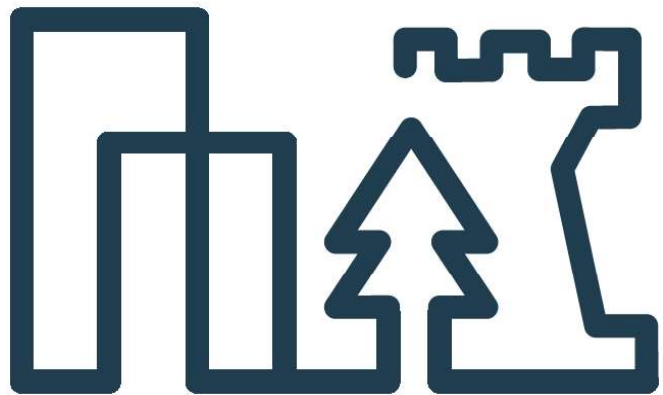


APPENDIX 8: CONSEQUENTIAL FLOOD RISK ASSESSMENT





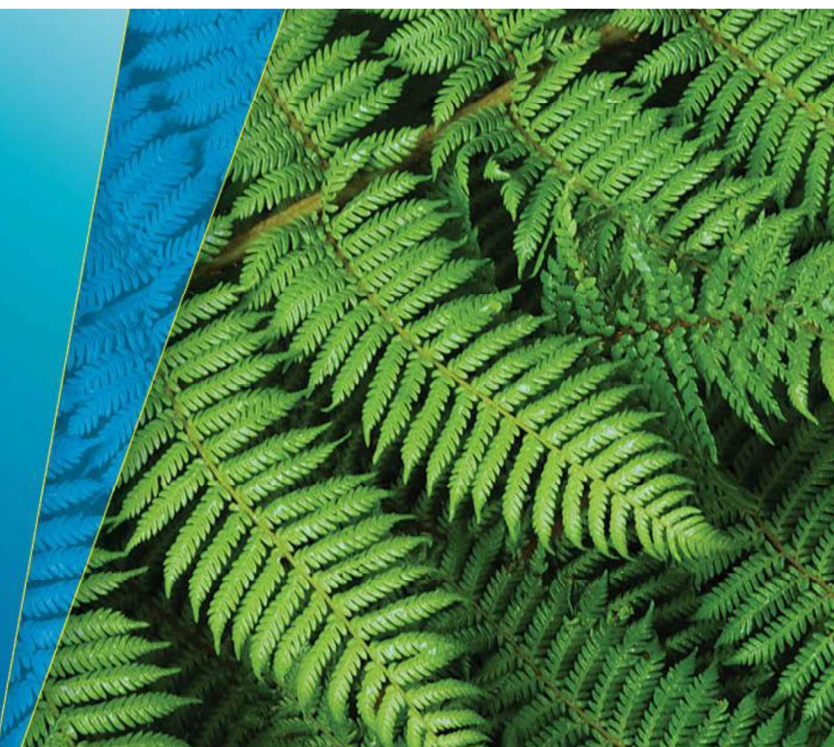
Te Karaka Consequential Flood Risk Assessment

Prepared for
Gisborne District Council

Prepared by
Tonkin & Taylor Ltd

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Executive summary

Gisborne District Council engaged Tonkin & Taylor Ltd to undertake a consequential flood risk assessment for the proposed upgraded Te Karaka stopbank. The proposed stopbank is intended to reduce flood risk for Te Karaka township from flooding in the Waipaoa River, up to a “design event” flow of 5,625 m³/s (with an additional 600 mm freeboard allowance). The primary purpose of this report is to evaluate the consequential adverse flood effects (disbenefits) of the proposed stopbank for locations outside of its intended ‘benefit area’.

To assess these consequential effects, this assessment uses outputs from a two-dimensional hydraulic model for the Waipaoa River. The model was used to evaluate ‘pre-upgrade’ and ‘post-upgrade’ cases across three event scenarios: a Cyclone Gabrielle-sized event, a 5,625 m³/s design event (approximately a 100-year or 1% Annual Exceedance Probability event, in the present day¹), and an over-design event (approximately a 500-year or 0.2% Annual Exceedance Probability (AEP) flood event event, with climate change¹). The results indicate that while the stopbank reduces flood risk to approximately 161 hectares during the design event, it reduces effective floodplain storage and forces flows into a narrower corridor. Consequently, land immediately upstream and adjacent to the stopbank experiences increases in flood depth, velocity and hazard, with 10 hectares of newly flooded land and 157 hectares experiencing a hazard category increase.

Within the benefit area, 215 buildings experience a flooding benefit during the design event, reducing from typically around 2 m of flood depth without the upgraded stopbank, to dry with the upgraded stopbank. However, outside the area of reduced flood risk, 23 buildings (including 6 residential dwellings) experience adverse flooding effects. Flood impacts on road infrastructure follow a similar pattern, with roads within the township having reduced flood risk and adjacent rural roads experiencing increased flood depths and hazard classifications. A comparison has been made between the modelled flood hazard classifications and those in the National Policy Statement for Natural Hazards 2025 (NPS NH).

Preliminary assessment of local bridges carried out previously by T+T indicates that the upgraded stopbank will increase structural loads and scour depths (by up to 0.8 m) on the Rangatira Road and Kanakanaia Road bridges under the design flow.

Modelling of the overdesign event (14,869 m³/s) indicates that the proposed upgraded stopbank would be overtopped, resulting in widespread hazard for the township, although this flooding is slightly reduced compared to the pre-upgrade case.

An alternate stopbank alignment at Kanakanaia Road has also been assessed in comparison to the proposed alignment, with only a minimal difference in impact to dwellings, roads, or bridges, and only a localised difference in flood depths on land parcels at, or nearby to, the alternate alignment.

¹ Peak flow rates and annual recurrence intervals were provided by Gisborne District Council. More details on these values can be found in Section 8.1.

1 Introduction

Gisborne District Council (GDC) has engaged Tonkin & Taylor Ltd (T+T) to undertake a consequential flood risk assessment for the proposed Te Karaka Stopbank, located in Te Karaka, Gisborne. Following Cyclone Gabrielle, improved flood mitigation measures were identified as necessary for the Te Karaka community. The preferred option recommendation which has been adopted is for an upgraded, higher stopbank on a new, largely retreated alignment. The purpose of the proposed stopbank is to reduce flood risk to the existing properties in the township of Te Karaka and immediate surrounding rural land from flooding, up to the design event in the Waipaoa River (5,625 m³/s), including an allowance for freeboard.

This report presents a summary on the consequential flood effects of the proposed stopbank, with a priority focus on the effects of the stopbanks outside of the immediate 'benefit area' of the stopbank.

It briefly describes the model runs used and the basis of this assessment (Section 2). Section 3 outlines the general consequential flood effects (extents, depths, velocities and hazard); and Section 4 details the effects on infrastructure and buildings, while Section 5 describes specific residential dwellings, localised infrastructure, and significant community sites. Section 6 discusses the effects of an alternate alignment and Section 7 summarises the previous work on bridge scour and loading.

This work has been undertaken in accordance with the conditions of engagement dated 17 February 2025 and variation dated 25 February 2026.

1.1 Background

The proposed stopbank alignment is shown in Figure 1.1. The proposed alignment follows the edge of the elevated river terrace on the true right bank of the Waipaoa River from the upstream of the township at State Highway 2, to the downstream of the township, also at State Highway 2. In the middle of the stopbank alignment is an area of high ground.

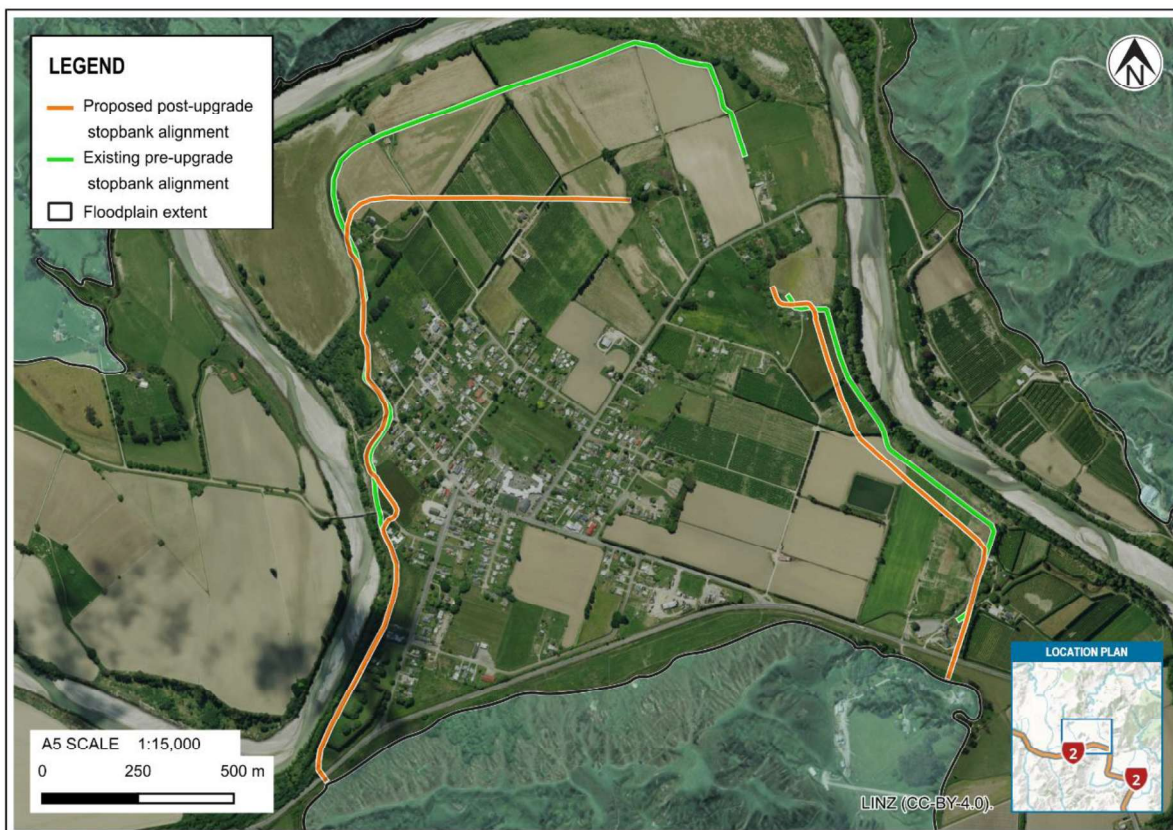


Figure 1.1: Existing and proposed post-upgrade stopbank alignments

The proposed stopbank will be approximately 3.8 km long and varies between 1 m and 4.8 m high, for a crest level of between 46.35 m RL and 40.39 m RL in New Zealand Vertical Datum 2016 (NZVD 2016). The proposed stopbank is to be constructed with a 2: 1 side slope and a crest width of 4 m. Figure 1.2 below illustrates a typical cross-section of the proposed Te Karaka stopbank.

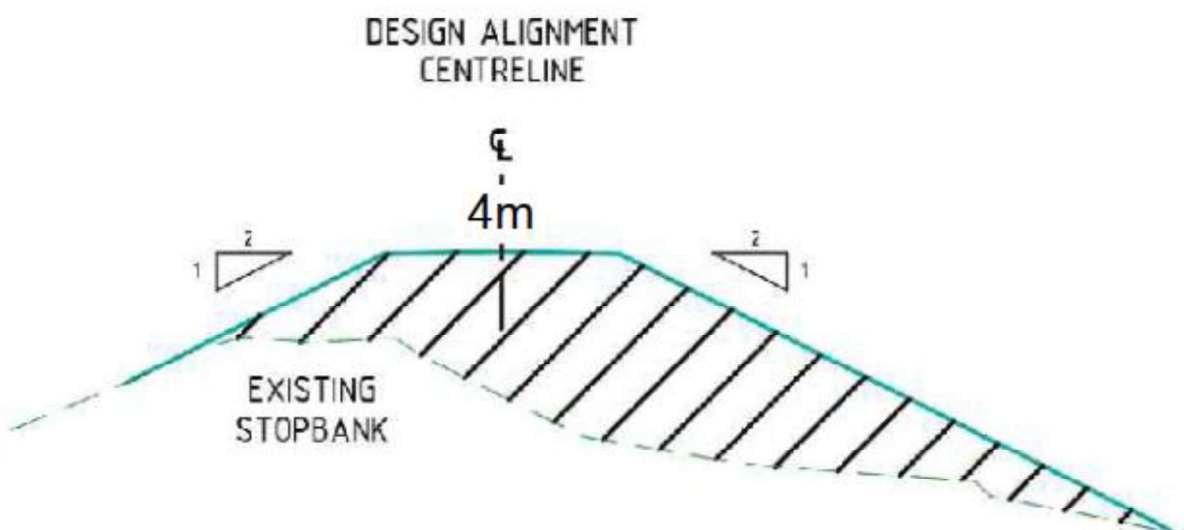


Figure 1.2: Proposed stopbank general geometry. Civil Project Solutions, 2026.

For some sections of the proposed stopbank alignment, the stopbank follows the existing stopbank. Along these sections, the new stopbank will be built over the existing stopbank (see Figure 1.2).

Preliminary geometric design for the stopbank and associated works has been provided by Civil Project Solutions (CPS). The alignment and design crest level of the stopbank may change during subsequent design stages (detailed design and construction).

2 Flood model runs overview

To assess the consequential flood effects of the proposed stopbank, DHI Group Ltd (DHI) has simulated different flood scenarios using a 2-dimensional hydraulic model. Six runs have been modelled, based on three different hydrological events, each compared between the “pre-upgrade” and “post-upgrade” scenarios. The “pre-upgrade” scenario represents the existing terrain and current flood defences, while the “post-upgrade” scenario incorporates the proposed stopbanks geometric design. Table 2.1 provides additional detail on these model runs.

Table 2.1: Overview of model runs and flows

Run ID	Event	Scenario	Discharge (m ³ /s)	Estimated Annual Exceedance Probability (% AEP)
D40	Cyclone Gabrielle	Pre-upgrade – terrain not modified	4,200*	2.5% AEP, present day
D41	Cyclone Gabrielle	Post-upgrade – proposed stopbank represented in model	4,200*	2.5% AEP, present day
D42	Design Event (Cyclone Bola flows + 25%)	Pre-upgrade – terrain not modified	5,625	1% AEP, present day
D43	Design Event (Cyclone Bola flows + 25%)	Post-upgrade – proposed stopbank represented in model	5,625	1% AEP, present day
D44	Overdesign event	Pre-upgrade – terrain not modified	14,869	0.2% AEP (with climate change at 2130, RCP 8.5)
D45	Overdesign event	Post-upgrade – proposed stopbank represented in model	14,869	0.2% AEP (with climate change at 2130, RCP 8.5)

Note: Peak flow rates and AEP values at Kanakanaia Bridge were provided by GDC. The overdesign event is a 0.2% AEP event including climate change effects to 2130 represents a rare flood event. For more details, see Section 8.1.

2.1 Hydraulic modelling

The purpose of the model is to assess the flood mitigation effects, consequential effects, and design considerations of the proposed stopbank in Te Karaka township and surrounding area. The model was built by DHI in Mike+ software with a 2-dimensional floodplain and river based on LiDAR survey and bathymetry, as well as 1-dimensional elements and a transition to a 1D-2D coupled model approximately 10 km downstream of Te Karaka. Model runs represent approximately 48-hour duration events (Hydrograph Figures 11 and 12 in the DHI report). The model domain encompasses a 36 km long reach of the Waipaoa River from 5 km upstream of Te Karaka to 26 km downstream (including a 5 km reach adjacent to the township). For the purposes of this assessment, we have focussed on the 20 km reach where the Waipaoa River is represented two-dimensionally, from adjacent to 290 Whatatutu Rd (river benchmark 39.5 mile), to adjacent to Mullooly Rd (river

benchmark 26.5 mile), a floodplain area of approximately 23 km². This reach incorporates inflows from the Waipaoa River, as well as the Waikohu River, the Waihora River, and numerous small inflows. Figure 2.1 shows the general layout of the model and the project scope area.

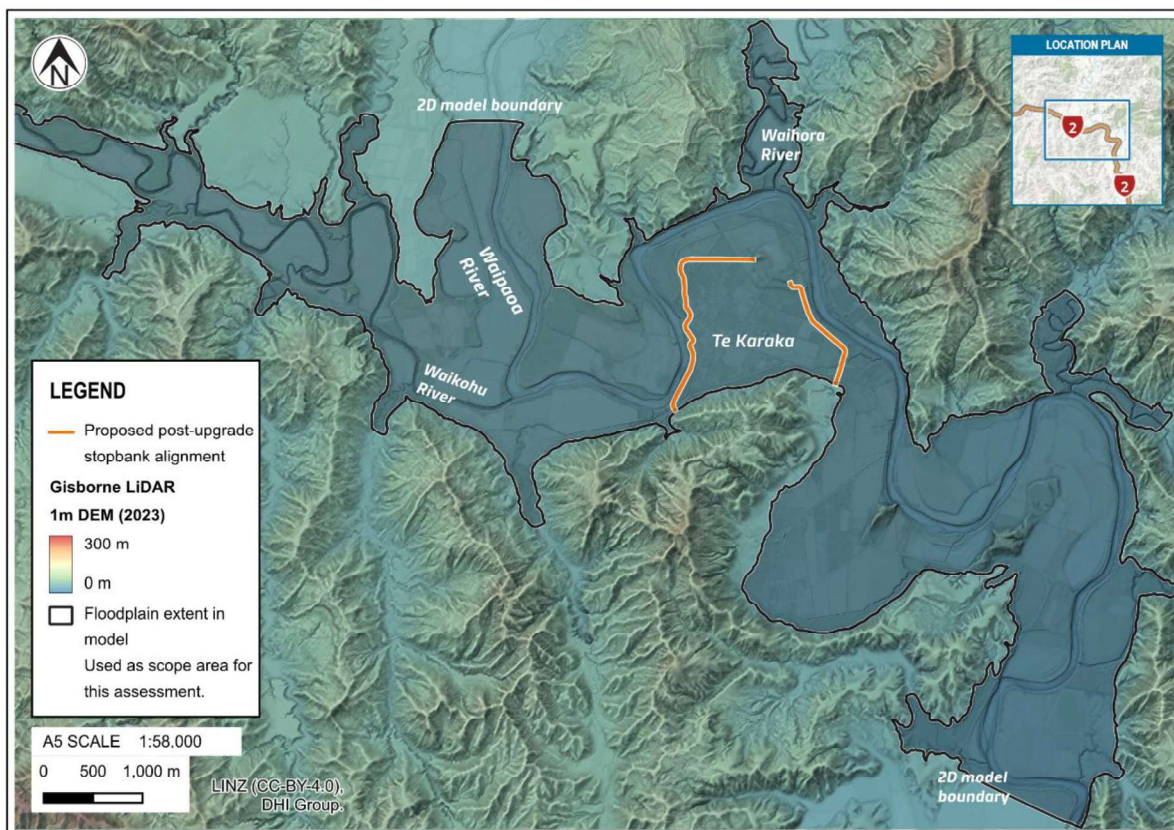


Figure 2.1: General layout of the DHI Group hydraulic model in the assessed area. Additionally shows the project scope area used in this assessment.

In the pre-upgrade case, existing stopbanks/bunds are represented in the model topography. In the post-upgrade case, the proposed stopbank is included in the model as a topographic adjustment to the mesh, along the alignment in Figure 1.1 and based on the geometric design provided by Civil Project Solutions (CPS).

Bridges, some culverts, and roughness elements have been incorporated in the model. More details on the hydraulic model build, including boundary conditions and roughness parameters, can be found in the draft DHI model build report (DHI Group Ltd., 2026).

The outputs from these hydraulic model runs serve as the foundation for the consequential flood risk assessment detailed in the subsequent sections.

2.2 Basis of assessment

The proposed upgraded stopbank crest levels have been designed on the basis of a specific hydrological event representing Cyclone Bola flows + 25%, with the 25% representing an increase of flows for climate change from a study on the Ngaruroro catchment (Hawke's Bay)². This 'design event' is not intended to represent a specific return period, but approximates to a present-day 1% AEP event³. The proposed stopbank crest levels include an additional 600 mm freeboard above the design flood level. Figure 2.2 shows the flood depths in the design event with the stopbank included, in the post-upgrade case. Maps detailing the pre-upgrade flood depths are in Appendix A.

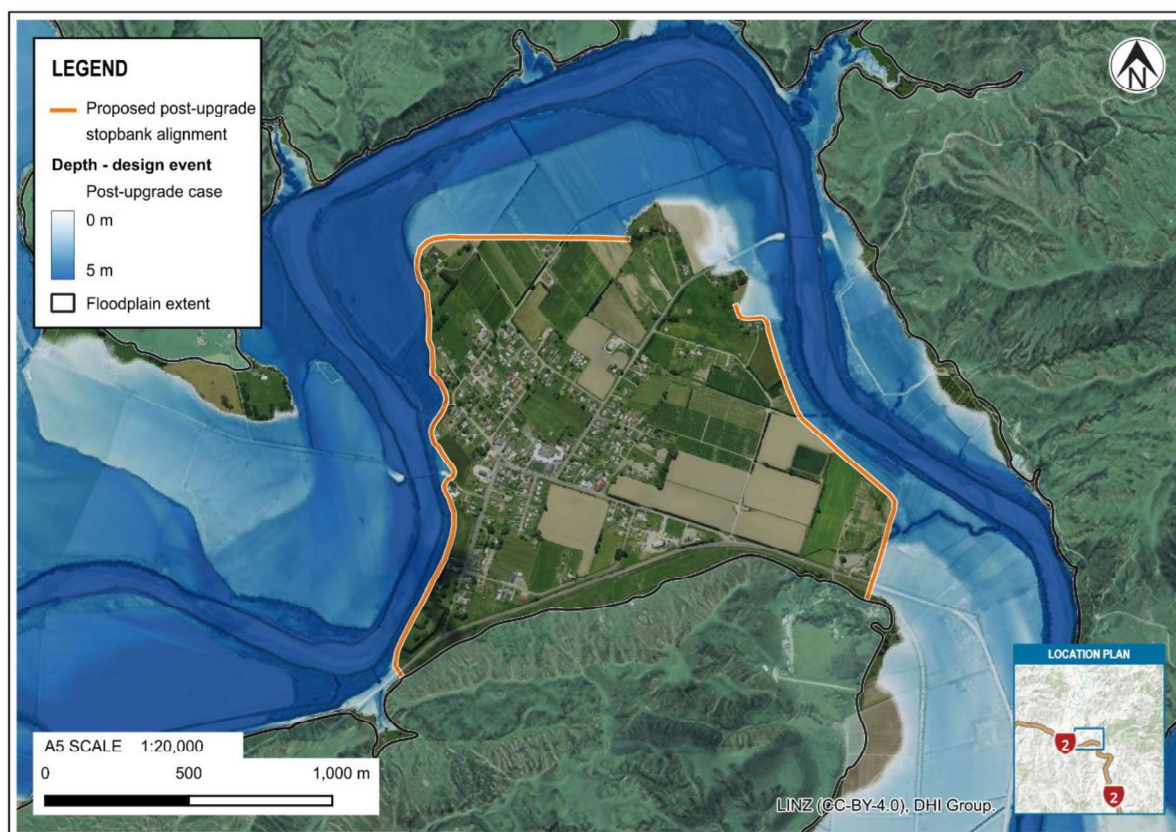


Figure 2.2: General depths adjacent to Te Karaka township in the design event – post-upgrade case.

For the purposes of this consequential flood risk assessment, two additional scenarios are assessed: the estimated 2.5% AEP 'Cyclone Gabrielle' event, and a 0.2% AEP 'overdesign event'. This assessment concentrates on the design event.

The focus of this assessment is on the disbenefits (adverse consequential flooding effects, such as increased flood depths or hazard classifications) associated with the post-upgrade case, outside the immediate Te Karaka area benefitting from the upgraded flood defences. Benefits are summarised only briefly in this assessment. Figure 2.3 shows the previously identified 'benefit area' with reduced flood risk provided by the flood defences in the design event.

² Waipoua Stopbank Improvements 2015 – 2030: Technical Memorandum (GDC, June 2024, ref: A1640108)

³ As provided by GDC, see Section 8.1.

Further details on the flood damages to specific dwellings, particularly those with an increased flood depth in the design event, are covered in a memorandum from Christensen Consulting Ltd, 'Te Karaka Consequential Flood Damage Assessment' (17 March 2026).

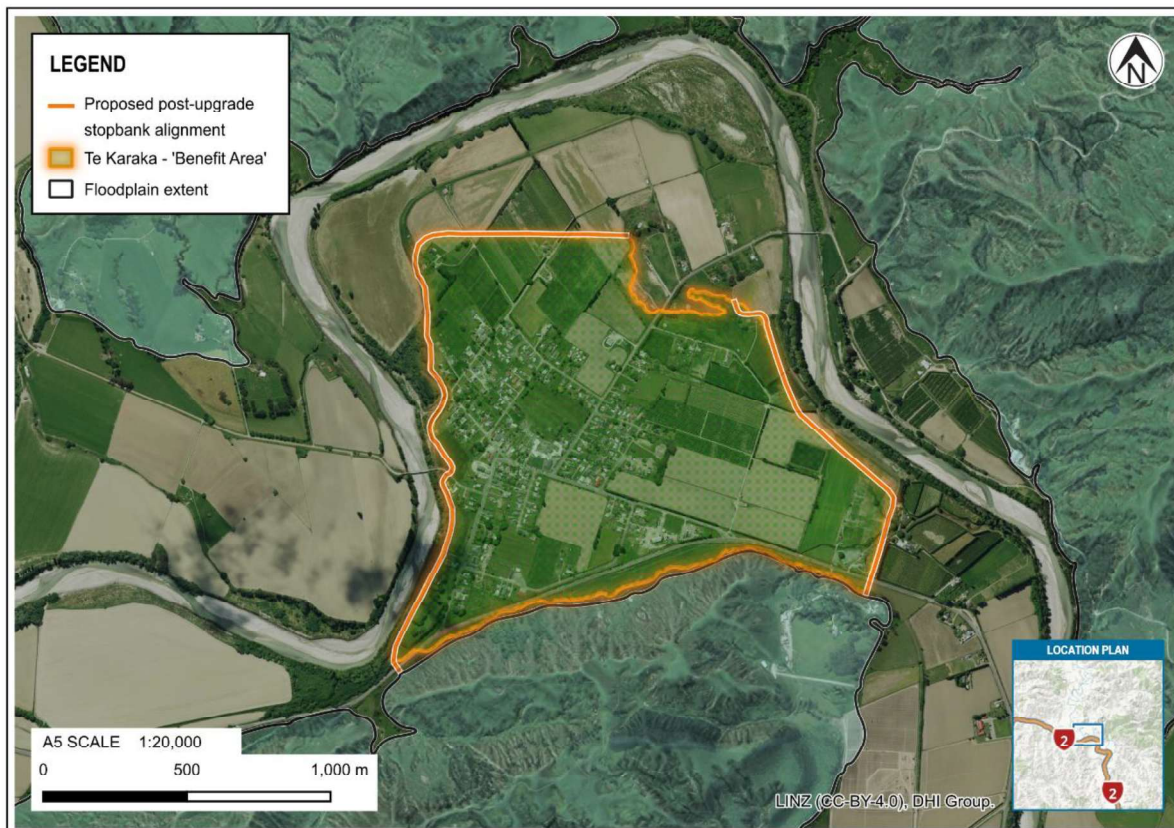


Figure 2.3: Area directly benefitting from proposed post-upgrade flood defences.

This assessment covers the following:

- 1 Peak flood depth differences.
- 2 Maximum velocity differences.
- 3 Change in hazard category by area of land.
- 4 Change in hazard category by building and residential dwelling.
- 5 Identification of all properties and residential dwelling subject to a hazard category increase, or flood depth increase if > 50 mm.
- 6 Commentary on changes in velocity, hazard, and depth at the locations of critical infrastructure and community sites.
- 7 Hazard changes by road.
- 8 Change in impacts of an altered alignment at Kanakanaia Road.
- 9 Summary of previous work on scour and loading at bridges.

3 Flood effects

3.1 Extent

In the design event, approximately 161 ha is no longer flooded in the post-upgrade case⁴. This is largely within the ‘benefit area’ of the township provided with reduced flood risk from the flood defence upgrades, and some small margins of lower floodwaters in the reach downstream of the township (see Figure 3.1). Meanwhile, approximately 10 ha is newly flooded in the post-upgrade case, at the margins of higher floodwaters in the reach adjacent to, and upstream of the township. This includes areas on the margin of the Waihora and Waikohu River floodplains. A total of 2,092 ha is flooded in both cases in the design event, within the project scope area. Table 3.1 shows the area no longer flooded, newly flooded, and flooded in both cases for all three events. Detailed maps indicating these areas can be found in Appendix B.

Table 3.1: Flood extent changes as a result of the proposed stopbank upgrade

Event	Difference in flooded areas		
	Newly flooded	No longer flooded	Still flooded
Design event	10 ha	161 ha	2,092 ha
Cyclone Gabrielle flows	2 ha	153 ha	2,046 ha
Over-design event	6 ha	~ 0 ha	2,433 ha

Note: Areas in this table only refer to the flooded area (any depth) within the scope area (see Figure 2.3).

3.2 Flood depths

Outside of the immediate benefit area, the post-upgrade case has a hydraulic effect on peak flood depths, extending effectively through the whole 2D model domain. In the design event, peak flood depths increase in the post-upgrade case upstream of and adjacent to the stopbank, and as far downstream as Ahirau Rd. The largest increase in peak flood depths is immediately adjacent to the stopbank, especially around the apex of the Te Karaka bend (see Figure 3.1), and up the Waihora River, where depths are close to 1 m higher in the post-upgrade case. Downstream from Te Karaka, there is a reduction in peak flood depths, especially around Matawai Rd/State Highway 2 about Takipū Marae. Downstream of the Marae, peak flood depths decrease less than 100 mm in the post-upgrade case, extending to the end of the reach. Areas experiencing different levels of flood depth change are detailed in Table 3.2. Detailed maps indicating the changes in flood depths for all events can be found in Appendix B.

⁴ Throughout this report, the term “flooding” refers to fluvial (river) flooding only. Local pluvial (rainfall-induced stormwater) flooding may still occur in some areas; this flooding type is beyond the scope of this project.

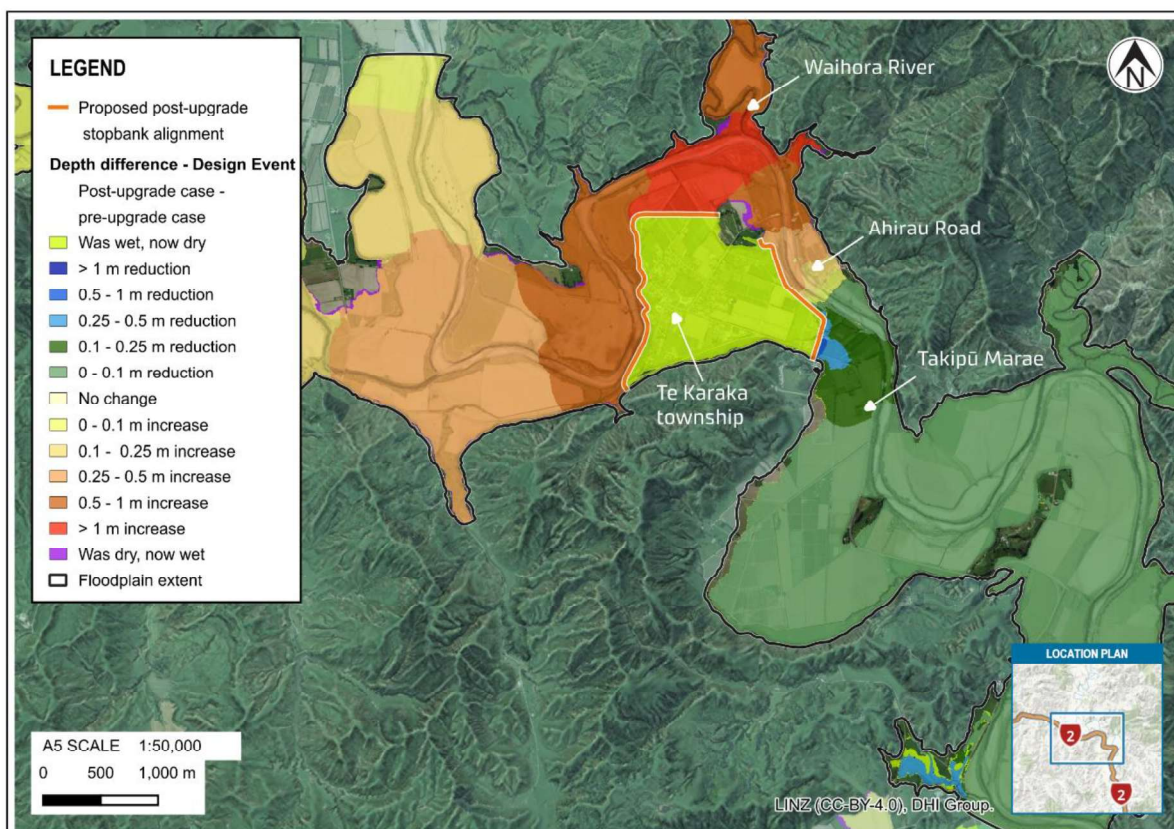


Figure 3.1: Depth difference – design event – post-upgrade case compared to pre-upgrade case.

Table 3.2: Summary of flood depth change by land area

Post-upgrade case – difference to pre-upgrade case	Event		
	Design event (5,625 m ³ /s)	Cyclone Gabrielle flows (4,200 m ³ /s)	Over-design event (14,869 m ³ /s)
> 1 m reduction	0 ha	0 ha	0 ha
0.5 - 1 m reduction	1 ha	1 ha	1 ha
0.25 - 0.5 m reduction	14 ha	4 ha	14 ha
0.1 - 0.25 m reduction	48 ha	23 ha	13 ha
0 - 0.1 m reduction	931 ha	592 ha	372 ha
Any reduction (total)	994 ha	620 ha	401 ha
No change (within 0.001 m)	44 ha	212 ha	34 ha
0 - 0.1 m increase	283 ha	1,066 ha	988 ha
0.1 - 0.25 m increase	189 ha	30 ha	278 ha
0.25 - 0.5 m increase	296 ha	74 ha	551 ha
0.5 - 1 m increase	215 ha	37 ha	181 ha
> 1 m increase	69 ha	8 ha	1 ha
Any increase (total)	1,053 ha	1,214 ha	1,998 ha

Note: Table 3.2 refers to areas flooded, for each event, in both the pre-upgrade case and the post-upgrade case. For areas newly flooded or no longer flooded in each event, please refer to Table 3.1. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

3.3 Velocity

The post-upgrade case stopbank alignment results in changes to the peak velocity in each case, although these don't extend as far upstream or downstream as depth changes. In the design event, velocities are lower on the floodplain immediately upstream of the stopbank and immediately downstream of the stopbank. Velocities are also lower within the channel around the apex of the bend near the confluence with the Waihora River. Velocities increase on the berms adjacent to the stopbank around the meander bend, especially on the upstream corner to the north of the settlement. In the design event, more land is subject to decreased velocities in the post-upgrade case, although more land is subject to an extreme increase in velocities than an extreme decrease. In the Cyclone Gabrielle event, there is more land which is subject to an increase in velocities than a decrease. For the overdesign event, the area subject to a velocity increase is very similar to the area subject to a decrease. Figure 3.2 shows the velocity changes as a result of the post-upgrade case, in the design event. Land area in each band of velocity changes are indicated in Table 3.3 and maps are provided in Appendix C.

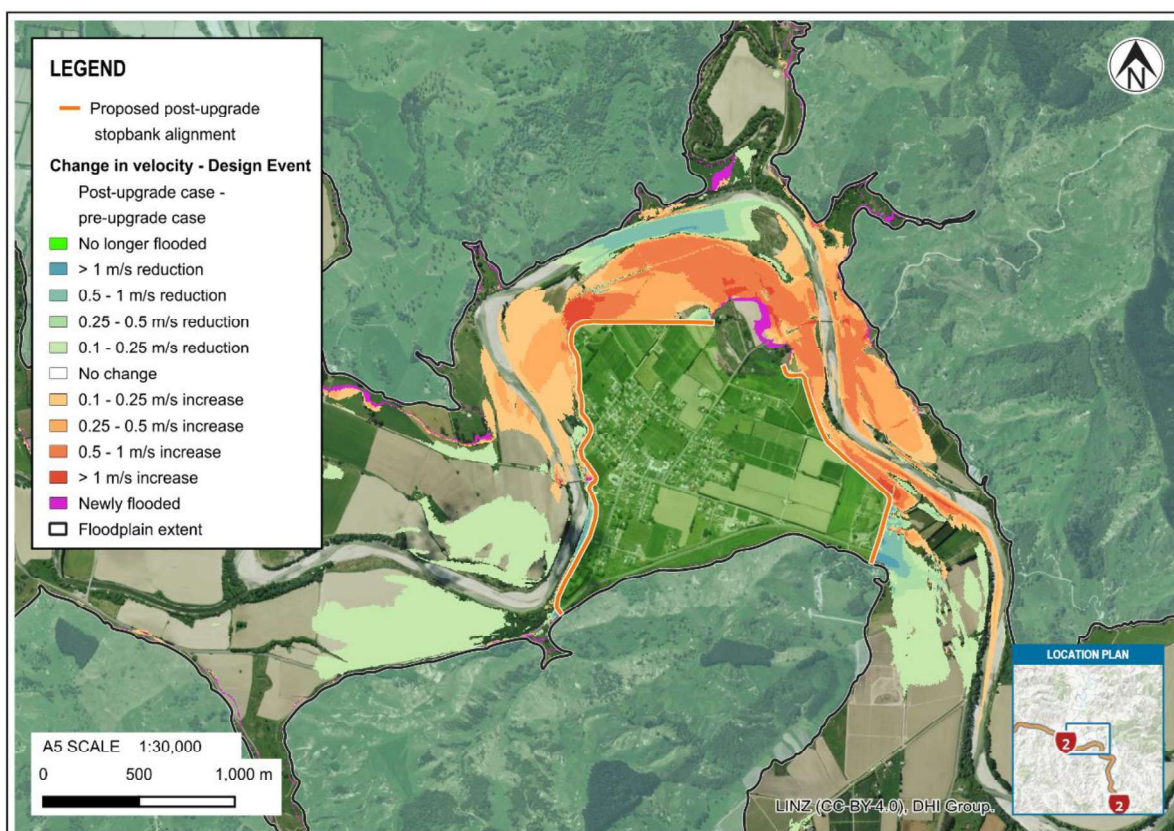


Figure 3.2: Change in peak flood velocity in the design event, between the pre-upgrade case and the post-upgrade case.

Table 3.3: Summary of peak velocity change by land area

Post-upgrade case – difference to pre-upgrade case	Event		
	Design event	Cyclone Gabrielle flows	Over-design event
> 1 m/s reduction	2 ha	1 ha	1 ha
0.5 - 1 m/s reduction	9 ha	9 ha	19 ha
0.25 - 0.5 m/s reduction	10 ha	10 ha	73 ha
0.1 - 0.25 m/s reduction	93 ha	34 ha	231 ha
> 0.1 m/s reduction (total)	114 ha	54 ha	324 ha
0 - 0.1 m/s reduction	1,391 ha	578 ha	831 ha
Any reduction (total)	1,506 ha	631 ha	1,154 ha
No change	98 ha	258 ha	73 ha
0 - 0.1 m/s increase	359 ha	1,075 ha	1,029 ha
0.1 - 0.25 m/s increase	45 ha	35 ha	64 ha
0.25 - 0.5 m/s increase	42 ha	28 ha	58 ha
0.5 - 1 m/s increase	36 ha	14 ha	46 ha
> 1 m/s increase	4 ha	2 ha	8 ha
> 0.1 m/s increase (total)	127 ha	80 ha	176 ha
Any increase (total)	487 ha	1,155 ha	1,205 ha

Note: Table 3.3 refers to areas flooded, for each event, in both the pre-upgrade case and the post-upgrade case. For areas newly flooded or no longer flooded in each event, please refer to Table 3.1. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

3.4 Hazard

For each event and case, peak flood hazard (as a function of instantaneous velocity and depth) is calculated using the Smith, et al., 2014 Hazard Vulnerability curves⁵ (see Figure 3.5). Figure 3.3 shows the hazard in the design event, in the pre-upgrade case. Much of the assessed Waipaoa River floodplain experiences a peak hazard of H6 (the highest category), with lower hazard at the margins of the floodplain or in elevated areas. The design event hazard is an assessment of consequence at the 1% AEP, which equates to the 'Possible' likelihood in the NPS NH. Table 3.4 compares the Smith, et al., 2014 Hazard Vulnerability classifications to the consequence and risk classifications from the NPS NH risk matrix, at this 'Possible' likelihood (1% AEP). These classifications are based on the descriptions of the different hazard categories in Smith, et al. and the descriptions of the consequence classes in the NPS NH, and do not explicitly consider the criticality or vulnerability of exposed assets, nor a direct assessment risk to life.

Table 3.4: Hazard classifications (design event) referenced to NPS NH risk matrix

Hazard Class (Smith, et al., 2014)	NPS NH – Consequence	NPS NH – Risk at 'Possible' likelihood
H6	Catastrophic	High
H5	Major to Catastrophic	High
H4	Major	High

⁵ As described in the Water New Zealand National Stormwater Modelling Guide, 2024.

H3	Moderate	Medium
H2	Minor	Medium
H1	Negligible	Low

Note: This is an interpretation of the wording in the NPS NH. The Hazard Vulnerability classifications (Smith, et al., 2014) do not consider the criticality or vulnerability of assets, nor the probability of exposure.

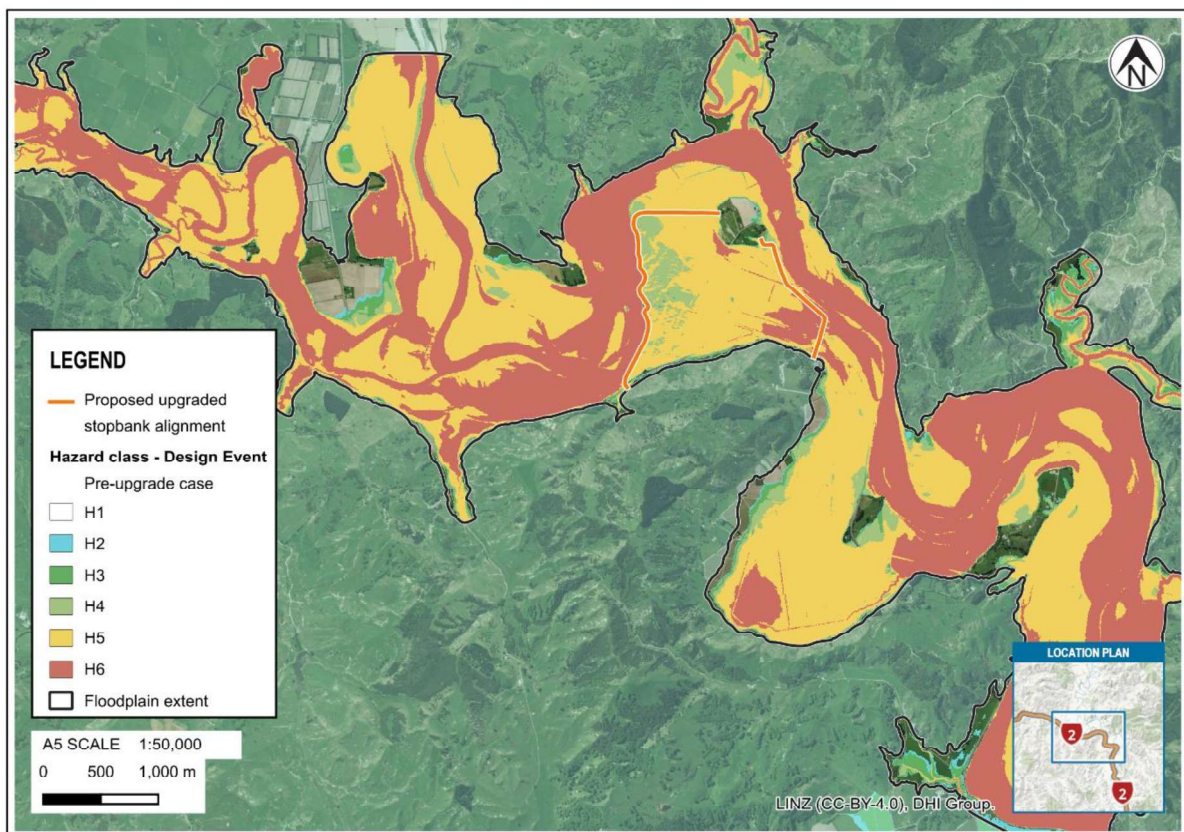


Figure 3.3: Pre-upgrade case, design event peak flood hazard (Smith, et al., 2014 classes).

For the design event flows in the post-upgrade case (when compared to the pre-upgrade case), hazard increases are limited to isolated areas adjacent to, and upstream of the Te Karaka stopbank, and reductions occur within the area of reduced flood risk and in isolated areas downstream. Changes in flooding hazard in the design event are shown in Figure 3.4.

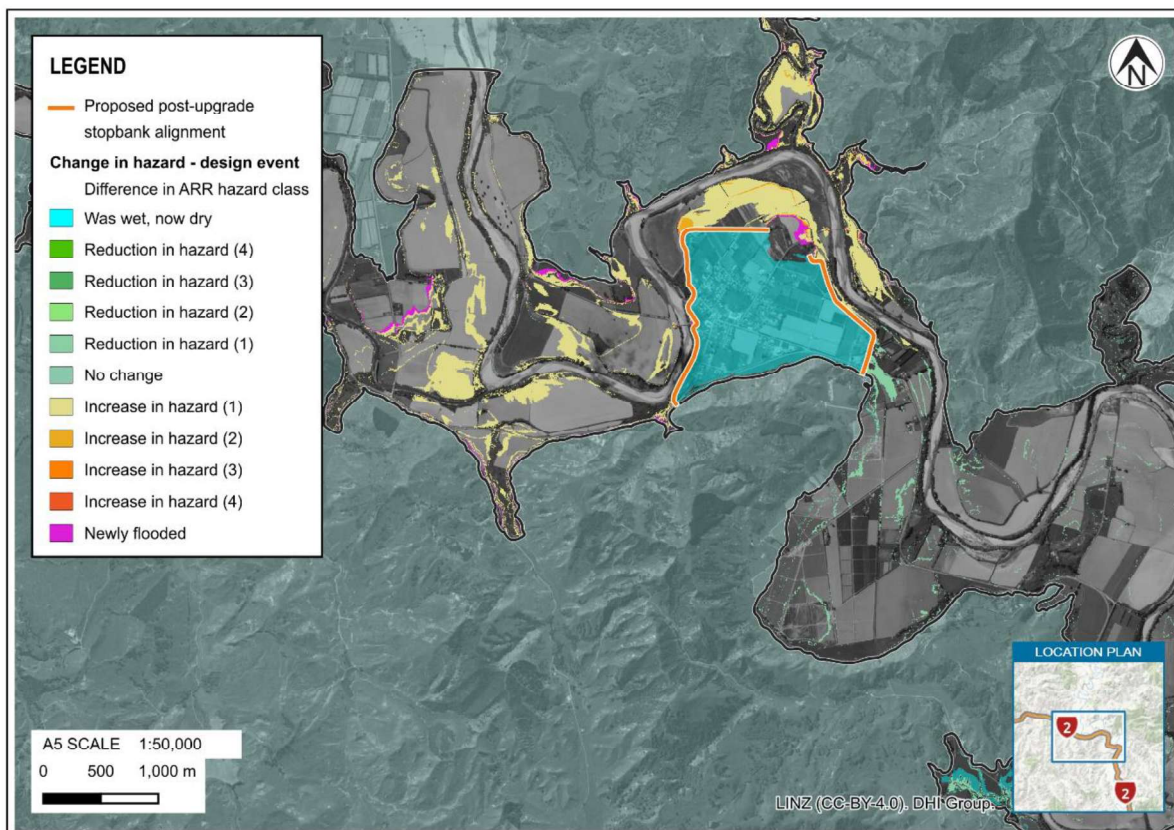


Figure 3.4: Change in peak hazard in the design event – pre-upgrade case to post-upgrade case.

In total, 157 ha of land has an increase in hazard, with the majority of this being areas which were subject to H5 hazard becoming subject to H6 hazard in the post-upgrade case, and areas which were dry in the pre-upgrade becoming subject to flooding in the post-upgrade case. A total of 210 ha of land have a decrease in hazard, largely within the 'benefit area' at Te Karaka township which has reduced flood risk in the post-upgrade case.

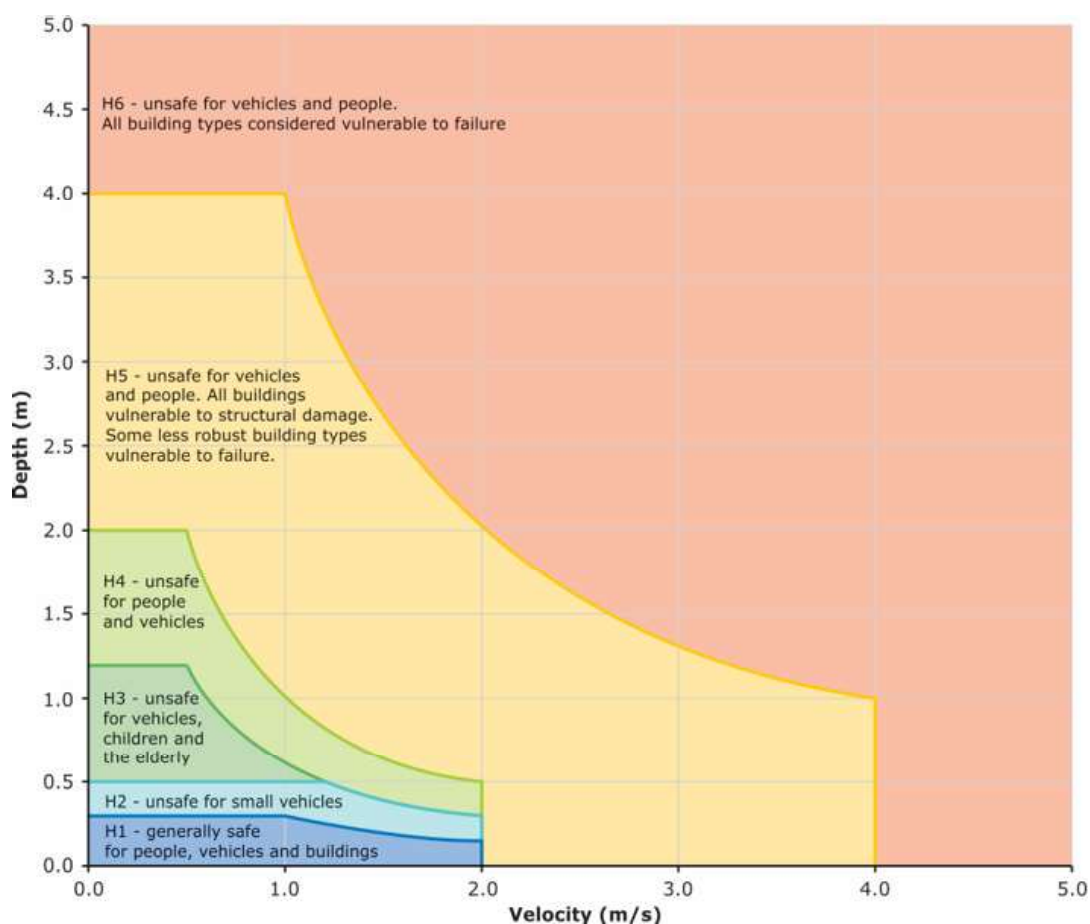


Figure 3.5: Combined flood hazard curves adopted by Water NZ Stormwater Modelling Guide (2024), by Smith, et. al., 2014.

Table 3.4 below provides a cross-reference of the flood hazard classifications for the surrounding land area, measured in hectares (ha). The matrix compares the pre-upgrade hazard classes (columns) against the post-upgrade hazard classes (rows) to illustrate how the proposed stopbank alters the hazard level across the modelled extent. This table captures the transition of land between different hazard states, summarising the total area that experiences an increase, decrease, or no change in hazard classification in the post-upgrade scenario.

Table 3.5: Changes to H1- H6 hazard classification, by land area

	Pre-upgrade									
		H1	H2	H3	H4	H5	H6	Decrease	Increase	Total
Post-upgrade	H1	223 ha	7 ha	5 ha	24 ha	111 ha	16 ha	162 ha	-	385 ha
	H2	4 ha	12 ha	4 ha	0 ha	0 ha	0 ha	4 ha	4 ha	20 ha
	H3	5 ha	4 ha	42 ha	4 ha	0 ha	0 ha	4 ha	9 ha	55 ha
	H4	1 ha	1 ha	14 ha	68 ha	10 ha	0 ha	10 ha	15 ha	93 ha
	H5	0 ha	0 ha	2 ha	27 ha	768 ha	14 ha	14 ha	29 ha	812 ha
	H6	0 ha	0 ha	0 ha	2 ha	97 ha	995 ha	-	99 ha	1,094 ha
	Decrease	-	7 ha	9 ha	27 ha	121 ha	31 ha	195 ha		
	Increase	11 ha	5 ha	16 ha	29 ha	97 ha	-		157 ha	
	Total	234 ha	23 ha	66 ha	124 ha	985 ha	1,026 ha			2,458 ha

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

Data Format: Values within the table represent the total affected land area measured in hectares (ha).

Interpreting Changes: The 'Decrease' and 'Increase' columns and rows aggregate the total hectares of land that shift to a lower or higher hazard classification, respectively. For example, a value intersecting the H5 pre-upgrade column and the H4 post-upgrade row indicates land that experienced a reduction in hazard

No Change: Values where the pre-upgrade and post-upgrade hazard classes are identical (e.g., H1 to H1) represent land areas where the proposed upgrades result in no change to the hazard classification.

Additional maps detailing the change in hazard can be found in Appendix D.

4 Effects on infrastructure

4.1 Buildings

There are 606 buildings subject to some degree of flooding in the assessed extent, in at least one of the three modelled events, in either the post-upgrade or pre-upgrade scenarios. These generally represent the buildings flooded in (at least) the over-design event, in one of the scenarios. Of these, the majority are within Te Karaka township and have flood risk reduced by the proposed stopbank upgrade, up to the design event flows + 600 mm freeboard (but not the overdesign event). The remaining buildings are outside of this extent, within the Waipaoa River floodplain. Of these 194 buildings in the floodplain, 49 buildings flooded in at least one of the modelled events are residential dwellings. Benefits and disbenefits are assessed for all buildings, but with a specific focus on disbenefits to residential dwellings outside of the Te Karaka 'benefit area'.

Table 4.1 below cross-references the flood hazard classifications outside the immediate Te Karaka 'benefit area' during the design event. The matrix compares the pre-upgrade hazard classes (*columns*) against the post-upgrade hazard classes (*rows*) to demonstrate how the proposed stopbank alters the hazard level for these specific structures. The table captures the transition of buildings between different hazard classes, summarising the total number of structures that experience an increase (*red*), decrease (*green*), or no change in their hazard classification in the post-upgrade case.

Table 4.1: Changes in H1-H6 hazard classification, by buildings (dwellings in brackets) outside the area of reduced flood risk

		Pre-upgrade								Total
		H1	H2	H3	H4	H5	H6	Decrease	Increase	
Post-upgrade	H1	1 (0)	-	-	1 (1)	1 (0)	-	2 (1)	-	3 (1)
	H2	2 (0)	-	-	-	-	-	-	2 (0)	2 (0)
	H3	2 (1)	-	5 (1)	1 (1)	1 (0)	-	2 (1)	2 (1)	9 (3)
	H4	-	-	3 (1)	17 (3)	4 (0)	-	4 (0)	3 (1)	24 (4)
	H5	1 (1)	1 (0)	-	4 (0)	75 (15)	-	-	6 (1)	81 (16)
	H6	-	-	-	1 (0)	7 (1)	3 (0)	-	8 (1)	11 (1)
	Decrease	-	-	-	2 (2)	6 (0)	-	8 (2)		
	Increase	5 (2)	1 (0)	3 (1)	5 (0)	7 (1)	-		21 (4)	
	Total	6 (2)	1 (0)	8 (2)	24 (5)	88 (16)	3 (0)			130 (25)

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

Data Format: Values within the table are presented in the format of Total Buildings (Residential Dwellings). For example, "75 (15)" indicates that 75 buildings in total fall into that specific hazard shift, of which 15 are residential dwellings.

Interpreting Changes: The 'Decrease' and 'Increase' columns and rows aggregate the total number of structures that shift to a lower or higher hazard classification, respectively. Values where the pre-upgrade and post-upgrade hazard classes are identical (e.g., H1 to H1) represent buildings with no change in their hazard classification.

4.1.1 Disbenefits

Across all modelled events, an adverse flooding effect to a building is defined in this case as an increase in the flood hazard classification, **or** a localized flood depth increase of at least 50 mm, when comparing the post-upgrade case to the pre-upgrade case.

In the design event, 23 individual buildings are subject to an adverse flooding effect. Of these, six are identified as residential dwellings (see Table 4.2 below). In the Cyclone Gabrielle flows, 11 buildings are subject to an adverse flooding effect. Of these, three are identified as residential dwellings (see Table 4.4 below). In the overdesign event, 67 individual buildings are subject to an increased flooding effect. Of these, 14 are residential dwellings (see Table 4.4 following).

The following tables detail the specific changes in mean flood levels and maximum hazard classifications for the affected residential dwellings across the design, Cyclone Gabrielle, and overdesign events. More details on the sampling of these values is included in Section 7.

Table 4.2: Design event flood levels and hazard for dwellings with worsened flooding

Residential Address	Design event – levels and hazard				
	Pre-Upgrade Mean Flood Level	Post-Upgrade Mean Flood Level	Flood Level Difference	Pre-Upgrade Maximum Hazard	Post-Upgrade Maximum Hazard
103 Kanakanaia Road	41.90 m RL	42.60 m RL	+0.70 m	H1	H5
108 Kanakanaia Road	41.76 m RL	42.40 m RL	+0.64 m	H5	H6
23 Mangaoae Road	41.43 m RL	41.81 m RL	+0.38 m	H4	H4
45 Bridge Road	46.15 m RL	46.41 m RL	+0.27 m	H3	H3
46 Bridge Road	46.07 m RL	46.37 m RL	+0.29 m	H3	H4
96 Kanakanaia Road	41.86 m RL	42.58 m RL	+0.72 m	H1	H3

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

Similar adverse effect assessments were undertaken for the alternative modelled scenarios. The residential dwellings subject to adverse effects during the Cyclone Gabrielle flows and the overdesign event are detailed in the subsequent tables below.

Table 4.3: Cyclone Gabrielle event flood levels and hazard for dwellings with worsened flooding

Residential Address	Cyclone Gabrielle event – levels and hazard				
	Pre-Upgrade Mean Flood Level	Post-Upgrade Mean Flood Level	Flood Level Difference	Pre-Upgrade Maximum Hazard	Post-Upgrade Maximum Hazard
23 Mangaoae Road	40.45 m RL	40.60 m RL	+0.15 m	H1	H2
2416 Matawai Road*	39.18 m RL	38.97 m RL	-0.21 m	H3	H4
108 Kanakanaia Road	40.84 m RL	41.14 m RL	+0.30 m	H5	H5

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

*2416 Matawai Road is subject to a reduction in flood level in the post-upgrade case, but a small increase in flood velocity, which puts it over the threshold for an increase in hazard.

Table 4.4: Over-design event flood levels and hazard for dwellings with worsened flooding

Residential Address	Over-design event – levels and hazard				
	Pre-Upgrade Mean Flood Level	Post-Upgrade Mean Flood Level	Flood Level Difference	Pre-Upgrade Maximum Hazard	Post-Upgrade Maximum Hazard
101 Whatatutu Road	49.41 m RL	49.60 m RL	+0.18 m	H2	H3
103 Kanakanaia Road	45.84 m RL	45.99 m RL	+0.15 m	H6	H6
108 Kanakanaia Road	45.80 m RL	45.94 m RL	+0.14 m	H6	H6
23 Mangaoae Road	45.62 m RL	45.72 m RL	+0.10 m	H6	H6
2982 Matawai Road	51.06 m RL	51.17 m RL	+0.11 m	H5	H5
35 Paulson Road	45.71 m RL	45.84 m RL	+0.13 m	H6	H6
45 Bridge Road	49.05 m RL	49.43 m RL	+0.38 m	H5	H6
46 Bridge Road	49.01 m RL	49.40 m RL	+0.39 m	H6	H6
73 Whatatutu Road (A)	49.10 m RL	49.47 m RL	+0.37 m	H5	H5
73 Whatatutu Road (B)	49.07 m RL	49.45 m RL	+0.38 m	H5	H5
85 Kanakanaia Road	45.85 m RL	45.97 m RL	+0.12 m	H4	H5
88 Rangatira Road	-	47.47 m RL	<i>Newly flooded</i>	H1	H3
90 Kanakanaia Road	45.77 m RL	45.89 m RL	+0.12 m	H5	H5

Residential Address	Over-design event – levels and hazard				
	Pre-Upgrade Mean Flood Level	Post-Upgrade Mean Flood Level	Flood Level Difference	Pre-Upgrade Maximum Hazard	Post-Upgrade Maximum Hazard
96 Kanakanaia Road	45.84 m RL	45.99 m RL	+0.15 m	H6	H6
Whatatutu Road (A)	50.14 m RL	50.29 m RL	+0.15 m	H1	H1
Whatatutu Road (B)	49.98 m RL	50.07 m RL	+0.09 m	H2	H2
Whatatutu Road (C)	50.14 m RL	50.25 m RL	+0.11 m	H1	H1
Whatatutu Road (D)	49.86 m RL	49.95 m RL	+0.09 m	H1	H1
Whatatutu Road (E)	-	49.61 m RL	<i>Newly flooded</i>	H1	H1

Note: Properties designated as 'Newly flooded' (88 Rangatira Road and Whatatutu Road (E)) are not inundated during the pre-upgrade overdesign event. In the post-upgrade scenario, the altered flood hydraulics result in new inundation at these locations, establishing baseline flood levels and resulting in new H3 and H1 hazard classifications, respectively. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown. Supplied hazard information from DHI shows H1 where there is no depth – see Section 8.3.

In general, the consequential flood risk disbenefits appear to scale with the flood magnitude. During lower flows, the proposed stopbank upgrade and realignment has a minimal effect on hazard class and nearby dwellings, while the 0.2% AEP + CC overdesign event drives a more severe and widespread hazard increase.

Further details on the levels, depths, velocities and nature of the flooding at the six residential dwellings subject to an adverse flooding effect in the design event are included in Section 5.

4.1.2 Benefits

For the purposes of this assessment, a positive flooding effect (or 'benefit') resulting from the proposed stopbank upgrades is defined as either a decrease in the flood hazard classification or a localised flood depth reduction of at least 50 mm when comparing the post-upgrade case to the pre-upgrade case.

In general, flooding benefits in each of the events are concentrated in the previously identified Te Karaka township 'benefit area', which has reduced flood risk (up to the design event + 600 mm freeboard) provided by the proposed stopbank. A brief summary of the buildings, properties, etc. within the 'benefit area' is provided in Table 4.5. In the overdesign event, the benefit area is still modelled to flood even in the post-upgrade case, however, flooding depths are reduced in some areas (see Appendix B).

Table 4.5: Parcels and buildings (in the 'benefit area' with flooding benefit in each event, in the post-upgrade case (as compared to the pre-upgrade case).

Event	Properties (parcels) with flooding benefit	Buildings with flooding benefit
Cyclone Gabrielle	277	209
Design Event	284	215
Overdesign Event	106	96

Outside of the immediate benefit area, there are some dwellings which experience a positive flooding effect in each of the events. In the design event, 44 buildings, including 12 residential dwellings and one marae (Takipū Marae) experience a positive flooding effect. However, despite these improvements, all but one of these dwellings still experience a hazard class of H5 in the design event, with the post-upgrade case.

4.2 Roads

In the design event, the proposed post-upgrade case stopbank results in a mixed pattern of changes to flooding for roads across the assessed network (see Figure 4.1 and Figure 4.2). For roads within Te Karaka township (italicised), the post-upgrade case reduces flooding entirely, reducing the hazard to the lowest hazard class, generally from a hazard of H3 or H4. Roads adjacent to, or upstream of, the township and proposed stopbank upgrade generally show an increase in flooding depth, and associated increases in hazard. For Matawai Rd (State Highway 2), there are flood depth increases to the west of the township, largely less than 0.5 m, but increasing immediately to the west of the stopbank. Rangatira Rd, Mangaoae Rd, and Graham Rd are all subject to an increase in flood depth (between + 0.2 m and + 0.39 m on average). These are all subject to median hazard levels from H4 to H6. Other roads, including Matawai Rd (State Highway 2), to the south-east of the township, have a small reduction in flooding depths.

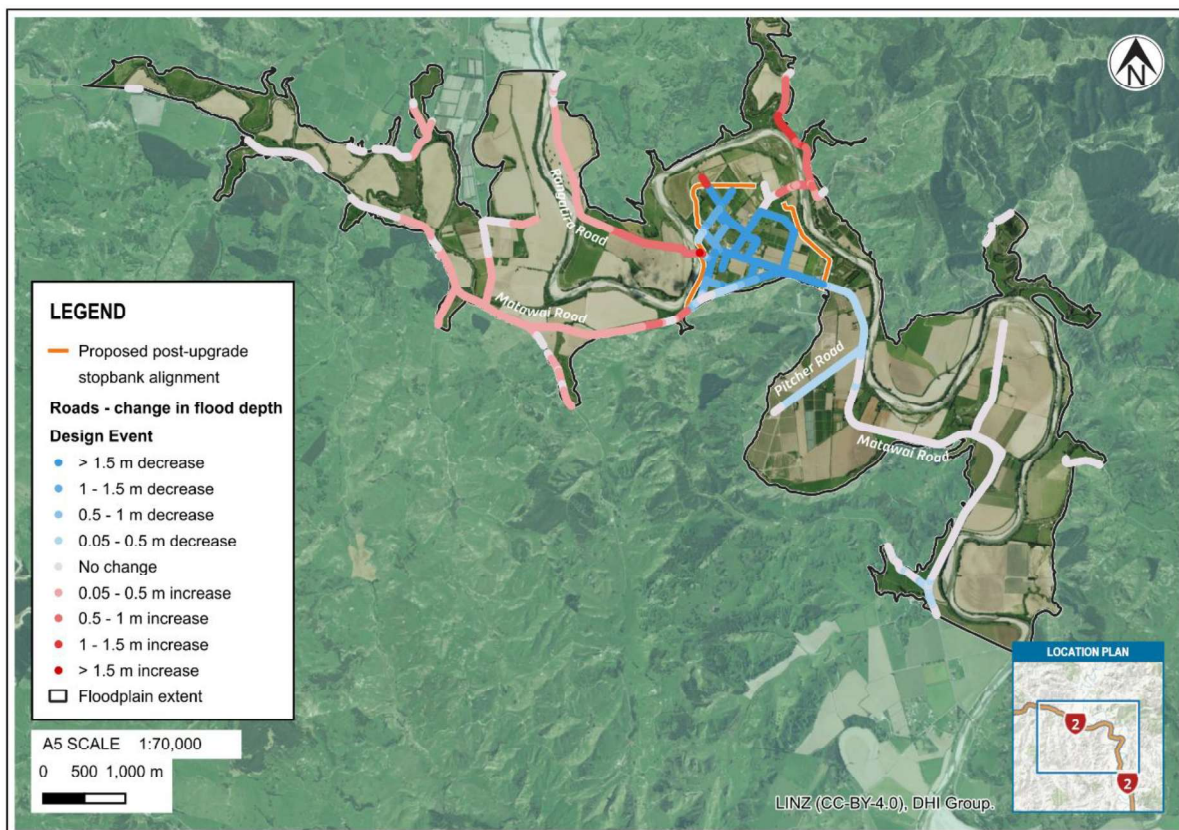


Figure 4.1: Change in flood depth along roads in the design event



Figure 4.2: Change in flood depth along town roads in the design event

Specific quantitative changes across the assessed road network during the design event are detailed below. Table 4.6 outlines the changes in mean flood depths, while Table 4.7 outlines the shifts in median flood hazard classifications. Within these tables, italicised road names indicate locations within Te Karaka township which have reduced flood risk provided by the post-upgrade stopbank, whereas bolded road names denote roads located outside of this primary benefit extent

Table 4.6: Changes in mean flood depth for assessed roads at peak level during the design event

Road name	Mean peak flood depth		
	Pre-upgrade case	Post-upgrade case	Change
<i>Ahirau Road</i>	0.00 m	0.00 m	-
<i>Balfour Road</i>	1.74 m	0.00 m	-1.74 m
<i>Barry Street</i>	1.38 m	0.00 m	-1.38 m
Bridge Road	0.90 m	1.03 m	+0.13 m
<i>Cliff Road</i>	1.09 m	0.00 m	-1.09 m
<i>Currie Street</i>	1.80 m	0.00 m	-1.80 m
Dymock Road	0.83 m	1.09 m	+0.25 m
Graham Road	2.84 m	3.05 m	+0.21 m
<i>Ioapa Road</i>	2.22 m	0.00 m	-2.22 m
Kaitara Road	1.34 m	1.37 m	+0.03 m
Kanakanaia Road	1.94 m	2.07 m	+0.13 m

Road name	Mean peak flood depth		
	Pre-upgrade case	Post-upgrade case	Change
<i>Kipling Road</i>	1.30 m	0.00 m	-1.30 m
<i>Library Road</i>	1.27 m	0.00 m	-1.27 m
<i>Main Road</i>	2.30 m	0.00 m	-2.30 m
Mangaoae Road	1.41 m	1.81 m	+0.39 m
<i>Matawai Road/SH2</i>	1.79 m	1.68 m	-0.10 m
McMillan Road	0.12 m	0.02 m	-0.10 m
<i>Morris Road</i>	1.81 m	0.83 m	-0.97 m
Newman Road	2.57 m	2.53 m	-0.04 m
<i>Paulson Road</i>	3.29 m	0.00 m	-3.29 m
Pitcher Road	1.82 m	1.77 m	-0.05 m
Poynter Road	1.62 m	1.59 m	-0.03 m
Rangatira Road	1.99 m	2.33 m	+0.34 m
<i>Rangitawhio Street</i>	1.89 m	0.00 m	-1.89 m
<i>Station Road</i>	1.74 m	0.00 m	-1.74 m
Whatatutu Road	1.61 m	1.78 m	+0.17 m

Note: Italicised road names are within Te Karaka township and have reduced flood risk in the post-upgrade stopbank case. Bold road names are outside of the township extent. Names that are both bold and italicised have portions inside the township and portions outside. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

Table 4.7: Changes in median flood hazard classification for assessed roads at peak hazard during the design event

Road name	Median flood hazard		
	Pre-upgrade case	Post-upgrade case	Change
<i>Ahirau Road</i>	H1	H1	
<i>Balfour Road</i>	H5	H1	-4 classes
<i>Barry Street</i>	H5	H1	-4 classes
Bridge Road	H1	H1	
<i>Cliff Road</i>	H5	H1	-4 classes
<i>Currie Street</i>	H5	H1	-4 classes
Dymock Road	H3	H3	
Graham Road	H5	H5	
<i>Ioapa Road</i>	H5	H1	-4 classes
Kaitara Road	H4	H4	
<i>Kanakanaia Road</i>	H5	H5	
<i>Kipling Road</i>	H5	H1	-4 classes
<i>Library Road</i>	H4	H1	-3 classes
<i>Main Road</i>	H5	H1	-4 classes
Mangaoae Road	H5	H6	+1 class

Road name	Median flood hazard		
	Pre-upgrade case	Post-upgrade case	Change
<i>Matawai Road/SH2</i>	H5	H5	
McMillan Road	H1	H1	
<i>Morris Road</i>	H5	H1	-4 classes
Newman Road	H5	H5	
<i>Paulson Road</i>	H5	H1	-4 classes
Pitcher Road	H5	H5	
Poynter Road	H5	H5	
Rangatira Road	H5	H5	
<i>Rangitawhio Street</i>	H4	H1	-3 classes
<i>Station Road</i>	H5	H1	-4 classes
Whatatutu Road	H4	H4	

Note: Italicised road names are within Te Karaka township and have reduced flood risk in the post-upgrade stopbank case. Bold road names are outside of the township extent. Names that are both bold and italicised have portions inside the township and portions outside. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

4.3 Bridges

Several bridges within the project scope area have a consequential flooding impact from the proposed stopbank upgrade case. The key bridges with the most extreme impacts are the Rangatira Road and Kanakanaia Road bridges, previously assessed for scour and loading at a preliminary level in an email by T+T dated 7 November 2025, see Section 7. Other bridges on Matawai Rd/SH2 to the west of the township, crossing the Mangamāhaki Stream and the Kurunui Stream, as well as on Whatatutu Road crossing the Waikohu River, all have increased flood levels in the post-upgrade case. Table 4.8 and Table 4.9 below indicate the changes in water levels and velocities.

Table 4.8: Pre- and post-upgrade peak flood levels in each event for key bridges.

Bridge	Design event			Gabrielle Event			Overdesign Event		
	Pre-upgrade water level (m RL)	Post-upgrade water level (m RL)	Change in level (m)	Pre-upgrade water level (m RL)	Post-upgrade water level (m RL)	Change in level (m)	Pre-upgrade water level (m RL)	Post-upgrade water level (m RL)	Change in level (m)
Whatatutu Rd - Waikohu River	46.09	46.38	+0.29	45.47	45.48	+0.01	49.03	49.41	+0.38
Rangatira Rd - Waipaoa River	44.48	45.31	+0.83	44.04	44.11	+0.06	47.19	47.98	+0.78
Matawai Rd – Mangamāhaki Stream	48.49	48.53	+0.04	47.88	47.88	-	51.57	51.67	+0.10
Matawai Rd - Kurunui Stream	50.71	50.71	-	50.04	50.04	-	53.84	53.87	+0.03

Bridge	Design event			Gabrielle Event			Overdesign Event		
	Pre-upgrade water level (m RL)	Post-upgrade water level (m RL)	Change in level (m)	Pre-upgrade water level (m RL)	Post-upgrade water level (m RL)	Change in level (m)	Pre-upgrade water level (m RL)	Post-upgrade water level (m RL)	Change in level (m)
Kanakanaia Rd - Waipaoa River	41.81	42.48	+0.67	40.91	41.21	+0.30	45.81	45.95	+0.15

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

Table 4.9: Pre- and post-upgrade peak flood velocities in each event for key bridges.

Bridge	Design event			Gabrielle Event			Overdesign Event		
	Pre-upgrade velocity (m/s)	Post-upgrade velocity (m/s)	Change in velocity (m/s)	Pre-upgrade velocity (m/s)	Post-upgrade velocity (m/s)	Change in velocity (m/s)	Pre-upgrade velocity (m/s)	Post-upgrade velocity (m/s)	Change in velocity (m/s)
Whatatutu Rd - Waikohu River	2.73	2.73	-	2.52	2.53	+0.01	2.77	2.77	-
Rangatira Rd - Waipaoa River	3.48	3.46	- 0.02	3.43	3.53	+ 0.1	3.68	3.61	- 0.07
Matawai Rd – Mangamāhaki Stream	0.33	0.33	-	0.96	0.96	-	0.41	0.41	-
Matawai Rd - Kurunui Stream	0.25	0.25	-	2.39	2.39	-	0.31	0.31	-
Kanakanaia Rd - Waipaoa River	3.89	3.92	+ 0.03	3.93	3.93	-	3.97	4.03	+0.06

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

5 Specific sites of interest

5.1 Residential dwellings

This section details the specific flood effects for the six residential dwellings identified as experiencing adverse flooding effects during the design event. Where surveyed floor levels are available, the tables below provide specific comparisons against modelled flood levels to indicate whether the habitable floors are overtopped and by what margin.

5.1.1 103 Kanakanaia Road

The proposed stopbank upgrade significantly increases the flood risk for the entire parcel at 103 Kanakanaia Road (Karaka 14 Block, Ref GS3B/988), including its sole dwelling and a garage/shed. The surveyed floor level for the dwelling is 42.53 m RL (NZVD 2016).

Table 5.1: Flood statistics for dwelling at 103 Kanakanaia Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean peak flood level	41.90 m RL	42.60 m RL (+700 mm)
	Mean peak velocity	0.21 m/s	1.29 m/s (+1.08 m/s)
	Maximum hazard class	H1	H5
	Floor overtopped?	No	Yes
	Level difference to surveyed floor level	-0.63 m	0.07 m
Overdesign	Mean flood level	45.84 m RL	45.99 m RL (+150 mm)
	Mean velocity	1.39 m/s	1.88 m/s (+0.49 m/s)
	Maximum hazard class	H6	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	3.31 m	3.46 m
Gabrielle	Mean flood level	N/A	N/A
	Mean velocity	N/A	N/A
	Maximum hazard class	N/A	N/A
	Floor overtopped?	No	No
	Level difference to surveyed floor level	-	-

Note: The dwelling at 103 Kanakanaia Rd is not within the flood extents during a Cyclone Gabrielle-sized event in either case. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The parcel as a whole is subject to an increase in flood hazard in the design event and the dwelling is already located at the most elevated position in the parcel. The possible evacuation route is along Kanakanaia Rd, and elevated, flood-free (in the design event) land is accessed within approximately 200 m from the dwelling.

The dwelling is subject to a peak hazard class of H1 in the design event (pre-upgrade case), meaning that it is generally safe with low depths and velocities. In the post-upgrade case, it is subject to a hazard class of H5, meaning that it is unsafe for vehicles and buildings, and the building itself is vulnerable to structural damage or failure.

5.1.2 108 Kanakanaia Road

The proposed stopbank upgrade increases the flood risk for the parcel at 108 Kanakanaia Road (Karaka 11A1 Block, Ref GS131/3), including the sole dwelling and a small shed. The surveyed floor level of the dwelling is 40.84 m RL (NZVD 2016).

Table 5.2: Flood statistics for dwelling at 108 Kanakanaia Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	41.76 m RL	42.40 m RL (+640 mm)
	Mean velocity	1.43 m/s	1.74 m/s (+0.31 m/s)
	Maximum hazard class	H5	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	0.92 m	1.56 m
Overdesign	Mean flood level	45.80 m RL	45.94 m RL (+140 mm)
	Mean velocity	1.46 m/s	2.16 m/s (+0.70 m/s)
	Maximum hazard class	H6	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	4.96 m	5.10 m
Gabrielle	Mean flood level	40.84 m RL	41.14 m RL (+299 mm)
	Mean velocity	1.38 m/s	1.50 m/s (+0.12 m/s)
	Maximum hazard class	H5	H5
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	0.00 m	0.30 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The south-western corner of the property is not subject to a flood hazard in the design event, and the dwelling is not located in the most elevated location in the parcel. The possible evacuation route is along Kanakanaia Rd, and elevated, flood-free (in the design event) land is accessed within approximately 200 m from the dwelling.

The dwelling is subject to a peak hazard class of H5 in the pre-upgrade case, meaning that it is unsafe for vehicles and people, with the building vulnerable to structural damage. In the post-upgrade case, it is subject to H6, meaning that conditions worsen and the building is considered vulnerable to failure.

5.1.3 23 Mangaoae Road

The proposed stopbank upgrade increases the flood risk for the parcel at 23 Mangaoae Road (Tangutuhanui 1B2A Block, Ref GS2B/1445), including the sole dwelling and numerous small sheds. The surveyed floor level of the dwelling is 40.97 m RL (NZVD 2016).

Table 5.3: Flood statistics for dwelling at 23 Mangaoae Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	41.43 m RL	41.81 m RL (+380 mm)
	Mean velocity	0.26 m/s	0.62 m/s (+0.35 m/s)
	Maximum hazard class	H4	H4
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	0.46 m	0.84 m
Overdesign	Mean flood level	45.62 m RL	45.72 m RL (+100 mm)
	Mean velocity	1.26 m/s	1.47 m/s (+0.21 m/s)
	Maximum hazard class	H6	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	4.65 m	4.75 m
Gabrielle	Mean flood level	40.45 m RL	40.60 m RL (+150 mm)
	Mean velocity	0.05 m/s	0.11 m/s (+0.06 m/s)
	Maximum hazard class	H1	H2
	Floor overtopped?	No	No
	Level difference to surveyed floor level	-0.52 m	-0.37 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The north-eastern side of the property is not subject to a flood hazard in the design event, and the dwelling is not located in the most elevated location in the parcel. The possible evacuation route is along Mangaoae Rd, and elevated, flood-free (in the design event) land is accessed within approximately 30 m from the dwelling. The margin of the floodplain is less than 100 m from the dwelling.

The dwelling is subject to a peak hazard class of H4 in the pre-upgrade case, meaning that it is unsafe for vehicles and people. In the post-upgrade case, it remains at H4 with no change in hazard conditions.

5.1.4 45 Bridge Road

The proposed stopbank upgrade increases the flood risk for the parcel at 45 Bridge Road (Lot 3 DP 7800, Ref GS5B/1319), including the sole dwelling and a shed. The surveyed floor level of the dwelling is 45.82 m RL (NZVD 2016).

Table 5.4: Flood statistics for dwelling at 45 Bridge Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	46.15 m RL	46.41 m RL (+270 mm)
	Mean velocity	0.28 m/s	0.31 m/s (+0.03 m/s)
	Maximum hazard class	H3	H3
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	0.33 m	0.59 m
Overdesign	Mean flood level	49.05 m RL	49.43 m RL (+380 mm)
	Mean velocity	0.84 m/s	0.79 m/s (-0.05 m/s)
	Maximum hazard class	H5	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	3.23 m	3.02 m
Gabrielle	Mean flood level	45.48 m RL	45.48 m RL
	Mean velocity	0.01 m/s	0.01 m/s
	Maximum hazard class	H1	H1
	Floor overtopped?	No	No
	Level difference to surveyed floor level	-0.34 m	-0.34m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The western side of the property is not subject to a flood hazard in the design event, and the dwelling is not located in the most elevated location in the parcel. The possible evacuation route is along Bridge Road, and elevated, flood-free (in the design event) land is accessed within approximately 150 m.

The dwelling is subject to a peak hazard class of H3 in the pre-upgrade case, meaning that it is unsafe for vehicles, children and the elderly. In the post-upgrade case, it remains at H3 with no change in hazard conditions.

5.1.5 46 Bridge Road

The proposed stopbank upgrade increases the flood risk for the parcel at 46 Bridge Road (Lot 1 DP 447441, Ref 564682), including the sole dwelling and a large shed/garage. The surveyed floor level of the dwelling is 45.26 m RL (NZVD 2016).

Table 5.5: Flood statistics for dwelling at 46 Bridge Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	46.07 m RL	46.37 m RL (+300 mm)
	Mean velocity	0.18 m/s	0.20 m/s (+0.02 m/s)
	Maximum hazard class	H3	H4
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	0.81 m	1.11 m
Overdesign	Mean flood level	49.01 m RL	49.40 m RL (+390 mm)
	Mean velocity	0.67 m/s	0.64 m/s (-0.03 m/s)
	Maximum hazard class	H6	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	3.75 m	4.14 m
Gabrielle	Mean flood level	45.44 m RL	45.44 m RL
	Mean velocity	0.08 m/s	0.08 m/s
	Maximum hazard class	H2	H2
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	0.18 m	0.18 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The entire property parcel is subject to a flood hazard in the design event, although the dwelling is not located on the most elevated location in the parcel. The possible evacuation route is along Bridge Road, and elevated, flood-free (in the design event) land is accessed within approximately 150 m.

The dwelling is subject to a peak hazard class of H3 in the pre-upgrade case, meaning that it is unsafe for vehicles, children and the elderly. In the post-upgrade case, it is subject to H4, meaning that conditions worsen and it becomes unsafe for all people.

5.1.6 96 Kanakanaia Road

The proposed stopbank upgrade increases the flood risk for the parcel at 96 Kanakanaia Road (Karaka 12 Block, Ref GS2C/1190), including the sole dwelling, a garage and two small sheds. The surveyed floor level of the dwelling is 42.38 m RL (NZVD 2016).

Table 5.6: Flood statistics for dwelling at 96 Kanakanaia Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	41.86 m RL	42.58 m RL (+720 mm)
	Mean velocity	0.00 m/s	0.08 m/s (+0.08 m/s)
	Maximum hazard class	H1	H3
	Floor overtopped?	No	Yes
	Level difference to surveyed floor level	-0.52	0.20 m
Overdesign	Mean flood level	45.84 m RL	45.99 m RL (+150 mm)
	Mean velocity	0.48 m/s	0.57 m/s (+0.08 m/s)
	Maximum hazard class	H6	H6
	Floor overtopped?	Yes	Yes
	Level difference to surveyed floor level	3.46 m	3.61 m
Gabrielle	Mean flood level	N/A	N/A
	Mean velocity	N/A	N/A
	Maximum hazard class	N/A	N/A
	Floor overtopped?	No	No
	Level difference to surveyed floor level	-	-

Note: The dwelling at 96 Kanakanaia Road is not within the flood extent during a Cyclone Gabrielle-sized event in either the pre-upgrade or post-upgrade case. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The southern corner of the property is not subject to a flood hazard in the design event, and the dwelling is not located in the most elevated location in the parcel. The possible evacuation route is along Kanakanaia Rd, and elevated, flood-free (in the design event) land is accessed within approximately 100 m from the dwelling.

The dwelling is subject to a peak hazard class of H1 in the pre-upgrade case, meaning that it is generally safe for vehicles, people and buildings. In the post-upgrade case, it is subject to H3, meaning that it becomes unsafe for vehicles, children and the elderly.

5.1.7 2416 Matawai Road

The dwelling at 2416 Matawai Road (Lot 2 DP 3735, Ref GS96/4) is subject to an increase in flood hazard in the Gabrielle-sized event as a result of the proposed post-upgrade stopbank. In all events, the dwelling is subject to a reduction in mean flood level, but an increase in flood velocities. In the Gabrielle event, this puts the dwelling from H3 (unsafe for vehicles, children and the elderly), up to H4 (unsafe for all people and vehicles), due to the small (+ 0.43 m/s) increase in peak flood velocity. The floor level of the building has not been surveyed, so depth above the mean ground level has been reported, with ground levels extracted from the LiDAR topography.

Table 5.7: Flood statistics for dwelling at 2416 Matawai Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	40.33 m RL	39.98 m RL (-350 mm)
	Mean velocity	0.87 m/s	1.46 m/s (+0.58 m/s)
	Maximum hazard class	H5	H5
	Depth above mean ground level	1.95 m	1.60 m
Overdesign	Mean flood level	44.20 m RL	44.18 m RL (-20 mm)
	Mean velocity	1.95 m/s	2.09 m/s (+0.14 m/s)
	Maximum hazard class	H6	H6
	Depth above mean ground level	5.82 m	5.80 m
Gabrielle	Mean flood level	39.18 m RL	38.97 m RL (-210 mm)
	Mean velocity	0.65 m/s	1.08 m/s (+0.43 m/s)
	Maximum hazard class	H3	H4
	Depth above mean ground level	0.80 m	0.59 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

In the design event, the hazard does not change, with a class of H5 (unsafe for vehicles and people, all buildings vulnerable to structural damage or failure) in both the pre-upgrade and post-upgrade case.

5.1.8 62 Whatatutu Road

There are two dwellings at 62 Whatatutu Road (Lot 43 DP 1486), which are subject to a high to extreme hazard in both the pre-upgrade case and the post-upgrade case. These dwellings were inundated in Cyclone Gabrielle and were categorised under the Future of Severely Affected Land (FOSAL) framework as Category 3, meaning that the risk of future severe weather events cannot be mitigated, with intolerable risk of injury or death. Both of these dwellings are subject to an increase in flood depth in the post-upgrade case. The floor levels of these buildings have not been surveyed but the depth above mean ground level is reported, with the mean ground level extracted from the LiDAR topography.

The northern dwelling is subject to a hazard class of H4 in the design event in the pre-upgrade case, meaning that there is a risk to all people and vehicles. In the post-upgrade case, the hazard class increases to H5, where there is risk to all people and vehicles, as well as risk to buildings of damage, or, for more vulnerable building types, failure.

Table 5.8: Flood statistics for northern dwelling at 62 Whatatutu Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	46.03 m RL	46.34 m RL (+310 mm)
	Mean velocity	0.28 m/s	0.27 m/s (-0.01 m/s)
	Maximum hazard class	H4	H5
	Depth above mean ground level	1.64 m	1.95 m
Overdesign	Mean flood level	48.97 m RL	49.36 m RL (+390 mm)
	Mean velocity	0.56 m/s	0.55 m/s (-0.01 m/s)
	Maximum hazard class	H6	H6
	Depth above mean ground level	4.58 m	4.97 m
Gabrielle	Mean flood level	45.40 m RL	45.41 m RL (+10 mm)
	Mean velocity	0.23 m/s	0.23 m/s
	Maximum hazard class	H4	H4
	Depth above mean ground level	1.01 m	1.01 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The southern dwelling is subject to a hazard class of H4 in the design event in the pre-upgrade case, meaning that there is a risk to all people and vehicles. In the post-upgrade case, the hazard class increases to H5, where there is risk to all people and vehicles, as well as risk to buildings of damage, or, for more vulnerable building types, failure.

Table 5.9: Flood statistics for southern dwelling at 62 Matawai Road – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	46.03 m RL	46.34 m RL (+310 mm)
	Mean velocity	0.30 m/s	0.28 m/s (-0.02 m/s)
	Maximum hazard class	H4	H5
	Depth above mean ground level	1.78 m	2.08 m
Overdesign	Mean flood level	48.97 m RL	49.36 m RL (+390 mm)
	Mean velocity	0.64 m/s	0.61 m/s (-0.02 m/s)
	Maximum hazard class	H6	H6
	Depth above mean ground level	4.72 m	5.11 m
Gabrielle	Mean flood level	45.40 m RL	45.41 m RL (+10 mm)
	Mean velocity	0.19 m/s	0.18 m/s (-0.01 m/s)
	Maximum hazard class	H4	H4
	Depth above mean ground level	1.14 m	1.15 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

5.2 Community sites

5.2.1 Rangatira Marae (66 Rangatira Road)

The Te Aitanga ā Māhaki (Ngāti Wahia) marae, Rangatira Marae, sits adjacent to the Waipaoa River on the true left, across the river from the proposed stopbank upgrade. The proposed stopbank increases the flood risk for the parcel at 66 Rangatira Road (Rangatira 3 J 1 A 1 Block, Ref 561989), including the wharenuī (Te Whakahau) and the other marae building. The floor level of the marae buildings have not been surveyed. The mean ground level at the wharenuī from LiDAR is 41.00 m RL (NZVD 2016), the maximum ground level is 41.21 m RL.

Table 5.10: Flood statistics for wharenuī at Rangatira Marae – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	43.92 m RL	44.77 m RL (+850 mm)
	Mean velocity	1.00 m/s	1.25 m/s (+0.25 m/s)
	Maximum hazard class	H5	H6
	Depth above mean ground level	2.92 m	3.77 m
Overdesign	Mean flood level	46.66 m RL	47.28 m RL (+620 mm)
	Mean velocity	1.72 m/s	2.18 m/s (+0.46 m/s)
	Maximum hazard class	H6	H6
	Depth above mean ground level	5.66 m	6.28 m
Gabrielle	Mean flood level	43.53 m RL	43.55 m RL (+20 mm)
	Mean velocity	0.80 m/s	0.84 m/s (+0.04 m/s)
	Maximum hazard class	H5	H5
	Depth above mean ground level	2.53 m	2.55 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

There are bunds which surround the marae. However, these are modelled to be overtopped in any of the above events. We understand that Rangatira Marae is in the process of relocation to a new, protected site through the FOSAL Whenua Māori process, managed between the hapū and Department of Prime Minister and Cabinet (DPMC).

The marae is subject to a peak hazard class of H5 in the pre-upgrade case, meaning that it is unsafe for vehicles and people, with the building vulnerable to structural damage. In the post-upgrade case, it is subject to H6, meaning that conditions worsen and the building is considered vulnerable to failure.

5.2.2 Takipū Marae (2343 Matawai Road)

The Te Aitanga ā Māhaki (Te Whānau a Taupara) marae, Takipū Marae, sits on Matawai Rd/State Highway 2 to the southeast of Te Karaka township on the true right of the Waipaoa River, downstream of the township. The proposed stopbank upgrade slightly reduces the flood risk for the parcel at 2343 Matawai Rd (Ruangarehu K Block, Ref 364073) including to the whareniui (Te Poho o Pikihero) and the other marae buildings, in the design event and an event equivalent to Cyclone Gabrielle. However, the proposed stopbank upgrade slightly increases the flood risk in the overdesign event. The floor level of the building has not been surveyed; however, the mean ground levels around the whareniui, from the LiDAR survey, are approximately 36.66 m RL (NZVD 2016).

Table 5.11: Flood statistics for whareniui at Takipū Marae – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	38.54 m RL	38.42 m RL (-120 mm)
	Mean velocity	1.26 m/s	1.15 m/s (-0.11 m/s)
	Maximum hazard class	H5	H5
	Depth above mean ground level	1.91 m	1.78 m
Overdesign	Mean flood level	41.98 m RL	42.00 m RL (+20 mm)
	Mean velocity	2.41 m/s	2.41 m/s
	Maximum hazard class	H6	H6
	Depth above mean ground level	5.34 m	5.36 m
Gabrielle	Mean flood level	37.56 m RL	37.42 m RL (-140 mm)
	Mean velocity	0.77 m/s	0.69 m/s (-0.08 m/s)
	Maximum hazard class	H4	H3
	Depth above mean ground level	0.93 m	0.79 m

Note: Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

We understand that Takipū Marae is in the process of relocation to a new, protected site through the FOSAL Whenua Māori process, managed between the hapū and Department of Prime Minister and Cabinet (DPMC).

The marae is subject to a peak hazard class of H5 in the pre-upgrade case, meaning that it is unsafe for vehicles and people, with the building vulnerable to structural damage. In the post-upgrade case, it is subject to H6, meaning that conditions worsen and the building is considered vulnerable to failure.

5.2.3 Te Karaka Area School (Main Road)

Te Karaka Area School is located within the primary Te Karaka township benefit area. In the post-upgrade scenario, the school has reduced flood risk from inundation during both the design event and Cyclone Gabrielle flows, resulting in a reduction to an H1 hazard classification. During the overdesign event, the school remains subject to flooding, though flood depths and velocities are slightly reduced. Table 5.12 below shows the key metrics in each of the events, in the pre- and post-upgrade cases for the main school building block.

Table 5.12: Flood statistics for main school block at Te Karaka Area School – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	41.97 m RL	-
	Mean velocity	0.63 m/s	-
	Maximum hazard class	H5	H1
	Depth above mean ground level	1.77 m	-
Overdesign	Mean flood level	46.11 m RL	46.09 m RL (-24 mm)
	Mean velocity	1.18 m/s	0.87 m/s (-0.31 m/s)
	hazard class	H6	H6
	Depth above mean ground level	5.91 m	5.88 m
Gabrielle	Mean flood level	40.80 m RL	-
	Mean velocity	0.52 m/s	-
	Maximum hazard class	H3	H1
	Depth above mean ground level	0.60 m	-

Note: Hyphens (-) denote that the site is no longer inundated in the post-upgrade scenario for that specific modelled event. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The school is subject to a peak hazard class of H5 in the pre-upgrade case, meaning that it is unsafe for vehicles and people, with the building vulnerable to structural damage. In the post-upgrade case, it is subject to H1, meaning that conditions improve significantly and it becomes generally safe.

5.3 Other sites

5.3.1 Puha Substation (Bridge Road)

The Firstlight Network Puha Substation on Bridge Rd/Whatatutu Rd (servicing Waikohu/Puha) sits at the margins of the Waipaoa River floodplain on a slightly elevated terrace between the Waikohu River and Waipaoa River. The proposed stopbank upgrade slightly increases the flood risk to the substation (Lot 1 DP 4694, Ref GS117/81), in the overdesign event. In all other events, or in the pre-upgrade case, the flood extents do not reach the substation, however, in the post-upgrade case in the overdesign event, the substation experiences shallow, low velocity inundation.

Table 5.13: Flood statistics for Puha Substation (Bridge Road) – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	-	-
	Mean velocity	-	-
	Maximum hazard class	H1	H1
	Depth above mean ground level	-	-
Overdesign	Mean flood level	-	49.49 m RL
	Mean velocity	-	0.03 m/s
	Maximum hazard class	H1	H3
	Depth above mean ground level	-	0.09 m
Gabrielle	Mean flood level	-	-
	Mean velocity	-	-
	Maximum hazard class	H1	H1
	Depth above mean ground level	-	-

Note: Hyphens (-) denote that the site is not inundated during the specified modelled scenario. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The substation site is subject to a peak hazard class of H1 in both the pre-upgrade and post-upgrade cases, meaning that it remains generally safe for vehicles, people and buildings.

5.3.2 Te Karaka Wastewater Treatment Ponds (Matawai Road)

The Gisborne District Council Wastewater Treatment Ponds lies on Matawai Rd, servicing the Te Karaka community. It is located within the proposed stopbanks 'benefit area', but within the current Waipaoa River floodplain. The post-upgrade scenario provides complete flood risk reduction to the plant during both the design event and Cyclone Gabrielle flows, reducing the hazard classification to H1. However, during the overdesign event, the site remains subject to significant flooding with a slight increase in peak flood levels.

Table 5.14: Flood statistics for Te Karaka Wastewater Treatment Ponds (Matawai Road) – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	41.29 m RL	-
	Mean velocity	1.46 m/s	-
	Maximum hazard class	H6	H1
	Depth above mean ground level	2.81 m	-

Event	Metric	Pre-upgrade case	Post-upgrade case
Overdesign	Mean flood level	45.38 m RL	45.53 m RL (+0.15 m)
	Mean velocity	2.18 m/s	2.15 m/s (-0.04 m/s)
	Maximum hazard class	H6	H6
	Depth above mean ground level	6.89 m	7.04 m
Gabrielle	Mean flood level	40.24 m RL	-
	Mean velocity	0.90 m/s	-
	Maximum hazard class	H5	H1
	Depth above mean ground level	1.75 m	-

Note: Hyphens (-) denote that the site is not inundated during the specified modelled scenario. Totals and differences are calculated using unrounded values and then rounded for presentation. Therefore, they may not equal the sum or difference of the rounded values shown.

The treatment pond is subject to a peak hazard class of H6 in the pre-upgrade case, meaning that it is unsafe for vehicles and people, and the building is vulnerable to failure. In the post-upgrade case, it is subject to H1, meaning that conditions improve significantly and it becomes generally safe.

5.3.3 Contractors' Sheds (48 Whatatutu Road)

The contractors' sheds at 48 Whatatutu Road (two parcels, Refs 40234 and GS1C/400) experience an increase in flood depths in the post -upgrade case in all three events. The main building (LINZ Building ID 4652144) is detailed in Table 5.12 below. Floor levels are surveyed for these sheds at 44.72 m RL NZVD.

Table 5.15: Flood statistics for Contractors' Sheds (48 Whatatutu Road) – Pre-upgrade case and post-upgrade case

Event	Metric	Pre-upgrade case	Post-upgrade case
Design	Mean flood level	46.04 m RL	46.35 m RL (+310 mm)
	Mean velocity	0.10 m/s	0.14 m/s (+0.04 m/s)
	Maximum hazard class	H4	H4
	Level difference to surveyed floor level	1.32 m	1.63 m
Overdesign	Mean flood level	48.99 m RL	49.38 m RL (+ 390 mm)
	Mean velocity	0.63 m/s	0.63 m/s
	Maximum hazard class	H6	H6
	Level difference to surveyed floor level	4.27 m	4.66 m
Gabrielle	Mean flood level	45.40 m RL	45.41 m RL (+ 10 mm)
	Mean velocity	0.03 m/s	0.03 m/s
	Maximum hazard class	H3	H3
	Level difference to surveyed floor level	0.68 m	0.69 m

The sheds are subject to a peak hazard class of H4 in the pre-upgrade case, meaning that they are unsafe for vehicles and people. In the post-upgrade case, they remain at H4 with no change in hazard conditions.

6 Effects of alternate alignment

A small section of the proposed post-upgrade stopbank was subsequently assessed with an alternate alignment, due to uncertainty regarding land acquisition processes for whenua Māori adjacent to Kanakanaia Road. The alternate alignment (see **Error! Reference source not found.**) is through 69 Kanakanaia Road, adjoining with a section of road raising along Kanakanaia Road from numbers 69 to 81. As well as modelling the alternate alignment, DHI modelled an alternate soil borrow site at 44 Morris Road. This alternate alignment and borrow pit location has only been assessed for effects on flood risk in the design event, and not in smaller or larger events. Comparisons have been made against the results from the originally proposed stopbank alignment, in order to assess whether this potential change may change the results of the assessment.

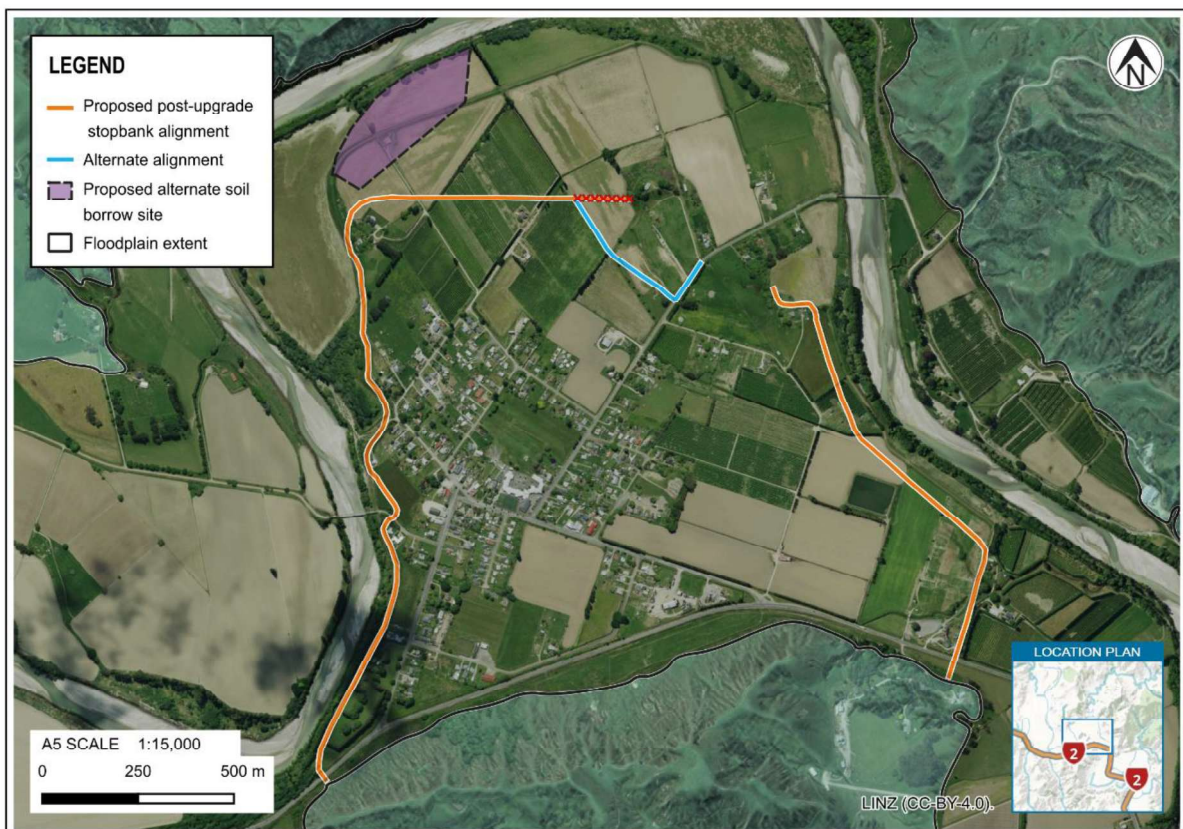


Figure 6.1: General layout of alternate alignment at Kanakanaia Road.

The alternate alignment has a small, but localised impact on flood levels in the design event, as compared to the previously discussed post-upgrade stopbank alignment. Part of the parcel at 69 Kanakanaia Road, as well as part of Karaka 17 Block (Kanakanaia Road) and a small part of 81/81a Kanakanaia Road would now flood, as they are no longer behind the stopbank.

Other than the immediate area noted above, flood depths increase over a swath of floodplain upstream, and immediately adjacent to, the alternate alignment (see Figure 6.2), of up to ~0.25 m in isolated areas at 44 Morris Road. This is due to the alternate soil borrow site incorporated in the model, at 44 Morris Road, rather than a remote hydraulic impact from the alternate alignment.

The model results from DHI show a very minor reduction in flood depths upstream of Morris Road, to near the model boundary. The results also show a very minor increase in flood depths beginning 6.5 km downstream of the change in alignment. These minor changes (less than 0.01 m) are interpreted as insignificant and likely to be a product of the modelling tolerances, or the alternate soil borrow site, rather than a direct hydraulic impact from the alternative alignment.

No residential dwellings or bridges have any change in flood level (within 0.01 m) in comparison to the originally proposed alignment and borrow site. There is one building at 44 Morris Road which has a 0.129 m increase in peak flood depth and a 0.158 m/s increase in peak flood velocity, which appears to be a farm shed. This is due to the alternate borrow site at 44 Morris Road. The hazard at this shed is H6 (most extreme) regardless of the alignment. No other buildings have a significant change in flood depth or flood velocities.

The section of Morris Road outside of the stopbank is subject to a mean increase in flood depth of 0.116 m in the alternate alignment case, as compared to the proposed upgrade. This is due to the alternate borrow site at 44 Morris Road.

A number of land parcels are subject to an increase in flood levels, all either in the newly flooded area or immediately adjacent to the stopbank, as far upstream as Morris Road, on the true right of the river. No land parcels are subject to an increase in hazard class. Further map figures indicating the change in depth, velocity, and hazard (comparing the alternate option in the design event to the originally proposed option) are in Appendix G.

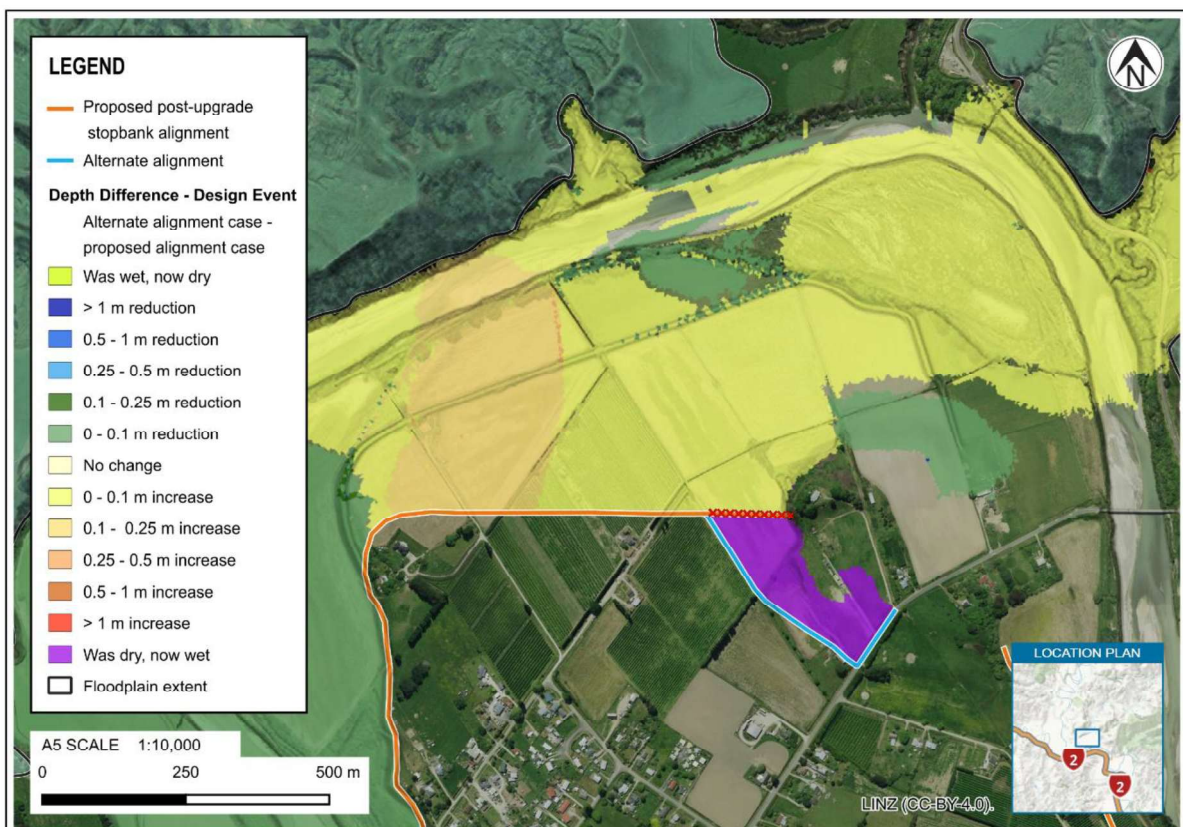


Figure 6.2: Depth differences in the design event, comparing the alternate alignment (post-upgrade) to the proposed alignment (post-upgrade).

7 Summary of previous work on bridge scour and loading at Te Karaka

T+T previously undertook a preliminary, high-level assessment of the scour depth and structural loads acting on the Rangatira Road and Kanakanaia Road bridges. This assessment evaluated the degree of load increase imposed by the 5,625 m³/s design flow when comparing the pre-upgrade scenario to the post-upgrade (proposed stopbank) scenario.

7.1 Rangatira Rd Bridge

Under the design flow, the proposed stopbank upgrade is estimated to significantly increase structural loads on the Rangatira Bridge. This includes up to a 101% increase in bending moment loads on the superstructure, up to a 44% increase in lateral loads, up to a 40% increase in vertical uplift loads, and up to a 50% increase in pier bending moment loads. Scour depth is estimated to increase by up to 0.7 m (representing approximately 10% of the overall scour depth). Fortunately, the bridge piles are keyed into underlying bedrock, which provides significant vertical stability and prevents the piles from being undermined. While a preliminary check indicates the piers can sustain the flexural loads under the post-upgrade design flow, a full structural assessment of all load paths is required to confirm overall capacity.

7.2 Kanakanaia Rd Bridge

For the Kanakanaia Bridge, the proposed stopbank upgrade is estimated to increase bending moment loads on the superstructure by up to 79%, with lateral and vertical uplift loads increasing by up to 29%, and pier bending moment loads increasing by up to 32%. Scour depth is estimated to increase by up to 0.8 m (approximately 10% of the overall scour depth). Unlike the Rangatira Bridge, these piles are not founded on rock but extend up to 20 m into underlying materials. Crucially, preliminary observations indicate that the 5,625 m³/s design flood event would significantly exceed the flexural strength of the existing piers even under the current stopbank scenario. A full structural assessment of all load paths is required to confirm overall capacity.

7.3 Limitations and Recommendations

This preliminary assessment was subject to several limitations. Only a single flow case (the 5,625 m³/s design event) was assessed, and structural checks were limited to the flexural capacity of the pier at the top of the cap beam (shear strength was not checked). Debris raft forces, pressure (compression) scour, and abutment scour have not yet been calculated. It is also unknown whether hydraulic loads or seismic actions governed the original bridge designs. Furthermore, historical aggradation has been observed at both sites (estimated at 2.0–2.5 m at Rangatira Bridge and 0.5–1.0 m at Kanakanaia Bridge), which likely influences flood levels.

To fully understand the actual risk to these critical infrastructure sites, the preliminary assessment recommended several next steps, including:

- Completing a full structural capacity assessment of the bridges to resist the modelled loads.
- Assessing abutment and pressure scour, specifically incorporating debris blockage scenarios.
- Confirming the Importance Level of the structures with the Journeys team to determine the appropriate Serviceability Limit State (SLS) event.
- Carrying out additional hydraulic model runs for the SLS event (with and without blockage) to inform risk consideration.
- Confirming original bridge design assumptions and levels of service.
- Integrating the results of aggradation analyses by T+T to understand historical and future risk profiles.

8 Limitations and Assumptions made in this assessment

8.1 Hydrology

The flows used in the flood model runs (by DHI Group) were provided to DHI Group⁶ and to T+T by GDC, as were the Annual Exceedance Probabilities (AEP) associated with these flows, which are approximate only. T+T has not reviewed these values (either peak flow rates, or AEP) and cannot comment on the adoption of these values for the flood modelling, nor the use of these values for the purposes of this assessment.

8.2 Sampling of values

For the purposes of this assessment, values relating to vector features (e.g., building polygons, points along road centrelines, bridge centrelines, land parcels, etc.) are calculated by sampling the flood model outputs (whether depth, level, hazard, velocity, etc.) underneath the full extent of each vector feature. For example, the “mean flood level” quoted for a building polygon is the area-weighted average of all cells in the flood level results raster covered by that building polygon. Unless otherwise indicated, the following statistics were used for each type of output:

- Velocity: maximum
- Hazard: maximum
- Level: mean
- Depth: mean

8.3 Data sources

A number of data sources were used to source information about building footprints, roads, bridges, and land parcels. Each of these data sources has its own limitations and uncertainties which are carried through to this assessment. Table 8.1 covers the datasets used in this assessment, and the potential limitations with each of these datasets.

Table 8.1: Datasets used in this assessment

Layer	Sources and licenses	Limitations
Roads	Open Street Map (OSM) – <i>Open Data Commons Database License</i> – ‘Way’ layer. Verified against LINZ Road Centrelines, Google Maps.	• Community-sourced data. • Inspection showed closer alignment of centrelines when compared to LINZ layer. • Lines may not match with road crest and values may not represent actual flood depths for vehicles travelling along road.
Bridges	LINZ Bridge Centrelines (Topo 1:50k) – <i>CC-BY-4.0</i> .	• Based on LINZ Topographic Map series. Bridge locations closely matched those in the aerial imagery. • May not represent local detail. • We have not reviewed the model to identify if all of these bridges are represented. • Local hydraulic effects may lead to higher local flood levels at bridges.

⁶ Waipaoa River (Te Karaka Resilience Project) Model Build Report. DHI Group Ltd. In draft.

Layer	Sources and licenses	Limitations
Buildings	LINZ Building Outlines – CC-BY-4.0.	- Based on earlier aerial imagery and automatic feature extraction algorithms. - Does not necessarily represent exact building footprints, as are on the ground today. - Building usages (residential, non-residential, etc.) were classified manually using aerial imagery and online street view data and have been QA-checked but have not been ground-truthed. - Buildings may cause local hydraulic effects which would change the flood levels/velocities which they experience.
Land parcels	Gisborne District Council <i>Tairāwhiti Maps</i> – Valuation Assessments	Flood levels, depths, and velocities may vary significantly across a parcel, and so the quoted values for different parcels in Appendix E do not represent the range of values across each parcel.
Flood model result rasters	DHI Group Ltd.	- T+T has not reviewed any of the flood model results for accuracy. - Supplied hazard rasters include areas with no depth as “H1” – the lowest hazard class. These values have not been excluded in this assessment.

9 Conclusions

GDC has engaged T+T to assess the flood effects for the proposed upgraded Te Karaka stopbank. The stopbank design currently provides flood risk reduction for the design 5,625 m³/s flow with 600 mm of freeboard.

A flood effects assessment has been undertaken using the flood modelling results from the DHI Group Ltd.'s Waipaoa River hydraulic model, for scenarios both with and without the proposed stopbank, to evaluate changes in flood depth, velocity and hazard across the surrounding area in the design flow scenario, the Cyclone Gabrielle flow scenario, and the over-design flow scenario. The results indicate that the flood effects increase adjacent to the stopbank and around the bend of the Waipaoa River at Te Karaka as a result of the proposed stopbank, for most of the modelled events. Flood effects are generally increased to a minor extent upstream of this and generally reduced downstream of Te Karaka. The new stopbank reduces the effective floodplain storage for the design event across the floodplain at the township and contains the flows within a narrower overall corridor. Overall, there is a significant reduction in the number of buildings and residential dwellings flooded as a result of the proposed stopbank in the design event, with nearly all of these benefitted dwellings being in the township of Te Karaka. Outside of this, effects are mixed, with some dwellings and other community sites having worsened flooding effects in the design event.

The effects of an alternate alignment at Kanakanaia Road only subtly differ from the proposed alignment, with a small area newly flooded and only minor impacts elsewhere, with no residential buildings or bridges negatively impacted.

10 Applicability

This report has been prepared for the exclusive use of our client Gisborne 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.

We understand and agree that our client will submit this report as part of an application for resource consent and that Gisborne District Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Report prepared by:



.....

Matt Adams
Water Resources Consultant

Authorised for Tonkin & Taylor Ltd by:



.....

Damian Velluppillai
Senior Water Resources Engineer

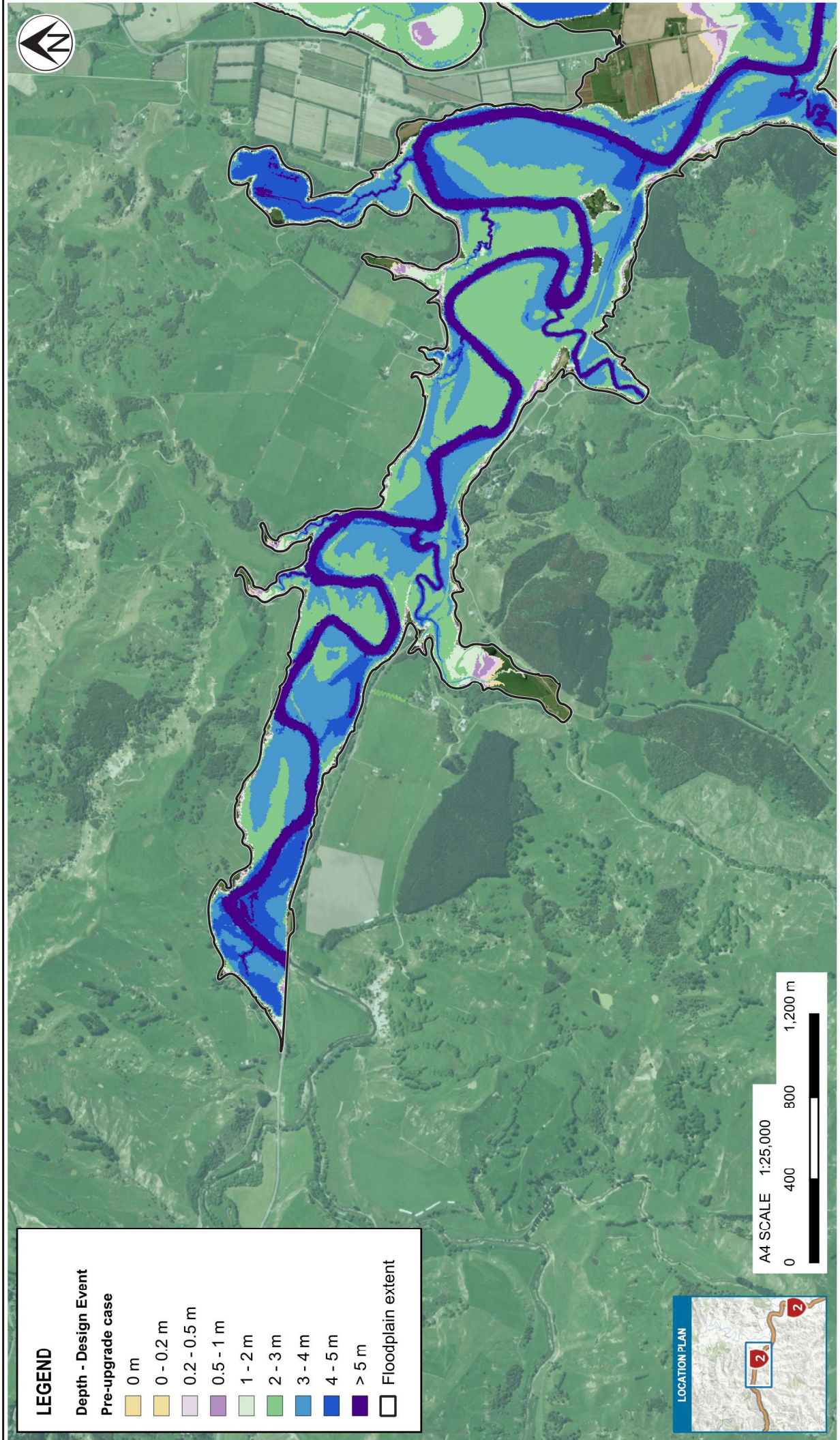
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Appendix A Depth maps

- **Figure 1 – Depth – Design Event – Pre-upgrade case – Rev 0.**

COPYRIGHT ON THIS FIGURE IS RESERVED. DO NOT SCALE FROM THIS FIGURE. T:\Wellington\IT Projects\1092556\1092556_0020 Te Karaka optioneering\WorkingMaterial\05 Consequential Flood Risk Assessment\GIS\MapDocuments\1\Karaka_ConsequentialFloodRiskAssessmentfigs Layout_1_Depth - Design Event - Pre-upgrade case Drawn by MAAO



LEGEND

Depth - Design Event

Pre-upgrade case

0 m

0 - 0.2 m

0.2 - 0.5 m

0.5 - 1 m

1 - 2 m

2 - 3 m

3 - 4 m

4 - 5 m

> 5 m

Floodplain extent





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NOTES:
Aerial Imagery: Gisborne 0.1m Rural
Aerial Photos (LINZ - CC-BY 4.0)
Model Result Files: Provided by DHI
Group.

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PROJECT TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT

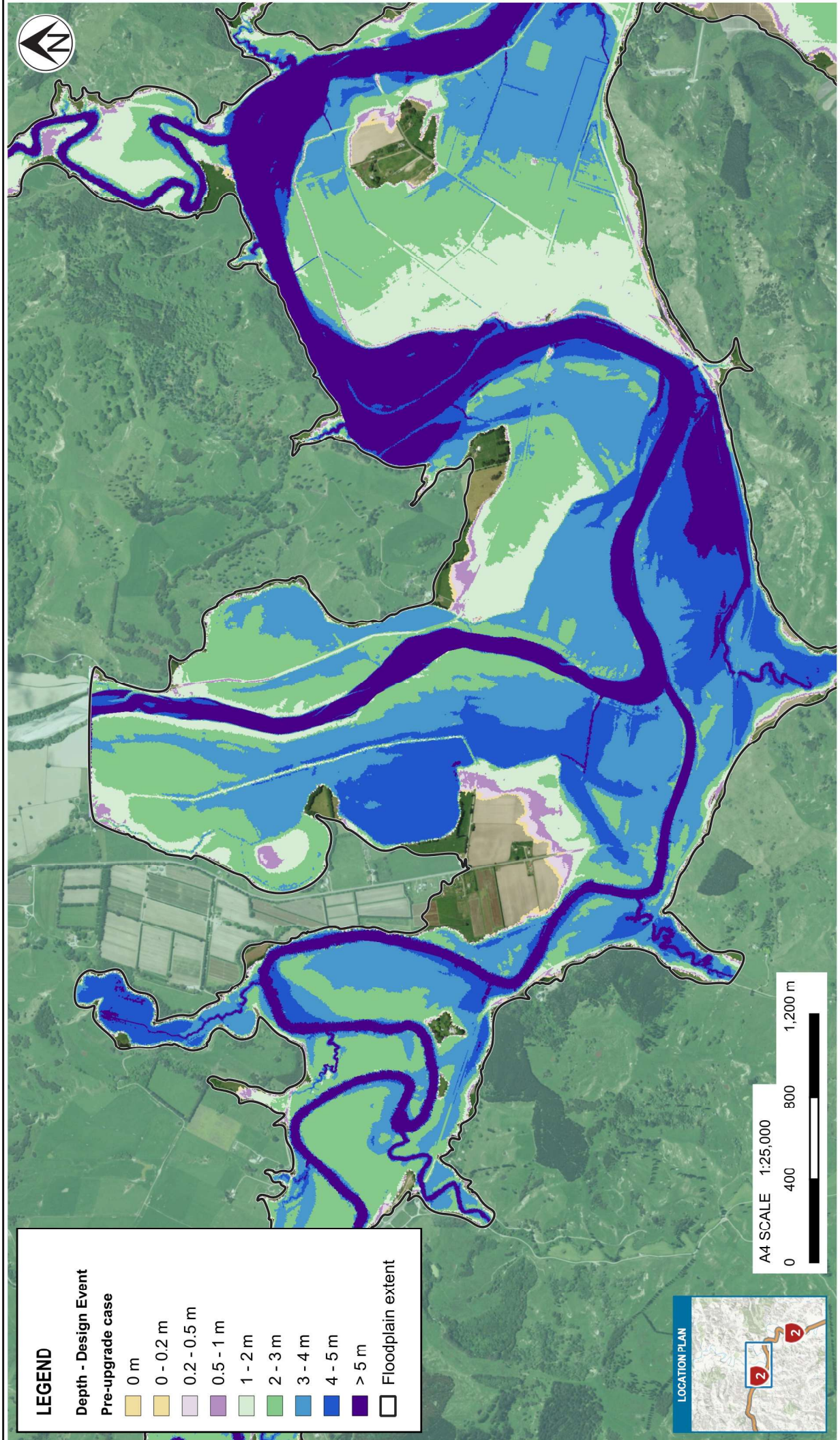
TITLE DEPTH - DESIGN EVENT - PRE-UPGRADE CASE

SCALE (A4) 1:25,000

FIG No. FIGURE 1.1

REV 0

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LEGEND

Depth - Design Event

Pre-upgrade case

0 m

0 - 0.2 m

0.2 - 0.5 m

0.5 - 1 m

1 - 2 m

2 - 3 m

3 - 4 m

4 - 5 m

> 5 m

Floodplain extent

A4 SCALE 1:25,000

0 400 800 1,200 m

LOCATION PLAN

NOTES:
Aerial Imagery: Gisborne 0.1m Rural
Aerial Photos (LINZ - CC-BY 4.0)
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TITLE **DEPTH - DESIGN EVENT - PRE-UPGRADE CASE**

SCALE (A4) **1:25,000**

FIG No. **FIGURE 1.2**

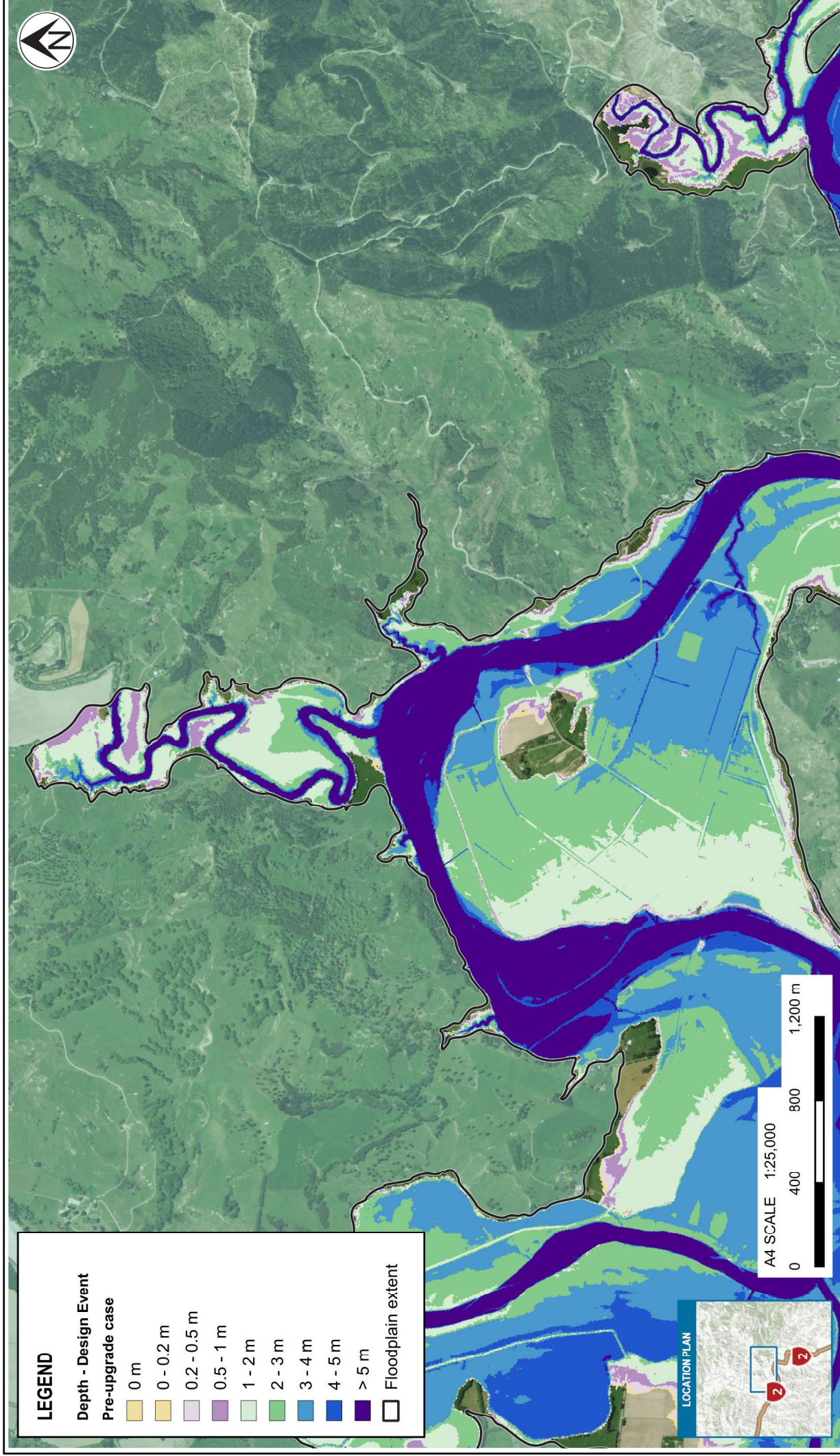
REV **0**



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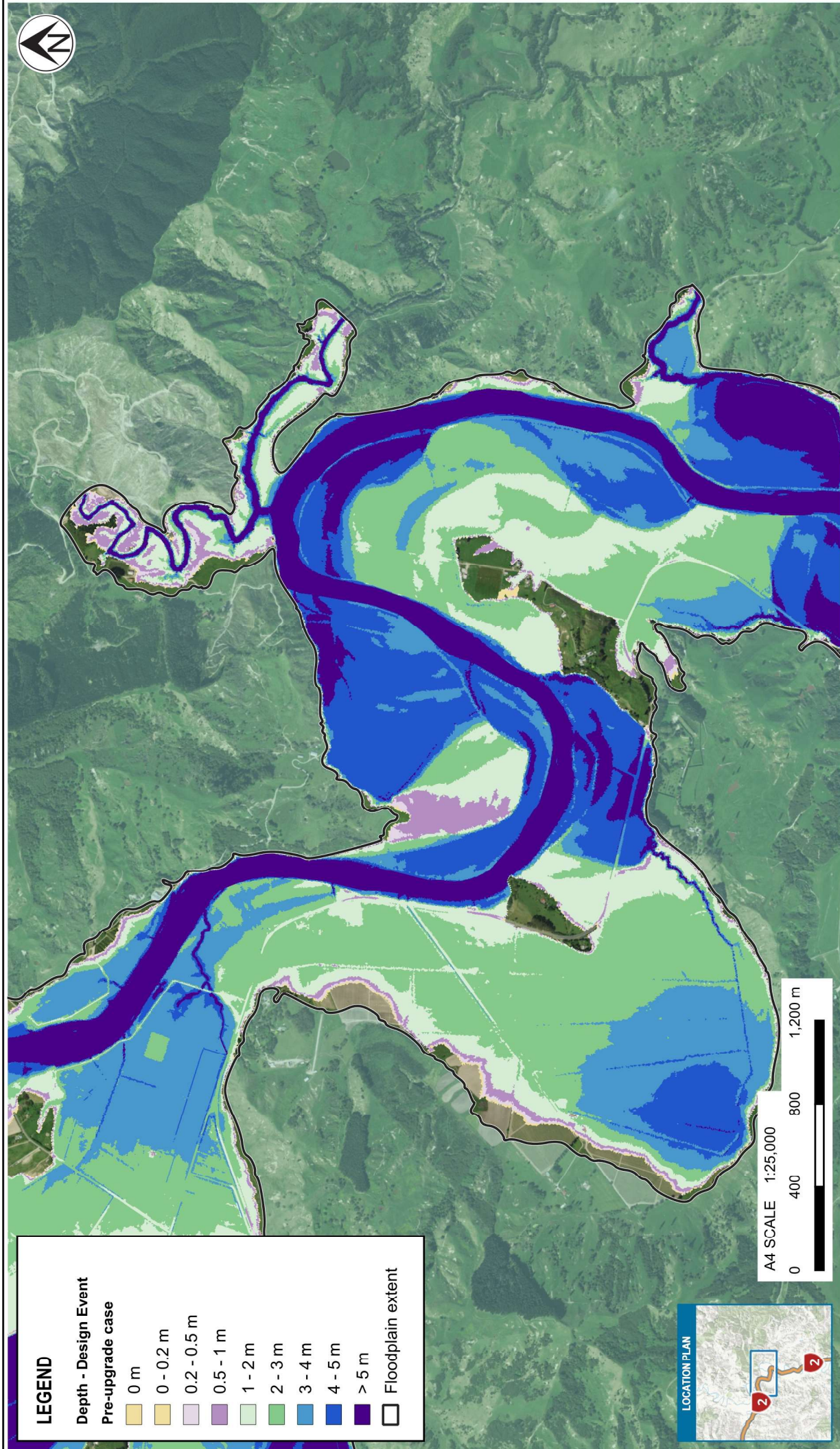
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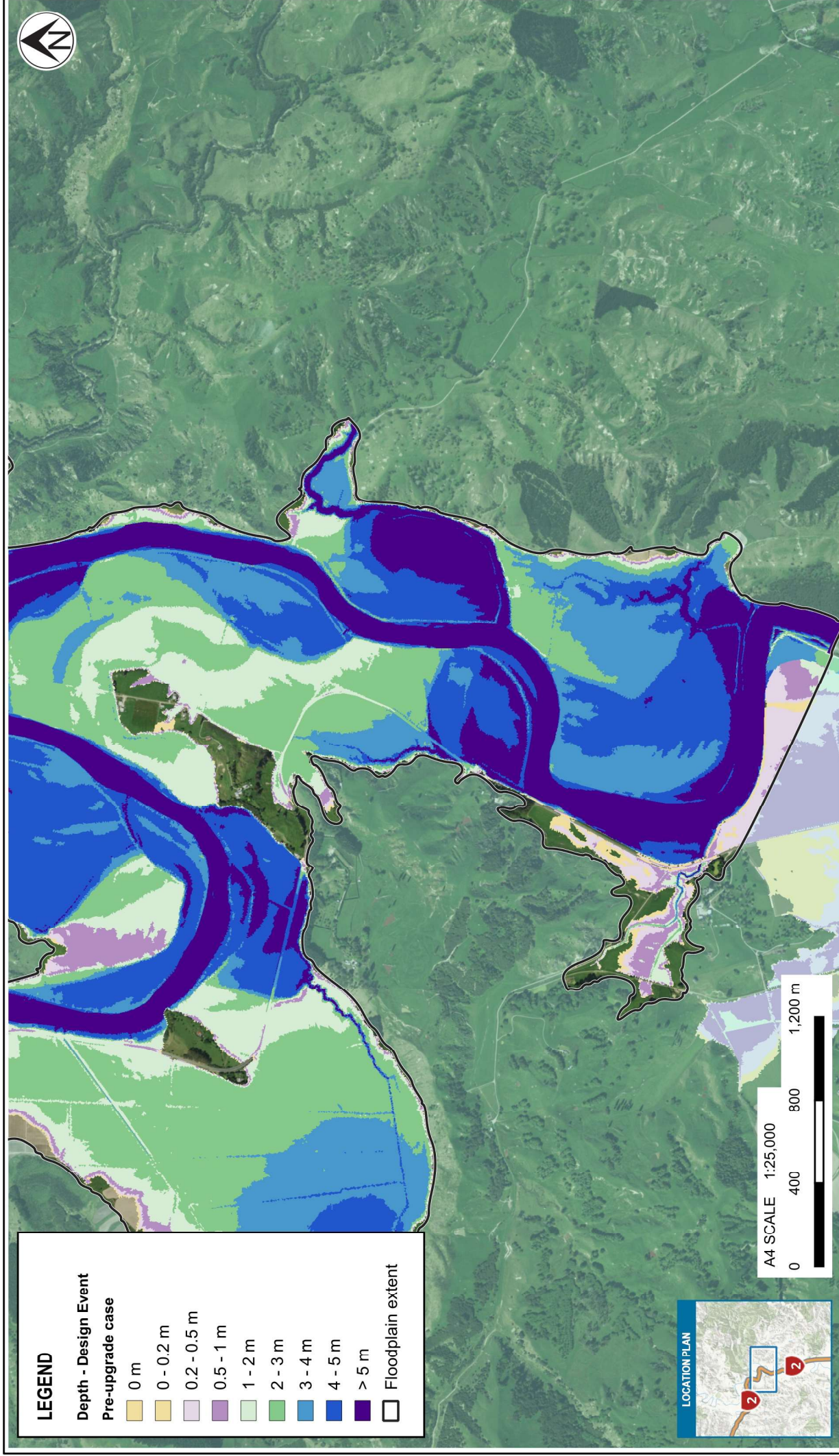
PROJECT TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT

TITLE DEPTH - DESIGN EVENT - PRE-UPGRADE CASE

SCALE (A4) 1:25,000

FIG No. FIGURE 1.4

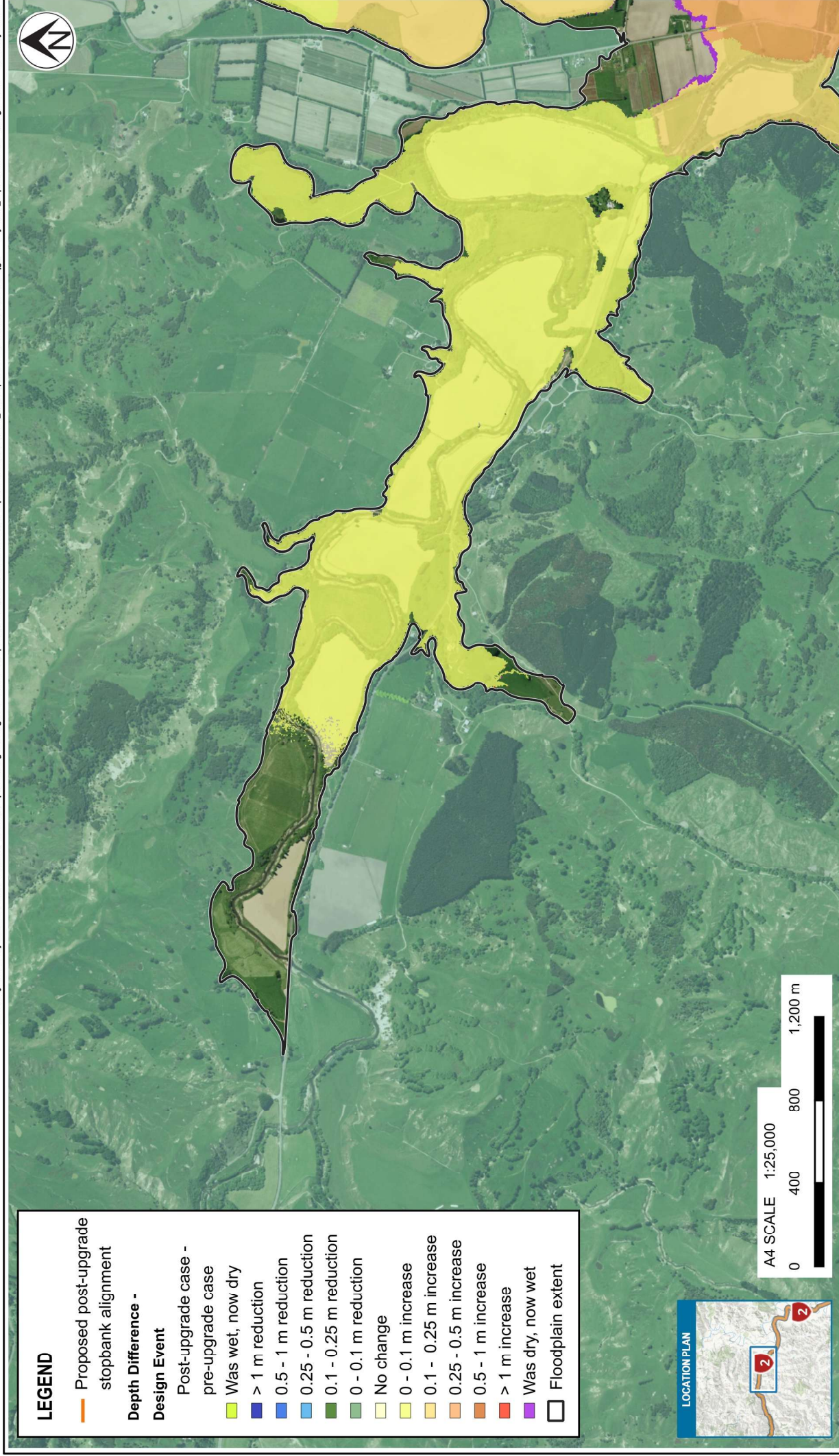
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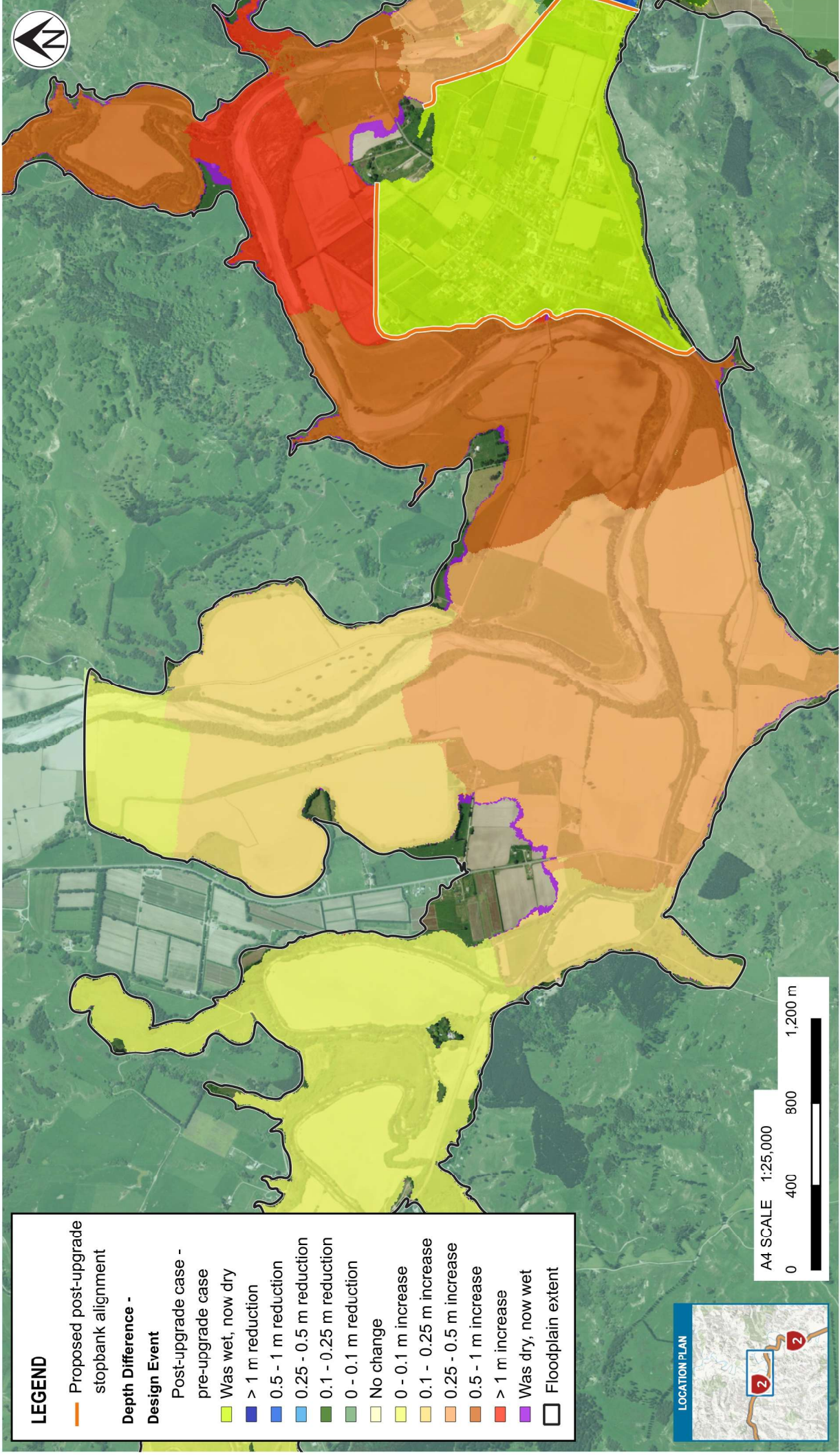
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Appendix B Peak flood depth difference maps

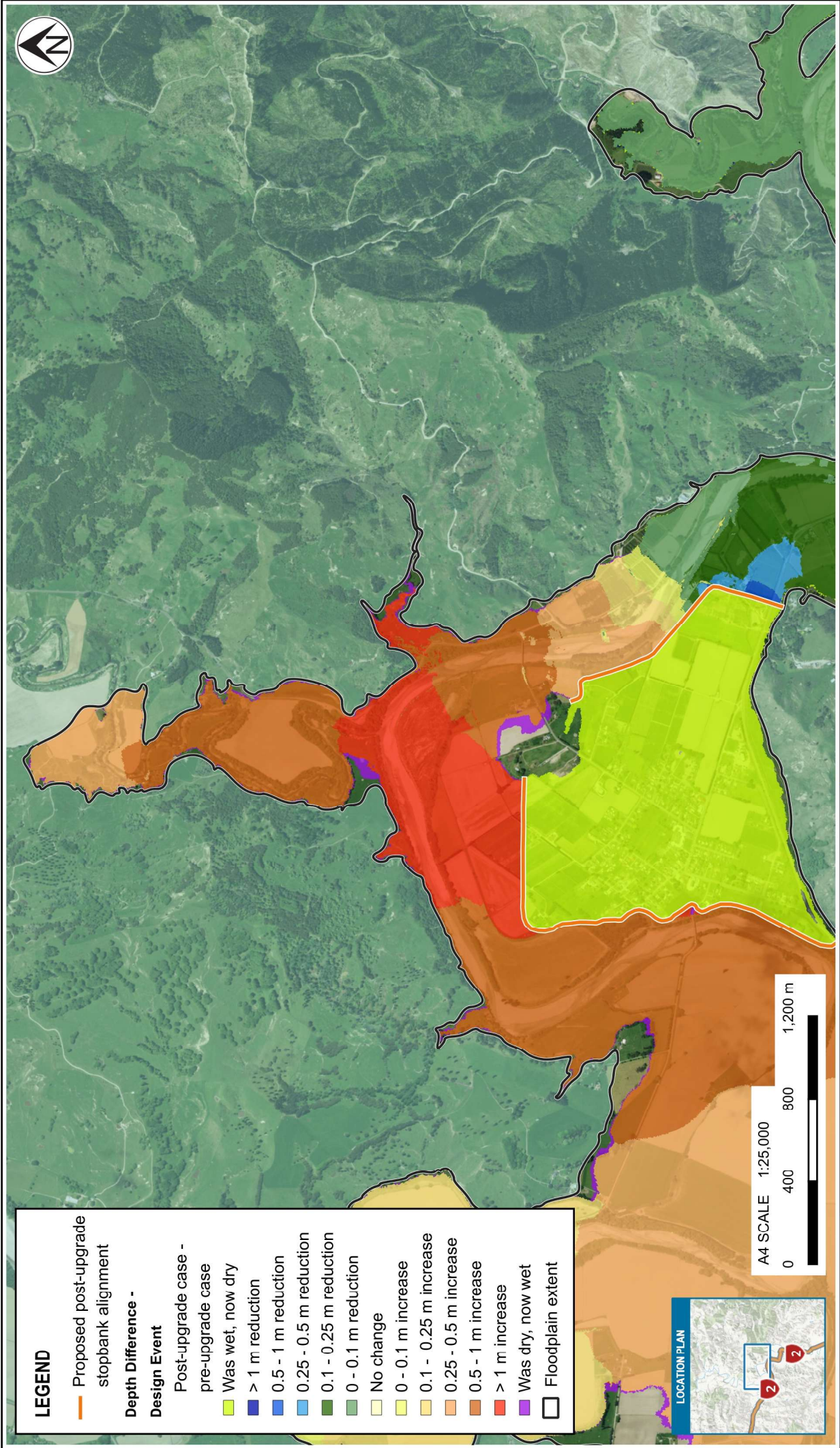
- **Figure 2 – Depth Difference – Design Event – Rev 0.**
- **Figure 3 – Depth Difference – Gabrielle Event – Rev 0.**
- **Figure 4 – Depth Difference – Over-design Event – Rev 0.**



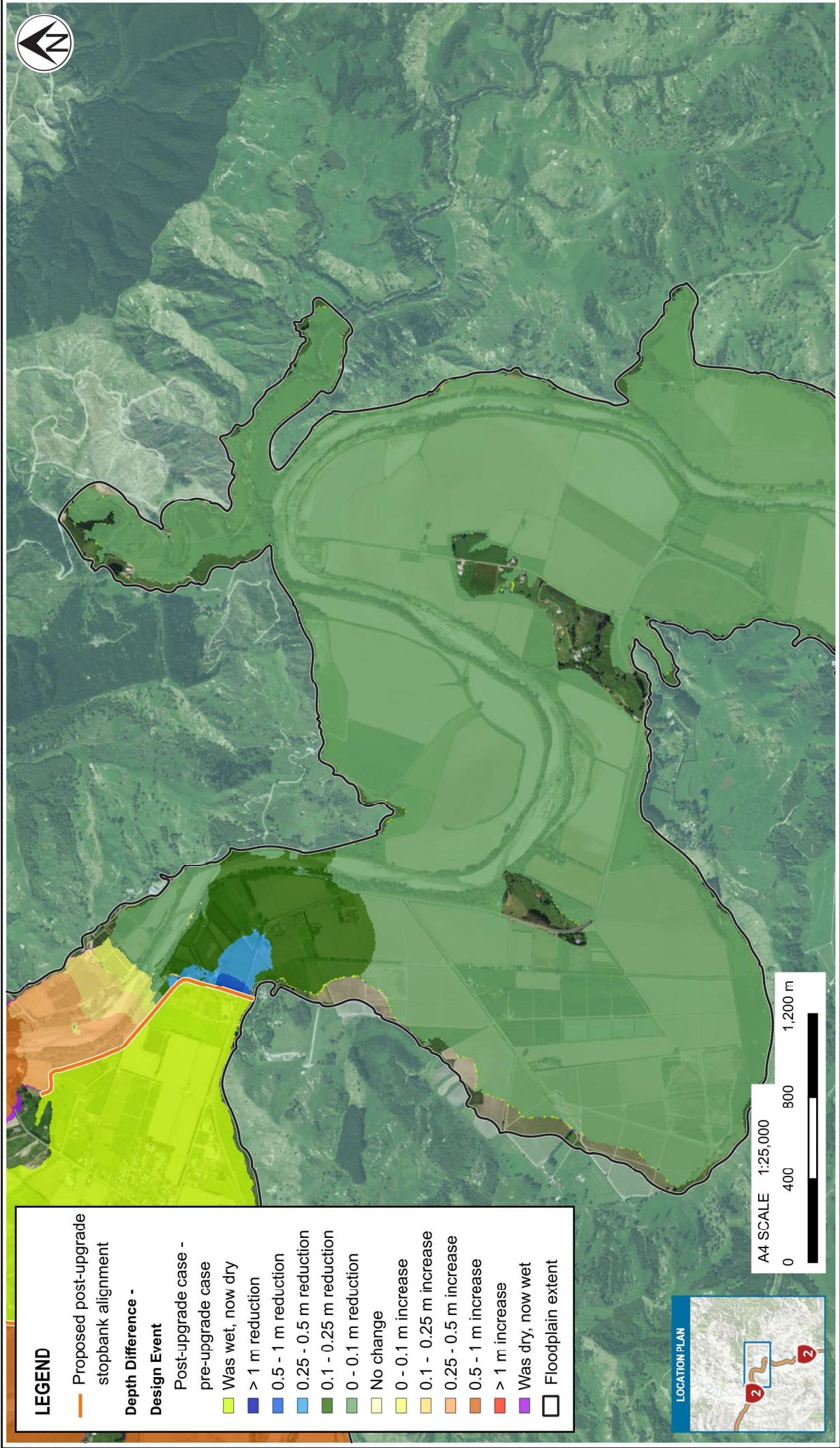
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						SCALE (A4) 1:25,000										
					APPROVED	DATE	FIG No. FIGURE 2.1	REV 0								



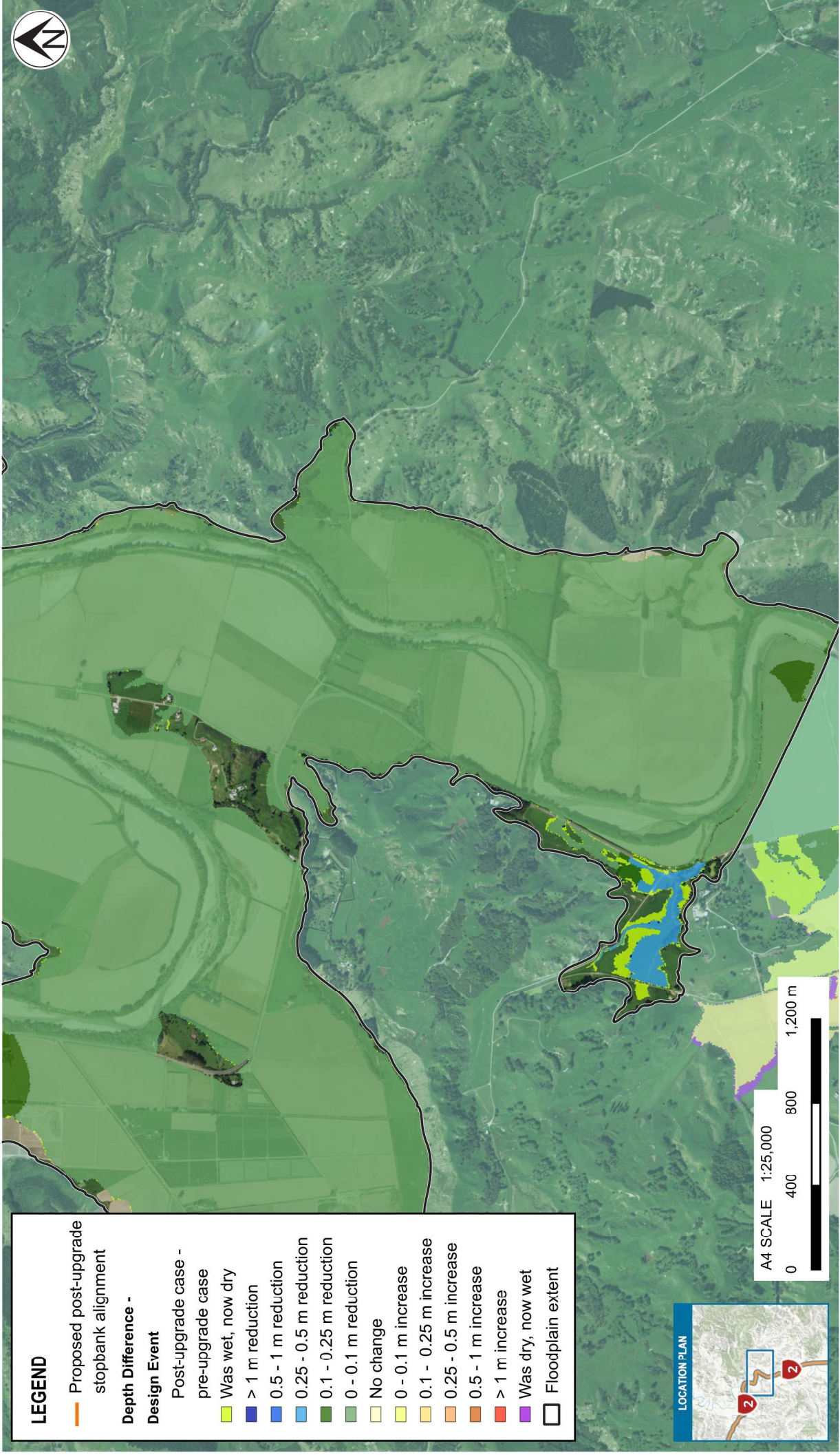
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						FIG No. FIGURE 2.2	
						REV 0	



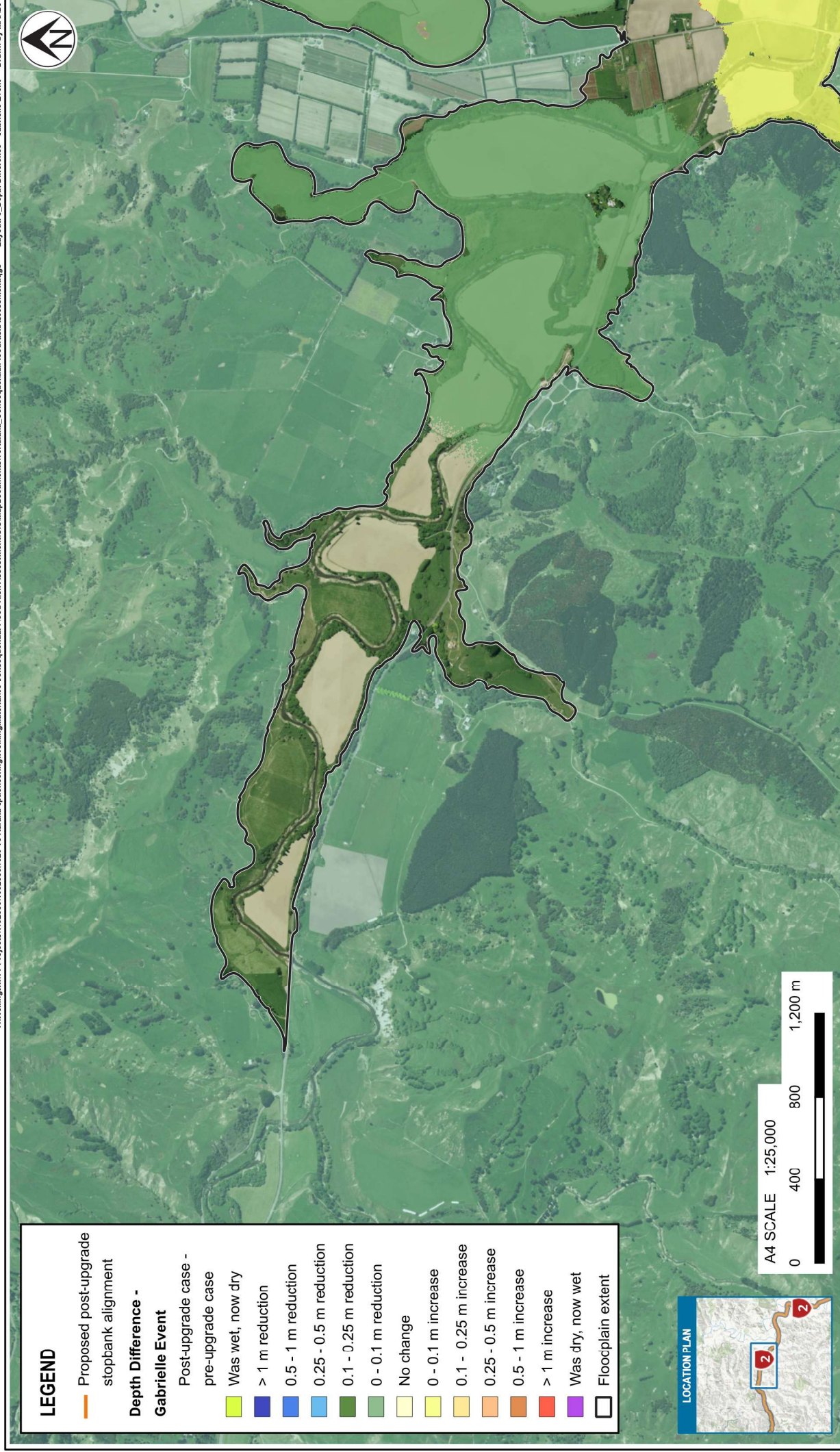
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						REV 0	



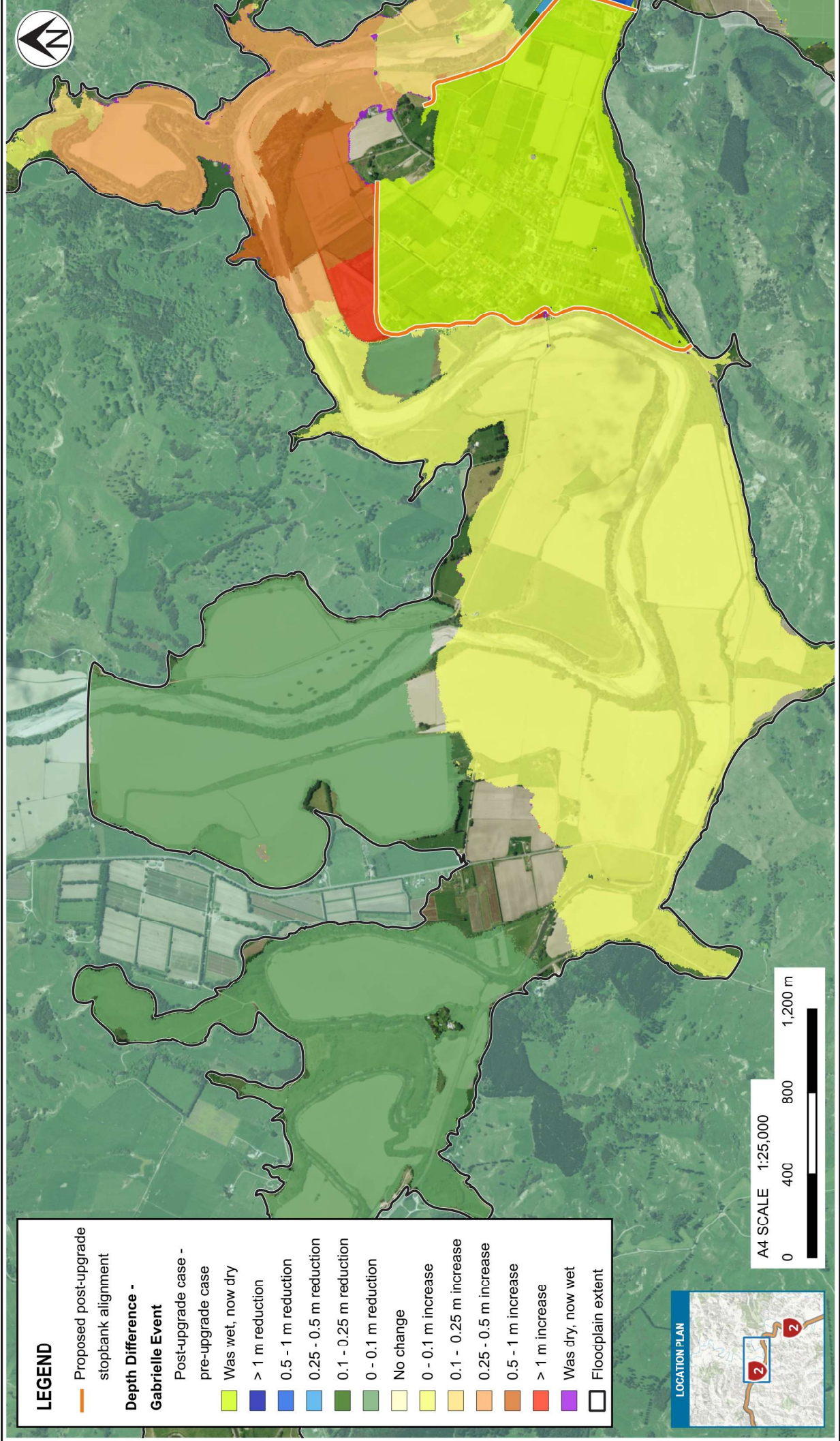
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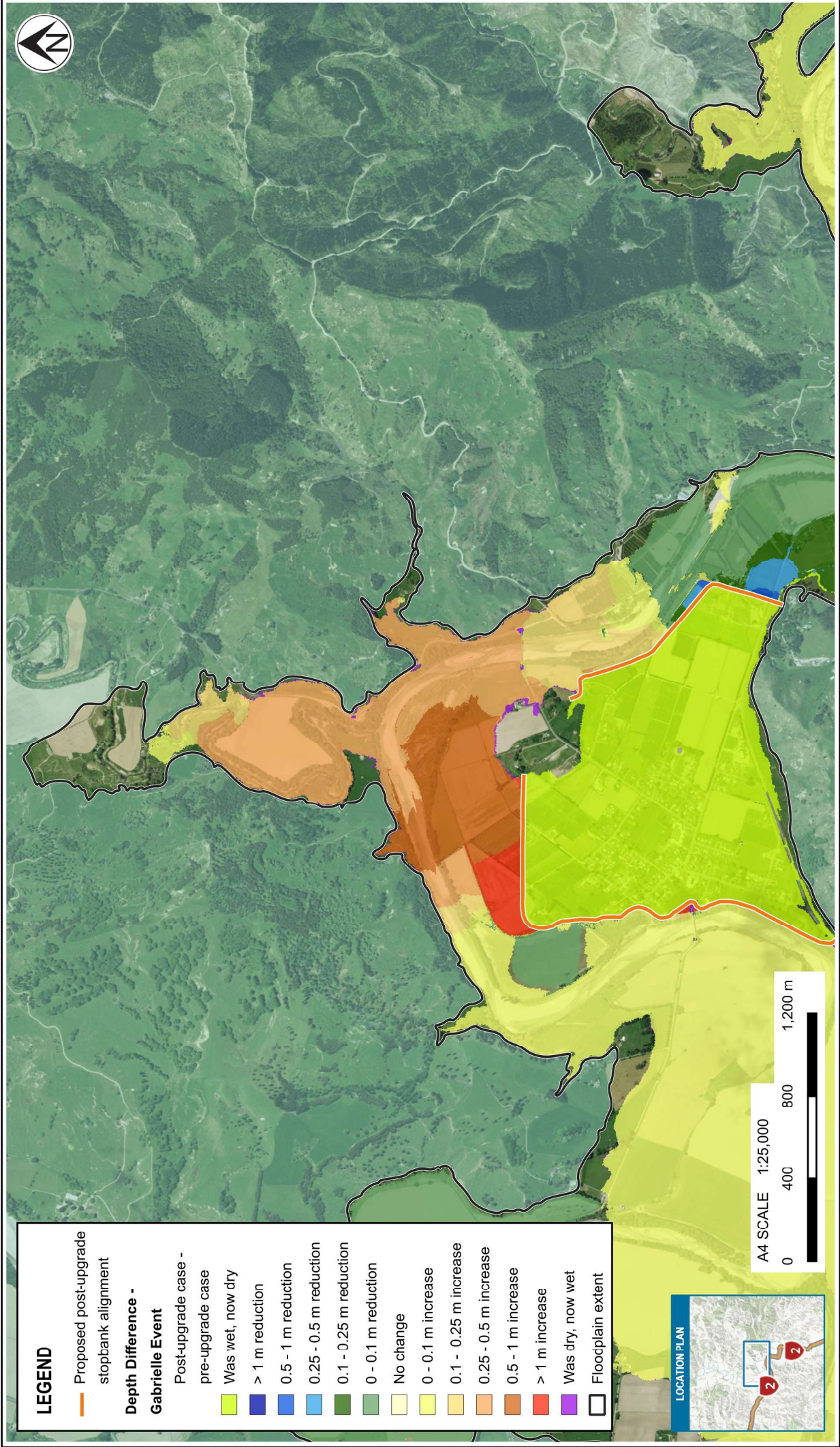
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								SCALE (A4) 1:25,000	
								FIG No. FIGURE 3.1	
								REV 0	



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LEGEND

Proposed post-upgrade stopbank alignment

Depth Difference - Gabrielle Event

Post-upgrade case - pre-upgrade case

Was wet, now dry

> 1 m reduction

0.5 - 1 m reduction

0.25 - 0.5 m reduction

0.1 - 0.25 m reduction

0 - 0.1 m reduction

No change

0 - 0.1 m increase

0.1 - 0.25 m increase

0.25 - 0.5 m increase

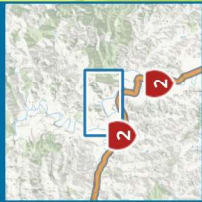
0.5 - 1 m increase

> 1 m increase

Was dry, now wet

Floodplain extent

LOCATION PLAN



A4 SCALE 1:25,000

0 400 800 1,200 m



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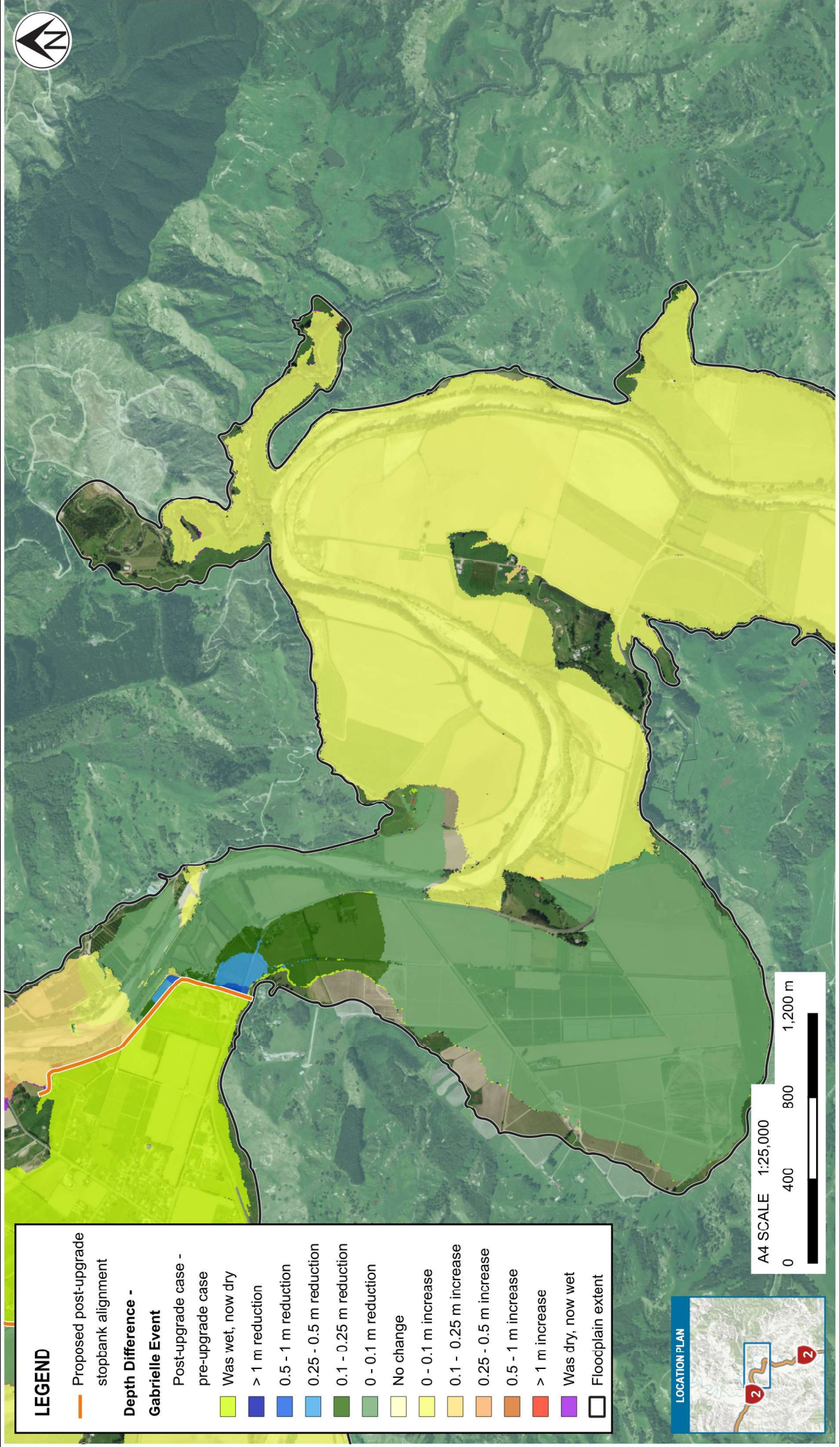
PROJECT **TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT**

TITLE **DEPTH DIFFERENCE - GABRIELLE EVENT**

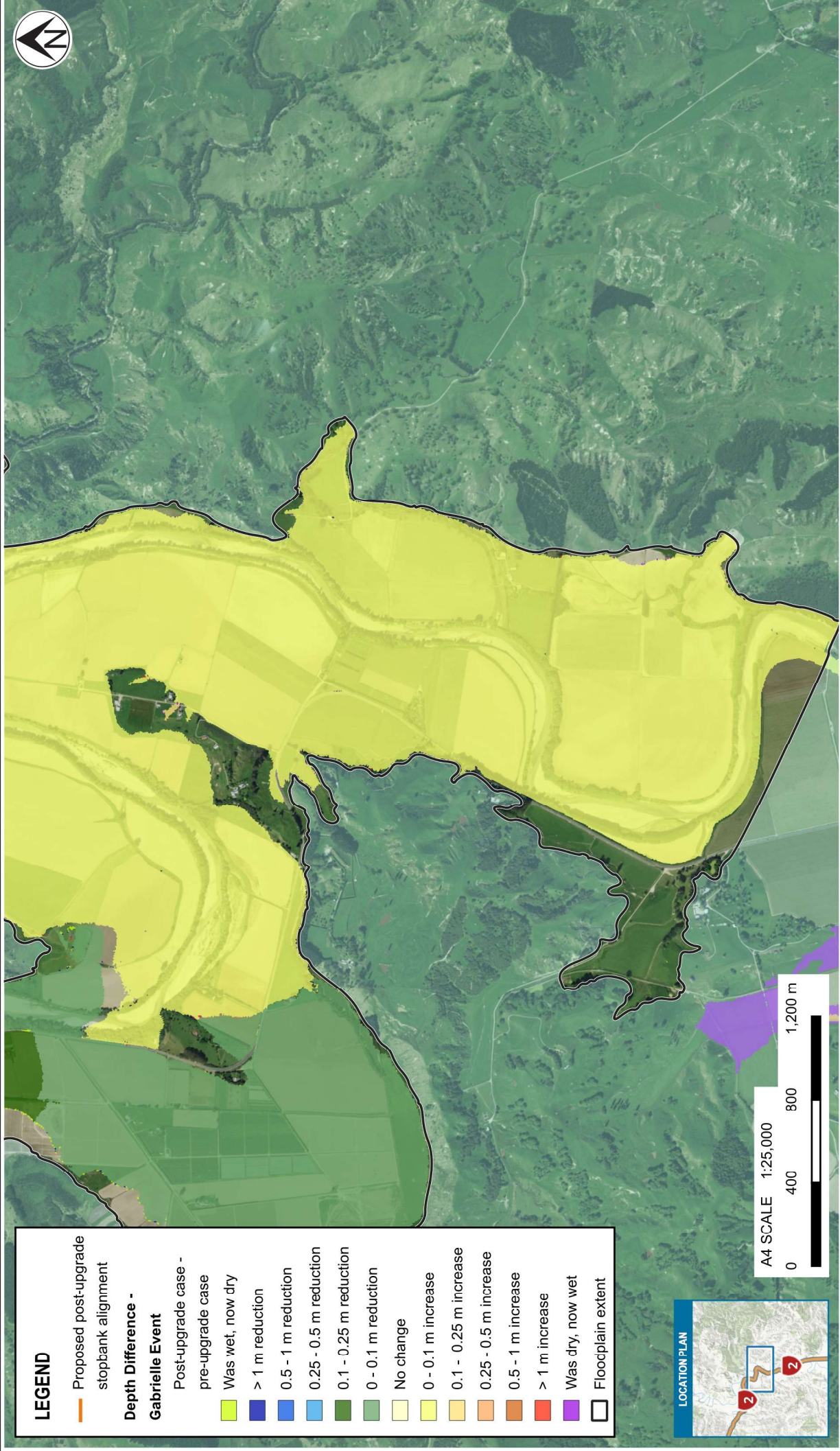
SCALE (A4) **1:25,000**

FIG No. **FIGURE 3.3**

REV **0**



NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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						SCALE (A4) 1:25,000	
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						REV 0	



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				APPROVED		SCALE (A4) 1:25,000	
				DATE		FIG No. FIGURE 3.5	
						REV 0	

LEGEND

Proposed post-upgrade stopbank alignment

Depth Difference - Over-design Event

Post-upgrade case - pre-upgrade case

Was wet, now dry

> 1 m reduction

0.5 - 1 m reduction

0.25 - 0.5 m reduction

0.1 - 0.25 m reduction

0 - 0.1 m reduction

No change

0 - 0.1 m increase

0.1 - 0.25 m increase

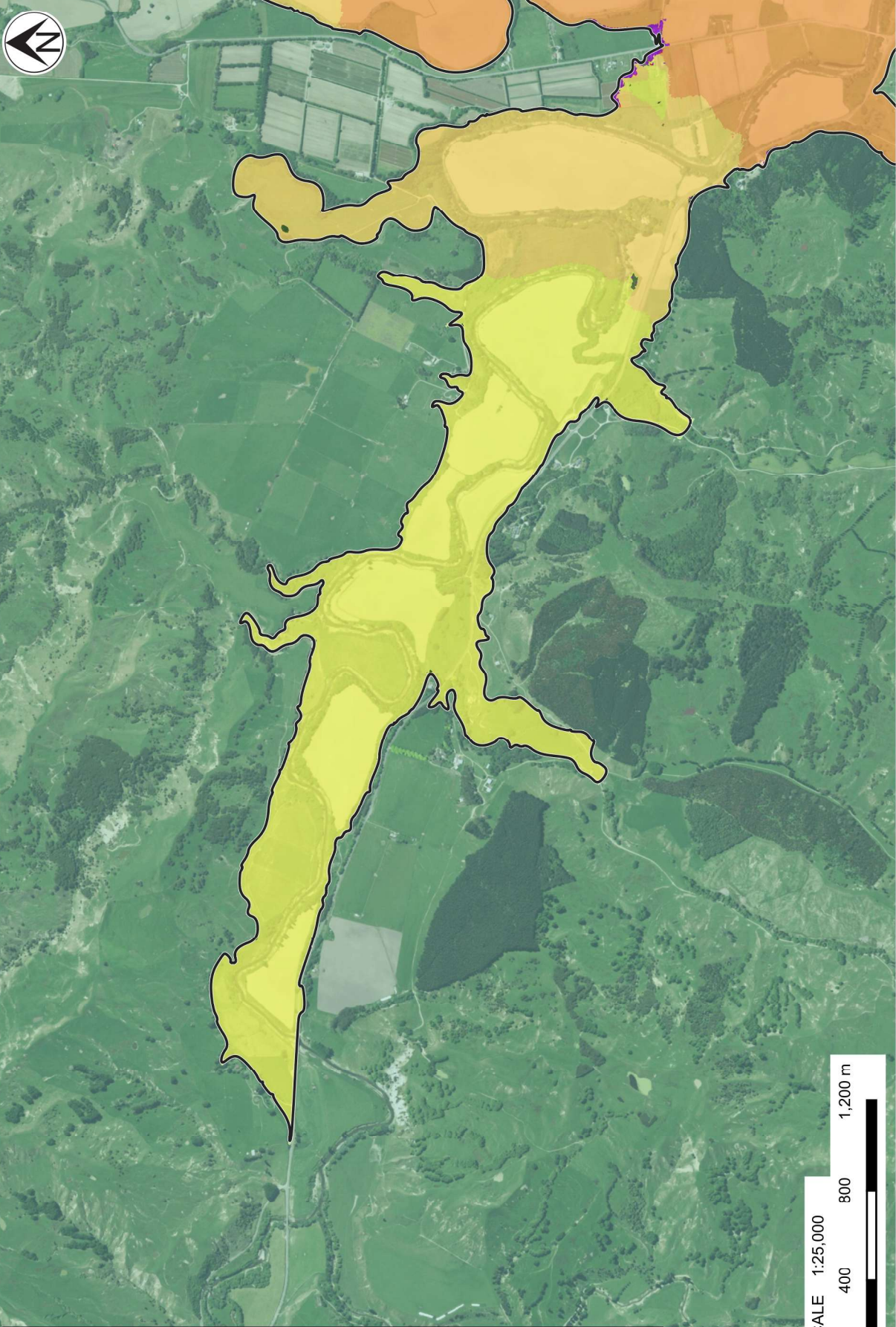
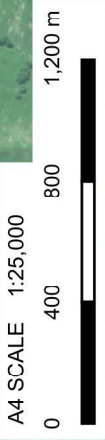
0.25 - 0.5 m increase

0.5 - 1 m increase

> 1 m increase

Was dry, now wet

Floodplain extent



CLIENT

PROJECT

TITLE

GISBORNE DISTRICT COUNCIL

TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT

DEPTH DIFFERENCE - OVER-DESIGN EVENT

NOTES:

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Model Result Files: Provided by DHI Group.

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SCALE (A4)

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FIG No.

FIGURE 4.1

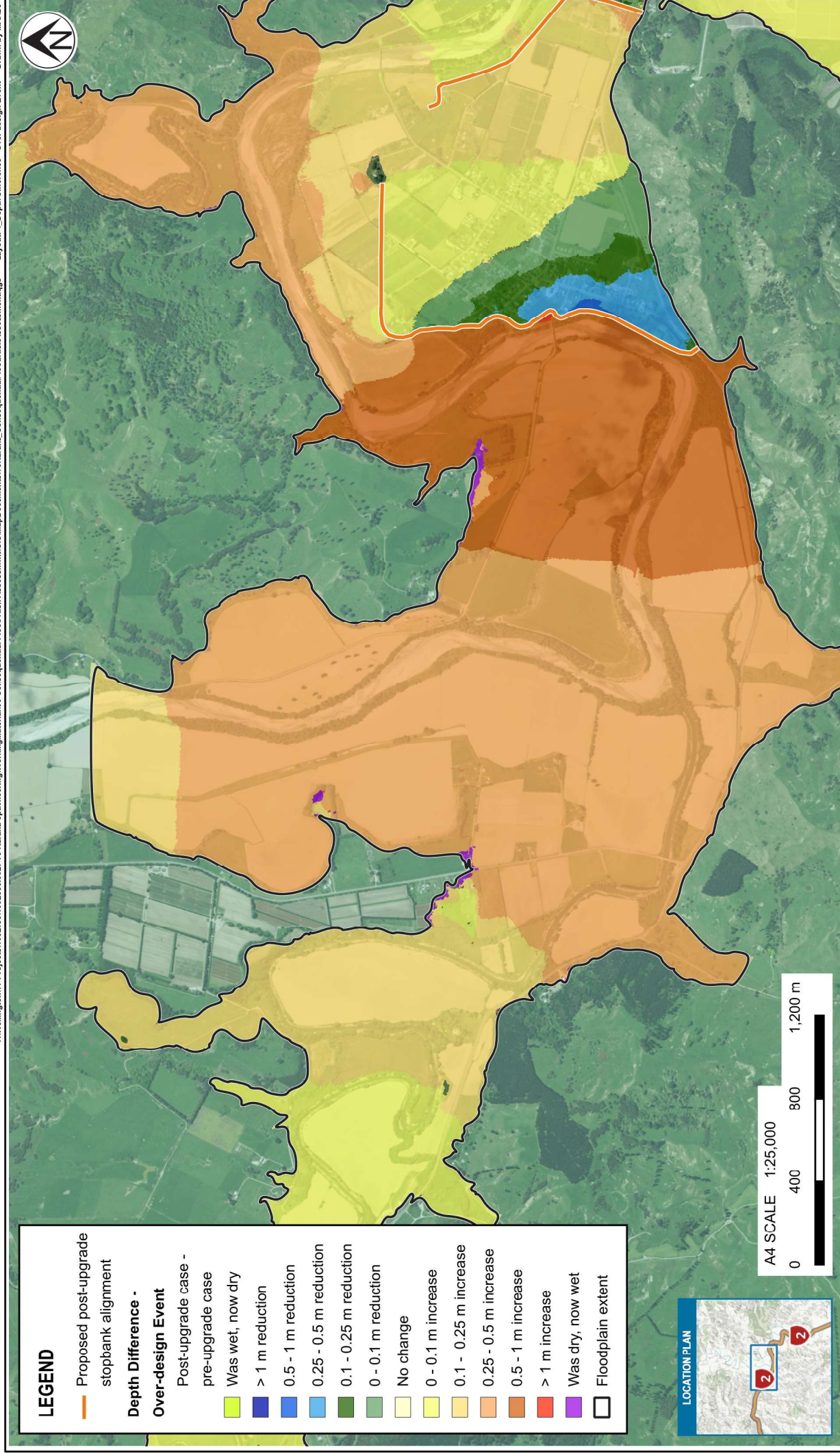
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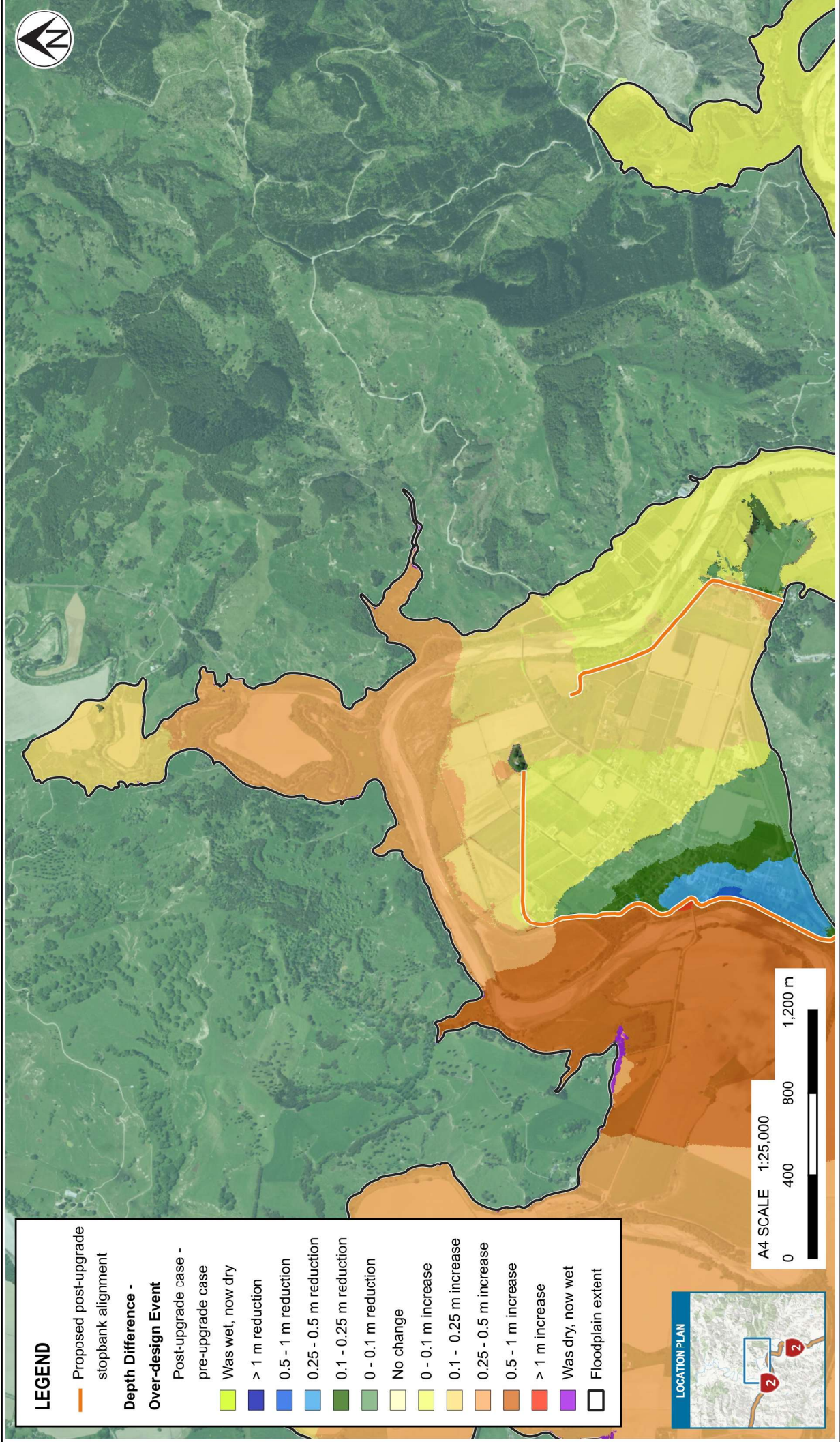
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							TITLE DEPTH DIFFERENCE - OVER-DESIGN EVENT		
SCALE (A4) 1:25,000								FIG No. FIGURE 4.2	REV 0



NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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						FIG No. FIGURE 4.3	
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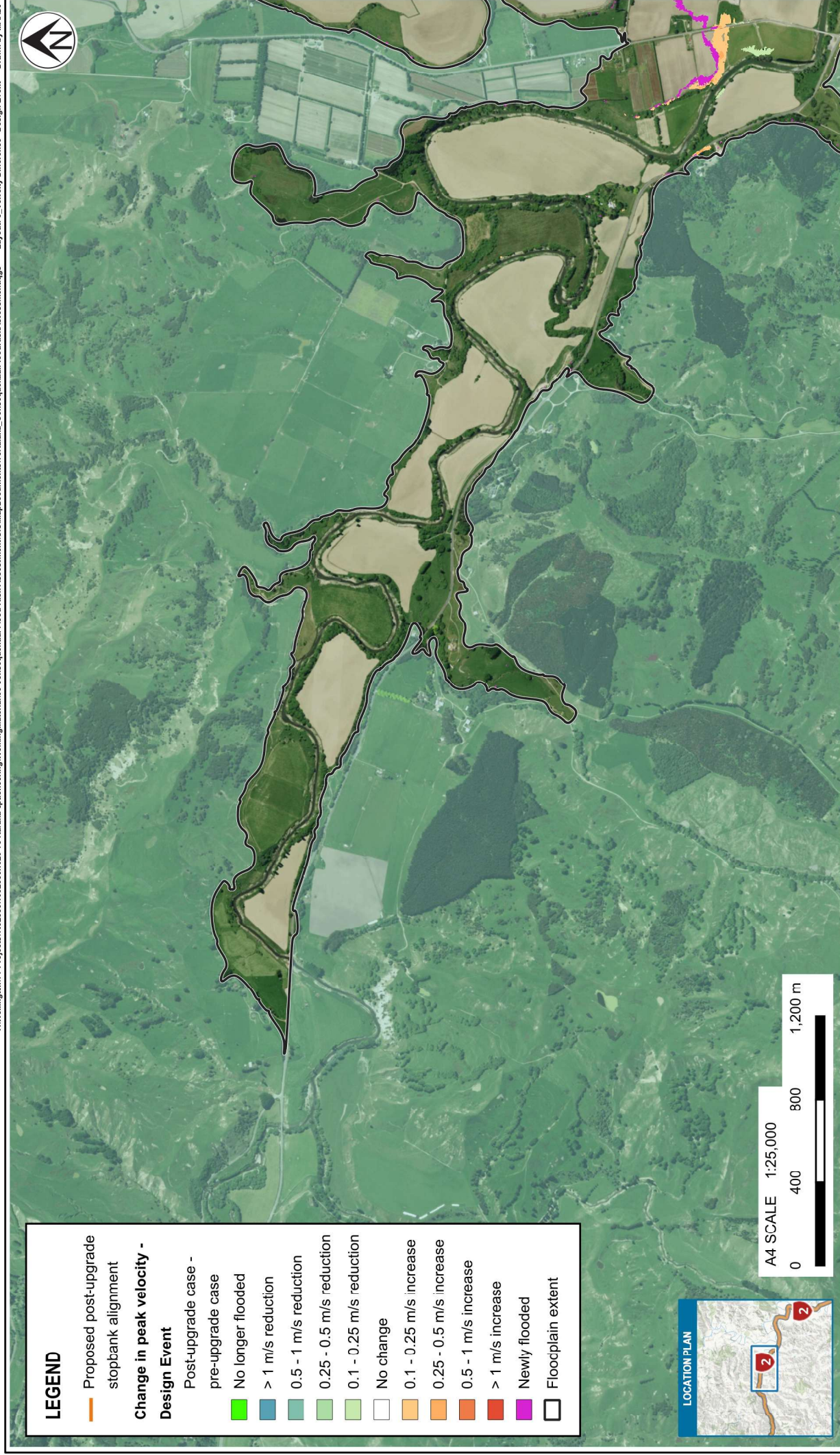
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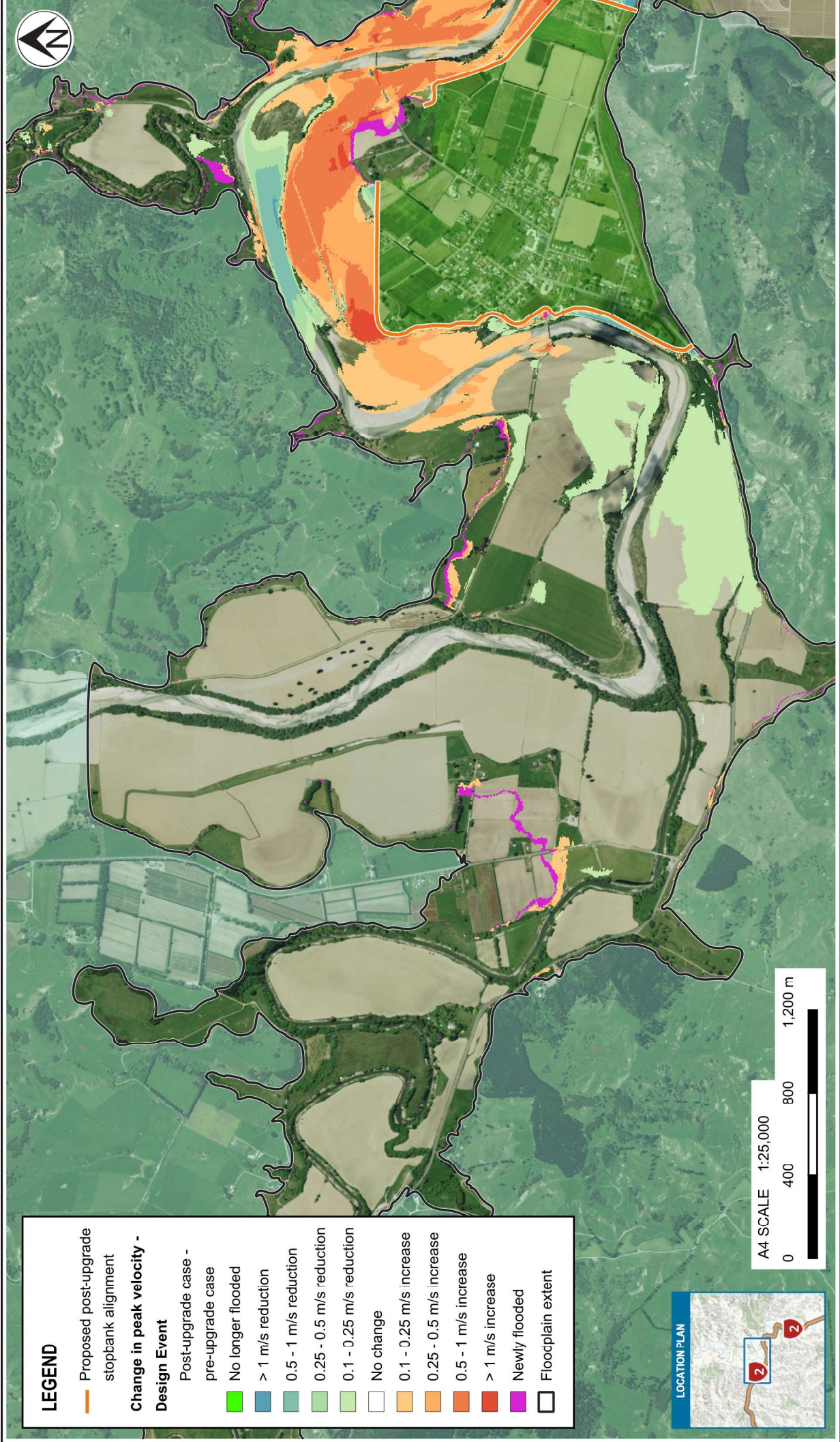
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Appendix C Maximum velocity difference maps

- **Figure 5 – Velocity Difference – Design Event – Rev 0.**
- **Figure 6 – Velocity Difference – Gabrielle Event – Rev 0.**
- **Figure 7 – Velocity Difference – Over-design Event – Rev 0.**



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						FIG No. FIGURE 5.1	REV 0										

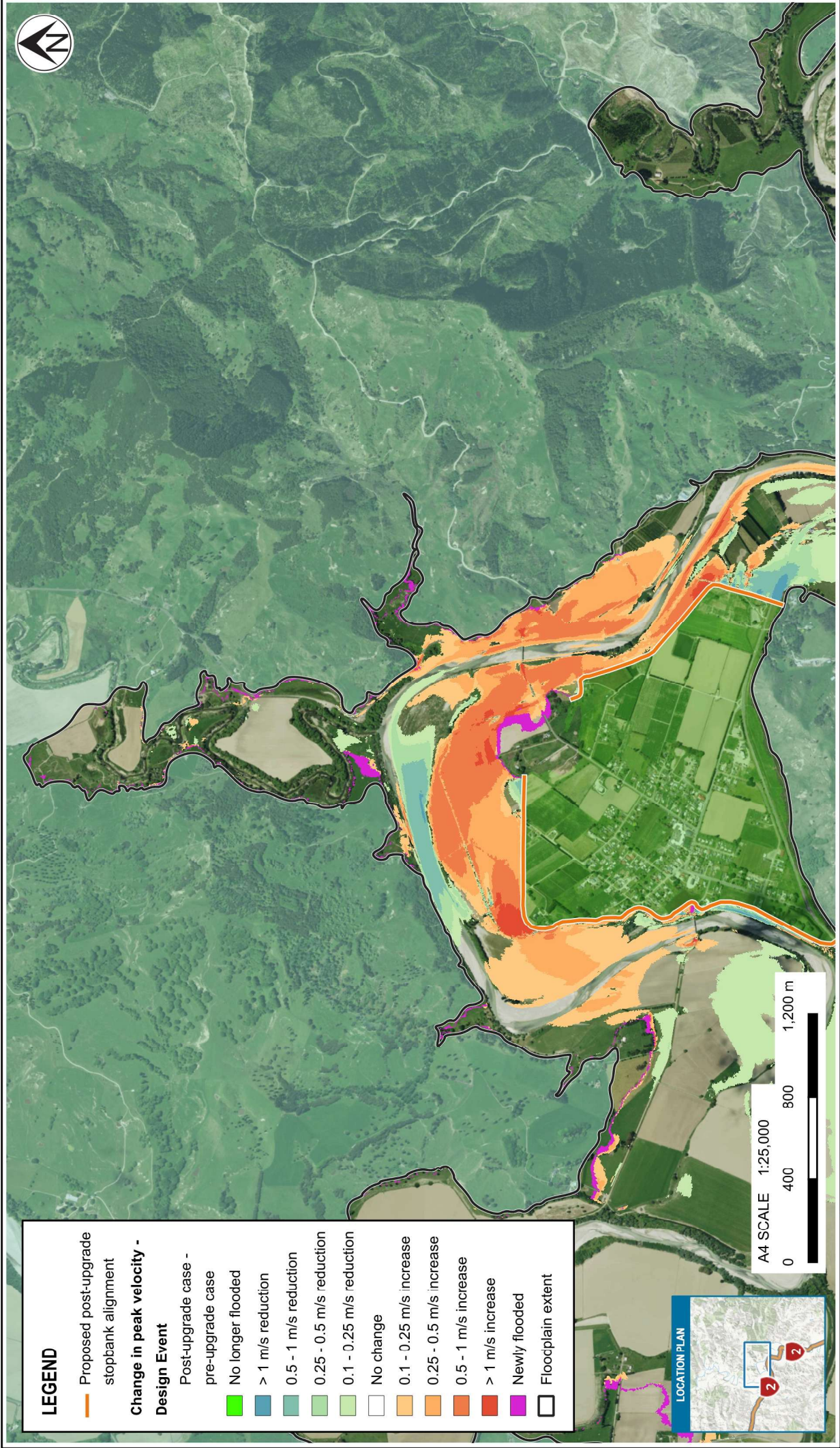


 Tonkin +Taylor www.tonkintaylor.co.nz Exceptional thinking together		NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.																	
REVISIONS		NO.		BY		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL											
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												TITLE VELOCITY DIFFERENCE - DESIGN EVENT							
												SCALE (A4) 1:25,000		FIG No. FIGURE 5.2		REV 0			



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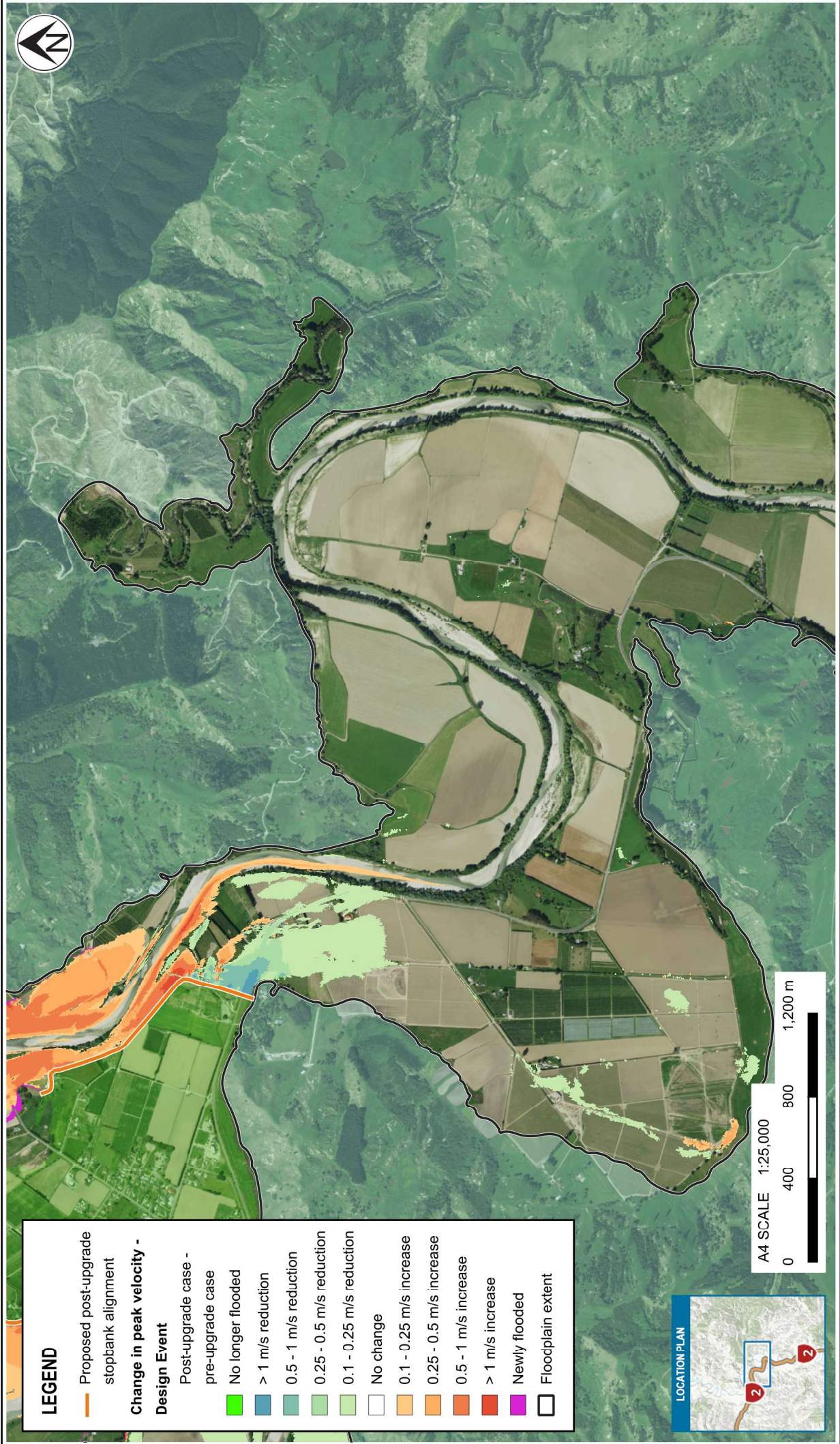
 Tonkin +Taylor www.tonkintaylor.co.nz <i>Exceptional thinking together</i>		NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		NO. BY		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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						APPROVED		DATE		SCALE (A4) 1:25,000	
										FIG No. FIGURE 5.3	
										REV 0	



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					DATE					



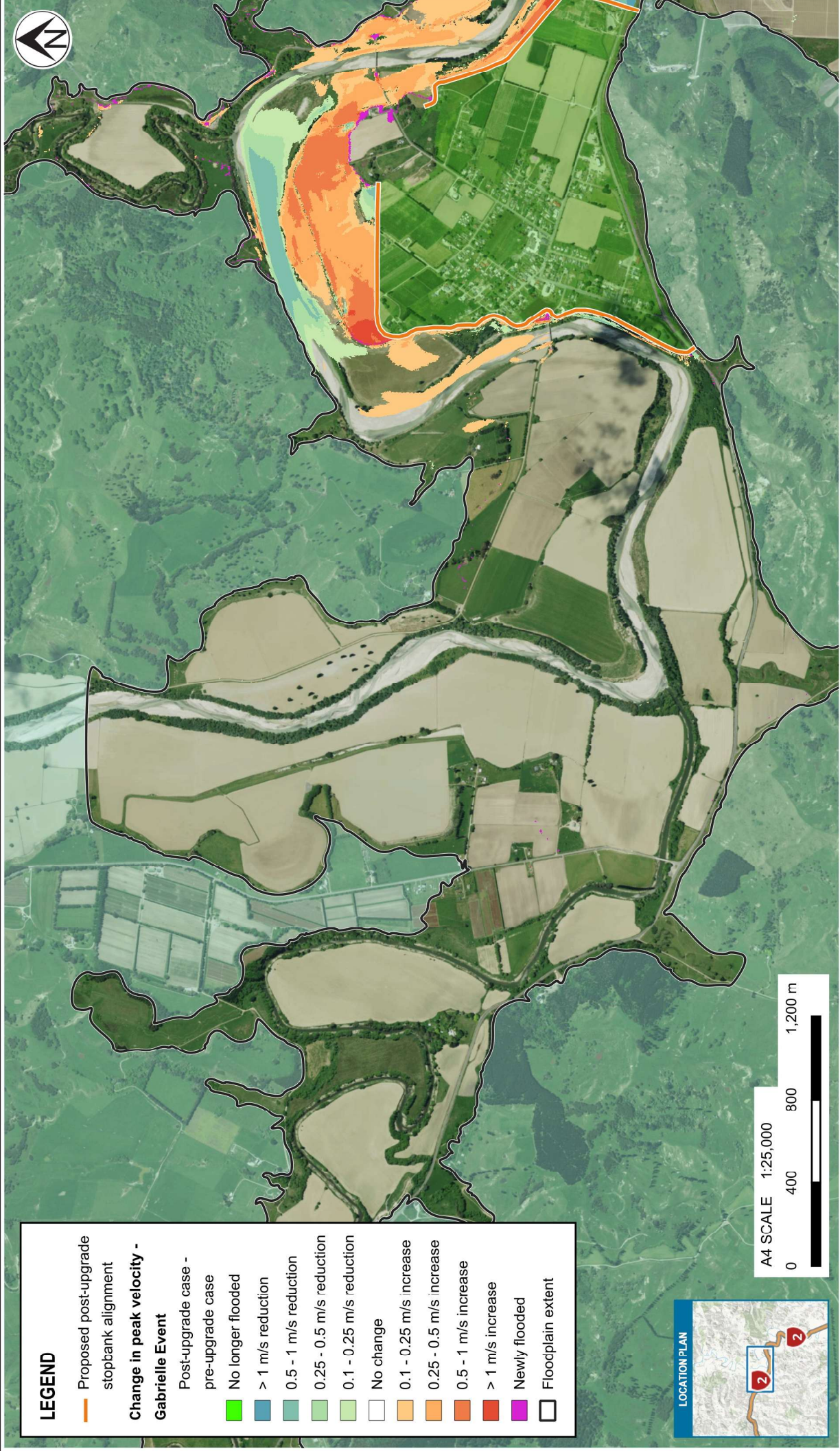
 Tonkin +Taylor www.tonkintaylor.co.nz Exceptional thinking together		NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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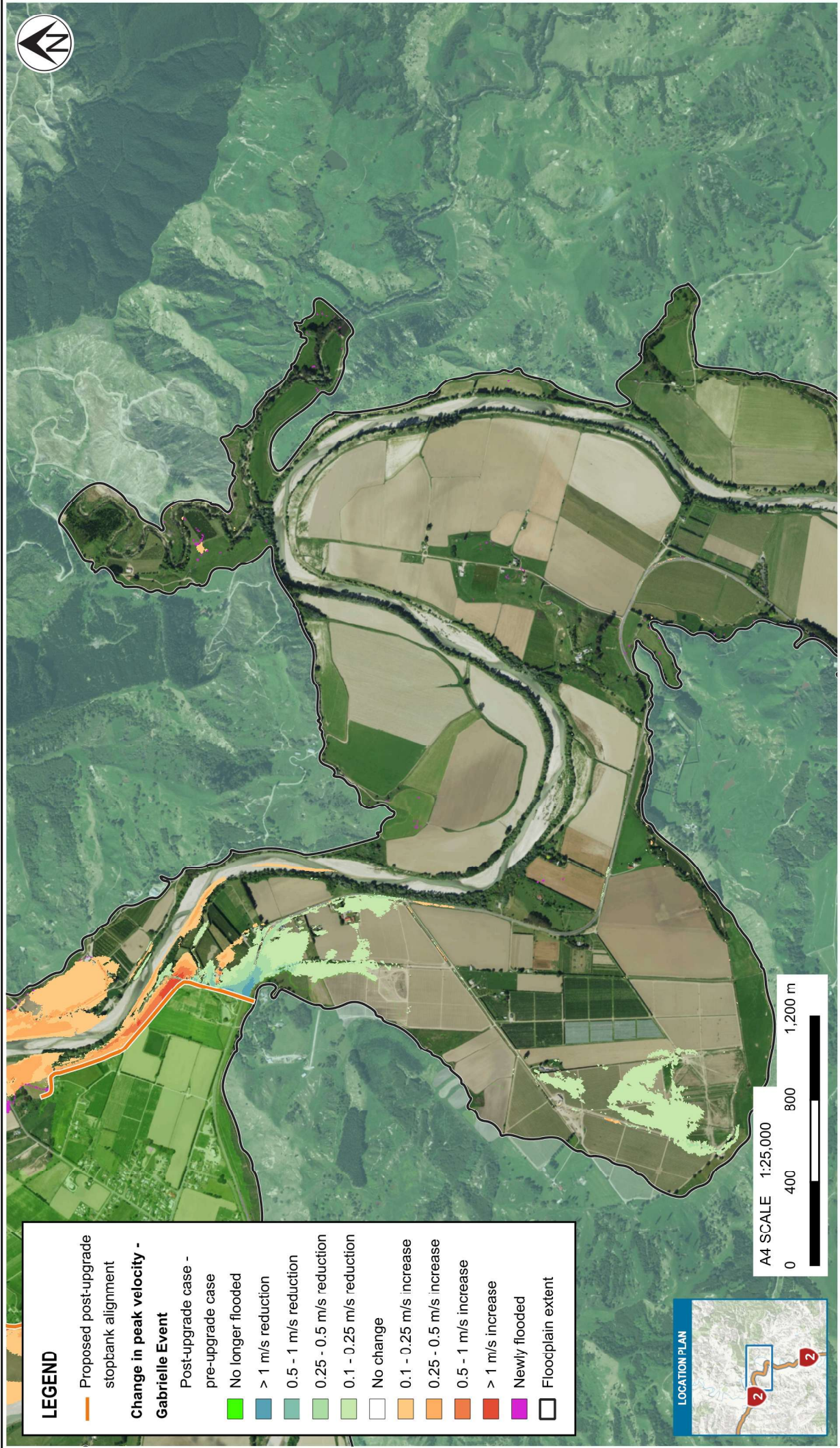
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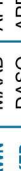


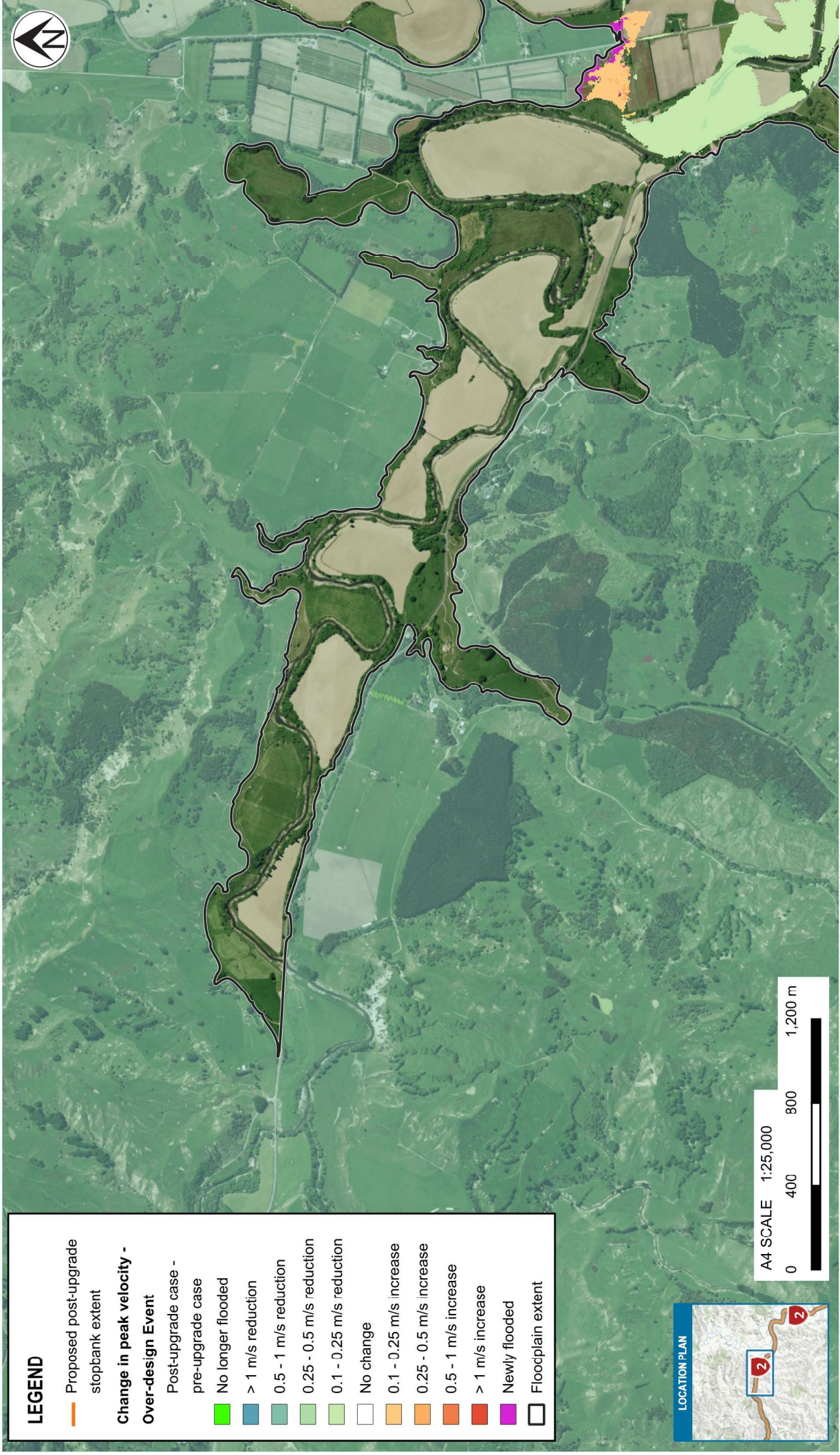
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						DATE					



NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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						REV 0	



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								FIG No. FIGURE 6.5	
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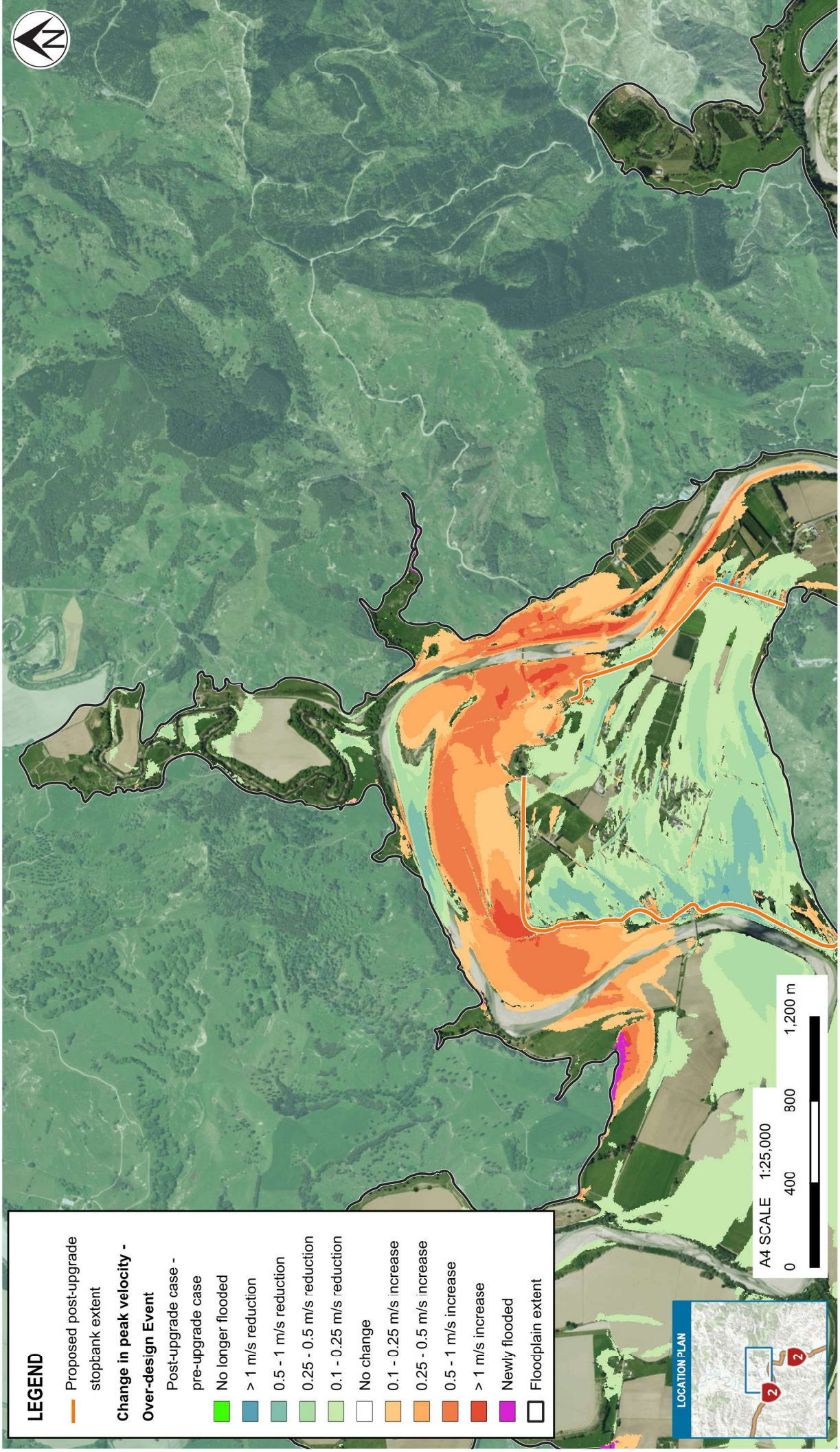
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						DATE		REV 0		



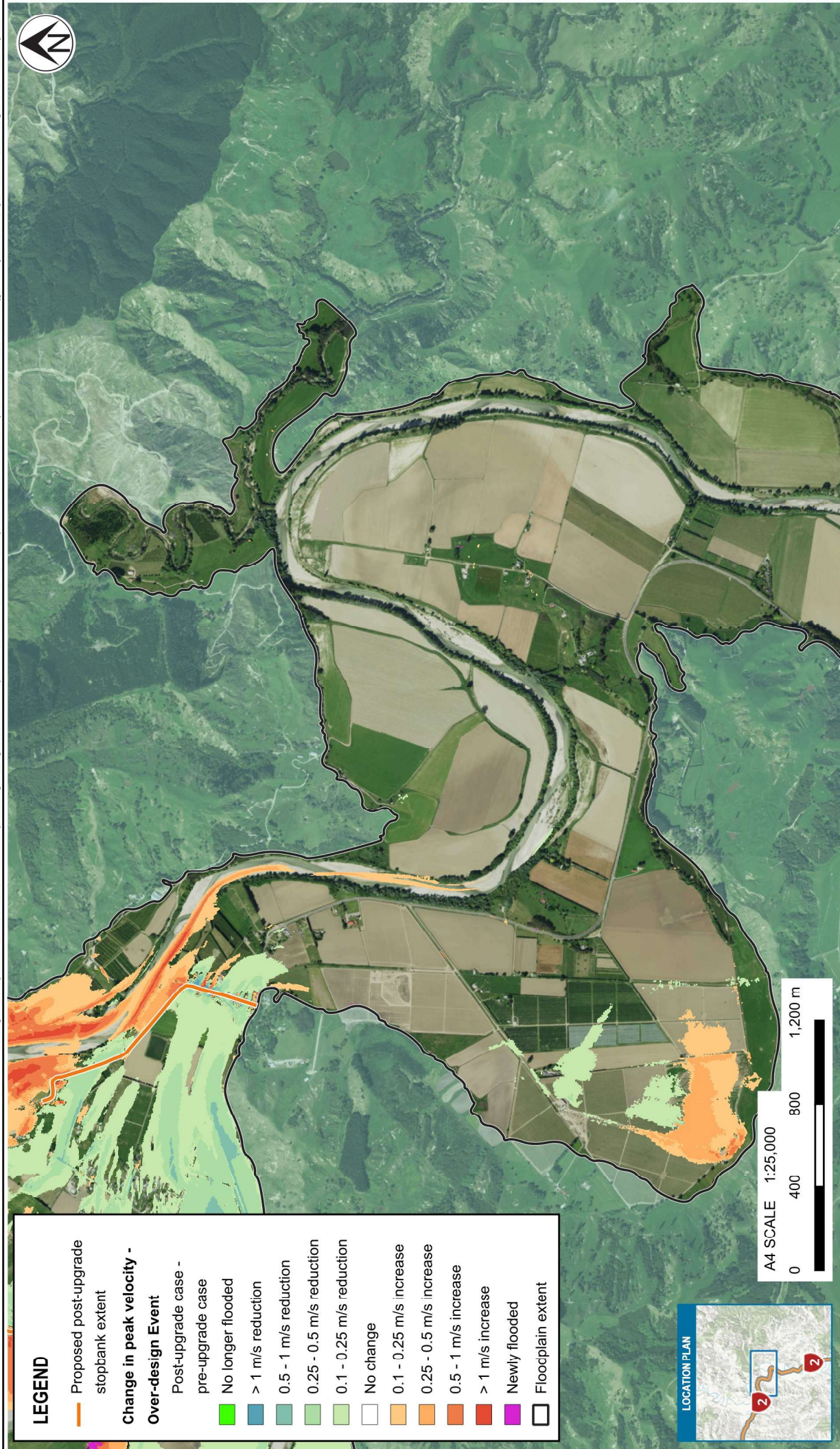
Exceptional thinking together

Aerial Imagery: Gisborne 0.1m Rural
Aerial Photos (LINZ - CC-BY-4.0)
Model Result Files: Provided by DHI
Group.

REV 0



NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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						REV 0	



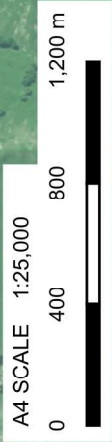
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						FIG No. FIGURE 7.4	
						REV 0	



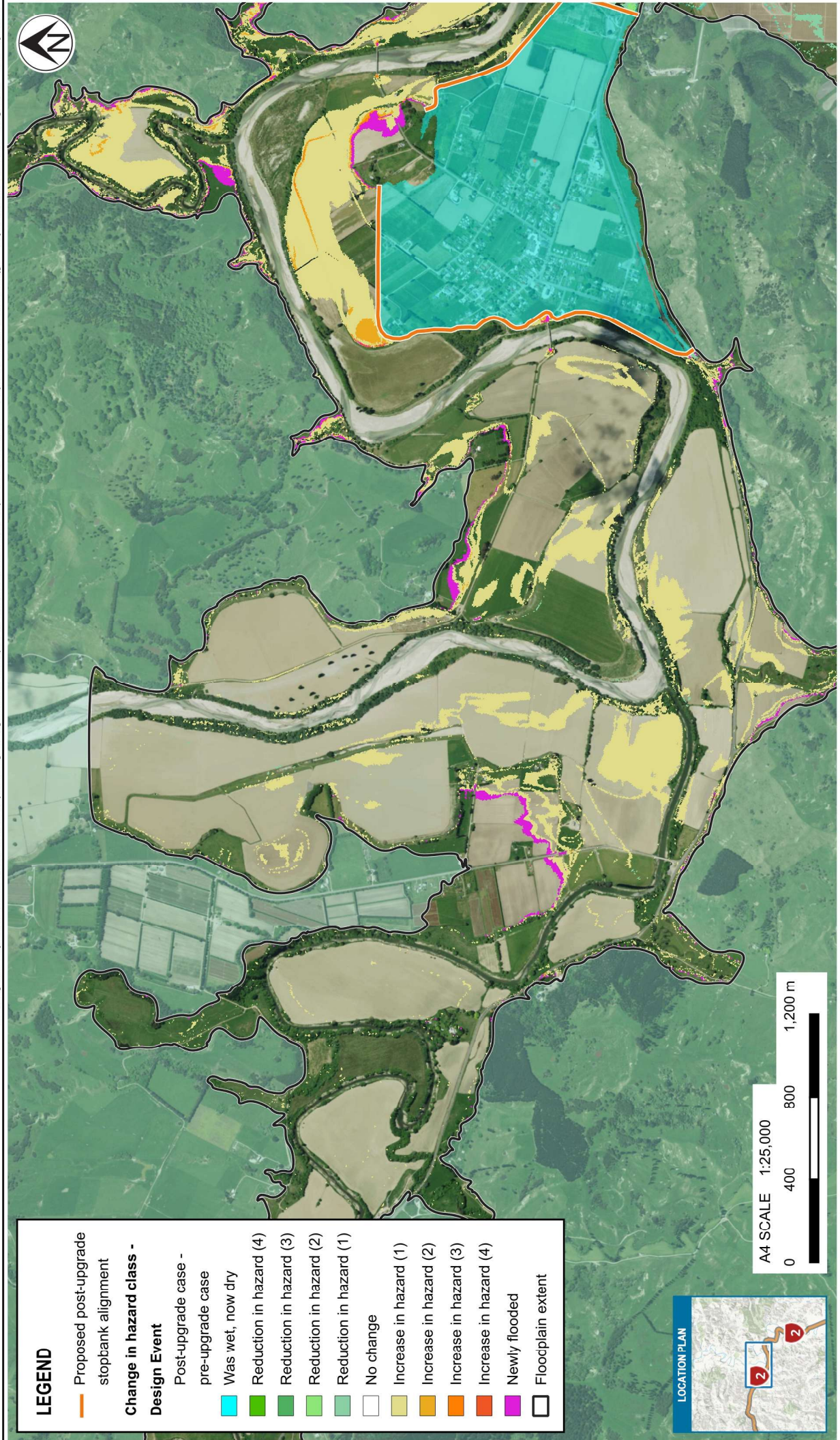
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						TITLE VELOCITY DIFFERENCE - OVER-DESIGN EVENT					
							SCALE (A4) 1:25,000	FIG No. FIGURE 7.5	REV 0		

Appendix D Peak hazard difference maps

- **Figure 8 – Hazard Difference – Design Event – Rev 0.**
- **Figure 9 – Hazard Difference – Gabrielle Event – Rev 0.**
- **Figure 10 – Hazard Difference – Over-design Event – Rev 0.**



NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.	REVISIONS		NO.	BY	PROJECT No. 1092556.0020	CLIENT GIBBORNE DISTRICT COUNCIL PROJECT TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT TITLE HAZARD DIFFERENCE - DESIGN EVENT
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APPROVER						SCALE (A4) 1:25 000 FIG No. FIGURE 8.1 REV 0



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Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0)
Model Result Files: Provided by DHI Group.

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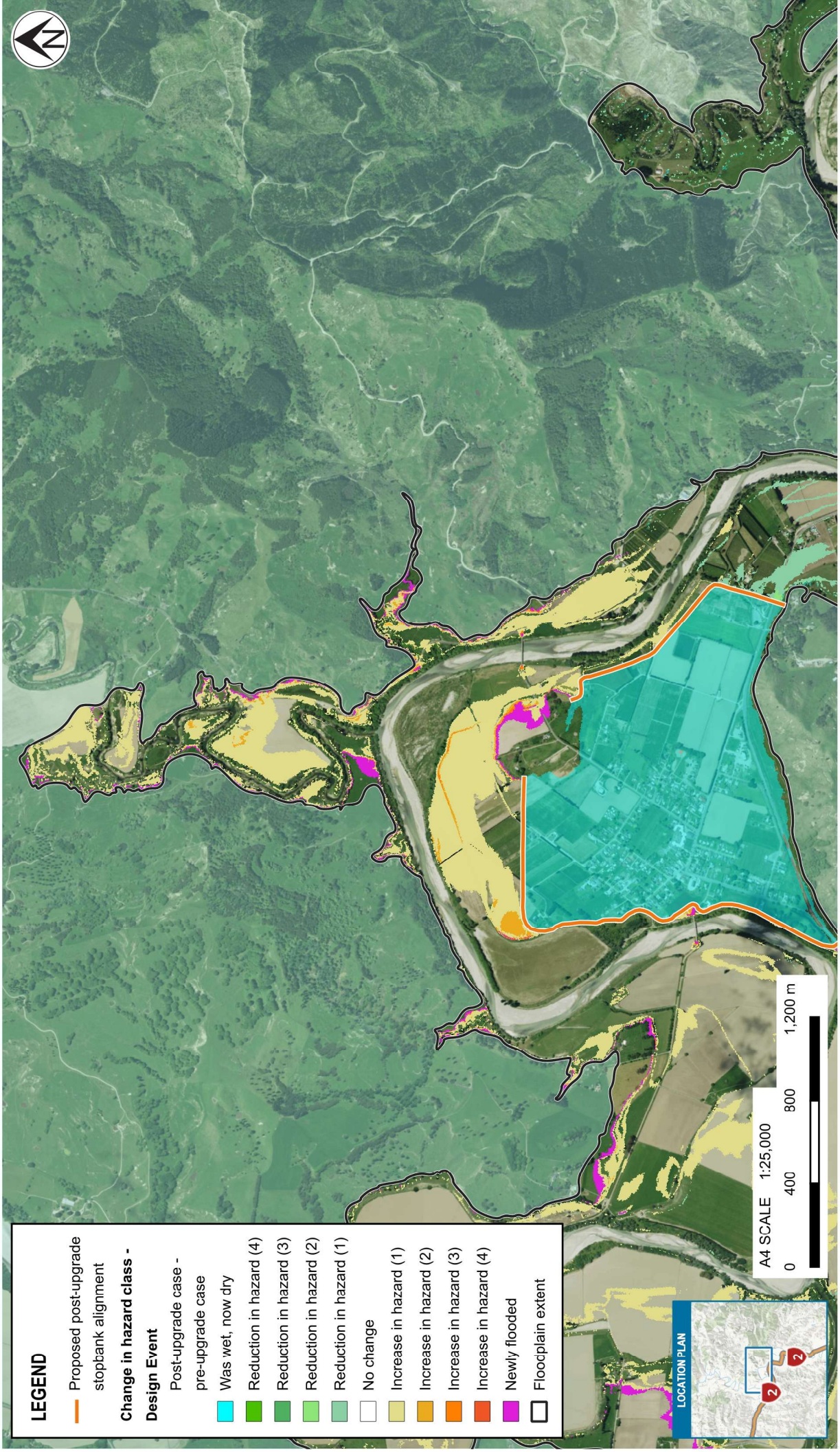
PROJECT **TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT**

TITLE **HAZARD DIFFERENCE - DESIGN EVENT**

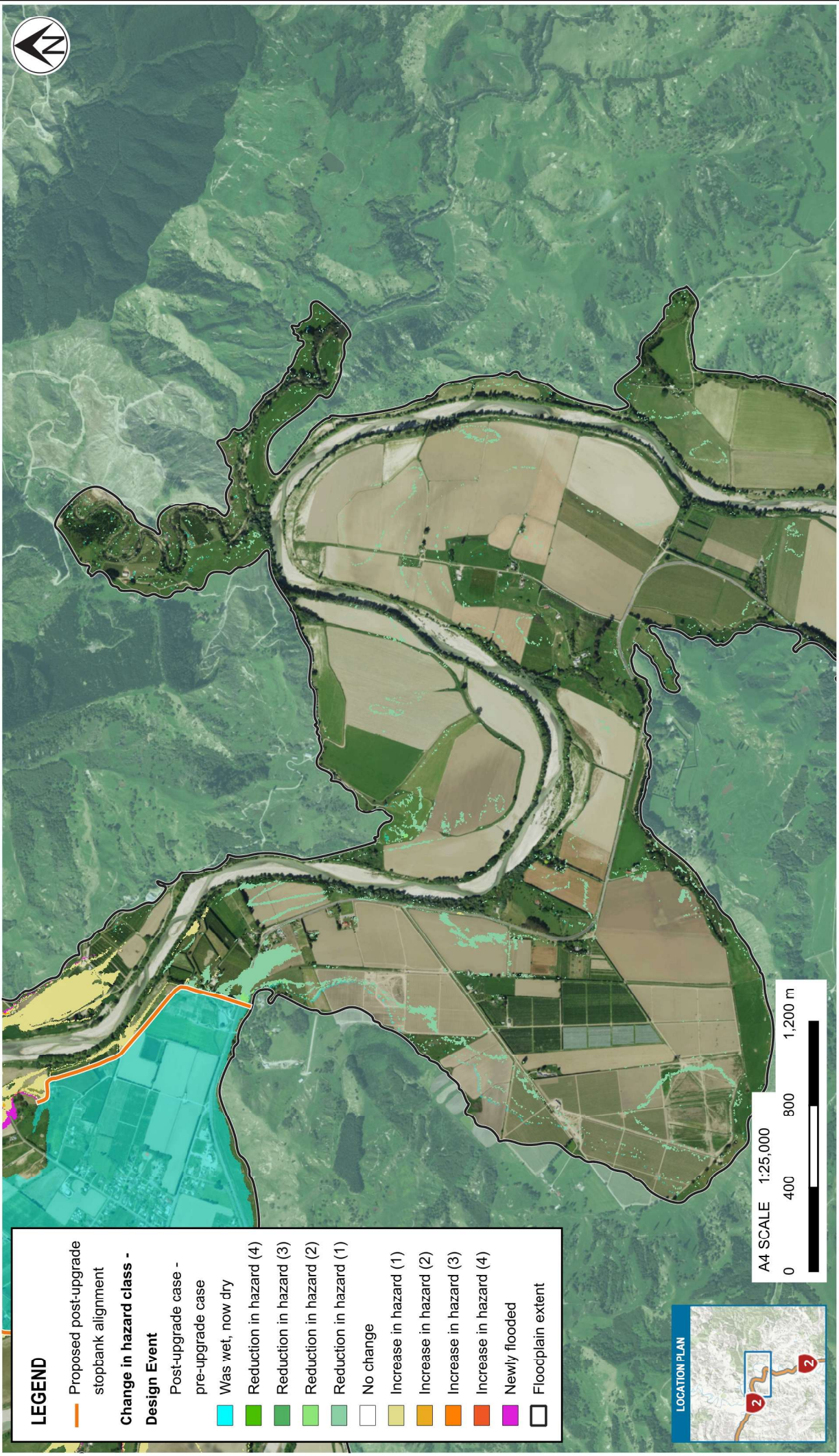
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FIG No. **FIGURE 8.2**

REV **0**



NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL	
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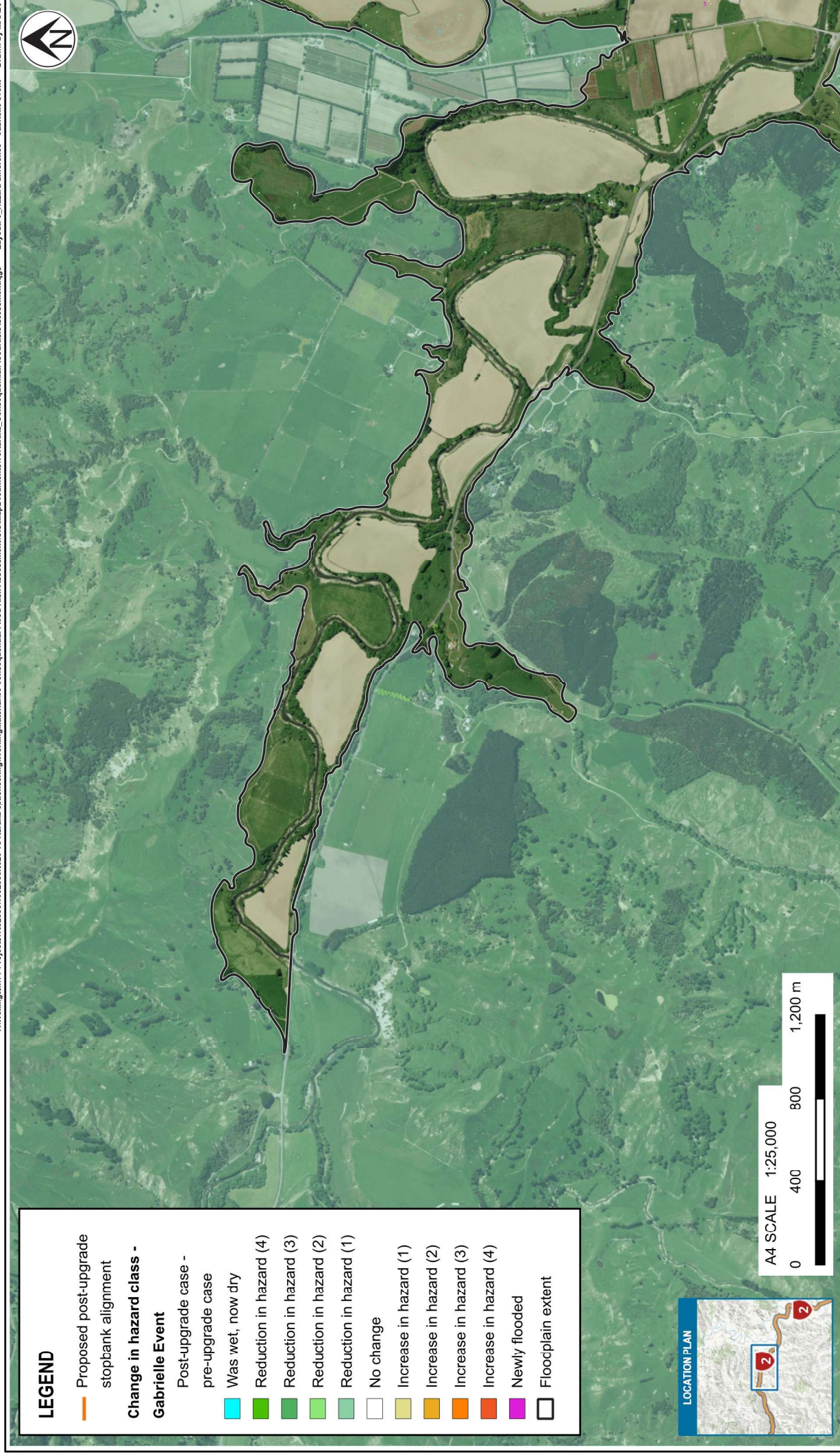
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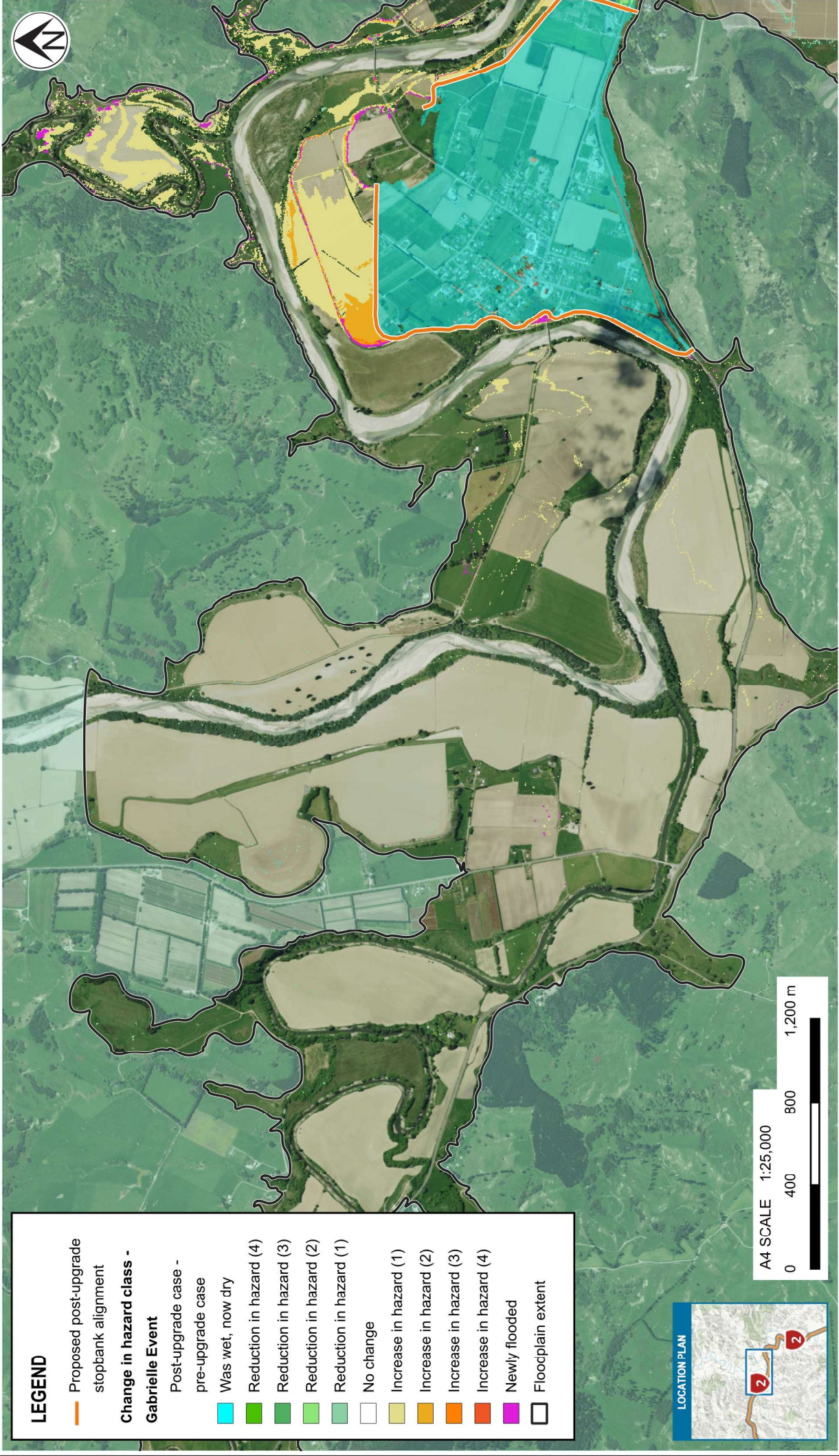
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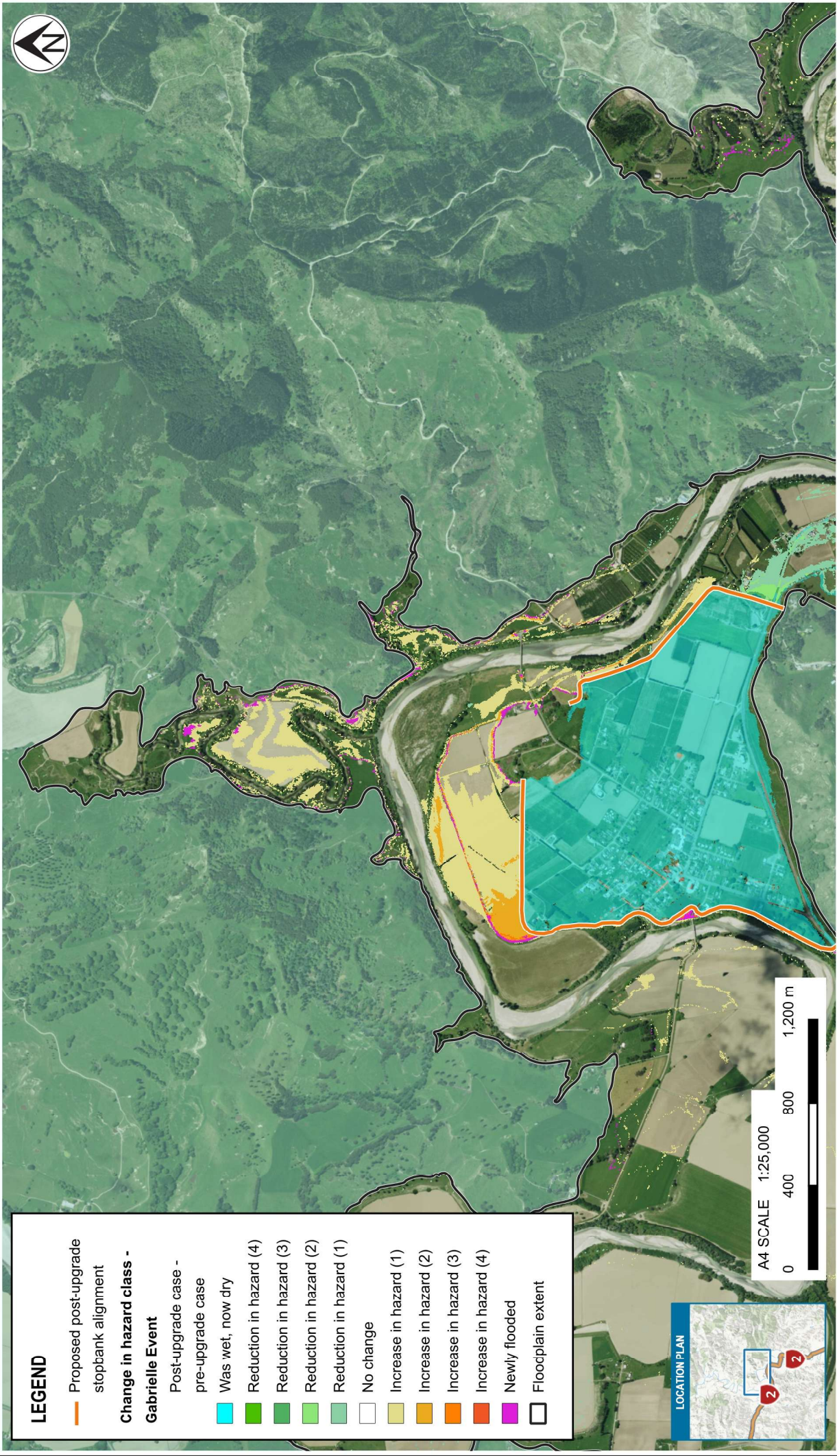
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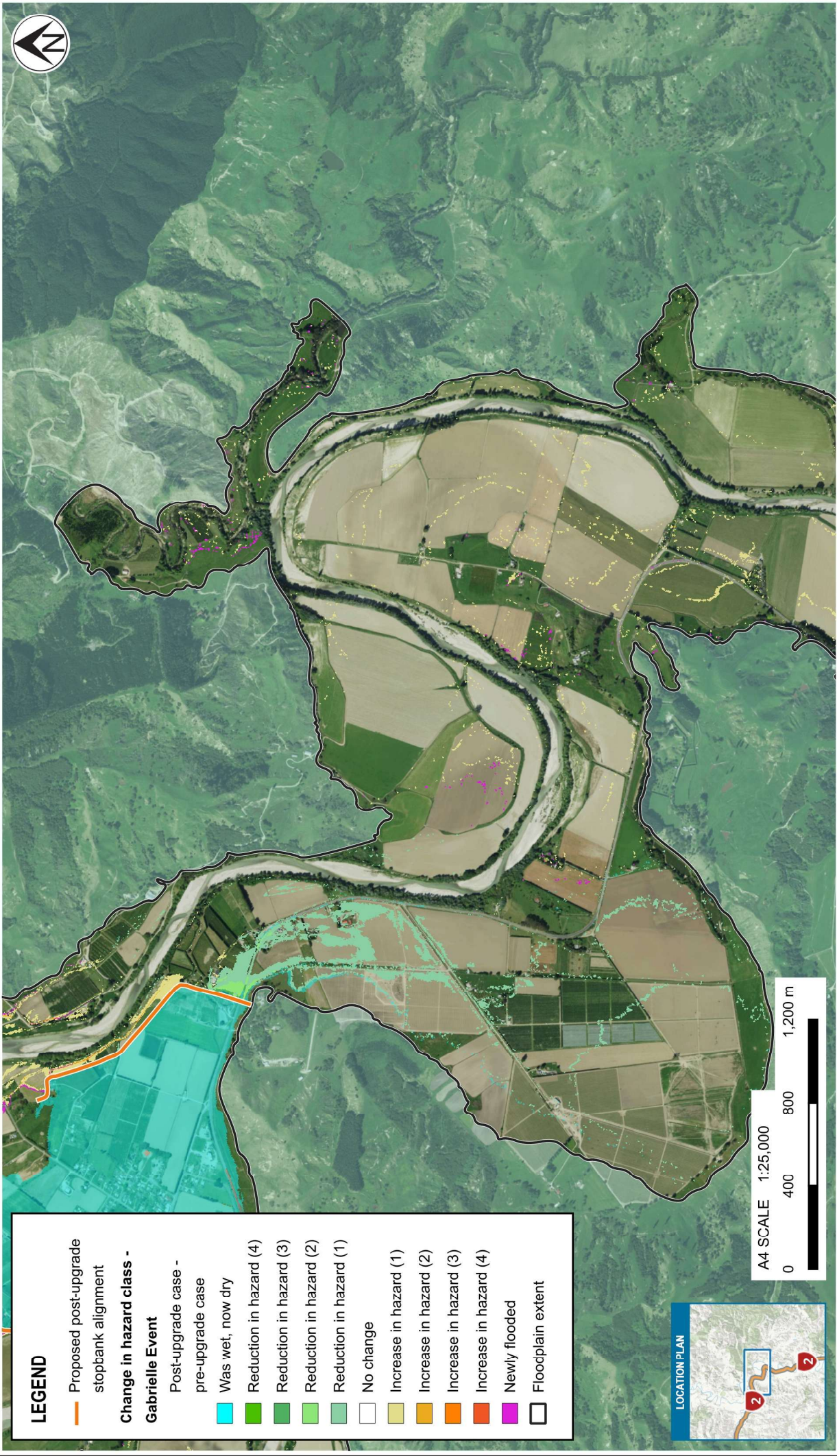
 Tonkin +Taylor www.tonkintaylor.co.nz Exceptional thinking together	NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY-4.0) Model Result Files: Provided by DHI Group.	REVISIONS		NO.	BY	PROJECT No. 1092556.0020	CLIENT GISBORNE DISTRICT COUNCIL			
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						APPROVED	DATE	SCALE (A4) 1:25,000	FIG No. FIGURE 9.1	REV 0



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LEGEND

Proposed post-upgrade
stopbank alignment

Change in hazard class -
Gabrielle Event

Post-upgrade case -
pre-upgrade case

Was wet, now dry

Reduction in hazard (4)

Reduction in hazard (3)

Reduction in hazard (2)

Reduction in hazard (1)

No change

Increase in hazard (1)

Increase in hazard (2)

Increase in hazard (3)

Increase in hazard (4)

Newly flooded

Floodplain extent

LOCATION PLAN

A4 SCALE 1:25,000

0 400 800 1,200 m



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NOTES:

Aerial Imagery: Gisborne 0.1m Rural
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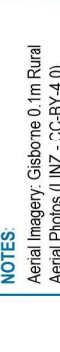
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										APR.26	
										TITLE HAZARD DIFFERENCE - GABRIELLE EVENT	

LEGEND

Proposed post-upgrade stopbank alignment

Change in hazard class - Over-design Event

Post-upgrade case - pre-upgrade case

Was wet, now dry

Reduction in hazard (4)

Reduction in hazard (3)

Reduction in hazard (2)

Reduction in hazard (1)

No change

Increase in hazard (1)

Increase in hazard (2)

Increase in hazard (3)

Increase in hazard (4)

Newly flooded

Floodplain extent





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GISBORNE DISTRICT COUNCIL

PROJECT

TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT

TITLE

HAZARD DIFFERENCE - OVER-DESIGN EVENT

SCALE (A4)

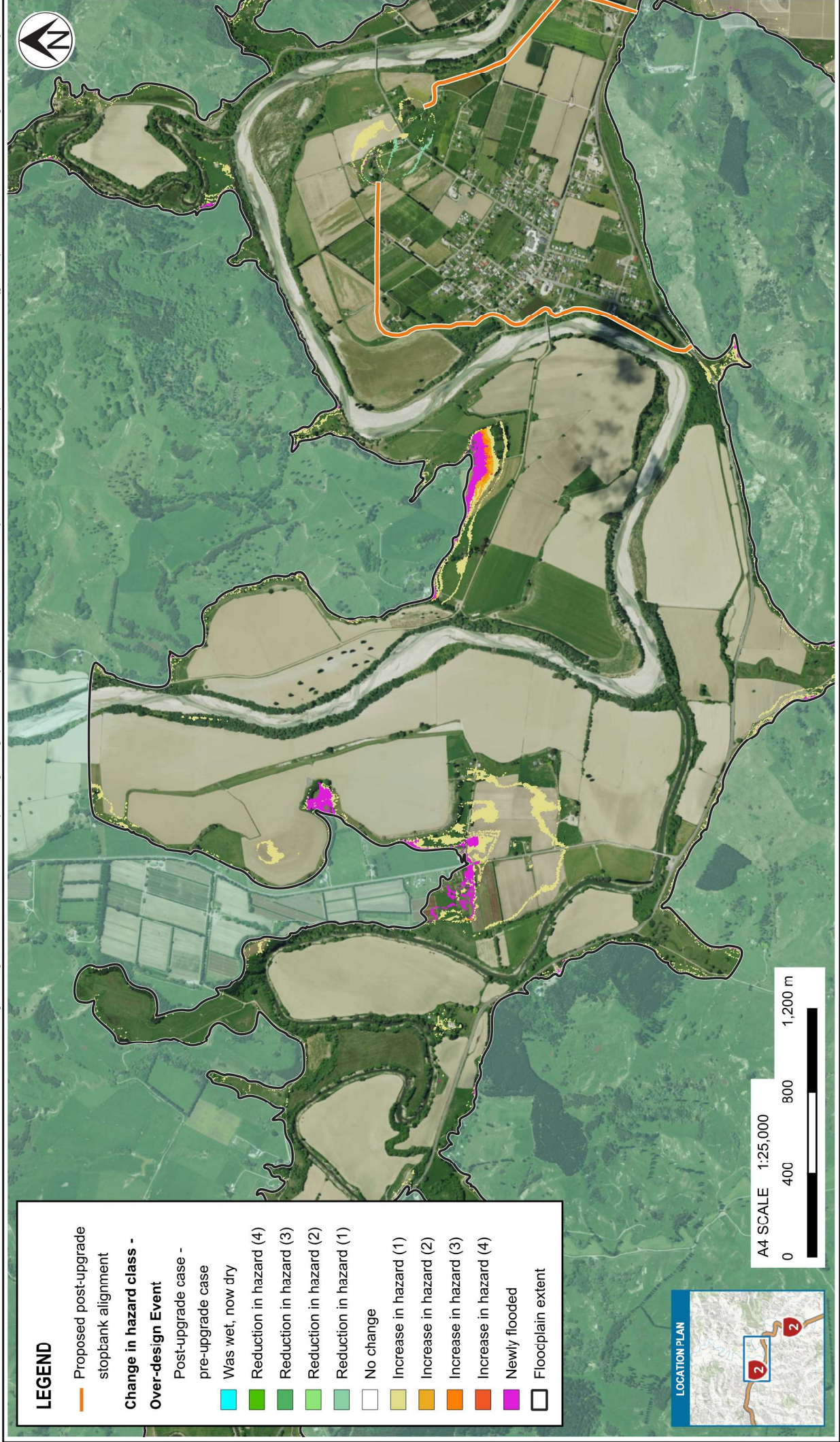
1:25,000

FIG No.

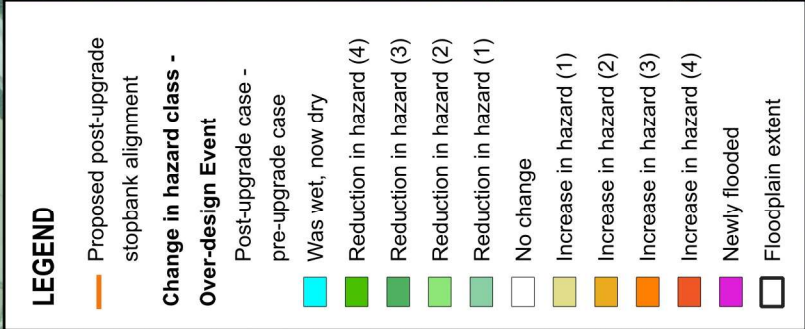
FIGURE 10.1

REV

0



 Tonkin +Taylor www.tonkintaylor.co.nz Exceptional thinking together		NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.		REVISIONS		NO.		BY		PROJECT No. 1092556.0020		CLIENT GISBORNE DISTRICT COUNCIL							
				First version (13/04/2026)		0		MAAD		DESIGNED DRAWN CHECKED		MAAD MAAD DASO		APR.26 APR.26 APR.26		PROJECT TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT			
																TITLE HAZARD DIFFERENCE - OVER-DESIGN EVENT			
														SCALE (A4) 1:25,000		FIG No. FIGURE 10.2		REV 0	



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REVISIONS		NO.	BY	PROJECT No. 1092556.0020		
First version (13/04/2026)		0	MAAD	DESIGNED	MAAD	APR.26
				DRAWN	MAAD	APR.26
				CHECKED	DASO	APR.26
						
				APPROVED	DATE	

CLIENT GISBORNE DISTRICT COUNCIL

PROJECT TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT

TITLE HAZARD DIFFERENCE - OVER-DESIGN EVENT

SCALE (A4) 1:25,000

FIG No. FIGURE 10.4

REV 0





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DATE

CLIENT **GISBORNE DISTRICT COUNCIL**

PROJECT **TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT**

TITLE **HAZARD DIFFERENCE - OVER-DESIGN EVENT**

SCALE (A4) **1:25,000**

FIG No. **FIGURE 10.5**

REV **0**

Appendix E Land parcel details.

- Attached file – MS Office Excel Spreadsheet - “Appendix E – Land Parcel Details.xlsx”

Appendix F Building details

- Attached file – MS Office Excel Spreadsheet - “Appendix F – Building Details.xlsx”

Appendix G Alternate alignment – peak flood depth difference maps

- **Figure 11 – Peak flood depth difference – Design Event – Alternate Alignment – Rev 0.**



LEGEND

- Proposed post-upgrade stopbank alignment
- Alternate alignment

Depth Difference - Design Event

Alternate alignment case - proposed post-upgrade alignment case

- Was wet, now dry
- > 1 m reduction
- 0.5 - 1 m reduction
- 0.25 - 0.5 m reduction
- 0.1 - 0.25 m reduction
- 0 - 0.1 m reduction
- No change
- 0 - 0.1 m increase
- 0.1 - 0.25 m increase
- 0.25 - 0.5 m increase
- 0.5 - 1 m increase
- > 1 m increase
- Was dry, now wet
- Floodplain extent

LOCATION PLAN



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REVISIONS

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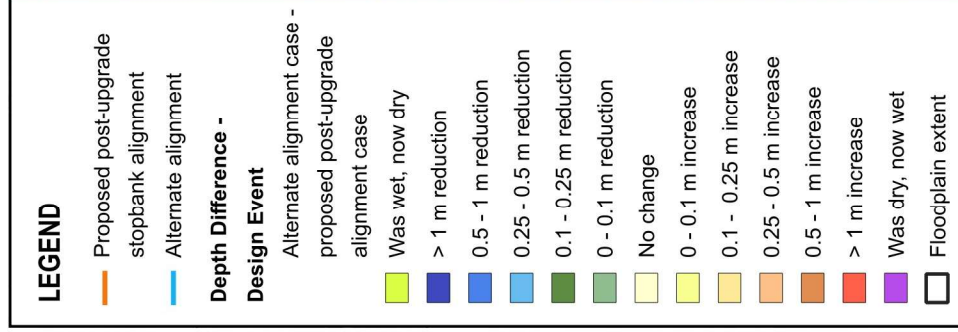
PROJECT **TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT**

TITLE **DEPTH DIFFERENCE - DESIGN EVENT - ALTERNATE ALIGNMENT**

SCALE (A4) **1:25,000**

FIG No. **FIGURE 11.1**

REV **0**



A4 SCALE 1:25,000

0 400 800 1,200 m

NOTES: Aerial Imagery: Gisborne 0.1m Rural Aerial Photos (LINZ - CC-BY 4.0) Model Result Files: Provided by DHI Group.	REVISIONS		NO.	BY	PROJECT No. 1092556.0020		CLIENT	GISBORNE DISTRICT COUNCIL				
	First version (13/04/2026)		0	MAAD	DESIGNED	MAAD	APR.26	PROJECT	TE KARAKA CONSEQUENTIAL FLOOD RISK ASSESSMENT			
					DRAWN	MAAD	APR.26					
					CHECKED	DASO	APR.26	TITLE	DEPTH DIFFERENCE - DESIGN EVENT - ALTERNATE ALIGNMENT			
								SCALE (A4)	1:25,000	FIG No.	FIGURE 11.2	REV
					APPROVED		DATE					

