ENVIRONMENT COURT OF NEW ZEALAND
WELLINGTON REGISTRY

I MUA I TE KOOTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA

ENV-2023-WLG-000005

Under	the Resource Management Act 1991
In the matter of	the direct referral of applications for resource consent and notices of requirement under sections 87G and 198E of the Act for the Ōtaki to North of Levin Project
By	Waka Kotahi NZ Transport Agency

STATEMENT OF REBUTTAL EVIDENCE OF ANDREW ROBERT CRAIG ON BEHALF OF WAKA KOTAHI NZ TRANSPORT AGENCY

Dated 10 October 2023

BUDDLE FINDLAY

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INTRODUCTION

1. My full name is **Andrew Robert Craig.**

2. I prepared a Technical Assessment F – Hydrology and Flooding (**Technical Assessment F**) regarding hydrology and flooding effects as part of the application documents of the proposed Ōtaki to North of Levin Project (**Ō2NL Project** or **Project**), dated 14 October 2023.

3. My qualifications and experience are set out in Technical Assessment F.

4. In this rebuttal evidence I use the same defined terms as in my Technical Assessment F.

5. I confirm that I have read the Code of Conduct for expert witnesses contained in section 9 of the Environment Court Practice Note 2023. This evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

6. This rebuttal evidence responds to points made in evidence by:

   (a) Ms Anna Carter and Mrs Karen Prouse, the Prouse Trust Partnership, Mr Stephen and Mrs Karen Prouse;

   (b) Mr Peter Kinley, representing Manawatū-Whanganui Regional Council (**Horizons**) and Greater Wellington Regional Council (**GWRC**); and

   (c) Mr John McArthur, representing Horowhenua District Council (**HDC**) and Kapiti Coast District Council (**KCDC**).

EXECUTIVE SUMMARY

7. I continue to stand by the modelling and my opinion expressed through Technical Assessment F, including the precautionary use of the 1:100 AEP event with climate change RCP6.0 to 2130 which is approximately 25% larger (and with commensurately larger effects) than the 1:200 AEP event required by the One Plan.

8. I have read the Evidence of Dr Jack McConchie and am in general support of his observations, many of which I helped to inform through the modelling presented in Technical Assessment F.

9. I have read the Hydrology and Flooding Joint Witness Statement (**JWS**). I was not an attendee or signatory to the JWS, but I agree with the agreed position stated within it that "a condition relating to habitable floor levels would be appropriate".

10. I have worked with the Waka Kotahi NZ Transport Agency (**Waka Kotahi**) Project team and specifically Ms Ainsley McLeod and Dr Jack McConchie on the development of the latest conditions proposed by Waka Kotahi. It is my opinion that the proposed conditions on internal flooding level of an existing habitable floor and the requirement for general accordance with the latest model results, [as captured in the RGA condition sets] provide an appropriate level of certainty of the maximum level of effects within which the detailed design should be developed.

11. Urban or rural residential areas that have higher density of habitable floors will be protected by the proposed conditions, since achieving the 10mm tolerance will result in most of the intervening areas between nearby buildings being well below 50mm. The same condition, applied in conjunction with good design practice by Waka Kotahi, will also avoid or minimise any significant downstream cumulative effects.

12. Regarding localised effects upstream of the Project, I am confident that the detailed design will be able to improve upon my modelled results in many locations by refinements to the design. However, in the context of this Project, I do not support the conditions proposed by Councils requiring 50mm or 100mm to be achieved in urban or rural zoned land respectively where there is no existing building present. The key reasons for my position are:

    (a) Waka Kotahi and the Project construction alliances will continue to make all reasonable efforts to minimise effects through design refinements, guided by their own design standards and the CEDF.

    (b) The Councils and in particular Mr Kinley expressed 'concern' at potential 'unacceptable' effects but have failed to provide any evidence of actual quantifiable effects that would justify the setting of the thresholds that they have proposed. I am unaware of any robust effects justification for the levels that are proposed.

    (c) It is my opinion that well managed pasture has some natural tolerance to rare and short duration flooding exceeding the thresholds suggested by the submitters. A desktop literature review provided limited scientific

evidence on the impacts of short duration flooding, apart from optimising production from deliberate flood irrigation. However, Paulik et al[1] found by actual observations after a major flood event that "Pasture die off occurred when flood inundation duration exceeded five days". Such long durations of flooding do not occur at or near the designation on account of the Project.

(d) There are some locations along the Project's 24km alignment where meeting 50mm or 100mm thresholds proposed by Councils could result in unnecessarily large and intrusive infrastructure with greater other or combined adverse effects (such as material supply, carbon emissions, noise, landscape and visual impacts, ecological and fish passage impacts, and unnecessary cost implications). Seeking to meet these thresholds via large intrusive infrastructure to avoid a hydrological change that in my opinion is less than minor would, in my opinion, not be treating the Whenua with respect. I address specific locations (identified based on the current concept design modelling) in more detail in response to the submitters below and in **Appendix A**.

RESPONSE TO MS CARTER AND MRS PROUSE

Additional culverts to reduce potential flooding

13. Since the production of the concept design drawings and Technical Assessment F, I have tested the potential for refinements to the design to reduce the extent of flooding on the Prouse property at 1024 Queen Street East, to explore how detailed design may suitably address flooding effects. This includes consideration of that portion proposed to be leased for construction that will later be returned to the Prouse estate.

14. Additional culverts were added to the model, with their locations based on natural concentrations of overland flow observed in the baseline model (without Ō2NL Project).

15. The 'bund' that separates overland flows from the highway swales has been moved closer to the highway and integrated with the Shared Use Path (**SUP**) (i.e., the SUP sits on top of the bund). This is the logical design arrangement

[1] Paulik, R., Crowley, K., Cradock-Henry, N. A., Wilson, T. M., & McSporran, A. (2021). Flood Impacts on Dairy Farms in the Bay of Plenty Region, New Zealand. Climate, 9(2), 30. MDPI AG. Retrieved from http://dx.doi.org/10.3390/cli9020030

but had not yet been applied at sufficient detail in the original concept design model.

16. The revised modelling shown below indicates that a substantial reduction in flood levels can be achieved for the 1:100 AEP flood event with climate change, when compared to the original concept results in Technical Assessment F. There are some design details such as the size and form of stilling basins and/or inlet trash screens that are not yet optimised. Whilst the design will be refined further through detailed design, this modelling indicates the sort of performance that is likely to be achieved.

17. Reasonable endeavours will be made by Waka Kotahi designers to further minimise any increases in flood level. The conditions proposed and attached to Ms McLeod's evidence include wording to ensure detailed design continues to lessen flooding effects as far as reasonably practicable.

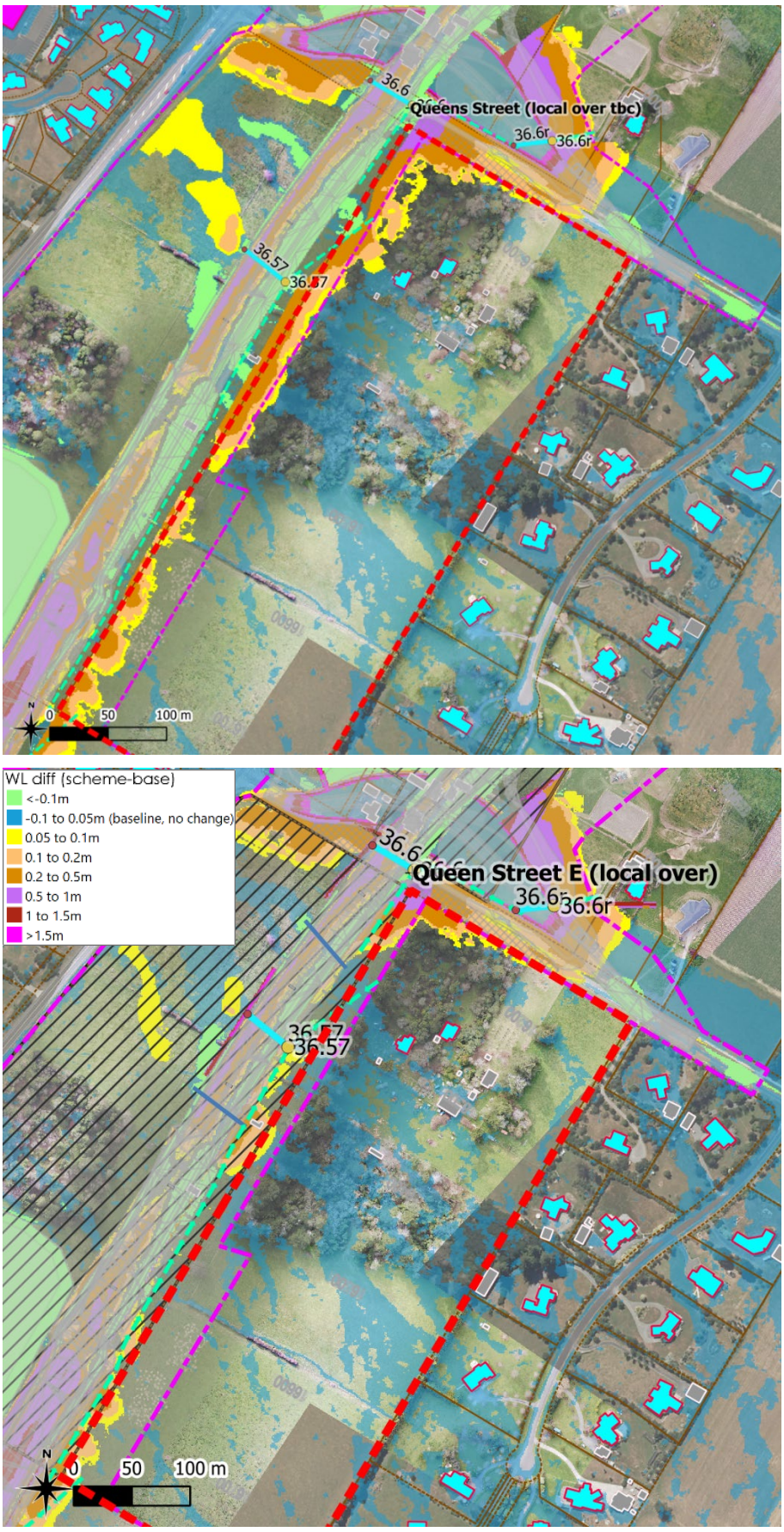


Figure 1: Prouse property 1:100 AEP flood event with climate change (top image original results, bottom image with additional culverts)

18. Statements made by Mr Kinley referenced by Mrs Prouse (paragraph 31), and Ms Carter (paragraphs 62-65) were made by Mr Kinley before the more recent assessment with additional culverts. I therefore regard the references to Mr Kinley's statements as superseded by the modelling results shown above.

19. Ms Carter seems to have incorrectly interpreted my flood mapping outputs in her paragraph 20(g) where she suggests baseline depths on the property "between 0.01m (10mm) and 0.05m (50mm)". Baseline model depths exceed 0.2m in places along both the designation boundary and the property boundary. The blue colour shown on the 'difference' images labelled '-0.1 to 0.05m (baseline, no change)' are showing those areas that are already wet (>0.05m) in the baseline model, and where the ***difference*** between with and without project is within this narrow band from -0.1m to +0.05m (to account for model tolerance), reflecting no change from the status quo. This does not imply that the baseline depths are -0.1m to +0.05m.

20. The modelled water level increase at the northern corner of the Prouse property (shown in the Figure 2 below) for the 1:200 AEP current climate (the event magnitude referenced in the One Plan) is 0.2m with the additional culverts in place. Any other locations of increased flood level along the property boundary will be less than this magnitude.

Figure 2: Northern corner of the Prouse property (looking south) where greatest increase in flood level occurs

21. Given the existing pastural land use shown in the photo, and its occasional use as an accessway to the rear paddock[2], I consider the land use would be reasonably tolerant to slight, localised and short duration increases in flood

[2] Evidence of Ms Anna Carter on behalf of Prouse Trust Partnership, Mrs Karen and Mr Stephen Prouse, at [59]

levels during rare flood events. Therefore, I consider this effect less than minor from the perspective of hydrology and flooding.

22. As indicated in my summary, I do not support a condition as indicated by Mrs Prouse[3] constraining effects to less than 50mm increase in flood level which could result in other perverse outcomes or effects in order to avoid this less than minor effect.

RESPONSE TO MR KINLEY

Selection of the threshold to identify effects

23. Whilst not a numbered paragraph, I notice the heading that Mr Kinley has used above paragraph 22, which I have repeated above. Conceptually I agree with using relatively tight threshold(s) to ***identify*** changes in model results, but as I indicated in my Technical Assessment F,[4] the intention is to then evaluate whether the identified changes are potentially acceptable based on land use and morphological context.

24. The lack of flood hazard conditions as raised by Mr Kinley[5] has in my opinion been addressed by the latest conditions proposed by Waka Kotahi.

25. Mr Kinley regards some instances of the modelled change in flood level to be 'unacceptable.'[6] However, he has provided no evidence as to the basis for the change being unacceptable. Thus, the thresholds that he proposes have no supporting evidence.

26. Mr Kinley mentions that he has identified 40 properties above what he considers reasonable thresholds.[7] For discussion on these properties, I refer to my Appendix A. Since the results Mr Kinley evaluated, additional improvements have been made at some locations (such as the Prouse property and in the vicinity of culvert 35.3 at 379 Arapaepae Road), and other locations are likely to be improved through detailed design in line with Waka Kotahi guidance, specifications, the CEDF and conditions. However, I do not support the notion that all rural zoned areas should require a blanket tolerance of 0.1m increase in flood level. I consider most of the land use would be reasonably tolerant to slight, localised and short duration increases in flood levels during rare flood events. My view is informed by Paulik et al[8]

[3] Evidence of Mrs Karen Prouse on behalf of herself, Prouse Trust Partnership and Mr Stephen Prouse at [35].
[4] Technical Assessment F, at [118].
[5] Evidence of Mr Peter Kinley on behalf of Horizons and GWRC at [22].
[6] Evidence of Mr Peter Kinley at [30], [33](b) and [36].
[7] Evidence of Mr Peter Kinley at [36].
[8] Above, n 1.

who found from actual observations after a major flood event that “Pasture die off occurred when flood inundation duration exceeded five days”. Such long durations of flooding do not occur at or near the proposed designations on account of the Ō2NL Project. I provide further site-specific context in Appendix A.

27. In his evidence, Mr Kinley makes reference to the Waka Kotahi P46 and the Bridge Manual.[9] Mr Kinley has quoted both guidance documents as seeking to not cause or create ‘unacceptable’ effects outside of the designation. Neither these guidance documents nor Mr Kinley provide an evidence-based approach for setting ‘unacceptable’ effects thresholds. Therefore, in my opinion consideration should be given to land use and morphological context, with reference to available supporting evidence as I have provided above. .

28. In his evidence, Mr Kinley states:[10]

> *“Flooding of non-urban land can have effects apart from the increase in flood levels and increase flood durations. Flood levels are a useful proxy for increased flood frequency. An increase in flood depth also increases the area that is impacted. Further, when flooding occurs more often, the ground becomes wetter. This can lead to lower value pasture, can be subject to pugging which decreases pasture life and can create sediment-laden runoff, and could lead to increased maintenance requirements for farm infrastructure. More frequent flooding with greater depths can also increase the effort required to clean up after each flood. An increase in flood depth will also increase the area that is subject to these effects.”*

It is my opinion that Mr Kinley is overstating a number of aspects here. Pugging (soil compaction and pore structure damage by stock or heavy vehicles) can happen anywhere when the soil is sufficiently wet. This level of saturation can occur a few times year in well drained soils to many times a year in poorly drained soils. The Ō2NL Project will not change the level or extent of pugging risk in such frequent events, since effects in such frequent events are contained within the designation. The Ō2NL Project will not change the level or extent of pugging risk in rare events as soils will be saturated everywhere and the presence of deeper water for an hour or two

[9] Evidence of Mr Peter Kinley at [37].
[10] Evidence of Mr Peter Kinley at [41](d).

will not cause any additional damage from water or from pugging. This is not a basis to set the thresholds proposed by Mr Kinley.

Habitable buildings

29. I consider this matter addressed through the latest proposed conditions.

30. In response to Mr Kinley's paragraphs 47-49 on demonstrating no increase in internal habitable floors, I am happy with the condition proposed by Waka Kotahi, and that it is easy to demonstrate. All existing building perimeters can be first screened for an increase of >0.01m in flood level, and a filter then applied to remove those where surrounding depths are less than a minimum threshold above surrounding terrain. Those buildings that remain potentially at risk could at the discretion of the Alliance be surveyed remotely by drone, but the method and final results would be shared transparently with the regulator and in my opinion do not need additional wording to form the condition of consent.

Flooding flow velocity

31. The velocity concerns initially raised by Mr McArthur regarding flow velocities arose due to some model errors away from the Project area of influence. I discussed these sites with Mr Kinley and Mr McArthur on 6 September 2023, and the meeting agreed that these sites were no longer a concern. This view is also reflected in Mr McArthur's evidence.[11] I therefore consider this matter resolved, and in my opinion a condition relating to velocity or hazard is not necessary.

RESPONSE TO MR MCARTHUR

32. I agree with Mr McArthur's paragraph 11 opinion[12] that "*acceptable velocity and flood duration impacts outside of the designation boundaries can be achieved during the detailed design of the Project under 1% AEP design storm conditions incorporating current climate change estimates out to 2130.*" However, Mr McArthur does not provide an evidence basis for the velocity or hazard thresholds proposed by the Councils. The velocity concerns initially raised by Mr McArthur regarding flow velocities arose due to some model errors away from the Project area of influence. I discussed these sites with Mr Kinley and Mr McArthur on 6 September 2023, and the meeting agreed that these sites were no longer a concern. This view is reflected in Mr

[11] Evidence of Mr John McArthur on behalf of HDC and KCDC at [11].
[12] Evidence of Mr John McArthur on behalf of HDC and KCDC at [11].

McArthur's evidence as quoted above. In my opinion a condition relating to velocity or hazard is not necessary.

33. Mr McArthur suggests that the Project may "*increase the frequency of ponding and nuisance flooding*".[13] The events in question are very rare, as the Project does not cause any 'ponding' upstream of culverts to extend beyond the designation for at least 1:10 AEP. As I illustrate in Appendix A, the isolated locations where ponding or 'nuisance flooding' may occur during rare events is of short duration such as an hour or two, on rural land with no buildings present. The statement by Mr McArthur therefore does not provide an evidenced basis for setting of the threshold that Councils proposed. As I have referenced Paulik et al above,[14] I consider that the land use will have reasonable tolerance for the rare and short duration localised increases in water levels.

UPDATED MAP SET

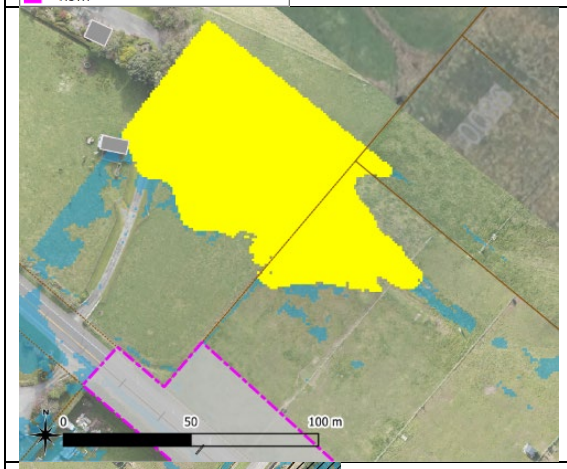
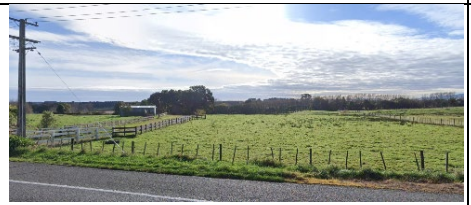
34. Updated map set for the 1:100 AEP event with climate change RCP6.0 to 2130 are included as **Appendix B**. These show the updated envelope of effects having added the additional culverts to the model for the Prouse property and just south of culvert 35.3.

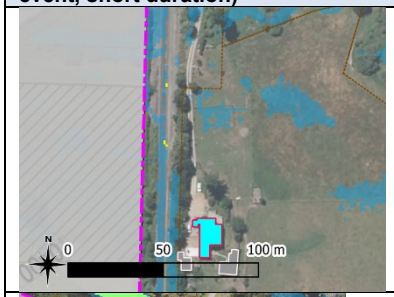
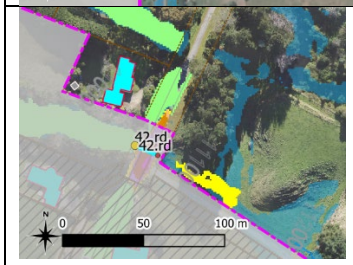
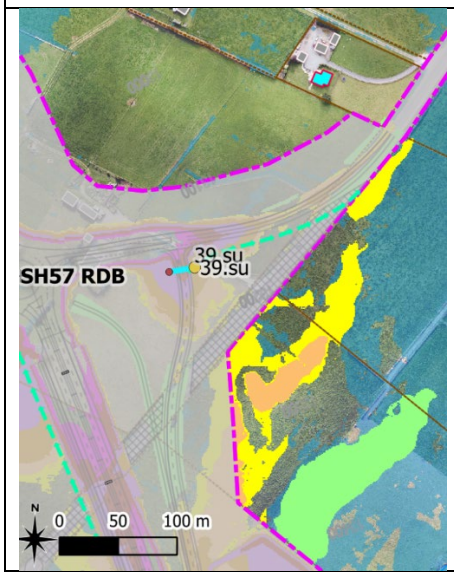
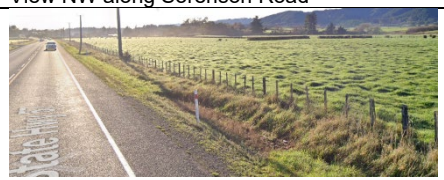
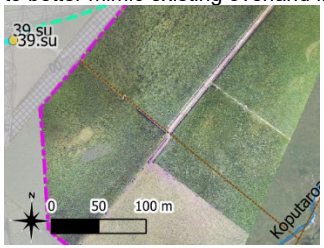
Andrew Robert Craig

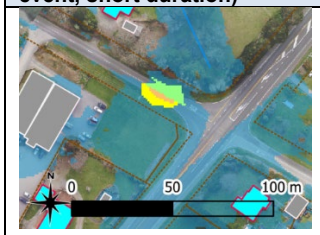
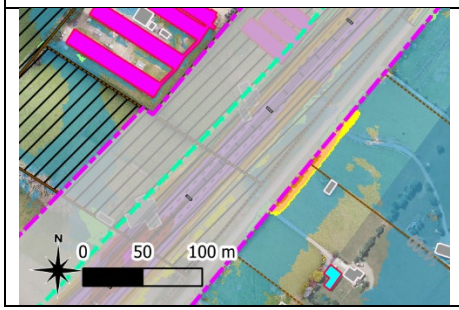
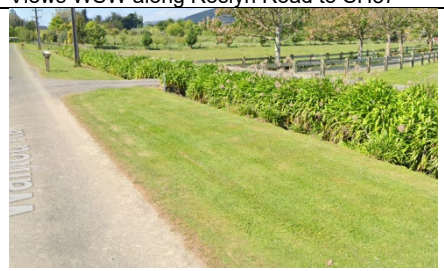
10 October 2023

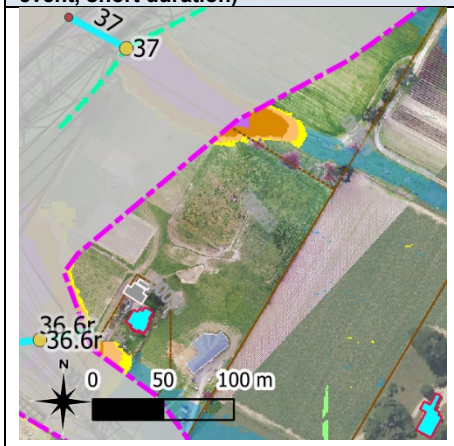
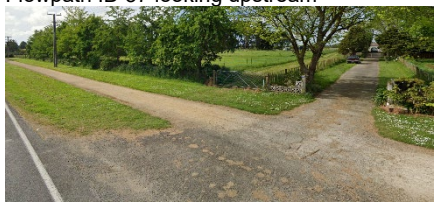
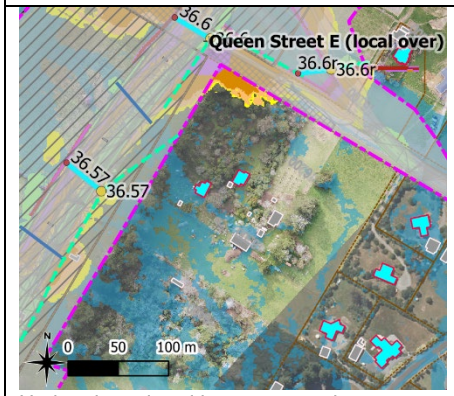
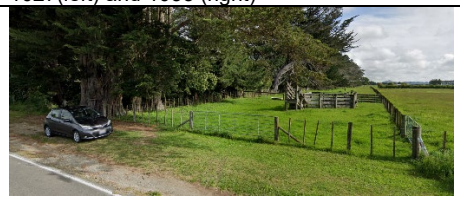
[13] Evidence of Mr John McArthur at [14].
[14] Above n 1,

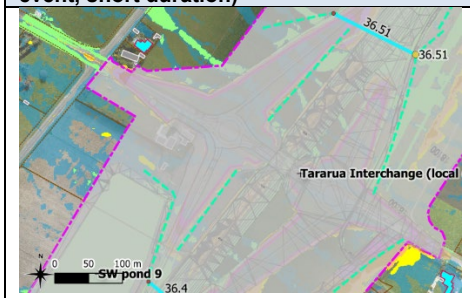
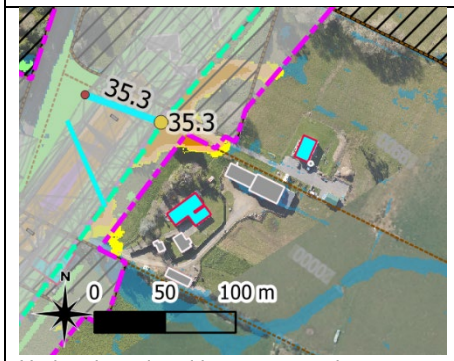
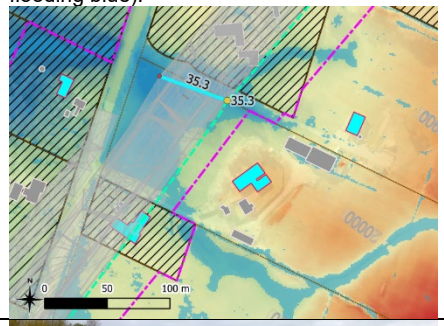
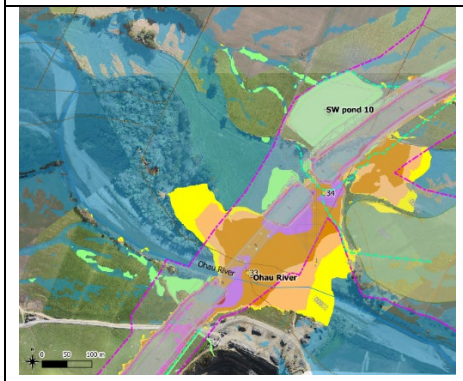
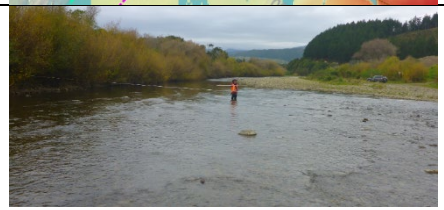
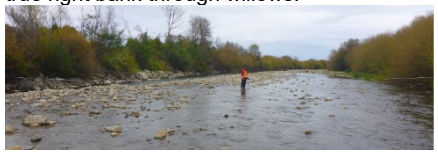
APPENDIX A: SITE SPECIFIC DISCUSSION

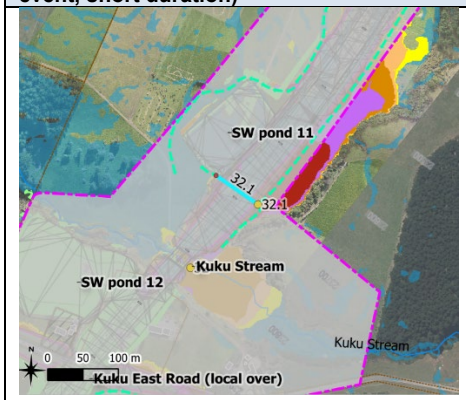
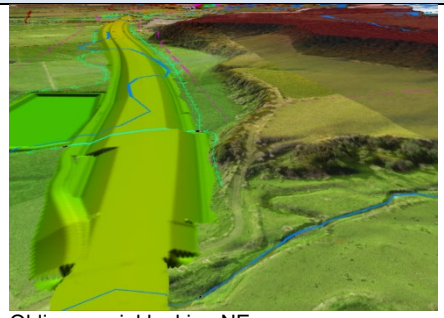
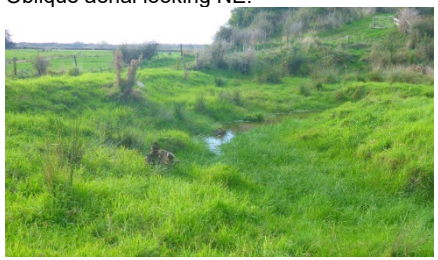
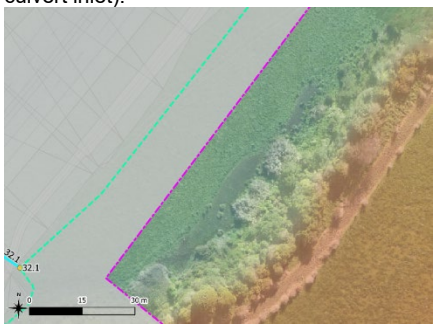
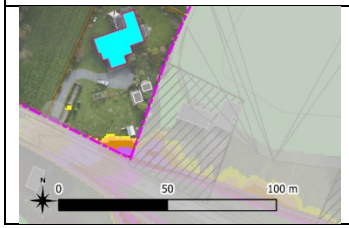
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
Legend for flood level difference in all images: WL diff (scheme-base) <-0.1m -0.1 to 0.05m (baseline, no change) 0.05 to 0.1m 0.1 to 0.2m 0.2 to 0.5m 0.5 to 1m 1 to 1.5m >1.5m	Photographs sourced from EOS Ecology Õ2NL Project team and from Google.	
	 View NE from SH1.	**250 SH1;** **1 Koputaroa Road.** **Model error.** Model boundary not set correctly (model boundary should allow flow to drain northwards, but closed boundary prevents natural drainage). To be resolved in detailed design modelling. **No effects anticipated once error corrected.**
	 View NW from Koputaroa Road	**1 Koputaroa Road**. **Model error.** Design surface & model accidentally spills beyond designation, to be resolved in detailed design. **No effects anticipated once error corrected**.

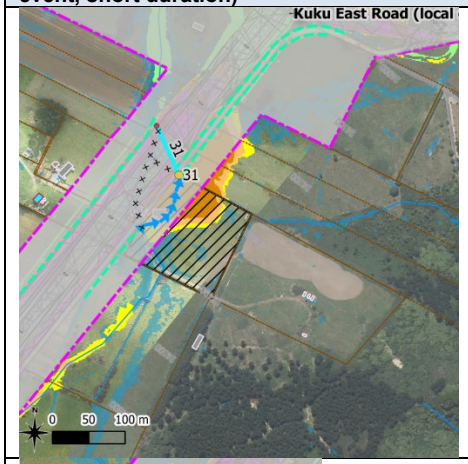
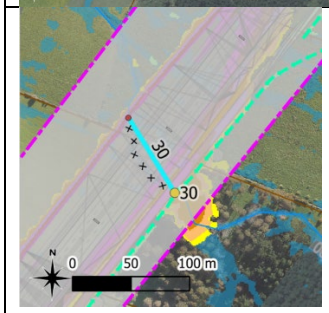
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
		**KiwiRail NIMT corridor adjacent to 46 Heatherlea Road East** **Model error.** Model noise with no surrounding differences. Can be ignored. **No effects anticipated**.
	 View NW along Sorenson Road	**Sorenson Road + 47 Sorenson Road** **Model error.** Design surface & model accidentally spills beyond designation within road corridor, to be resolved in detailed design. **No flood effects anticipated once model corrected**.
	 View WNW from SH57	**317 Arapaepae Road** Rural zoned. Increases only marginally above 0.1m in a low patch in a paddock that has occasional natural ponding. Overland flow paths around SW pond not fully optimised in **design & model**. Will likely be improved in detailed design to better mimic existing overland flowpaths to <0.1m. 

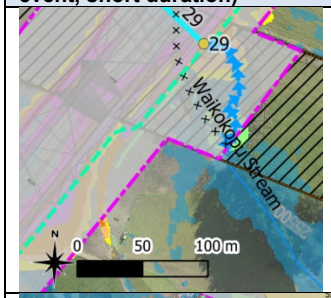
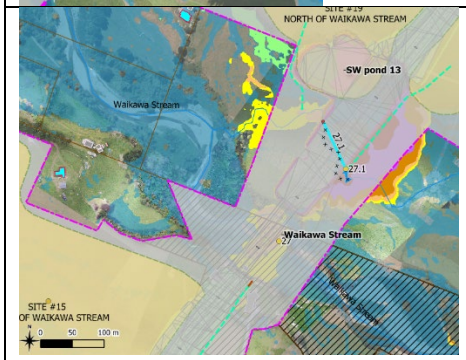
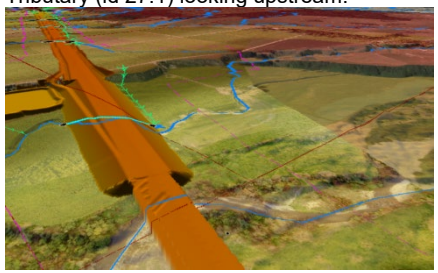
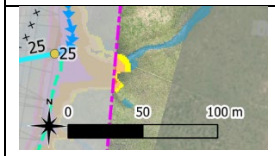
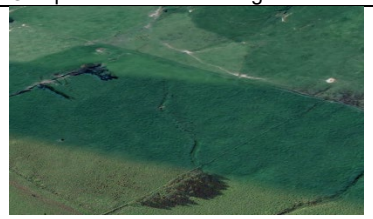
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	  Views WSW along Roslyn Road to SH57	**Roslyn Road corridor at SH57** **Model error** in one of the small culverts under the intersection (identified in checks post NoR application), will be resolved in detailed design modelling. **No flood effects anticipated once error corrected**.
		**100 and 96 Waihou Road** Rural zoned. Narrow strip approximately 100m long. **Model error**. A bund from an earlier iteration of local road design was accidentally left in model, which reduces the capacity of the swale in photograph, but the intent is to leave existing road unmodified. To be resolved in detailed design modelling. **No real flood anticipated once error corrected**.

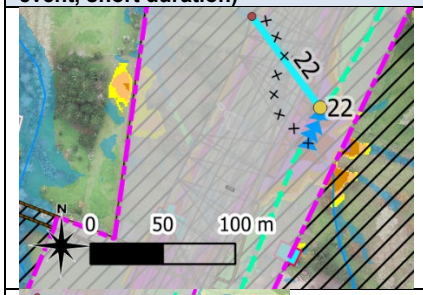
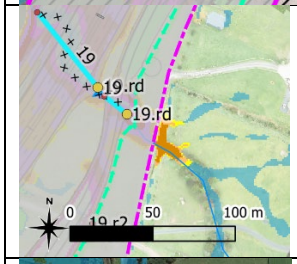
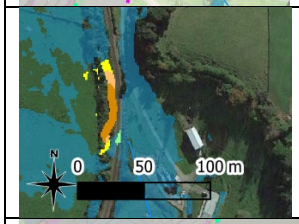
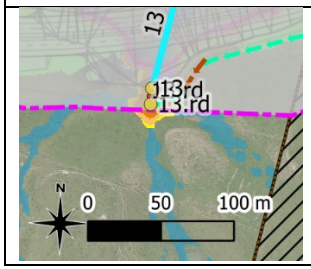
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	 Flowpath ID 37 looking upstream  View from Queens St E northwards onto 1027(left) and 1033 (right)	**34 Arapaepae Road** **1027 Queen Street East** **1033 Queen Street East** Rural zoned. Localised increase up to ~0.6m upstream of culvert 37 (34 Arapaepae in existing overland flow path), and <0.4m on 1027/1033 at designation. Likely to be reduced through detailed design and refined modelling.
 Updated results with two extra culverts.	 Corner of Prouse property looking south	**1024 Queen Street East (Prouse)** Rural zoned at time of design/modelling, pasture and tree stand. Updated with two additional culverts compared to original, shows improved results (now <0.6m). Might be possible to further reduce by improving culvert 36.6, but large peak flow hence difficult to guarantee or quantify reduction until detailed design.

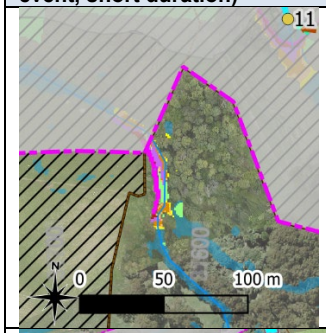
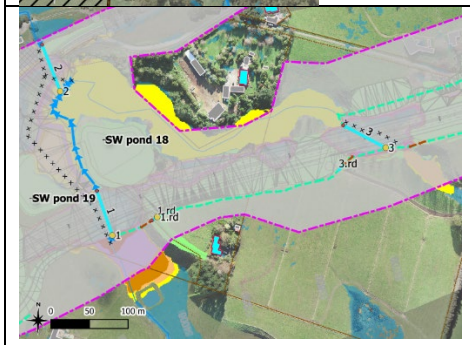
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	 246 Tararua looking west.	**Tararua Road corridor (west)** **246 Tararua Road** Both rural zoned. Flooding to the road corridor on west caused by change of local road elevation rather than flood depth, no flood effects anticipated. Flooding is anticipated at 246 Tararua Road to southeast of image outside road corridor covering 430m^2 along designation reaching a depth of circa 0.2m in the trees/swale along property boundary. Will likely be reduced in detailed design.
 Updated results with one extra culvert.	Ground view not available. Showing baseline topography (higher elevations red, baseline flooding blue). 	**379A Arapaepae Road** **379 Arapaepae Road** Rural zoned. Updated results with additional culvert now show small areas with increase <0.25m at northern corner of 397 at designation. Might be possible to further reduce the flood depth by improving culverts, but difficult to guarantee or quantify reduction until detailed design.
	 Photo looking upstream. Flow breaks out onto true right bank through willows.  Photo looking downstream, note hardening on true left bank.	**210 Muhunoa East Road** **559 SH1** **194Muhunoa East Road** Rural and hydro zone. Existing floodplains, dynamic morphological environment with historic floodplain terraces. Patch of increased flood depth to the east of 34 due to realignment of overland terraced flowpath within designation, might be possible to reduce in detailed design. Main river and immediate floodplains also see discussion and screenshots about this location in Technical Assessment F (paragraphs 124-136).

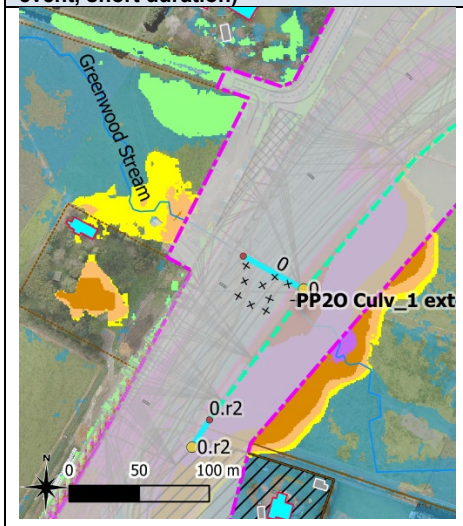
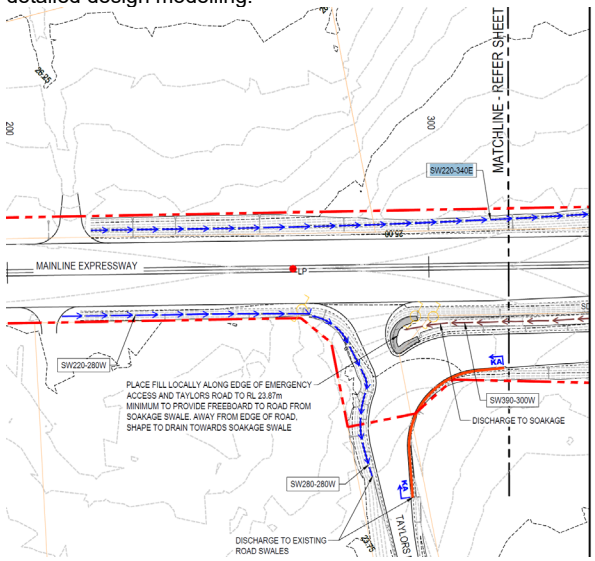
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	 Oblique aerial looking NE.  View north from river (over historic loop).	**93 Kuku East Road** Rural zone. Pasture strip at base of hill/terrace, already subject to occasional ponding (see below). Increased flooding of just over 1m in strip 22m wide and 110m long. Short duration attenuation provides slight flooding benefit to the Marae, but not yet optimised to provide benefits over range of events, which is a possible opportunity (e.g., staged culvert inlet). 
		**65 Kuku East Road** **Model error.** Design surface & model accidentally spills beyond designation, to be resolved in detailed design. **No effects anticipated once model corrected**.

1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	 View from Kuku East Road looking SSW.	**663 SH1** **669 SH1** **695 SH1** **703 SH1** Rural zone. Water level increase max 0.4m along designation. From the south, slight increase in overland flow due to some water not getting through culvert ID 30 and hence spilling toward culvert 31, likely to be improved in detailed design (this will also reduce the quantity at culvert 31).
	 View looking upstream into tree block.	**761 SH1** Rural zone. Tree block. Localised flood depth increases of 0.25m which decays to <0.1m within 15m upstream of designation.

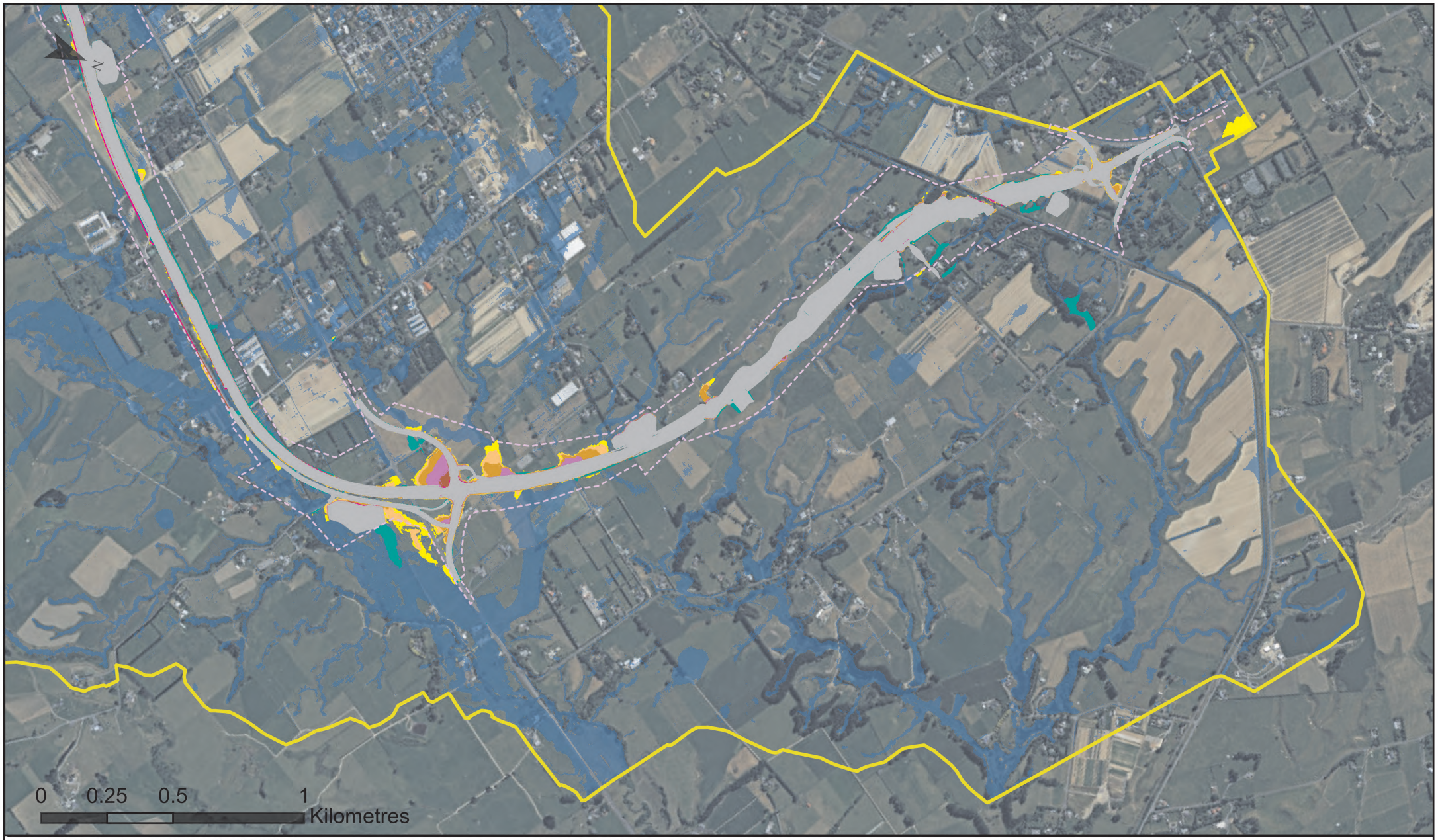
1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	No ground view available. See comments to right.	**775 SH1** **809 SH1** Rural zoned. **Model errors.** 775 SH1 very small patch of increased flood depth up to 0.12m caused by an unexpected difference in DEM (model / software issue). 809 SH1 (south of culvert ID 29) caused by change of local access track elevation in model (since superseded) rather than change in flood depth. No flood effects anticipated at both locations once the errors are corrected.
	 Tributary (id 27.1) looking upstream.  Oblique aerial view looking ENE.	**37 Martins Road** **861 SH1** Rural zone, pasture, on a natural floodplain confined by historic floodplain terraces. Upstream flood depth increase reaches 0.62m in places on designation, large peak flow from tributary plus some Waikawa floodplain flow, hence difficult to guarantee or quantify reduction until detailed design. Small patch of up to 0.13m increase downstream which could be resolved in detailed design.
	 No access. Minor flow path near centre of oblique aerial view above.	**80 North Manakau Road** Rural zone, pasture. Small patch with increase up to 0.25m along designation, approximately 20m long.

1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	No ground view available. Refer comments to right.	**53 Wi Tako Street** Rural zoned. Land upstream of culvert ID 22 is Waka Kotahi/Crown owned. Patch on west is a model error that will be resolved in detailed design. No flood effects anticipated here once error corrected.
	 No photos available upstream of access track.	**29 Eastern Rise** "Rural Other" zone. Mix grass and riparian vegetation. Due to a late change in design of access track the modelled culvert under access track is now possibly undersized. Opportunity in detailed design to review whether existing access track with existing culvert could be used (or extended if required) to reduce or resolve the upstream effects.
	No photos. Refer comments to right.	**KiwiRail corridor** **1155 SH1** **Model error.** Kiwirail corridor (swale), model mesh anomaly in swale next to railway, surrounding model flood depth differences less than 10mm. To be resolved in detailed design model. No flood effects anticipated here once error corrected.
	 View from Manukau Heights Dr looking west.	**75 Manakau Heights Dr** Rural. Increase in flood depth of up to 0.17m in lower fenced corner of property already subject to occasional ponding.
	 View in paddock looking south.	**424 SH1** Rural. Increase in flood depth of up to 0.4m in a small low-lying area of paddock.

1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	No ground view. Refer comments to right.	**415 SH1** Rural. **Model error.** Slight difference from baseline DEM inadvertently caused when migrating version of HEC-RAS. Not an effect of the Project. To be resolved in detailed design model.
	 Flowpath ID 3 looking downstream.  Flowpath ID 1 looking upstream.	**184 SH1** **114 SH1** **178 SH1** Rural, pasture. Very small patch of increased flood depth at flowpath ID 3 of up to 0.12m. At stream flowpath ID 1 flood depth increase of up to 0.6m in existing floodplain. Potential opportunity in detailed design to refine culverts 1, 2 and 3 which act as an interdependent 'system', so would need to consider hydraulic performance, possible valley wetland ecological enhancements within the designation and possible fish passage improvement at culvert 2.

1:100 AEP with climate change RCP6.0 2130 (rare event, short duration)	Ground views (where available)	WK commentary (with extra visuals where applicable)
	 View from existing SH1 looking upstream (east).	**94 SH1** **85 SH1 (WK/Crown owned)** Rural. Upstream increases in flood depth of up to 0.8m. Overestimated due to deficiency in baseline model not fully representing PP2O drainage swales that drain toward Greenwood culvert (see below). Same issue also overestimated effects downstream. Both upstream and downstream effects likely to shown much smaller once the baseline model is corrected. This will be done during detailed design modelling. 

APPENDIX B: UPDATED MAP SET OF WATER SURFACE ELEVATION DIFFERENCE FOR 1:100 AEP WITH CLIMATE CHANGE



Model Results, 1:100 AEP Water Surface Elevation Difference, Scheme Minus Baseline

This map shows the difference in maximum water surface elevations for the 1:100 AEP event with RCP 6.0 2130 climate change considerations. The North and Ohau models show differences for a 4hr event, while the South model includes both 1hr and 4hr max elevation differences.

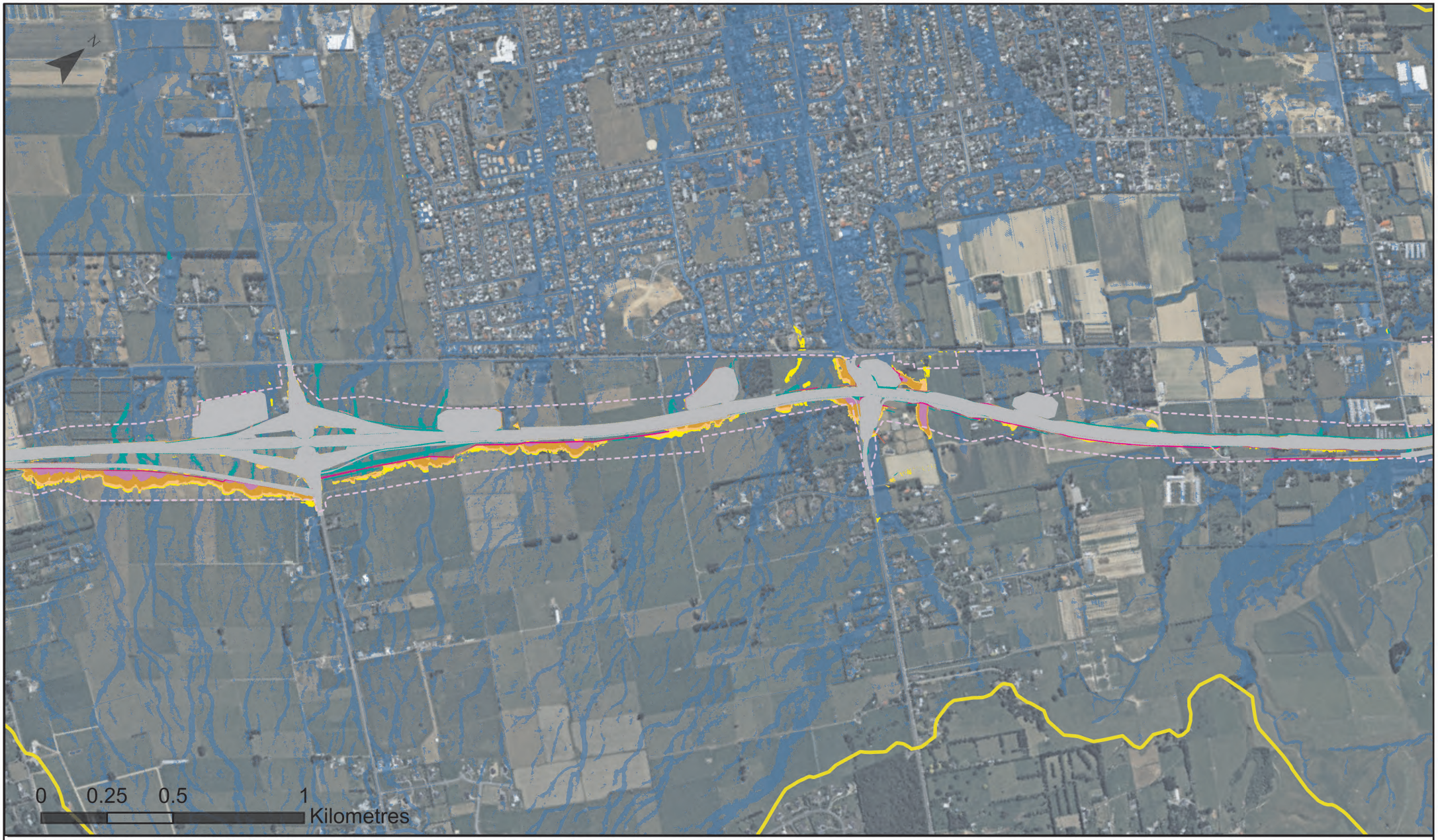
Stantec

Max WSE Difference (m)

- Less than -0.1
- -0.1 to 0.05 (baseline no change)
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- Greater than 1.5

- South Model Extent
- Ohau Model Extent
- North Model Extent
- Proposed Designation July 2022
- Concept Design Footprint

Data Sources:Basemap Service Credits: Stats NZ, Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Map displayed in NZGD 2000 New Zealand Transverse Mercator coordinate system.
Author: Stantec (2023)



Model Results, 1:100 AEP Water Surface Elevation Difference, Scheme Minus Baseline

This map shows the difference in maximum water surface elevations for the 1:100 AEP event with RCP 6.0 2130 climate change considerations. The North and Ohau models show differences for a 4hr event, while the South model includes both 1hr and 4hr max elevation differences.

Stantec

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- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- Greater than 1.5

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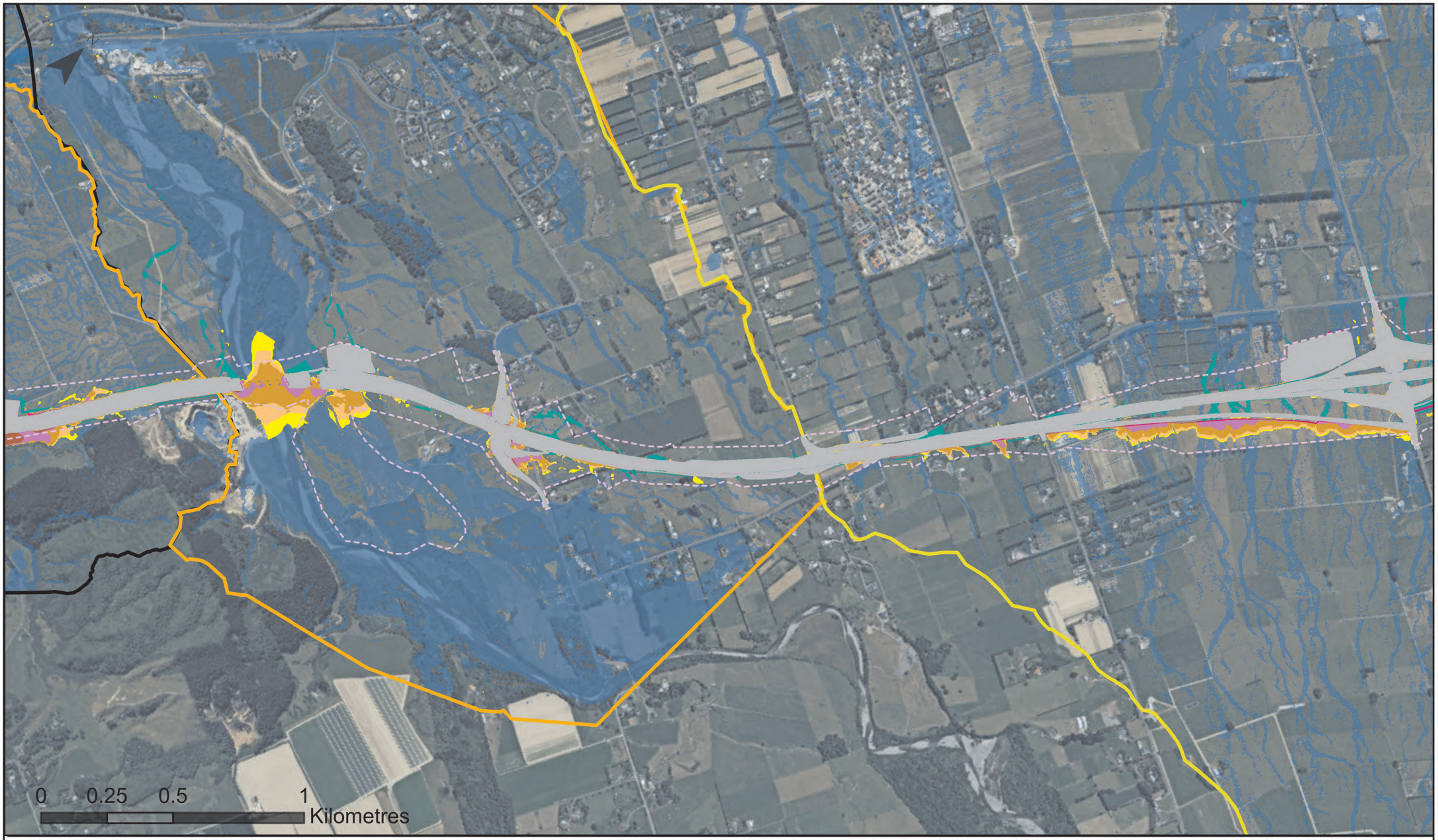
- Ohau Model Extent
- North Model Extent
- Proposed Designation July 2022
- Concept Design Footprint

Data Sources:Basemap Service Credits: Stats NZ, Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Map displayed in NZGD 2000 New Zealand Transverse Mercator coordinate system.
Author: Stantec (2023)



Model Results, 1:100 AEP Water Surface Elevation Difference, Scheme Minus Baseline

This map shows the difference in maximum water surface elevations for the 1:100 AEP event with RCP 6.0 2130 climate change considerations. The North and Ohau models show differences for a 4hr event, while the South model includes both 1hr and 4hr max elevation differences.

Stantec

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- 0.05 to 0.1
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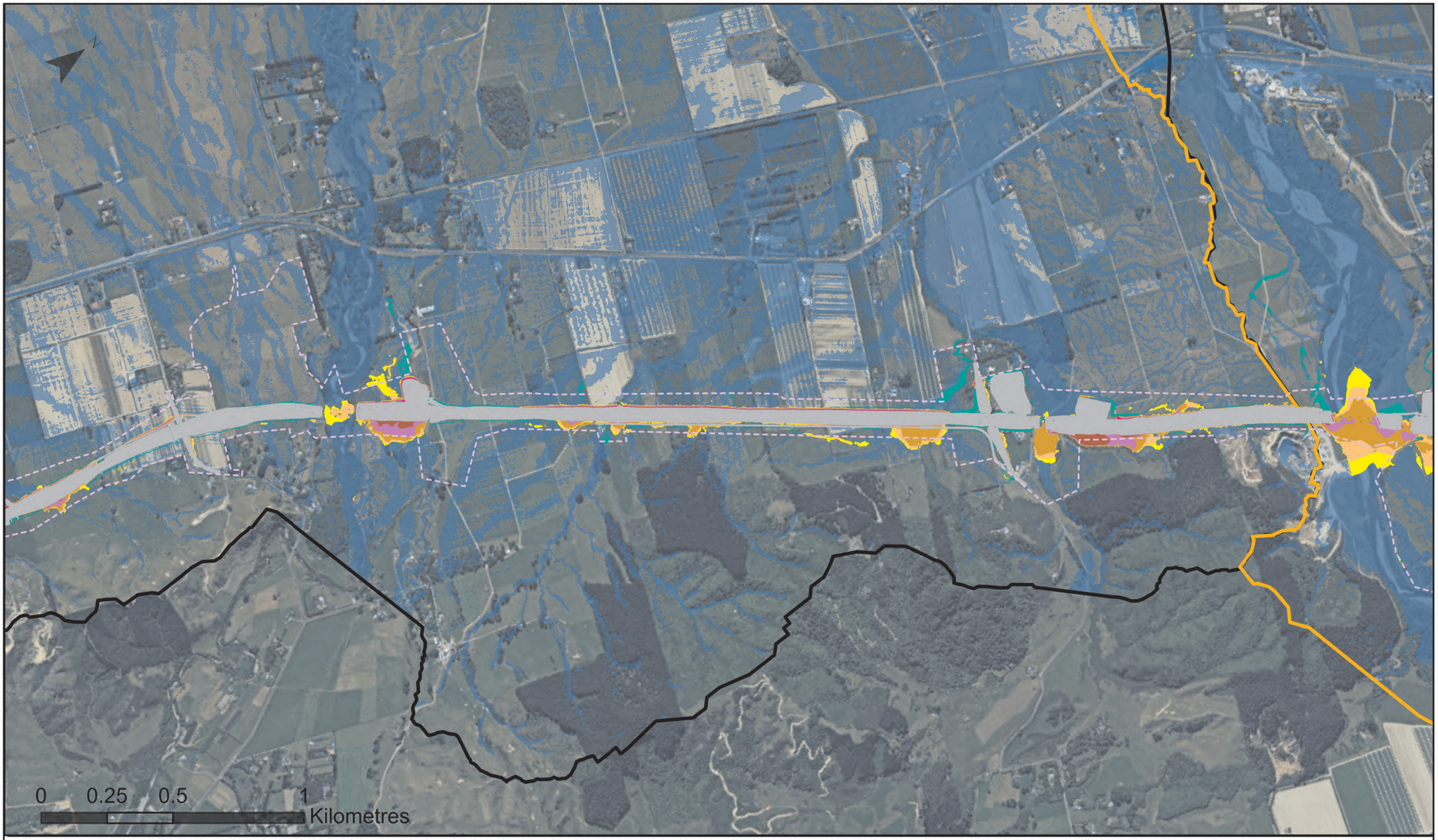
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- Greater than 1.5

- South Model Extent
- Ohau Model Extent
- North Model Extent
- Proposed Designation July 2022
- Concept Design Footprint

Data Sources:Basemap Service Credits: Stats NZ, Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Map displayed in NZGD 2000 New Zealand Transverse Mercator coordinate system.
Author: Stantec (2023)



Model Results, 1:100 AEP Water Surface Elevation Difference, Scheme Minus Baseline

This map shows the difference in maximum water surface elevations for the 1:100 AEP event with RCP 6.0 2130 climate change considerations. The North and Ohau models show differences for a 4hr event, while the South model includes both 1hr and 4hr max elevation differences.

Stantec

Max WSE Difference (m)

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- -0.1 to 0.05 (baseline no change)
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
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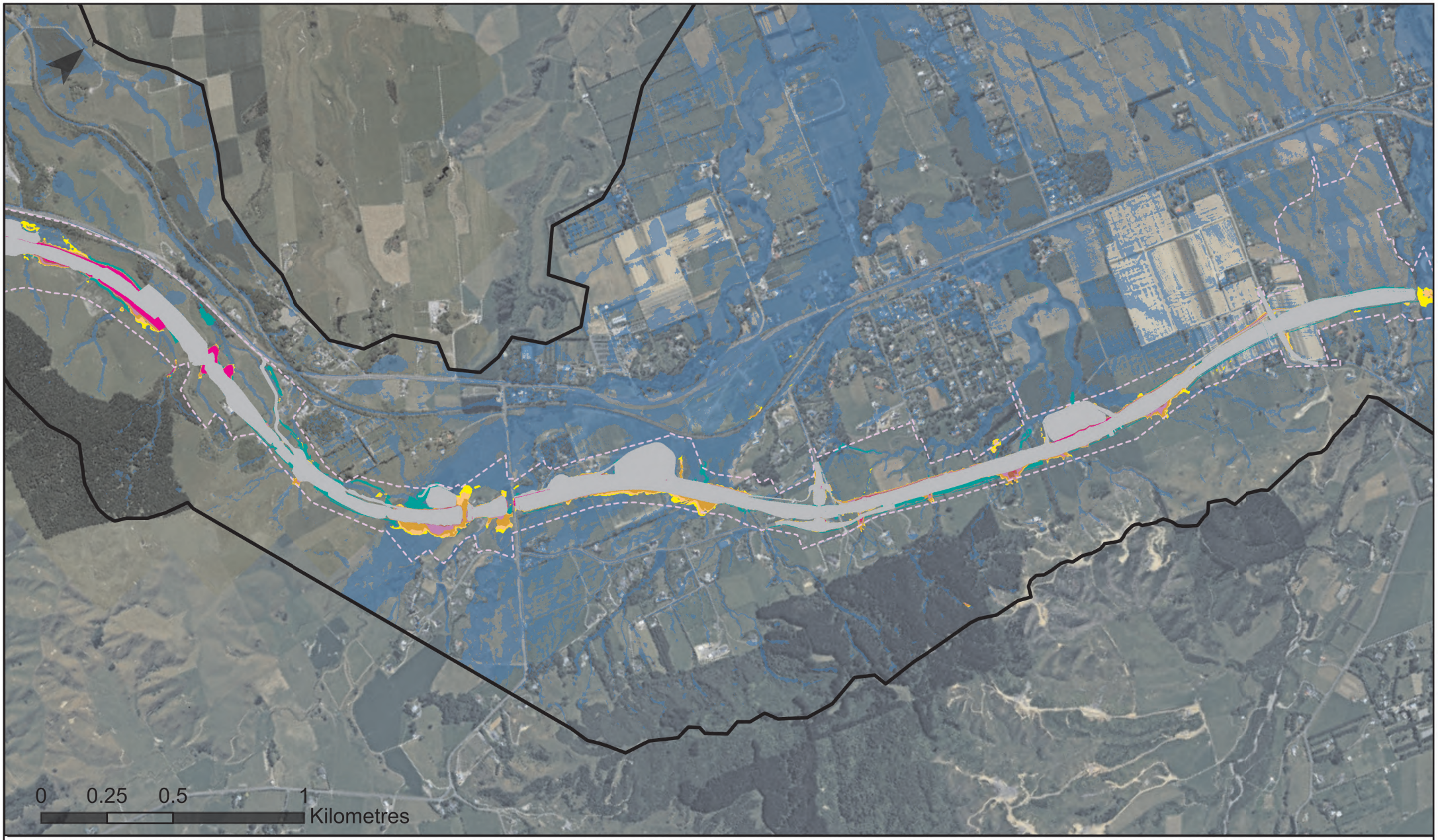
- South Model Extent
- Ohau Model Extent
- North Model Extent
- Proposed Designation July 2022
- Concept Design Footprint

Data Sources:Basemap Service Credits: Stats NZ, Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Map displayed in NZGD 2000 New Zealand Transverse Mercator coordinate system.
Author: Stantec (2023)



Model Results, 1:100 AEP Water Surface Elevation Difference, Scheme Minus Baseline

This map shows the difference in maximum water surface elevations for the 1:100 AEP event with RCP 6.0 2130 climate change considerations. The North and Ohau models show differences for a 4hr event, while the South model includes both 1hr and 4hr max elevation differences.

Stantec

Max WSE Difference (m)

- Less than -0.1
- -0.1 to 0.05 (baseline no change)
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
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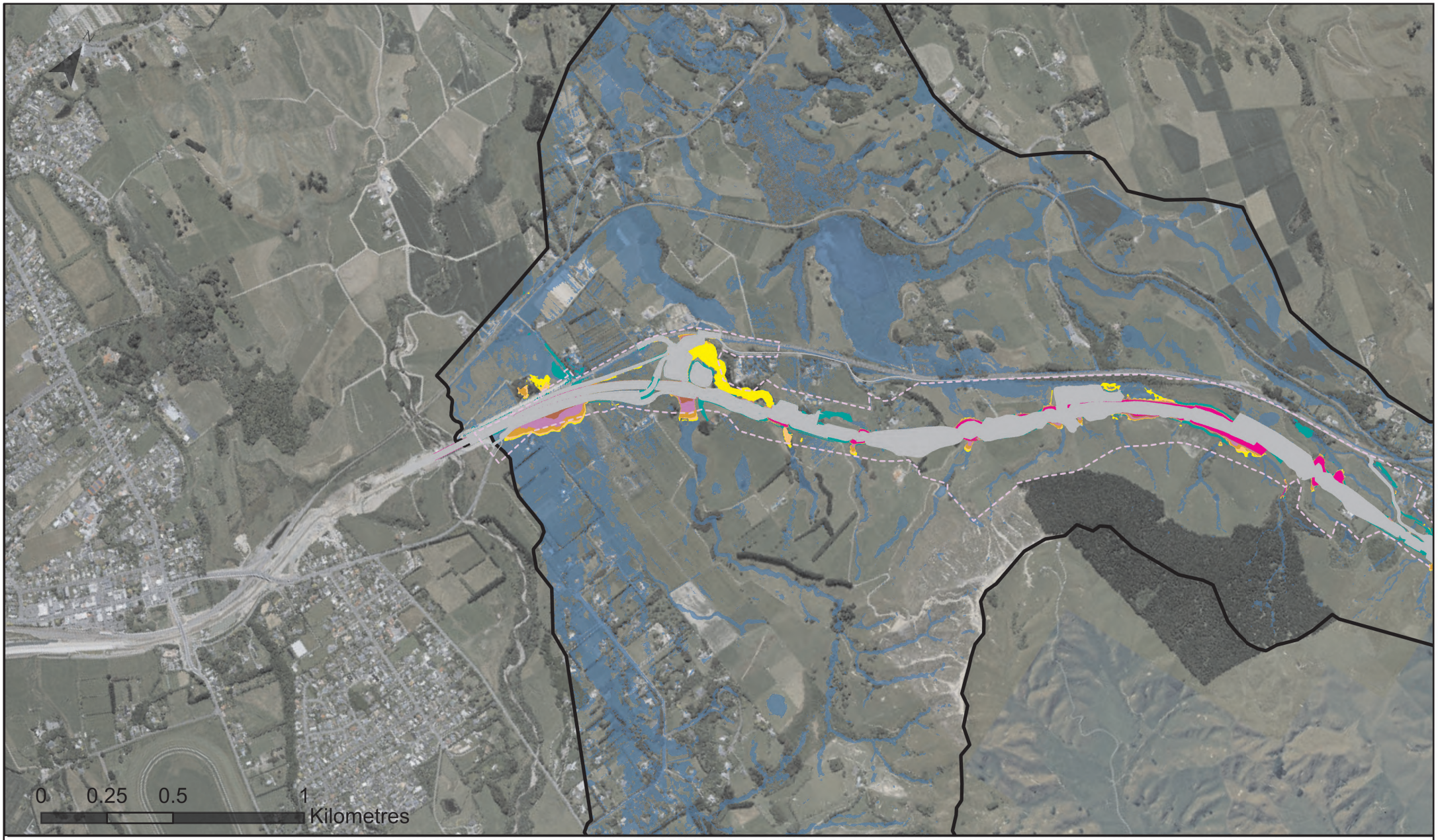
Map displayed in NZGD 2000 New Zealand Transverse Mercator coordinate system.
Author: Stantec (2023)



Model Results, 1:100 AEP Water Surface Elevation Difference, Scheme Minus Baseline

This map shows the difference in maximum water surface elevations for the 1:100 AEP event with RCP 6.0 2130 climate change considerations. The North and Ohau models show differences for a 4hr event, while the South model includes both 1hr and 4hr max elevation differences.

Stantec

Max WSE Difference (m)

- Less than -0.1
- -0.1 to 0.05 (baseline no change)
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- Greater than 1.5

- South Model Extent
- Ohau Model Extent
- North Model Extent
- Proposed Designation July 2022
- Concept Design Footprint

Data Sources:Basemap Service Credits: Stats NZ, Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Map displayed in NZGD 2000 New Zealand Transverse Mercator coordinate system.
Author: Stantec (2023)