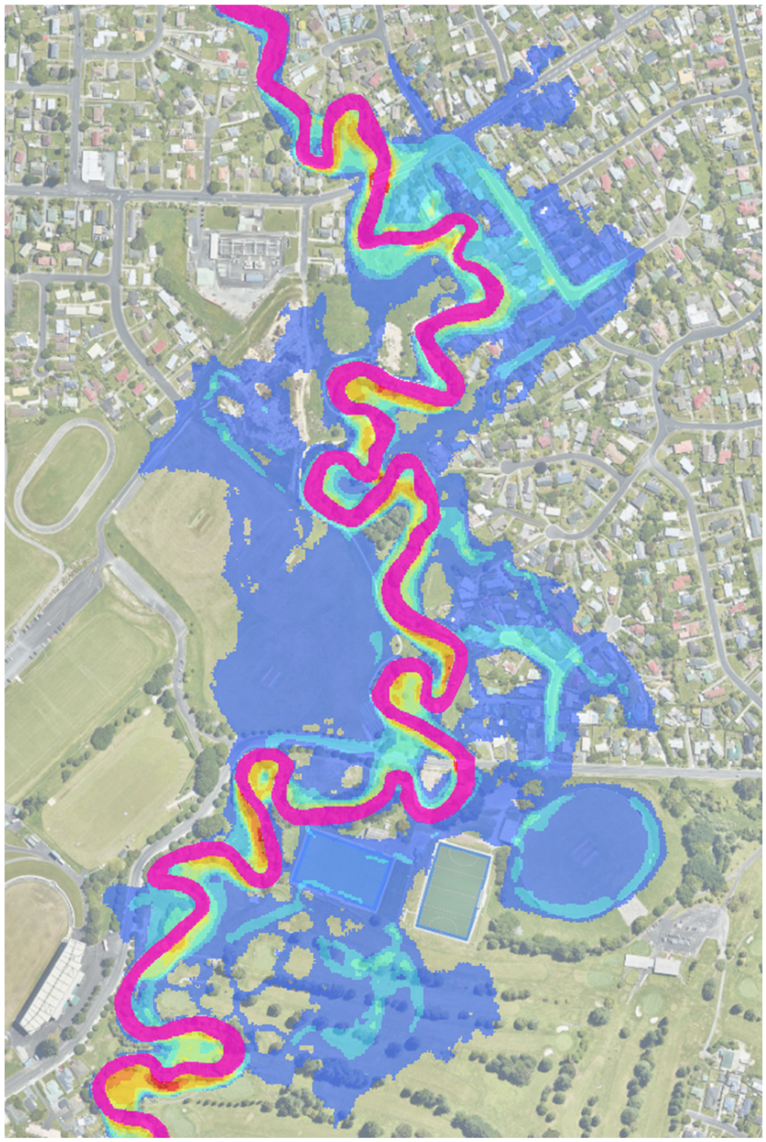
Utuhina – Hydraulic Model

Additional Modelling and Mapping



Bay of Plenty Regional Council

Report

August 2022

The expert in **WATER ENVIRONMENTS**

This report has been prepared under the DHI Business Management System
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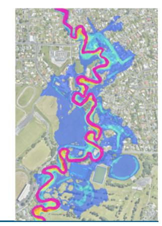
BUREAU VERITAS
Certification Denmark A/S

Utuhina – Hydraulic Model

Additional Modelling and Mapping

Prepared for	Bay of Plenty Regional Council
Represented by	Kathy Thiel-Lardon, Senior Environmental Engineer



Utuhina Stream,
Flood hazard map snippet

Project manager	Philip Wallace
Project number	44800902-01
Approval date	8 August 2022
Revision	Final 1.0
Classification	Restricted

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APPENDICES

FIGURES

1 Introduction

In 2021, DHI Water and Environment Ltd. (DHI) presented a final report (DHI, 2021) on flood modelling of the Utuhina Stream and floodplain to the Bay of Plenty Regional Council (BOPRC). Results for a range of calibration events and design scenarios were included in the reporting. Digital maps of design floods were also provided to the client.

Since that time, BOPRC has requested additional flood modelling and mapping, as follows:

- Flood maps incorporating a freeboard allowance
- Hazard maps (combining velocity and depth)
- Future urban infill scenarios (with resulting changes in runoff)

This report documents the assumptions and results of the additional work. The report is intended to be an addendum to the original 2021 report.

2 Freeboard mapping

Freeboard is intended to allow for uncertainty in model predictions, due to uncertainty in model data and assumptions (e.g cross-section changes, inflow assumptions, channel and surface roughness) and due to the possibility of such phenomena as waves, debris blockages or localised obstructions.

Note that the resulting flood surface is not intended to represent a single actual flood surface over the entire inundated area, but rather to indicate what should be allowed for at a particular location.

2.1 Defined freeboard allowance

According to the BOPRC Asset Management Plan for river scheme assets (BOPRC, 2021), the design standard for the lower Utuhina Stream downstream of Old Taupo Road calls for protection from a 1% AEP event, with 500 mm freeboard.

However, as discussed in the previous Utuhina modelling report (DHI, 2021), 700 mm freeboard should be applied to the current model results, in light of calibration results. This has been applied to the entire modelled reach of the Utuhina Stream. It has also been applied to the Mangakakahi Stream downstream of Old Taupo Road. For the remaining watercourses, 500 mm freeboard has been applied.

The previous report (DHI, 2021) included a recommendation that a minimum of 300 mm freeboard be applied over the floodplain. After subsequent discussion with BOPRC, this is increased to 500 mm. This is also consistent with general provisions in the Building Code (MBIE, 2020).

Thus, in summary the defined or nominal freeboard allowances are:

- Utuhina Stream channel: 700 mm
- Mangakakahi Stream channel, downstream of Old Taupo Road: 700 mm
- remaining 1-D channels: 500 mm
- floodplain: 500 mm

2.2 Incorporating the freeboard allowance

Simply adding the defined freeboard to results leaves a discontinuity, i.e. a vertical wall of water, at the margins of the predicted flood extent. Alternatively, extending the “with freeboard” surface until it meets the ground level potentially extends the flooded area by unrealistic amounts, especially in very flat floodplains. To avoid these issues, a method for hydraulically distributing the freeboard has been used (Wallace, 2008).

As applied to the Utuhina investigations, the method involves the following steps:

- Extract the peak flood levels from the 1-D and 2-D components, for each of the “urban-centred” and “upper-Utuhina-centred” storms,
- Determine the maximum flood level between the two “urban-centred” and “upper-Utuhina-centred” storms, at all locations in the model domain
- Add the defined freeboard to the peak levels
- Run the model with a starting condition of these “with freeboard” levels and zero flow.

In effect, a block of water (equal in height to the defined freeboard) is added on top of peak flood levels and that water let to spill. Once the simulation has proceeded long enough so that water levels everywhere are receding, the simulation is stopped. The peak levels reached on the floodplain in that simulation then become the final “with freeboard” flood surface.

3 Hazard mapping

In addition to the depth of flooding, the degree of flood hazard, and risk to human safety, is also a function of flood velocity. Flood hazard maps are therefore a useful tool for emergency management.

3.1 Depth x velocity

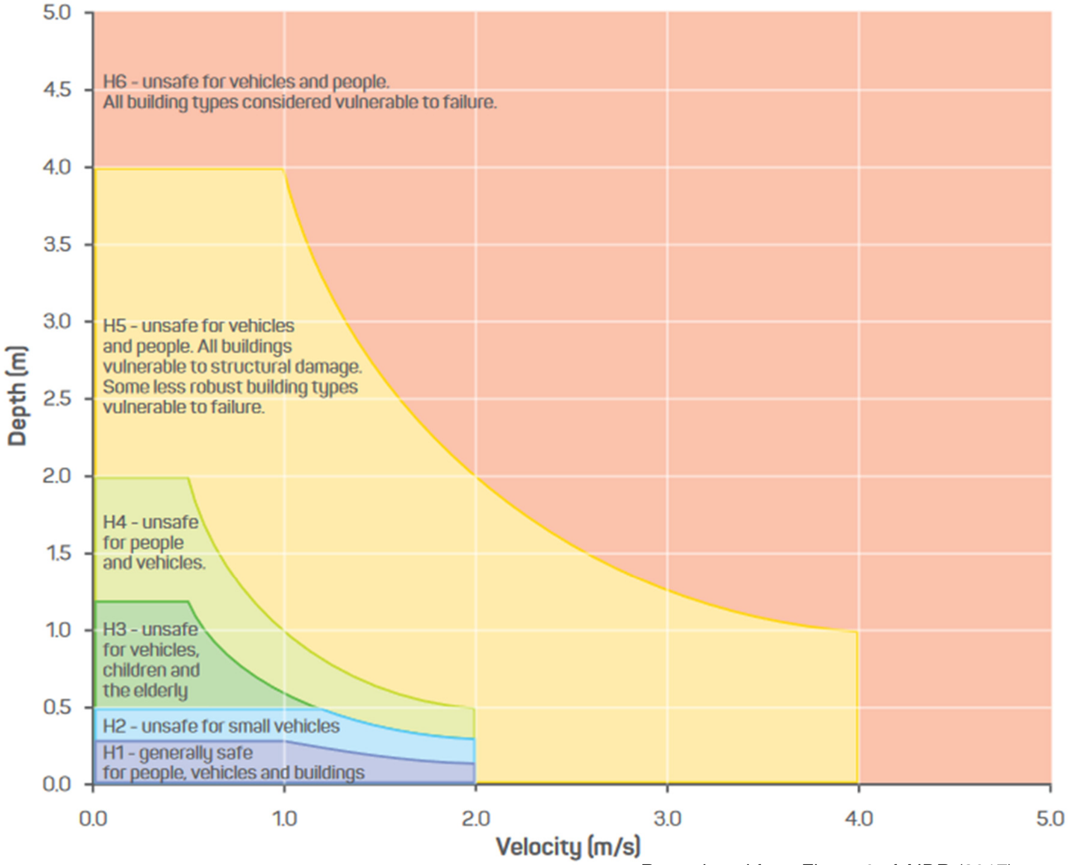
A simple way of presenting flood hazard information is to plot the peak values of the product of instantaneous depth and velocity (i.e. depth x velocity). The higher the product, the greater the hazard.

3.2 Hazard classification

As depth x velocity may not adequately represent the actual risk to human safety (for instance, deep floodwaters with near-zero velocity would give a very small value of depth x velocity), hazard can also be categorised according to zones on a velocity versus depth graph. Variations of such classifications can be found in the literature. One of these was first presented in a research document by Smith et al (2014) and subsequently adopted in Australian guidance (AIDR (2017) and DPE (2022)). It has been reproduced in Figure 3-1 and has been used in this current investigation.

Having such a classification also allows the areas within the "freeboard zone" (i.e., the margins of the floodplain that are not shown as flooded in the raw model results but are shown as flooded once freeboard is included) to be assigned a hazard. With a purely "depth x velocity" approach, velocities in the "freeboard" zone are uncertain and possibly small. Assuming a zero-velocity in the freeboard zone still allows a hazard class to be assigned.

The classification also puts the nature of the hazard into context, with its explanation of who and what would be at risk in each class. While the depth-velocity product can show the relative differences in hazard between different areas, the actual values of the product are perhaps of little use in explaining the hazard.



Reproduced from Figure 6 of AIDR (2017)

Figure 3-1 Flood hazard classification

4 Existing situation results

The calibration and design scenarios modelled earlier and reported in the 2021 DHI report are based on the existing level of development in the catchment. Floodmaps (showing depths and extents) are presented in that report.

4.1 Freeboard maps

Freeboard maps have now been prepared for the 2% AEP and 1% AEP (2130 climate) scenarios, using the method described in section 2 of this current report. These are presented in Figure 4-1 and Figure 4-2, respectively. These can be compared to Figures 6-23 and 6-24 in the 2021 report.

All maps shown in this report represent results from the maximum of the urban- and upper Utuhina-centred storms at any location.

Note that the 2% AEP freeboard simulation was carried out with v2022 of the MIKE FLOOD software, whereas all others reported here were carried out with v2017 (to be consistent with the original modelling as presented in the 2021 report). Tests for the 1% AEP freeboard simulation show that there are some minor differences in results between the two versions of the software.

Finally, note that an update to Rotorua Lake design levels is anticipated. Once that Rotorua Lake Levels Assessment is completed, design surface water levels in the vicinity of the lake will be updated, including a suitable allowance for uncertainty in lake levels due to wave runup, seiches and tectonic effects.

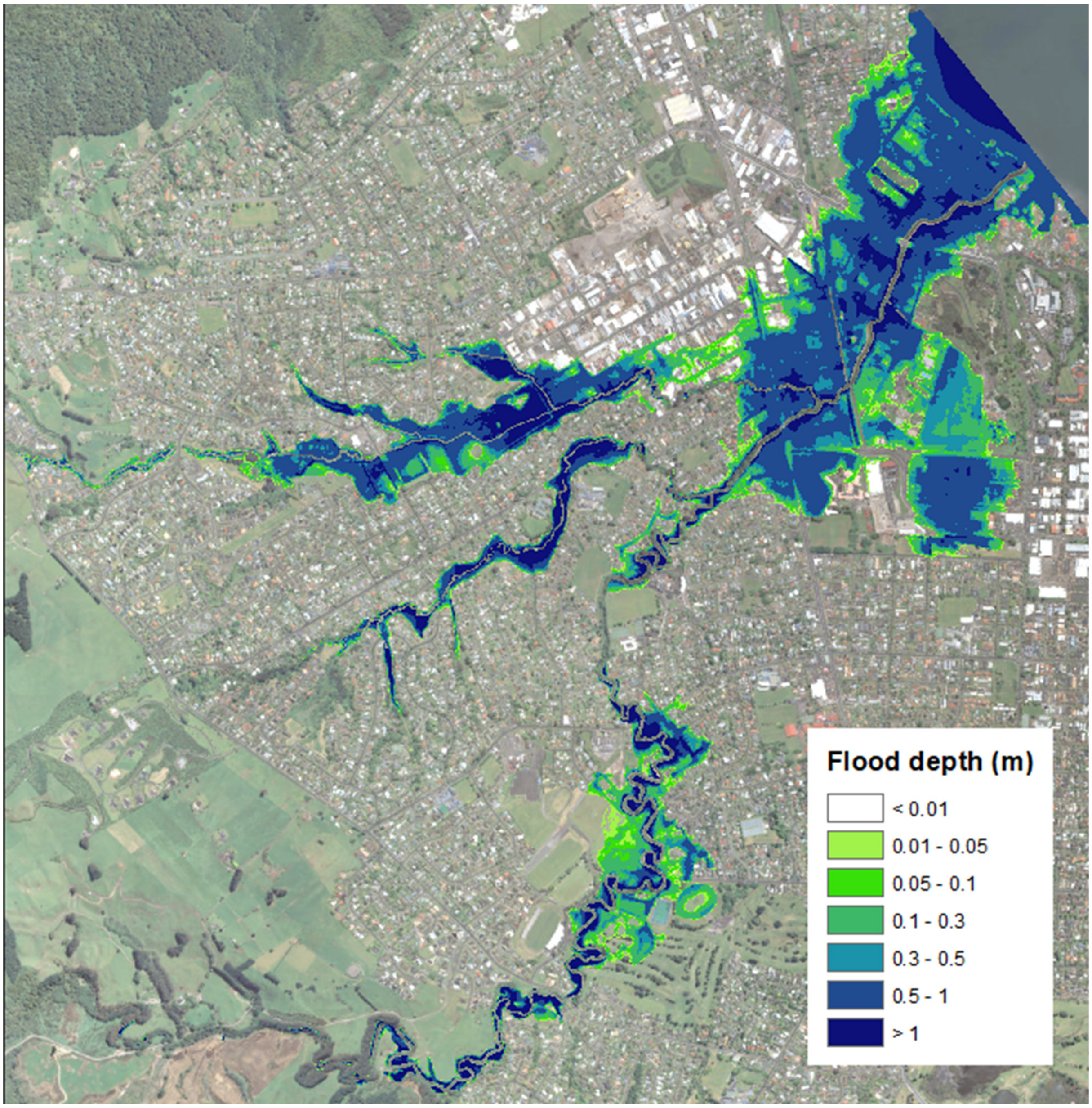


Figure 4-1 Flood map, 2% AEP 2130 climate, with freeboard allowance

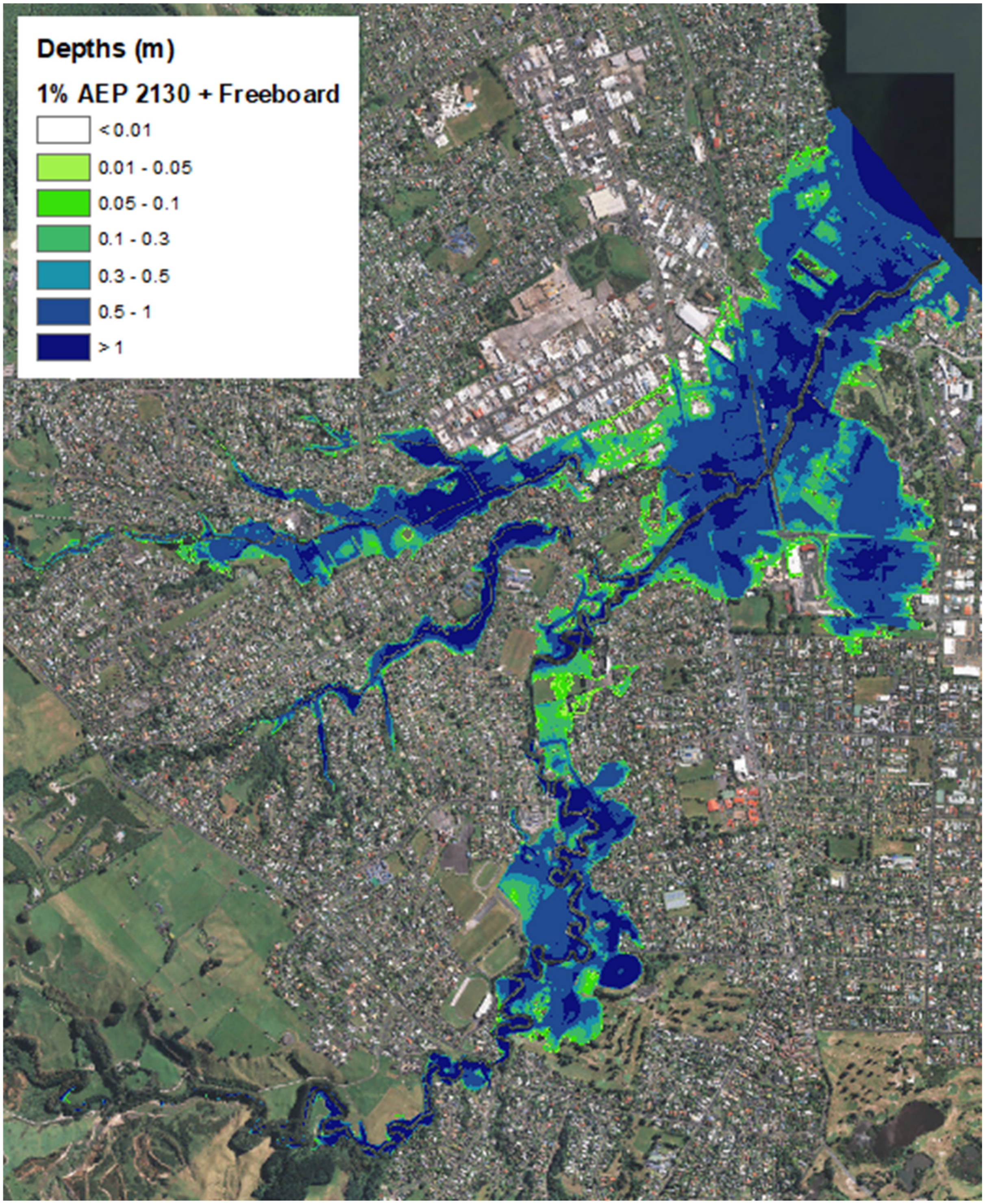


Figure 4-2 Flood map, 1% AEP 2130 climate, with freeboard allowance

The effect of the freeboard allowance for the 1% AEP 2130 scenario, compared to the “without freeboard” scenario, is also shown in Figure 4-3. Most of the differences are around 500 mm difference, but there are areas of greater difference near the Utuhina Stream. The lake area shows as around 100 mm difference, as a 1% AEP lake level condition was assumed at the downstream boundary (rather than adding the 500 mm nominal freeboard there). (As noted above, design levels in the vicinity of the lake will require updating once an updated Rotorua Lakes Level Assessment has been finalised.)

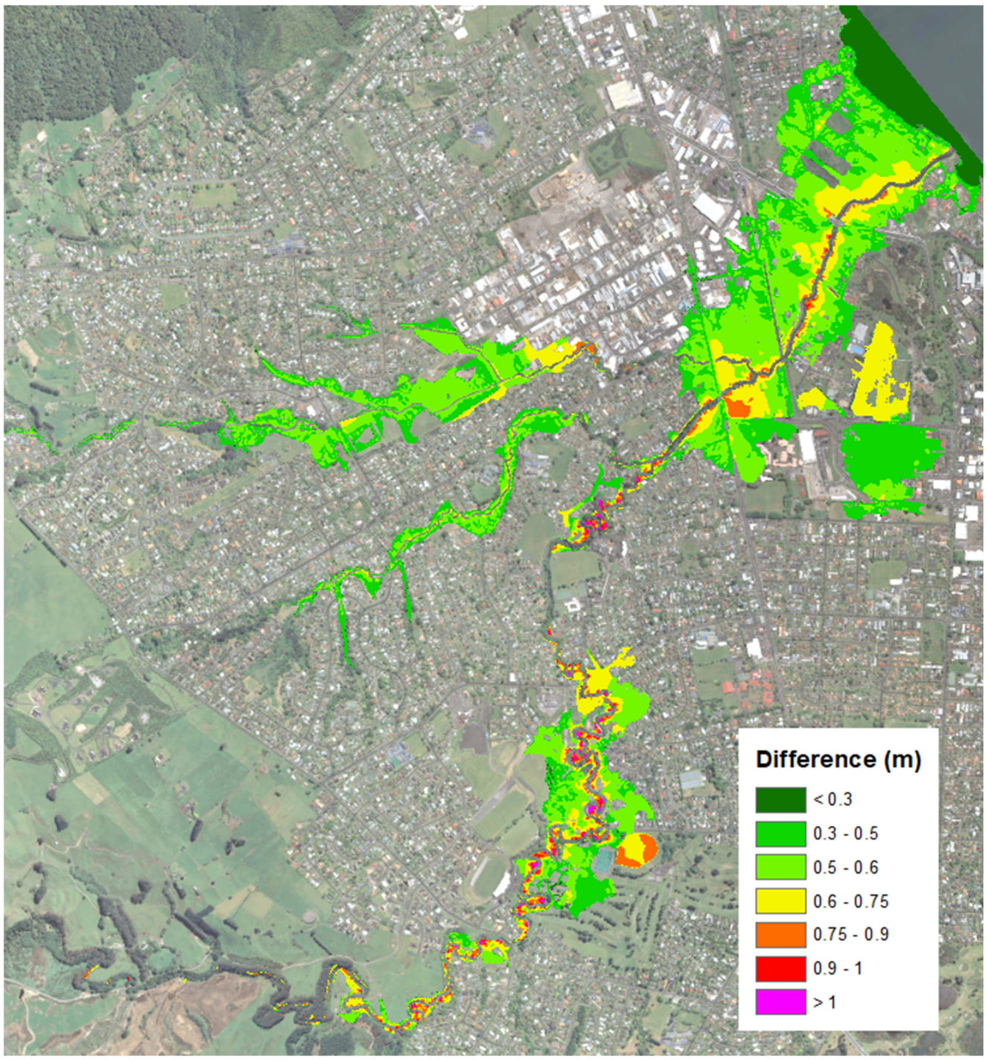


Figure 4-3 Difference, with and without freeboard allowance, 1% AEP 2130 climate

4.2 Hazard maps

4.2.1 Depth-velocity product

Predicted maximum values of the instantaneous (depth x velocity) over the floodplain are shown in Figure 4-4, for the 1% AEP 2130 case.

The depth-velocity product has not been quantified for the stream channels modelled in 1-D; these are shown as pink and will have high (depth x velocity) values.

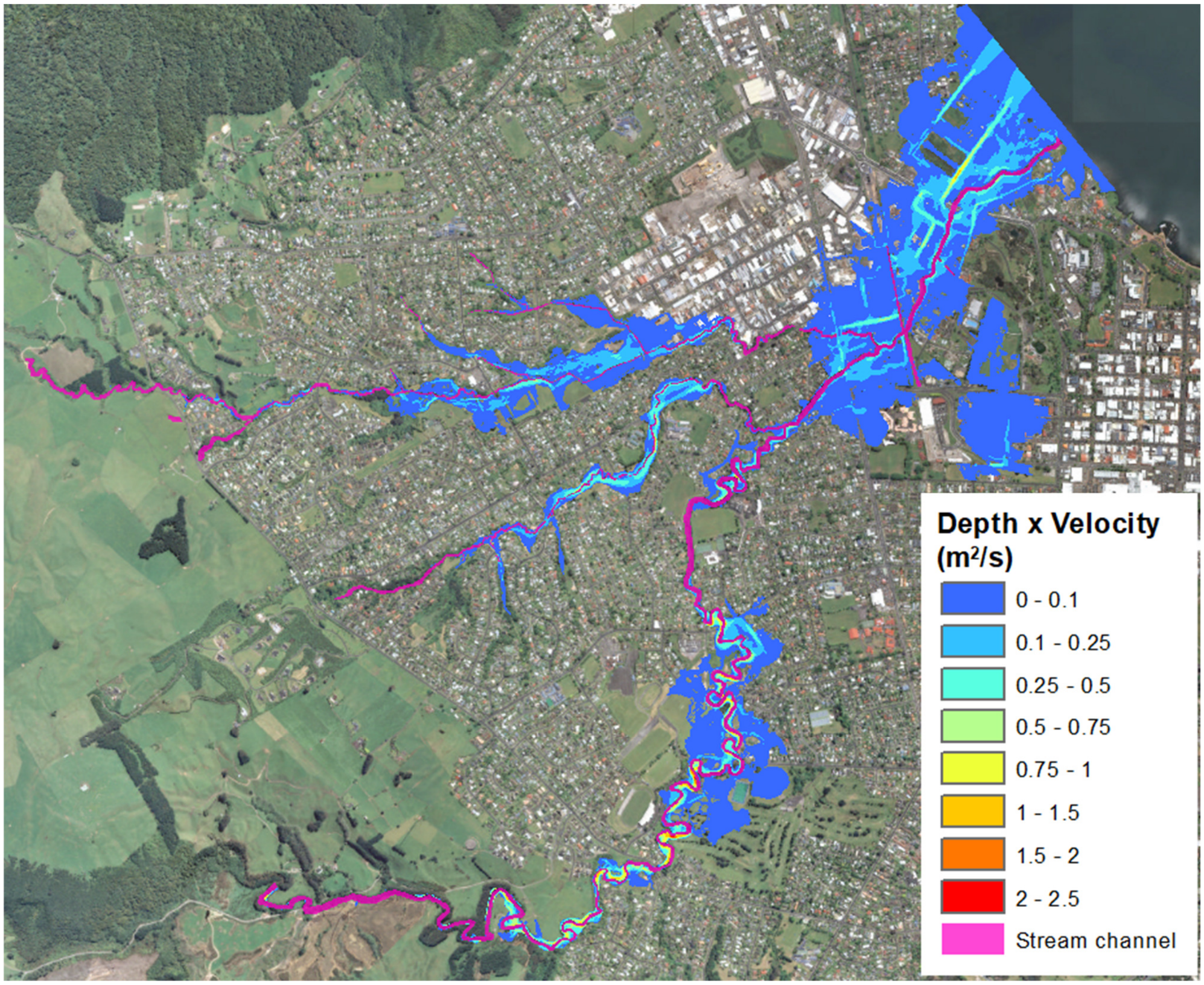


Figure 4-4 Flood map, maximum (depth x velocity) 1% AEP 2130 climate

4.2.2 Hazard classes

The “no-freeboard” result files have been post-processed to provide instantaneous values of the hazard classes presented in Figure 3-1, for each of the two storm scenarios for the 1% AEP 2130 case. The maximum values for the simulations have then been extracted, to provide a raster of the maximum hazard values.

Separately, the peak water depth results from the freeboard simulation have been assessed against the hazard classification, but assuming that the velocities are zero. The resulting hazard value raster is then compared with the raster from the “no freeboard” assessment and the maximum values written to a new raster.

Lastly, the area within the stream channels (modelled in 1-D) has been assigned a hazard class value of 6, on the assumption that flow will be fast flowing and deep over most of the width of the channels.

In summary, the hazard classification results are derived as follows:

- Prepare hazard class rasters for the floodplain, for each of the “urban-centred” and “upper-Utuhina-centred” storms, (no freeboard), and find the maximum value at all locations, saving as a new raster
- Prepare another hazard class raster, for the “with freeboard” depths (zero velocity)
- Prepare a maximum raster of these last two rasters
- Add in the stream channels, with hazard class 6.

The resulting values of the hazard classification (as set out in Figure 3-1) for the 1% AEP 2130 (existing development) scenario are shown in Figure 4-5.

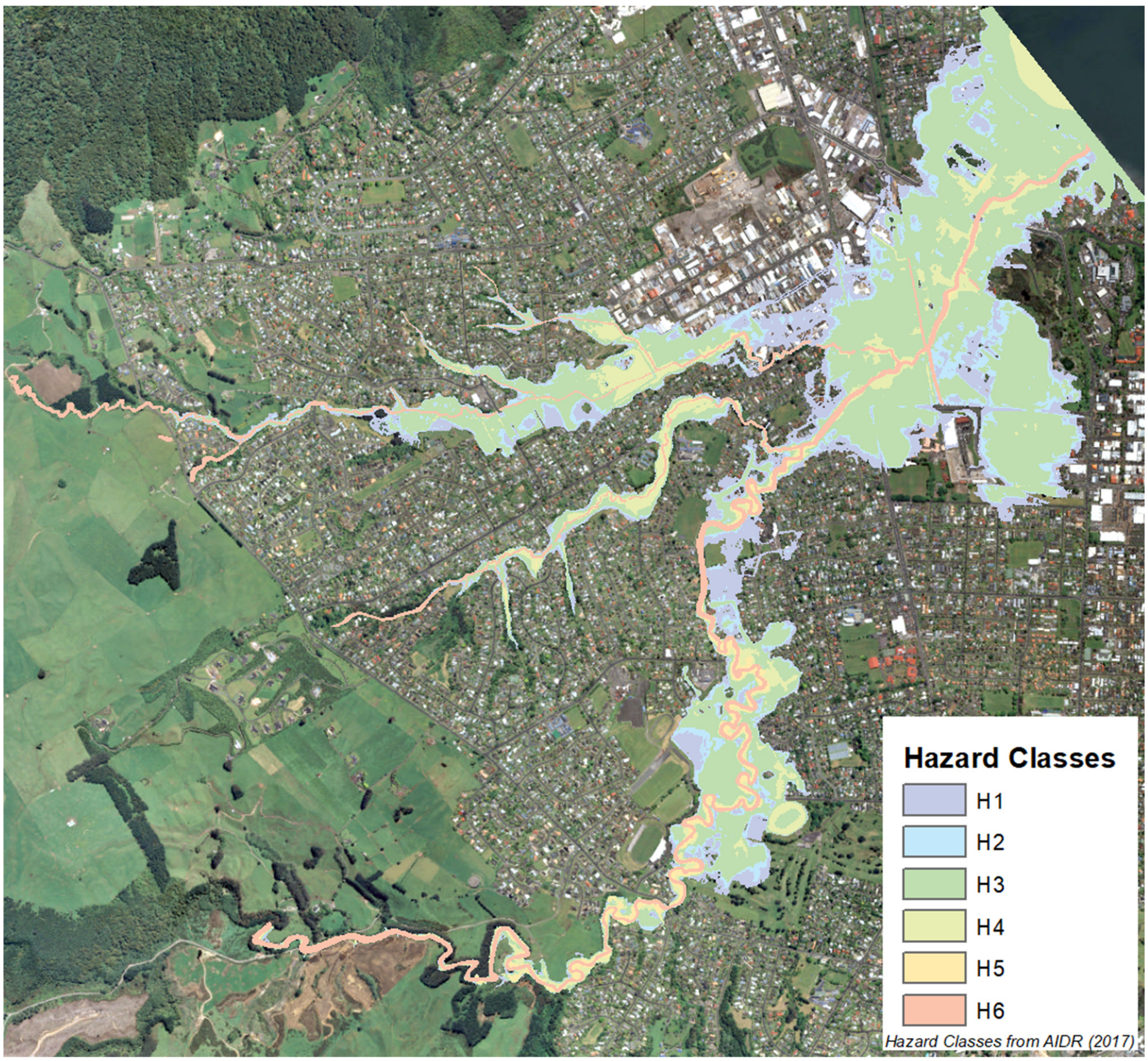


Figure 4-5 Hazard classification, 1% AEP 2130, (including freeboard)

5 Infill scenarios results

BOPRC requested that two future urban development scenarios be modelled: “Infill A” and “Infill B”. As these would result in different runoff characteristics, and hence different inflows to the hydraulic model, to the scenarios modelled previously, the hydrological model was rerun to provide the appropriate model inflows. Appendix C summarises the hydrological modelling undertaken.

Again, two storms were modelled for each infill scenario: an urban- and an upper Utuhina-centred storm.

5.1 Freeboard maps

Peak flood depths for each of the two infill scenarios (each in turn representing the maximum of the two storm scenarios at any location) are presented in Figure 5-1 and Figure 5-2. Freeboard has been incorporated, following the procedure outlined in section 2

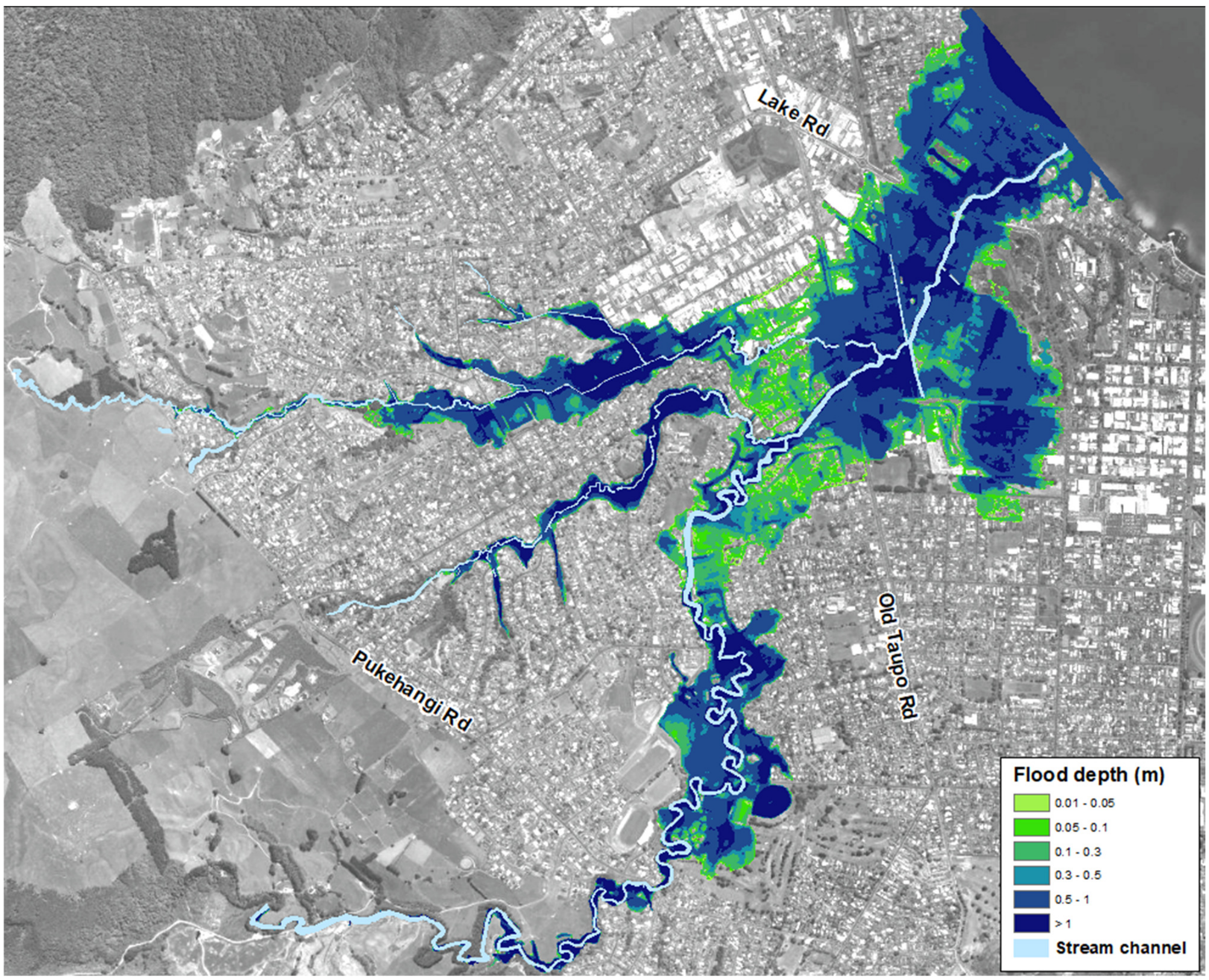


Figure 5-1 Flood depth map, 1% AEP 2130 climate, Infill Scenario A with freeboard

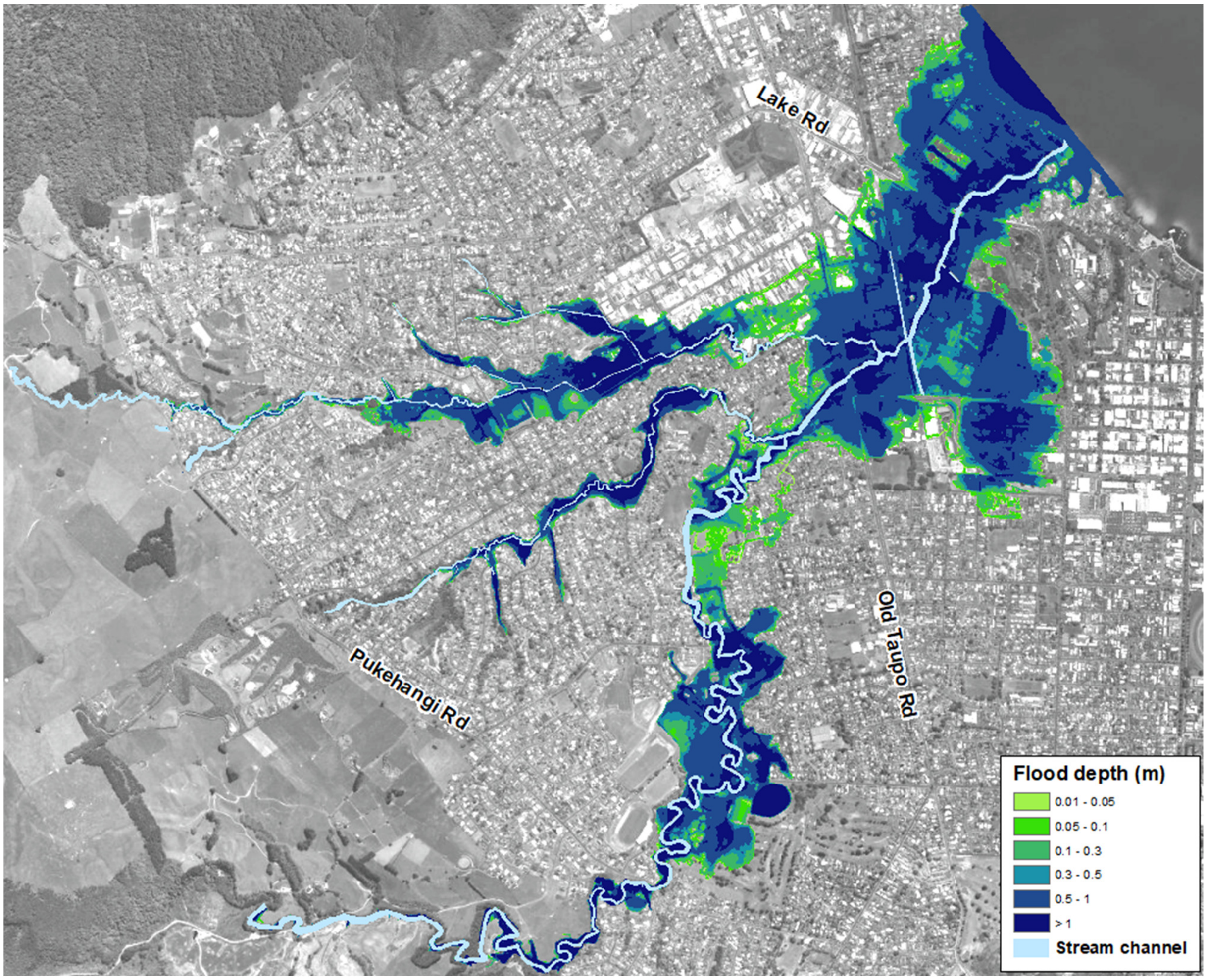


Figure 5-2 Flood depth map, 1% AEP 2130 climate, Infill Scenario B with freeboard

Peak flood levels, relative to Moturiki Vertical Datum 1953, over the floodplain are shown in Figure 5-3 and Figure 5-4. However, as discussed in 4.1, design flood levels in close proximity to the lake may be subject to change once an update to design lake levels is completed. BOPRC should be consulted for the latest advice regarding design flood levels near the lake.

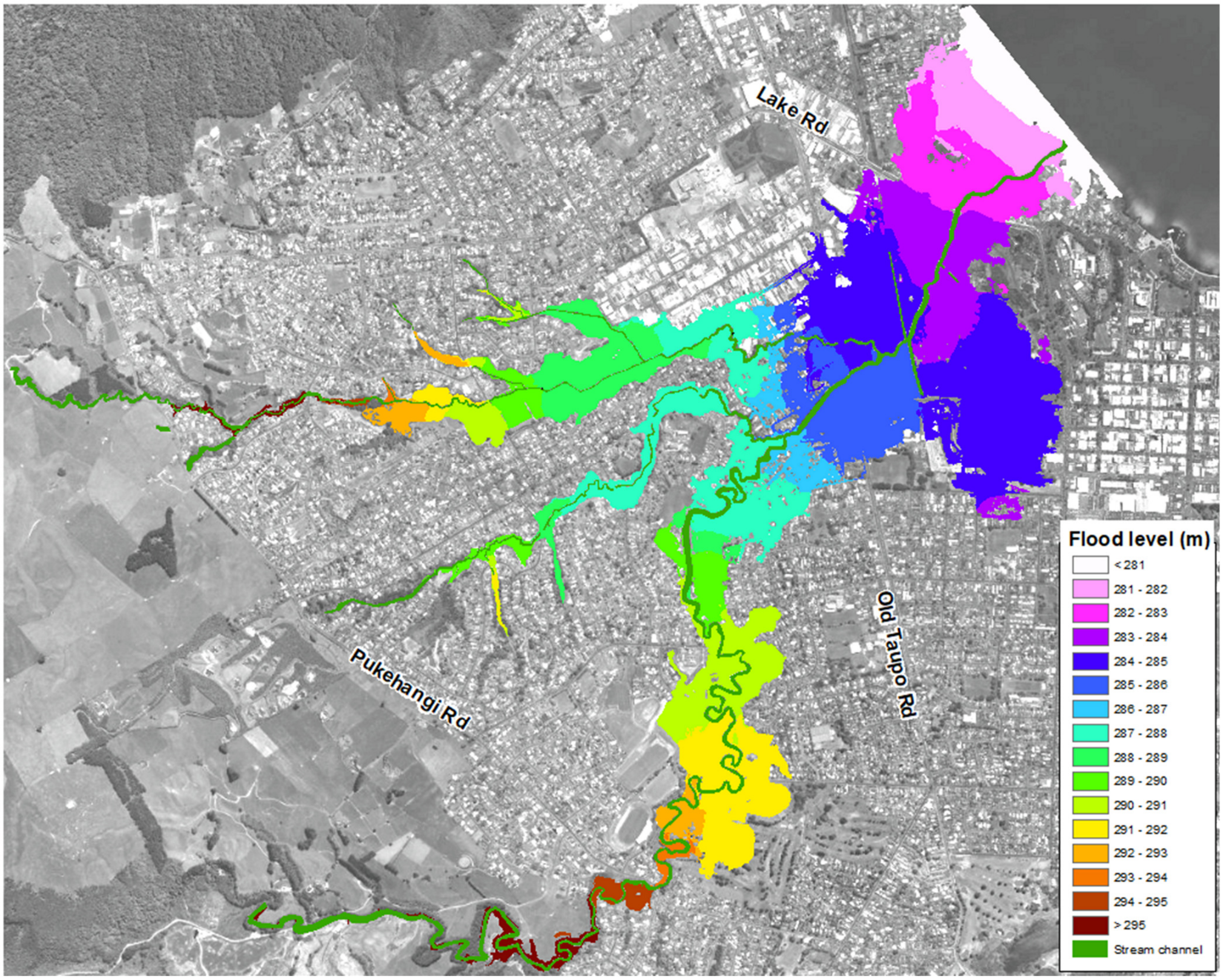


Figure 5-3 Flood level map, 1% AEP 2130 climate, Infill Scenario A with freeboard

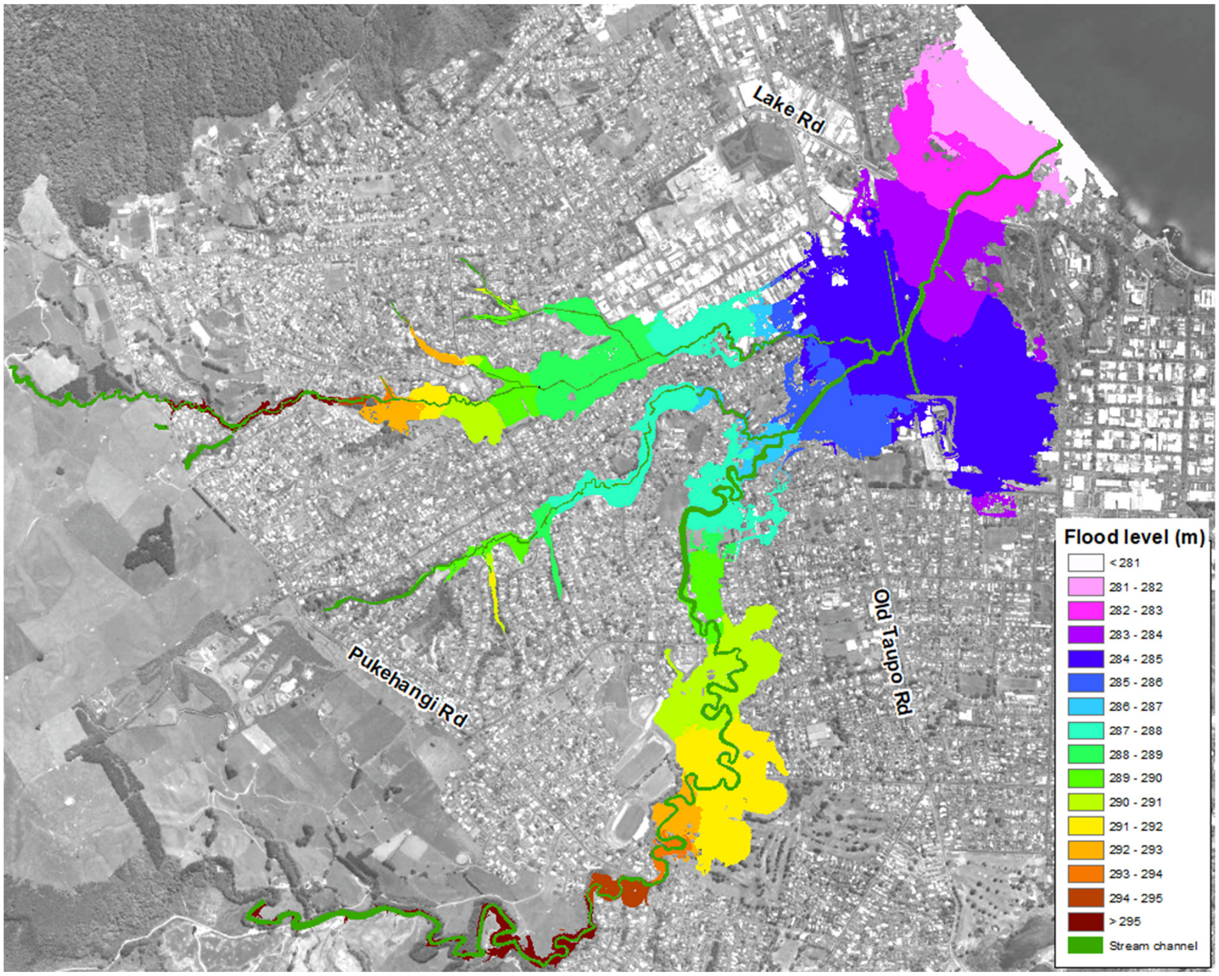


Figure 5-4 Flood level map, 1% AEP 2130 climate, Infill Scenario B with freeboard

5.2 Hazard maps

Flood hazard maps, using the Australian classification, are presented in Figure 5-5 and Figure 5-6. The procedure for preparing these has followed that outlined in section 4.2.2. Refer to Figure 3-1 for explanation of the hazard categories.

Depth x velocity maps have not been prepared for the infill scenarios, given that the hazard classification system better explains the risk to people and assets.

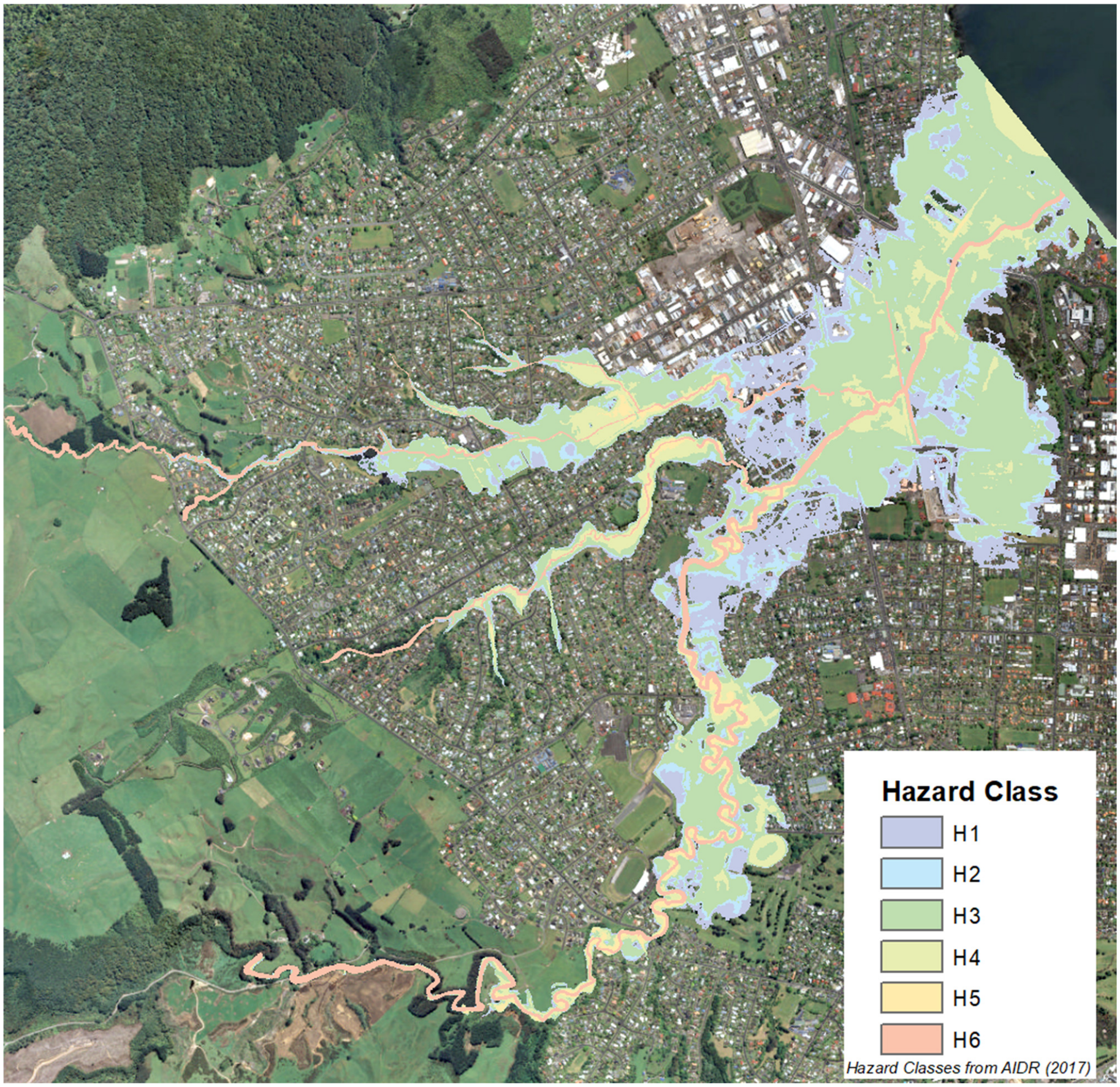


Figure 5-5 Hazard classification, 1% AEP 2130, Infill Scenario A (including freeboard)

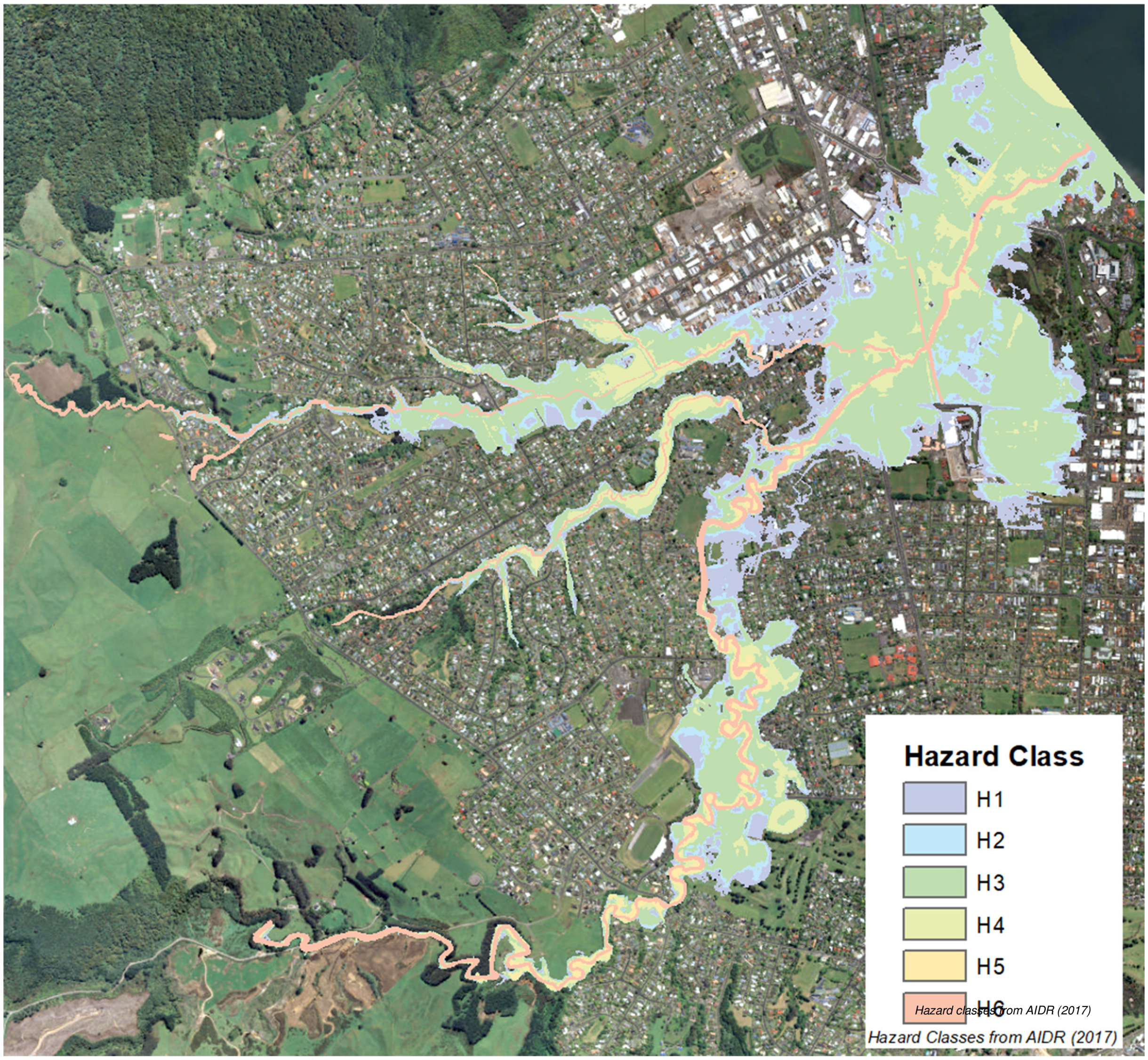


Figure 5-6 Hazard classification, 1% AEP 2130, Infill Scenario B (including freeboard)

6 Conclusions

Freeboard has been applied to selected flood scenarios previously modelled and reported in DHI (2021). The resulting floodmaps with freeboard capture the area of floodplain that is potentially at risk from flooding in the design scenarios, under future climate conditions (2130).

As the danger posed by floodwaters is a function of velocity as well as depth, a hazard map showing the product of depth and velocity has been prepared. However, a potentially more useful hazard map is one based on Australian research, where hazard is assigned one of six classes, depending on the particular combination of depth and velocity and reflecting how safe the conditions are to people and assets. Such a map has also been prepared. This shows that over much of the floodable area, conditions in the design scenario would be unsafe for at least the more vulnerable portion of the population (children, elderly) and for vehicles.

BOPRC also requested that two future urban development scenarios be modelled: “Infill A” and “Infill B”. Flood maps of peak depth and the hazard classes have again been prepared. At a city-wide scale, the differences between the existing development, Infill A and Infill B scenarios are not great. However there are local differences and, as expected, Infill A shows slightly more flooding than Infill B, which in turn shows slightly more than the existing development scenario.

Rasters of the various floodmaps have been provided to BOPRC.

7 References

/1/ AIDR (2017); *Australian Disaster Resilience Guideline 7-3: Flood Hazard*. Australian Institute for Disaster Resilience

/2/ Bay of Plenty Regional Council (2021); *Rivers and Drainage Asset Management Plan 2021-2071*

/3/ DHI (2021); *Utuhina - Phases 2 and 3: Numerical Modelling*. Prepared for Bay of Plenty Regional Council, 2021.

/4/ DPE (2022); *Flood Hazard: Flood Risk Management Guide FB03.* Department of Planning and Environment, NSW Government. February 2022.

/5/ MBIE (2020); *Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 Surface Water*.

/6/ Smith G.P., Davey E.K. and Cox R.J. (2014); *Flood hazard*. Technical report 2014/07, Water Research Laboratory, University of New South Wales, Sydney.

/7/ Wallace, P. (2008); *Applying Freeboard to Floodplain Model Results and Hazard Maps*. DHI User Group Meeting, Auckland, 2008

/8/ West, P. (2021); *BOPRC Flood Forecasting Systems: Utuhina Hydrological Model Establishment*. Blue Duck Design Ltd, 15 March 2021

/9/ West, P. (2022); *Utuhina Hydrological Modelling. Scenario Testing: Residential planning zones impervious-surface-area percentage scenarios.* Blue Duck Design Ltd., 10 May 2022

APPENDICES

APPENDIX A – Project Brief

A Project Brief

Instructions for the additional modelling and floodmapping were provided by BOPRC in a series of emails. These included those reproduced below.

Utuhina 1% 2130 max dxv maps

KT Kathy Thiel-Lardon <Kathy.Thiel-Lardon@boprc.govt.nz>
To philip.wallace

Reply | Reply All | Forward | ...

Mon 7/03/2022 12:00 pm

You replied to this message on 7/03/2022 12:15 pm.

Hi Phil,

I am not sure if you already produced these, but if not can you please produce the Utuhina 1% 2130 max dxv maps.

Thanks

Kathy Thiel-Lardon
Senior Environmental Engineer
Bay of Plenty Regional Council Toi Moana

P: 0800 884 880 **DD:** 0800 884 881 x8144

DHI

RE: Utuhina 1% 2130 max dxv maps

Kathy Thiel-Lardon <Kathy.Thiel-Lardon@boprc.govt.nz>
To philip.wallace
Cc Peter West; Mark Townsend

Reply | Reply All | Forward

Thu 24/03/2022 3:12 pm

You replied to this message on 20/05/2022 12:24 pm.

Hi Phil,

Hope you and your family are staying safe and healthy.
I was wondering whether you were able to produce the max dxv maps or have an updated ETA.

I also would like you to please model two future development scenarios for the 1% AEP 2130 as supporting information for RLCs infill plan change.

a) Current allowance in the district plan
maximum impervious surface standards in residential zones
– Residential 1 Zone: 80%
– Residential 2 Zone: from 100%

b) Proposed reduced allowance in the district plan
maximum impervious surface standards in residential zones
– Residential 1 Zone: 70%
– Residential 2 Zone: from 80%

I would need both depth maps and dxv maps.

This can be done under the current brief for optioneering phase please.
I need results as early as possible, considering Marks new priority list.

Pete, can you please produce the inputs for Phil ASAP.

Let me know if you have any questions.

Cheers

Kathy Thiel-Lardon
Senior Environmental Engineer
Bay of Plenty Regional Council Toi Moana

RE: Utuhina 1% 2130 max dxv maps

Kathy Thiel-Lardon <Kathy.Thiel-Lardon@boprc.govt.nz>
To philip.wallace
Cc Mark Townsend

Reply | Reply All | Forward

Tue 31/05/2022 3:53 pm

Hi Phil,

As discussed, now.
Can you please arrange for the scenarios A & B to be run for including modelling uncertainties.
In addition, we need an addendum to the report to cover the uncertainties runs as well as scenarios a and b.

I have some urgency here, but appreciate that you are under the pump.

Mark, can you please advise priorities, I am hoping this can go ahead of Purenga as it is for RLC?

thanks

Kathy Thiel-Lardon
Senior Environmental Engineer
Bay of Plenty Regional Council Toi Moana

P: 0800 884 880 **DD:** 0800 884 881 x8144

APPENDIX B–Model Files

MIKE FLOOD and Raster Files

B MIKE FLOOD Files

Input and output files for selected final model simulations can be tracked via the *.couple* files noted in Table B-1.

Unless otherwise noted, the models were run with MIKE 2017 (SP2) on DHI computers.

All simulations used the "low order" solution technique within MIKE 21 FM. Ideally, the "higher order" option would have been used, but this would have led to long simulation times. From past experience with other projects, the high order results are typically not significantly different from low order results.

Processed raster files (in *.asc* format) for viewing in GIS software are also listed.

Table B-1 MIKE FLOOD *.couple* files and raster *.asc* files

.couple file	Machine	start date	finish date	comments	Raster files supplied
Utuhina_Q100_2130_Storm070_0pt55(UrbanCentre)	ackl-80 (DHI)	29/11/2020 21:37	1/12/2020 17:48		
Utuhina_Q100_2130_Storm070_0pt55(UtuhinaCentre)	ackl-80 (DHI)	16/11/2020 21:32	18/11/2020 11:51		1%aep_2130_max_vxd.asc
Utuhina_Q50_2130_FB-extended	REC-1	6/03/2022 9:55	6/03/2022 13:00	v2022	utuhinaq50_2130_fb_depth.asc utuhinaq50_2130_fb_waterlevel.asc
Utuhina_Q100_2130_FB-extended	ackl-80 (DHI)	10/11/2021	11/11/2021 7:50		Utuhina_Q100_2130_FB_depth_v2.asc utuhinaq100_2130_fb_maxwl.asc Utuhina_Q100_2130_FB_extent_inclChannel_v2.asc
Utuhina_Q100_2130_FB-extended	REC-1	4/03/2022 13:51	4/03/2022 18:01	v2022	
Utuhina_Q100_2130_InfillScenarioA-upperUtuhinaCentre	rogue-one (DHI)	12/05/2022 21:44	15/05/2022 10:52		infillamaxh.asc
Utuhina_Q100_2130_InfillScenarioA-urbancentre	rogue-one (DHI)	12/05/2022 21:50	15/05/2022 11:14		infilla_1%aep2130_maxdepth.asc
Utuhina_Q100_2130_InfillScenarioB-upperUtuhinaCentre	rogue-one (DHI)	12/05/2022 21:44	15/05/2022 10:50		infillbmaxh.asc
Utuhina_Q100_2130_InfillScenarioB-urbancentre	rogue-one (DHI)	12/05/2022 21:51	15/05/2022 11:07		infillb_1%aep2130_maxdepth.asc
Utuhina_Q100_2130_FB-InfillA	rogue-one (DHI)	11/06/2022 11:56	13/06/2011 17:11		infillscenarioa_freeboard_maxdepth.asc hazardclass-infilla_inclfb.asc
Utuhina_Q100_2130_FB-InfillB	rogue-one (DHI)	11/06/2022 12:06	11/06/2022 18:11		infillscenariob_freeboard_maxdepth.asc hazardclass-infillb_inclfb.asc

APPENDIX C – Hydrology

Utuhina Hydrological Modelling

C Hydrology

Peter West of Blue Duck Design Ltd carried out hydrological modelling of the Utuhina catchment, to provide design inflows for the hydraulic model. His report on the hydrological modelling of the two infill scenarios is reproduced here. This can be read in conjunction with his earlier report describing the hydrological model[1].

[1] Blue Duck Design Ltd (2021); *Utuhina Hydrological Model Establishment Calibration update.* 15 March 2021

Utuhina Hydrological Modelling

Scenario Testing:
Residential planning zones
impervious-surface-area
percentage scenarios

Blue Duck Design Ltd
Consulting River Engineers

10 May 2022

Peter West
Blue Duck Design Ltd

Executive Summary

This memo describes hydrological modelling of the effects on flood flows in the Utuhina Stream catchment from potential urban residential development scenarios in relation to the Rotorua Lakes District Plan.

The product of the work reported here is the generation of input-files to BOPRC's hydraulic MIKE model of the Utuhina Stream and the Utuhina catchment's urban area.

Background

The limits on impervious surface areas in the Rotorua Lakes District Plan are being reviewed by Rotorua Lakes Council (RLC), for residential zones 1 and 2 (ResZ1, ResZ2).

Currently, the district plan limits impervious surfaces to 80% of each parcel's land area in zone ResZ1 and 100% in ResZ2.

This memo describes the methods used to produce hydraulic MIKE model boundary files for two "City-Future" scenarios. These scenarios are both at a design event probability of 1% AEP with 3.68 degrees of atmospheric warming due to climate change:

1. City-Future-A: Maximum land development of ResZ1 areas to the currently permitted 80% impervious, and ResZ2 areas to 100% impervious;
2. City-Future-B: Land development of ResZ1 areas to 70% impervious, and ResZ2 areas to 80% impervious;

In addition to these two scenarios, an as-calibrated "City-Now" scenario has been modelled that represents the current extents/percentage of impervious surfaces in the urban areas.

NLR Hydrologic Model of Utuhina Stream Catchment

In 2019-2020 Bay of Plenty Regional Council (BOPRC) developed a hydrological model of the Utuhina Stream catchment that includes representation of rain-runoff from urban areas of Rotorua City. Details of the NLR hydrologic model, its calibration, and the design-storm method used to operate it in design-mode are most recently described in our March 2021 memo [1].

With respect to impervious surface scenario modelling, the hydrological modelling (this memo) is the first step in a two-step process. The hydrological modelling takes inputs of rainfall data and catchment character, and produces flow-outputs (1st Step). These are then used as flow-input boundary-conditions for hydraulic modelling that determines flood levels and velocities (2nd Step).

Hydrological modelling of urban runoff – City-Now Scenario

The hydrological model has been calibrated against 5 large flood events in the catchment. Although calibration data is very limited, modelling of runoff from the urban areas is consistent with the available rainfall/flood observations. It is also in line with published values for the types of soil present and the degree of urban density.

Comprehensive estimates are not available for the current percentage of impervious ground cover in residential areas of the catchment. A report by WSP OPUS for RLC in May 2018 [2] notes that average impervious ground cover percentages on residential lots in the Otamatea catchment (a large urban subcatchment of the Utuhina) were estimated at 38% by visual analysis of aerial photography.

The calibrated model's effective proportional runoff coefficient (C)[1] for urban areas under the existing situation is based on a simplification that "urban"[2] land can be represented as if residential lots cover roughly 75% of the area with the remaining 25% covered by impervious surface (such as roads). In line with BOPRC guidance publications [3], impervious surfaces were considered to have a runoff coefficient of C=0.85. The calibration work found this simplification to be not-inconsistent with observations (of rainfalls and stream-flows).

In summary: runoff from existing urban surfaces is based on 38% of 75% of the urban areas being impervious (C=0.85); also that 100% of 25% is impervious (C=0.85); and that the remainder: 62% of 75% is fully pervious. From the calibrated effective bulk-area parameter (for urban areas) of C=0.54, this pervious-area runoff coefficient is therefore C=0.18. Note that in non-urban areas the dominant urban Rotorua soil type (Ngakuru Sandy Loam) was found in calibration to respond at C=0.14 - a value also consistent with other BOPRC analysis in the Rotorua area [4],[5].

It is important to note that some ResZ1 areas are classed as either Parkland or Forest within LandCare NZ's LCDB4. Therefore these were modelled as non-urban in the City-Now scenario. Their runoff character is based on soil type and ground cover (vegetation) in the same way as rural areas. These areas are not included in the percent impervious assumptions described above. Urban Parkland areas are coloured light green in figure 2 below. Selected forested areas are shown as dark green.

[1] The model applies a dynamic runoff coefficient that responds to the "soil-state" of the model's conceptual reservoir. In urban areas, the small, short catchments respond rapidly to rainfall and so retain their reservoir state at very close to the initial state - hence f1 (the model's initial runoff parameter) is effectively the same as the Rational Method "C" parameter.

[2] The modelling made use of LandCare NZ's Land Cover Database (LCDB4.1) which has an "urban" category for classes: "built-up land", "urban parkland" and "transport infrastructure".

Within the model, the runoff parameter applied to each subcatchment is calculated proportionally by area from its constituent areas of zoning class, soils, and land cover.

City-Future scenarios - Residential Zones 1 & 2

Unlike for the City-Now scenario described above, for the City-Future scenarios percent-impervious-area data were explicitly determined for every land-parcel. This was carried out for every parcel that is either zoned in one of the urban zoning classes or classed urban by LCDB4 (some small areas of rural-zoned parcels are classed urban by LCDB4).

All privately owned land parcels currently zoned Residential-1 (ResZ1) within the catchment are shown (light brown) in the map below (Figure 1). Unlike our previous MPD analysis [6] parcels owned by RLC (coloured light blue) are not excluded from this analysis. The ResZ1 collection does exclude roads, and parcels with other zonings (such as corner shops, which are zoned commercial).

Under the operative district plan ResZ1 areas can be developed to have up to 80% of their ground surface area covered with impervious materials (City-Future-A scenario). Under the City-Future-B scenario, all parcels zoned ResZ1 are modelled at 70% impervious-area.

Parcels zoned ResZ2 are coloured red in figure 1. These are modelled at 100% impervious in City-Future-A scenario, and at 80% impervious in City-Future-B scenario.

Modelling in the PC2 Area

In 2020 RLC and BOPRC collaborated on modelling of the Utuhina catchment to determine hydrological impacts of the PC2 plan change alongside Pukehangi Road. For that investigation, a separate hydrological model of the PC2 area by RLC's consultants WSP was nested within BOPRC's Utuhina catchment modelling [7].

For the work reported here, the PC2 area has been modelled using the BOPRC model. It is represented across the three design scenarios “as calibrated”. This means that no change to the runoff character has been modelled in that area. The reason for this approach is that under the plan change provisions any development activities within the PC2 area are required to show no hydrological impact – for example by implementing mitigation ponds and dams.

This assumption may not be entirely valid for final design of future flood protection systems downstream, but it is considered appropriate for indicative modelling of the impact of planning rules for the remainder of the urban area.

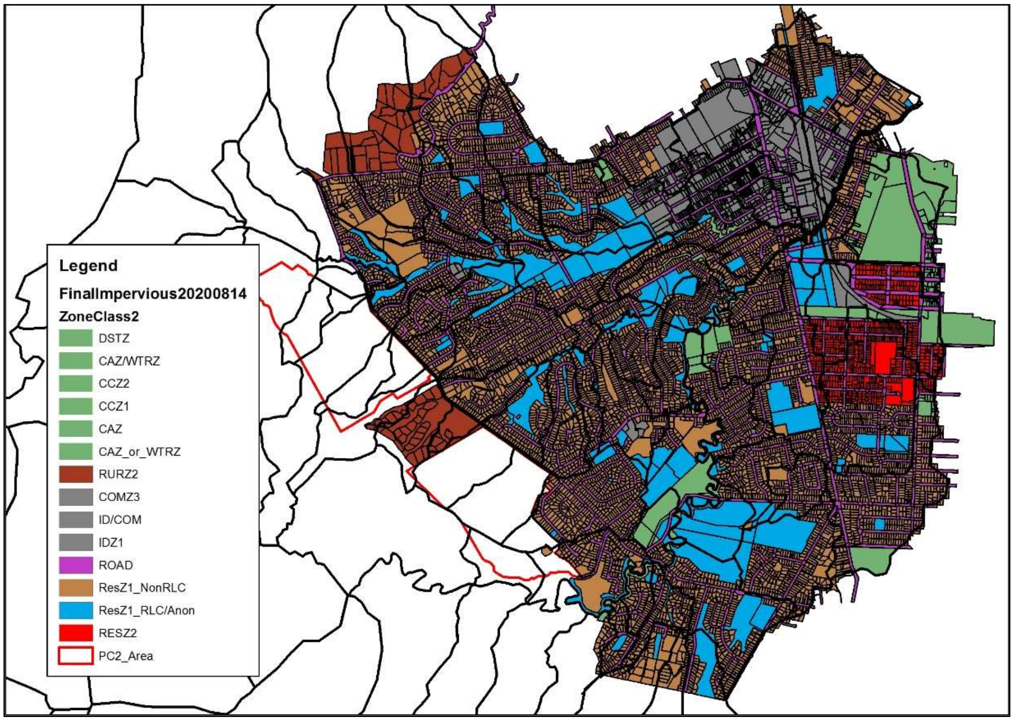


Figure 1: Map of urban Utuhina Catchment, Rotorua City showing the zoning extents. ResZ1 parcels in private ownership are shown in light brown. ResZ1 areas owned by RLC or other public entity are shown light blue. ResZ2 areas are shown in red.

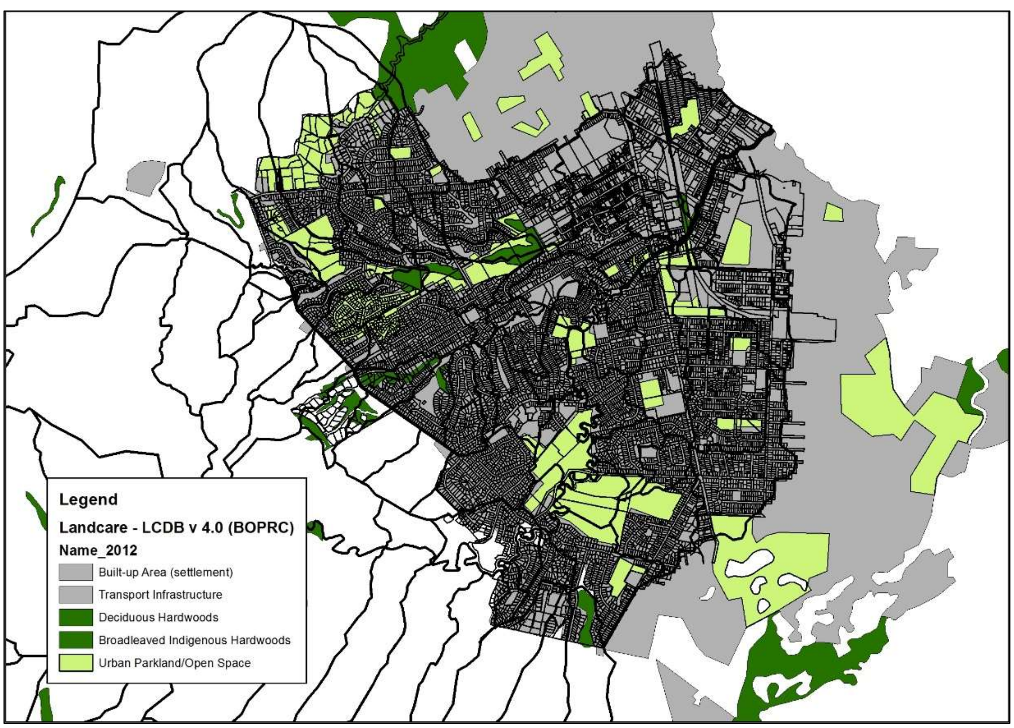


Figure 2: LCDB4 land-cover classification map of urban Utuhina Catchment, Rotorua City. Grey areas are either "built up area" or "Transport Infrastructure". Urban Parkland is shown light green. Selected forested areas are shown dark green.

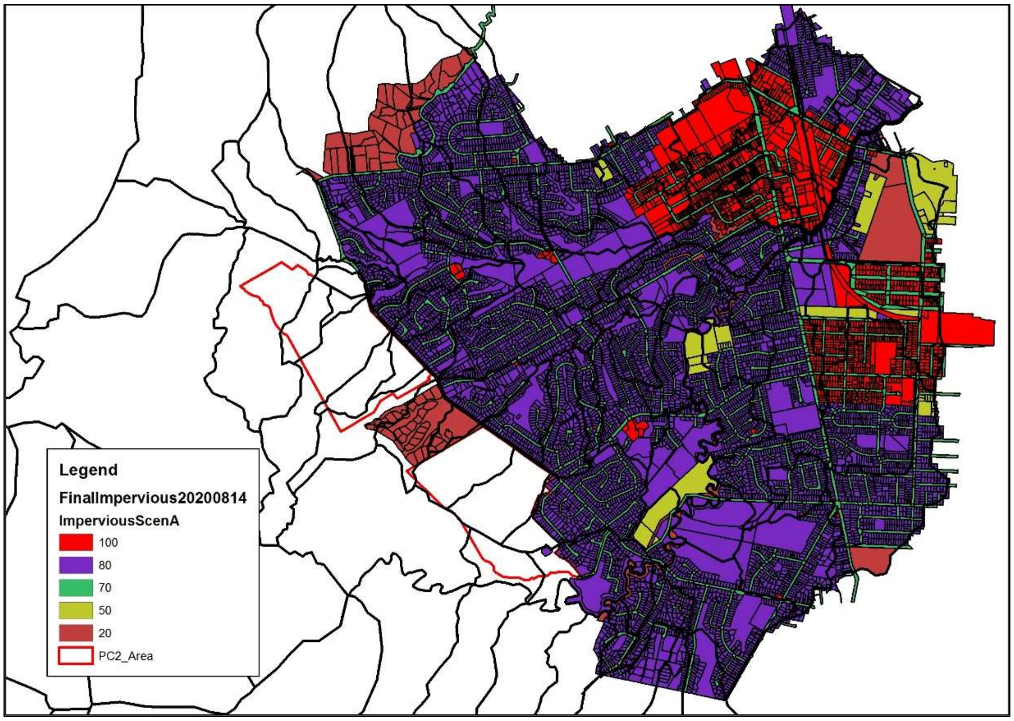


Figure 3: Percent impervious area map for Scenario City-Future-A.

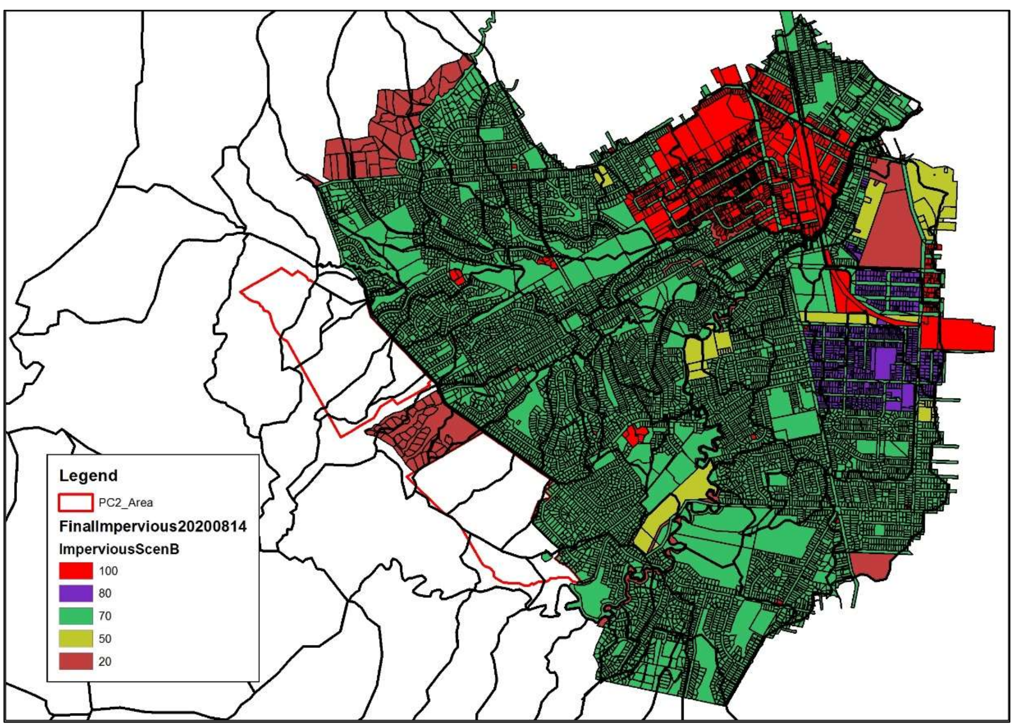


Figure 4: Percent impervious area map for Scenario City-Future-B.

References

[1] Blue Duck Design Ltd*, Utuhina Hydrological Model Establishment Calibration update*, 15 March 2021

[2] WSP OPUS, May 2018, *Catchment 14 - Stormwater Model Build and System Performance Report,* Table 3.4

[3] *Hydrological and Hydraulic Guidelines*, BOPRC Guideline 2012/02, Table 5.2

[4] *Hydraulic Modelling of the Ngongotaha Stream*, BOPRC Operations Publication 2007/05

[5] *Waingaehe Stream Hydraulic Capacity Review*, BOPRC Operations Publication 2008/02

[6] Blue Duck Design Ltd, *Utuhina Hydrological Modelling, Indicative residential development effects under current zoning rules*, 5 August 2020

[7] WSP, PC2 – Pukehangi Heights, Stormwater Report, 14 September 2020