THAMES COROMANDEL DISTRICT COUNCIL

WHANGAMATA
MODEL BUILD AND SYSTEM PERFORMANCE

AUGUST 2023

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Revision Schedule

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Executive Summary

Study Objectives

The principal objective of this study is to assess the current level of service provided by the existing Whangamata catchment stormwater infrastructure, including the estimated frequency and extent of inundation within the catchment.

Catchment

The town of Whangamata has developed from a small gold mining and logging based settlement to a community consisting of permanent homes, holiday homes and camping grounds. Whangamata has increasingly become home to relatively few permanent residents, whilst over the summer months the population swells with absentee property owners and visitors holidaying.

The soil conditions of Whangamata vary from flat sandy soils that provide very good soakage to clayey loam that has less soakage potential. The low lying flat main part of Whangamata township has limited drainage network installed and is susceptible to stormwater ponding / surface flooding.

Historically, the primary stormwater management approach has been via ground soakage. However, the increase of infill subdivision and construction of larger properties and infill development has increased hard stand areas (impermeable surfaces). This reduces the natural infiltration capacity and increases the stormwater runoff and the subsequent likelihood of ponding / flooding on private properties and road reserves.

Recent storm events have caused flooding and have raised concerns about the extent and capacity of the existing stormwater system, and the potential impacts of climate change need to be accounted for in TCDC's future planning.

Model Build

A detailed hydrological and hydraulic model of the Whangamata Catchment was developed in accordance with the Waikato Regional Council Stormwater Runoff Modelling Guideline (TR2018/02). InfoWorks ICM v12.0 (Dec 2020) software has been used to develop the linked 1D-2D hydrological and hydraulic model, which integrates two-dimensional (2D) surface modelling with one-dimensional (1D) pipe and open channel flow.

The adopted hydrological method for generating and modelling the excess rainfall runoff is based on the SCS Unit Hydrograph Method[1] as per Waikato Regional Council (WRC) guidelines and applied as a combination of:

- Rain-on-Grid method for the developed lower lying catchments, where excess rainfall runoff (after deduction of initial abstraction and infiltration losses) is entered on the 2D surface and runoff routing is calculated within the hydraulic model component.
- Lumped catchment assessment for the Te Weiti and Waikiekie streams. For this method the catchment of the respective streams is identified, including an assessment of the response time

[1] Soil Conservation Service Unit Hydrograph Method

(i.e. time of concentration). A runoff hydrograph is generated representing the runoff of the entire lumped catchment.

The 1D component of the hydraulic model comprises the piped network as derived from GIS data, survey data, design and as-built drawings, and site observations (refer to Appendix C). Specific features are:

- Williamson Park Pond and Outlet
- Otahu Road Stormwater Pump Station
- Underground Storage and Soakage Systems
- Te Weiti and Waikiekie Culverts

The 2D surface is primarily based on LiDAR[1] survey data flown in 2013 in combination with 5m contour data in areas where no LiDAR data is available.

For the detailed hydrological model 24hr design rainfall data was obtained from NIWA[2] for various locations within the catchment, including allowances for the impact of climate change for future development scenarios (i.e. MPD[3]). Impervious areas have been assessed based on aerial photographs for the ED[4] scenario, and District Plan zoning limits for the MPD scenario.

A constant tailwater level has been assumed as downstream boundary condition for the model. The adopted level is based on the Mean High Water Spring level published by WRC[5]. Tailwater levels at outfalls along the Wentworth River have been adjusted following sensitivity analysis on the impact of elevated flood levels in that river. An allowance of 1.0m sea level rise has been added to all tailwater levels in the MPD scenario as per MfE[6] recommendations.

Limitations of the model are listed under Section 3.8.2. It is noted that the model has not been calibrated against existing storm events due to the lack of suitable data. As a result, the reported flood levels are estimates based on numerous uncertainties. As such, these estimates should be treated as indicative for the purposes of determining flood levels; however, the model can be utilised to assess the relative effects of potential option upgrades. Also note that modelling results represent computed flood inundation levels and exclude freeboard allowance.

Model validation includes the following validation / sensitivity runs:

- Te Weiti and Waikiekie flow validation
- Te Weiti and Waikiekie culvert flow validation
- Modelling catchpits
- Lowering Williamson Road Pond overflow level to 3.0mRL
- Storm duration
- Inconsistent GIS data near rugby field
- Elevated flood levels Wentworth River.

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[1] LiDAR (Light Detection And Ranging) - method for measuring ground surface levels
[2] NIWA HIRDS v4 – High Intensity Rainfall Design System – 2018
[3] MPD = Maximum Probable Development
[4] ED = Existing Development
[5] Waikato Regional Council Coastal Inundation Tool
[6] Coastal Hazards and Climate Change, Ministry for the Environment, Dec 2017

The model has been run for the scenarios and design storm events listed in Table 5-1. Flood maps have been prepared for the MPD scenario with ARI 10yr and 100yr 24-hour design storm event (refer Appendix D).

Findings

The findings from this study include:

- A hydrological and hydraulic model has been developed of the Whangamata township and northern urban areas. This model has been used to complete a dynamic assessment of design rain storms for 2, 10 & 100yr ARIs for existing development (current climate conditions) and maximum probable development (including climate change allowances).
- The reported flows and levels are estimates based on numerous uncertainties that affect the confidence in this estimation, such as soil infiltration rates, LiDAR data, rainfall, tide levels, dynamic blockages due to debris and vegetation, localised obstructions, and so on. As such, these estimates should be treated as indicative for the purposes of determining flood levels; however, the model can be utilised to assess the relative effects of potential option upgrades.
- Validation activities for this model have found that:
    - Te Weiti and Waikiekie culverts are adequately represented in the model.
    - Excluding individual catchpits from the model is acceptable.
    - Lowering the Williamson Road Pond overflow level provides limited benefits.
    - The flood maps in this report are based on simulation of the 24hr nested design storm event. For analysing flood mitigation options, 12hr simulation runs are acceptable.
    - The impact of elevated flood levels in the Wentworth River are small, but have been included in the model.
- The Whangamata township is a flat low-lying catchment heavily relying on soakage infiltration for stormwater runoff. Public constructed soakholes are not included in the model (except for Otahu Road infiltration system and pump storage system) due to lack of information on these soakage systems. It is expected that there are more constructed public soakage systems, which could impact on modelled flood levels.
- The model estimates that flooding in Whangamata township under both existing and maximum probable development scenario is widespread over much of the township.
- Estimated ponding during heavy rainfall events is a normal occurrence and provides a fair volume of flood storage. However, it causes frequent nuisance flooding along many roads in the catchment, especially in the areas lacking piped reticulation.
- Urban development and intensification increased rainfall runoff and reduces infiltration capacity which increases the risk of flooding.
- Reticulated drainage has limited application due to flat slopes and potential backwater effects, particularly when sea level rise is considered.
- Properties at the northern end of the township (near the marina) with ground levels of approximately 1.5-2.0m above MSL are at risk of coastal inundation, and particularly when sea level rise is included.

- An overview of the flood inundation maps is shown below and are presented in Appendix D for the 10yr and 100yr 24hr design storm event under MPD conditions. Presented levels are computed peak inundation levels and do not include freeboard to allow for:
    - physical processes that may not have been allowed for (like waves created by traffic)
    - uncertainties in the precision of the hydraulic modelling
    - uncertainties in the estimation of physical processes.

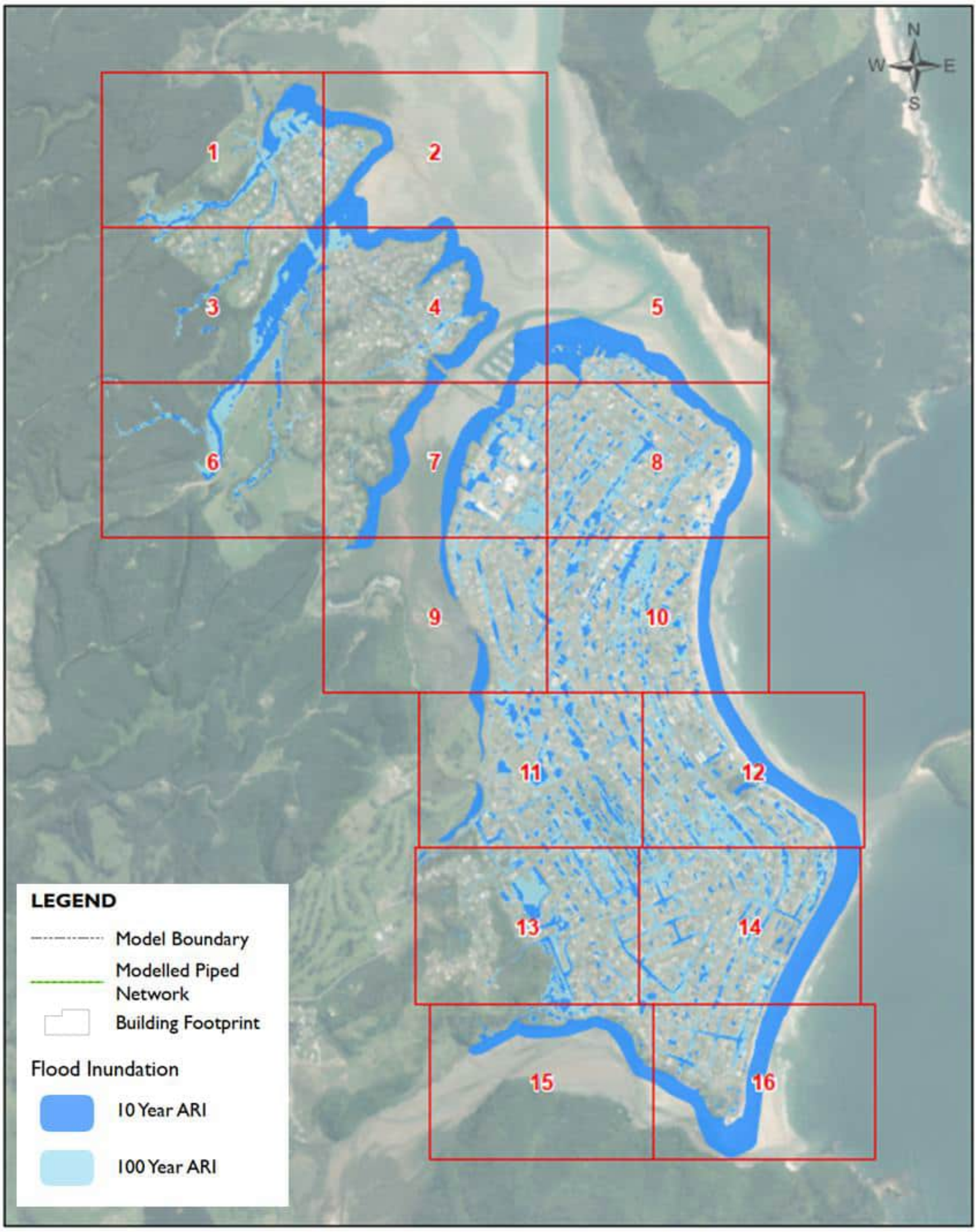

Figure 1-1 Flood Inundation Maps – MPD including Climate Change

Recommendations

The recommendations of this study are to:

- To improve the quality of the model and modelling results the following is recommended:
  - o Identification and survey (if possible) of public soakage systems to better assess flood storage volume and soakage rates of these systems.
  - o Survey of floor levels in critical areas to allow better estimates of current flood risk and quantification of flood mitigation benefits.
- Set minimum recommended building levels to ensure that new buildings and building extensions are constructed at a safe level to minimise risk of habitable floor flooding. It is recommended to apply a minimum freeboard to finished floor level of 300mm. A freeboard of 500mm could be considered along confined waterways and overland flow paths (i.e., non-flat catchment areas). TCDC may wish to increase this freeboard by an additional 100mm to account for the revised 2018 MFE climate change forecast. Refer to Section 4.8 for details.
- Maximise ground infiltration by:
  - o installing swales along the roads with designed infiltration trenches including prevention of siltation.
  - o Requesting new developments to include soakage systems suitable to discharge runoff from a minimum 24hr 10yr ARI design storm, including climate change allowance. Such system must include well-designed filter systems to prevent siltation and blockage.
  - o Implement a soakage maintenance plan for all private and public soakage systems.
- Maintain a record of all soakage systems including a maintenance database.
- Investigate and assess options to manage flood inundation risk including a prioritisation of issues and a cost benefit analysis of options to develop a stormwater masterplan.
- Developing a flood mapping programme to update and publish flood maps on a regular cycle to reflect the latest climate change guidance and catchment changes.

Contents

EXECUTIVE SUMMARY
Study Objectives i
Catchment i
Model Build i
Findings iii
Recommendations v
1 INTRODUCTION 1
1.1 Study Objectives 1
1.2 Study Activities and Scope 1
1.3 Previous Reports 1
1.4 Projection and Vertical Datum 1
2 CATCHMENT DESCRIPTION 2
2.1 Location 2
2.2 Topography 3
2.3 Geology and Soils 5
2.4 District Plan Zoning 6
2.5 Stormwater Drainage System 8
2.6 Reported Flooding Issues 12
3 MODEL BUILD 14
3.1 Overview 14
3.2 Modelling Software 14
3.3 Rapid Flood Hazard Assessment 14
3.4 Review of Existing Data 14
3.4.1 Topographical Data 14
3.4.2 LiDAR data versus GIS data 14
3.4.3 Asset Data 16
3.4.4 Rainfall 16
3.4.5 Hydrometric Data 18
3.4.6 Impervious Area 18
3.5 Hydrological Model 22
3.5.1 Method Used 22
3.5.2 Rain-on-Grid Catchments 22
3.5.3 Lumped Catchments 24
3.6 Hydraulic Model 25
3.6.1 Model Set up 25
3.6.2 DEM 25
3.6.3 Hydraulic Model Extents 25
3.6.4 Energy Losses 29
3.6.5 Specific Drainage Features 29
3.7 Boundary Conditions 32
3.7.1 Rainfall Data 32
3.7.2 Tidal Data 32
3.8 Model Limitations and Assumptions 34
3.8.1 Network Model Assumptions 34
3.8.2 Model Limitations 37

3.8.3 Hydrological Model Assumptions 38
3.8.4 Hydraulic Model Assumptions 38
3.9 Model Peer Review 39
4 MODEL VALIDATION 40
4.1 Te Weiti and Waikiekie Flow Validation 40
4.2 Te Weiti and Waikiekie Culvert Flow Validation 43
4.3 Modelling Catchpits 45
4.4 Lowering Williamson Road Pond Overflow Level to 3.0mRL 47
4.5 Storm Duration 48
4.6 Inconsistent GIS Data near Rugby Field 49
4.7 Elevated flood levels Wentworth River 51
4.8 Climate Change Guidance 54
5 SYSTEM PERFORMANCE ASSESSMENT 56
6 FINDINGS AND RECOMMENDATIONS 58
6.1 Summary of findings 58
6.2 Recommendations 59
7 References 60
APPENDIX A – HYDROLOGICAL PARAMETERS
APPENDIX B – RAPID FLOOD HAZARD ASSESSMENT
APPENDIX C – SITE OBSERVATIONS
APPENDIX D – FIGURES
APPENDIX E – RECOMMENDED SURVEY LOCATIONS

List of Tables

Table 2-1 Main stormwater outlets (≥600mm) 8
Table 3-1 24hr Design Rainfall Depth for various locations 17
Table 3-2 Temporal Pattern derived from local HIRDS Rainfall Data 17
Table 3-3 Impervious coverage assumptions - Existing Development 20
Table 3-4 Impervious coverage assumptions - Maximum Probable Development 21
Table 3-5 Example Land Use Zones 23
Table 3-6 Hydrological data for lumped sub-catchments 24
Table 3-7 Summary of hydraulic model components 26
Table 3-8 Mesh parameters 26
Table 3-9 Tidal Conditions 33
Table 3-10 Minimum transitional New Zealand-wide SLR allowances and scenarios for use in planning instruments where a single value is required at local/district scale while in transition towards adaptive pathways using the New Zealand-wide SLR scenarios 33
Table 3-11 Stormwater pipes with decreasing diameter in downstream direction 34
Table 4-1 Validation Peak Flow from stream catchments (in m^3/s) 41
Table 4-2 Te Weiti Culvert Validation 43
Table 4-3 Waikiekie Culvert Validation 44
Table 4-4 Impact Modelled Storm Duration on Peak Flood Depth 48
Table 4-5 Wentworth River Design Flows 51
Table 4-6 Joint probability scenarios 51

Table 4-7: Summary of 24hr design rainfall depths between scenarios ... 54
Table 5-1 Model simulation matrix ... 56

List of Figures

Figure 1-1 Flood Inundation Maps – MPD including Climate Change ... iv
Figure 2-1 Whangamata Modelled Catchments ... 2
Figure 2-2 DEM levels from LiDAR in Whangamata township (mRL) ... 4
Figure 2-3 Whangamata township and hillside catchments ... 5
Figure 2-4 Model Domain Hydrological Soil Groups ... 6
Figure 2-5 Model Domain District Plan Zones (Source: TCDC) ... 7
Figure 2-6 Concrete lined open drain at Park Avenue Reserve ... 9
Figure 2-7 Recent duplication of SW outlet into Williamson Park pond ... 10
Figure 2-8 Gabion basket and concrete nib overflow from Williamson Park pond onto beach ... 10
Figure 2-9 SH25 Culvert at Te Weiti Stream ... 11
Figure 2-10 SH25 Culvert at Waikiekie Stream ... 11
Figure 2-11 Location of flood incidents ... 13
Figure 3-1 LiDAR Ground Level versus GIS Lid Level ... 15
Figure 3-2 Variance between LiDAR and GIS Lid Level ... 15
Figure 3-3 Temporal Pattern 24-hour Design Rainfall Event ... 18
Figure 3-4 Simplified District Plan zoning and respective hydrological zone ID. ... 19
Figure 3-5 Sample area to calculate impervious footprint of other hard stand impervious areas ... 20
Figure 3-6 Cumulative Rainfall Runoff Depth for various land use types ... 24
Figure 3-7 “2D Zone”, “Mesh Zone”, and “Mesh Level Zone” extents ... 28
Figure 3-8 Overflow path between Williamson Park Pond and the beach ... 30
Figure 3-9 Otahu Road Pump Station ... 31
Figure 3-10 Underground storage and soakage near Otahu Road Pump Station ... 31
Figure 3-11 Coastal inundation MHWS including 1.0m SLR ... 34
Figure 3-12 Reduction pipe diameter on Hetherington Road ... 36
Figure 3-13 Reduction pipe diameter on Seabreeze Lane ... 36
Figure 4-1 Te Weiti North Peak Flow Validation ... 41
Figure 4-2 Te Weiti South Peak Flow Validation ... 42
Figure 4-3 Waikiekie Peak Flow Validation ... 42
Figure 4-4 Sensitivity Run - Modelling Catchpits near Williamson Park ... 45
Figure 4-5 Sensitivity Run - Modelling Catchpits upstream of Kotuku Street ... 46
Figure 4-6 Sensitivity Run - Lowering Pond Overflow Level ... 47
Figure 4-7 Main stormwater drain under rugby field ... 49
Figure 4-8 Sensitivity Run – Inconsistent GIS data rugby field ... 50
Figure 4-9 Sensitivity Run – Elevated flood levels Wentworth River (north) ... 52
Figure 4-10 Sensitivity Run – Elevated flood levels Wentworth River (south) ... 53
Figure 4-11 Sensitivity Run – Comparison of flood inundation extent and depths ... 55
Figure 5-1: Flood Inundation Map Grid – 10 & 100 year ARI MPD 24 hour event ... 57
Figure 7-1 Rainfall Profile Areas ... 67

1 INTRODUCTION

1.1 Study Objectives

The principal objective of this study is to assess the current level of service provided by the existing Whangamata catchment stormwater infrastructure, including the estimated frequency and extent of inundation within the catchment.

1.2 Study Activities and Scope

The activities and scope of the Model Build and System Performance stage of the study include (refer to the respective sections of this report):

- Section 1 – Introduction
- Section 2 - Catchment Description:
  An overview of the catchment, its extent and its main characteristics like topography, soils, district plan zoning limits, and key stormwater infrastructure features and flooding issues.
- Section 3 - Model Build:
  This section comprises the following key tasks of the Model Build process:
    - Review of existing data
    - Hydrological model
    - Hydraulic model
    - Boundary conditions
    - Modelling limitations and assumptions
- Section 4 - Model Validation
  A model validation was completed for the performance of the Te Weiti and Waikiekie streams including culvert performance. It also includes a range of model sensitivity tests.
- Section 5 - System Performance Assessment
  The performance of the system is presented with associated Flood Inundation Maps.
- Section 6 - Findings and Recommendations
  The report concludes with a summary of the key project findings and recommendations.

1.3 Previous Reports

The following reports are relevant to this study:

- Whangamata Stormwater Catchment Management Study – Updated Issues and Options Report, Draft – Version 2, Opus, Sep 2005.
- Whangamata Stormwater Model Build – Data Anomalies Report, Water Engineering Consultants, Aug 2006.
- Williamson Road Stormwater Assessment, HAL Memorandum, 9 May 2018.
- Whangamata Stormwater Master Plan – Proposal, HAL & Morphum Environmental, Nov 2018.
- Whangamata Stormwater Master Plan – Strategic Context and Risks, Morphum Dec 2019.

1.4 Projection and Vertical Datum

All data in the model and this report are in terms of:

- New Zealand Transverse Mercator 2000 (NZTM2000) horizontal projection, and
- Auckland 1946 (AKL1946) vertical datum.

2 CATCHMENT DESCRIPTION

2.1 Location

The town of Whangamata has developed from a small gold mining and logging based settlement to a community consisting of permanent homes, holiday homes and camping grounds. Whangamata has become home to an increasing number of permanent residents, whilst over the summer months the population swells with absentee property owners and visitors holidaying.

The town is bordered by the Otahu River to the south, the Te Weiti Stream to the north, and the Whangamata Harbour and the sea to the east (Refer Figure 2-3 below). The urbanised area comprises:

- The main township on the flat grounds between the Whangamata Harbour and the Otahu River.
- The more undulated urban area north of the Moana Anu Anu Estuary.

The modelled main catchment areas are (from north to south):

- Te Weiti Catchment (215 ha)
- Waikiekie Catchment (664 ha)
- Township Catchment (440 ha)

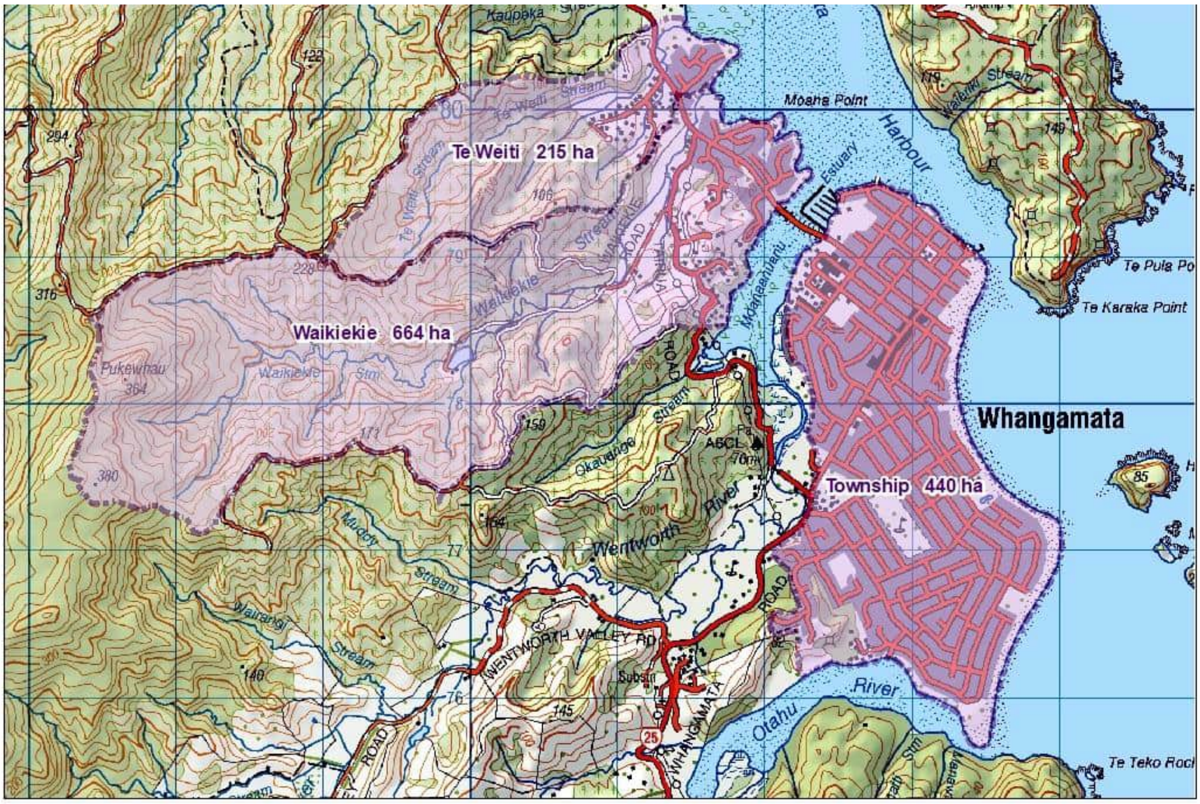

Figure 2-1 Whangamata Modelled Catchments

The Okauange Stream and Wentworth River catchments discharge into the Moana Anu Anu Estuary northwest of the town centre. These catchments and associated flood risk are excluded from the scope of this study. It is also noted that Waikato Regional Council does not have flood levels of this river that could be used as downstream boundary condition for discharges from the Whangamata Township catchment. However, sensitivity analysis is included in this study to estimate the effect of elevated flood levels in Wentworth River.

The soil conditions of Whangamata vary from flat sandy soils that provide very good soakage to clayey loam that has less soakage potential. The low lying flat main part of Whangamata township has limited drainage network installed and is susceptible to stormwater ponding / surface flooding.

Historically, the primary stormwater management approach has been via ground soakage. However, the increase of infill subdivision and construction of larger properties and infill development has increased hard stand areas (impermeable surfaces). This reduces the natural infiltration capacity and increases the stormwater runoff and the subsequent likelihood of ponding / flooding on private properties and road reserves.

Recent storm events have caused flooding and have raised concerns about the extent and capacity of the existing stormwater system, and the potential impacts of climate change need to be accounted for in TCDC's future planning.

2.2 Topography

The majority of the Whangamata township is located on flat alluvial sand with small sand dunes along the coastline to the east and steep hills to the west. A number of streams/rivers flow from the hills eastwards to the sea.

The total catchment area of the modelled catchments is approximately 1,320 ha. The urban development is primarily on the main flat land and ground levels closer to the coast. Ground levels generally vary here between 4 and 6 m above MSL, except for the northern end of the peninsula with property ground levels as low as 1.5 m above MSL. This area is shown in the forefront of Figure 2-2 below. North of the Moana Anu Anu Estuary the topography is more elevated. The hills to the west of the township are typically under forestry and rural land-uses.

The DEM (Digital Elevation Model) used for the hydraulic model is based on LiDAR flown in 2013, levels for this DEM are understood to be in Auckland Vertical Datum 1946.

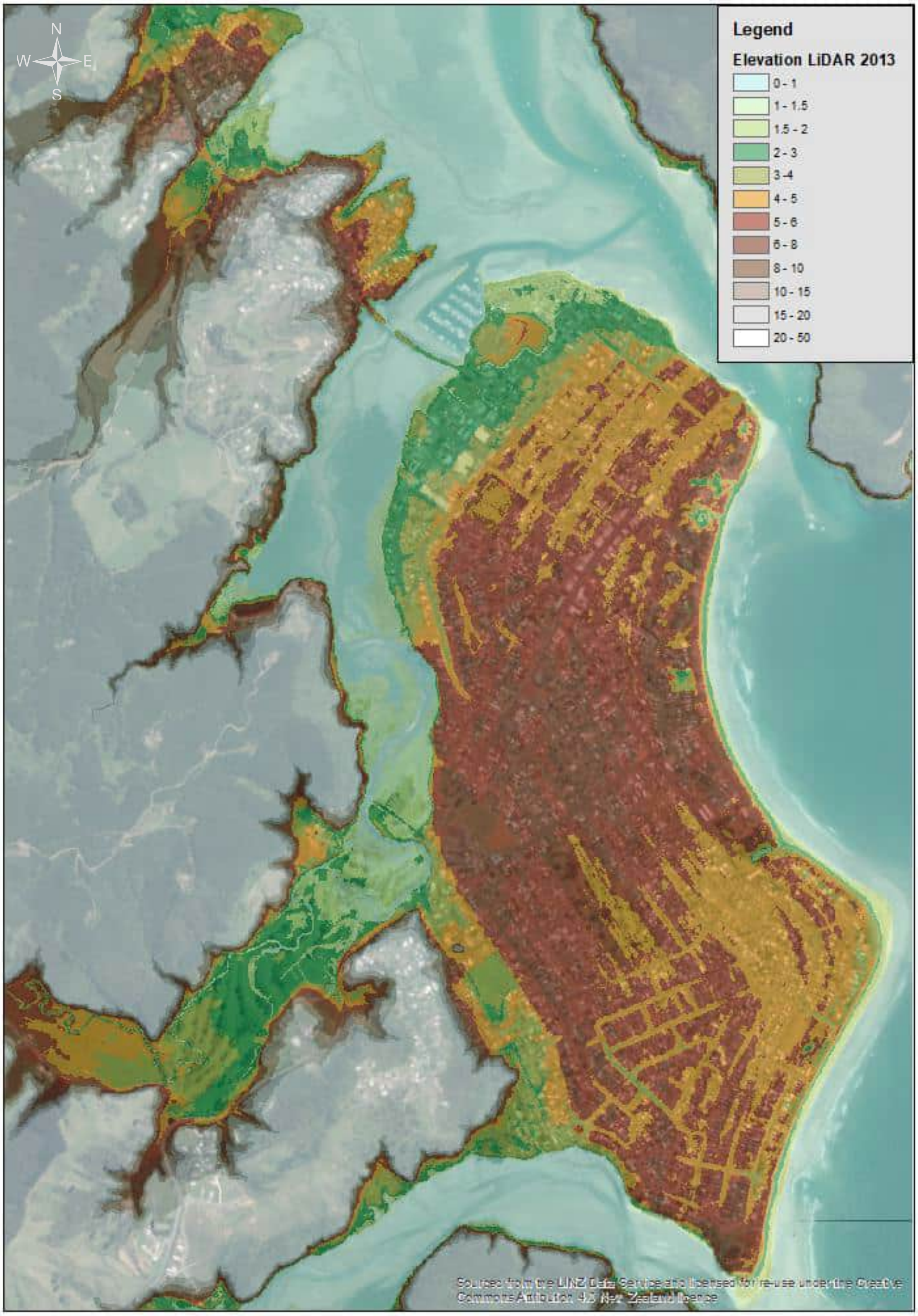

Figure 2-2 DEM levels from LiDAR in Whangamata township (mRL)

Figure 2-3 Whangamata township and hillside catchments

2.3 Geology and Soils

Soil maps have been obtained from Landcare Research soil maps and used to classify the infiltration capacity of the soils using the Hydrological Soil Group that is specified in the Waikato Stormwater Runoff Modelling Guidelines (Refer WRC 2018). The allocation of the various soil groups as defined in these soil maps are shown in Figure 2-4 below. The Whangamata urban catchment comprises primarily of sandy or sandy loam soils (Soil Group A). Lower infiltrating soils are typically found in the valleys and along watercourses such as Wentworth River (mainly Soil Group B) and Waikiekie Stream (Soil Group C/D), which consist of clayey loam and peaty loam.

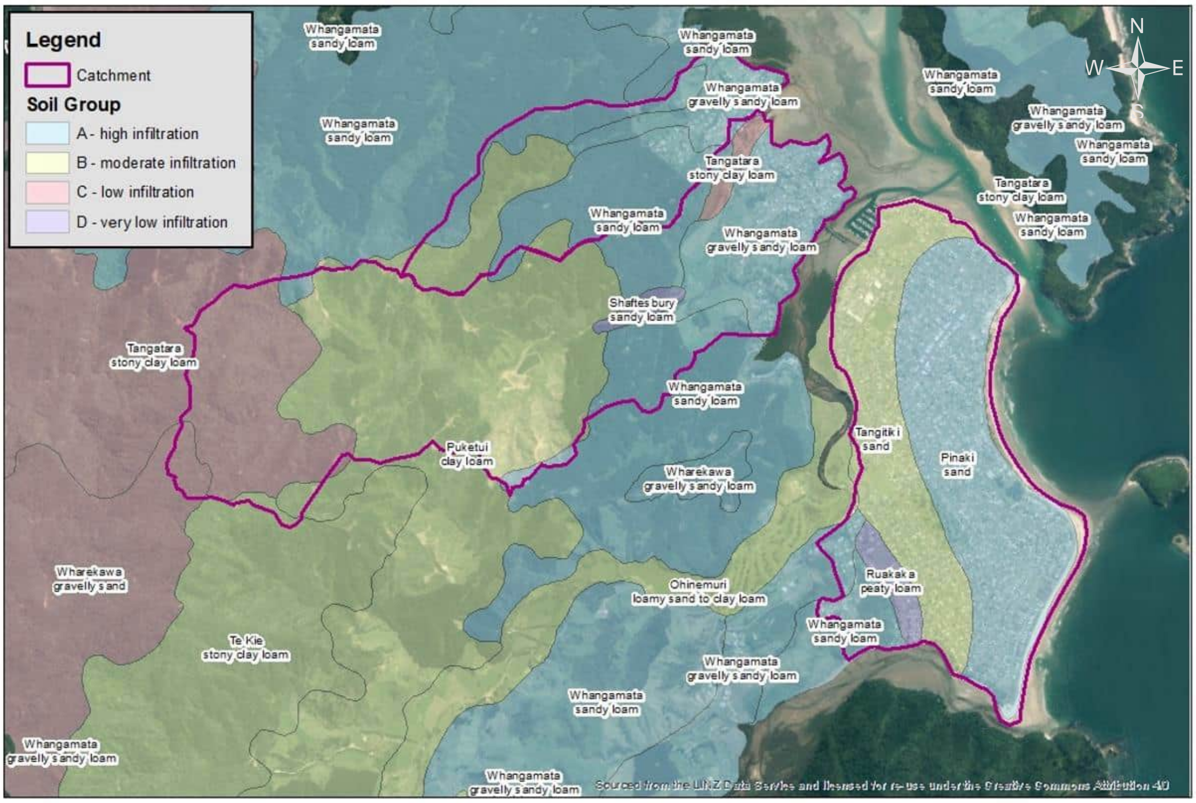

Figure 2-4 Model Domain Hydrological Soil Groups

The infiltration characteristics and impact on excess stormwater runoff for each of the soil groups is represented in the rainfall timeseries. The infiltration losses have been calculated and the net excess runoff is modelled using the Rain on Grid method (refer Section 0 and 3.5).

2.4 District Plan Zoning

The current land uses within the Whangamata catchment are shown in Figure 2-5. according to the TCDC District Plan online Zone GIS maps.

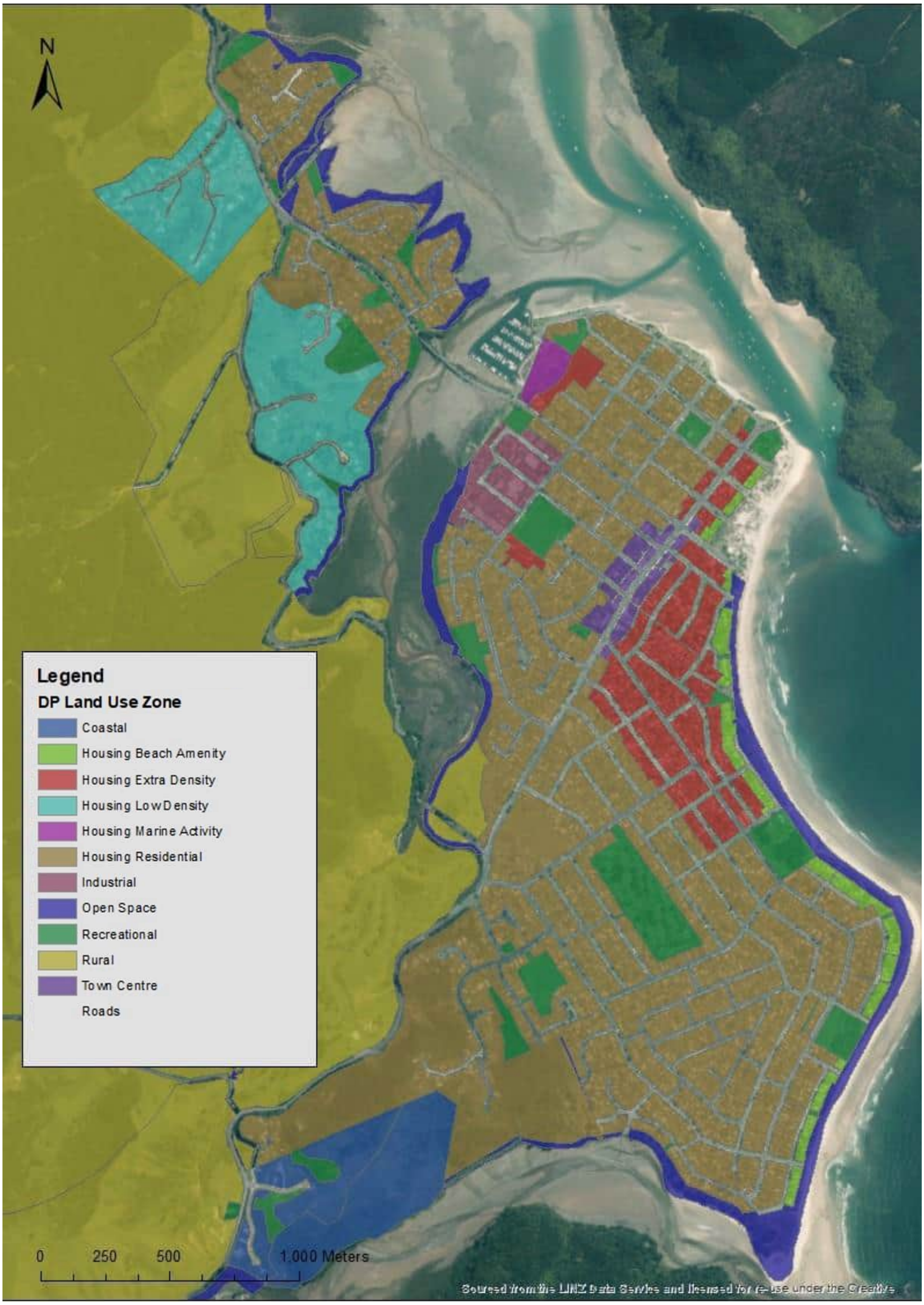

Figure 2-5 Model Domain District Plan Zones (Source: TCDC)

Most of the urban area is zoned residential, with extra density residential areas near the marina and between the town centre and the beach. South of the marina is an industrial area. The northern urban area is predominantly residential with low density housing further up the hills.

Detailed data on adopted Maximum Probable Development (MPD) percentage impervious areas are presented in Section 3.4.6.

2.5 Stormwater Drainage System

Stormwater drainage in the main township area comprises a mixture of gravity piped stormwater drains and natural and artificial soakage (e.g. constructed soakholes).

The piped stormwater network is presented in Figures B1 & B2 in Appendix D. The main piped network outlets (i.e. outlets 600mm diameter and larger) are summarised in the table below:

Table 2-1 Main stormwater outlets (≥600mm)

Location	Outlet Size	Receiving Environment
Hetherington Road between the main bridge and the marina.	675 mm dia	Moana Anu Anu Estuary
Various outlets south of Hetherington Road bridge, including:		Moana Anu Anu Estuary and Wentworth River
• Casement Road	Up to 600 mm dia discharging into open channel	
• Lindsay Road	600 mm dia	
• Wattle Place	600 mm dia	
• Sharyn Place	675 mm dia	
• Mayfair Ave	750 mm dia	
Achilles Avenue	825 mm dia	Wentworth River
Kotuku Street	900 & 1000 mm dia	Otahu River
Williamson Park Pond	900 & 1050 mm dia	Coast
Beach Road	1050 mm dia	Whangamata Harbour

No detailed information has been provided on soakage systems and crude assumptions have been made in terms of available soakage infiltration capacity (Refer Section 3.4.6).

An open concrete lined v-shaped drain runs through Park Avenue Reserve (about 1km southwest of the town centre) and continues along McKellar Place Walkway to the south. It discharges local runoff and runoff from the hills further to the west into the Otahu River (including some culverts / piped sections). The Park Avenue Reserve provides for some limited flood storage, in the order of 0.5-1m depth (refer Figure 2-6).

Figure 2-6 Concrete lined open drain at Park Avenue Reserve

A pump station is located at the eastern end of Otahu Road, which includes an artificial underground storage area. The pump station discharges into Otahu River and has a high-level overflow pipe discharging onto the beach.

A stormwater pond is located at the north-eastern end of Williamson Road. In 2019, a project was completed duplicating the main piped section between Williamson Road / Ocean Road intersection and the pond (refer Figure 2-7 below). Runoff discharged into the pond is stored and slowly infiltrates into the ground. A weir overflow comprising gabion baskets and a concrete nib (refer Figure 2-8 below) allows for runoff to discharge onto the beach during times of high stormwater runoff and elevated pond levels.

Figure 2-7 Recent duplication of SW outlet into Williamson Park pond

Figure 2-8 Gabion basket and concrete nib overflow from Williamson Park pond onto beach

There are a couple of stormwater drains that discharge into beach dune depression areas like Island View Road and Hunt Road. No details have been provided on the design principles of these systems and whether they include artificial underground soakage systems. It is expected that these systems rely on natural soakage into the well-draining beach sands.

North of the Moana Anu Anu Estuary, two large culverts allow runoff of the Te Weiti and Waikiekie Stream to cross State Highway 25 (refer Figure 2-9 & Figure 2-10 below). South of Herbert Drive is a series of small retention ponds installed as part of Moana Park development. These ponds discharge directly upstream of the Te Weiti SH25 culvert.

Figure 2-9 SH25 Culvert at Te Weiti Stream

Figure 2-10 SH25 Culvert at Waikiekie Stream

2.6 Reported Flooding Issues

Flood incidents reported by residents have been obtained from TCDC's flood incident database, which contains incidents from 2009 to 2019. The location of reported incidents are presented in Figure 2-11 below. The figure shows:

- Reported Flood Incidents, which shows the location of incidents related to observed flooding of roads, properties, and buildings.
- Reported Maintenance Issues, which shows the location of maintenance issues related to flooding and drainage.
- Flood Incident Heatmap, which shows the areas with higher or lower volume of reported flood incidents. It is noted that the heatmap is based on the number of flood incidents only and excludes maintenance issues.

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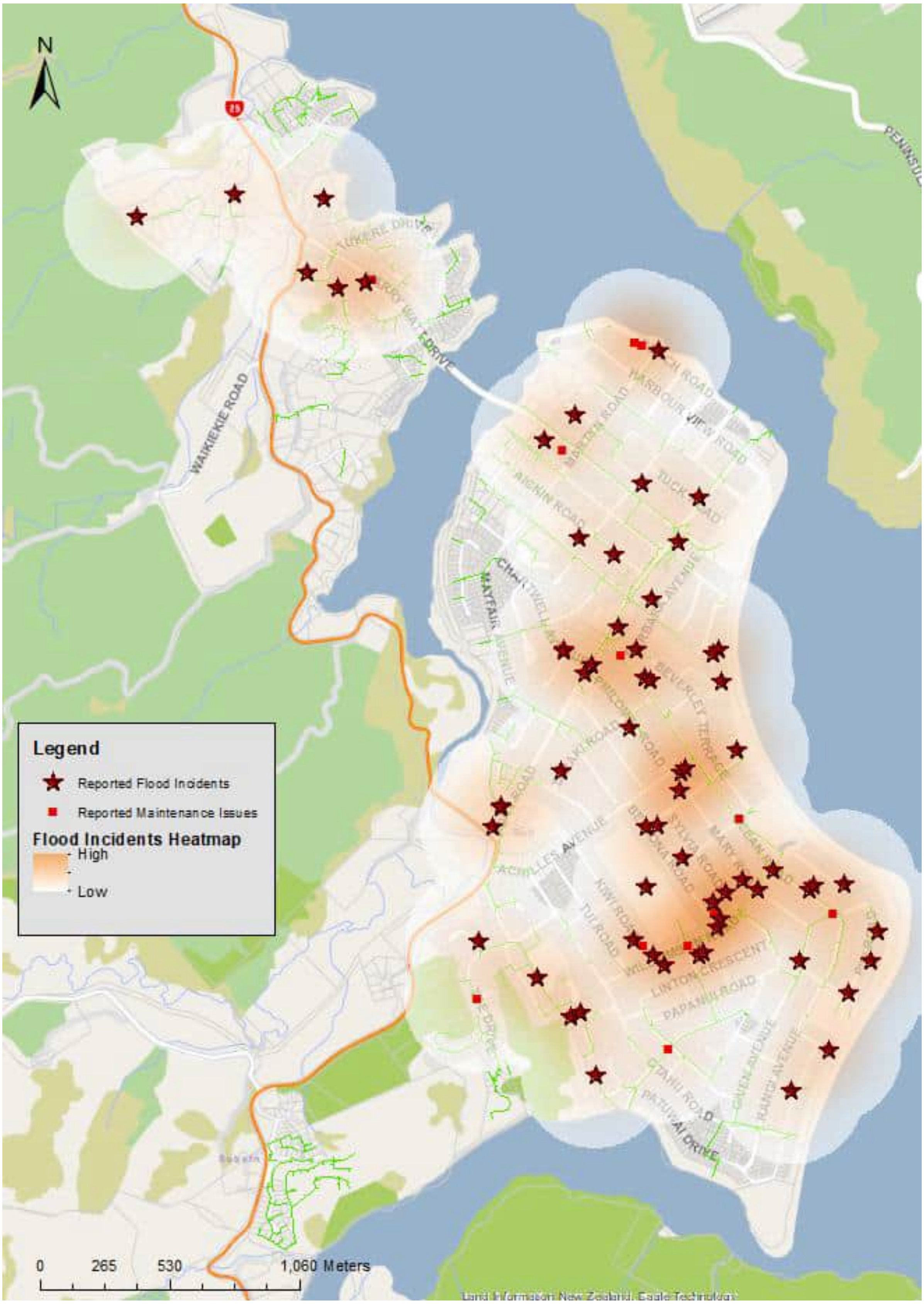

Figure 2-11 Location of flood incidents

3 MODEL BUILD

3.1 Overview

The detailed hydrological and hydraulic model of the Whangamata Catchment was developed in accordance with the Waikato Regional Council Stormwater Runoff Modelling Guideline (TR2018/02). This involved refinement of the hydrology and the topographical surface and included the 1D piped network and structures. Specifics of this modelling process are outlined below. Supplementing this process a Rapid Flood Hazard Assessment was completed to assist in scoping the detailed model extents. Refer to Appendix B for details.

3.2 Modelling Software

InfoWorks ICM v12.0 (Dec 2020) software, developed by Innovyze, has been used to develop the linked 1D-2D hydrological and hydraulic model of the Whangamata catchment. ICM is software that integrates two-dimensional (2D) surface modelling with one-dimensional pipe and open channel flow.

Hydrological modelling was also supplemented by the HEC-HMS v4.3 software developed by the U.S. Army Corps of Engineers.

3.3 Rapid Flood Hazard Assessment

A Rapid Flood Hazard Assessment (RFHA) has been undertaken to provide an initial assessment of the floodplain, with the methodology outlined in Appendix B.

3.4 Review of Existing Data

3.4.1 Topographical Data

The DEM for the hydraulic model is based on the same topographical data as that used for the RFHA (refer Section 0 above), which is a merge of the following data sets:

- 2013 LiDAR, which has a larger coverage of the catchment, but is limited to levels below approximately 40 to 50m.
- 5m contour data that covers the entire area.
- The extent of the 2D surface has significantly been reduced as the upper catchments are now represented as lumped catchments instead of Rain-on-Grid catchments. Other modifications to the DEM were required to ensure a mathematically stable connection between the piped network and the 2D surface. Modifications to the DEM are described in Section 3.6.2 further below.

3.4.2 LiDAR data versus GIS data

A comparison has been made between the 2013 LiDAR data and manhole lid levels presented in TCDC GIS. The 2013 LiDAR ground levels of 283 manholes have been compared with their Lid Level as specified in the TCDC GIS asset data system. It is noted that the LiDAR data is presented in Auckland Vertical Datum 1946, while no reference is provided in the GIS data to what vertical datum the levels are referenced too.

Figure 3-1 below shows both the LiDAR and GIS levels for the respective manholes. Note that only the levels below 20mRL are shown. The figure shows that there seems to be a structural variance between the two data sets with a median value of +0.84m. Figure 3-2 shows a histogram of the same data set, which indicates that 87% of the manholes have a LiDAR level of more than 0.5m above the GIS level.

As a result, the GIS ground level data is not considered suitable for modelling purposes and the modelled ground levels have been based on the 2013 LiDAR data (i.e. AVD-46). Manhole invert levels are primarily based on the existing 1D model (see Section 3.4.3 for details). A review of the long section profiles showed that those levels were generally providing consistent gradients and looked suitable for modelling purposes.

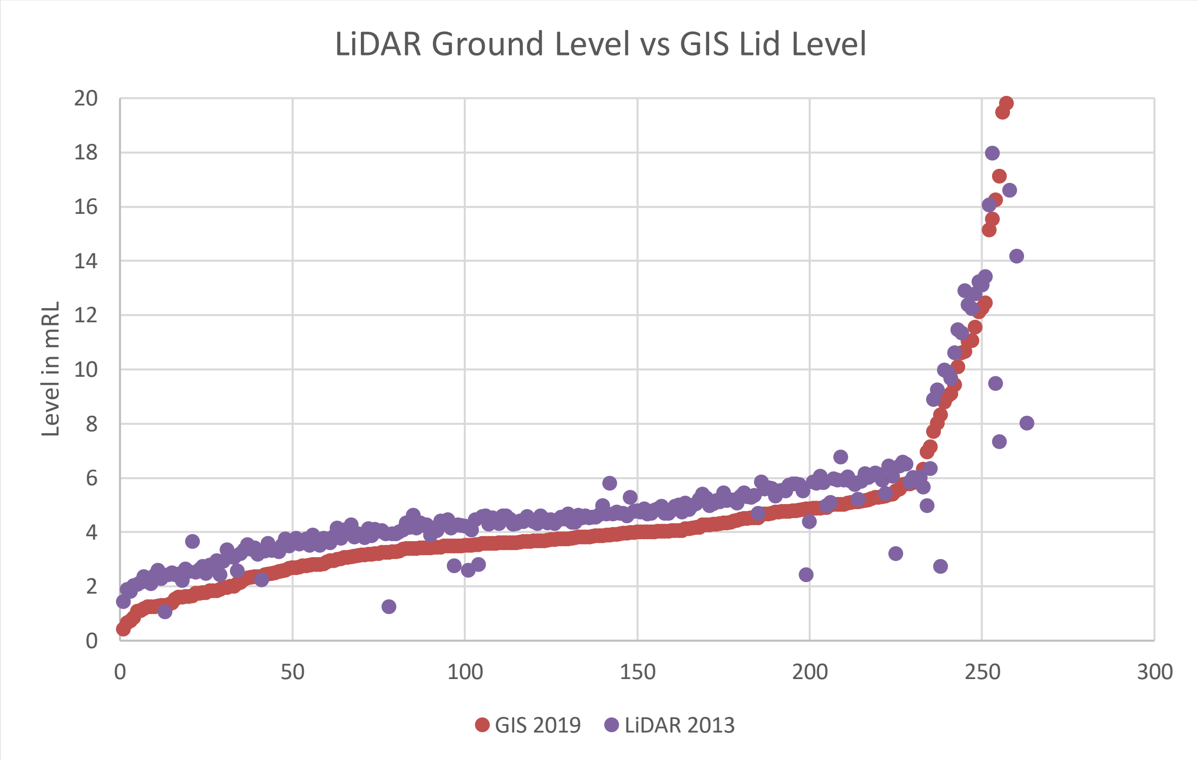

Figure 3-1 LiDAR Ground Level versus GIS Lid Level

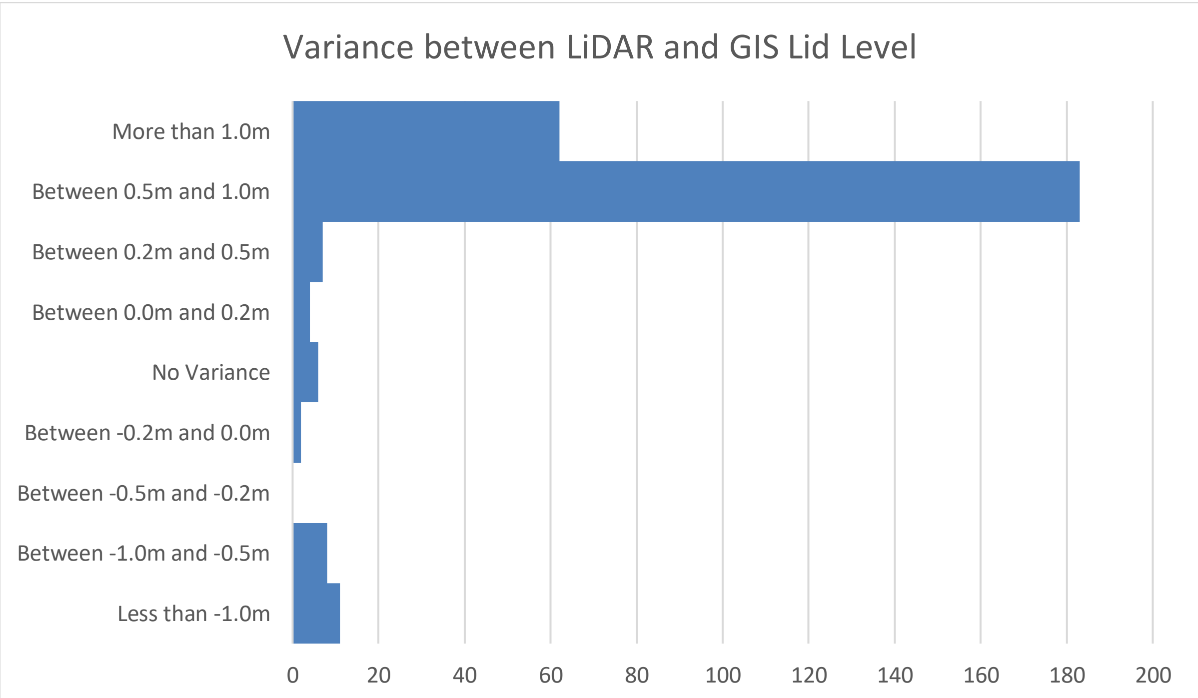

Figure 3-2 Variance between LiDAR and GIS Lid Level

3.4.3 Asset Data

The bulk of model asset data was sourced from:

- the1D USEPA SWMM model developed by Water Engineering Consultants (WEC) in 2006, combined with TCDC's GIS database providing data for areas excluded from the 1D model (e.g. north of Moana Anu Anu Estuary) and new drainage networks.
- asset data surveys (i.e. in 2007 and July 2011).
- design and as-built plans of recent upgrades and developments (e.g. Williamson Park, Otahu Road pump station, and Moana Park).
- observations and approximate measurements undertaken during a site visit in July 2019 (e.g. drainage network around Williamson Park and Te Weiti and Waikiekie culverts crossing SH25 north of Moana Anu Anu Estuary).

Most of the data was obtained from the existing 1D SWMM model. TCDC's GIS data was lacking detail (i.e., many levels were missing) and lacking confirmation of vertical datum references (refer Section 3.4.2 above). WEC had gone through a thorough process of asset data review and analysis during their model build process. Assumptions had been made and the model was checked to ensure continuity of the network and gravity drainage. The modelled network was therefore considered to be of better quality than TCDC's GIS Asset Data database. No additional asset survey pick-up was considered necessary.

For locations with missing asset data, the following assumptions were typically applied:

- Apart from surveyed structures, all manhole lid levels were estimated from the most recently captured LiDAR to correspond with the modelled 2D ground surface.
- All pipes <100mm diameter and subsoil drains were excluded from the model.
- Missing invert data was assumed 0.7m below the GIS lid level, or LiDAR level if lid level is also missing (approximately 25 manholes in total).
- Missing outlet invert levels were estimated from LiDAR ground levels.
- All manhole diameters were estimated using ICM-software default assumptions, which is based on the size and number of connecting conduits.
- Inverts for manholes with negative depths were overwritten by GIS measured depth below LiDAR ground surface, or 0.7m depth where no GIS depth data exists.

All data sources and assumptions are flagged in the model. Appendix E includes a summary of the recommended asset survey locations.

3.4.4 Rainfall

For the detailed hydrological model 24hr design rainfall depths were obtained from HIRDSv4 (NIWA, 2018) for various locations within the catchment. Based on the data, the rainfall zones shown in Figure 3-1 were identified. The respective 24hr rainfall depth for various probability events are presented in Table 3-1 below.

An allowance for the impact of climate change on rainfall intensities have been included in the model, in accordance with TR2018/02. The allowance is based on MfE 2008 guidelines, which adopts an increase of up to 16.8% assuming 2.1°C average temperature rise. Note that MfE published updated Climate Change Projections for New Zealand in 2018. A sensitivity assessment was completed to compare the modelled flood inundation results between the 2008 and 2018 guidance documents and is summarised in Section 4.8.

Table 3-1 24hr Design Rainfall Depth for various locations

Probability	24hr Rainfall Depth Existing Climate (in mm)			24hr Rainfall Depth Including Climate Change (in mm)		
	Township	**Urban North & Lower Rural**	**Upper Rural**	**Township**	**Urban North & Lower Rural**	**Upper Rural**
2YR ARI	131	144	176	143	157	192
10YR ARI	205	225	273	232	255	309
100YR ARI	320	350	425	374	409	495

Source: HIRDS-v4 NIWA 2018
Notes: Climate change allowance in accordance with MfE's 2008 guidelines

Temporal rainfall patterns are generated from the local HIRDS data as per TR2018/02 (WRC, 2018) guidelines. Two standard patterns are used for the entire catchment; one for the current climate and the other including the impact of climate change (refer Table 3-2 and Figure 3-3 below). 24hr nested rainfall profiles are generated from these patterns and used as timeseries in the hydrological HEC-HMS model (refer Section 3.5 below).

Table 3-2 Temporal Pattern derived from local HIRDS Rainfall Data

Time		Normalised Intensity (I/I24)	
From	**To**	**Current Climate**	**Incl. Climate Change**
0:00	6:00	0.46	0.41
6:00	9:00	0.79	0.75
9:00	11:00	1.43	1.45
11:00	11:30	2.52	2.71
11:30	11:40	3.62	4.01
11:40	11:50	3.62	4.01
11:50	12:00	6.06	6.71
12:00	12:10	11.44	12.69
12:10	12:20	4.81	5.30
12:20	12:30	3.62	4.01
12:30	13:00	2.52	2.71
13:00	15:00	1.43	1.45
15:00	18:00	0.79	0.75
18:00	0:00	0.46	0.41

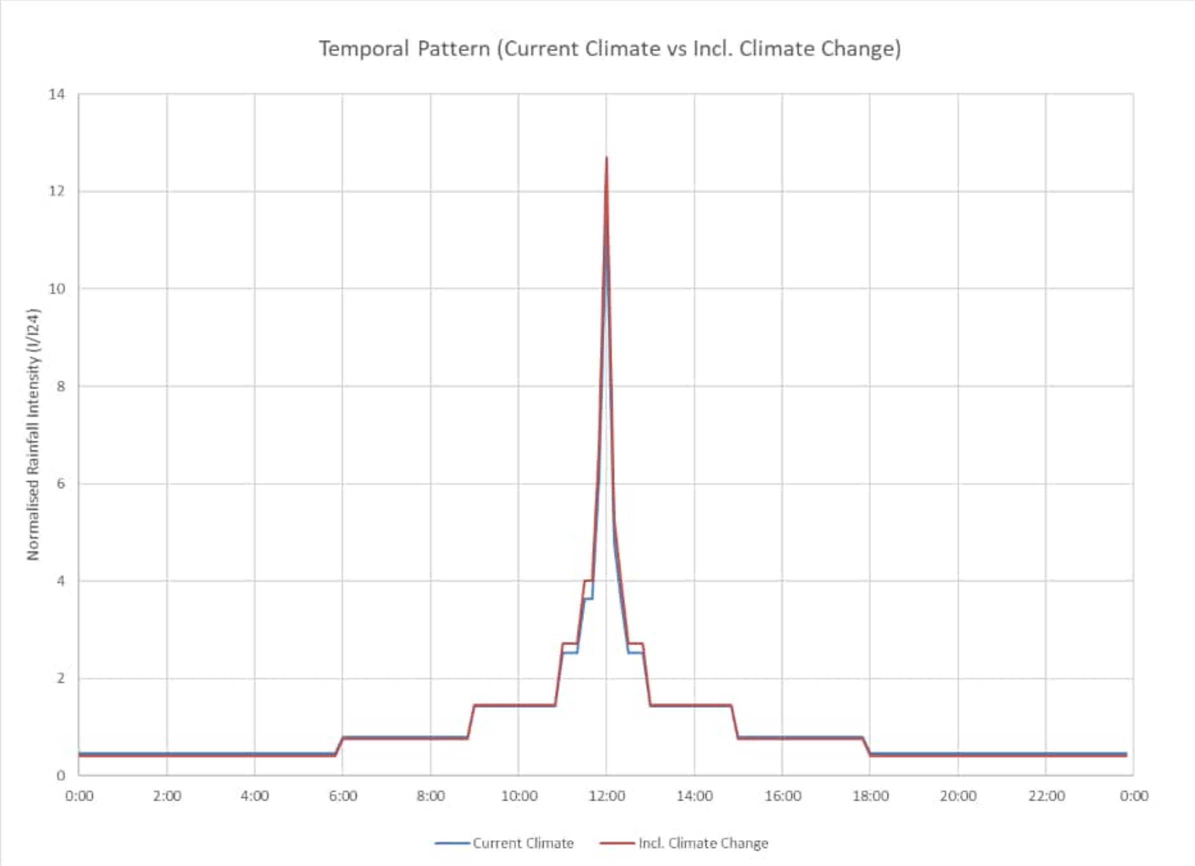

Figure 3-3 Temporal Pattern 24-hour Design Rainfall Event

3.4.5 Hydrometric Data

No long-term flow gauge is available in the Whangamata catchment. Consequently, model validation against gauging data was not undertaken.

3.4.6 Impervious Area

For the hydrological model, the catchment has been split into 51 different "hydrological" zones, depending on:

- TCDC District Plan Zones and Policy Areas
- Rainfall
- Soil type (Hydrological Soil Group).

For each of these hydrological zones a representative impervious area coverage has been assessed.

The respective zones are shown in Figures C1 & C2 in Appendix D. It is noted that the following simplifications have been made to limit the number of hydrological zones in the model:

- Roads have been included with adjacent zoned land, rather than having a separate zone for each housing block.
- Housing Zone Beach Amenity has been incorporated with adjacent housing zones.
- Very narrow sections (primarily open space) have been removed.
- Industrial and Service Industrial have been combined into Industrial.
- Town Centre and Pedestrian Frontage have been combined into Town Centre.

The resulting simplified zoning plan, including the respective hydrological zone is shown in Figure 3-4 below (refer also Figures C1 & C2 in Appendix D).

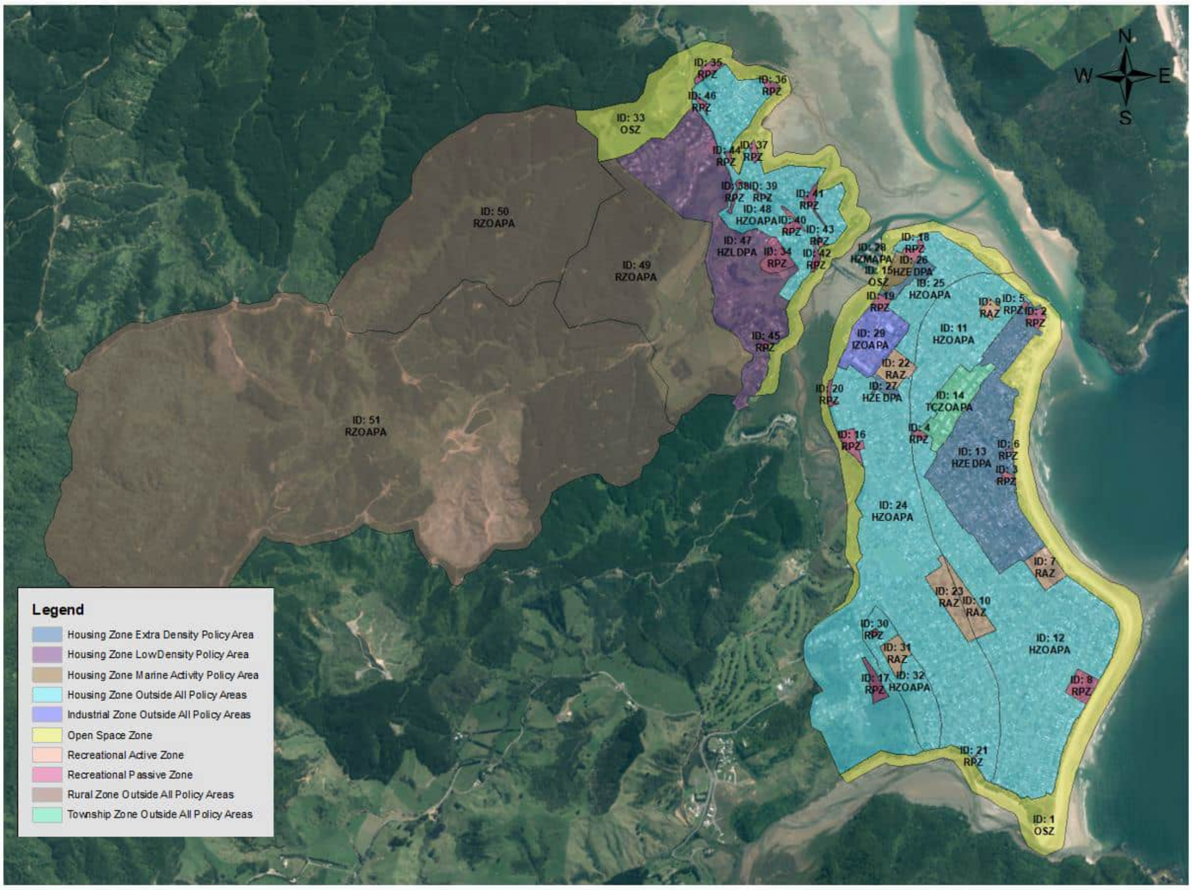

Figure 3-4 Simplified District Plan zoning and respective hydrological zone ID.

Existing Development

For the Existing Development scenario, the impervious area has been estimated based on:

- TCDC GIS Building Footprint data
- Aerial Imagery.

TCDC has data for building footprints but not for other impervious surfaces such as driveways, road carriageways and footpaths. Percentage impervious area has been assessed using a combination of the building footprint layer and aerial images. For this assessment, each hydrological zone has been assessed individually. This involved a combination of:

- Calculating the building footprint area and the road reserve area using the respective GIS layers
- Manually estimating the other hard stand areas (like driveways, garages, sheds, etc.).

For manual estimate of the other hard stand areas (especially the residential areas), a representative ratio between building footprint and the other hard stand areas was calculated using a 10ha sample area (refer Figure 3-5 below).

Buildings have been separated from other impervious areas, as the runoff of residential buildings is assumed to be discharged by means of soakage. Note that commercial and industrial buildings are assumed to be connected to a reticulated network. Buildings in Type D soils are not expected to discharge into soakage due to the poor soakage characteristics of the soil. There are no buildings on Type C soils in Whangamata.

Figure 3-5 Sample area to calculate impervious footprint of other hard stand impervious areas

Table 3-3 below provides a summary of the assessed percentages of impervious area for the various land use types (as per the District Plan). Within each of the District Plan land use zones, the assessed impervious coverage may vary. A full list of the 51 hydrological zones that have been identified is provided in Appendix A. The overall coverage is also presented in Figures C1 & C2 in Appendix D.

Table 3-3 Impervious coverage assumptions - Existing Development

District Plan ID	District Plan Land Use Description	Building roofs connected to soakage*	Total Modelled Impervious Coverage
HZBPA	Housing Zone Beach Amenity [1]	N/A	N/A
HZEDPA	Housing Zone Extra Density	5 – 31%	17 – 53%
HZLDPA	Housing Zone Low Density	6%	12%
HZMAPA	Housing Zone Marine Activity	2%	54%
HZOAPA	Housing Zone	17%	40%
IZOAPA	Industrial Zone	23%	70%
IZSIPA	Industrial Zone Service[2]	N/A	N/A
OSZ	Open Space	0%	0%

[1] Beach Amenity zoned land has been combined with adjacent housing zone.
[2] Industrial Zone Service has been combined with Industrial Zone.

District Plan ID	District Plan Land Use Description	Building roofs connected to soakage*	Total Modelled Impervious Coverage
PF	Pedestrian Frontage Town Centre[1]	N/A	N/A
RAZ	Recreational Active Zone	0 – 10%	0 – 30%
RPZ	Recreational Passive Zone	0 – 5%	0 – 23%
RZFDPA	Rural Zone Future Development	0%	0%
RZOAPA	Rural Zone	0%	0%
TCZOAPA	Town Centre Zone	28%	75%

Note: Soakage only assumed for catchments with HSG Type A or B.

A detailed table specifying the adopted percentages for each hydrological zone is presented in Appendix A and graphically represented in Figure C.1.

Maximum Probable Development

For the MPD scenario, the impervious footprint is based on the District Plan development restrictions for the respective land use specified (refer TCDC District Plan Portal[2]). Additional percentage impervious area has been included to allow for road impervious footprints and hardstand areas. The percentages adopted for the model are presented in Table 3-4 below.

Table 3-4 Impervious coverage assumptions - Maximum Probable Development

Zone	Zone Description	DP Max Site Coverage	Building roofs connected to soakage*	Total Impervious Coverage
HZBPA	Housing Zone Beach Amenity	N/A	N/A	N/A
HZEDPA	Housing Zone Extra Density	45%	30%	60%
HZLDPA	Housing Zone Low Density	15%	10%	20%
HZMAPA	Housing Zone Marine Activity	60%	40%	60%
HZOAPA	Housing Zone	35%	33%	50%
IZOAPA	Industrial Zone	70%	0%	70%
IZSIPA	Industrial Zone Service	N/A	N/A	N/A
OSZ	Open Space Zone	1%	0%	0%
PF	Pedestrian Frontage Town Centre	N/A	N/A	N/A
RAZ	Recreational Active Zone	60%	0%	15%
RPZ	Recreational Passive Zone	15%	0%	15%
RZFDPA	Rural Zone Future Development	10%	0%	10%
RZOAPA	Rural Zone	10%	0%	0%
TCZOAPA	Town Centre Zone	0%	0%	80%

Notes:

- Three areas have an ED % impervious area that is larger than the MPD maximum. For these, the higher ED % impervious area has been adopted.
- The maximum site coverage for Recreation Active Zone is 60%, which is considered too high and unrealistic. This has been reduced to 15%, being the same as Recreation Passive Zone.
- The 1% maximum site coverage for Open Space Zoned land has been reduced to 0% for model simplification reasons, as it is not expected to have a significant impact on the results due to the relatively small increase.
- Residential housing zones include additional allowance for road impervious area (5% for Low Density and 15% for all others).
- Building roof soakage is only assumed for non-commercial land use zones with HSG Type A or Type B.

[1] Pedestrian Frontage Town Centre zoned land has been combined with Town Centre Zone.
[2] TCDC District Plan Portal Part VIII – Zone Rules (https://eplan.tcdc.govt.nz/pages/plan/Book.aspx?exhibit=TCDC_Plans_External)

- Building roof areas are assumed to be 2/3 of the impervious footprint. Building roof areas have been reduced for three areas to avoid MPD runoff being less than ED runoff due to high soakage assumptions.
- The Industrial Service Zone has been combined with the Industrial Zone.

3.5 Hydrological Model

3.5.1 Method Used

Modelling of the excess runoff is based on the guidelines outlined in the Waikato Regional Council Stormwater Runoff Modelling Guideline (TR2018/02). The key features of the TR2018/02 rainfall-runoff model are:

- A standard 24-hour temporal rainfall pattern derived from HIRDS local data, having peak rainfall intensity at mid-duration. Shorter duration rainfall bursts with a range of durations from 10 minutes to 24 hours are nested within the 24-hour temporal pattern.
- Excess runoff depth calculated using SCS runoff curve number method, with curve numbers determined from the TR2018/02 guidelines, according to classifications assigned to soil types or Hydraulic Soil Groups (HSGs) obtained from Landcare Research[1] soil maps.

  It is noted that for urbanised areas the allocated soil group has been altered to account for soil disruption and compaction following development of the land. A residential or commercial zoned catchment with a group A soil has been allocated the CN value for a group B soil (similarly a HSG B becomes HSG C).

The adopted hydrological method for generating and modelling the excess rainfall runoff is a combination of:

- Rain-on-Grid method for the developed lower lying catchments. This is the same method that has been used for the RFHA, where excess rainfall runoff (after deduction of initial abstraction and infiltration losses) is entered on the DEM surface and runoff is calculated within the hydraulic model component.
- Lumped catchment assessment for the Te Weiti and Waikiekie streams. For this method the catchment of the respective streams is identified including an assessment of the response time (i.e. time of concentration). A runoff hydrograph is generated representing the runoff of the entire lumped catchment. This runoff is coupled to a location on the DEM where the respective stream enters the so called 2D-Zone (i.e. a zone that represents the extent of the modelled surface).

The Rain-on-Grid method requires that the entire catchment is represented by a DEM. This may result in large computation times, which is the downside for large catchment models. The lumped catchment approach is much faster but can be complicated to model if the catchments do not have clear boundaries or specific discharge points. It is also noted that excluding catchments outside the area of interest provides a large potential for reduction of the DEM extent, and so may result in a significant reduction in computation times. The Rain-on-Grid method is therefore ideally suited for flat non-confined catchments (like the urbanised areas), while lumped catchments are ideal for modelling runoff of large confined catchments (like the large stream catchments).

3.5.2 Rain-on-Grid Catchments

For the Rain-on-Grid catchment areas the excess rainfall runoff has been calculated for each of the land use zones listed in Appendix A. The resulting timeseries are applied directly to each mesh element of

[1] Landcare Research S-Map Online, https://smap.landcareresearch.co.nz/

the modelled ground surface in the respective land use zones. The subsequent routing of the runoff is modelled in 2D using the DEM and triangular mesh (refer Section 3.6 below).

For this method, timeseries were developed representing the excess rainfall runoff for each land use zone depending on:

- Soil Type (i.e. Hydrological Soil Group) (refer Section 2.3 above).
- Rainfall obtained from HIRDSv4 for various locations in the catchment (refer 3.4.4 above).
- Percentage impervious area based on District Plan zoning (refer Section 3.4.6 above).

For each land use zone, the following pervious and impervious areas were identified, and excess runoff calculated:

- Roof Soakage:

  For non-commercial buildings, roof runoff located in areas with well-draining soils (i.e. HSG A or B) is assumed to be discharged by means of on-site soakage systems with a discharge capacity equal to the 2-year peak rainfall.

- Other Impervious Areas:

  For other impervious areas it is assumed that 100% of the rainfall runs off, which is slightly more conservative than the using a CN of 98.

- Pervious Areas:

  Runoff from pervious areas has been calculated for each land use type and rainfall zone using HEC-HMS software. Refer to Appendix C for adopted CN values.

The calculated excess runoff depth has been included in the model as a Rainfall time series boundary. In each of the identified Rain-on-Grid catchment zones, the respective net excess runoff is represented by a unique profile, of which there are 49 in total (plus the two rainfall profiles for the lumped catchments).

An example of the rainfall and excess runoff for a selection of three land use types is provided in Figure 3-6 below. It shows the cumulative rainfall for the 24hr 100yr design storm event, including allowance for climate change, versus the calculated excess runoff for the land use zones listed under Table 3-5 below for soil type A.

Table 3-5 Example Land Use Zones

ID	DP Description	2D Zone	HSG	% Impervious Area - MPD		
				Roof Soakage	**Other Imp Area**	**Perv Area**
3	Recreation Passive Zone	Township	A	0%	15%	85%
12	Residential Zone	Time Step	B	33%	17%	50%
14	Commercial Zone	Time Step	B	0%	80%	20%

Figure 3-6 shows that the runoff of residential zoned land is similar to the runoff of recreational land. This is due to the assumption that roof runoff is discharged through soakage with a capacity of the 2yr rainfall event. As a result, the contribution of runoff from the roofs of buildings occurs only during the peak half hour of the storm event.

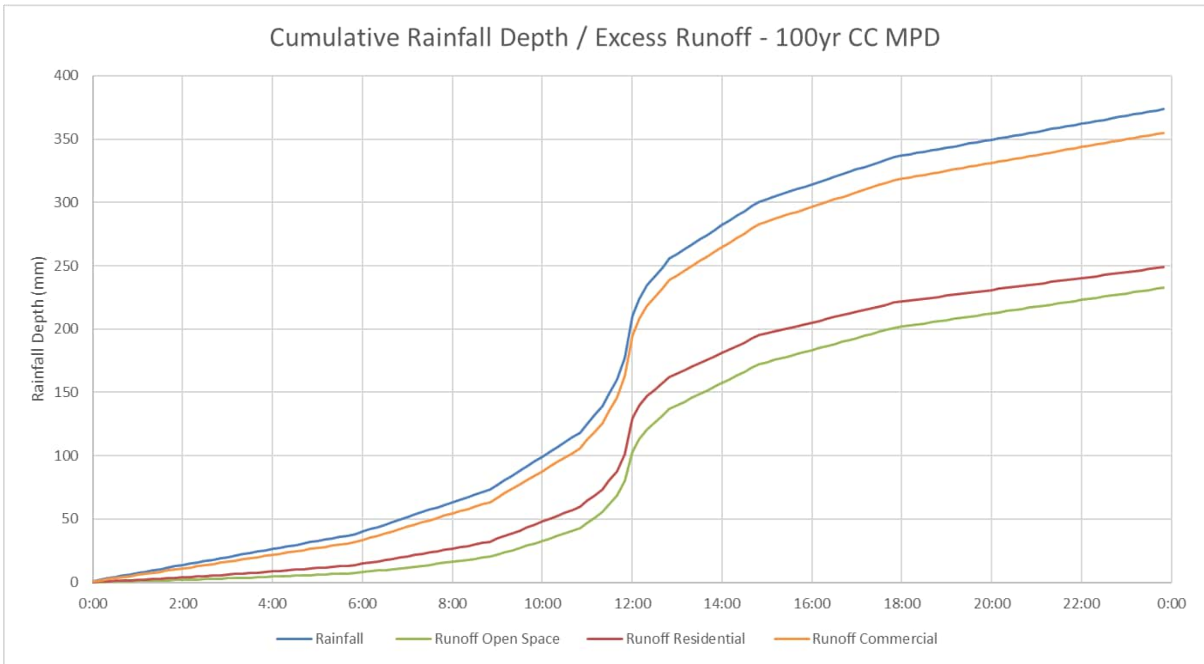

Figure 3-6 Cumulative Rainfall Runoff Depth for various land use types

3.5.3 Lumped Catchments

For the lumped catchments of the Te Weiti and Waikiekie streams, the catchment boundaries were delineated in GIS software based primarily the 5m contour data as the LiDAR only covers the lower extent of the catchments. The catchment boundaries are shown in Figure A of Appendix D.

Infiltration characteristics are based on the respective soil type classification as shown in Section 2.3. The weighted CN value has been calculated using GIS. The impervious area has been assumed to be 0% for both ED and MPD scenarios. Sub-catchment lengths and slopes were computed using data from manually digitised flow lines in GIS based on the equal area method as specified in ARC TP108 document (ARC, 1999). The time of concentration was estimated using the ARC TP108 methodology (ARC, 1999).

The hydrological parameters for the three catchments are presented in Table 3-6 below, adopted for both existing (ED) and future (MPD) development scenarios.

Table 3-6 Hydrological data for lumped sub-catchments

Catchment	Total Area (Ha)	Weighted CN	Initial Abstraction (mm)	Flow Length (m)	Slope (Equal Area)	Time of Concentration (min)
Te Weiti North	102	42	17.9	2200	4.1%	75
Te Weiti South	40	34	24.3	1100	8.0%	45
Waikiekie	511	56	9.8	5300	3.2%	120[1]

[1] The Time of Concentration for the Waikiekie stream has been adjusted to 180min following flow validation (refer Section 4.1 below).

The above catchment characteristics are included in the ICM model as sub-catchments.

The following rainfall time series have been set up representing the rainfall in the catchments (Refer Table 3-1 for details):

- Te Weiti North and South: Urban North & Lower Rural (Time Series Profile 50)
- Waikiekie: Upper Rural (Time Series Profile 51)

3.6 Hydraulic Model

3.6.1 Model Set up

The hydraulic model adopted the RFHA model 2D mesh as a base and added the 1D piped network.

3.6.2 DEM

The hydraulic model of the study area was developed incorporating the 2D digital elevation model (DEM) used for the RFHA model including some modifications. This DEM is a combination of the 2013 LiDAR data and the 5m contour data in areas where no 2013 LiDAR data is available (refer Section 0).

Modifications were required to adequately model the inlet and outlet structures that are linked to the 2D surface. LiDAR data often does not adequately pick up the low points of streams and channels due to vegetation and water surface light reflection. For model stability, it is essential that invert levels of linked 1D-2D structures have the same level. It is therefore necessary to adjust the DEM.

This is done by using Mesh Level Zones. For most linked structures, a small area of the 2D surface is lowered to match the invert level of the respective structure. For some locations, it was considered preferable to adjust longer sections of the stream to ensure positive gradient and ultimately a better mathematical computation. These areas are:

- Sections of both Te Weiti and Waikiekie Stream, which involved lowering the channel upstream and downstream of the State Highway culverts. Streambed levels were assumed to be 200 to 300 mm below water surface level (based on observations during site walk over).
- The concrete drains at Park Avenue Reserve and McKellar Place Walkway, to ensure that the low points of the concrete channel adequately represented in the model.

3.6.3 Hydraulic Model Extents

The 2D hydraulic model extent is defined by the 2D Zone as shown in Figure 3-7 below. This covers an area of 269 ha north of the Wentworth River and 494 ha south of it. The total catchment area (including the lumped catchments outside the 2D model extent) is approximately 1,400 ha.

The primary stormwater drainage network system is represented in the model by nodes (i.e. manholes, inlets, outlets, catchpits) and conduits as connecting pipes. A summary of various hydraulic model components is given in Table 3-7, and briefly described below.

Table 3-7 Summary of hydraulic model components

Hydraulic Model Components	Values
1D Model Components	
Total number of stormwater network system nodes	577
Number of manholes / sumps	492
Number of outfalls	74
Number of dummy nodes	10
Number of storage nodes	1
Total number of conduits	498
2D Model Components	
Total area of model domain	763 ha
Number of mesh vertices	845,193
Number of mesh triangles	1,689,926
Number of mesh elements	1,662,423

Two different mesh sizes have been adopted, as shown in Table 3-8 below. Although the meshing has been done with a Minimum Element Area of 2m^2, the generated minimum element size is 1.7m^2.

Table 3-8 Mesh parameters

Location	Minimum Element Area	Maximum Triangle Area
Within main areas of interest	2 m^2	5 m^2
Outside main areas of interest	20 m^2	100 m^2

1D Components

Model nodes are utilised to represent the stormwater drainage network system attributes such as manholes, inlets, outlets, and catchpits. Catchpits are generally not included in the model, to reduce model complexity and the level of detail (refer to Section 4.3 for further information).

To provide the exchange of flow between the 2D surface and the piped network, manholes are modelled as nodes with "2D" Flood Type, with water exchange occurring at manhole lid level. Following peer review, it was recommended to use nodes with "Gully 2D" Flood Type to prevent unrealistically high inflows from the 2D surface. However, this resulted in unusual results with large jumps in the node's 2D results. In coordination with the peer reviewer and TCDC it was therefore decided to use the traditional "2D" Flood Type, except for locations were the inflow causes unrealistic impact on the model results. For those locations, individual catchpits are included in the model, but with a flow restriction of 100L/s maximum (using orifice structures with limited discharge) for the following three locations:

- 125 Lorraine Place
- 106 Apperly Street
- 104 Kotuku Street.

Two types of outfalls have been used, 'Outfalls' and 'Outfalls 2D', where runoff from "Outfalls" are lost from the model, while 'Outfalls 2D' discharge their runoff onto the 2D surface. In general, "Outfalls" were used when flows ware discharged into the coastal area, not affecting any areas or structures downstream. A constant water level boundary is allocated to the outfall representing the sea level. The 'Outfalls 2D' are typically used for culvert and pipe outlets discharging onto land within the catchment.

Model conduits were utilised to represent stormwater drainage pipes. The pipe data input to the model comprised of diameter, upstream and downstream inverts and connecting nodes based on the TCDC GIS asset database or survey information.

Six dummy manholes and three dummy conduits were inserted to model the downstream connection of the three lumped hill sub-catchments.

Streams are represented and modelled using the 2D DEM surface. It is common that the streambed is not or not well represented in the LiDAR and DEM, due to:

- Dense vegetation blocking the penetration of LiDAR to the actual ground surface
- LiDAR typically picking up water surface level instead of stream bed level
- Loss of detail during the conversion from LiDAR points to DEM triangular surface.

To ensure that the streambed is properly represented in the 2D model, mesh level zones have been specified. These represent the low flow streambed. The base width of the mesh level zone is set at 2m. The streambed levels have been estimated at approximately 3 locations for each stream section. This estimate is based on observations during the site visit in July 2018, using aerial images, and LiDAR.

2D Components

The 2D mesh is bounded by the 2D Zones, indicated by the orange line in Figure 3-7 below. A coarse mesh definition is applied for this zone, with the parameters Maximum Triangle Area set at 100 m^2, and the Minimum Element Area at 20 m^2. Note that Rain-on-Grid is applied, with a Manning's roughness of 0.02. Within the 2D zone, several "Mesh Zones" define areas of finer detail, as indicated by the purple line in Figure 3-7. For the Mesh Zones, the Maximum Triangle Area is $5m^2$ and the Minimum Element Area is set at $2m^2$.

In addition to the mesh zones, there are "Mesh Level Zones" (refer red areas in Figure 3-7 below), which are areas of modification of the terrain surface. These include (refer also Section 3.6.2 above):

- Te Weiti and Waikiekie streams, both downstream and upstream of the SH25 culverts.
- Open channel drains
- Culvert inlet and outlet structures coupled to the 2D surface
- Linkage of dummy manholes used for coupling the inflow hydrographs of the streams onto the 2D surface.

This was adopted to better represent the 1D features and to ensure that there is no level difference between the 1D invert level and the 2D surface level at 1D-2D coupled structures.

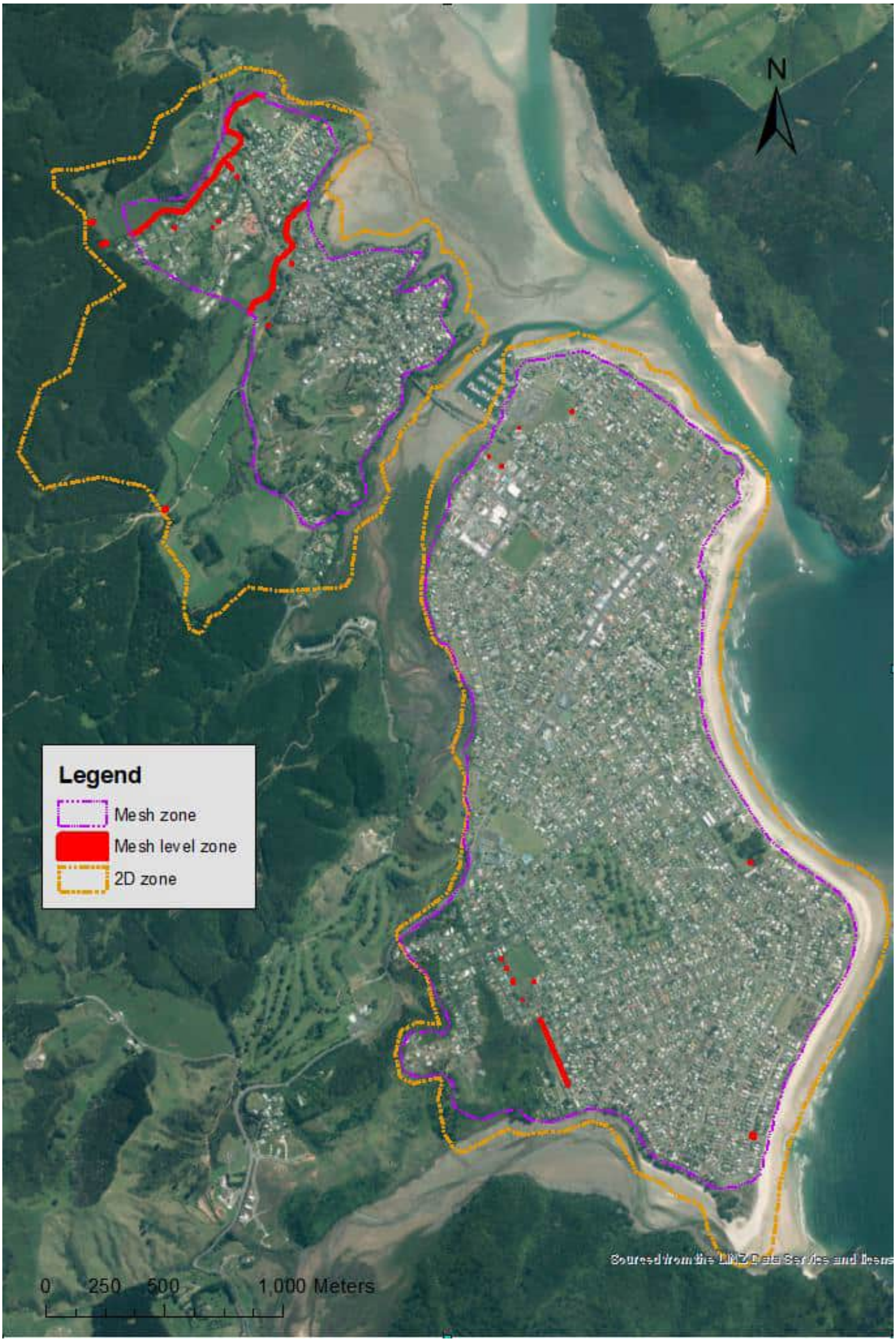

Figure 3-7 "2D Zone", "Mesh Zone", and "Mesh Level Zone" extents

3.6.4 Energy Losses

1D Network Head Losses

Friction factors were assigned to the conduits as a Manning's roughness of 0.013. Default values were adopted for upstream and downstream head loss, with "Normal" head loss type appropriate for "well-constructed manholes on pipe systems". The ICM inference tool was used to infer pipe entrance head loss coefficients. Nodes were modelled assuming "full benching".

For the two SH25 culverts at Te Weiti and Waikiekie streams a roughness of 0.02 was adopted.

2D Surface Friction losses

Roughness Zones have been specified to represent the following areas:

- Developed areas (both residential and commercial/industrial: n = 0.35
- Rural, Open Space and Recreational areas: n = 0.05
- Road Reserve: n = 0.02

These values are based on Auckland Council's "Stormwater Modelling Specification" (Nov 2011) in combination with the Australian Rainfall Runoff (ARR 2012).

Building footprints were not specifically modelled or blocked out. This is due to the large number of polygons to model, causing complexity within the 2D meshed area and extending simulation times. However, these are represented by the relatively high roughness value for the entire property.

It is noted that for most of the township area catchment the roughness coefficient is not considered to be a critical model parameter due to the flatness of the terrain and resulting low flow velocities.

3.6.5 Specific Drainage Features

Details on specific drainage structures / features are provided below:

Williamson Park Pond and Outlet

Williamson Park Pond receives stormwater runoff from the southwestern part of the township catchment. The piped network to the pond has recently been upgraded (Refer TCDC Williamson Park Stormwater Outlet Duplication Project, WSP / OPUS 2019). The upgrade comprises a new outlet from the Ocean Road / Williamson Road intersection, where the Williamson Road stormwater pipe is separated from the existing 900mm dia outlet. It now discharges through a new 1050mm dia pipe into the pond.

The pond has no piped outlet. The primary means of water discharge is through soakage. It has an overflow onto the beach, consisting of a gabion basket structure with an 8m wide concrete level spreader on top of it. During the site visit in July 2019, some of the overflow was covered by dunes and the length of the overflow was observed to be 6m (Refer Figure 2-8 in Section 2.5 and Figure 3-8 below).

Figure 3-8 Overflow path between Williamson Park Pond and the beach

The level of this level spreader is modelled at 3.5m AVD-46. The level was surveyed in July 2018 by TCDC at 2.56m with an unknown datum. A conversion was made to AVD-46 based on the available data sources (i.e. TCDC GIS, OPUS 2018 survey, WSP/OPUS Design drawings and 2013 LiDAR). As there is a discrepancy between the 2013 LiDAR and the WSP/OPUS design, the level is expected to be between 3.29m and 3.53m AVD-46. The modelled level of 3.5m AVD-46 is considered a conservative assumption.

It is noted that maintenance of the overflow structure occurred after the 2013 LiDAR, as dune sand had built up over time. The LiDAR levels near the outfall are therefore considered too high. In the model this has been adjusted by specifying a 6m wide mesh level zone between the pond and the beach at the 3.5m AVD-46 overflow level.

Otahu Road Stormwater Pump Station

The model includes a stormwater pump station at the eastern end of Otahu Road (refer Figure 3-9). The capacity of the pump station, underground flood storage and piped network is based on as-built drawings and design data from Thames Civil Engineering Ltd (Thames, 2012). The modelled capacity of the pump station is 40L/s and the rising main discharges the runoff into a manhole at Otahu Road and Given Avenue intersection, which is about 200m to the west. A 375mm dia gravity pipe discharges the runoff into Otahu River at 149 Patuwai Drive.

Figure 3-9 Otahu Road Pump Station

The pump station wet well has a high-level overflow pipe to the beach. Based on site observations, the diameter of this pipe is 525mm and the length is 45m. The overflow level was measured to be at 1m below ground level.

Figure 3-10 Underground storage and soakage near Otahu Road Pump Station

Underground Storage and Soakage Systems

Additional underground storage directly south of the pump station is included in the model based on as-built drawings by RMS Surveyors (Thames, 2012). The storage consists of Atlantis Flo tanks providing storage and soakage infiltration (refer Figure 3-10 below). The assumed infiltration rate is 10mm/hr (refer Appendix A, TR-55) over the surface area of the storage units.

Further to the west (between the pump station and Marie Crescent) two rows of Triton Drainage Cells also provide underground storage and soakage. This has been included in the model based on the RMS Surveyors as-built drawings (Thames - 2012). The width of the units is assumed 1.4m and the height 0.86m. The infiltration rate is assumed to be 10mm/hr.

It is understood that there are other underground soakage systems within the township area. These have not been included in the model, due to lack of data on these systems.

Te Weiti and Waikiekie Culverts

Two culverts crossing SH25 have been included in the model. The modelled culverts are based on dimensions taken during the site visit, which are:

- Te Weiti Culvert 2.5m wide x 1.2m high
- Waikiekie Culvert 5.5m wide x 2.1m high

More details on these culverts and their performance are provided in Section 4.2.

3.7 Boundary Conditions

3.7.1 Rainfall Data

Rainfall data have been derived from HIRDS v4 as per WRC TR2018/02. A nested 24-hour duration temporal rainfall profile was developed from the HIRDS rainfall data. The rainfall depths used for the model are presented in Section 3.4.4 above.

3.7.2 Tidal Data

A constant tailwater level has been assumed as downstream boundary condition for the model. The adopted level is based on the Mean High Water Spring (MHWS) level published by the Waikato Regional Council Coastal Inundation Tool (refer Waikato Regional Council web-site[1]). The MHWS levels for various climate change scenarios are presented in Table 3-9 below.

Note that the levels presented in the above tool refer to Moturiki Vertical Datum 1953 (MVD-53), while the model and this report refer to Auckland Vertical Datum 1946 (AVD-46). Based on LINZ data[2], the difference between the two datums is 26mm (AVD-46 = MVD-53 + 0.026m), which has been used for the conversion of the levels.

Tailwater levels at outfalls along the Wentworth River have been adjusted following sensitivity analysis on the impact of elevated flood levels in that river (refer Section 4.7 for details).

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1 https://www.waikatoregion.govt.nz/services/regional-services/regional-hazards-and-emergency-management/coastal-hazards/coastal-flooding/coastal-inundation-tool/

2 https://www.linz.govt.nz/data/geodetic-system/datums-projections-and-heights/vertical-datums/vertical-datum-relationship-grids

Table 3-9 Tidal Conditions

Climate Change Scenario	Model Scenario	MHWS (MVD-53)	MHWS (AVD-46)
Present Day	ED	1.07mRL	1.10mRL
Future Projection 0.5m Sea Level Rise	n/a	1.57mRL	1.60mRL
Future Projection 1.0m Sea Level Rise	MPD	2.07mRL	2.10mRL

The Existing Development (ED) model is based on the present day sea level conditions, while for the Maximum Probable Development (MPD) scenario the future projection with 1.0m sea level rise has been adopted. This is based on the recommendations provided in Coastal Hazards and Climate Change guidance for local government (MfE, 2017) as shown in Table 3-10 below, assuming Category C is the most relevant for Whangamata and TCDC.

The impact of sea level rise along low-lying properties on the northern end of the peninsula is shown in Figure 3-11 below. The image shows the extent of the sea at MHWS assuming 1.0m SLR. It is noted that this excludes the impact of low barometric pressure, storm surge, wave run-up, and runoff from rainfall, which result in a further increase in flood levels.

Table 3-10 Minimum transitional New Zealand-wide SLR allowances and scenarios for use in planning instruments where a single value is required at local/district scale while in transition towards adaptive pathways using the New Zealand-wide SLR scenarios

Category	Description	Transitional response
A	Coastal subdividion, greenfield developments and major new infrastructure	Avoid hazard risk by using sea-level rise over more than 100 years and the H+ scenario
B	Changes in land use and redevelopment (intensification)	Adapt to hazards by conducting a risk assessment using the range of scenarios and using the pathways approach
C	Land-use planning controls for existing coastal development and assets planning. Use of single values at local/district scale transitional until dynamic adaptive pathways planning is undertaken	1.0 m SLR
D	Non-habitable short-lived assets with a functional need to be at the coast, and either low-consequences or readily adaptable (including services)	0.65 m SLR

Source: Table 12 of Coastal Hazards and Climate Change, Ministry for the Environment, Dec 2017 (MfE, 2017)

Figure 3-11 Coastal inundation MHWS including 1.0m SLR[1]

3.8 Model Limitations and Assumptions

3.8.1 Network Model Assumptions

A total of 17 pipes have been identified as decreasing in diameter in the downstream direction. These pipes are listed in Table 3-11 below. Several decreasing diameter locations have been confirmed and have potentially been designed as such (i.e., providing storage and soakage). One section has been adjusted in the model based on engineer's judgement (Conduit SWMH_302020.1) and is discussed in Section 4.6. Two pipe sections have been flagged TBC (To Be Confirmed) and are recommended to be considered for survey.

Table 3-11 Stormwater pipes with decreasing diameter in downstream direction

Conduit ID	Node ID	Location	Description
SWCP_207755.1	SW_Storage_553054	801 Otahu Rd	Soakage System at Otahu Rd pump station (confirmed by drawings)
SWMH_201689.1	SWMH_551785	1000 Port Rd	525 mm Ø into 375 mm Ø Likely some storage/soakage system
SWMH_201692.1	SWMH_301110	804 Port Rd	525 mm Ø into 375 mm Ø Likely some storage/soakage system

[1] Source: Waikato Regional Council Coastal Inundation Tool (Refer Waikato Regional Council website, https://coastalinundation.waikatoregion.govt.nz/).

Conduit ID	Node ID	Location	Description
SWMH_201694.1	SWMH_551785	906 Port Rd	525 mm Ø into 375 mm Ø Likely some storage/soakage system
SWMH_201695.1	SWMH_201696	1006 Port Rd	525 mm Ø into 225 mm Ø Likely some storage/soakage system
SWMH_201795.1	SWMH_203338	322 Williamson Rd	450 mm Ø into 300 mm Ø No significant impact expected
SWMH_203397.1	SWMH_203398	100 Ocean Rd	375 mm Ø into 300 mm Ø No significant impact expected
SWMH_204155.1	SWMH_550935	620 Port Rd	525 mm Ø into 450 mm Ø No significant impact expected
SWMH_204516.1	SWMH_203248	Near parking area behind 103 Winifred Ave	300 mm Ø into 225 mm Ø No significant impact expected
SWMH_301102.1	SWMH_301101	103 Winifred Avenue	600 mm Ø to 450 mm Ø Confirmed by survey
SWMH_301111.1	SWMH_301117	329 Port Rd	Flow split 375 mm Ø into 375 & 300 mm Ø
SWMH_302020.1	SWMH_301085	212 Martyn Rd (playground near golf club)	675 mm Ø into 450 mm Ø This has been modelled as a 600mm dia continuous pipe (refer Section 4.6)
SWMH_302105.1	SWMH_550421	300 Hetherington Rd	675 mm Ø to 600 mm Ø To be confirmed (refer Figure 3-12 below)
SWMH_302876.1	SWMH_301099	100 Hetherington Rd	450 mm Ø into 375 mm Ø Confirmed by survey
SWMH_303404.1	SWMH_303405	123 Seabreeze Ln	375 mm Ø into 300 mm Ø To be confirmed (refer Figure 3-13 below)
SWMH_303779.1	SWMH_303778	108 Casement Rd	300 mm Ø into 225 mm Ø No significant impact expected
SWMH_553141.1	SWMH_203249	Near parking area behind 103 Winifred Ave	300 mm Ø into 225 mm Ø No significant impact expected

Figure 3-12 Reduction pipe diameter on Hetherington Road

Figure 3-13 Reduction pipe diameter on Seabreeze Lane

3.8.2 Model Limitations

The following constraints apply to this model analysis:

- The present modelling adopts the Waikato Regional Council stormwater runoff model (TR2018/02), the assumptions and limitation from this methodology should also be read in conjunction with this report.
- General model assumptions (like soil infiltration rates, percentage impervious area, surface roughness, etc.) are averaged over wider areas and do not represent localised variations.
- The ground surface is represented as a triangular mesh with element size of 2 to 5 m^2. Each mesh element has a ground level allocated being the average level based on LiDAR data. Level variances within the element are not represented.
- The Wentworth River and the Otahu River are not part of the flood model and no information has been provided on flood levels in these rivers. Elevated levels in these rivers can have a backwater or flooding affect in the Whangamata township. Sensitivity analysis is included in this study to estimate the effect of elevated flood levels in Wentworth River.
- No calibration of the Whangamata Catchment model has been undertaken, with hydraulic and hydrological parameters developed from guidance documentation and engineering judgement. These adopted parameters may vary from actual catchment conditions, which could also change over time.
- The model accuracy for historical flood events will be dependent on the antecedent ground conditions and spatial rainfall variation. Antecedent ground conditions are variable, depending on the season and the timing of the storm within the sequence of storms. The runoff model is limited to the average antecedent moisture condition.
- The modelled overland flow paths are based on the LiDAR information. The extent of the flow paths may vary due to simplified model assumptions. Overland flow paths that pass through properties can have fences, vegetation and walls that alter flow path routes and may result in localised variances in flood levels.
- The extent of floodplains and ponding areas were mapped based on LiDAR ground contours. No specific survey was conducted for flood extent mapping. Therefore, the accuracy of the flood extent maps depends on the compound effects of uncertainties in the TP108 rainfall-runoff model, uncertainties in the hydraulic model parameters, and the accuracy of the LiDAR contour model.
- Large areas of the Whangamata catchment and especially the township rely on soakage as the primary means of stormwater drainage. The uncertainties related to the performance of soakage systems are:
    - Infiltration rates can vary significantly depending on the location.
    - Soakage systems are at risk of clogging up through small sediments and subsequently reduce infiltration capacity and performance. The actual capacity depends on design (i.e., provision to prevent clogging up) and maintenance.
    - Infiltration can be affected due to elevated groundwater levels.
    - Often, soakage systems are designed for a combination of storage and infiltration, assuming a certain design rainfall profile. This means that for long duration storms the storage component may have reached maximum volume whilst inflow is more than infiltration and consequently flooding occurs.
- Assessing the actual capacity of a soakage system is highly complex, due to:
    - Lack of information on the location and design of specifically build systems. No information has been received on the design (and/or construction) such as the

underground storage volume, site specific infiltration rates, and infiltration surface area except for the underground storage and soakage at Otahu Road.
    - Lack of information on provisions to prevent silting up of the system, the subsequent condition, and how this affects the infiltration capacity.
- For the model it is assumed that:
    - Industrial and commercial buildings are connected to a piped network system.
    - Roofs of residential housing are connected to an on-site soakage system with the assumption that the system has the capacity equal to the current climate peak rainfall intensity for the 2yr ARI rainfall event.
    - No soakage system has been assumed for roads and catchpits.
    - No soakage system has been assumed in areas with low infiltration capacity (i.e. Type C and D Hydrological Soil Groups) except for the normal infiltration that can be expected for these soils.
- The soakage is modelled by reducing the rainfall by the assumed soakage rate. The respective excess runoff (i.e. rainfall – infiltration loss) is entered onto the 2D surface. No further infiltration is assumed, and consequently ponded water in depression areas remains in the model (i.e. will not soak away once rainfall recedes). This results in ever-increasing water levels (until it reaches a natural overflow pathway) when storm durations increase.
- Reported flooded properties are based on flood extent data only. It does not consider the level of habitable floors. Floor levels have not been surveyed.
- No freeboard is included in the presented modelling results, to provide for physical processes that may not have been allowed for, uncertainties in the precision of the hydraulic modelling, and the estimation of physical processes.

In summary, the reported flows and levels are estimates based on numerous uncertainties. This affects the level confidence in estimates for parameters such as floor levels, tide levels, rainfall, soil infiltration rates, LiDAR data, interpolation between surveyed stream cross-sections, dynamic blockages due to debris and vegetation, and so on. These estimates should therefore be treated as indicative for the purposes of determining flood levels; however, the model can be utilised to assess the relative effects of potential option upgrades.

3.8.3 Hydrological Model Assumptions

- The sub-catchment length was measured from the most distant point of the catchment to the inflow node.
- The sub-catchment slopes were calculated from the 1m grid raster dataset based on LiDAR data according to the Equal Area Method as outlined in ARC TP108 document.
- The 2, 10, and 100-year 24-hour rainfall profiles used in the model are based on WRC TR2018/02 runoff modelling guidelines.

3.8.4 Hydraulic Model Assumptions

- No blockage has been assumed in catch pits, manholes, pipes, culverts and entry points into the stormwater network system.
- No sedimentation has been allowed for in the pipes, i.e. all pipes can perform at full capacity.
- No specific underground soakage system has been included in the model, except for the underground storage at Otahu Road stormwater pump station, which has been based on as-built data.

3.9 Model Peer Review

The Whangamata draft SPA model was peer reviewed by AECOM in August 2020. The purpose of this review was to confirm the hydrological and hydraulic model was suitable to inform the following:

- Development of the Whangamata strategic stormwater masterplan,
- Identification and assessment of the stormwater improvement works to mitigate flooding issues in the catchment.

A transportable of the model database was provided to AECOM in August 2020 with a draft copy of the SPA report. The peer review was completed in November 2020.

TCDC engaged Metis Consultants to review the Whangamata Model Build & System Performance Assessment final reporting, and this was completed in May 2023.

4 MODEL VALIDATION

4.1 Te Weiti and Waikiekie Flow Validation

Te Weiti and Waikiekie streams are modelled as lumped catchments, as described in Section 3.5.3 above. The runoff peak flow has been validated with other hydrological methods typically used in New Zealand, these being:

- Rational Method[1]
- Flood Frequency Method[2].

Catchment data for both methods can be obtained from the NIWA New Zealand River Flood Statistics website. For the Rational Method, a Runoff Coefficient of 0.25 has been adopted for all three stream catchments, assuming medium soakage soil types with bush and scrub cover (refer Table 1 of MBIE, 2016).

The computed peak flows for three rainfall probability events (assuming existing climate conditions for a 24-hour nested storm) are presented in Table 4-1 and Figure 4-1 to Figure 4-3 below.

Te Weiti Flow Validation

The validation shows that the SCS UHM generated flows reasonably match the flows generated using the Rational or Flood Frequency method for the Te Weiti stream (both northern and southern branch). For the 10yr and 100yr ARI events the SCS UHM flows are higher, while for the 2yr ARI event the flows are slightly lower.

Waikiekie Flow Validation

For the Waikiekie stream the SCS UHM peak flows are about twice as large as the other assessments. It was therefore decided to increase the modelled time of concentration from 120 min to 180 min to improve match. With the increased time of concentration, the flows adopted in the model are about 50% above the other assessments.

[1] Refer MBIE (2016): New Zealand Building Code – E1 Surface Water
[2] Refer McKerchar (1989): Flood Frequency in New Zealand

Table 4-1 Validation Peak Flow from stream catchments (in m^3/s)

Probability	SCS UHM	Rational Method	Flood Frequency Method
Te Weiti North			
2yr ARI	2.4 m^3/s	2.2 m^3/s	3.1 m^3/s
10yr ARI	5.8 m^3/s	4.1 m^3/s	5.8 m^3/s
100yr ARI	12.4 m^3/s	7.3 m^3/s	9.1 m^3/s
Te Weiti South			
2yr ARI	0.8 m^3/s	1.1 m^3/s	0.9 m^3/s
10yr ARI	2.1 m^3/s	2.1 m^3/s	1.7 m^3/s
100yr ARI	4.9 m^3/s	3.8 m^3/s	2.7 m^3/s
Waikiekie Original (Tc=120 min)			
2yr ARI	22.5 m^3/s	7.7 m^3/s	12.8 m^3/s
10yr ARI	45.4 m^3/s	14.2 m^3/s	24.1 m^3/s
100yr ARI	85.7 m^3/s	25.3 m^3/s	38.2 m^3/s
Waikiekie Adjusted (Tc = 180 min)			
2yr ARI	17.9 m^3/s	7.7 m^3/s	12.8 m^3/s
10yr ARI	36.1 m^3/s	14.2 m^3/s	24.1 m^3/s
100yr ARI	68.1 m^3/s	25.3 m^3/s	38.2 m^3/s

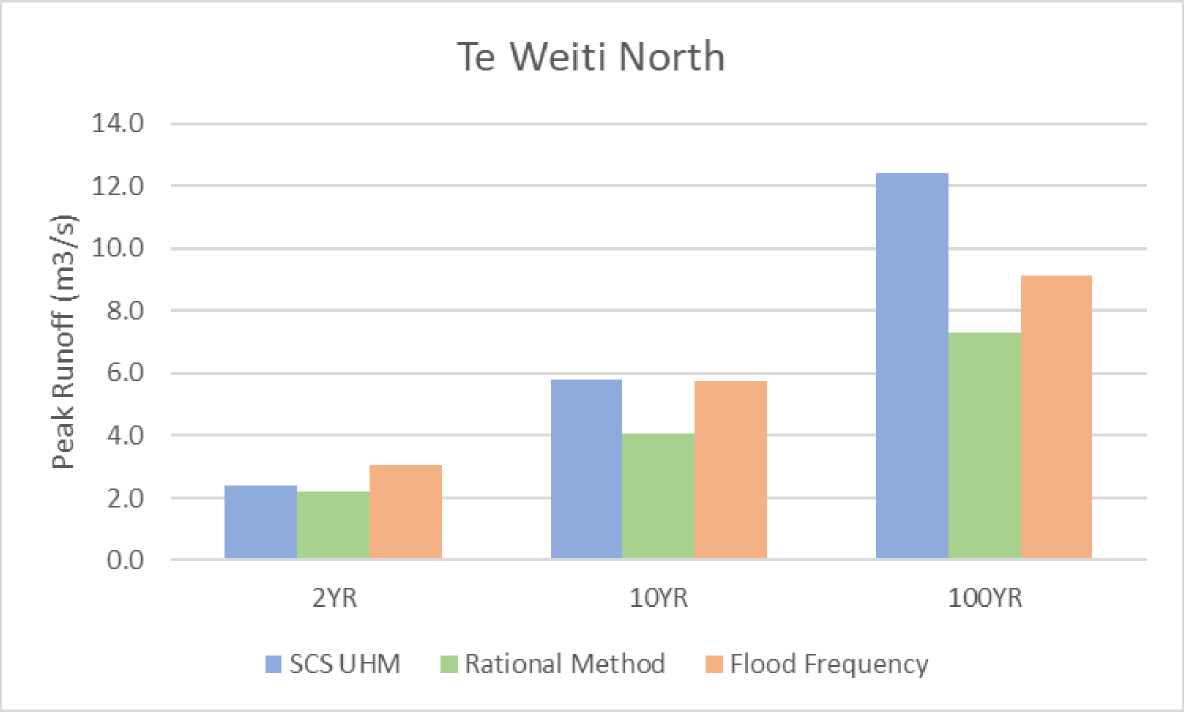

Figure 4-1 Te Weiti North Peak Flow Validation

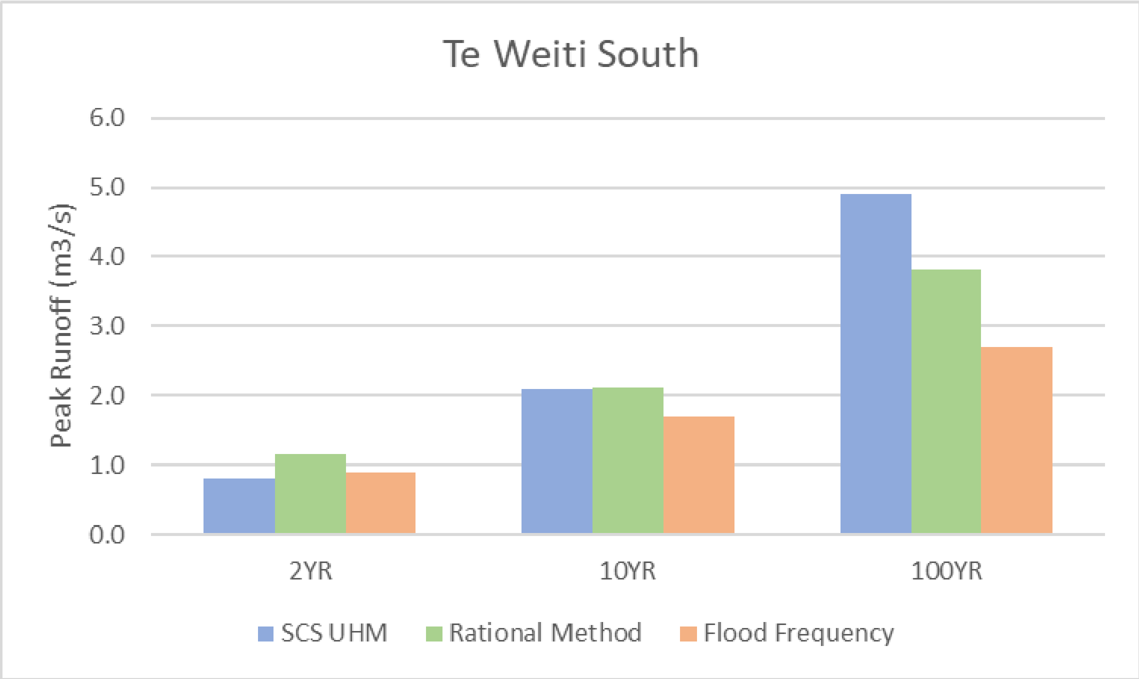

Figure 4-2 Te Weiti South Peak Flow Validation

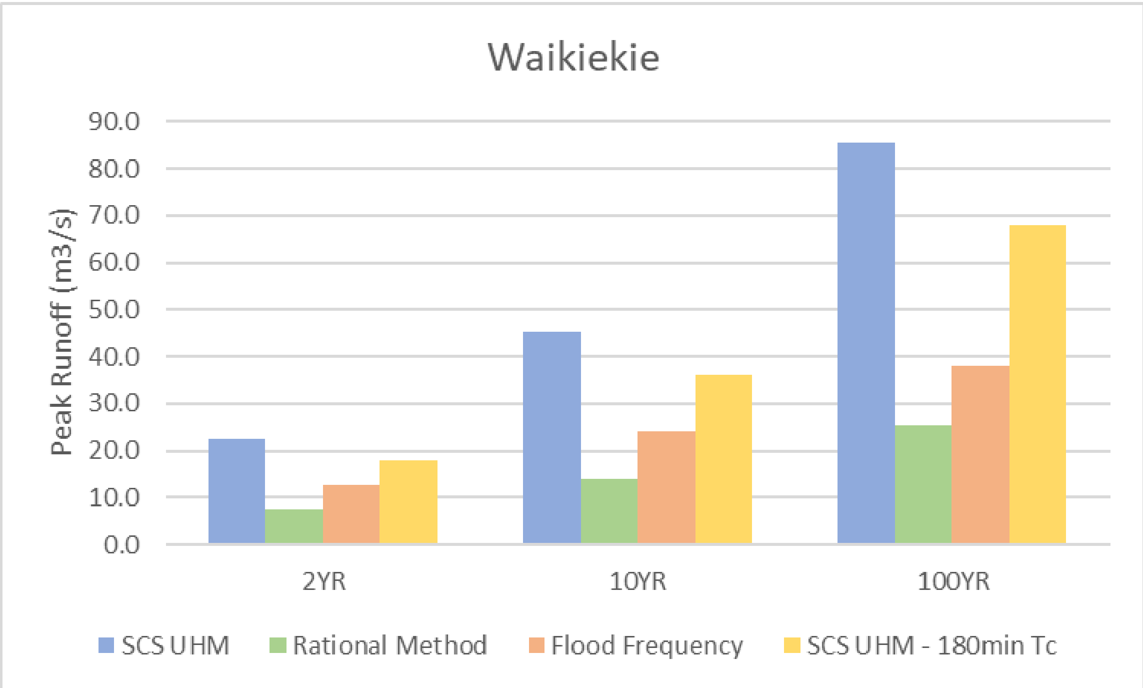

Figure 4-3 Waikiekie Peak Flow Validation[1]

[1] Note that the SCS UHM with a time of concentration of 180 min has been adopted in the model.

4.2 Te Weiti and Waikiekie Culvert Flow Validation

The modelled hydraulic performance of the two culverts under SH25 at Te Weiti and Waikiekie streams has been validated against culvert performance computations using HY-8[1] software. Following the initial results of this validation test, culvert parameters and modelling method have been modified to achieve better resemblance.

For the Baseline scenario, the culverts were modelled as "Conduit 2D" type structures, while for the sensitivity runs the "Conduit" type was used. The results are presented in Table 4-2 for the Te Weiti Culvert and Table 4-3 for the Waikiekie Culvert. For the comparison with HY-8 software ICM modelled peak flow and tailwater level was used as boundary conditions. The computed upstream water levels (and head loss dH) were compared to assess the performance for both methods. The flow used for the validation are the peak flows modelled under the Baseline scenario.

The following parameters have been adopted for the conduits:

- Bottom roughness culvert n = 0.020
- Top roughness culvert n = 0.015
- Culvert inlet head loss coefficient k = 0.5
- Culvert outlet head loss coefficient k = 1.0

The Te Weiti Culvert (refer Table 4-2 below) has 0.6m head loss over the culvert for the ICM Baseline scenario, compared with a head loss of 0.23m computed using HY-8 software and 0.20m using the Conduit method.

Table 4-2 Te Weiti Culvert Validation

Parameter	ICM Baseline – Conduit 2D	ICM Sensitivity Run - Conduit	HY-8
Width		2500 mm	
Height		1200 mm	
IL US		1.80 mRL	
IL DS		1.70 mRL	
Flow		4.5 m^3/s	
WL US	4.05 mRL	**3.70 mRL**	**3.68 mRL**
WL DS	3.45 mRL	**3.50 mRL**	**3.45 mRL**
Head Loss dH	0.6 m	**0.20 m**	**0.23 m**

For the Waikiekie Culvert, the head loss is 0.44m for the Conduit 2D Baseline scenario and 0.55m for the Conduit Sensitivity scenario. The variance in modelled head loss compared with the HY-8 computation is similar (i.e. 50 to 60mm variance). The more conservative Conduit method is preferable as it is more conservative (refer Table 4-3 below).

Following this analysis, it was concluded that the Sensitivity scenario (using the Conduit methodology to model culvert flows) is more consistent with the HY-8 computed head losses. It has therefore been adopted for both culverts.

[1] HY-8 Culvert Hydraulic Analysis Program, US Department of Transportation, Federal Highway Administration, https://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/

Table 4-3 Waikiekie Culvert Validation

Parameter	ICM Baseline – Conduit 2D	ICM Sensitivity Run - Conduit	HY-8
Width		5500 mm	
Height		2100 mm	
IL US		0.90 mRL	
IL DS		0.80 mRL	
Flow		30.9 m^3/s	
WL US	4.30 mRL	**4.04 mRL**	**4.35 mRL**
WL DS	3.86 mRL	**3.49 mRL**	**3.86 mRL**
Head Loss dH	0.44 m	**0.55 m**	**0.49 m**

4.3 Modelling Catchpits

The representation of the piped network is limited to pipes of 225mm diameter or larger and manholes. Catchpits and their leads are generally not included in the model. The impact of this model assumption has been tested by running a sensitivity scenario that includes all the stormwater drainage pipes and the catchpits in Williamson Road (refer Figure 4-4 below). The modelled baseline stormwater network is shown as black lines, while the pipes added to the modelled sensitivity scenario are presented in red. The sensitivity test is based on the MPD scenario for the 100yr 6hr design storm event, including climate change allowance.

The impact of including the catchpits and leads into the model is less than 5mm reduction (light yellow-green areas) in flood levels with some areas showing a small increase in flood levels (orange areas). This increase is likely due to the increased flow into the piped network under Williamson Road creating a backwater affect for the flows from the Ocean Road network. As the impact is within the +/-5mm range, it is considered acceptable to use a simplified model that does not include all the sumps and their leads, which results in slightly conservative flood levels.

Figure 4-4 Sensitivity Run - Modelling Catchpits near Williamson Park

An additional simulation was completed with all stormwater drainage pipes and catchpits that discharge to the primary outfall at Kotuku Street (refer Figure 4-5 below). This was completed based on the MPD scenario for the 100yr 6hr design storm event, including climate change allowance.

The impact of including the catchpits and leads results in a decrease in flood levels of 10 to 20mm within this area. This is a larger reduction in peak flood levels in comparison to the previous results (+/-5mm) but remains within the acceptable target for a simplified model.

Further recommendations to account for the modelled flood level uncertainty are included in Section 6.2.

Figure 4-5 Sensitivity Run - Modelling Catchpits upstream of Kotuku Street

4.4 Lowering Williamson Road Pond Overflow Level to 3.0mRL

The impact of lowering the overflow level from Williamson Road Pond to the sea from approximately 3.5mRL down to 3.0mRL has been modelled and analysed. The change in flood elevation is shown in Figure 4-6 below.

As expected, the results show a drop in peak flood levels within the pond of approximately 450mm, which is slightly less than the lowering of the overflow level. Flood levels at the intersection Ocean Road / Williamson Road reduced by 30 to 40mm, while further away from the pond the change is less than 30mm.

This shows that lowering of the overflow level of the pond has very limited impact on flood levels outside the reserve area.

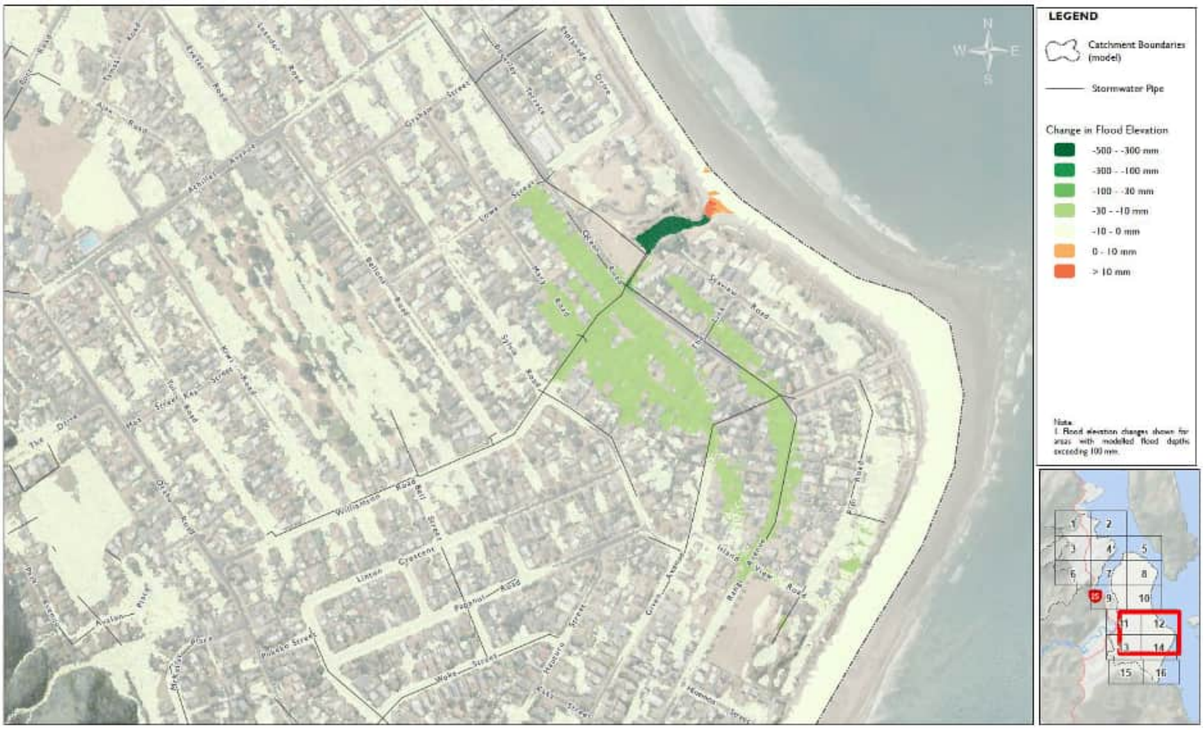

Figure 4-6 Sensitivity Run - Lowering Pond Overflow Level

4.5 Storm Duration

Waikato Regional Council requires flood risk assessments to be modelled using a 24-hour nested design storm. Considering the long computation time (approximately 10 hours for the 24-hour storm) the sensitivity of the storm duration on flood risk has been undertaken to justify using 12hr simulation runs for options analysis.

For the analysis, simulation runs have been undertaken and compared for 6hr, 12hr, and 24hr storm durations (for the MPD 100yr ARI + CC design storm). The differences in modelled peak flood elevation are presented in two different maps (refer Appendix D):

- Figure F3.1 Showing the difference between the 12hr simulation versus the 6hr simulation
- Figure F3.2 Showing the difference between the 24hr simulation versus the 12hr simulation.

The modelled variances can broadly be summarised as shown in Table 4-4 below.

Table 4-4 Impact Modelled Storm Duration on Peak Flood Depth

Description / Location	Difference in modelled peak elevation (100yr MPD + CC)	
	12hr vs 6hr simulation	**24hr vs 12hr simulation**
General – majority of the flood plain	0 - 50 mm	0 – 20 mm
Main street near shops	0 – 10 mm	0 – 5 mm
Ponding / soakage areas near the dunes	100 -150mm	80 – 130 mm
Waikiekie	50 – 100 mm	30 – 50 mm
Te Weiti	50 - 100 mm	30 – 50 mm

The increase in peak flood levels between the 24hr and 12hr simulation run is about half of the increase between the 12hr and 6hr simulation. For the general flooding in the catchment (i.e. excluding the streams and ponding areas along the dunes) the increase is less than 20mm.

It is also noted that the increase in flooding in the two streams is relatively small compared to the flow depth (i.e. in the order of 2m) and does not affect many properties.

For the ponding areas in the dunes it is expected that the model is conservative, as it does not account for ongoing infiltration / soakage of ponded water in those areas. Only the direct loss to infiltration when rain falls onto the surface is accounted for in the model.

Based on the above, it is considered acceptable to adopt 12hr simulation runs for the model when analysing flood mitigation options. For assessing peak flood levels for design and planning purposes, the 24hr storm duration will be adopted. The flood maps as presented in Appendix D are for the 24hr storm duration.

4.6 Inconsistent GIS Data near Rugby Field

A main stormwater piped network discharges runoff from the township centre and runs under Lincoln Road, the rugby field and Lindsay Road where it discharges into the Wentworth River. The TCDC GIS asset data shows the following pipe dimensions (refer to the highlighted section in Figure 4-7 below):

- 525mm dia under Lincoln Road
- 675mm dia under the rugby field
- 450mm dia under Lindsay Road
- 600mm dia outfall into Wentworth River

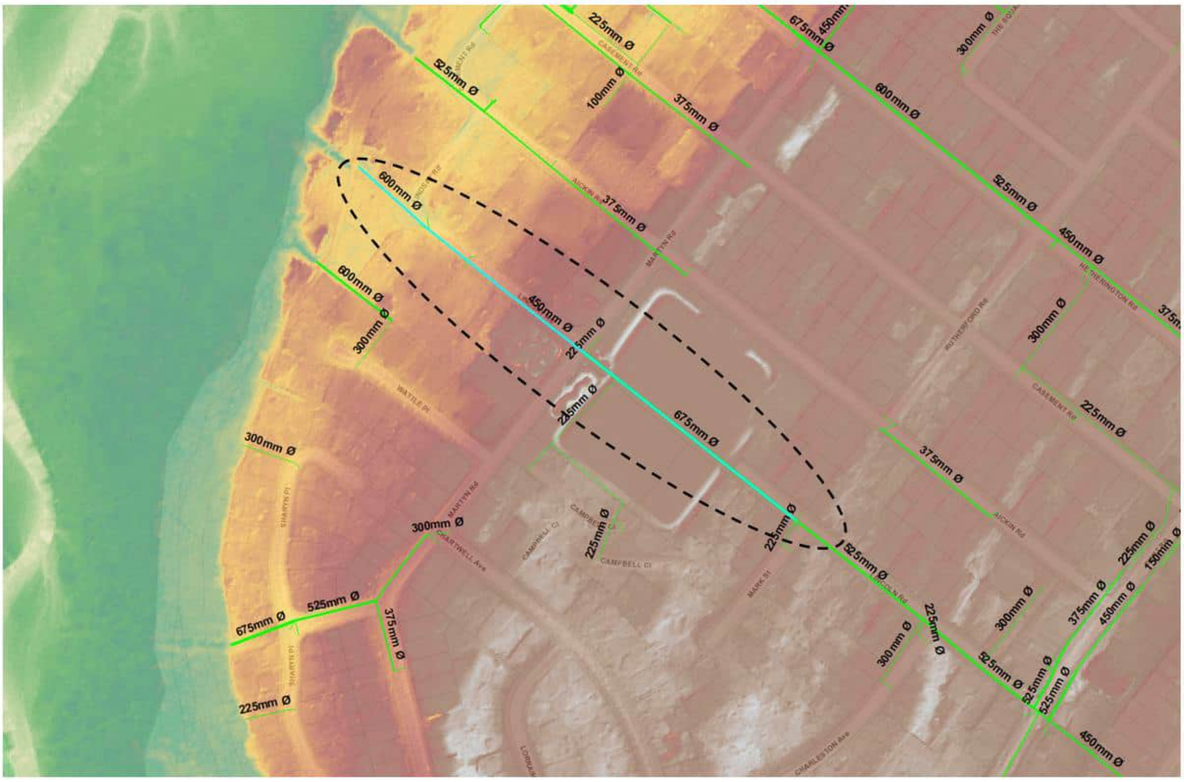

Figure 4-7 Main stormwater drain under rugby field

Note that the pipe diameter reduces in size from 675mm down to 450mm at Martyn Road (i.e. northwest of the rugby field). The diameter of the outfall has been confirmed by survey.

Based on the information available, the historic 1D model assumed that the 450mm dia and the 675mm dia are all 600mm dia in line with the outfall, as this would be the most logical from a stormwater design perspective (i.e. no reduction in pipe dimensions going downstream). However, the possibility exists that the GIS data is correct.

A sensitivity run has been carried out to assess the impact of modelling the system as per GIS asset data. The sensitivity run is based on the 6-hour MPD 100-year (incl. climate change) scenario. The variance in flood levels within the catchment is shown in Figure 4-8 below.

The results show an increase in flood levels upstream (southeast) of the rugby field up to 20mm. Near the outfall the flood levels are reduced by up the 10mm.

Figure 4-8 Sensitivity Run – Inconsistent GIS data rugby field

4.7 Elevated flood levels Wentworth River

The Wentworth River (2,400 ha catchment) flows to the west of the township and discharges into the Whangamata Harbour north of the township. Under heavy rain conditions, elevated water levels in the river may affect the stormwater runoff in low-lying catchments discharging into the river. The baseline model adopts a static tail water level at all stormwater outlets set to the MHWS (Mean High Water Spring) level (refer Section 3.7.2 above). An indicative assessment has been undertaken to set more realistic tail water level conditions and their effect on flood risk within the township.

A separate 2D model has been set up to model the Wentworth River from approximately 1.5km upstream of the SH25 bridge down to the sea (approximately 300m south of the Port Road jetty). The modelled flood levels near the locations of outfalls have been adopted as boundary condition within the catchment model. The sensitivity to flood levels within the township has been visualised.

Assumptions:

- Design flows have been derived from NIWA New Zealand River Flood Statistics (refer Table 5.5 below). The adopted flows are based on the Flood Frequency Method. To allow for the impact of climate change, the design flows have been increased by 17%, representing 2.1°C temperature rise.

Table 4-5 Wentworth River Design Flows

River Flow Probability	Peak Flow Existing Climate	Peak Flow incl. Climate Change
MAF (Mean Annual Flood)	63 m^3/s	74 m^3/s
ARI 10 year	119 m^3/s	139 m^3/s
ARI 100 year	188 m^3/s	220 m^3/s

- Peak river flood levels have been computed using a DEM of the river based on LiDAR data. This does not represent the underwater flow area and is therefore considered conservative.
- Riverbed roughness has been assumed 0.045 based on WRC TR-20-07 Waikato Stormwater Management Guideline (May 2020) Table 14.1 (Minor Streams, irregular section, with pools, slight channel meander).
- The modelled peak flood levels in the Wentworth River have been adopted as a constant tailwater level for outfalls discharging along the Wentworth River.
- Wentworth River levels have been modelled with a constant MHWS (Mean High Water Spring) level at the coast.
- As the response time of the Wentworth River catchment (2,400 ha) is considered much longer than the Whangamata township catchment (500 ha) the following joint probability assumptions have been made:

Table 4-6 Joint probability scenarios

Probability Event	Rainfall Probability	Wentworth River Level Probability
ARI 2 year	ARI 2 year	MHWS level
ARI 10 year	ARI 10 year	Mean Annual Flood
ARI 100 year	ARI 100 year	ARI 10 year

For the sensitivity test, the 6-hour MPD 100-year (incl. climate change) scenario was run with the modelled Wentworth River flood levels as boundary condition for the outfalls. The variance in flood levels within the catchment is in two areas:

- North (refer Figure 4-9 below):
  From Mako Road near the marina up to Sharyn Place / Mayfair Avenue with increases up to 40mm at the industrial area around Lindsay Road.
- South (refer Figure 4-10 below):
  An increase of up to 30mm around the intersection of Waihi Whangamata Road with Hilton Drive and Achilles Avenue.

Figure 4-9 Sensitivity Run – Elevated flood levels Wentworth River (north)

Although the variances in flood levels are small (i.e., up to 40mm), it is proposed to include the elevated Wentworth River levels as boundary conditions in the baseline model.

Figure 4-10 Sensitivity Run – Elevated flood levels Wentworth River (south)

4.8 Climate Change Guidance

The development of the SPA model applied the 2008 MfE climate change guidance[1]. More recent guidance was published in 2018, titled "*Climate Change Projections for New Zealand Atmospheric projections based on simulations undertaken for the IPCC 5th Assessment 2nd edition*". To determine the difference in flood hazard between the climate change guidance documents, a sensitivity assessment was completed.

For the purposes of the sensitivity assessment, conservative parameters from the 2018[2] document were adopted, applying the RCP 8.5 scenario, assuming an annual average increase in temperature of 3.13°C (beyond 2100), and an 8.6% increase in 24-hour rainfall depth during 100-year ARI storm intensities. The comparison between the 2008 and 2018 climate change 24-hour rainfall depth parameters is summarised below.

Table 4-7: Summary of 24hr design rainfall depths between scenarios

ARI	SPA MPD Scenario (2008 MfE) 24 Hour Depth in mm			Sensitivity Scenario (2018 MfE) 24 Hour Depth in mm		
	Township	**Urban North & Lower Rural**	**Upper Rural**	**Township**	**Urban North & Lower Rural**	**Upper Rural**
100 Year	**374**	409	495	**406**	444	538

Note that the updated climate change guidance does not provide any percentage increases for rainfall intensities for less than 1-hour durations, whereas the 2008 climate change guidance outlined intensities up to 10-minute periods. Hence, an updated temporal pattern based on the updated guidance could not be derived as part of this assessment. The SPA model assessment developed a temporal pattern based on the HIRDSv4 RCP8.5 (2081-2100) 100-year scenario. This temporal profile was considered appropriate for the sensitivity assessment.

Two rainfall scenarios have been assessed, as below:

1. 100 Yr MPD + CC (existing draft SPA results), 24HR Rainfall Depth: 374mm
2. 100 Yr MPD Sensitivity (adjusted rainfall depth to match latest MfE CC guidance), 24HR Rainfall Depth: 406mm

Figure 4-11 illustrates the simulated change in inundation depth between the two scenarios for selected locations. Overall, the difference in the simulated inundated depths, for the selected sites, between the two scenarios are generally less than 100m with only minor changes in inundation extents between the two scenarios.

Due to the minor differences, it is recommended to apply a freeboard to account for uncertainties in the flood analysis, as per the recommendation in Section 6.2. A further recommendation is to update the flood map documentation on a regular basis to account for updated climate change guidance documentation.

[1] Climate change effects and impacts assessment – A Guidance Manual for Local Government in New Zealand – 2nd Edition 2008

[2] Climate Change Projections for New Zealand Atmospheric projections based on simulations undertaken for the IPCC 5th Assessment 2nd edition 2018

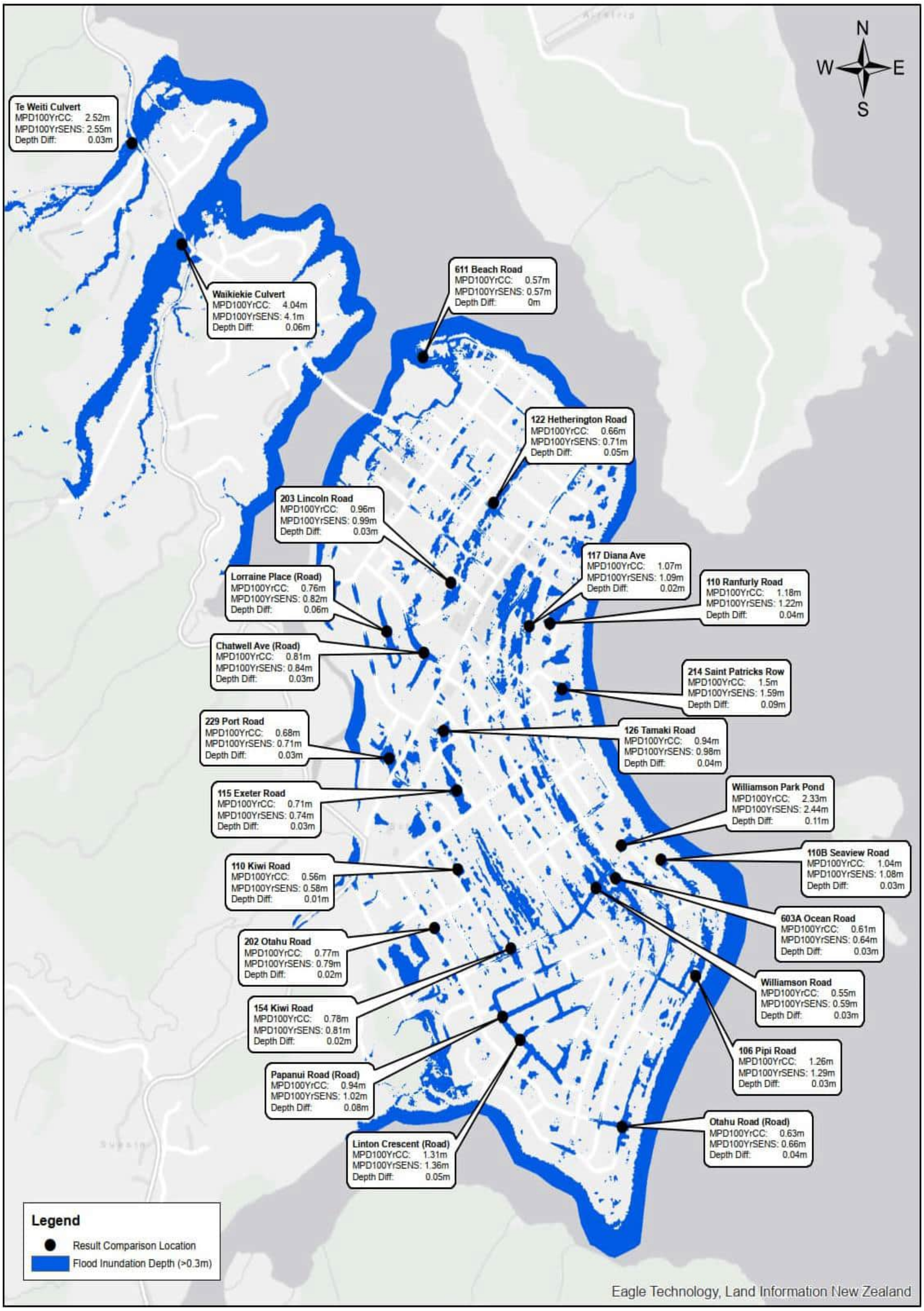

Figure 4-11 Sensitivity Run – Comparison of flood inundation extent and depths

5 SYSTEM PERFORMANCE ASSESSMENT

The model has been run for the scenarios and design storm events listed in Table 5-1 below. Flood inundation maps have been prepared for the MPD scenario with ARI 10yr and 100yr 24-hour design storm event (refer Figures E1-E16 in Appendix D). Note that these maps represent the computed flood levels and do not include freeboard to allow for:

- physical processes that may not have been allowed for
- uncertainties in the precision of the hydraulic modelling
- uncertainties in the estimation of physical processes.

Table 5-1 Model simulation matrix

Simulation	Figure	Land Use	Design Storm Event	Boundary	
				Rainfall	Tide Level (m RL)
1	n.a.	ED	2-year	ARI 2yr	1.10
2	n.a.	ED	10-year	ARI 10yr	1.10
3	n.a.	ED	100-year	ARI 100yr	1.10
4	n.a.	MPD	2-year	ARI 2yr + CC	2.10
5	E1-E16	MPD	10-year	ARI 10yr + CC	2.10
6	E1-E16	MPD	100-year	ARI 100yr + CC	2.10

Figure 5-1 illustrates the grids representing the flood inundation maps for the MPD scenario with 10 and 100 year ARI 24 hour design storm events (refer Figures E1-E16 in Appendix D).

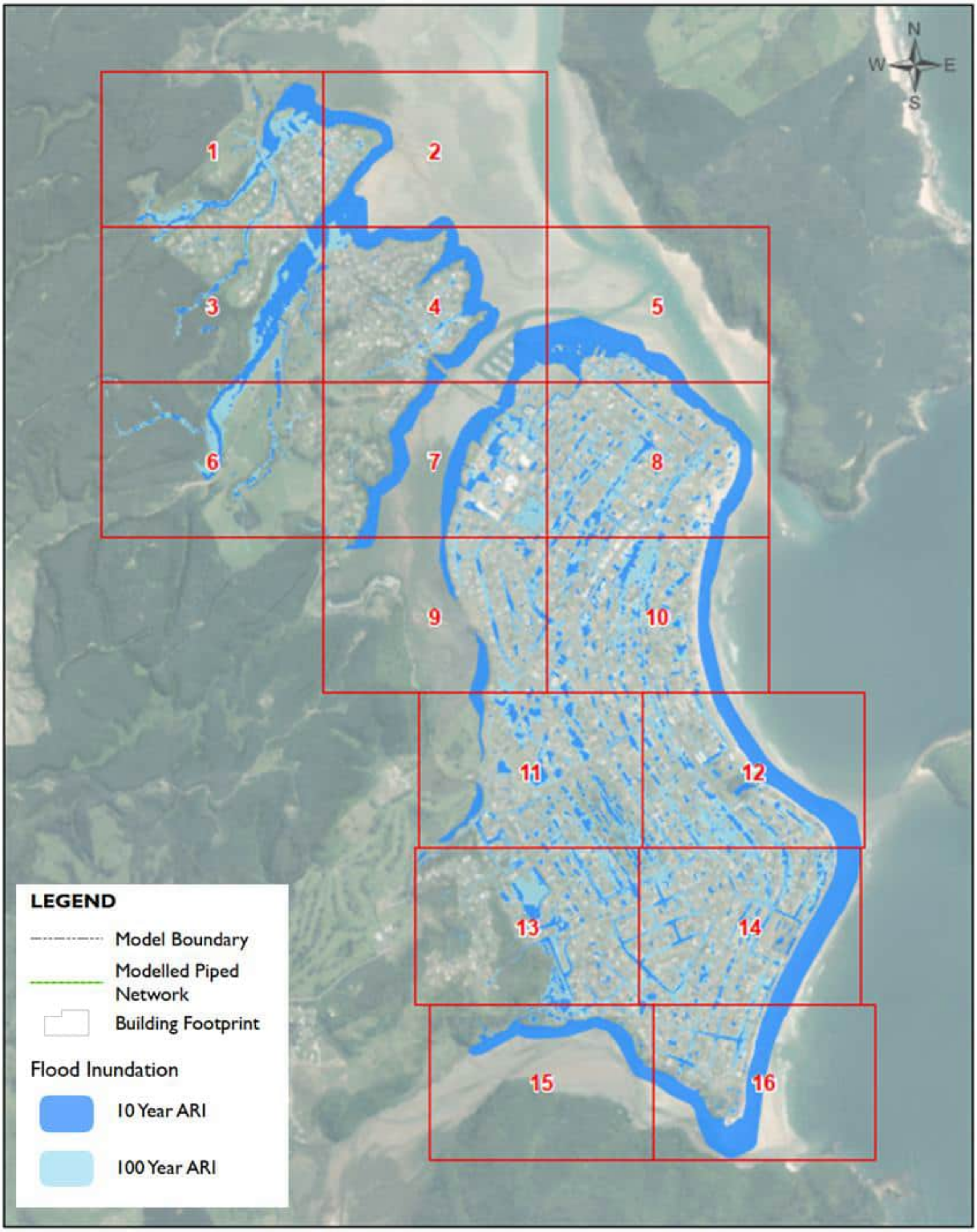

Figure 5-1: Flood Inundation Map Grid – 10 & 100 year ARI MPD 24 hour event

6 FINDINGS AND RECOMMENDATIONS

6.1 Summary of findings

The findings from this study include:

- A hydrological and hydraulic model has been developed of the Whangamata township and northern urban areas. This model has been used to complete a dynamic assessment of design rain storms for 2, 10 & 100yr ARIs for existing development (current climate conditions) and maximum probable development (including climate change allowances).
- The reported flows and levels are estimates based on numerous uncertainties that affect the confidence in this estimation, such as soil infiltration rates, LiDAR data, rainfall, tide levels, dynamic blockages due to debris and vegetation, localised obstructions, and so on. As such, these estimates should be treated as indicative for the purposes of determining flood levels; however, the model can be utilised to assess the relative effects of potential option upgrades.
- Validation activities for this model have found that:
    - Te Weiti and Waikiekie culverts are adequately represented in the model.
    - Excluding individual catchpits from the model is acceptable.
    - Lowering the Williamson Road Pond overflow level provides limited benefits.
    - The flood maps in this report are based on simulation of the 24hr nested design storm event. For analysing flood mitigation options, 12hr simulation runs are acceptable.
    - The impact of elevated flood levels in the Wentworth River are small, but have been included in the model.
- The Whangamata township is a flat low-lying catchment heavily relying on soakage infiltration for stormwater runoff. Public constructed soakholes are not included in the model (except for Otahu Road infiltration system and pump storage system) due to lack of information on these soakage systems. It is expected that there are more constructed public soakage systems, which could impact on modelled flood levels.
- The model estimates that flooding in Whangamata township under both existing and maximum probable development scenario is widespread over much of the township.
- Estimated ponding during heavy rainfall events is a normal occurrence and provides a fair volume of flood storage. However, it causes frequent nuisance flooding along many roads in the catchment, especially in the areas lacking piped reticulation.
- Urban development and intensification increased rainfall runoff and reduces infiltration capacity which increases the risk of flooding.
- Reticulated drainage has limited application due to flat slopes and potential backwater effects, particularly when sea level rise is considered.
- Properties at the northern end of the township (near the marina) with ground levels of approximately 1.5-2.0m above MSL are at risk of coastal inundation, and particularly when sea level rise is included.
- Flood inundation maps are presented in Appendix D for the 10yr and 100yr 24hr design storm event under MPD conditions. Presented levels are computed peak inundation levels and do not include freeboard to allow for:
    - physical processes that may not have been allowed for (like waves created by traffic)
    - uncertainties in the precision of the hydraulic modelling
    - uncertainties in the estimation of physical processes.

6.2 Recommendations

The recommendations of this study are to:

- To improve the quality of the model and modelling results the following is recommended:
  - Identification and survey (if possible) of public soakage systems to better assess flood storage volume and soakage rates of these systems.
  - Survey of floor levels in critical areas to allow better estimates of current flood risk and quantification of flood mitigation benefits.
- Set minimum recommended building levels to ensure that new buildings and building extensions are constructed at a safe level to minimise risk of habitable floor flooding. It is recommended to apply a minimum freeboard to finished floor level of 300mm. A freeboard of 500mm could be considered along confined waterways and overland flow paths (i.e. non-flat catchment areas). TCDC may wish to increase this freeboard by an additional 100mm to account for the revised 2018 MFE climate change forecast refer Section 4.8 for details.
- Maximise ground infiltration by:
  - installing swales along the roads with designed infiltration trenches including prevention of siltation.
  - Requesting new developments to include soakage systems suitable to discharge runoff from a minimum 24hr 10yr ARI design storm, including climate change allowance. Such system must include well-designed filter systems to prevent siltation and blockage.
  - Implement a soakage maintenance plan for all private and public soakage systems.
- Maintain a record of all soakage systems including a maintenance database.
- Investigate and assess options to manage flood inundation risk including a prioritisation of issues and a cost benefit analysis of options to develop a stormwater masterplan.
- Developing a flood mapping programme to update and publish flood maps on a regular cycle to reflect the latest climate change guidance and catchment changes.

7 References

AC 2012	Rapid Flood Hazard Assessments Modelling Specification, Auckland Council, Aug 2012
ARC 1999	TP108 Guidelines for stormwater runoff modelling in the Auckland Region, Technical Procedure no. 108, Auckland Regional Council, April 1999
ARR 2012	Australian Rainfall Runoff – Project 15 Two Dimensional Modelling in Urban and Rural Floodplains – Nov 2012.
MBIE-2016	New Zealand Building Code - E1 Surface Water, Ministry of Business, Innovation and Employment, 2016
McKerchar-1989	Flood Frequency in New Zealand, Publication No. 20, Hydrology Centre, McKerchar and Pearson, 1989
MfE 2008	Climate change effects and impacts assessment: A guidance manual for local government in New Zealand, 2nd Edition, Ministry for the Environment, May 2008
MfE 2017	Coastal Hazards and Climate Change, Ministry for the Environment, Dec 2017
MfE 2018	Climate Change Projections for New Zealand, Atmospheric projections based on simulations undertaken for the IPCC 5th Assessment, 2nd Edition, Ministry for the Environment Sep 2018
NIWA 2018	High Intensity Rainfall Design System version 4 (HIRDSv4), NIWA, 2018, https://hirds.niwa.co.nz/
TCDC	TCDC District Plan Portal https://eplan.tcdc.govt.nz/pages/plan/Book.aspx?exhibit=TCDC_Plans_External
Thames 2012	Otahu Road stormwater catchment upgrade, Project Completion Report, Thames Civil Engineering Ltd, Aug 2012
NRCS 1986	TR-55 Urban Hydrology for Small Watersheds, Technical Release 55, United States Department of Agriculture, National Resources Conservation Services, June 1986
WRC	Coastal Inundation Tool, Waikato Regional Council, https://www.waikatoregion.govt.nz/services/regional-services/regional-hazards-and-emergency-management/coastal-hazards/coastal-flooding/coastal-inundation-tool/
WRC 2018	Waikato stormwater runoff modelling guideline, Technical Report 2018/2, Waikato Regional Council, June 2018
WSP|OPUS 2019	TCDC Williamson Park Whangamata, Stormwater Outlet Duplication Project, Design Drawings, WSP|OPUS, June 2019

APPENDIX A – HYDROLOGICAL PARAMETERS

Hydrological Parameters for each catchment.

Zone ID[1]	DP Description	2D Zone	HSG[2]	CN	% Impervious Area - ED			% Impervious Area - MPD[3]		
					Roof Soakage	Other Imp Area	Perv Area	Roof Soakage	Other Imp Area	Perv Area
1	Open Space Zone	Township	A	49	0%	0%	100%	0%	0%	100%
2	Recreation Passive Zone	Township	A	49	5%	16%	79%	5%	16%	79%
3	Recreation Passive Zone	Township	A	49	0%	0%	100%	0%	15%	85%
4	Recreation Passive Zone	Township	A	49	0%	6%	94%	0%	15%	85%
5	Recreation Passive Zone	Township	A	49	0%	0%	100%	0%	15%	85%
6	Recreation Passive Zone	Township	A	49	0%	0%	100%	0%	15%	85%
7	Recreation Active Zone	Township	A	49	2%	0%	98%	0%	15%	85%
8	Recreation Passive Zone	Township	A	49	0%	2%	98%	0%	15%	85%
9	Recreation Active Zone	Township	A	49	10%	20%	70%	10%	20%	70%
10	Recreation Active Zone	Township	A	49	1%	5%	94%	0%	15%	85%
11	Residential Zone	Township	B*	69	17%	23%	60%	33%	17%	50%
12	Residential Zone	Township	B*	69	17%	23%	60%	33%	17%	50%
13	Extra Density Residential Zone	Township	B*	69	18%	24%	58%	33%	27%	40%
14	Commercial Zone	Township	B*	69	10%	65%	25%	0%	80%	20%
15	Open Space Zone	Township	B	69	0%	0%	100%	0%	0%	100%
16	Recreation Passive Zone	Township	B	69	1%	0%	99%	0%	15%	85%
17	Recreation Passive Zone	Township	B	69	0%	0%	100%	0%	15%	85%
18	Recreation Passive Zone	Township	B	69	0%	23%	77%	0%	23%	77%
19	Recreation Passive Zone	Township	B	69	0%	8%	92%	0%	15%	85%
20	Recreation Passive Zone	Township	B	69	0%	0%	100%	0%	15%	85%
21	Recreation Passive Zone	Township	B	69	0%	0%	100%	0%	15%	85%
22	Recreation Active Zone	Township	B	69	2%	4%	94%	0%	15%	85%
23	Recreation Active Zone	Township	B	69	1%	5%	94%	0%	15%	85%
24	Residential Zone	Township	C*	79	17%	23%	60%	33%	17%	50%
25	Residential Zone	Township	C*	79	17%	23%	60%	33%	17%	50%
26	Extra Density Residential Zone	Township	C*	79	5%	12%	83%	28%	32%	40%
27	Extra Density Residential Zone	Township	C*	79	31%	22%	47%	40%	20%	40%
28	Marine Service Zone	Township	C*	79	2%	52%	46%	20%	40%	40%
29	Industrial Zone	Township	C*	79	0%	70%	30%	0%	70%	30%
30	Recreation Passive Zone	Township	D	84	0%	0%	100%	0%	15%	85%
31	Recreation Active Zone	Township	D	84	0%	0%	100%	0%	15%	85%
32	Residential Zone	Township	D	84	0%	40%	60%	0%	50%	50%

[1] Refer Figure C1 & C2 Appendix D for location of respective zones

[2] HSG = Hydraulic Soil Group

[3] Highlighted %Impervious Area has been adjusted to ensure %Impervious Area for MPD is not smaller than ED. Highlighted %Roof Soakage has been adjusted to ensure runoff volume for MPD is not smaller than ED.

Zone ID[1]	DP Description	2D Zone	HSG[2]	CN	% Impervious Area - ED			% Impervious Area - MPD[3]		
					Roof Soakage	Other Imp Area	Perv Area	Roof Soakage	Other Imp Area	Perv Area
33	Open Space Zone	Urban North	A	49	0%	0%	100%	0%	0%	100%
34	Recreation Passive Zone	Urban North	A	49	0%	15%	85%	0%	15%	85%
35	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
36	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
37	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
38	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
39	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
40	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
41	Recreation Passive Zone	Urban North	A	49	0%	2%	98%	0%	15%	85%
42	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
43	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
44	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
45	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
46	Recreation Passive Zone	Urban North	A	49	0%	0%	100%	0%	15%	85%
47	Low Density Residential Zone	Urban North	B*	69	6%	6%	88%	10%	10%	80%
48	Residential Zone	Urban North	B*	69	17%	23%	60%	33%	17%	50%
49	Rural Lower Zone	Rural Lower	A	30	0%	0%	100%	0%	10%	90%
50	Te Weiti Catchment[1]	Rural Lower	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51	Waikiekie Catchment[2]	Rural Upper	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

B*/C* Hydraulic Soil Group classification within Residential and Commercial zones has been increased one level to allow for reduced infiltration due to compaction as per WRC TR201802.

[1] Te Weiti Catchment is modelled as a lumped catchment in ICM. See Table 3-5 for hydrological parameters.
[2] Waikiekie Catchment is modelled as a lumped catchment in ICM. See Table 3-5 for hydrological parameters.

APPENDIX B – RAPID FLOOD HAZARD ASSESSMENT

RAPID FLOOD HAZARD ASSESSMENT

A Rapid Flood Hazard Assessment (RFHA) has been undertaken to provide an initial assessment of the floodplain. The assessment is based on the methodology specified in the Rapid Flood Hazard Assessments Modelling Specification, Auckland Council, Aug 2012 (AC, 2012). The assessment assumes that no pipe network is available, which allows for a rapid assessment of the flood extent to be undertaken. A digital terrain model was developed from LiDAR and contour data of the entire catchment area. The Rain on Grid approach was then used to produce the 100-year RFHA result.

Digital Elevation Model for RFHA

The following topographical data sets are available:

- 2006 LiDAR, which covers the township and some of the hills to the east.
- 2013 LiDAR, which has a larger coverage of the catchment, but exclude some of the higher areas within the catchment.
- 5m contour data that covers the entire area.

The 2013 LiDAR is the most accurate and up-to-date data set available and therefore preferred to be used for the model. However, it lacks data at elevated areas (typically above RL 30 to 40m), which are within the area of interest for assessing flood risk.

It is also noted that at the boundary of the 2013 LiDAR there are significant variances in elevation (in the order of meters) between the three data sets. This creates issues along the boundaries when data sets are merged. To minimise inaccuracies and resolve ground profile consistency (i.e. preventing artificial ponding areas), the following has been adopted:

- Limiting to two datasets, these being:
    - the most accurate and up to date 2013 LiDAR
    - and the 5m contour data for the remaining missing areas and the higher elevations
- Smoothing of the 5m contour data along the boundary of the two datasets.

The RFHA assumes the pipe network is fully blocked and is therefore not included in the assessment. However, the DEM has been cut for the RFHA at two locations to represent these large two culverts under SH25 crossing the Te Weiti and the Waikiekie streams. It is considered unlikely that these culverts will become blocked.

Local depressions and storage areas have been filled in to provide a conservative assessment of the flood risks.

No specific buildings have been identified that could significantly obstruct the flows.

A triangular mesh is used for the modelling. Three different meshing zones have been created with varying mesh cell sizes. The large rural areas are represented in a relatively large mesh, whilst the urban areas and the rural streams have a much smaller mesh size. This allows for more detailed (and more accurate) model results in the areas of interest, whilst not excessively increasing the computation times.

The adopted mesh parameters are presented in the table below.

Mesh Parameters

Mesh Zone	Min Element Area	Max Triangle Area	Roughness
Rural Catchments	50 m^2	200 m^2	0.1
Streams	2 m^2	10 m^2	0.1
Urban Catchments	2 m^2	5 m^2	0.1

Rainfall Data

The RFHA is based on a Rain on Grid rainfall approach, where infiltration losses are calculated depending on soil type and impervious footprint. The resulting excess runoff is then used as boundary condition and connected to the 2D surface creating surface runoff.

The rainfall data in the catchment has been derived from HIRDSv4 (refer to NIWA, 2018). The variance in the rainfall over the catchment is shown in Figure 7-1 below. This figure shows the 24-hour 100yr ARI (Average Recurrence Interval) rainfall depths for 8 locations in the catchment. The approximate rainfall depths are:

- 320mm in the township,
- 350mm in the northern urban area and the lower rural areas, and
- 425mm in the upper rural areas.

For the RFHA, the rainfall over the catchment has been assumed to be uniform, based on the methodology specified in the RFHA Modelling Specification (AC, 2012). This methodology is a conservative assumption, as shown in the below calculation:

$$Rain = Rain_{min} + (Rain_{max} - Rain_{min}) * 0.8$$

Where:

$Rain_{min}$ = 320 mm

$Rain_{max}$ = 425 mm

$Rain$ = 320 + (425 – 320) * 0.8 = 404 mm

This is for the existing climate conditions. For the RFHA, a climate change allowance in accordance with Ministry for the Environment guidelines (MfE, 2008), assuming 2.1ºC temperature rise by 2090, has been included. This results in the following 24h design rainfall depth:

Rain_24h_2090: 472 mm

The rainfall temporal pattern is as per TP108 (ARC 1999) and TR2018/02 (WRC, 2018). Note that this rainfall pattern was superseded by the subsequent model build as outlined in Section 3.4.4 below, adopting instead a temporal pattern derived from HIRDSv4.

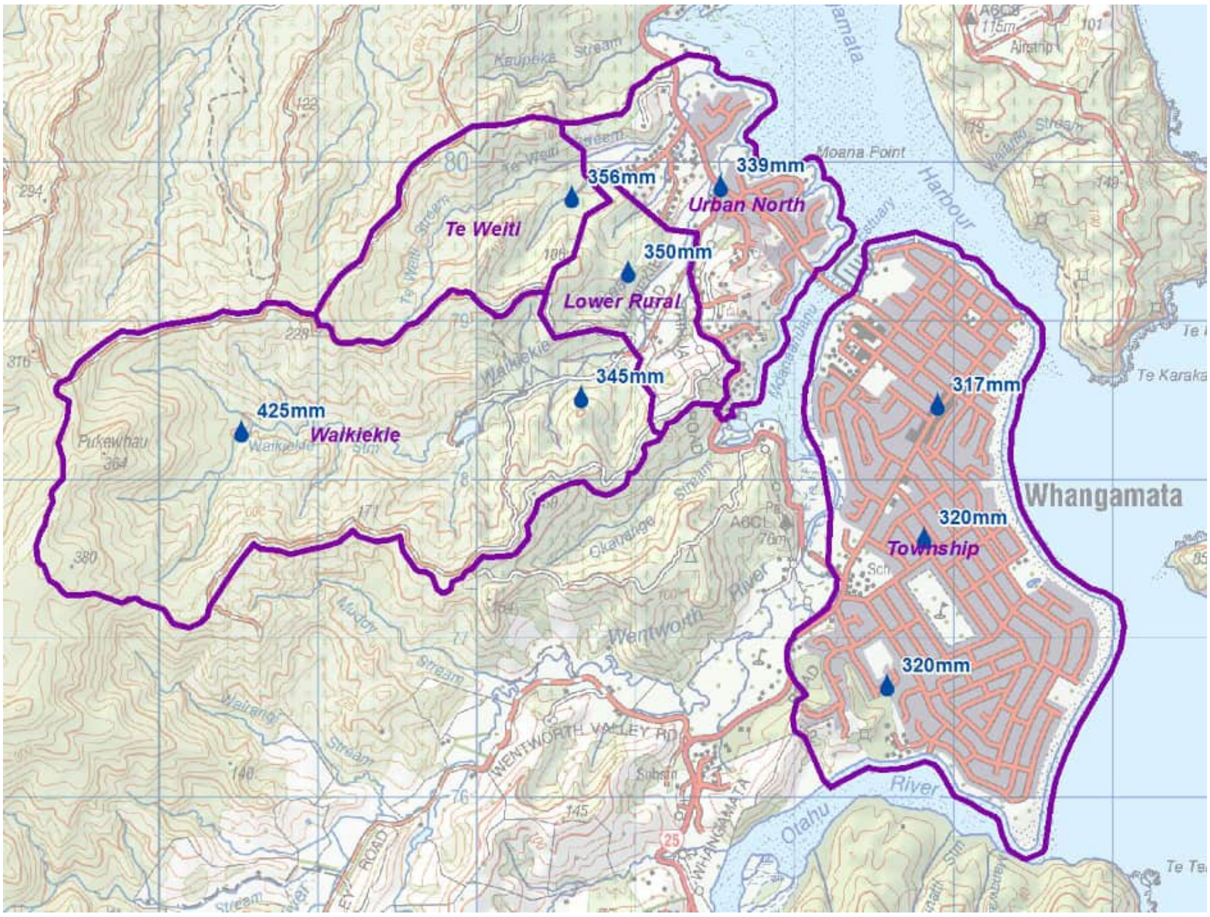

Figure 7-1 Rainfall Profile Areas

Rainfall Runoff Modelling

For the RFHA, the hydrological model runoff is calculated using the SCS[1] Runoff Curve Number (CN) method as is specified in TR2018/02[2]. This method is also known as the SCS Unit Hydrograph Method (SCS-UHM) and is specified in TP-108 (ARC-1999). The curve number represents the infiltration characteristics of the catchment depending on:

- Cover Type, which describes the land usage, like open space, bush, or impervious area.
- Hydrological Condition, which is the condition of the vegetation (i.e. poor, fair, or good).
- Hydrological Soil Group (HSG), which depends on the soil type and respective infiltration rate. There are four HSG's defined labelled Type A to D.

CN values have been derived from Table 5-2 in TR2018/02. Relevant values for the Whangamata catchment are shown below for the various cover or land use types in the catchment.

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[1] Refer NRCS 1986 – Urban Hydrology for Small Watersheds, TR55

[2] TR2018/02 – Waikato stormwater runoff modelling guidelines, 2018

Curve Numbers adopted for surfaces

Cover Type	Cover Description	HSG - Hydrologic Soil Group			
		A	**B**	**C**	**D**
Urban Pervious Areas	Open Space - Fair Hydrological Condition (grass cover 50% - 75%)	49	69	79	84
Rural Pervious Areas	Bush – Good Hydrologic Condition	30	55	70	77
Impervious Areas		98	98	98	98

For the RFHA, timeseries of excess rainfall runoff have been generated using HEC-HMS software. The catchment has been split into two separate areas, the area northwest of the Moana Anu Anu Estuary and the township, to allow for the large difference in impervious footprint. The assumed hydrological parameters to calculate the infiltration losses are presented below. It is noted that the TR2018/02 method uses a formula for the Initial Abstraction that has been modified from the equation in the original SCS version.

Hydrological Parameters RFHA Catchments

Catchment	Predominant Soil Type	Cover	CN Pervious Area	% Imp Area	Weighted CN	Initial Abstraction
Urban Catchments	A	Open Space / Fair Condition	49	70%	83	2.6 mm
Rural Catchments	B	Bush / Good Condition	55	0%	55	10.4 mm

The RFHA method specifies use of a uniform percentage impervious area across the catchment of 70%. This is a conservative percentage and typically suitable for urbanised catchments. The catchment northwest of Moana Anu Anu Estuary has primarily bush and rural land use, and the developed area is about 50% low density and 50% normal housing density. It would therefore not be realistic to model the runoff based on 70% impervious footprint. Also, the adopted rainfall of 404 mm (excl. CC) is conservative. For simplicity reasons, a 0% impervious footprint has been assumed for rural catchments. A 70% impervious footprint has been assumed for the township catchment (refer to the table above).

ICM software is used to model the runoff based on the Rain-on-Grid method, where the generated excess runoff is entered onto the triangular mesh elements representing the topography of the catchment.

APPENDIX C – SITE OBSERVATIONS

Site Visit Summary

General Information

Client	Thames-Coromandel District Council
Location	Whangamata
Date	25/07/2019
Time	11:00 - 2:30 pm
Weather	Raining

Site Visit Summary

Site Visit Locations

Location	Reason for Visit
1. Williamson Park SW Pond	View newly constructed project feeding in to SW pond. Confirm pipe directions and outlet parameters. View SW Pond weir outlet strucutre.
2. Ocean Road Manhole	Confirm if bifurcation exists in manhole. Note it did not exist.
3. Mary Road	View road ponding after current rainfall.
4. Williamson Road	View current project works.
5. Kiwi Road	View road ponding after current rainfall.
6. Aickin Road	View road ponding after current rainfall.
7. Lowe Street	View road ponding after current rainfall.
8. Otahu Rd SWPS	View operation of SWPS.
9. Kotuku Street Outfalls	Confirm diameter of outfalls. Suspected DN225mm pipe was a 900mm outlet.
10. McKellar Place	Confirm diameter of inlet towards Kotuku Street outlet. Confirmed 900mm pipe inlet.
11. Park Ave	Confirm diameter of inlet within Park Ave open chanel drain heading towards McKellar Place and Kotuku Street Outfalls.
12. NZTA Culvert Waikiekie Stream	Confirm dimensions of NZTA culvert running under SH25.
13. NZTA Culvert Te Weiti Stream	Confirm dimensions of NZTA culvert running under SH25.
14. Herbert Drive Culvert	Confirm dimensions of culvert running under the entrance to Herbet Drive.
Ocean Road/Williamson Park Manhole	Further investigation into how the non-bifurcation functions.

Williamson Park SW Pond 1

Location of Williamson Park SW Pond

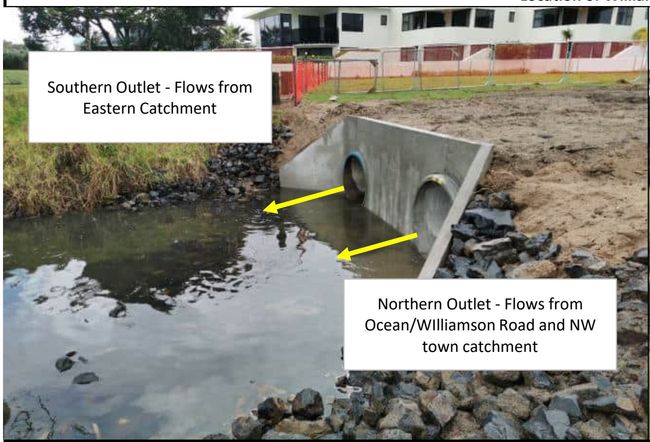


Photo 0 - New 2019 Project - Twin outfall to pond

Photo 1 - Williamson Park SW Pond view to Beach (North)

Photo 2 - Inside Manhole above outfall chamber

Photo 3 - Weir outlet for SW Pond

Williamson Park SW Pond 2

Location of Williamson Park SW Pond

Photo 4 - Weir outlet for SW Pond view to Beach (North East)

Photo 5 - Weir outlet for SW Pond (South West) - Gabian baskets are 4x levels

Photo 6 - Weir outlet for SW Pond view to Pond - Gabian baskets are 4x levels

Photo 7 - Top of Weir Outlet - Approx 5m RL

Williamson Park SW Pond 3

Location of Williamson Park SW Pond

Photo 8 - Williamson Park SW Pond view to Pond (South West)

Photo 9 - Weir outlet for SW Pond view to Beach (North East)

Photo 10 - New 2019 Project - Twin outfall to pond and manhole chamber

Ocean Road Manhole

Intersection of Ocean Road and Lowe Road

Photo 11 - Inside Manhole - Direction suspected towards Williamson Park

Mary Road SW Pooling

Intersection of Lowe Street and Mary Road

Photo 12 - Ponding on intersection of Marty Road/Lowe Street

Williamson Road SW Pooling

Intersection of Mary Road and Williamson Road

Photo 13 - Works View North of works on Williamson Road

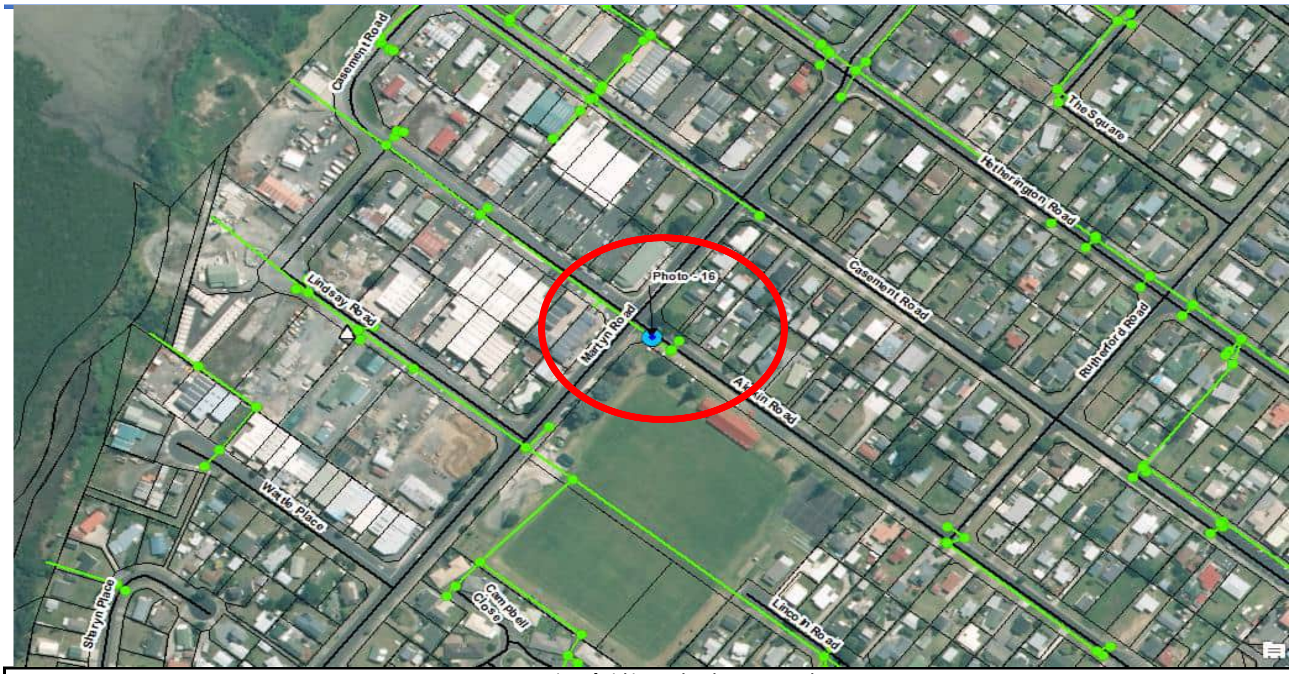
Kiwi Road SW Pooling

Intersection of Mary Road and Williamson Road

Photo 14 - Ponding mid way on Kiwi Road

Photo 15 - Ponding mid way on Kiwi Road

Aickin Road SW Pooling



Intersection of Aickin Road and Martyn Road

Photo 16 - Commonly flooded area on the corner of Aickin/Martyn Road

Lowe Road SW Pooling

Intersection of Lowe Road and Slyvia Road

Photo 17 - Ponding on the intersction of Lowe Street and Sylvia Road

Otahu Road SWPS

Location of SWPS at end of Otahu Road

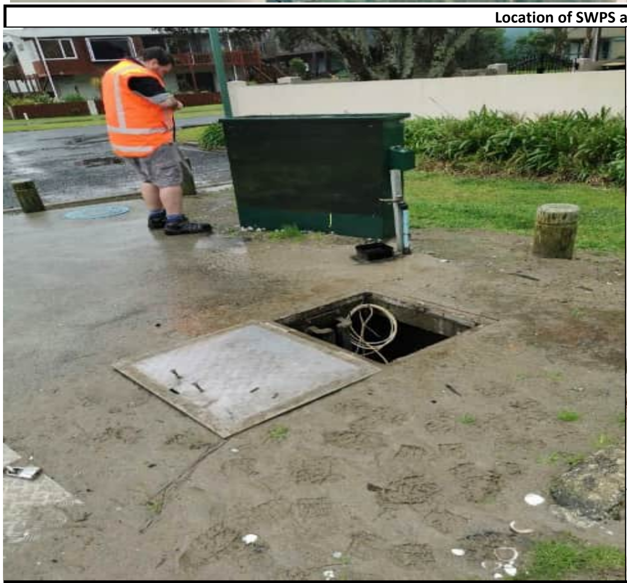


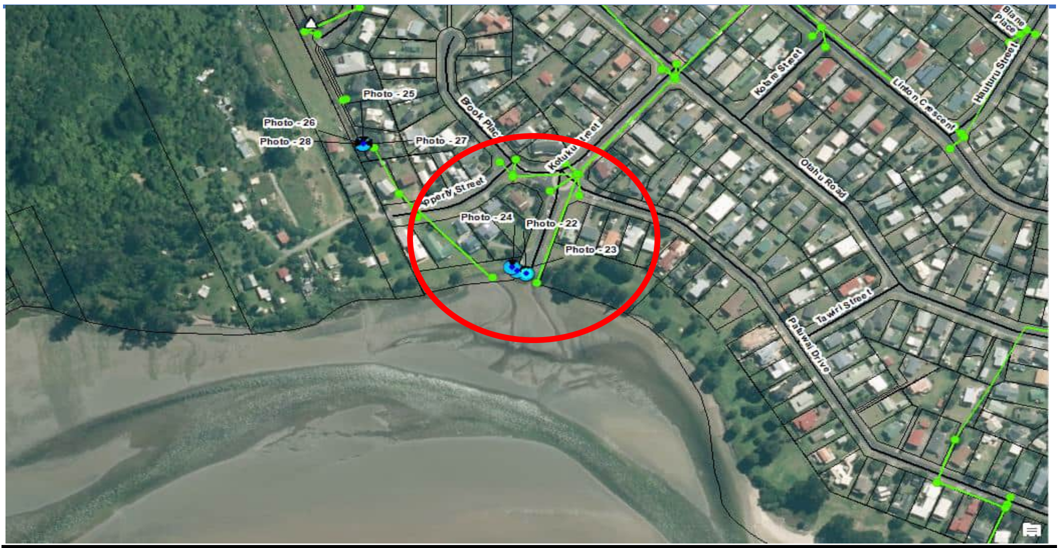
Photo 18 - Otahu SWPS Wetwell - Large circular diameter

Photo 19 - Otahu SWPS Wetwell - Northern Chamber - 2 Pumps

Photo 20 - Otahu SWPS - Asset ID

Photo 21 - Otahu SWPS - Top of Pump - 1.7m from Lid Level

Kotuku Street Outfalls



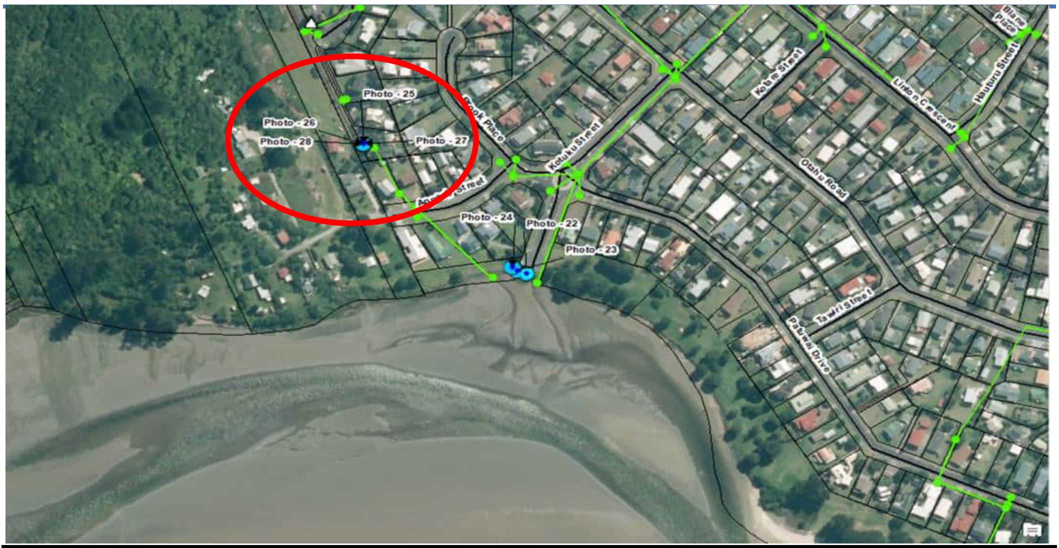
Kotuku Street Outfalls

Photo 22 - Outfall photo for Asset ID 551163

Photo 23 - Outfall photo for Asset ID 553249

Photo 24 - Outfall photo for Asset ID 553249 - DN1000mm Corrugated Steel

McKellar Place



McKellar Street open chanel drain and inlet

Photo 25 - Concrete Lined Stormwater Drain

Photo 26 - Concrete Wingwall and Grate Inlet

Photo 27 - Concrete Wingwall and Grate Inlet-Manhole above

Photo 28 - Concrete Wingwall and Grate Inlet - DN900mm Concrete Inlet

Park Ave 1

Park Ave SW Network

Photo 29 - Commonly flooded road section between catchpits 201289 & 300722

Photo 30 - Concrete Lined SW Chanel View to North West

Photo 31 - Concrete Lined SW Chanel View to South West

Photo 32 - DN900mm Concrete Inlet - Pipe to the East not captured (PE225?)

Park Ave 2

Park Ave SW Network

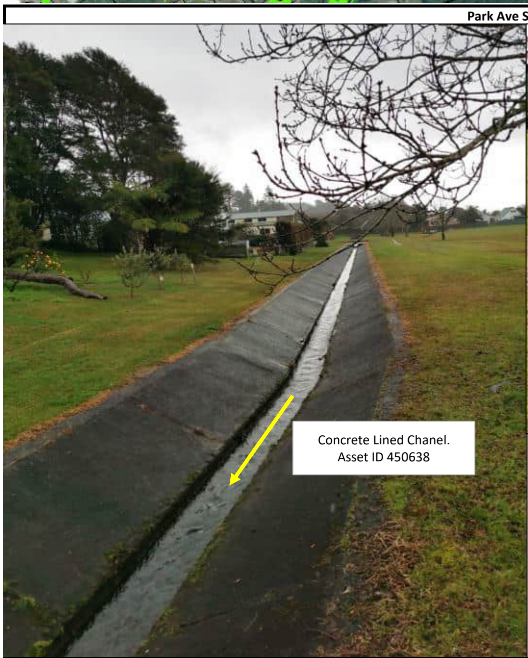


Photo 33 - Concrete Lined SW Chanel View to North

Photo 34 - DN900mm Concrete Inlet - Invert 1m below ground level

Photo 35 - Concrete walk over bridge

Photo 36 - Inlet 300mm Concrete from Western direction

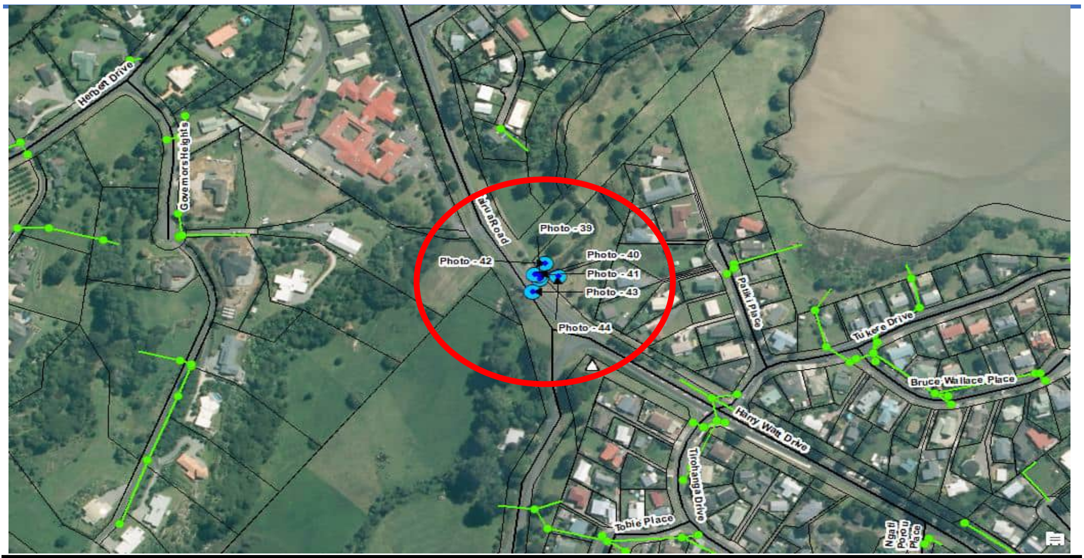
Park Ave 3

Park Ave SW Network

Photo 37 - Concrete Inlets around wingwall

Photo 38 - Concrete Inlets around wingwall - Both appear same diameter

NZTA Culvert 1 Waikiekie Stream 1



NZTA Culvert SH25 Waikiekie Stream

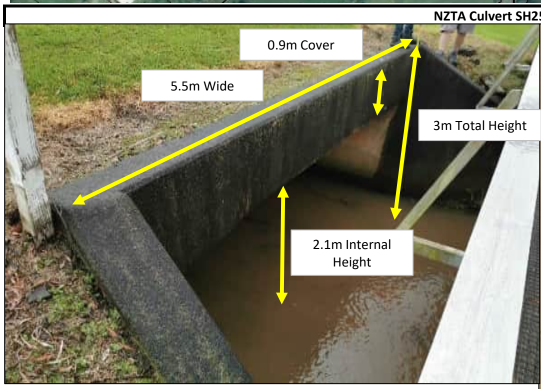


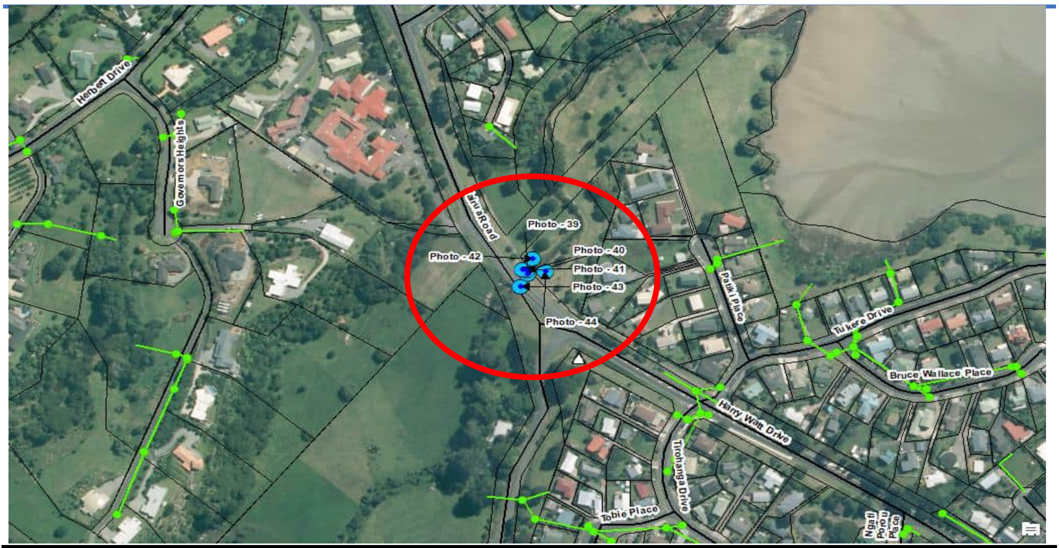
Photo 39 - SH25 Bridge Culvert Northern Side

Photo 40 - SH25 Bridge Asset ID

Photo 41 - SH25 Bridge Asset ID

Photo 42 - SH25 Bridge Culvert Northern Side

NZTA Culvert 1 Waikiekie Stream 2

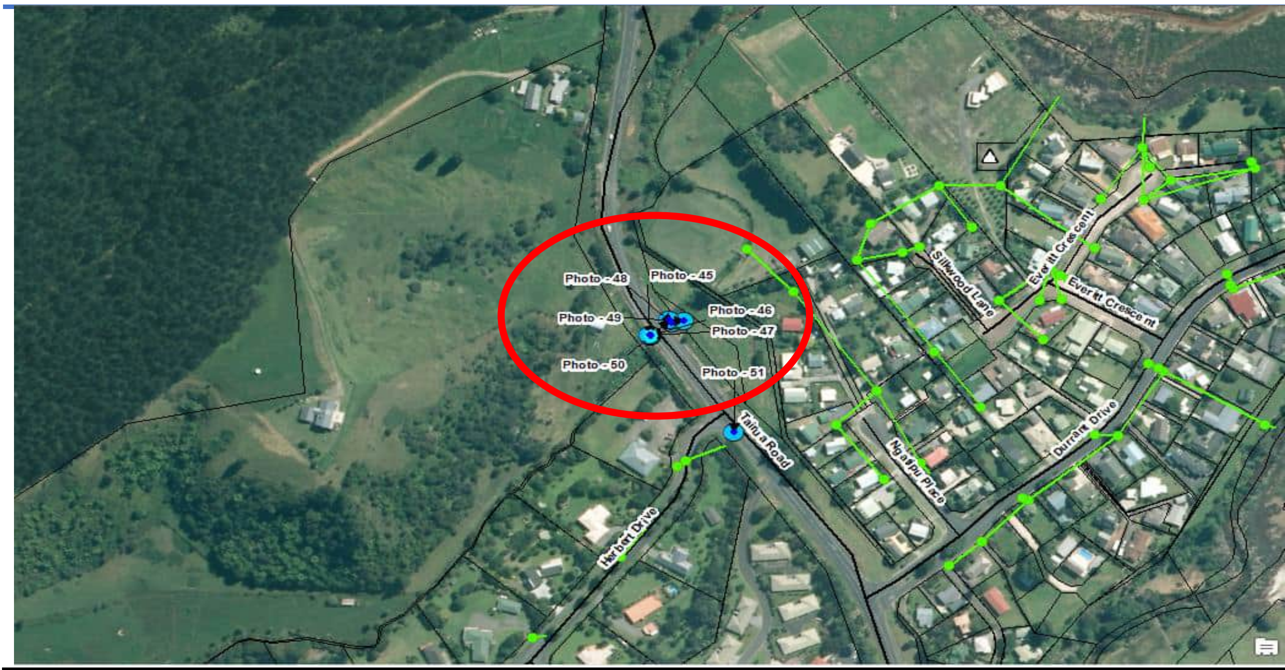


NZTA Culvert SH25 Waikiekie Stream

Photo 43 - IL 3.5m less than road. 2m culvert height. 1.5m cover

Photo 44 - Size - 2.1m height x 5.5m Width. 3m height total. 0.9 cover

NZTA Culvert 2 Te Weiti Stream



NZTA Culvert Te Weiti Stream

Photo 45 - Photo of Te Weiti upstream

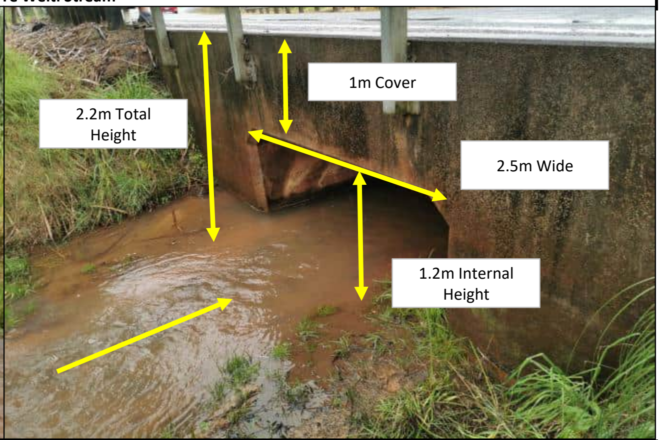
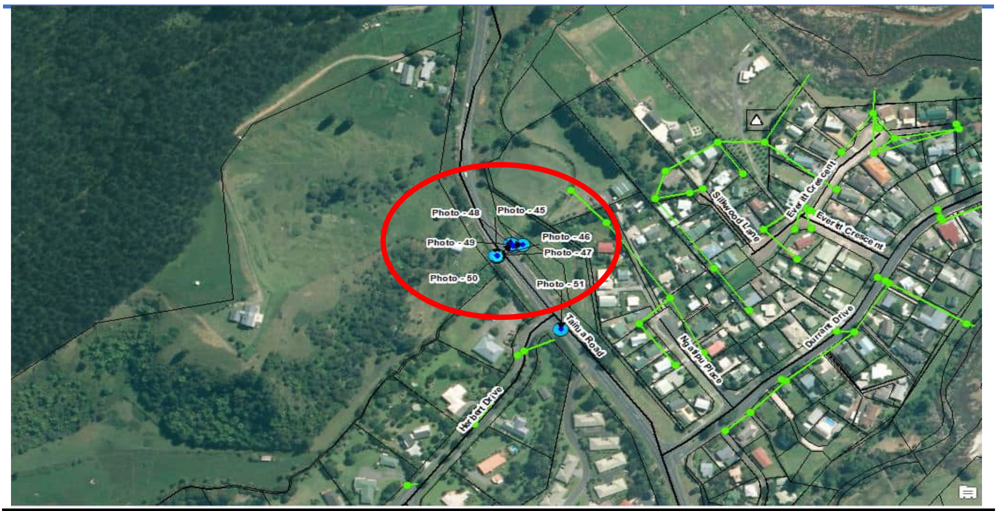


Photo 46 - 2.5m w x 1.2m h. 1m cover from road to top of culvert. 2.2m to invert

Photo 47 - 200mm blockage with sediment

Photo 48 - Southern view of culvert

NZTA Culvert 2 Te Weiti Stream

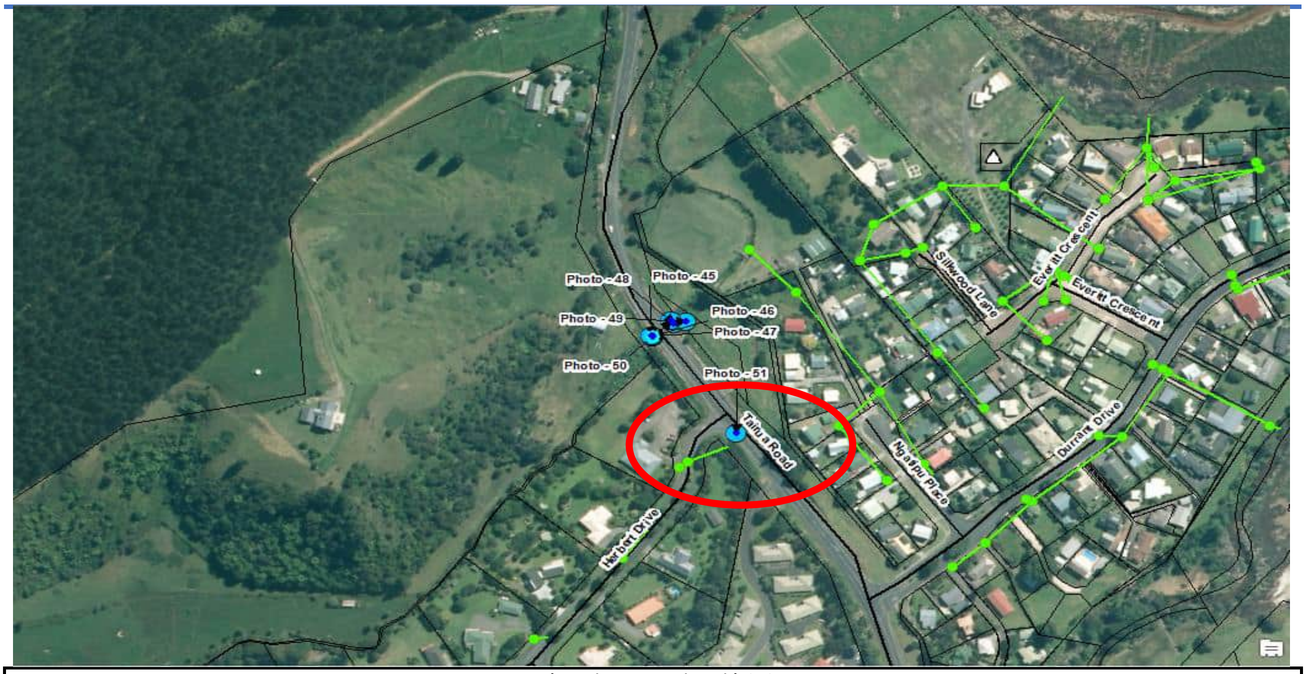


NZTA Culvert Te Weiti Stream

Photo 49 - SH25 Bridge Asset ID

Photo 50 - Southern view of culvert

Herbert Drive Culvert



Herbet Drive Intersection with SH25

Photo 51 - Estimated 750mm diameter. 2.5mm below ground level (invert)

Ocean Road/Williamson Park Manholes

Ocean Road/Williamson Park Manhole verification

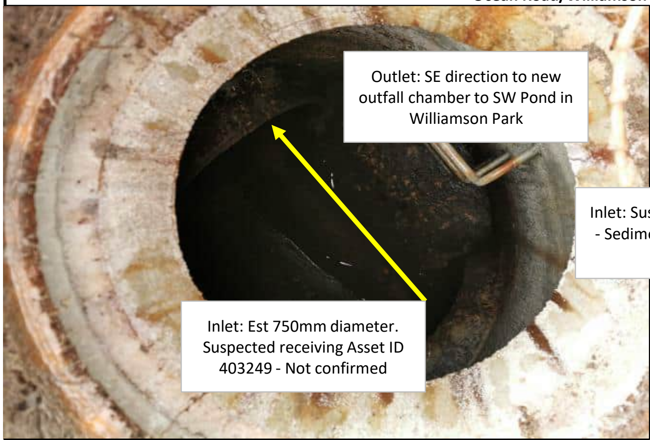


Photo 52 - Manhole in Williamson Park - 2.1m LL to IL

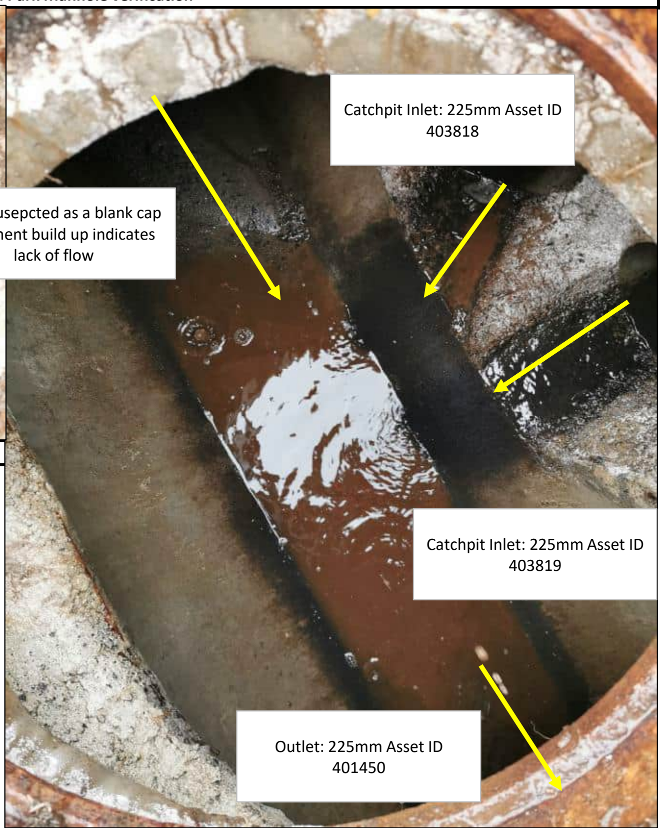


Photo 53 - 600mm line. 900mm LL to IL. Suspected blank cap NW of line

APPENDIX D – FIGURES

Figure A	**Catchment Overview**
Figure B	**Depression Areas**
Figure C1	**Impervious Area ED**
Figure C2	**Impervious Area MPD**
Figure D	**Index Map Grid**
Figure E1-16	**Flood Inundation Maps MPD**
Figure F	**Sensitivity Figures**

LEGEND

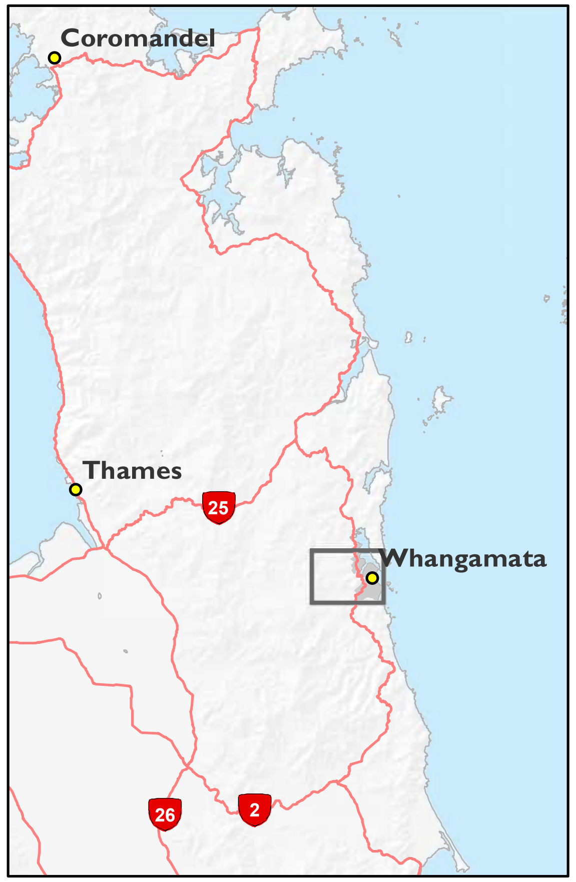
Contours (25m)

State Highway

Minor roads

Stream / Overland Flow Path

Catchment Boundaries (model)



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1	FINAL FOR ISSUE	HAL	21 JULY 2023	DRAWN	TAMI NICOLL	4 DEC 2019
				DWG CHECKED	MANU WARD	4 DEC 2019
				STATUS	ISSUED	31 JULY 2023
				FILENAME		
				APPROVED		

THAMES COROMANDEL DISTRICT COUNCIL

HAL HYDRAULIC ANALYSIS LIMITED

0 300 600 1,200 1,800 2,400 Meters

SCALE (at A3) 1:21,500

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: **J000147**

ISSUE: **FINAL**

DRAWING TITLE: **Catchment Overview**

DRAWING No: **FIGURE A**

LEGEND

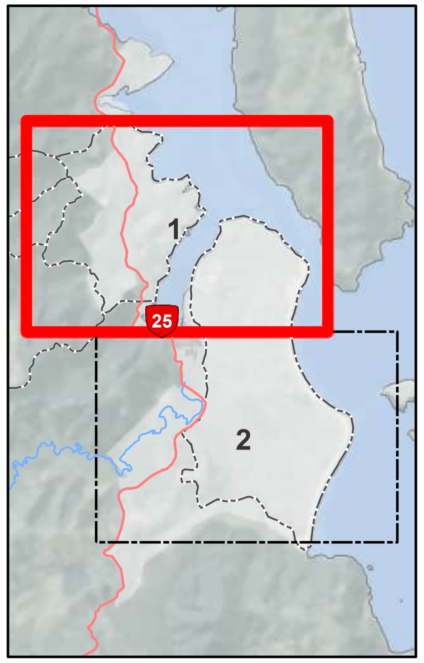
Network (model)

Catchment Boundaries (model)

Depressions

> 300mm depth

Note:
1. Depression areas exceeding 300 mm in depth shown.
2. Depressions shown within modelled catchment area only; depressions may exist outside of these bounds.



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				FILENAME		
				APPROVED		

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HAL HYDRAULIC ANALYSIS LIMITED

0 125 250 500 750 1,000 Meters

SCALE (at A3): 1:10,000

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J000147

ISSUE: FINAL

DRAWING TITLE: **Depression Areas**

DRAWING No: **FIGURE B1**

LEGEND

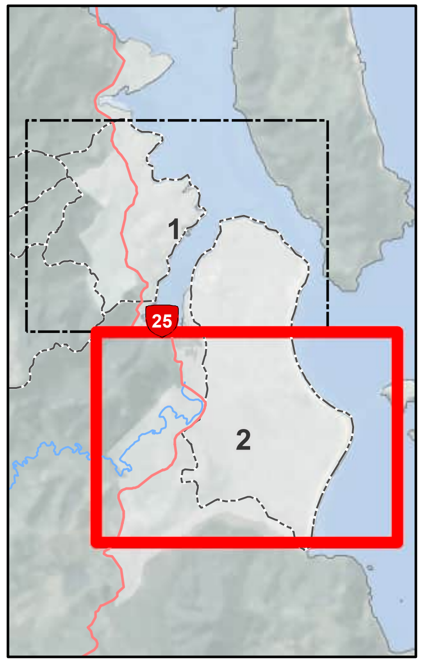
Network (model)

Catchment Boundaries (model)

Depressions

> 300mm depth

Note:
1. Depression areas exceeding 300 mm in depth shown.
2. Depressions shown within modelled catchment area only; depressions may exist outside of these bounds.



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				DWG CHECKED	MANU WARD	4 DEC 2019
				STATUS	ISSUED	31 JULY 2023
				FILENAME		
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0 125 250 500 750 1,000 Meters

SCALE (at A3) 1:10,000

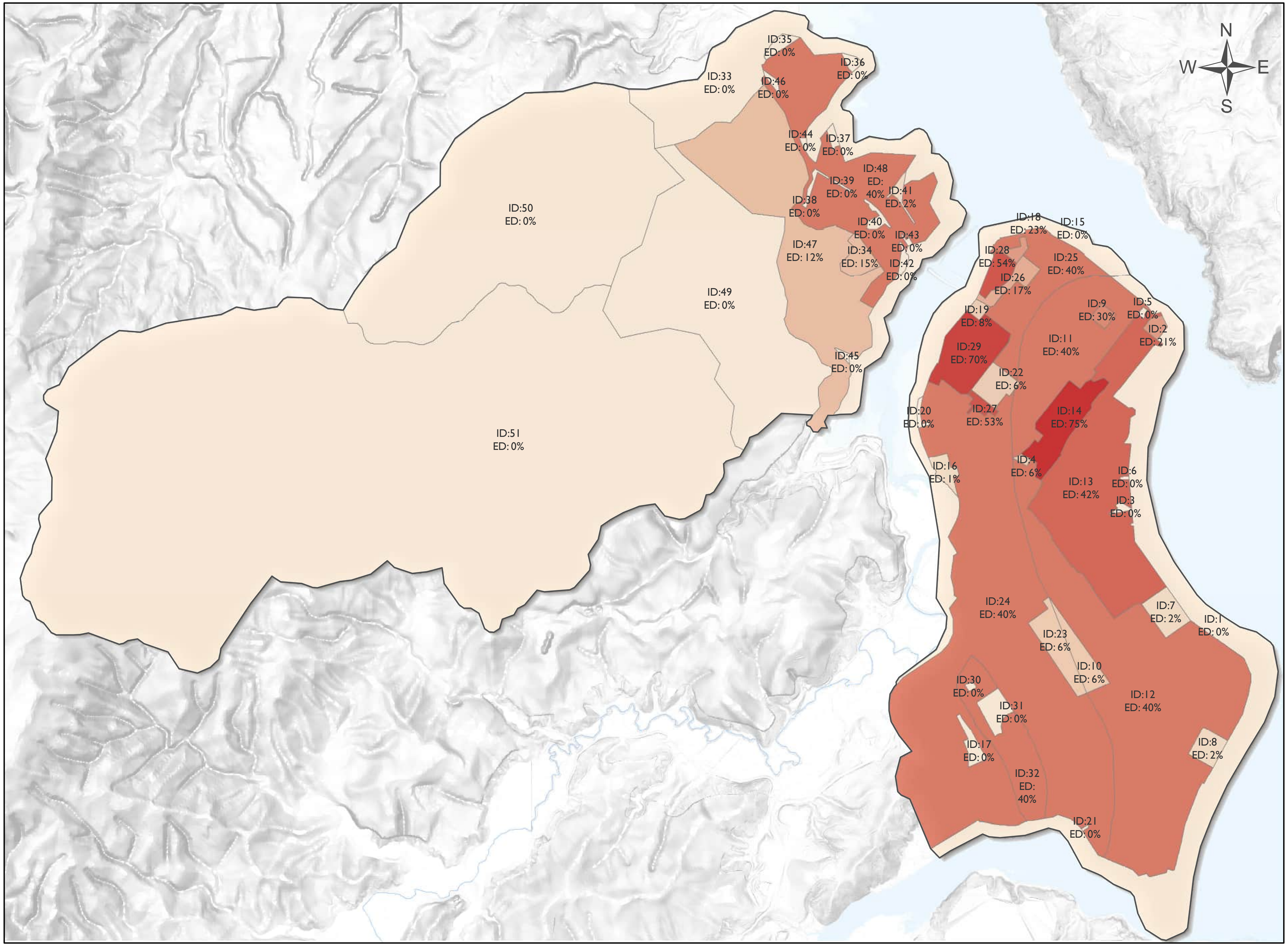
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J000147

ISSUE: FINAL

DRAWING TITLE: **Depression Areas**

DRAWING No: **FIGURE B2**

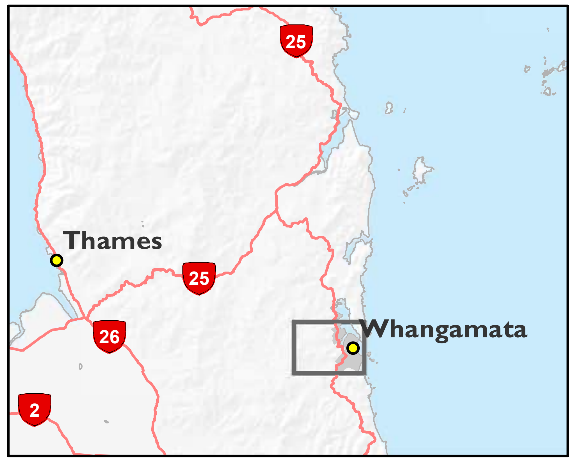


LEGEND

Percent Impervious (ED)

- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80

Note:
1.Impervious area based on TCDC Building Footprint layer and LINZ aerial image updated 2018.



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0 300 600 1,200 1,800 2,400 Meters

SCALE (at A3): 1:21,500

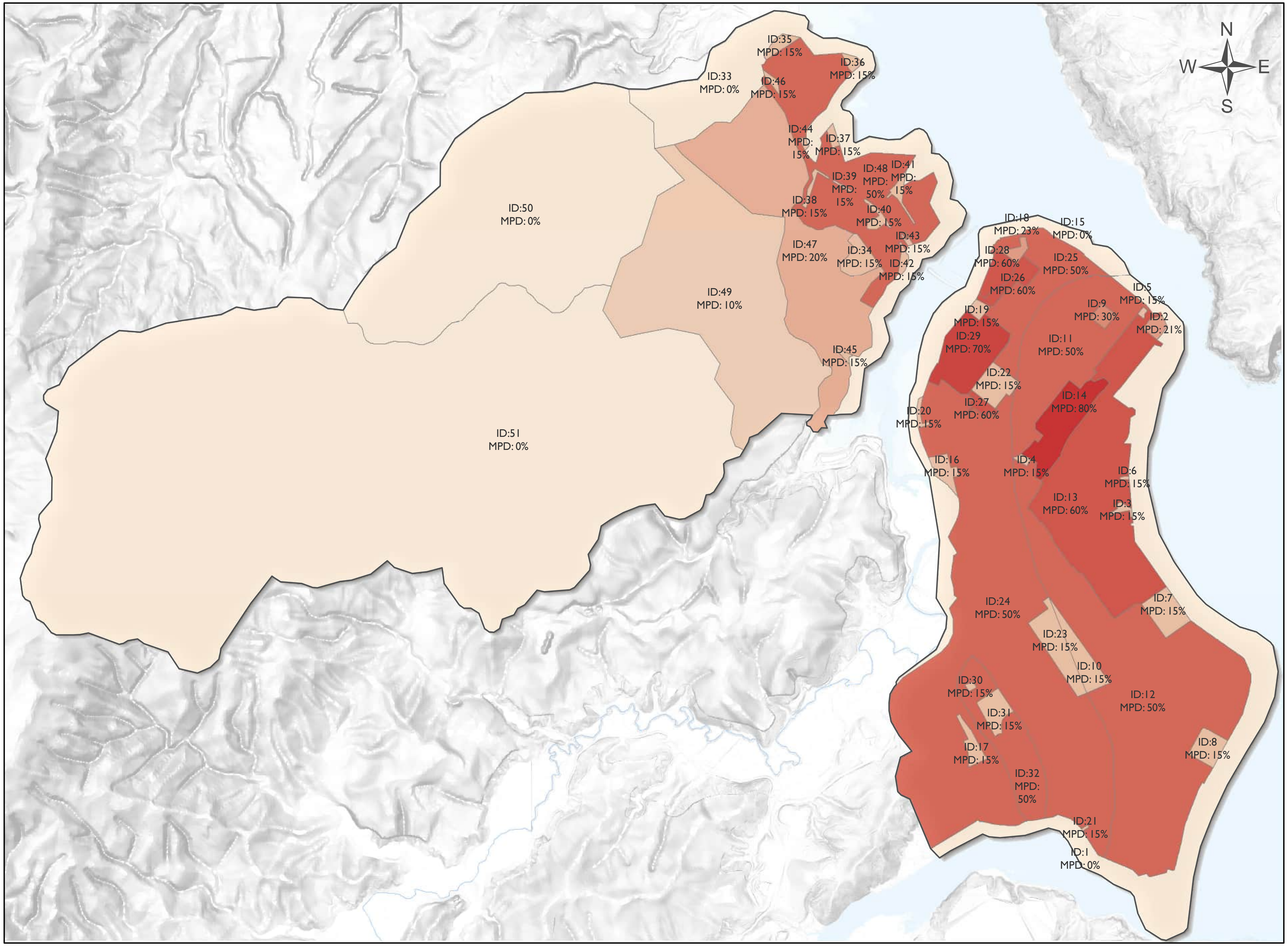
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J000147

ISSUE: FINAL

DRAWING TITLE: **Impervious Area, Existing Development (ED)**

DRAWING No: **FIGURE C1**

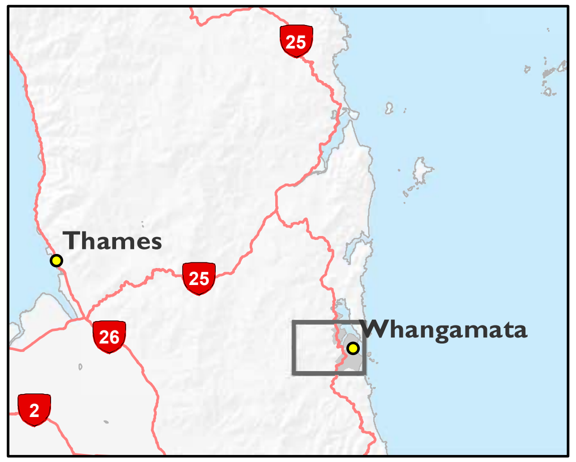


LEGEND

Percent Impervious (MPD)

- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80

Note:
1.Impervious area based on TCDC "Proposed Thames-Coromandel District Plan - Appeals Version - 17 October 2019", including some amendments (refer to Whangamata Model Build and System Performance Report for details).



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0 300 600 1,200 1,800 2,400 Meters

SCALE (at A3): 1:21,500

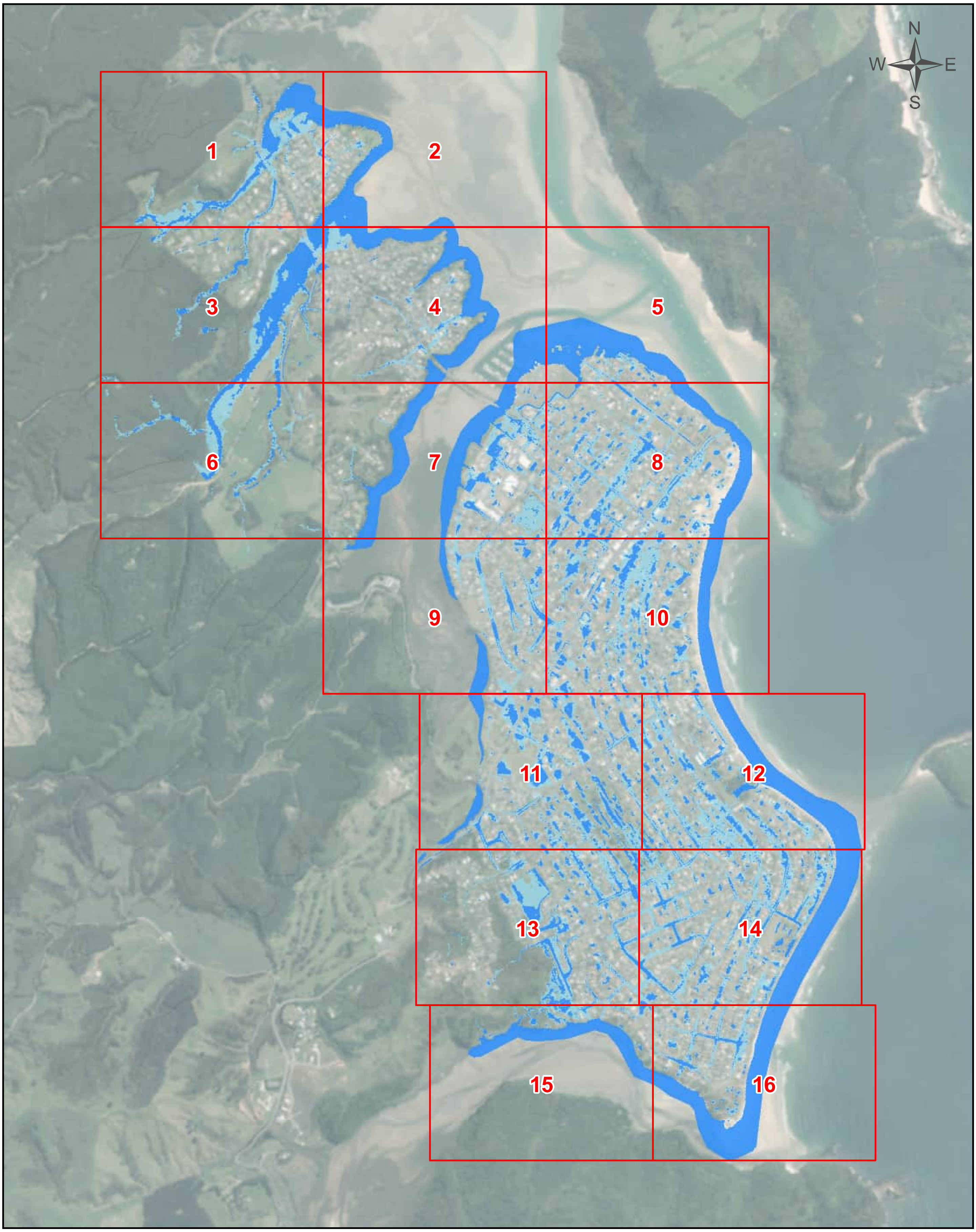
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J000147

ISSUE: FINAL

DRAWING TITLE: **Impervious Area, Maximum Probable Development (MPD)**

DRAWING No: **FIGURE C2**



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HAL HYDRAULIC ANALYSIS LIMITED

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SCALE (at A4)
1:24,000

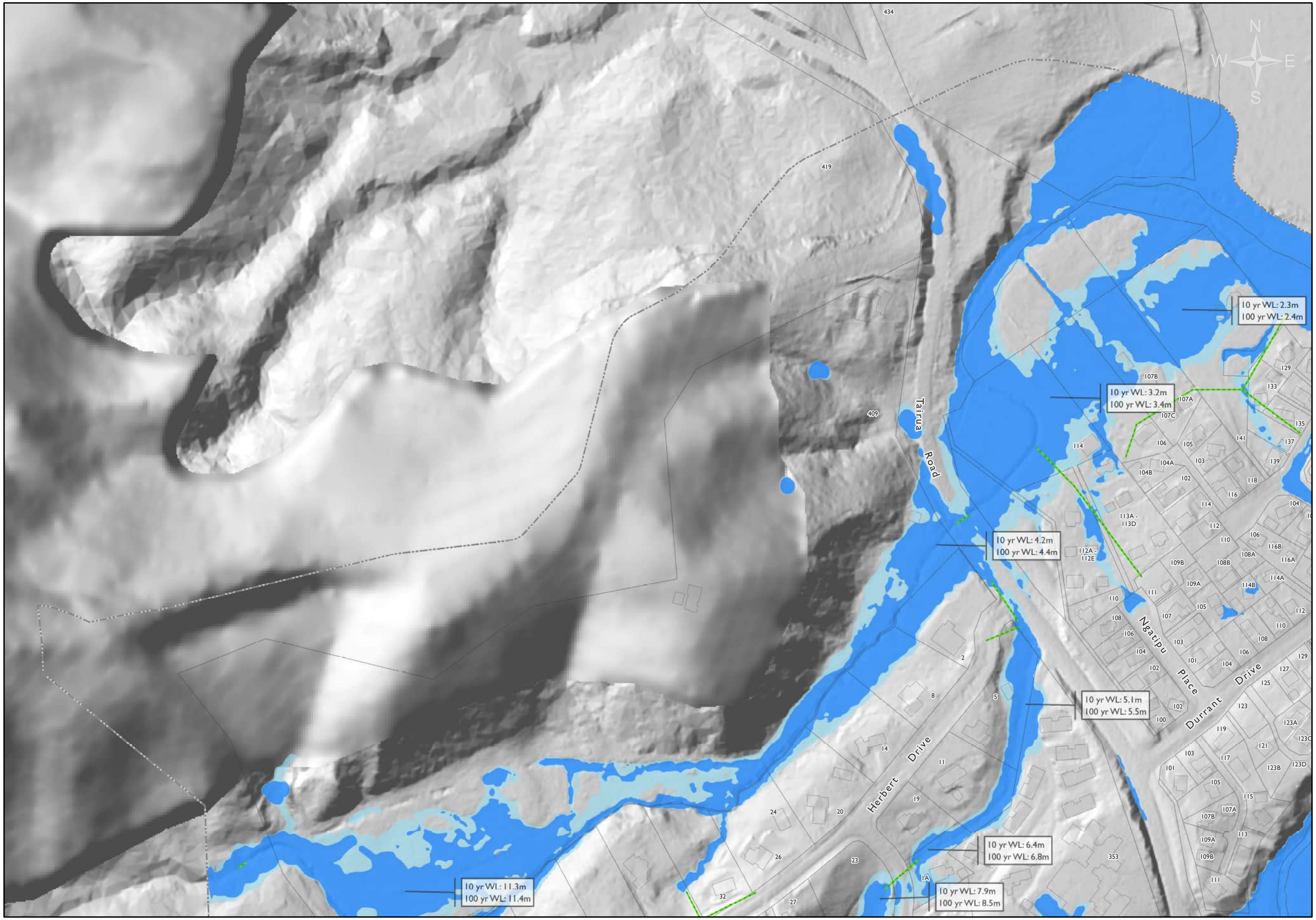
PROJECT:
WHANGAMATA FLOODPLAIN MAPPING

DRAWING TITLE:
INDEX MAP GRID
Flood Extent

PROJECT NO:
J000147

ISSUE:
FINAL
31 JULY 2023

DRAWING No:
FIGURE D



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:

1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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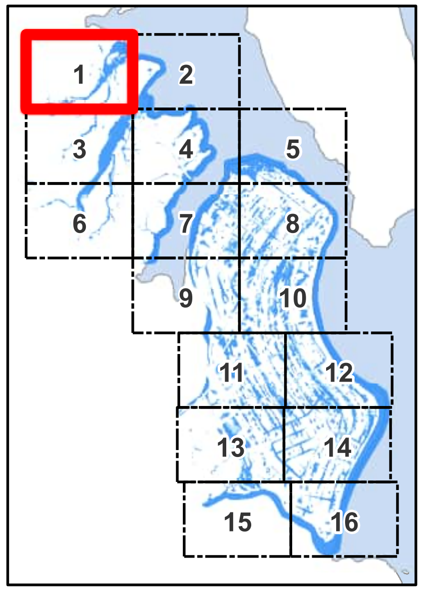

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				STATUS	ISSUED	30 SEP 2023
				FILENAME		
				APPROVED		

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HAL

0 25 50 100 150 200 250 300 Meters

SCALE (at A3): 1:3,000

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E1**

LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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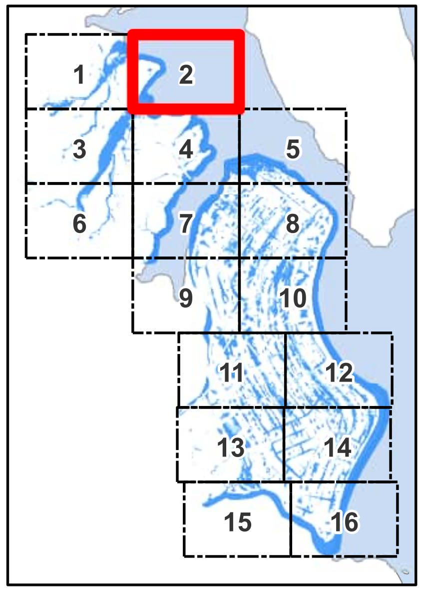

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				STATUS	ISSUED	30 SEP 2023
				FILENAME		
				APPROVED		

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THAMES COROMANDEL DISTRICT COUNCIL

HAL

0 25 50 100 150 200 250 300 Meters

SCALE (at A3): 1:3,000

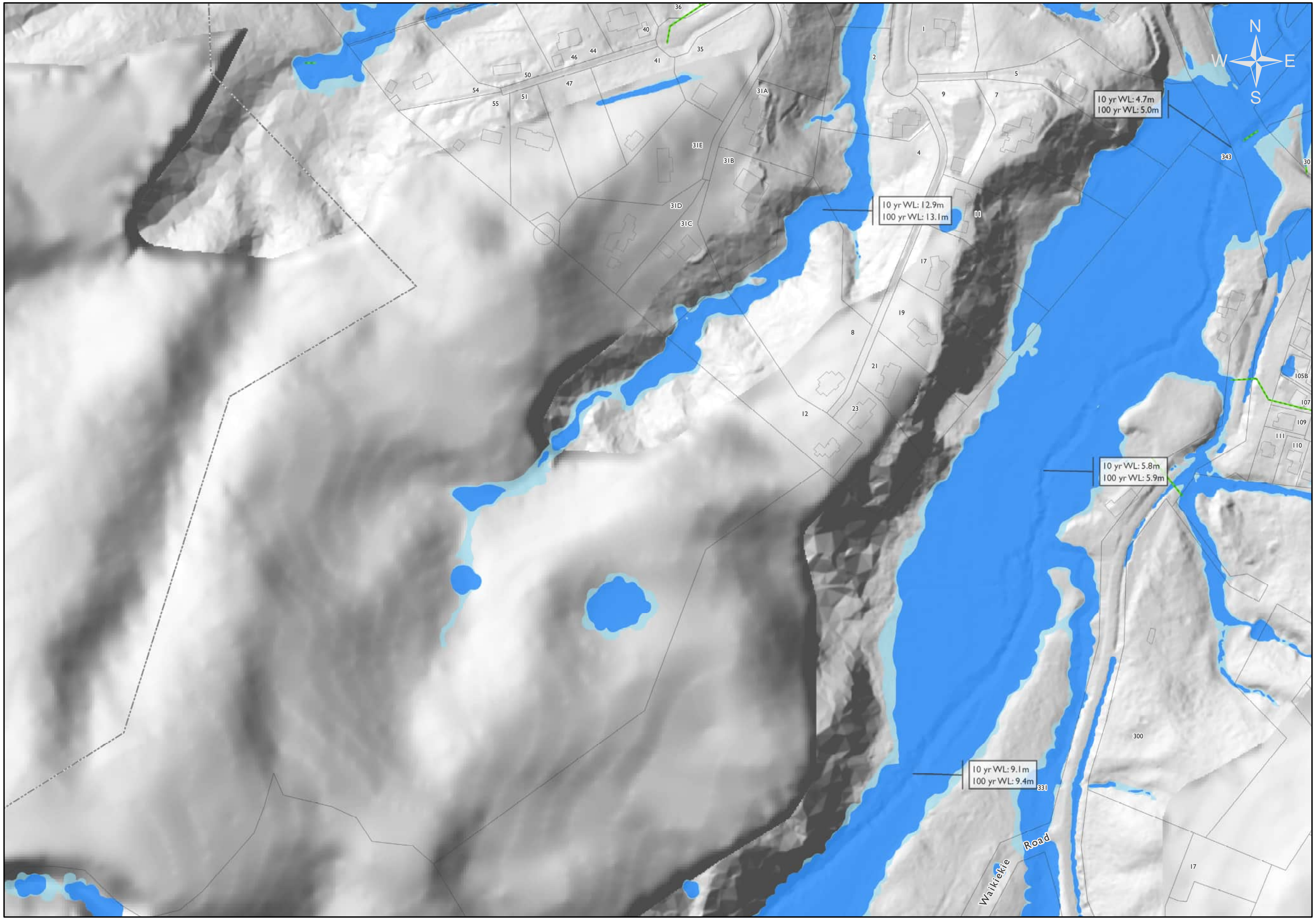
PROJECT: WHANGAMATA FLOODPLAIN MAPPING

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: Flood Inundation - MPD Incl. Climate Change

DRAWING No: FIGURE E2



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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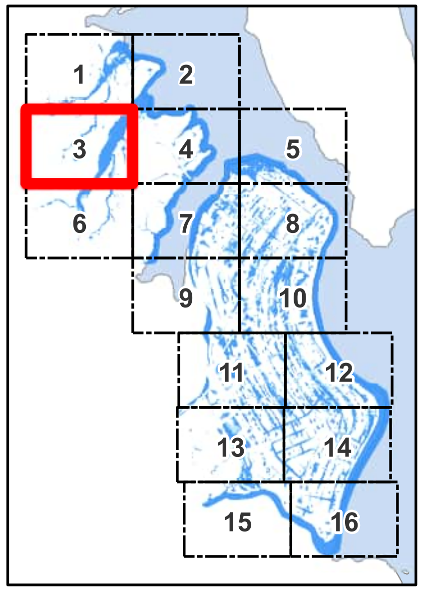

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SCALE (at A3) 1:3,000

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: **J0547**

ISSUE: **FINAL DRAFT**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E3**

LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
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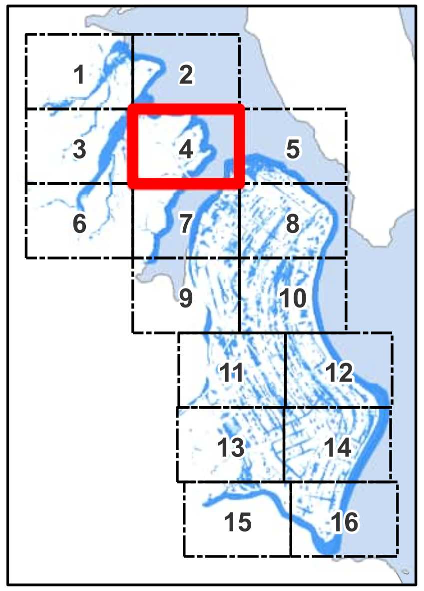

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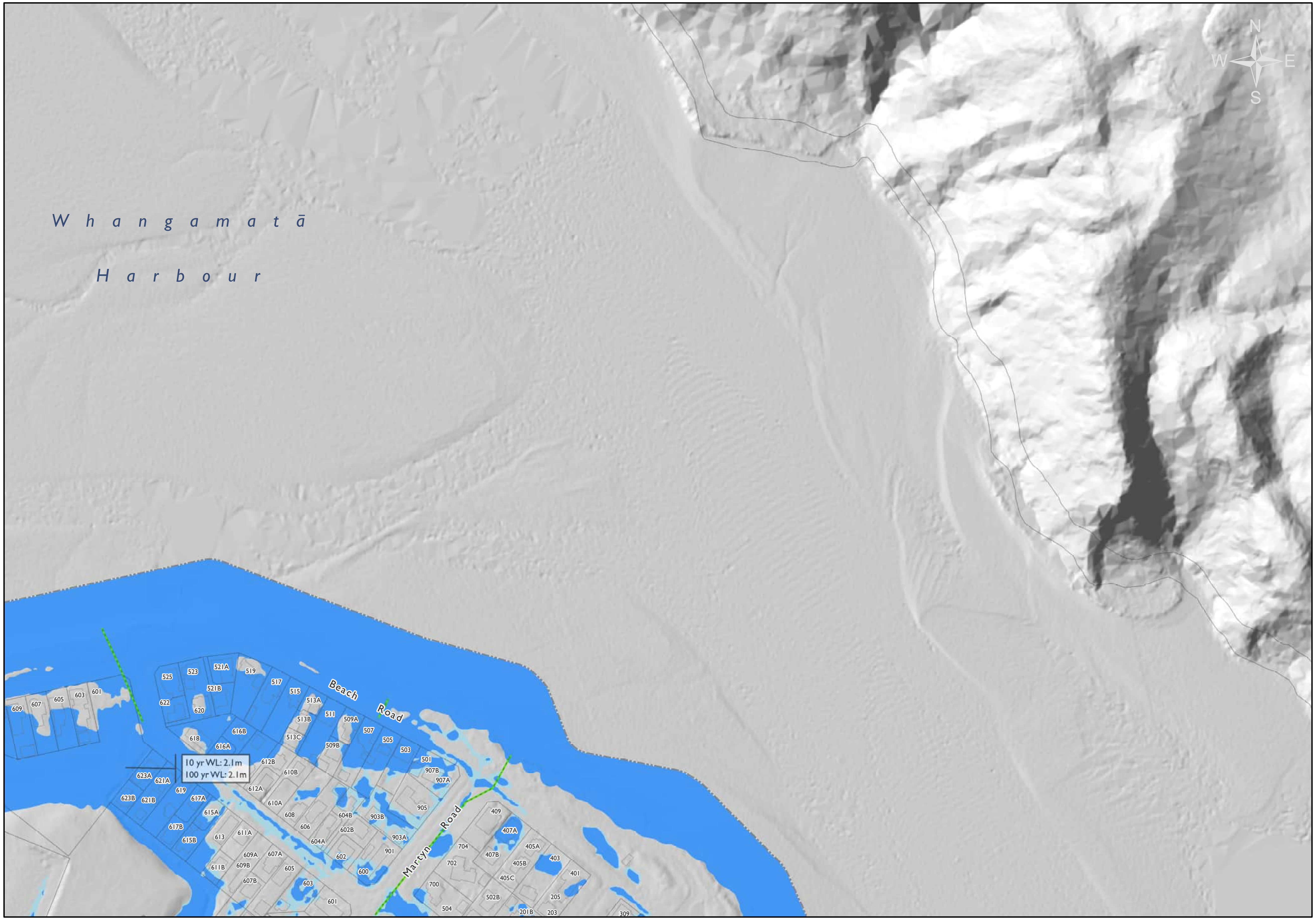
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E4**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
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4. ARI = Average Recurrence Interval
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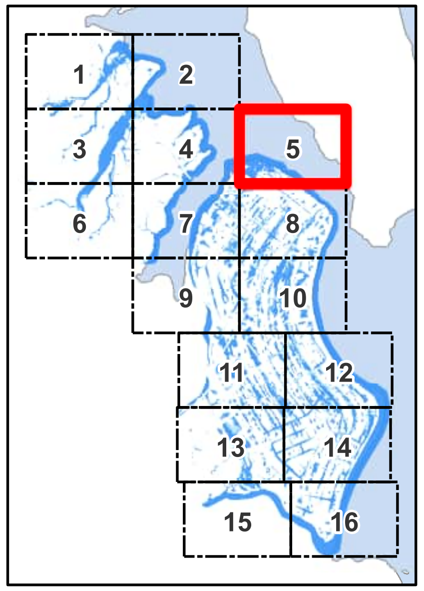

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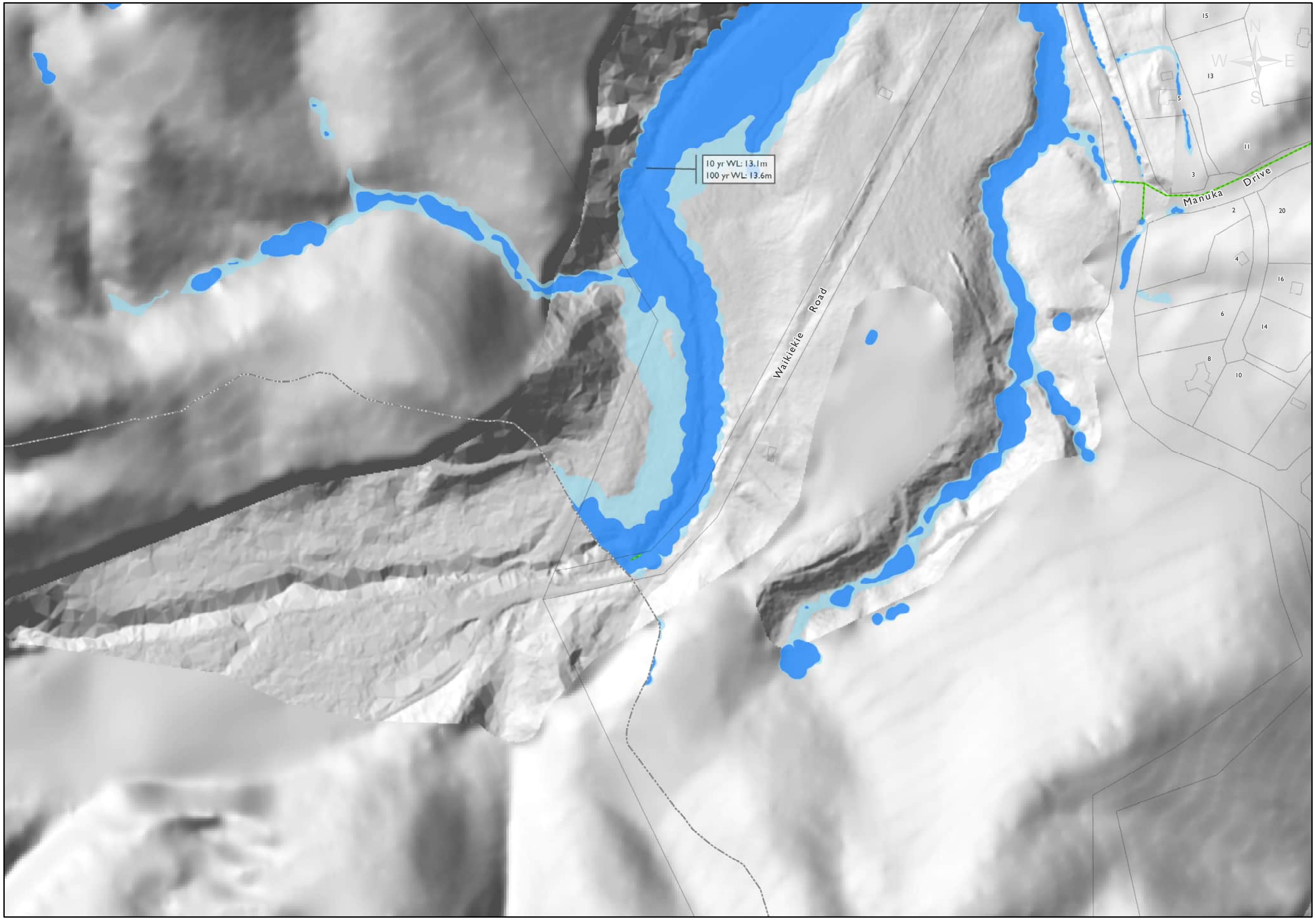
ISSUE: FINAL DRAFT

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E5**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
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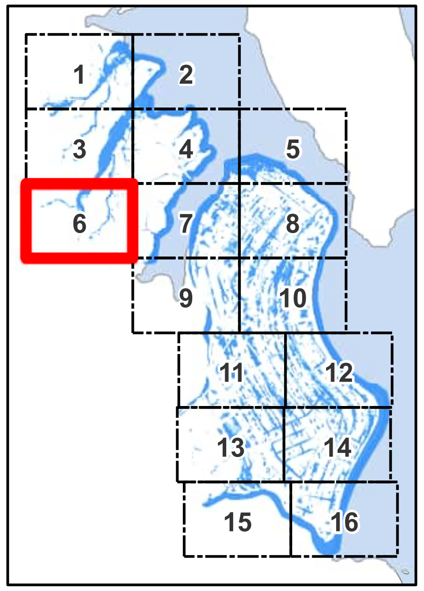

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PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E6**

LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:

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3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
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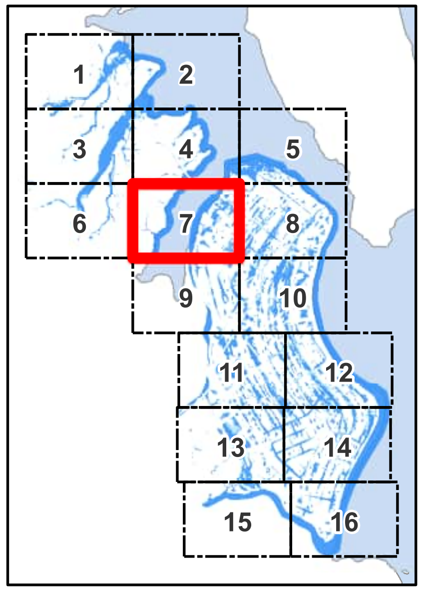

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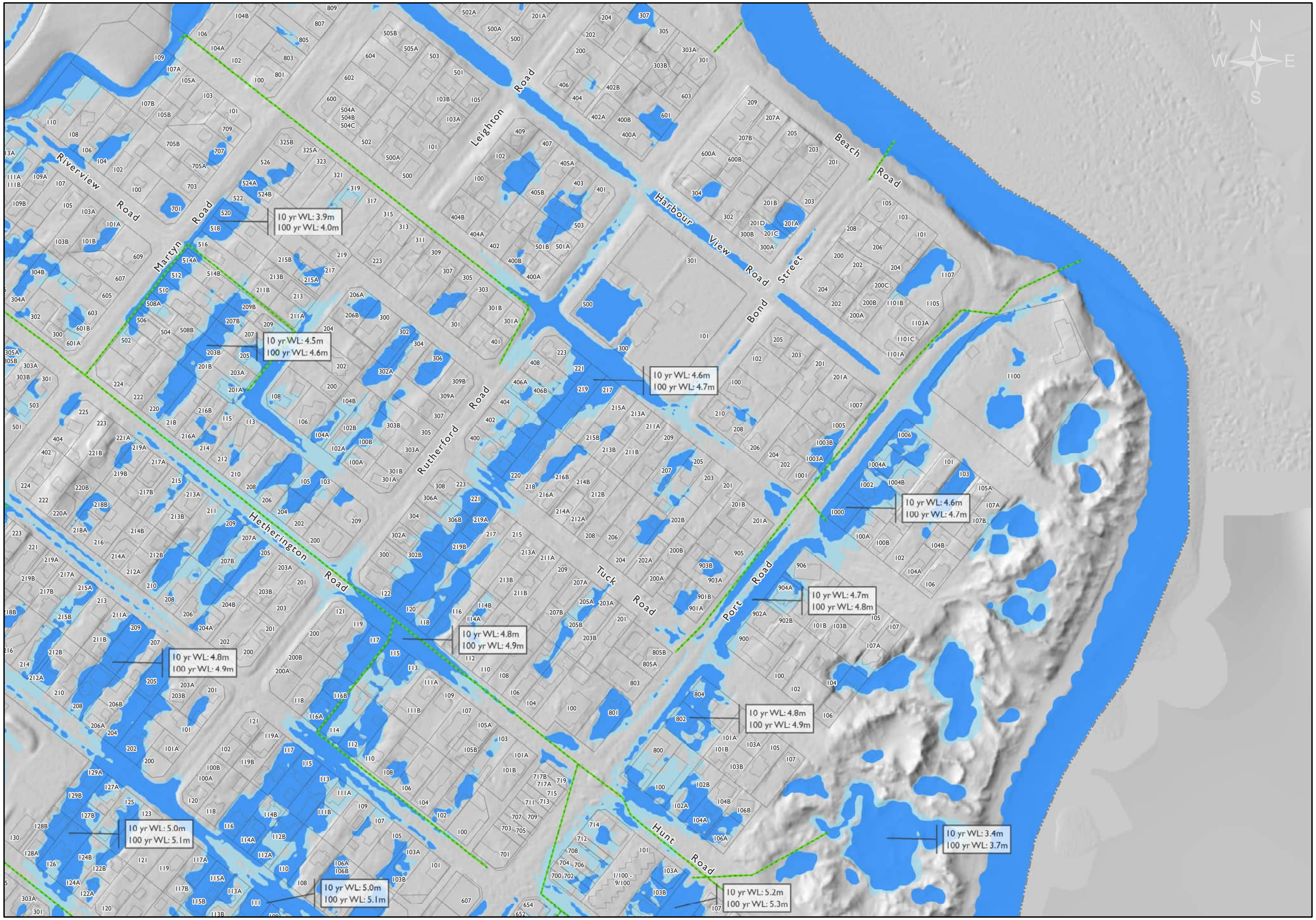
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E7**



LEGEND

Model Boundary

Modelled Piped Network

Building Footprint

Parcel Boundary

Flood Inundation

10 Year ARI

100 Year ARI

Note:

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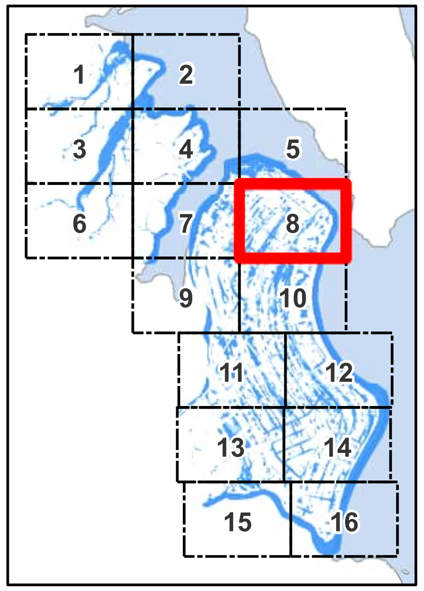

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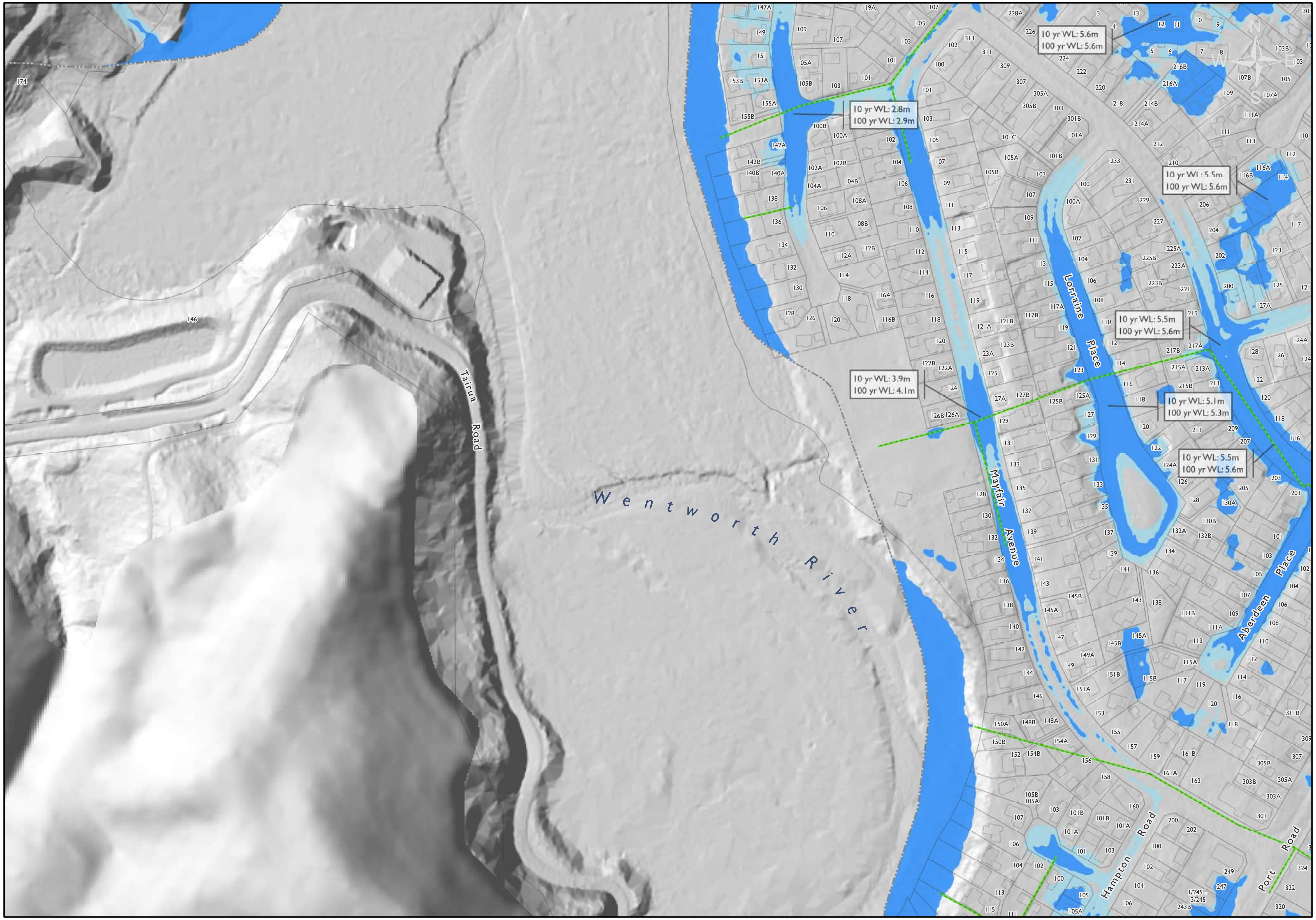
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: **J0547**

ISSUE: **FINAL DRAFT**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E8**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
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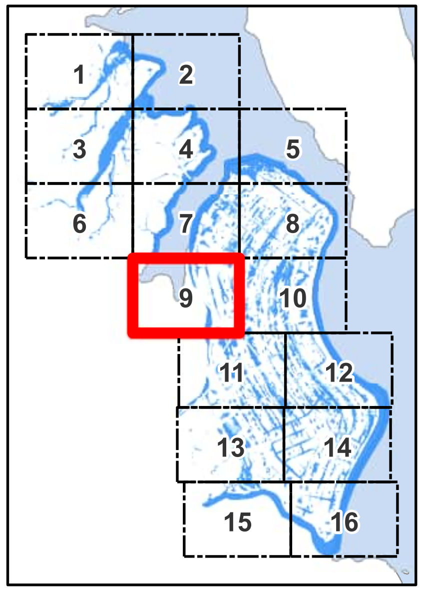

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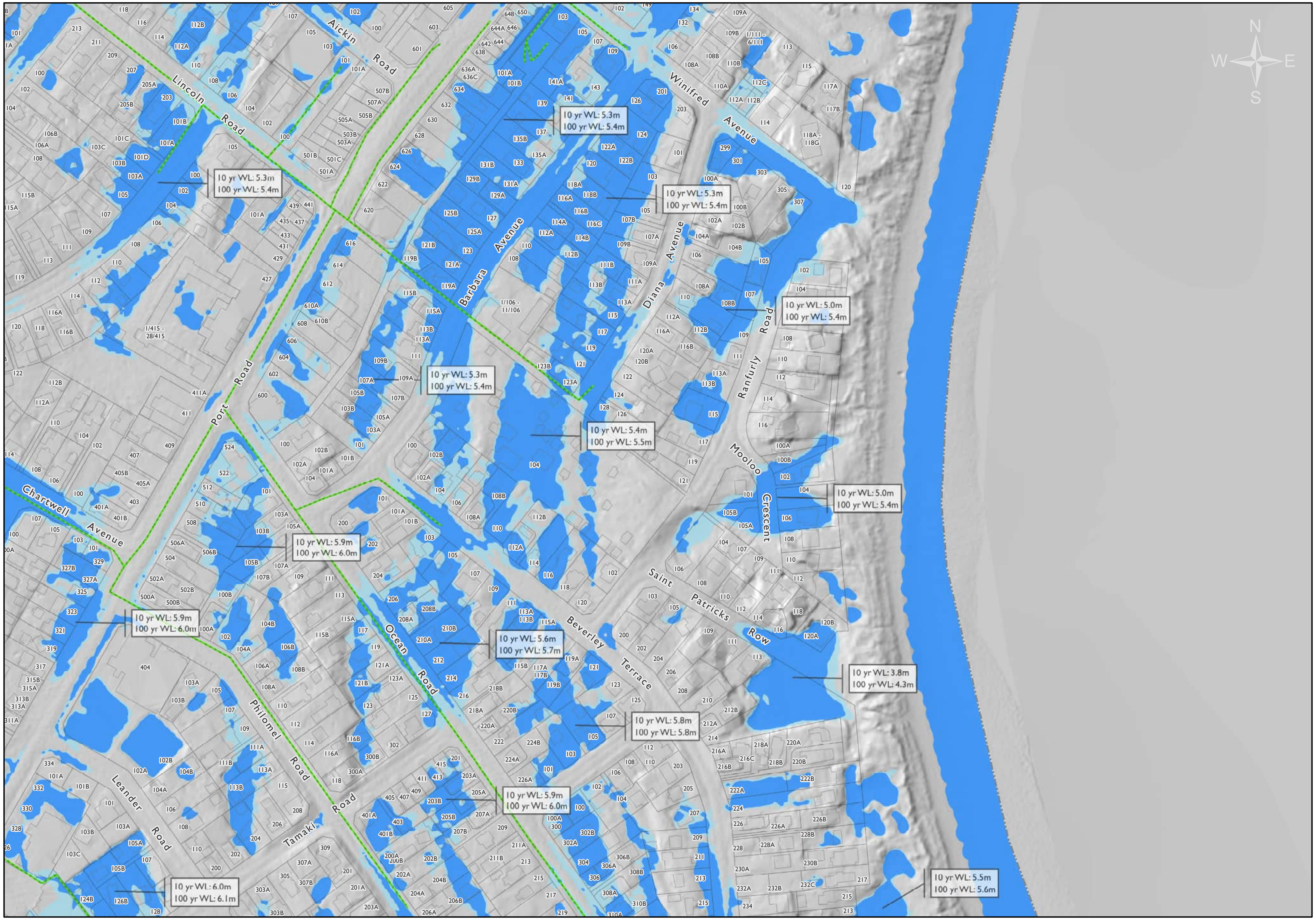
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: **J0547**

ISSUE: **FINAL DRAFT**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E9**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
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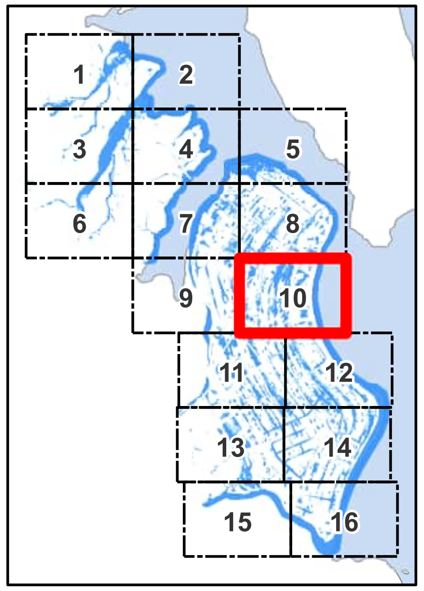

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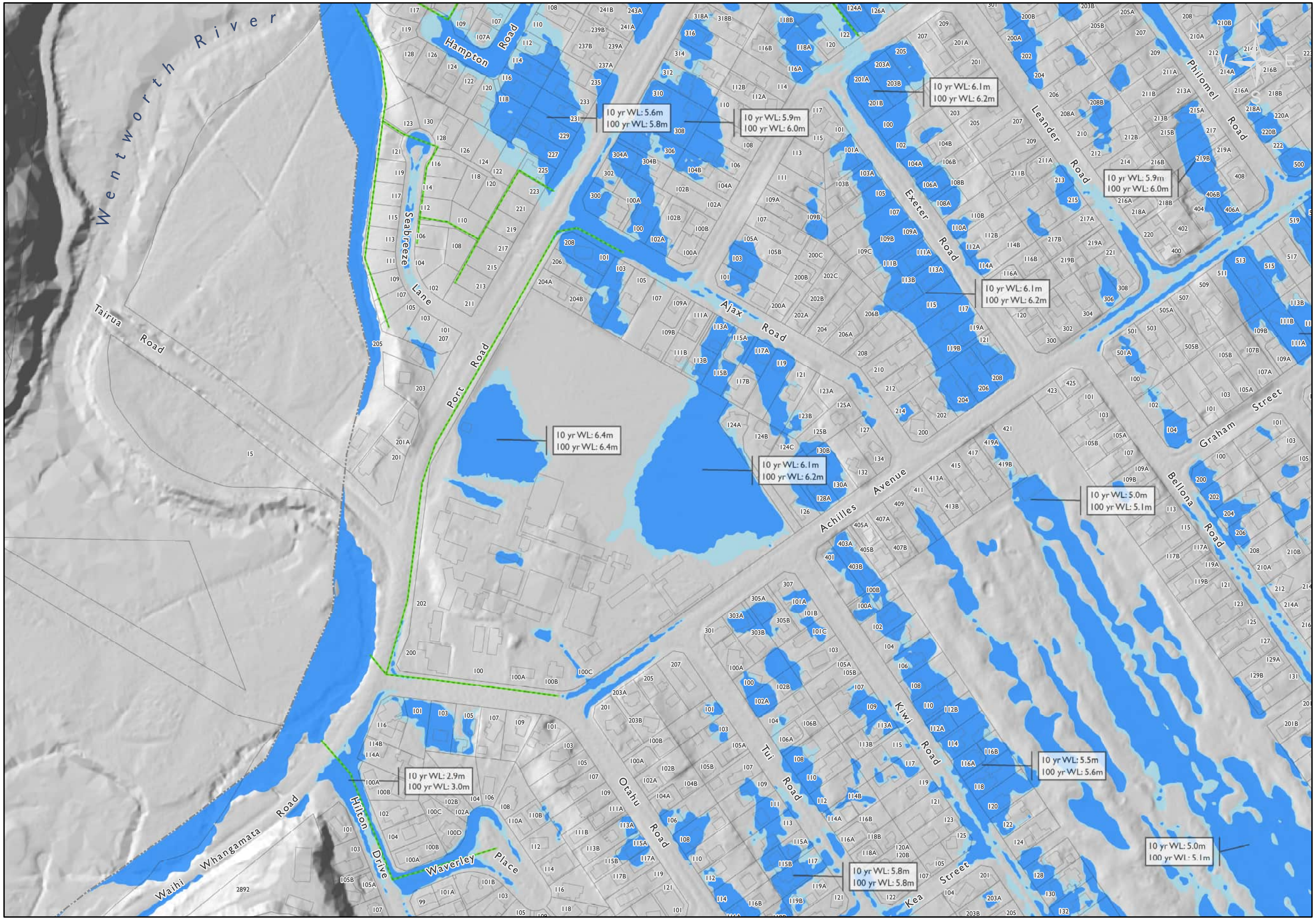
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E10**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:

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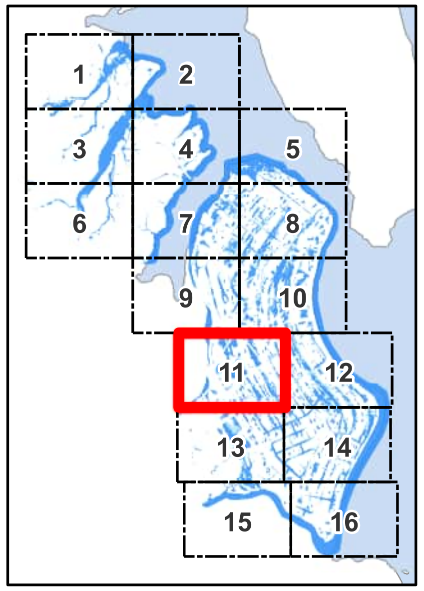

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PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING No: **FIGURE E11**

LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
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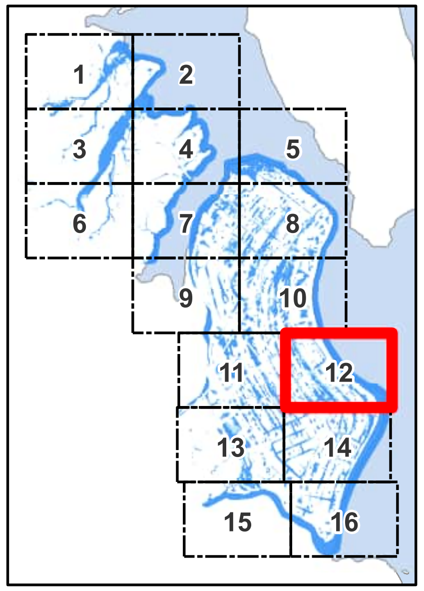

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1	REV 1 FOR CLIENT COMMENT	RVL	19 MAR 2021	DESIGN	RVL	19 MAR 2021
2	FINAL DRAFT	HAL	30 SEP 2023	DRAWN	TM / EE	19 MAR 2021
				DWG CHECKED	TAL	30 SEP 2023
				STATUS	ISSUED	30 SEP 2023
				FILENAME		
				APPROVED		

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HAL

0 25 50 100 150 200 250 300 Meters

SCALE (at A3): 1:3,000

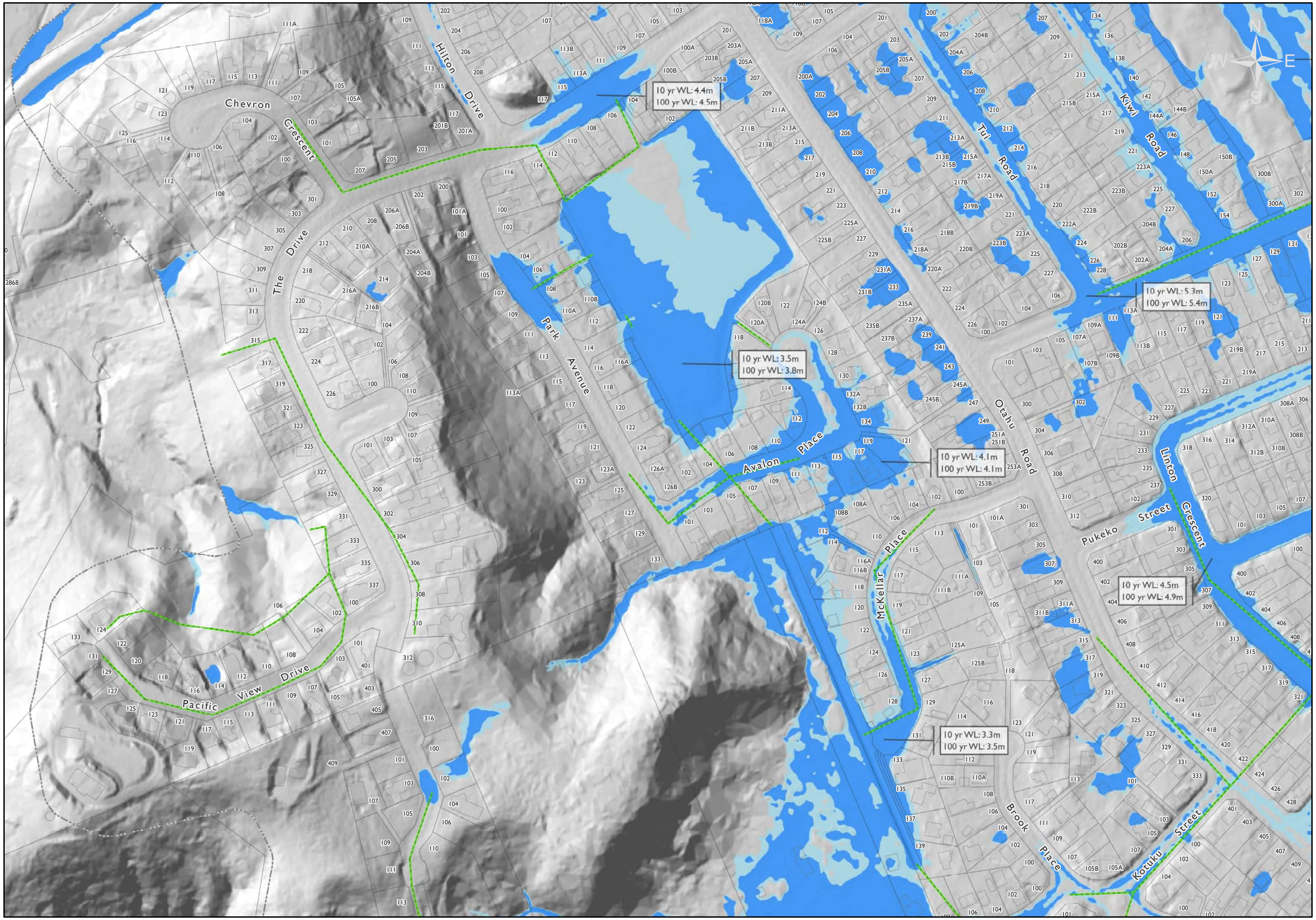
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E12**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than $100m^2$ are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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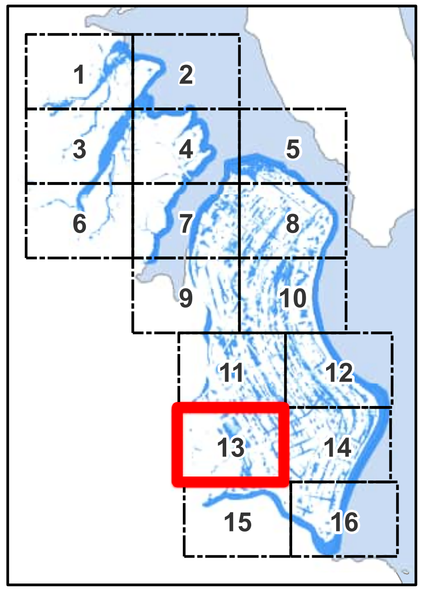

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	BY	DATE
DESIGN	RVL	19 MAR 2021
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DWG CHECKED	TAL	30 SEP 2023
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SCALE (at A3) 1:3,000

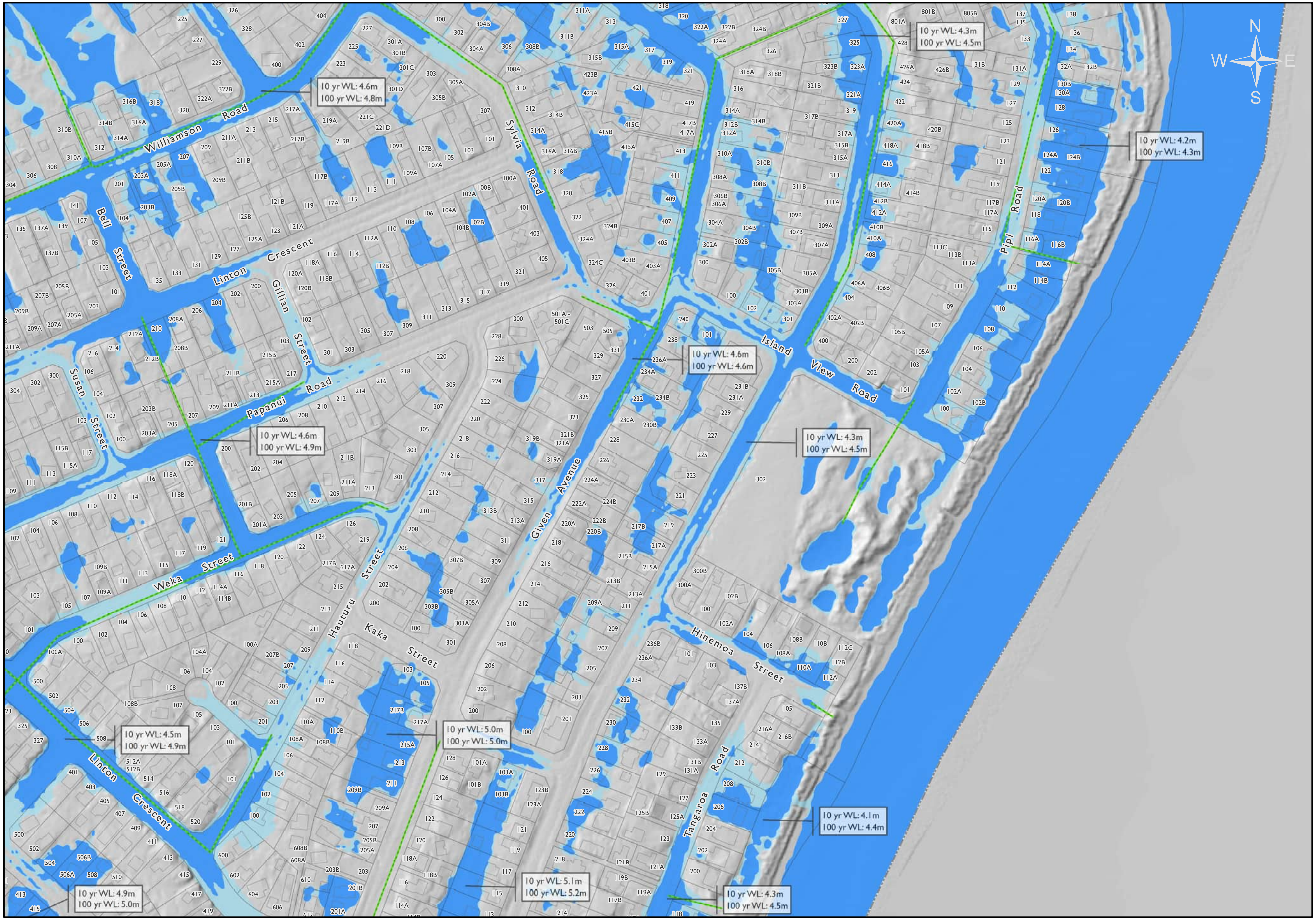
PROJECT NO: J0547

ISSUE: FINAL DRAFT

PROJECT:
WHANGAMATA FLOODPLAIN MAPPING

DRAWING TITLE:
Flood Inundation - MPD Incl. Climate Change

DRAWING No:
FIGURE E13



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:

1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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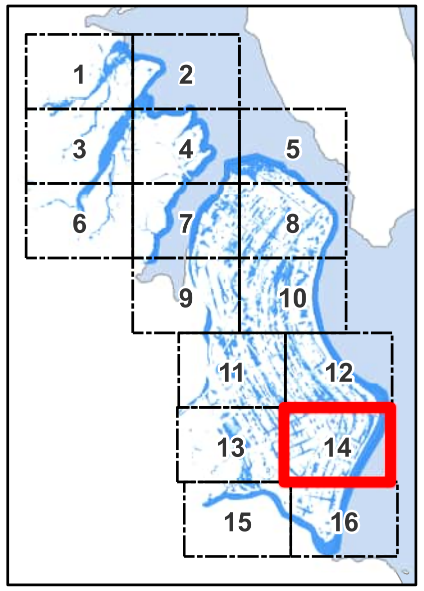

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0 25 50 100 150 200 250 300 Meters

SCALE (at A3) 1:3,000

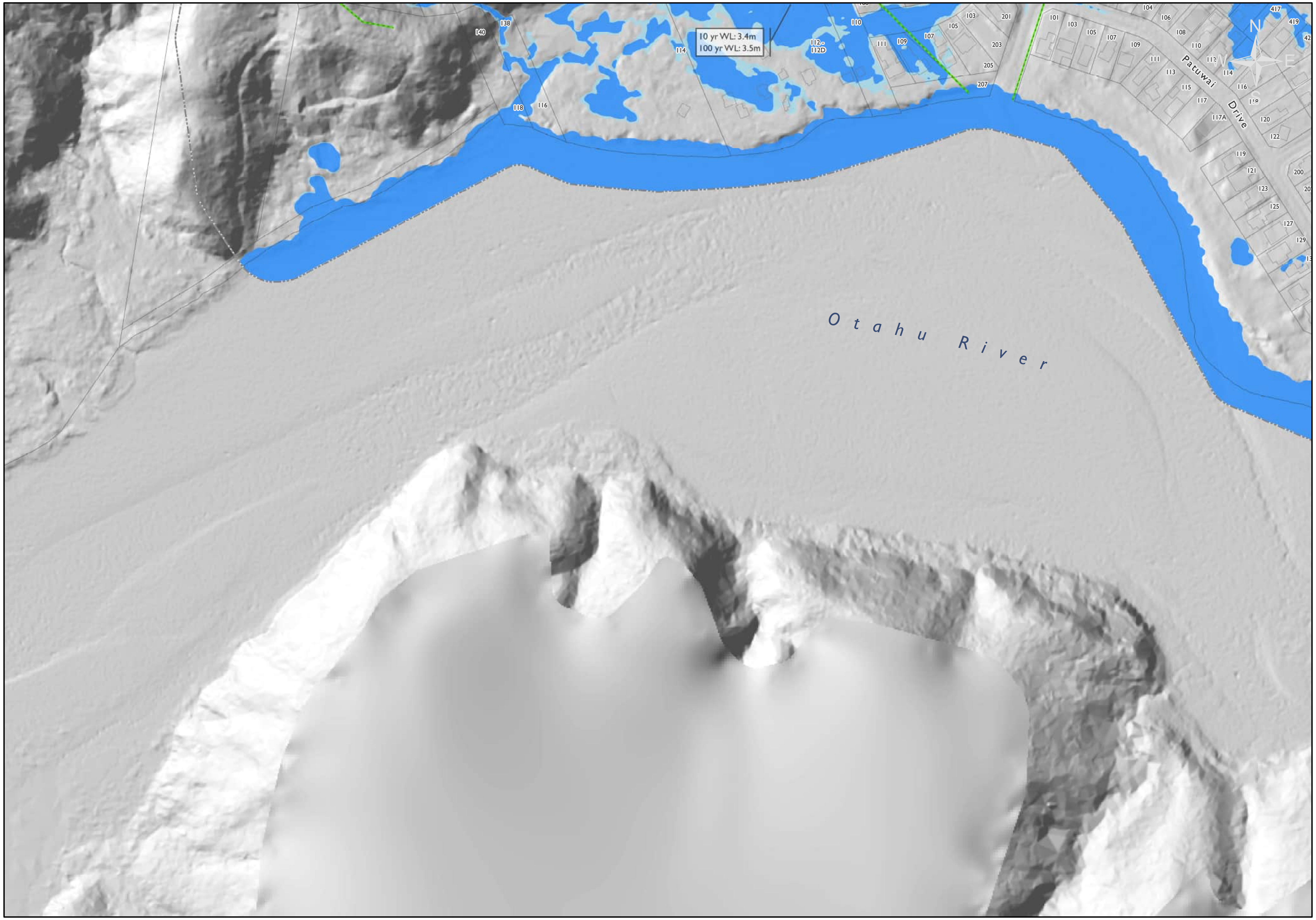
PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: **J0547**

ISSUE: **FINAL DRAFT**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E14**



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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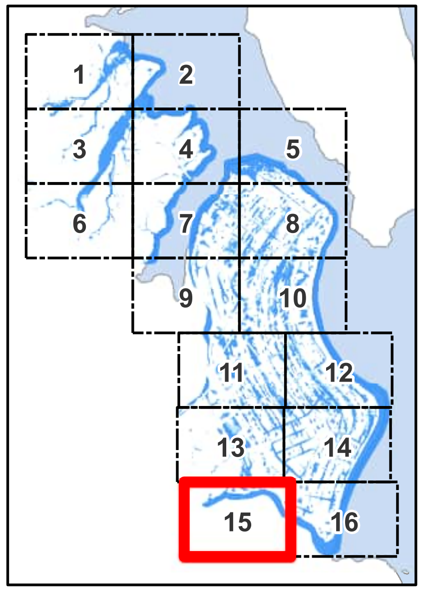

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0 25 50 100 150 200 250 300 Meters

SCALE (at A3)
1:3,000

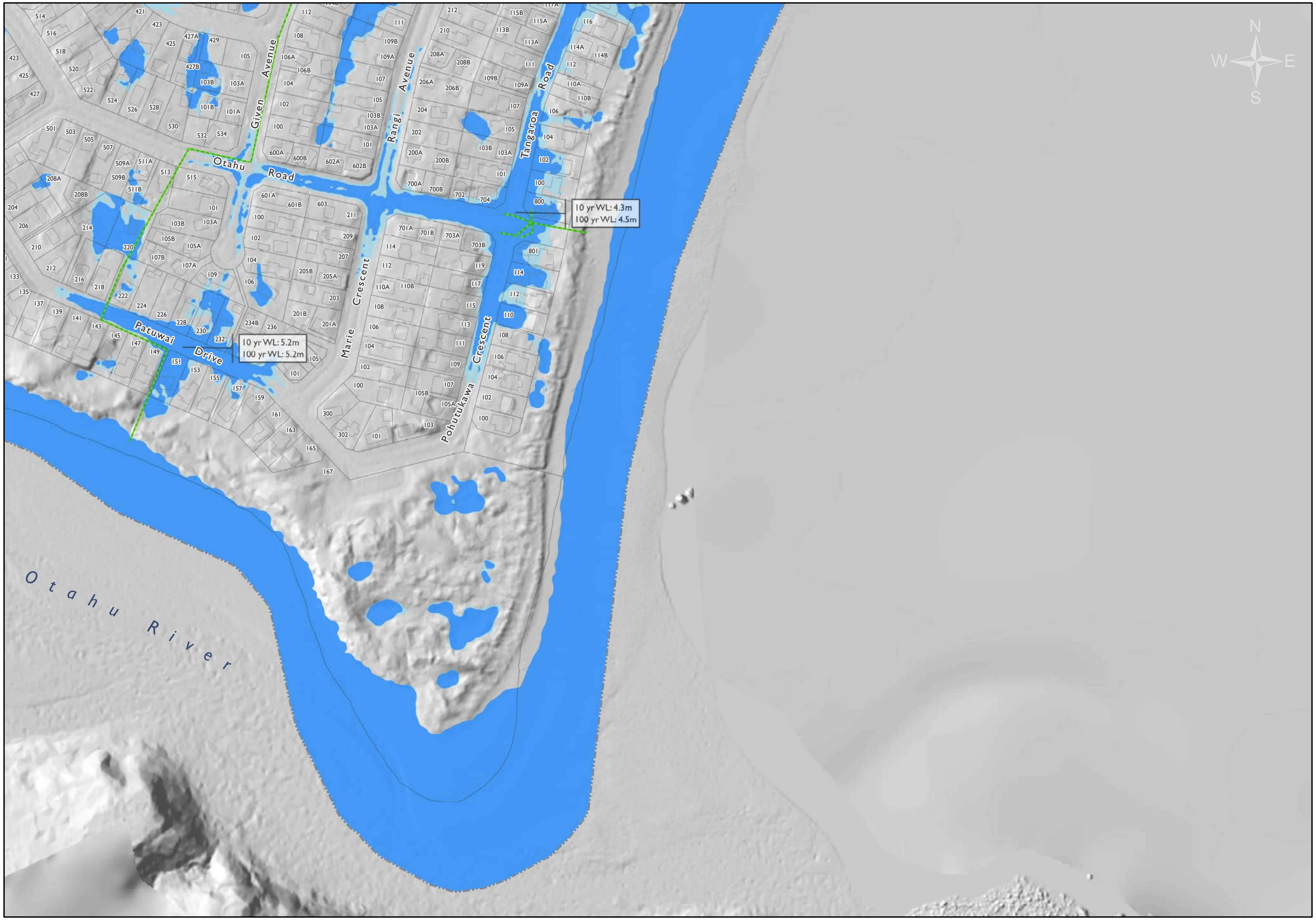
PROJECT:
WHANGAMATA FLOODPLAIN MAPPING

PROJECT NO: J0547

ISSUE: FINAL DRAFT

DRAWING TITLE:
Flood Inundation - MPD Incl. Climate Change

DRAWING No:
FIGURE E15



LEGEND

- Model Boundary
- Modelled Piped Network
- Building Footprint
- Parcel Boundary

Flood Inundation

- 10 Year ARI
- 100 Year ARI

Note:
1. Flood map shows modelled flood depths exceeding 100mm.
2. Flood map excludes freeboard allowance. Refer to Model Build and System Performance Report for freeboard recommendation.
3. Isolated areas where modelled flood depth is greater than 100mm but area smaller than 100m² are excluded.
4. ARI = Average Recurrence Interval
5. All levels are in Auckland Vertical Datum 1946.
6. Flood levels and extent along the coast, Whangamata Harbour, Moana Anu Anu Estuary, Wentworth River, and Otahu River represent the modelled water level boundary condition in the respective receiving environment and does not represent peak inundation.

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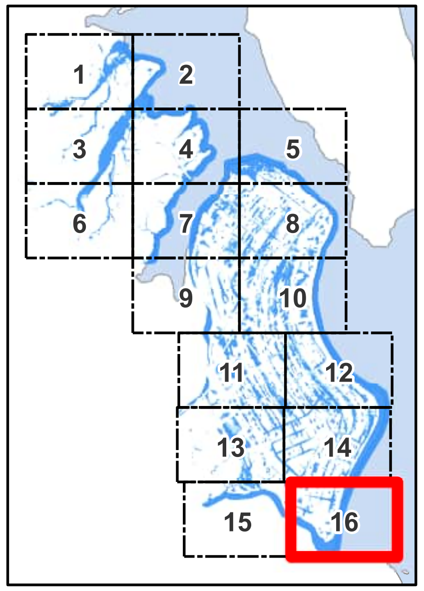

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SCALE (at A3): 1:3,000

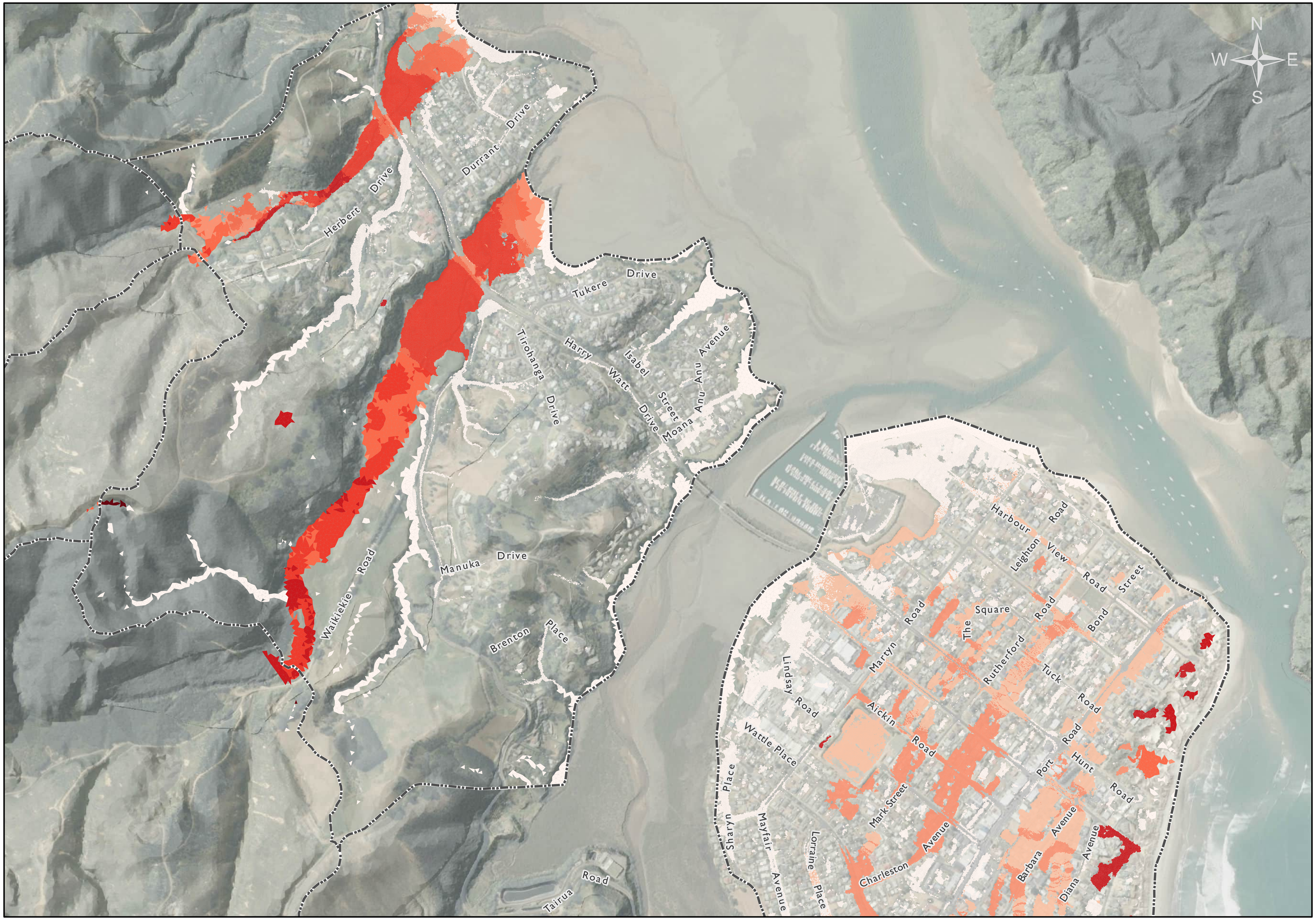
PROJECT NO: J0547

ISSUE: FINAL DRAFT

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

DRAWING TITLE: **Flood Inundation - MPD Incl. Climate Change**

DRAWING No: **FIGURE E16**



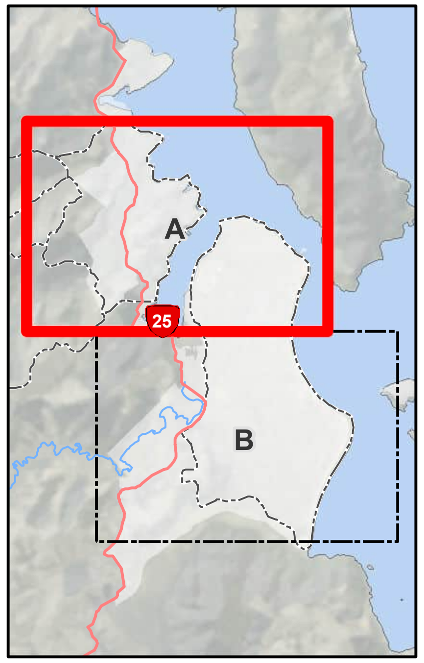
LEGEND

Catchment Boundaries (model)

Change in Flood Elevation

- +/- 5 mm
- 5 - 10 mm
- 10 - 30 mm
- 30 - 50 mm
- 50 - 100 mm
- 100 - 300 mm
- 300 - 360 mm

Note:
1. Flood elevation changes shown for areas with modelled flood depths exceeding 100 mm.



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0	DRAFT FOR CLIENT COMMENT	RVL	18 JUN 2020	DESIGN	RENE VAN LIEROP	18 JUN 2020
1	FINAL FOR ISSUE	HAL	21 JULY 2023	DRAWN	TAMI NICOLL	18 JUN 2020
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				STATUS	ISSUED	31 JULY 2023
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SCALE (at A3): 1:10,000

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J000147

ISSUE: FINAL

DRAWING TITLE: **Sensitivity Storm Duration: 12hr vs 6hr Simulation Difference Map Peak Flood Levels MPD 100yr+CC**

DRAWING No: **FIGURE F3.1A**

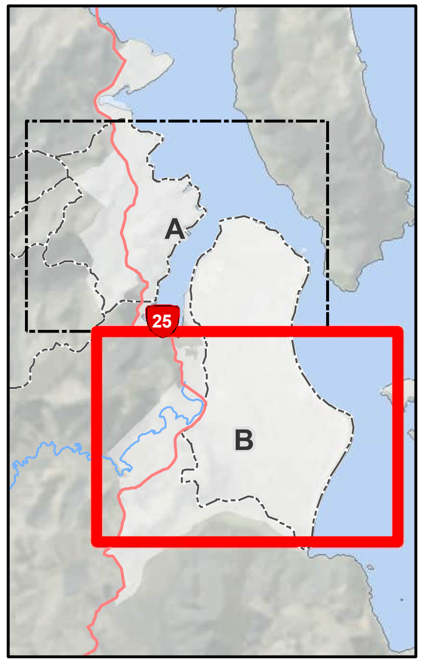
LEGEND

Catchment Boundaries (model)

Change in Flood Elevation

- +/- 5 mm
- 5 - 10 mm
- 10 - 30 mm
- 30 - 50 mm
- 50 - 100 mm
- 100 - 300 mm
- 300 - 360 mm

Note:
1. Flood elevation changes shown for areas with modelled flood depths exceeding 100 mm.



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				STATUS	ISSUED	31 JULY 2023
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SCALE (at A3): 1:10,000

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: J000147

ISSUE: FINAL

DRAWING TITLE: **Sensitivity Storm Duration: 12hr vs 6hr Simulation Difference Map Peak Flood Levels MPD 100yr+CC**

DRAWING No: **FIGURE F3.1B**

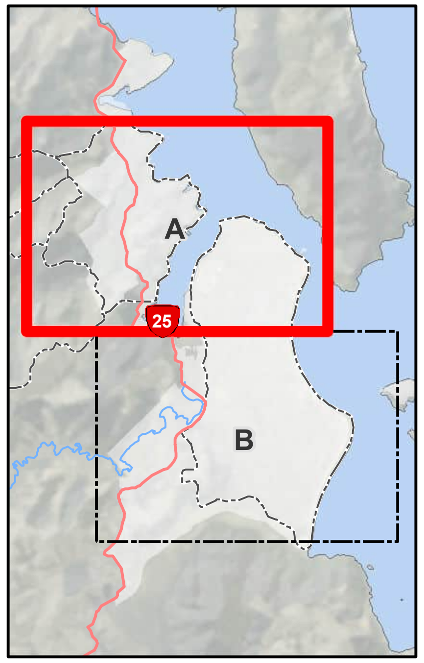
LEGEND

Catchment Boundaries (model)

Change in Flood Elevation

- +/- 5 mm
- 5 - 10 mm
- 10 - 30 mm
- 30 - 50 mm
- 50 - 100 mm
- 100 - 300 mm
- 300 - 330 mm

Note:
1. Flood elevation changes shown for areas with modelled flood depths exceeding 100 mm.



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PROJECT NO: J000147

ISSUE: FINAL

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

DRAWING TITLE: **Sensitivity Storm Duration: 24hr vs 12hr Simulation Difference Map Peak Flood Levels MPD 100yr+CC**

DRAWING No: **FIGURE F3.2A**

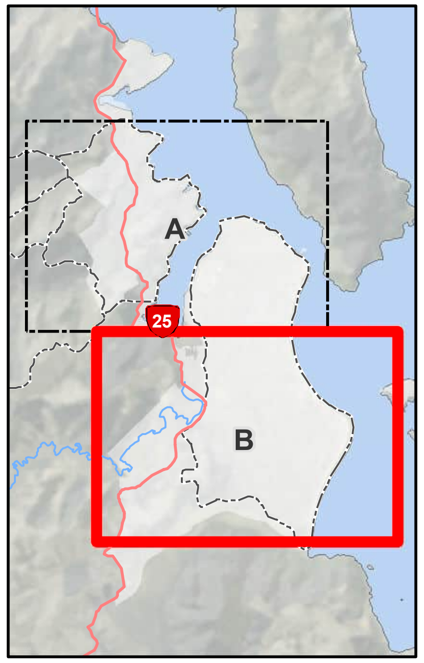
LEGEND

Catchment Boundaries (model)

Change in Flood Elevation

- +/- 5 mm
- 5 - 10 mm
- 10 - 30 mm
- 30 - 50 mm
- 50 - 100 mm
- 100 - 300 mm
- 300 - 330 mm

Note:
1. Flood elevation changes shown for areas with modelled flood depths exceeding 100 mm.



REV	AMMENDMENTS	BY	DATE		BY	DATE
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SCALE (at A3) 1:10,000

PROJECT: **WHANGAMATA FLOODPLAIN MAPPING**

PROJECT NO: **J000147**

ISSUE: **FINAL**

DRAWING TITLE:
Sensitivity Storm Duration: 24hr vs 12hr Simulation
Difference Map Peak Flood Levels MPD 100yr+CC

DRAWING No: **FIGURE F3.2B**

APPENDIX E – RECOMMENDED SURVEY LOCATIONS

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWOUT_20 1258	201258	Outfall 2D	3.94	2013 LiDAR Data	4.04	System Default	Survey Invert Levels
SWMH_20 1631	201631	Manhole	2.72	2013 LiDAR Data	1.85	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1635	201635	Manhole	5.70	2013 LiDAR Data	4.63	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1672	201672	Manhole	4.77	2013 LiDAR Data	4.15	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1685	201685	Manhole	4.24	2013 LiDAR Data	3.50	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1686	201686	Manhole	4.63	2013 LiDAR Data	3.70	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1692	201692	Manhole	4.57	2013 LiDAR Data	3.85	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1706	201706	Manhole	5.26	2013 LiDAR Data	4.57	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_20 1718	201718	Manhole	4.98	2013 LiDAR Data	4.26	System Default	Survey Invert Levels
SWMH_20 1727	201727	Manhole	5.58	2013 LiDAR Data	4.70	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1803	201803	Manhole	5.04	2013 LiDAR Data	4.45	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 1804	201804	Manhole	4.97	2013 LiDAR Data	4.50	Estimate - Overwritten GIS	Survey Invert Levels
SWCP_201 865	201865	Manhole	3.84	2013 LiDAR Data	3.03	System Default	Survey Invert Levels
SWCP_201 866	201866	Manhole	3.90	2013 LiDAR Data	3.29	System Default	Survey Invert Levels
SWCP_201 867	201867	Manhole	4.11	2013 LiDAR Data	3.30	System Default	Survey Invert Levels
SWCP_201 868	201868	Manhole	3.64	2013 LiDAR Data	2.83	System Default	Survey Invert Levels
SWMH_20 3248	203248	Manhole	4.68	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_20 3249	203249	Manhole	4.60	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_20 3352	203352	Manhole	1.49	2013 LiDAR Data	0.53	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_20 3353	203353	Manhole	2.51	2013 LiDAR Data	1.60	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 3383	203383	Manhole	4.08	2013 LiDAR Data	3.05	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_20 3386	203386	Manhole	3.94	2013 LiDAR Data	3.37	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_20 3397	203397	Manhole	5.67	2013 LiDAR Data	4.65	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_20 3398	203398	Manhole	5.69	2013 LiDAR Data	4.65	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 3411	203411	Manhole	4.59	2013 LiDAR Data	3.49	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_20 3416	203416	Manhole	3.97	2013 LiDAR Data	3.30	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 3443	203443	Manhole	4.11	2013 LiDAR Data	3.30	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20 3834	203834	Manhole	45.03	2013 LiDAR Data	43.82	Estimate - Blank GIS Data Values Filled	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWMH_204133	204133	Manhole	5.13	2013 LiDAR Data	4.01	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_204155	204155	Manhole	5.85	2013 LiDAR Data	4.20	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_204156	204156	Manhole	5.71	2013 LiDAR Data	4.40	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_204160	204160	Manhole	5.13	2013 LiDAR Data	3.70	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_204516	204516	Manhole	4.66	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_204665	204665	Manhole	1.38	2013 LiDAR Data	0.39	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_207802	207802	Manhole	2.32	2013 LiDAR Data	0.90	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_207838	207838	Manhole	4.76	2013 LiDAR Data	4.20	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_207839	207839	Manhole	4.74	2013 LiDAR Data	4.19	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_207890	207890	Manhole	4.67	2013 LiDAR Data	4.14	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_300631	300631	Manhole	3.52	2013 LiDAR Data	2.08	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300632	300632	Manhole	2.75	2013 LiDAR Data	1.79	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300646	300646	Manhole	3.27	2013 LiDAR Data	1.70	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300649	300649	Manhole	5.40	2013 LiDAR Data	2.16	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300653	300653	Manhole	42.81	2013 LiDAR Data	41.68	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300654	300654	Manhole	43.43	2013 LiDAR Data	40.84	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300661	300661	Manhole	62.87	2013 LiDAR Data	59.46	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300662	300662	Manhole	61.31	2013 LiDAR Data	59.98	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_300693	300693	Manhole	7.87	2013 LiDAR Data	4.50	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUT_300698	300698	Outfall 2D	12.46	2013 LiDAR Data	12.52	System Default	Survey Invert Levels
SWMH_300713	300713	Manhole	3.95	2013 LiDAR Data	1.86	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_300721	300721	Manhole	4.08	2013 LiDAR Data	3.12	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_300726	300726	Manhole	5.93	2013 LiDAR Data	3.11	Estimate - Overwritten GIS	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWMH_300727	300727	Manhole	5.17	2013 LiDAR Data	2.87	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_300728	300728	Manhole	3.54	2013 LiDAR Data	2.20	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301064	301064	Manhole	6.30	2013 LiDAR Data	4.86	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_301067	301067	Manhole	10.91	2013 LiDAR Data	9.31	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_301069	301069	Manhole	6.78	2013 LiDAR Data	3.89	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301070	301070	Manhole	5.84	2013 LiDAR Data	4.52	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301071	301071	Manhole	5.85	2013 LiDAR Data	2.67	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301074	301074	Manhole	5.94	2013 LiDAR Data	4.44	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301075	301075	Manhole	5.93	2013 LiDAR Data	4.48	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301079	301079	Manhole	5.22	2013 LiDAR Data	3.02	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301082	301082	Manhole	3.89	2013 LiDAR Data	2.20	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301083	301083	Manhole	4.91	2013 LiDAR Data	2.70	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301085	301085	Manhole	4.58	2013 LiDAR Data	1.74	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301086	301086	Manhole	3.25	2013 LiDAR Data	1.37	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_301087	301087	Manhole	2.74	2013 LiDAR Data	1.19	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301088	301088	Manhole	2.17	2013 LiDAR Data	1.03	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301092	301092	Manhole	4.44	2013 LiDAR Data	2.68	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301093	301093	Manhole	4.59	2013 LiDAR Data	2.98	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301100	301100	Manhole	4.96	2013 LiDAR Data	3.90	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301101	301101	Manhole	5.18	2013 LiDAR Data	4.08	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_301104	301104	Manhole	4.80	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_301109	301109	Manhole	4.65	2013 LiDAR Data	3.60	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301112	301112	Manhole	5.83	2013 LiDAR Data	4.88	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301117	301117	Manhole	5.88	2013 LiDAR Data	4.72	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301120	301120	Manhole	6.45	2013 LiDAR Data	4.21	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301125	301125	Manhole	5.82	2013 LiDAR Data	3.80	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301126	301126	Manhole	5.19	2013 LiDAR Data	3.27	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301133	301133	Manhole	5.54	2013 LiDAR Data	3.78	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301135	301135	Manhole	5.84	2013 LiDAR Data	3.88	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301143	301143	Manhole	4.24	2013 LiDAR Data	3.00	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301147	301147	Manhole	3.69	2013 LiDAR Data	2.68	Estimate - Overwritten GIS	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWMH_30 1149	301149	Manhole	3.66	2013 LiDAR Data	2.47	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1159	301159	Manhole	4.00	2013 LiDAR Data	3.02	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1161	301161	Manhole	4.03	2013 LiDAR Data	2.81	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_30 1164	301164	Manhole	4.50	2013 LiDAR Data	3.50	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1165	301165	Manhole	4.83	2013 LiDAR Data	3.60	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1168	301168	Manhole	4.33	2013 LiDAR Data	3.09	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1171	301171	Manhole	4.59	2013 LiDAR Data	3.32	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1173	301173	Manhole	4.98	2013 LiDAR Data	4.10	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1176	301176	Manhole	4.47	2013 LiDAR Data	3.30	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1177	301177	Manhole	4.33	2013 LiDAR Data	3.49	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1178	301178	Manhole	4.55	2013 LiDAR Data	3.59	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1179	301179	Manhole	4.35	2013 LiDAR Data	3.62	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1183	301183	Manhole	3.04	2013 LiDAR Data	1.65	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1186	301186	Manhole	3.75	2013 LiDAR Data	1.27	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1211	301211	Manhole	4.33	2013 LiDAR Data	3.30	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1213	301213	Manhole	4.59	2013 LiDAR Data	3.13	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1215	301215	Manhole	4.17	2013 LiDAR Data	3.14	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1619	301619	Manhole	55.55	2013 LiDAR Data	51.50	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_30 1620	301620	Manhole	42.94	2013 LiDAR Data	41.33	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_30 1631	301631	Manhole	3.80	2013 LiDAR Data	2.61	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_30 1649	301649	Manhole	4.84	2013 LiDAR Data	3.72	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 1997	301997	Manhole	2.24	2013 LiDAR Data	1.25	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_30 1998	301998	Manhole	4.67	2013 LiDAR Data	3.95	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_30 2001	302001	Manhole	1.79	2013 LiDAR Data	0.55	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_30 2002	302002	Manhole	2.58	2013 LiDAR Data	1.27	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 2014	302014	Manhole	4.68	2013 LiDAR Data	3.63	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_30 2020	302020	Manhole	5.00	2013 LiDAR Data	1.89	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_30 2021	302021	Manhole	5.32	2013 LiDAR Data	3.67	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_30 2023	302023	Manhole	4.59	2013 LiDAR Data	3.38	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_30 2037	302037	Manhole	3.96	2013 LiDAR Data	2.65	Estimate - Blank GIS Data Values Filled	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWMH_302105	302105	Manhole	3.35	2013 LiDAR Data	2.13	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_302106	302106	Manhole	5.74	2013 LiDAR Data	3.90	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_302803	302803	Manhole	46.46	2013 LiDAR Data	44.93	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_302804	302804	Manhole	47.15	2013 LiDAR Data	44.26	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_302805	302805	Manhole	45.84	2013 LiDAR Data	43.77	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_302806	302806	Manhole	42.57	2013 LiDAR Data	40.70	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_302807	302807	Manhole	39.62	2013 LiDAR Data	38.11	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_302808	302808	Outfall	34.48	2013 LiDAR Data	34.50	System Default	Survey Invert Levels
SWMH_302876	302876	Manhole	5.05	2013 LiDAR Data	3.92	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_302877	302877	Manhole	5.21	2013 LiDAR Data	3.98	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_303356	303356	Manhole	4.94	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_303357	303357	Manhole	4.80	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_303358	303358	Manhole	4.77	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWMH_303401	303401	Manhole	5.56	2013 LiDAR Data	3.54	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_303720	303720	Manhole	2.94	2013 LiDAR Data	1.30	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_303778	303778	Manhole	5.04	2013 LiDAR Data	4.18	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_303779	303779	Manhole	4.85	2013 LiDAR Data	4.19	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_500837	500837	Manhole	33.99	2013 LiDAR Data	32.41	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_500840	500840	Manhole	31.50	2013 LiDAR Data	30.00	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550021	550021	Manhole	4.56	2013 LiDAR Data	2.76	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_550422	550422	Manhole	3.44	2013 LiDAR Data	2.14	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550423	550423	Manhole	3.62	2013 LiDAR Data	1.75	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550929	550929	Manhole	2.51	2013 LiDAR Data	1.25	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550930	550930	Manhole	5.74	2013 LiDAR Data	4.46	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550931	550931	Manhole	6.18	2013 LiDAR Data	4.46	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550934	550934	Manhole	4.17	2013 LiDAR Data	3.06	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550935	550935	Manhole	5.48	2013 LiDAR Data	3.83	Estimate - Blank GIS Data Values Filled	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWMH_550938	550938	Manhole	4.63	2013 LiDAR Data	2.88	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550939	550939	Manhole	4.63	2013 LiDAR Data	2.88	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_550951	550951	Manhole	3.40	2013 LiDAR Data	1.68	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUTFALL_551150	551150	Outfall	5.28	2013 LiDAR Data	3.00	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551781	551781	Manhole	21.16	2013 LiDAR Data	20.19	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_551782	551782	Manhole	12.29	2013 LiDAR Data	12.00	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551783	551783	Manhole	3.55	2013 LiDAR Data	2.00	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551784	551784	Manhole	2.48	2013 LiDAR Data	1.50	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551785	551785	Manhole	4.33	2013 LiDAR Data	3.49	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551786	551786	Manhole	5.63	2013 LiDAR Data	4.60	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551787	551787	Manhole	5.61	2013 LiDAR Data	4.50	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551789	551789	Manhole	4.01	2013 LiDAR Data	2.64	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551790	551790	Manhole	4.39	2013 LiDAR Data	2.93	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_551791	551791	Manhole	3.59	2013 LiDAR Data	2.06	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_552381	552381	Manhole	4.62	2013 LiDAR Data	3.24	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_552439	552439	Manhole	6.07	2013 LiDAR Data	4.80	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_552441	552441	Manhole	24.12	2013 LiDAR Data	23.22	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_552501	552501	Manhole	2.28	2013 LiDAR Data	1.29	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_552546	552546	Manhole	14.22	2013 LiDAR Data	13.50	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWMH_552917	552917	Manhole	47.47	2013 LiDAR Data	44.46	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWMH_552940	552940	Manhole	5.32	2013 LiDAR Data	4.55	Interpolation based on US and DS levels	Survey Invert Levels
SWMH_553112	553112	Manhole	3.09	2013 LiDAR Data	1.93	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_553141	553141	Manhole	4.68	2013 LiDAR Data	4.11	System Default	Survey Invert Levels
SWOUTFALL_553176	553176	Outfall	0.83	2013 LiDAR Data	-0.20	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_20190130151712	2.01901E+13	Manhole	4.80	2013 LiDAR Data	3.80	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
SWMH_20190201130616	2.01902E+13	Manhole	4.67	2013 LiDAR Data	3.64	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_20190208112338	2.01902E+13	Manhole	6.70	2013 LiDAR Data	5.62	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWMH_20190208112415	2.01902E+13	Manhole	3.82	2013 LiDAR Data	2.81	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWOUTFALL_20190208112431	2.01902E+13	Outfall 2D	1.81	2013 LiDAR Data	1.89	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
Dummy_OR02	Dummy Node	Manhole	3.92	2013 LiDAR Data	1.50	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
Dummy_OR04	Dummy Node	Manhole	4.04	2013 LiDAR Data	1.50	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
Dummy_OR03	Dummy Node	Manhole	4.04	2013 LiDAR Data	1.50	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
Dummy_OR01	Dummy Node	Manhole	4.09	2013 LiDAR Data	1.50	Invert from LiDAR estimated ground level and assumed depth (1.0 - 1.5m)	Survey Invert Levels
SWIN005	Not in GIS	Manhole	6.51	2013 LiDAR Data	6.50	2013 LiDAR Data	Survey Invert Levels
SWIN003	Not in GIS	Manhole	6.00	2013 LiDAR Data	5.90	Existing SWMM Model	Survey Invert Levels
SWOUT001	Not in GIS	Outfall 2D	2.10	2013 LiDAR Data	2.10	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUTFALL_551088	Not in GIS	Outfall	2.28	2013 LiDAR Data	2.06	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUTFALL_551151	Not in GIS	Outfall	3.67	2013 LiDAR Data	2.18	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUTFALL_551164	Not in GIS	Outfall	4.67	2013 LiDAR Data	2.00	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUTFALL_551728	Not in GIS	Outfall	0.07	2013 LiDAR Data	0.00	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
SWOUTFALL_551722	Not in GIS	Outfall	5.18	2013 LiDAR Data	0.12	Invert from GIS ground level and assumed depth (1.0m)	Survey Invert Levels
SWOUTFALL_300664	Not in GIS	Outfall	29.53	2013 LiDAR Data	28.57	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551086	Not in GIS	Outfall	1.78	2013 LiDAR Data	0.63	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551089	Not in GIS	Outfall	1.90	2013 LiDAR Data	0.96	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551090	Not in GIS	Outfall	2.91	2013 LiDAR Data	2.96	Invert from LiDAR estimated ground level and measured	Survey Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
						depth (e.g. from GIS Survey Asbuilt)	
SWOUTFALL_551091	Not in GIS	Outfall	2.31	2013 LiDAR Data	1.17	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551092	Not in GIS	Outfall	3.82	2013 LiDAR Data	2.67	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551094	Not in GIS	Outfall	15.35	2013 LiDAR Data	13.61	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551148	Not in GIS	Outfall	0.69	2013 LiDAR Data	0.15	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551152	Not in GIS	Outfall	6.00	2013 LiDAR Data	5.54	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
SWOUTFALL_551158	Not in GIS	Outfall	2.24	2013 LiDAR Data	1.31	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Invert Levels
WP_SWMH_2	Not in GIS	Manhole	4.35	2013 LiDAR Data	2.70	System Default	Survey Invert Levels
SWOUTFALL_300634	Not in GIS	Outfall	1.20	2013 LiDAR Data	1.22	System Default	Survey Invert Levels
SWOUTFALL_300641	Not in GIS	Outfall	1.44	2013 LiDAR Data	1.09	System Default	Survey Invert Levels
SWOUTFALL_300646	Not in GIS	Outfall	2.21	2013 LiDAR Data	1.25	System Default	Survey Invert Levels
SWOUTFALL_300649	Not in GIS	Outfall	2.57	2013 LiDAR Data	1.82	System Default	Survey Invert Levels
SWOUTFALL_303496	Not in GIS	Outfall	0.28	2013 LiDAR Data	0.00	System Default	Survey Invert Levels
SWOUTFALL_554057	Not in GIS	Outfall	1.37	2013 LiDAR Data	0.70	System Default	Survey Invert Levels
SWOUT005	Not in GIS	Outfall 2D	4.90	2013 LiDAR Data	4.90	System Default	Survey Invert Levels
SWOUTFALL_203352	Not in GIS	Outfall	0.08	2013 LiDAR Data	0.46	2013 LiDAR Data	Survey Invert Levels
SWMH_303667	Not in GIS	Manhole	3.85	As-Built Drawings	2.90	Estimate - Blank GIS Data Values Filled	Survey Invert Levels
WP_OUTLET_4(P2)	551736	Outfall 2D	2.38	Construction Drawing Data	2.38	Construction Drawing Data	Survey Lid and Invert Levels
WP_SWMH_3	Not in GIS	Manhole	4.19	Construction Drawing Data	2.40	Construction Drawing Data	Survey Lid and Invert Levels
WP_OUTLET_4(P1)	Not in GIS	Outfall 2D	2.38	Construction Drawing Data	2.38	System Default	Survey Lid and Invert Levels
SWOUT_551087	551087	Outfall 2D	8.30	Estimate - Blank GIS Data Values Filled	7.75	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Lid and Invert Levels
SWOUT_551161	551161	Outfall 2D	1.44	Estimate - Blank GIS Data Values Filled	1.44	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUT_553362	553362	Outfall 2D	1.00	Estimate - Blank GIS Data Values Filled	0.38	Invert from GIS ground level and	Survey Lid and Invert Levels

Recommended Node Survey Locations							
Model Node ID	TCDC Asset ID	Type	Lid Level (mRL)	Lid Level Flag	Invert Level (mRL)	Invert Level Flag	Survey Recommendation
						assumed depth (1.0m)	
SWIN001	Not in GIS	Manhole	2.25	Estimate - Blank GIS Data Values Filled	2.15	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUTFALL_551251	Not in GIS	Outfall 2D	19.00	Estimate - Blank GIS Data Values Filled	17.58	Invert from LiDAR estimated ground level and measured depth (e.g. from GIS Survey Asbuilt)	Survey Lid and Invert Levels
SWOUTFALL_551792	Not in GIS	Outfall	2.50	Estimate - Blank GIS Data Values Filled	2.50	System Default	Survey Lid and Invert Levels
SWOUT_551160	Not in GIS	Outfall 2D	1.45	Estimate - Blank GIS Data Values Filled	1.45	System Default	Survey Lid and Invert Levels
SWOUT004	Not in GIS	Outfall 2D	2.90	Estimate - Blank GIS Data Values Filled	2.90	System Default	Survey Lid and Invert Levels
SWOUT_551104	551104	Outfall 2D	2.25	Existing SWMM Model	2.25	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUT_551721	551721	Outfall 2D	2.70	Existing SWMM Model	2.70	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWIN002	Not in GIS	Manhole	2.96	Existing SWMM Model	2.86	Existing SWMM Model	Survey Lid and Invert Levels
SWOUT002	Not in GIS	Outfall 2D	2.85	Existing SWMM Model	2.85	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUTFALL_003	Not in GIS	Outfall	0.40	Existing SWMM Model	0.40	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUTFALL_551155	Not in GIS	Outfall	1.00	Existing SWMM Model	1.00	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUTFALL_551157	Not in GIS	Outfall	0.50	Existing SWMM Model	0.50	Estimate - Blank GIS Data Values Filled	Survey Lid and Invert Levels
SWOUTFALL_551714	Not in GIS	Outfall	0.12	Existing SWMM Model	0.12	Invert from GIS ground level and assumed depth (1.0m)	Survey Lid and Invert Levels
SWOUT003	Not in GIS	Outfall 2D	5.90	Existing SWMM Model	5.90	2006 LiDAR Data	Survey Lid and Invert Levels
SWOUTFALL_551163	551163	Outfall	1.10	Site Visit	0.01	2006 LiDAR Data	Survey Invert Levels
CU_IN_NZTA_02	Dummy Node	Outfall 2D	0.90	Site Visit	0.90	Site Visit	Survey Invert Levels
CU_OUT_NZTA_02	Dummy Node	Outfall 2D	0.80	Site Visit	0.90	Site Visit	Survey Invert Levels
CU_IN_NZTA_01	Dummy Node	Outfall 2D	1.80	Site Visit	1.80	System Default	Survey Invert Levels
CU_OUT_NZTA_01	Dummy Node	Outfall 2D	1.70	Site Visit	1.70	System Default	Survey Invert Levels
SWIN004	Not in GIS	Manhole	3.10	Site Visit	3.00	Site Visit	Survey Invert Levels
SWMH_301198	301198	Manhole	4.61	Survey	1.70	Estimate - Overwritten GIS	Survey Invert Levels
SWMH_301208	301208	Manhole	4.11	Thames Coromandel District Council 2019 GIS	3.60	System Default	Survey Lid and Invert Levels

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
Dummy_OR01.1	Dummy_OR01	Not in GIS	1400	Soakage Cell confirm dimensions
Dummy_OR03.1	Dummy_OR03	Not in GIS	1400	Soakage Cell confirm dimensions
DUMMY_TE_WEITI_N_IN.1	DUMMY_TE_WEITI_N_IN	Not in GIS	600	Assumed shape. US & DS Invert to survey
DUMMY_TE_WEITI_S_IN.1	DUMMY_TE_WEITI_S_IN	Not in GIS	600	Assumed shape. US & DS Invert to survey
DUMMY_WAIKIEKIE_IN.1	DUMMY_WAIKIEKIE_IN	Not in GIS	600	Assumed shape. US & DS Invert to survey
SWCP_201888.1	SWCP_201888	401500	450	DS Invert to Survey
SWCP_201889.1	SWCP_201889	401503	450	DS Invert to Survey
SWIN_301185.1	SWIN_301185	101331	900	US & DS Invert to survey
SWIN_551101.1	SWIN_551101	401001	900	Assumed diameter. US & DS Invert to survey
SWIN001.1	SWIN001	Not in GIS	900	Not showing on TCDC GIS
SWIN002.1	SWIN002	Not in GIS	525	Not showing on TCDC GIS
SWIN003.1	SWIN003	Not in GIS	300	Not showing on TCDC GIS
SWIN004.1	SWIN004	Not in GIS	750	Not showing on TCDC GIS
SWIN005.1	SWIN005	Not in GIS	750	Not showing on TCDC GIS
SWMH_201184.1	SWMH_201184	400973	300	US and DS Invert to Survey
SWMH_201225.1	SWMH_201225	400977	450	US and DS Invert to Survey
SWMH_201258.1	SWMH_201258	400992	300	US and DS Invert to Survey
SWMH_201631.1	SWMH_201631	401324	600	US and DS Invert to Survey
SWMH_201635.1	SWMH_201635	401326	375	US and DS Invert to Survey
SWMH_201637.1	SWMH_201637	401328	300	US and DS Invert to Survey
SWMH_201654.1	SWMH_201654	401345	300	US and DS Invert to Survey
SWMH_201662.1	SWMH_201662	401373	300	US and DS Invert to Survey
SWMH_201664.1	SWMH_201664	401374	300	US and DS Invert to Survey
SWMH_201666.1	SWMH_201666	401375	300	US and DS Invert to Survey
SWMH_201668.1	SWMH_201668	401377	375	US and DS Invert to Survey
SWMH_201670.1	SWMH_201670	401368	300	US and DS Invert to Survey
SWMH_201672.1	SWMH_201672	401371	300	US and DS Invert to Survey
SWMH_201673.1	SWMH_201673	401372	300	US and DS Invert to Survey
SWMH_201677.1	SWMH_201677	401367	300	US and DS Invert to Survey
SWMH_201684.1	SWMH_201684	401383	300	US and DS Invert to Survey
SWMH_201685.1	SWMH_201685	401382	300	US and DS Invert to Survey
SWMH_201687.1	SWMH_201687	401385	300	US and DS Invert to Survey
SWMH_201689.1	SWMH_201689	401388	525	US and DS Invert to Survey
SWMH_201692.1	SWMH_201692	401392	525	US and DS Invert to Survey
SWMH_201694.1	SWMH_201694	401389	525	US and DS Invert to Survey
SWMH_201695.1	SWMH_201695	401386	525	US and DS Invert to Survey
SWMH_201706.1	SWMH_201706	401405	300	US and DS Invert to Survey
SWMH_201710.1	SWMH_201710	401408	300	US and DS Invert to Survey
SWMH_201713.1	SWMH_201713	401414	300	US and DS Invert to Survey
SWMH_201727.1	SWMH_201727	401418	300	US and DS Invert to Survey
SWMH_201743.1	SWMH_201743	401427	300	US and DS Invert to Survey
SWMH_201745.1	SWMH_201745	401432	300	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_201749.1	SWMH_201749	401428	300	US and DS Invert to Survey
SWMH_201752.1	SWMH_201752	401433	375	US and DS Invert to Survey
SWMH_201755.1	SWMH_201755	401436	600	US and DS Invert to Survey
SWMH_201762.1	SWMH_201762	401444	300	US and DS Invert to Survey
SWMH_201769.1	SWMH_201769	401449	300	US and DS Invert to Survey
SWMH_201686.1	SWMH_201686	401384	300	Assumed diameter. US & DS Invert to survey
SWMH_201779.1	SWMH_201779	101302	300	US and DS Invert to Survey
SWMH_201784.1	SWMH_201784	101291	300	US and DS Invert to Survey
SWMH_201795.1	SWMH_201795	101286	450	US and DS Invert to Survey
SWMH_201803.1	SWMH_201803	401458	300	US and DS Invert to Survey
SWMH_201804.1	SWMH_201804	401457	300	US and DS Invert to Survey
SWMH_20190201130616.1	SWMH_20190201130616	403839	600	US and DS Invert to Survey
SWMH_20190208112338.1	SWMH_20190208112338	2.019E+13	375	US and DS Invert to Survey
SWMH_20190208112415.1	SWMH_20190208112415	2.019E+13	375	US and DS Invert to Survey
SWMH_202829.1	SWMH_202829	402137	300	US and DS Invert to Survey
SWMH_202830.1	SWMH_202830	402138	300	US and DS Invert to Survey
SWMH_202851.1	SWMH_202851	101334	1000	US and DS Invert to Survey
SWMH_202873.1	SWMH_202873	403240	375	US and DS Invert to Survey
SWMH_203247.1	SWMH_203247	406938	375	US and DS Invert to Survey
SWMH_203255.1	SWMH_203255	403676	300	US and DS Invert to Survey
SWMH_203338.1	SWMH_203338	404866	300	US and DS Invert to Survey
SWMH_203352.1	SWMH_203352	403779	300	US and DS Invert to Survey
SWMH_203353.1	SWMH_203353	403780	300	US and DS Invert to Survey
SWMH_203354.1	SWMH_203354	404152	300	US and DS Invert to Survey
SWMH_203386.1	SWMH_203386	401509	300	US and DS Invert to Survey
SWMH_203388.1	SWMH_203388	403817	300	US and DS Invert to Survey
SWMH_203397.1	SWMH_203397	403822	375	US and DS Invert to Survey
SWMH_203398.1	SWMH_203398	403823	300	US and DS Invert to Survey
SWMH_203403.1	SWMH_203403	101228	300	US and DS Invert to Survey
SWMH_203416.1	SWMH_203416	403838	300	US and DS Invert to Survey
SWMH_203443.1	SWMH_203443	403888	300	US and DS Invert to Survey
SWMH_204133.1	SWMH_204133	405963	450	US and DS Invert to Survey
SWMH_204143.1	SWMH_204143	405969	300	US and DS Invert to Survey
SWMH_204152.1	SWMH_204152	405977	300	US and DS Invert to Survey
SWMH_204155.1	SWMH_204155	405982	525	US and DS Invert to Survey
SWMH_201758.1	SWMH_201758	401441	450	US Invert to survey
SWMH_204156.1	SWMH_204156	405984	450	US and DS Invert to Survey
SWMH_204160.1	SWMH_204160	405993	300	US and DS Invert to Survey
SWMH_204161.1	SWMH_204161	405994	300	US and DS Invert to Survey
SWMH_204162.1	SWMH_204162	405995	300	US and DS Invert to Survey
SWMH_201774.1	SWMH_201774	101275	300	Assumed diameter. US & DS Invert to survey
SWMH_204163.1	SWMH_204163	405996	300	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_204516.1	SWMH_204516	406985	300	US and DS Invert to Survey
SWMH_204665.1	SWMH_204665	407336	300	US and DS Invert to Survey
SWMH_207838.1	SWMH_207838	408432	300	US and DS Invert to Survey
SWMH_207839.1	SWMH_207839	408433	300	US and DS Invert to Survey
SWMH_207890.1	SWMH_207890	408430	300	US and DS Invert to Survey
SWMH_207895.1	SWMH_207895	408518	300	US and DS Invert to Survey
SWMH_300624.1	SWMH_300624	400964	600	US and DS Invert to Survey
SWMH_300625.1	SWMH_300625	400952	525	US and DS Invert to Survey
SWMH_300626.1	SWMH_300626	400953	300	US and DS Invert to Survey
SWMH_300629.1	SWMH_300629	400954	300	US and DS Invert to Survey
SWMH_300631.1	SWMH_300631	400955	300	US and DS Invert to Survey
SWMH_300632.1	SWMH_300632	400956	300	US and DS Invert to Survey
SWMH_300634.1	SWMH_300634	400957	375	US and DS Invert to Survey
SWMH_300635.1	SWMH_300635	400958	300	US and DS Invert to Survey
SWMH_300641.1	SWMH_300641	400959	375	US and DS Invert to Survey
SWMH_300642.1	SWMH_300642	400960	300	US and DS Invert to Survey
SWMH_300643.1	SWMH_300643	403252	300	US and DS Invert to Survey
SWMH_300646.1	SWMH_300646	400961	300	US and DS Invert to Survey
SWMH_300648.1	SWMH_300648	400962	300	US and DS Invert to Survey
SWMH_300649.1	SWMH_300649	400963	300	US and DS Invert to Survey
SWMH_300650.1	SWMH_300650	400974	700	US and DS Invert to Survey
SWMH_300656.1	SWMH_300656	400965	300	US and DS Invert to Survey
SWMH_300657.1	SWMH_300657	400966	300	US and DS Invert to Survey
SWMH_300658.1	SWMH_300658	400967	300	US and DS Invert to Survey
SWMH_300659.1	SWMH_300659	400968	300	US and DS Invert to Survey
SWMH_300660.1	SWMH_300660	400969	300	US and DS Invert to Survey
SWMH_300663.1	SWMH_300663	400971	375	US and DS Invert to Survey
SWMH_300665.1	SWMH_300665	400972	300	US and DS Invert to Survey
SWMH_300666.1	SWMH_300666	400970	375	US and DS Invert to Survey
SWMH_300667.1	SWMH_300667	400996	375	US and DS Invert to Survey
SWMH_300672.1	SWMH_300672	400976	300	US and DS Invert to Survey
SWMH_300673.1	SWMH_300673	400978	300	US and DS Invert to Survey
SWMH_300674.1	SWMH_300674	400979	300	US and DS Invert to Survey
SWMH_300677.1	SWMH_300677	400984	300	US and DS Invert to Survey
SWMH_300678.1	SWMH_300678	400983	300	US and DS Invert to Survey
SWMH_300679.1	SWMH_300679	400982	300	US and DS Invert to Survey
SWMH_300680.1	SWMH_300680	400981	300	US and DS Invert to Survey
SWMH_300681.1	SWMH_300681	400980	300	US and DS Invert to Survey
SWMH_300689.1	SWMH_300689	400988	300	US and DS Invert to Survey
SWMH_300691.1	SWMH_300691	400987	300	US and DS Invert to Survey
SWMH_300692.1	SWMH_300692	400986	300	US and DS Invert to Survey
SWMH_300693.1	SWMH_300693	400985	525	US and DS Invert to Survey
SWMH_300694.1	SWMH_300694	400989	525	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_300695.1	SWMH_300695	400990	300	US and DS Invert to Survey
SWMH_300696.1	SWMH_300696	400991	300	US and DS Invert to Survey
SWMH_300697.1	SWMH_300697	100763	300	US and DS Invert to Survey
SWMH_300698.1	SWMH_300698	400993	300	US and DS Invert to Survey
SWMH_300699.1	SWMH_300699	400994	300	US and DS Invert to Survey
SWMH_300710.1	SWMH_300710	400997	375	US and DS Invert to Survey
SWMH_300711.1	SWMH_300711	400998	300	US and DS Invert to Survey
SWMH_300713.1	SWMH_300713	401000	900	US and DS Invert to Survey
SWMH_300715.1	SWMH_300715	401002	300	US and DS Invert to Survey
SWMH_300716.1	SWMH_300716	401003	375	US and DS Invert to Survey
SWMH_300717.1	SWMH_300717	401004	375	US and DS Invert to Survey
SWMH_300718.1	SWMH_300718	401005	375	US and DS Invert to Survey
SWMH_300721.1	SWMH_300721	401008	300	US and DS Invert to Survey
SWMH_300722.1	SWMH_300722	401009	300	US and DS Invert to Survey
SWMH_300723.1	SWMH_300723	401010	600	US and DS Invert to Survey
SWMH_300724.1	SWMH_300724	401011	375	US and DS Invert to Survey
SWMH_300725.1	SWMH_300725	401012	300	US and DS Invert to Survey
SWMH_300726.1	SWMH_300726	401014	375	US and DS Invert to Survey
SWMH_207802.1	SWMH_207802	408314	600	US Invert to survey
SWMH_300727.1	SWMH_300727	401015	375	US and DS Invert to Survey
SWMH_300728.1	SWMH_300728	401016	375	US and DS Invert to Survey
SWMH_300729.1	SWMH_300729	401017	800	US and DS Invert to Survey
SWMH_300730.1	SWMH_300730	404133	600	US and DS Invert to Survey
SWMH_301043.1	SWMH_301043	401306	375	US and DS Invert to Survey
SWMH_301044.1	SWMH_301044	401307	375	US and DS Invert to Survey
SWMH_301045.1	SWMH_301045	101148	300	US and DS Invert to Survey
SWMH_301051.1	SWMH_301051	401303	300	US and DS Invert to Survey
SWMH_301052.1	SWMH_301052	401304	300	US and DS Invert to Survey
SWMH_301055.1	SWMH_301055	101153	300	US and DS Invert to Survey
SWMH_301056.1	SWMH_301056	401308	450	US and DS Invert to Survey
SWMH_301057.1	SWMH_301057	401309	525	US and DS Invert to Survey
SWMH_301058.1	SWMH_301058	401310	300	US and DS Invert to Survey
SWMH_301059.1	SWMH_301059	401312	300	US and DS Invert to Survey
SWMH_301060.1	SWMH_301060	401313	300	US and DS Invert to Survey
SWMH_301062.1	SWMH_301062	401315	525	US and DS Invert to Survey
SWMH_301063.1	SWMH_301063	401316	525	US and DS Invert to Survey
SWMH_301064.1	SWMH_301064	401318	525	US and DS Invert to Survey
SWMH_301065.1	SWMH_301065	401319	450	US and DS Invert to Survey
SWMH_301066.1	SWMH_301066	401320	450	US and DS Invert to Survey
SWMH_301067.1	SWMH_301067	401322	300	US and DS Invert to Survey
SWMH_301068.1	SWMH_301068	401317	300	US and DS Invert to Survey
SWMH_301069.1	SWMH_301069	401013	375	US and DS Invert to Survey
SWMH_301070.1	SWMH_301070	401325	375	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_301071.1	SWMH_301071	401330	450	US and DS Invert to Survey
SWMH_301072.1	SWMH_301072	401331	375	US and DS Invert to Survey
SWMH_301073.1	SWMH_301073	404132	375	US and DS Invert to Survey
SWMH_301074.1	SWMH_301074	401333	375	US and DS Invert to Survey
SWMH_301075.1	SWMH_301075	401334	375	US and DS Invert to Survey
SWMH_301076.1	SWMH_301076	401335	375	US and DS Invert to Survey
SWMH_301079.1	SWMH_301079	401339	525	US and DS Invert to Survey
SWMH_301082.1	SWMH_301082	401343	675	US and DS Invert to Survey
SWMH_301088.1	SWMH_301088	403791	600	US and DS Invert to Survey
SWMH_301089.1	SWMH_301089	401351	525	US and DS Invert to Survey
SWMH_301090.1	SWMH_301090	401353	375	US and DS Invert to Survey
SWMH_301091.1	SWMH_301091	401355	375	US and DS Invert to Survey
SWMH_301092.1	SWMH_301092	401356	600	US and DS Invert to Survey
SWMH_301093.1	SWMH_301093	403899	525	US and DS Invert to Survey
SWMH_301094.1	SWMH_301094	401359	450	US and DS Invert to Survey
SWMH_301096.1	SWMH_301096	401370	300	US and DS Invert to Survey
SWMH_301098.1	SWMH_301098	401360	375	US and DS Invert to Survey
SWMH_301099.1	SWMH_301099	401361	375	US and DS Invert to Survey
SWMH_301100.1	SWMH_301100	401362	375	US and DS Invert to Survey
SWMH_301101.1	SWMH_301101	405964	450	US and DS Invert to Survey
SWMH_301102.1	SWMH_301102	401381	600	US and DS Invert to Survey
SWMH_301105.1	SWMH_301105	401443	300	US and DS Invert to Survey
SWMH_301106.1	SWMH_301106	401440	375	US and DS Invert to Survey
SWMH_301107.1	SWMH_301107	401434	525	US and DS Invert to Survey
SWMH_301108.1	SWMH_301108	401387	450	US and DS Invert to Survey
SWMH_301109.1	SWMH_301109	401390	300	US and DS Invert to Survey
SWMH_301110.1	SWMH_301110	403244	300	US and DS Invert to Survey
SWMH_301111.1	SWMH_301111	401397	375	US and DS Invert to Survey
SWMH_301112.1	SWMH_301112	401394	300	US and DS Invert to Survey
SWMH_301113.1	SWMH_301113	401395	300	US and DS Invert to Survey
SWMH_301114.1	SWMH_301114	401396	300	US and DS Invert to Survey
SWMH_301116.1	SWMH_301116	403228	300	US and DS Invert to Survey
SWMH_301117.2	SWMH_301117	407423	300	US and DS Invert to Survey
SWMH_301118.1	SWMH_301118	401399	375	US and DS Invert to Survey
SWMH_301119.1	SWMH_301119	401401	375	US and DS Invert to Survey
SWMH_301120.1	SWMH_301120	401406	375	US and DS Invert to Survey
SWMH_301121.1	SWMH_301121	401402	375	US and DS Invert to Survey
SWMH_301122.1	SWMH_301122	404136	300	US and DS Invert to Survey
SWMH_301123.1	SWMH_301123	401403	300	US and DS Invert to Survey
SWMH_301124.1	SWMH_301124	401407	450	US and DS Invert to Survey
SWMH_301125.1	SWMH_301125	404138	525	US and DS Invert to Survey
SWMH_301126.1	SWMH_301126	401413	525	US and DS Invert to Survey
SWMH_301127.1	SWMH_301127	401415	300	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_301128.1	SWMH_301128	401409	450	US and DS Invert to Survey
SWMH_301129.1	SWMH_301129	401410	450	US and DS Invert to Survey
SWMH_301130.1	SWMH_301130	401412	375	US and DS Invert to Survey
SWMH_301131.2	SWMH_301131	401419	300	US and DS Invert to Survey
SWMH_301132.1	SWMH_301132	401421	375	US and DS Invert to Survey
SWMH_301133.1	SWMH_301133	401422	600	US and DS Invert to Survey
SWMH_301134.1	SWMH_301134	401512	750	US and DS Invert to Survey
SWMH_301135.1	SWMH_301135	401423	450	US and DS Invert to Survey
SWMH_301136.1	SWMH_301136	401424	450	US and DS Invert to Survey
SWMH_301137.1	SWMH_301137	401426	300	US and DS Invert to Survey
SWMH_301138.1	SWMH_301138	401425	375	US and DS Invert to Survey
SWMH_301139.1	SWMH_301139	401431	300	US and DS Invert to Survey
SWMH_301140.1	SWMH_301140	401430	300	US and DS Invert to Survey
SWMH_301141.1	SWMH_301141	401429	300	US and DS Invert to Survey
SWMH_301143.1	SWMH_301143	401437	600	US and DS Invert to Survey
SWMH_301144.1	SWMH_301144	401435	525	US and DS Invert to Survey
SWMH_301146.1	SWMH_301146	401442	375	US and DS Invert to Survey
SWMH_301147.1	SWMH_301147	401446	375	US and DS Invert to Survey
SWMH_301148.1	SWMH_301148	401447	375	US and DS Invert to Survey
SWMH_301149.1	SWMH_301149	401445	450	US and DS Invert to Survey
SWMH_301151.1	SWMH_301151	401448	300	US and DS Invert to Survey
SWMH_301152.1	SWMH_301152	403249	750	US and DS Invert to Survey
SWMH_301153.1	SWMH_301153	401451	675	US and DS Invert to Survey
SWMH_301157.1	SWMH_301157	401454	825	US and DS Invert to Survey
SWMH_301158.1	SWMH_301158	401455	750	US and DS Invert to Survey
SWMH_301159.1	SWMH_301159	401456	375	US and DS Invert to Survey
SWMH_301160.1	SWMH_301160	401464	825	US and DS Invert to Survey
SWMH_301161.1	SWMH_301161	401465	825	US and DS Invert to Survey
SWMH_301162.1	SWMH_301162	401471	375	US and DS Invert to Survey
SWMH_301163.1	SWMH_301163	401466	825	US and DS Invert to Survey
SWMH_301164.1	SWMH_301164	401468	300	US and DS Invert to Survey
SWMH_301165.1	SWMH_301165	401469	300	US and DS Invert to Survey
SWMH_301166.1	SWMH_301166	401470	300	US and DS Invert to Survey
SWMH_301168.1	SWMH_301168	404141	750	US and DS Invert to Survey
SWMH_301170.1	SWMH_301170	401463	750	US and DS Invert to Survey
SWMH_301171.1	SWMH_301171	401462	750	US and DS Invert to Survey
SWMH_301173.1	SWMH_301173	404139	375	US and DS Invert to Survey
SWMH_301175.1	SWMH_301175	401459	375	US and DS Invert to Survey
SWMH_301176.1	SWMH_301176	401507	375	US and DS Invert to Survey
SWMH_301177.1	SWMH_301177	401474	375	US and DS Invert to Survey
SWMH_301178.1	SWMH_301178	401473	300	US and DS Invert to Survey
SWMH_301179.1	SWMH_301179	401472	300	US and DS Invert to Survey
SWMH_301181.1	SWMH_301181	404135	300	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_301182.1	SWMH_301182	401475	300	US and DS Invert to Survey
SWMH_301183.1	SWMH_301183	401476	300	US and DS Invert to Survey
SWMH_301187.1	SWMH_301187	401487	375	US and DS Invert to Survey
SWMH_301188.1	SWMH_301188	401490	350	US and DS Invert to Survey
SWMH_301189.1	SWMH_301189	403901	450	US and DS Invert to Survey
SWMH_301190.1	SWMH_301190	401488	375	US and DS Invert to Survey
SWMH_301191.1	SWMH_301191	401489	375	US and DS Invert to Survey
SWMH_301193.1	SWMH_301193	401480	750	US and DS Invert to Survey
SWMH_301194.1	SWMH_301194	401485	300	US and DS Invert to Survey
SWMH_300712.1	SWMH_300712	400999	300	US Invert to survey
SWMH_301195.1	SWMH_301195	101363	300	US and DS Invert to Survey
SWMH_301197.1	SWMH_301197	401481	300	US and DS Invert to Survey
SWMH_301198.1	SWMH_301198	401479	750	US and DS Invert to Survey
SWMH_301199.1	SWMH_301199	101344	300	US and DS Invert to Survey
SWMH_301202.1	SWMH_301202	401492	300	US and DS Invert to Survey
SWMH_301203.1	SWMH_301203	401493	300	US and DS Invert to Survey
SWMH_301204.1	SWMH_301204	401497	375	US and DS Invert to Survey
SWMH_301205.1	SWMH_301205	401496	375	US and DS Invert to Survey
SWMH_301206.1	SWMH_301206	401495	375	US and DS Invert to Survey
SWMH_301209.1	SWMH_301209	101400	300	US and DS Invert to Survey
SWMH_301210.1	SWMH_301210	405206	300	US and DS Invert to Survey
SWMH_301211.1	SWMH_301211	401510	300	US and DS Invert to Survey
SWMH_300719.1	SWMH_300719	401006	450	US Invert to survey
SWMH_300720.1	SWMH_300720	401007	450	US Invert to survey
SWMH_301212.1	SWMH_301212	401511	300	US and DS Invert to Survey
SWMH_301213.1	SWMH_301213	401508	300	US and DS Invert to Survey
SWMH_301214.1	SWMH_301214	401505	375	US and DS Invert to Survey
SWMH_301215.1	SWMH_301215	401506	375	US and DS Invert to Survey
SWMH_301619.1	SWMH_301619	402139	300	US and DS Invert to Survey
SWMH_301620.1	SWMH_301620	402140	375	US and DS Invert to Survey
SWMH_301621.1	SWMH_301621	402141	450	US and DS Invert to Survey
SWMH_301622.1	SWMH_301622	402142	450	US and DS Invert to Survey
SWMH_301623.1	SWMH_301623	402143	600	US and DS Invert to Survey
SWMH_301624.1	SWMH_301624	402144	675	US and DS Invert to Survey
SWMH_301631.1	SWMH_301631	402173	300	US and DS Invert to Survey
SWMH_301649.1	SWMH_301649	401391	300	US and DS Invert to Survey
SWMH_301926.1	SWMH_301926	403673	375	US and DS Invert to Survey
SWMH_301928.1	SWMH_301928	403675	375	US and DS Invert to Survey
SWMH_301929.1	SWMH_301929	403674	525	US and DS Invert to Survey
SWMH_301933.1	SWMH_301933	403677	525	US and DS Invert to Survey
SWMH_301997.1	SWMH_301997	401352	525	US and DS Invert to Survey
SWMH_302001.1	SWMH_302001	404128	300	US and DS Invert to Survey
SWMH_302002.1	SWMH_302002	404130	675	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_302003.1	SWMH_302003	404131	375	US and DS Invert to Survey
SWMH_302004.1	SWMH_302004	401332	375	US and DS Invert to Survey
SWMH_302006.1	SWMH_302006	401020	600	US and DS Invert to Survey
SWMH_302012.1	SWMH_302012	403826	300	US and DS Invert to Survey
SWMH_302014.1	SWMH_302014	404140	600	US and DS Invert to Survey
SWMH_301186.1	SWMH_301186	101332	900	Assumed diameter. US & DS Invert to survey
SWMH_302021.1	SWMH_302021	406001	525	US and DS Invert to Survey
SWMH_302022.1	SWMH_302022	403852	375	US and DS Invert to Survey
SWMH_302023.1	SWMH_302023	401461	750	US and DS Invert to Survey
SWMH_302037.1	SWMH_302037	401486	525	US and DS Invert to Survey
SWMH_302105.1	SWMH_302105	401342	675	US and DS Invert to Survey
SWMH_302106.1	SWMH_302106	404107	450	US and DS Invert to Survey
SWMH_302465.1	SWMH_302465	404924	300	US and DS Invert to Survey
SWMH_302477.1	SWMH_302477	404930	300	US and DS Invert to Survey
SWMH_302479.1	SWMH_302479	404932	300	US and DS Invert to Survey
SWMH_302803.1	SWMH_302803	405789	300	US and DS Invert to Survey
SWMH_302804.1	SWMH_302804	405790	300	US and DS Invert to Survey
SWMH_302805.1	SWMH_302805	405791	300	US and DS Invert to Survey
SWMH_302806.1	SWMH_302806	405792	300	US and DS Invert to Survey
SWMH_302807.1	SWMH_302807	405793	300	US and DS Invert to Survey
SWMH_302876.1	SWMH_302876	405961	450	US and DS Invert to Survey
SWMH_302877.1	SWMH_302877	405962	450	US and DS Invert to Survey
SWMH_302878.1	SWMH_302878	405955	300	US and DS Invert to Survey
SWMH_302879.1	SWMH_302879	405954	300	US and DS Invert to Survey
SWMH_302880.1	SWMH_302880	405966	300	US and DS Invert to Survey
SWMH_302881.1	SWMH_302881	405967	300	US and DS Invert to Survey
SWMH_302882.1	SWMH_302882	405980	525	US and DS Invert to Survey
SWMH_302885.1	SWMH_302885	405983	525	US and DS Invert to Survey
SWMH_302886.1	SWMH_302886	405985	450	US and DS Invert to Survey
SWMH_302887.1	SWMH_302887	405987	300	US and DS Invert to Survey
SWMH_302889.1	SWMH_302889	406000	525	US and DS Invert to Survey
SWMH_303333.1	SWMH_303333	406949	300	US and DS Invert to Survey
SWMH_303334.1	SWMH_303334	406950	300	US and DS Invert to Survey
SWMH_303356.1	SWMH_303356	406988	300	US and DS Invert to Survey
SWMH_303357.1	SWMH_303357	406987	300	US and DS Invert to Survey
SWMH_303358.1	SWMH_303358	406986	300	US and DS Invert to Survey
SWMH_303401.1	SWMH_303401	407088	375	US and DS Invert to Survey
SWMH_303402.1	SWMH_303402	407085	300	US and DS Invert to Survey
SWMH_303403.1	SWMH_303403	407089	375	US and DS Invert to Survey
SWMH_303404.1	SWMH_303404	407091	375	US and DS Invert to Survey
SWMH_303405.1	SWMH_303405	407094	300	US and DS Invert to Survey
SWMH_303406.1	SWMH_303406	407096	300	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_303407.1	SWMH_303407	407097	300	US and DS Invert to Survey
SWMH_303408.1	SWMH_303408	407098	300	US and DS Invert to Survey
SWMH_303409.1	SWMH_303409	407099	300	US and DS Invert to Survey
SWMH_303410.1	SWMH_303410	407100	450	US and DS Invert to Survey
SWMH_303496.1	SWMH_303496	407337	300	US and DS Invert to Survey
SWMH_303554.1	SWMH_303554	407424	300	US and DS Invert to Survey
SWMH_303620.1	SWMH_303620	408065	450	US and DS Invert to Survey
SWMH_303621.1	SWMH_303621	408064	450	US and DS Invert to Survey
SWMH_301078.1	SWMH_301078	401340	700	Assumed diameter. US & DS Invert to survey
SWMH_303622.1	SWMH_303622	408063	600	US and DS Invert to Survey
SWMH_303720.1	SWMH_303720	408313	600	US and DS Invert to Survey
SWMH_303779.1	SWMH_303779	408434	300	US and DS Invert to Survey
SWMH_301083.1	SWMH_301083	401349	600	Assumed diameter. US & DS Invert to survey
SWMH_301085.1	SWMH_301085	401348	600	Assumed diameter. US & DS Invert to survey
SWMH_301086.1	SWMH_301086	401347	600	Assumed diameter. US & DS Invert to survey
SWMH_301087.1	SWMH_301087	401346	600	Assumed diameter. US & DS Invert to survey
SWMH_303812.1	SWMH_303812	405927	300	US and DS Invert to Survey
SWMH_303813.1	SWMH_303813	405978	375	US and DS Invert to Survey
SWMH_303833.1	SWMH_303833	408519	300	US and DS Invert to Survey
SWMH_550021.1	SWMH_550021	401357	525	US and DS Invert to Survey
SWMH_550421.1	SWMH_550421	401341	600	US and DS Invert to Survey
SWMH_550422.1	SWMH_550422	404106	675	US and DS Invert to Survey
SWMH_550423.1	SWMH_550423	401019	600	US and DS Invert to Survey
SWMH_550929.1	SWMH_550929	401323	700	US and DS Invert to Survey
SWMH_550930.1	SWMH_550930	401404	300	US and DS Invert to Survey
SWMH_550931.1	SWMH_550931	404137	375	US and DS Invert to Survey
SWMH_550932.1	SWMH_550932	403851	525	US and DS Invert to Survey
SWMH_550934.1	SWMH_550934	401467	750	US and DS Invert to Survey
SWMH_550935.1	SWMH_550935	403892	450	US and DS Invert to Survey
SWMH_550938.1	SWMH_550938	401358	525	US and DS Invert to Survey
SWMH_301095.1	SWMH_301095	401369	300	US Invert to survey
SWMH_550939.1	SWMH_550939	403900	525	US and DS Invert to Survey
SWMH_550951.1	SWMH_550951	403762	375	US and DS Invert to Survey
SWMH_302020.1	SWMH_302020	403850	600	Assumed diameter. US & DS Invert to survey
SWMH_551781.1	SWMH_551781	400995	300	US and DS Invert to Survey
SWMH_551782.1	SWMH_551782	401305	375	US and DS Invert to Survey
SWMH_551783.1	SWMH_551783	401311	300	US and DS Invert to Survey
SWMH_551784.1	SWMH_551784	404129	675	US and DS Invert to Survey
SWMH_551785.1	SWMH_551785	101205	375	US and DS Invert to Survey
SWMH_551786.1	SWMH_551786	403225	300	US and DS Invert to Survey
SWMH_551787.1	SWMH_551787	401420	375	US and DS Invert to Survey

Recommended Conduit Survey Locations				
Conduit ID	Upstream Node ID	TCDC Asset ID	Diameter (>225mm)	Survey Recommendation
SWMH_551789.1	SWMH_551789	401438	900	US and DS Invert to Survey
SWMH_551790.1	SWMH_551790	401491	375	US and DS Invert to Survey
SWMH_551791.1	SWMH_551791	401483	450	US and DS Invert to Survey
SWMH_551792.1	SWMH_551792	405205	300	US and DS Invert to Survey
SWMH_552439.1	SWMH_552439	401314	525	US and DS Invert to Survey
SWMH_552442.1	SWMH_552442	401354	300	US and DS Invert to Survey
SWMH_552501.1	SWMH_552501	403898	525	US and DS Invert to Survey
SWMH_552546.1	SWMH_552546	401321	450	US and DS Invert to Survey
SWMH_552917.1	SWMH_552917	405806	300	US and DS Invert to Survey
SWMH_552935.1	SWMH_552935	405979	375	US and DS Invert to Survey
SWMH_552936.1	SWMH_552936	405981	525	US and DS Invert to Survey
SWMH_552940.1	SWMH_552940	405986	450	US and DS Invert to Survey
SWMH_552950.1	SWMH_552950	406025	525	US and DS Invert to Survey
SWMH_552951.1	SWMH_552951	406024	525	US and DS Invert to Survey
SWMH_553141.1	SWMH_553141	406984	300	US and DS Invert to Survey
SWMH_301154.1	SWMH_301154	401452	900	Assumed diameter. US & DS Invert to survey
SWMH_301155.1	SWMH_301155	403889	900	Assumed diameter. US & DS Invert to survey
SWMH_301156.1	SWMH_301156	Not in GIS	1050	Not showing on TCDC GIS
SWMH_302104.1	SWMH_302104	404105	375	Assumed diameter. US & DS Invert to survey
SWMH_301192.1	SWMH_301192	401484	575	US Invert to survey
SWMH_301196.1	SWMH_301196	401482	450	US Invert to survey
SWMH_301200.1	SWMH_301200	401477	900	US Invert to survey
SWMH_301201.1	SWMH_301201	401478	300	US Invert to survey
SWMH_301207.1	SWMH_301207	401494	375	US Invert to survey
SWMH_301650.1	SWMH_301650	403248	825	US Invert to survey
SWMH_301927.1	SWMH_301927	403674A	375	US Invert to survey
SWMH_302011.1	SWMH_302011	401450	600	DS Invert to Survey
SWMH_551146.1	SWMH_551146	Not in GIS	300	Not showing on TCDC GIS
SWMH_303411.1	SWMH_303411	407101	450	US Invert to survey
SWMH_303553.1	SWMH_303553	401393	375	DS Invert to Survey
SWMH_303666.1	SWMH_303666	408157	300	DS Invert to Survey
SWMH_303667.1	SWMH_303667	408159	300	DS Invert to Survey
SWMH_551160.1	SWMH_551160	Not in GIS	600	Not showing on TCDC GIS
SWMH_552381.1	SWMH_552381	101397	300	US Invert to survey
SWMH_552441.1	SWMH_552441	402145	300	US Invert to survey
SWMH_554057.1	SWMH_554057	Not in GIS	600	Not showing on TCDC GIS
WP_SWMH_2.1	WP_SWMH_2	Not in GIS	1050	Not showing on TCDC GIS
WP_SWMH_3.1	WP_SWMH_3	Not in GIS	1050	Not showing on TCDC GIS

Recommended Conduit Reducing Diameter Locations			
Conduit ID	**Node ID**	**Location**	**Description**
SWCP_207755.1	SW_Storage_553054	801 Otahu Rd	Soakage System at Otahu Rd pump station (confirmed by drawings)
SWMH_201689.1	SWMH_551785	1000 Port Rd	525 mm Ø into 375 mm Ø Likely some storage/soakage system
SWMH_201692.1	SWMH_301110	804 Port Rd	525 mm Ø into 375 mm Ø Likely some storage/soakage system
SWMH_201694.1	SWMH_551785	906 Port Rd	525 mm Ø into 375 mm Ø Likely some storage/soakage system
SWMH_201695.1	SWMH_201696	1006 Port Rd	525 mm Ø into 225 mm Ø Likely some storage/soakage system
SWMH_201795.1	SWMH_203338	322 Williamson Rd	450 mm Ø into 300 mm Ø No significant impact expected
SWMH_203397.1	SWMH_203398	100 Ocean Rd	375 mm Ø into 300 mm Ø No significant impact expected
SWMH_204155.1	SWMH_550935	620 Port Rd	525 mm Ø into 450 mm Ø No significant impact expected
SWMH_204516.1	SWMH_203248	Near parking area behind 103 Winifred Ave	300 mm Ø into 225 mm Ø No significant impact expected
SWMH_301102.1	SWMH_301101	103 Winifred Avenue	600 mm Ø to 450 mm Ø Confirmed by survey
SWMH_301111.1	SWMH_301117	329 Port Rd	Flow split 375 mm Ø into 375 & 300 mm Ø
SWMH_302020.1	SWMH_301085	212 Martyn Rd (playground near golf club)	675 mm Ø into 450 mm Ø This has been modelled as a 600mm dia continuous pipe
SWMH_302105.1	SWMH_550421	300 Hetherington Rd	675 mm Ø to 600 mm Ø To be confirmed
SWMH_302876.1	SWMH_301099	100 Hetherington Rd	450 mm Ø into 375 mm Ø Confirmed by survey
SWMH_303404.1	SW_303405	123 Seabreeze Ln	375 mm Ø into 300 mm Ø To be confirmed
SWMH_303779.1	SWMH_303778	108 Casement Rd	300 mm Ø into 225 mm Ø No significant impact expected
SWMH_553141.1	SWMH_203249	Near parking area behind 103 Winifred Ave	300 mm Ø into 225 mm Ø No significant impact expected