Wellsford Plan Change – Meeting with Waka Kotahi NZTA 21/04/2022

Agenda

- Proposed development
- Work undertaken to date:
  - Flood modelling
  - Stormwater management
  - Draft Stormwater Management Plan
- Other matters

Proposed development

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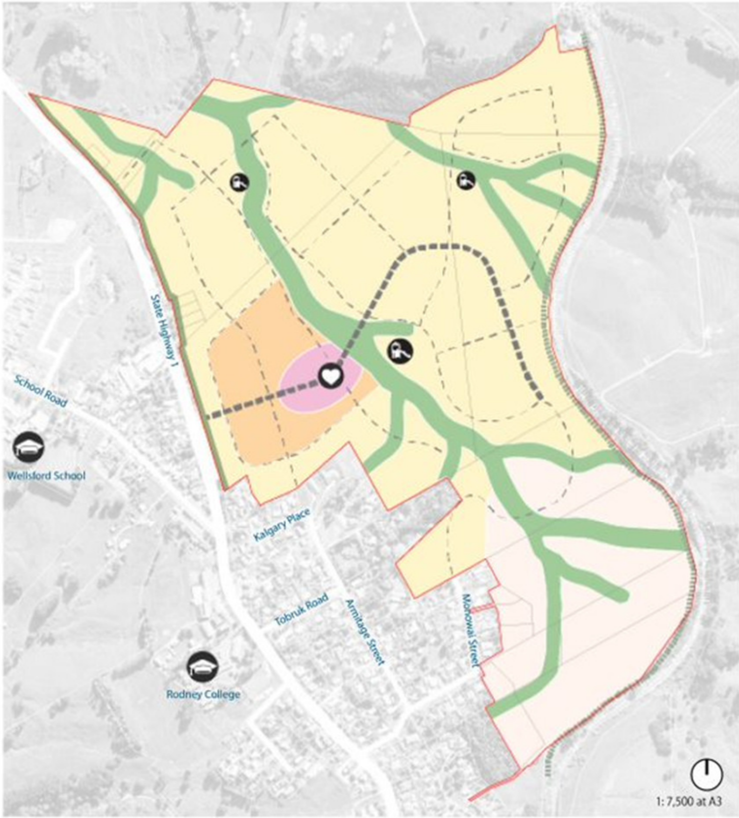
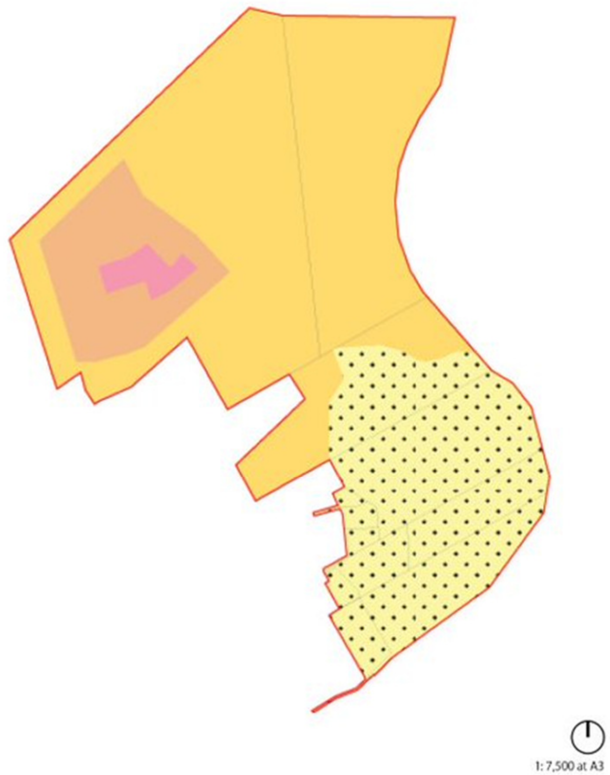
Est.1970



Structure Plan

Legend

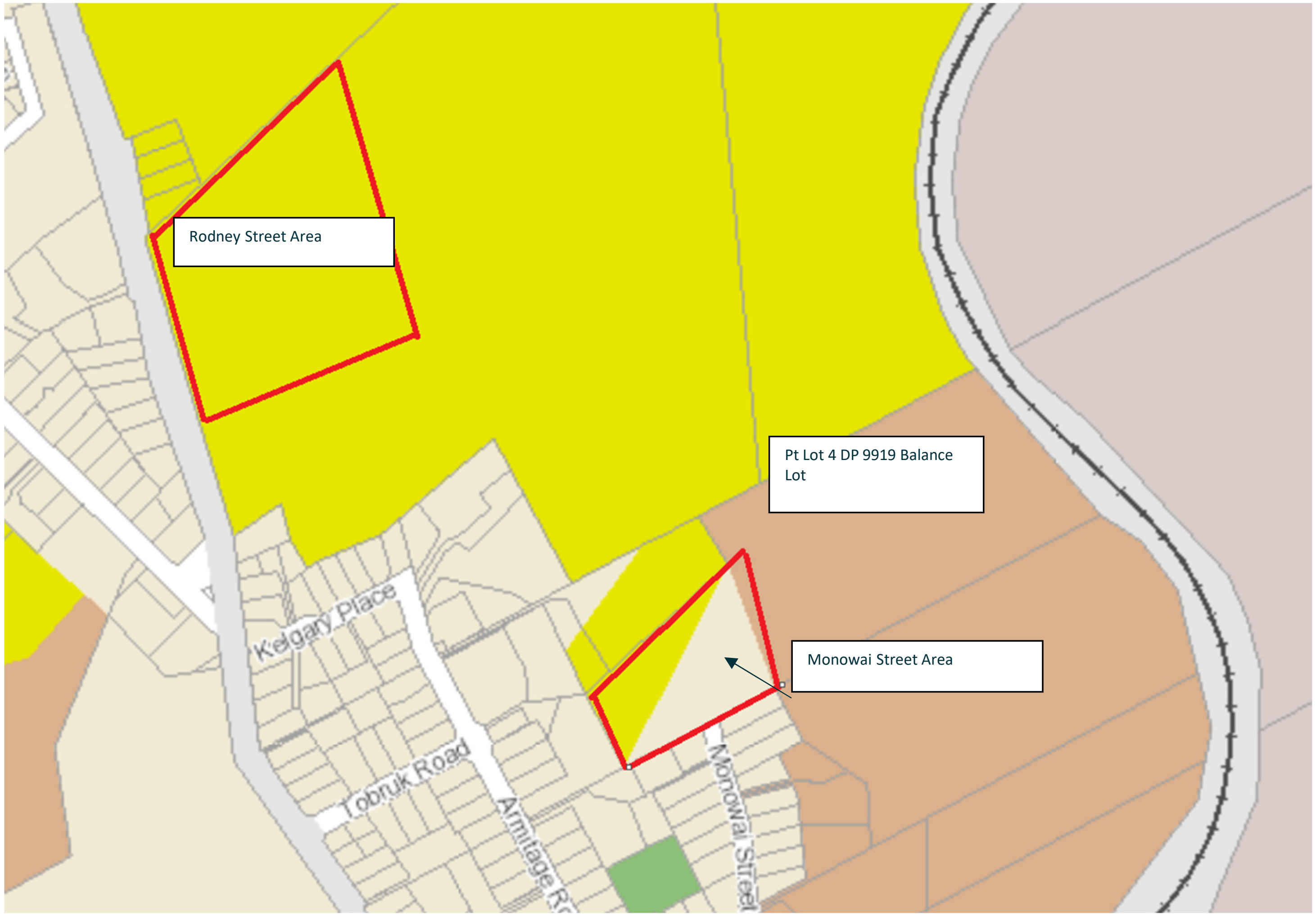
- Structure plan extent
- Property Boundary
- Indicative Lifestyle Living
- Indicative Lower Density Residential
- Indicative Medium Density Residential
- Indicative Village Centre
- Ecological Areas / Open Spaces
- Main Collector Road
- Local Streets
- Greenway Cycleway
- 10m Landscape Buffer
- Indicative Playground
- Indicative Village Centre Public Space
- Existing Schools



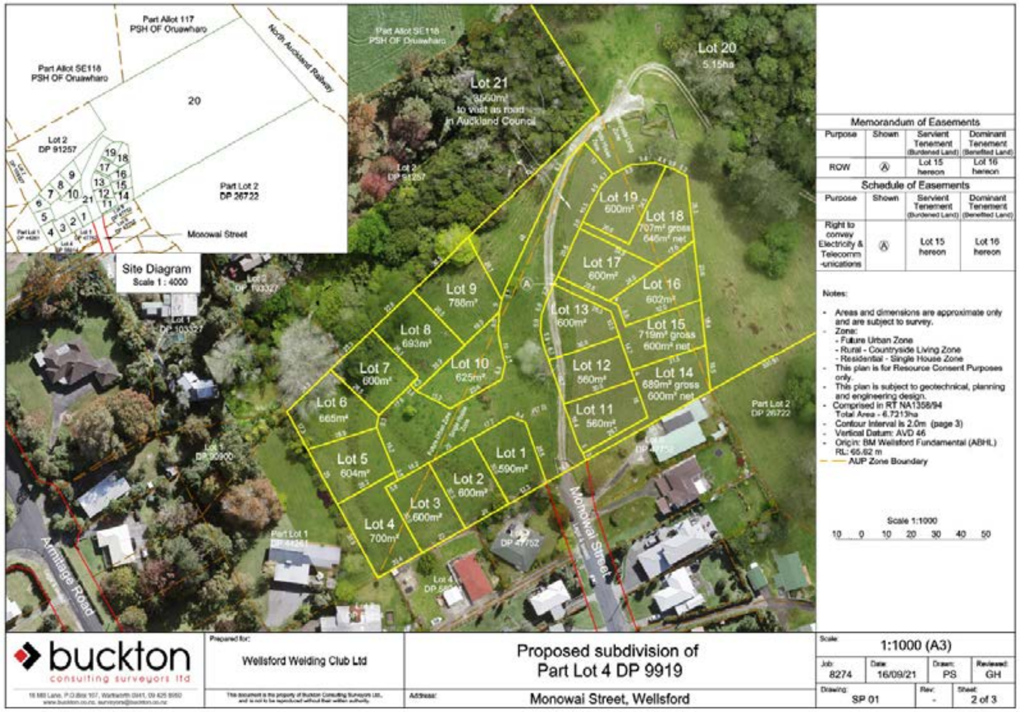
Legend

- Extent
- Existing Property Boundary
- Residential - Large Lot Zone
- Residential - Mixed Housing Suburban Zone
- Residential - Mixed Housing Urban Zone
- Business - Neighbourhood Centre Zone
- Subdivision Variation Control

Fast-Track consent application

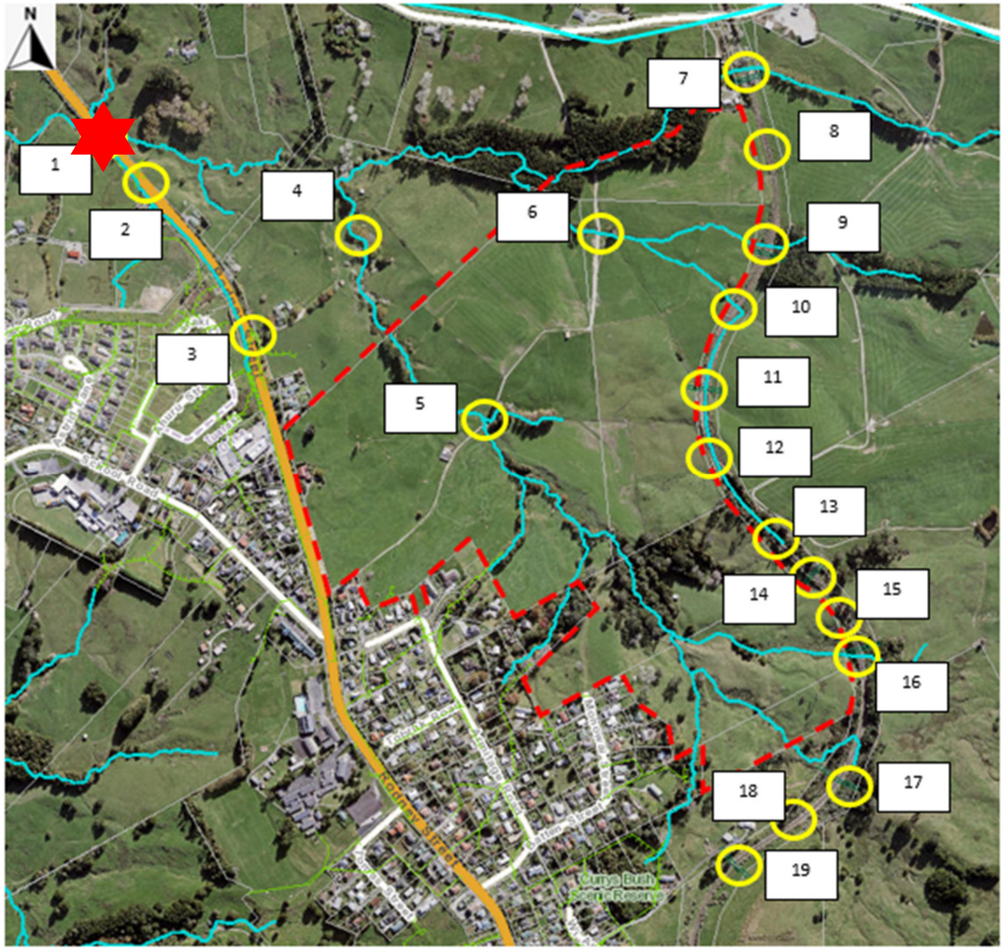


Fast-Track consent application

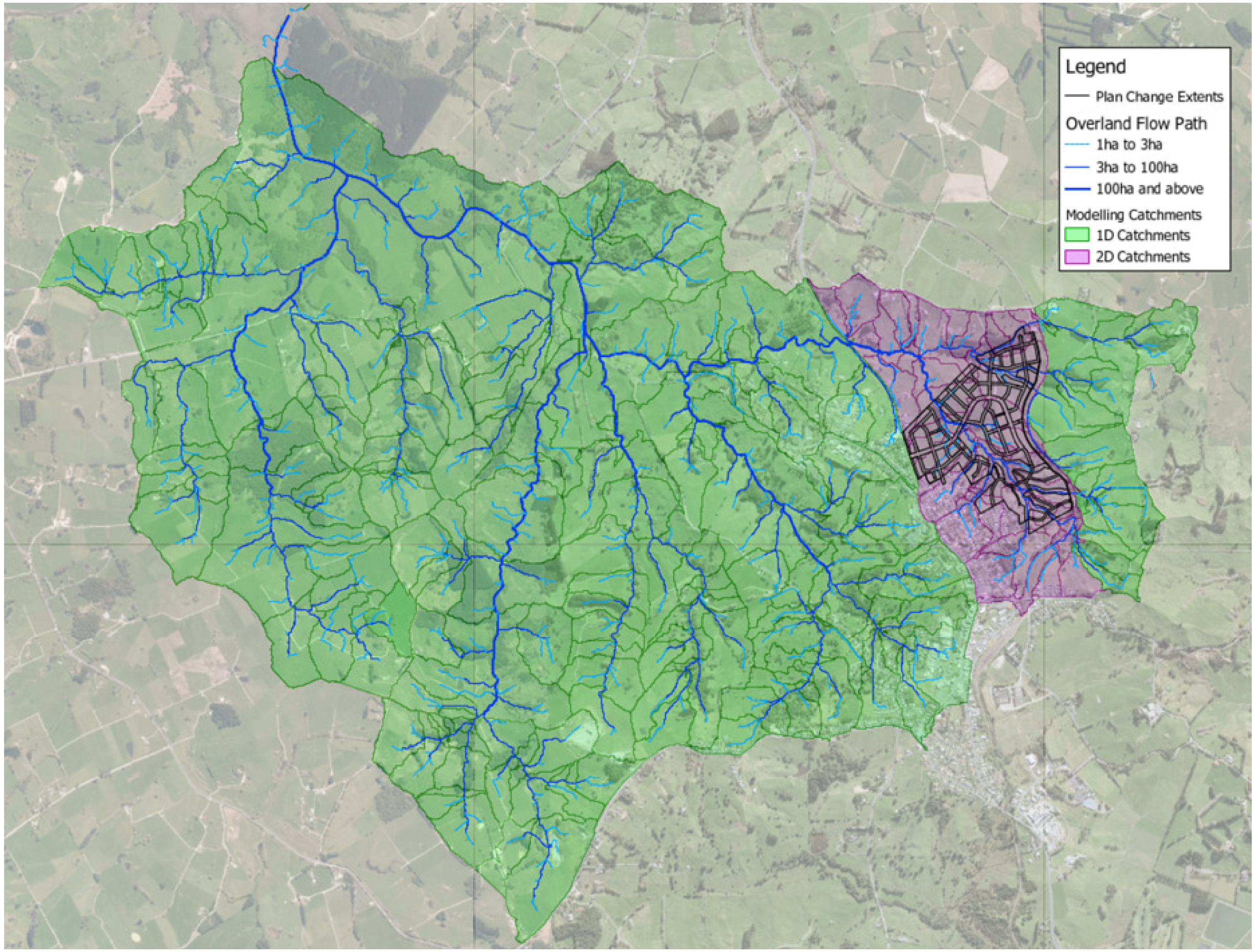


Key infrastructure

- Key infrastructure:
  - 1-3 – NZTA/ Auckland Council/ AT
  - 7-19 – KiwiRail
  - Survey undertaken for SH and Kiwirail culverts where accessible
- Council has no model information for this area
- Flood modelling was therefore undertaken by Woods to assess effects resulting from PPC



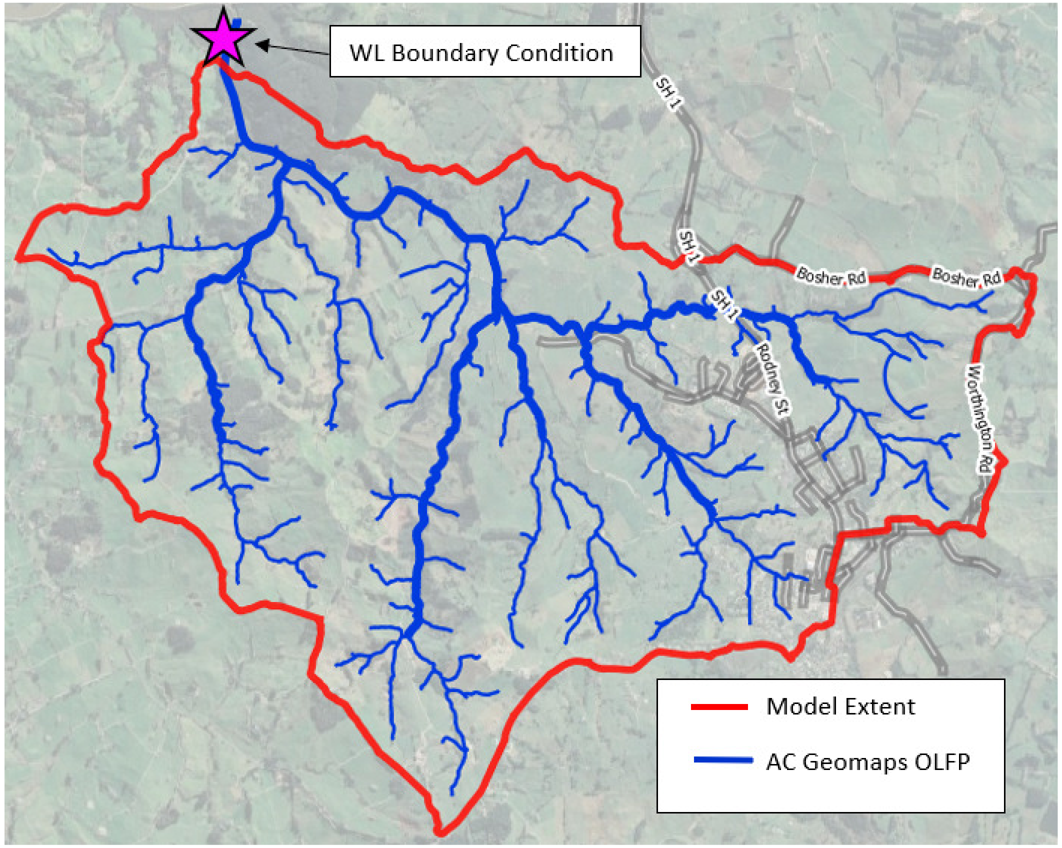
Flood modelling – Extent of model



Flood modelling – Boundary conditions and Rainfall depths

- Coastal tailwater boundary condition applied for all scenarios where Oruawharo River discharges to Kaipara Harbour at a constant water level of 3.3m based on MHWS 10%ile with 1m sea level rise consideration for climate change

Storm Event	Rainfall Depth (mm)	Rainfall Depth including Climate Change - SWCoP V3 – 3.8^{0}C (mm)
2 year	95	121
10 year	170	222
100 year	260	345



Flood modelling – Modelled scenarios

Scenario		Land use	Rainfall	Purpose
Pre-development/ existing development	ED	Existing impervious coverage	2-, 10- 100-year - 3.8°C	Create a base line scenario with 3.8 °C climate change factor. Understand existing deficiencies in infrastructure and effects i.e., SH1 Use as a comparative model to compare relevant post development PPC models.
Post-development	ED + PPC	Existing impervious coverage + Private Plan Change (MPD)	2-, 10- 100-year - 3.8°C	Create a base line scenario with 3.8 °C climate change factor. Understand deficiencies in infrastructure and effects i.e., SH1 as a result of PPC. Understand and isolate effects as a result of development within the PPC area only with neighbouring areas at the existing development.
Post-development (MPD)	MPD + PPC	Maximum probable development (MPD as per AUP: OiP) + Private Plan Change	2-, 10- 100-year - 3.8°C	Create a base line scenario with 3.8 °C climate change factor Understand deficiencies in infrastructure and effects i.e., SH1 as a result of PPC and MPD coverages Understand cumulative effects as a result of development within the PPC area and MPD coverages in other areas

Afflux between ED and ED+ PPC (3.8^{0}C) for 100-year

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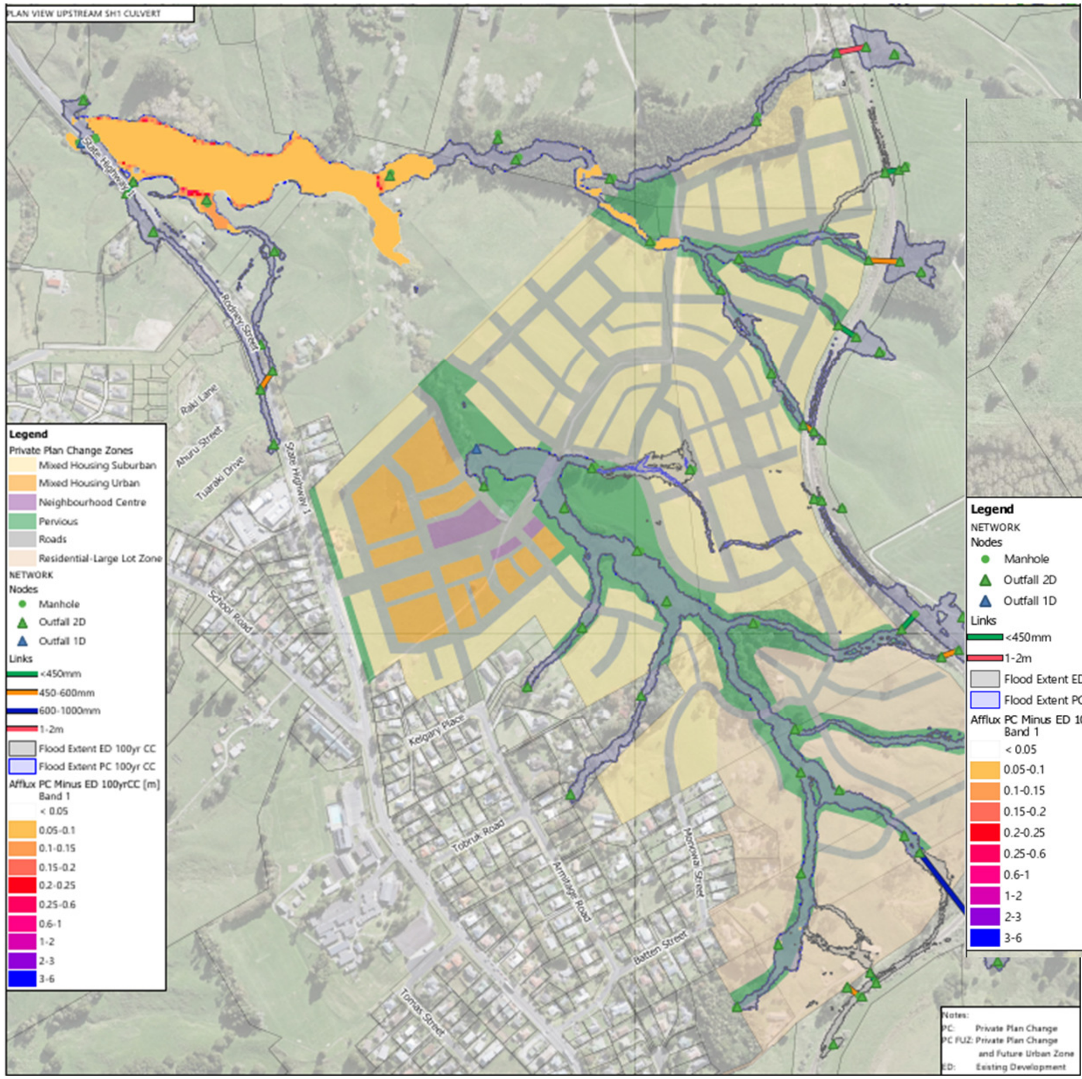
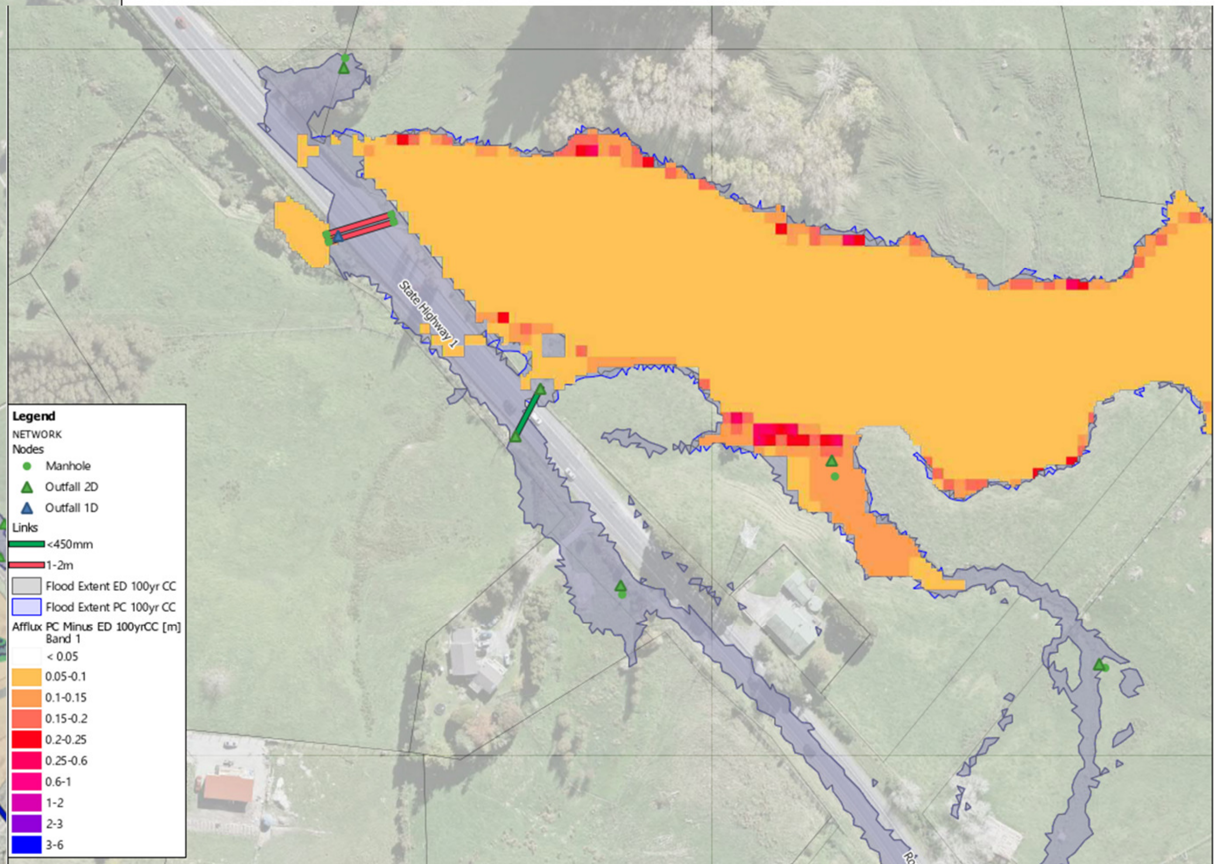
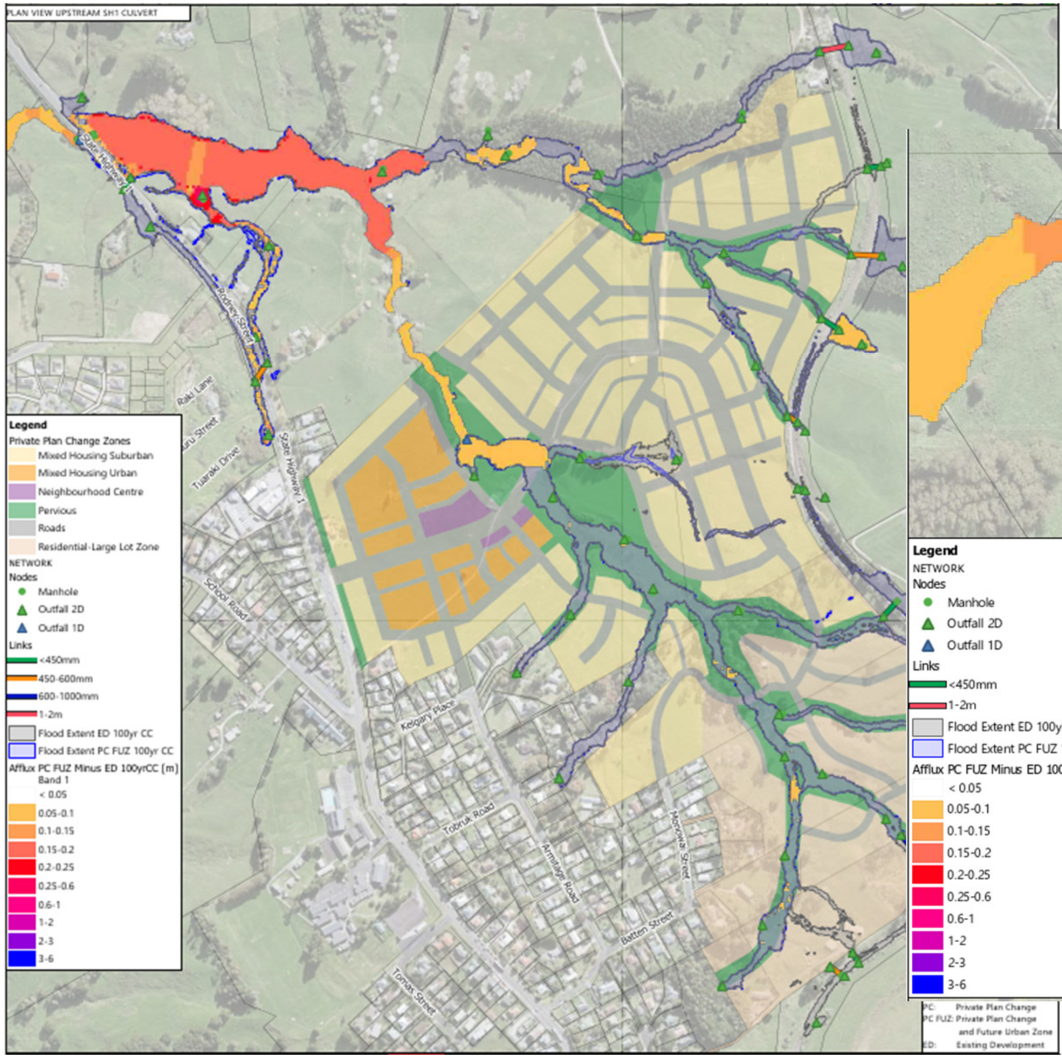
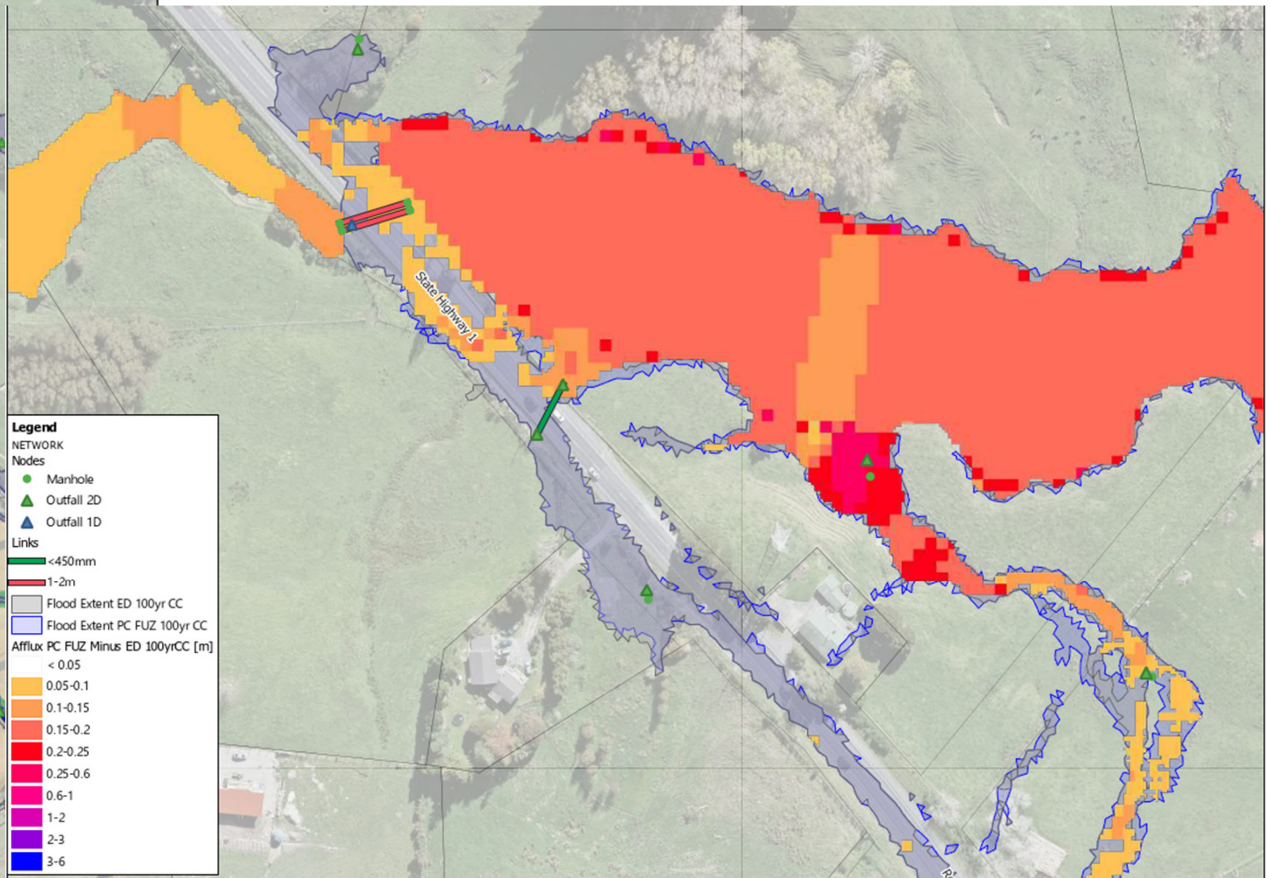


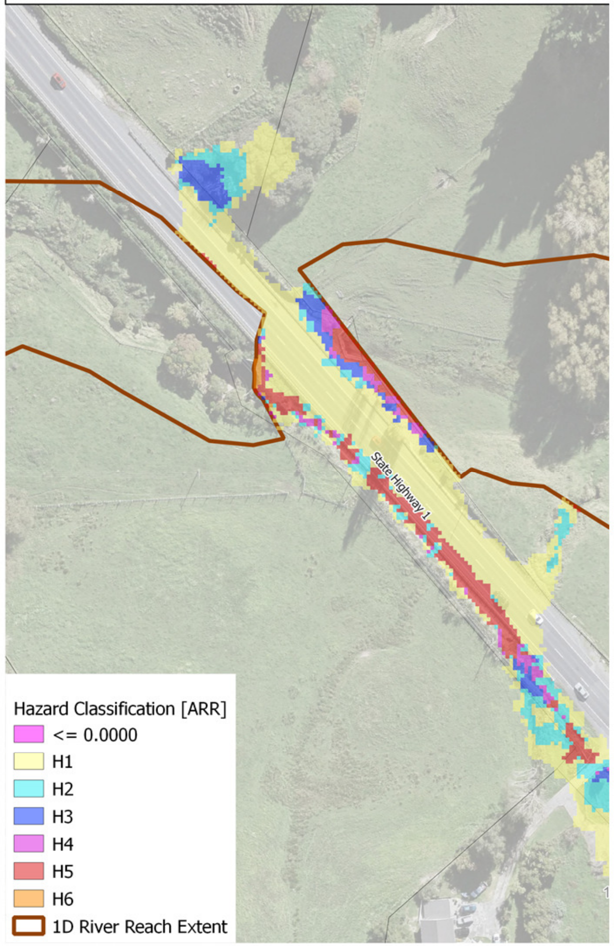


Afflux between ED and MPD+ PPC (3.8^{0}C) for 100-year

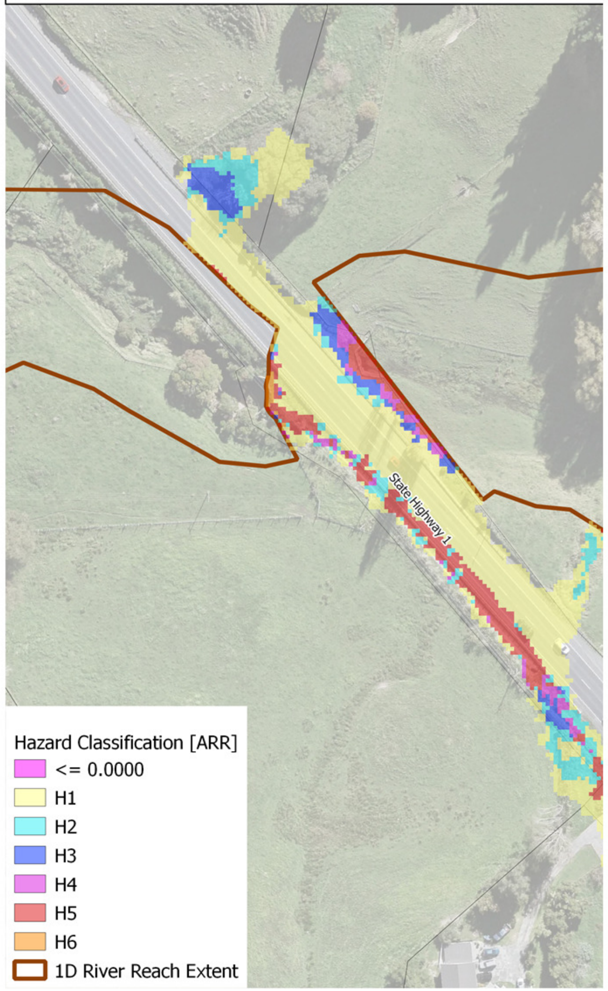




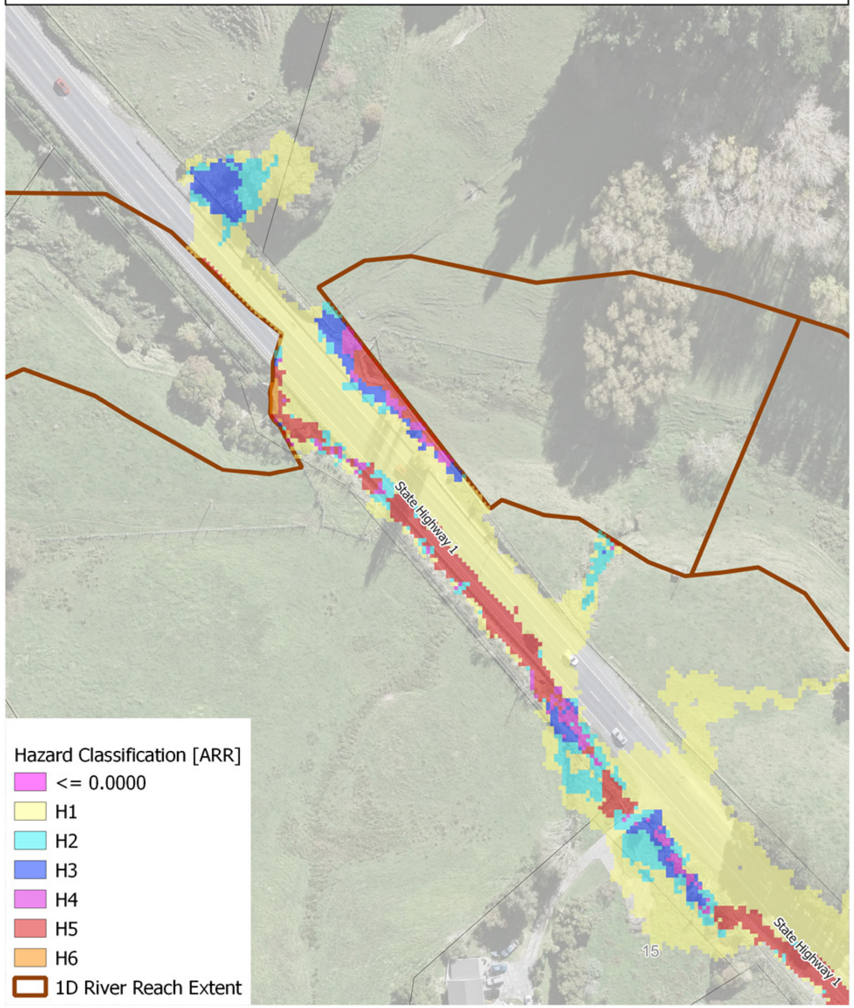
ED - 10 YR CC

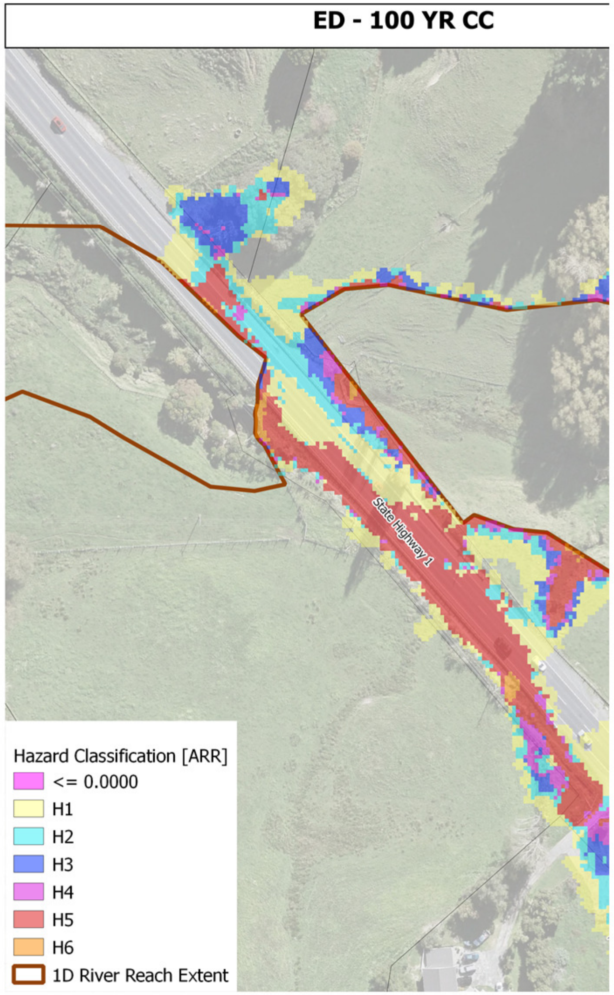


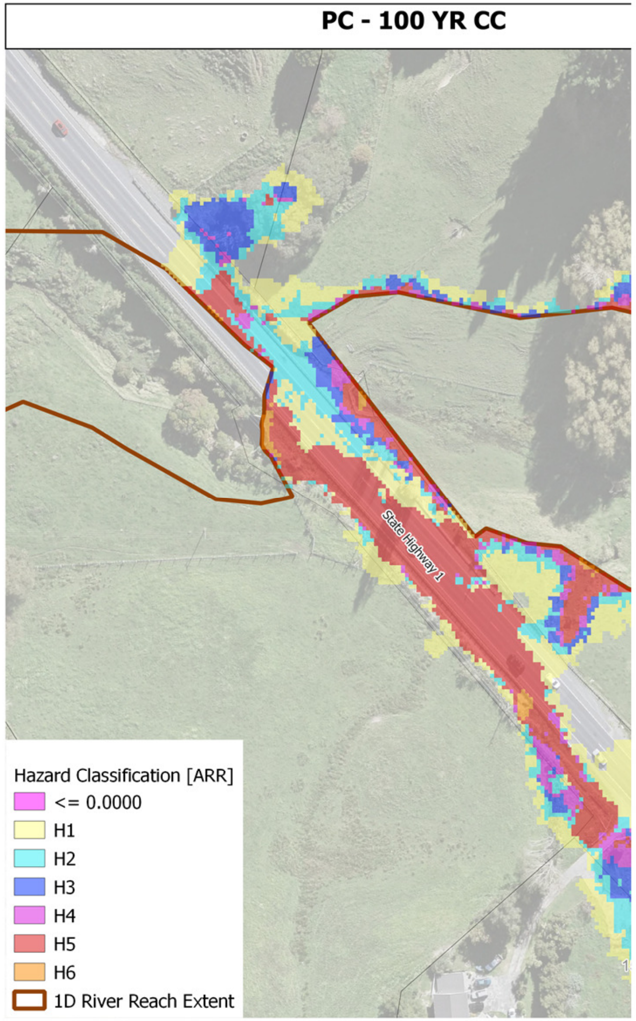
PC - 10 YR CC

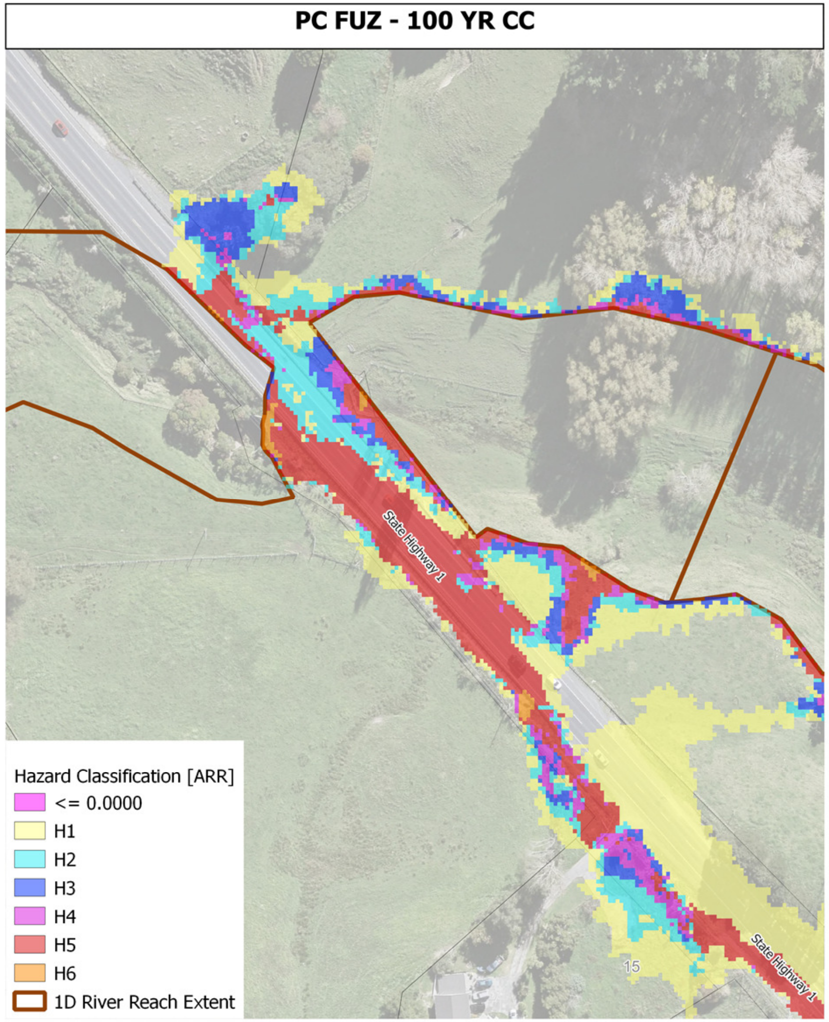


PC FUZ - 10 YR CC




ED - 100 YR CC
State Highway 1
Hazard Classification [ARR]
<= 0.0000
H1
H2
H3
H4
H5
H6
1D River Reach Extent


PC - 100 YR CC
State Highway 1
Hazard Classification [ARR]
<= 0.0000
H1
H2
H3
H4
H5
H6
1D River Reach Extent


PC FUZ - 100 YR CC
State Highway 1
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<= 0.0000
H1
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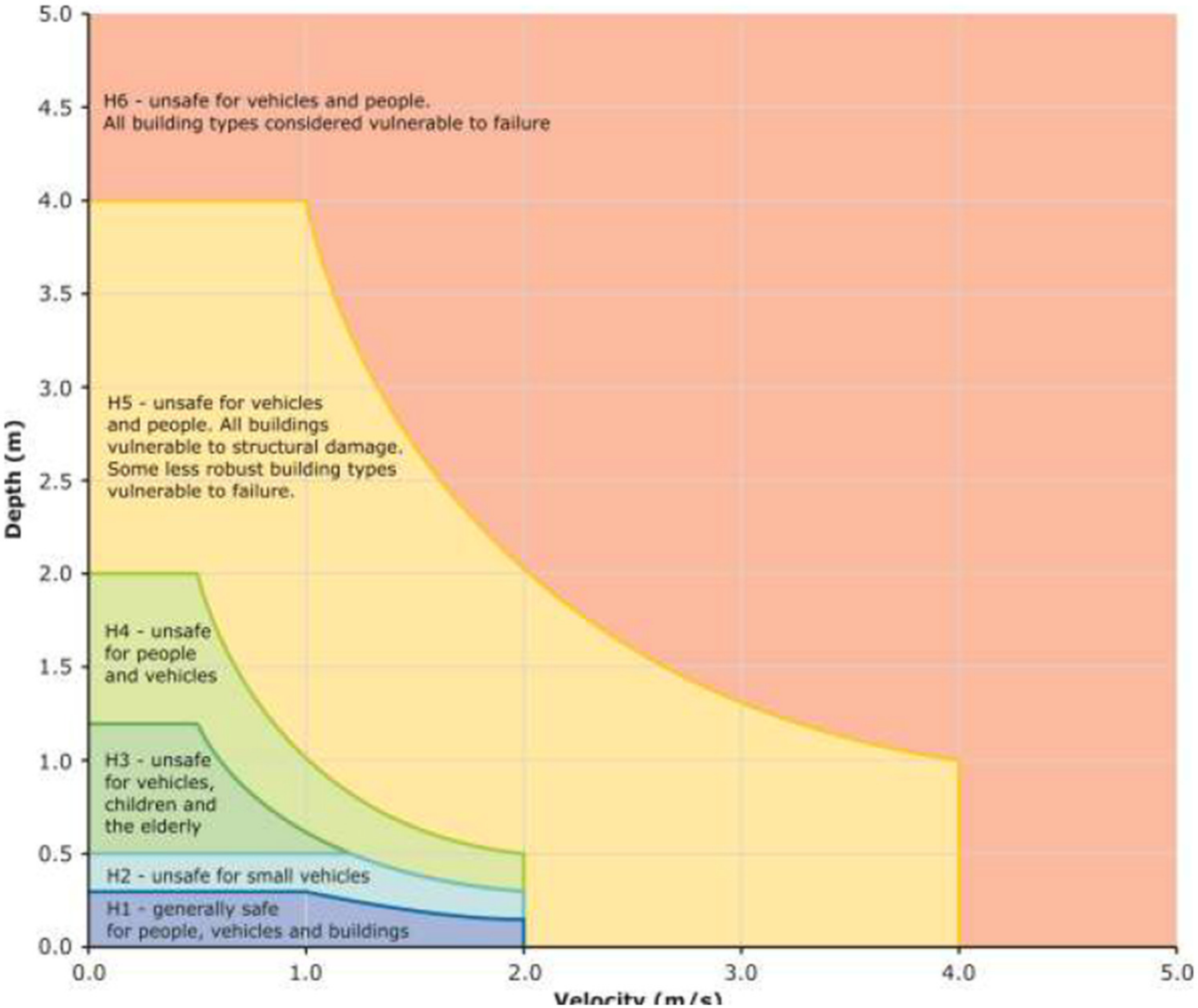

H6 - unsafe for vehicles and people.
All building types considered vulnerable to failure
H5 - unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure.
H4 - unsafe for people and vehicles
H3 - unsafe for vehicles, children and the elderly
H2 - unsafe for small vehicles
H1 - generally safe for people, vehicles and buildings
Depth (m)
Velocity (m/s)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

Stormwater management

- In accordance with NDC Schedule 4 for 'greenfields':
    - Water quality for all impervious areas
    - Hydrology mitigation (retention and detention)

- Draft Stormwater Management Plan

- Opportunity to have centralised devices along stream edge

Questions/ Next steps

- Lodging Plan Change by end of April and keen to engage with Waka Kotahi up to notification to resolve any issues.

- Working with Healthy Waters on the model review and SMP

- Currently undertaking consultation on Draft Structure Plan.

- Any questions

Location	MS Teams			
Time & Date	1pm	22/04/2022	**Taken by**	Bidara Pathirage
Attendees	**Initials**	**Name**		**Company**
	AD	Ajay Desai		Woods
	BP	Bidara Pathirage		Woods
	MH	Miguel Hernandez		Woods
	CS	Cosette Saville		Barker & Associates
	NR	Nick Roberts		Barker & Associates
	DG	David Greig		Waka Kotahi NZTA
	RJ	Rajika Jayaratne		Waka Kotahi NZTA
	SH	Sarah Ho		Waka Kotahi NZTA

Apologies	**Initials**	**Name**	**Company**
	PW	Pranil Wadan	Woods
	VJ	Venelyn Jandayan	Waka Kotahi NZTA

High level Meeting Minutes – 22/04/2022

Wellsford North Plan Change – Meeting with Waka Kotahi NZTA

1. Introductions around the table
2. NR and CS provides an introduction to the project, proposed Structure Plan and the Plan Change. It is noted the Plan Change area is smaller than the Structure Plan which is proposed for the FUZ zone north of Wellsford. An introduction to the Fast Track sites are also provided (Rodney Street area and Monowai Street area).
3. RJ raises where access to the development is proposed. NR confirms one single access is proposed from State Highway 1.
4. SH asks for clarification on the Plan Change area and Structure Plan. NR confirms the Plan Change area is only proposed for the areas the applicant owns, however in accordance with guidelines, the Structure Plan is proposed for areas outside the applicant's ownership i.e., areas to the north (zoned FUZ). The areas not part of the Plan Change will be subject to a future plan change either to be led by Council or relevant property owners.
5. AD runs through the stormwater work that has been undertaken to date. It is noted there is some key infrastructure in the area i.e., NZTA culvert/ asset under SH1 and Kiwi rail assets. Accessible assets have been surveyed to aid stormwater assessments including flood modelling to identify effects of Plan Change. Healthy Waters have informed there is no flood model for the area.
6. AD discusses the extent of the flood model, boundary conditions and rainfall depths. Climate change allowance of 3.8^{0}C (RCP 8.5) to 2110 has been allowed for 2, 10 and 100-year scenarios modelled and presented.
7. AD discusses 100-year water level differences. It is noted the existing streams are generally incised and results indicate that flooding is generally contained within the streams. Flood risk is identified along SH1 which overtops in the existing scenario with climate change and have peak flood depths in excess of 0.6 m. With Plan Change and MPD (wider structure plan area) the increases are approximately 150mm when compared to existing scenario.

8. AD goes through flood risk and hazard assessment undertaken in accordance with Australian Rainfall Runoff Guidelines (ARR, 2016)[1]. Based on the work undertaken, even there is a minimum increase in flood depths with Plan Change, the flood hazards remain similar confirming that there is no increased flood risk. RJ notes there is an existing risk within SH1. RJ asks whether 2.1^{0}C has been simulated, BP notes only 3.8^{0}C and no CC scenarios have been simulated in consultation with Healthy Waters. RJ notes the impact is minimal, however there is an impact with minimal changes in hazard risk.

9. RJ questions the confidence in the model. AD notes model has been validated by HY-8 and is currently undergoing a review process with Healthy Waters for sign off. All parameters and approach including climate change considerations have been agreed with their technical reviewers.

10. The existing culvert size is noted to be a twin 2m dia. Under SH1. DG/ RJ discusses whether culverts can be upgraded by Waka Kotahi NZTA to minimise risk i.e., upsize culvert or bridge long term. AD notes Woods haven't undertaken any optioneering as there are no flood effects from Plan Change and the Plan Change can proceed without any downstream upgrades. This needs to be reassessed for Structure Planning purposes. RJ asks whether 2yr and 5yr events have been simulated. AD and MH confirm in the 2yr scenario, there is no overtopping of SH1.

11. RJ questions where there are any upstream flooding due to the culvert, AD confirms flows overtop these structures and flow downstream back into the stream. RJ also questions other culverts i.e., culverts labelled 2 and 3. However it is noted the capacity restrictions and overtopping are not due to the water coming from these culverts but hasn't been looked at in detail.

12. AD discussed stormwater management plan is being worked through and stormwater management is generally in accordance with Schedule 4 of the Network Discharge Consent (NDC).

13. Next steps are discussed – currently working with Healthy Waters with lodgement planned for end of April/ early May. Consultation is proposed after lodgement prior to hearings to ensure any issues identified are resolved.

14. RJ and DG requests all information to be submitted for review and further comments.

15. DG questions timeframes. CS confirms the first fast track sites proposed to be developed in 2023/2024. With the Plan Change, approximately 3-4 years before construction is expected.

16. DG and RJ to check if any existing flooding has been recorded in Waka Kotahi NZTA systems. AD notes the work undertaken demonstrates the issues are existing and is not due the plan change or structure plan. DG/ RJ note Waka Kotahi to take long term responsibility to whether upgrade culvert or other options to reduce existing risk. AD confirms that these upgrades are now decoupled from the Plan Change demonstrating that there are no increases in flood risk/hazards.

17. RJ asks what information will be issued. AD confirms the SMP, flood model, model build report and model review form to be issued at the same time to Healthy Waters.

List of actions

Action	By	When
Issue model information and SMP for review	Woods	29/04/2022*

*to be shared along with Healthy Waters submission

[1] ARR Project Reports and Data (arr-software.org)

Appendix C

Model Build Memorandum

To	**From**
Wellsford Welding Club	*Miguel Hernandez – 3-Waters Engineer*
	W-REF: P21-395
	29 April 2022
	Reviewer: Pranil Wadan – Principal Engineer – 3 Waters Manager

Wellsford North Plan Change – Model Build Memorandum

1. Introduction

Wellsford Welding Club is looking to undertake a Private Plan Change (PPC) in the Wellsford North area. The development is classified as a 'greenfields' development under Schedule 4 of Auckland Council's Regionwide Network Discharge Consent (NDC) and requires a stormwater management plan to be compliant with the NDC requirements. Woods have undertaken flood modelling for the PPC and surrounding areas which is summarised in this memorandum. This memorandum should be read in conjunction with the Wellsford North Plan Change – Stormwater Management Plan prepared by Woods, dated 02/05/2022.

The PPC is located within the wider Kaipara Wellsford catchment. The flood modelling intent is to assess any flood effects resulting from the PPC and any flood risks within the development area while supporting the Stormwater Management Plan. The PPC area location can be seen in Figure 1.

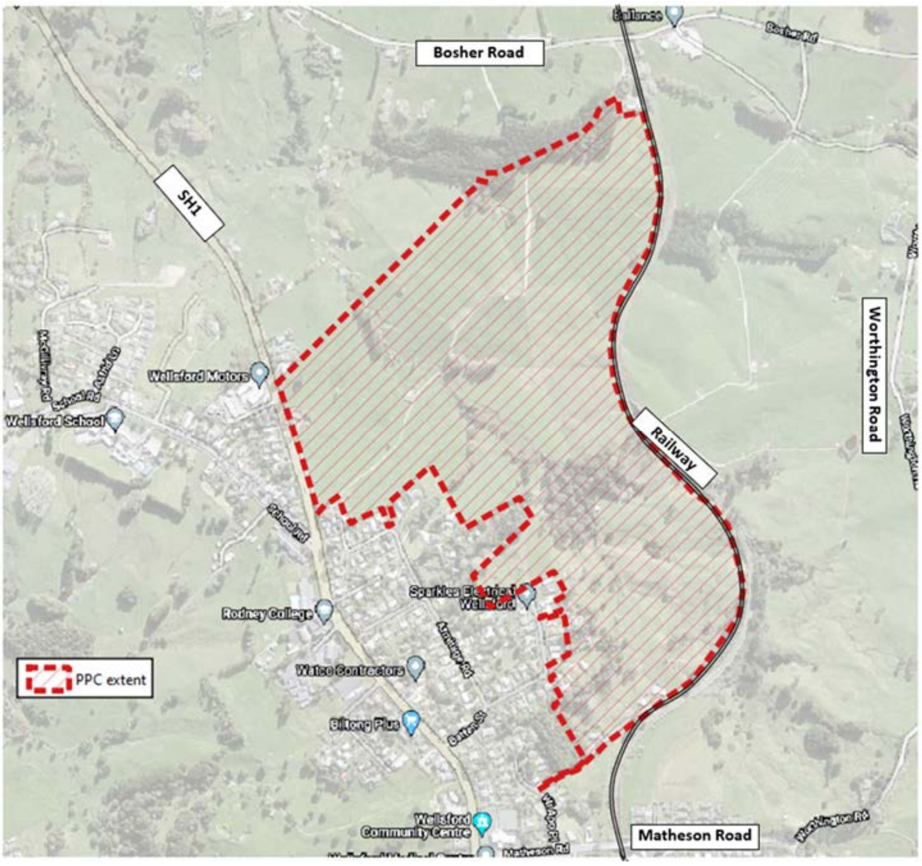

Figure 1: PPC location plan

Woods have developed an Infoworks ICM model (by Innovyze, version 2021.6) to assess 15 different scenarios, including the updates in the Stormwater Code of Practice (SWCoP) - V3 (January 2022). The ICM model dynamically couples 1-D and 2-D model elements to represent stormwater networks, open channels (1D), and overland flow (2D) focused in the PPC area. The Auckland Council model review form has been made to this model, see in order to be reviewed by the Healthy Waters (HW) department. The model review form is attached in Appendix B.

2. Model Extent

The PPC area is located within the Kaipara Wellsford catchment. The model extent was determined using the Auckland Council Geomaps overland flow path layer to include all the areas contributing to the Wellsford North Plan Change area. The model extent also includes areas downstream of the Wellsford North Plan Change area where catchments contribute to permanent streams and ultimately discharge to the Oruawharo River. The model extent is approximately 1,708 hectares in, as shown in Figure 2.

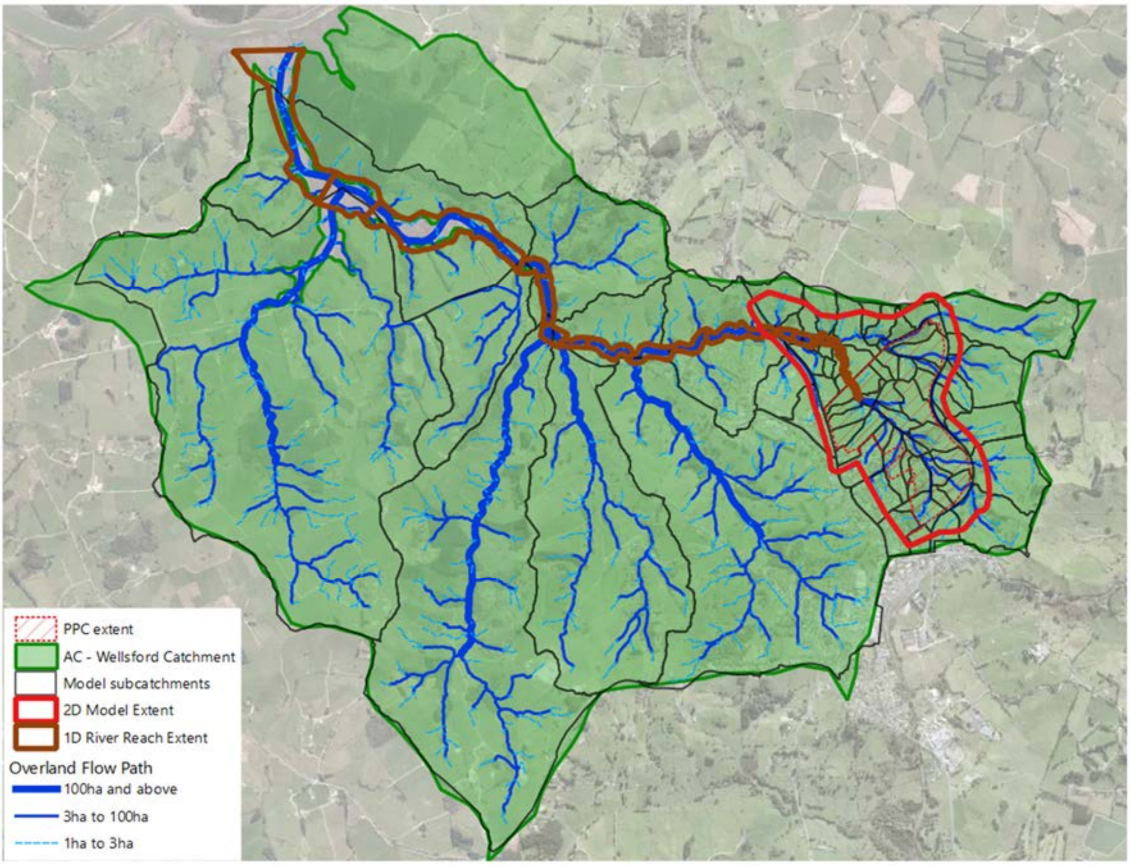

Figure 2: Model extent

3. Subcatchments

The delineation of the subcatchments within the model extent is based on the latest 2016 LiDAR data and the Auckland Council Geomaps overland flow path layer. The modelled subcatchments areas range between 1.35 ha and 433 ha. To represent the flood on the flat PPC area, the subcatchments have been loaded either to the 2D surface through dummy nodes or directly to Oruawharo river reach (1D). A total of 68 subcatchments have been modelled, and they are seen in Figure 3. From the 68 subcatchments, 49 have been loaded to the 2D surface and 19 to the river reach. For the 2D subcatchments, were generated 49 source points composed of 49 dummy links, 49 dummy intake dummy manholes and 49 dummy 2D outlets.

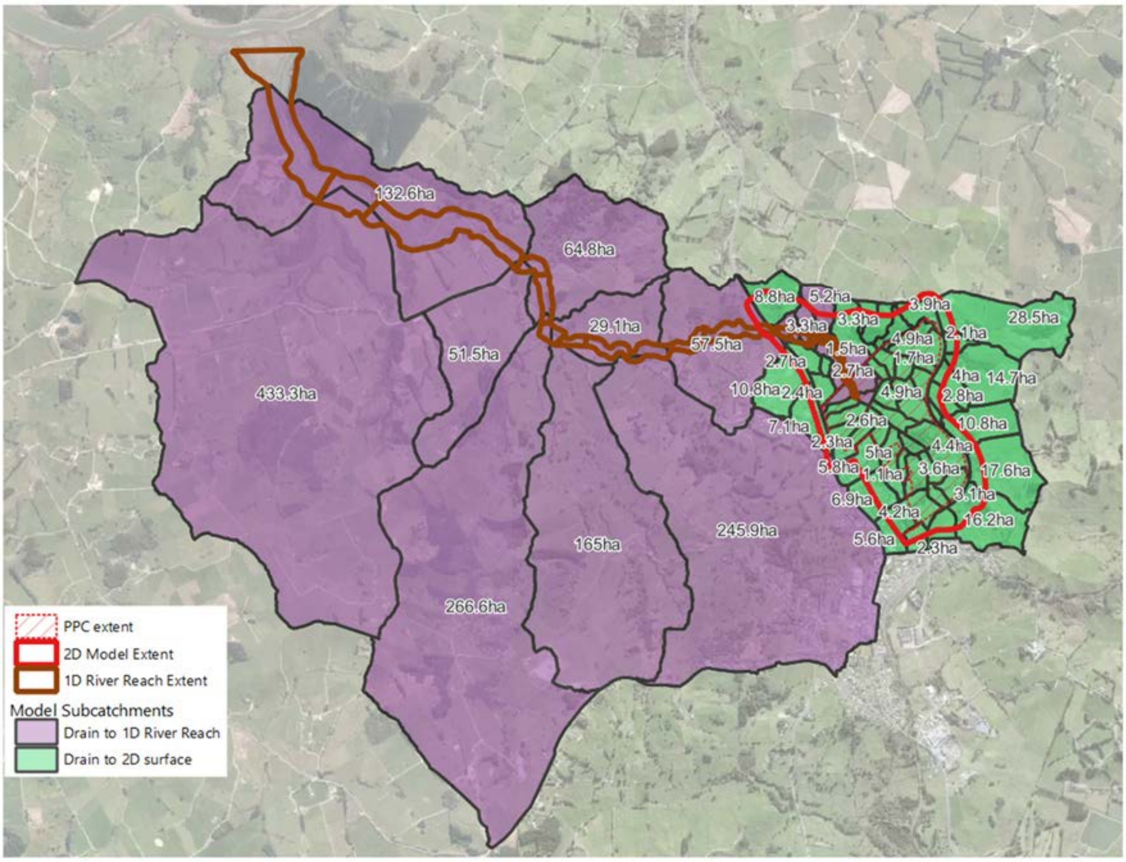

Figure 3: Modelled subcatchments

The subcatchment delineation remains the same for all modelled scenarios, although the catchment loading inside the PPC extent varies in the future scenarios. The subcatchment loading inside the PPC for the existing development scenario is shown in Figure 4. Figure 5 shows the loading for the proposed plan change scenarios, highlighting (in red) the five subcatchments that change the loading to follow the proposed plan change.

Figure 4: Subcatchment loading in the existing scenario

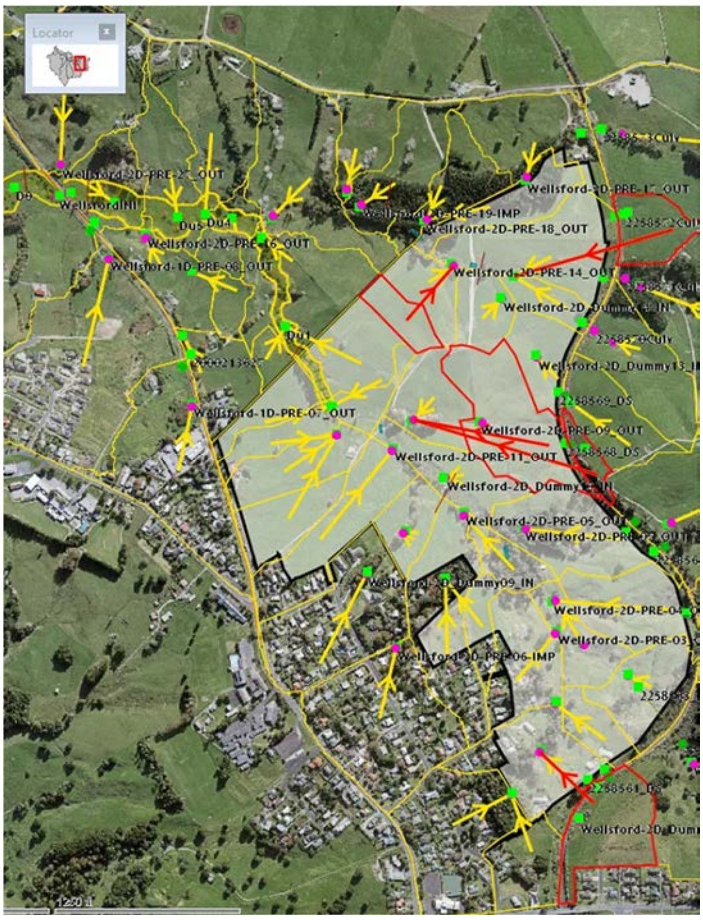

Figure 5. Subcatchment loading in the future scenarios

4. Land Use

4.1. Existing Development (ED)

The land use for the Kaipara Wellsford catchment, where the PPC area is located, is predominantly rural, comprising rural lifestyle blocks and pasture. There are residential and commercial areas along Rodney Street. The existing development impervious percentage for the Kaipara Wellsford Catchment is approximately 5.1%.

The existing impervious percentage inside the PPC is approximately 3.3% based on the Geomaps impervious surfaces layer.

Figure 6 shows the land use close to the PPC.

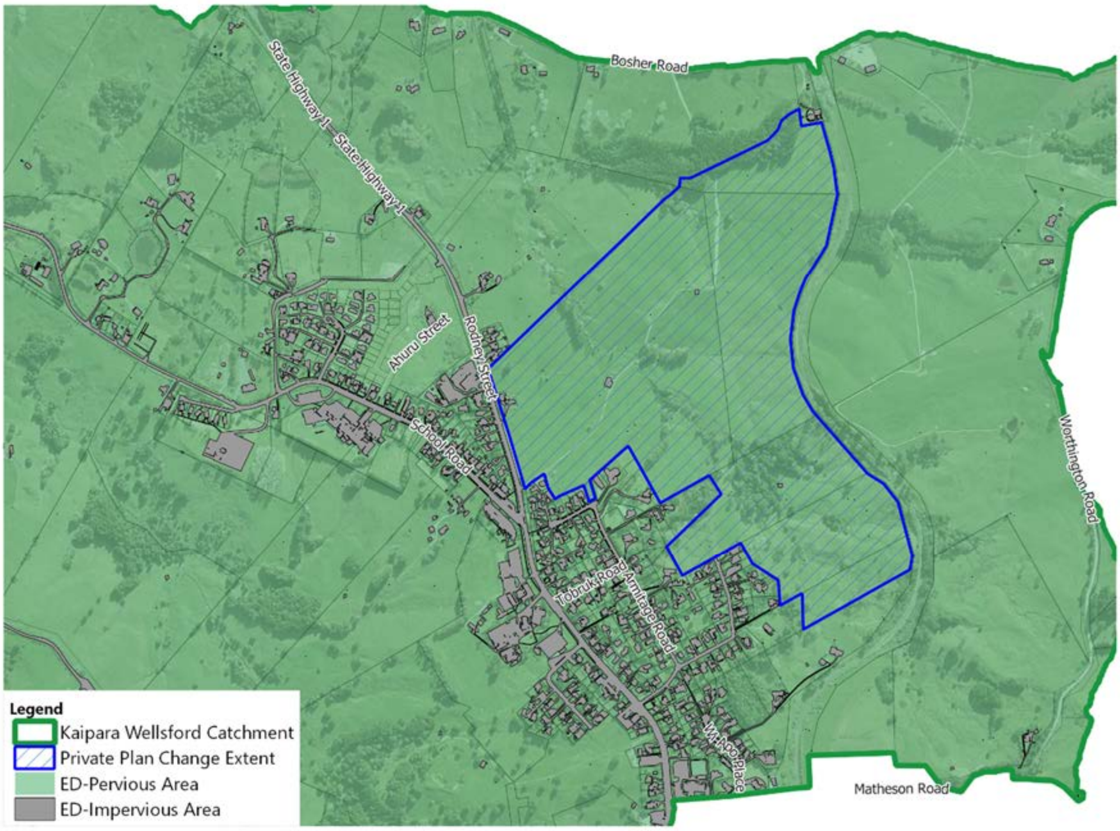

Figure 6. Existing development land use

4.2. Existing Development (MPD), including Private Plan Change (PPC)

The PPC is located in an area designated predominantly Future Urban Zone, with a few areas also including Rural Production Zone, Rural Countryside Living Zone and Single House Use as per the Auckland Unitary Plan – Operative in Part (AUP-OiP).

The PPC includes three different residential zones and one small business centre zone, as is shown in Figure 6. Additionally, Figure 7 shows the proposed structure plan for Wellsford North which is described in detail in the Wellsford North Plan Change – Stormwater Management Plan.

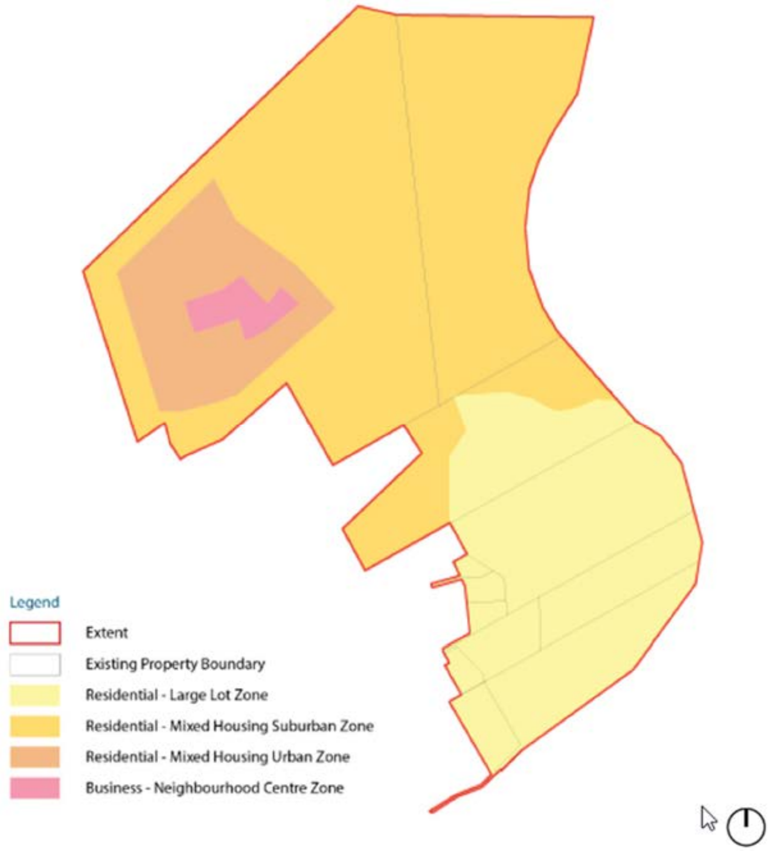

Figure 7. Proposed land use

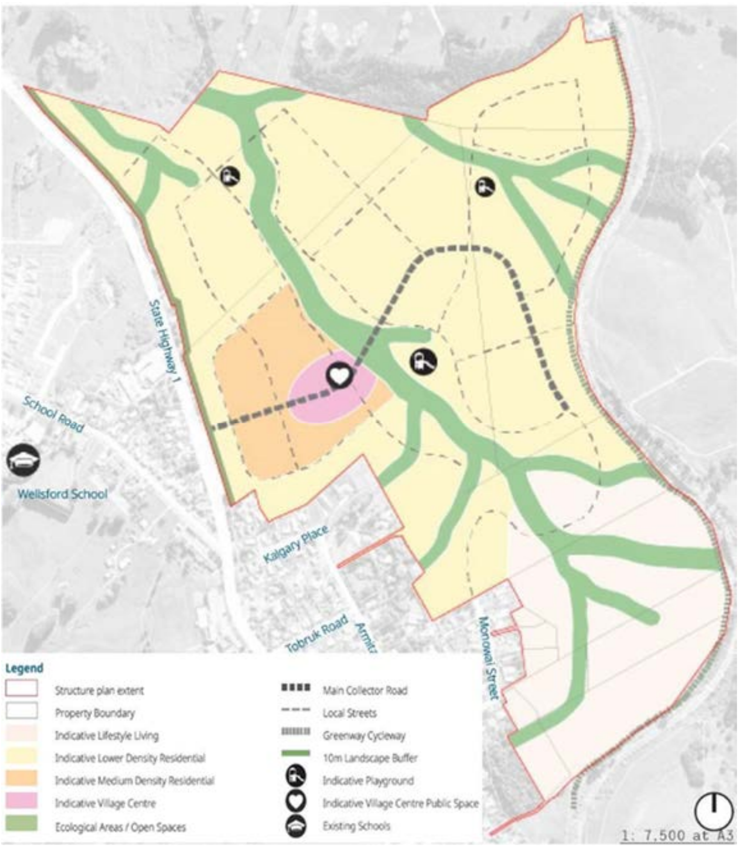

Figure 8: Proposed structure plan

Based on the provided land use and the Healthy Waters latest imperviousness recommendation, Table 1 listed the established imperviousness percentage values.

Table 1. Impervious percentages for the Proposed Plan Change (PPC) land use

Source	Zoning	Impervious %
Proposed Plan Change (PPC)	Residential-Large Lot Zone	35
	Mixed Housing Suburban Zone	60
	Mixed Housing Urban Zone	60
	Neighbourhood Centre Zone	100
	Pervious [Open Space Conservation Zone]	10
	Roads	90

The PPC layout proposed zoning can be seen in Figure 9. The Impervious percentage for the Kaipara Wellsford catchment is approximately 21.2%, and for the PPC is 48.0%.

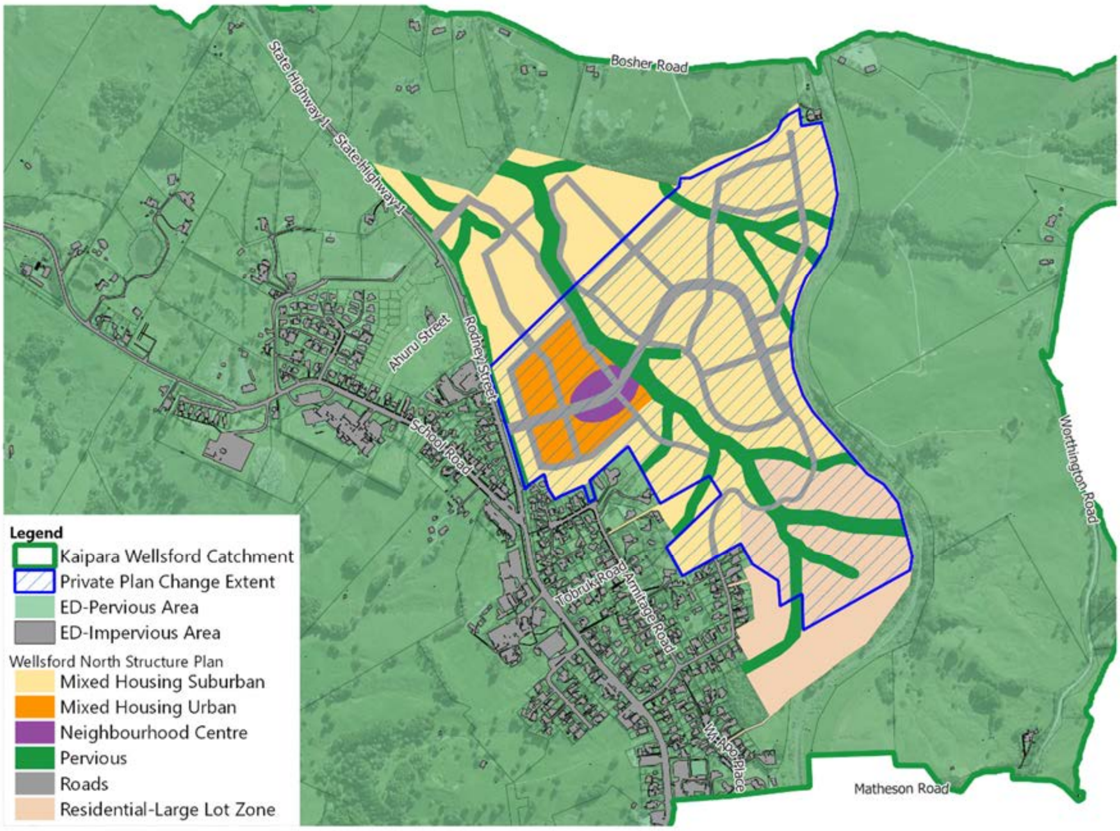

Figure 9. Existing development and PPC land use

4.3. Maximum Probable Development (MPD), including Private Plan Change (PPC)

The MPD land use assumptions for the Kaipara Wellsford catchment were derived from the Auckland Unitary Plan – Operative in Part (AUP-OiP). Inside the PPC extent, there were given the same impervious percentage coverage as previously mentioned in Table 1. The impervious assumptions were also updated as per Healthy Waters latest recommended imperviousness table list for each AUP zone, see Appendix C. The maximum probable development scenario impervious percentage assumptions for different zonings are provided in Table 2.

The maximum probable development impervious percentage for the Kaipara Wellsford catchment is approximately 43.3% and for the PPC is around 48%. The future zonings used in the modelling were derived from the Auckland Unitary Plan – Operative in Part (AUP-OiP) as seen in Figure 10.

Table 2: Zoning areas maximum impervious assumptions

Source	Zoning	Impervious %
AUP	Residential-Large Lot Zone	35
	Open Space - Conservation Zone	10
	Residential - Single House Zone	60
	Road [i]	90
	Strategic Transport Corridor	100
	Rural - Countryside Living Zone2	25
	Future Urban Zone5	70
	Open Space - Informal Recreation Zone	10
	Rural - Rural Production Zone2	5
	Open Space - Sport and Active Recreation Zone	33

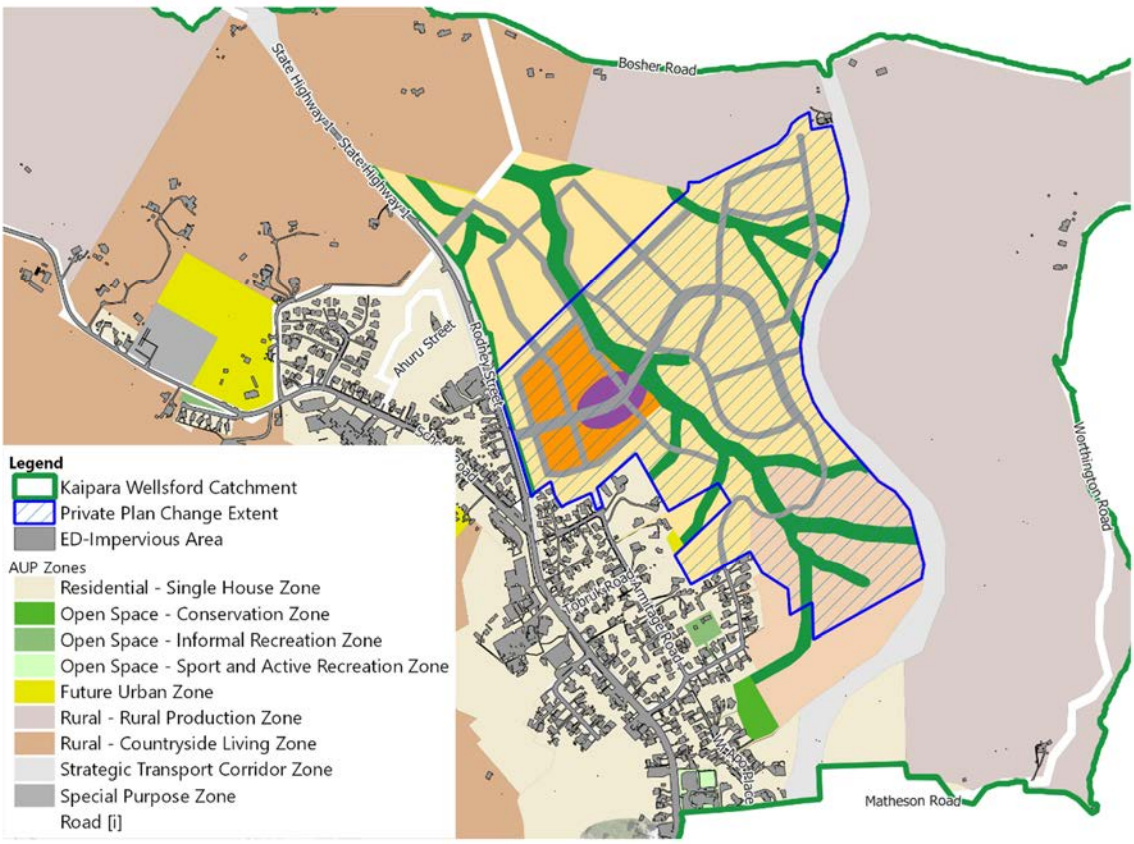

Figure 10: MPD and PPC land use as per AUP-OiP

5. Terrain Data

LiDAR 2016 DEM data and the terrain survey data provided by Buckton Consulting Surveyors Ltd for the PPC area has been used in the modelling, as seen in Figure 11. The two sets of terrain data were used to create the surface used in the modelling for all scenarios.

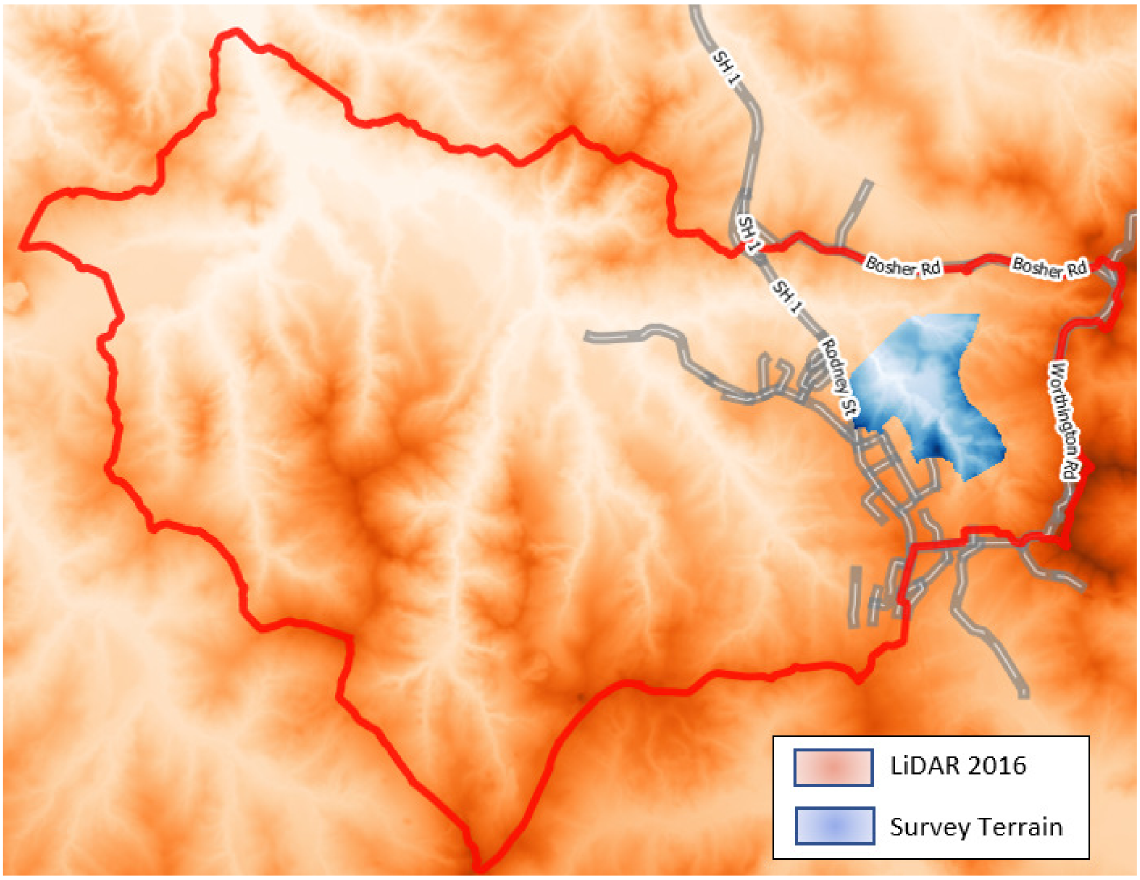

Figure 11: Terrain data sets

6. Hydrological Model

The hydrological model was developed using the SCS method based on the TP108 approach and modelled using the Unit Hydrograph Method as per the Stormwater Flood Modelling Specifications (Nov 2011). Overlapping subcatchments were modelled separately for the impervious and pervious areas for existing development, existing development including Private Plan Change and maximum probable development including Private Plan Change scenarios.

6.1. Time of concentration

The time of concentration in the existing development scenario and the existing development, including private plan change scenario, ranged from 10 mins to 260 mins. It is noted that subcatchments located downstream of the catchment near the coast are very flat, presenting a very long time of concentration.

6.2. Initial Abstraction

Impervious areas were given a 0 mm initial abstraction, and pervious areas were given a 5 mm initial abstraction.

6.3. Curve Number

The impervious areas were assigned a Curve Number (CN) value of 98 for all modelled scenarios.

The pervious areas were assigned a Curve Number (CN) value of 74 for all modelled scenarios.

7. Hydraulic Model

7.1. Culverts

The primary network is predominantly existing and private culvert/structures within, upstream and downstream of the PPC area, as shown in Figure 12. The public assets owners are NZTA, Auckland Council (Healthy Waters) and Kiwi Rail, and details of the information requested can be found in the Wellsford North Plan Change – Stormwater Management Plan.

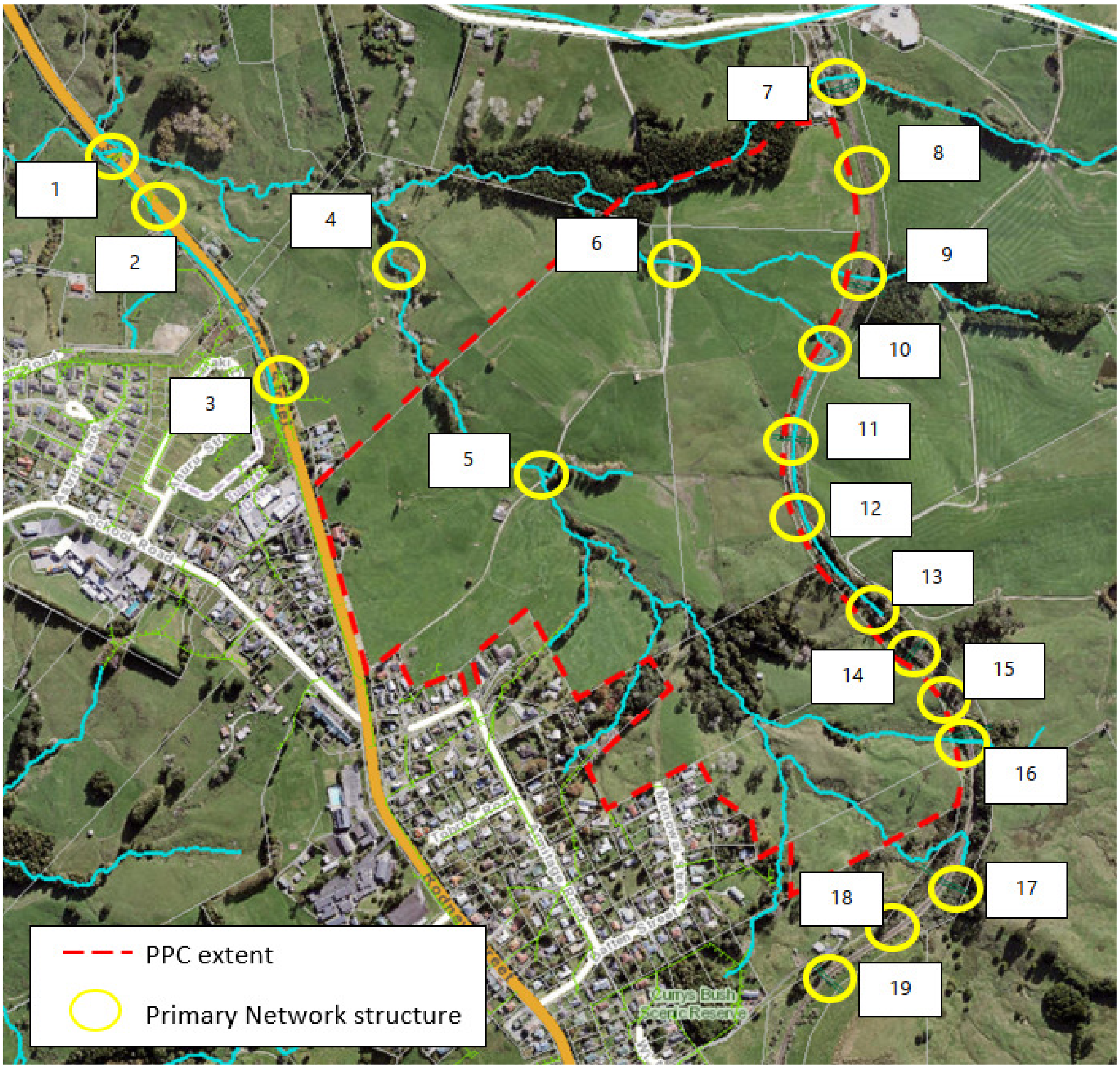

Figure 12: Existing infrastructure (Source: Auckland Council Geomaps)

Due to the limited asset information available, Woods performed a field survey to collect assets data to be included in the flood modelling for better representation and accuracy. Nine were visited from the 19 assets, where photos and spot heights were taken. Table 3 shows what assets were visited and highlighted in grey are the assets modelled as 1D culverts. In total, were modelled 15 culverts, the survey information and parameters details can be found in Appendix A.

Table 3. Asset information

No	Asset type	Asset Number	Diameter (mm)	SW Model	Survey and/or Photos
1	Rectangular culvert	2000006345	2200	YES	YES
2	Circular Culvert	2000063746	450	YES	YES
3	Circular Culvert	2000805184	450	YES	YES
4	Circular Culvert	-	-	Adjusted Terrain	NO
5	Circular Culvert	-	-	Adjusted Terrain	NO
6	Circular Culvert	-	-	Adjusted Terrain	NO
7	Box Culvert	2258573	1200	YES	YES
8	Circular Culvert	2258572	225	YES	YES
9	Circular Culvert	2258571	450	YES	YES
10	Circular Culvert	2258570	300	YES	NO
11	Circular Culvert	2258569	450	YES	YES
12	Circular Culvert	2258568	225	YES	NO
13	Circular Culvert	2258567	300	YES	YES
14	Circular Culvert	2258566	300	NO	NO
15	Circular Culvert	2258565	600	YES	YES
16	Circular Culvert	2258564	450	YES	NO
17	Circular Culvert	2258563	920	YES	NO
18	N/A	2258562	300	YES	NO
19	N /A	2258561	300	YES	NO

The extent of the stormwater network remained the same for the existing development scenario and the future development scenarios. Table 4 summarises the network derived from the culvert's assets.

Table 4: Stormwater network derived from culverts

Node Type	Number
Inlets / Oulets	32
Culvert Inlets	15
Culvert Outlets	2
Links	16 (One twin culvert)

7.2. Roughness

Roughness for the stormwater pipes in the model was assigned as shown in Table 5.

Table 5: Stormwater pipe roughness values

Pipe Material	Manning's (n)	Manning (1/n)
Concrete (Normal)	0.012	85

A summary of the stormwater network assets included in the existing development scenario and the existing development, including private plan change scenario, can be seen in Table 6.

Table 6: Existing development scenario and the existing development including private plan change scenario stormwater network summary

Node Type	Number
Inlets	16
Outlets	16
Links	16
Source Point (Dummy Node and Link)	44

7.3. Head losses

The head losses applied at the inlets and outlets for all modelled scenarios is as per the Auckland Council Modelling Specifications (2011) and summarised in Table 7.

Table 7: Model losses summary

Node Type	Parameter
Culvert Inlet	"Culvert_Inlet" with Km = 0.5
Culvert Outlet	"Culvert_Inlet" with Km = 1

Specific Q-H relations were applied at the culvert's inlets, and they were derived from the HY-8 software. Details of the Q-H relations are summarised in Appendix A.

8. Boundary Conditions

A total of three storm events with two different profiles and climate change (CC) uplifts were generated based on TP108 design rainfall approach for all modelled scenarios. A summary of the rainfall depths can be seen in Table 8.

Table 8: Rainfall depths summary

		SWCoPv3 -3.8°c		
	Depth [mm]	% Increment	Depth (mm)	Profile
2 Year	95	27.4%	121	1
	85		108	2
10 Year	120	30.8%	157	1
	160		209	2
100 Year	260	32.7%	345	1
	250		332	2

A coastal tailwater boundary condition was applied for all modelled scenarios where the Oruawharo River discharges to the Kaipara Harbour at a constant water level of 3.3 m based on the Mean High-Water Springs (MHWS) 10%ile with 1 m sea level rise consideration for climate change. The location at which the coastal tailwater boundary condition was applied can be seen in Figure 13.

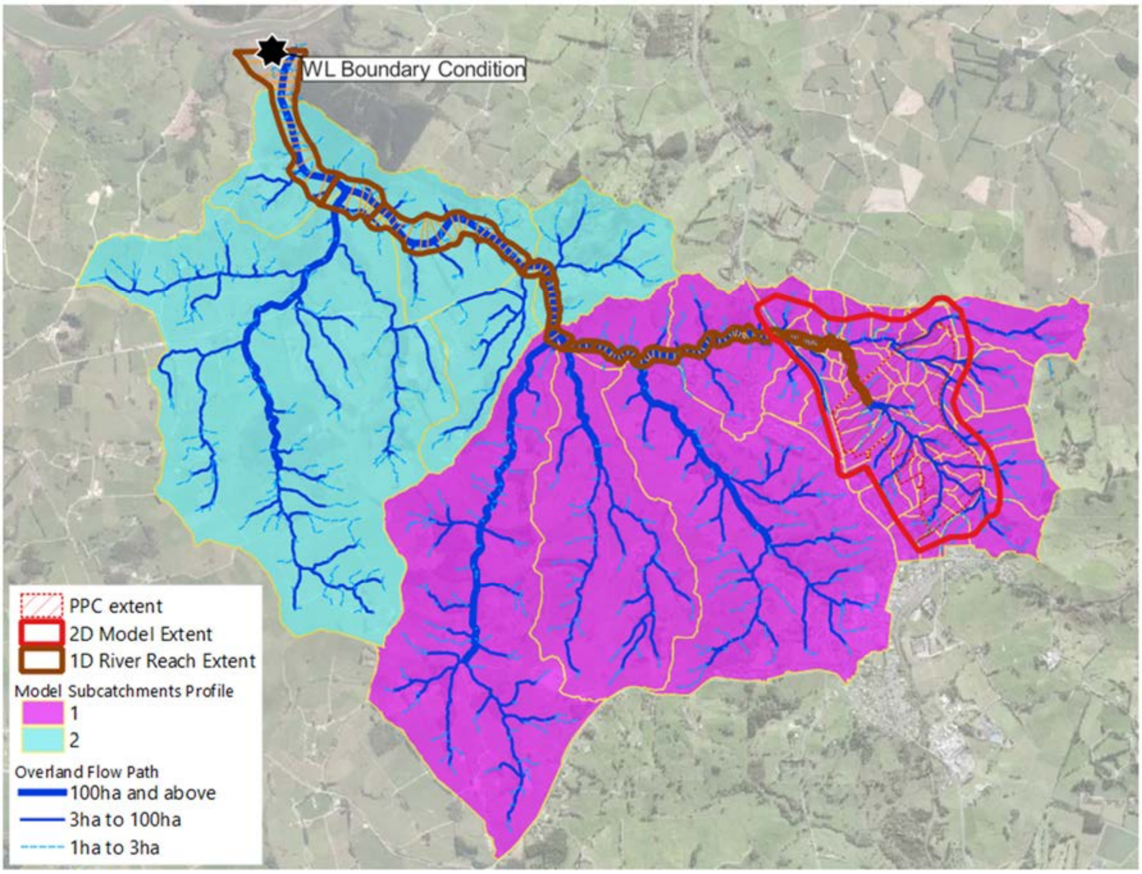

Figure 13: Coastal tailwater boundary condition location

9. One Dimension Modelling

Part of the Oruawharo river was represented as a 1D river reach, and the culverts were represented as 1D conduits connected to the surface or the river reach, see section 7.1. The river reach 1D extent is shown in Figure 13, and it covers a total length of 6.03 kilometres of the Oruawharo river. It was split in two by the twin culvert on the SH1 (model ID 2000811317) at the chainage 857m. Cross-sections were defined by interpolation or derived from LiDAR 2016. The modelled culverts and open channels can be seen in Figure 14.

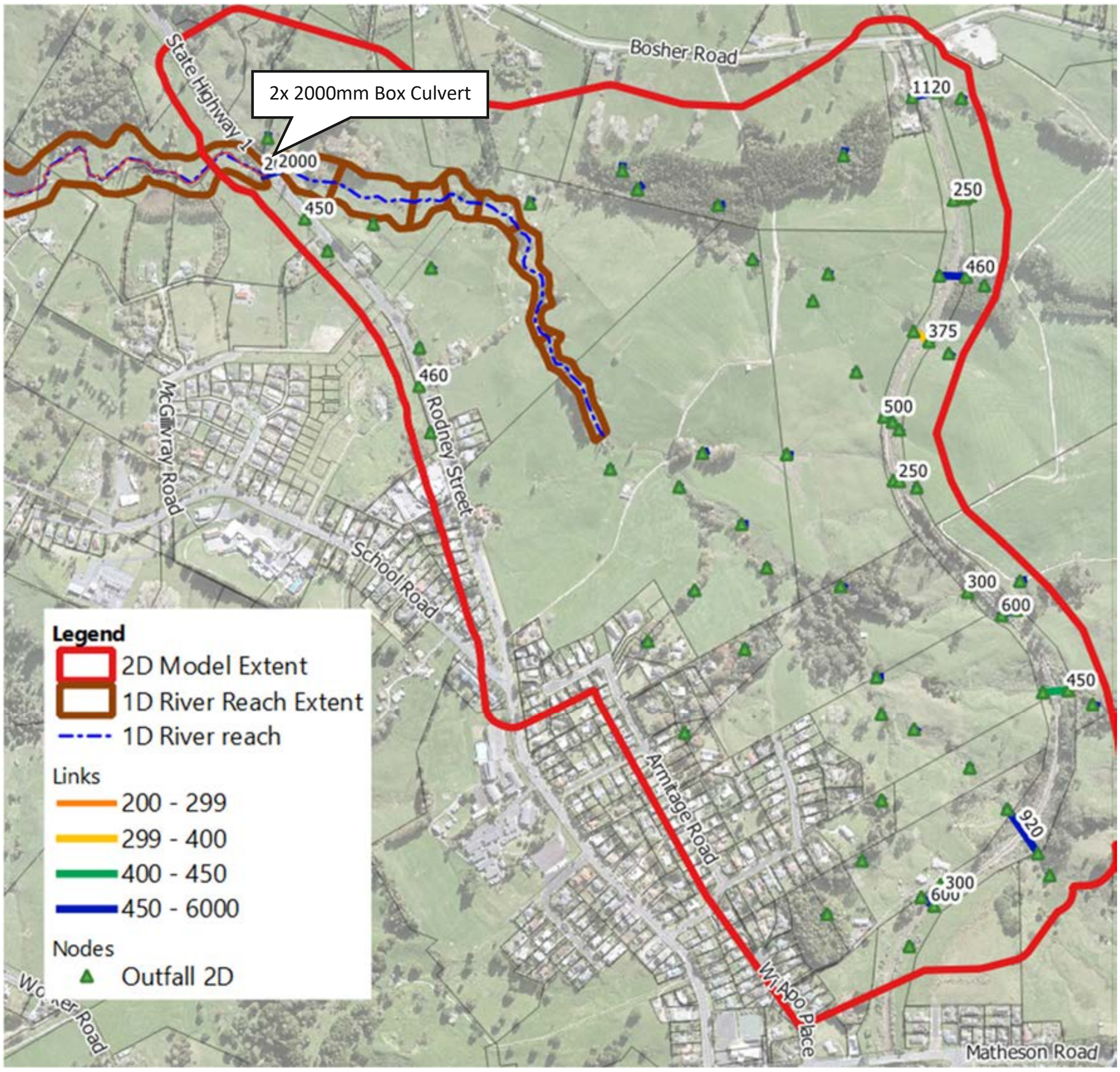

Figure 14. Modelled culverts and open channels inside the area of interest.

Table 9 provides a summary of modelled open channels and culverts.

Table 9: Summary of modelled channels and culverts

Model Component	No
Open Channel	2
Culverts	16

For the model river reach, a Manning's (n) roughness of 0.03 and 0.04 was assumed for the riverbed and the riverbank, respectively. These values were considered based on aerials and photos taken along the channel.

10. Two Dimension Modelling

The 2D model was created in ICM using LiDAR 2016 and terrain survey, as previously mentioned in Section 5, with a flexible mesh approach. The mesh resolution was set to a maximum of 5 $m^{2,}$ (minimum of 2 m^2), which is considered suitable to generate flow paths and floodplains. However, the combined terrain presented areas where ponding was occurring due to presumed missing private infrastructures. Therefore, the terrain was manually adjusted in certain areas to represent a free flow pass forward approach. The 2D model extent and the six areas where the terrain was adjusted can be seen in Figure 15.

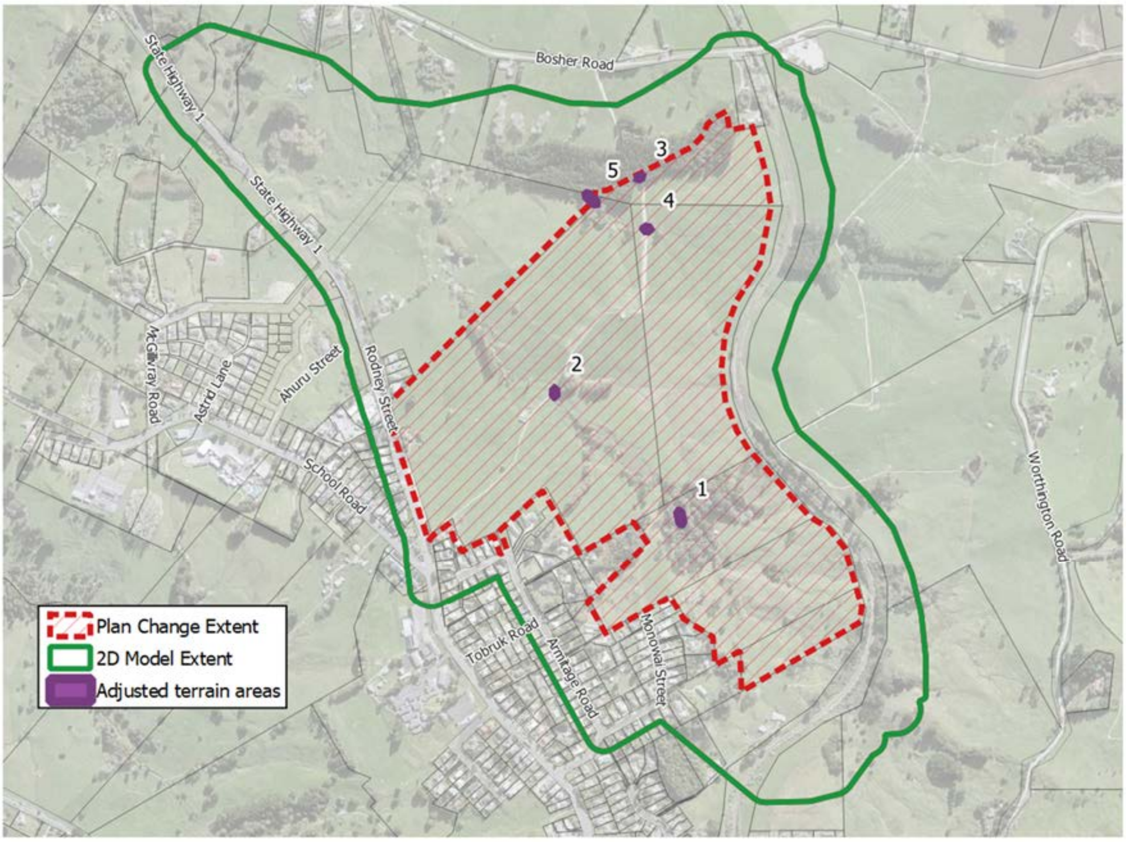

Figure 15: 2D-Modelling extent and adjusted terrain areas

The Manning's roughness applied to the 2D model is summarised in Table 10 and shown in Figure 16. These values were taken from the Auckland Council SW Modelling Specification November 2011.

Table 10: Manning roughness values used in Mike 21 models

Land Use	Manning's n
Roads	0.02
Residential	0.1
Open Space	0.05
Stream banks	0.04
Stream wet base	0.03

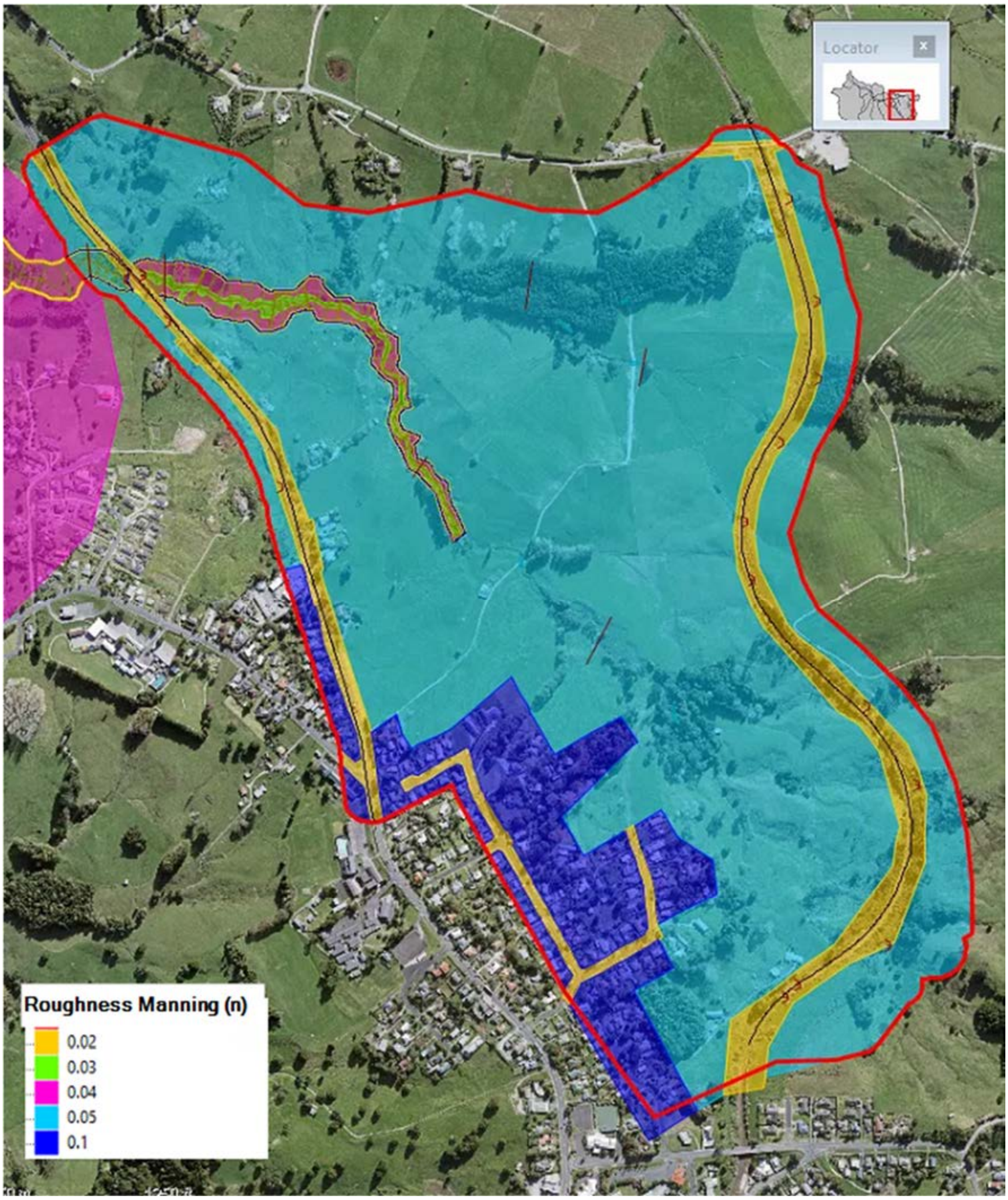

Figure 16. Roughness values on the 2D domain

11. Model Scenarios

Table 11 shows the fifteen scenarios that have been simulated for three different storm events to assess any flood effects resulting from the PPC and any flood risks within the development area. All scenarios were run over a period of 24 hours.

Table 11. Model scenarios

No	Network	Land use	Storm Event (ARI)	Climate Change	Rainfall depth (mm)	Tide level
1	Existing	Existing Development (ED)	10yr	NO	120/160	2.3 + 1 mRL (MHWS 10%il)
2			100yr		260/250	
3			2yr	Yes 3.8°C	121/108	
4			10yr		157/209	
5			100yr		345/332	
6		Existing Development and proposed Plan Change (PPC)	10yr	NO	120/160	
7			100yr		260/250	
8			2yr	Yes 3.8°C	121/108	
9			10yr		157/209	
10			100yr		345/332	
11		Proposed Plan Change and Future Urban Zone (PPC FUZ)	10yr	NO	120/160	
12			100yr		260/250	
13			2yr	Yes 3.8°C	121/108	
14			10yr		157/209	
15			100yr		345/332	

The model results were analysed to extract the flood extents, peak water levels and flood depths for each scenario to have a better understanding of the flood risk for the existing development, existing development including the Private Plan Change Scenario and the maximum probable development, including Private Plan Change scenarios.

The model results are included in the Wellsford North Plan Change - Stormwater Management Plan.

12. Limitations and Assumptions

The following assumptions and limitations are noted:

- This model has been prepared to provide guidance on flood levels and depths within the modelled catchment area for the modelled scenario. The modelling process relies on a range of assumptions and simplifications and may be subject to errors and inaccuracies. The compounding effects of the uncertainties in the TP108 rainfall model (ARC, 1999), the uncertainties in the LiDAR data and the uncertainties in hydraulic parameters such as roughness could result in the water level varying from the mapped levels.
- The LiDAR data has an absolute vertical accuracy of +/- 0.10m. Deviations in vertical accuracy can occur in areas of dense vegetation. Below water ground levels are not reliably represented in the LiDAR data.
- A uniform roughness was assumed along the Oruawharo River, and interpolated cross-sections using LiDAR 2016 were created to define it as there was no survey data captured along the open channel.
- Woods have developed the Wellsford North Plan Change model to understand existing flood risks and provide flood assessments for the Private Plan Change and not intended for general catchment planning purposes.
- Field survey did not include all culverts along the KiwiRail Northern rail and presumed private infrastructure.

APPENDIX A

Culvert Information

No	us_node_id	Asset Owner	Survey Levels	ds_node_id	Photo Inlet	Photo Outlet	Diameter (mm)	Shape and material	INLET COEFF. CONTROL*					INLET / OUTLET LOSS COEFF			
									Nr *	K	M	C	Y	Type Inlet	Ki	Type Outlet	Kf
2	2000063746	AC - Transport	YES	2000819719	NO	YES	450	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
3	2000805184	NZTA	YES	2000213627	YES	NO	450	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
1	2000811317 N	AC - Stormwater	YES	2000293597 N	YES	YES	2000	Circular Concrete	2	0.0018	2.0000	0.0292	0.7400	Circular/Headwall and wingwalls	0.5	Straight line (wingwall)	0.5
1	2000811317 S	AC - Stormwater	YES	2000293597 S	YES	YES	2000	Circular Concrete	2	0.0018	2.0000	0.0292	0.7400	Circular/Headwall and wingwalls	0.5	Straight line (wingwall)	0.5
19	2258561_US	Kiwi Rail	NO	2258561_DS	NO	YES	600	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
18	2258562_US	Kiwi Rail	NO	2258562_DS	NO	NO	300	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
17	2258563_US	Kiwi Rail	NO	2258563_DS	NO	NO	920	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
16	2258564_US	Kiwi Rail	NO	2258564_DS	NO	NO	450	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
15	2258565_US	Kiwi Rail	YES	2258565_DS	NO	YES	600	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
13	2258567_US	Kiwi Rail	YES	2258567_DS	YES	NO	300	Circular Concrete	-	-	-	-	-	Square manhole (no culvert). Modelled has manhole 2D. 1by1 manhole 1m²		-	-
12	2258568_US	Kiwi Rail	NO	2258568_DS	NO	NO	250	Circular Concrete	3	0.0045	2.0000	0.0317	0.6900	Projecting / Square Edge	0.5	-	-
11	2258569_US	Kiwi Rail	YES	2258569_DS	YES	YES	500	Circular Concrete	1	0.0098	2.0000	0.0398	0.6700	Headwall / square edge	0.5	-	-
10	2258570_US	Kiwi Rail	NO	2258570_DS	NO	NO	375	Circular Concrete	1	0.0098	2.0000	0.0398	0.6700	Headwall / square edge	0.5	-	-
9	2258571_US	Kiwi Rail	YES	2258571_DS	NO	YES	460	Circular Concrete	1	0.0098	2.0000	0.0398	0.6700	Headwall / square edge	0.5	-	-
8	2258572_US	Kiwi Rail	YES	2258572_DS	NO	YES	250	Circular Concrete	1	0.0098	2.0000	0.0398	0.6700	Headwall / square edge	0.5	-	-
7	2258573_US	Kiwi Rail	YES	2258573_DS			1120x1120	Rectangular/Headwall	20	0.4950	0.6670	0.0314	0.8200	Any/ Square End (No wingwalls)	0.3		

*Coefficients based on ‘Culvert, Screen and Outfall Manual. Ciria 2019’. Table A7.5 and A7.