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 12: Rezoning requests (larger scale)
and:	**Carter Group Property Limited** *(Submitter 237)*
and:	**Rolleston Industrial Developments Limited** *(Submitter 160)*

Statement of evidence of Ben Throssell (Flooding) on behalf of Carter Group Limited and Rolleston Industrial Developments Limited

Dated: 5 March 2024

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STATEMENT OF EVIDENCE OF BEN THROSSELL ON BEHALF OF CARTER GROUP LIMITED AND ROLLESTON INDUSTRIAL DEVELOPMENTS LIMITED

INTRODUCTION

1 My full name is Benjamin Graham Throssell. I am a Senior Engineer with Pattle Delamore Partners Limited (*PDP*), an environmental consulting firm specialising in water matters.

2 I hold a Bachelor of Engineering (Hons) (Natural Resources Engineering) from the University of Canterbury. I have 12 years of experience specialising in water resources engineering, with particular expertise in assessing flood hazard and constructing 2D hydraulic models. I have prepared and presented expert evidence at Council hearings on flood hazard matters around the Waimakariri District and the wider Canterbury region. I have also prepared flood hazard and mitigation models for the Esk Valley following the catastrophic Cyclone Gabrielle flood events in 2023. Further, I am leading a team to quantify the severity of the Auckland Anniversary flood events on behalf of Auckland Council.

3 I am familiar with the Submitters' request to rezone land bound by Mill Road, Whites Road, Bradleys Road (the *Site*).

4 I was involved in private plan change 31 (*PC31*) to rezone this land under the operative District Plan.

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.

SCOPE OF EVIDENCE

6 My evidence will address my assessment methodology and conclusions regarding flood effects on and off the Site from the proposed rezoning request.

7 In preparing my evidence, I have reviewed:

7.1 The Outline Development Plan (*ODP*);

7.2 The evidence of **Mr Eoghan O'Neill**;

7.3 Further submissions relevant to my expertise relating to the rezoning of the Site; and

7.4 The relevant documents from PC31.

SUMMARY OF EVIDENCE

8 I oversaw the construction of a flood model which has been employed to determine the effects of flooding from the proposed development for the 200-year flood event (the *PDP Model*) and assess if the effects of flooding on new dwellings can be mitigated appropriately.

9 I consider that new dwellings built in accordance with NH-S1 (Flood Assessment Certificate) will provide adequate mitigation from flooding. This essentially amounts to finished floor levels built to the 200-year event plus 500 mm. I understand that this proposed development will comply with this requirement.

10 I consider that enabling the conveyance of floodwaters through the Site without diverting them to other locations will ensure off site effects are minimised. One way to achieve this is minimising development in areas where the existing conveyance of floodwaters is significant.

11 To assess the difference in flood elevations, I have taken all building footprints, not just habitable dwellings, and extracted the average water level over each footprint for both the post-developed and pre-developed water levels. I take the difference between these two water levels to be the effects on the building footprint.

12 The PDP Model has demonstrated that there is a viable subdivision layout which ensures the effects of the proposed subdivision on flood levels will not exceed 20 mm for any habitable dwelling. I consider this effect is less than minor.

13 I conclude that Ōhoka is prone to low hazard flood events, similar to those experienced in June 2014, July 2022 and July 2023. I note the magnitude of these events at Ōhoka was probably between a 10-year and 50-year event. The stormwater solution within the Site will provide mitigation of any additional stormwater generated by the Site for events of these magnitudes.

14 For more significant events, modelling of the 200-year event shows the flood hazard is still low for areas south of Mill Road/downstream of Whites Road and moderate for areas north of Mill Road. I note with the proposed development the PDP Model predicts limited increases greater than 10 mm for areas north of Mill Road and no

increase greater than 20 mm for habitable dwellings elsewhere within the PDP Model.

15 The consequences of extreme flooding on infrastructure and property have been recently demonstrated in the flood events of 2023 (Cyclone Gabrielle and Auckland Anniversary). The likelihood of these events is increasing as the effects of climate change are becoming apparent. Both regions, in which development had previously been approved, are now going through a land categorisation process in which a number of properties are being red-stickered. In my opinion, the flood hazard categorisation of land should be a key consideration that we account for in planning processes. Development should be encouraged on land that is not subject to high flood hazard, and discouraged on land that is subject to high flood hazard.

METHODOLOGY AND MODELLING

16 I oversaw the development of a 2D hydraulic model prepared by PDP using Tuflow modelling software. The purpose of the PDP Model was to determine the effects of flooding as a result of any filling required to meet the minimum floor levels set for this Site.

17 At its simplest, a hydraulic model consists of three components:

17.1 A digital terrain model, which represents the elevation surface of the land;

17.2 Boundary conditions, which control how water enters and exits the model domain; and

17.3 A roughness value which is used to represent the energy losses incurred by the free water surface. Energy losses can be thought of as the resistance incurred by the water surface, where higher resistance equates with greater energy losses and a higher roughness value. The roughness value is related to the surface type. For example, the free water surface will incur greater losses when flowing through dense vegetation compared to an asphalt surface.

18 The digital terrain model has been derived from LIDAR data. The PDP Model employs the latest dataset available at the time of writing, the Canterbury LiDAR 1m DEM. This was captured between 1 May 2020 and 12 November 2020 and made available on 22 November 2022.

19 Upstream boundary conditions for the PDP Model were provided by WDC, extracted from the District Wide Model.

20 Roughness values have been set via inspection of aerial photographs, geospatial files and a Site visit to determine surface type.

21 To determine the effects of the proposed development on flooding, the PDP Model was run with the existing environment (i.e. as it is currently). This scenario provides the baseline for which development effects could be compared against.

22 I ran additional post-development models with the proposed buildings and topographic modifications. The differences in flood elevations and velocities between this model and the pre-development scenario represents the effects of development on flooding.

23 I had input into the subdivision layout to ensure that suitable mitigation of flood effects can be achieved. PDP helped design the subdivision layout to optimise the conveyance of existing floodwater. **Attachment 1** shows the main hydraulic features of the PDP Model. Key features are:

23.1 Post-development conveyance through the Ōhoka Stream matching pre-development conveyance. This ensures that water is not transported through the proposed development at a quicker rate;

23.2 A building set-back of 15 m from the northern corner of the subdivision. This ensures that existing overland flow/conveyance is maintained;

23.3 Along Whites Rd, a building set-back of at least 15 m is required to help balance conveyance in a flood event;

23.4 Minimise development adjacent to the Ōhoka Stream, particularly at the upstream boundary adjacent to Bradleys Rd; and

23.5 Stormwater attenuation areas have also been included in the PDP Model. These have been blocked out of the PDP Model to ensure attenuation volumes are available for stormwater generated by the proposed development and not filled by external floodwater entering the Site via Ōhoka Stream or similar.

24 Rainfall was included in the PDP Model. The PDP Model incorporates both the effects of floodplain displacement and the effects of increased run-off due to an increase in impervious cover.

25 An infiltration component was also added to the PDP Model. For impervious areas, an infiltration rate of zero has been applied.

26 I note there is always uncertainty associated with selecting an appropriate infiltration rate for pervious areas and therefore we have run two models in parallel, one with a low infiltration rate and one with a high infiltration rate. This provides an envelope of effects and determines the sensitivity of the PDP Model to this assumption.

27 I note that a lower infiltration rate will produce more run-off and vice versa. When considering effects on flooding due to development, the infiltration rate for pervious areas determines the difference in run-off produced. A higher infiltration rate will produce a greater difference in flow pre and post development and I consider a higher rate is likely to provide a conservative estimate of effects.

28 I have selected a lower infiltration rate which matches the ultimate rate specified in the District Wide Model. For Ōhoka, this is DRAINAGE 1 class (DHI, 2020)[1], 1.67 mm/hr.

29 To determine an upper infiltration rate, I present **Attachment 2**, **Attachment 3** and **Attachment 4** which, for the Cust River catchment, show the proportion of rainfall which became runoff for the June 2014, July 2022 and July 2023 flood events. These attachments show that for the 2014 and 2022 flood events, rainfall intensities did not exceed 8 mm/hr and the percentage of rainfall that became runoff was between 40 and 50%. For the 2023 event, intensities reached just over 14 mm/hour and the percentage of rainfall that became runoff was approximately 49%.

30 If infiltration rates were 8 mm/hr, then no runoff for either the 2014 or 2022 events would have been observed. An infiltration rate of 4 mm/hr assumes that, for a rainfall intensity of 8 mm/hr, 50% of the rainfall will become runoff.

31 Therefore, I select an infiltration rate of 5 mm/hr and I consider this is a conservatively high rate for the following reasons:

31.1 Observed data for the Cust River tells us the runoff ratio is higher than 0.375 (5/8 = 0.375) and therefore infiltration rates are lower;

31.2 The ECan soils layer[2] shows that soils within the Cust River catchment are better drained (have higher infiltration rates) when compared to the proposed subdivision area which is classed as poorly drained. This indicates that infiltration rates

[1] DHI. (2020). Flood Hazard Models Update District and Urban and MIKE FLOOD models. Waimakariri District Council.

[2] https://gis.ecan.govt.nz/arcgis/rest/services/Public/Landcare_SMap_Layers/MapServer

for the proposed subdivision are likely to be lower when compared to the Cust River catchment; and

31.3 Rainfall intensities in 2014 and 2022 are generally less than 8 mm/hr, therefore comparing infiltration rates to this intensity is conservative.

WDC DISTRICT WIDE MODEL

32 The WDC District Wide Model (the *District Wide Model*) is a separate flood model constructed by DHI on behalf of WDC. It was most recently updated in 2021. This flood model aims to provide flood hazard predictions for the entire Waimakariri District for the 100-year, 200-year and 500-year flood events.

33 PDP have adopted the hydrological assumptions made in the District Wide Model and applied them to the PDP Model. Boundary conditions for the PDP Model are required upstream of Bradleys Road. These boundary conditions specify how much flow enters the PDP Model. These flows have been provided by WDC who have extracted the flows from the District Wide Model.

34 It is worth considering the accuracy and/or conservatism of these hydrological parameters which have been imported from the District Wide Model.

35 The District Wide Model employs a rain on grid approach which is influenced by rainfall depth, infiltration, roughness and terrain assumptions.

36 Regarding rainfall assumptions in the District Wide Model, DHI (2020)[3] reports:

> "*The district flood hazard models all employ a 24 hour nested storm event. The nested storm approach is used in the flood hazard models due to the long model run times and the need to manage the number of simulation runs. The nested storm is created using the 'Alternating Block Method' and is constructed using rainfall depths from the 1, 3, 6, 9, 12, 18 and 24 hour storm events. The profile features 24 equally distributed time steps. The 24 hour storm was selected as this is approximately the critical time of concentration for the coastal parts of the district from rainfall originating in the foothills behind Oxford and Okuku*."

37 On climate change, DHI (2020) reports:

[3] https://openmaps.waimakariri.govt.nz/HazardsReports/DistrictFloodMappingDHI.pdf

> *"For stormwater and flood modelling WDC uses the RCP8.5 emissions scenario for the period 2081 – 2100 (80 year projection). This is consistent with MfE guidance around long life infrastructure assets. The rainfall projections for RCP8.5 are included in the HIRDS4 output."*

38 Therefore, by adopting the District Wide Model hydrology, I conclude our modelled scenarios include climate change, specifically RCP (Representative Concentration Pathway) 8.5 for the period 2081 - 2100.

39 Turning to the validation of the District Wide Model, DHI (2020) reports there is limited opportunity for validation or calibration of this District Wide Model. DHI (2020) reports:

> *"The MIKE 21 model results for a 1 in 100 year event give a peak flow of 910m³/s at the Fox Creek Okuku gauge, Figure 3-6. This is around double the flow estimated using frequency analysis, indicating that the infiltration rates may be too conservative in the hillside areas. However, given the uncertainties involved in the flood frequency analysis, it is difficult to determine by how much"*
>
> Further:
>
> *"Despite the potential overestimation of flow, it is believed that the model is still performing better in this area than in the earlier modelling".*

40 Whilst the hill catchments are not of particular relevance to our area of interest (Ōhoka), this validation shows that District Wide Model appears to be conservative in its uncertainty. That is, runoff is likely overestimated rather than underestimated for hill catchments.

41 As no model validation information specific to Ōhoka is presented for the District Wide Model, I have compared the flow predictions made by the District Wide Model with design flood estimates provided by Tonkin and Taylor (2017)[4].

42 The Tonkin and Taylor study was commissioned by ECan to provide flood estimates for 42 sites on selected Canterbury Rivers including the Ōhoka Stream. This report provides the most up to date and comprehensive review of available historical flood studies including

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[4] Tonkin and Taylor (2017). Flood frequency analysis for Canterbury Rivers. Environment Canterbury, Christchurch.

McKerchar and Pearson[5] (1989), NIWA[6] (2011), Tomlinson[7] (1980) and HIRDS V3[8].

43 ECan has recently[9] updated the flood frequency statistics for many of the sites presented in this Tonkin and Taylor study although the Ōhoka Stream site has not been included in this update. Therefore, I consider the Tonkin and Taylor (2017) report provides the best available estimates on design flows.

44 For the Ōhoka Stream at Cust Main Drain confluence, Tonkin and Taylor (2017) adopt the following flows (with no allowance for climate change) of:

44.1 60 m^3/s for the 100-year event;

44.2 70 m^3/s for the 200-year event;

44.3 80 m^3/s for the 500-year event;

45 For comparison, at the same location, the District Wide Model predicts flows of:

45.1 100 m^3/s for the 100-year event;

45.2 160 m^3/s for the 200-year event;

45.3 240 m^3/s for the 500-year event;

46 I note the Tonkin and Taylor (2017) estimates do not include climate change. The increase in the 24-hour rainfall depth, out to 2081 - 2100 for RCP 8.5, is 22% (NIWA, 2023)[10]. For the six hour event, which is more relevant to the Ōhoka Stream as the time of concentration is likely to be closer to six hours, the increase in rainfall for the same period is 30%. I note that flow response to rainfall is non-linear, that is, a 10% increase in rainfall will not

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[5] McKerchar, A.I. and Pearson, C.P., (1989). Flood Frequency in New Zealand. Publication No, 20 of the Hydrology Centre, Christchurch.

[6] NIWA (2011). Review of flood frequency in the Canterbury region. Report R11/50, August 2011.

[7] Tomlinson, A.I. (1980). The frequency of high intensity rainfall. Part 1. Soil Water Rach Publ No. 19. Ministry of Works and Development Christchurch.

[8] Thompson C (2011). HIRDS. V3: High Intensity Rainfall Design System – The method underpinning the development of regional frequency analysis of extreme rainfalls for New Zealand.

[9] ECan (2024): https://api.ecan.govt.nz/TrimPublicAPI/documents/download/4873422

[10] NIWA. (2023). High Intensity Rainfall Design System v4. Retrieved June 13, 2023, from NIWA: https://hirds.niwa.co.nz/

necessarily result in a 10% increase in flow. Further, the flow response typically exceeds the rainfall response.

47 The District Wide Model gives us an indication as to how flow increases will respond to rainfall increases. When comparing the 100-year, 200-year and 500-year events supplied by the District Wide Model, every percentage increase in rainfall results in a 2.2% increase in flow. Therefore, a 30% increase in rainfall depth will likely generate a 66% increase in flow. Applying this adjustment factor to the Tonkin and Taylor (2017) flow estimates gives:

47.1 100 m^3/s for the 100-year event;

47.2 116 m^3/s for the 200-year event;

47.3 133 m^3/s for the 500-year event;

48 Therefore, I conclude the hydrological inputs of the PDP Model, which have been derived from the District Wide Model (as per paragraph 33), are likely conservative for the 200-year and 500-year events.

MODEL RESULTS

49 In this section, I will cover the effects from flooding on freeboard for off-site dwellings and the effects on flood levels for off-site dwellings.

50 I want to distinguish between the various categories of flooding. I accept that high groundwater conditions, springs and heavy soils mean that the proposed Site and the surrounding Ōhoka area is subject to what I would categorise as low-hazard flooding from smaller events such as those experienced in 2014, 2022 and 2023. That is, flooding that is unlikely to cause significant damage to infrastructure or result in loss of life.

51 Whilst the WDC hazard classifications are useful, I consider a more extensive categorisation of flooding is provided by the Australian Rainfall and Runoff Guidelines[11]. I note that the flood hazard curves from these guidelines are often employed in New Zealand and the hazard curves are recommended by the Greater Wellington Flood Hazard Modelling Standard (May 2021)[12].

52 **Attachment 5** shows the flood hazard classification for the 200-year pre-development event. This figure shows that:

[11] Australian Rainfall and Runoff – Book 6 Flood Hydraulics (2016), after Smith et al., 2014

[12] Greater Wellington Regional Council - Flood Hazard Modelling Standard (2021)

52.1 For the area south of Mill Rd (where the Site is), the hazard in the vast majority of the area for this event is classified as low (H1) outside of the channels meaning that it is generally safe for people and buildings;

52.2 North of Mill Road, the hazard classification outside of the Ōhoka Stream ranges from H2 (unsafe for small vehicles) to H4 (unsafe for people and vehicles);

52.3 Therefore, I conclude that the area north of Mill Road is more vulnerable to high-risk flooding when compared to the area south of Mill Road.

53 I consider that whilst Ōhoka may be subject to more frequent flooding when compared to other areas in Canterbury, this flooding is low hazard. For significant events, such as the 200-year event, the flood hazard is still low for areas south of Mill Road and moderate for areas north of Mill Road.

54 Primarily the PDP Model is aiming to solve a conveyance issue. In other words, how can the post-developed Site be configured to best match the flood waters discharged in the pre-development state? This is demonstrated in **Attachments 6A, 6B and 6C** which show the predicted flow discharged from the Site in the pre-development and post-development models.

55 Summarising the PDP Model results with the lower and higher infiltration rates, I find the difference in total peak flood flow leaving the subdivision (over Mill Road and White Road) is:

55.1 0.9 m^3/s for the lower infiltration rate model (1.67 mm/hr). 60.7 m^3/s pre-development and 61.8 m^3/s post-development; and

55.2 1.7 m^3/s for the higher infiltration rate model (5.00 mm/hr). 58.3 m^3/s pre-development and 60.0 m^3/s post-development.

56 I conclude that the use of 5 mm/hr as an infiltration rate will provide a more conservative assessment of the effects on flooding and I have employed this model in my further analysis of the results below.

57 **Attachment 6A** shows the total flow leaving the subdivision over the combined length of Mill Road and Whites Road. This attachment shows that the difference between pre-developed and post-developed flows is largely indistinguishable (58.3 m^3/s vs 60.0 m^3/s, a difference of around 1. m^3/s or a 2.9% increase in flow).

58 **Attachment 6A** also shows the total flow if rainfall is excluded from the PDP Model. There are two key differences:

58.1 An earlier peak is observed when rainfall is included. Whilst this looks significant, water levels will be determined by the peak flow and therefore, this will have little effect on the PDP Model. This peak is due to the employment of a nested storm profile as specified by the District Wide Model; and

58.2 The peak flow without rainfall is around 2.6 m^3/s lower, or around 96% of the flow with rainfall. This demonstrates that flood hydraulics are dominated by the catchment upstream of the proposed subdivision and whilst the inclusion of rainfall will improve the accuracy of the PDP Model, it is unlikely to have a significant impact on conclusions.

59 **Attachment 6B** shows the flow over each of Mill Road and Whites Road. The flow over these roads capture all of the flood water leaving the subdivision. Mill Road is located on the northern boundary of the subdivision and Whites Road is located on the eastern boundary. For Mill Road, the peak flow is slightly reduced post development (15.3 m^3/s to 15.6 m^3/s) whilst for Whites Road, the peak flow has increased slightly post development (42.3 m^3/s to 42.6 m^3/s). I note that further changes to the subdivision design and subsequent modelling could be completed to better balance the conveyance of these flows and provide a very close match to pre-developed flows.

60 **Attachment 6C** shows the flow over various locations along Whites Road. This shows that as we increase the granularity of the PDP model interrogation, there is a greater discrepancy between the pre-development and post-development flows. In general though, peak flows are generally within 0.5 m^3/s (500 L/s) with the exception of the South and Mid South Channel for which the post-developed flow is up to 1.0 m^3/s (1,000 L/s) more than the pre-developed flow.

61 I conclude from these three attachments (**6A**, **6B** and **6C**) that conveyance of floodwaters through the Site is the main issue that needs to be solved from a flood effects lens. Therefore, I consider the modelling demonstrates that the most effective mitigation is to ensure development is minimised in areas where the existing conveyance of floodwaters is significant. Alternatively, channel re-shaping and site contouring may also achieve a similar outcome which can be explored at the subdivision consenting stage.

EFFECTS ON FREEBOARD

62 To determine the effects on freeboard off-site, three inputs are required:

62.1 The finished floor levels, or as-built levels, of existing dwellings;

62.2 The pre-development flood level; and

62.3 The post-development flood level.

63 To obtain accurate finished floor levels would require a detailed survey of the Ōhoka township which is beyond the scope of this analysis and should be completed, if required, at the resource consenting stage. As a preliminary screening exercise, I have estimated finished floor levels using the following approach:

63.1 Estimate the ground level for each dwelling using LIDAR. When the LIDAR is post-processed and converted to a Digital Terrain Model (*DTM*), structures are removed from the dataset. Therefore, the area beneath the footprint is an interpolated surface made up of the capture points around the perimeter of the structure. Dwellings are typically built from the highest elevation contained within the building footprint. I have assumed that the average elevation contained within the building footprint is representative of the ground level.

63.2 Whilst the District Plan requires a freeboard over the 200-year model event, I note that the majority of these dwellings would have been constructed prior to this requirement. Therefore, to be conservative I have assumed that finished floor levels will be 300 mm above the ground elevation.

64 Water levels for the pre-development and post-development events for each habitable dwelling have been obtained by extracting the average flood level over the building footprint.

65 Building footprints have been obtained from LINZ although I have excluded footprints which are within the proposed subdivision.

66 I note there are 1,007 building footprints remaining within the modelled area. Of these, manual inspection against aerial photography and Google street view shows that 394 of these footprints could be habitable dwellings. For the purposes of this assessment, I do not consider garages or utility sheds habitable dwellings.

67 With these assumptions, I obtain the following results:

67.1 335 of the dwellings are within a low or no hazard area (as defined by WDC) and therefore the applicable freeboard is 400 mm.

67.2 The remaining 59 dwellings are within a medium or high hazard area and therefore the applicable freeboard is 500 mm.

67.3 Applying the recommended freeboards for each dwelling and comparing the recommended minimum floor level to the 200-year pre-development flood level, I find:

(a) 3 dwellings meet the recommended freeboard requirements:

(b) 391 dwellings do not meet the recommended freeboard requirements.

67.4 Completing the same assessment but with the post-development flood level, I find:

(a) 3 dwellings meet the recommended freeboard requirements:

(b) 391 dwellings do not meet the recommended freeboard requirements.

68 Therefore, I conclude there is no change or impact on compliance with recommended freeboard requirements for existing dwellings as a result of the proposed development.

EFFECTS ON FLOOD LEVELS

69 The effects on post-development flood levels are presented in **Attachment 7**. This attachment shows that outside of the subdivision:

69.1 Effects north of Mill Rd are generally less than 10 mm;

69.2 South of Mill Rd and east of Whites Rd, the effects are greatest at the subdivision boundary and dissipate as the floodwater moves east. There are generally only small pockets of flood increases which exceed 10 mm.

70 To assess the difference in flood elevations, I have taken all building footprints, not just habitable dwellings, and extracted the average water level over the footprint for both the post-developed and pre-developed water levels. I take the difference between these two water levels to be the effects on the building footprint.

71 Summarising the effects of development for the 200-year event on all building footprints, my analysis shows:

71.1 A decrease in flood elevations of more than 20 mm for one building footprint;

71.2 A change in flood elevations of between -20 and 10 mm for 995 building footprints;

71.3 An increase in flood elevations of between 10 and 20 mm for nine building footprints; and,

71.4 An increase in flood elevations of greater than 20 mm for two building footprints (24 mm and 28 mm).

72 Inspection of aerial imagery and google street view shows that both building footprints with an increase of greater than 20 mm are sheds. The locations of these sheds are shown in **Attachment 8.**

73 Given that for all other building footprints, and therefore all habitable dwellings, there are no predicted increases in the flood elevation of greater than 20 mm, I conclude that my assessment demonstrates the effects of flooding on these dwellings are less than minor. When considering effects, I note there is limited guidance available. Therefore, I take the following items into consideration:

73.1 The size of the development – I consider a 50 mm effect on two habitable dwellings from a proposed one lot development is less acceptable than the same effect from a hundred lot development;

73.2 The sensitivity of the effected dwellings to flooding – A 50 mm effect on a habitable dwelling with 1,000 mm of freeboard is more acceptable than the same effect on a habitable dwelling that has no freeboard; and

73.3 The magnitude of the effect – A 100 mm effect is less acceptable than a 50 mm effect.

74 I also conclude that the subdivision layout presented is a viable configuration that results in less than minor effects of flood hazard.

75 I note further modelling will be required at the detailed design and consenting stage to ensure that a less than minor effect (no more than 20 mm) is achieved with the final subdivision surface. Given most of the existing dwellings within the modelled area of interest do not satisfy the WDC freeboard requirements, I conclude that WDC will be unlikely to accept effects which significantly reduce the available freeboard for existing dwellings.

DEVELOPMENT IN THE WAIMAKARIRI DISTRICT FROM A FLOOD RISK PERSPECTIVE

76 Recent extreme flooding events like those in 2023 (Cyclone Gabrielle and Auckland Anniversary) highlight the significant risks to infrastructure and property posed by floods. As climate change intensifies, the likelihood of such events is expected to rise. Notably, both affected regions are now undergoing a land categorisation process, with some previously approved developments and land are now categorised uninhabitable (red-stickered) as the risk to building on that land is too high.

77 In my opinion, flood hazard consideration should be a critical component of planning processes. Preferential development in areas identified as none, low or medium hazard would be a prudent approach.

78 Regarding development in coastal areas, I note the new guidance document issued (2024) by the Ministry for the Environment (*MfE*) titled 'Coastal hazards and climate change guidance'. For changes in land use, or greenfield developments, this document recommends application of the medium confidence SSP5-8.5 H+ RSLR projection over a 100-year time horizon. SSP5-8.5 H+ is a Relative Sea Level Rise (*RSLR*) projection that accounts for climate change and vertical land movement under Shared Socioeconomic Pathway 8.5 (*SSP-8.5*), the 'H+' refers to the 83rd percentile result, broadly equivalent to one standard deviation.

79 **Attachment 10** shows the relative sea level rise projection for the SSP-8.5 scenario plus VLM for Kaiapoi. For a 100-year time horizon, out to 2130, the SSP-8.5 H+ scenario estimates a relative rise in mean sea levels of 2.07 m. The mean sea level is zeroed for the year 2005 which means changes are relative to that year.

80 The latest publicly available coastal hazard modelling for the Waimakariri District was produced by Jacobs in 2020, titled "Phase 2 Coastal Inundation Modelling". I understand these are the model results presented on the WDC flood hazard maps[13]. For much of the proposed developable area adjacent to Kaiapoi, these maps show flood depths in excess of 1 m, which carry a high hazard classification under the ECan Regional Policy Statement. This is also demonstrated in the constraint maps included in the evidence of **Mr Walsh** which employs the same base data as the WDC flood hazard maps.

81 The recent guidance updates from MfE (2024) recommend a RSLR scenario equal to 2.07 m rather than the 1 m adopted by the model

[13] https://waimakariri.maps.arcgis.com/apps/instant/portfolio/index.html?appid=c6bc05f87d4f47ecae975e5241657913

results presented on the WDC maps[14]. Applying this recommended RSLR increase would further increase flood depths over and above those presented on the WDC maps.

82 I note the Proposed National Policy Statement[15] (MfE, 2023) for Natural Hazard states:

"in areas of high natural hazard risk, new development is avoided unless the level of risk is reduced to at least a tolerable level"

83 I note the document is silent on what a "tolerable level" is. I consider that development in high hazard areas inherently carries significant risk to life, property and infrastructure. In my opinion, reducing risk to a tolerable level would require a high degree of confidence that all elements of the flood hazard will be mitigated including, but not limited to:

83.1 Protection of property from flooding;

83.2 Evacuation routes and pathways in the event of a stopbank breach or larger than expected event;

83.3 Long term monitoring and maintenance plans for critical infrastructure which provides protection for the proposed development;

83.4 Long term insurability of assets and infrastructure; and

83.5 Consideration of residual risk if reliant on infrastructure such as sea walls and stopbanks.

CONCLUSION

84 I consider that conveyance of floodwaters through the Site is the main issue that needs to be solved from a flood effects lens. Therefore, I consider the most effective mitigation will be to ensure development is minimised in areas where the existing conveyance of floodwaters is significant.

85 The updated PDP Model has demonstrated that there is a viable subdivision layout which minimises development in areas of existing flood conveyance. This layout ensures the effects of the proposed

[14] Noting that at the time of the modelling exercise, this guidance was unavailable and also noting that the Jacobs modelling exercise did include a 1.88 m SLR scenario. 1.88 m was the previously recommended increase in sea level by Ministry for Environment for controlling planning for coastal sub-divisions, greenfield development and major new infrastructure.

[15] https://environment.govt.nz/assets/publications/RMA/Proposed-National-Policy-Statement-for-Natural-Hazard-Decision-making-2023.pdf

subdivision on flood levels will not exceed 20 mm for any habitable dwelling.

86 For habitable dwellings, I conclude that an average increase in flood elevation of less than 20 mm for the 200-year event is a less than minor effect.

87 I conclude that Ōhoka is prone to low hazard flood events, similar to those experienced in June 2014, July 2022 and July 2023. I note the magnitude of these events at Ōhoka was probably between a 10-year and 50-year event. The stormwater solution within the Site will provide mitigation of any additional stormwater generated by the Site for events of these magnitudes.

88 For more significant events, modelling of the 200-year event shows the flood hazard is still low for areas south of Mill Road/downstream of Whites Road and moderate for areas north of Mill Road. I note the PDP Model predicts generally limited effects greater than 10 mm for areas north of Mill Road and no increase greater than 20 mm for habitable dwellings elsewhere within the PDP Model.

89 New dwellings within the proposed development should be built with a minimum floor level of 500 mm above the 200-year event to provide adequate mitigation from flooding.

Dated: 5 March 2024

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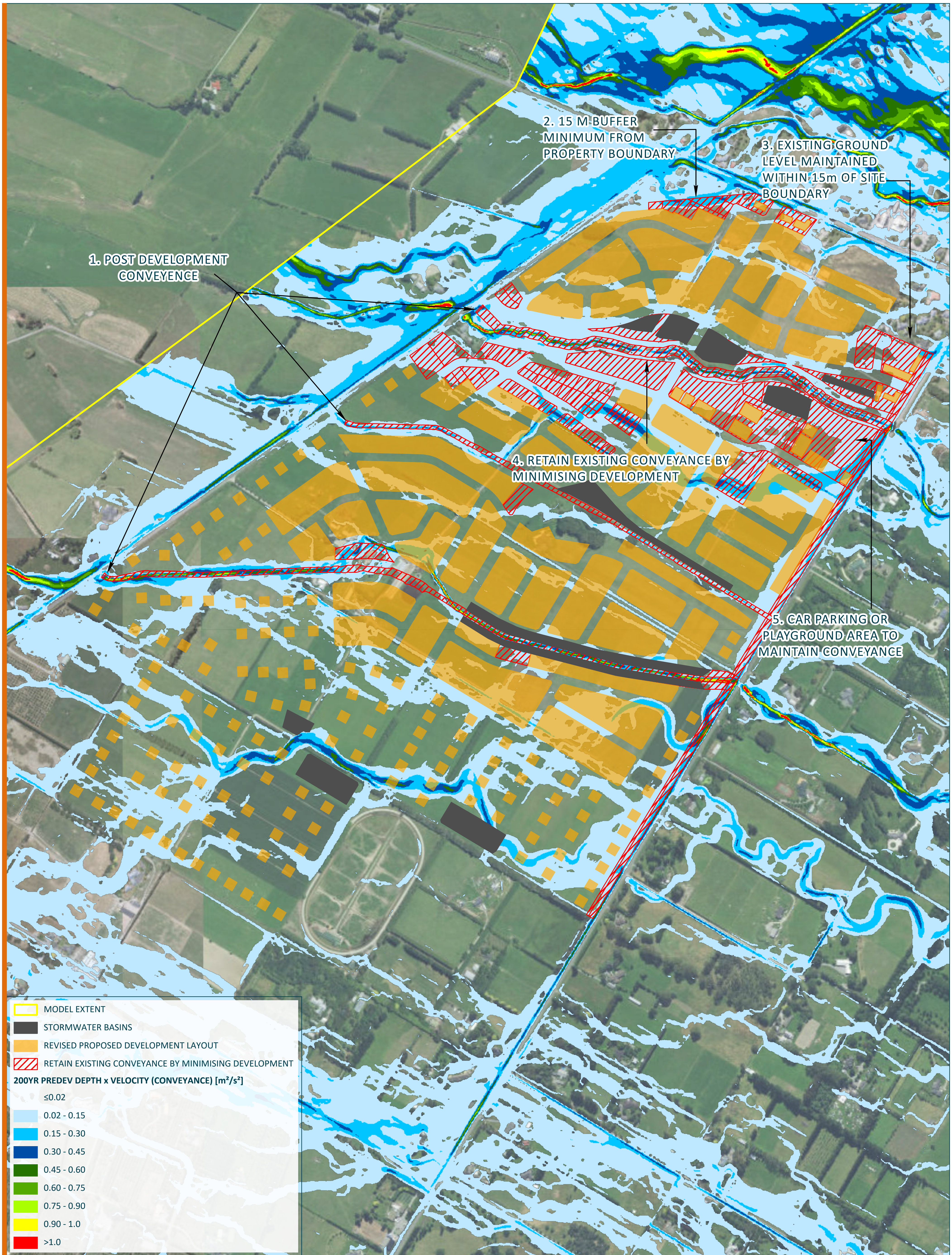
Ben Throssell

ATTACHMENT 1: HYDRAULIC FEATURES



pdp

ATTACHMENT 1: MODELLED SUBDIVISION LAYOUT

OHOKA PLAN CHANGE

SOURCE:
1. AERIAL IMAGERY: EAGLE TECHNOLOGY, LAND INFORMATION NEW ZEALAND, GEBCO, COMMUNITY MAPS CONTRIBUTORS.

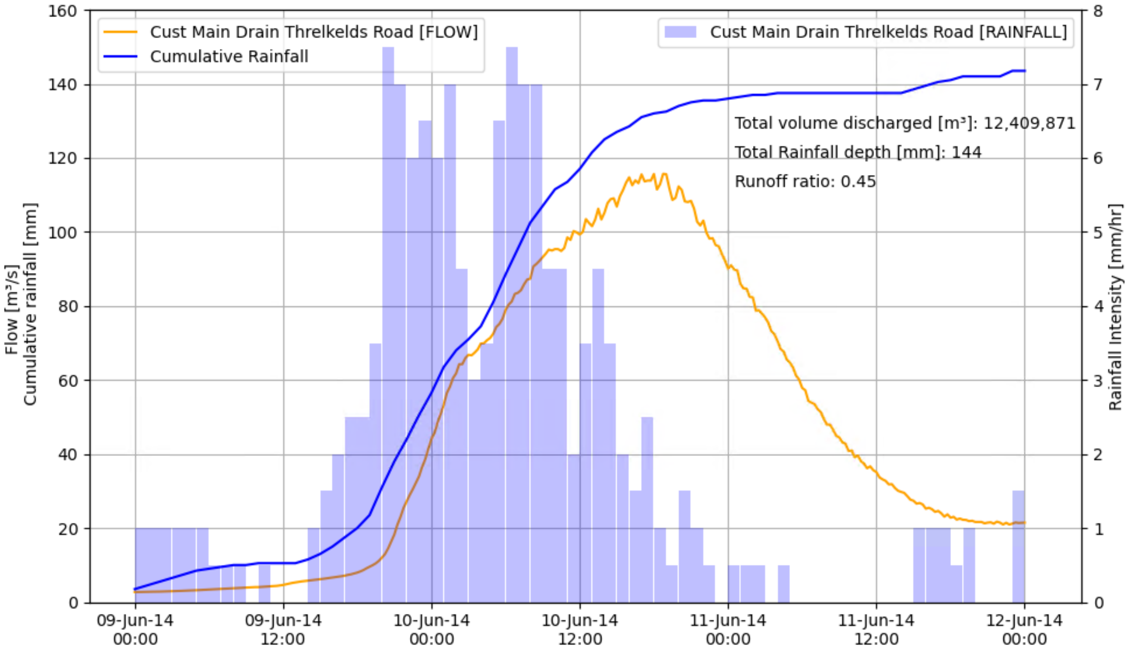
SCALE : 1:7,000 (A3)

REVISION: 01 | DATE: JUN 23 | BY: JR

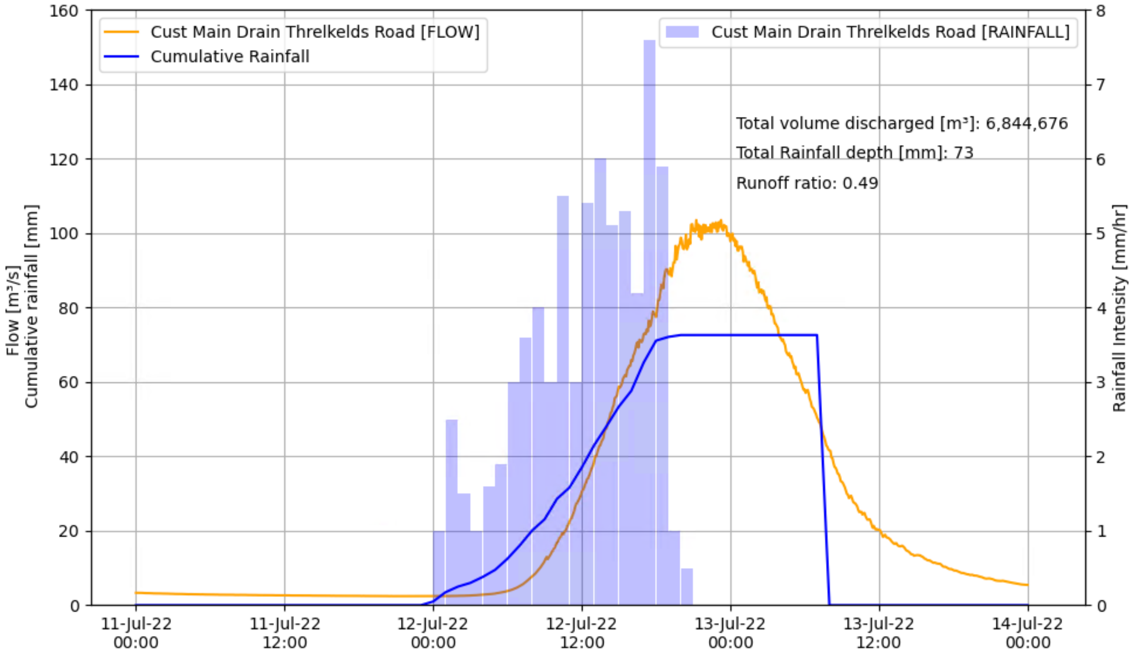
CLIENT: ROLLESTON INDUSTRIAL DEVELOPMENTS LIMITED

C04518300_GIS001

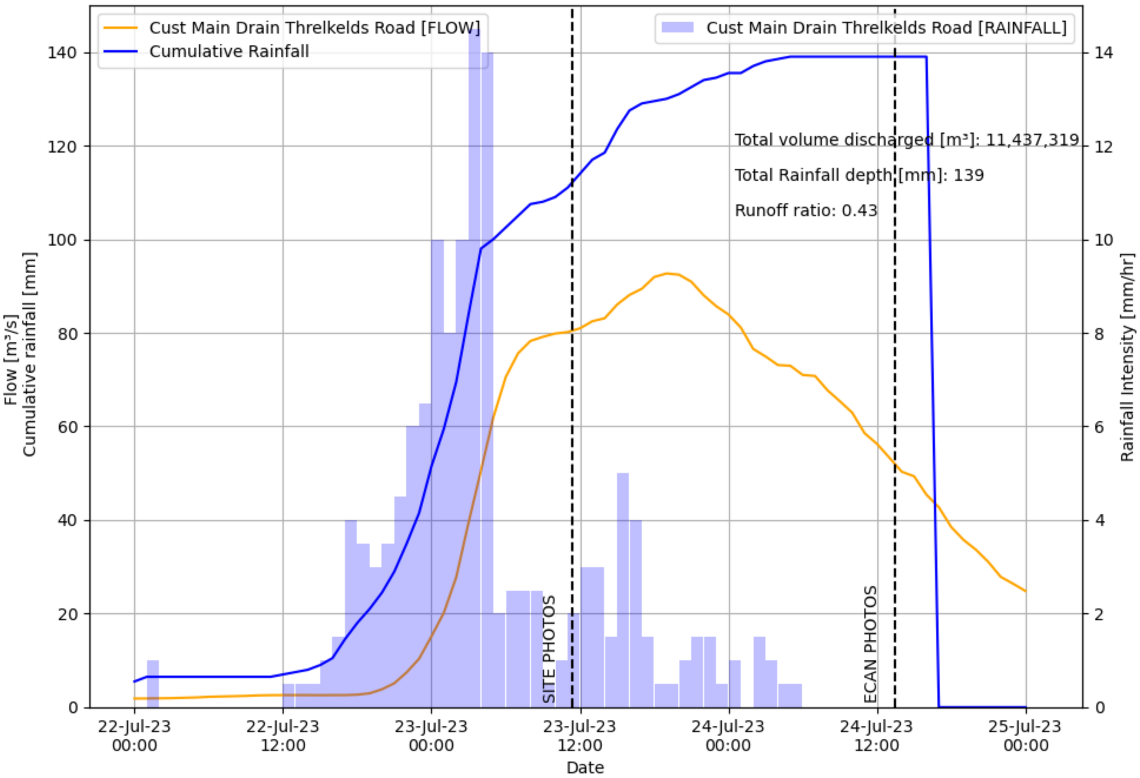
ATTACHMENT 2: RECORDED FLOWS AND DEPTHS FOR CUST RIVER AT THRELKELDS ROAD FOR 9 JUNE TO 12 JUNE 2014



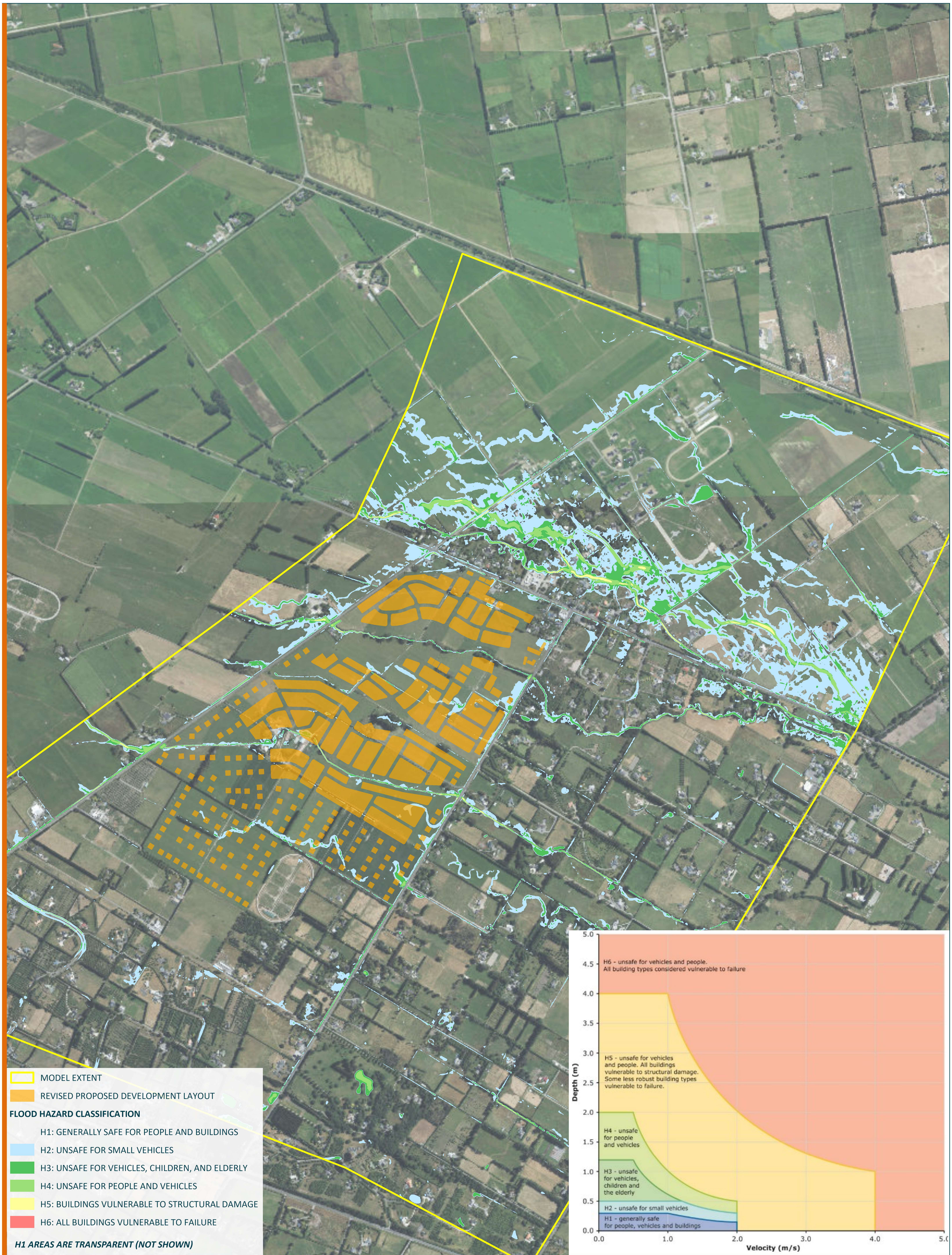
ATTACHMENT 3: RECORDED FLOWS AND DEPTHS FOR CUST RIVER AT THRELKELDS ROAD FOR 11 JULY TO 14 JULY 2022



ATTACHMENT 4: RECORDED FLOWS AND DEPTHS FOR CUST RIVER AT THRELKELDS ROAD FOR 22 JULY TO 26 JULY 2023



ATTACHMENT 5: FLOOD HAZARD CLASSIFICATION



pdp

ATTACHMENT 5: FLOOD HAZARD CLASSIFICATION FOR THE 200YR PRE DEVELOPMENT EVENT

OHOKA PLAN CHANGE

SOURCE:
1. AERIAL IMAGERY: EAGLE TECHNOLOGY, LAND INFORMATION NEW ZEALAND, GEBCO, COMMUNITY MAPS CONTRIBUTORS.

0 250 500
Meters
SCALE : 1:15,000 (A3)

N

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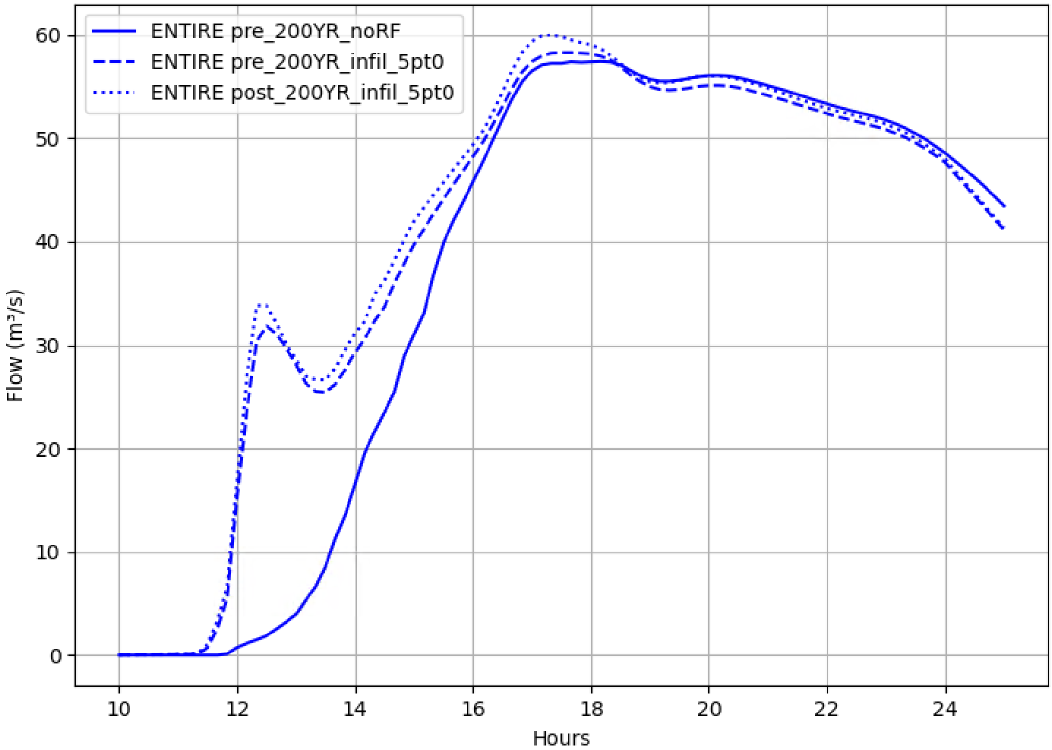
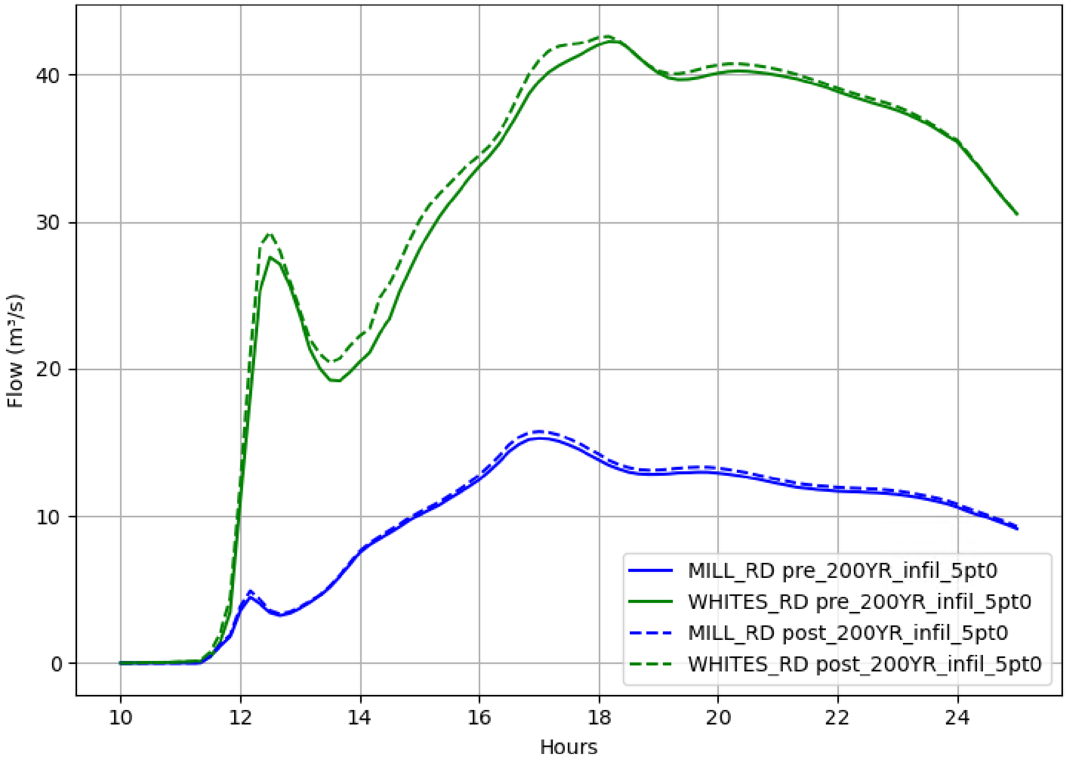
C04518300_GIS002

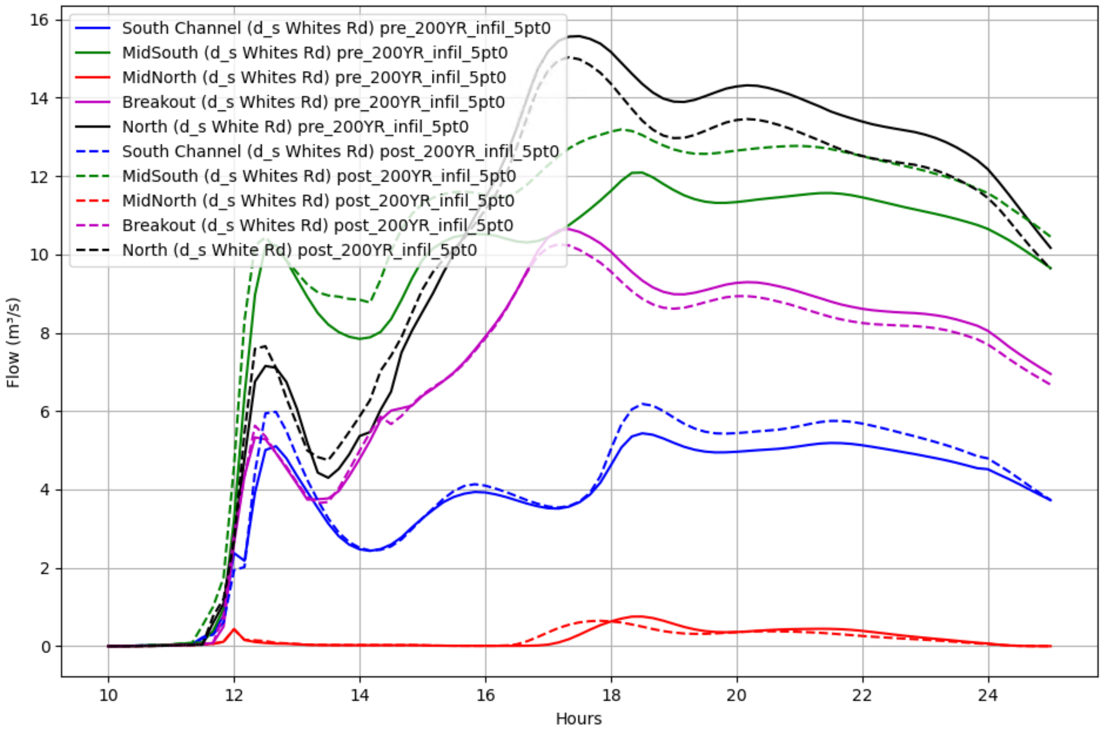
Attachment 6A: Predicted total flow leaving the subdivision (over Mill Rd and Whites Rd combined) for the 200-year flood event. Showing the pre-development scenario and post-development scenario, both with rainfall and the pre-development scenario without rainfall.



Attachment 6B: Predicted total flows over Mill Rd and Whites Rd for the 200-year flood event. Showing the pre-development scenario and post-development scenario, both with rainfall.



Attachment 6C: Predicted flows leaving the subdivision (at various locations over Whites Rd) for the 200-year flood event. Showing the pre-development scenario and post-development scenario, both with rainfall. Locations of the flow extraction points are presented in Attachment 9.



ATTACHMENT 7: EFFECTS ON FLOOD LEVELS

pdp

ATTACHMENT 7: DIFFERENCES IN FLOOD ELEVATION FOR THE 200YR EVENT

OHOKA PLAN CHANGE

SOURCE:
1. AERIAL IMAGERY: EAGLE TECHNOLOGY, LAND INFORMATION NEW ZEALAND, GEBCO, COMMUNITY MAPS CONTRIBUTORS.
2. ROAD INFORMATION DERIVED FROM LINZ.
3. BUILDING FOOTPRINTS DERIVED FROM LINZ.

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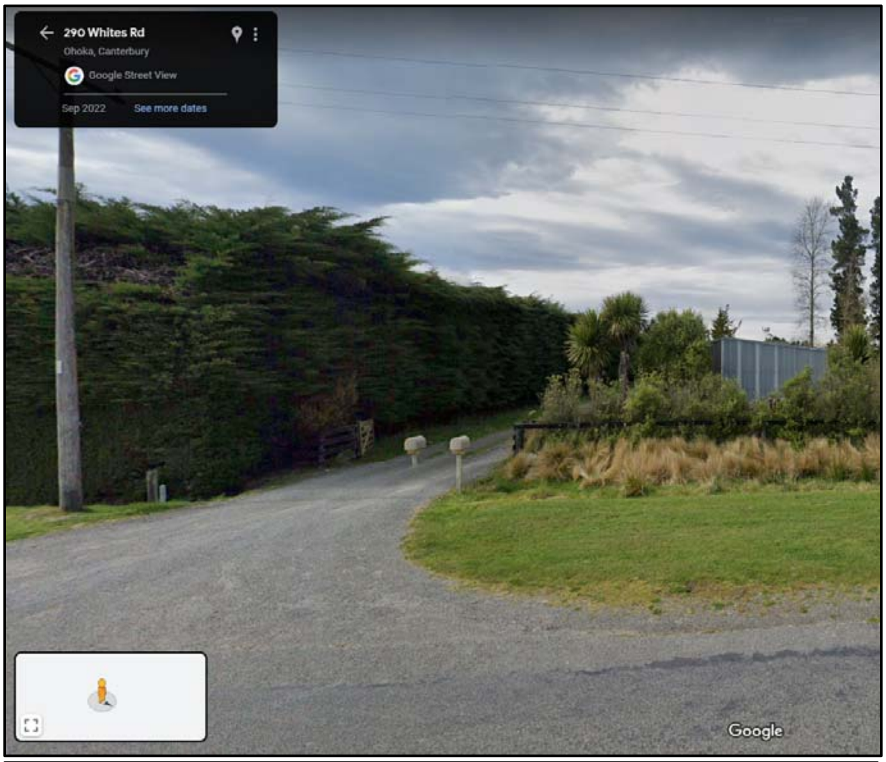
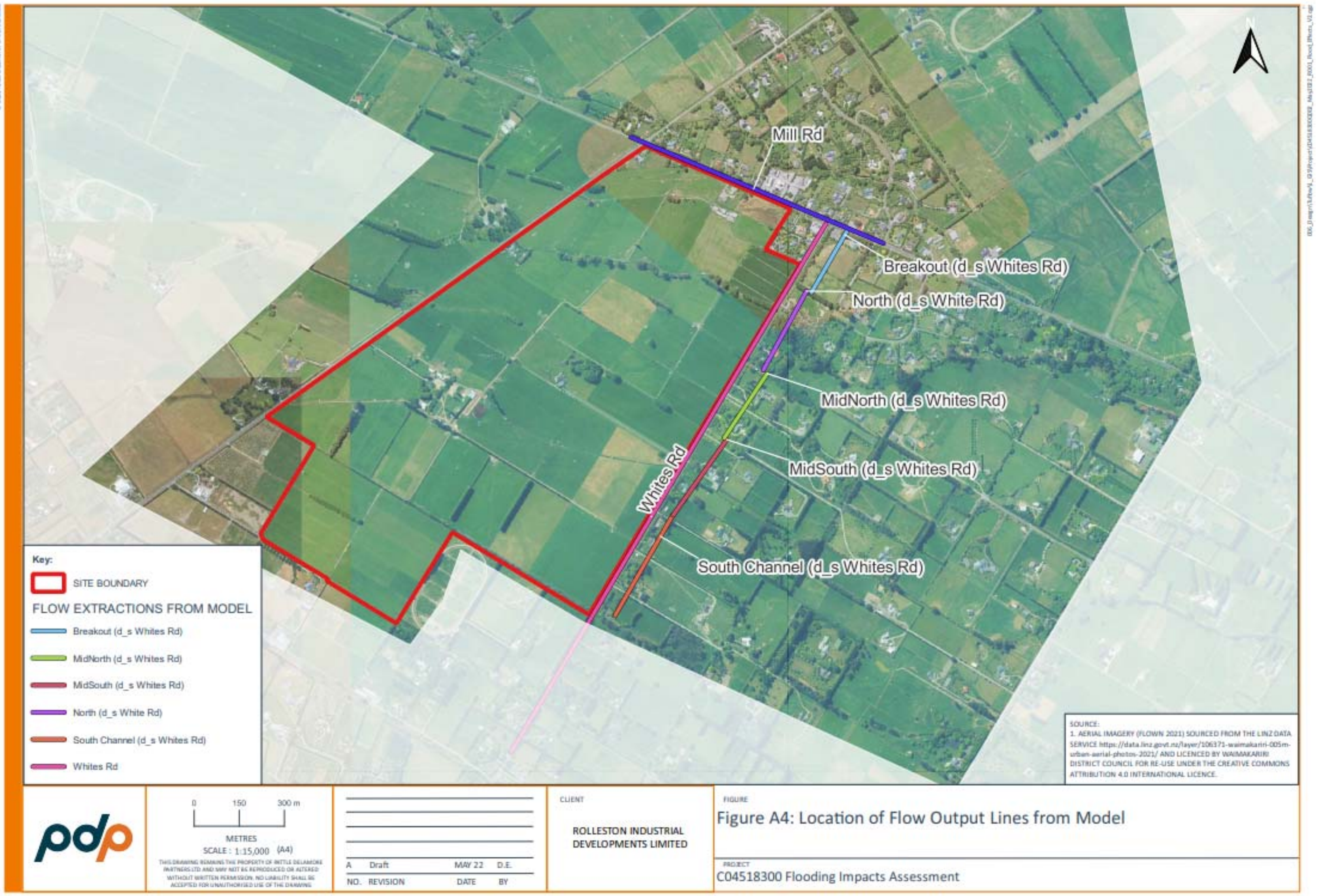
C04518300_GIS006

ATTACHMENT 8: LOCATION OF TWO BUILDING FOOTPRINTS WHERE THE AVERAGE WATER LEVEL INCREASE ACROSS THE FOOTPRINT EXCEEDS 20 MM (290 AND 296 WHITES ROAD)


290 Whites Rd
Ohoka, Canterbury
Google Street View
Sep 2022
See more dates
Google


0 mm
0 mm
0 mm
24 mm
0 mm
10 mm
28 mm
WHITES ROAD
0 mm
200-YEAR FLOOD LEVEL DIFFERNCE [MM]
< 20 mm
>= 20 mm
0
25
50 m

ATTACHMENT 9: SHOWING LOCATIONS WHERE FLOWS HAVE BEEN EXTRACTED FROM THE MODEL.



ATTACHMENT 10: RELATIVE SEA LEVEL RISE PROJECTIONS FROM SEARISE.NZ FOR KAIAPOI