BEFORE INDEPENDENT HEARING COMMISSIONERS APPOINTED BY THE WAIMAKARIRI DISTRICT COUNCIL

IN THE MATTER OF	The Resource Management Act 1991 (**RMA** or **the Act**)
AND	
IN THE MATTER OF	Hearing of Submissions and Further Submissions on the Proposed Waimakariri District Plan (**PWDP** or **the Proposed Plan**)
AND	
IN THE MATTER OF	Hearing of Submissions and Further Submissions on Variations 1 and 2 to the Proposed Waimakariri District Plan
AND	
IN THE MATTER OF	Submissions and Further Submissions on the Proposed Waimakariri District Plan by **Momentum Land Limited**

EVIDENCE OF RICHARD CLARKE BRUNTON
ON BEHALF OF MOMENTUM LAND LIMITED REGARDING STREAM 12
REZONING OF LAND

Dated: 5 March 2024

Presented for filing by:
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INTRODUCTION

1 My name is Richard Clarke Brunton.

2 I am a Water Resources Engineer at Tonkin & Taylor Ltd.

3 I hold the qualifications of Bachelor of Natural Resources Engineering with Honours from the University of Canterbury.

4 I have 14 years' experience in New Zealand and Canada within the water engineering sector. I am a Chartered Professional Engineer (CPEng) and a member of Engineering New Zealand (CMEngNZ).

5 I have expertise in stormwater and flood management. I have worked on projects for central and local government, developers, and other commercial entities. Recent projects I have been involved in include:

a. Technical lead for Otago Regional Council undertaking flood hydraulic modelling and development of flood mitigation for the Taieri River flood protection scheme.

b. Hydraulic modeler and technical lead for Selwyn District Council undertaking hydraulic modelling of the Springfield township to predict flooding during the May 2021 Canterbury flood event.

c. Technical lead for Palmerston North City Council undertaking a stormwater modelling assessment of several catchments.

d. Technical lead for Beach Road Estates Ltd undertaking flood hydraulic modelling and assessment of the Beach Grove subdivision located adjacent to the plan change area. I also have experience with the Silverstream Estates subdivision located to the west of Kaiapoi.

6 I am familiar with the area to which the application for plan change relates. I have visited the site on several occasions, most recently on 4th April 2023.

7 I have read the Environment Court's Code of Conduct and agree to comply with it. My qualifications as an expert are set out above. The matters addressed in my evidence are within my area of expertise, however where I make statements on issues that are not in my area of expertise, I will state whose evidence I have relied upon. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in my evidence.

SCOPE OF EVIDENCE

8 In my evidence I address the following:

a. The context of my evidence;

b. A description of the receiving environment;

c. A summary of the proposal;

d. A description of surface flooding and proposed flood mitigation;

e. An assessment of the potential effects on surface flooding;

f. Statutory assessment of the proposal; and

g. Commentary on matters raised by Section 42A report.

SUMMARY OF EVIDENCE

9 This evidence is in respect of a submission by Momentum Land Limited (**Momentum**) on the Waimakariri District Council (**WDC**) notified proposed District Plan (**Proposed Plan / PWDP**) and a submission by Momentum on Variation 1 to the Proposed Plan which allows for housing intensification in accordance with the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021. Momentum seeks to rezone the two blocks of land (the "**Site**") including Lot 2 DP 83191 and Lot 2 DP 4532 from Rural Lifestyle to Medium Density Residential.

10 My evidence is in support of the rezone proposed by Momentum and covers aspects relating to surface flooding.

11 Momentum proposes the following surface flooding mitigation for the Site:

a. Filling the Site to elevate ground levels above the existing flood level and constructing new buildings at or above a minimum finished floor level. Minimum finished floor levels for new buildings within the Site are anticipated to be above the 200-year Average Return Interval (ARI) event, incorporating an allowance for predicted climate change plus 500 mm freeboard, and;

b. Constructing a stormwater system to collect and convey runoff generated from within the Site to the receiving drainage system.

12 I have conducted an assessment to assess the potential effects of Momentum's proposal on surface flooding within the Site and surrounding area. The assessment relies on the results of hydraulic models which predict coastal, rainfall and river derived flood water depths for several ARI events. The models allow for predicted climate change effects including increased rainfall and sea-level rise.

13 The hydraulic model shows that during a 200-year event with existing pre-development conditions, the Site and surrounding area are significantly inundated with water depths in the order of 1 to 2 metres. When ground levels are elevated in the model as per Momentums proposal, modelled water depths within the Site during a 200-year event reduce to zero. This shows that Momentums proposal appropriately mitigates surface flooding for the considered events.

14 The hydraulic model shows that elevating ground levels within the Site will displace flood water and cause a small increase in water depth within the surrounding area. Water depths increase by up to 14 mm in the 5-year event, 34 mm in the 50-year event and 50 to 70 mm in the 200-year event. In context, water depths within the surrounding area during a 200-year event are in the order of 1 to 2 metres. I consider a 50 to 70 mm increase atop a 1 to 2 metre water depth insignificant and would be indiscernible.

15 The hydraulic model shows that Momentum's proposal does not cause any additional buildings within the surrounding area to be inundated in the 5-year to 200-year events. All existing buildings that are inundated in the pre-development condition are also inundated in the post-development condition when incorporating Momentum's proposal.

16 The hydraulic model shows that in a 50-year event, Momentum's proposal may cause a small reduction in floor level freeboard to several existing buildings within the surrounding area. However, most of these buildings, including Kaiapoi North School still retain sufficient freeboard as per the New Zealand Building Code to protect them from inundation. For buildings that do not have sufficient freeboard as per the New Zealand Building Code, Momentum's proposal has no significant effect.

17 In a 50-year event, Momentum's proposal may cause a very small increase in potential flood damage to one existing property (containing three buildings).

The model shows that the buildings are already inundated under existing pre-development conditions. The increase in the damage ratio (a measure of the percentage loss of a buildings value) due to Momentum's proposal is 0.4% for one building and 1.1% for two buildings. I consider this increase to be insignificant.

18 The Site is currently located within a High Hazard area as defined in the Canterbury Regional Policy Statement (**CRPS**), it being subject to water depths greater than 1 metre in a 500-year (**0.2% AEP**) flood event. Once ground levels are elevated within the Site as per Momentum's proposal, water depths reduce significantly, and the Site would no longer be subject to the CRPS definition of High Hazard Areas. In my opinion, Momentum's proposal appropriately mitigates flood hazards within the Site.

19 The hydraulic modelling shows that there is minimal change to the High Hazard Areas because of Momentum's proposal within urban areas surrounding the Site. This is because the displacement effect of Momentum's proposal causes a small (approximately 50 mm) increase in water depth. At the outer margins of the High Hazard Areas, this small increase causes water depth to exceed 1 m in some sporadic areas. The adverse effect on flood hazard for people, property, and infrastructure from a 50 mm increase atop areas already subjected to inundation of 1 to 2 metres is considered minimal.

20 In my opinion, other potential effects on aspects such as nuisance flooding to property, agricultural activities and erosion and scour are insignificant.

21 Momentum's proposal will not significantly alter the overall behaviour of surface flooding within the area. Other than the small increases in water depths summarised above, the overall behaviour of flooding remains unaffected.

22 I consider that the proposed mitigation is appropriate from a surface flooding perspective and that significant adverse effects on surface flooding will be mitigated with minimal effects on the surrounding area. The hydraulic model used to assess Momentum's proposal includes predicted climate change allowances for rainfall and sea level rise. The RCP8.5 climate change scenario has been used which is consistent with WDC's natural hazards modelling and in my experience, is commonly adopted for undertaking flooding assessments

within New Zealand. In my view the proposal is consistent relevant flood hazard provisions of the CRPS and the PWDP.

23 In summary, I consider that Momentum's proposal to rezone the Site from Rural to Medium Density Residential is appropriate subject to the implementation of Momentum's proposed surface flooding mitigation.

CONTEXT

24 My evidence is in respect of a submission by Momentum on the WDC notified Proposed Plan and a submission by Momentum on Variation 1, which allows for housing intensification in accordance with the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021.

25 Momentum's submissions seek to rezone two blocks of land from Rural Lifestyle to Medium Density Residential. The two blocks comprise of:

a. "South Block": Lot 2 DP 83191, being 6.04 hectares of land at 310 Beach Road.

b. "North Block": Lot 2 DP 4532, Lot 1 DP 5010, and Lot 5 DP 313322, totalling 28.5 hectares of land at 177 Ferry Road

26 The two blocks are identified on Figure 1.

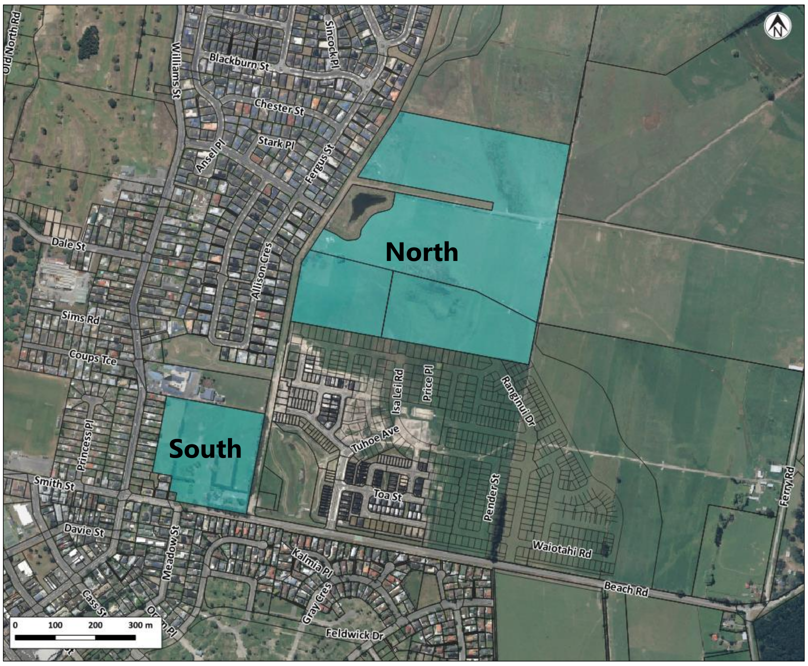

Figure 1: Site Blocks

27 My evidence is in support of the rezone proposed by Momentum's submission and covers aspects relating to surface flooding.

28 In my evidence, I refer to the North and South blocks collectively as the "Site". Where a distinction between the blocks is necessary, I use the naming convention "North" and "South".

THE RECEIVING ENVIRONMENT

General Description

29 The Site is in north-east Kaiapoi, west of Ferry Road, east of Williams Street and north of Beach Road.

30 The North block is currently used for rural grazing. The South block is used for rural grazing land but also contains a dwelling and garages/outbuildings.

31 The North block is bordered by rural grazing land to the north and east, the Beach Grove subdivision to the south and residential development to the west. The South block is bordered by residential areas to the west and south, the Beach Grove subdivision to the east and Kaiapoi North School to the north.

32 Ground levels within the Site are generally flat, with levels between approximately 0.5 and 1.8 m RL. On average, ground level within the Site is approximately 1.0 m RL.

Hydrological Features

33 There are several hydrological features within the area, including:

a. Stormwater pipe systems: Collect urban surface water runoff from neighbouring residential areas.

b. Stormwater treatment ponds: The Beach Grove pond located south-west of the Beach Grove subdivision and the "Moorcroft Pond" located to the west of the North block.

c. Local Drains: Receive runoff from rural land within and surrounding the North block, the "Moorcroft Pond" outlet and existing urban stormwater pipe system outlets to the north and west of the South block.

d. Beach Road swale: Receives runoff from Beach Grove and local drains along the south and east boundary of the South block. The swale originates near the Beach Road/paper road intersection and flows east along the north side of Beach Road before discharging into Feldwick Drain via a culvert under Beach Road. Water which exceeds the capacity of the culvert will bypass and flow into McIntosh Drain to the east. WDC have recently installed a flap gate on the swale adjacent to Beach Grove to prevent water backflowing up the swale.

e. McIntosh Drain: Originates to the north of the North block and flows south towards the Kaiapoi River. At Beach Road, the drain flows through a culvert before discharging into the Kaiapoi River to the south. A control gate and pump are installed in the drain near the Kaiapoi River.

f. Feldwick Drain: Originates near Feldwick Drive and Laurel Lane and receives flow from the stormwater system to the south of Beach Road and flows south into the Kaiapoi River. A control gate and pump are installed in the drain near the Kaiapoi River.

34 Runoff from within the North block flows overland and along small ditches towards the east before entering McIntosh Drain located on the eastern side of the block. Runoff from within the South block flows overland and into the two local drains located along the south and east boundary of the block. These drains flow through a culvert under the paper road and into the Beach Road swale.

35 WDC operate a control gate and pump in the McIntosh and Feldwick Drains, located near the Kaiapoi River. When the water level in the river is high, the gates close, preventing water from discharging into the river. This can result in water ponding within areas north of the river and Beach Road. When the water level in the river lowers, the gates open and water flows into the river. The pump lowers the ponding by pumping water from the drains into the river when the gates are closed.

36 There are several stopbanks within the area including on the north bank of the Kaiapoi River and both banks of Kairaki Creek. The stopbanks prevent water from flowing into the area north of the Kaiapoi River when the water levels within the river and creek are high.

37 WDC have recently undertaken works to reduce the flooding north of the Kaiapoi River. This program of works included upgrading the McIntosh Drain culvert under Beach Road and installing a new pump station in Feldwick Drain.

38 The location of the existing hydrological features described above are shown in Figure 2.

Figure 2: Existing hydrological features

39 Imagery taken during a flood event in 2014, shown in Figure 3, demonstrates some of the hydrological features described above. The image shows water ponding north of the Kaiapoi River and Beach Road due to the closure of the control gates.

Figure 3: Aerial imagery taken during 2014 event

THE PROPOSAL

40 Momentum proposes the following flood mitigation for the Site:

a. Filling the Site to elevate ground levels above the existing flood level and constructing new buildings at or above a minimum finished floor level.

b. Constructing a stormwater system to collect and convey runoff generated from within the Site to the receiving drainage system.

41 Minimum finished floor levels for new buildings within the Site are anticipated to be above the 200-year event, incorporating an allowance for predicted climate change plus 500 mm freeboard. The final level of Site ground levels will be determined during subdivision consenting based on the most up to date flooding information available at that time. This is consistent with other development in the area including the adjacent Beach Grove subdivision.

42 Runoff from the North block is proposed to be managed by a piped and/or swale stormwater system. This system will flow into new stormwater treatment pond/s located to the east of the block. The ponds will discharge into McIntosh Drain.

43 Runoff from the South block is proposed to be managed by a piped and/or swale stormwater system. This system will flow into a new swale around the perimeter of the block. The swale will discharge into the existing Beach Road swale near the intersection of Beach Road and the paper road.

44 Momentum's proposed flood mitigation is similar to that used for the adjacent Beach Grove subdivision.

45 I refer to Outline Development Plan (ODP) for location of features described above.

ASSESSMENT OF PROPOSED FLOOD MITIGATION

Existing Information

46 My assessment of Momentum's proposed flood mitigation is based on the interpretation of hydraulic models. Hydraulic modelling uses computer models to simulate flooding behaviour under various climate and topographic scenarios.

47 There are four existing hydraulic models which are relevant to the Site:

a. 5-year and 50-year Woodend and Kaiapoi model simulating local rainfall, river, and backwater derived surface flooding;

b. 200-year Localised model simulating local rainfall and river flooding;

c. 200-year Ashley River breakout model simulating a failure of the Ashley River stopbank; and

d. 200-year Coastal Inundation model simulating the effect of coastal storms and tides.

48 The models allow for predicted climate change, specifically the Representative Concentration Pathway 8.5 (**RCP8.5**), 100-year projection scenario. Rainfall and sea-level inputs are adjusted according to the climate change predictions. Sea-level inputs allow for 1.0 m of mean sea-level rise. RCP8.5 is a potential future climate trajectory scenario of greenhouse gas emissions. It is described by MfE 2018[1] as *"essentially 'business as usual' with very high greenhouse gas concentrations by 2100 and beyond*". The use of RCP8.5 is consistent with WDC's natural hazards modelling[2] and in my experience, is commonly adopted for undertaking flooding assessments within New Zealand.

49 The accuracy of hydraulic models varies depending on several factors, including the complexity of the model, the quality of the input data, and the assumptions made. These factors can affect the accuracy of the model outputs. I consider that the hydraulic models are suitable for the purpose of assessing the relative potential impacts on surface flooding.

Hydraulic Model Updates

50 I have updated the hydraulic models to better represent the existing and proposed features within the Site and surrounding areas. I have modelled two scenarios, including:

a. A pre-development scenario with existing land use and topography.

b. A post-development scenario incorporating Momentum's proposed development and flood mitigation.

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[1] Ministry for the Environment 2018. 'Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition. Wellington: Ministry for the Environment'.

[2] Waimakriri District Council Natural Hazards Interactive Viewer: https://waimakariri.maps.arcgis.com/apps/instant/portfolio/index.html?appid=c6bc05f87d4f47ecae975e5241657913

51 The updates made to the hydraulic models are summarised in Table 1.

Table 1: Hydraulic model updates

Model	**Pre-development**	**Post-development**
5-year 50-year	Elevating ground levels, updating land use, and adding stormwater pipes within all consented stages of the Beach Grove subdivision. Realignment of McIntosh Drain and updated McIntosh Drain culvert at Beach Road. Added WDC's shovel ready Beach Road pump station diversion from the Beach Road swale and Feldwick drain.	Elevating ground levels within the Site to generally between 2.4 to 2.9 m RL. Updated land use within the Site from rural to residential. A new swale around the perimeter of the South block. A new culvert near the paper road/Beach Road intersection to discharge the new swale into the Beach Road swale. Updates to other existing stormwater pipes.
200-year	Elevating ground levels within all consented future stages of the Beach Grove subdivision. Added the existing twin box culvert on Tuhoe Ave at Beach Grove.	Elevating ground levels within the Site to 2.5 m RL.

Hydraulic Model Results

<u>5-year event:</u>

52 5-year event pre-development and post-development water depths for the critical duration[3] event (3 hours) are shown in Figure 4. Water depths of less than 50 mm have been omitted to aid visual clarity.

[3] The duration of rainfall resulting in the highest water levels.

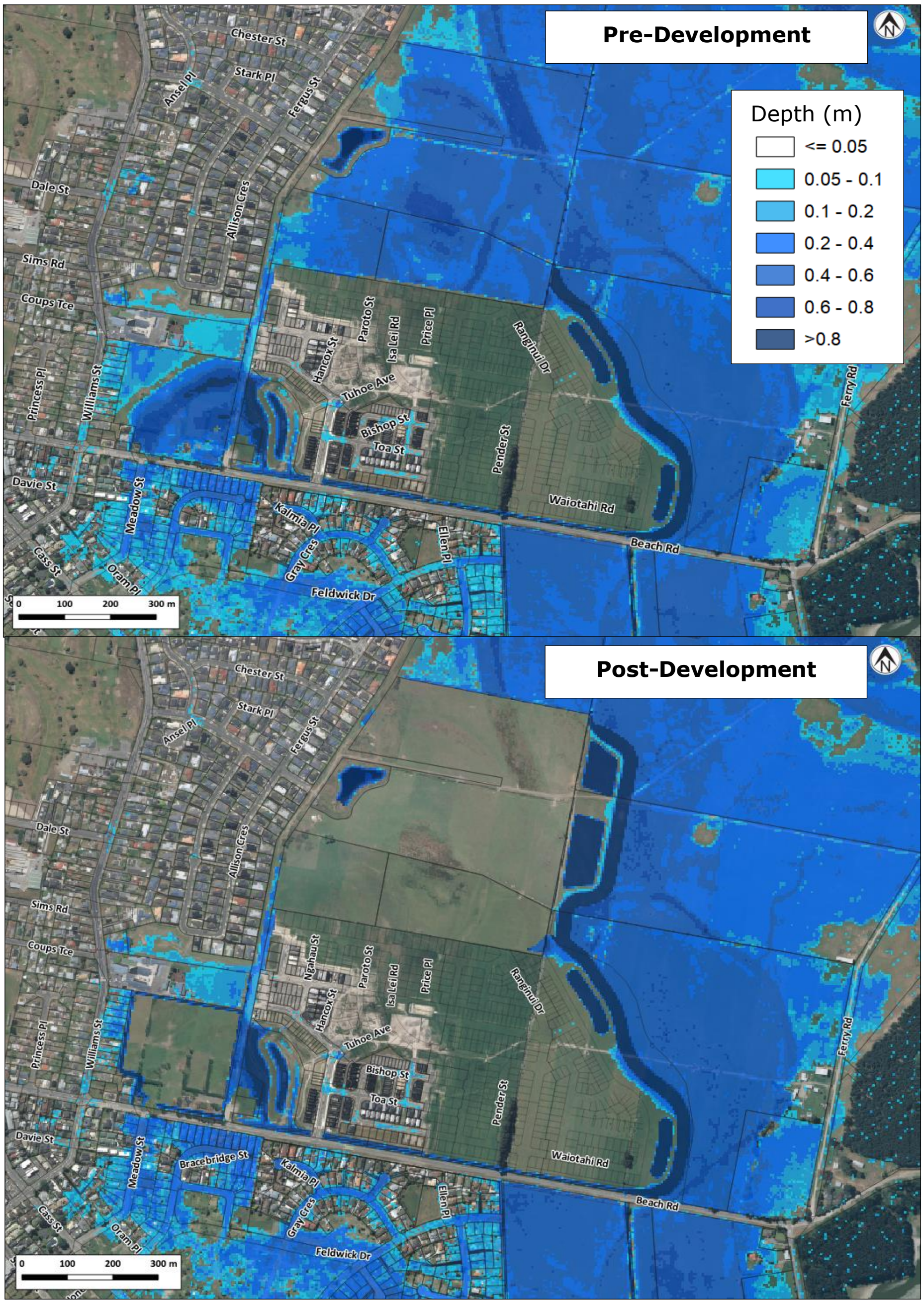

Figure 4: Pre-development and post-development water depth: 5-year event

53 Figure 5 shows a water depth difference between post-development and pre-development for the 5-year event. Negative difference (blue - green) shows a decrease in water depth, positive difference (yellow - orange) shows an increase in water depth.

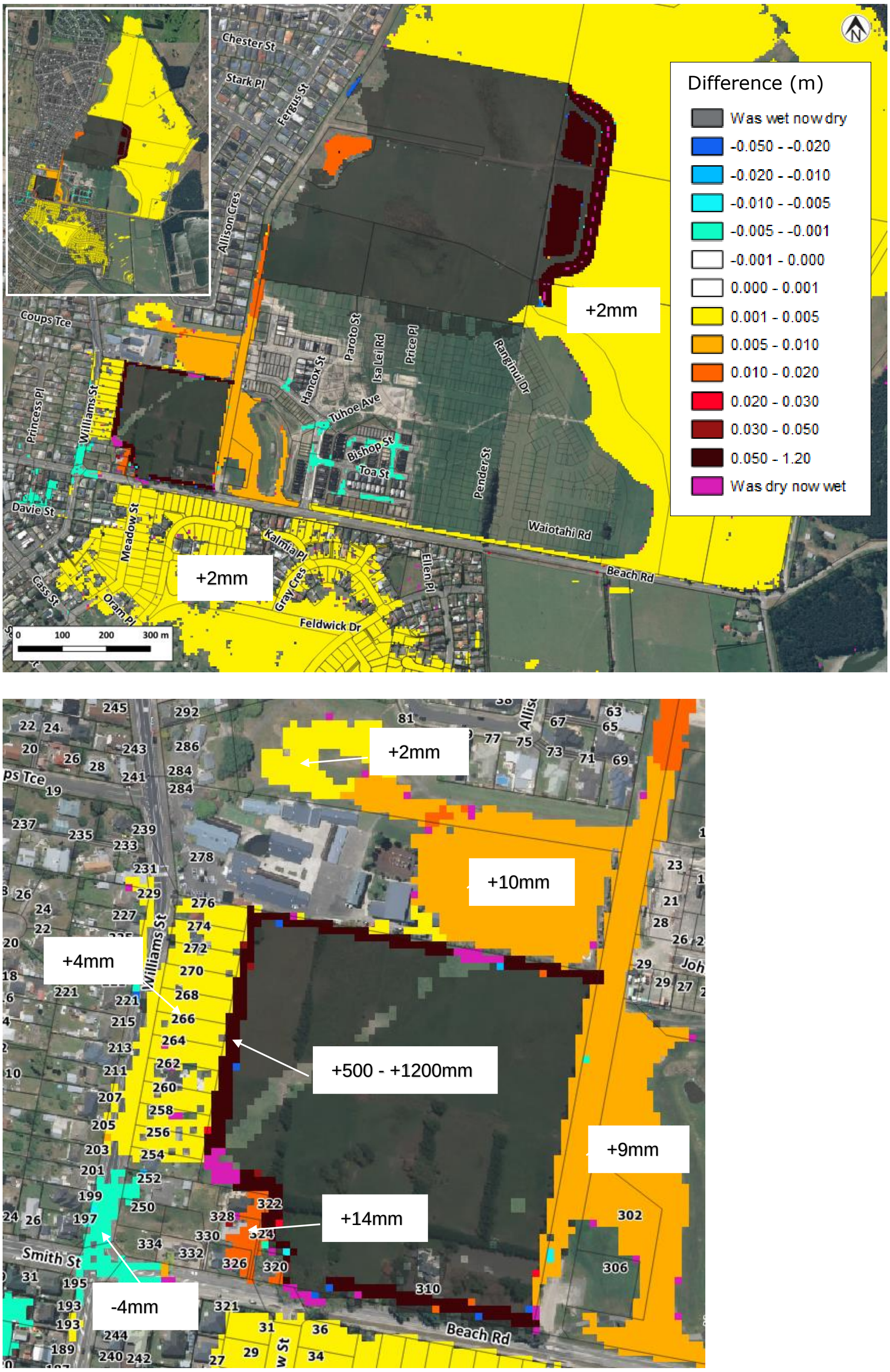

Figure 5: Difference of 5-year event (Post minus Pre-development)

54 The 5-year event difference map shows:

a. Water depth increases by up to +4 mm on Williams Street, north of Beach Road.

b. Water depth increases by up to +14 mm at 322, 324 and 326 Beach Road.

c. Water depth increases by up to +10 mm at Kaiapoi North School and Moorcroft Reserve. The increase is mostly contained within the school sports grounds.

d. Water depth increases by up to +4 mm at other properties along Williams Street.

e. Water depth increases by +500 - +1200 mm within the proposed swale around the perimeter of the South block. This is caused by the difference in the pre-development and post-development Site ground levels. The water level is very similar between pre-development and post-development scenarios.

f. Water depth increases by up to +2 mm south of Beach Road.

<u>50-year event:</u>

55 50-year event pre-development and post-development water depths for the critical duration events (3 and 6 hours) are presented in Figures 6 and 7.

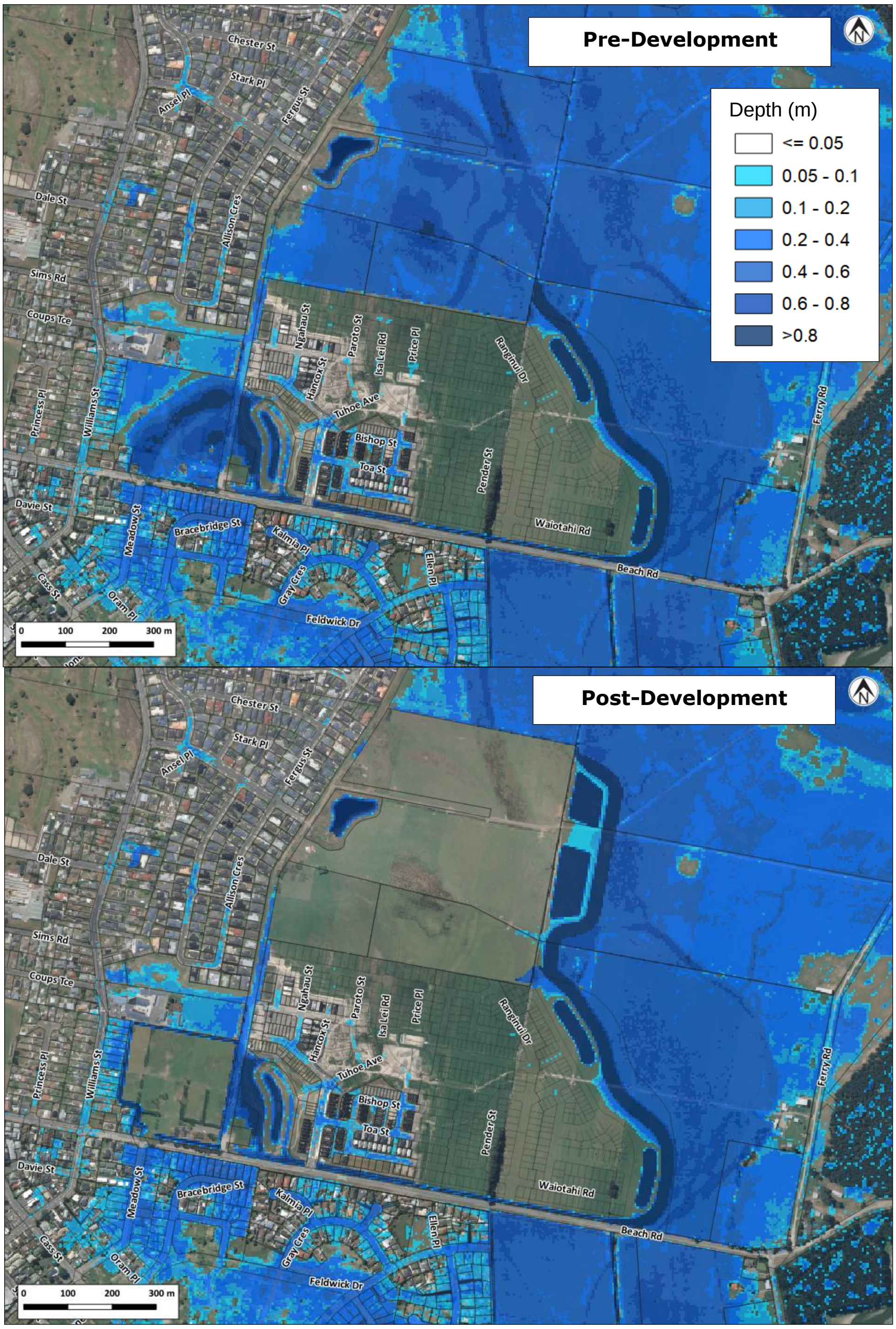

Figure 6: Pre-development and post-development water depth: 50-year event 3-hour storm duration

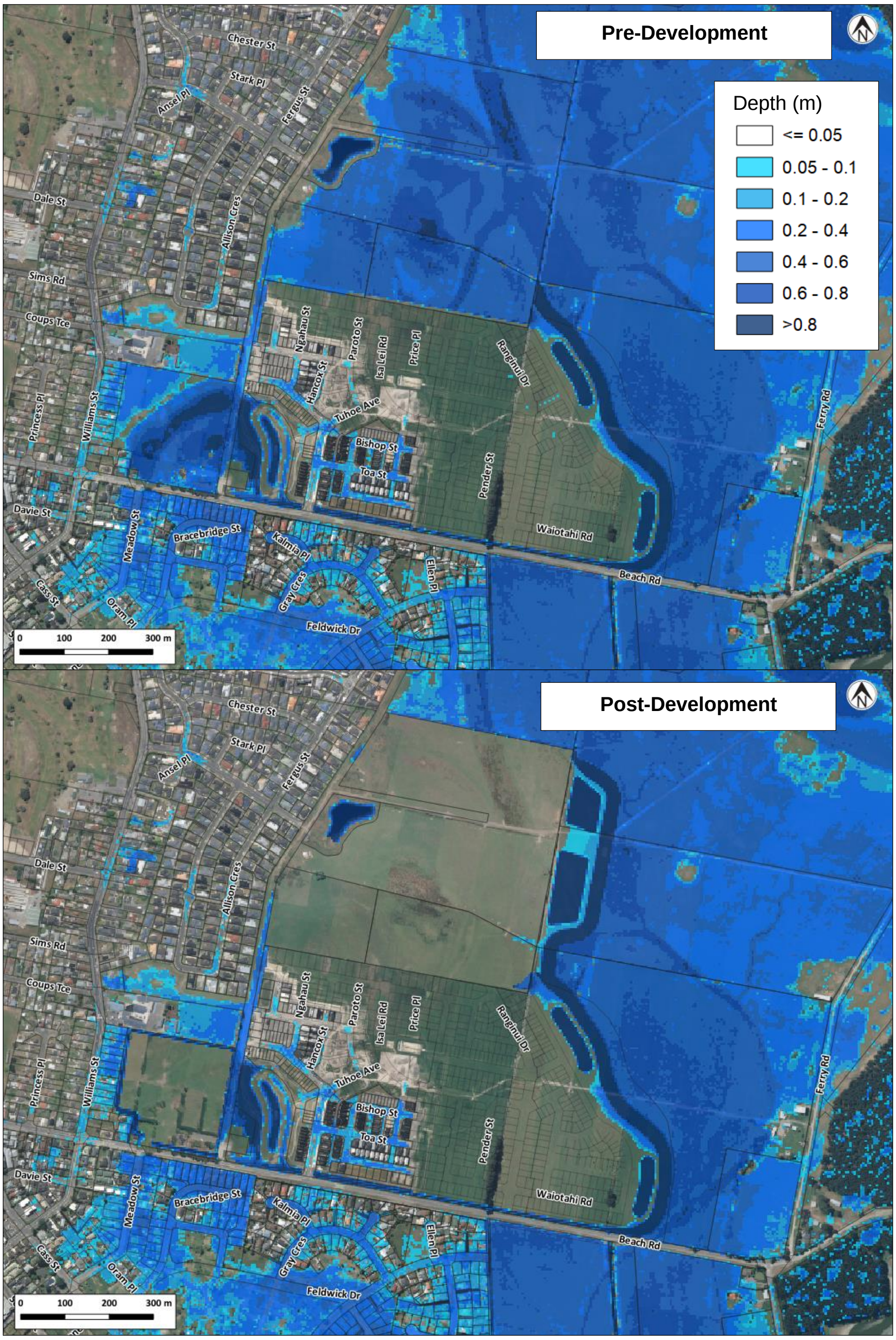

Figure 7: Pre-development and post-development water depth: 50-year event 6-hour storm duration

56 Figures 8 and 9 show the water depth difference between post-development and pre-development for the 50-year event (3-hour and 6-hour durations).

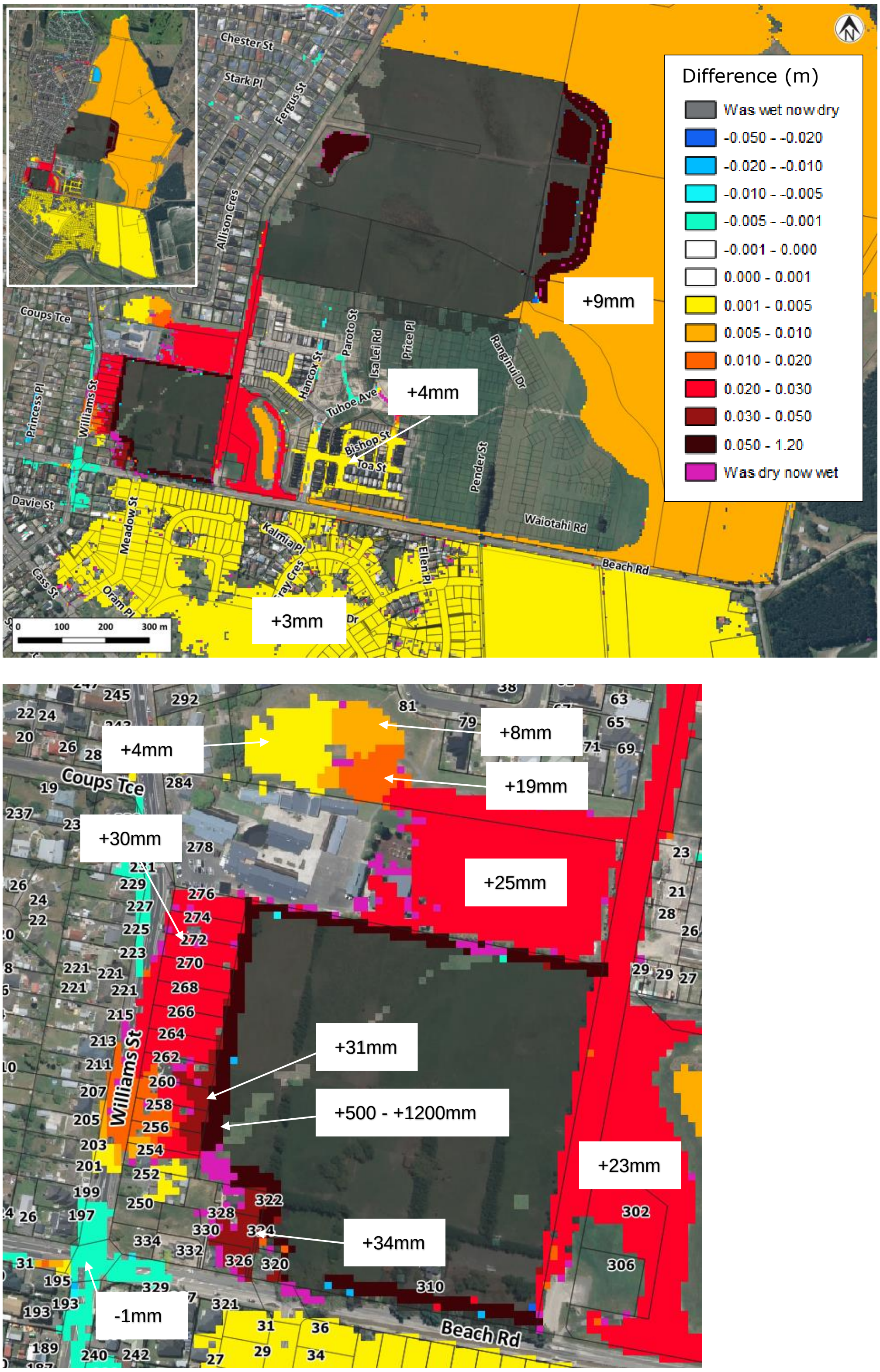

Figure 8: Difference of 50-year event 3-hour storm duration (Post minus Pre-development)

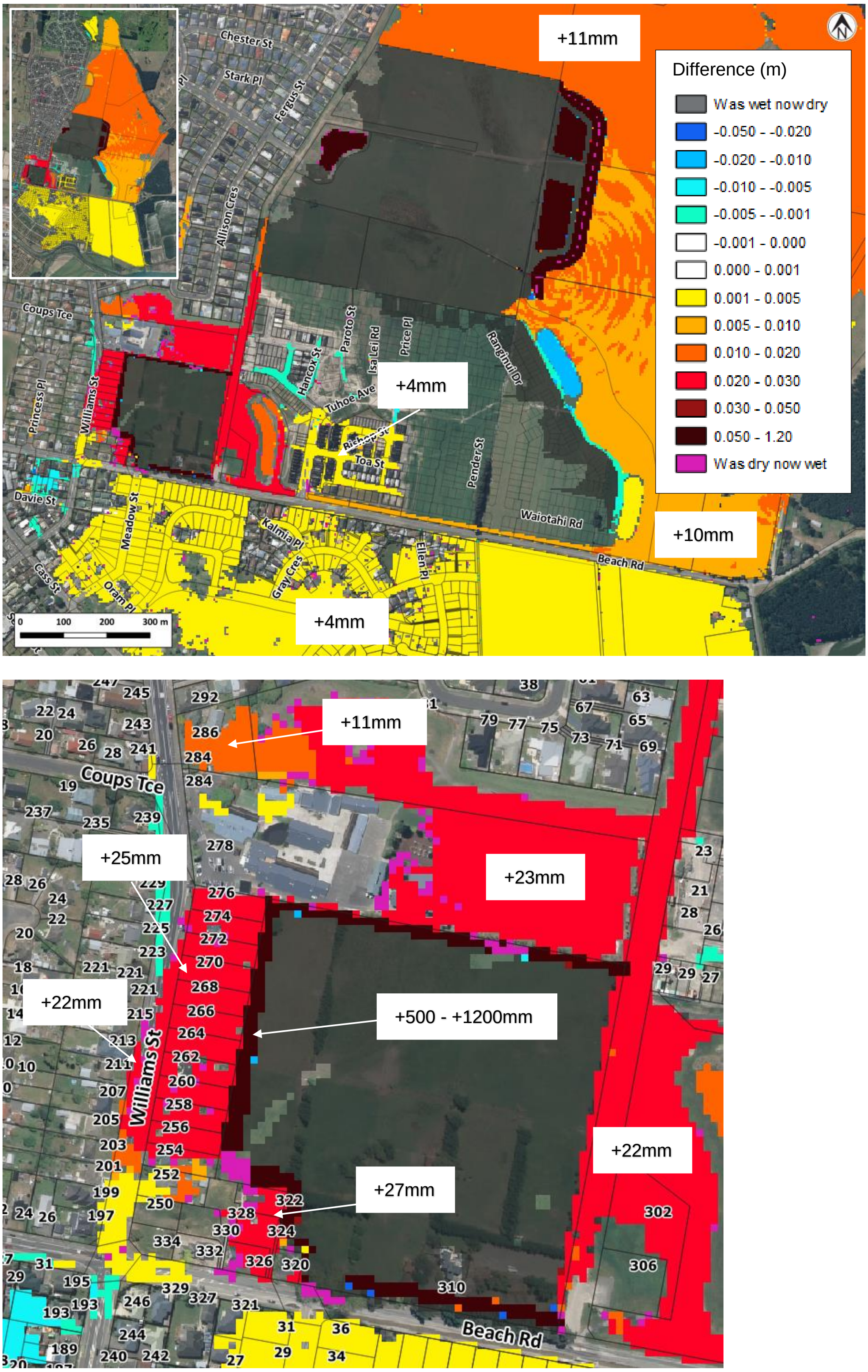

Figure 9: Difference of 50-year event 6-hour storm duration (Post minus Pre)

57 The 50-year event difference map shows:

a. Water depth increases by up to +22 mm on Williams Street, north of Beach Road.

b. Water depth increases by up to +34 mm at 322, 324 and 326 Beach Road.

c. Water depth increases by up to +25 mm at Kaiapoi North School and Moorcroft Reserve. The increase is mostly contained within the school sports grounds.

d. Water depths increase by up to +11 mm at 286 Williams Street.

e. Water depths increase by up to +31 mm at several properties along Williams Street. This increase is mostly contained within property backyards.

f. Water depths increase by up to +30 mm at several other properties along Williams Street.

g. Water depths increase by up to +4 mm along several roads within the Beach Grove subdivision.

h. Water depths increase by +500 - +1200 mm within the proposed swale around the perimeter of the South block. This is caused by the difference in the pre-development and post-development Site ground levels. The water level is very similar between pre-development and post-development scenarios.

i. Water depths increase by up to +4 mm south of Beach Road.

<u>200-year event:</u>

58 200-year event pre-development and post-development water depth maps for the Localised model are presented in Figure 10. My conclusions drawn for the Localised model also apply to the Ashley Breakout model as the water depths are similar.

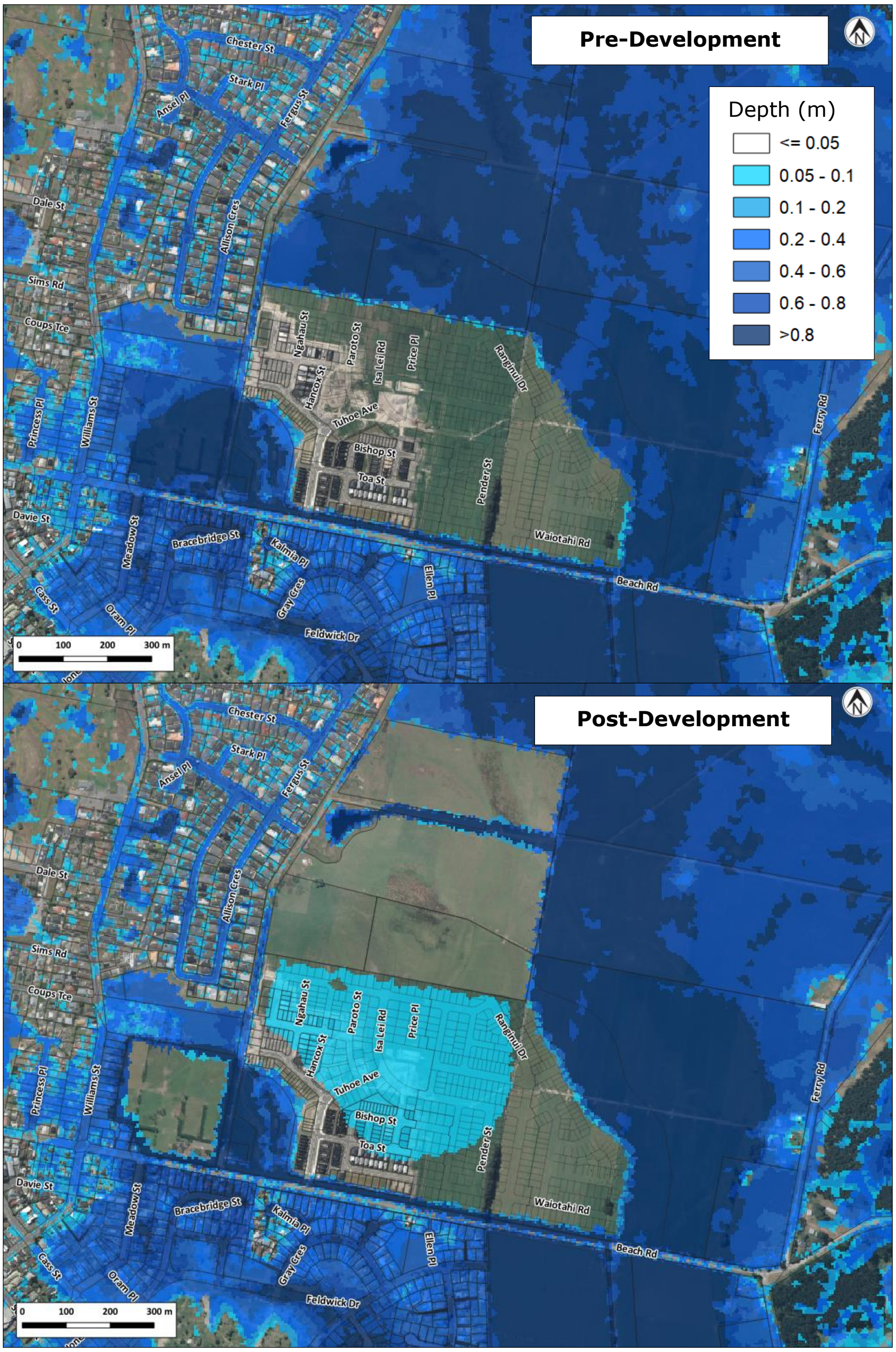

Figure 10: Pre-development and post-development water depth: 200-year Localised event

59 Figure 11 shows the water depth difference between post development and pre-development for the 200-year event.

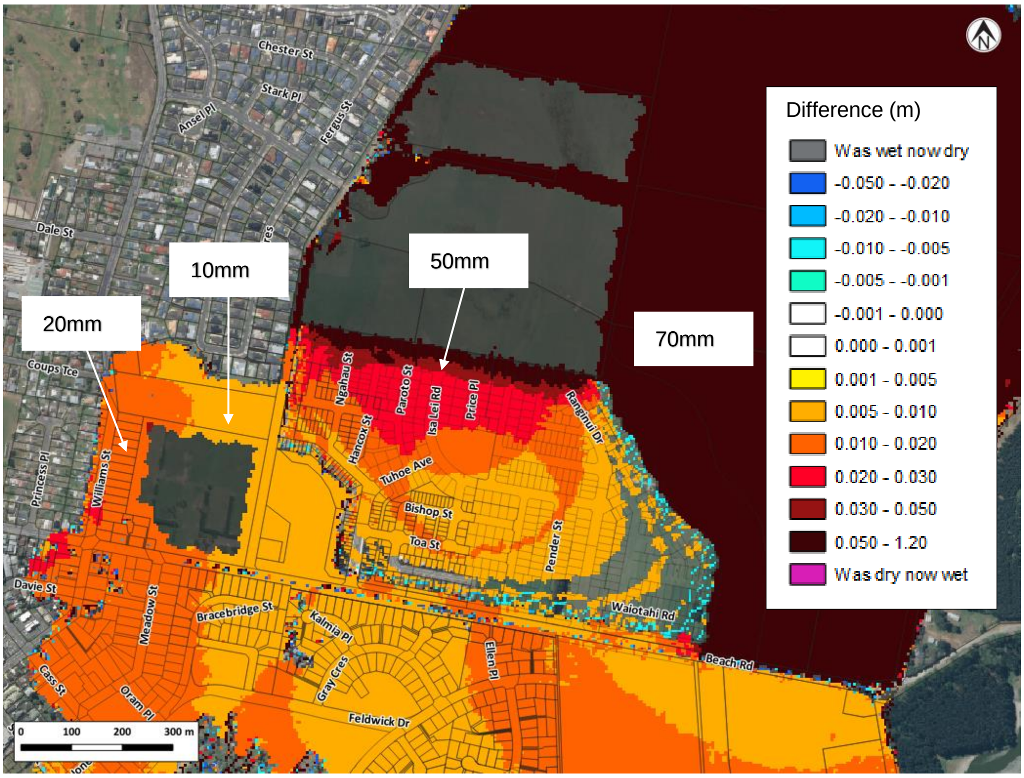

Figure 11: Difference of 200-year Localised event (Post minus Pre)

60 The 200-year difference map shows:

a. Water depth increases by up to +20 mm at properties along Williams Street, Kaiapoi North School and south of Beach Road.

b. Water depth increases by up to +70 mm on rural land to the east and north of the North block.

c. Water depth increases by up to +50 mm within the Beach Grove subdivision. This increase is artificially generated because of the model's relatively coarse ground level inputs. At the boundary of Beach Grove and the North block, a small volume of water gets artificially trapped. This displays as a water depth increase on the Figure 10 difference map. This model anomaly will not affect the overall accuracy of the model.

61 200-year event pre-development and post-development water depth maps for the Coastal Inundation model are presented in Figure 12.

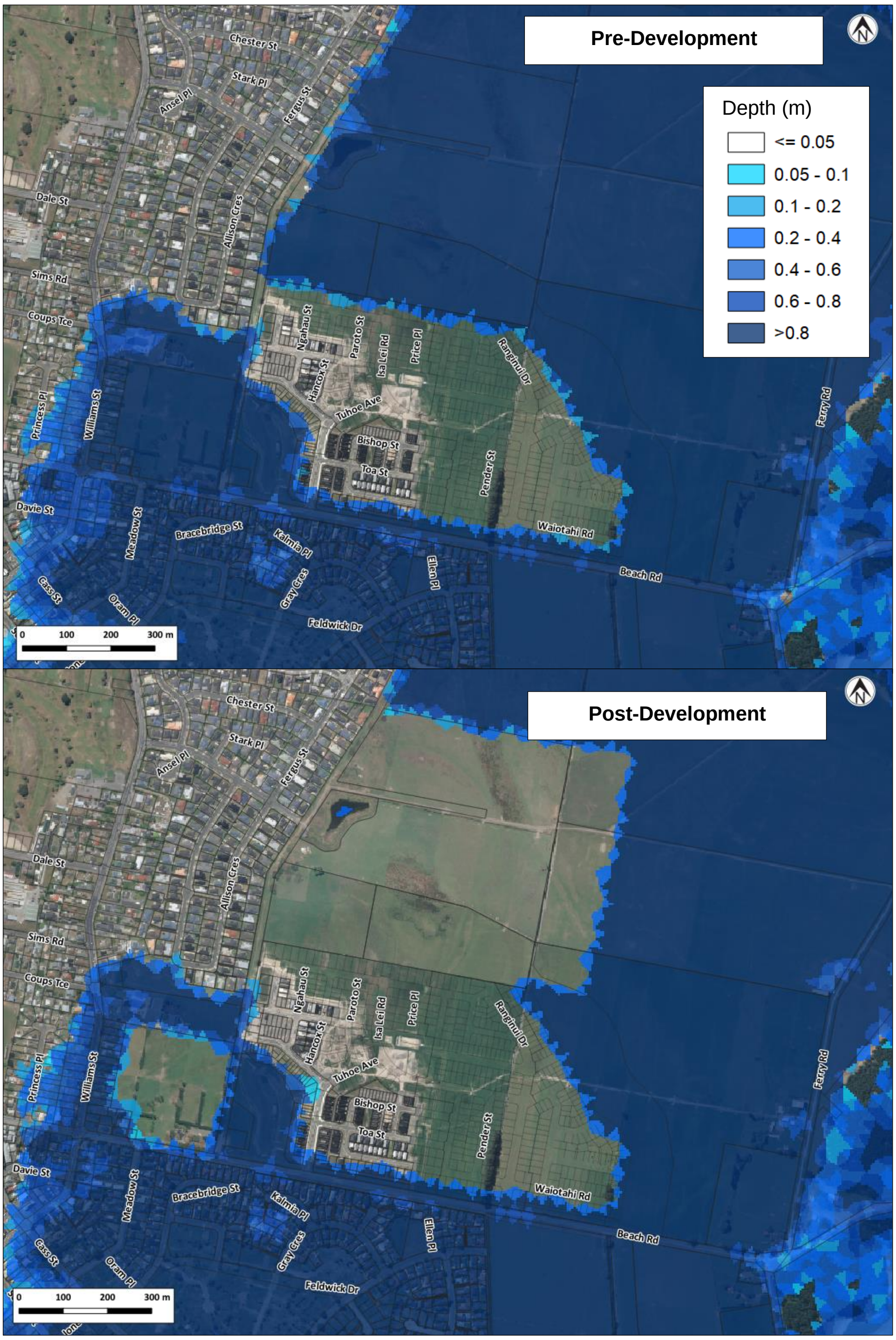

Figure 12: Pre-development and post-development water depth: 200-year Coastal Inundation event

62 Figure 13 shows the water depth difference map between post development and pre-development for the 200-year Coastal event.

Figure 13: Difference map of 200-year Coastal event (Post minus Pre)

63 The 200-year Coastal Inundation differencing map shows that water depths increase by up to +50 mm within the surrounding area.

Summary of hydraulic model results

64 The hydraulic model shows that Momentum's proposal to elevate ground levels above the existing flood level reduces water depths to zero within the Site during the modelled 5-year, 50-year and 200-year events.

65 The hydraulic model shows that elevating ground levels within the Site will displace water and cause a small increase in water depth within the surrounding area. Water depths increase by up to 14 mm in the 5-year event, 34 mm in the 50-year event and 70 mm in the 200-year event. In context, pre-development water depths within the area during a 200-year event are in the order of 1 to 2 metres. I consider a 70 mm increase atop a 1 to 2 metre water depth insignificant and would be indiscernible.

ASSESSMENT OF POTENTIAL EFFECTS ON SURFACE FLOODING

66 I have conducted the following assessments to assess the potential effects of Momentum's proposal on floor levels, freeboard, damage, and hazard.

Floor level assessment

67 This section of my evidence compares modelled water depths to floor levels of existing buildings surrounding the Site.

68 A floor level survey of potentially affected buildings within the area has been completed. The survey focused on buildings that show an increase in water depth of 20 mm or more in a 50-year post-development event. This was on the basis that an increase of less than 20 mm corresponds to a negligible increase in flooding.

69 **Table A1**, **Appendix A** presents the surveyed floor levels and the pre-development and post-development flood levels for the 5-year, 50-year and 200-year events. A summary of the table is provided below:

69.1 5-year and 50-year events:

a. Three buildings at 286 Williams Street are inundated in both the 5-year and 50-year events, and in both pre-development and post-development scenarios. The increase in water depth is 1 mm in the 5-year event and 11 mm in the 50-year event.

b. All other surveyed buildings are not inundated.

69.2 200-year event:

a. **Localised model:** In both the pre-development and post-development scenarios, nine buildings are inundated along Williams Street, Beach Road, and Ferry Road. Eleven buildings within the Kaiapoi North School are also inundated. The increase in water depth for the post-development scenario is 10 to 20 mm.

b. **Ashley Breakout model:** In both the pre-development and post-development scenarios, five buildings are inundated along Williams Street, Beach Road, and Ferry Road. Two buildings within the Kaiapoi North School are also flooded. The increase in water depth for the post-development scenario is 10 to 20 mm.

c. **Coastal Inundation model:** In both the pre-development and post-development scenarios, all surveyed buildings are inundated. The increase in water depth for the post development scenario is 50 mm.

70 The hydraulic model shows that Momentum's proposal does not cause any additional buildings to be inundated. All existing buildings that are inundated in pre-development are also inundated in post-development.

Freeboard assessment

71 This section of my evidence compares modelled water depths at buildings surrounding the Site to the floor level freeboard requirements as per the New Zealand Building Code (**NZBC**).

72 The NZBC, contained in Schedule 1 of the Building Regulations 1992, sets the minimum performance standards buildings must meet regarding protection from flood inundation. NZBC Verification Method E1/VM1 establishes compliance with the NZBC and states for housing and communal non-residential (e.g. schools) buildings:

'Surface water, resulting from an event having a 2% probability[4] *of occurring annually, shall not enter buildings',* and: *'The level of the floor shall be set at the height of the secondary flow plus an allowance for freeboard. The freeboard shall be: 500 mm where surface water has a depth of 100 mm or more and extends from the building directly to a road or car park, other than a car park for a single dwelling. 150 mm for all other cases',* and: *'The 500 mm freeboard allows for waves generated by vehicles. Such waves will not be sustained unless there is at least 100 mm depth of water and an unobstructed path from the point where the wave is generated to the building'*

73 Most of the existing buildings along Williams Street were constructed (circa 1970s), at which time E1/VM1 had not been published. There are difficulties applying standards developed in 1992 to existing houses constructed before 1992. In these circumstances, E1/VM1 provides only a useful reference point or guide.

74 E1/VM1 is supported by Riedel (1986), which concludes that a wave can be sustained so long as there is at least 100 mm depth of water for the wave to

[4] The 2% probability event is equivalent to the 50-year event.

travel through. A reduction in the depth of water below 100 mm will force the wave to break, reducing the overall wave height and run-up.

75 In wave theory, the maximum plausible non-breaking wave height that can be generated in a certain depth of water can be estimated as:

Maximum wave height (H) = 0.8 (γ) x the water depth derived by Riedel (1986).

76 **Table A2**, **Appendix A** provides an assessment of freeboard for each surveyed building against E1/VM1. For each building, the 50-year event water depth was extracted from the model along the road adjacent to each building. The required E1/VM1 freeboard was then determined based on whether the water depth on the road was greater or less than 100 mm.

77 A summary of the table is provided below.

a. 286 Williams Street does not comply with E1/VM1 for both the pre-development and post-development scenarios. Although the flood level for the three buildings increases by 11 mm in the post-development scenario, there is no change to the E1/VM1 condition, which remains unachieved. A vehicle generated wave is not plausible for this property as flooding on Willaims street is minimal.

b. 260 and 258 Williams Street do not comply with E1/VM1 for both the pre-development and post-development scenarios. Whilst the flood level for these buildings increases by 14 to 26 mm, there is no change to the E1/VM1 condition, which remains unachieved. The water depth on Williams Street is around 110 to 120 mm, and therefore generation of a wave is plausible. Based on wave theory, the wave height is estimated to be 80 to 100 mm. Based on this wave height, these buildings would have sufficient freeboard to prevent flooding above floor level.

c. 322 and 324 Beach Road do not comply with E1/VM1 for both the pre-development and post-development scenarios. Whilst the flood level for these buildings increases by 34 mm, there is no change to the E1/VM1 condition, which remains unachieved. A vehicle generated wave is not plausible for these properties as they do not have road frontage.

d. 117 Ferry Road does not comply with E1/VM1 for both the pre-development and post-development scenarios. However, there is no increase in water depths at this property because of the development. i.e. the development has no effect on the available freeboard.

e. All other properties comply with E1/VM1 in both pre-development and post-development scenarios.

78 Overall, the hydraulic model shows that in a 50-year event, Momentum's proposal causes a small reduction in floor level freeboard to several existing buildings. However, most of these buildings, including the Kaiapoi North School still retain sufficient freeboard as per the New Zealand Building Code to protect them from inundation. For buildings that do not have sufficient freeboard as per the New Zealand Building Code, Momentum's proposal has no significant effect.

Damage assessment

79 This section of my evidence assesses the potential increase in damage to buildings from an increase in modelled water depths.

80 The hydraulic model results show that the 286 Williams Street property may experience an increase in water depth above floor level of 11 mm in a 50-year event. There are three separate buildings located within the property.

81 I have estimated the potential increase in damage to the three buildings in a 50-year event using the method from RiskScape. RiskScape is an application used for hazard risk analysis and provides indicative flood damage curves for various building types, showing water depth above the building floor level on the x-axis and damage ratio on the y-axis as shown in Figure 14. The damage ratio is a measure of the percentage loss of a building's value.

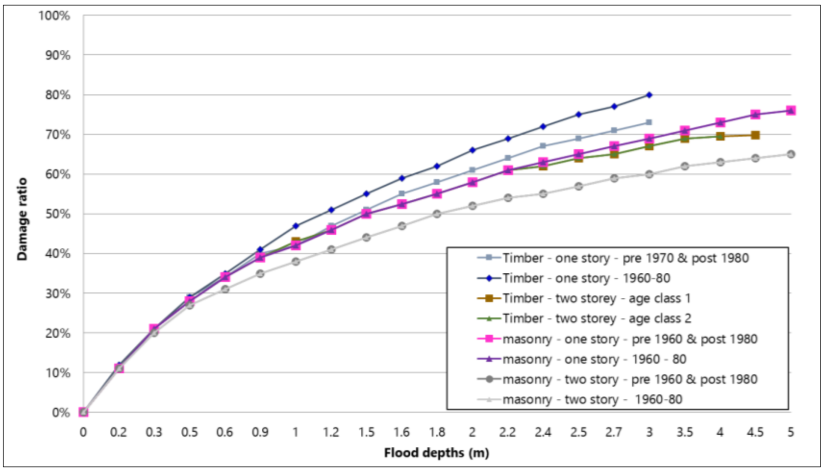

Figure 14: Flood damage curves

82 Based on the RiskScape damage curves, the increase in potential damage caused by the increase in water depth at 286 Williams Street in the 50-year event is 0.4% for one building and 1.1% for two buildings. I consider this increase to be insignificant.

Flood hazard

83 The Site is located within a High Hazard Area as defined in the CRPS[5], it being subject to water depths greater than 1 metre in a 500-year (0.2% AEP) flood event.

84 The PWDP identifies the Site as being within the Non-Urban Flood Assessment Overlay (North Block), the Urban Flood Assessment Overlay (South Block) and the Coastal Flood Assessment Overlay. Rules associated with these overlays require Flood Assessment Certificates and Coastal Flood Assessment Certificates to be sought from WDC[6]. Those Certificates will identify if a site is within a "high flood hazard area"[7] or a "high coastal flood hazard area"[8]. I note that the definition for each of these terms in the PWDP is similar to that of "high hazard area" in the CRPS. If a Certificate does not identify a site as being within a high flood hazard area or high coastal flood hazard area, it will specify the minimum finished floor level calculated as follows:

a. Flood hazard: the highest of:

i. Flooding predicted to occur in a 200-year Localised Rainfall Event plus up to 500 mm freeboard; or

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[5] "High hazard area", Definitions, CRPS.

[6] Non-Coastal Hazards Rules NH-R1, NH-R2; Coastal Hazards Rules NH-R15, NH-R16; Natural Hazard Standards NH-S1 (Flood Assessment Certificate) and NH-S2 (Coastal Flood Assessment Certificate.

[7] *"High flood hazard area means: a. land where there is inundation by floodwater, and where the water depth (metres) x velocity (metres per second) is greater than or equal to 1, or where depths are greater than 1 metre, in a 0.2% Annual Exceedance Probability flood event."*, Definitions, PWDP.

[8] *"means: a. land likely to be subject to coastal erosion, including the cumulative effects of sea level rise, over the next 100 years; and b. land subject to water depth of 1 metre or greater in a 1% AEP (1 in 100-year) storm surge event (excluding tsunami), concurrent with 5% AEP (1 in 20-year) river flow event with a median sea level rise projection over the next 100 years based on an RCP8.5 high emissions scenario."*, Definitions, PWDP

ii. Flooding predicted to occur in a 200-year Ashley River Breakout Event concurrent with a 20-year Localised Rainfall Event plus up to 500 mm freeboard; or

iii. Flooding predicted to occur in a 100-year Storm Surge Event concurrent with a 20-year River Flow Event with sea level rise based on an RCP8.5 climate change scenario, plus up to 500 mm freeboard.

b. Coastal flood hazard:

i. the minimum land level shall equal the flooding level predicted to occur in a 1 in 100-year Storm Surge Event concurrent with a 1 in 20-year River Flow Event with sea level rise of 1m based on an RCP8.5 climate change scenario; or

ii. the minimum land and floor level combination shall equal land filled to be within 300 mm of the required land level under i.; and a floor level that meets the minimum level specified in a.

85 Figures B1 and B2, **Appendix B** show the indicative High Hazard Areas in the pre-development and post-development scenarios for the Site. The maps show the High Hazard Areas based on the 500-year Coastal Inundation event. Because the Costal Inundation water depths are significantly higher than the Localised and Ashley Breakout depths, the Coastal Inundation event has been adopted for this assessment of High Hazard Areas.

86 Figure B1 shows extensive areas of High Hazard within and surrounding the Site in the pre-development scenario. The extensive areas of High Hazard reflect the 1 to 2 metre water depths predicted over much of the area during the Coastal Inundation event.

87 Figure B2 shows that once ground levels are elevated within the Site as per Momentum’s proposal, modelled water depths reduce significantly, and the Site would no longer meet the CRPS definition of High Hazard Areas. Based on this, I consider that Momentum’s proposal appropriately mitigates flood hazards within the Site.

88 Figure B2 shows that beyond the Site, there is minimal change to the modelled High Hazard Areas between pre-development and post-development scenarios. The minimal change to High Hazard areas reflects the

very small increase in water depth during the Coastal Inundation event (approximately 50 mm).

89 There may be sporadic areas which change from no High Hazard to High Hazard because of a 50 mm increase in water depth. This can only occur where the pre-development flood depths are between 0.951 and 1 metre. In my opinion, there would be minimal adverse effects on flood hazard for people, property, and infrastructure if this were to occur, because:

d. The perceived risk to people's safety because of an additional 50 mm atop of 0.951 metre water depth would be indiscernible; and

e. Property and infrastructure subject to a water depth of 0.951 metre would already be significantly inundated in the pre-development scenario. An additional 50 mm atop of 0.951 metre water depth would not significantly increase flood damage or risk to property and infrastructure.

Other potential effects and matters

90 **Resilience**: Momentum's proposal to elevate ground levels above the existing flood level provides a resilient mitigation defence to protect against unacceptable flood risk provided climate change is accounted for. This is because elevating ground levels does not significantly rely on the functioning of drainage infrastructure such as pipes, stopbanks, or pump stations, which can be prone to failure in such events.

Catchment wide flooding impacts: Momentum's proposal will not significantly alter the overall behaviour of flooding within the area. Other than the small increases in water depths summarised in my evidence, the overall behaviour of flooding remains unaffected.

91 **Nuisance flooding on property:** In the 5-year event, the model predicts an increase in water depth of up to 14 mm within existing residential properties for a duration of 2-3 hours. In my opinion, this increase would be indiscernible.

92 **Potential effects on agricultural activities:** Within rural areas to the east of the North block, the model predicts an increase in water depth of up to 2 and 11 mm in the 5-year and 50-year events respectively, for a duration of 2-3 hours. In my opinion, this will not affect existing agricultural activities within the area.

93 **Erosion and scour:** Based on the modelled water velocities, which are very low, erosion and scour is unlikely to occur under either pre-development or post-development conditions.

94 **Coastal flooding:** The water depth in the Coastal Inundation event is significantly higher (in the order of 0.6 m) than the Localised and Ashley Breakout events. Flooding in the Coastal Inundation event is caused by overtopping of the stopbanks along Kairaki Creek. In my opinion, it is reasonable to expect that as sea-level rises with climate change, these stopbanks would be upgraded to protect existing urban areas of east Kaiapoi. If these stopbanks are upgraded to prevent overtopping, the flood level would be significantly reduced. This approach would be consistent with previous upgrades throughout New Zealand. For example, the Canterbury Regional Council recently completed upgrades of the nearby Waimakriri River stopbanks where climate change effects were a key consideration. However, my opinions expressed above regarding the potential adverse effects for people, property, and infrastructure arising from Momentum's proposal are not dependant on upgrading of stopbanks.

STATUTORY ASSESSMENT

Canterbury Regional Policy Statement

CRPS Chapter 11

95 **Objective 11.2.1**: **Avoid new subdivision, use and development of land that increases risks associated with natural hazards:** "*New subdivision, use and development of land which increases the risk of natural hazards to people, property and infrastructure is avoided or, where avoidance is not possible, mitigation measures minimise such risks*."

Momentum proposes to elevate existing ground levels above the floodplain to mitigate significant adverse effects on flood hazard within the Site. When ground levels are elevated, the risk of flooding within the Site is reduced to be below the High Hazard threshold as defined in the CRPS. As a result, significant adverse effects on flood hazard within the Site are avoided.

The hydraulic model shows that there are minimal adverse effects on flood hazard to the area surrounding the Site as a result of Momentum's proposal. Any sporadic increases in water depth will likely have minimal adverse effects because the small increase in water depth, atop areas already subject to deep water depths, would be indiscernible.

Based on my assessment, I consider that the proposed mitigation is appropriate from a surface flooding perspective and that significant adverse effects on flood hazard will be mitigated with minimal effects on the surrounding area.

Policy 11.3.1: Avoidance of inappropriate development in high hazard areas: "T*o avoid new subdivision, use and development (except as provided for in Policy 11.3.4) of land in high hazard areas, unless the subdivision, use or development:"*

(6) "Within greater Christchurch, is proposed to be located in an area zoned in a district plan for urban residential, industrial or commercial use, or identified as a "Greenfield Priority Area" on Map A of Chapter 6, both at the date the Land Use Recovery Plan was notified in the Gazette, in which the effect of the natural hazard must be avoided or appropriately mitigated."

"the policy acknowledges that, while potentially still adversely affected by natural hazard events, there may be some development that is appropriate in high hazard areas."

As described above, I consider Momentum's proposal appropriately mitigates the effects of flood hazards.

Provided suitable climate change allowance is incorporated into Momentum's proposed mitigation (which it will be through application of the PWDP natural hazard rules described in Paragraph 84), I consider that residential development is appropriate for the Site.

96 **Objective 11.2.2: Adverse effects from hazard mitigation are avoided or mitigated:** "*Adverse effects on people, property, infrastructure and the environment resulting from methods used to manage natural hazards are avoided or, where avoidance is not possible, mitigated*."

The hydraulic model shows that there are minimal adverse flooding effects to the area surrounding the Site because of Momentum's proposal. In large flooding events, this is because the small increase in water depth, atop an area already subject to deep flooding, would be indiscernible to people and any increase in damage to property, infrastructure and the environment would be insignificant.

In smaller events (such as the 5 and 50-year events), the hydraulic model shows no significant adverse effects on surrounding floor levels, freeboard and damage are likely to occur because of Momentum's proposal. Further detail is provided in Paragraphs 66 to 82.

97 **Objective 11.2.3 Climate change and natural hazards (and supporting Policy 11.3.8):** "*The effects of climate change, and its influence on sea levels and the frequency and severity of natural hazards, are recognised and provided for.*"

The hydraulic model used to assess Momentum's proposal includes predicted climate change allowances for rainfall and sea level rise. The RCP8.5 climate change scenario has been used which is consistent with WDC's natural hazards modelling and in my experience, is commonly adopted for undertaking flooding assessments within New Zealand. Further detail regarding this is provided in Paragraph 48.

98 **CRPS Chapter 6**

Objective 6.2.1 Recovery Framework: *"Recovery, rebuilding and development are enabled within Greater Christchurch through a land use and infrastructure framework that:*

(8) protects people from unacceptable risk from natural hazards and the effects of sea-level rise."

As described in Paragraph 95, Momentum's proposal to elevate existing ground levels reduces the water depths within the Site to below the High Hazard Area threshold and protects people from unacceptable flood risk, without impacting exacerbating flooding and inundation risk for surrounding properties. The hydraulic model used to assess Momentum's proposal includes climate change allowances as described in Paragraph 48 of my evidence.

Policy 6.3.3 Development in accordance with outline development plans: *"Development in greenfield priority areas or Future Development Areas and rural residential development is to occur in accordance with the provisions set out in an outline development plan or other rules for the area. Subdivision* *must not proceed ahead of the incorporation of an outline development plan in a district plan. Outline development plans and associated rules will:"*

(11) "Show how the adverse effects associated with natural hazards are to be avoided, remedied or mitigated as appropriate and in accordance with Chapter 11 and any relevant guidelines"

Adverse effects on flood hazards are appropriately mitigated as described in Paragraphs 95-97 (assessment against Chapter 11).

99 **Policy 6.3.11 Monitoring and Review:** (5. e) "*urban development does not lie between the primary and secondary stopbanks south of the Waimakariri River which are designed to retain floodwaters in the event of flood breakout*"

The Site does not lie between the primary and secondary stopbanks south of the Waimakariri River.

100 **Policy 6.3.12 Future Development Areas:** "*Enable urban development in the Future Development Areas identified on Map A, in the following circumstances:*

(6) The effects of natural hazards are avoided or appropriately mitigated in accordance with the objectives and policies set out in Chapter 11"

The effects of flood hazards are appropriately mitigated as described in Paragraphs 95-97 (assessment against Chapter 11).

Proposed Waimakariri District Plan

101 **SD-O7 Natural Hazards and resilience:** "*The District responds to natural hazard risk, including increased risk as a result of climate change, through: (1) avoiding subdivision, use and development when risk is unacceptable; and (2) mitigating other natural hazard risks*."

Momentum's proposal to elevate existing ground levels above the floodplain (accounting for predicted climate change) appropriately mitigates flood hazards within the Site. Once ground levels are elevated, the risk of flood hazard is low.

102 **Policy UFD-P1 Density of residential development:** "*In relation to the density of residential development*:"

(2. c) "avoids or mitigates natural hazard risk in any high hazard area within existing urban areas."

The hydraulic model shows once ground levels are elevated within the Site as per Momentum's proposal, modelled water depths reduce to zero in the 200-year event, which is not considered 'high flood hazard area' or 'high coastal flood hazard area' as defined by the PWDP. Based on this, I consider that Momentum's proposal appropriately mitigates high hazards.

103 **Objective NH-01 Risk from Natural Hazards:** "*New subdivision, land use and development:*"

(1) Manages natural hazard risk, including coastal hazards, in the existing urban environment to ensure that any increased risk to people and property is low.

The hydraulic model shows once ground levels are elevated within the Site as per Momentum's proposal, the flood risk to people and property is low and acceptable in the context of the PWDP's policy framework.

MATTERS RAISED BY SUBMITTERS

104 I note a small number of submitters[9] raised concerns about significant risk to the area from localised flooding events. The hydraulic modelling shows the risk of flooding to the Site can be mitigated by elevating ground levels as per Momentum's proposal and that the flooding effects on the surrounding area are insignificant.

CONCLUSION

105 My evidence addresses surface flooding and proposed flood mitigation associated with submissions by Momentum Land Limited on the PDP and Variation 1 that seek to rezone Rural Lifestyle land to Medium Density Residential at Kaiapoi. My conclusions are provided in the Summary of Evidence section.

106 Thank you for the opportunity to present my evidence.

Richard Brunton
Date:

5 March 2024

[9] Matters raised by submitters Jay Holly [75.1], Dawn Revell [80.1], Allan Charles [81.1], Faye Andrea Rose [94.1]

APPENDICES

Appendix A Tables

Table A1: Surveyed floor levels and modelled flood levels

Table A2: Floor level freeboard assessment

Appendix B Flood hazard maps

Appendix A Tables

Table A1: Surveyed building floor levels and modelled flood levels

'-' = Zero modelled water level i.e. no flooding at building
XXXX = Modelled flood level above surveyed floor level
Flood levels taken at building location
50-year event flood levels are highest of the 3-hour or 6-hour duration events.
Levels in terms of Lyttelton Vertical Datum 1937

Property		Floor Level[1]	5-year		50-year		200-year Localised		200-year Ashley Breakout		200-year Coastal Inundation	
			Pre-dev	Post-dev	Pre-dev	Post-dev	Pre-dev	Post-dev	Pre-dev	Post-dev	Pre-dev	Post-dev
278	Williams Street (Kaiapoi North School)	2.35	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.86	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.81	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.82	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.83	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.81	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.80	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.79	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.78	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.79	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
		1.70	1.433	1.443	1.477	1.500	1.86	1.88	1.74	1.76	2.44	2.49
		1.69	1.433	1.443	1.477	1.500	1.86	1.88	1.74	1.76	2.44	2.49
		1.98	1.426	1.436	1.477	1.500	1.86	1.88	1.74	1.76	2.44	2.49
286	Williams Street	1.21	1.457	1.458	1.508 (1.491)[2]	1.509 (1.502)[2]	1.86	1.88	1.74	1.76	2.44	2.49
276		1.97	1.433	1.437	1.477	1.502	1.86	1.88	1.74	1.76	2.44	2.49
274		2.04	1.433	1.437	1.477	1.502	1.86	1.88	1.74	1.76	2.44	2.49
272		1.99	1.434	1.438	1.477	1.502	1.86	1.88	1.74	1.76	2.44	2.49
270[3]		1.82	1.433	1.437	1.477	1.502	1.86	1.88	1.74	1.76	2.44	2.49
268		1.94	1.434	1.438	1.477	1.503	1.86	1.88	1.74	1.76	2.44	2.49
266		1.89	1.434	1.438	1.477	1.503	1.86	1.88	1.74	1.76	2.44	2.49
264		1.97	1.434	1.438	1.478	1.503	1.86	1.88	1.74	1.76	2.44	2.49
262		1.96	1.434	1.438	1.478	1.503	1.86	1.88	1.74	1.76	2.44	2.49
260		1.94	1.442	1.446	1.478	1.503	1.86	1.88	1.74	1.76	2.44	2.49
258		1.98	1.459	1.463	1.482	1.504	1.86	1.88	1.74	1.76	2.44	2.49
256		2.03	1.462	1.466	1.483	1.504	1.86	1.88	1.74	1.76	2.44	2.49
254		2.08	1.465	1.469	1.482	1.504	1.86	1.88	1.74	1.76	2.44	2.49
252		1.97	-	-	1.498	1.508	1.86	1.88	1.74	1.76	2.44	2.49
250		1.82	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
322	Beach Road	1.57	1.423	1.437	1.476	1.503	1.86	1.88	1.74	1.76	2.44	2.49
324		1.54	1.423	1.437	1.476	1.503	1.86	1.88	1.74	1.76	2.44	2.49
326		1.72	1.423	1.437	1.476	1.503	1.86	1.88	1.74	1.76	2.44	2.49
328[4]		2.09	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
330		1.92	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
332		1.86	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
334		1.81	-	-	-	-	1.86	1.88	1.74	1.76	2.44	2.49
117	Ferry Road	1.54	-	-	-	-	1.84	1.85	1.74	1.75	2.44	2.49
95		1.95	1.421	1.423	1.481	1.492	1.84	1.85	1.74	1.75	2.44	2.49
81		2.05	-	-	-	-	1.84	1.85	1.74	1.75	2.44	2.49
63		1.96	-	-	1.450	1.456	1.84	1.85	1.74	1.75	2.44	2.49
83[4]		1.95	-	-	-	-	1.84	1.85	1.74	1.75	2.44	2.49
306	Beach Road (Preschool)	2.40	-	-	-	-	1.86	1.88	1.74	1.75	2.44	2.49

1. Surveyed floor levels provided by Woods.
2. 3-hour duration flood level
3. Unable to obtain FFL survey – Floor level approximated from surveyed cladding level on house exterior.
4. Unable to obtain FFL survey – floor level approximated from eave level.

Table A2: Floor level freeboard assessment

'-' = Zero water depth i.e. no flooding on road
XXXX = Vehicle wave could be generated on road (modelled water depth >100 mm on road)
XXXX = Actual freeboard less than NZBC E1/VM1 freeboard requirement
XXXX = Modelled 50-year event flood level above surveyed building floor level
Actual freeboard calculated from highest water level from 3-hour or 6-hour duration events.

Property		50-year modelled water depth on road[1] (m)	Required Freeboard NZBC E1/VM1[2] (mm)	Actual freeboard in 50-year event[3] (mm)		Maximum wave height at building[4] (mm)	Comment
				Pre-dev	Post-dev		
278	Williams Street (Kaiapoi North School)	-	150	680	680	-	E1/VM1 achieved
		-	150	160	160	-	
		-	150	150	150	-	
		-	150	160	160	-	
		-	150	210	210	-	
		-	150	230	230	-	
		-	150	170	170	-	
		-	150	160	160	-	
		-	150	150	150	-	
		-	150	217	217	-	
		-	150	223	200	-	
		-	150	213	190	-	
		-	150	503	480	-	
286 (a)	Williams Street	-	150	-298	-299	-	E1/VM1 not achieved. Floor level flooded in pre and post-development scenarios. No wave plausible.
286 (garage)		-	150	-338	-339	-	
286 (c)		-	150	-268	-269	-	
276		-	150	493	468	-	E1/VM1 achieved
274		-	150	563	538	-	E1/VM1 achieved
272		-	150	513	488	-	E1/VM1 achieved
270		0.06	150	343	318	-	E1/VM1 achieved
268		0.06	150	463	437	-	E1/VM1 achieved
266		0.08	150	413	387	-	E1/VM1 achieved
264		0.07	150	492	467	-	E1/VM1 achieved
262		0.09	150	482	457	-	E1/VM1 achieved
260		0.12	500	462	437	0.10	E1/VM1 not achieved in both pre and post-dev. Wave height limited to 0.1 m
258		0.11	500	498	476	0.08	E1/VM1 not achieved in both pre and post-dev. Wave height limited to 0.08 m
256		0.13	500	547	526	0.10	E1/VM1 achieved
254		0.13	500	598	576	0.10	E1/VM1 achieved
252		0.11	150 (>100 mm depth does not extend to building)	473	462	0.08	E1/VM1 achieved
250		0.18	150 (>100 mm depth does not extend to building)	190	190	0.14	E1/VM1 achieved
322	Beach Road	-	150	94	67	-	E1/VM1 not achieved in both pre and post-dev. No wave plausible
324		-	150	64	37	-	E1/VM1 not achieved in both pre and post-dev. No wave plausible
326		-	150	244	217	-	E1/VM1 achieved
328		-	150	150	150	-	E1/VM1 achieved
330		-	150	300	300	-	E1/VM1 achieved
332		0.07	150	180	180	-	E1/VM1 not achieved.

							No increase in flooding at this property between pre and post-dev scenarios.
334		0.12	150 (>100 mm depth does not extend to building)	330	330	0.09	E1/VM1 achieved
117		-	150	70	70	-	E1/VM1 not achieved. No increase in flooding at this property between pre and post-dev scenarios.
95	Ferry Road	-	150	469	458	-	E1/VM1 achieved
81		-	150	534	534	-	NZBC E1/VM1 freeboard achieved
63		-	150	510	504	-	E1/VM1 achieved
83		-	150	356	356	-	E1/VM1 achieved
306	Beach Road (Preschool)	-	500	200	200	-	E1/VM1 achieved

1. Maximum 50-year event post-development water depth on road. Maximum depth along property frontage within road carriageway.
2. 500 mm if surface water has a depth of 100 mm or more and extends from the building directly to a road or car park, other than a car park for a single building. 150 mm for all other cases. As per NZBC E1/VM1.
3. Freeboard calculated from surveyed floor level minus the 50-year event post-development flood level. Where property is not flooded, freeboard calculated from ground level at building. Note ground levels vary around building perimeter.
4. Maximum wave height at house = 0.8 x the water depth.

Appendix B Flood hazard maps