Before an Independent Hearings Panel
Appointed by Waimakariri District Council

under:	the Resource Management Act 1991
in the matter of:	Submissions and further submissions on the Proposed Waimakariri District Plan
and:	Hearing Stream 12D: Ōhoka rezoning request
and:	**Carter Group Property Limited** *(Submitter 237)*
and:	**Rolleston Industrial Developments Limited** *(Submitter 160)*

Reconvened hearing statement of evidence of Ben Throssell (Flooding)

Dated: 17 October 2024

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FURTHER SUPPLEMENTARY STATEMENT OF EVIDENCE OF BEN THROSSELL

INTRODUCTION

1 My full name is Benjamin Graham Throssell.

2 My area of expertise, experience, and qualifications are set out in my statement of evidence dated 5 March 2024 for this hearing stream.

3 I also provided evidence in my supplementary statement of evidence dated 13 June 2024.

4 The purpose of this evidence is to is to respond to matters listed in paragraphs 7 and 8 of the Panel's Minute 40.

CODE OF CONDUCT

5 Although this is not an Environment Court hearing, I note that in preparing my evidence I have reviewed the Code of Conduct for Expert Witnesses contained in Part 9 of the Environment Court Practice Note 2023. I have complied with it in preparing my evidence. I confirm that the issues addressed in this statement of evidence are within my area of expertise, except where relying on the opinion or evidence of other witnesses. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

STORMWATER EXPERT CONFERENCING – STREAM 12D, 6 AUGUST 2024

6 I attended the engineering conferencing for hearing stream 12D. Whilst I contributed to discussion on all questions, in this supplementary evidence I will provide further explanation related to question 6 set out in the Joint Witness Statement (*JWS*):

> '*Can the proposed development appropriately manage downstream effects from a 50-year flood event?*'

7 The agreed position on this question is:

> *"All experts agree that there are mitigations that can be identified and implemented within the site to address offsite effects from the 50-year event, immediately downstream of the site to approximately Christmas Rd bridge. Downstream of this point there are existing low-lying rural areas which are prone to flooding and which will receive an increased volume of stormwater as a result of the development. The effect of this additional volume, below Christmas Rd bridge, has not been assessed by modelling to date. Whilst there is uncertainty regarding the effects on flooding around*

Christmas Road Bridge there are further mitigation options that could be implemented to address these effects such as increased attenuation storage and/or reduced intensity of development. We note additional modelling would be required to further assess these effects at the subdivision consenting stage."

8 Much of the discussion focused on the additional volumes released from the proposed development and the sensitivity of the described location (downstream of Christmas Road bridge) to increased flood volumes rather than increased flood flows (which are expected to be zero due to attenuation provided by the proposed stormwater solution).

9 I completed two additional investigations to help inform a position on the potential effects at this location:

9.1 A memo (attached at **Appendix 1**) titled "Downstream effects in a 50-year event". This memo quantifies the impact of the additional stormwater volume (26,000 m^3) released by the proposed development in the 50-year event. Using conservative assumptions, I conclude in the memo that the effect is likely to be around the minor/less than minor threshold of 20 mm. This memo was presented to the other experts prior to finalisation of the JWS. It helped determine a position on downstream flood effects in a 50-year event.

9.2 I also ran a hydraulic model to help determine whether the effects at the location of interest (downstream of Christmas Road) were more sensitive to flood volumes or flood flows and quantify the expected response to an increase in flood volume. These results were also presented to the other experts prior to finalisation of the JWS.

10 To assess the impact of the proposed development, I conducted two hydraulic model simulations:

10.1 50-year flow: Represents the post-development catchment with the subdivision in place.

10.2 Constant 50-year flow: The same base scenario but with the maximum flow rate applied throughout the entire event duration (30 hours).

11 The input flows for both scenarios are provided in Figure 1 below. This model is only for the purposes of testing sensitivity to flood flows and flood volumes. For the modelled events:

11.1 Both events employ the same peak flow (50-year event) at 92 m^3/s; and, 11.2 The events have very different volumes, the constant 50-year flow event has a volume of around 10 million m³ whilst the 50-year flow event has a volume of around 3.5 million m³.

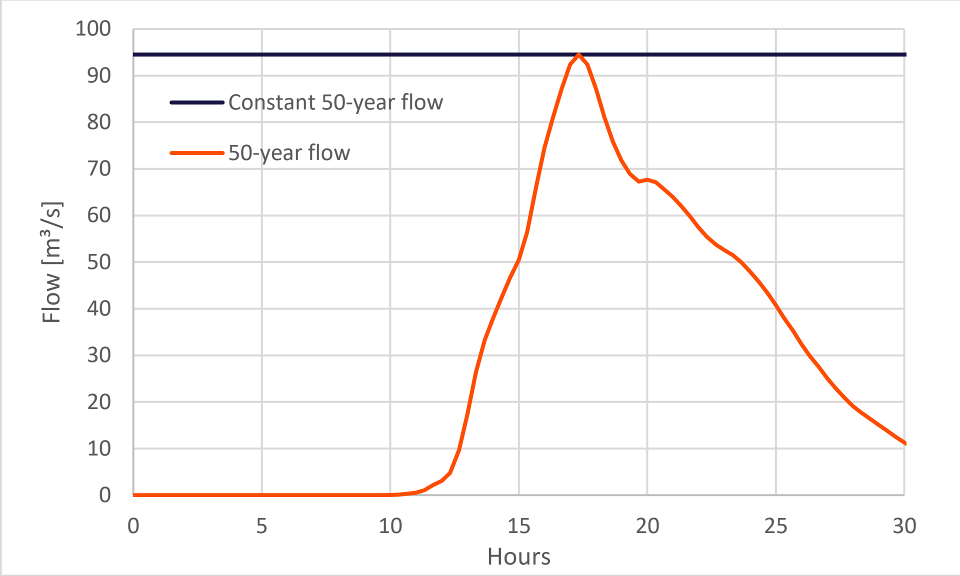

Figure 1: Model inflows for the constant 50-year flow model and the 50-year flow model.

12 At Christmas Road, the flood depths just downstream of Christmas Road are:

12.1 1.13 m for the constant 50-year flow event; and,

12.2 1.07 m for the 50-year flow event.

13 This shows that the holding the flow constant, and, increasing the volume of the event (from 3.5 million m³ to 10 million m³) causes the flood depth to increase by 60 mm downstream of the Christmas Road bridge. Or, a 7 million m³ increase in event volume, causes a 60 mm increase in flood depth. For comparison, the predicted increase in flood volume due the development is no more than 26,000 m³.

14 Therefore, I conclude that the effects of the proposed development downstream of the Christmas Road bridge are likely to be less than minor. If they are not, there are further mitigation options that can be implemented to reduce the effects (additional attenuation and reduced development intensity). These options can be assessed at the subdivision consent stage and would be assessed using a revised version of the hydraulic model that has been employed for investigations to date.

STORMWATER EXPERT CONFERENCING – STREAM 12C/12D, 04 SEPTEMBER 2024

15 I also attended the stormwater conferencing for hearing stream 12C/12D. Whilst I contributed to the discussion on question 1 set out in the Joint Witness Statement (JWS), my primary area of expertise relates to question 2:

> '*If it is identified that there would be adverse cumulative effects, what might the triggers be for upgrades or new infrastructure to be provided, how could these be reflected in district plan provisions for each rezoning request.?*'

16 As there were no adverse cumulative effects on groundwater resurgence identified, much of the discussion focussed on the potential adverse cumulative effects of stormwater.

17 I retain my position in the agreed statement. I re-iterate that it would not be possible to assess cumulative effects at this stage as we do not know what the maximum probable development scenario will be until after the district plan change process. I note there are further options that can be implemented to mitigate cumulative effects, for example, over attenuation, whereby site run-off is lower than pre-development. These are discussed in the JWS.

18 I consider that cumulative effects, and any potential mitigation options, can be further investigated at the subdivision consent stage. These can be assessed using a revised version of the hydraulic model that has been employed for investigations to date.

CONCLUSIONS

19 In conclusion, I consider the downstream effects on flooding for the 50-year event are likely to be 20 mm or less and therefore meet the minor/less than minor threshold.

20 Cumulative downstream effects will be further assessed at the subdivision stage, which is the appropriate time to do so.

Dated: 17 October 2024

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Ben Throssell

APPENDIX 1

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Downstream effects in a 50-year event

TO	Chris Bacon and Colin Roxburgh	FROM	Ben Throssell and Eoghan O'Neill
	Waimakariri District Council	DATE	05 August 2024
RE	Downstream effects of Ohoka Development in a 50-year event		

1.0 Purpose

During conferencing on flood matters (31 Aug 2024), concerns were raised regarding potential effects just upstream of Silverstream in a 50-year event. It was suggested that this area may be more sensitive to increased discharge volumes. Preliminary calculations undertaken during conferencing indicated that the additional discharge expected from a 24-hour, 50-year storm event could result in a 20 mm water level rise upstream of Silverstream, around the minor/less than minor threshold. This calculation was based on a discharge volume of 10,000 m³. After conferencing, WDC questioned what the effect might be if the additional discharge volume was 26,000 m³, the proposed volume of the stormwater basins. This memo aims to quantify this potential impact.

2.0 Methodology

During conferencing, these downstream effects due to the additional stormwater volume were estimated using a back of the envelope approach:

- Assume that all additional stormwater volume is released into the area upstream of Silverstream at the peak of the flood event. This assumption is conservative for two reasons:
  - Not all additional stormwater will end up at Silverstream; and,
  - Not all additional stormwater will be discharged at the peak of the event.
- Assume the area upstream of Silverstream acts as a bath-tub. This means flood levels are controlled entirely by volume rather than flow. Flood levels will be controlled by both flow and event volume but the assumption that flood levels are controlled entirely by event volume is conservative;
- Take the volume discharged and divide it by the ponded area to estimate the effect. In conferencing, as no modelled 50-year event was available, the ponded area was taken to be the area where flood depths exceeded 1.5 m in the 100-year event.

The methodology to assess the effects of the 26,000 m³ discharge followed in this memo largely aligns with the methodology applied in conferencing.

3.0 WDC Model

The WDC model considers the 100-year, 200-year and 500-year events and therefore cannot be used to directly estimate the extent of ponding in a 50-year event. However, model provides indicative flood levels of the ponding area in question (upstream of the Ohoka Stream/Kaiapoi River confluence). Figure 1 shows:

- The 500-year peak flood elevation is 4.80 mRL and maintained for eight hours;
- The 200-year peak flood elevation is 4.65 mRL and maintained for four hours; and,
- The 100-year peak flood elevation is 4.55 mRL and maintained for two hours.

Therefore, the flood elevation for the 50-year event will not exceed 4.55 mRL and is unlikely to be maintained for more than two hours.

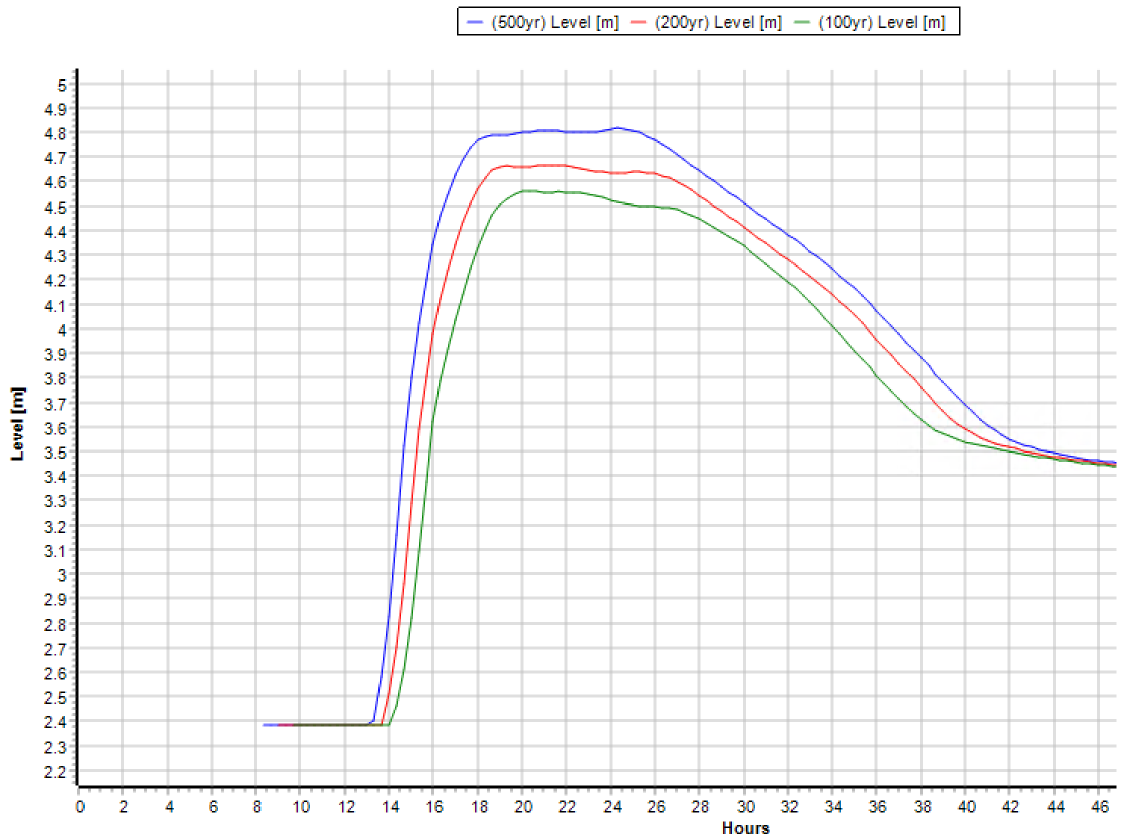


Figure 1: Modelled flood levels (LVD37) vs time for the Ohoka ponding area, abstracted from the WDC hydraulic model.

4.0 Hypsometric curves

To assess the potential impact of additional stormwater discharges on flood levels, we developed a hypsometric curve (Figure 2) using the 2014 LIDAR data (Figure 3). This curve relates ground elevation to areas and can be used to determine the elevation required to store a given volume.

Figure 2 shows:

- The primary y-axis shows the change in vertical elevation, two series are plotted on this axis, a volume released of 26,000 m³ (stormwater basins) and a volume released of 10,000 m³ (PDP hydraulic model difference);
- A 10,000 m³ discharge requires a 50 ha ponding area to limit flood level increases to 20 mm. This equates to an elevation of 2.87 mRL;
- A 26,000 m³ discharge requires a 130 ha ponding area to achieve the same level of protection. This equates to an elevation of 3.96 mRL; and,
- For the WDC modelled flood events (100-year, 200-year and 500-year), the flood elevations all exceed the minimum elevations required to limit flood level increases for the 26,000 m³ additional stormwater discharge.

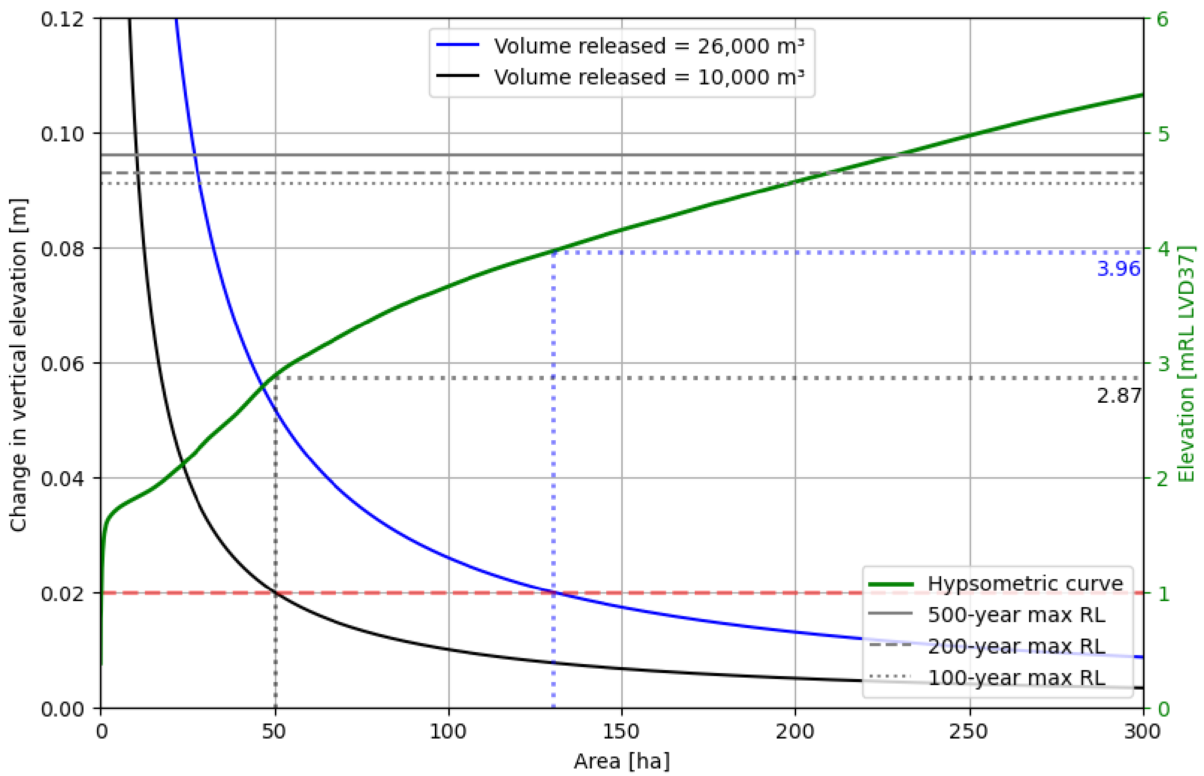


Figure 2: Hypsometric curve for LIDAR shown in Figure 3.

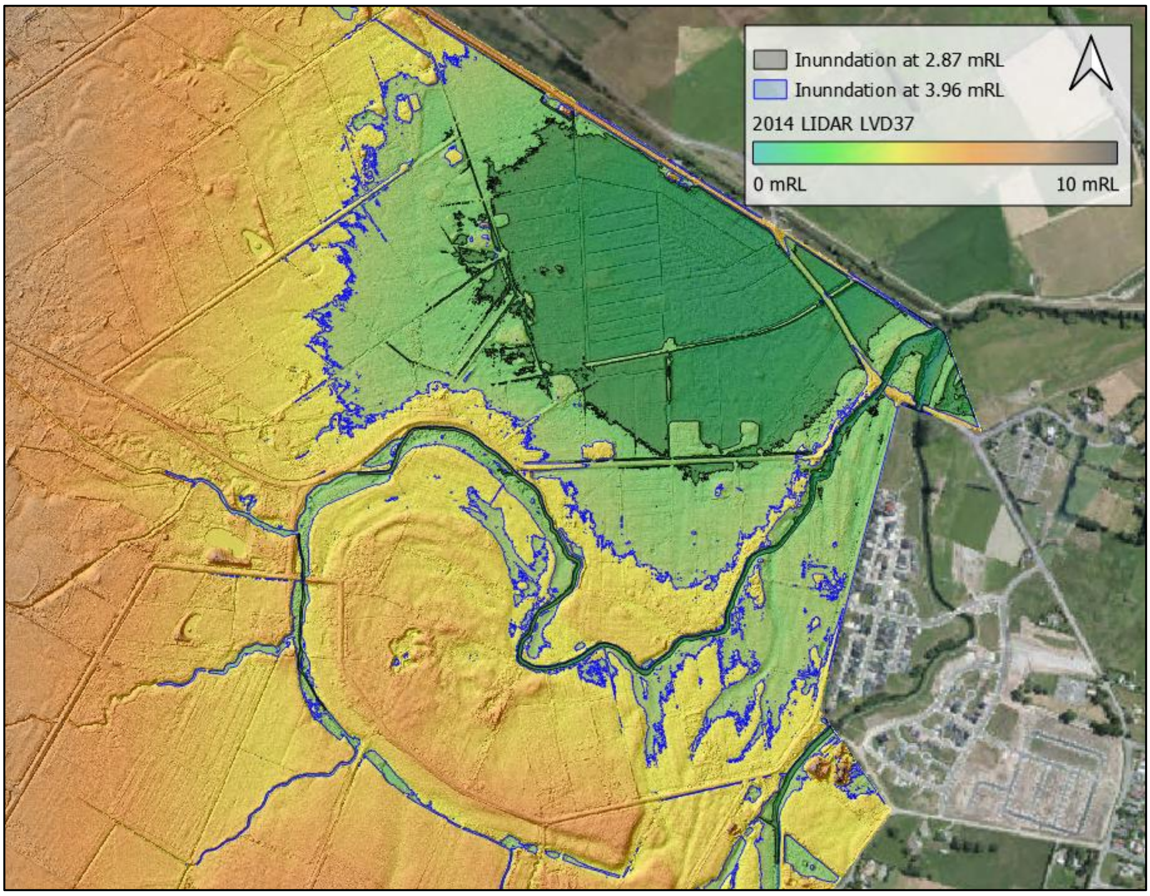


Figure 3: 2014 LIDAR (LVD37) used to generate hypsometric curve. The LIDAR has been clipped to expected flood extent for the Ohoka Stream. 2014 Environment Canterbury (ECan) aerial employed as the background.

4.1 Analysis

The WDC model predicts maximum flood elevations for the 500-year, 200-year and 100-year events of 4.80, 4.65 and 4.55 mRL respectively. The minimum flood elevation required to ensure that the additional discharge (26,000 m³) from a 50-year event does not exceed 20 mm is 3.96 mRL. Whist the 50-year event has not been modelled by WDC, from the progression of flood levels of the larger events, it appears reasonable to infer that a 50-year flood elevation would likely exceed 3.96 mRL. This means that the increase in flood levels due to this additional discharge would be less than 20 mm.

2014 Flood Event

To provide additional context, we compared the minimum required ponding areas (for additional stormwater releases of 10,000 m³ and 26,000 m³) to the extent of flooding observed during the 2014 event. The additional stormwater discharges used in our analysis correspond to a projected 50-year flood event, including climate change factors. Therefore, it is useful to have an indication on the magnitude of the 2014 event as this will determine if the assessment is conservative or not.

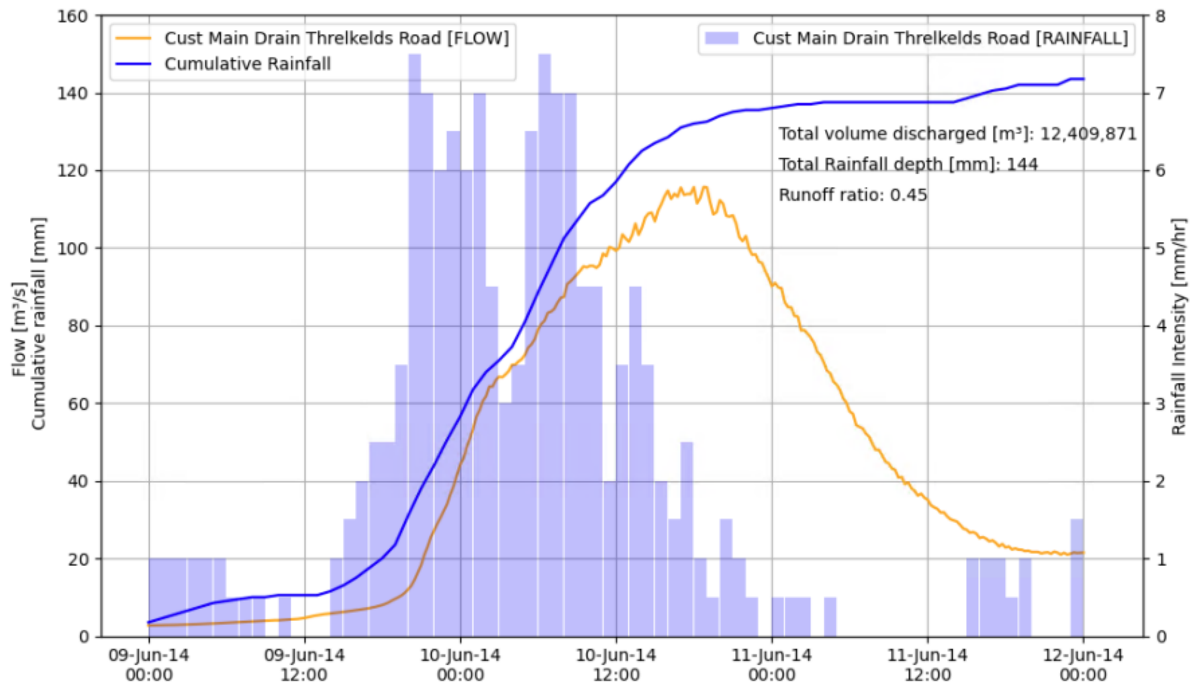
4.2 Assigning a return period to the 2014 event

The 2014 event was described in the PC31 evidence of Ben Throssell. Figure 4 shows the accompanying attachment from this evidence. In summary, paragraph 76 and 77 state:

- The Ōhoka rainfall recorder was not operative at this time and therefore, I have relied on the Cust recorder26 (at Threlkelds Rd) to determine sub-hourly rainfall data:
  - 40.0 mm was recorded over a six-hour duration, between a 5-year (36.6 mm) and 10-year (44.6 mm) event according to HIRDS V4;
  - 76.2 a maximum depth of 72.0 mm was recorded over a 12-hour duration, about a 20-year event (73.4 mm) according to HIRDS V4; and,
  - 76.3 a maximum depth of 114.0 mm was recorded over a 24-hour duration, exactly a 40-year (114 mm) event according to HIRDS V4.
- The flow recorded in Cust River peaked at 115.634 m^3/s. My flood frequency analysis shows that this flow has a return period of somewhere between 20 years (102 m^3/s) and 50 years (125 m^3/s).

Since the time of writing evidence, ECan have updated[1] their flood frequency statistics for Cust Main Drain. ECan estimate the 50-year event at 136 m^3/s and the 20-year event at 109 m^3/s. which puts the 2014 event as somewhere between the two. The only larger recorded flow event over the 37-year record was in 1995 (117 m^3/s).

In summary, our best estimate for the 2014 event at Silverstream is around, a 50-year event or less. We acknowledge WDC consider it was closer to a 100-year event.



Attachment 3: Recorded flows and depths for Cust River at Threlkelds Road for 9 June to 12 June 2014

Figure 4: Reproduction of Attachment 3 from Ben Throssell's PC31 evidence.

[1] https://api.ecan.govt.nz/TrimPublicAPI/documents/download/4873422

4.3 Comparison with HIRDS rainfall data

Table 1 shows the HIRDS data for 100-year historic event and 50-year event with climate change. This table shows that depths for the 50-year event with climate change will exceed a 100-year historic event.

Table 1: HIRDSV4 rainfall depths for Ohoka

HIRDS	6HR	24HR
100-year historic	75.9 mm	138 mm
50-year RCP8.5 2081-2100	85.2 mm	147 mm

In summary, we concluded that the 50-year RCP8.5 2081-2100 event is larger than the 2014 event. That is, the estimated additional stormwater generated by the site (between 10,000 and 26,000 m³ is likely an over-estimate for the volume that would have been released in the 2014 event and this makes the comparison conservative.

4.4 Historic imagery

To further assess the potential impact of additional stormwater discharge, we compared the required ponding areas with historical flood data from the June 2014 event. ECan's Flood Imagery Register[2] (FIR) provides oblique aerial photographs (Figure 5) captured at the peak flow of the Cust Main Drain on June 10th, 2014 (4 pm). These images have been georeferenced and traced to estimate the flood extent in 2014. Figure 6 shows:

- The inundation extent associated with 3.96 mRL (minimum elevation for a 26,000 m³ discharge with no more than 20 mm flood level increase) is shown, alongside the extent for a 10,000 m³ discharge (2.87 mRL).
- The traced flood extent derived from the two georeferenced images obtained from the FIR (Figure 5). The 2014 flood extent roughly matches the 3.96 mRL extent, with some discrepancies:
  - Downstream section (adjacent to Cust Main Drain): The 3.96 mRL extent overestimates the flood extent.
  - Upstream section (adjacent to Ohoka Stream): The 3.96 mRL extent underestimates the flood extent.
- These discrepancies are likely due to variations in the hydraulic grade along the Ohoka Stream which is not reflected in the bath-tub analysis.

[2] https://apps.canterburymaps.govt.nz/FIR

3000 - Looking north across Butchers Road toward Ohoka Stream

3001 - Ohoka Stream. Looking north toward Mill Road

Figure 5: Oblique aerials obtained from the FIR of the 2014 event. Ohoka Stream in the foreground and Cust Main Drain in the background.

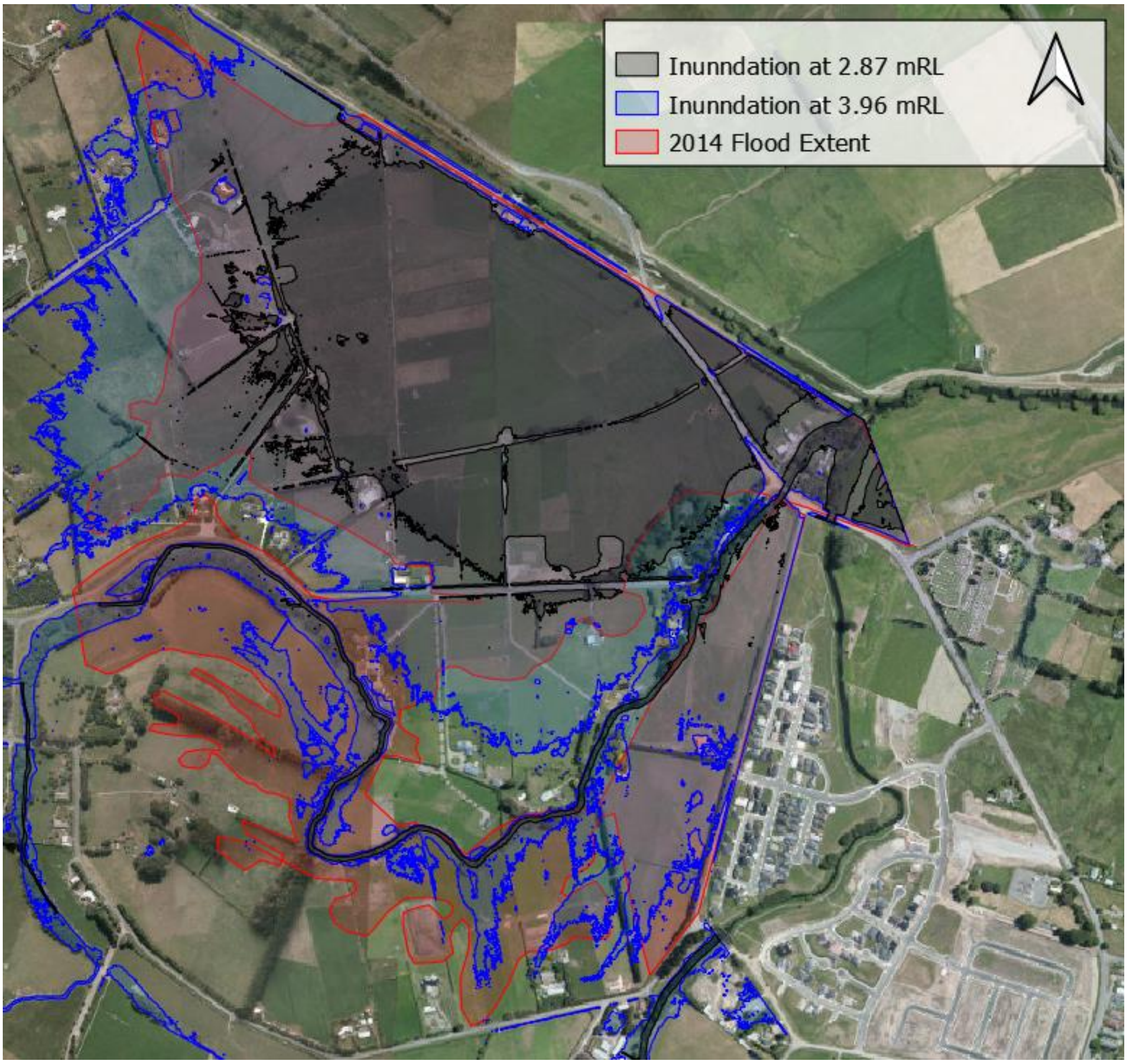


Figure 6: Comparison of 2014 flood extents taken from geo-referenced imagery (Figure 5) and the minimum ponded extents.

5.0 Conclusions

Our analysis undertaken to quantify the potential impact of additional stormwater discharge on flood levels upstream of Silverstream during a 50-year event adopts a conservative approach. The preliminary calculations presented during conferencing, which indicated a potential 20 mm rise in water levels due to a 10,000 m³ discharge, have been re-evaluated using the volume of the stormwater basins, 26,000 m³.

Key elements of this analysis include:

- **Peak Discharge Timing Assumption**: Assuming that all additional stormwater volume is released at the peak of the flood event is conservative as it is unlikely that all additional stormwater will discharge simultaneously over the period of peak flood levels. The WDC model the peak flood level for the 100-year event will be maintained for around two hours and a peak level for the 50-year event will likely be maintained for less than two hours.
- **Volume-Controlled Flood Levels**: Treating the area upstream of Silverstream as a bath-tub, where flood levels are controlled entirely by volume rather than flow and volume is also conservative.

- **Ponding Area Estimates**: Using the 2014 event which was less than a 50-year event with climate changed to compare ponded extents for a stormwater volume from a 50-year event with climate change is also conservative.

Comparative analysis with the historic 2014 flood event, which was likely smaller than the 50-year event used to estimate the additional stormwater discharge, shows the effects are likely to be around the minor/less than minor threshold of 20 mm.

The WDC model, which does not directly provide data for a 50-year event, predicts peak flood levels of 4.80m, 4.65m, and 4.55m for the 500-year, 200-year, and 100-year return periods, respectively. Our analysis indicates that to accommodate an additional 26,000 m^3 of stormwater without exceeding a 20 mm rise in water level, a minimum elevation of 3.96 mRL is required. Given the trend in flood levels for larger events, it is likely that a 50-year flood would surpass this threshold meaning the effects of the additional stormwater discharge would be less than 20 mm.

In conclusion, whilst the methodology and assumptions adopted in this analysis are conservative, they still show that the estimated effects from the additional stormwater discharge will be a flood level increase of less than or close to 20 mm. This is the threshold of a minor or less than minor effect.

6.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Waimakariri District Council and others (not directly contracted by PDP for the work), including Environment Canterbury, National Institute of Water and Atmosphere and Land Information New Zealand. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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Reviewed and approved by

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