IN THE MATTER:	of the Resource Management Act 1991 (**RMA**)
AND	
IN THE MATTER:	Proposed Plan Change 2: Pukehangi Heights to the Rotorua District Plan under Part 5, Sub-Part 5 – Streamlined Planning Process and Schedule 1 Part 5 of the RMA

STATEMENT OF EVIDENCE OF PHILIP WALLACE ON BEHALF OF BAY OF PLENTY REGIONAL COUNCIL – HYDRAULIC MODELLING AND FLOOD IMPACTS

18 September 2020

Qualifications and Experience

1. My full name is Philip Lawrence Wallace. I am a director of River Edge Consulting Ltd. I have held this role since 2008.

2. Between 2014 and early 2020 I also was employed as a Principal Engineer by DHI Water and Environment Ltd ("DHI").

3. I hold a Bachelor of Engineering (Hons) in Civil Engineering from the University of Auckland and a Master of Science (Hons) in Resource Management from the University of Canterbury.

4. I have over 30 years of experience in the fields of river engineering, river modelling and floodplain management. I have particular familiarity with the Utuhina Stream and catchment, having prepared an Asset Management Plan for the Kaituna Catchment Control Scheme (which covers the Utuhina Stream) in 2003 and having developed and refined hydraulic models of the Utuhina Stream and floodplain since 2006.

5. I am a member of the following professional organisations:

   (a) New Zealand Hydrological Society

   (b) International Association for Hydro-Environment Engineering and Research ("IAHR")

   (c) New Zealand Water and Wastes Association ("Water New Zealand")

   (d) Rivers Group (a technical group of Engineering New Zealand and Water New Zealand). (I am a current committee member and Treasurer)

6. I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2014 and I agree to comply with it. I confirm that the issues addressed in this statement of evidence are within my area of expertise, except where I state I am relying on the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from my expressed opinion.

Scope of Evidence

7. My evidence covers the following:

   (a) Background to the hydraulic model built for BOPRC;

   (b) Performance of current flood protection assets in lower Utuhina;

   (c) Overview of the hydraulic modelling approach undertaken to assess the effects of the Proposed Plan Change; and

   (d) Results of the assessment of Plan Change effects

Hydraulic Model Background

8. DHI was engaged by the Bay of Plenty Regional Council (**Regional Council**) in 2018 to update and extend an existing hydraulic model of the Utuhina Stream and floodplain. The objectives of the project were to assess the flood hazard posed by the Utuhina Stream and its tributaries and to have a model that could be used to help assess flood mitigation options. (Hereinafter, the hydraulic model is referred to as the Model.)

9. The model software used is MIKE FLOOD, developed by DHI and used extensively within New Zealand and world-wide for flood hazard studies. This software simulates both channel flow and overland flow, dynamically linking them during a simulation.

10. The Model extent is as shown in Figure 1.

11. The Model incorporates the three main stream channels (Utuhina, Otamatea and Mangakakahi) as well as short lengths of tributary channels and culverts. Other than those culverts, the model does not explicitly include the city stormwater pipe network.

12. Inflows to the Model were derived from the Non-Linear Reservoir (NLR) hydrological model of the Utuhina catchment that Mr. West of Blue Duck Design Ltd. describes in his evidence. Approximately 75 inflow hydrographs, each representing the flow contribution from a subcatchment, were derived from the NLR model and applied as point or distributed inflows to the hydraulic model.

13. Together, the hydraulic model (Model) and the NLR hydrological model are referred to as the Greater Utuhina Catchment Model (GUCM).

14. The downstream end of the Model is at Lake Rotorua and lake levels form the downstream boundary conditions for the model.

15. The Model has been calibrated against data from five flood events that occurred between 2011 and 2018. Calibration of the Model has been an iterative process run in conjunction with the hydrological model calibration.

16. Several design flood scenarios have then been run through the Model. Each design scenario consists of a specified design storm (ranging from 10% AEP to 0.2% AEP), a specified lake level and a climate change assumption. Results derived from these model simulations include predicted flood extents and depths, in the form of flood maps, longitudinal profiles and hydrographs at defined locations. Other outputs include flood velocity, duration above a threshold depth and channel flows.

Current Level of Flood Protection

17. The Regional Council maintains flood protection assets (stopbanks and floodwalls) in the lower Utuhina catchment, as part of the Kaituna Catchment Control Scheme. The Regional Council's Rivers and Drainage Asset Management Plan 2018-2068 specifies protection against a 1% AEP (annual exceedance probability) flood event, downstream of Old Taupo Road. Figure 2, a flood map derived from Model results, shows that this standard is not being met. Floodwaters are predicted to spill out of the stream channels or overtop flood defences and flow onto the floodplain into residential and industrial areas. There are a number of practical difficulties and obstacles to achieving the design standard and any additional runoff from the Pukehangi Plan Change area could not be readily accommodated. If there was such additional runoff, it would lead to earlier and additional spillage to the floodplain, exacerbating the flood risk to those residential and industrial areas.

Assessment of Proposed Plan Change

Modelling approach undertaken to assess effects

18. The Model can be used to test the downstream impact of the proposed Plan Change developments on flood extent, flood depth, duration of flooding and flood velocity. While there is some inherent uncertainty in model inputs, which is then reflected in model predictions and for which "freeboard" is usually added to those predictions,

models have particular value in assessing the relative impacts of proposals or options. Where model set-ups only differ in the changes due a particular proposal, and all other parameters are kept the same, there is greater confidence in the relative impact of those changes.

19. Runoff from the Plan Change site and contributing catchments, for both the existing situation in the Plan Change area ("Pre-development") and for the "post-development" land use has been supplied by WSP to Mr. West. He in turn has incorporated that information into the NLR model. Outputs from that model have then been supplied to be used as inputs into the Model. Mr. West has modified the NLR hydrological model to allow a direct comparison of the existing situation and the Proposed Plan Change.

20. The Model has been run for a range of flood scenarios and for both the existing situation in the Plan Change area ("Pre-development") and for the "post-development" land use.

21. The flood scenarios involve a range of design storms as well as climate change assumptions (current climate and 2130 climate under RCP 8.5). Two variations of downstream urban development (and hence of urban runoff) were also considered: existing land use ("CityNow") and the maximum development allowed under the District Plan ("FutureCity").

22. The design flood scenarios modelled were:

    (a) 10% AEP storm, current climate, "CityNow"

    (b) 2% AEP storm, current climate, "CityNow"

    (c) 1% AEP storm, current climate, "CityNow"

    (d) 1% AEP storm, 2130 climate (RCP 8.5), "CityNow"

    (e) 0.2% AEP storm, 2130 climate (RCP 8.5), "CityNow"

    (f) 1% AEP storm, 2130 climate (RCP 8.5), "FutureCity".

23. Iterations of the "post-development" situation, involving refinements of mitigation measures and giving site outflows as supplied by WSP, have been tested over recent months. The most recently tested is the "Scenario 15" referred to in the WSP "*Stormwater Report"* dated 14 September 2020. My evidence presents results from Scenario 15.

24. In its stormwater report, WSP also refers to “Scenario 16” that it has considered. I understand that Scenario 16 differs from Scenario 15 in the size and invert levels of the outlet pipes from the detention ponds. Discharge information from Scenario 16 has not yet been supplied by WSP and Scenario 16 has not been run through the GUCM to assess the downstream impacts.

Modelling results

25. The relative changes in peak flood level in the stream channels, resulting from the Proposed Plan Change, are shown in Figures 3-5 for all the flood scenarios modelled. Other than a small localised increase immediately upstream of the Otamatea Stream in some flood scenarios (a peculiarity of the timing of the peaks from each of the three main stream catchments) no increases are predicted.

26. Likewise, the effect of the proposal is generally to cause slightly lower peak flood depths on the floodplain, as shown in Figure 6 (reproduced in Appendix B of the WSP *Stormwater Report*). Results are similar for other flood scenarios modelled and are also shown in Figure 40 of the evidence of Ms Kathleen Thiel-Lardon and in Appendix B of the WSP report. (I note that Figure B-5 of the WSP report should refer to the “current climate”.)

27. Peak velocities in the stream channels and on the floodplain under Scenario 15 are also predicted to be slightly lowered in general, as shown in Figures 7-10 and in Appendix B of the WSP report. Any increases are insignificant.

28. The use of detention ponds in Scenario 15 to avoid increased water levels and velocities downstream results in an increase in flood duration downstream. Figure 11 shows a map of the predicted changes to duration above a 50 mm threshold depth (Figure B-12 in the WSP report), while Figures 13-15 illustrate the differences in water for selected locations on the floodplain (Figure 12) and in the stream channels. Note that as the stormwater network is not explicitly incorporated into the GUCM hydraulic model, actual durations on the floodplain for both the pre-development and post-development cases would likely be reduced from the model predictions, but the predicted differences between the two are considered to be a reasonable estimate.

29. The duration impacts in the lower floodplain area appear to be relatively small. Further upstream, adjacent to the Otamatea and Mangakakahi Streams, a longer duration is predicted. Further analysis with the RLC stormwater models for Catchments 14 and 15 (Section 3.2.2.1 of the WSP report) would be required to

determine if stormwater levels in the pipe network remained elevated and if that would cause any additional flood losses.

Conclusions

30. A calibrated model (the "GUCM") has been developed on behalf of BOPRC, which is a suitable tool to assess the downstream hydraulic impacts of the Proposed Plan Change.

31. The Model predicts that the design standard for flood protection (1% AEP) is not met in the lower Utuhina Stream catchment.

32. There are difficulties in achieving the design standard of flood protection lower Utuhina catchment. There is no room to accommodate additional runoff and increased peak discharges that could result from the Proposed Plan Change.

33. The Model indicates that, with mitigation options as assumed in Scenario 15 presented by WSP, there is a general decrease in peak runoff and in peak flood levels and velocities downstream of the Proposed Plan Change area. Results for all design flood events simulated, ranging from 10% AEP to 0.2% AEP, show similar spatial patterns for the reduced levels and velocities. There is some increase in duration in some locations, which may require further analysis to confirm that there are no adverse effects from that.

34. Results presented are specific to Scenario 15 provided. Scenario 16 has not been tested with the GUCM and if that or any future variation to the mitigation option is to be progressed, the downstream effects would need to be assessed with the aid of the GUCM.

DATE 18 September 2020

Philip Wallace

ATTACHMENT

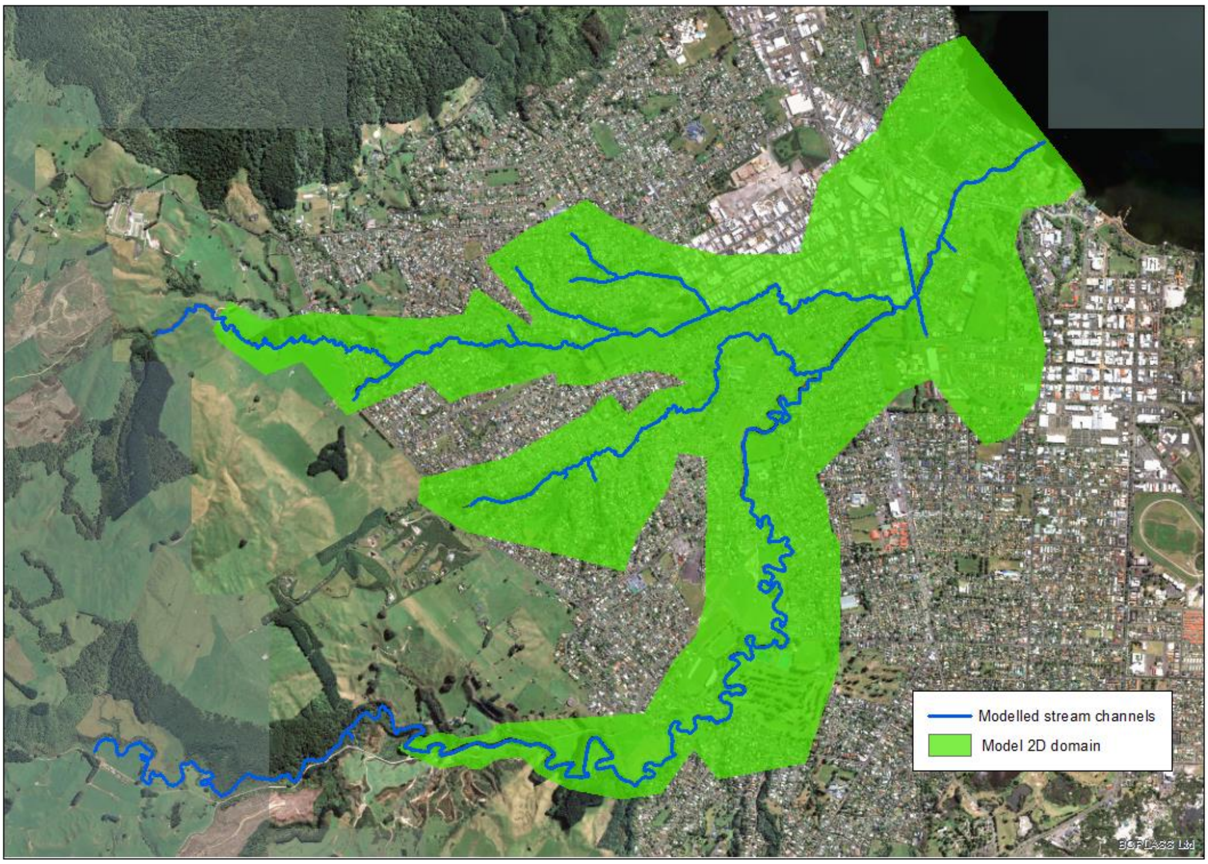

Figure 1 Utuhina hydraulic model extent

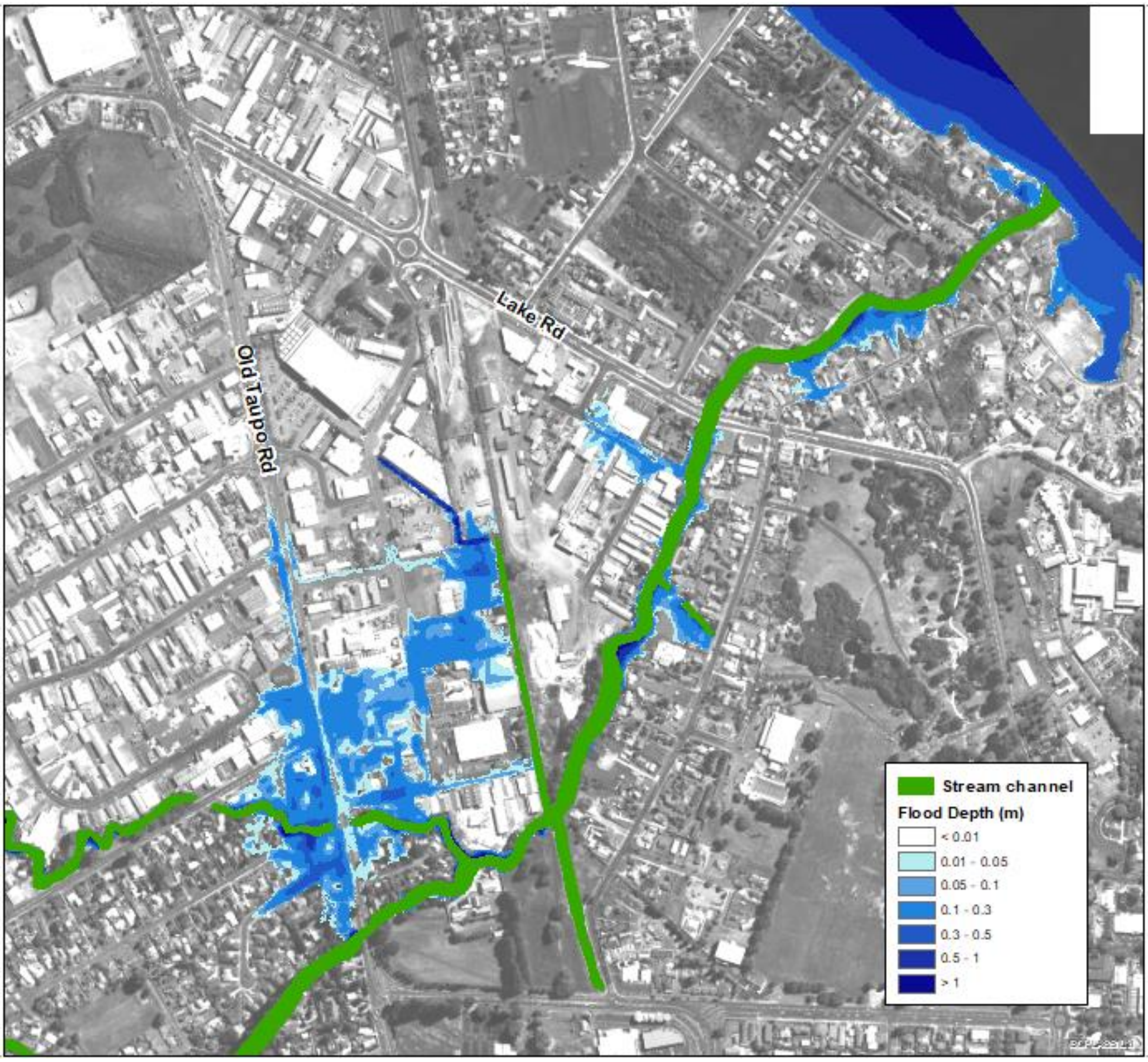

Figure 2 Predicted flood extent and depths, 1% AEP, current climate

FLOOD LEVEL IMPACTS, STREAM CHANNELS
Effect on peak flood levels of Proposed Plan Change under Scenario 15

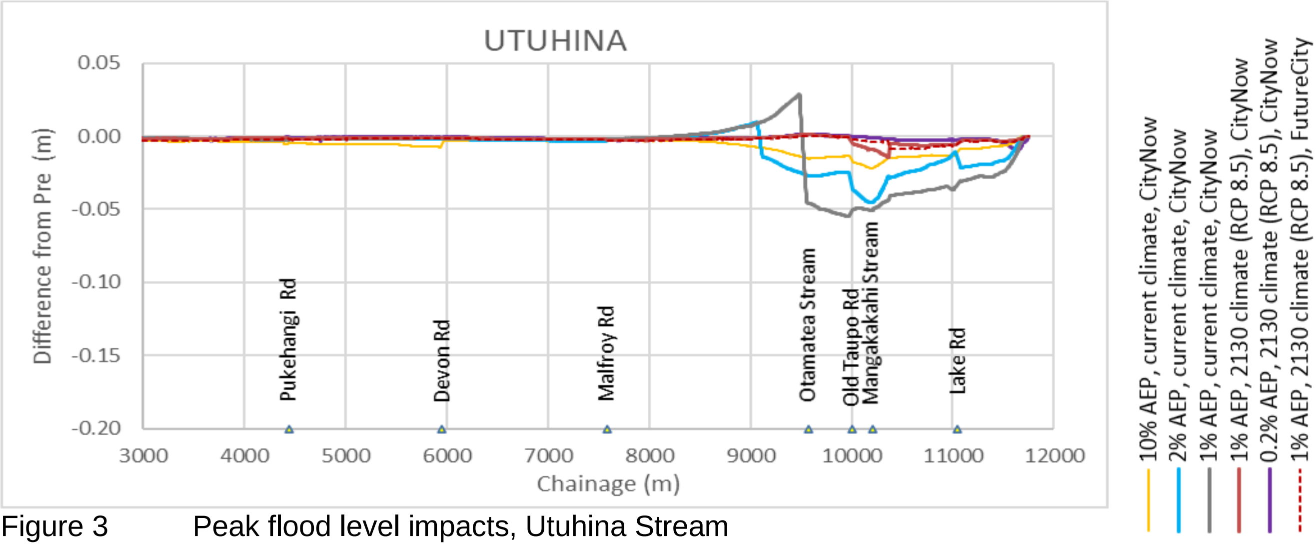

Figure 3 Peak flood level impacts, Utuhina Stream

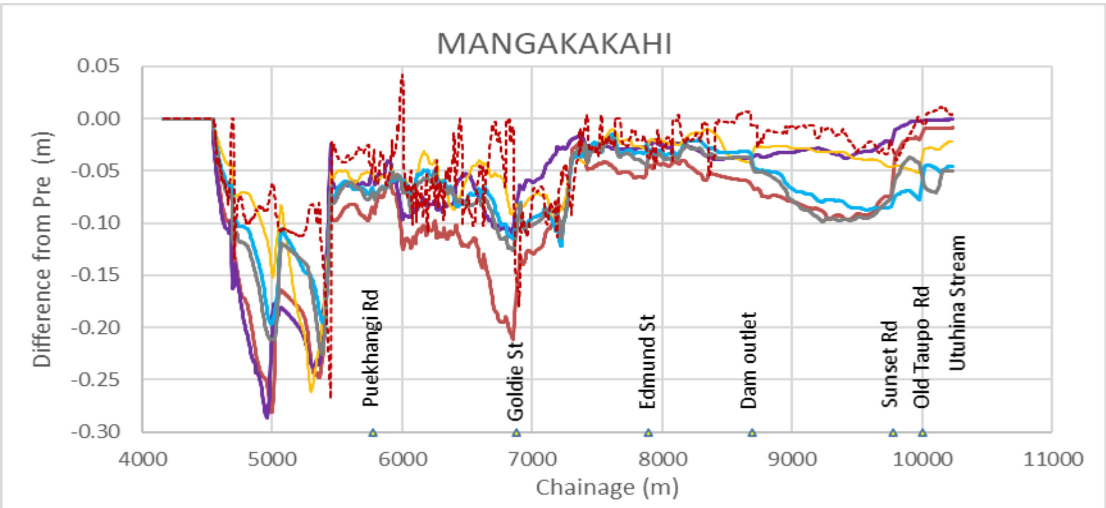

Figure 4 Peak flood level impacts, Mangakakahi Stream

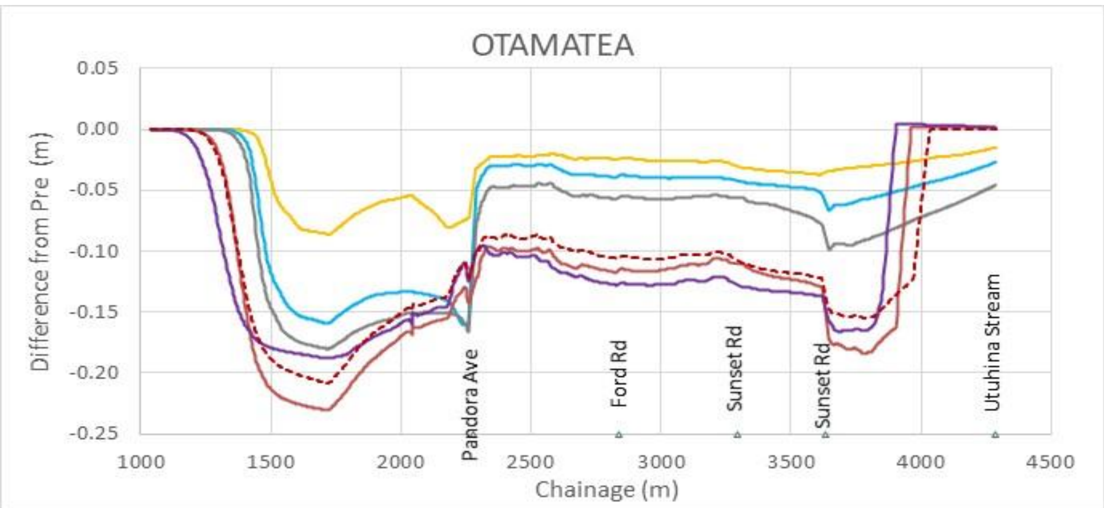

Figure 5 Peak flood level impacts, Otamatea Stream

Flood depth impacts, floodplain

Effect on peak flood depths of Proposed Plan Change under Scenario 15
1% AEP, 2130 climate (RCP 8.5), "CityNow"

Figure 6 Impact on flood depths (floodplain), 1% AEP 2130 climate, "CityNow"

Velocity IMPACTS, STREAM CHANNELS
Effect on peak flood velocities (channel-averaged) of Proposed Plan Change under Scenario 15
1% AEP, 2130 climate (RCP 8.5), "CityNow" (Other events show similar patterns)

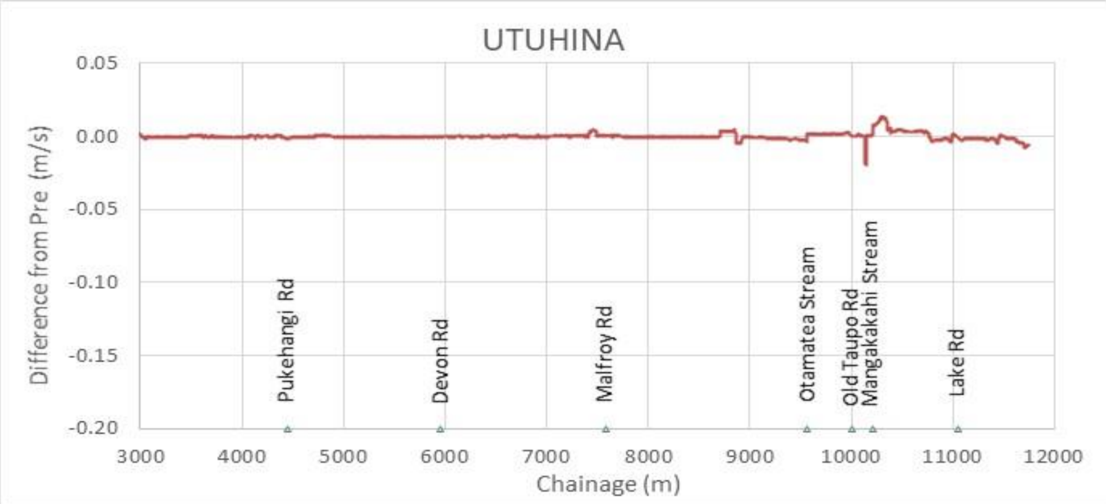

Figure 7 Peak flood velocity impacts, Utuhina Stream

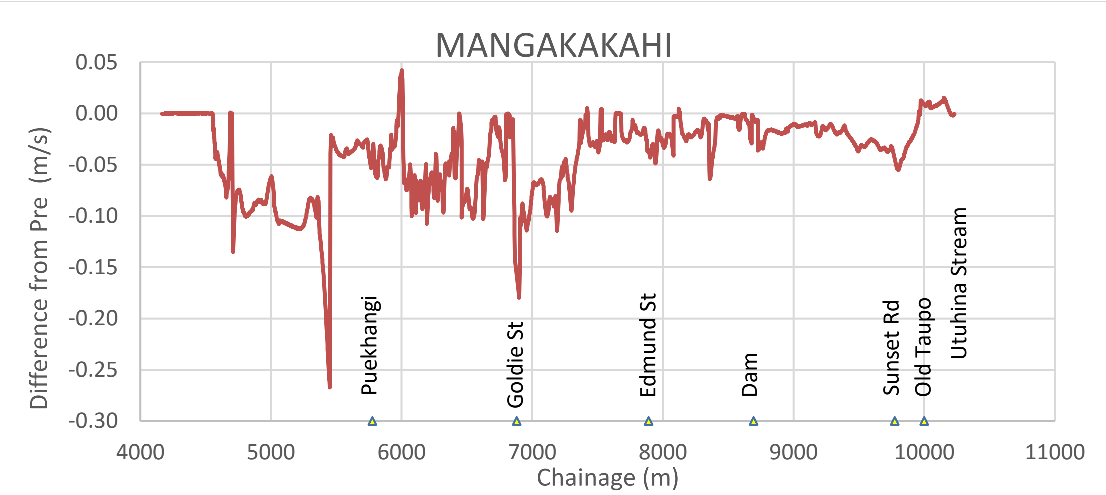

Figure 8 Peak flood velocity impacts, Mangakakahi Stream

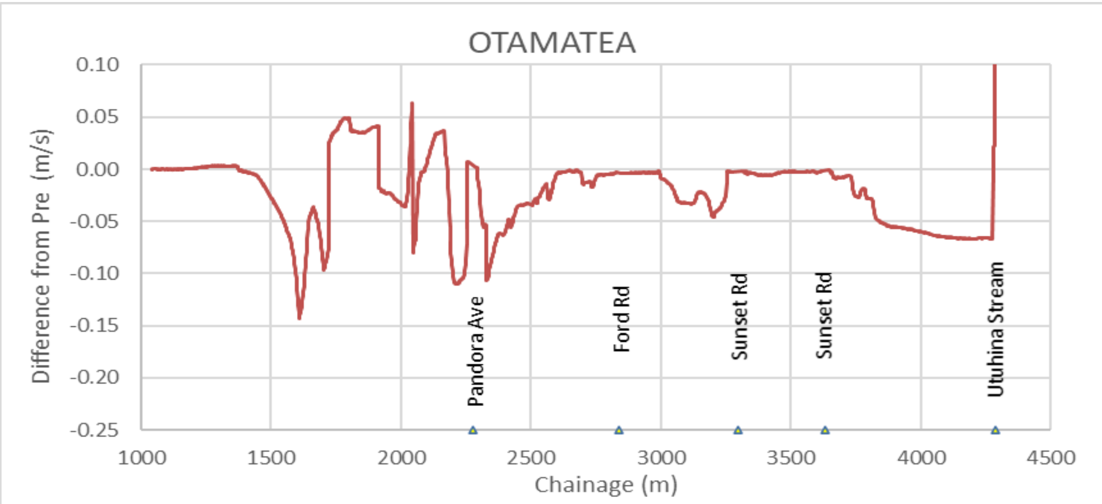

Figure 9 Peak flood velocity impacts, Otamatea Stream

Flood velocity impacts, floodplain
Effect on peak flood velocities of Proposed Plan Change under Scenario 15
1% AEP, 2130 climate (RCP 8.5), "CityNow"

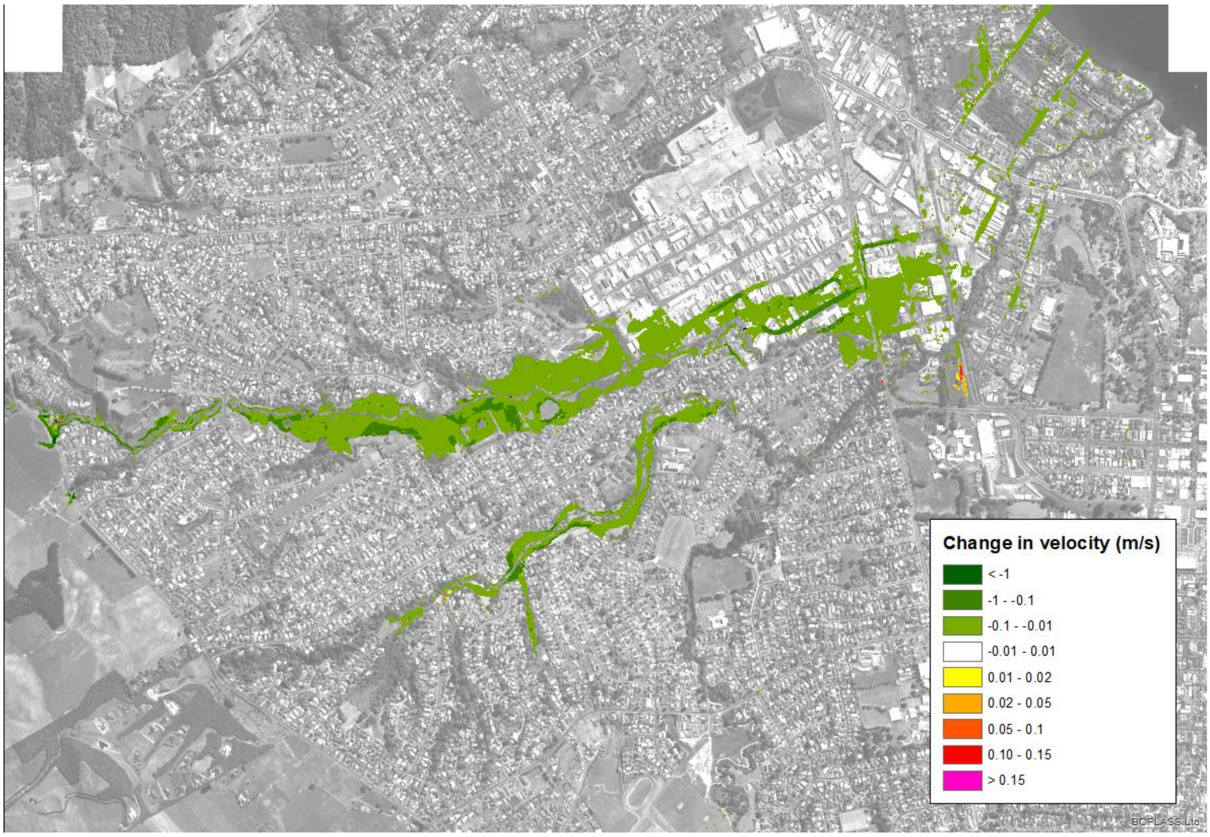

Figure 10 Impact on flood velocity (floodplain), 1% AEP 2130 climate, "CityNow"

Flood duration impacts, floodplain
Effect on flood duration of Proposed Plan Change under Scenario 15
1% AEP, 2130 climate (RCP 8.5), "CityNow" (Duration maps for other events not prepared)

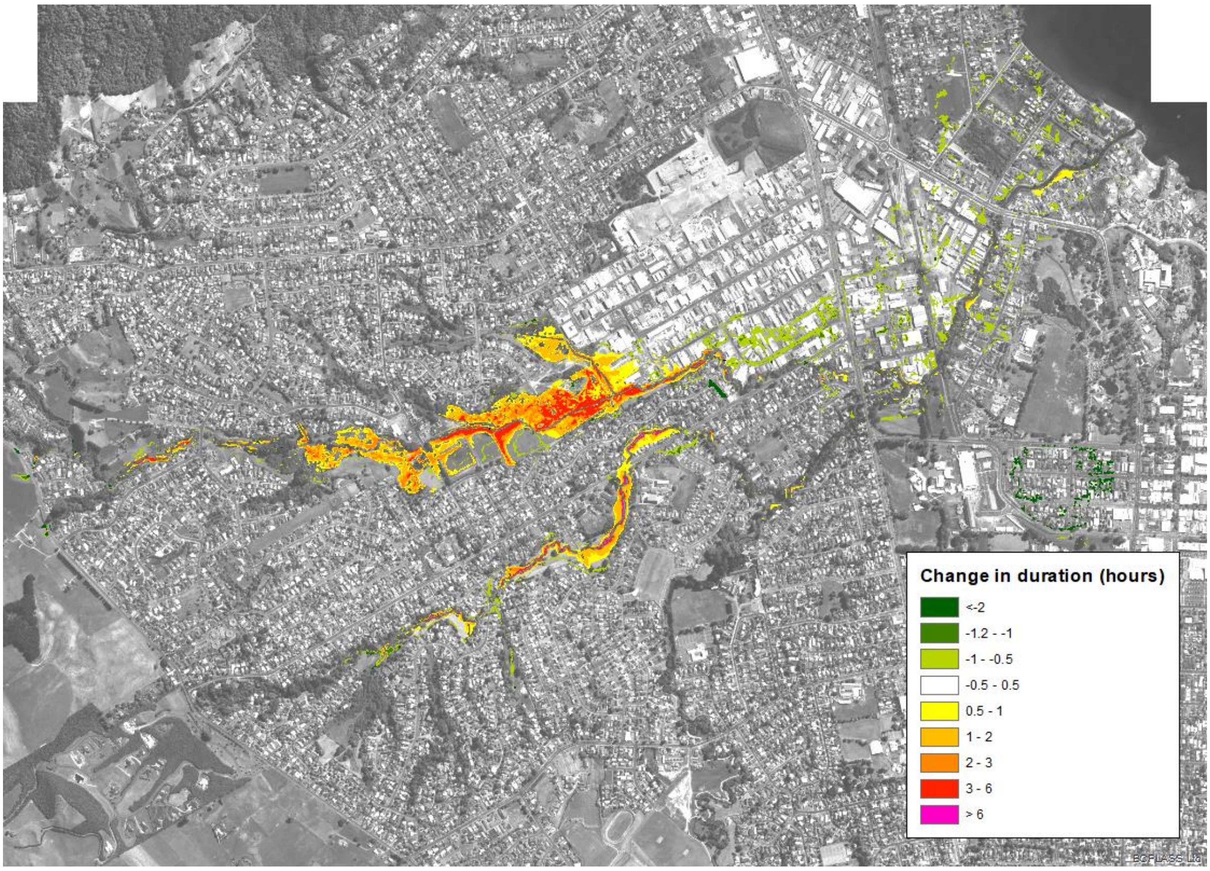

Figure 11 Impact on flood duration above 50 mm depth (floodplain), 1% AEP 2130 climate, "CityNow"

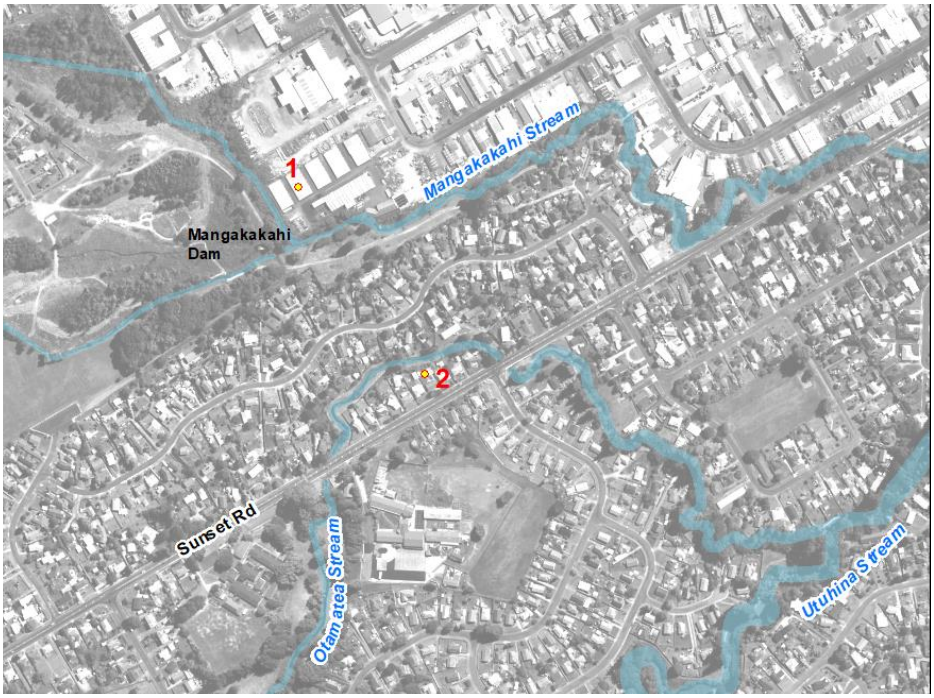

Figure 12 Locations of water depth hydrographs in Figures 13 and 14

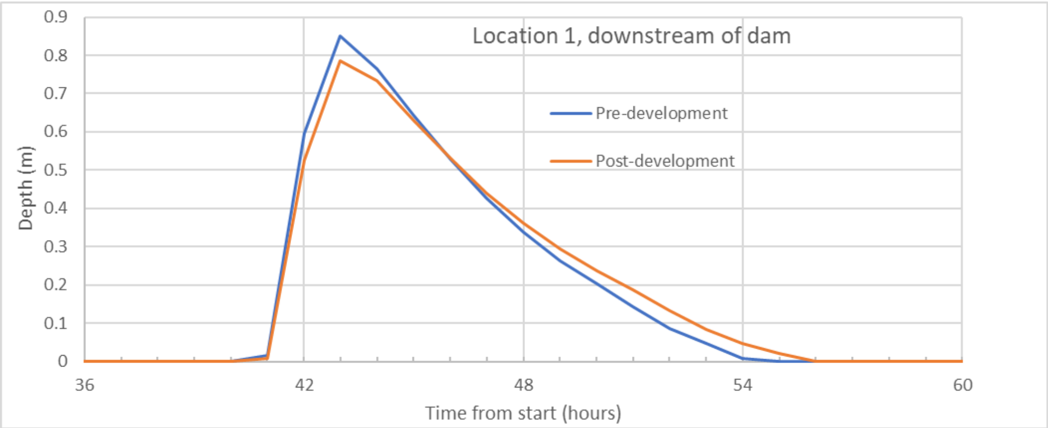

Figure 13 Water depth, 1% AEP 2130 climate, “CityNow”, sample location 1 (downstream of Mangakakahi Dam)

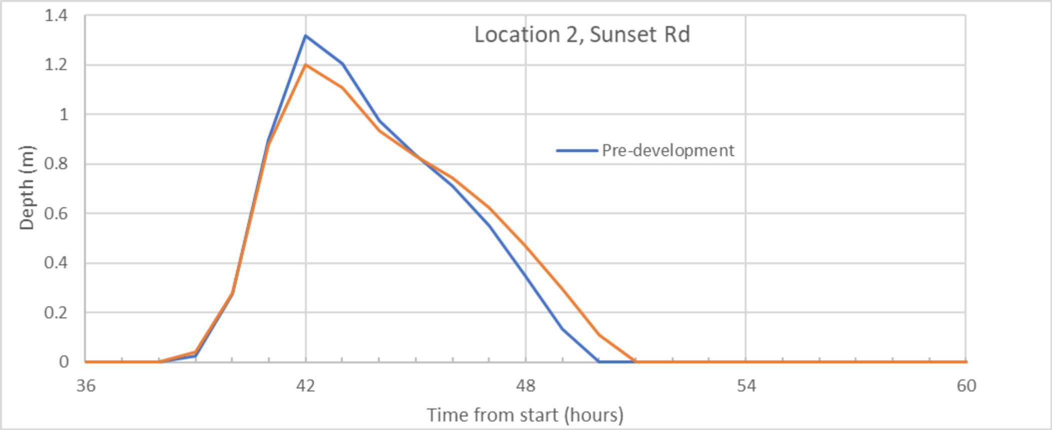

Figure 14 Water depth, 1% AEP 2130 climate, “CityNow”, sample location 1 (Sunset Rd)

Flood duration impacts, stream channel (sample locations);
Effect on water level hydrograph of Proposed Plan Change under Scenario 15
1% AEP, 2130 climate (RCP 8.5), "CityNow"

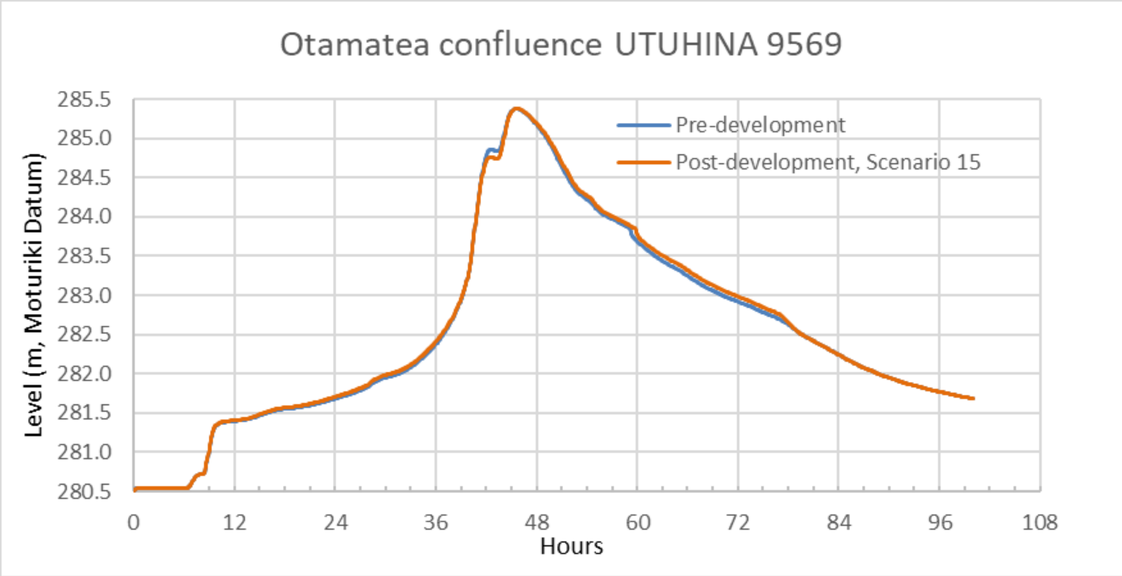

Figure 15 Water level, 1% AEP 2130 climate, "CityNow", Utuhina Stream at Otamatea confluence

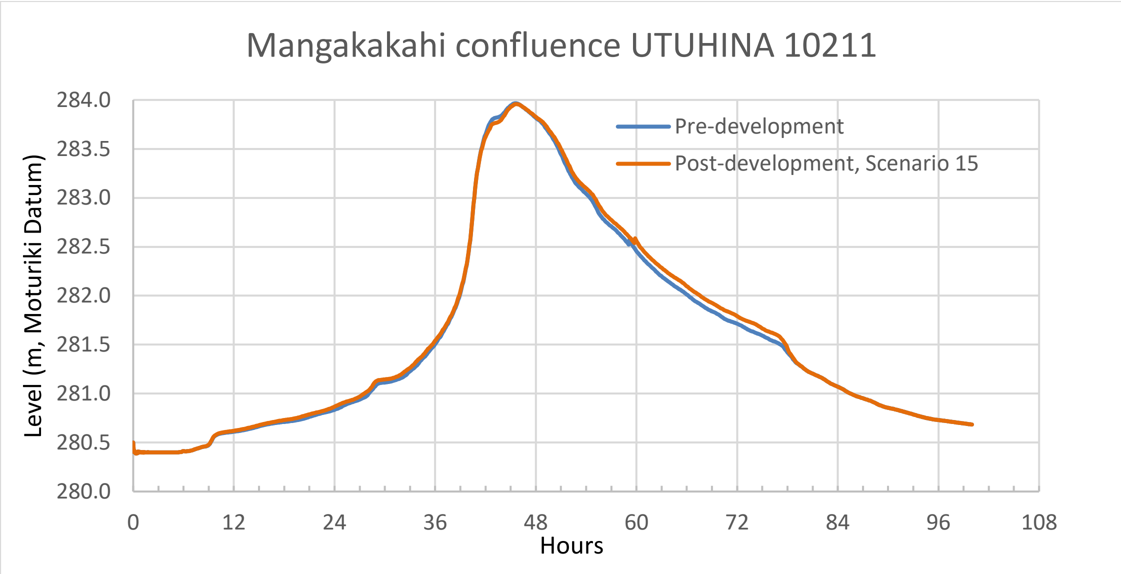

Figure 16 Water level, 1% AEP 2130 climate, "CityNow", Utuhina Stream at Mangakakahi confluence