FLOOD ASSESSMENT REPORT

Rangitoopuni Development
Riverhead, Auckland

PROJECT INFORMATION

CLIENT:	Rangitoopuni Developments Limited Partnership
PROJECT:	147007 and 147016

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1. OVERVIEW

1.1 INTRODUCTION

The purpose of this report is to provide a flood assessment to support the proposed redevelopment of the Riverhead Forest Fast Track application. This proposal would see Lot 1 developed for 208 1ha countryside living lots; and Lot 2 developed for a Retirement Village of 260 Villas with 36 care-units and associated amenities. The concept plan for the area is identified in Figure 1 Concept Plan (below).

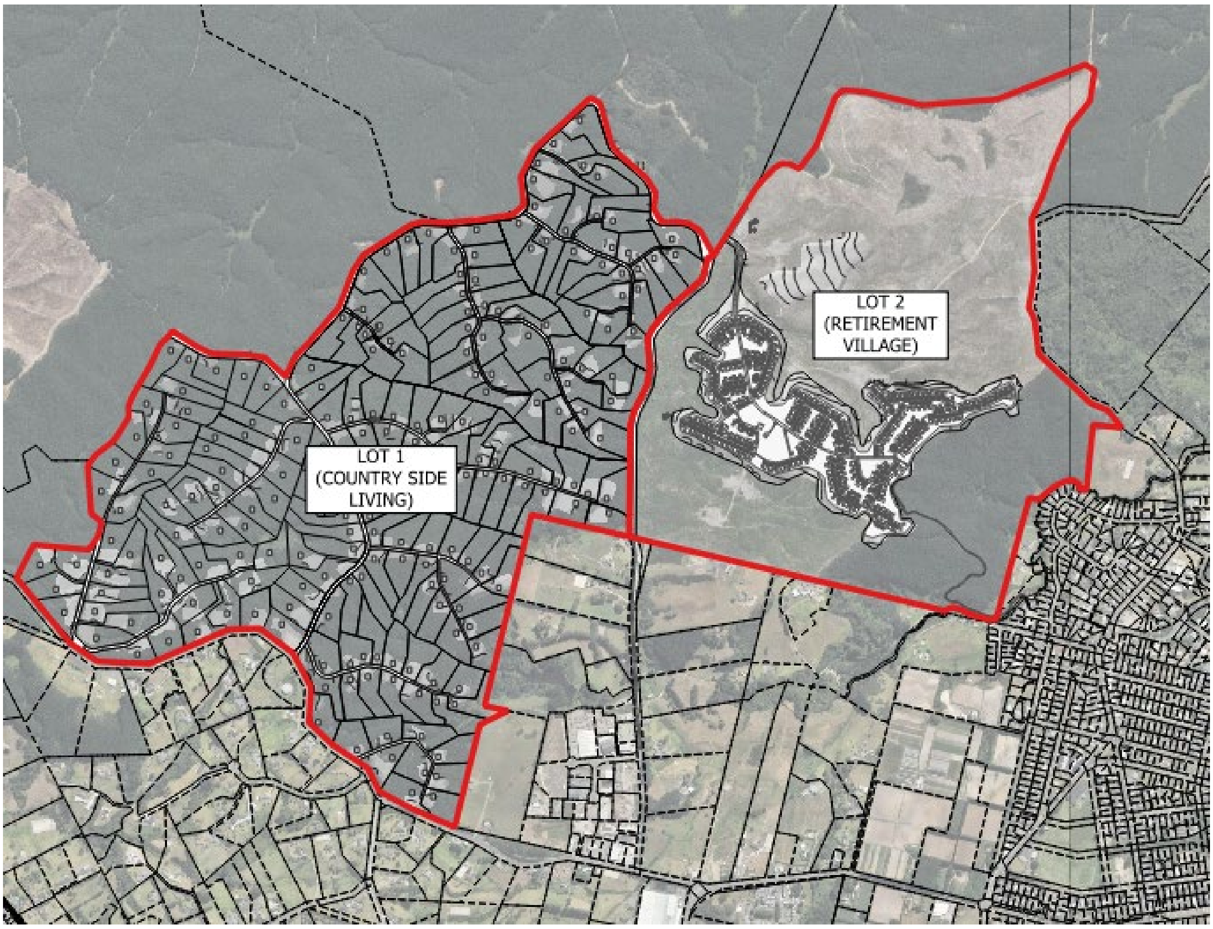

Figure 1 : Concept Plan: Lot 1, 208 1ha lots and Lot 2 Retirement Village

The primary objective of the flood model is to investigate the potential impact of the proposed development on the neighbouring and downstream properties and to mitigate adverse flooding effects where required for and up to the 1% AEP rainfall event. A flood model using HEC HMS and HEC RAS software has been developed by Maven to support the proposal.

Maven Associates has consulted with the Healthy Waters (HW) modelling team in Auckland Council (AC) as part of the pre-application process who provided general comments on the flood model build, and catchment parameters and assumptions.

This report provides information relating to the flood model build, modelling results and conclusions. The report supports and should be read in conjunction with the development's Infrastructure Report and Stormwater Management Plan.

1.2 SITE DESCRIPTION

The subject site forms part of the wider Riverhead (Rangitopuni) Forest holdings. The site is located between Riverhead Township to the east, and Kumeu/Huapai to the south-west. The site is well connected, having ease of connections to SH16 and the Northwestern motorway.

The site features frontage and access from Old North Road (to the south), Deacon Road and Forestry Road. The site has been recently logged, and is intended to be developed for residential purposes, with the balance of the land within Lot 1 planted out in native vegetation as part of the development.

The site features moderate to steep rolling topography, with prominent ridgelines, gullies and identified streams contained within. The site is contained within two stormwater catchments – Lot 1 straddles the Kaipara Catchment (western half), with the eastern area in the Riverhead Catchment. Lot 2 is wholly contained within the Riverhead Catchment. The streams in the Riverhead Catchment flow east, to the rear of the Township, before discharge into the Rangitopuni River upstream of the Riverhead-Coatesville Highway bridge.

There is no existing building within the site. The site benefits from several lawful and existing vehicle crossings and forestry roads within, which are formed to a rural road standard (compacted gravel, table drains etc).

1.3 CATCHMENT DESCRIPTION

The subject site is located within two stormwater catchments. The western portion of the site is located at the upper reach of the Central Kaipara Catchment and the eastern catchment is located within the middle of the Riverhead Catchment. The location of the site relative to the overall catchments is shown below within Figure 2.

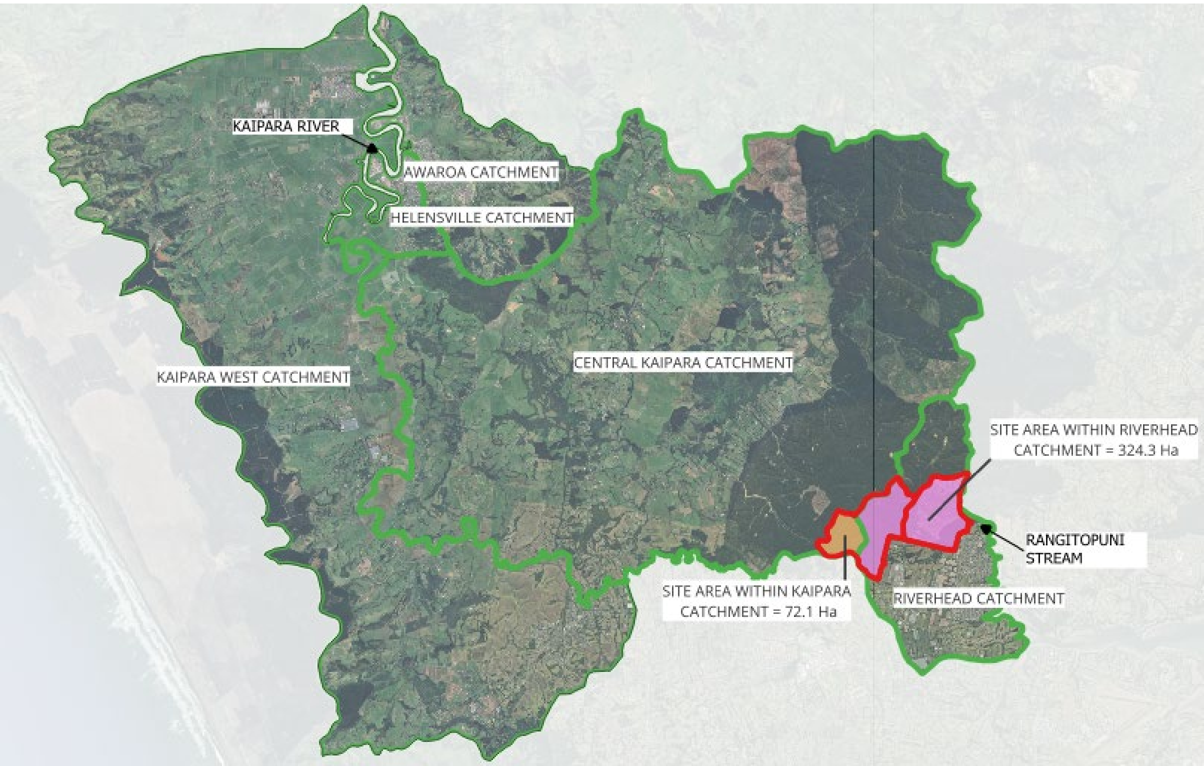

Figure 2: Stormwater Catchment Plan Overview

1.3.1 Western Catchment (Central Kaipara Catchment)

The western portion of the site, with an area of 72.1 Ha is located at the top of a reach within the Central Kaipara Catchment. The catchment eventually discharges to the Kaipara River. The existing overland flowpaths within this portion of the site are largely contained to the streams and associated margins.

It is noted that there are two existing culverts located where flows discharge from the site. Auckland Council's GeoMaps has illustrated the predicted overland flow path (OLFPs) and flood plains in the area for 1% AEP storm event (Figure 3), which indicates the floodplain extent.

1.3.2 Eastern Catchment (Riverhead Catchment)

The remaining 324.3 Ha is located within the middle of the Riverhead Catchment. The receiving environment of the Riverhead Catchment is the Waitemata Harbour via the Rangitopuni stream. The existing overland flowpaths within the site are largely contained to the streams and associated margins.

Downstream of the site the Auckland Council Geomaps shows a floodplain between the site and Rangitopuni Stream. The existing floodplain extents is shown to inundate the current Forestry Road carriageway. A wide floodplain with a width of up to 250m is shown between Forestry Road and Duke Street. Downstream of Duke Street, the floodplain is shown to encroach multiple properties along Wautaiti Drive, Crabb Fields Lane and Cobbers Lane before discharging into the Rangitopuni Stream.

It is noted that there are multiple existing culverts that cross the streams and/or overland flowpaths. Auckland Council's GeoMaps has illustrated the predicted overland flow path (OLFPs) and flood plains in the area for 1% AEP storm event (Figure 3), which indicates the floodplain extent.

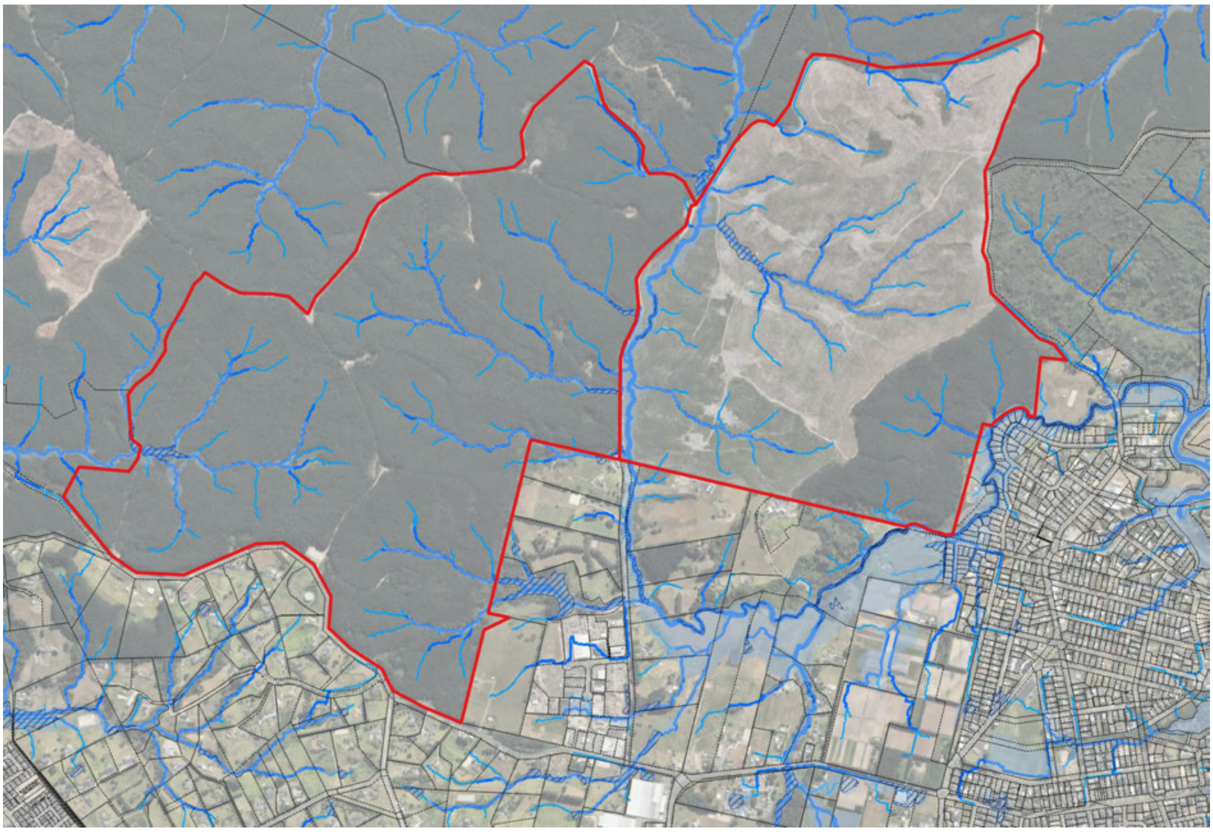

Figure 3: Auckland Council Geomaps Extract showing Flooding and OLFPs

2. MODEL BUILD

A HEC RAS 2D hydraulic model (version 6.6) was prepared to assess the flooding aspects of the development. The flood model build outline is provided in the following sections.

2.1 MODELLING APPROACH

The following modelling approach has been implemented for the assessment for each of the storm events (50% AEP, 10% AEP and 1% AEP) :

1. A catchment wide predevelopment model was prepared for each of the storm events.
2. Using inflow hydrographs generated from the catchment wide model, a reduced model was created which included the site area and downstream floodplain.
3. A post development model was prepared for each of the assessed scenarios.
4. A comparison and impact assessment were undertaken to assess the impact of the development downstream for each of the scenarios.

Due to the sensitive nature of the existing flooding in Riverhead catchment downstream of the site, additional flood modelling storm events have been conducted for the Riverhead Catchment including the 20%AEP, 5%AEP and 2%AEP storm events. Methodology for each of the events has been carried out similar to outlined above in points 1 to 4.

2.2 DATA

The following data has been used for the flood model build:

- Average TP108 24-hour rainfall depth for the 2d flow area for 50%AEP, 20%AEP, 10%AEP, 5%AEP, 2%AEP and 1% AEP;
- There are 20 culverts included in the 2D model. The culverts' details are based on survey, site visits and GeoMaps.
- There are 7 proposed (upgraded) large culverts with diameters above 1500m which have been included in the proposed scenario
- Terrain data
    - Auckland 1m LiDAR DEM (2016-2018)
    - Maven Site survey (Drone and on-site)
    - Proposed Ground level surface
- Generated Landcover shapefile
- Generated predevelopment and post development Infiltration shapefile
- Mean High Water Spring (MHWS)- 10 Coastal Marine Area Boundary for the Auckland Region
- Maximum impervious percentage for AUP Zones for rural zones MPD (Maximum Probable Development) was obtained from Auckland Council Geomaps future Impervious layers.

2.3 CATCHMENTS

2.3.1 Catchment Delineation

The catchments were delineated based on the Auckland 1m LiDAR DEM (2016-2018) from LINZ using HEC HMS delineation tool.

The catchment wide modelled area for the eastern catchment was 1,003 Ha. The reduced catchment area for the eastern and western catchment is 103.3 Ha and 363.8 Ha respectively. Refer to Appendix A for a plan showing the catchment extents.

3. HYDROLOGY

Hydrological parameters for the HEC RAS model were prepared in accordance with the TP108 methodology, details are outlined below.

3.1 DESIGN RAINFALL

The design rainfall data was generated from the standard TP108 24-hour temporal pattern and the 24-hour rainfall average depth from TP108 24hr rainfall depth contours for the catchment. Table 3.1 and 3.2 below shows modelled rainfall depths.

Storm event	TP108 Rainfall Depth (mm)	Design Climate Change	Future Rainfall Depth (mm)
50%AEP	80.1	2.1 degrees (15.1%)	90.2
20%AEP	112.0	2.1 degrees (16.4%)	130.4
10%AEP	130.2	2.1 degrees (17.0%)	152.3
5%AEP	156.0	2.1 degrees (17.2%)	182.8
2%AEP	182.0	2.1 degrees (17.6%)	214.0
1%AEP	196.4	3.8 degrees (32.7%)	260.6

Table 3.1 Eastern Catchment TP108 Rainfall Depths

Storm event	TP108 Rainfall Depth (mm)	Design Climate Change	Future Rainfall Depth (mm)
50%AEP	80.0	2.1 degrees (15.1%)	90.1
10%AEP	126.7	2.1 degrees (17.0%)	141.5
1%AEP	186.5	3.8 degrees (32.7%)	247.5

Table 3.2 Western Catchment TP108 Rainfall Depths

3.2 INFILTRATION

Please refer to the two Geotech Reports prepared by ENGEO, report references (20190.000.001). The reports outline that topsoil depths vary between 200-400mm. East Coast Bays Formation soils were encountered within all investigation boreholes underlying existing fill, Alluvial soils and Albany Conglomerate. Underlying the residually weathered soils of the East Coast Bays Formation comprised extremely weak, to very weak interbedded sequences of siltstone and sandstone.

In accordance with TP108 calculations, a Group C hydrological soil classification has been adopted. As outlined in TP108 curve numbers should be selected based on the TP108 SCS Table 2-2.

3.2.1 Existing Forestry Land Cover

As described in section 1.2 the existing and current site has been used for commercial forestry. Lot 2 has been logged six years ago, with Lot 1 logged in the last two years. The land use could be classified with a CN of 74 for "lightly grazed / good grass cover" to a CN of 88 for "minimal vegetation cover". For the purposed of this assessment a conservative approach has been taken with the assumption of an existing curve number of 74.

The use of the lower Curve Number (CN) for the pre-development condition in a runoff assessment is considered a conservative approach because it assumes greater infiltration and less runoff than may actually occur.

This results in a lower baseline runoff estimate, making the difference between pre- and post-development runoff appear larger. Consequently, post-development stormwater management measures must be designed to mitigate a potentially exaggerated increase in runoff, ensuring a more robust drainage system.

This approach provides a margin of safety, helping to prevent underestimation of stormwater impacts and reducing the risk of flooding or erosion. Whilst this method ensures a conservative design, it is important to note that may lead to overestimation of stormwater infrastructure needs.

3.2.2 Proposed Planted Bush Land Cover

The balance of undeveloped area of Lot 1 is proposed to be planted with covenanted bush vegetation. Per TP108 SCS Table 2-2 a Curve number of 70 should be used for bush land use. This curve number reflects the moderate runoff potential of forested areas with less permeable soils. Bushland vegetation intercepts rainfall, reducing direct runoff, while organic matter enhances infiltration.

3.2.3 Proposed Impervious Areas

Per TP108 SCS Table 2-2 a Curve number of 98 has been used for sealed roads and roofs because these surfaces are highly impervious, allowing almost no infiltration and generating near-total runoff during rainfall events.

3.2.4 Initial Abstraction

Per table 3.1 in TP108 the below initial Abstraction (Ia) has been assumed for all the catchments:

- Ia=5mm for pervious area
- Ia=0 for impervious area

3.2.5 Weighted Curve Numbers

Weighted curve numbers and Initial abstractions was calculated based on above assumptions and impervious percentage for each catchment. See section 3.3 for details.

3.2.6 SMAF Roof Collection

(for 50%, 20%, 10%, 5% and 2% AEP storm events in Countryside Living Lots)

To simulate the collection of rainwater from roof areas during storms into tanks in the HEC-RAS model for the Countryside Living lots, the initial abstraction has been increased to 35mm within the roof area extents, this is equivalent to the SMAF (Stormwater Management Area Flow) retention depth.

Each lot has a roof area of 250m², with a total of 208 lots. This assumes that 750m² of impervious areas is discharged unattenuated, which is a further conservative assumption.

3.2.7 Retirement Village Stormwater Dry Pond

(for 50% and 10%AEP storm events in Countryside living Lots only)

The catchment draining to the stormwater dry pond has a total area of 18.0 Ha. To model the effect of the stormwater network capturing runoff and directing it to a pond during 50%, 20%, 10%, 5% and 2%AEP a localised adjustment to the area's initial abstraction was used increasing it to the 10%AEP storm event rainfall depth of 152mm and an inflow hydrograph was used to simulate the pipe discharge to the pond using HEC HMS and a boundary inflow into the HEC RAS model (refer to Appendix B for HEC HMS model setup).

3.3 LANDCOVER

Maximum impervious coverage has been assumed for areas outside the site using MPD (Maximum Probable Development) outlined in the Auckland Unitary Plan. See plans in Appendix A for a summary of the weighted CN values. Impervious areas for the site areas are summarised below.

3.3.1 Predevelopment

The predevelopment site assuming an almost fully pervious Lot. With the minor exception of the existing Deacon Road carriage way has been modelled with an impervious percentage of 85% with a CN = 94.4 (less than 1% of the site area).

The balance of the existing site has been modelled as fully pervious with a CN = 74 (see section 3.2 for further details on CN number selection).

3.3.2 Lot 1 – Countryside Living Post development

The Countryside Living Lot has a total area of 222.7 Ha. The post development landcover assumed consists of:

- Roading and driveway - The total area within the Lot allocated as JOAL/driveway is approximately 11.5 Ha. This area has been modelled with a 70% impervious coverage and 30% pervious coverage for grass swale/landscaping
- Each of the 208, 1 Ha Lots has been modelled with a total impervious area of 1,000m² and landscaping area of 1,500m²
- The balance of the Lot with an area of 158.72 Ha has been modelled as covenant bush

Landuse	CN	Site Area
Pervious Landscaping	74	34.95 Ha (16%)
Pervious - Covenanted Bush	70	158.72 Ha (71%)
Impervious	98	29.06 Ha (13%)

Table 3.3 Lot 1 land cover summary

The composite CN value for Lot 1 is 74.2.

3.3.3 Lot 2 – Retirement Village

Lot 2 has a total area of 173.60 Ha, the post development landcover shall consist of:

- Approximately 24.50 Ha development area for the retirement village platform area (80% Impervious).
- Approximately 1.57 Ha of Forestry Road corridor extension (85% Impervious).
- The balance of the Lot with an area of 147.5 Ha has been modelled as existing coverage with a CN value of 74.

3.3.4 MPD Scenario

A sensitivity scenario has been included in the assessment with the site modelled with an impervious percentage of 11.65% (per the Auckland Geomaps OLFP layer). This MPD assumption has been done as this is what Council's flood modelling and PPC 100's modelling assumes for the impervious state and runoff from the site.

3.4 ATTENUATION

The following section summarises the attenuation devices proposed to mitigate any exacerbation of downstream flooding of the site.

3.4.1 Countryside Living Subdivision (Lot 1) - Flood Attenuation

Construction of a specific designed culvert (culvert 11) and spillway is proposed at the base of JOAL 1 within the western catchment which falls to the Kaipara River. This ensures no increase of flows for the 50%, 10% and 1% AEP events and provides downstream mitigation for the western catchment.

Culvert 11

- Construction of two specific designed culverts beneath JOAL 1 shall be sized to attenuate 50%, 10% and 1%AEP storm events. Details of the configuration of the devices include:
  - Primary Outlet – 1200mm circle culvert located at the stream bed (with 440mm depth embedment for fish passage).
  - Secondary Outlet 10% and 1% AEP - 4000mm x 1500mm box culvert located at 56.6mRL (inlet).
  - Emergency Spillway – JOAL1 served as emergency spillway with Min. level of 59.02 mRL

- The total upstream volume stored below emergency spillway crest is approximately 18,140 m^3.

3.4.2 Retirement Village (Lot 2) - Flood Attenuation

The combination of two attenuation devices provides stormwater management for the eastern catchment. The proposed devices include two specific designed culverts (culvert 7 and culvert 7 primary) located beneath Accessway 1 and a dry stormwater detention pond adjacent the Retirement Village.

Culvert 7

- Construction of a specific designed culverts and an emergency spillway beneath JOAL 1 is proposed and shall be sized to attenuate all storm events. Details of the configuration of the devices include:
  - Primary Outlet – 600mm circular culvert located at the stream bed (with 25% embedment for fish passage)
  - Emergency Spillway – 20m wide emergency spillway is located at 38.20 mRL
  - The total upstream volume stored below emergency spillway crest is approximately 19,000 m^3.

Retirement Village stormwater dry pond

- Construction of a large attenuation basin at the base of the engineered embankment, referred to as the RV stormwater dry pond shall provide 50%AEP and 10%AEP attenuation to approximately 18 Ha of the Lot's catchment. Details of the configuration of the devices include:
  - Primary Outlet = 225mm circular orifice
  - Emergency spillway - 18m wide spillway is located at 35.9mRL - (Vol = 13,000 m^3)
  - Maximum Water Surface Elevation ('WSE') (fully blocked) = 36.14 mRL (14,000 m^3)
  - Assuming 300mm free board top of embankment = 36.44 mRL (15,270 m^3)

3.4.3 Modelling Routing for Dry Pond (HEC HMS)

The catchment draining to the stormwater dry pond has a total area of 18.0 Ha. To model the effect of the stormwater network capturing runoff and directing it to a pond during 50%, 20%, 10%, 5% and 2% AEP a localised adjustment to the area's initial abstraction was used and an inflow hydrograph was used to simulate the pipe discharge to the pond.

See Appendix B for HEC HMS model parameters.

4. CULVERTS

These sections outlined the culverts used in the model. Where possible site survey has been carried out to obtain details of culverts. Plans summarising the modelled culverts may be found in the Appendix A.

4.1 EXISTING CULVERTS

4.1.1 Existing Minor Culverts (Less than DN1500)

A total of 26 culverts have been modelled into the 50% and 10% storm events models. A summary of the culverts may be found in the Appendix A.

4.1.2 Existing Major Culverts

An existing 2600mm culvert (named "pond 6") is located at the intersection of Forestry and Deacon Roads.

4.2 PROPOSED/UPGRADED CULVERTS

4.2.1 Forestry Road Culverts

There are six proposed/upgraded culverts with diameters above 1500mm proposed along the new Forestry Road alignment. Please refer to Maven drawings 147016-RV-C480 and 147016-RV-C490 series for further detail and location of culverts.

4.2.2 Western catchment Culvert Culverts

There is one proposed/upgraded culvert with diameters above 1500mm proposed beneath the Joal 1 Countryside Living Lot. Refer to Maven 147007-CSL-C480 and 147007-CSL-C490 series drawings.

4.3 PROPOSED BRIDGES

The existing 2600mm culvert located at the intersection of Forestry and Deacon Road has been assessed to be undersized, overtopping during a 10%AEP storm event. The existing culvert is proposed to be upgraded to a bridge structure, which is detailed within Maven engineering drawing 147016-RV-C481.

4.4 ATTENUATION CULVERTS

Attenuation culverts outlined in Section 3.4 have been modelled in the proposed scenarios.

4.5 CULVERT BLOCKAGE FACTORS FOR 1%AEP STORM

In accordance with the Auckland Council Stormwater Code of Practice (SWCoP), a blockage scenario was also assessed. The blockage assessment (referred to as 50% blocked later in the report) uses the assumptions outlined in the SWCoP section 4.3.9.8 accounts for partial obstruction due to debris accumulation, sedimentation, or lack of maintenance. Assumptions for the 50% blockage scenario includes total blockage of the culvert in cases where it is less than DN1,500, and 50% capacity reduction if the culvert is greater than or equal to DN1,500.

5. HYDRAULICS (HEC RAS)

HEC RAS model (version 6.6) was used to assess the hydraulic features of the catchment flows. The model build is summarised in the following sections.

5.1 GEOMETRY

The geometry includes following components:

- 2D flow the 2D model extent generally consists of 5m x 5m cells
- Break lines: break lines have been placed along roads, channels, OLFPs.
- Flow boundary condition line: external lines where flow hydrographs are loaded to 2D flow area.
- Downstream boundary condition line: where water leaves 2D flow area through downstream boundary conditions (see section 4.3 for detail).

- **Culverts:** modelled as 2D connection in the model

5.2 TERRAIN MODEL

Terrain model was formed by merging the following resources:

- 2016 1m LiDAR DEM (AVD) provided by HW, and
- Site topography survey (including drone lidar)
- Proposed ground levels

5.3 BOUNDARY CONDITION

A downstream coastal boundary has been used where the catchment discharges to Rangitopuni Stream: the following coastal boundary condition adopted was obtained from the Coastal Marine Area Boundary for the Auckland Region

MHWS+1m rise=1.55 +1=2.55 m (NZVD2016).

5.4 STRUCTURES

Culverts

The existing and proposed culverts modelled in the 2D model as outlined in section 4.

Downstream Bridges

There are five private accessway bridge structures downstream of the site. In the flood model, the channels at the bridge locations remain open in the terrain and the bridge decks are not added. Downstream impact assessment shows no increases in flood level in areas where bridges are located.

5.5 ENERGY LOSS

A Manning's roughness shape file was used for the model with assigned values below:

- 0.03 for roads and streams
- 0.3 existing building footprints
- 0.1 for rest of area

5.6 COMPUTATION

The Shallow Water Equations (SWE-ELM) method (original/faster) was used for the simulation. A base computation time step of 4 seconds was applied, with an output interval set to 10 minutes. The maximum Courant number ranged from 0.7 to 1.5, with time step adjustments varying between 0.5 seconds and 16 seconds to ensure numerical stability and accuracy in the simulation.

6. CONSULTATION

Two pre-application meetings have been held with representatives of Auckland Council and Healthy Waters. These meetings were held on 07 March 2025, and a follow up meeting (specific to stormwater and flooding) was held on 12 March 2025.

This was attended by various representatives from Healthy Waters (including the two catchment managers, stream/hydrology specialist and other supporting personal). The high-level approach to stormwater management was provided from Maven.

Specific details relative to the flood modelling and assumptions were also discussed and agreed on.

A further sensitivity check of 5-yr, 20-yr, 50-yr with climate change and 100-yr without climate change was also asked for, which has been modelled and reported on for the Eastern Catchment. No other rainfall events were asked for within the meeting.

7. MODEL SCENARIOS

Modelled scenarios include:

- Base scenarios – Pre Development and Post Development (50%, 20%, 10%, 5%, 2% and 1%AEP) with Climate Change
- Sensitivity – Pre Development and Post Development (1%AEP) without Climate Change
- Sensitivity – 50% Blockage Overland flow Pre Development and Post Development (1%AEP) with Climate Change

Table 1: Modelled Scenarios Summary:

Scenario	Storm event	Development	Design Climate change	Comment
1	50%AEP	Predevelopment	2.1 degrees (15.1%)	Site predevelopment & Outside site MPD
2	50%AEP	Post development	2.1 degrees (15.1%)	Site post development& Outside site MPD
3	10%AEP	Predevelopment	2.1 degrees (17.0%)	Site predevelopment & Outside site MPD
4	10%AEP	Post development	2.1 degrees (17.0%)	Site post development& Outside site MPD
5	1%AEP	Predevelopment	3.8 degrees (32.7%)	Site predevelopment & Outside site MPD
6	1%AEP	Post development	3.8 degrees (32.7%)	Site post development& Outside site MPD
7	1%AEP	Predevelopment	3.8 degrees (32.7%)	Site predevelopment & Outside site MPD (50% Culvert Blockage)
8	1%AEP	Post development	3.8 degrees (32.7%)	Site post development & Outside site MPD (50% Culvert Blockage)
9	1%AEP	Predevelopment	No climate change	Site predevelopment & Outside site MPD (50% Culvert Blockage)
10	1%AEP	Post development	No climate change	Site post development & Outside site MPD (50% Culvert Blockage)
11	20%AEP	Predevelopment	2.1 degrees (16.4%)	Site predevelopment & Outside site MPD

12	20%AEP	Post development	2.1 degrees (16.4%)	Site post development& Outside site MPD
13	5%AEP	Predevelopment	2.1 degrees (17.2%)	Site predevelopment & Outside site MPD
14	5%AEP	Post development	2.1 degrees (17.2%)	Site post development& Outside site MPD
15	2%AEP	Predevelopment	2.1 degrees (17.6%)	Site predevelopment & Outside site MPD
16	2%AEP	Post development	2.1 degrees (17.6%)	Site post development& Outside site MPD

All areas outside the site extents have been modelled with MPD impervious percentage. A plan showing the impervious coverages and CN values may be found in Appendix A.

8. MODEL RESULTS

8.1 VALIDATION RESULTS

Auckland Council Healthy Waters has provided flood information associated with the site from the latest 2D flood model. The AC model result was based on MPD condition and rainfall with climate change for 3.8 °C increase. Maven's flood model has run a scenario with the above condition for validation. The result shows satisfactory comparisons with flows to be in general accordance with HWs model (+/- 5%).

8.2 FLOOD MAPS

The model result maps for entire model extent for all the scenarios are provided in Appendix C, including maximum flood depth maps (pre- and post-development) and flood level difference maps between post development and pre-development condition.

Tabular results at key locations may also be found in Appendix D.

9. MODEL RESULTS

The effect assessment investigates the potential impact of the proposed development within the site on the downstream flood risk, as well as the potential benefits or adverse impacts.

9.1 OVERALL CATCHMENT - IMPACT ASSESSMENT

Overall, the downstream impacts from the proposed development have been mitigated through covenant bush planting and attenuation devices outlined in sections 3.2 and 3.4.

Peak flows and water levels downstream of the site for each of the design stormwater events, 50%, 20%, 10%, 5%, 2% and 1% AEP with climate change have been reduced for the Eastern Catchment (Riverhead Catchment). Additional storm events have been simulated due to the flood sensitive nature of the downstream environment.

Peak flows and water levels downstream of the site for each of the design stormwater events, 50%, 10% and 1% AEP with climate change have been reduced for the Western Catchment (Kaipara Catchment).

Two downstream effects were identified in the comparison maps which are summarised below and elaborated in sections 9.2 and 9.3:

1. Existing flooding on Forestry Road carriageway has been eliminated (refer to section 9.2, previous 1.4m maximum depth).

2. An isolated increase in peak water surface elevation up to 80mm was identified in front of 100 Forestry Road for 1%AEP with Climate Change Scenario (50% blocked), Refer to section 9.3.

9.2 FORESTRY ROAD - IMPACT ASSESSMENT

The existing alignment and levels within Forestry Road was subject to flooding that exceeds the allowable 200mm depths for a public or private road and does not allow safe vehicle access. The existing flooding extent and levels of the pre-development scenario are set out below within Figure 4.

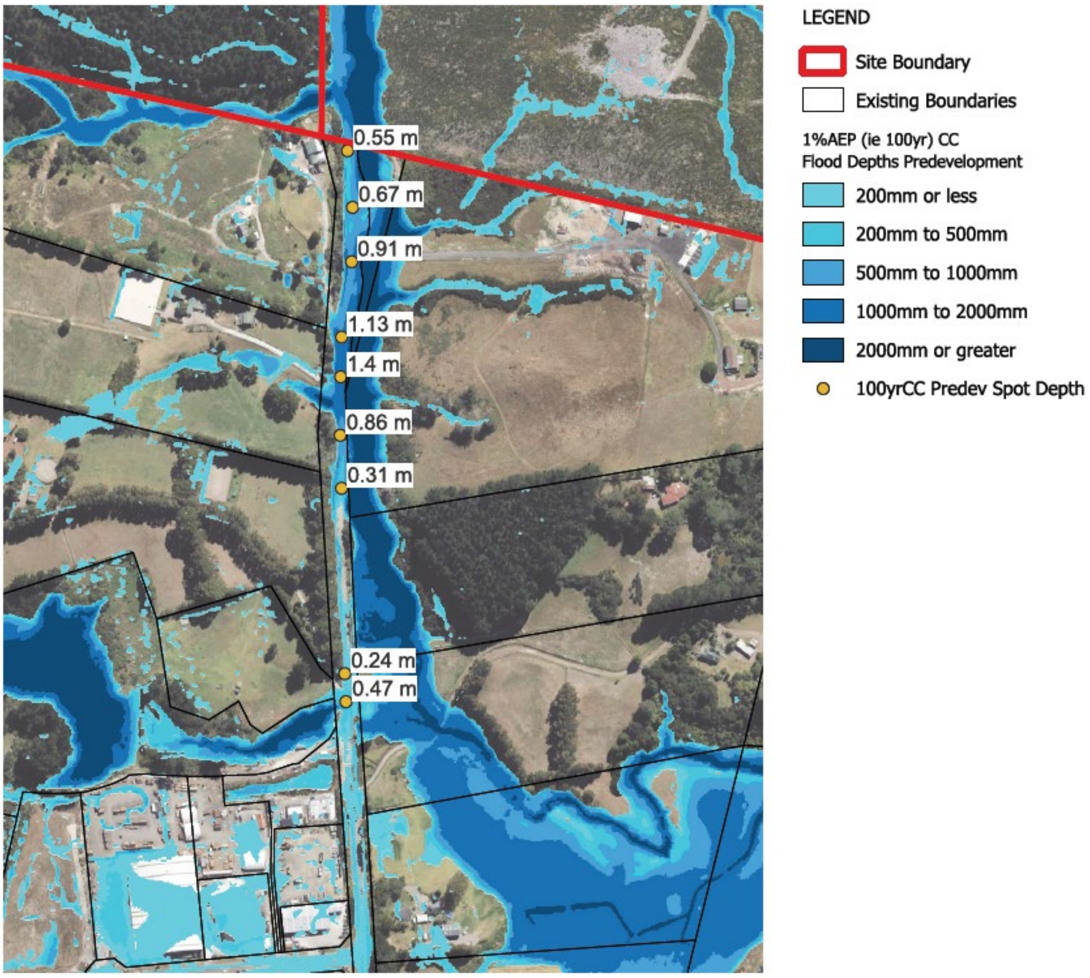

Figure 4: Pre-development Flood Levels in Forestry Road

The Forestry Road extension is a proposed public road to vest and as such, has been designed to ensure compliance with Auckland Transport Transport Design Manual (TDM) and the relevant sections of the Auckland Council SW CoP V4.

The main risk to the existing road users comes during times of flood events. To ensure safe vehicle passage in the future, the road level has been lifted with culverts sized for a 1% AEP storm event proposed where applicable. The lifted road shall ensure the maximum ponding depth within the road to vest does not exceed 200mm.

Refer to the Figure 5 below showing the proposed flood depths within Forestry Road extension post-development.

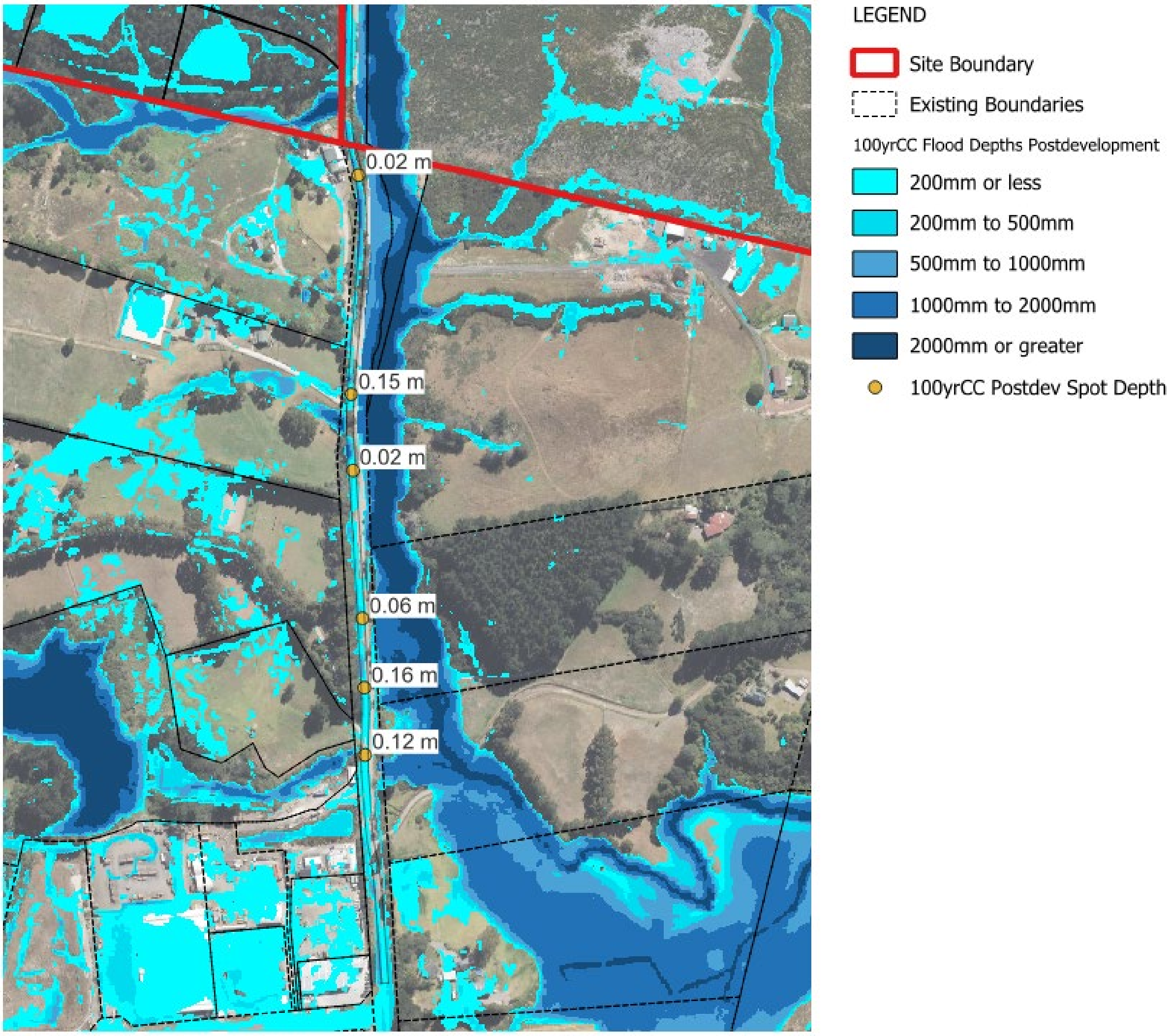

Figure 5: Post-development Flood Levels in Forestry Road

The design of Forestry Road extension has factored in downstream effects. Whilst there is reduction of flood levels along Forestry Road from pre-development levels as a consequence of the works proposed; in one location, maximum ponding depths have increased by 80mm, which is discussed in further detail below.

9.3 100 FORESTRY ROAD - IMPACT ASSESSMENT

A localized increase in water level was identified near 100 Forestry Road (Lot 8 DP 60666) and Pt Allot 91 Psh of Paremoremo SO 95 as a consequence of the works proposed, where significant - and assumed to be unlawful - modification of the stream and margins has occurred.

Given the narrow nature of the road's legal width, and the requirement to lift the road to ensure safe vehicle passage along its length, there is no ability to avoid a minor increase in flood levels at this one location when the flood waters are funnelled through this pinch-point, caused by the two ridges which extend down from both the east and the west. The effects are further amplified by the significant modification that has occurred around the stream and margins.

During the 1% AEP storm event with climate change, post development 50% blocked scenario water levels associated with 100 Forestry Road's access increase by 80mm at the lot access, resulting in a rise in flood depth from 1040mm to 1120mm, as can be seen within Figure 6 and 7 below. On review of the model results, the pre-development water level is exceeded for a total of ten minutes during the 1% AEP storm event with climate change (50% blocked scenario).

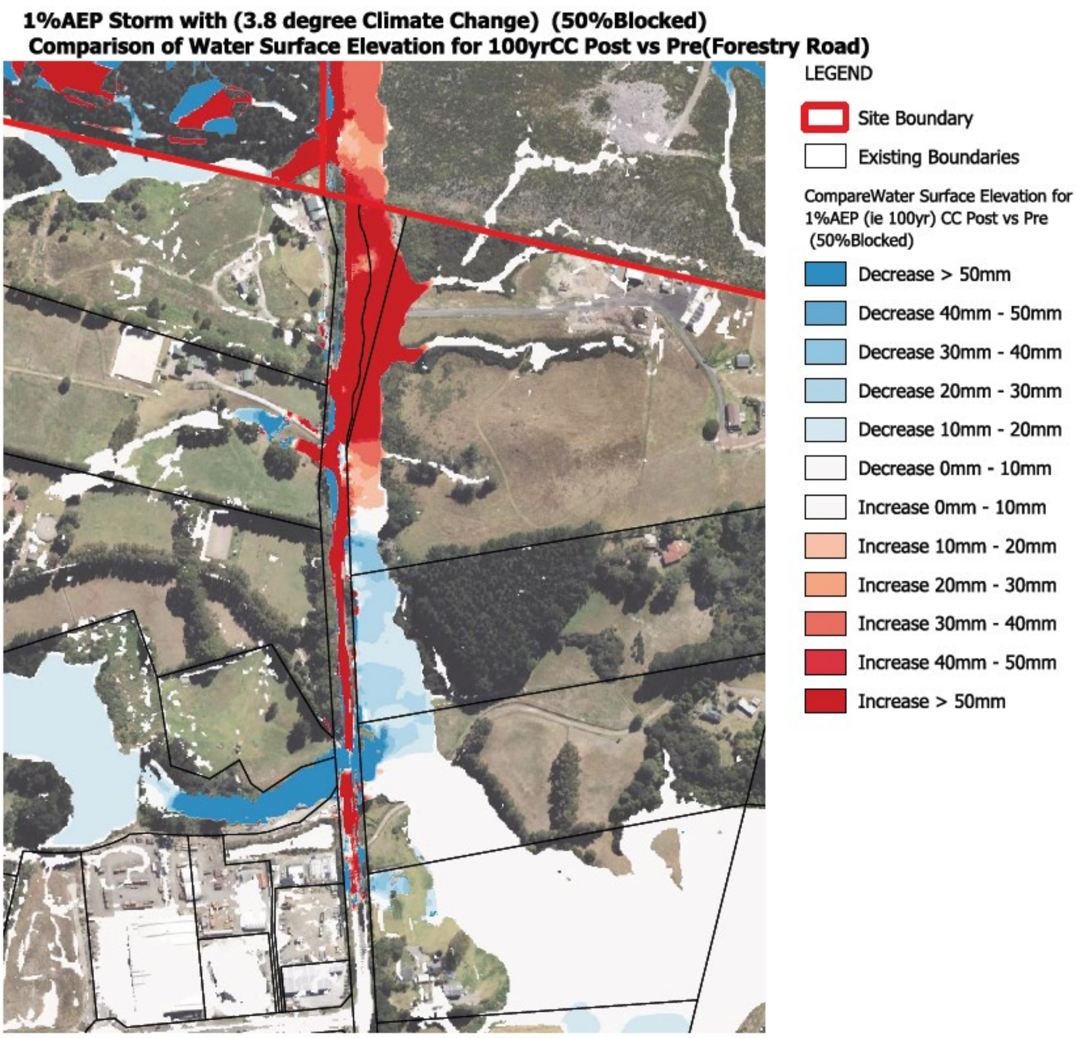

Figure 6: Water surface elevation comparison between Post development and Pre-development Flood Levels in Forestry Road

This increase is considered to have less than minor adverse effects, as the area is already subject to significant flooding under existing conditions and would be impassable in any event. There is no change in the frequency of flooding at this location (i.e. modelling of smaller events has shown a reduction in flows and flood levels) and as noted above the overall flood resilience for the road is significantly improved. Further, change in time of inundation for the 100-year event (10 minutes) is considered insignificant between the pre and post-development scenarios.

The flooding does not impact existing buildings or exacerbate property damage potential.

9.3.1 Cross-section Assessment

A cross-section assessment was prepared along the driveway of 100 Forestry Road to assess the scenario outlined above. The cross section further illustrates the increase is considered to have less than minor adverse effects, as the area is already subject to significant flooding under existing conditions and would be impassable in any event. The flooding does not impact existing buildings or exacerbate property damage potential.

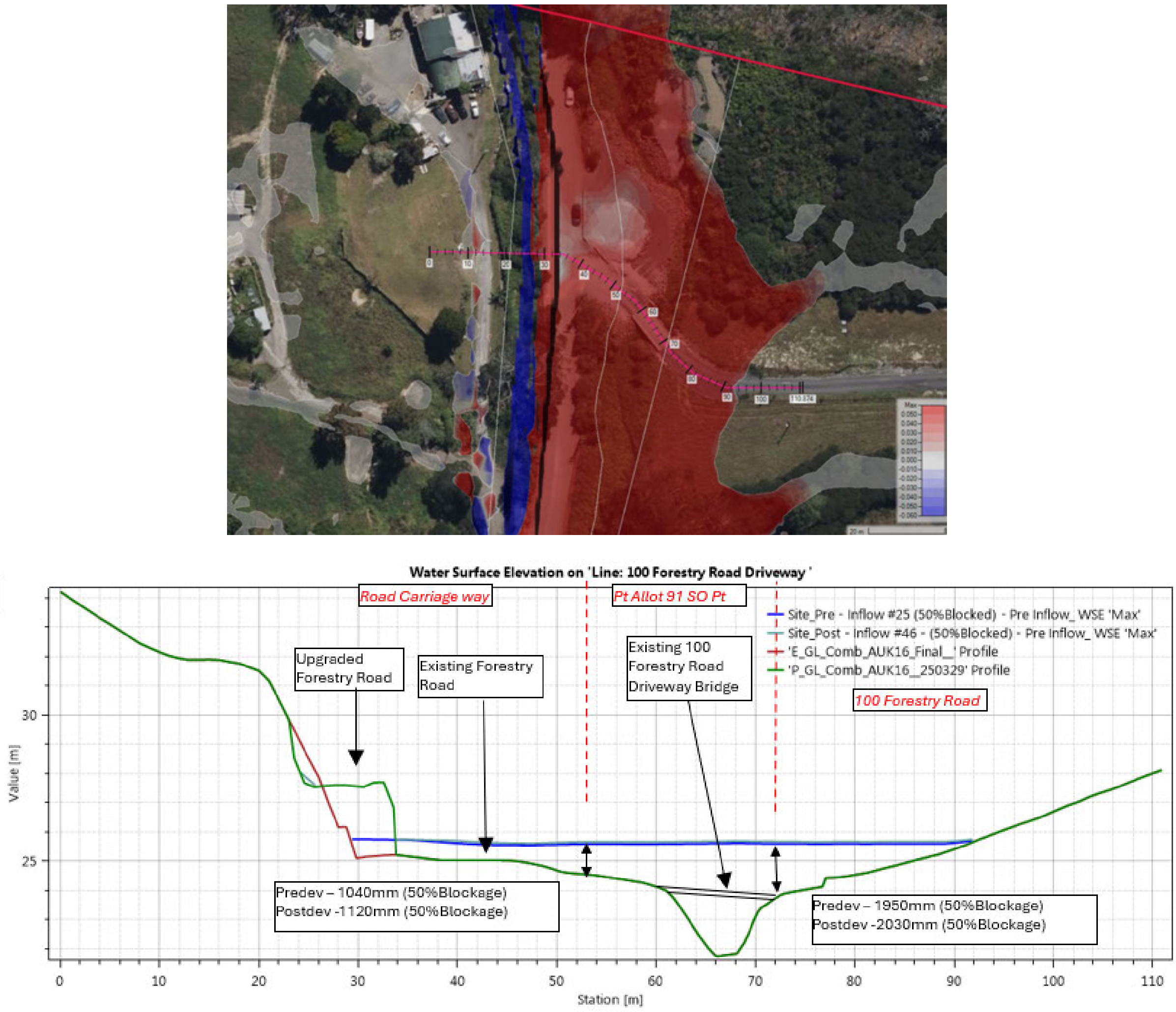

Figure 7: Cross section of 100 Forestry Road Driveway (Comparison between Predevelopment and post development for 1%AEP CC (50%Blockage)

10. FLOOD HAZARD ASSESSMENT

A depth velocity flood hazard map has been generated for the post development 1% AEP scenario with (50% Blockage) and may be found in Appendix E. No notable high-risk hazards were identified in areas of proposed lot platforms and road carriage ways and JOALs. Depth velocities are shown to have a depth of velocity of 0.4 m^2/s and below showing 1% AEP flows to be within the pedestrian safety threshold outline in Auckland Transport TDM Table 3 Major Event - Roadway Flow Limitations.

11. E36 - HAZARD RISK ASSESSMENT REPORT

Refer to the attached assessment contained within Appendix F.

12. CONCLUSION

In conclusion, the proposed development, along with the implemented mitigation measures demonstrates that the development will have no adverse impact on downstream areas.

The proposed mitigation measures include native planting and protection (Lot 1), attenuation of SMAF flows for roof areas for smaller events, catchment wide attenuation in the two catchments through Culvert 1-1 and Culvert 7 with further attenuation for the Retirement Village provided by way of the attenuation basin.

The combination of these measures ensures that flood levels will remain effectively controlled, ensuring no downstream increased flooding for the modelled 2-year, 5-year, 10-year, 20-year, 50-year and 100-year rainfall events with Climate Change for the eastern catchment (Riverhead Catchment) and no downstream increased flooding for the modelled 2-year, 10-year, 20-year and 100-year rainfall events with Climate Change for the western catchment (Kaipara Catchment).

The assumptions within the Maven flood model and outputs are conservative in nature, further providing increased resilience and increased mitigation to the downstream, receiving environment.

In fact, we note that the modelled outcomes indicate minor reductions in downstream flood levels when compared to pre-development levels.

The one exception relates to the minor increase in flood levels through one isolated stretch of Forestry Road which effects a single vehicle crossing. This is deemed to have less than minor effects due to existing height of flood water is already 1m+, whilst the duration of flooding is largely consistent. Maven's view is that the improvements to Forestry Road (removing flooding) provides positive effects and increased resilience for all existing users.

The analysis and results confirm that the development is both sustainable and compliant with flood risk management requirements, providing a safe and resilient solution that mitigates potential flood hazards.

Therefore, the development can proceed without any negative effects on downstream flood risk, with all impacts considered to be less than minor.