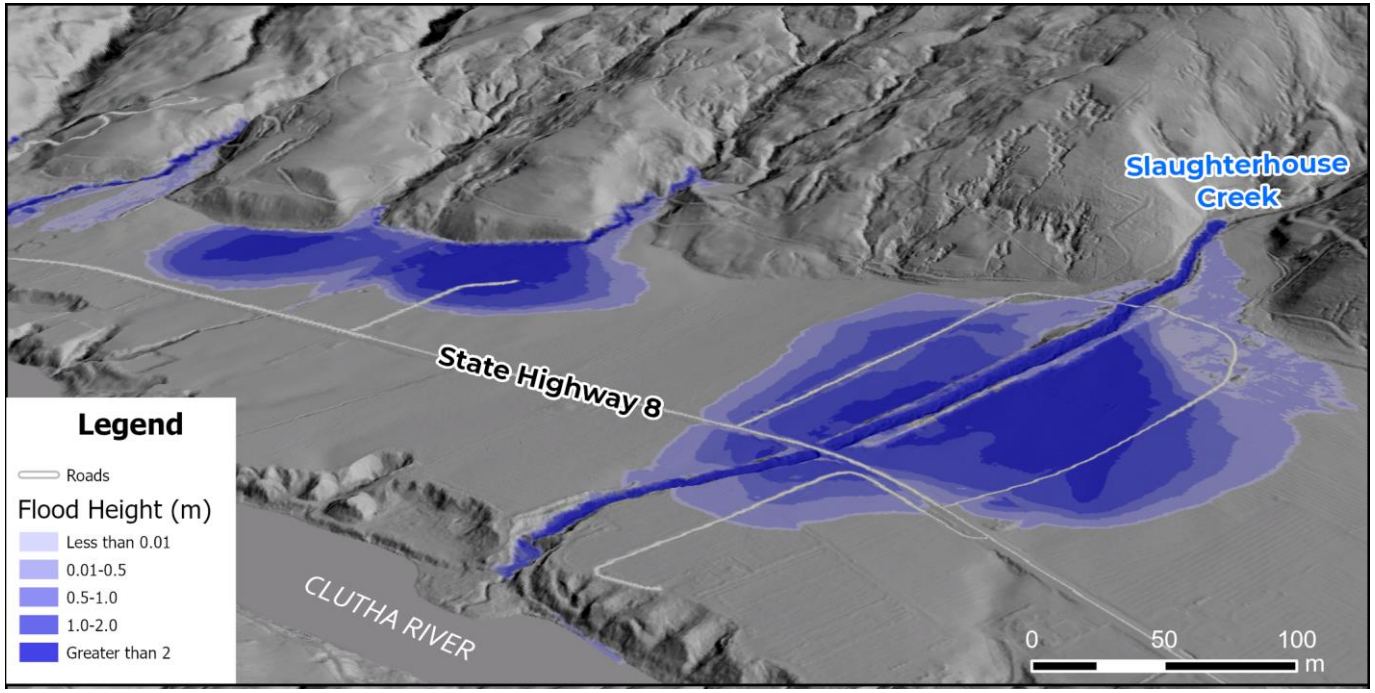
Hydrological Model

How do streams react to rainfall events?

Geomorphological assessment

What can we expect from future events?

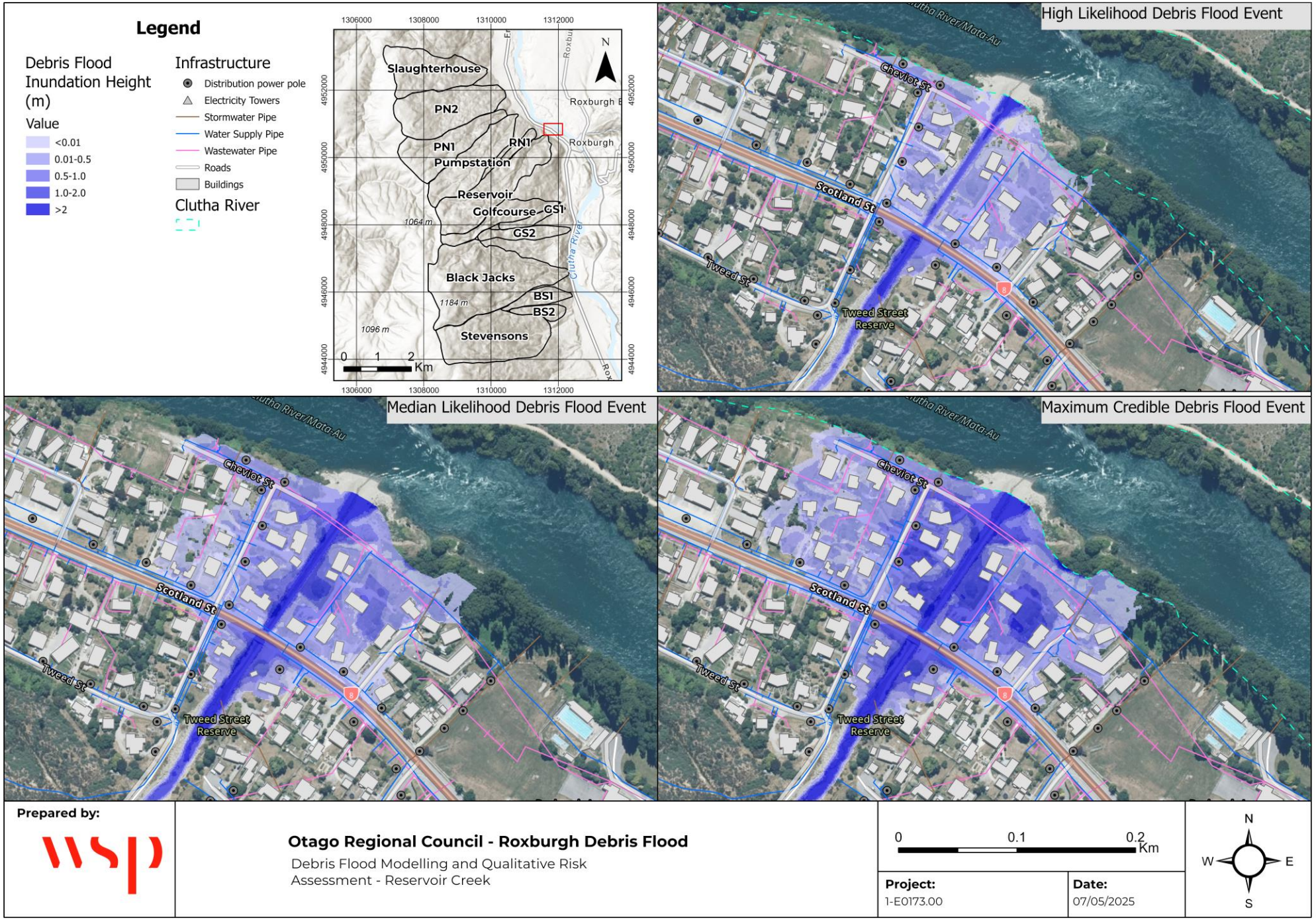
OUTPUTS



Debris flood modelling

3 scenarios were assessed as per the partially operative ORC Regional Policy Statement:

Event	Description	Trigger	Return Period (including climate change)
High likelihood event	More frequent but smaller scale debris floods. Similar in size to Pumpstation/Golf course 2017 events.	40-60 mm of rainfall in 1 hour	100 – 300 years
Median likelihood event	Larger debris flood volume and extent, less frequent that high likelihood event.	60-100 mm of rainfall in 1 hour.	500 – 1,400 years
Maximum credible event	Large scale but very infrequent debris flood events. Not observed in human records.	>140 mm of rainfall in 1 hour.	10,000-12,000 years.


Legend
Debris Flood Inundation Height (m)
Value
<0.01
0.01-0.5
0.5-1.0
1.0-2.0
>2
Infrastructure
Distribution power pole
Electricity Towers
Stormwater Pipe
Water Supply Pipe
Wastewater Pipe
Roads
Buildings
Clutha River
1306000
1308000
1310000
1312000
4952000
4950000
4948000
4946000
4944000
N
Slaughterhouse
PN2
PN1
RN1
Pumpstation
Reservoir
Golfcourse
GS1
GS2
Black Jacks
BS1
BS2
Stevensons
Roxburgh
1064 m
1184 m
1096 m
0 1 2 Km
High Likelihood Debris Flood Event
Median Likelihood Debris Flood Event
Maximum Credible Debris Flood Event
Clutha River/Mata-Au
Cheviot St
Scotland St
Tweed St
Tweed Street Reserve
Prepared by:
Otago Regional Council - Roxburgh Debris Flood
Debris Flood Modelling and Qualitative Risk Assessment - Reservoir Creek
0 0.1 0.2 Km
N
W
E
S
Project:
1-E0173.00
Date:
07/05/2025

Legend

Debris Flood Inundation Height (m)

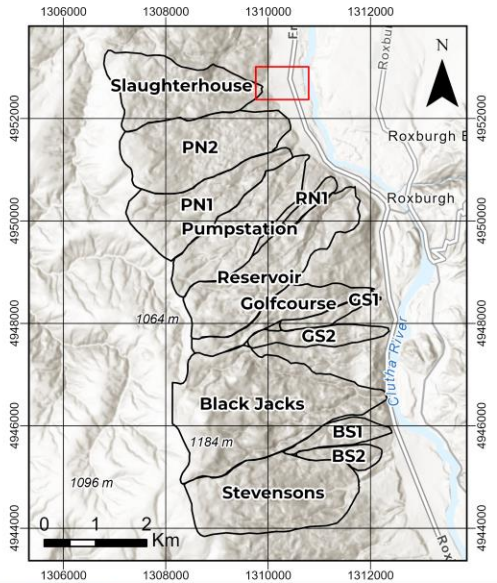
Value

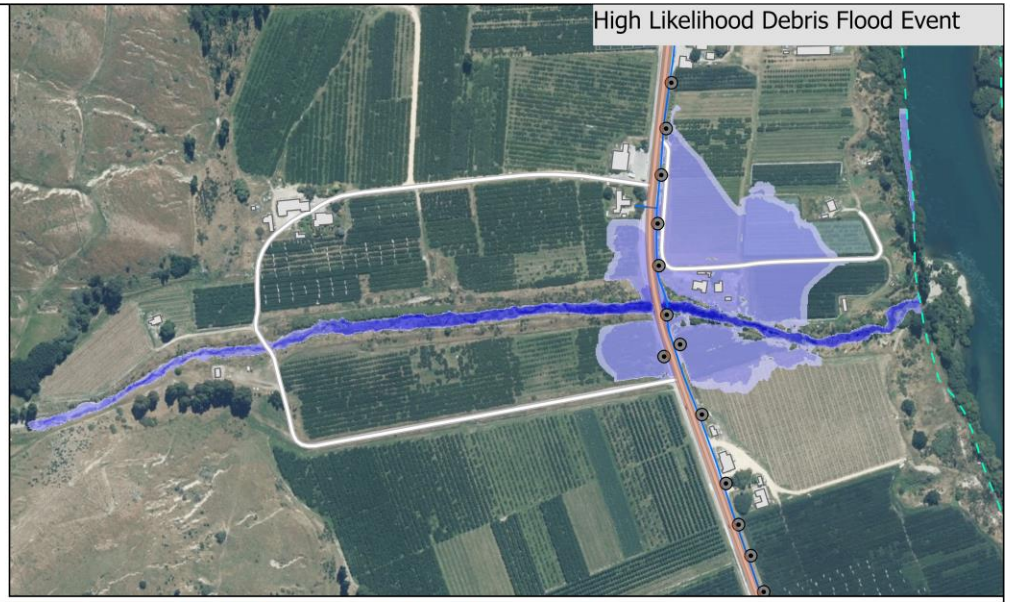
- <0.01
- 0.01-0.5
- 0.5-1.0
- 1.0-2.0
- >2

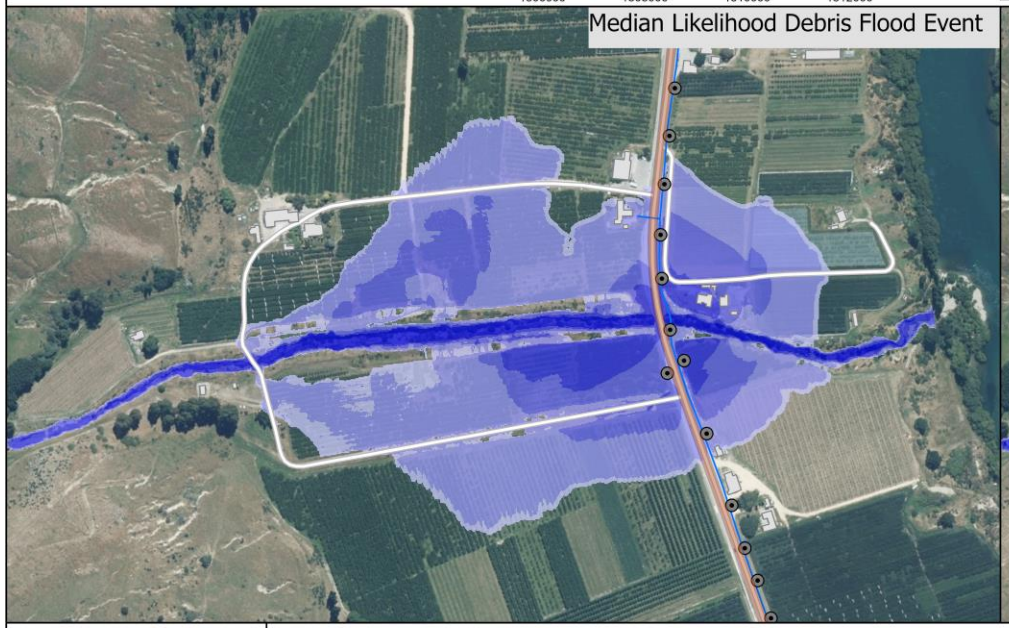
Infrastructure

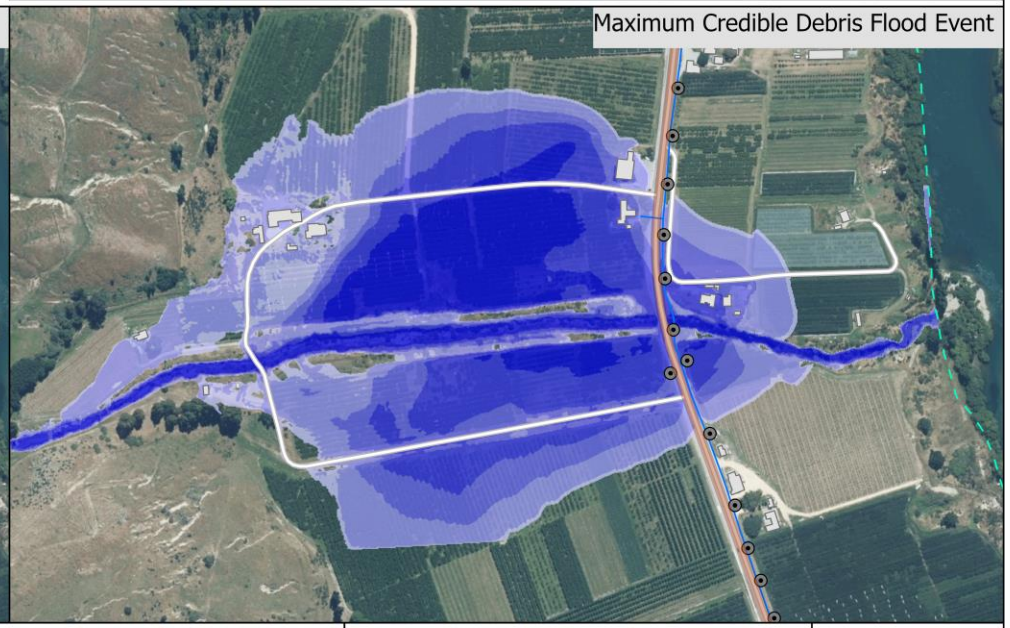
- Distribution power pole
- Electricity Towers
- Stormwater Pipe
- Water Supply Pipe
- Wastewater Pipe
- Roads
- Buildings

Clutha River









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Debris Flood Modelling - Slaughterhouse Creek

0 0.15 0.3 Km

N W E S

Project: 1-E0173.00

Date: 30/04/2025

QUALITATIVE RISK ASSESSMENT

ORC AND CODC COUNCILLOR PRESENTATION

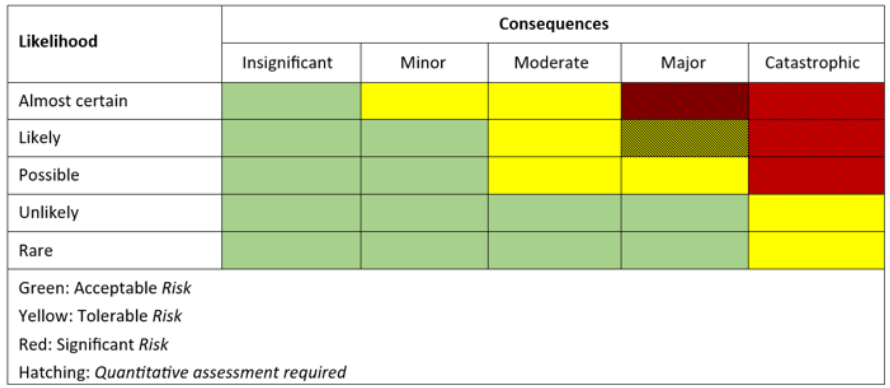
Prepared for Otago Regional Council | February 2026

Initial qualitative risk screening

- A qualitative risk screening was completed to identify the highest risk fans for further assessment.
- Qualitative risk calculated as:

$$Risk = Hazard\ Likelihood \times Consequence$$

- Consequences determined using existing criteria for buildings, people, and lifelines:
  - Physical damage, injuries/fatalities, lifeline damage and outages.
- Uses pORPs APP6 framework.
- Useful screening tool



Results

Catchment	High Likelihood Event	Median Likelihood Event	Maximum Credible Event	Highest Assessed Risk	Quantitative Risk Assessment Required
PN1	5	5	5	5	Yes
GS2	4	5	5	5	Yes
BS2	4	5	5	5	Yes
Stevensons	4	5	5	5	Yes
PN2	4	5	5	5	Yes
Slaughterhouse	2	5	5	5	Yes
GS1	2	5	5	5	Yes
Pumpstation	4	4	5	5	Yes
BS1	4	4	5	5	Yes
Reservoir	3	4	5	5	No*
Golf course*	2	4	4	4	No*
RN1*	1	1	3	3	No*
Blackjacks	1	2	2	2	No

*ORC would like to understand the spatial quantitative risk of Reservoir, Golf course, and RN1 for future planning and as such these catchments will be considered in the next phase.

QUANTITATIVE RISK ASSESSMENT

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Prepared for Otago Regional Council | February 2026

How is quantitative risk calculated?

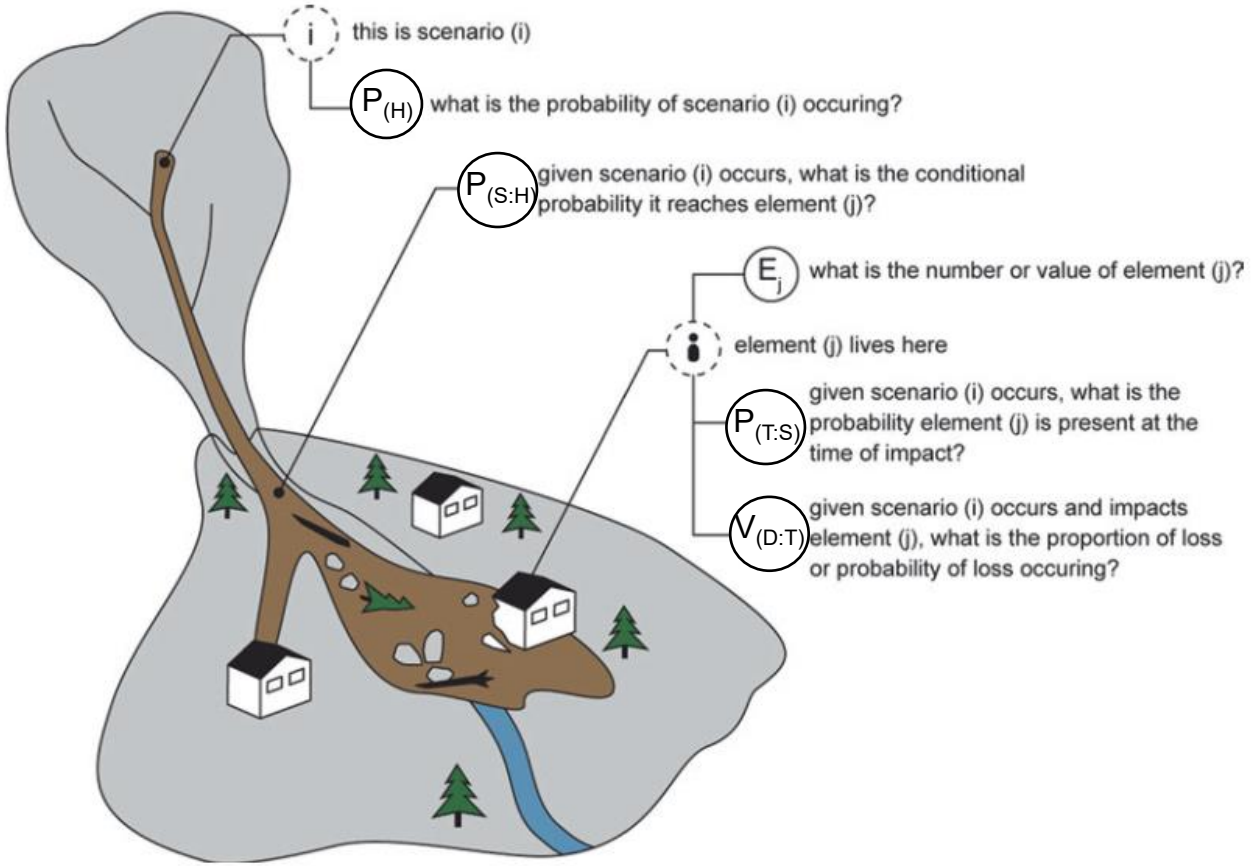
- We are to assess life risk using AGS Guidelines for Landslide Risk Assessment.
- **For people**, risk calculated as **annual individual fatality risk (AIFR):**

$$AIFR = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$$

- AIFR means in any given year what is the likelihood of fatality of the most exposed individual in the study area.
- **For buildings**, risk calculated as **annual property risk (APR):**

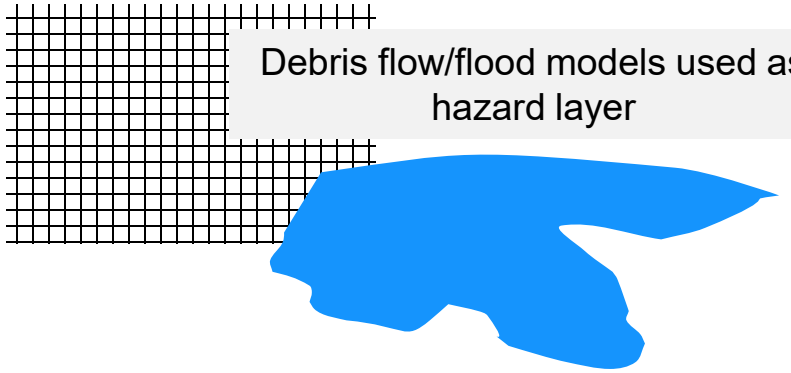
$$APR = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(B)}$$

- APR means in any given year what is the likelihood of a building being damaged.



How do we determine risk spatially?

Each fan divided into 1 by 1m grid cells.

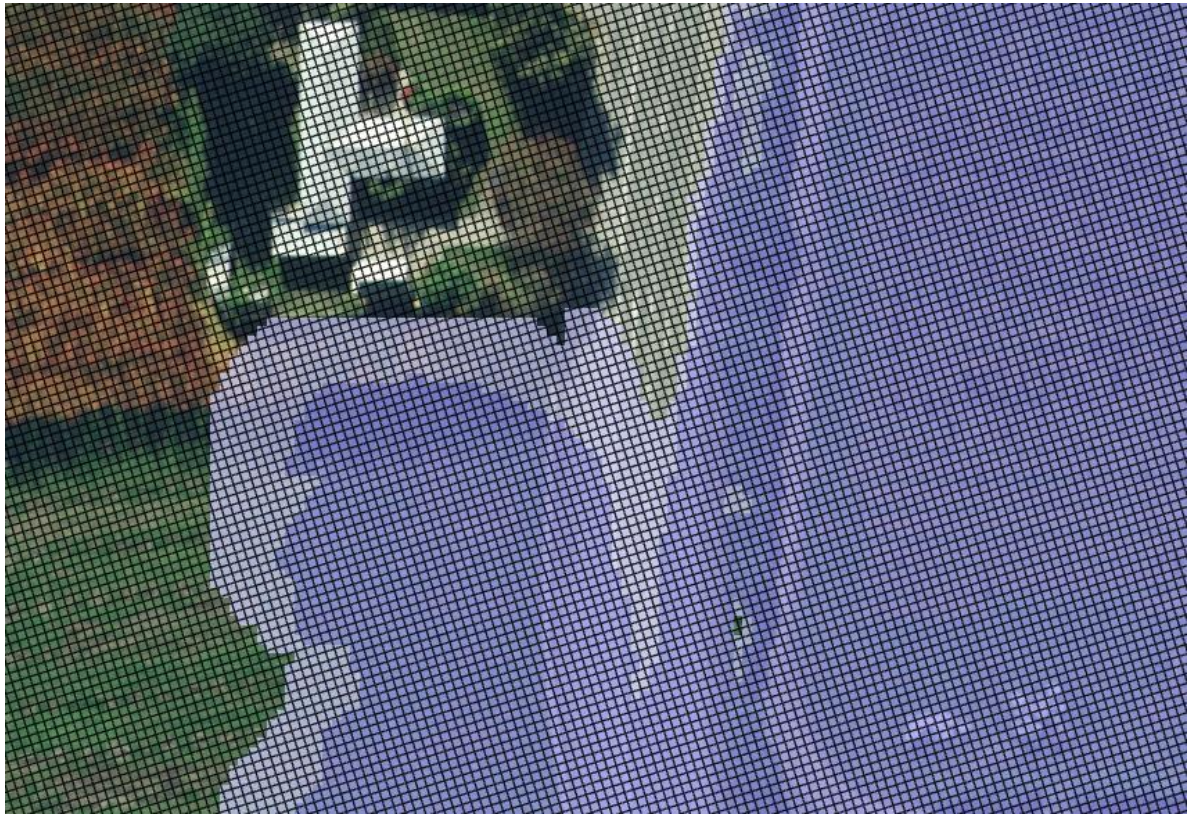


Debris flow/flood models used as hazard layer

For each grid cell assign:

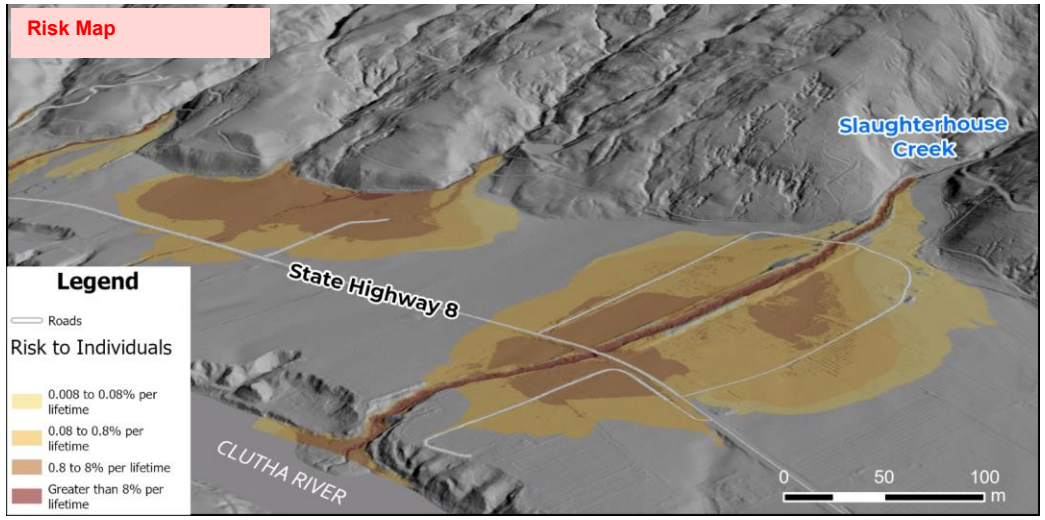
- Probability of hazard occurring
- Probability that hazard reaches exposed element
- Probability that exposed element is present at the time of the event
- Vulnerability of exposed element given the depth of inundation and velocity of the event.
- AIFR and APR

Debris flood model inundation (purple), grid cells (black)



Risk mapping and tolerability

Colour	Risk Value	Risk Tolerability - Existing Development	Risk Tolerability - New Development
	1E-06 to 1E-05	Acceptable	Tolerable
	1E-05 to 1E-04	Tolerable	Significant
	1E-04 to 1E-03	Significant	
	>1E-03		



- Proposed Otago Regional Policy Statement APP6 risk tolerability criteria applied to calculated risk values.
- Both present day and severe climate change scenario mapped.
- Risk values (i.e. 1E-06) expressed as annual risk of fatality or property risk.
- Very small values so scientific notation used in maps.
- See below table for what notation means.

'10 to the negative ...per year'	Is the same as...(per year)	Is the same as once in...	Is the same as...(80-year lifetime)
10^{-2}	1%	100 years	80% per lifetime
10^{-3}	0.1%	1,000 years	8% per lifetime
10^{-4}	0.01%	10,000 years	0.8% per lifetime
10^{-5}	0.001%	100,000 years	0.08% per lifetime
10^{-6}	0.0001%	1,000,000 years	0.008% per lifetime

Prepared by:

Otago Regional Council - Roxburgh Debris Flood

Quantitative Risk Assessment- Reservoir

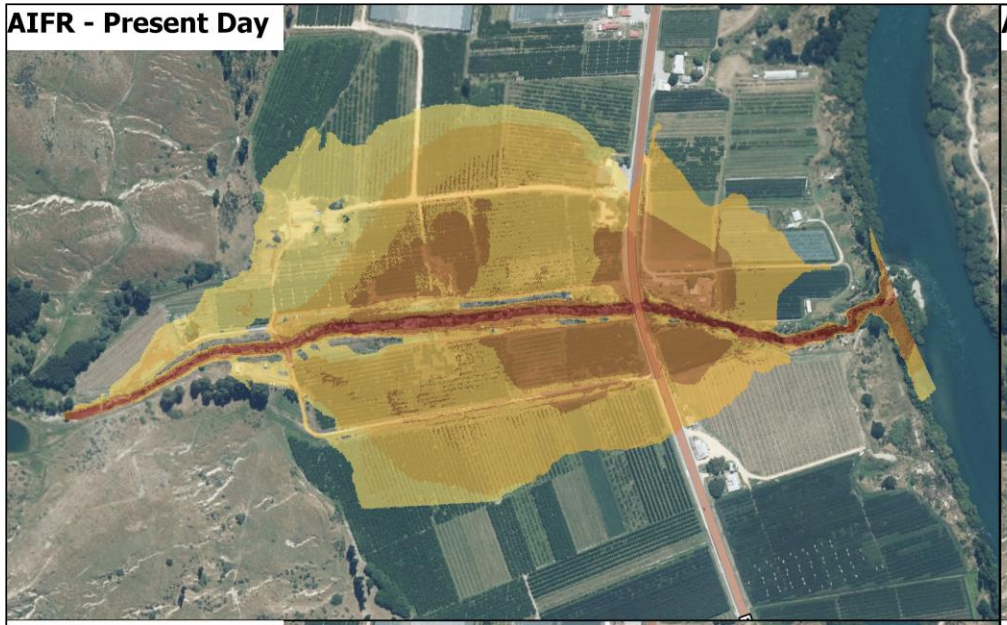
Colour	Risk Value	Risk Tolerability - Existing Development	Risk Tolerability - New Development
	<1E-06	Acceptable	Acceptable
	1E-06 to 1E-05		Tolerable
	1E-05 to 1E-04	Tolerable	Significant
	1E-04 to 1E-03	Significant	
	>1E-03		

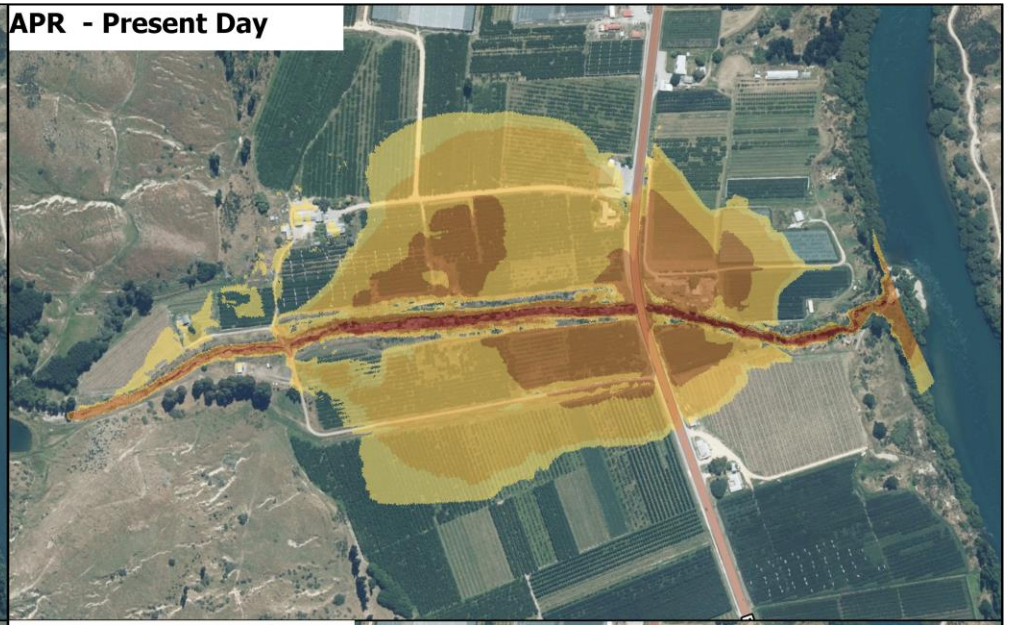
0 0.1 0.2 Km

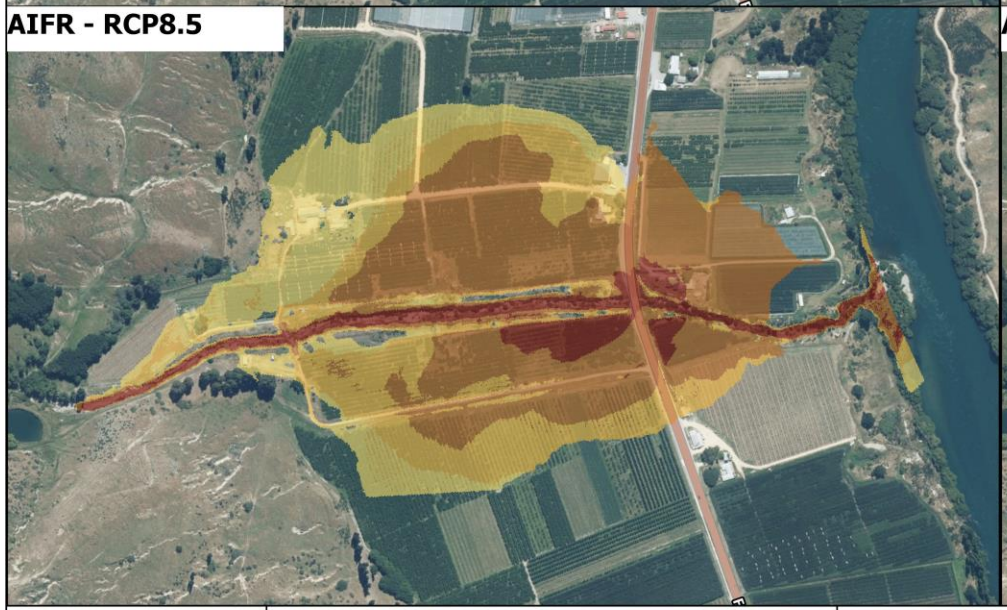
N W E S

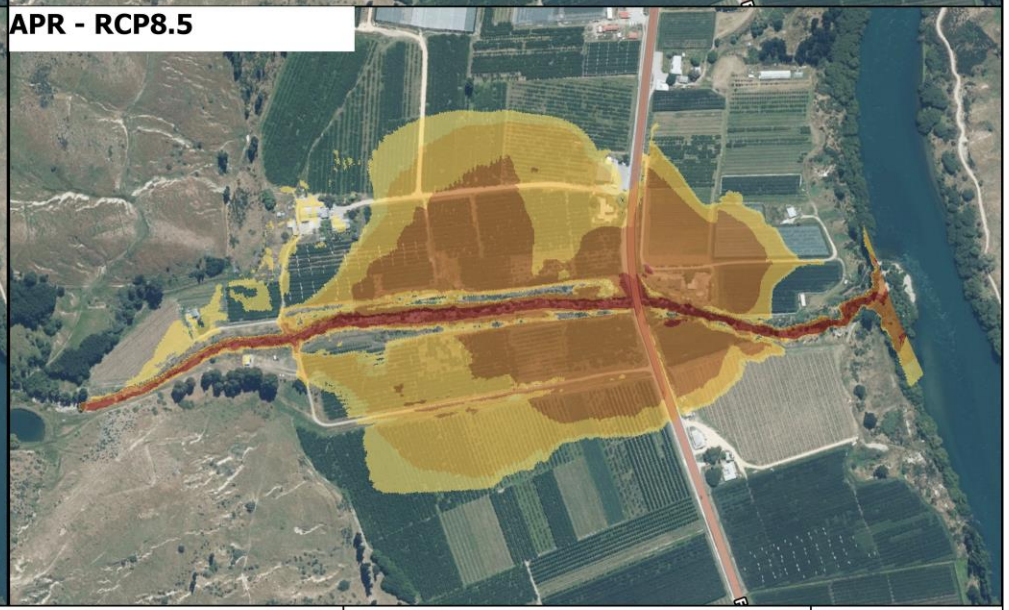
Project: 1-E0173.00

Date: 30/07/2025









Prepared by:

Otago Regional Council - Roxburgh Debris Flood

Quantitative Risk Assessment- Slaughterhouse

Colour	Risk Value	Risk Tolerability - Existing Development	Risk Tolerability - New Development
	<1E-06	Acceptable	Acceptable
	1E-06 to 1E-05		Tolerable
	1E-05 to 1E-04	Tolerable	Significant
	1E-04 to 1E-03	Significant	
	>1E-03		

0 0.23 0.45

Km

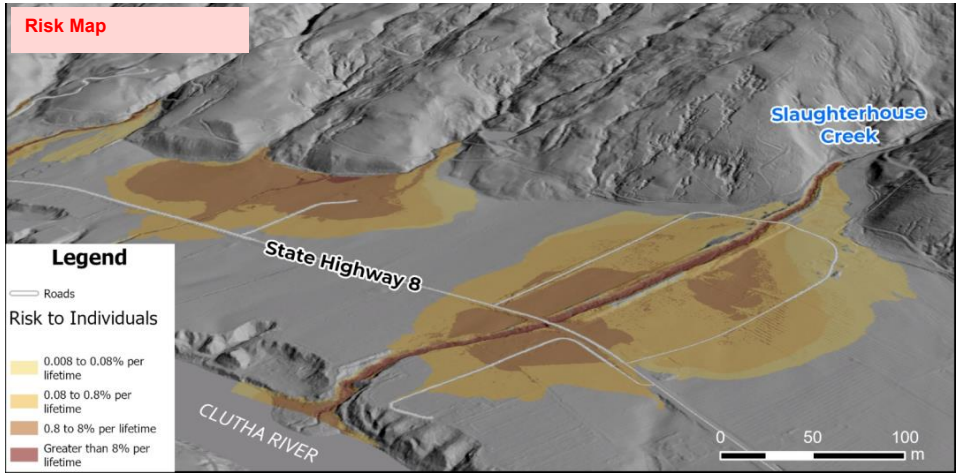
N W E S

Project: 1-E0173.00

Date: 30/07/2025

What did we find?

- All fans in the assessment have areas of significant risk.
- Spatial analysis reveals that areas within close proximity to main channels – typically within 200–300 m – are most vulnerable, with risk decreasing with distance and elevation.
- Refer to the maps in Appendix H of the report for more information.



How to reduce future debris flood impacts?

There are a range of different options available to help manage debris flood impacts:

- Physical structures
- Non-structural measures
- Planning tools
- Long-term adaptation and resilience

Debris flow barrier - Geobrugg

SUMMARY

- The Teviot Valley is exposed to hydrogeomorphic hazards including debris floods.
- These hazards can cause damage to buildings, infrastructure, and are public safety concerns.
- We modelled debris floods in 13 catchments to identify high risk areas on each alluvial fan.
- Analysis shows all fans have areas of significant risk.
- Higher risk areas are proximal to channels and within topographical depressions on each fan.
- Hazard and risk maps help guide mitigation including regulatory planning and engineering design.

ORC AND CODC COUNCILLOR PRESENTATION

Prepared for Otago Regional Council | February 2026

QUESTIONS

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