Omokoroa Stormwater Model

Model Build Update and System Performance Report

Prepared for Western Bay of Plenty District Council
Prepared by Beca Limited

31 July 2019

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Contents

Appendices

Revision History

Revision Nº	Prepared By	Description	Date
0	**Elliot Tuck**	Draft for Client Review	14/06/2019
1	**Elliot Tuck**	Final	31/09/2019

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Elliot Tuck/Tracey Myers**		31/07/2019
Reviewed by	**Gareth Hall**		31/07/2019
Approved by	**Graham Levy**		31/07/2019
on behalf of	Beca Limited		

Executive Summary

In 2017 Western Bay of Plenty District Council had a new stormwater network model constructed for the Omokoroa Peninsula. This model was a 1D model with basic overland flow paths included in the 1D layout. In 2018, Beca Limited created a 2D model for the Stormwater Management Plan (SWMP) Addendum. This model had no pipe network included and was used for planning purposes.

Since the models were constructed, there has been a lot of development resulting in hydrological changes. These changes are in line with the District Plan Zoning for the area. In December 2018, Western Bay of Plenty District Council commissioned Beca Limited to combine the 1D and 2D models and include the updates.

At the time of the 2017 model build, there was no urban development south of the railway. Rural areas between the railway and the northern (urban) end of the peninsula was also largely undeveloped. Since then, the land both north and south of the railway has been developed. Therefore, new model runs are based on land use changes proposed in the District Plan.

Rainfall figures for New Zealand have also been updated (HIRDS V4). These figures have been incorporated into the model including an allowance for climate change using RCP 8.5 to the year 2100. These new figures represent a reduction in rainfall when compared to HIRDS V3 which was used by the previous models.

The stormwater network has also been updated to reflect the latest GIS data available. This allowed more data to be added to the existing modelled network (mainly in the form of additional sumps/catchpits) but also new developments that have occurred. One limitation to this is, although the new model contains the latest pipe network the surface attached to these new networks still relies on LiDAR flown in 2010 and will not represent flow paths in these newly developed areas.

The model uses updated tide predictions, supplied by NIWA, which also account for sea level rise.

The model remains uncalibrated due to a lack of suitable data for calibration.

Model results produced by the combined model are similar to those produced by the 2018 2D model. The added benefit of the combined model is the ability to interrogate the pipe network during rainfall events. This update provides greater confidence in the model results for the peninsular.

1 Introduction

1.1 Background

In May 2017, a 1D stormwater network model for the Omokoroa Peninsula was prepared for Western Bay of Plenty District Council (WBoPDC) by Mott MacDonald. The model was produced to complete a system performance study of the network. This model included the stormwater network at the time of building, catchments delineated using LiDAR and a basic representation of overland flow via 1D flow paths.

Since the network model was constructed in 2017, areas of the Omokoroa peninsular have been developed resulting changes to the runoff in a number of catchments. In 2018, Beca Limited created a 2D model (for the Stormwater Management Plan (SWMP) Addendum. This model had no network included and was used for stormwater planning purposes and was based on future land use.

In December 2018, Western Bay of Plenty District Council commissioned Beca Limited to provide an update to the model. The 1D and 2D models were combined and updates to the stormwater network added from GIS data provided by WBoPDC.

1.2 Scope of Work

This model is an update of the previous model, to recognise changes since 2017, including:

- Add 2017 1D network model to 2018 Beca 2D model
- Remove overland flow paths from the 1D model (now represented in 2D surface)
- Remove storage nodes from 1D model (now captured in 2D), apart from the basin that is not shown on the ground model near Omokoroa Road / Tralee Road roundabout.
- Add any new stormwater network from GIS supplied by WBoPDC
- Clean up network data from GIS suitable for a hydraulic model
- Update rainfall data using HIRDSV4 including allowance for climate change
- Add tide levels based on NIWA Tauranga Harbour model
- Run models for MPD land use based on District Plan
- Provide results for mapping by WBoPDC

2 Model Build

2.1 Modelling Software

The 1D network model was originally constructed in MIKE URBAN, Release 2014, Service Pack 3. The 2D model was constructed in ICM and therefore we have converted the 1D network model to this same format, ICM, Version 9.0. 2.Model Data

2.1.1 Asset Data

The data used in the model build was obtained from three main sources (supplied by WBoPDC):

1. 1D Network Model of Omokoroa Peninsula
2. WBoPDC GIS Data
3. DEM (derived from LiDAR survey)

At the beginning of the project a gap analysis of asset data was undertaken. We have assumed that the data in the 2017 network model was correct, so the gap analysis concentrated on the new network that was added to this model. The gap analysis identified assets where the GIS dataset was missing information or included inconsistent data (i.e. negative pipe slopes). Where appropriate missing data has been interpolated, such as LiDAR data has been used for manhole lid level elevations, where these were missing. It was discovered through this process that the council GIS network lacked continuity and required manual connection to allow runoff to be conveyed by the network in the model.

2.1.2 Hydrometric Data

No flow gauge data is available within this catchment.

2.1.3 Topographical Data

The model build utilised a 1 m resolution Digital Elevation Model (DEM) provided by WBoPDC. The LiDAR was flown in 2010. This data was then converted into a mesh for modelling (explained further in Section 4.3).

2.1.4 Combining Models

In joining the two models some element had to be removed such as:

- 1D overland flow paths. These were inserted in the 1D model to represent flow channels once the network had surcharged
- Stormwater basins that were represented in the surface

The Mott MacDonald 1D model was added to the Beca 2D model. We removed the overland flow paths from the network as it is now going to be modelled in the 2D. We added and cleaned up the extra information included in the GIS data provided by WBoPDC. We updated the rainfall and tide level data.

3 Hydrological Model

3.1 Method used

The hydrological routing model for the Omokoroa Stormwater model was developed following the methodology set out in the WBoPDC Guidelines *(Western Bay of Plenty District Council Modelling Guidelines, April 2014).* Losses are based on the Soil Conservation Service (SCS) curve number method (similar to that used by Auckland Council, Technical Publication 108). Curve numbers are based on soil type and land use cover.

3.2 Land Use

At the time of the 1D network model, there was almost no urban development south of the railway. Rural areas between the railway and the northern (urban) end of the peninsula were also largely undeveloped. Since then, the areas north and south of the railway have begun to be developed.

The Land Use in 1D network model was split into pervious and impervious. The land use used for the pervious areas is described as 'Open spaces, lawns, parks, golf courses, etc.' This equates to SCS curve number 61 for soil class B. The SCS curve number used for the impervious areas is 98, described as 'Paved parking lots, roofs, driveways, etc.).

The future land use map used in the combined modelling has been based on the structure plan zoning. The zone and soil type dictate which curve number or runoff was applied to each area. Table 1 shows the curve number for each soil type (A, B or C) and the land use zoning. The soil types were previously mapped and have been relied upon for this update. Soils in groups B and C were identified in the Omokoroa catchment.

The curve number is then weighted for the percentage of pervious and impervious in each differing land use.

Table 1 Curve Numbers used in modelling

Scenario	Land use	Percent Impervious [%]	Soil Group A	Soil Group B	Soil Group C
District Plan Zones	Rural residential	15	47.9	66.6	77.6
	Medium density residential	50	68.5	79.5	86.0
	Industrial	72	81.0	88.0	91.0
	Future Urban -->Medium Density	50	68.5	79.5	86.0
	Commercial	85	89.0	92.0	94.0
	Residential	80	86.2	90.6	93.2
	Stormwater Reserves	0	39.0	61.0	74.0

These curve numbers have been applied to the rainfall event prior to insertion in the 2D model. This is explained further in Section 3.3.1

3.3 Rainfall

3.3.1 Rainfall Data

The rainfall events were produced using NIWA's High Intensity Rainfall System (HIRDS) V4.

A 24-hour nested storm hyetograph was created using the alternative block method which incorporates the intensity for a range of durations. Figure 1 gives an example of the rainfall that has been used in the model.

The rainfall event has been applied to the model as net or excess rainfall. This means the losses (infiltration) have been calculated (using curve numbers) and removed from the rainfall hyetograph before it has been applied to the model surface. Figure 1 shows the nested rainfall hyetograph (blue) and the losses are plotted on top of this (red). The remaining rainfall is then applied to the model. The spatial application of the net rainfall is based on the future land use zones and soil type is applied as polygons to the modelled surface.

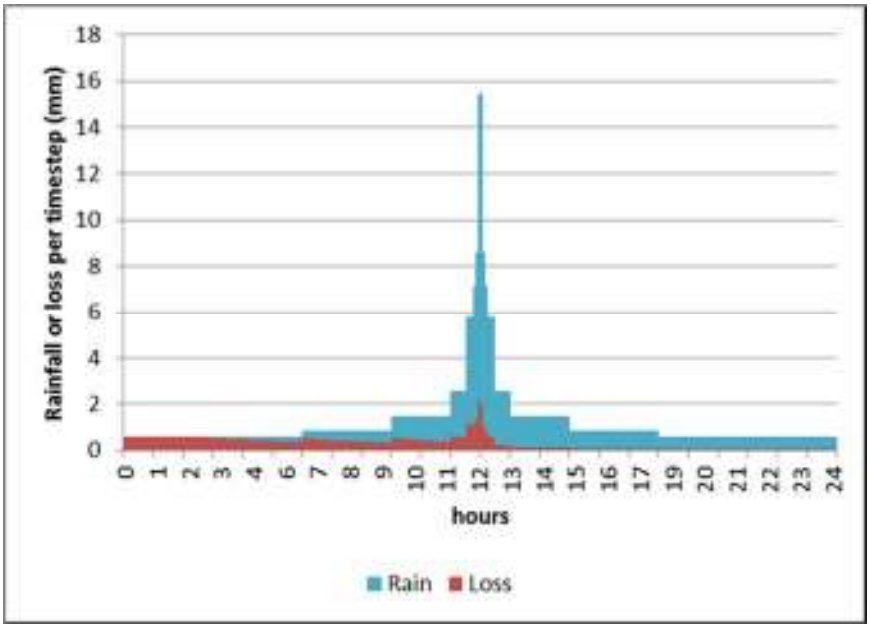

Figure 1 Example Rainfall Hyetograph Used in the Omokoroa Stormwater Model

3.3.2 500 Year ARI

HIRDS outputs only give values up to the 250 year ARI event. To extrapolate to the 500 year ARI event the following equation was used:

$$I(t,T) = \frac{19 \log T + 23}{(13+t)^{0.87}}$$

where I is intensity, T is recurrence interval, t is event duration. This method is documented in *Extreme Rainfall Events and Probable Maximum Precipitation*, 2013. Figure 2 Shows the fitted extrapolation plotted against the HIRDS intensities

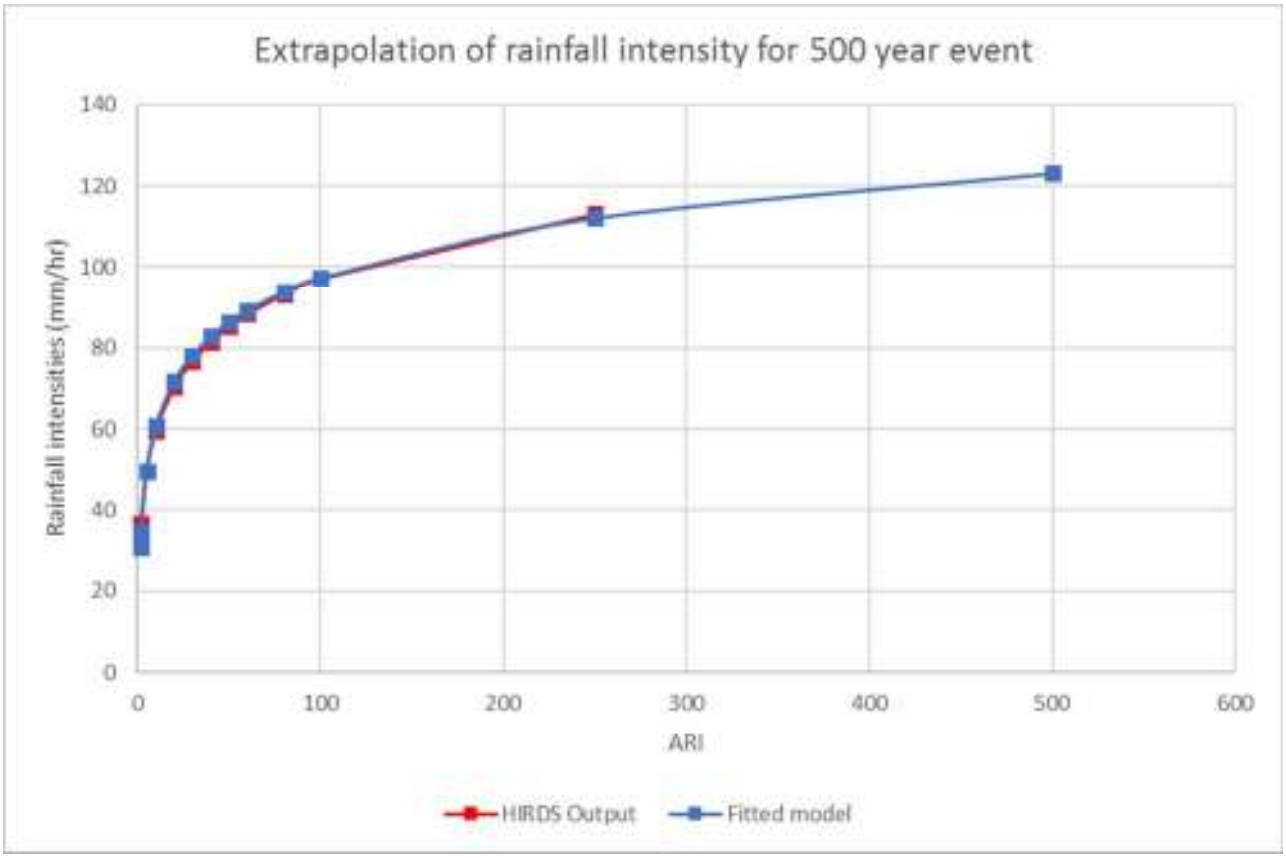

Figure 2 500 Year ARI 30min Rainfall Extrapolation

This extrapolation was applied to all durations from 10 minutes to 24 hours to allow a nested storm to be constructed.

3.3.3 Climate Change

Climate change has been allowed for in the rainfall by using Representative Concentration Pathways (RCP) scenario 8.5 to 2100.

3.3.4 Possible Maximum Flood (PMF)

The PMF requires that a possible maximum precipitation event is created. To develop a 24hr nested rainfall event (as used for the design events) we relied on two methodology. *Probable Maximum Precipitation for small areas and short durations*, *Thomson and Tomlinson, 1996* was used for the durations from 10 minutes to 6 hours and *A Guide to Probably Maximum Precipitation in New Zealand, NIWA, 1995* for durations from 6 hours to 24 hours. Table 2 shows a comparison of the 24-hour depths used in the modelling.

Table 2 24 Hour Rainfall Depths

ARI	2yr	10yr	20yr	50yr	100yr	500yr	PMP
24 hour depth (mm)	106	165	191	228	256	322	832
24 hour depth + CC (mm)	125	199	232	278	314	389	832

The PMP 24 hour depth is over twice that which would fall in a 500 year ARI event.

It should be noted that rain depths for this area have reduced from those of HIRDS V3, e.g. HIRDS V3 100yr ARI 24hr depth including CC was 343mm.

4 Hydraulic Model

4.1 Method Used

The stormwater network was modelled using ICM V9. The model was simulated as a continuous event over 24 hours.

4.2 Hydraulic Model Extents

Previously the 1D hydraulic analysis was completed by adding overland flow paths to the 1D model. For this update we have developed an integrated 1D/2D model, to better understand the overland flow paths and their interaction with the network.

All the piped network for Omokoroa Peninsula has been included in the model. This network consists of the pipes, manholes, and sumps.

Table 3 below summarises the hydraulic model components for the Omokoroa stormwater model.

Table 3 Hydraulic Model Components

Hydraulic Model Components	Values
Total number of stormwater network system nodes	1,099
Total number of stormwater network system pipes	1,111
Total number of outlets	106

Figure 3 shows the extents of the modelled stormwater network. The network extends from the railway line on the south to the tip of the peninsular.

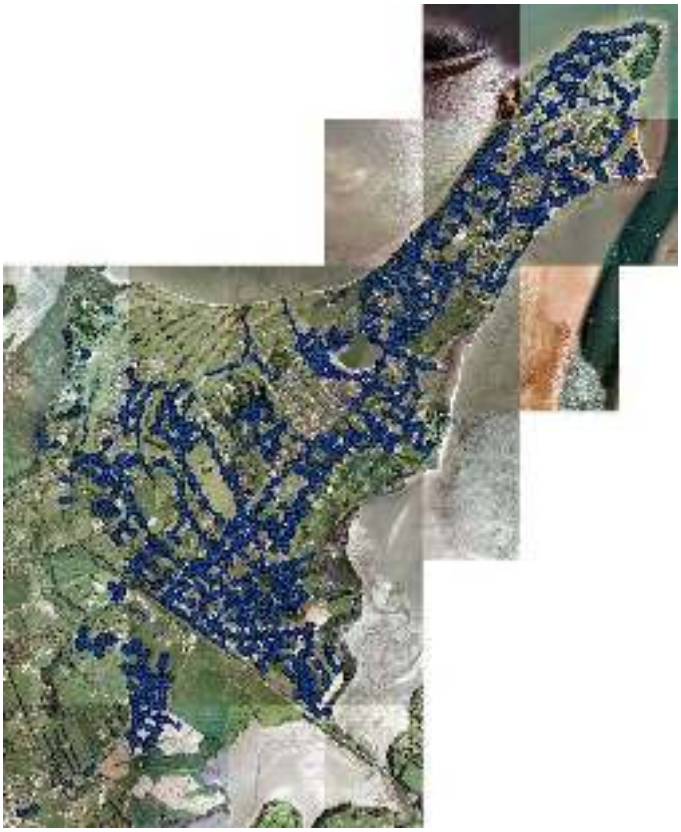

Figure 3 Modelled Stormwater Network

4.2.1 Primary Stormwater System

The primary system refers to all stormwater pipes and open channels designed for stormwater conveyance. For the primary system, 'nodes' represent inlets, manholes, junctions, and outlets.

No additional survey was undertaken as part of this project. It is recommended that checks be made on site if relying on any model network information for design purposes.

Node Locations and Names

Nodes were taken directly from the 2017 network model or directly from the GIS dataset supplied by WBoPDC.

Nodes from the GIS dataset were named according to the WBoPDC GIS asset IDs.

Node parameters

Given the change in modelling method from the 1D model (catchments applied directly to Manholes) to the 2D model Rain on grid model it required that sumps/catch pits be included to allow surface flow to enter the pipe network.

All nodes with no diameter listed in the GIS base data were assigned diameters based on the maximum pipe diameter of all connecting pipes. The minimum diameter applied was 1.05 m**.**

Node Cover Type

The '2D' lid type was applied to all the nodes apart from outfalls. This ensures that water spilling out of manholes is conveyed overland in the secondary system and water flowing from the surface can enter the network.

Detention Basins

There are 11 formal stormwater detention ponds in the Omokoroa catchment. The network model included nine of which 8 were removed. This was undertaken to prevent 'double counting' the storage in the system. One of the basins is not shown on the 2D surface, and this has been modelled as a storage node. Basin discharge controls have been included in the piped network.

Pipe Diameters

Pipe diameter values were predominantly sourced from WBoPDC GIS data, with interpolation and historic survey used to assign values where required.

Any pipes 100 mm diameter or less have been removed from the model. It was assumed, and confirmed by WBoPDC GIS, that these are private connections.

Pipe Inverts

For most links in the model, the invert of the pipe was taken directly from the supplied GIS data. Interpolation was applied where data was missing or inconsistent in the GIS. No site survey work was undertaken to confirm these.

4.2.2 Secondary System (Overland Flow Paths)

The 'secondary stormwater system' consists of overland flow paths which represent the surface water network (i.e. surface flooding pathways), which flow once the primary (piped) system is capacity is exceeded. In this case the overland flow paths are represented in the 2D surface.

4.3 2D Mesh

The method chosen was a Rain on Grid (ROG) approach. This method provides adequate definition and has the advantage of accurately defining catchments by providing flow to each stormwater inlet.

The model surface was built using LiDAR flown in 2010 which was then converted to a triangulated mesh. The maximum triangle size has been limited to 200 m² in rural areas. This was reduced to 50 m² on roads and in water courses. The triangle size was reduced in these areas to enable the model to more accurately calculate flow along roads and streams as this is where most of the overland flow converges.

4.4 Energy Losses

4.4.1 Link Losses

Manning's roughness coefficients were assigned to the links in the network model. These coefficients have been retained, and the same coefficients applied to the network that has been added. Table 4 gives the Link Energy Losses used in the model.

Table 4 Link Energy Losses

Link Material Type	Manning's n Used
Normal Concrete	0.013
Smooth Concrete	0.012

4.5 Boundary Conditions

Boundary conditions have been applied to the model in two different ways:

- Fixed water levels representing the highest tide have been applied directly to outlets
- A tide water level has been applied to the portion of the 2D surface representing the harbour

4.5.1 Tidal Data

NIWA is currently creating a hydraulic model of the tide levels in Tauranga Harbour. This work has not been finalised, but we have obtained interim results. We applied the tide level as a constant level at the ocean outfalls. We also created a 2D initial condition in the model, that allows the areas that would already be inundated start the simulation as wet, which helps with stability of the model. Table 5 gives the tide levels supplied by NIWA. The tide levels used are those associated with 1.25 m sea level rise (SLR) due to climate change. These were selected as we required 2%, 1% and 0.5% AEP to satisfy the scenario matrix, and were those used by NIWA in the Harbour Model and reflect SLR to 2130 scenario TCP 8.5 median (rather than 0.49 m to 2090 that is described in BoPRC guideline).

Table 5 Tide Levels including Sea Level Rise

AEP	SLR (m)					
	0.13	0.4	0.6	0.8	1.25	1.6
2%	2.07				3.24	
1%	2.23	2.53	2.74	2.95	3.39	3.74
0.2%	2.65				3.80	4.13

5 Model Limitations and Assumptions

5.1 Model Limitations

The Omokoroa model has been updated using the Western Bay of Plenty Stormwater Modelling Guidelines (April 2014).

No flow survey was undertaken, and therefore we have not calibrated or validated the model against existing flood events.

5.2 Hydrological Model Assumptions

The rainfall applied to the model was obtained from HIRDS V4 which does not include 500 year ARI event. To define this, we extrapolated the rainfall predictions from HIRDS, which will only be approximate.

Rainfall losses have been carried over from the 2018 2D model, where the land use coverage was based on District Plan Zones current at the time.

5.2.1 Attenuation Basin Operation

Of the 11 Stormwater basin within Omokoroa, 10 are represented in the 2D portion of the model and 1 has remained in 1D. Outlet structures have been retained from the network model. Detailed analysis of the operation of these basins has not been completed.

5.3 Hydraulic Model Assumptions

5.3.1 LiDAR data

We have assumed that the LiDAR data is correct and have not edited it. We have updated the manhole cover levels, where missing, to be the same as the LiDAR level. However, we note that in areas where development has occurred since the LiDAR was flown (2010) the ground surface model will not be accurate.

The Lidar data has then been converted to a mesh with triangle size limited to 50m² (road and water courses) and 200m² (rural). It has been assumed this is sufficient detail to represent flooding within the catchment.

5.3.2 Asset Data Errors

All network data connectivity was checked before being entered in the model. Checks were undertaken to identify missing or incomplete data, as well as inconsistencies in the GIS data set (such as negative slopes, pipes decreasing in diameter downstream, etc.).

We inferred missing ground levels using the ground model. We inferred missing pipe diameters by comparing against the upstream and downstream pipes. We interpolated missing invert levels using the ICM Inference tool. Some imported pipes required the use of the reverse links tool due to reversed Upstream/downstream link connections.

5.4 Quality Assurance and Quality Checks

5.4.1 Instabilities

During the initial runs of the combined model instabilities, mainly in the 1D network occurred. A series of minor fixes have been completed to reduce the instability seen within the results.

6 Model results

6.1 Simulation Matrix

15 runs were proposed. These contain a combination of rainfall and tide events (which is then reversed) both with and without climate change. Table 6 presents all scenarios run as part of this modelling assessment.

Table 6 Modelled Scenarios

Event	Rainfall (ARI)	Tide (ARI)
10 year ARI	10 year	2 year
	2 year	10 year
10 year ARI + CC	10 year	2 year
	2 year	10 year
50 year ARI	50 year	20 year
	20 year	50 year
50 year ARI + CC	50 year	20 year
	20 year	50 year
100 year ARI	100 year	20 year
	20 year	100 year
100 year ARI + CC	100 year	20 year
	20 year	100 year
500 year ARI + CC	500 year	100 year
	100 year	500 year
PMF	PMP	100 year

6.2 Model Results

The model results flood maps are attached in Appendix 1.

Given the size of the peninsular, modelled water depths at individual properties are difficult to determine due to the scale of the flood maps. If specific property water depth information is required the model outputs will need to be interrogated.

7 Conclusions

7.1 Conclusions

The 100 year ARI flood mapping shows similar results to those produced by the 2018 2D model. This is likely due to the fact that in the 100 year ARI event the pipe network is at capacity and a majority of flow is overland. The flooding has reduced slightly, and this is due to the reduction in rainfall caused by moving from HIRDS V3 to V4.

The gullies where overland flow converges are relatively confined meaning that as flows increase the extent of flooding remains similar.

To assess the effect of increasing ARI rainfall on flow a flow line has been drawn within a sub catchment to calculate flow passing over it. The location of the flow line is shown in Figure 4.

Figure 4 Location of flow line for comparison

The location of this line is in a catchment that has seen recent landuse change.

Figure 5 shows that flows range from 7m³/s in a 10 year ARI to almost 14m³/s in a 500 year ARI. The PMF hasn't been plotted due to scale but peaks at 40m³/s.

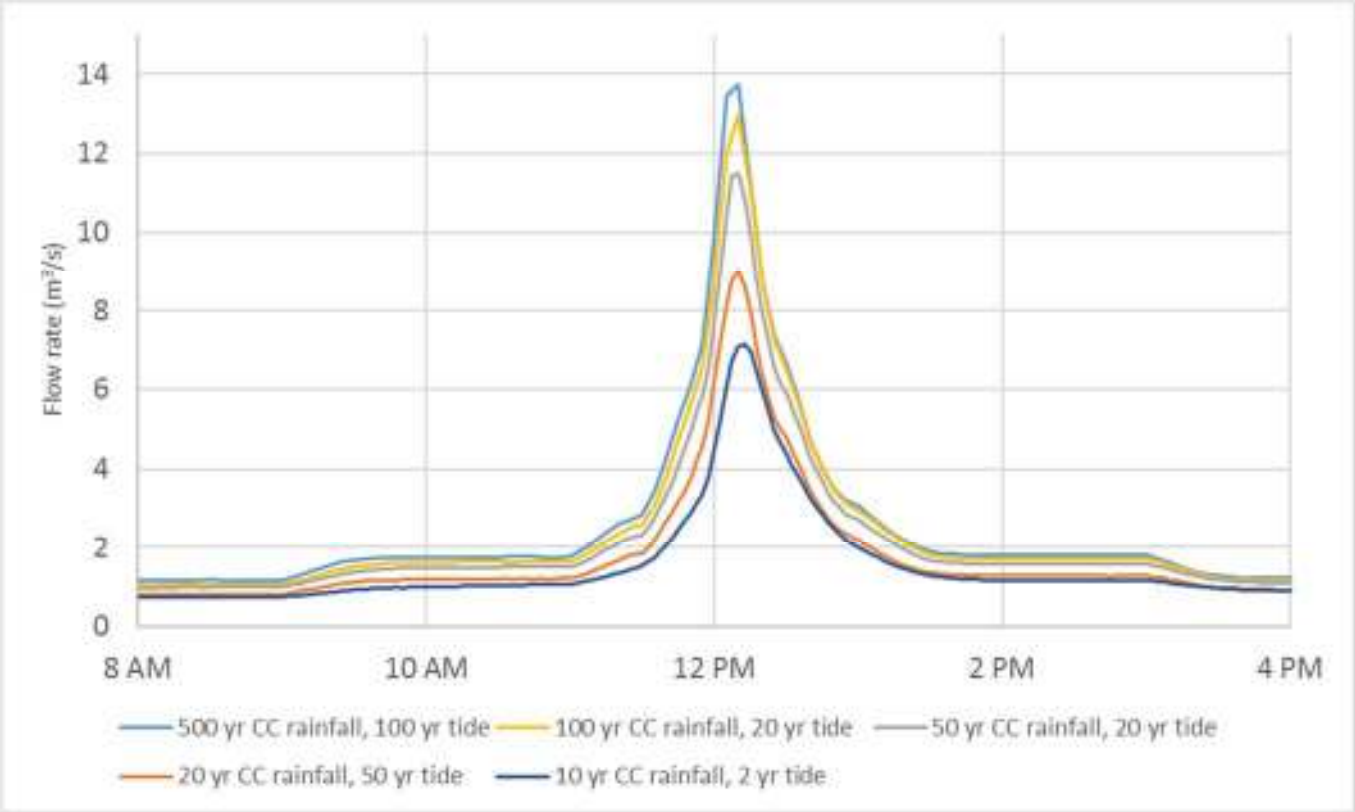

Figure 5 Comparison of flow at flow line

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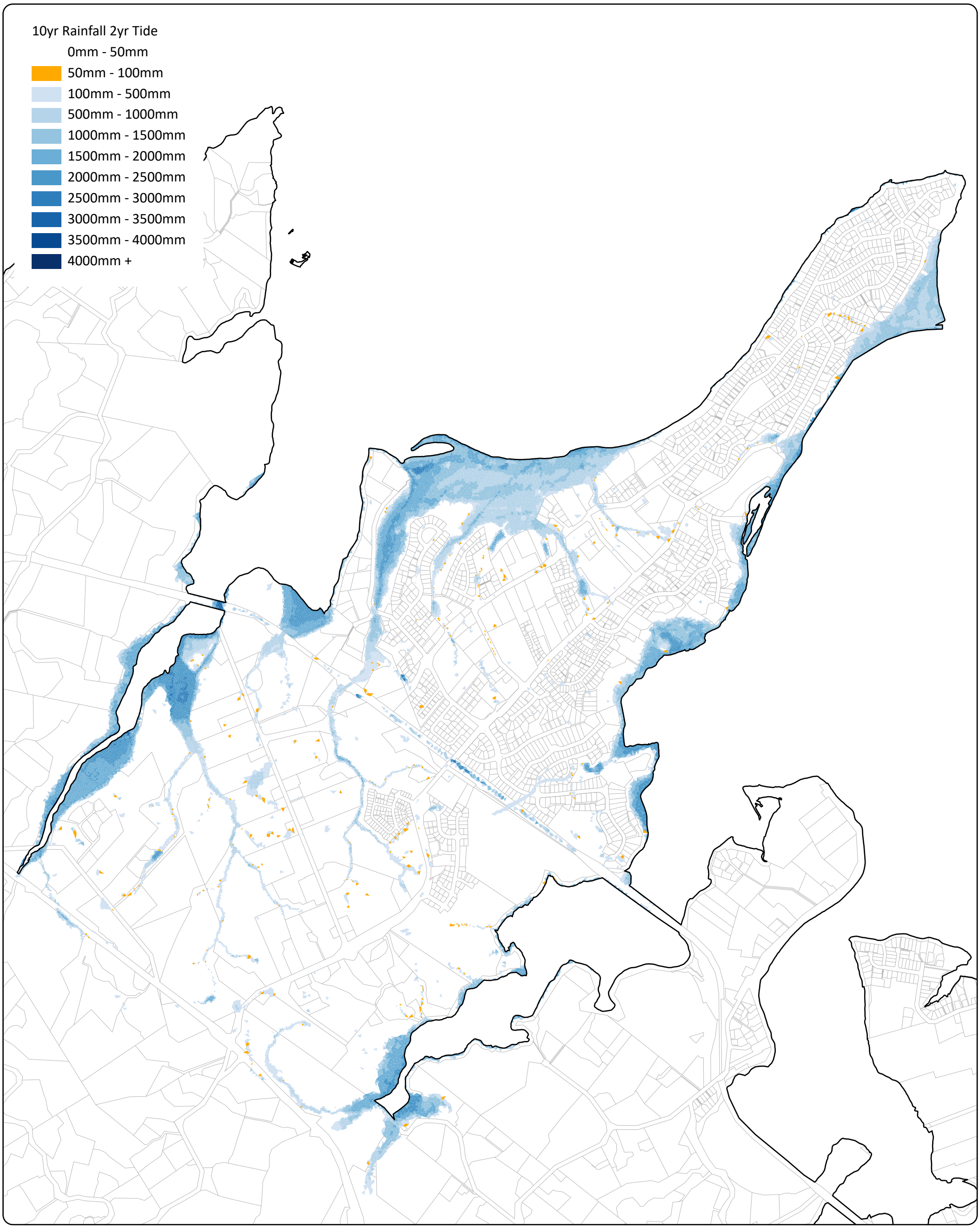
Appendix 1 Maximum Depth Flood Maps



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Date: 24-Jun-19
Operator: rro
Map: Omokoroa Modelling Results

Scale A3 - 1:17,000

0 125 250 500 750 1,000 Meters

Western Bay of Plenty District Council

Omokoroa Modelling Results
10yr ARI Rainfall, 2yr ARI Tide

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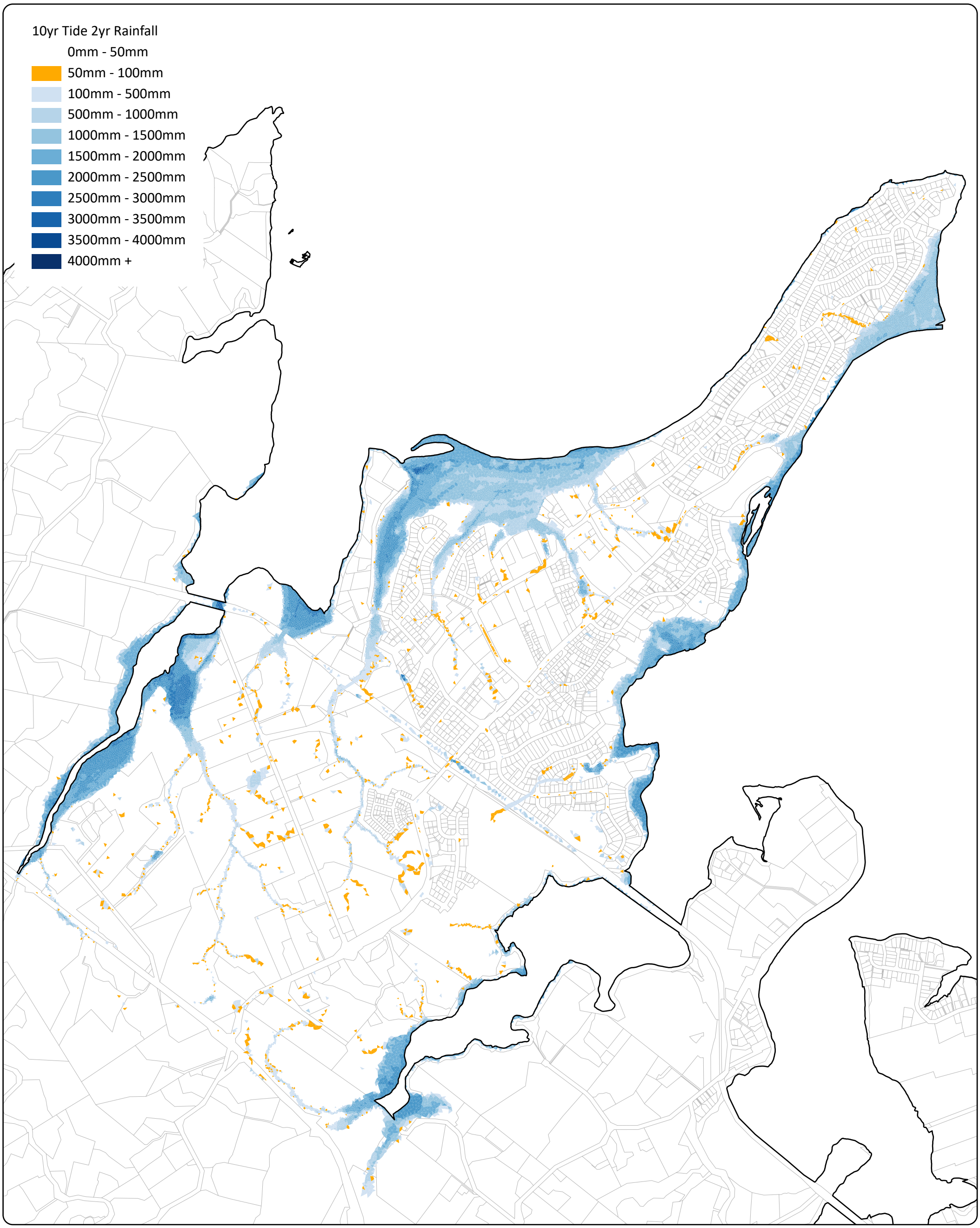

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Western Bay of Plenty District Council

Omokoroa Modelling Results
10yr ARI Tide, 2yr ARI Rainfall

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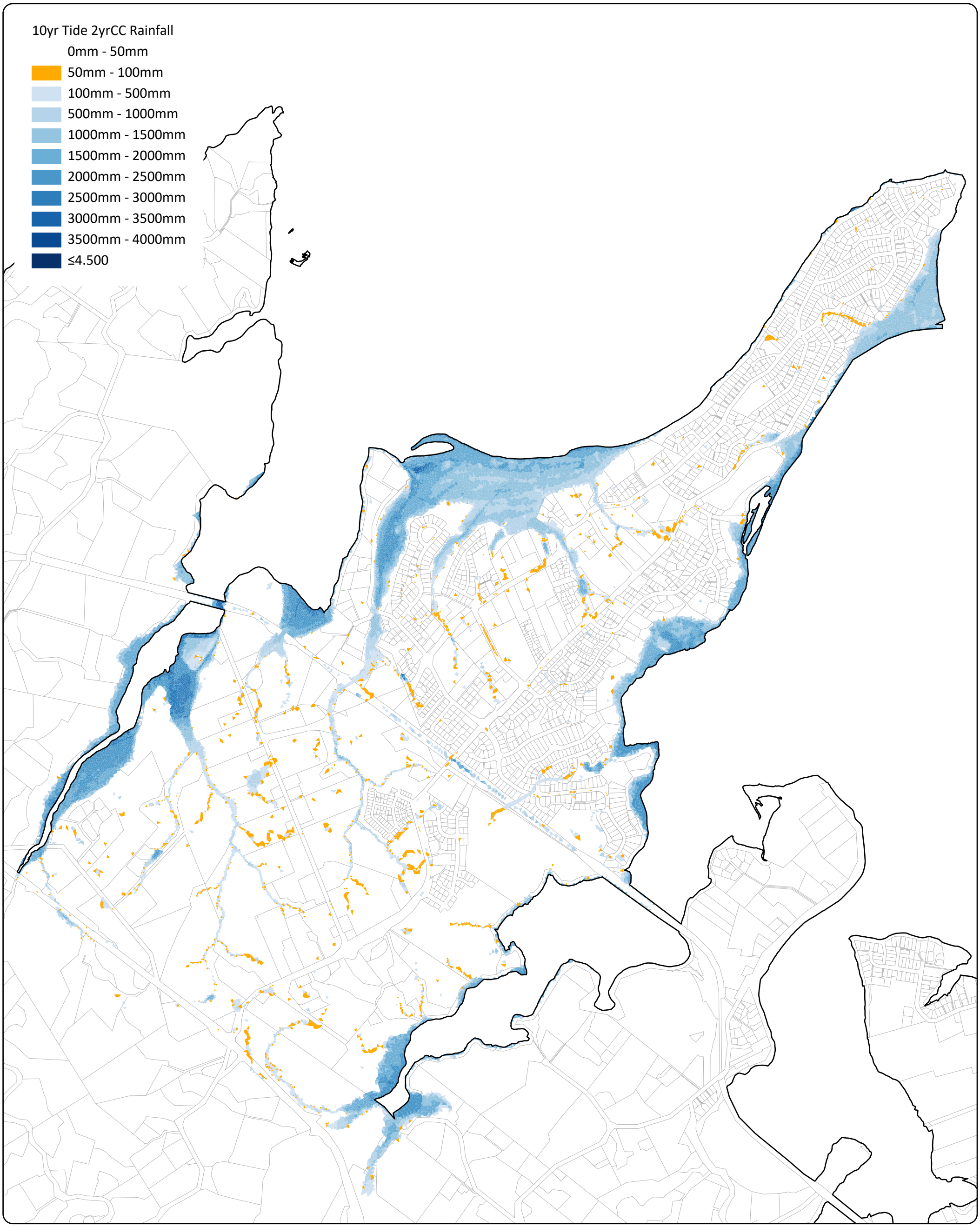

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Western Bay of Plenty District Council

Omokoroa Modelling Results
10yr ARI Tide, 2yr ARI Rainfall + CC

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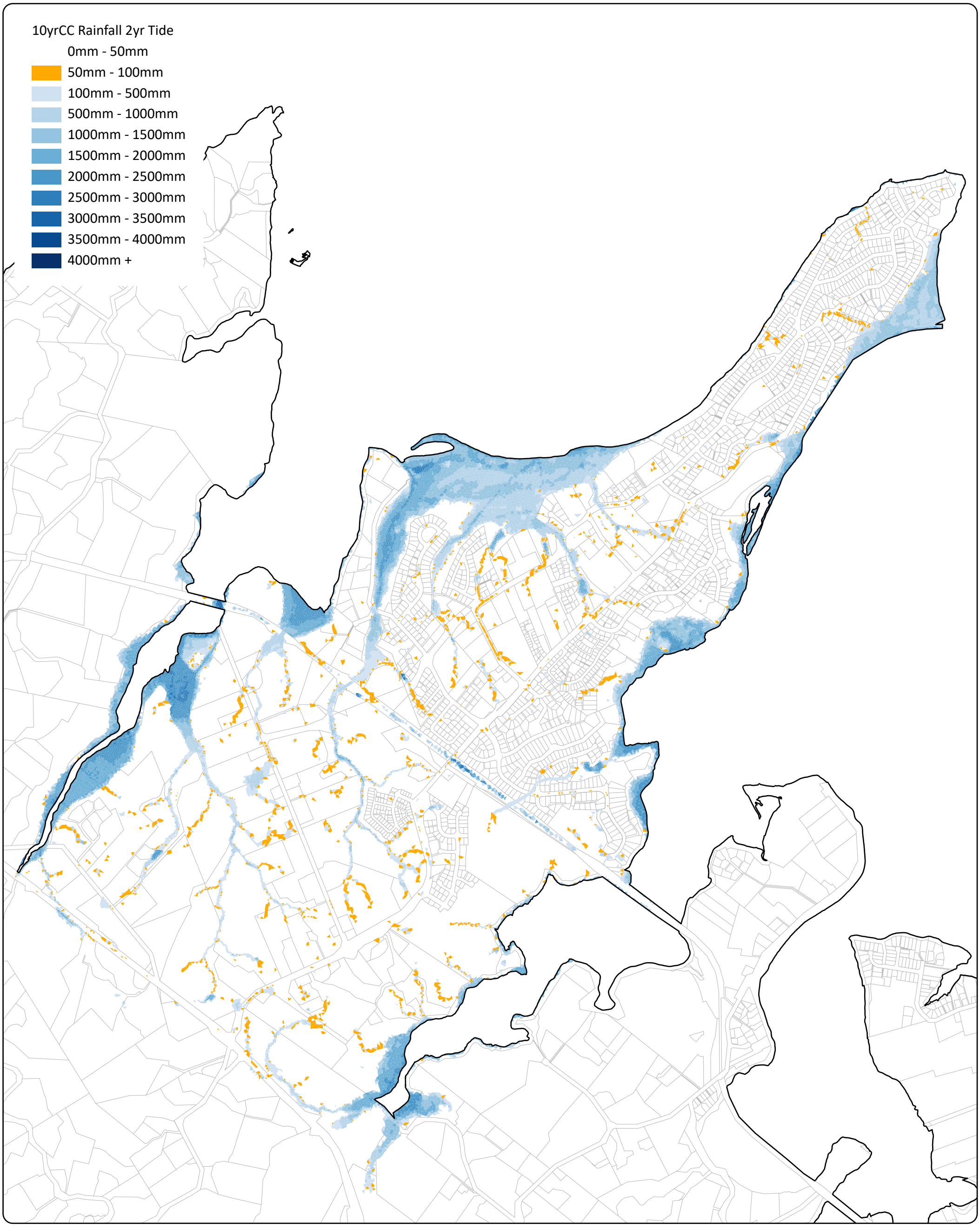

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Western Bay of Plenty District Council

Omokoroa Modelling Results
10yr ARI Rainfall + CC, 2yr ARI Tide

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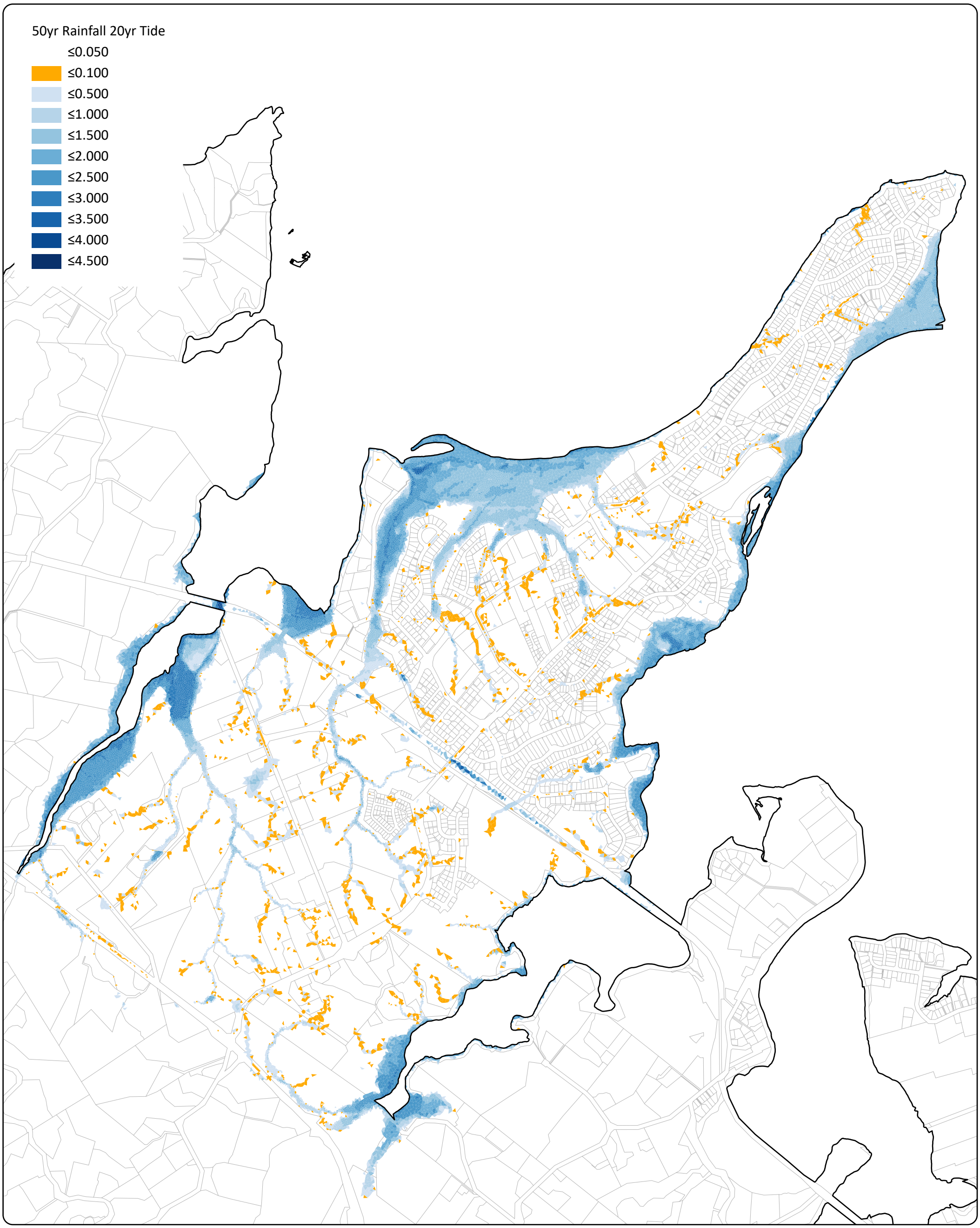

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Omokoroa Modelling Results
50yr ARI Rainfall, 20yr ARI Tide

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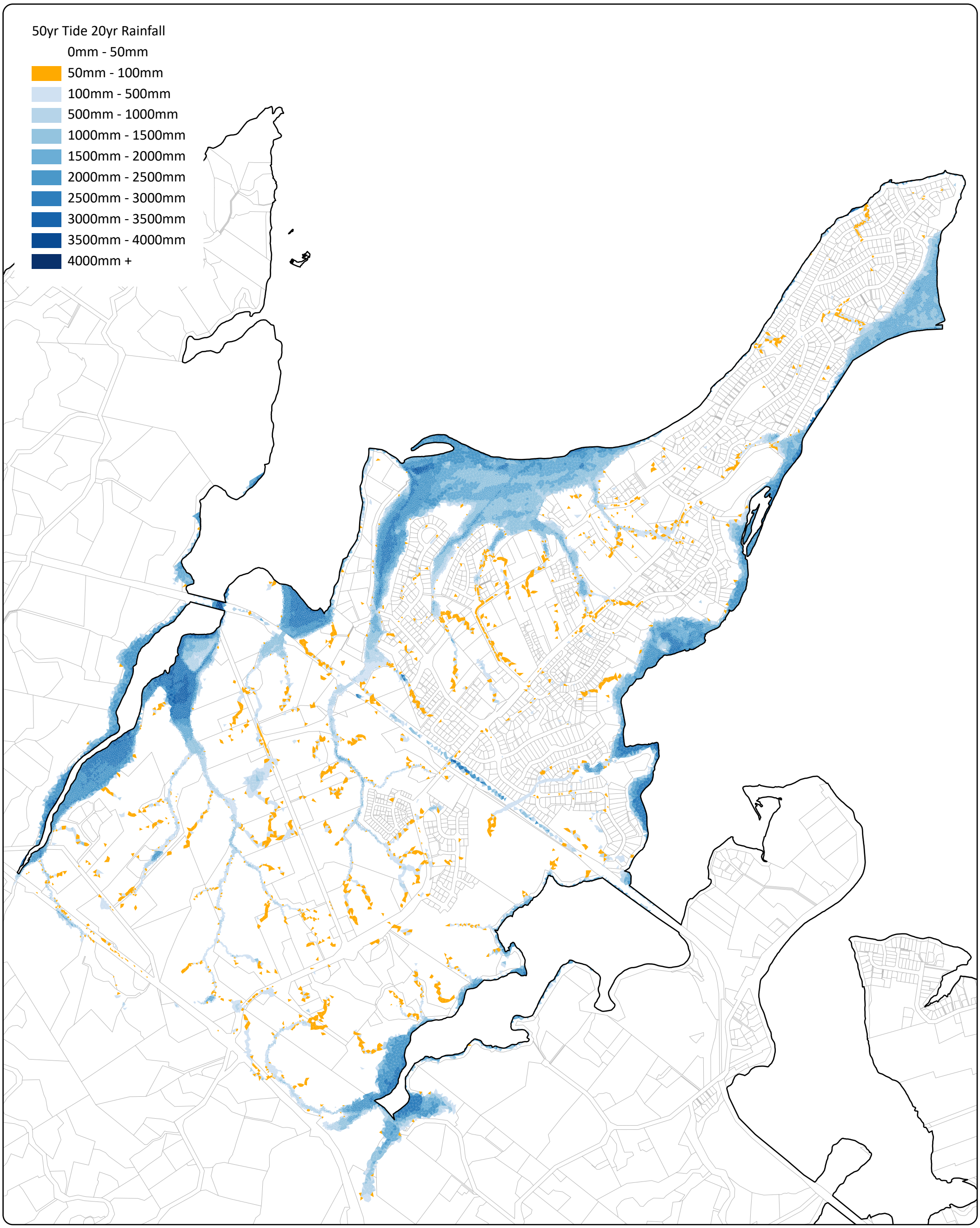

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Western Bay of Plenty District Council

Omokoroa Modelling Results
50yr ARI Tide, 20yr ARI Rainfall

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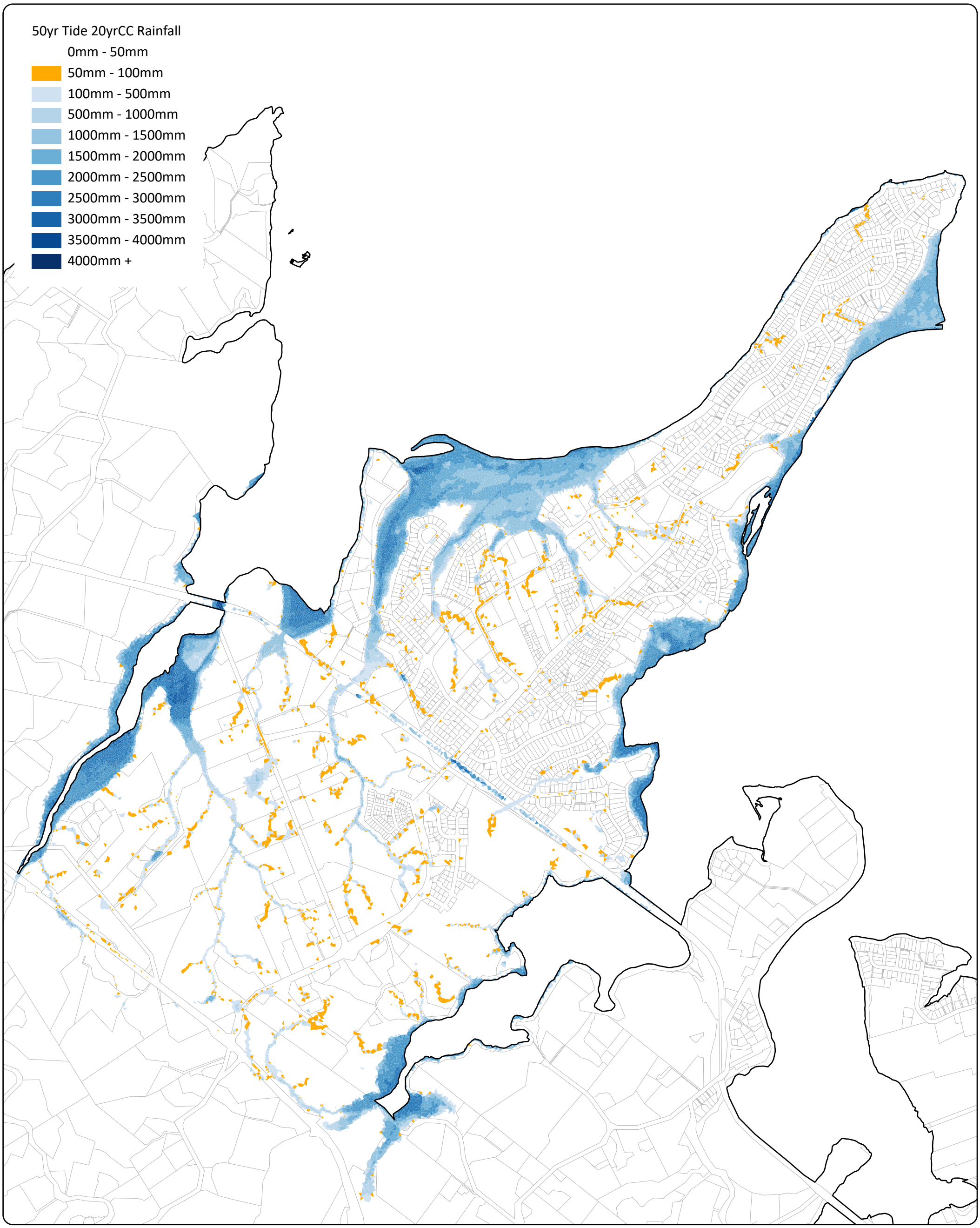

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50yr ARI Tide, 20yrCC ARI Rainfall

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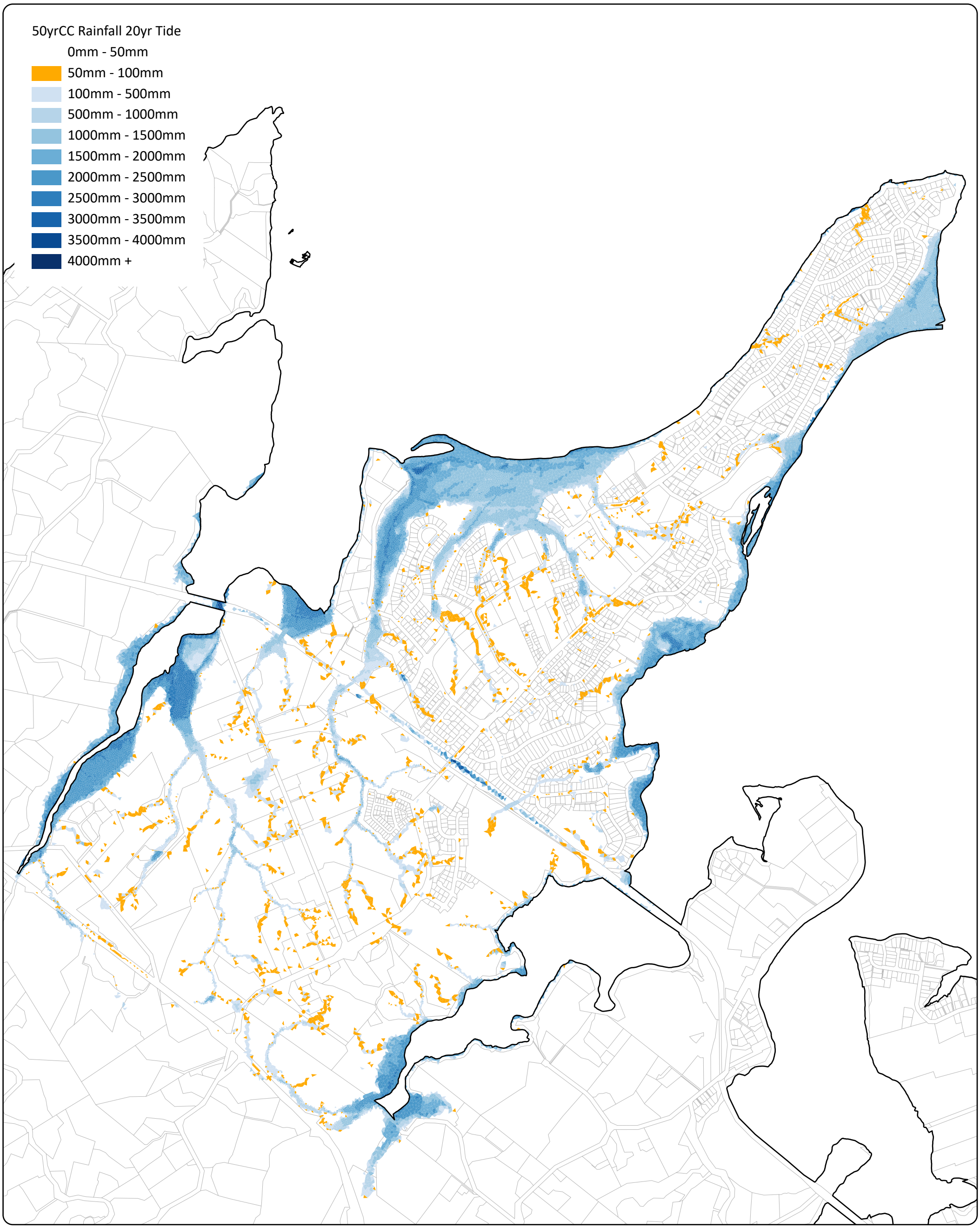

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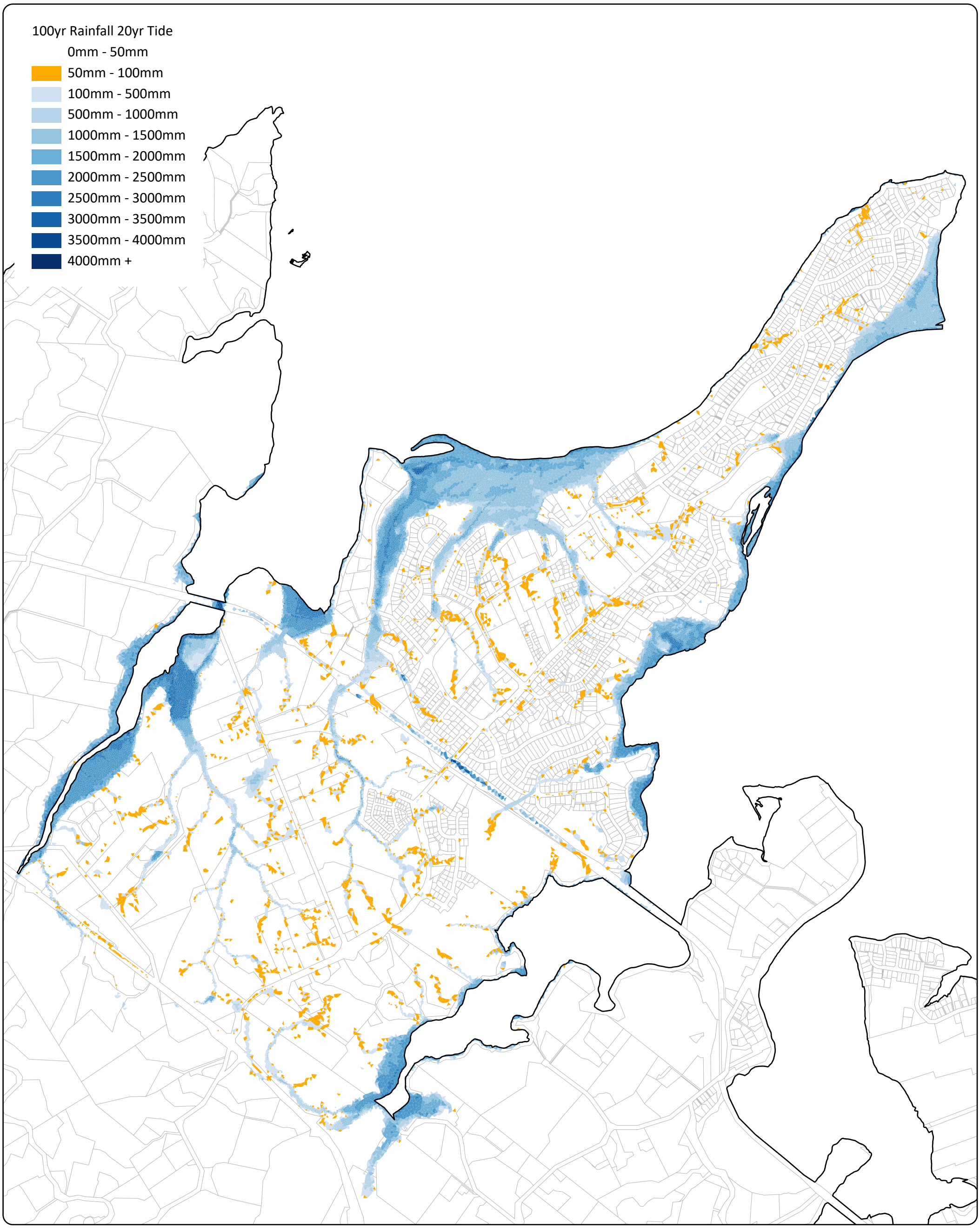
Omokoroa Modelling Results
50yr ARI Rainfall + CC, 20yr ARI Tide

N



Email: gis@westernbay.govt.nz
Date: 24-Jun-19
Operator: rro
Map: Omokoroa Modelling Results

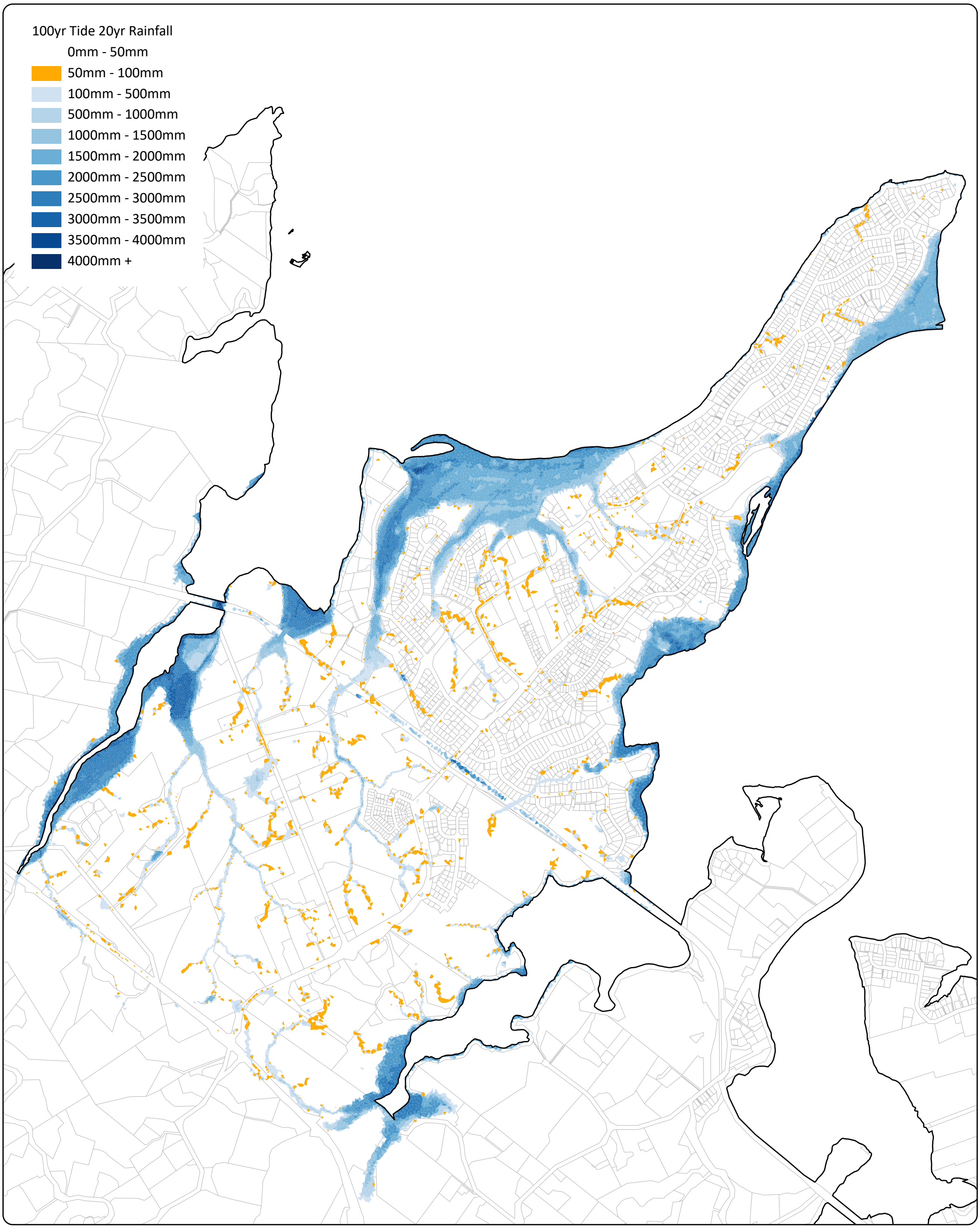
Scale A3 - 1:17,000

0 125 250 500 750 1,000 Meters

Western Bay of Plenty District Council

Omokoroa Modelling Results
100yr ARI Rainfall, 20yr ARI Tide

N



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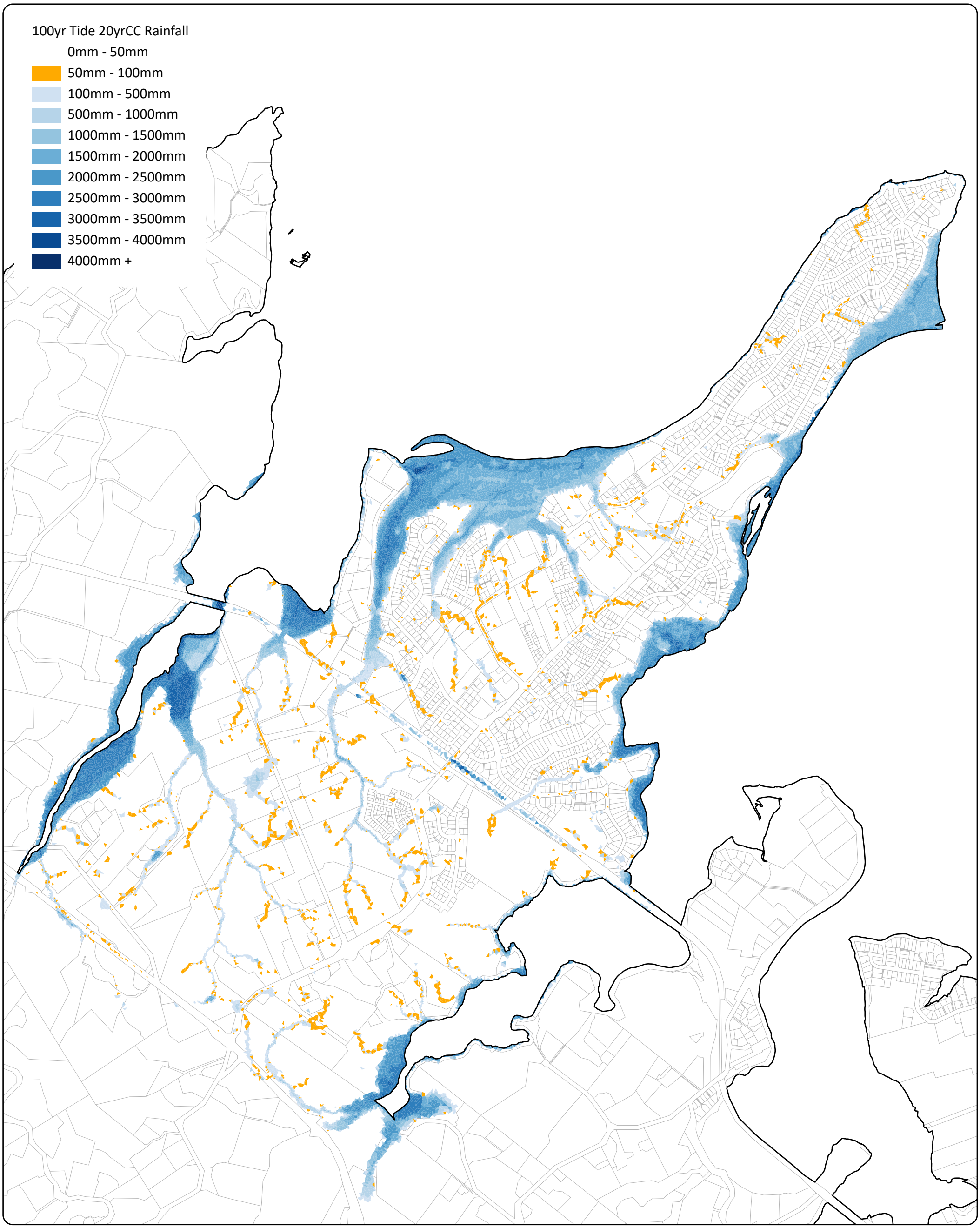

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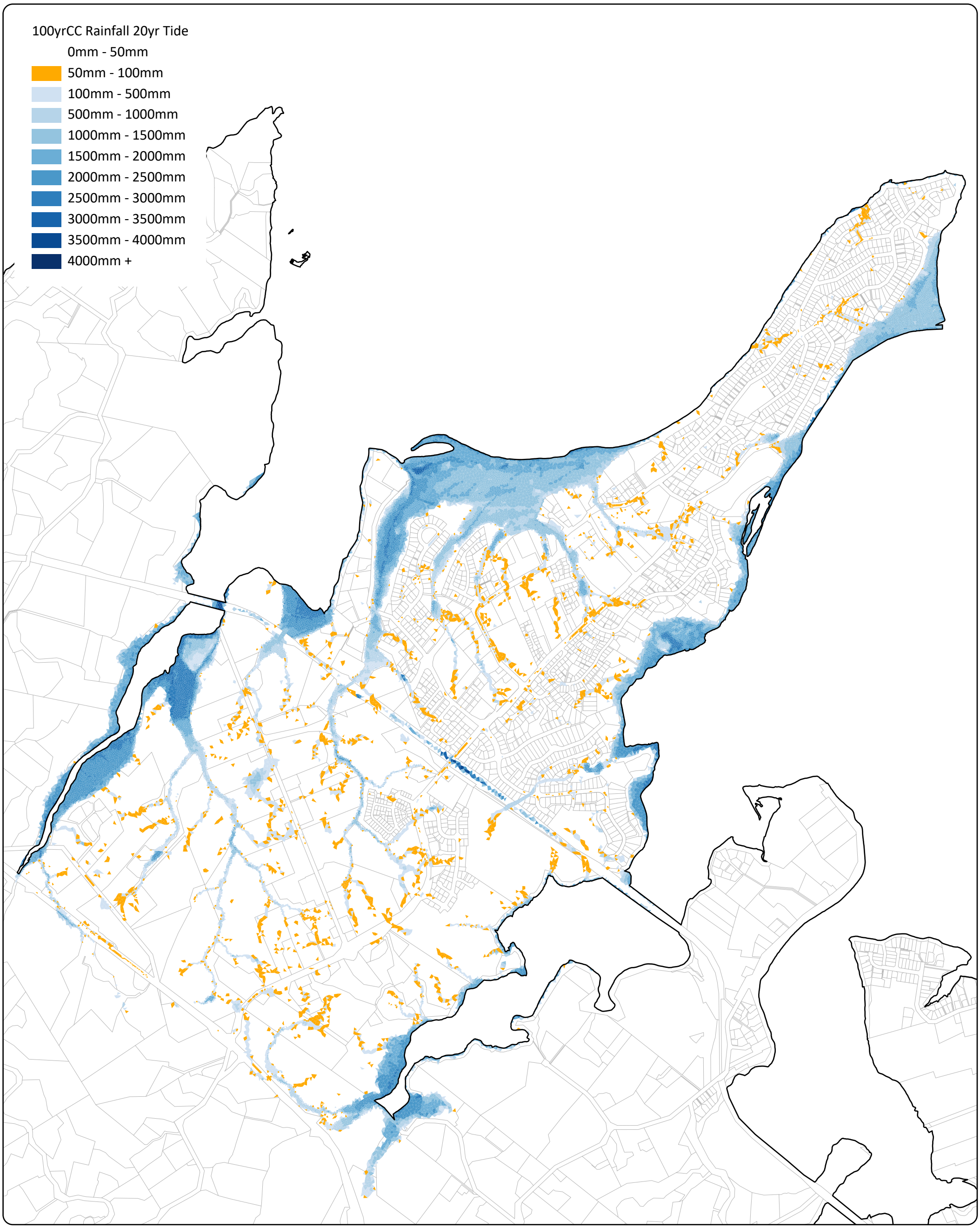

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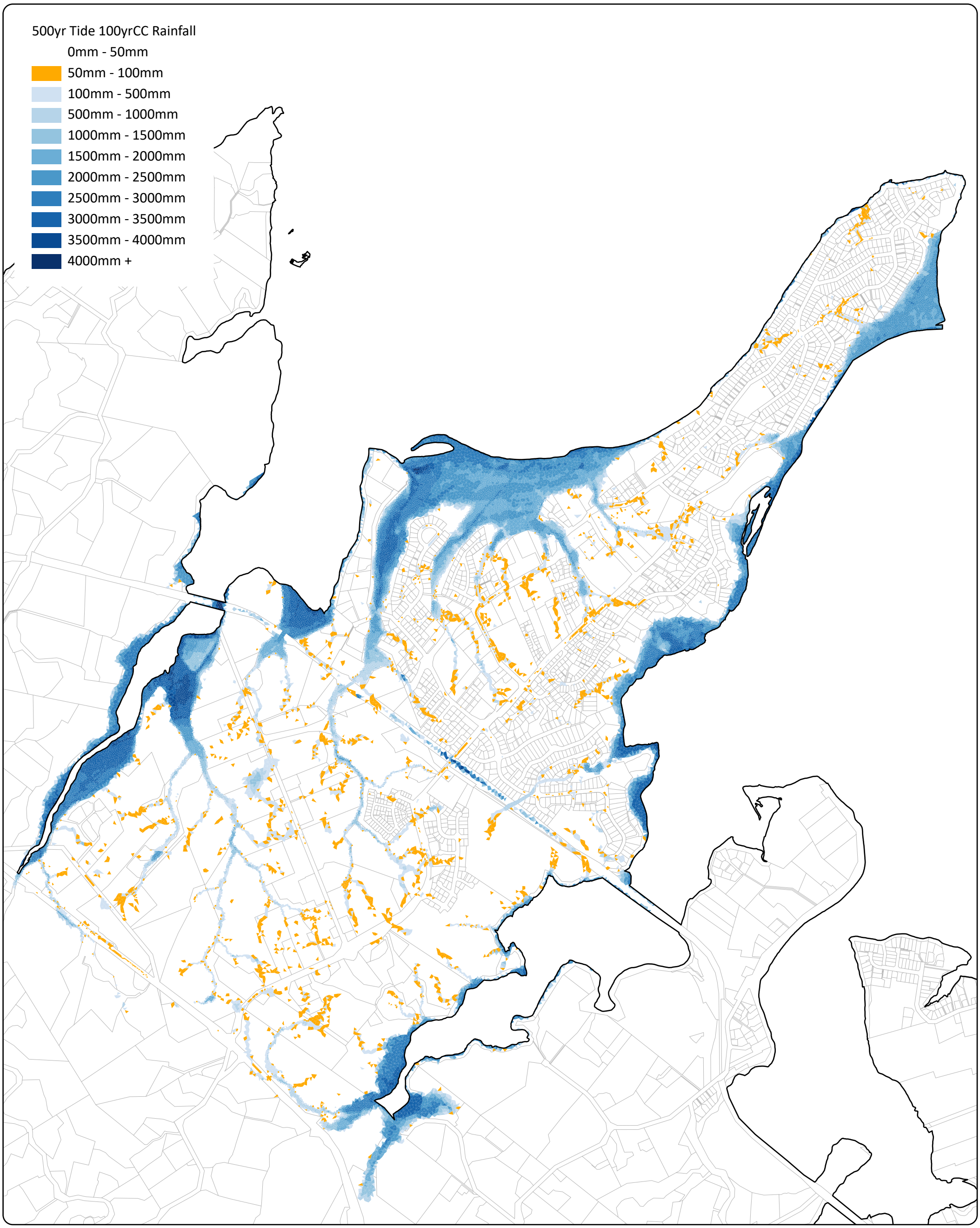

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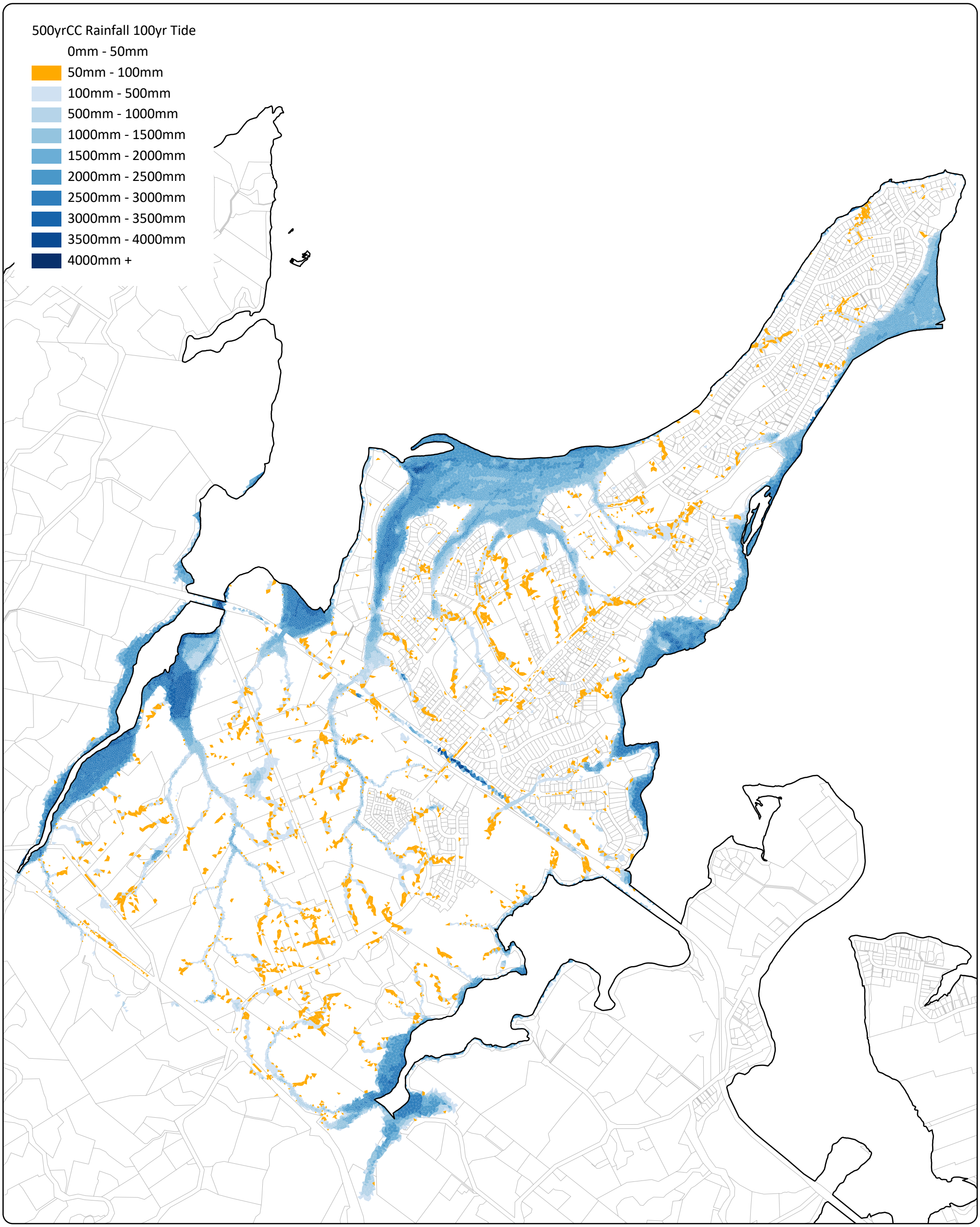

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