Omokoroa Stormwater Model

Model Build Update and System Performance Report

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

8 May 2020

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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
2	**Haddon Smith**	Updated to include new work	27/02/2020
3	**Haddon Smith**	Update for climate change allowance	05/05/2020

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Haddon Smith / Elliot Tuck**	[signature]	08/05/2020
Reviewed by	**Elliot Tuck**	[signature]	08/05/2020
Approved by	**Graham Levy**	[signature]	08/05/2020
on behalf of	Beca Limited		

Executive Summary

In 2017 Western Bay of Plenty District Council (WBoBDC) 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. At the time of the 2017 model build, there was no urban development south of the railway. Rural land 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.

In December 2018, WBoBDC commissioned Beca Limited to combine the 1D and 2D models and update the models to include the land use changes proposed in the District Plan. Results were described in revision 1 of this report based on the following:

- Rainfall events over a range of return periods with and without climate change
- Climate change to the year 2100 RCP8.5 (sourced from HIRDS V4). These new figures represented a reduction in rainfall when compared to HIRDS V3 which was used by the previous models
- The stormwater network updated to reflect the 2019 GIS data.
- Ground elevations based upon LiDAR flown in 2010. One limitation to this is, although the new model contained the latest pipe network the surface attached to these new networks, it still relied on LiDAR flown in 2010 and will not represent flow paths in these newly developed areas.
- Updated tide predictions, supplied by NIWA in February 2019, which also accounted for sea level rise.

Model results produced by the combined model were 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 peninsula.

In late 2019 Beca was commissioned to update the model and rerun a selection of the scenarios included in revision 1 of this report. The updated model runs include the following:

- Ground elevation based upon LiDAR flown in 2019, provided to Beca by WBoPDC in September 2019
- An updated the 1D network, based upon GIS provided to Beca by WBoPDC on 20th Feb 2020
- Climate change to 2130 extrapolated from rainfall data obtained from HIRDS V4.

The model remains uncalibrated due to a lack of suitable data for calibration. Since the model was constructed there has been a lot of development including land use and hydrological changes. In December 2018, Western Bay of Plenty District Council commissioned Beca Limited to provide an updated stormwater model.

Results are shown in attached flood maps and are also held in GIS electronic form by WBoPDC.

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, additional areas of the Omokoroa Peninsula have been developed resulting in 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 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.

In late 2019 and early 2020 Beca made some further updates to the model to include updated LiDAR, climate change to 2130 and further network changes, as described in sections 6 and 7.1. After the updates were completed, WBoPDC requested that Beca rerun a number of scenarios.

1.2 Scope of Work

The scope of the December 2018 commission was an update of the previous model, to recognise changes since 2017, including:

- Adding 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 terrain to 2019 LiDAR supplied by WBoPDC
- 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

The scope of the 2020 commission was as follows:

- Update the 2019 model with 2019 LiDAR, provided to Beca by WBoPDC in September 2019
- Update the 1D network, based upon GIS provided to Beca by WBoPDC on 20th Feb 2020
- Include climate change to 2130 based upon rainfall data obtained from HIRDS V4 and extrapolated to the 500 year return period and the year 2130 based upon 3.68 degrees Celsius of warming
- Rerun the scenarios relating to the 50 year, 100 year and 500 year return periods.

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. Model updates in early 2020 were completed in ICM version 10.0.3.

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. Where connections were added, assumptions were made based upon the location of manholes and incoming/outgoing pipes.

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 used for runs completed in June 2019 was flown in 2010; the LiDAR used from 2020 runs was flown in 2019. 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 these are now 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 2017 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 the 2017 1D network model (now superseded) 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 2019/2020 combined modelling has been based on *Omokoroa Structure Plan (2016)* zoning; this can be found in *Appendix 7* of the *Operative District plan*. 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 2019/2020 combined model

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 2019/2020 combined 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.

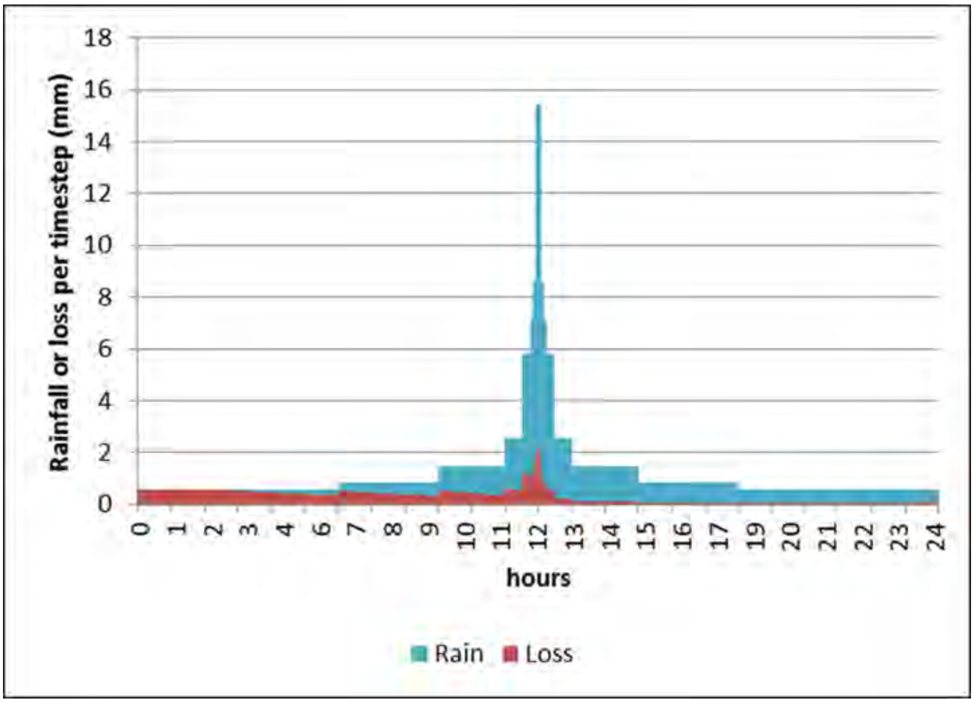

Figure 1 Example Rainfall Hyetograph Used in the Omokoroa Stormwater Model

3.3.2 500 Year ARI

HIRDS outputs only give values up to the 250 year ARI event. Extrapolation to the 500 year ARI was completed by fitting a curve to rainfall intensity vs reduced variate of the Gumbel distribution, y = - ln(-ln(F(x)). This method was recommended by Peter Blackwood of BOPRC in an email of Graham Levy on the 17th of April 2020. The curve is fitted to the "Historical data" table, with the 500y ARI values are obtained from this fitted function. This is illustrated in Figure 2.

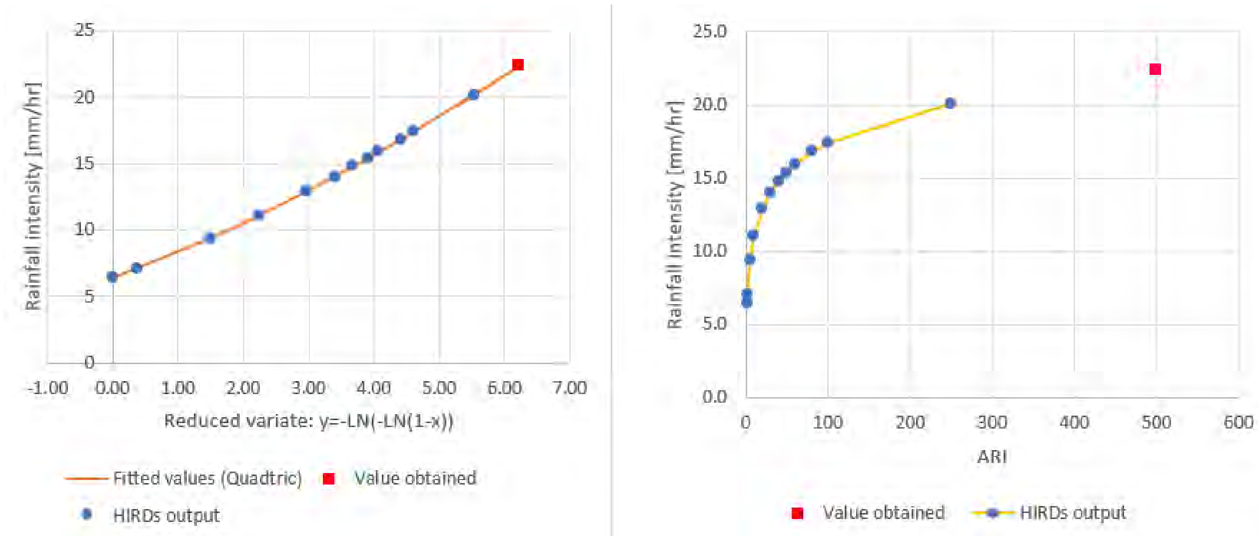

Figure 2: 12h intensities (mm/hr) vs reduced variate (left hand figure) and ARI (right hand figure)

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

For June 2019 model runs climate change has been allowed for in the rainfall by using Representative Concentration Pathways (RCP) scenario 8.5 to 2100. Output was obtained from NIWA's HIRDS V4.

For 2020 model runs, WBoPDC requested that the rainfall used includes climate change to 2130. As HIRDS V4 only includes the periods 2031-2050 and 2081-2100 extrapolation of rainfall intensity to 2130 was required. The extrapolation was completed using a table of percentage increase of rainfall intensity per degree warming, for each ARI and event duration. This table is taken from NIWA's HIRDS V4 report "High Intensity Rainfall Design System (August 2018)" Table 6. Percentage factors for durations less than 1hr are assumed to be the same as 1hr, as recommended by NIWA. Percentage factors of 200 & 500 year ARIs are assumed to be the same as 100y ARIs. The percentage increase in warming in 2130 was assumed to be 3.68 degrees Celsius, as requested by Peter Blackwood of BOPRC in an email of Graham Levy on the 16th of April 2020.

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 methodologies. *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 Infoworks ICM v9 for runs completed in June 2019 and Infoworks ICM v10 for February 2020 runs, see Table 5 for details. 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 1D stormwater network. The network extends from the railway line in the south to the tip of the peninsula in the north.

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 to a node 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. Where private connections are removed, runoff enters the 1D network from the 2D surface at the next available sump.

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 used for June 2019 runs was built using LiDAR flown in 2010, with 2019 LiDAR used for February 2020 runs. The model surface is represented by 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. gives the Link Energy Losses used in the model. All links are modelled with a manning's n roughness of 0.013.

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

We applied the tide level as a constant level at the ocean outfalls, based upon data provided by NIWA. We also created a 2D initial condition in the model, that allows the areas that would already be inundated to start the simulation as wet, which helps with stability of the model. Table 4 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 0.2% AEP to satisfy the scenario matrix, and were those used by NIWA in the Harbour Model and reflect SLR to 2130 scenario RCP 8.5 median (rather than 0.49 m to 2090 that is described in BoPRC guideline).

Table 4 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 a 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 used was flown (2010 for June 2019 model runs and 2019 for February 2020 runs) 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

In June 2019, during the initial runs of the model, model instabilities in the 1D network occurred. A series of minor fixes were completed to reduce the instabilities, such as sealing a small number of manholes.

6 Model updates – November 2019 to April 2020

In 2019, after revision 1 of this report was issued, new LiDAR flown in 2019 became available. Ground elevations have not changed markedly throughout most areas of Omokoroa, however where earthworks have occurred significant differences are observed. The south east end of Omokoroa is affected, around the new residential developments. A difference map of the 2010 and 2019 LiDAR s is given as Figure 4.

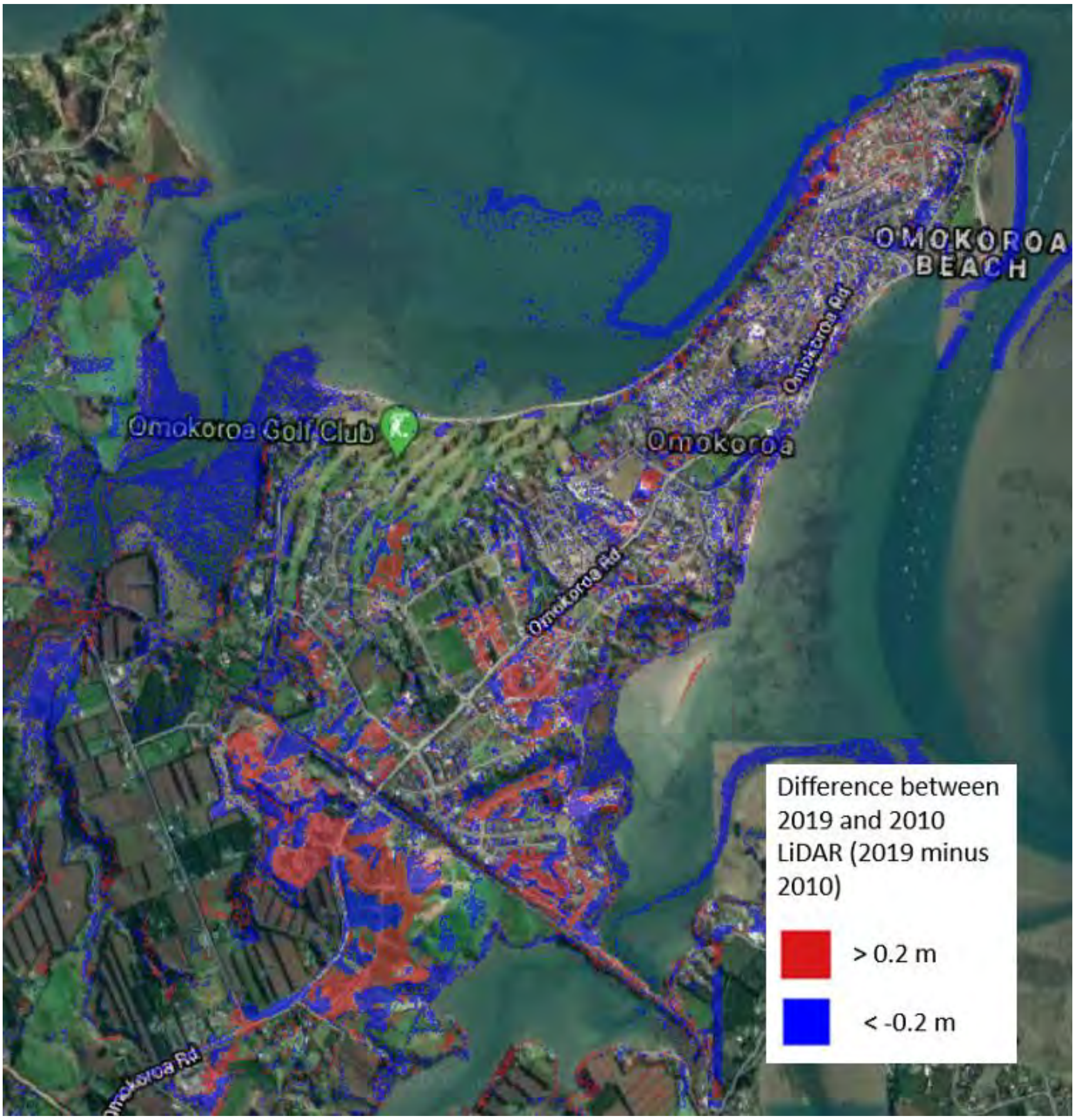

Figure 4: Difference map of new vs. old LiDAR

Furthermore, since the release of revision 1 of this report WBoPDC became aware that two culverts owned by KiwiRail which run underneath the railway line that runs through Omokoroa, were not contained in the GIS data used during the model build. These culverts were added to the model, as shown in Figure 6. Surveyors were unable to access these culverts due to health and safety issues caused by overgrowth; thus, invert levels and the position of the upstream and downstream ends of these culverts was assumed. Culvert width and height data was available and applied in the model. It should be noted that results show that these two culverts to convey a large volume of water and therefore uncertainly in invert levels and location could add inaccuracies to results nearby.

Due to these changes WBoPDC commissioned Beca to update the model with the new LiDAR and two railway culverts and rerun the 100 year ARI rain with 20 year ARI tide, and the 20 year ARI rain with 100 year ARI tide scenarios (Scenarios 5a and 5b shown in Table 5 of section 7.1). The 2010 LiDAR has been used in three small areas not covered by the 2019 LiDAR, as shown in Figure 5. These results were delivered to WBoPDC on the 1st of November 2019.

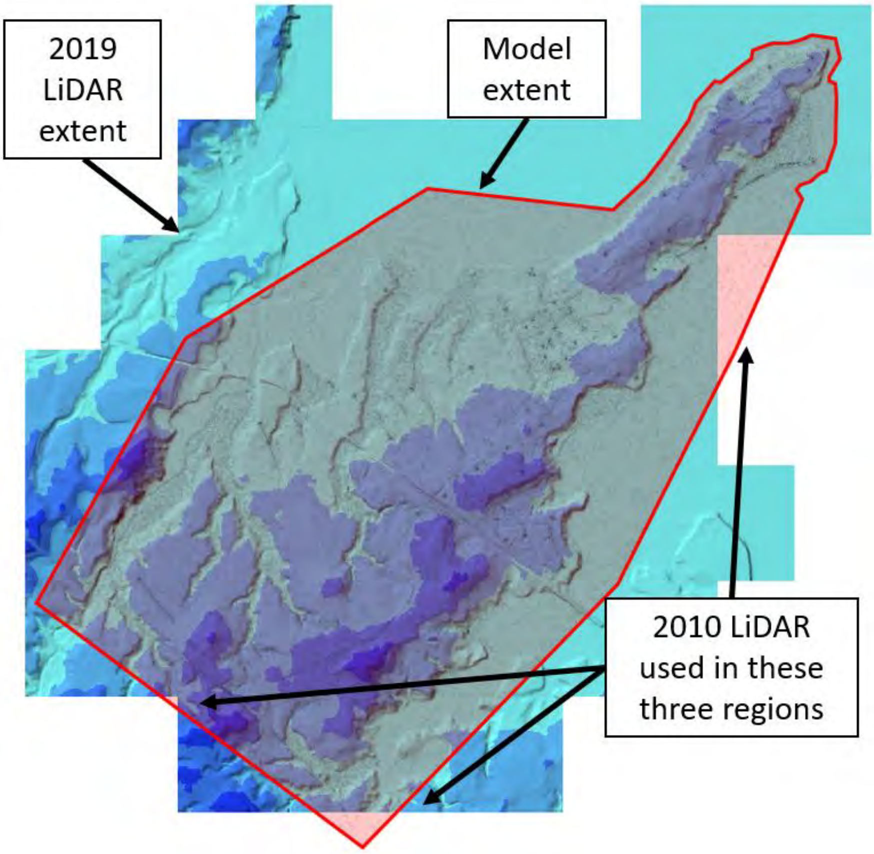

Figure 5: Section of the model where 2010 LiDAR was used, due to 2019 LiDAR not being available.

Following this, in January 2020, WBoPDC commissioned Beca to rerun scenarios 3a, 3b, 6a and 6b. While completing these runs it became apparent that there were a number of culverts and manholes in the WBoPDC's GIS that were not in the model, due to these being added to GIS after the initial stormwater model build. To resolve this, Beca updated the 1D network with new assets based upon an export of WBoPDC GIS dated 20th February 2020, as shown in Figure 6. Errors in the GIS data were fixed, such as pipes where the upstream and downstream inverts were the wrong way around, inverts missing and culverts with incorrect diameters. One culvert was missing from GIS and was added in the model. Details of these edits to GIS data can be provided if requested.

Figure 6: New culverts added to model

7 Model results

7.1 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 5 presents all scenarios run as part of this modelling assessment.

Table 5 Modelled Scenarios

Index	Event	Rainfall (ARI)	Tide (ARI)	Date of run
S1a	10 year ARI	10 year	2 year	June 2019
S1b		2 year	10 year	June 2019
S2a	10 year ARI + 2130 CC	10 year	2 year	June 2019
S2b		2 year	10 year	June 2019
S3a	50 year ARI	50 year	20 year	June 2019
S3b		20 year	50 year	June 2019
S4a	50 year ARI + 2130 CC	50 year	20 year	April 2020
S4b		20 year	50 year	April 2020
S5a	100 year ARI	100 year	20 year	June 2019
S5b		20 year	100 year	June 2019
S6a	100 year ARI + 2130 CC	100 year	20 year	April 2020
S6b		20 year	100 year	April 2020
S7a	500 year ARI + 2130 CC	500 year	100 year	April 2020
S8b		100 year	500 year	April 2020
S9	PMF	PMP	100 year	June 2019

7.2 Model Results

The model results flood maps are attached in Appendix 1.

Given the size of the peninsula, 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 in GIS. The results files in GIS format are held by WBoPDC.

8 Conclusions

8.1 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, even though depths / levels may change.

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 7.

Figure 7 Location of flow line for comparison

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

Figure 8 shows that flows range from 14m³/s in a 20 year rainfall ARI to over 27m³/s in the 500 year rainfall ARI.

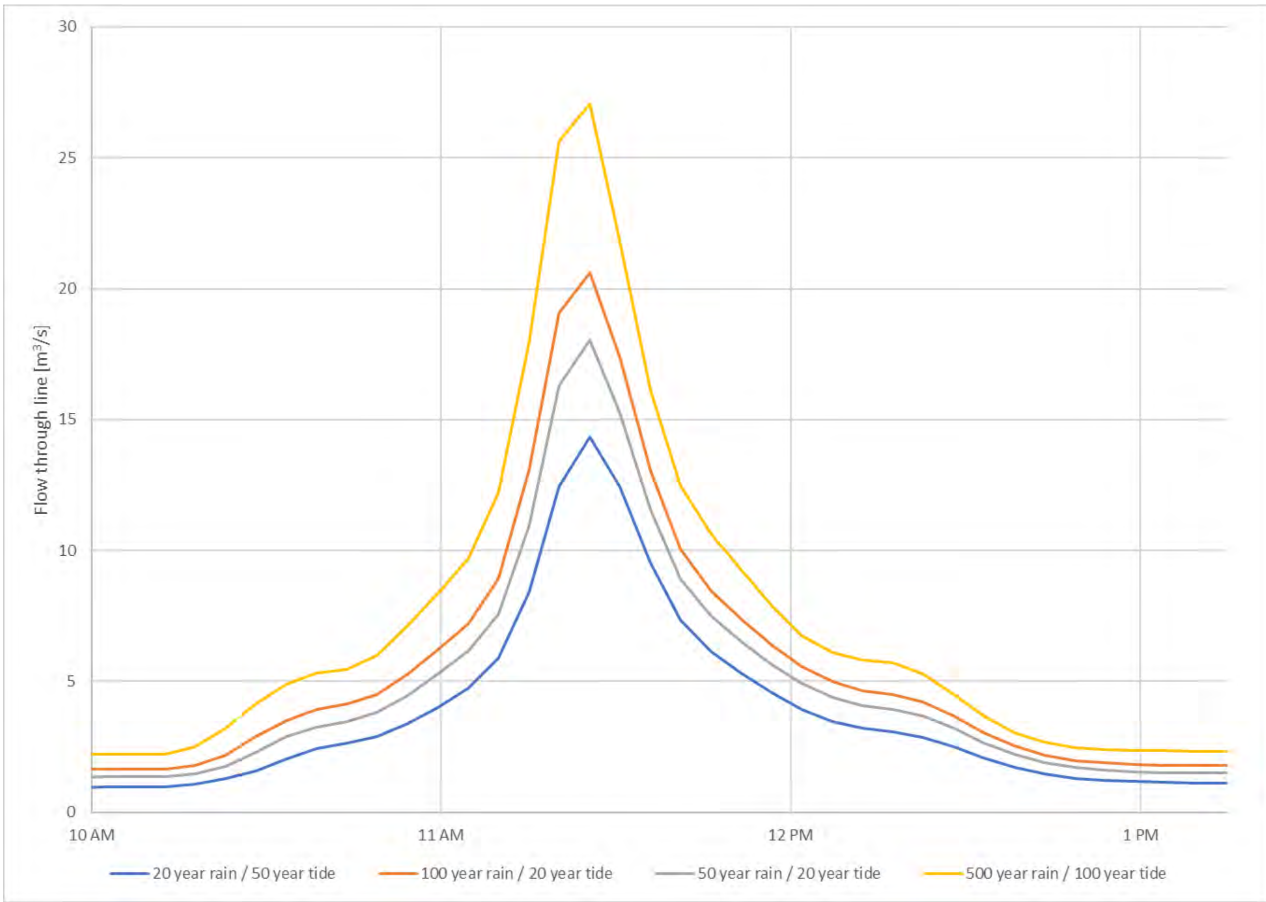

Figure 8 Comparison of flow through flow line

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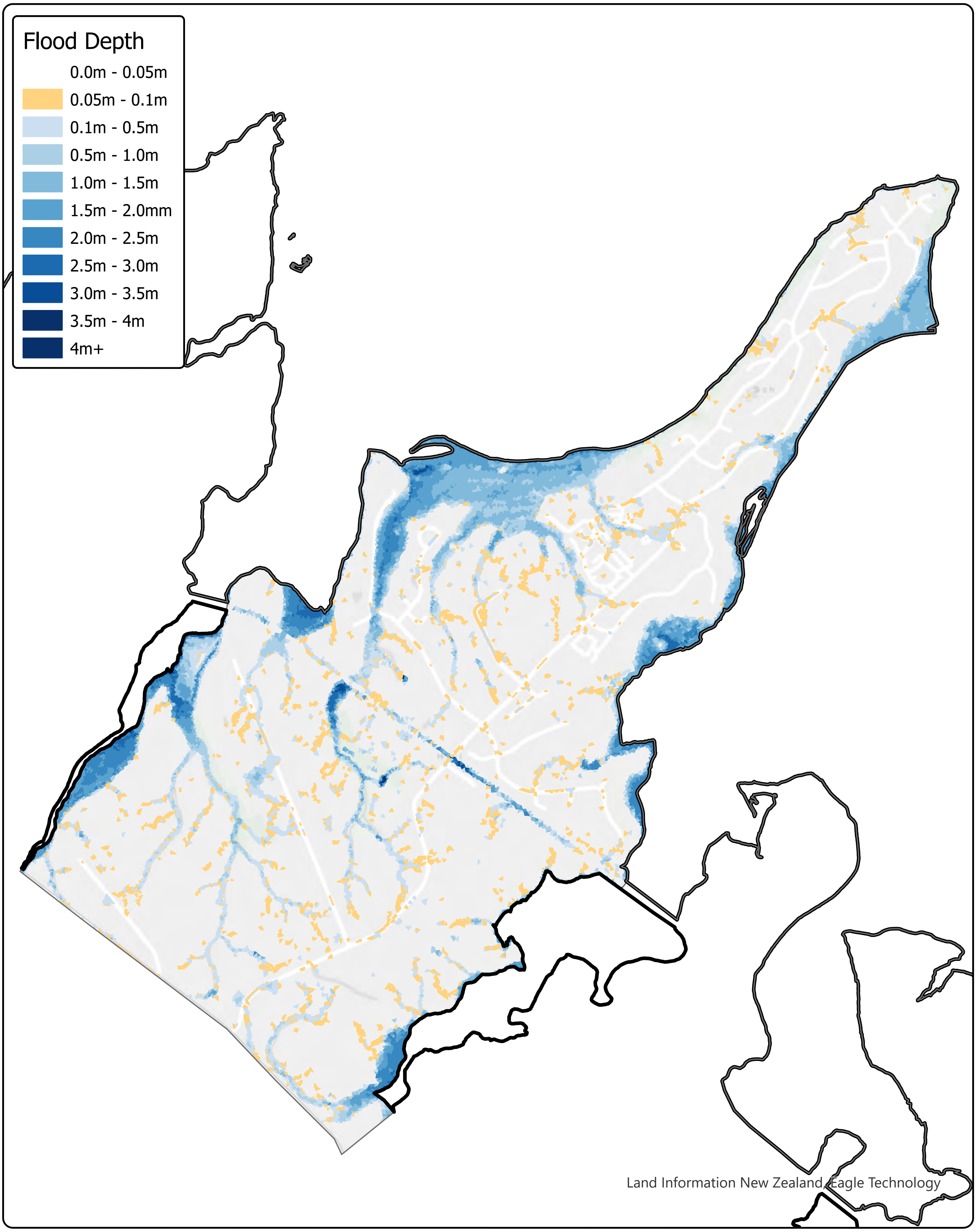
Appendix 1 Maximum Depth Flood Maps



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0 0.25 0.5 1 Kilometers

Western Bay of Plenty District Council

Omokoroa- 20y Rainfall 50y Tide

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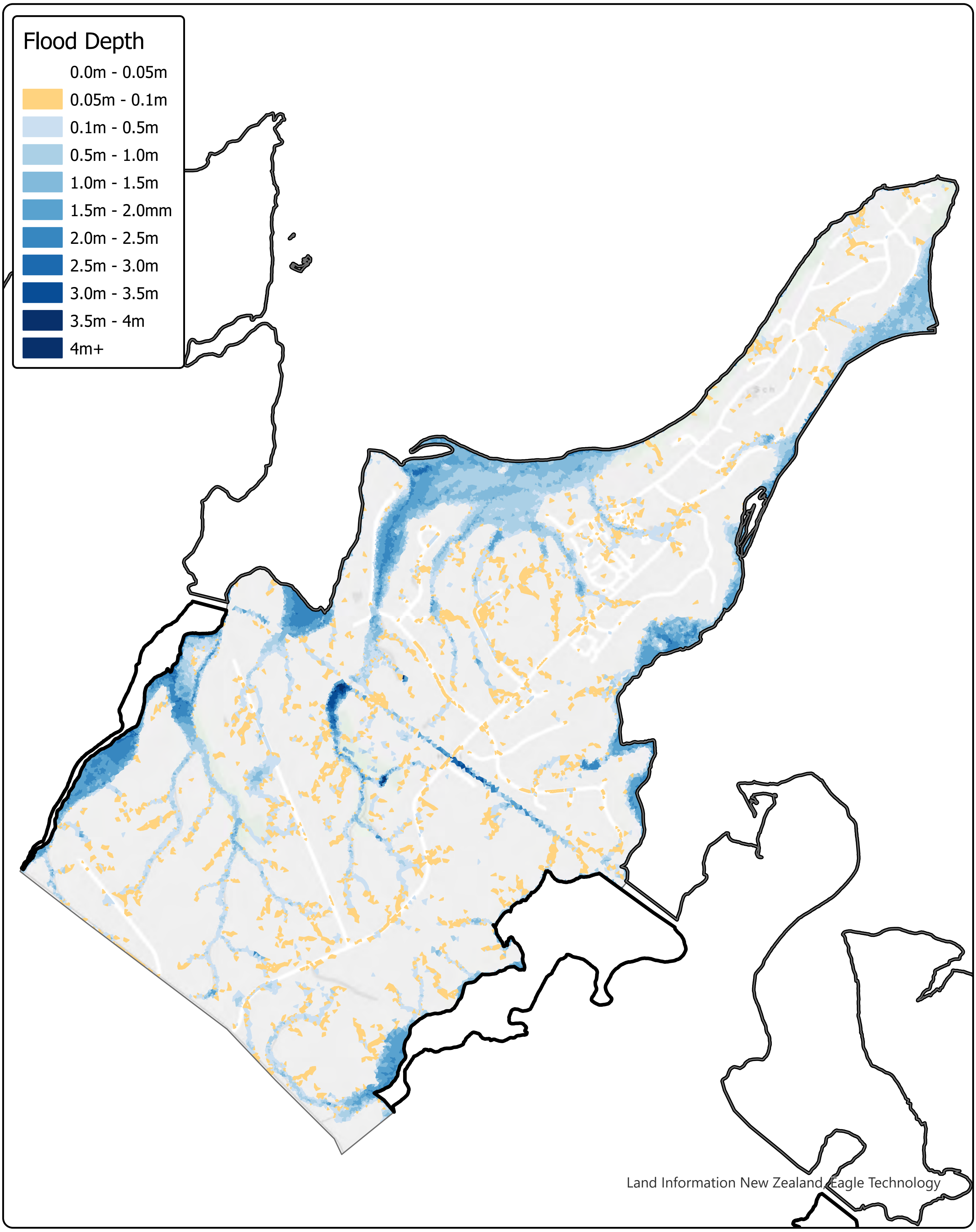

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Western Bay of Plenty District Council

Omokoroa- 50y Rainfall 20y Tide

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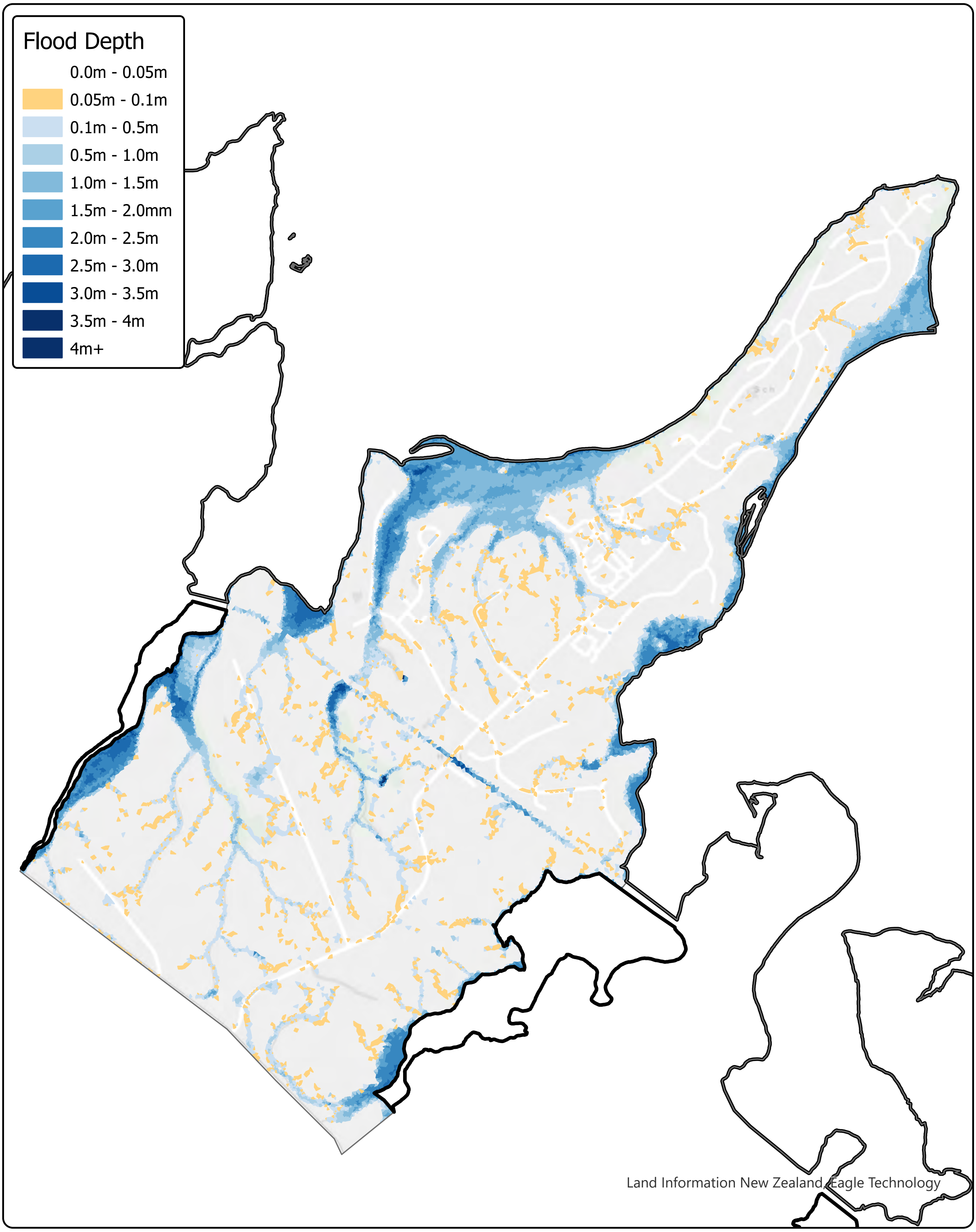

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0 0.25 0.5 1 Kilometers

Western Bay of Plenty District Council

Omokoroa- 20y Rainfall 100y Tide

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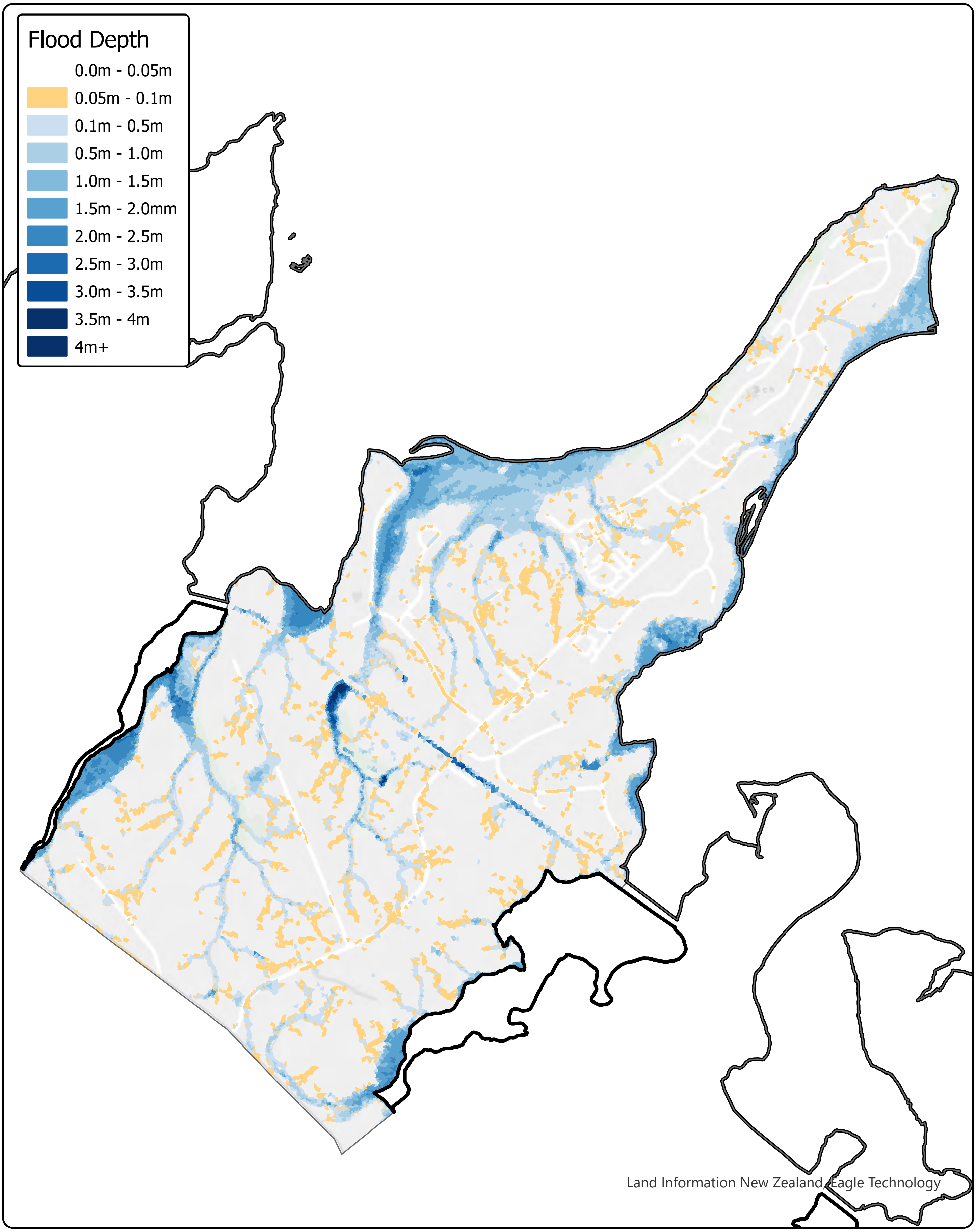

Email: gis@westernbay.govt.nz
Date: 2020-05-11
Operator: jdm1
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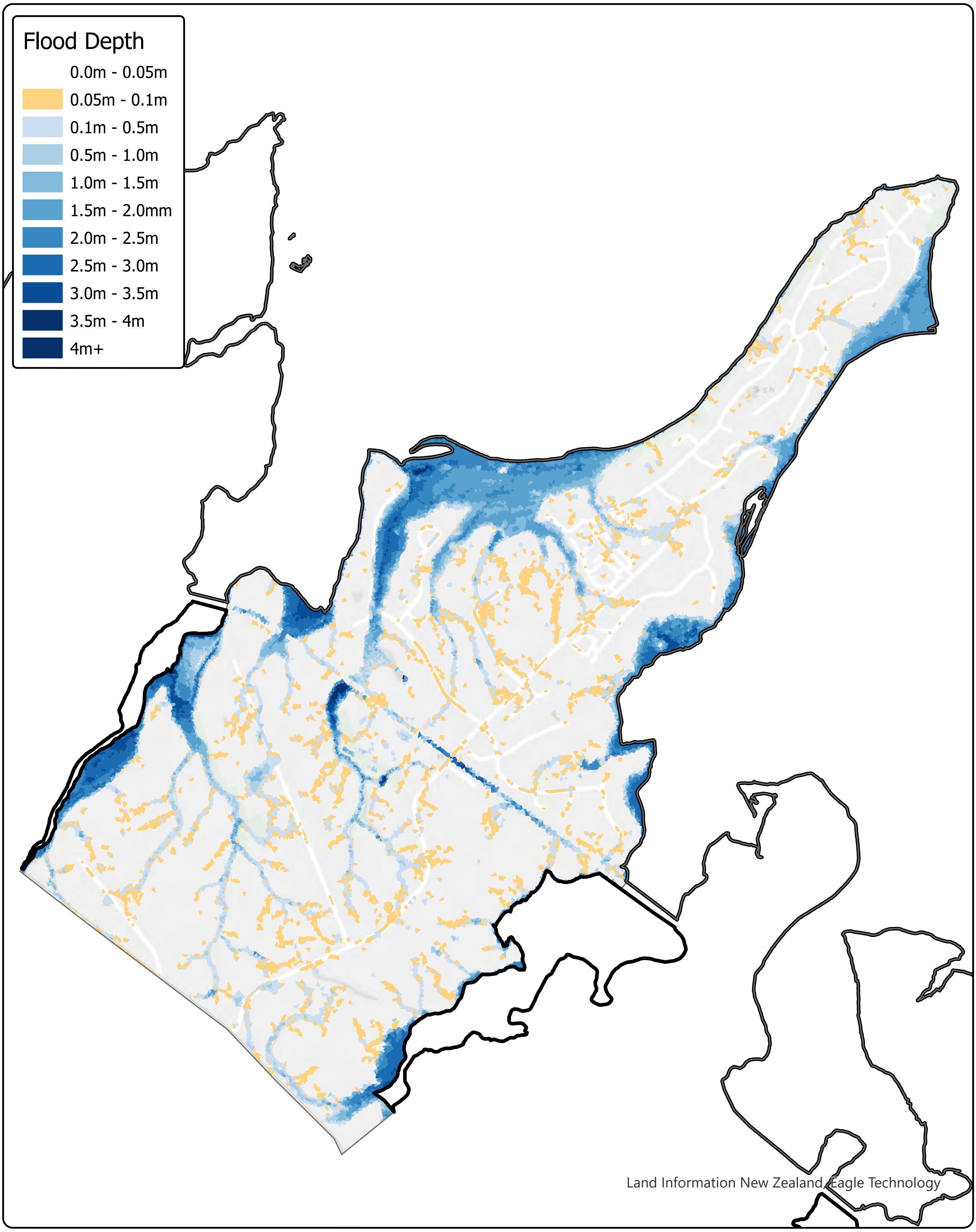
Scale A4 -1:25,000
0 0.25 0.5 1 Kilometers

Western Bay of Plenty District Council

Omokoroa- 100y Rainfall 20y Tide

N



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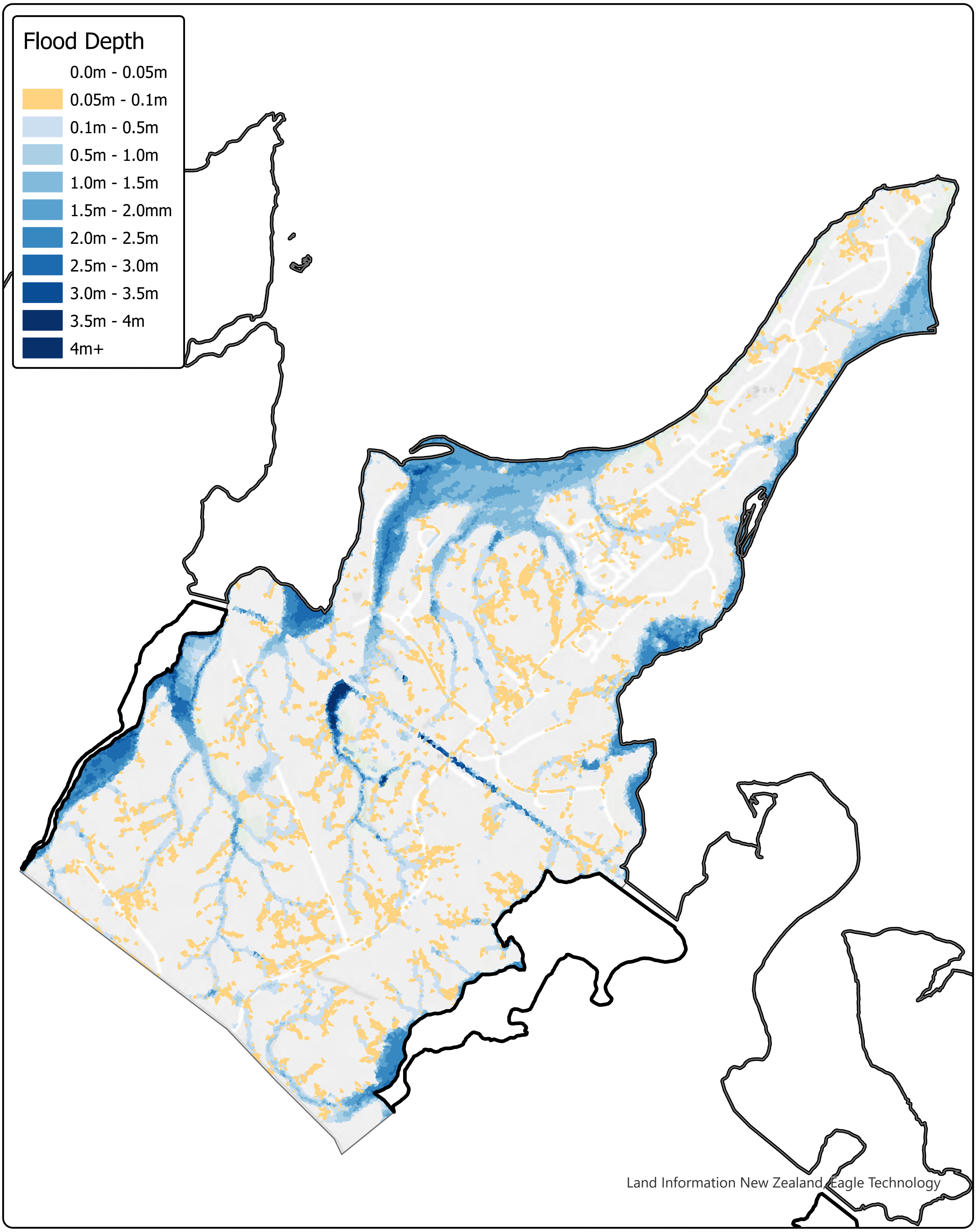
Scale A4 -1:25,000
0 0.25 0.5 1 Kilometers

Western Bay of Plenty District Council

Omokoroa- 100y Rainfall 500y Tide

N



Email: gis@westernbay.govt.nz
Date: 2020-05-11
Operator: jdm1
Map: E:\Shape\JDM\1._Projects\20200511 - Omokoroa Flood Maps for Beca report\20200511 -

Scale A4 -1:25,000

0 0.25 0.5 1 Kilometers

Western Bay of Plenty District Council

Omokoroa- 500y Rainfall 100y Tide

N