REPORT

Tonkin+Taylor

Western Bay of Plenty Flood Mapping

Model Build Report

Prepared for
Western Bay of Plenty District Council

Prepared by
Tonkin & Taylor Ltd

Date
February 2021

Job Number
1012463.v4

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Document Control

Title: Western Bay of Plenty Flood Mapping					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
12/05/2020	1	Draft for client review	Michael Fifield	Mark Pennington	Reuben Hansen
07/07/2020	2	Draft final for client review	Michael Fifield	Mark Pennington	Reuben Hansen
01/10/2020	3	Final issue	Michael Fifield	Mark Pennington	Reuben Hansen
19/02/2021	4	Final reissue	Michael Fifield	Mark Pennington	Reuben Hansen

Distribution:

Western Bay of Plenty District Council	1 electronic copy
Tonkin & Taylor Ltd (FILE)	1 electronic copy

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1 Introduction

Tonkin & Taylor Ltd (T+T) was engaged by the Western Bay of Plenty District Council (WBOPDC) to undertake a number of flood hazard assessments for rural catchment areas within the Western Bay of Plenty (WBOP) District. The purpose of this work was to provide a better understanding of the flood hazard within rural zoned areas and small settlements of other zones (e.g. residential, commercial, industrial, rural-residential and lifestyle) where there is currently limited, or out-of-date, flood hazard information available.

T+T has utilised six existing area-wide models, developed in 2017 for the NZ Treasury Department with AON, that cover most areas of the WBOP as the basis for this work. Urban portions of several of these model areas (e.g. Waihi Beach, Katikati, Omokoroa, Tauranga and Te Puke) have been modelled by T+T and/or other consultants at an urban scale level of detail, with this more detailed modelling likely to be of a higher resolution than that which has been completed as part of the work reported on in this document. It should therefore be noted that this work is not intended to supersede these more detailed urban models.

This report describes the model build applied to each of the six model domains and includes map outputs covering each of the model domains.

The modelling and reporting have been prepared for WBOPDC in accordance with the conditions of engagement dated 19 February 2020.

2 Model build

2.1 Model build purpose and philosophy

The purpose of this model build was to provide a better understanding of the flood hazard within areas where there is currently limited, or out-of-date, flood hazard information available. It is understood that WBOPDC intend to use the model outputs primarily for flood mapping purposes to identify areas of potential hazard. While the model build methodology described below is most appropriate for these purposes, caution should be taken when using model outputs for other means beyond this primary purpose.

It is understood that WBOPDC also intends to use these model outputs for assigning design flood levels. Due to the district-wide scale of modelling undertaken, accuracy of model outputs is naturally limited to the quality and availability of data inputs to the model. It is therefore strongly recommended that if flood levels are to be considered for design and consenting purposes, that field verification be undertaken. This is particularly the case where a minor degree of flooding (both in depth and in extent) has been predicted on a parcel which, given accuracy limitations in the approach, may or may not be real.

For areas where a high degree of accuracy in design flood level is required, where there is a significant consequence associated with flood level assessment or where ground levels are known to have changed, the recommended approach remains a site-specific assessment instead of the district-wide scale modelling that has been undertaken as part of this scope of work.

Listed below are a summary of limitations to the modelling work, described further in the following sections, that WBOPDC will need to consider when interpreting and using design flood level results.

- Digital Elevation Model (DEM) derived from remotely sensed LiDAR survey data (refer Section 2.3) – The limitations of accuracy of LiDAR data are well understood, and these limitations will apply to the model results obtained. In particular, LiDAR survey data and the resulting DEM will have lower accuracy in areas such as incised waterways, heavily vegetated areas, places where above-ground features have been removed and water bodies. Furthermore, where ground levels have been changed since the LiDAR survey was captured, the DEM and hence the model will not recognise these changes (and will be out of date).

- Stormwater infrastructure (refer Section 2.8.1) – For areas containing pit and pipe stormwater network, this model build uses a 2D+ methodology which consists of a simplified representation of many hydraulic elements within the model. A notable limitation of this approach is in the lack of ability for representation of detailed hydraulic performance. Although these areas of the model are limited in extent and, in most instances, would only convey a small overall volume of water in a future climate 100-year ARI rainfall event (that which is the focus of this study), caution should be made when using flood level outputs upstream and downstream of such locations. On-the-ground verification is recommended in such areas.
- Stormwater infrastructure (refer Section 2.8.2) – In addition to the 2D+ methodology, several 1D culverts were applied to the model at key locations where data on culvert size was available from the road assessment and maintenance management (RAMM) GIS dataset. The dataset identifies thousands of culverts across WBOP, so only key culverts have been applied to the model where deemed most influential to a 100-year ARI event. It was also evident that the dataset was not complete or did not cover all potential culvert locations within each model domain with some likely culvert locations unaccounted for. This is particularly evident in rural areas where it is likely for numerous private culverts to exist or where asset data capture is less complete, along rail networks, and in areas of new roading infrastructure. Furthermore, in the RAMM dataset not all culverts contain all relevant data (levels, diameters, wingwall flare, etc), with some approximations having been made during the modelling process to account for missing data.

A direct rainfall approach has been applied to this model, which can highlight accuracy deficiencies in input data by showing small “puddles” in predicted flooding. It is usual with flood depth results from this kind of modelling approach that the results be “cleaned” by removing puddles before publication. T+T has presented raw model results in this report, in anticipation of WBOPDC undertaking “cleaning” of model results before publication and further use.

It is worth noting that the modelling undertaken as part of this study simulates the flood related effects of an extreme 100-year average recurrence interval (ARI) rainfall event and an extreme 1.25 m sea level rise scenario that are based on future climate predictions. The severity of such an event is above that which has been experienced in the Western Bay of Plenty to date.

2.2 Model solver and model domain

The model has been built and run using the latest 2020 TUFLOW Quadtree solver and utilises recently released quadtree nesting and sub-grid-sampling technology. Six model domains, shown in Figure 2.1, have been derived which cover areas of the WBOP District from Waihi Beach to Otamarakau. The model domains are divided using sub-catchment boundaries so that each domain is hydrologically independent of one another, with the one exception being the Te Puke and Tauranga domains which overlap near the Kaituna River. Dividing the model domains also reduces the computational run times i.e. it would have been inefficient had the model been attempted to run as one.

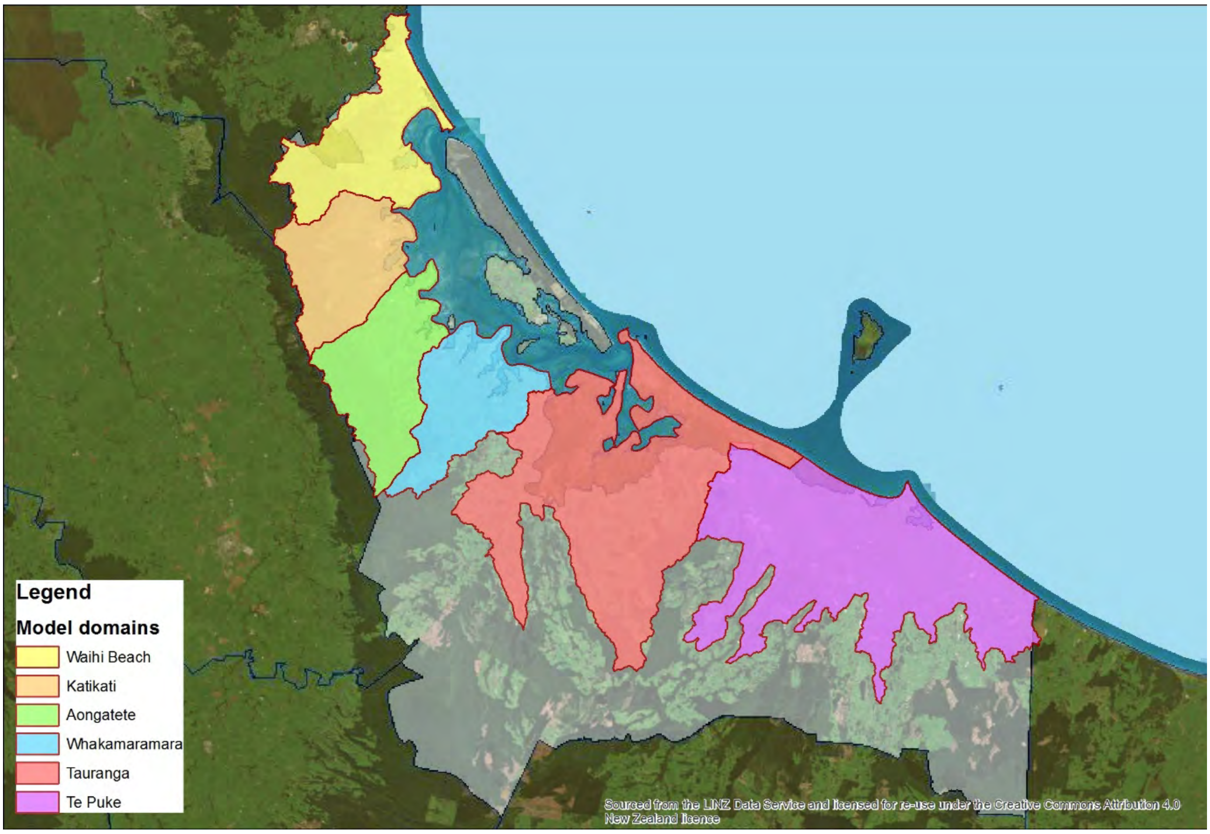

Figure 2.1: WBOP model domains with relation to the WBOP District boundary (in grey)

2.3 Digital elevation model (DEM)

A 1 m x 1 m (1 m^2) gridded DEM for ground level used in the model was provided by WBOPDC. The DEM represents a bare earth terrain, with all buildings and above-ground features having been removed. Using this approach, it is sometimes possible that flooding is shown to occur through the area occupied by large buildings. This is because the model does not recognise these as buildings and works only off the DEM. Care should be exercised in model results interpretation as a result.

It is understood by T+T that the following methodology and assumptions have been made by WBOPDC to derive the DEM:

- The DEM is composed of data from LiDAR surveys flown in 2011, 2015 and 2019, as shown in Figure 2.2. A hierarchy of data sources has been maintained to produce the resulting DEM, where more recent data was preferred in areas where data from each survey overlapped;
- The 2011 DEM was originally derived at a 2 m gridded resolution, and was resampled down to a 1 m gridded resolution, using cubic revolution, to match the grid resolution of the other 2015 and 2019 datasets; and
- DEM data captured in 2011 and 2015 was projected to the Moturiki 1953 vertical datum and for the purpose of this work has been converted to NZVD2016 to match the vertical datum of the most recent 2019 data. As a result, all models developed now use the NZVD2016 vertical datum.

While T+T has not conducted any independent review of the provided DEM, on inspection there do not appear to be any significant "edge effects" where the different datasets overlap. However, due to the severe rainfall and extreme sea level inundation events simulated as part of this work, the influence of "edge effects" becomes less critical because of the resulting large water depths. Should smaller, more frequently occurring storm events be simulated through the model, then the potential influence of “edge effects” should be considered further.

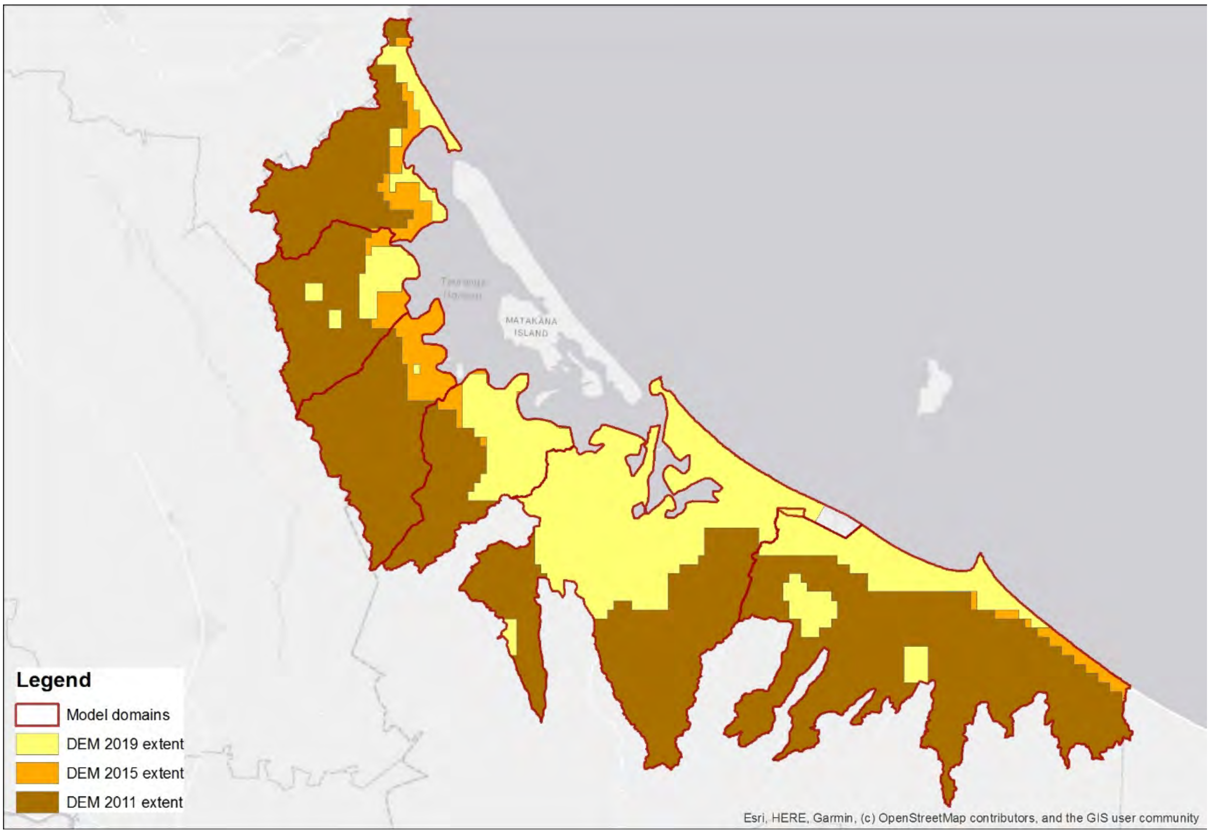

Figure 2.2: DEM data sources

The DEM has been applied to the TUFLOW model using a range of grid sizes which is made possible with the latest TUFLOW quadtree nesting and sub-grid sampling technology. Quadtree nesting allows the user to refine the computation grid size in areas where detail is required and make the computation grid size more coarse in areas where detail is not required. Varying the grid size allows the user to optimise the overall run-time of the model without compromising on detailed grid resolution where it is needed. Table 2.1 shows the different Quadtree nesting levels applied to each of the model domains and Figure 2.3 shows how this has been spatially varied.

The finest nest level, which uses a 2 m x 2 m grid, has been applied to small settlement areas defined by WBOPDC as of particular importance. In spite of this, the model’s “sub-grid sampling” capability allows for reading of the 1 m x 1 m grid and uses this for hydraulic calculation.

Table 2.1: Quadtree nesting grid size levels

Type	Quadtree nest level	Grid size (m)
Estuary/harbour	1	32
Retired native bush	2	16
Rural	3	8
Semi-rural & urban	4	4
Watercourse	4	4
Roads	4	4
Small Settlements	5	2

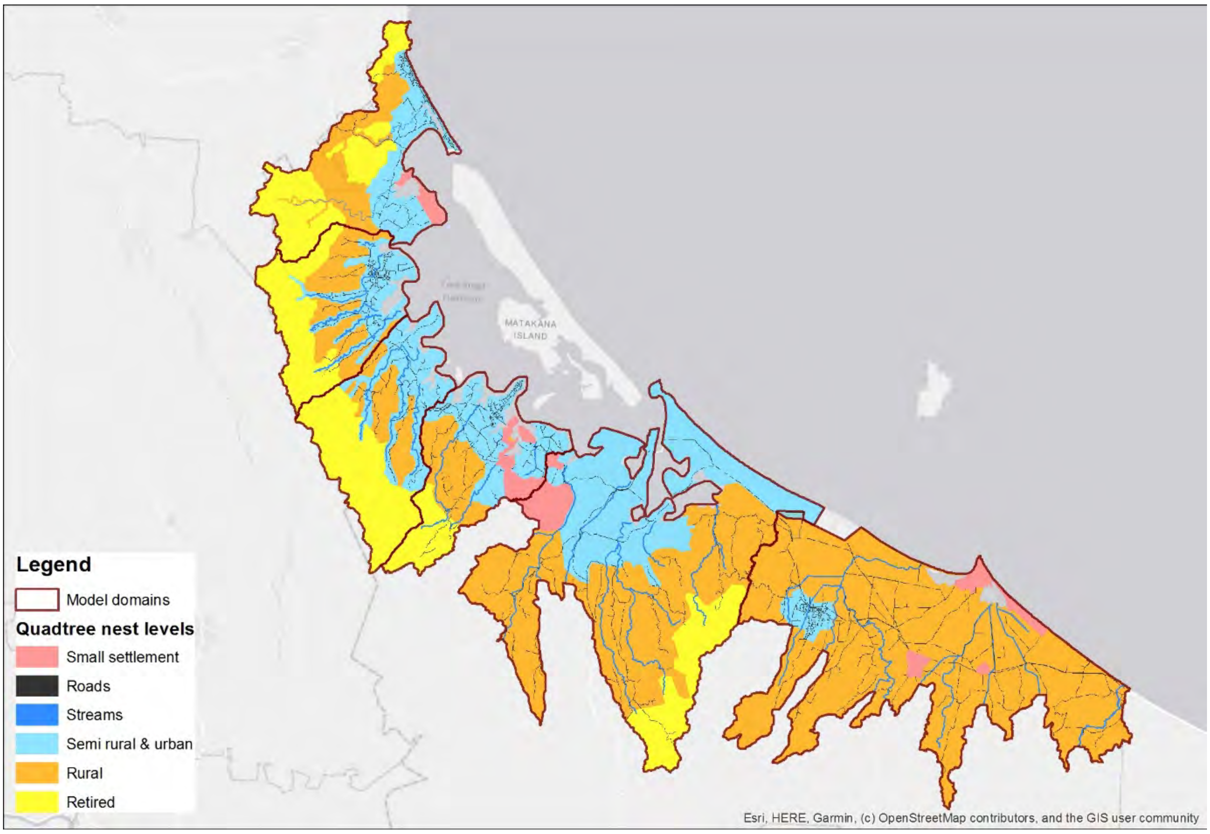

Figure 2.3: Quadtree nesting levels

From the above it can be seen that the urban areas of Waihi Beach, Katikati, Omokoroa, Tauranga and Te Puke have not been modelled at the finest grid resolution. This is because existing urban models cover these areas and should be preferred over the models described in this report. The “small settlement” areas identified above have been modelled at the finest grid size, as these were a specific focus of this project.

2.4 Land use roughness

Surface roughness values adopted in the model were based on land use as categorised in Landcare Research’s Land Cover Database version 5 (LCDBv5). This database was released in January 2020 and considers land use classification up until the end of 2018. The land use of each model domain, according to LCDBv5, is shown in Figure 2.4. Details of specific roughness values applied to the different land uses are summarised in Table 2.2.

In addition to the above, all road centrelines and major watercourse centrelines, identified on the WBOPDC online mapping tool, were located in GIS and buffered to widths of 10 m and 15 m respectively. The resulting areas were overlaid with a Manning's n roughness of 0.02 and 0.035 respectively.

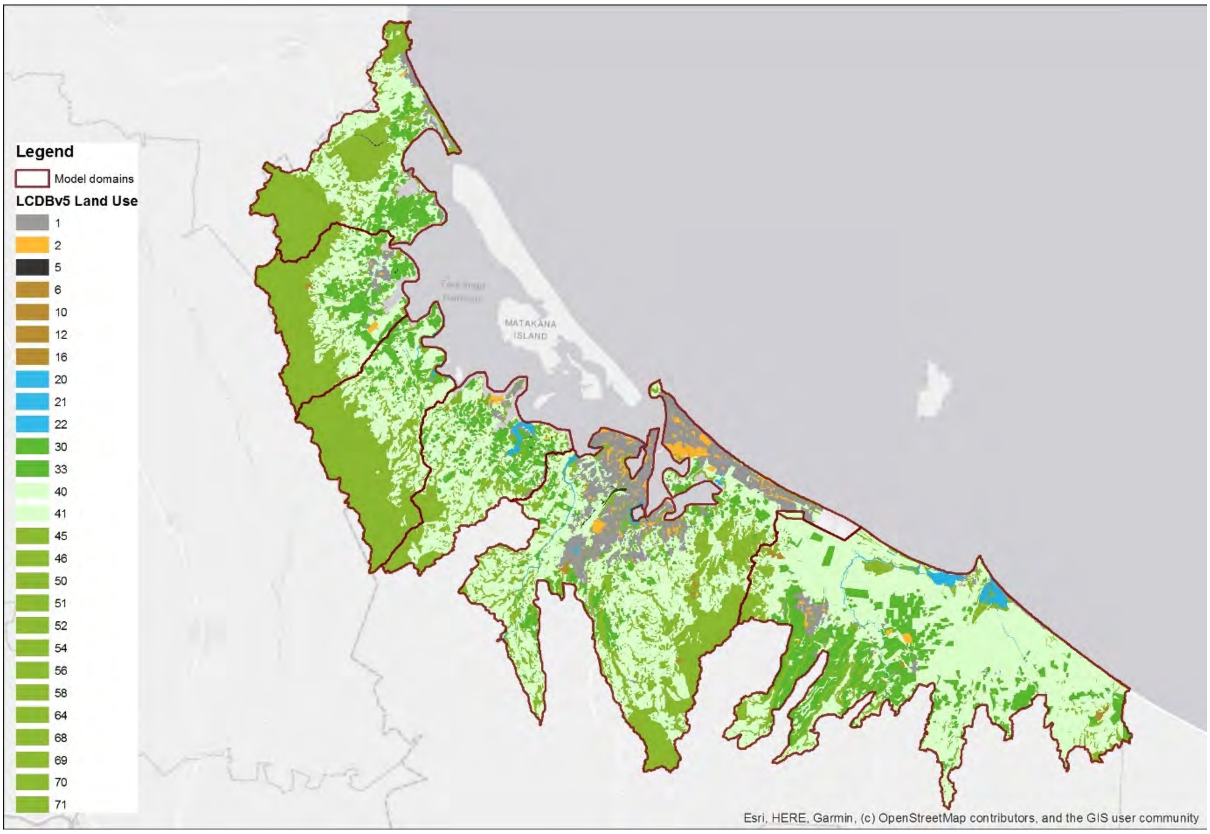

Figure 2.4: Land use (sourced from LCDBv5)

Table 2.2: LCDBv5 land types and corresponding Manning 'n' coefficients

Description	Code	Manning's n	Fraction Impervious	Legend
Built-up Area	1	Depth Varying	0.25[1]	
Urban Parkland/ Open Space	2	0.033		
Transport Infrastructure	5	0.016		
Surface Mine and Dump	6	0.028		
Coastal Sand and Gravel	10	0.025		
Landslide	12	0.028		
Gravel and Rock	16	0.039		
Lake and Pond	20	0.02		

[1] This value has been estimated at a global scale for the built-up area shown in the LCDBv5 land use layer, which includes many areas of limited or no impervious surface covering. This is appropriate for broad-scale investigation, but could be refined as more detailed investigations are required.

Description	Code	Manning's n	Fraction Impervious	Legend
River	21	0.035	1.0[2]	
Estuarine Open Water	22	0.022		
Short-rotation Cropland	30	0.1		
Orchard, Vineyard and Other Perennial Crops	33	0.06		
High Producing Exotic Grassland	40	0.05		
Low Producing Grassland	41	0.09		
Herbaceous Freshwater Vegetation	45	0.1		
Herbaceous Saline Vegetation	46	0.1		
Fernland	50	0.16		
Gorse and Broom	51	0.125		
Manuka and or Kanuka	52	0.1		
Broadleaved Indigenous Hardwoods	54	0.1		
Mixed Exotic Shrubland	56	0.08		
Grey Scrub	58	0.08		
Forest Harvested	64	0.16		
Deciduous Hardwoods	68	0.125		
Indigenous Forest	69	0.15		
Mangrove	70	0.15		
Exotic Forest	71	0.15		

A depth-varying Manning's n roughness value was used for 'Built-up Area' as this allows for a low roughness to be used at shallow depths to represent roofs and driveways. At higher depths, an increased roughness is applied to represent overland flow through urban areas, where fences, buildings and other above-ground features not represented in the DEM provide an impediment to flow. The depth varying roughness values are outlined in Table 2.3.

Table 2.3: Depth varying Manning's n coefficients for urban areas

Depth	Manning's n
Less than 50 mm	0.015
50 mm – 100 mm	The value varies linearly from 0.015 to 0.05
Greater than 100 mm	0.05

2.5 Catchment hydrology and rain-on-grid

Hydrological boundaries have been applied to the model domain using direct rainfall ("rain-on-grid"), and separately modelled lumped catchment hydrology that accounts for the inflow of several larger rural catchment watercourses.

[2] A value of 1 applies here as any rain that falls onto an existing water surface incurs zero loss.

At Waihi Beach, Katikati, Aongatete and Whakamarama only rain-on-grid hydrology was applied to the model, while at Tauranga and Te Puke, both rain-on-grid and lumped catchment hydrology was required due to the large rural catchments draining from the Kaimai Ranges.

Figure 2.5 shows the rain-on-grid model domains and the lumped sub-catchment boundaries applied to the model.

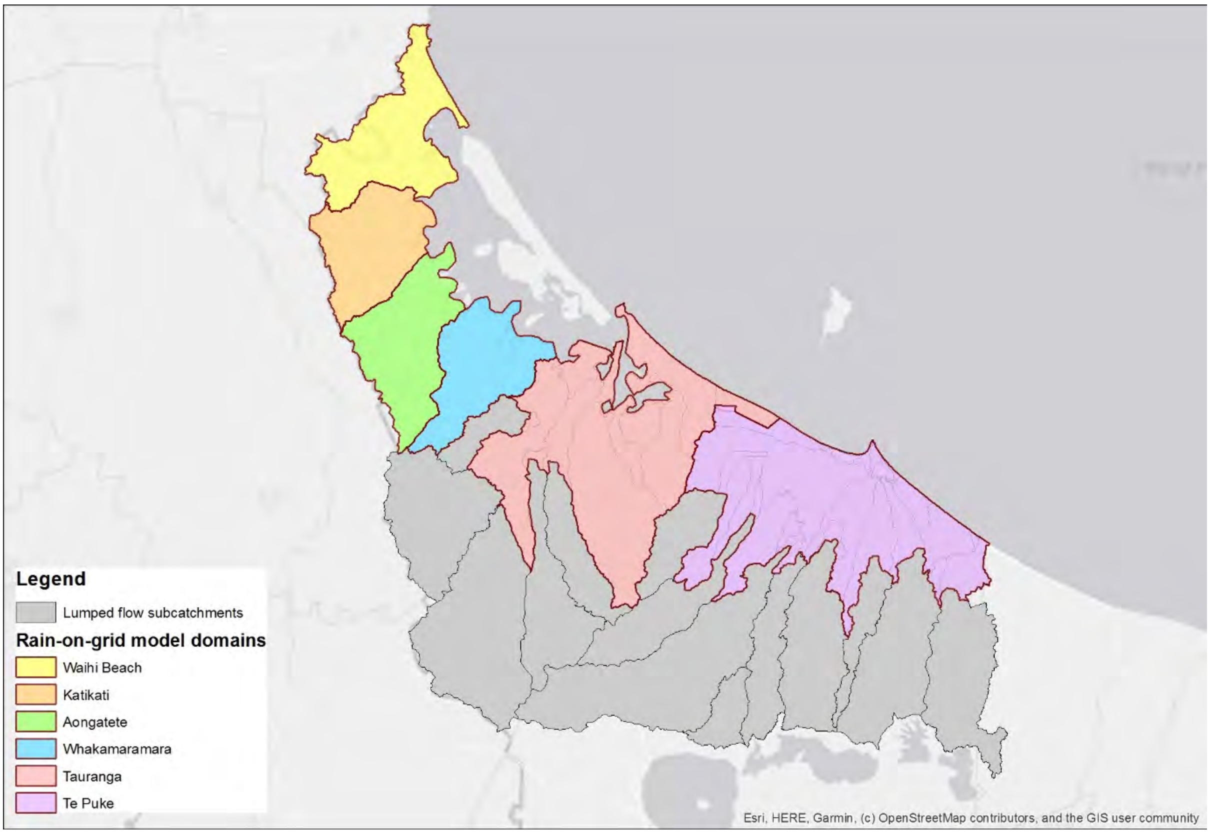

Figure 2.5: Rain-on-grid model domains and lumped sub-catchment boundaries

2.5.1 Rainfall

Rainfall was simulated in the flood model using a 'rain on grid' methodology. Design rainfall depths were estimated using the NIWA High Intensity Rainfall Design System (HIRDS) V4 values and adjustments were made to rainfall depths to account for future climate change predictions based on a representative concentration pathway (RCP) of 8.5, projected to the year 2130, which corresponds to a 3.83 degree temperature increase (see Appendix A for further explanation).

All direct rainfall and lumped catchment hydrological boundaries use HIRDSV4 temporal rainfall hyetographs, as shown in Figure 2.6. Hyetographs were produced for 20-year ARI (Average Recurrence Interval) and 100-year ARI rainfall events.

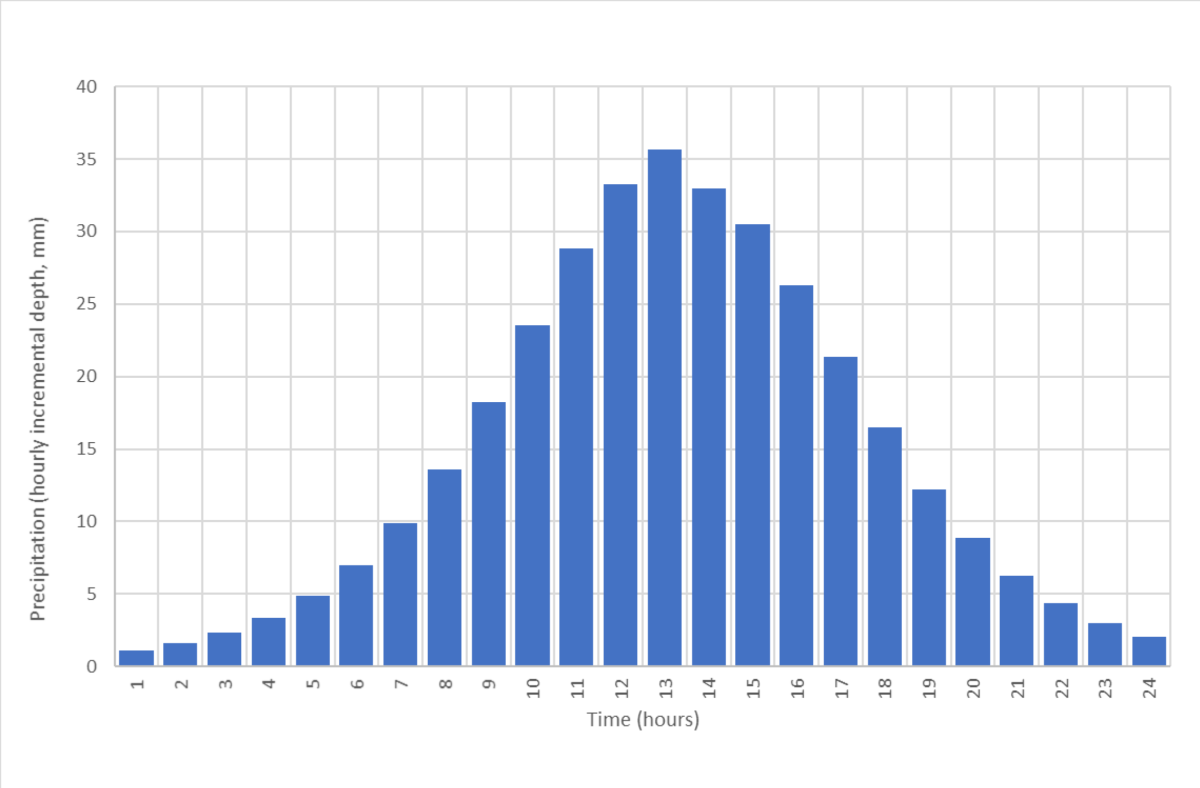

Figure 2.6: 100-year ARI 24 hour duration example HIRDSV4 temporal hyetograph

To ensure that the different response times of all catchments contributing to flooding in the model domain were captured, 1-hour, 6-hour, 12-hour and 24-hour rainfall hyetographs were simulated within the model for each ARI event, and enveloped maximum flood levels were derived to provide a "worst case" output for each ARI event. Critical duration outputs are described further in Section 4.1.

The four event durations selected were deemed representative of critical response times in the catchments modelled. It is acknowledged that the true critical duration could sit somewhere between, or either side of, each of the four durations selected. However, for the purposes of this district-wide study, modelling more event durations was considered to be beyond the level of necessary detail required. Certain sites may require site-specific consideration, especially if deemed to be of high importance or high consequence.

Rainfall was spatially varied both regionally at each model domain, and locally within each model domain. By deriving rainfall contour bands from the HIRDSV4 100-year ARI 24 hour duration event rainfall depth data, it is evident that there is a distinct increase in rainfall depth with distance from the coastline towards higher elevations of the Kaimai Ranges. To capture this spatial variation, rainfall depths were extracted from two centroid locations of each model domain, either side of the 300 mm rainfall contour, effectively providing an upper catchment and lower catchment rainfall representation, as shown in Figure 2.7. Although this doesn't capture the full extent of rainfall spatial variation across each catchment, it is considered of sufficient detail for the purpose of this study.

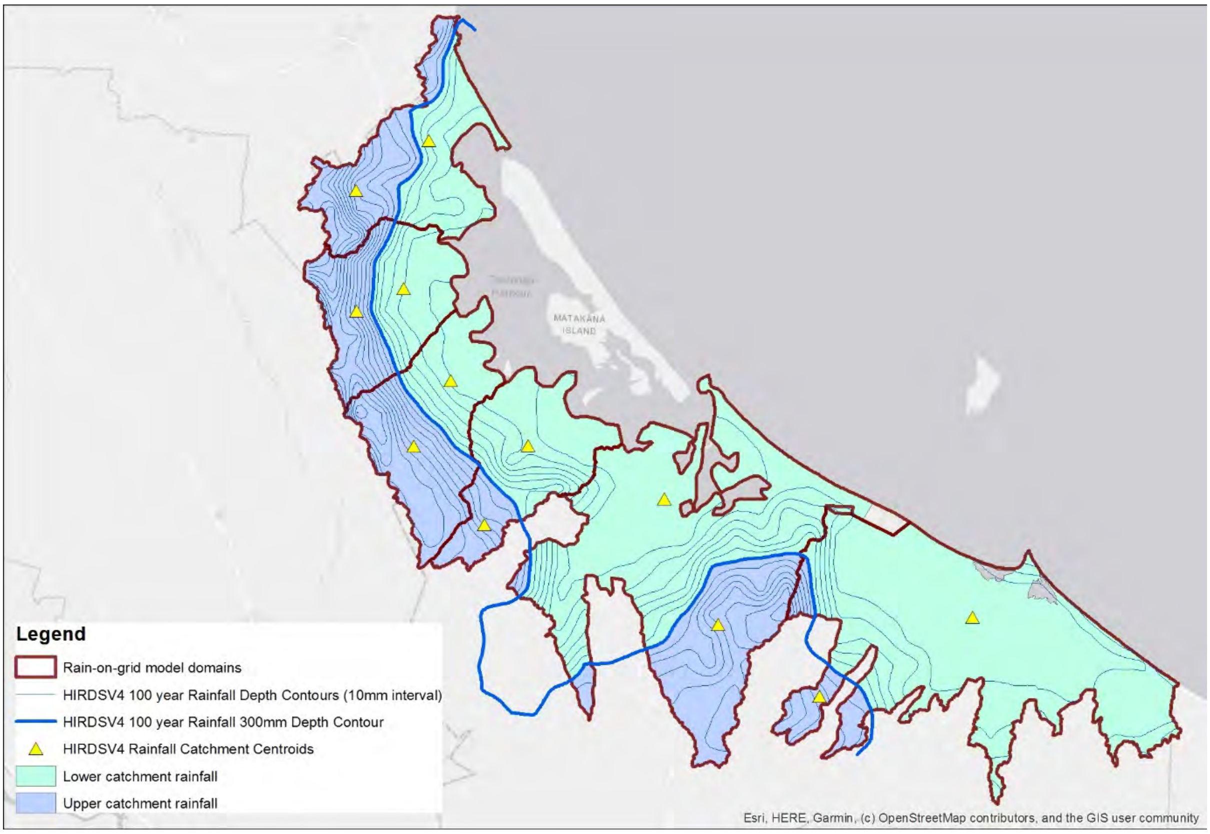

Figure 2.7: Upper and lower catchment spatial variation in rainfall

2.5.2 Inflows

Lumped catchment hydrology was used to simulate runoff from the sub-catchments upstream of the Tauranga and Te Puke model domains. Runoff hydrographs from these catchments were added to the model as specified inflows at the upstream extents of the model domain. For locations where dams exist, such as McLaren Falls, it was assumed that the dam was full and reservoir inflow was equal to reservoir outflow. The sub-catchments for which this methodology was applied are shown as light-grey shaded in Figure 2.5.

Existing SCS unit hydrograph models, developed as a part of the previous work undertaken for NZ Treasury Department with AON, were utilised to derive runoff hydrographs for all lumped sub-catchment inflows. The existing models had been calibrated to Bay of Plenty Regional Council (BOPRC) streamflow gauges at SH29 in the Kopurererua Stream and McCarrolls Farm in the Waimapu Stream together with BOPRC rainfall records from Waimapu at Glue Pot Road and Waimapu at McCarrolls Farm.

The same calibrated values were used in the HEC-HMS model to calculate runoff hydrographs for 20-year ARI and 100-year ARI rainfall events including allowance for climate change, as described in Section 2.5.1. Appendix A further describes the changes made to the models for use in this work.

2.6 Rain-on-grid infiltration losses

To develop hydrological data for rain-on-grid catchments, an “initial and continuing” loss method was applied to the model, with relevant data based on surface soil drainage types classified by the fundamental soil (FS) drainage layer and FS permeability layer sourced from Landcare Research and shown in Figure 2.8 and Figure 2.9.

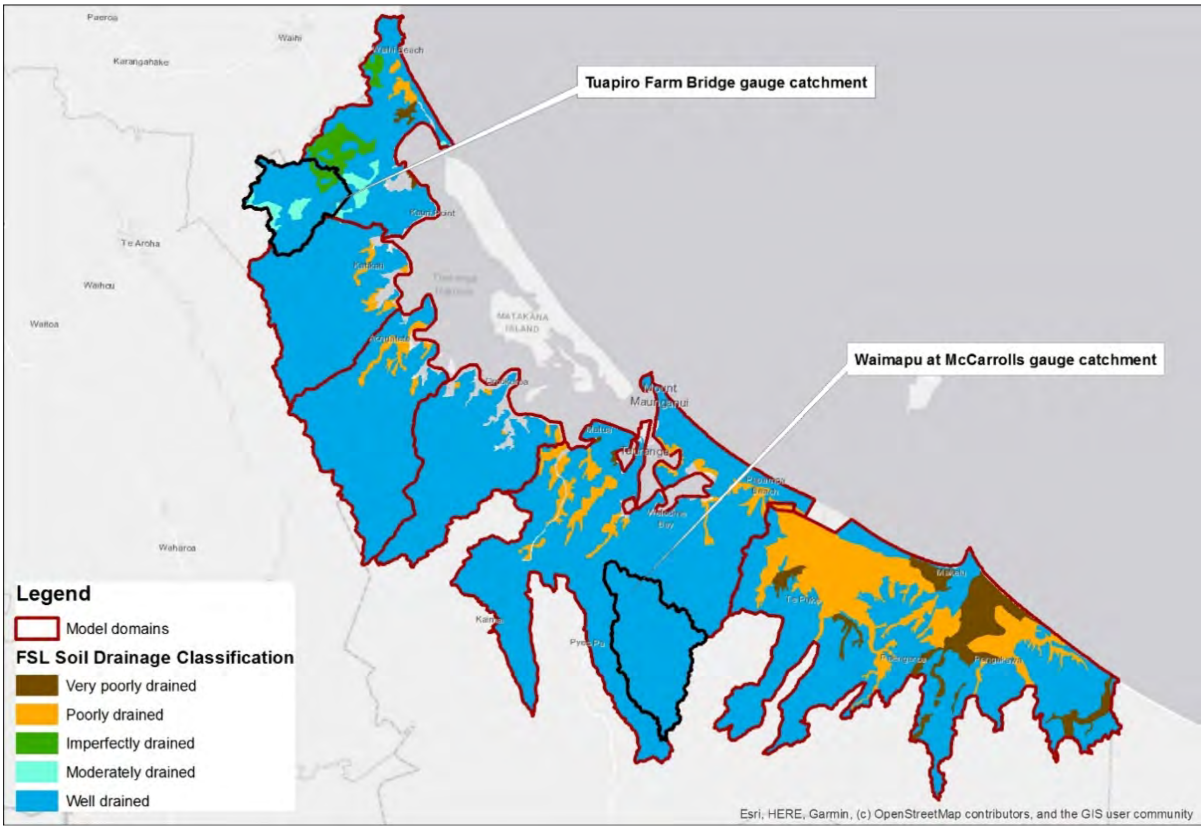

Figure 2.8: Soil drainage characteristics across WBOP, as classified by the Fundamental Soil Drainage Layer sourced from Landcare Research

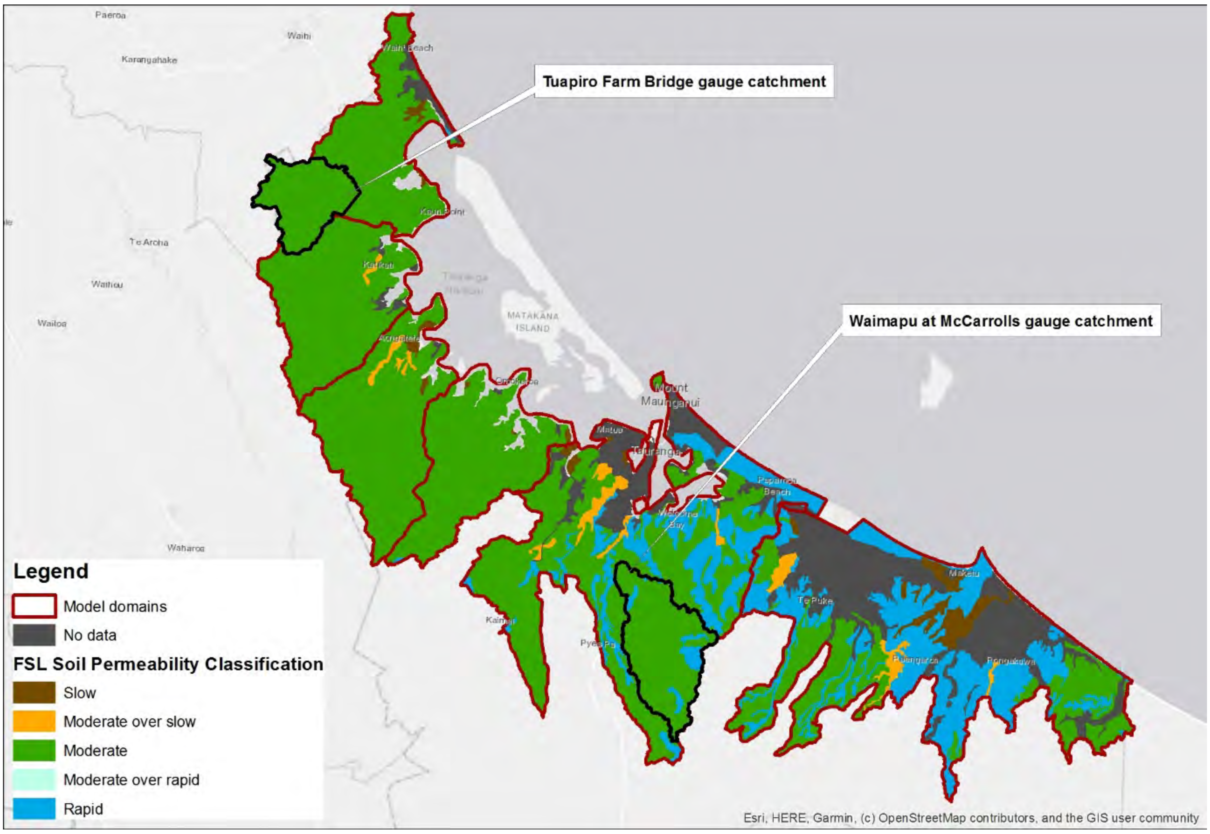

Figure 2.9: Soil permeability characteristics across WBOP, as classified by the Fundamental Soil Permeability Layer sourced from Landcare Research

In the modelling approach, initial losses were kept at zero for conservativeness. Continuing losses were derived by way of calibration with gauged flow events measured at the Tuapiro Stream catchment and Waimapu Stream catchment, and then verified against peak flow estimates taken from the online NIWA New Zealand River Flood Statistics 2018 database – this database presents flood estimates for discrete river reaches using the Henderson-Collins flood peak model.

According to the FS drainage layer, the majority soil drainage characteristic of WBOP catchments are "well-drained" soils, as shown in Figure 2.8. As such, only continuing loss parameters attributed to well drained soils have been adjusted for calibration purposes, as these are by far the major contributor of catchment runoff across the model domains.

Figure 2.10 shows calibration of modelled peak flows at the Farm Bridge gauge located on Tuapiro Stream for a rainfall event recorded in July 2016. Rainfall and flow gauge data were downloaded from the BOPRC online database. Results show the TUFLOW model underestimates the overall flow volume recorded at the gauge but provides a reasonably well-matched estimation of recorded peak flows. A continuing loss of 17 mm/hr for well drained soils was required to achieve calibration. The difference (between modelled and gauged) in total runoff volume occurring after the peak has been attained, indicates a likely contribution from interflow. This interflow component is treated as a loss in the model, whereas in reality this loss emerges later in the event to contribute to volume, but not to peak. As this investigation is focussed on peak levels attained, this hydrological approach was deemed appropriate.

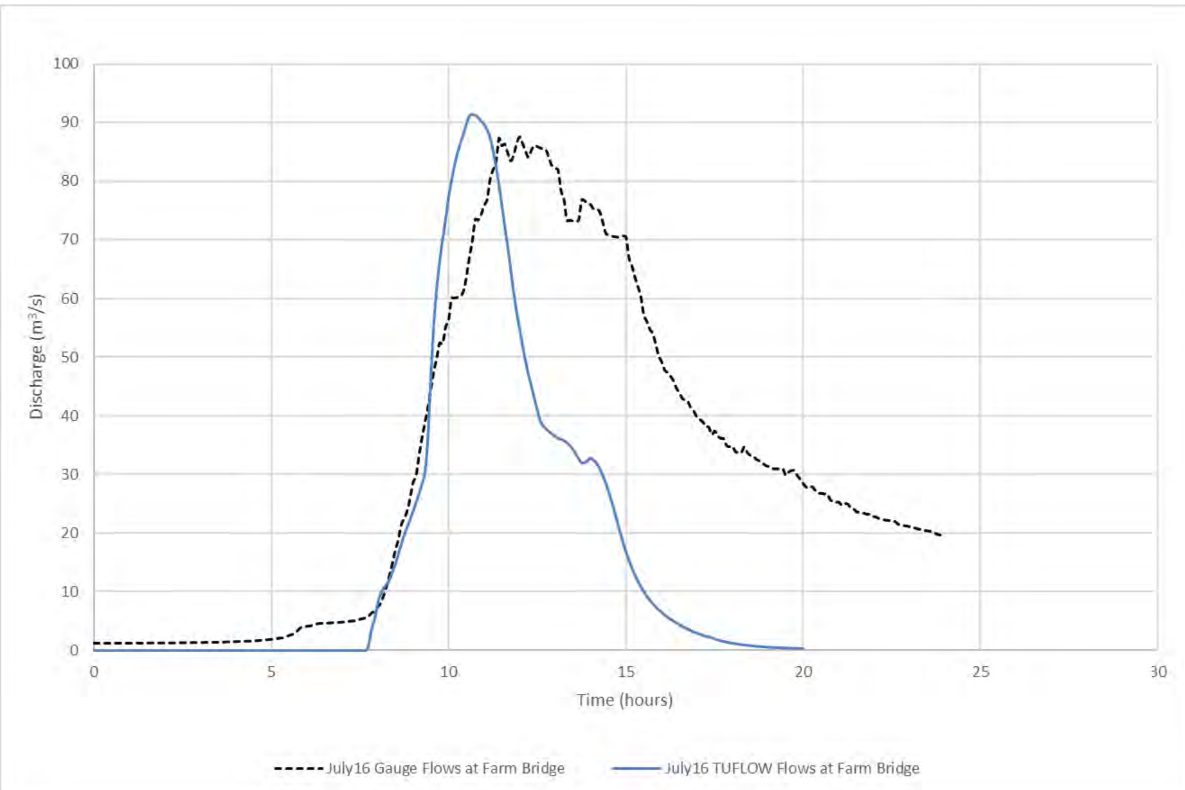

Figure 2.10: Gauged and modelled discharge hydrographs at Tuapiro Stream Farm Bridge in response to a July 2016 rainfall event

The calibrated continuing loss parameter of 17 mm/hr for well drained soils was verified using a 100-year average recurrence interval (ARI) present day design rainfall event and compared against the corresponding Henderson-Collins peak flow estimate at Tuapiro Farm Bridge of approximately 219 m^3/s. For the purposes of validating continuing loss parameters, a 100-year ARI 24 hour duration HIRDSV4 temporal rainfall hyetograph was applied to the model, as this provides a more realistic and comparable rainfall profile when compared with gauged rainfall events. The resulting peak flows of 202 m^3/s, as shown in Figure 2.11, suggests that a 17 mm/hr continuing loss is a reasonable fit for this catchment.

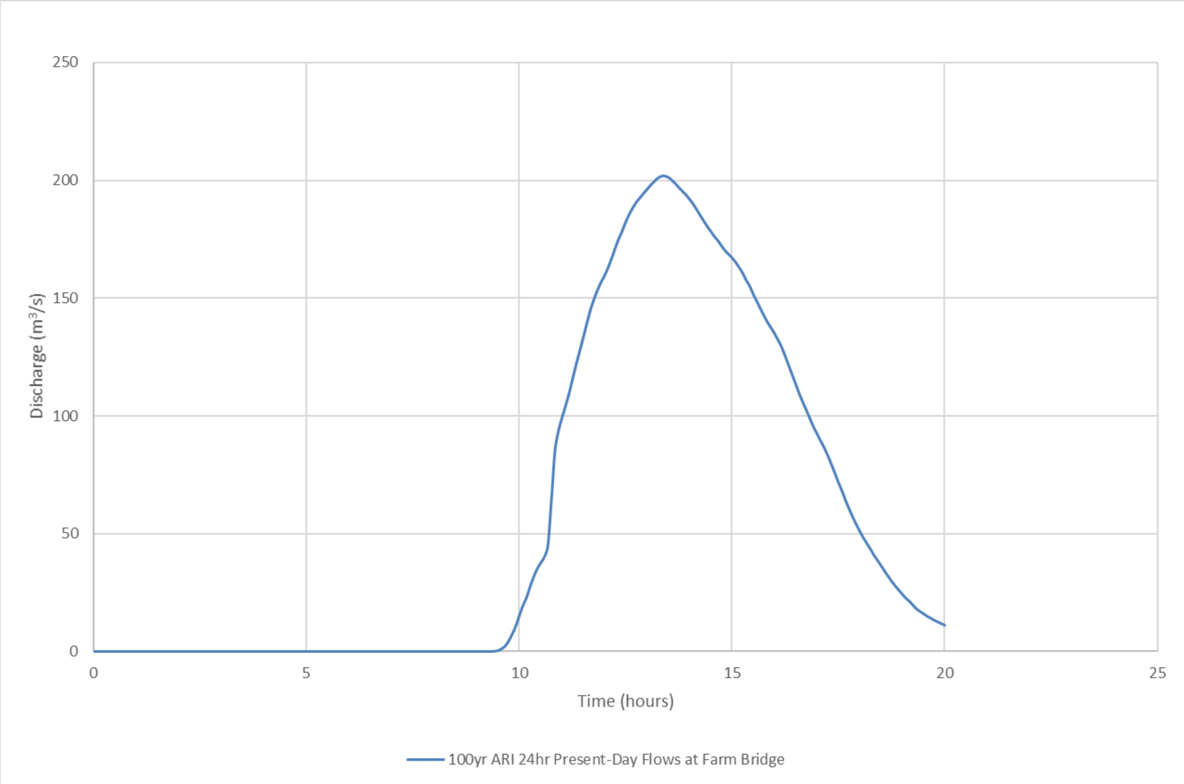

Figure 2.11: Discharge hydrograph at Tuapiro Stream Farm Bridge in response to a 100-year ARI 24-hour present-day rainfall event

Figure 2.12 shows calibration of peak flows at the McCarrolls gauge located on Waimapu Stream for a rainfall event recorded in January 2011. Rainfall and flow gauge data were provided by the BOPRC. Results show the TUFLOW model provides a reasonable fit with flows recorded at the gauge, with slight quicker response time on the rising and falling limb of the hydrograph. A continuing loss of 11 mm/hr for well drained soils was required to achieve calibration. While this result seems reasonable, it is recognised that the Waimapu Stream has a large catchment, within which some spatial variation in rainfall is likely.

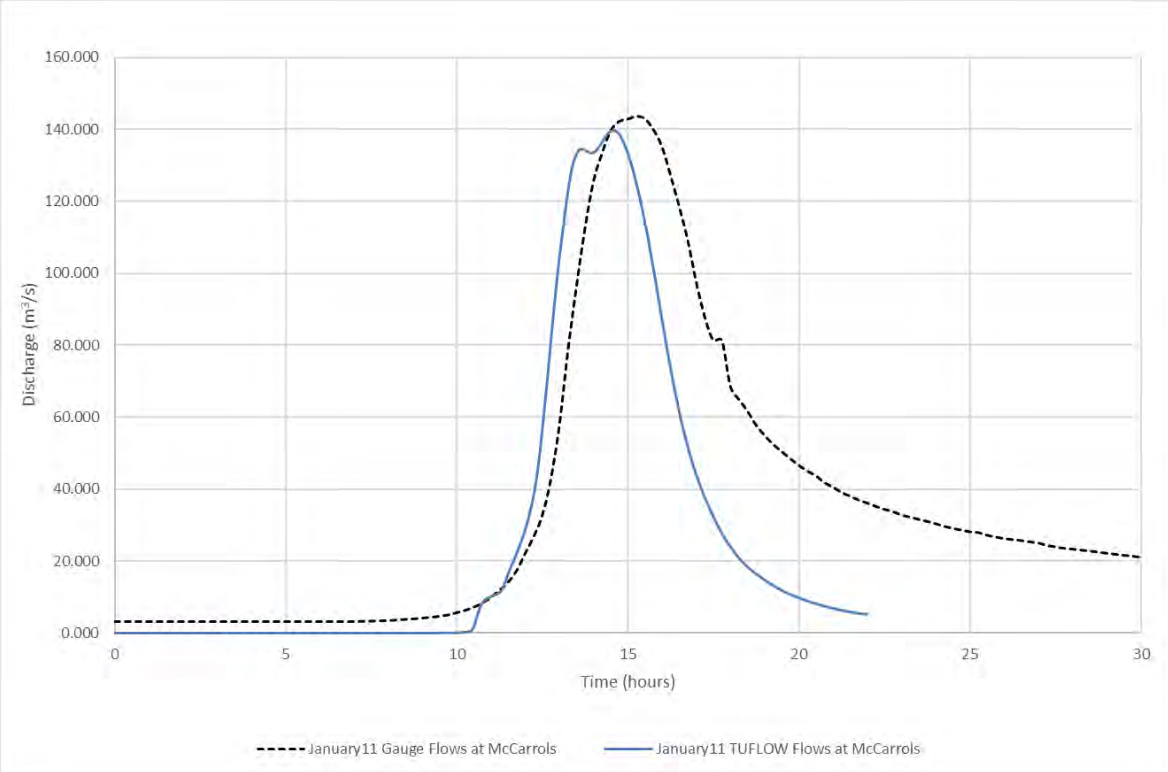

Figure 2.12: Gauged and modelled peak flows at Waimapu Stream at McCarrolls in response to a January 2011 rainfall event

Using the same methodology as was applied at Tuapiro Stream, the calibrated continuing loss parameter of 11 mm/hr for well drained soils was verified using a 100-year ARI present day design rainfall event and compared against the corresponding Henderson-Collins peak flow estimate at McCarrolls gauge of approximately 125 m^3/s. Using a continuing loss of 11 mm/hr results in much larger peak flows compared to Henderson-Collins 100-year ARI estimates, with a higher continuing loss value of 22 mm/hr required to achieve a comparable peak flow. However, as noted above, it is likely that the globally applied design rainfall for the 100-year ARI event should be spatially varied and that to achieve a design discharge of 100-year ARI, global application of 100-year ARI rainfall will probably over-estimate the resulting discharge.

The inconsistencies between calibrated continuing loss values and those required to achieve comparable peak flows to Henderson-Collins could be due to a number of reasons. Complex orographic climatic interactions in the Waimapu catchment are understood to exist making it difficult to make accurate gauge recordings of rainfall events as they move across the Kaimai ranges. Furthermore, soil permeability characteristics of the Waimapu catchment, as defined by the FS permeability layer shown in Figure 2.9, reveal areas of “rapid permeability” classified soil not explicitly differentiated in the FS soil drainage layer, which are likely to have influenced the derivation of peak flows by Henderson-Collins.

The “rapid permeability” soils cover large areas of the Tauranga and Te Puke catchments, as shown in Figure 2.9, and are likely to contribute to higher rates of soil infiltration than other catchment areas of WBOP where these soil types are not present. As such, a lower and upper bound continuing loss value for “well drained” soils have been defined. Lower bound values of 17 mm/hr have been applied to Waihi Beach, Katikati, Aongatete, and Whakamarama model domains, while upper bound values of 22mm/hr have been applied to Tauranga and Te Puke model domains.

Table 2.4 shows the loss values applied to all soil drainage types.

Table 2.4: Soil infiltration values

Soil drainage characteristic	Initial loss (mm)	Continuing loss (mm/hr)	
Very poorly drained	0	0.5	
Poorly drained	0	2	
Imperfectly drained	0	3.5	
Moderately drained	0	8	
Well drained	0	Lower	Upper
		17	22

2.7 Downstream boundary conditions

Dynamic sea level boundaries have been applied to the downstream boundary of all model domains with the timing of peak sea levels adjusted to coincide with the timing of peak rainfall intensity. Figure 2.13 shows an example downstream boundary condition applied to the model. Different tidal timing was required for each 1-hour, 6-hour, 12-hour and 24-hour event duration.

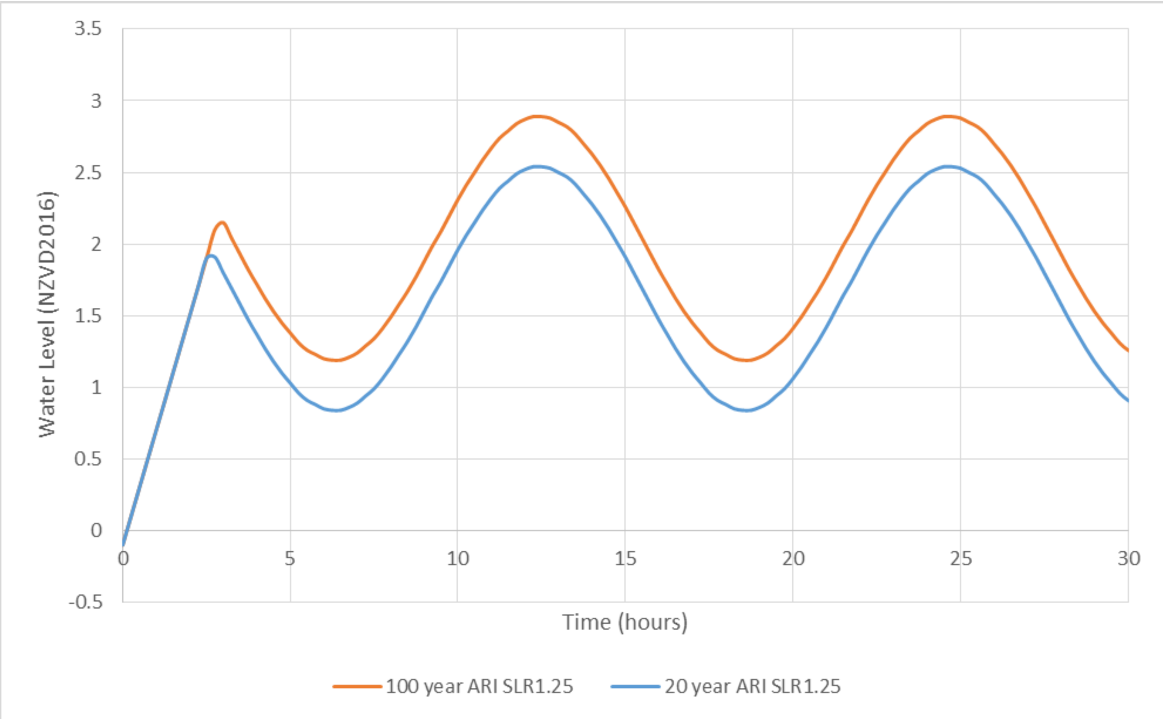

Figure 2.13: Example dynamic downstream sea level boundary applied to the model

Combined storm tide and wave set up sea levels for inner harbour boundaries were sourced from the outputs of the NIWA (2018) Tauranga Harbour Inundation modelling (Reeve et al. 2018 and NIWA 2019). As requested by WBOPDC, values attributed to 20-year ARI and 100-year ARI events with allowance for +1.25 m of sea level rise have been applied to the model.

Sea levels from the NIWA harbour modelling vary spatially across the full extent of the Tauranga Harbour and so have also been applied with spatial variation to each model domain. Sea level values applied to the model were sourced from the model output locations detailed in Reeve et al. (2018) and are shown in Table 2.5 and Figure 2.14.

Table 2.5: Peak of dynamic sea level boundaries applied to Harbour boundaries

NIWA results site (Reeve et al. 2018)	Corresponding TUFLOW model boundary	Peak sea level (m NZVD16) 20-year ARI inc. 1.25m SLR	Peak sea level (m NZVD16) 100-year ARI inc. 1.25m SLR
2	TaurangaI	2.54	2.89
4	TaurangaH	2.61	2.98
6	TaurangaG	2.77	3.18
15	TaurangaF	2.82	3.25
25	TaurangaE	2.67	3.04
29	TaurangaD	2.76	3.17
35	TaurangaC	2.69	3.07
39	TaurangaA	2.93	3.38
42	WhakamaramaH	2.81	3.23
47	WhakamaramaF	2.96	3.42
49	WhakamaramaE	2.87	3.31
51	WhakamaramaD	2.76	3.15
52	WhakamaramaC	2.90	3.33
55	WhakamaramaB	2.99	3.45
56	WhakamaramaA	3.10	3.59
57	AongateteF	2.99	3.44
58	AongateteE	3.03	3.50
59	AongateteD	2.87	3.30
60	AongateteC	2.94	3.39
63	AongateteB	2.65	3.02
65	AongateteA	2.86	3.29
66	KatikatiF	2.78	3.19
67	KatikatiE	2.68	3.06
70	KatikatiC	2.73	3.10
73	KatikatiB	2.65	3.00
75	KatikatiA	2.80	3.20
78	WaihiBeachF	2.71	3.08
81	WaihiBeachE	2.57	2.93
83	WaihiBeachD	2.58	2.96
84	WaihiBeachC	2.72	3.12
87	WaihiBeachB	2.79	3.22
95	WaihiBeachA	2.61	2.99

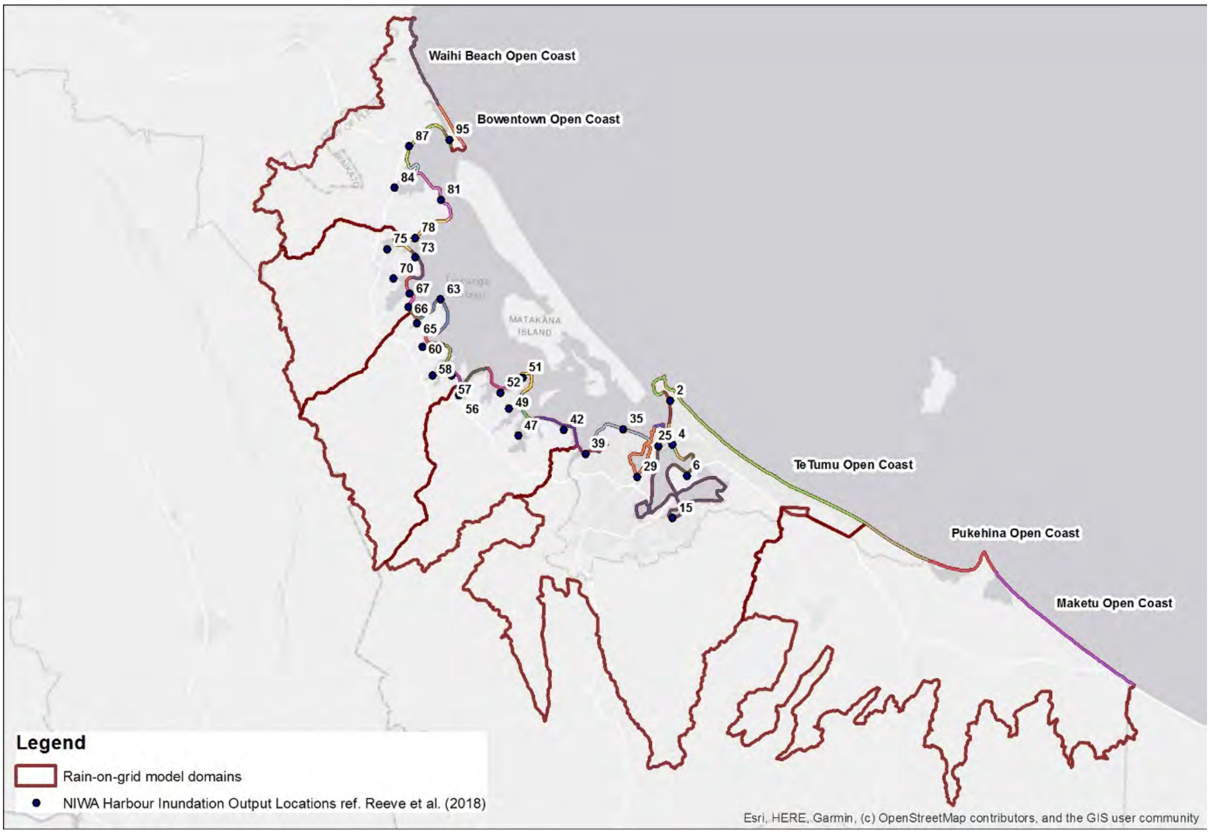

Figure 2.14: Downstream sea level boundaries

Wave set up values for the open coastline were provided by the BOPRC coastal calculator (Katalin Maltai, pers. Comm., April 2020) for Waihi Beach, Bowentown, Te Tumu, Pukehina and Maketu, as shown in Figure 2.14 and Table 2.6. The values were provided for 20-year ARI and 100-year ARI events with a present-day mean sea level, so were adjusted upward by +1.25 m to account for the same sea level rise allowance applied by NIWA to harbour inundation levels. It should be noted that these values do not consider the effects of wave-runup.

Table 2.6: Peak of dynamic sea level boundaries applied to open coast boundaries

BOPRC coastal calculator location	Peak sea level (m NZVD16) 20-year ARI inc. 1.25 m SLR	Peak sea level (m NZVD16) 100-year ARI inc. 1.25 m SLR
Waihi Beach open coast	3.60	4.22
Bowentown open coast	3.54	4.15
Te Tumu open coast	3.91	4.46
Maketu open coast	4.50	5.10
Pukehina open coast	3.60	4.20

T+T has not independently reviewed the sea levels applied to the model.

All sea level data sourced for the model were originally projected to the Moturiki1953 vertical datum, so levels have been adjusted to NZVD2016 to be consistent with the vertical datum of the DEM, using datum offset data available on the Land Information New Zealand (LINZ) online database.

2.8 Stormwater infrastructure

2.8.1 2-dimensional elements

Primary (piped) flow in the catchment was represented in the model by modifying the DEM to replace stormwater pipes with open channels with equivalent hydraulic performance (in accordance with the “2D+” methodology). The pipe sizes applied to a model using this methodology are dependent on grid size. Because the model makes use of different grid sizes in different areas, two datasets were applied to the model.

In small settlement areas where the computation grid size is 2 m x 2 m (4 m^2), only pipes larger than, or equal to, 225 mm diameter and smaller than 2250 mm diameter were represented, while in areas where the computation grid size is 4 m x 4 m (16 m^2), only pipes larger than, or equal to, 450 mm diameter were represented.

The application of the “2D+” methodology has been demonstrated to produce reliable results in previous studies and is considered appropriate for the purpose of this work, given that smaller pipes carry a relatively small proportion of total flood volume in larger events.

GIS files with pipe locations and sizes were provided by WBOPDC and TCC. The locations of some areas of 2D+ pipes are shown in Figure 2.15. Note that in the simulation of these pipes, the DEM is modified so that the hydraulic effects (volume and conveyance) of such pipes is replicated, which is appropriate for the purpose of this work. However, should more detailed understanding of hydraulic performance be required then further consideration of pipe representation should be made.

In addition to piped flow, open drainage channels, identified in the WBOPDC GIS dataset, were also modelled using the same method described above with an assumed depth of 0.5 m, to provide connectivity within the stormwater network. Larger hydraulic structures (e.g. bridges with widths greater than the 2D cell size or with no known dimensions), at key locations have been simplistically ”burnt” into the DEM based on estimated widths from aerial photographs and inverts take from the DEM.

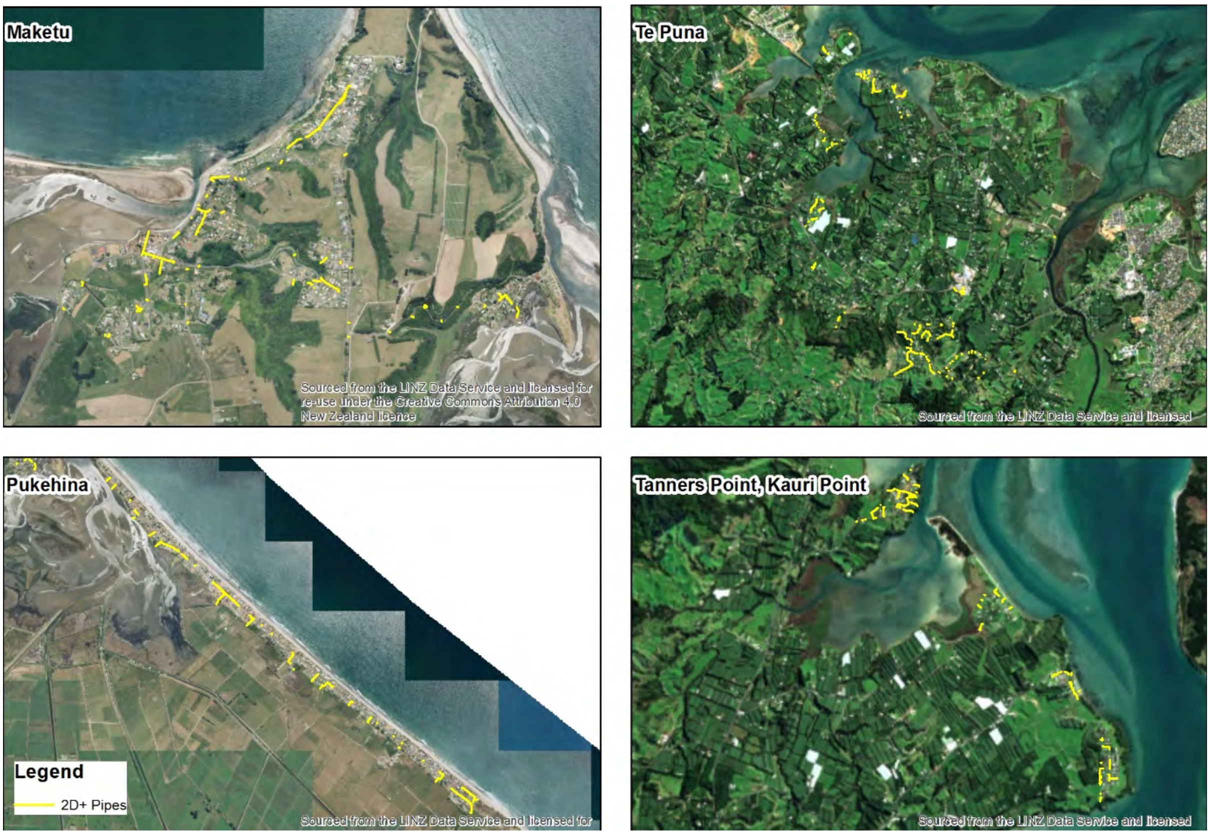

Figure 2.15: Example 2D+ pipe locations

2.8.2 1-dimensional elements

In addition to the 2D "simulated pipes", a number of culvert crossings at key locations where overland flow was impounded behind an embankment (e.g. road embankments) have been applied to the model using embedded 1D structures, as shown in Figure 2.16. The reason for modelling these features as 1D structures is because they are often buried deep beneath steep road embankments, which restricts the application of 2D+ pipes.

Culvert dimensions were sourced from a GIS dataset of road assessment and maintenance management (RAMM) culverts provided by WBOPDC. The dataset identifies thousands of culverts across WBOP, so only key culverts have been applied to the model where deemed most influential to a 100-year ARI event. It was also evident that the dataset was not complete, or did not cover all potential culvert locations within each model domain with some likely culvert locations unaccounted for. This is particularly evident in rural areas where it is likely that numerous private culverts exist, or where asset data capture is less complete, such as along rail networks and in areas of new roading infrastructure.

This RAMM dataset does not provide culvert inverts, lengths or alignments, all of which were estimated using aerial photographs and the LiDAR DEM.

Figure 2.16: RAMM 1D culvert locations applied to the models

3 Model run matrix

The model has been used to simulate a 100-year ARI design event with an allowance for climate change. A joint probability approach has been applied as recommended by BOPRC in the hydrological and hydraulic guidelines to flood hazard investigations. For the 100-year ARI design event, an envelope of rainfall and tidal combinations was applied consistent with the BOPRC hydrological and hydraulic guidelines.

Table 3.1 shows the model runs simulated for each model domain. It was agreed with WBOPDC that four event durations would be run for each rainfall event, to find the critical flood depth duration, as described further in Section 2.5 and Section 4.1.

Table 3.1: Model runs simulated for each model domain

Model run	Design event (ARI)	Rainfall event (ARI)	Rainfall event duration (hours)	Climate horizon	Sea level (ARI)	SLR allowance
1	100	20	1	RCP8.5 2130 (3.83 degrees)	100	+1.25 m
2		100		RCP8.5 2130 (3.83 degrees)	20	+1.25 m
3		20	6	RCP8.5 2130 (3.83 degrees)	100	+1.25 m
4		100		RCP8.5 2130 (3.83 degrees)	20	+1.25 m
5		20	12	RCP8.5 2130 (3.83 degrees)	100	+1.25 m
6		100		RCP8.5 2130 (3.83 degrees)	20	+1.25 m
7		20	24	RCP8.5 2130 (3.83 degrees)	100	+1.25 m
8		100		RCP8.5 2130 (3.83 degrees)	20	+1.25 m

4 Model outputs

4.1 Critical duration

Critical duration maps, based on maximum flood depth, for each ARI event are shown in Appendix B. These maps are intended to be read in conjunction with maximum flood depth maps to determine both the critical duration and the corresponding peak flood depth for a specific area of interest.

Critical duration varies spatially across each model domain and can be different for each ARI event modelled. That is, the same rainfall duration will not always yield the highest peak water level at a specific location for every ARI event. As expected, the 1-hour and 6-hour durations generally produce the greatest flood depths in upper catchment areas and smaller catchment areas, while the 12-hour and 24-hour durations were critical in lower catchment areas draining from larger rural catchments.

The 24-hour duration was observed to be most critical in the Te Puke and Tauranga model domains at lower catchment areas due to the large, lumped river catchment inflows and the expansive low-lying floodplain estuarine areas. It is not surprising that the 24-hour duration is critical in these areas as the 24-hour rainfall hyetographs was assessed as critical via lumped catchment hydrological analysis, and because of this, event durations greater than 24 hours were deemed unlikely to be critical and so have not been simulated.

4.2 Peak flood depth

Model outputs, represented as “peak of peak” maximum modelled flood depths for the 100-year ARI event simulated, have been provided in Appendix C. “Peak of peak” outputs are the enveloped maximum flood depth reached at any one cell in the model domain across the 1-hour, 6-hour, 12-hour and 24-hour duration events and provide a “worst-case” estimate of peak flood depth. The “peak of peak” overlays do not come from any single event simulation, but are compiled from all event simulations. Table 4.1 shows the model runs completed and the process of enveloping model outputs to determine one result file.

Table 4.1: Rainfall and sea level combinations for deriving peak flood depth outputs

<table>
<tr><th>Model run</th><th>Design event (ARI)</th><th>Rainfall event (ARI)</th><th>Rainfall event duration (hours)</th><th>Sea level (ARI)</th><th colspan="2">Process</th><th>Result</th></tr>
<tr><td>1</td><td rowspan="8">100</td><td>20</td><td rowspan="2">1</td><td>100</td><td rowspan="2">Envelope to find 1-hour maxima</td><td rowspan="8">Envelope to find maxima across all durations</td><td rowspan="8">100-year ARI event data</td></tr>
<tr><td>2</td><td>100</td><td>20</td></tr>
<tr><td>3</td><td>20</td><td rowspan="2">6</td><td>100</td><td rowspan="2">Envelope to find 6-hour maxima</td></tr>
<tr><td>4</td><td>100</td><td>20</td></tr>
<tr><td>5</td><td>20</td><td rowspan="2">12</td><td>100</td><td rowspan="2">Envelope to find 12-hour maxima</td></tr>
<tr><td>6</td><td>100</td><td>20</td></tr>
<tr><td>7</td><td>20</td><td rowspan="2">24</td><td>100</td><td rowspan="2">Envelope to find 24-hour maxima</td></tr>
<tr><td>8</td><td>100</td><td>20</td></tr>
</table>

It is worth reiterating that the modelling undertaken has been based on remotely sensed ground levels (LiDAR survey) and on design future rainfall events, both of which have accuracy limitations. The model results have generally been presented only to show flooding where maximum depth in excess of 100 mm has been estimated. Furthermore, a direct rainfall approach has been applied, which can highlight accuracy deficiencies in input data by showing small “puddles” in predicted flooding. It is usual with flood depth results from this kind of modelling approach that the results be “cleaned” by removing puddles before publication. T+T has presented raw model results in this report, in anticipation of WBOPDC undertaking “cleaning” of model results before publication and further use.

5 Applicability

This report has been prepared for the exclusive use of our client Western Bay of Plenty District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Michael Fifield	Reuben Hansen
Water Resource Consultant	Project Director

Technically reviewed by Mark Pennington, Technical Director Water Resource Engineering

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Appendix A: Lumped catchment hydrology memo

Tonkin+Taylor

Memo

To:	**Michael Fifield**	**Job No:**	**1012463**
From:	**John Hansford**	**Date:**	**2 November 2020**
cc:	**Mark Pennington**		
	Western Bay of Plenty District Council		
Subject:	**Generation of 100 year and 20 year ARI hydrographs from HIRDS version 4 rainfall**		

1 Introduction

In 2017 Tonkin+Taylor (T+T) prepared hydrographs for thirteen catchments in the Western Bay of Plenty area as part of a flood model set up for AON. Western Bay of Plenty District Council (WBoPDC) requested T+T to use the AON flood model to simulate flood extents from fully nested 24 hour 100 year and 20 year ARI design storm hyetographs with allowance for climate change projected to 2130 according to RCP 8.5.

As part of the study for AON simulations were carried out using observed rainfall and streamflow to assess whether or not the SCS CN and time of concentration (Tc) estimated the soil groups and SCS CN tables are reasonably representative for the catchments. Simulated flows for the Waimapu Stream at McCarrolls correspond well with the observed flows and formed the basis for accepting tabulated CN values selected on the basis of land use and soil group.

In addition to the analyses carried out in May 2020, WBoPDC requested T+T to simulate flood extents from inflow hydrographs generated using HIRDS version 4 temporal distributions design hyetographs for storm durations of 1, 6, 12 and 24 hours for 100 year and 20 year ARI design rainfall projected to 2130 time horizon according to RCP 8.5.

2 Design rainfall

The HIRDS V4 documentation provides projected temperature increases for four representative concentration pathways (RCPs) and four time horizons:

- Nominal 2040 (period 2031-2050)
- Nominal 2065 (period 2056-2075)
- Nominal 2090 (period 2081-2100)
- Nominal 2110 (period 2101-2020)

Extrapolating temperature increase beyond 2110 is not recommended because of increased uncertainty of projections and also projections at 2110 are already based on a reduced number of Global Climate Models (GCMs). Advice from NIWA (personal communications with Dr T Carey-Smith) is to project out short periods beyond 2110 using a straight line fitted through the four published temperature increases as shown in Figure 2.1 and summarised in Table 2.1. The extrapolated RCP 8.5 temperature increase to 2130 is 3.83°C.

Table 2.1: Projected sea surface temperature increase at each time horizon (°C)

	2040	2065	2090	2110	2120	2130
RCP 2.6	0.59	0.67	0.59	0.59	0.59	0.59
RCP 4.5	0.74	1.05	1.21	1.44	1.53	1.63
RCP 6.0	0.68	1.16	1.63	2.31	2.44	2.66
RCP 8.5	0.85	1.65	2.58	3.13	3.50	3.83

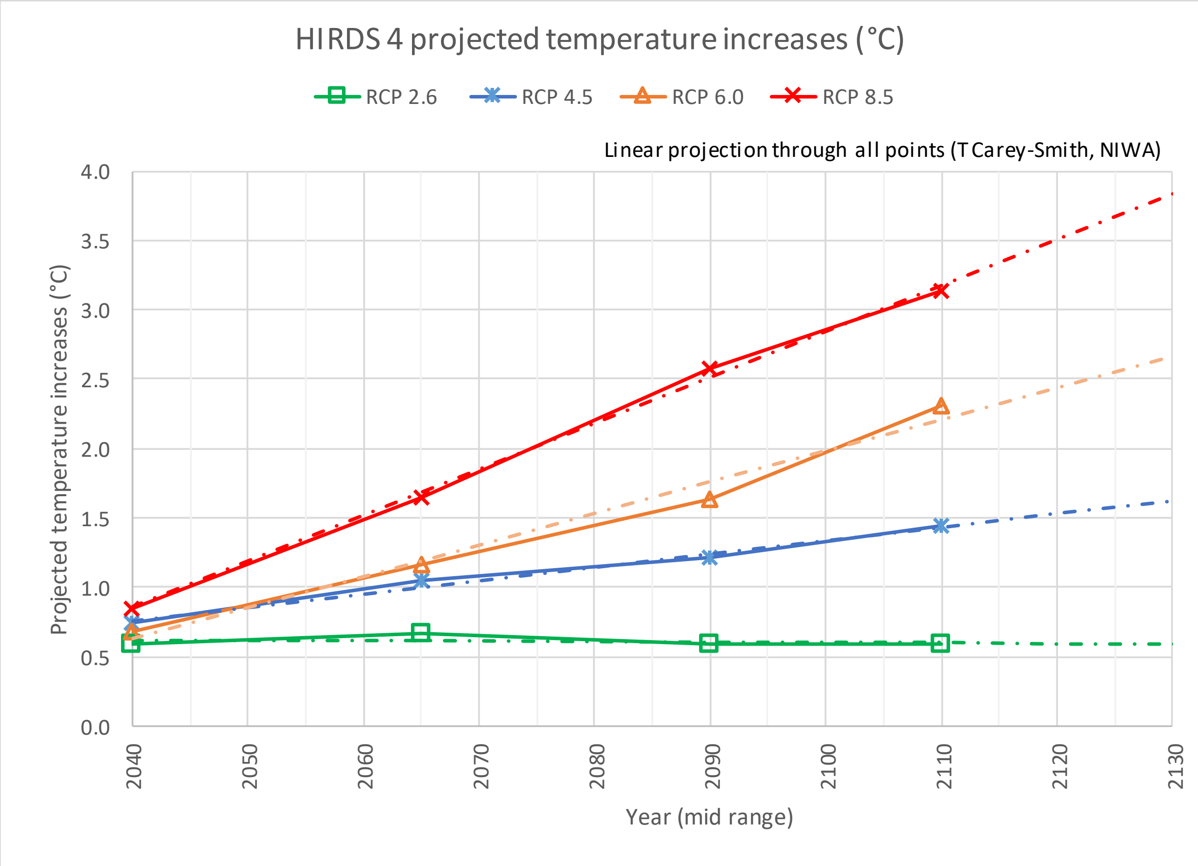

Figure 2.1: HIRDS V4 projected temperature increases with liner extrapolation to 2130

HIRDS storm rainfall data with climate change projected to 2130 according to RCP 8.5 was downloaded for each of the catchments. Areal reduction factors (ARF) were calculated using the formula in the HIRDS 4 documentation that incorporates catchment area, storm duration and ARI. The ARF factors are listed in Table 2.2 and the design rainfall depths in Table 2.3.

Table 2.2: Areal reduction factors

Catchment	Catchment area (km^2)	Areal reduction factors for storm duration (hours) and ARI									
		100 year					20 year				
		1	6	12	24	48	1	6	12	24	48
Kaikokopu	96.4	0.77	0.91	0.94	0.96	0.97	0.79	0.92	0.94	0.96	0.97
Kopurererua	51.1	0.82	0.93	0.95	0.97	0.98	0.84	0.94	0.96	0.97	0.98

Catchment	Catchment area (km^2)	Areal reduction factors for storm duration (hours) and ARI									
		100 year					20 year				
		1	6	12	24	48	1	6	12	24	48
Lower Kaituna	82.4	0.78	0.91	0.94	0.96	0.97	0.80	0.92	0.95	0.96	0.97
Mangapapa	165.3	0.71	0.88	0.92	0.94	0.96	0.73	0.90	0.93	0.95	0.96
Mangorewa	184.3	0.69	0.88	0.92	0.94	0.96	0.72	0.89	0.92	0.95	0.96
Ngamawahine	112.8	0.75	0.90	0.93	0.95	0.97	0.77	0.91	0.94	0.96	0.97
Ohourere	28.3	0.86	0.95	0.96	0.97	0.98	0.88	0.95	0.97	0.98	0.98
Omanawa	80.9	0.78	0.91	0.94	0.96	0.97	0.80	0.92	0.95	0.96	0.97
Pongakawa	112.3	0.75	0.90	0.93	0.95	0.97	0.77	0.91	0.94	0.96	0.97
Raparapahoe	48.1	0.83	0.93	0.95	0.97	0.98	0.84	0.94	0.96	0.97	0.98
Waiari	69.0	0.80	0.92	0.94	0.96	0.97	0.82	0.93	0.95	0.96	0.98
Waitahanui	97.7	0.77	0.91	0.94	0.96	0.97	0.79	0.92	0.94	0.96	0.97
Wharere	31.6	0.86	0.94	0.96	0.97	0.98	0.87	0.95	0.96	0.97	0.98

Table 2.3: Design rainfall depths

Catchment	HIRDS data point		Design rainfall (mm) for storm duration (hours) and ARI									
	Latitude	Longitude	100 year					20 year				
			1	6	12	24	48	1	6	12	24	48
Kaikokopu	-37.9263	176.4101	93.1	244.4	318.7	396.2	476.7	69.8	181.0	236.1	293.8	355.3
Kopurererua	-37.8512	176.1224	99.1	266.1	354.2	448.5	546.6	74.1	198.0	264.0	335.0	410.5
Lower Kaituna	-37.9607	176.3461	91.3	242.3	318.1	398.5	484.0	68.4	179.6	235.9	295.8	361.0
Mangapapa	-37.9196	176.0275	80.0	236.3	322.0	415.2	513.0	65.3	184.3	246.7	313.8	386.0
Mangorewa	-37.9635	176.2602	78.4	238.0	322.8	414.9	513.3	59.9	177.9	241.0	309.9	385.1
Ngamawahine	-37.8141	175.9649	90.9	260.5	353.4	454.4	558.9	68.9	195.0	264.6	340.7	421.4
Ohourere	-37.7443	176.0132	105.0	264.1	345.7	432.8	524.2	77.9	195.8	257.1	322.8	393.6
Omanawa	-37.8957	176.1020	91.7	256.6	346.0	442.7	543.2	69.2	191.8	258.8	331.7	409.1
Pongakawa	-37.9282	176.5074	88.2	229.8	299.1	370.9	444.6	66.1	169.8	221.0	274.4	330.6
Raparapahoe	-37.8350	176.2548	101.5	269.8	357.2	449.6	544.1	75.7	200.1	265.4	334.8	407.5
Waiari	-37.9049	176.2358	94.1	264.3	359.4	467.9	591.2	70.8	197.3	268.6	350.4	445.2
Waitahanui	-37.9550	176.5774	91.8	250.2	332.6	420.5	512.0	69.1	185.7	246.8	312.2	381.7
Wharere	-37.9118	176.4612	105.8	251.9	320.4	389.8	460.9	78.2	185.7	236.4	288.3	342.8

The HIRDS version 4 temporal distributions depend on region in New Zealand and storm duration, but is independent of ARI. The WBoPDC area is in the north of North Island region. The normalised temporal distributions are listed in Table 2.4.

Table 2.4: Incremental rainfall depths as percentage of total storm event

1 hour storm		6 hour storm		12 hour storm		24 hour storm		48 hour storm	
Time (min)	Incremental depth (% of total)	Time (hours)	Incremental depth (% of total)	Time (hours)	Incremental depth (% of total)	Time (hours)	Incremental depth (% of total)	Time (hours)	Incremental depth (% of total)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.86	0.25	0.61	0.50	0.46	1.00	0.31	2.00	0.30
10	3.22	0.50	0.78	1.00	0.61	2.00	0.46	4.00	0.44
15	5.39	0.75	0.99	1.50	0.82	3.00	0.67	6.00	0.65
20	8.53	1.00	1.25	2.00	1.08	4.00	0.97	8.00	0.96
25	12.33	1.25	1.57	2.50	1.42	5.00	1.41	10.00	1.41
30	15.70	1.50	1.96	3.00	1.85	6.00	2.01	12.00	2.03
35	16.26	1.75	2.43	3.50	2.40	7.00	2.84	14.00	2.89
40	13.91	2.00	2.97	4.00	3.07	8.00	3.92	16.00	4.02
45	10.29	2.25	3.59	4.50	3.87	9.00	5.25	18.00	5.42
50	6.58	2.50	4.28	5.00	4.78	10.00	6.77	20.00	6.99
55	3.83	2.75	4.99	5.50	5.77	11.00	8.30	22.00	8.54
60	2.11	3.00	5.70	6.00	6.77	12.00	9.57	24.00	9.77
		3.25	6.36	6.50	7.69	13.00	10.25	26.00	10.97
		3.50	6.89	7.00	8.41	14.00	9.48	28.00	12.08
		3.75	7.25	7.50	8.82	15.00	8.77	30.00	10.31
		4.00	8.06	8.00	8.61	16.00	7.56	32.00	7.92
		4.25	8.80	8.50	8.01	17.00	6.14	34.00	5.61
		4.50	7.98	9.00	6.97	18.00	4.74	36.00	3.74
		4.75	6.79	9.50	5.69	19.00	3.52	38.00	2.40
		5.00	5.47	10.00	4.41	20.00	2.55	40.00	1.50
		5.25	4.22	10.50	3.28	21.00	1.80	42.00	0.92
		5.50	3.14	11.00	2.37	22.00	1.26	44.00	0.56
		5.75	2.28	11.50	1.68	23.00	0.87	46.00	0.34
		6.00	1.63	12.00	1.17	24.00	0.59	48.00	0.21

3 Generation of hydrographs

The HEC-HMS model was used to generate 100 year and 20 year ARI 24 hour hydrographs using the RCP 8.5 2130 24 hour rainfall. The HEC-HMS input parameters and hydrograph peaks, with the maximum for each ARI in bold, are summarised in Table 3.1. The results show that the critical storm duration is between 12 and 24 hours, except the 100 year ARI critical duration in the Ohourere catchment is 6 hours. It should be noted that simulations using the SCS CN loss method results in longer critical durations than the constant loss method.

Table 3.1: Model parameters and simulated hydrograph peaks (RCP 8.5 2130)

Catchment	HEC-HMS parameters		Simulated peak discharge (m^3/s) for storm duration (hours)									
	CN	Lag (min)	100 year					20 year				
			1	6	12	24	48	1	6	12	24	48
Kaikokopu	45.1	331	71	362	479	489	453	41	222	301	314	299
Kopurererua	48.8	225	69	329	397	373	328	40	207	258	248	224
Lower Kaituna	50.2	327	69	345	452	460	425	40	214	289	300	286
Mangapapa	46.5	274	115	717	964	985	915	78	480	643	656	619
Mangorewa	54.4	298	145	884	1,173	1,195	1,100	87	564	770	801	758
Ngamawahine	53.4	179	188	911	1,038	941	807	112	588	689	637	563
Ohourere	61.8	134	102	321	312	256	207	60	211	211	176	147
Omanawa	48.1	279	75	407	534	537	491	44	257	347	357	336
Pongakawa	50.7	317	93	449	579	579	525	53	277	367	374	349
Raparapahoe	49.3	215	72	331	389	359	311	42	208	252	238	212
Waiari	50.4	295	68	362	483	500	473	40	230	316	336	328
Waitahanui	50.1	286	94	482	621	617	559	55	302	399	405	377
Wharere	42.3	291	31	131	162	156	140	17	79	101	99	91

2-Dec-20
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Appendix B: Peak flood depth critical duration

Waihi Beach

- *Figure B1. Waihi Beach Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depth Critical Duration*

Katikati

- *Figure B2. Katikati Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depth Critical Duration*

Aongatete

- *Figure B3. Aongatete Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depth Critical Duration*

Whakamarama

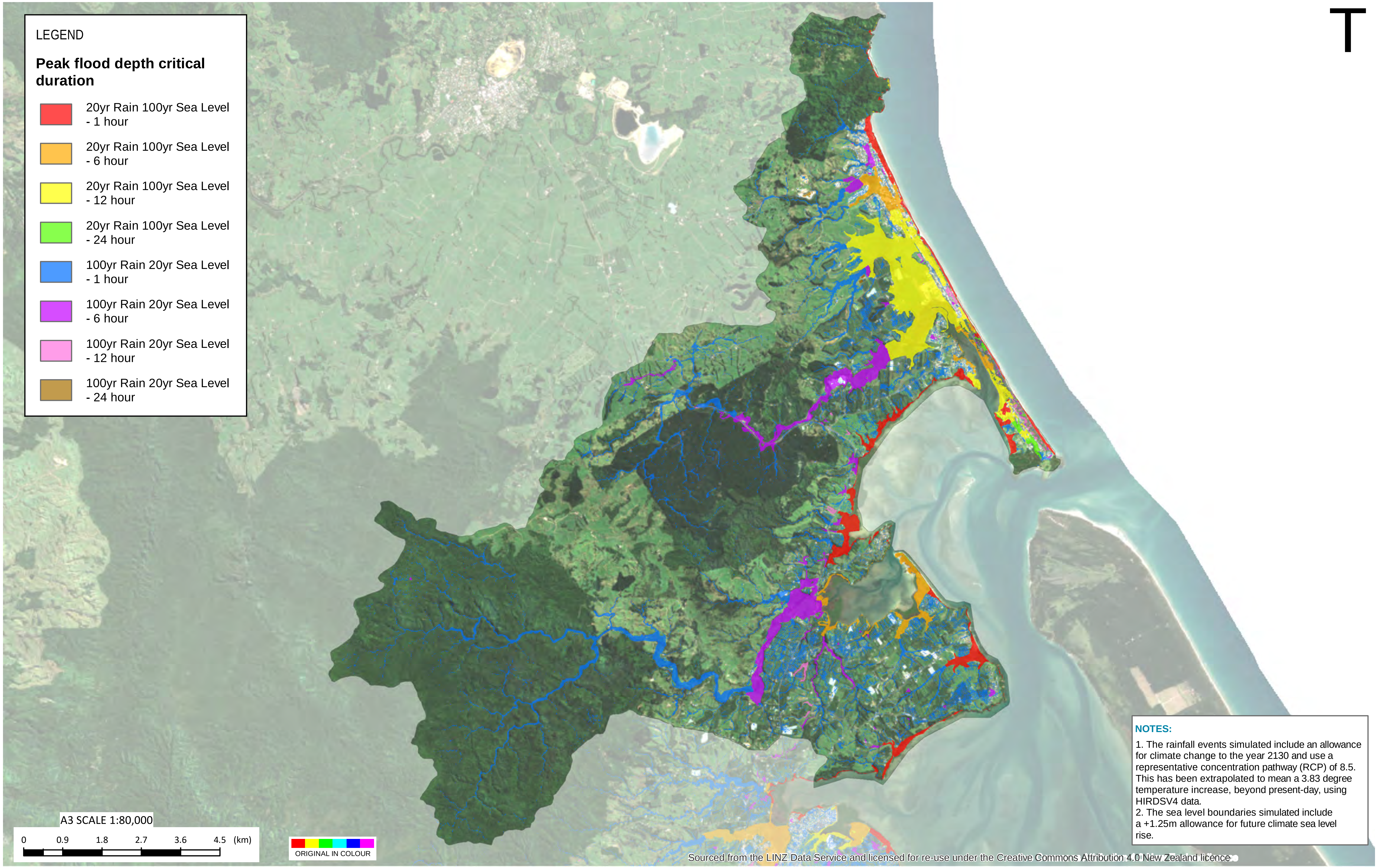
- *Figure B4. Whakamarama Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depth Critical Duration*

Tauranga

- *Figure B5. Tauranga Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depth Critical Duration*

Te Puke

- *Figure B6. Te Puke Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depth Critical Duration*



NOTES:

1. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
2. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.

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NOTES:
To be read in conjunction with Western Bay of Plenty Flood Hazard Mapping Model Build Report. The information presented on these figures is based on a numerical representation of the physical reality and is reliant upon input data and therefore bears uncertainty.

REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/20

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**
PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE WAIHI BEACH DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - CRITICAL PEAK FLOOD DEPTH DURATION

SCALE (A3) 1:80,000 FIG No. FIGURE B1. REV 0

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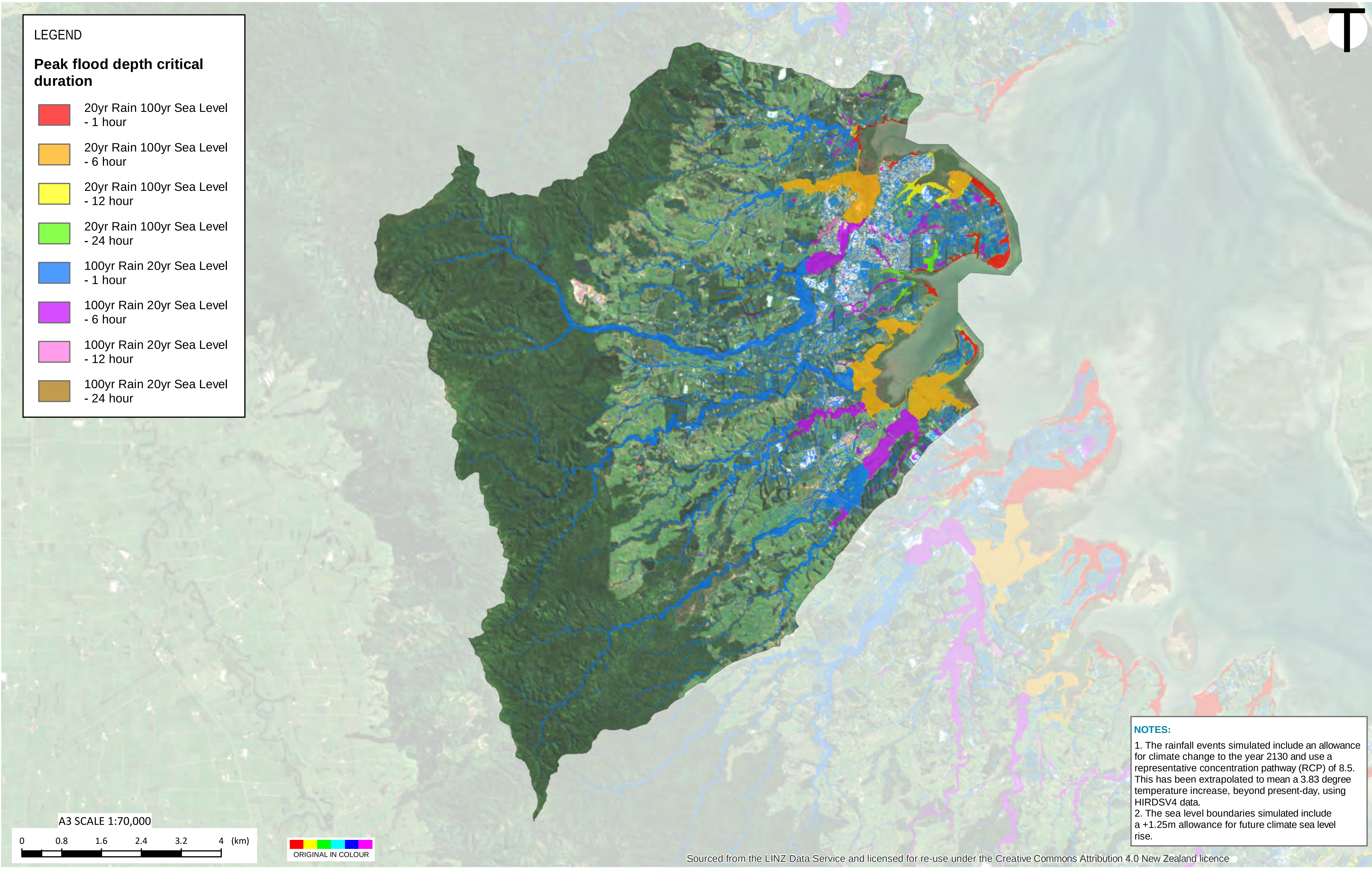

NOTES:

1. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
2. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.

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NOTES:
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PROJECT No.	1012463.00	
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	RCH	FEB.21
	APPROVED	DATE

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE KATIKATI DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - CRITICAL PEAK FLOOD DEPTH DURATION
SCALE (A3) 1:70,000 FIG No. FIGURE A6. REV 0

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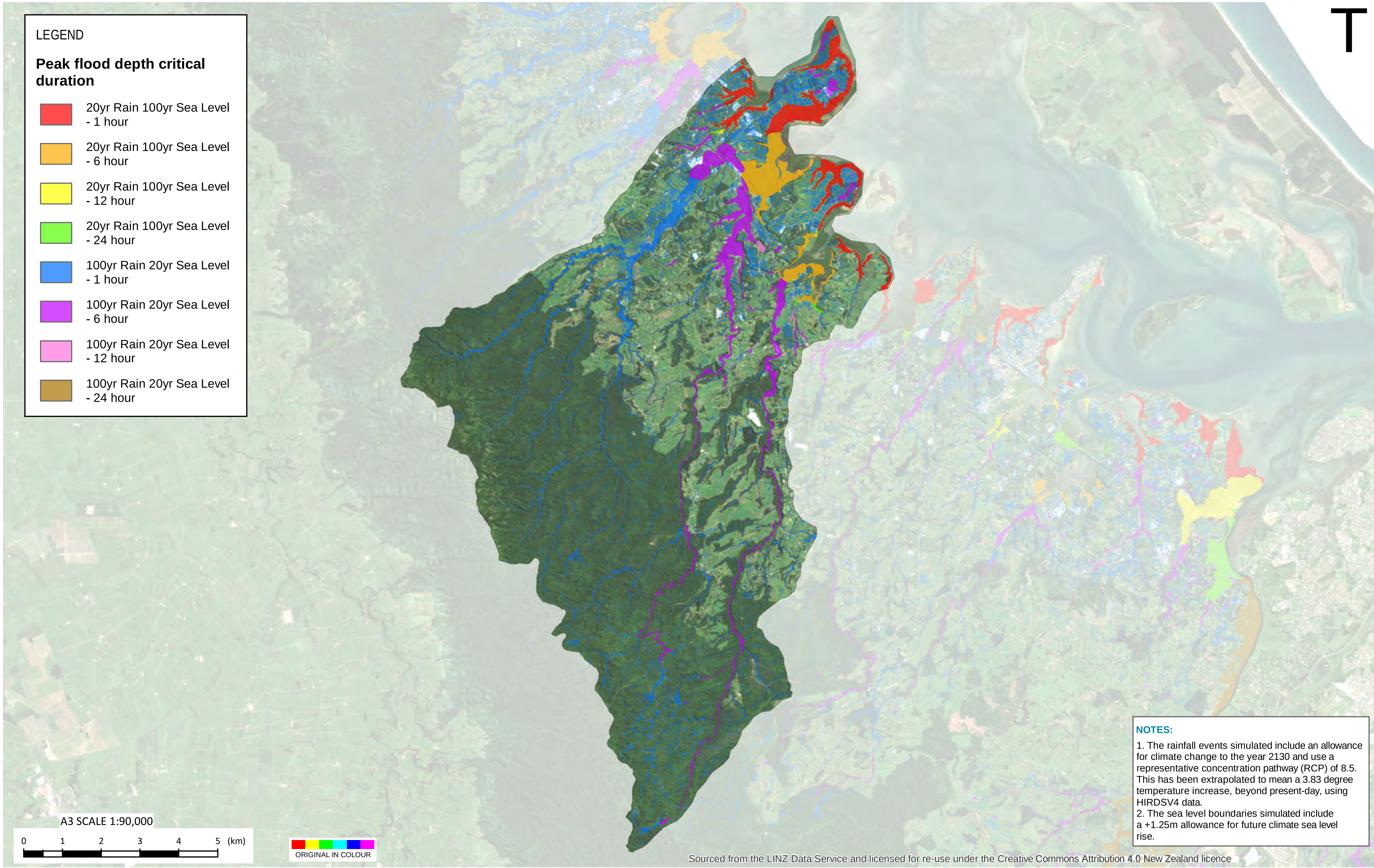

NOTES:

1. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
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DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
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CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**

PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**

TITLE AONGATETE DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - CRITICAL PEAK FLOOD DEPTH DURATION

SCALE (A3) 1:90,000 FIG No. FIGURE B3. REV 0

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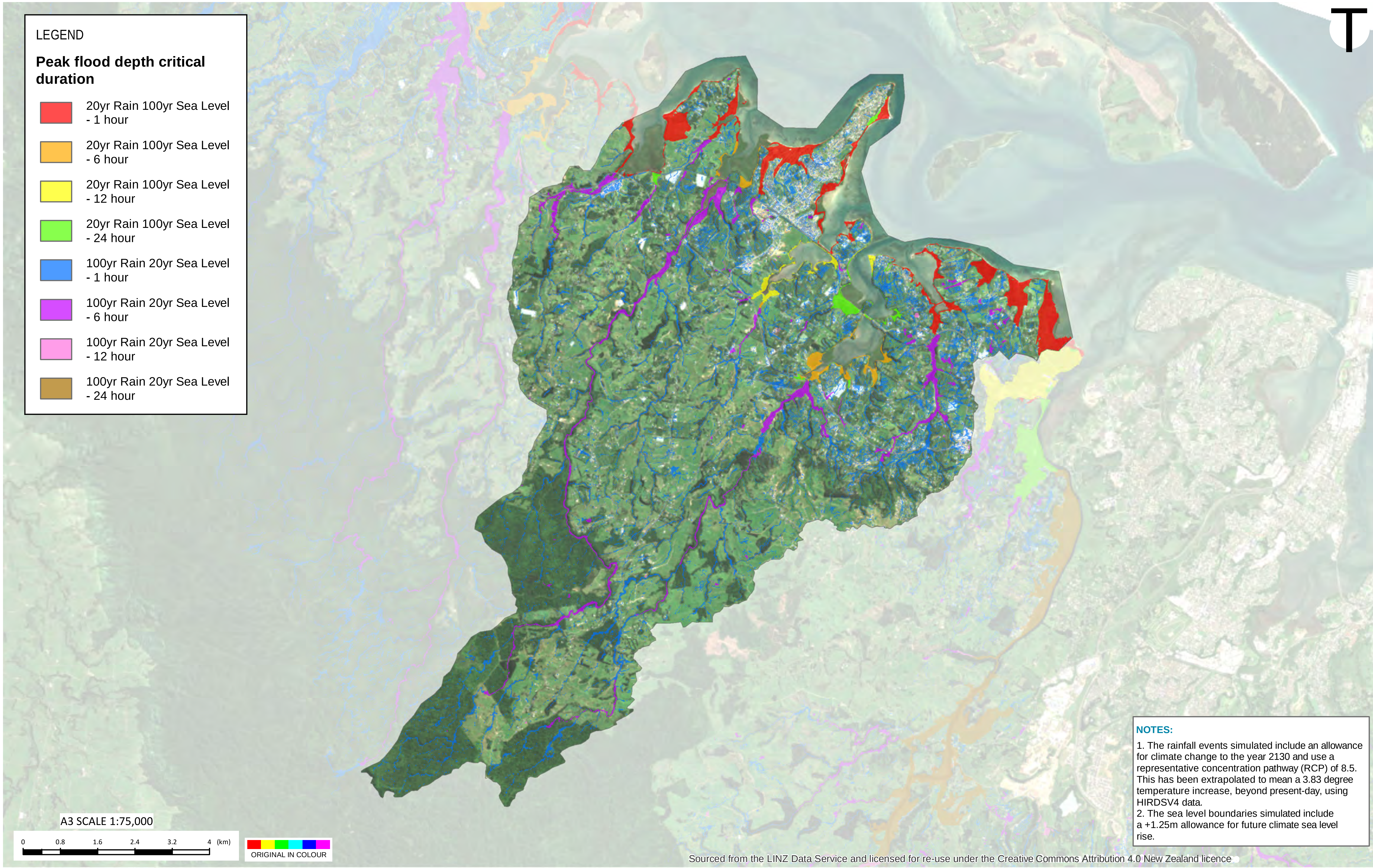

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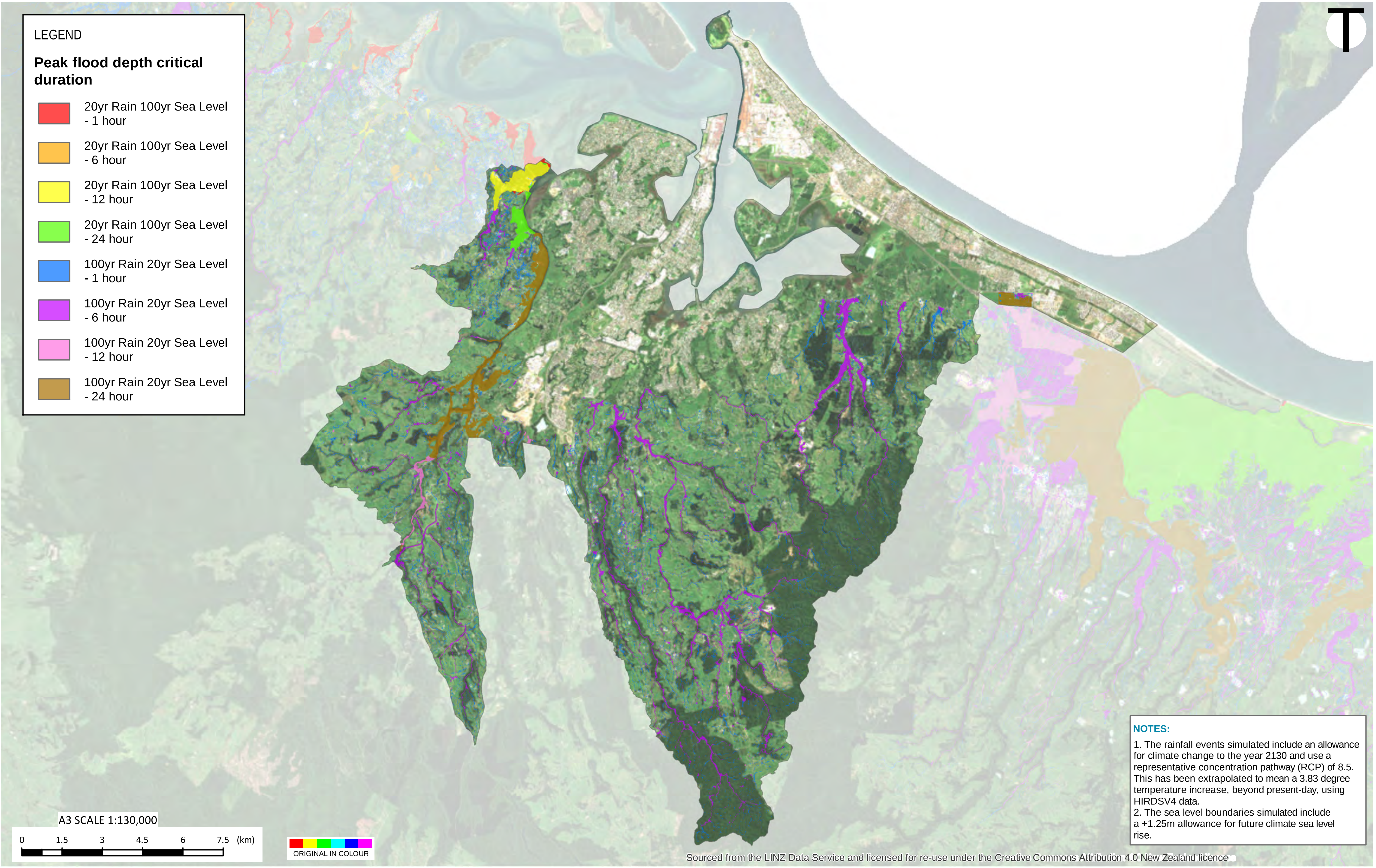
CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE WHAKAMARAMA DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - CRITICAL PEAK FLOOD DEPTH DURATION
SCALE (A3) 1:75,000 FIG No. FIGURE B4. REV 0



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PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE TAURANGA DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - CRITICAL PEAK FLOOD DEPTH DURATION
SCALE (A3) 1:130,000 FIG No. FIGURE B5. REV 0

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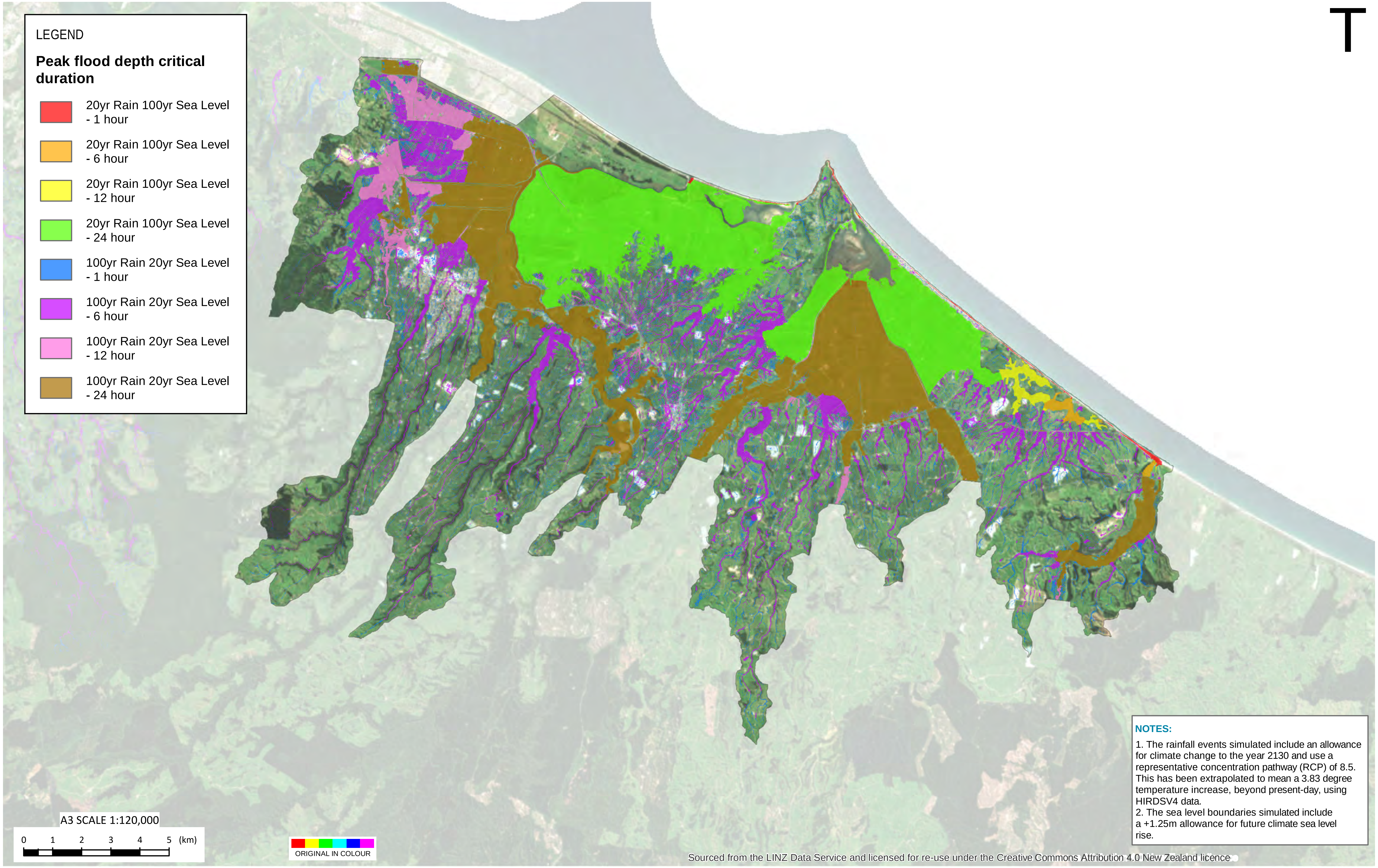

NOTES:

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PROJECT: **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE: TE PUKE DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - CRITICAL PEAK FLOOD DEPTH DURATION
SCALE (A3) 1:120,000   FIG No. FIGURE B6.   REV 0

Appendix C: Flood maps

Waihi Beach

- *Figure C1. Waihi Beach Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C2. Tanners Point – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C3. Tuapiro Point – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C4. Ongare Point – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C5. Kauri Point – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

Katikati

- *Figure C6. Katikati Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C7. Katikati Lifestyle Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

Aongatete

- *Figure C8. Aongatete Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

Whakamarama

- *Figure C9. Whakamarama Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C10. Plummers Point – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C11. Te Puna West – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C12. Tides Reach Rural-Residential Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C13. Minden Lifestyle Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

Tauranga

- *Figure C14. Tauranga Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

- *Figure C15. Te Puna Business Park – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C16. Tara Rd Rural-Residential Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

Te Puke

- *Figure C17. Te Puke Domain – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C18. Te Puke Lifestyle Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C19. Rangiuru Business Park – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C20. Paengaroa – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C21. Arawa Rd Residential Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C22. Maketu – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C23. Little Waihi – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C24. Pukehina – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*
- *Figure C25. Rogers Rd Residential Zone – 100-year ARI RCP8.5 2130 Rainfall and 1.25 m SLR Peak Flood Depths*

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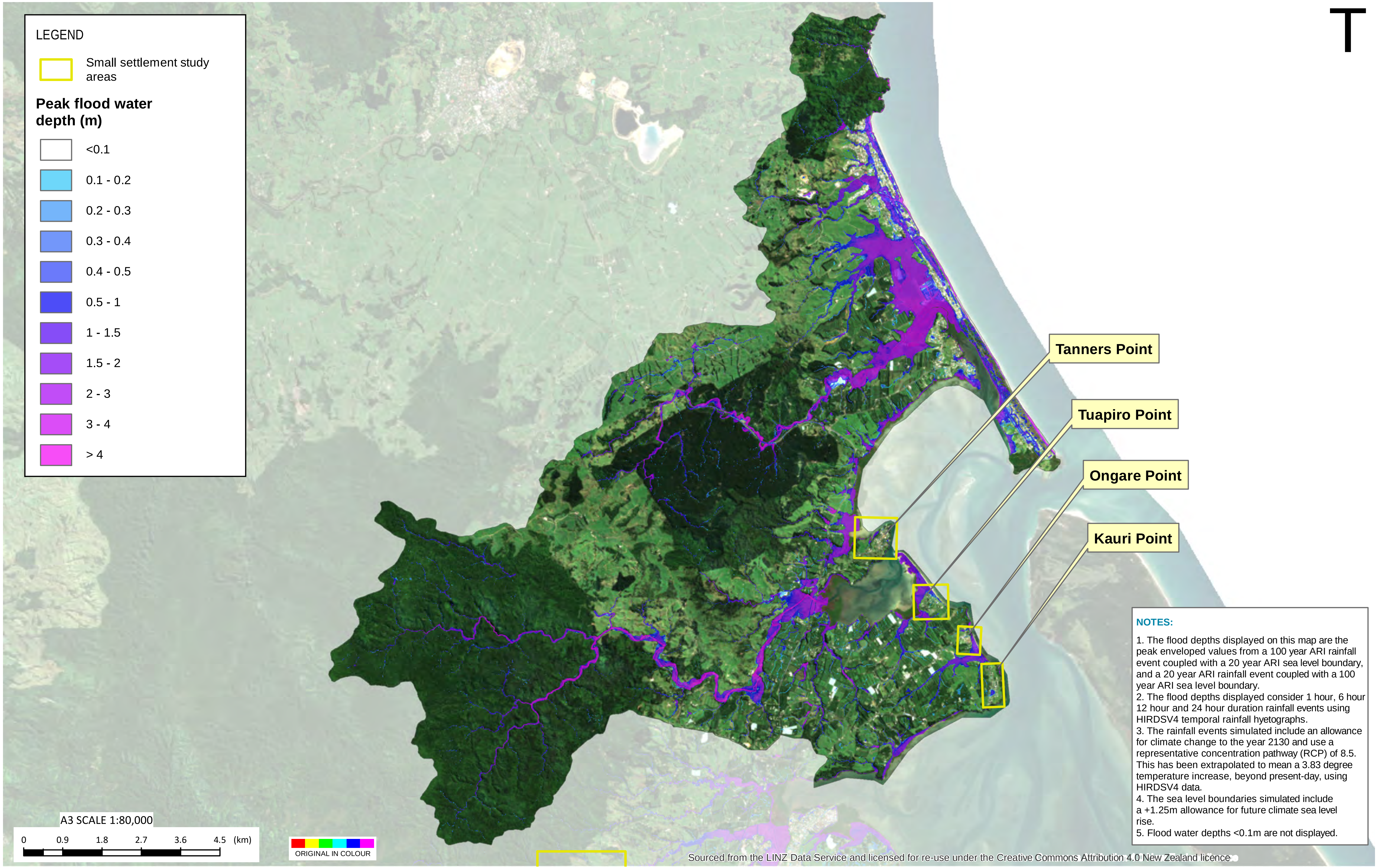

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**
PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE WAIHI BEACH DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:80,000 FIG No. FIGURE C1. REV 0

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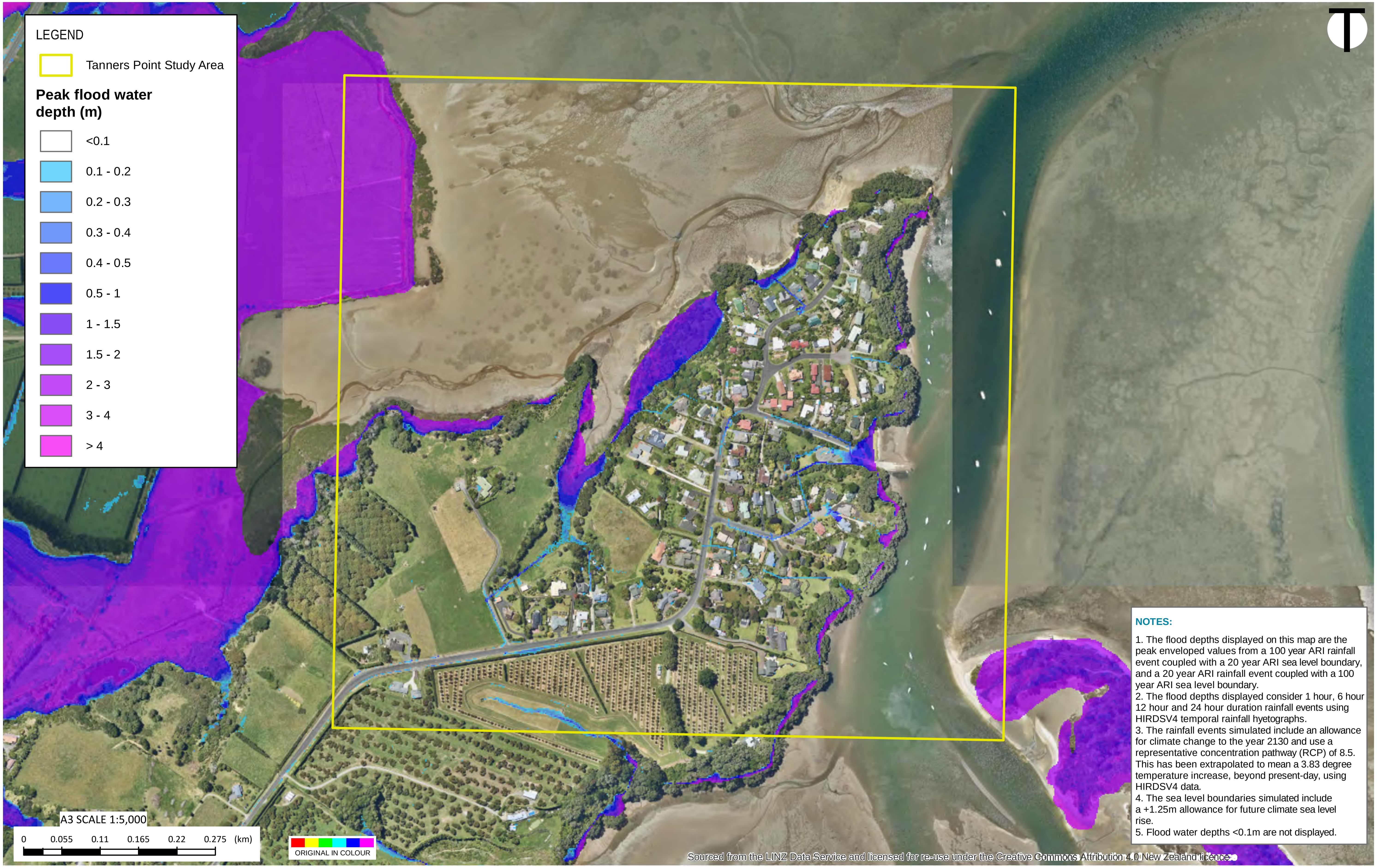

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
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CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**
PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE TANNERS POINT 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000   FIG No. FIGURE C2.   REV 0

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NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
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PROJECT No.	1012463.00	
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APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE TUAPIRO POINT 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000 FIG No. FIGURE C3. REV 0

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
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APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE ONGARE POINT 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000 FIG No. FIGURE C4. REV 0

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CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT: WESTERN BAY OF PLENTY FLOOD MAPPING

TITLE: KAURI POINT 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:5,000 FIG No. FIGURE C5. REV 0

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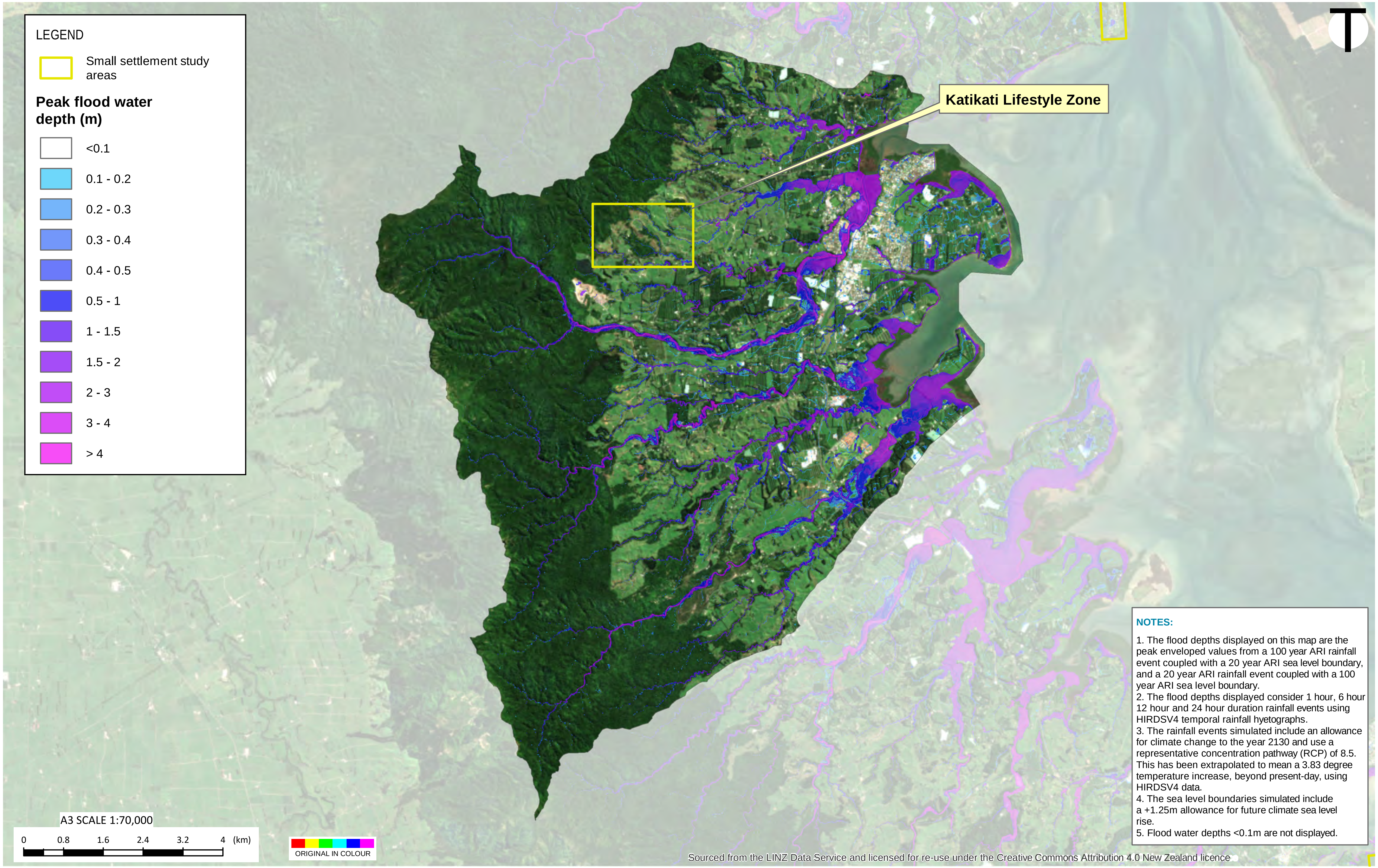

LEGEND

Small settlement study areas

Peak flood water depth (m)

- <0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
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TITLE KATIKATI DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:70,000   FIG No. FIGURE C6.   REV 0

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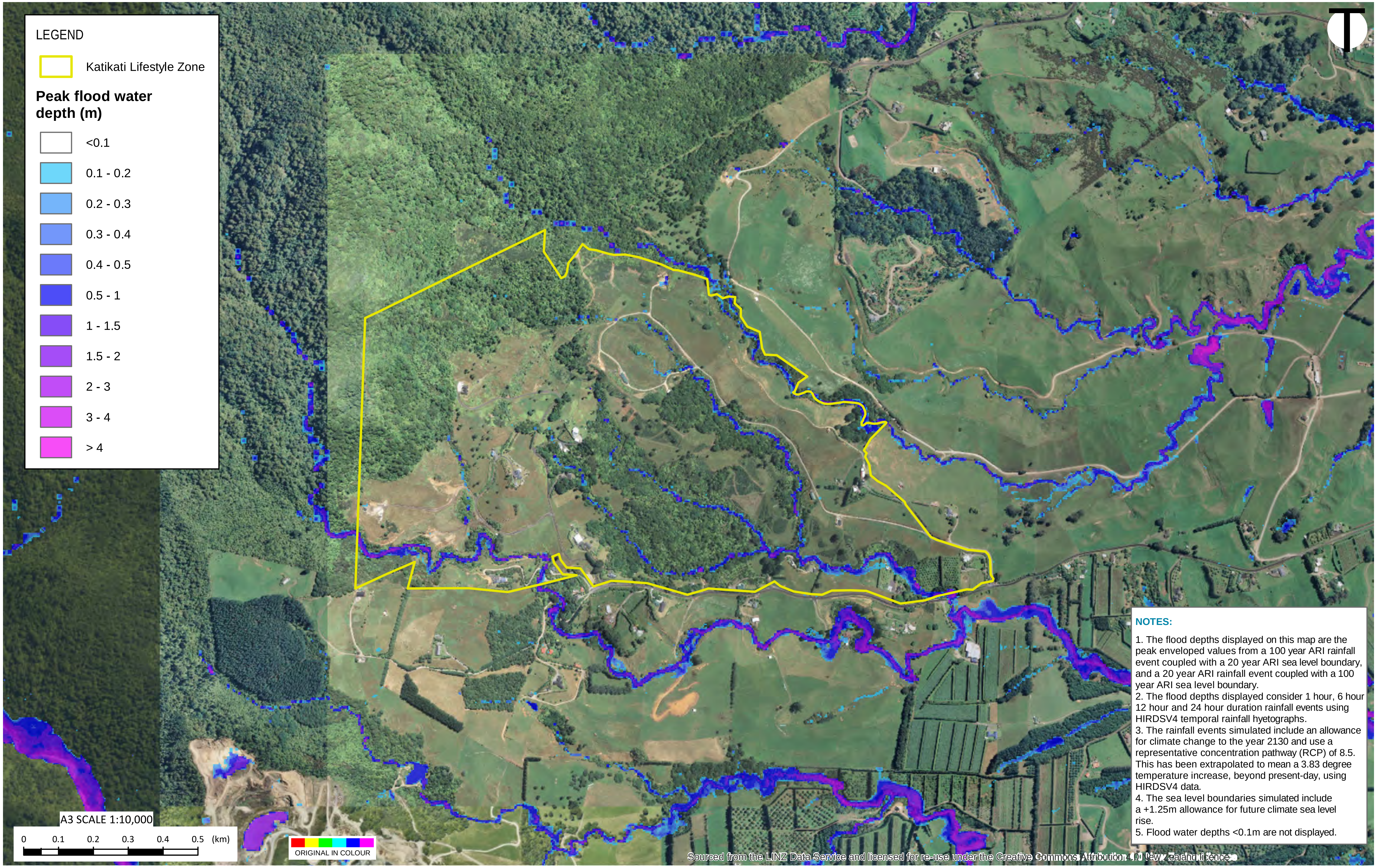

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PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING

TITLE KATIKATI LIFESTYLE ZONE 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:10,000 FIG No. FIGURE C7. REV 0

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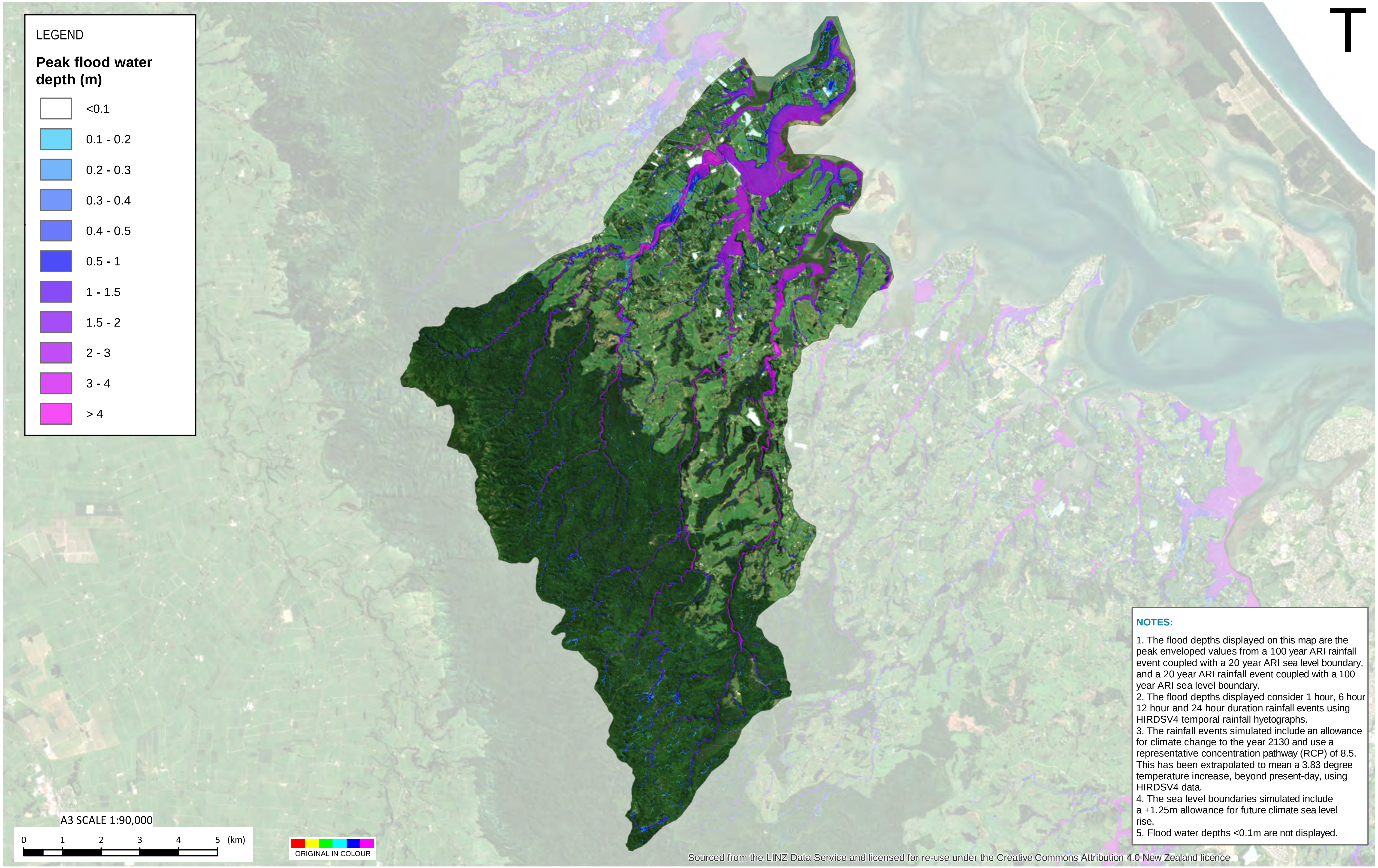

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
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CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE AONGATETE DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:90,000 FIG No. FIGURE C8. REV 0

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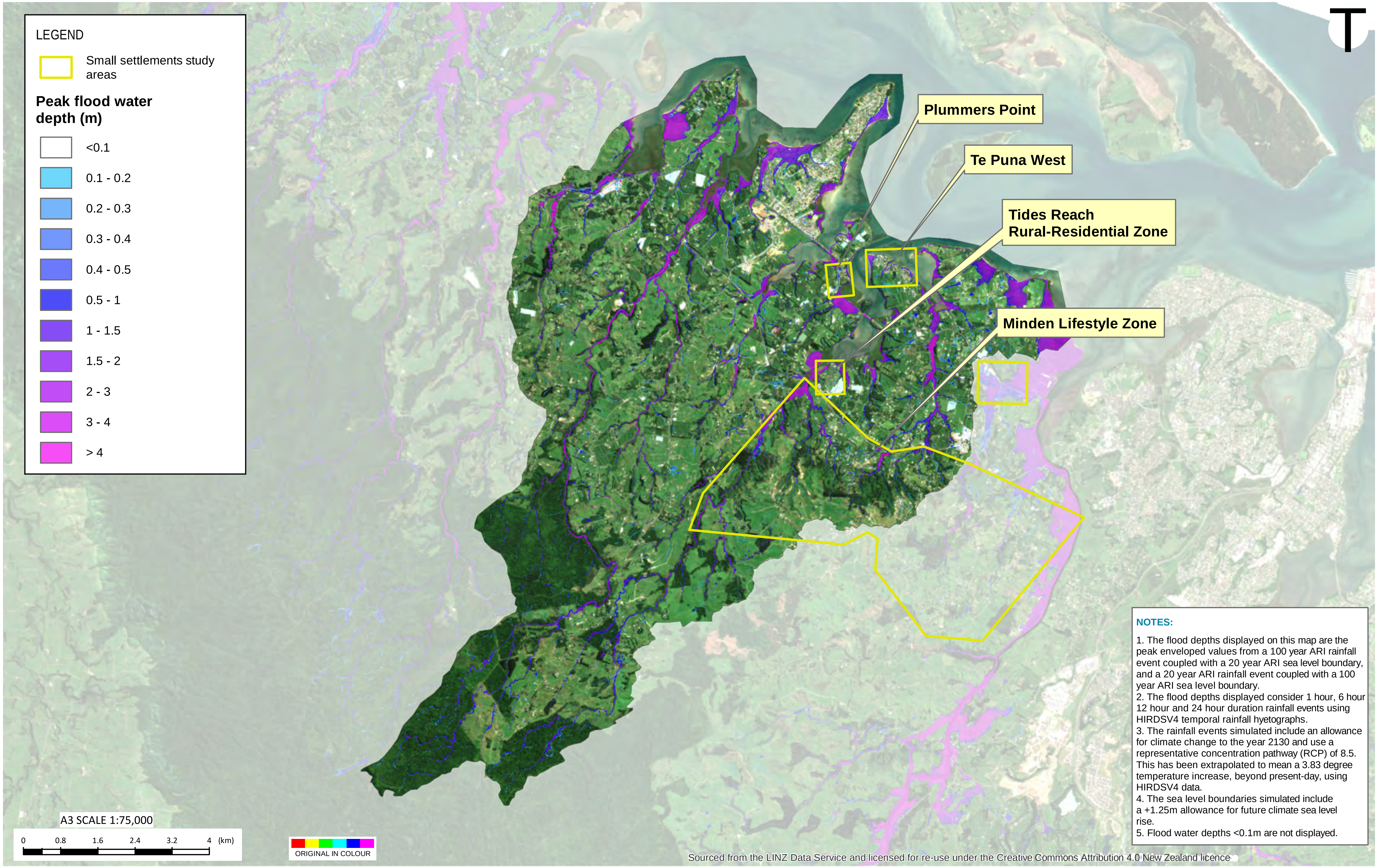

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
To be read in conjunction with Western Bay of Plenty Flood Hazard Mapping Model Build Report. The information presented on these figures is based on a numerical representation of the physical reality and is reliant upon input data and therefore bears uncertainty.

REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE WHAKAMARAMA DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:75,000 FIG No. FIGURE C9. REV 0

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NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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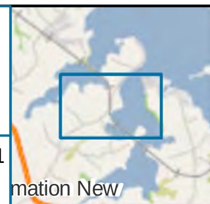
REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21



LOCATION PLAN

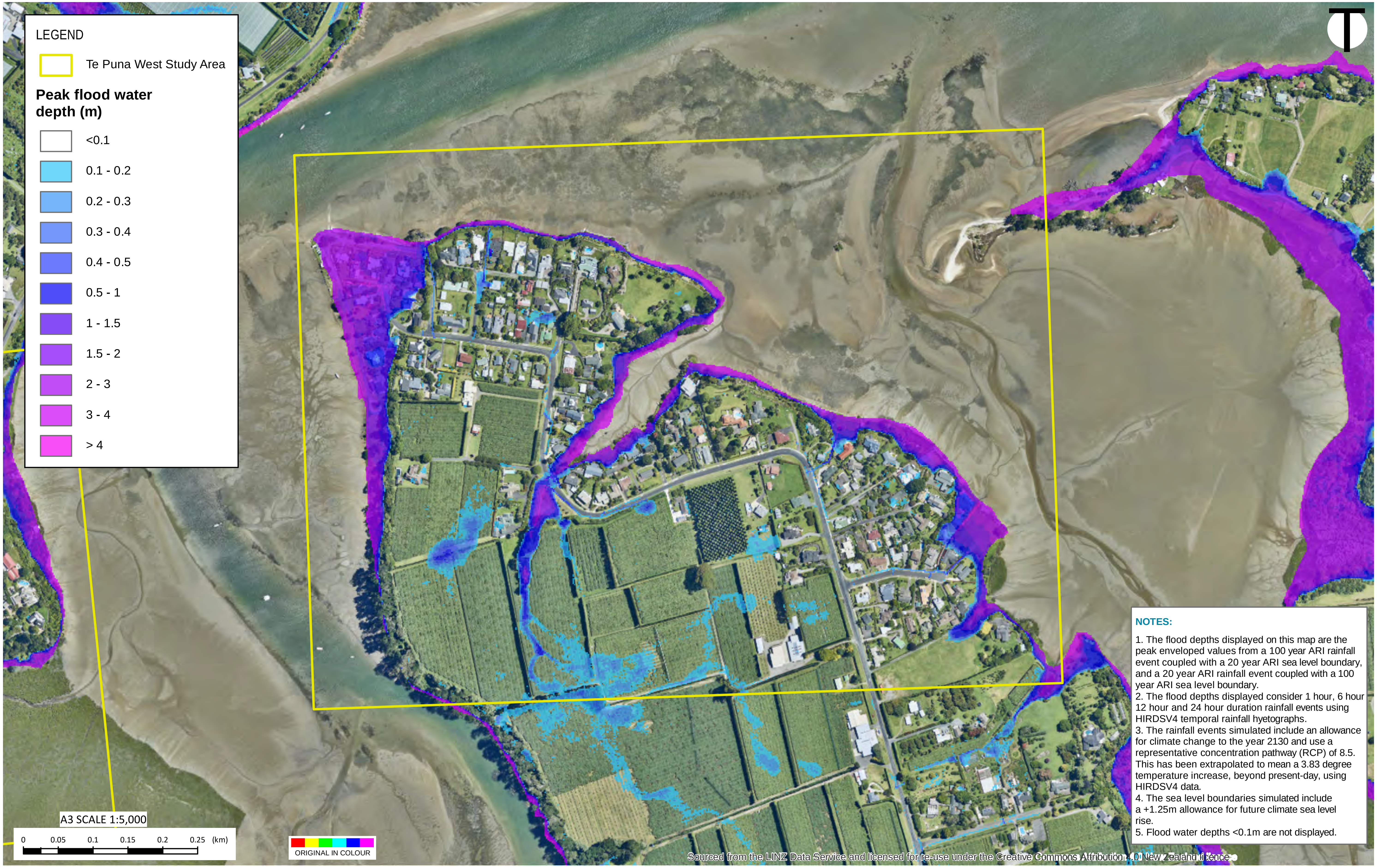
PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**

PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**

TITLE PLUMMERS POINT 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:5,000 FIG No. FIGURE C10. REV 0



NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:

To be read in conjunction with Western Bay of Plenty Flood Hazard Mapping Model Build Report. The information presented on these figures is based on a numerical representation of the physical reality and is reliant upon input data and therefore bears uncertainty.

REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

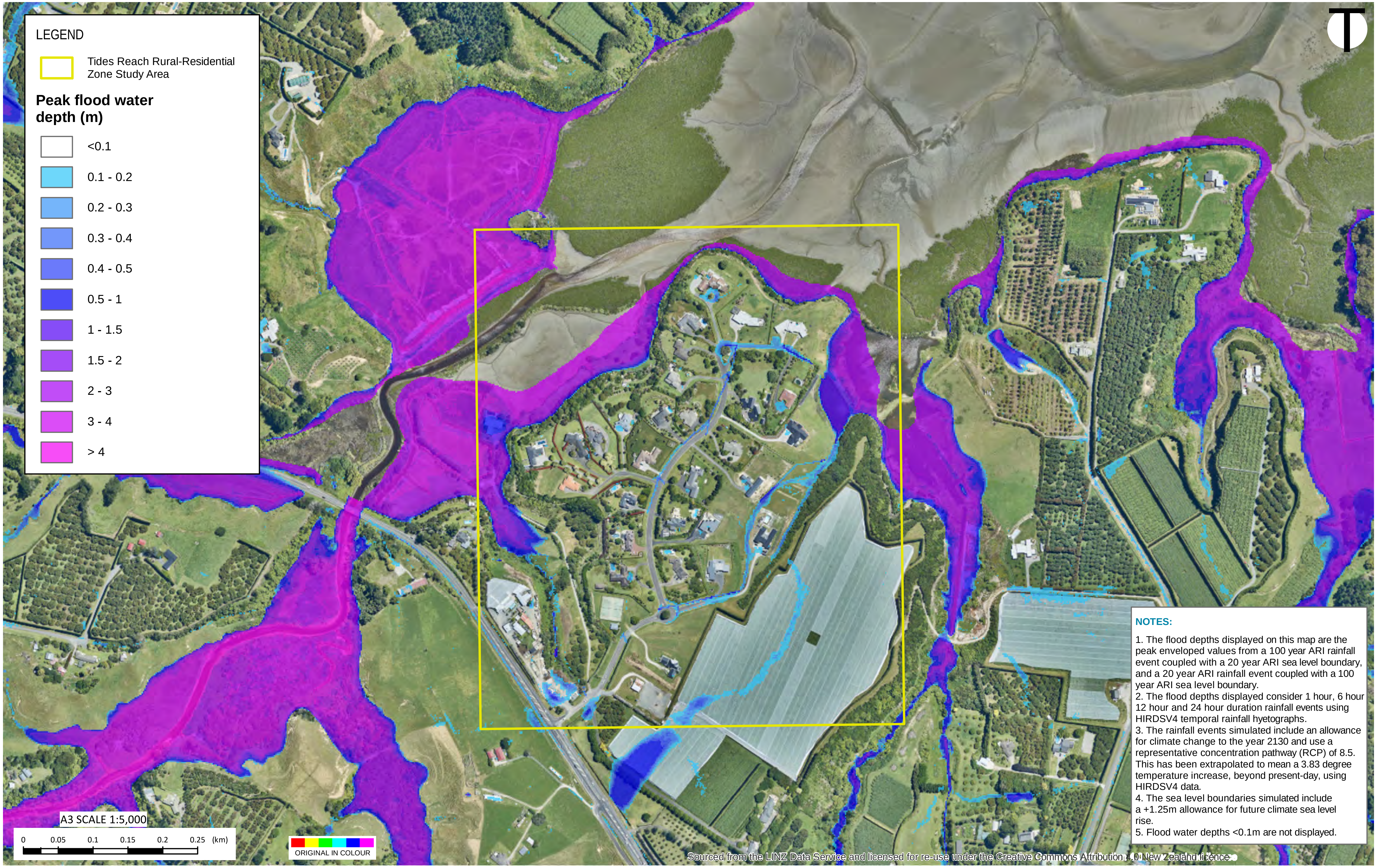
PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21 (DATE)

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**

PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**

TITLE TE PUNA WEST 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:5,000 FIG No. FIGURE C11. REV 0



NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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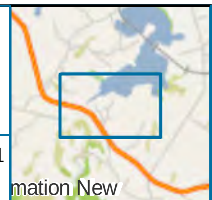
REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN



PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE TIDES REACH 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000 FIG No. FIGURE C12. REV 0

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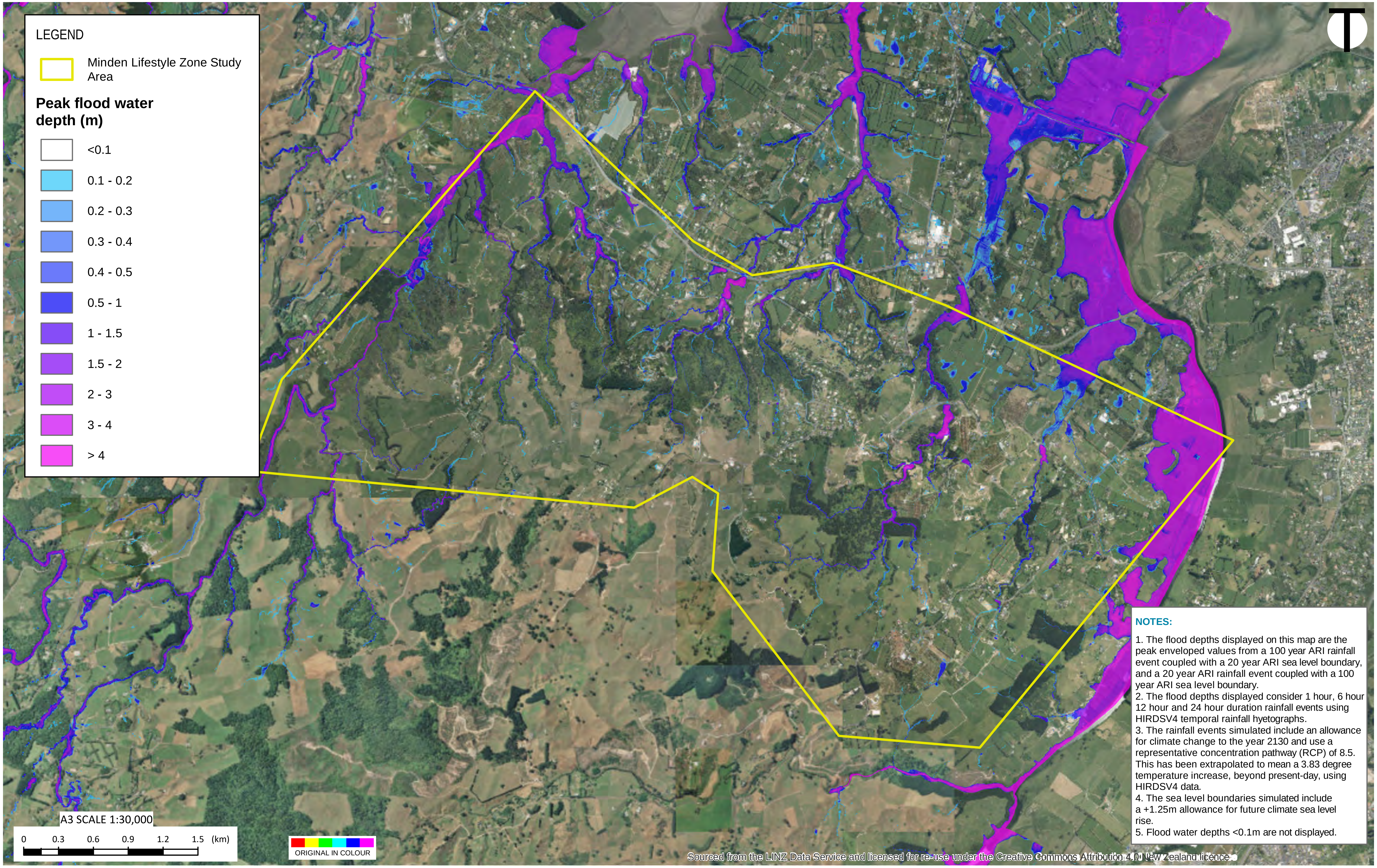

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN: mation New Eagle Technology

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE: MINDEN LIFESTYLE ZONE 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:30,000 FIG No. FIGURE C13. REV 0

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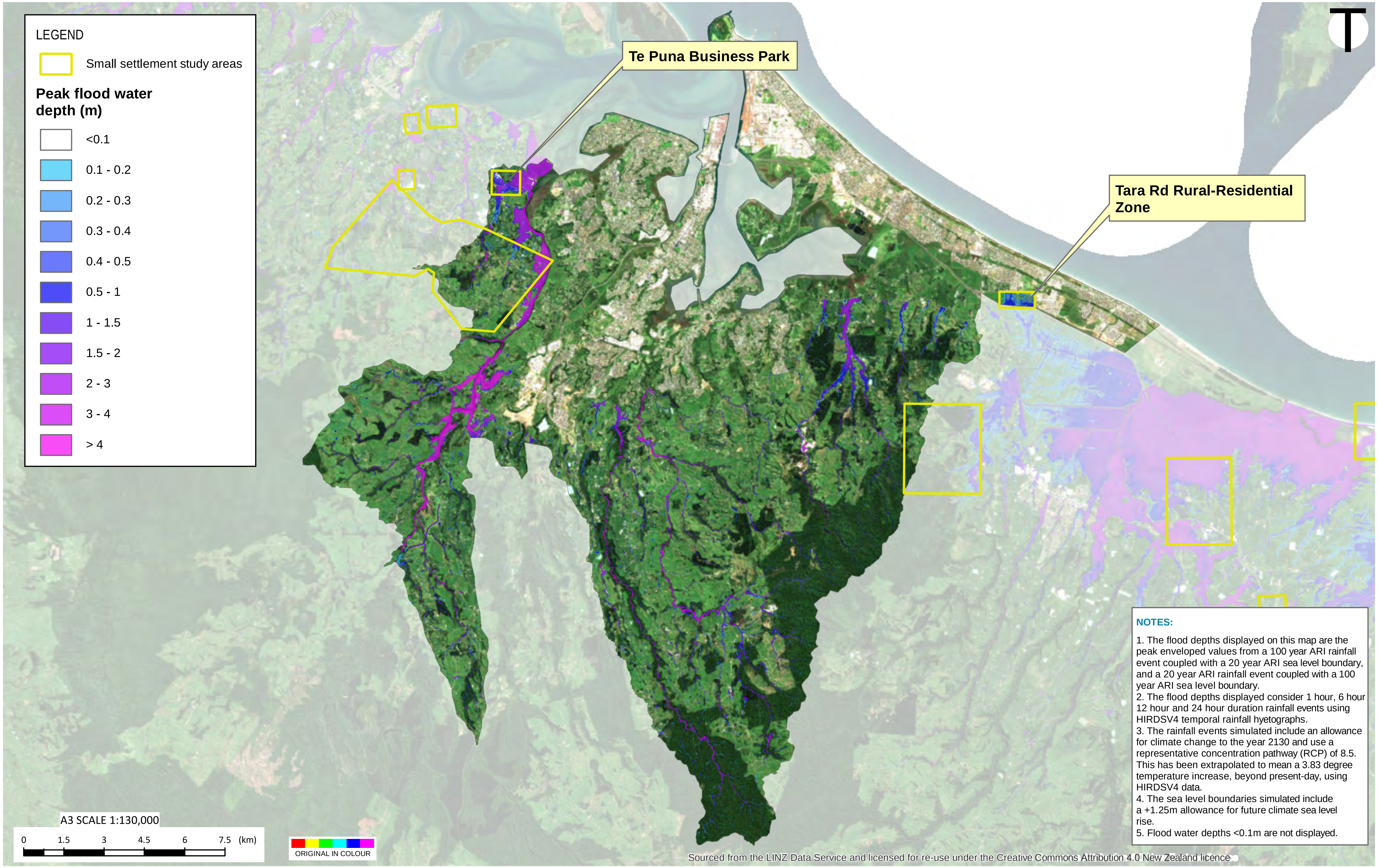

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
To be read in conjunction with Western Bay of Plenty Flood Hazard Mapping Model Build Report. The information presented on these figures is based on a numerical representation of the physical reality and is reliant upon input data and therefore bears uncertainty.

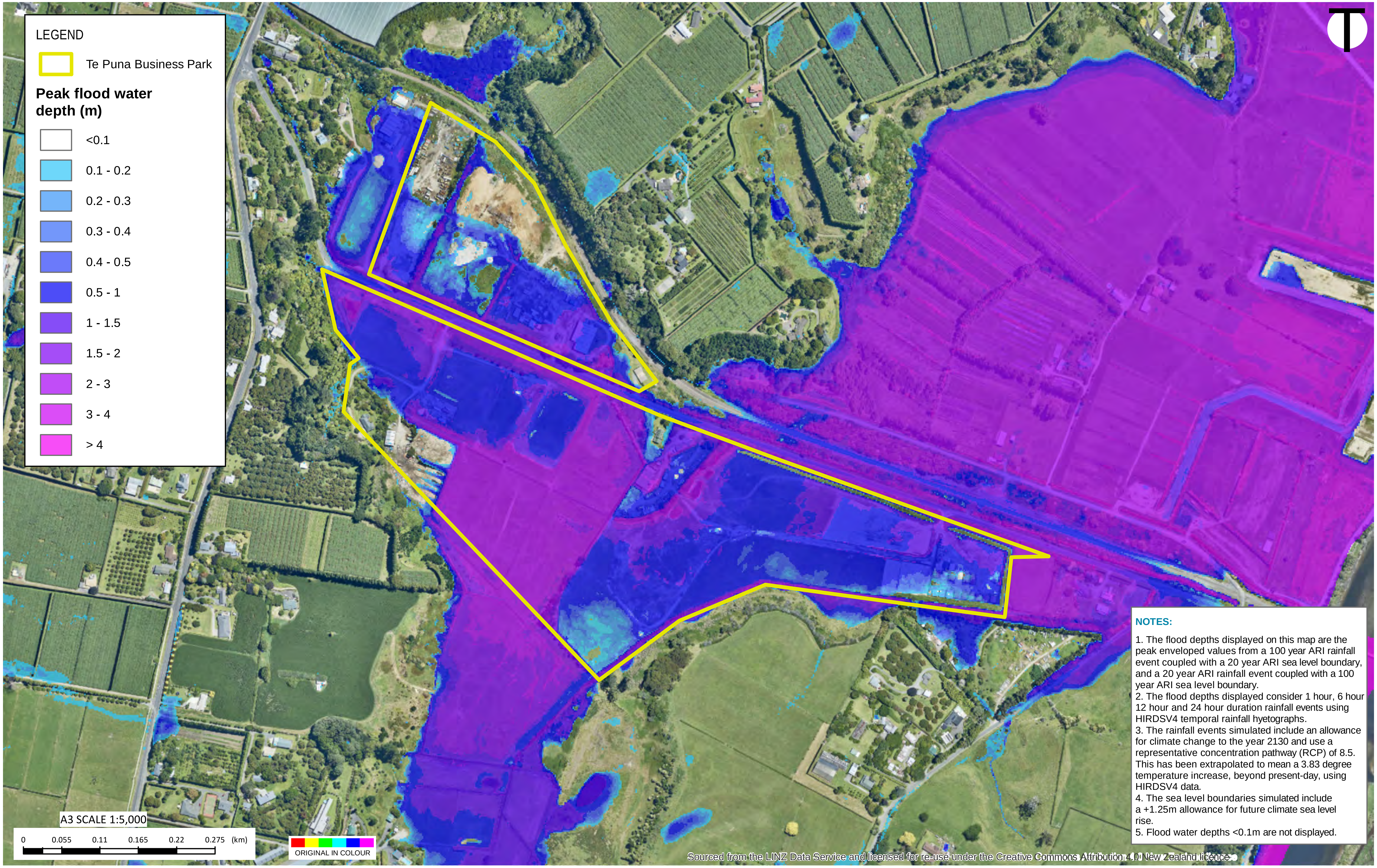
REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN: mation New Eagle Technology

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE TAURANGA DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:130,000 FIG No. FIGURE C14. REV 0



NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE: TE PUNA BUSINESS PARK 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000 FIG No. FIGURE C15. REV 0

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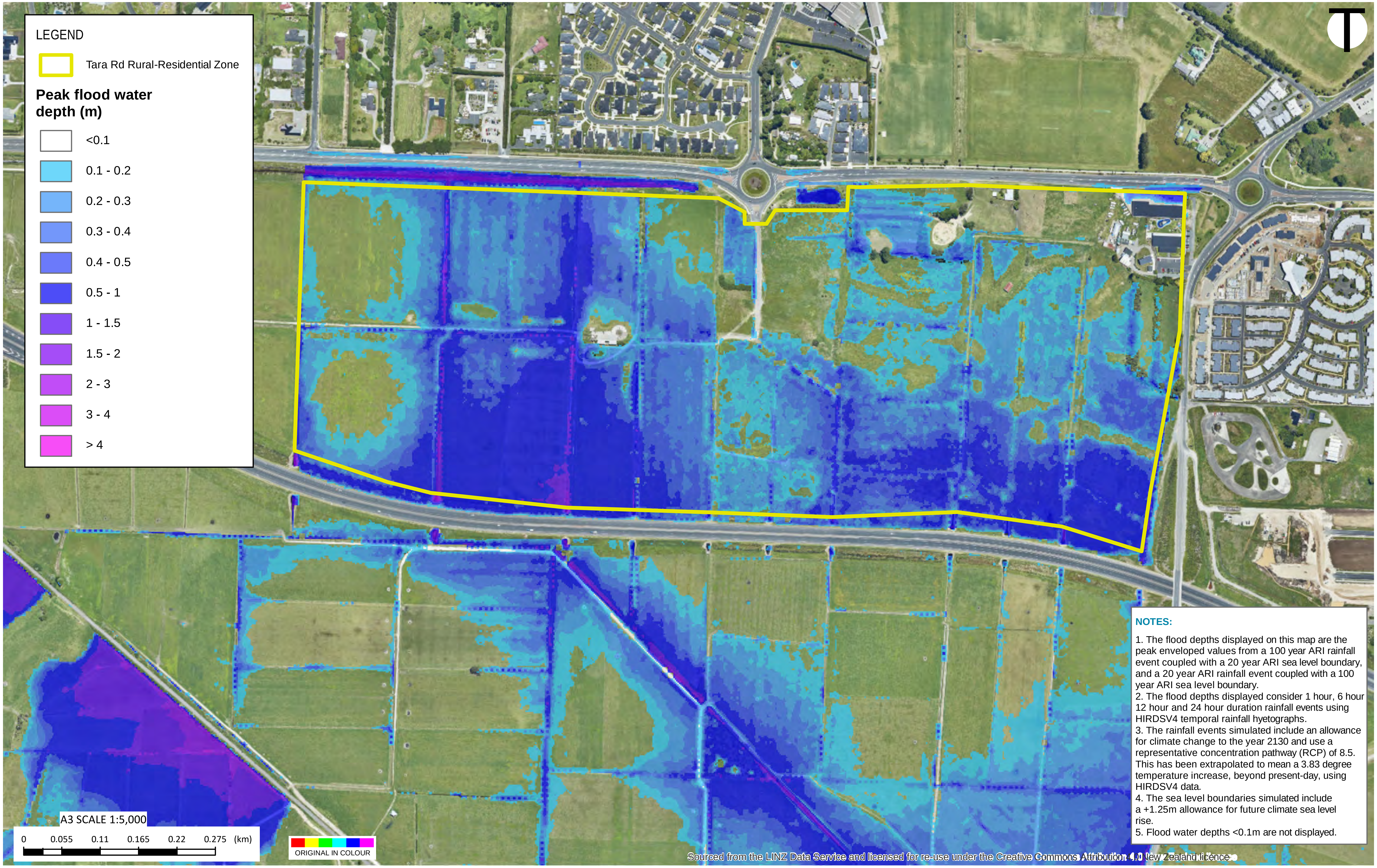

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
To be read in conjunction with Western Bay of Plenty Flood Hazard Mapping Model Build Report. The information presented on these figures is based on a numerical representation of the physical reality and is reliant upon input data and therefore bears uncertainty.

REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE TARA RD RURAL-RESIDENTIAL ZONE 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000 FIG No. FIGURE C16. REV 0

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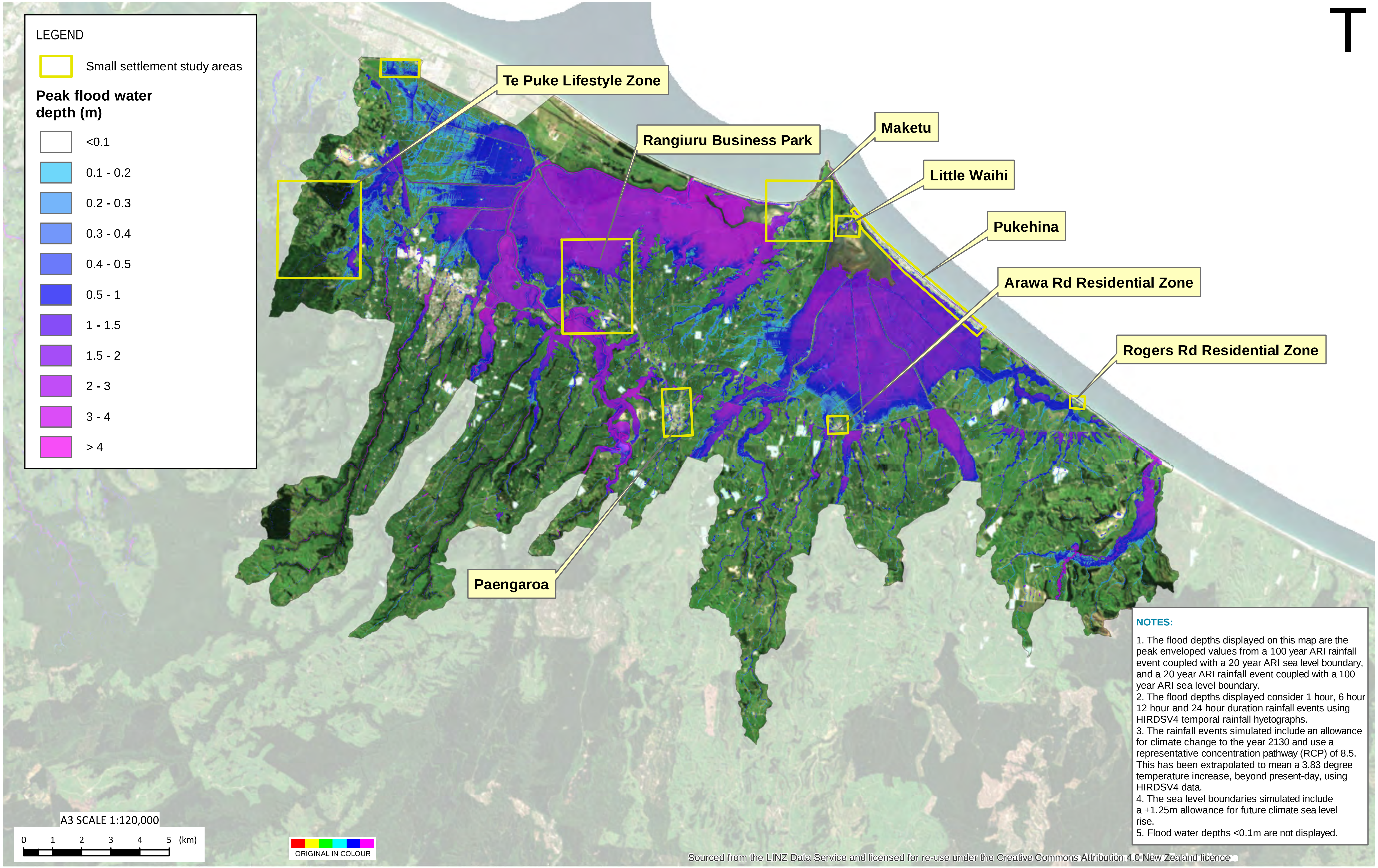

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
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4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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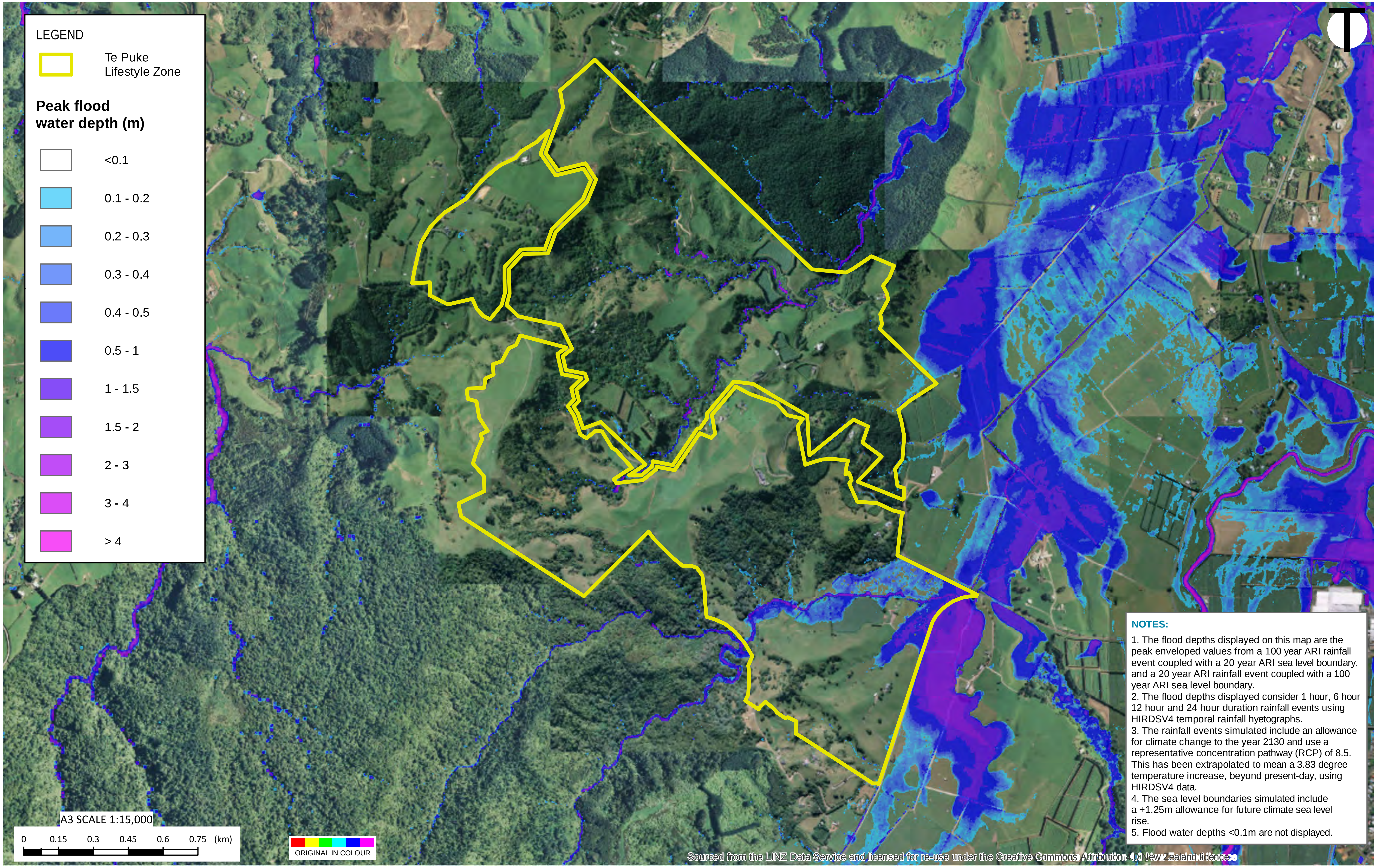
REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN: Tauranga — ...mation New ...agle Technology

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE: TE PUKE DOMAIN 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:120,000 FIG No. FIGURE C17. REV 0



NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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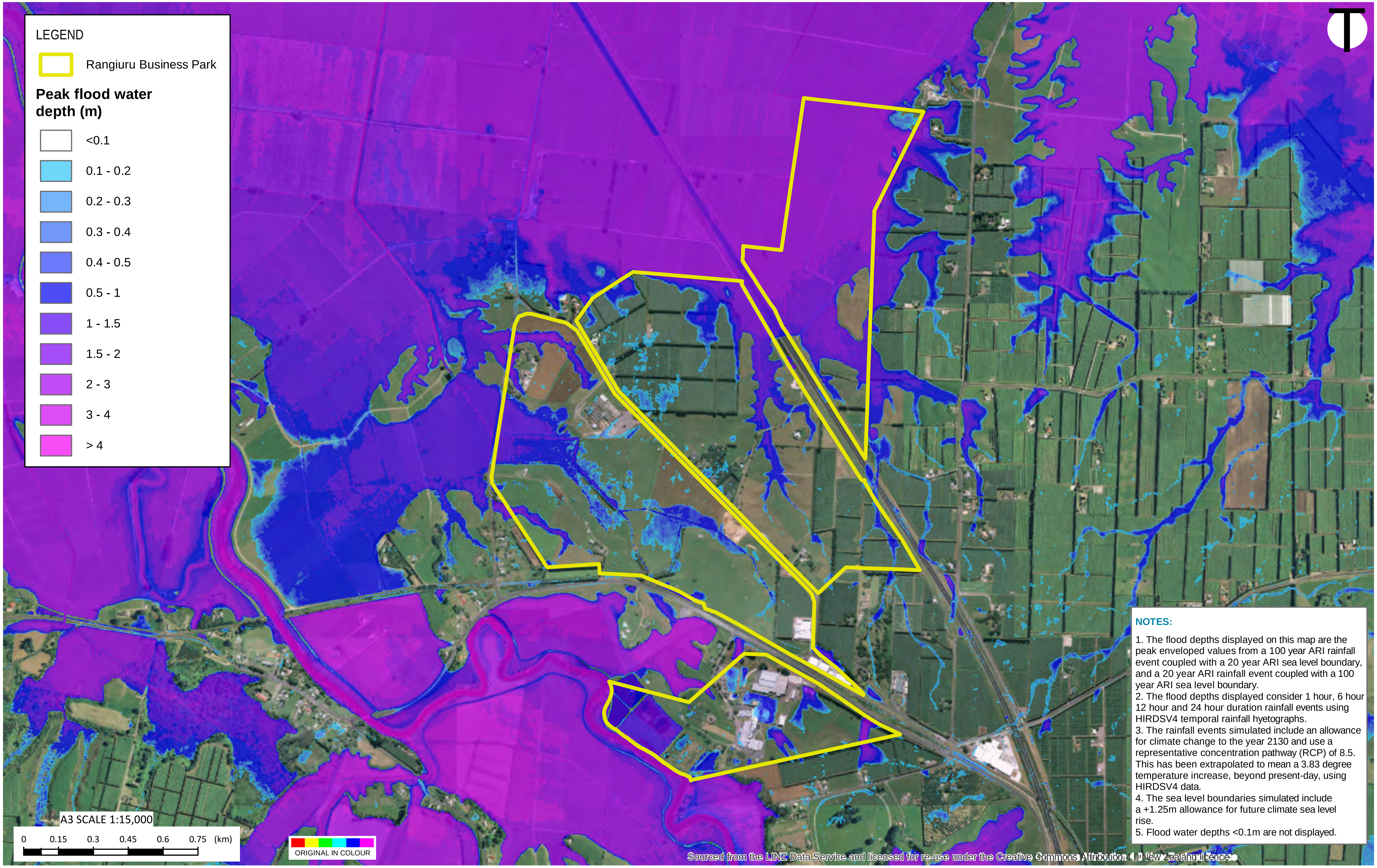
REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE TE PUKE LIFESTYLE ZONE 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:15,000 FIG No. FIGURE C18. REV 0



NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
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NOTES:
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REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE RANGIURU BUSINESS PARK 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:15,000 FIG No. FIGURE C19. REV 0

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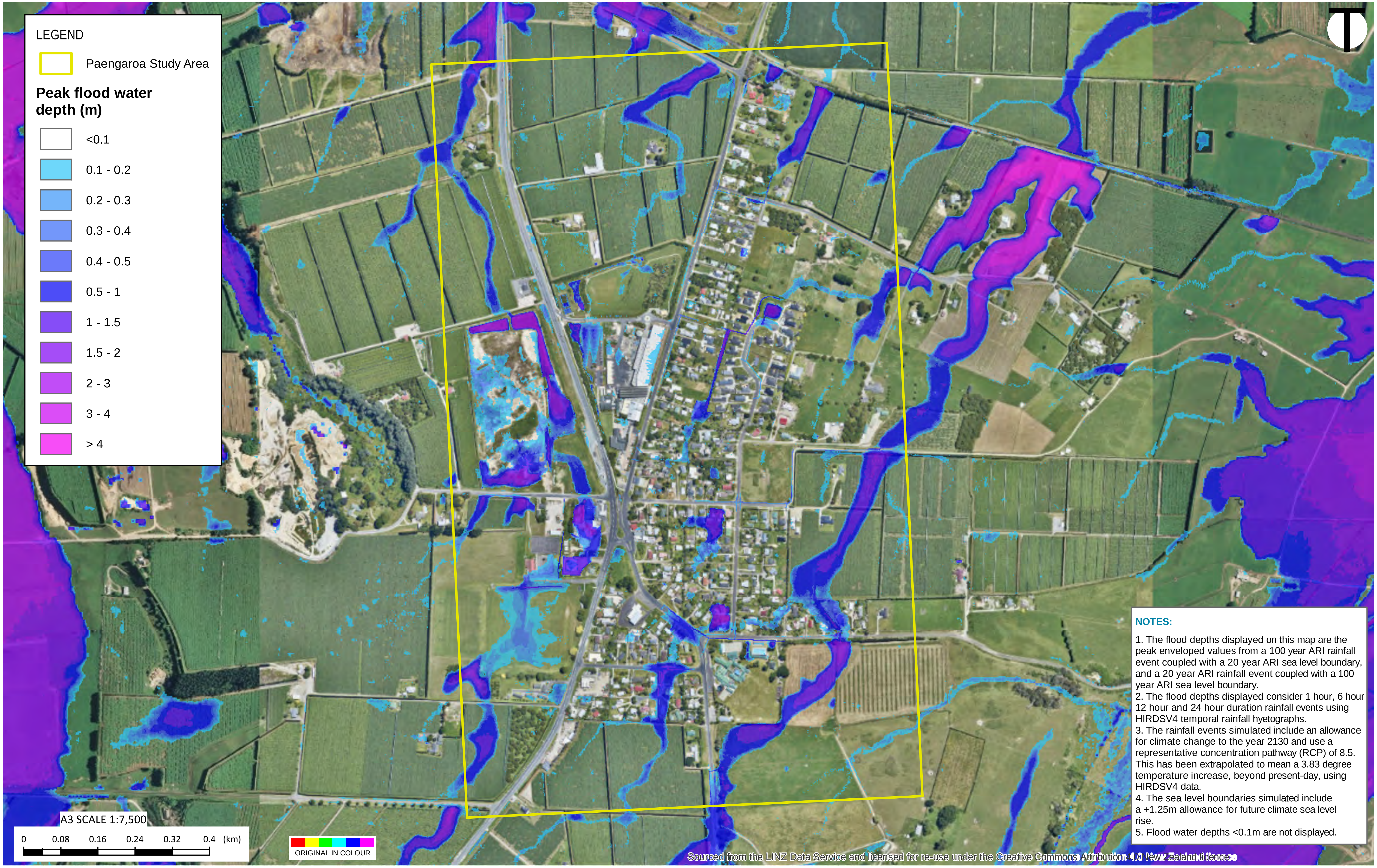

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
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5. Flood water depths <0.1m are not displayed.

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REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**
PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE PAENGAROA 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:7,500 FIG No. FIGURE C20. REV 0

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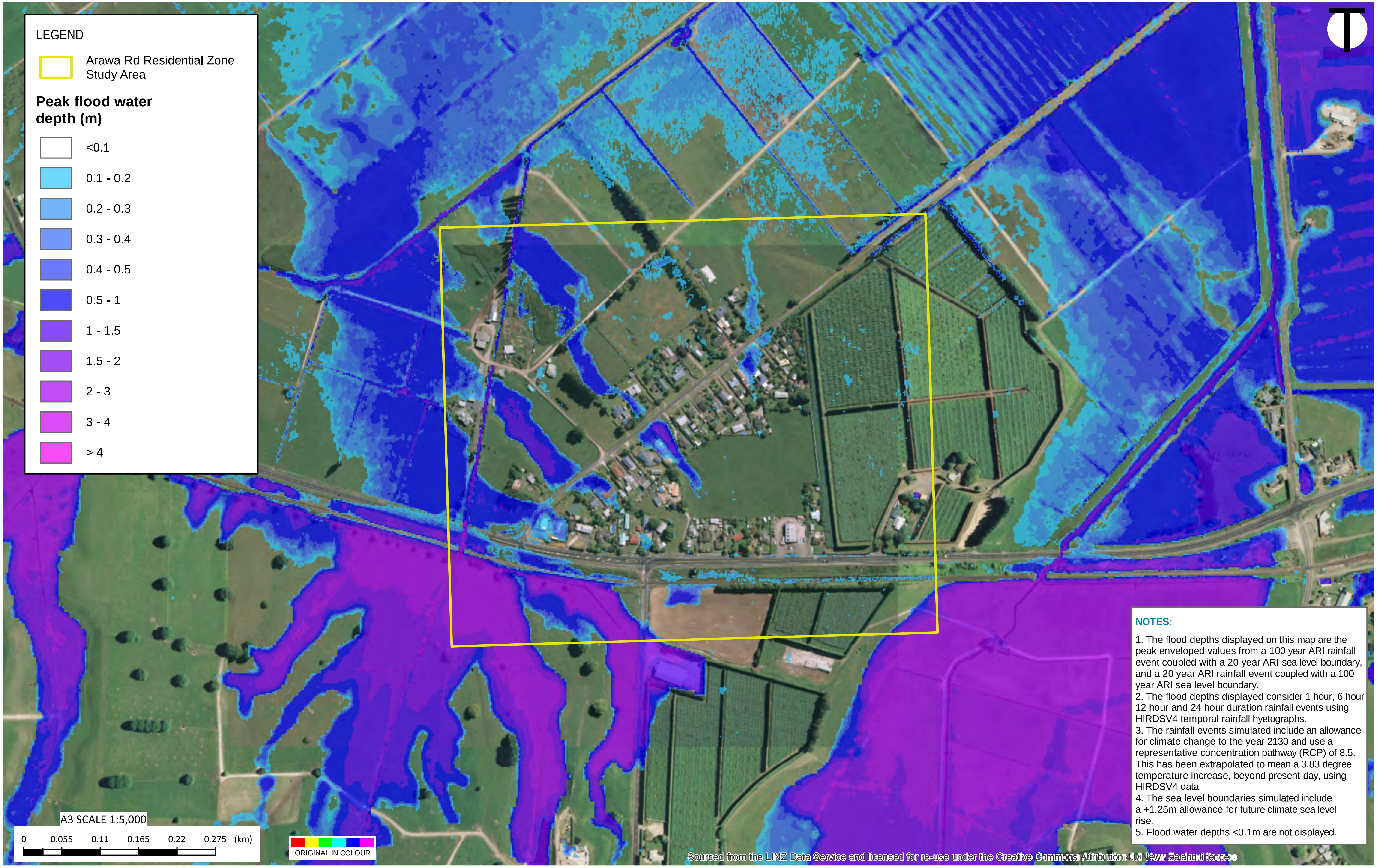

NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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NOTES:
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REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

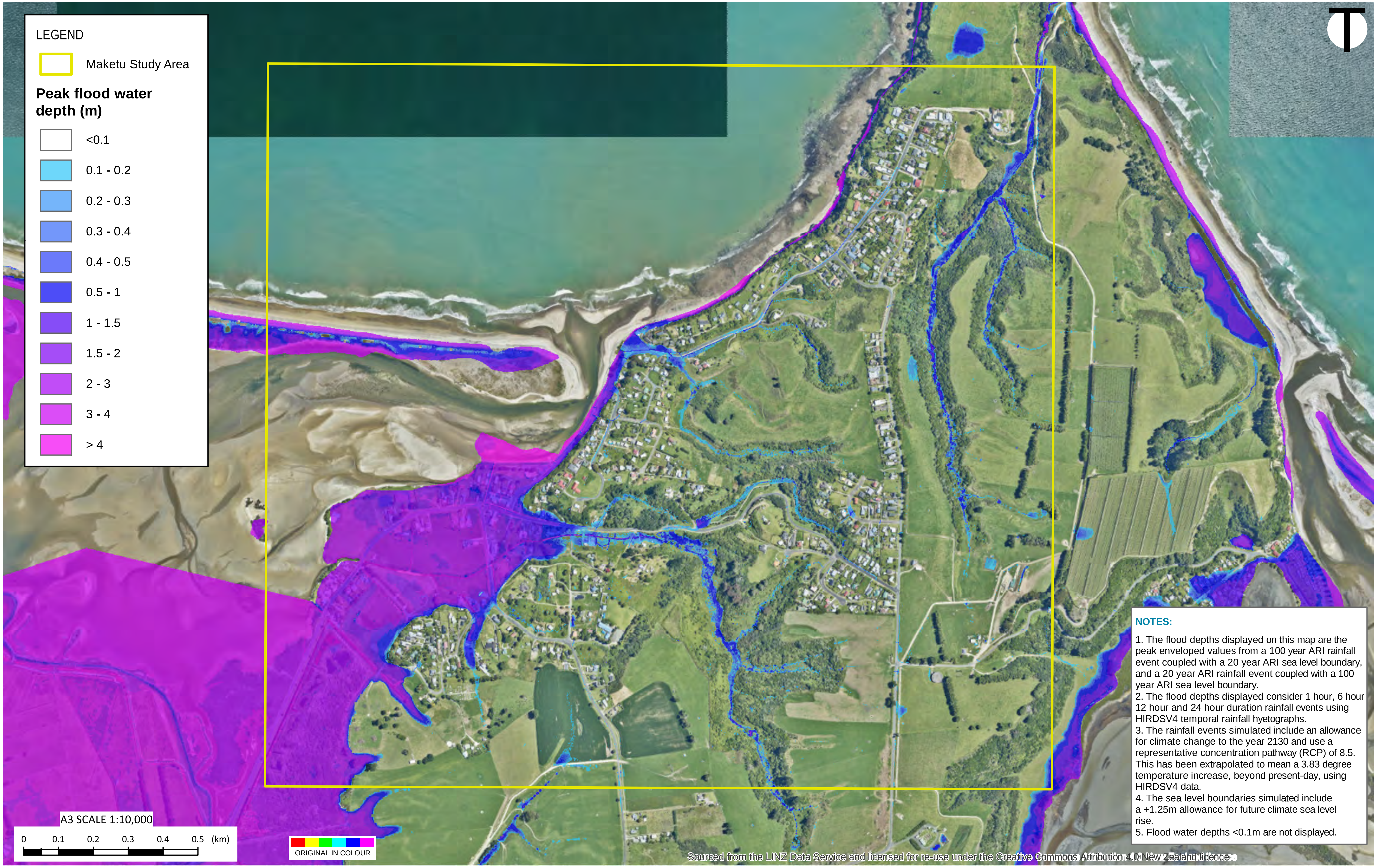
LOCATION PLAN

mation New

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**
PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE ARAWA RD RESIDENTIAL ZONE 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:5,000 FIG No. FIGURE C21. REV 0



NOTES:

1. The flood depths displayed on this map are the peak enveloped values from a 100 year ARI rainfall event coupled with a 20 year ARI sea level boundary, and a 20 year ARI rainfall event coupled with a 100 year ARI sea level boundary.
2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
3. The rainfall events simulated include an allowance for climate change to the year 2130 and use a representative concentration pathway (RCP) of 8.5. This has been extrapolated to mean a 3.83 degree temperature increase, beyond present-day, using HIRDSV4 data.
4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
5. Flood water depths <0.1m are not displayed.

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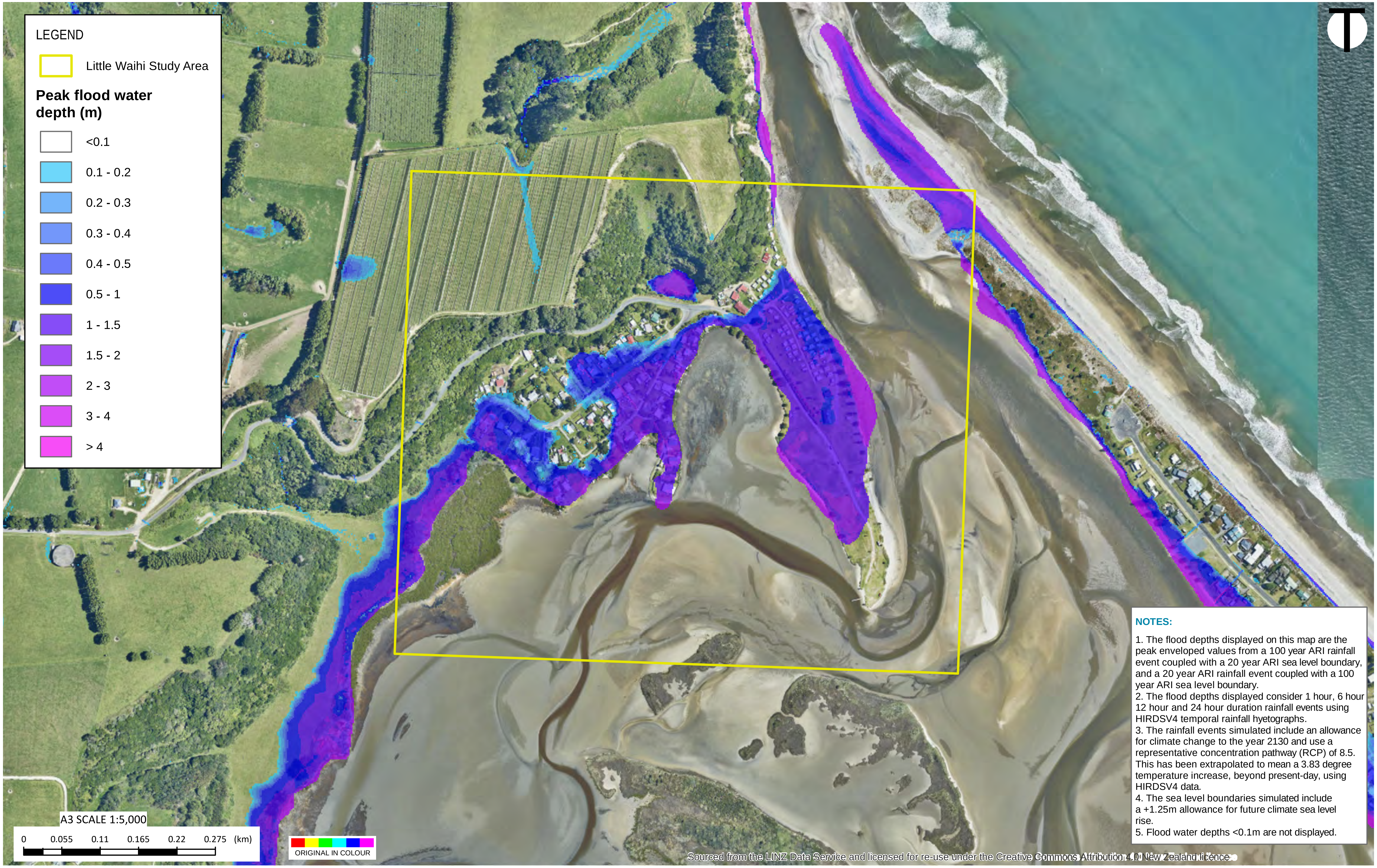
NOTES:
To be read in conjunction with Western Bay of Plenty Flood Hazard Mapping Model Build Report. The information presented on these figures is based on a numerical representation of the physical reality and is reliant upon input data and therefore bears uncertainty.

REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN: Maketu

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT: WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT: WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE: MAKETU 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:10,000 FIG No. FIGURE C22. REV 0



NOTES:

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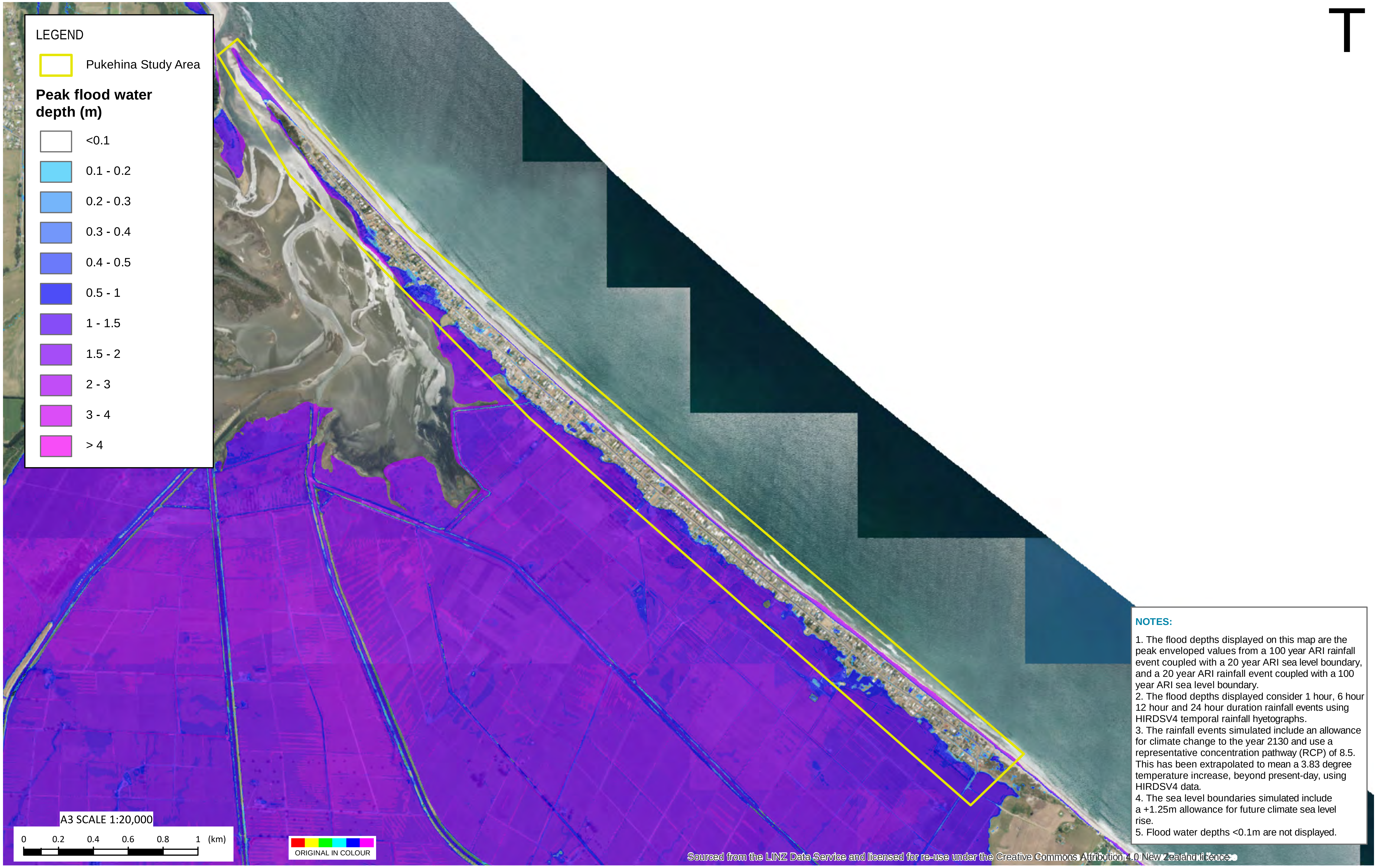
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT **WESTERN BAY OF PLENTY DISTRICT COUNCIL**
PROJECT **WESTERN BAY OF PLENTY FLOOD MAPPING**
TITLE LITTLE WAIHI 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:5,000 FIG No. FIGURE C23. REV 0



NOTES:

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REV	DESCRIPTION	GIS	CHK	DATE
1	Final issue	MICF	MSP	17/02/21

LOCATION PLAN
mation New

PROJECT No.	1012463.00	
DESIGNED	MICF	FEB.21
DRAWN	MICF	FEB.21
CHECKED	MSP	FEB.21
APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL
PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING
TITLE PUKEHINA 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS
SCALE (A3) 1:20,000 FIG No. FIGURE C24. REV 0

LEGEND

Rogers Rd Residential Zone Study Area

Peak flood water depth (m)

- <0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

A3 SCALE 1:5,000

0 0.055 0.11 0.165 0.22 0.275 (km)

ORIGINAL IN COLOUR

NOTES:

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2. The flood depths displayed consider 1 hour, 6 hour 12 hour and 24 hour duration rainfall events using HIRDSV4 temporal rainfall hyetographs.
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4. The sea level boundaries simulated include a +1.25m allowance for future climate sea level rise.
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LOCATION PLAN

mation New

PROJECT No.	1012463.00	
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APPROVED	RCH	FEB.21

CLIENT WESTERN BAY OF PLENTY DISTRICT COUNCIL

PROJECT WESTERN BAY OF PLENTY FLOOD MAPPING

TITLE ROGERS RD RESIDENTIAL ZONE 100 YEAR ARI RCP8.5 2130 DESIGN EVENT WITH 1.25M SLR - PEAK FLOOD DEPTHS

SCALE (A3) 1:5,000 FIG No. FIGURE C25. REV 0

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