

Science Advice

Date	26 June 2026
To	Environment Canterbury Corporate Services
From	Environment Canterbury Natural Hazards Science

Flood hazard for Environment Canterbury property, and potential flood mitigation requirements

Key Messages

Flooding of the Environment Canterbury land of interest from the Waimakariri River is unlikely (<5% chance) for flows with an average recurrence interval (ARI) of up to 200 years.

Rainfall events with an ARI of up to 200 years could cause some surface flooding on the Environment Canterbury land of interest, but primarily within historic channels.

Aside from a narrow margin along the existing secondary stopbank alignment, it is very unlikely (<1% chance) that the Environment Canterbury land of interest will need to be utilised for flood protection system upgrades over the next 50 years.

Introduction and Purpose

Environment Canterbury Corporate Services (Matt Fraser) has requested advice on:

1. the flood hazard posed by the Waimakariri River to Environment Canterbury land in the Halkett / West Melton / McLeans Island area (**Figure 1**) in events with an ARI of up to 200 years
2. the flood hazard posed by surface flooding (rainfall runoff) in events with an ARI of up to 200 years
3. which (if any) parts of the Environment Canterbury land of interest may be required in future for flood protection scheme upgrades

This advice will be used to inform the potential future use of Environment Canterbury land.

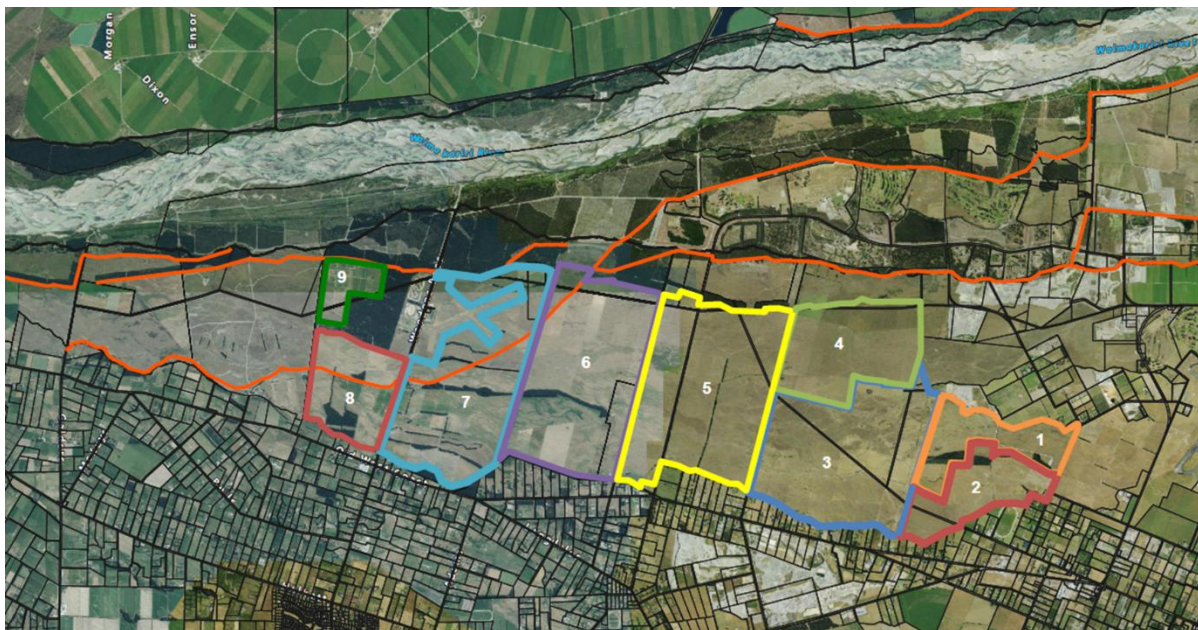


Figure 1. Environment Canterbury land of interest

Data and analysis

To produce the information needed to advise Corporate Services we have:

1. assessed if the Environment Canterbury land of interest will be impacted by flooding from the Waimakariri River in a 200-year ARI flow (including climate change allowances)
2. reviewed the results of existing rain-on-grid modelling to assess the surface flooding hazard

Hydraulic Model

To assess if the Environment Canterbury land of interest will be impacted by flooding from the Waimakariri River in a 200-year ARI flow (including climate change allowances), we constructed a hydraulic model. The model uses the 2D inland flooding module in Mike+ 2025 release version, with a flexible (triangulated) computational mesh. The model domain covers the reach from the Waimakariri Gorge, at SH72, to the confluence with the Kaiapoi River (around 2.5 km upstream of the ocean outflow) (**Figure 2**).



Figure 2. Model domain.

Mesh elements, numbering 1,692,499, were limited to a maximum area of 225 m², with a mean of 140 m². Extra detail was forced around the stopbanks and some important natural terraces using an 8m vertice spacing along these features. Subsequent surface interpolation was undertaken by calculating the mean value for each mesh element using the 1m NZVD2016 LiDAR dataset from LINZ, captured between 2020 and 2025.

To capture the crest heights of the stopbanks, groynes, and important natural terraces, these were added as 2D features to the model using 3D polylines sampled for height at a 1 m increment from the LiDAR.

Model boundaries were closed in the well terraced upper reach, changing to open (free outflow) from upstream of Courtenay. The downstream boundary was handled using a rating curve, in this case the theoretical discharge-head relation for the downstream cross section derived under critical flow conditions. An initial condition was included using a uniform water level of 0.6 m NZVD2016.

Hydraulic roughness was represented in the model using a Manning's 'n' coefficient. For the river gravels, Manning's values were estimated using gravel size data and a Griffiths gravel-bed formula converted from Darcy–Weisbach *f* to Manning's *n* using an assumed *R*. These varied from an 'n' of 0.017 at the coast, to 0.035 at the gorge. For the berm and floodplain, 0.05 was used to represent areas of grass, and 0.125 to represent heavier vegetation.

Precipitation and infiltration were set at zero.

Existing flood frequency analysis (Martin 2025) gives a 200-year ARI peak flow estimate of 4370 m³/s. Adding 20% to this flow to account for future climate change to 2075 and rounding up to the nearest 500 m³/s, gives a design flow of 5500 m³/s. We understand that considering climate change for a ~ 50-year time horizon is most relevant to potential future land use, and based on investigations completed for other rivers, we consider using a 20% increase to account for 50 years of future climate change to be a reasonable estimate.

A peak flow of 5500 m³/s was therefore added to the river via a point source located in the gorge, using a normalised and scaled hydrograph based on a flow event from October 2013. This was chosen as a representative event based on an assessment of the ten biggest recorded flow events of the last twenty years.

Maximum depth, velocity, and water level results were processed and exported. The results showed the Environment Canterbury land of interest to be unaffected by a 5500 m³/s flood flow (assuming no stopbank failure). The model results were then used in the stopbank breakout likelihood assessment.

Stopbank breakout likelihood assessment

While 2D hydraulic modelling provides a useful indication of flood depths, velocities, and water levels within a stopbanking scheme, it does not consider erosion and deposition of sediment or the migration of channels that can occur within large floods in a braided river system. These factors have resulted in stopbank breakouts during past flood events in Canterbury and further analysis is required to provide an estimate of stopbank erosion failure chance.

To assess the likelihood of stopbank erosion failure, we assessed the 2D hydraulic model results alongside the physical characteristics of river reaches where bank failure could affect the study area.

To assess the performance of the primary stopbanking system in a 200-year ARI flood flow, we utilised a draft tool which is currently being developed in-house to quantify the likelihood of stopbank failure under a range of river flows. This involved obtaining information on water velocities, levels, and any overtopping from the hydraulic model results and evaluating these alongside the size, quality, and condition of stopbanks and berms. We collated the information about the following physical scheme characteristics from sources including engineering survey data, condition reports, and satellite imagery:

- berm width
- berm quality
- bank strength
- bank surface condition

For this analysis, we considered the stopbank reaches in segments, defined by pre-existing survey cross sections marks. We extended these cross section lines to cover the primary and secondary banks (**Figure 3**).

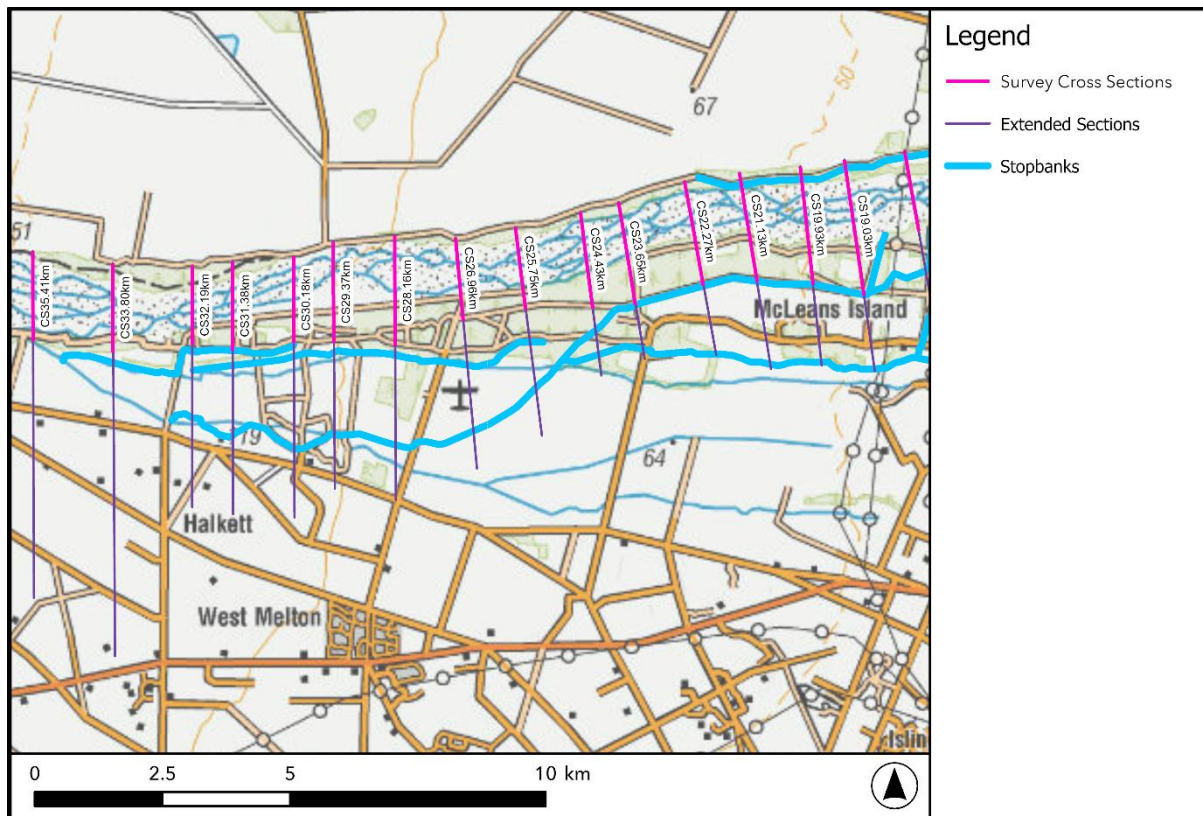


Figure 3. Extended cross sections

The following vulnerability functions and modifiers were developed to define how different grades of asset perform under different hazard conditions.

1. Overtopping erosion

The overtopping erosion vulnerability function compares the modelled width of any overtopping of the stopbank to the surface condition of the bank. However, for a flow of 5500 m³/s the modelling shows no overtopping at locations that could impact on the Environment Canterbury land of interest.

2. Adjacent flow erosion

The adjacent flow erosion vulnerability function considers the chance of water on the berm, adjacent to the bank, causing an erosive failure of the bank (**Table 1**). We compare peak modelled velocities within 20 m of the bank (not including overtopping) to the surface condition of the bank.

Description	Adjacent velocity score	Surface condition and failure chance				
		1	2	3	4	5
0 - 0.5 m/s	1	0%	0%	0%	0%	0%
0.5 - 1.2 m/s	2	1%	1%	2%	5%	10%
1.2 - 2.0 m/s	3	1%	4%	8%	12%	20%
2.0 - 3.5 m/s	4	2%	12%	30%	40%	50%
> 3.5 m/s	5	15%	30%	50%	80%	100%

Table 1. Adjacent flow erosion vulnerability function

Stopbanks have battered sides with slopes defined by a width to height ratio. These commonly range from ratios of 1.5:1 up to 3:1. Stopbank batter is used as a modifier (**Table 2**), as we assume a shallow batter angle will reduce the likelihood of adjacent flow erosion.

Batter	Score	Failure modifier
≥ 3:1	1	0.5
< 3:1 ≥ 2.5:1	2	0.75
< 2.5:1 ≥ 2.0:1	3	1
< 2.0:1 ≥ 1.5:1	4	1.2
< 1.5:1	5	1.4

Table 2. Adjacent flow erosion batter score modifier

For example, at reach CS24.43km, peak velocities against the bank are 1.1 m/s (**Figure 4**) which results in an adjacent velocity score of 2. This is compared to a surface condition score of 3 in the vulnerability function which results in a failure chance of 2%. The batter of 3:1 gives a batter score of 1 (excellent). Using the batter score failure modifier (0.5) results in a final adjacent flow erosion chance of 1%.

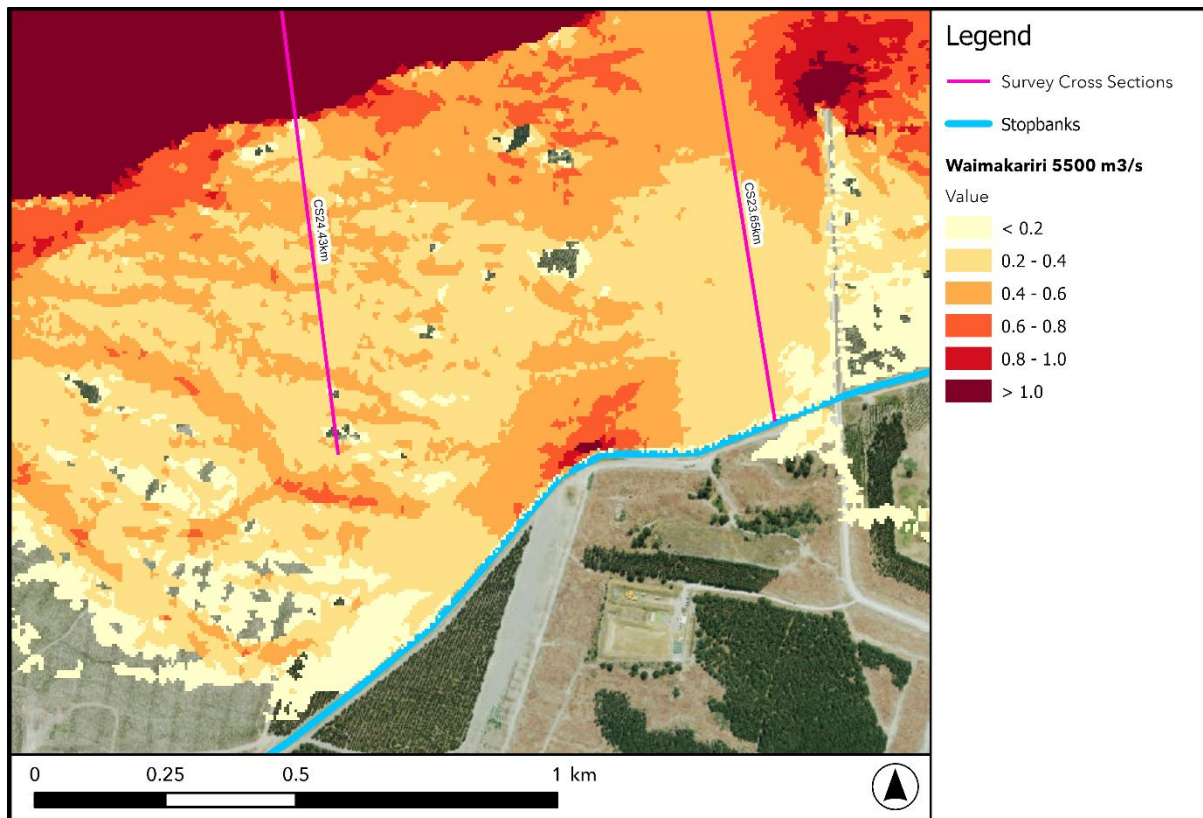


Figure 4. Peak modelled velocity against stopbank reach CS24.43 during a 5500 m³/s river flow.

3. Berm erosion

The berm erosion vulnerability function considers the chance of a main river braid eroding the berm and undermining the bank (**Table 3**). We assume that peak fairway velocities indicate a reach's erosive power and we compare this to the minimum width of the berm for that reach.

Peak fairway velocity	Erosion Score	Berm size and failure chance				
		1	2	3	4	5
0 - 0.8 m/s	1	0%	0%	0%	0%	0%
0.8 - 2.2 m/s	2	1%	1%	2%	5%	10%
2.2 - 3.5 m/s	3	1%	4%	8%	12%	20%
3.5 - 5.0 m/s	4	2%	12%	30%	40%	50%
5 + m/s	5	5%	30%	60%	80%	100%

Table 3. Berm erosion vulnerability function table

Berm width is scored using **Table 4**.

Minimum berm width	Berm width score
0 - 5 m	5
5 - 20 m	4
20 - 40 m	3
40 - 80 m	2
80 m +	1

Table 4. Berm width score table

The berm quality score is then used as a modifying factor (**Table 5**). A reach with a berm quality score of 1 should have strong edge protection and excellent vegetation, and will better resist the erosive power of a shifting braid. Conversely, a sparsely vegetated berm of mostly open gravel will be much more erodible.

Description	Berm quality score	Failure modifier
Strong edge protection	1	0.3
	2	0.6
	3	1
	4	1.5
Open gravel	5	2

Table 5. Berm quality modifier table

For example, peak fairway velocities at reach CS25.75km are 4.85 m/s for a modelled 5500 m³/s flow (**Figure 5**). The minimum berm width is about 1000 m resulting in a berm width score of 1 (excellent). Using the vulnerability function, the failure chance is 2%. The berm quality score is 1, resulting in a failure modifier of 0.3, and therefore a final berm erosion failure chance of 0.6%.

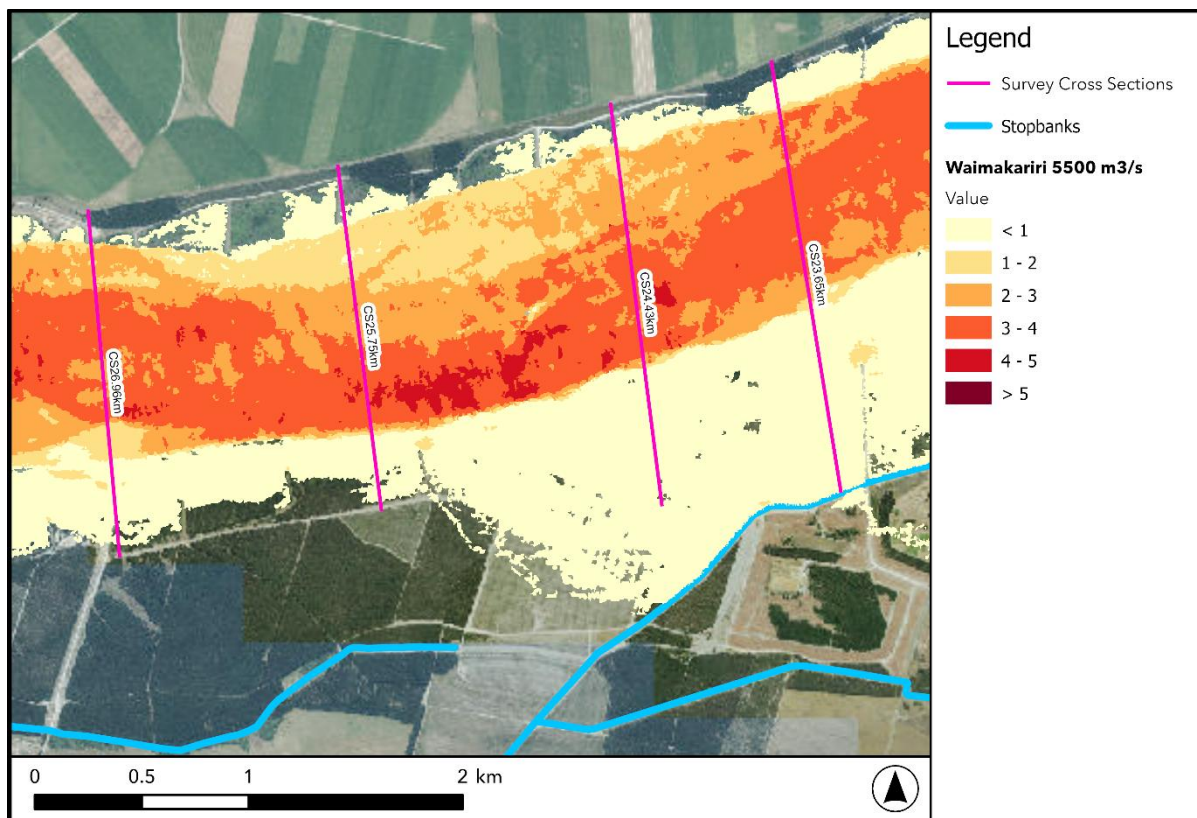


Figure 5. Peak fairway velocities at CS25.75km for a 5500 m³/s river flow

4. Primary bank erosion failure results

For each reach, the chance of erosion failure from each of the three vulnerability functions are summed. Summed failure chance for each reach of the primary bank at the modelled 5500 m³/s flow is presented in **Table 6**.

Reach	5500 m ³ /s river flow
CS38.63kmA	< 2%
CS37.01kmA	2 - 5 %
CS35.41kmA	2 - 5 %
CS33.80kmA	< 2%
CS32.19kmA	< 2%
CS31.38kmA	< 2%
CS30.18kmA	< 2%

CS29.37kmA	< 2%
CS28.16kmA	< 2%
CS26.96kmA	< 2%
CS25.75kmA	< 2%
CS24.43kmA	< 2%
CS23.65kmA	2 - 5 %
CS22.27kmA	< 2%
CS21.13kmA	< 2%
CS19.93kmA	< 2%
CS19.03kmA	2 - 5 %

Table 6. Overall failure chance at 5500 m³/s for each reach.

Interpretation

Waimakariri River flooding

The 2D hydraulic model results (which assume no stopbank failure) show the Environment Canterbury land of interest to be unaffected by a 5500 m³/s flood flow in the Waimakariri River, while the breakout likelihood assessment shows the chance of stopbank failure to be low (<5%).

Our standard approach for land use planning decisions is to assume that water will stay within a stopbanking scheme when the likelihood of a breakout is less than 10%. The results of our analysis show that this threshold is not exceeded at any reaches where a breakout could affect the study area.

Surface flooding

Rain-on-grid modelling has recently been carried out by Tonkin and Taylor on behalf of Selwyn District Council (Tonkin and Taylor, 2025). This predicts the depth and extent of flooding from direct rainfall runoff, and assumes no breakouts from the Waimakariri River. Results for a 200-year ARI rainfall event (including allowances for climate change to 2081-2100) are available for most of the Environment Canterbury land of interest (**Figure 6**). The modelling shows surface flooding to be primarily confined to historic channels, except where water ponds behind the secondary stopbank. Modelled flood depths are typically less than 1 m. The pattern and severity

of flooding on the Environment Canterbury land outside of the model study area would be similar to the areas immediately up-plain.

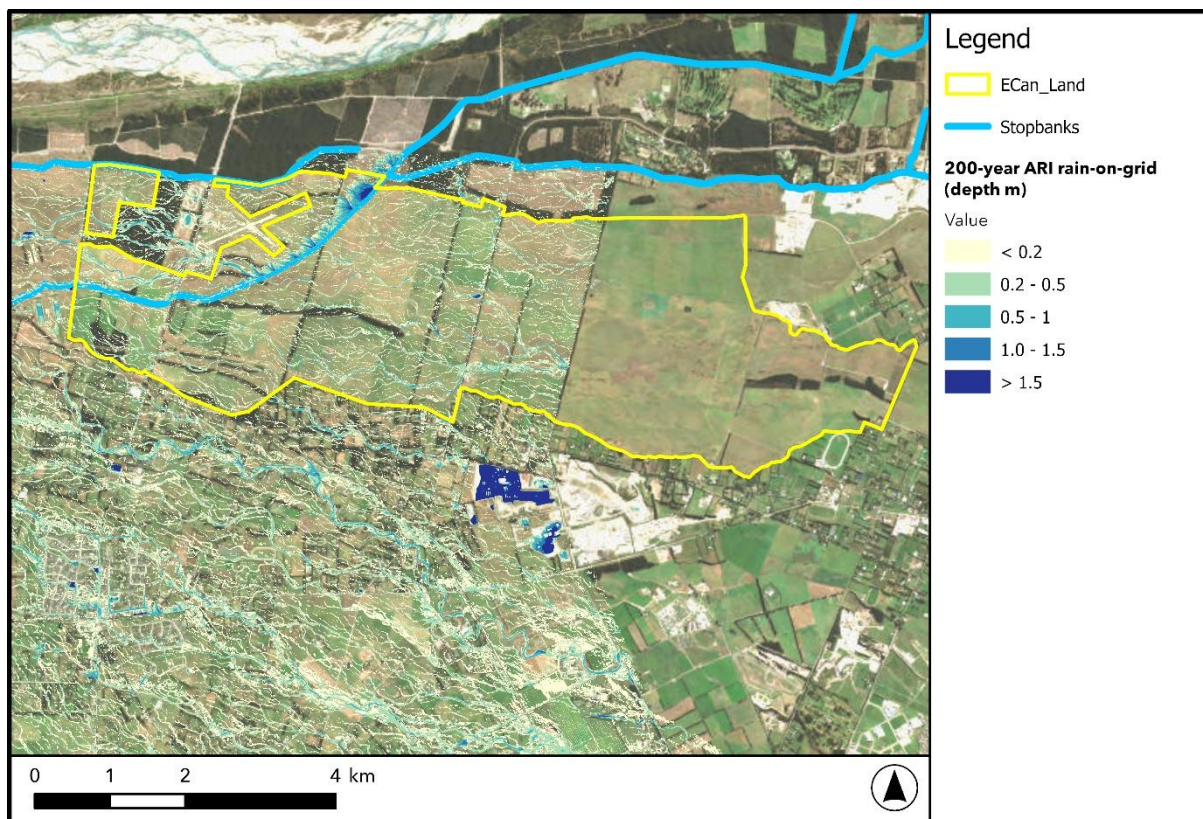


Figure 6. 200-year ARI rain-on-grid modelled flood depths

Future use of Environment Canterbury land for flood protection system upgrades

Parts of the Environment Canterbury land of interest are intersected by a secondary stopbank which is designed to capture breakout flows from the primary stopbank system (which could occur in less frequent flood events than the 200-year ARI event considered here) and return them to the river. It is likely that this secondary stopbank will need to be upgraded in the future to provide a higher standard of resilience against extreme flood flows.

Upgrading the secondary stopbank to contain significantly larger breakout flows could be feasibly achieved along the existing bank alignment (through widening and raising the bank) so long as a buffer of 65 m was retained along either side of the centreline for this purpose. It is therefore very unlikely (<1%) that any Environment Canterbury land beyond the existing secondary stopbank alignment would need to be utilised for flood protection system upgrades over the next 50 years.

Limitations

All aspects of this assessment include limitations and uncertainties. We have only carried out basic validation of the model against recorded river flood levels, and the model and breakout likelihood assessment methodology have not been comprehensively peer reviewed. However, the information is the best that is currently available and is suitable for the purposes of this assessment.

References

Martin, A. (2025). Flood Frequency Snapshot: 66401 Waimakariri River at Old Highway Bridge

Tonkin and Taylor Ltd (2025). Selwyn District Flood Model – Hydraulic Model Build Report