The East Harbour Stormwater Catchment

Model Build Report

Our water, our future.

Contents

1. Introduction

This report has been prepared to detail modelling analysis of the East Harbour stormwater catchment undertaken using InfoWorks Integrated Catchment Modelling (ICM) software.

This modelling study has been undertaken by Wellington Water Limited (Wellington Water Ltd) to assist management of stormwater in the catchment. The model is to be used for the generation of flood hazard maps and may subsequently be used to assess options for upgrading the stormwater system to mitigate flooding in the catchment.

1.1. Study Objectives

The objective of this study is to provide Wellington Water Ltd with an ICM stormwater/flooding model of the East Harbour catchment. The model is to include the stormwater reticulation network dynamically linked to the ground surface.

The model is to be used to produce flood maps for various design storm events with the current land use. The model should be suitable for use in detailed design of remedial options, setting recommended building levels, assessment of development impacts and for testing the impacts of increased rainfall intensity and sea level due to climate change.

The model will not be required to test coastal processes.

1.2. Model Build Summary

A model of the East Harbour stormwater catchment was developed for this study using InfoWorks ICM software. The model was developed using:

- Network data (GIS shape files);
- LiDAR derived digital elevation model (DEM);
- Raster layers representing hydrology curve number, hydrology initial losses, and surface roughness;
- As-built drawings sourced from Hutt City Council

This was supplemented with engineering judgement.

The model has been built to a high level of detail and includes all sumps, manholes, pipes, inlets and outlets identified from GIS data and as-builts available to Wellington Water, aerial imagery and Google Street view. Larger open channels have been modelled as one-dimensional river reaches and a fine mesh has been used in the two-dimensional model domain throughout the study area.

2. Catchment Description

2.1. Location

The study area for the East Harbour storm water model is shown in Figure 1. The model covers an area of approximately 790 hectares, which includes Eastbourne, Days Bay, Mahina Bay, York Bay and Lowry Bay.

The study area is bounded to the east by the ridgeline that runs through East Harbour National Park and the west by Wellington Harbour. The Northern boundary is the Point Howard and the southern boundary is Camp Bay which hasn't been included in the study area.

2.2. Terrain

The topography of the East Harbour study area is defined by the ridge on its eastern boundary and a maximum elevation of 373 m RL at ridge bounding Lowry Bay. The study area is relatively steep, draining to a flat floodplain extending along the shore. Figure 2 shows the general topography of the catchment.
The study area consists of five independently draining catchments, Eastbourne, Days Bay, Mahina Bay, York Bay and Lowry Bay and can be represented as one large or five smaller models with no effects on the modelling results.

2.3. Geology

From the GNS Science Geology Web Map, the basin in East Harbour (from the top of the ridge down to the shore) is composed of Sandstone and mudstone with minor conglomerate, basalt and chert; deformed locally, including broken formation and melange.

2.4. Landuse

Land use in the East Harbour catchment is predominantly Hill Residential in Lowry, York and Mahina bays while in Eastbourne the land use is predominantly General Residential see Figure 3. The land beyond residential areas, mainly on the hills bounding the catchment is classified as General Recreation.

2.5. Stormwater Drainage System

The East Harbour stormwater networks drain to a large number of outfalls, either within the harbour itself or into one of the small open drains/streams draining into it. Those draining into the harbour, in particular in Eastbourne, are subject to significant tidal influences which result in blockages of outlets with sand. There has been significant flooding within Eastbourne in recent years due to outlet blockages. There are several outlets that discharge into excavated basins on the beach.

The steep hills that bound the residential areas to the East, have a large watershed, which at several locations, result in flows exceeding conveying capacity of the downstream network resulting in reoccurring flooding events. Examples of this is flooding at Nikau St and Rona St in Eastbourne and Walter Rd/Cheviot Rd in Lowry Bay.

An important feature of Eastbourne catchment is a prevalence of private drainage discharging to local soak pits.

2.6. Reported Flooding Issues

Flooding is known to have occurred during February 2004, October 2009 and April 2019 storm events in Eastbourne, Days Bay and Lowry Bay. In low laying areas of Eastbourne, flooding issues are likely to be compounded by high tides and storm surge which would limit the capacity of the stormwater network.

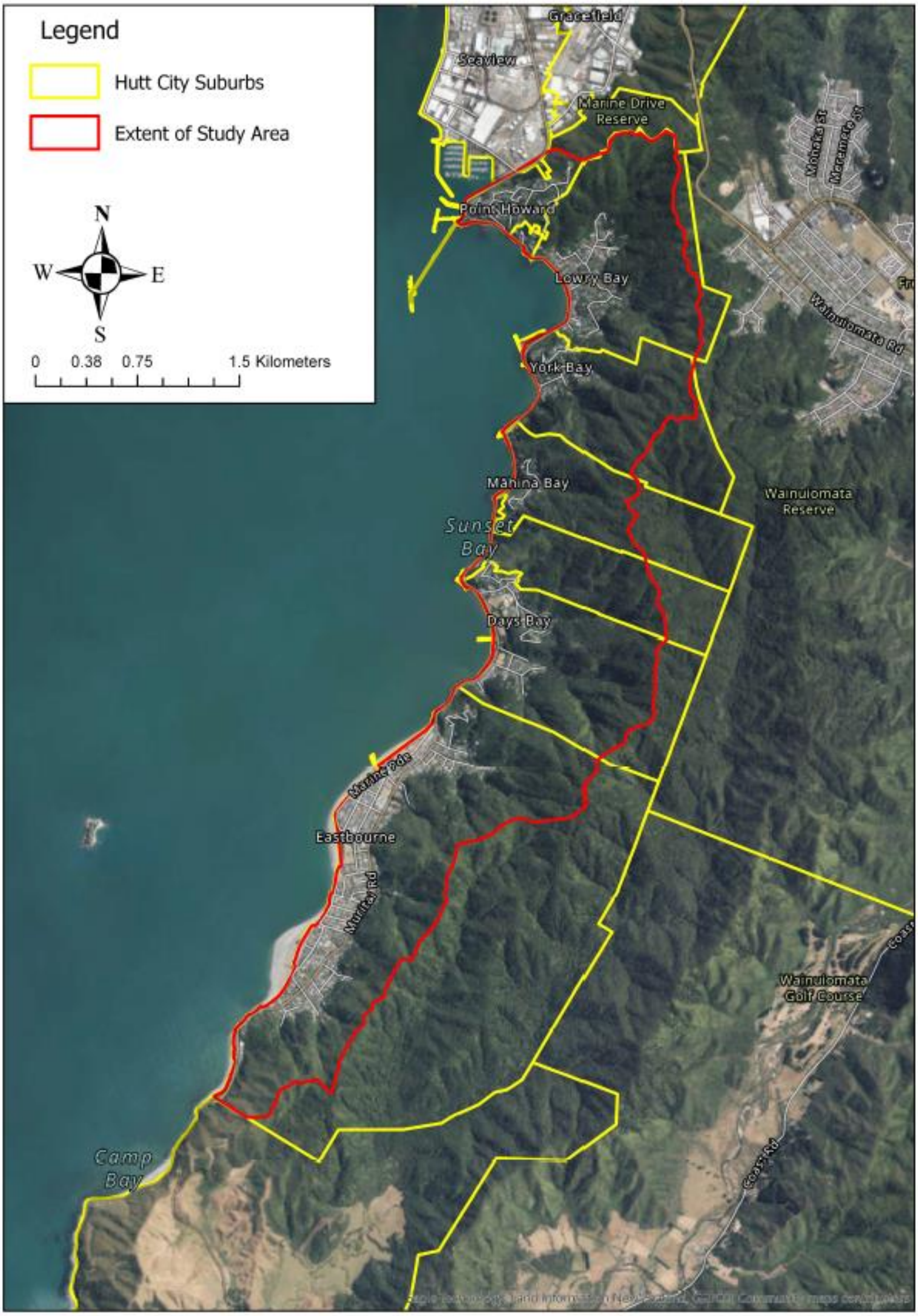


Figure 1 Catchment Location

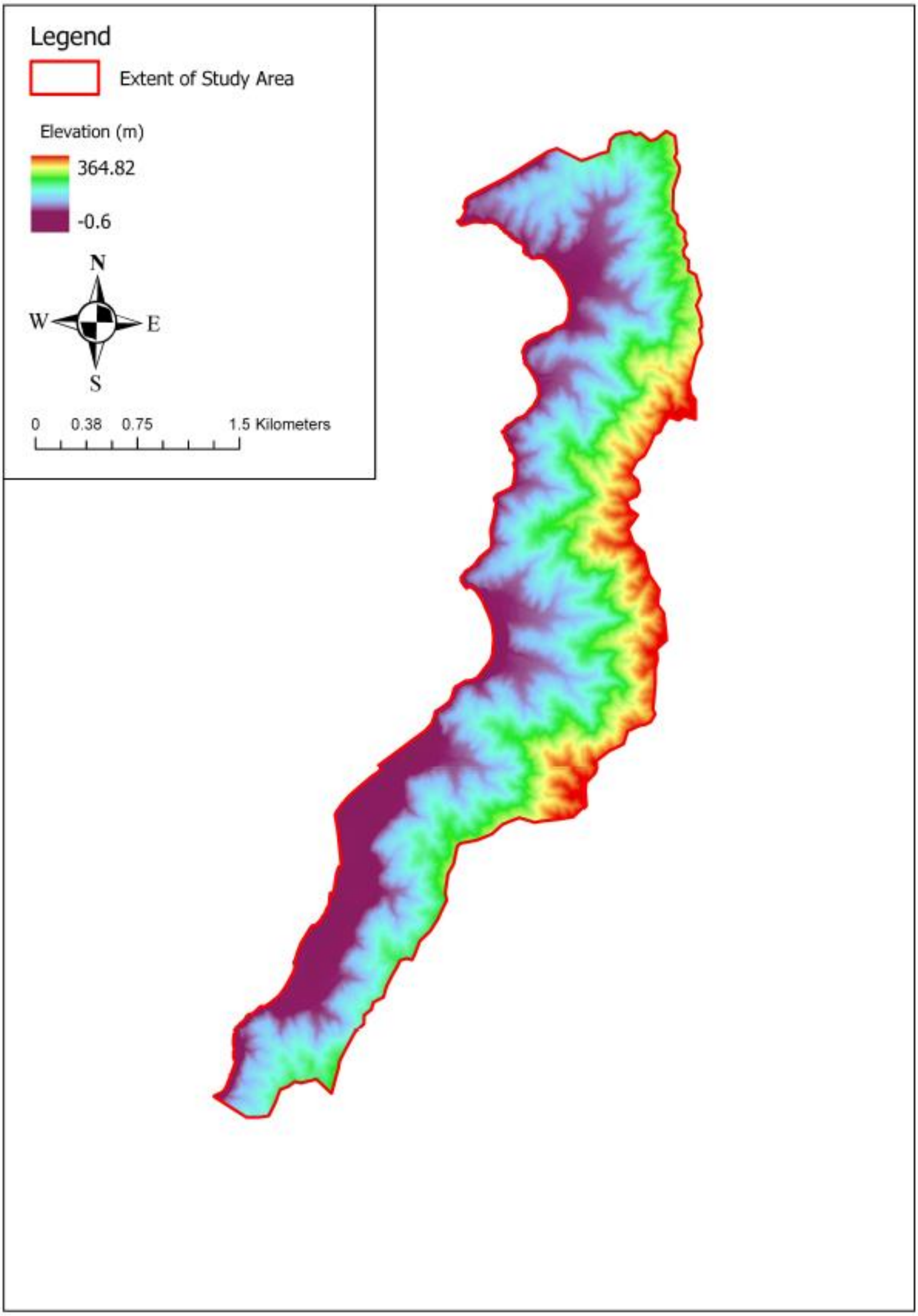


Figure 2 Topography

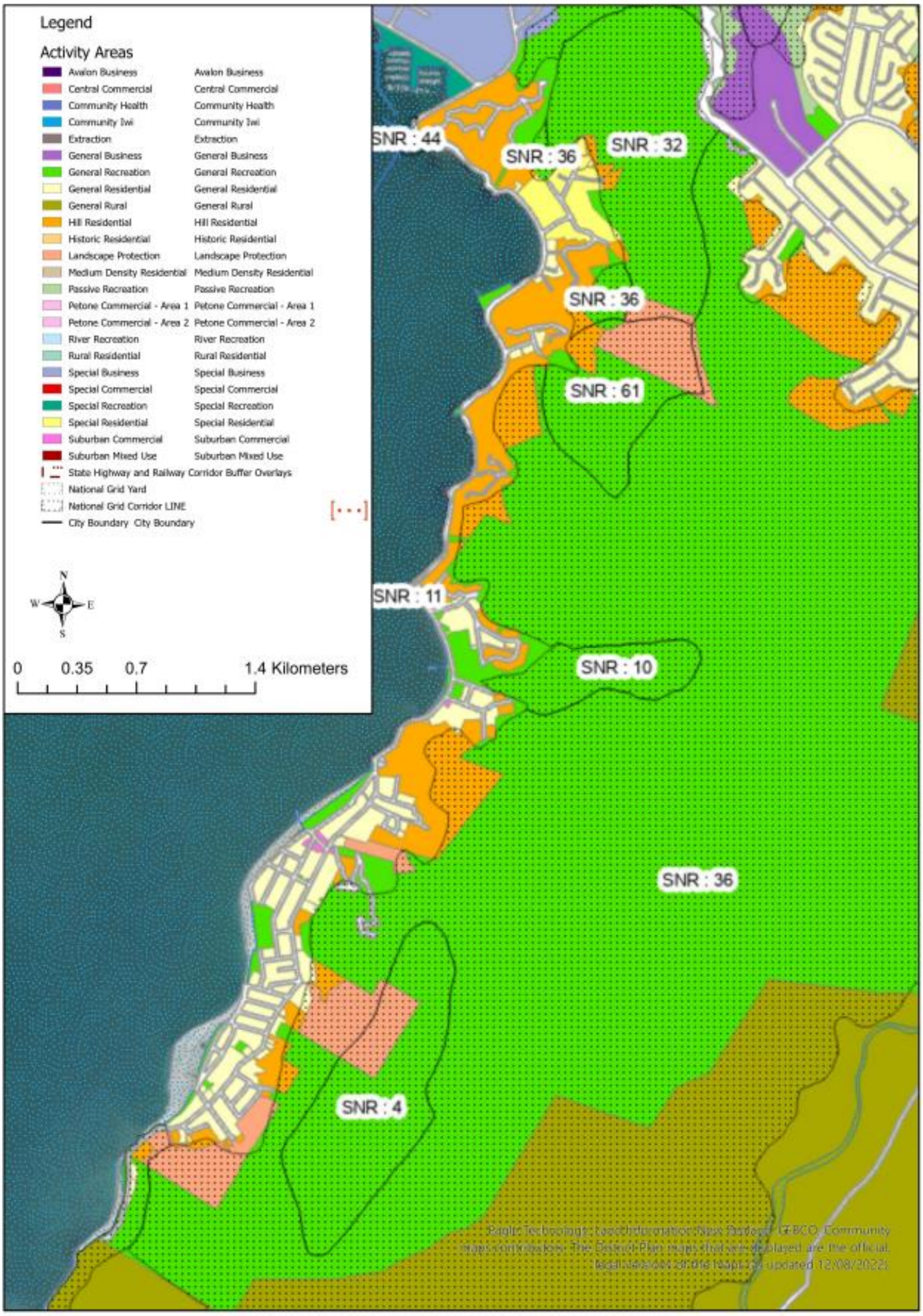


Figure 3 Land use designation

3. Model Build

3.1. Modelling Software

The model has been developed using the Innovyze software InfoWorks ICM v2023.2.2.

3.2. Data

3.2.1. Data Flags

Data from variety of sources has been used in the creation of the model. To identify its origin, the data has been flagged and the flag description provided in Appendix A.

3.2.2. Hydrologic / Hydrometric Data

Land use designation, curve numbers and surface roughness layers were available at Wellington Water Ltd for use in the model. These layers were spot checked and found to be reasonably sound. One exception that was identified is a paper road extending from MacKenzie Road into the upper hillside (Figure 4) which is recorded as almost impervious with CN value of 91. As this road does not exist, the composite CN value of the delineated subcatchment was greater than it is. The CN value for the subcatchment was revised from 67.81 to 63, to be consistent with CN value of the area at large.

3.2.3. Asset Data

The 1-D pipe network model is primarily based on GIS data available at Wellington Water Ltd in November 2019. All stormwater network assets that could be identified from the supplied GIS data have been included in the model, apart from some small diameter privately owned service lines that discharge to the kerb and channel. The extent of stormwater network model represented in the model is shown in Figure 5.

3.2.4. As-Built Data

As-built plans for sections of the pipe network were sourced from HCC in June 2019. The plans were reviewed to obtain additional asset information. The plans were predominantly used for invert levels of pipes and manholes and to confirm the connectivity of missing pipes.

3.2.5. Topographical Data

A 1m × 1m LiDAR derived digital elevation model (DEM) was available at Wellington Water Ltd to use in the model. Most of the urban areas that are included in the East Harbour model have a good coverage by 2016 LiDAR however some of the areas in the upper reaches of the hills do not have 2016 LiDAR coverage. To provide full coverage a combination 2013/2016 LiDAR was produced. This was deemed appropriate as the areas where better confidence was needed, did have the most recent LiDAR coverage and the more dated LiDAR was used for completeness in the hilly areas where high confidence was not deemed necessary.

The LiDAR did not fully represent ground surface in the tidal zone where tidal boundary needs to be applied. To represent tidal zone in the model, the DEM was updated to include the bathymetry data from the Wellington Harbour.

Figure 4 Non existent road with CN value of 91

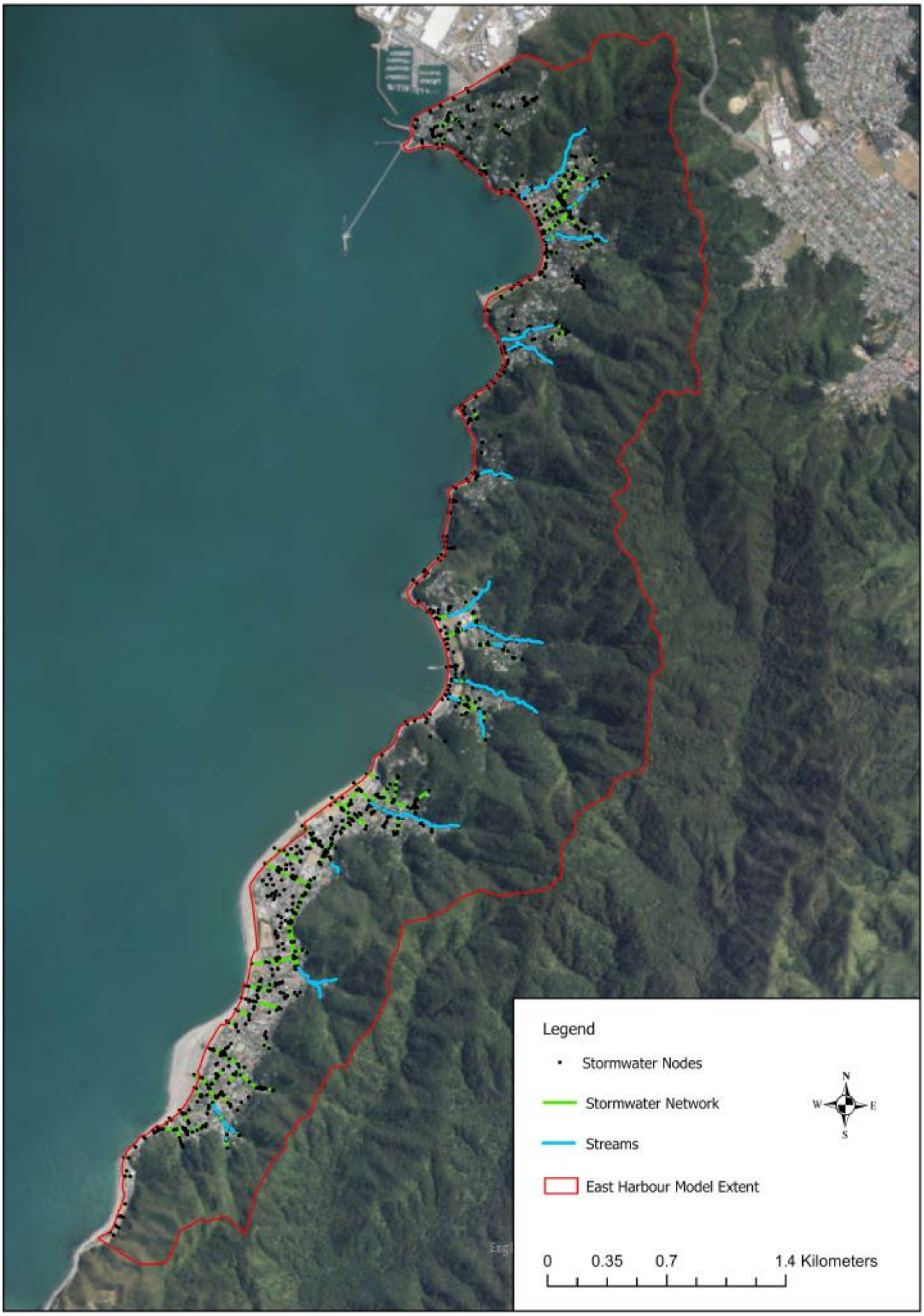


Figure 5 Drainage Network

3.3. Hydrological Model

3.3.1. Methodology

Catchment based hydrological models were developed in accordance with the *Quick Reference Guide for Design Storm Hydrology*, February 2016. This requires the use of the Soil Conservation Services (SCS) unit hydrograph method for sub-catchments applied in accordance with the Wellington Water *Quick Reference Guide for Design Storm Hydrology*, February 2016

3.3.2. Sub-catchment Delineation

3.3.2.1. Urban Sub-catchment Delineation

Sub-catchments have been delineated for each sump and open channel. Sub-catchment delineation was in accordance with the Wellington Water *Quick Reference Guide for Design Storm Hydrology*, February 2016 and was carried out using the UMM tool.

Sub-catchments were also delineated for each building with a direct drainage connection to the stormwater network. This is a significantly finer scale of catchment delineation than is typically applied to urban stormwater models. This approach allows the discharges from the hydrological model to be widely distributed across the hydraulic model.

3.3.2.2. Rural Sub-catchment Delineation

As large parts of the catchment were undeveloped there were also larger sub-catchments that were modelled as hydrological catchments connected to 1-D streams or discharging onto the 2-D surface. The largest sub-catchment was 58 ha and there were 7 sub-catchments with a total area larger than 20 ha. The average area of the 2D sub-catchments was 0.2 ha and of 1D sub-catchments was 4 ha

The study area has been delineated into 826 sub-catchments, as shown in **Error! Reference source not found.** consisting of 552 sub-catchments delineated for sumps and inlets, 110 to 1D open channels, 164 delineated to 2-D streams especially in the upper rural catchment and 117 sub-catchments delineated for buildings with a direct connection to the network.

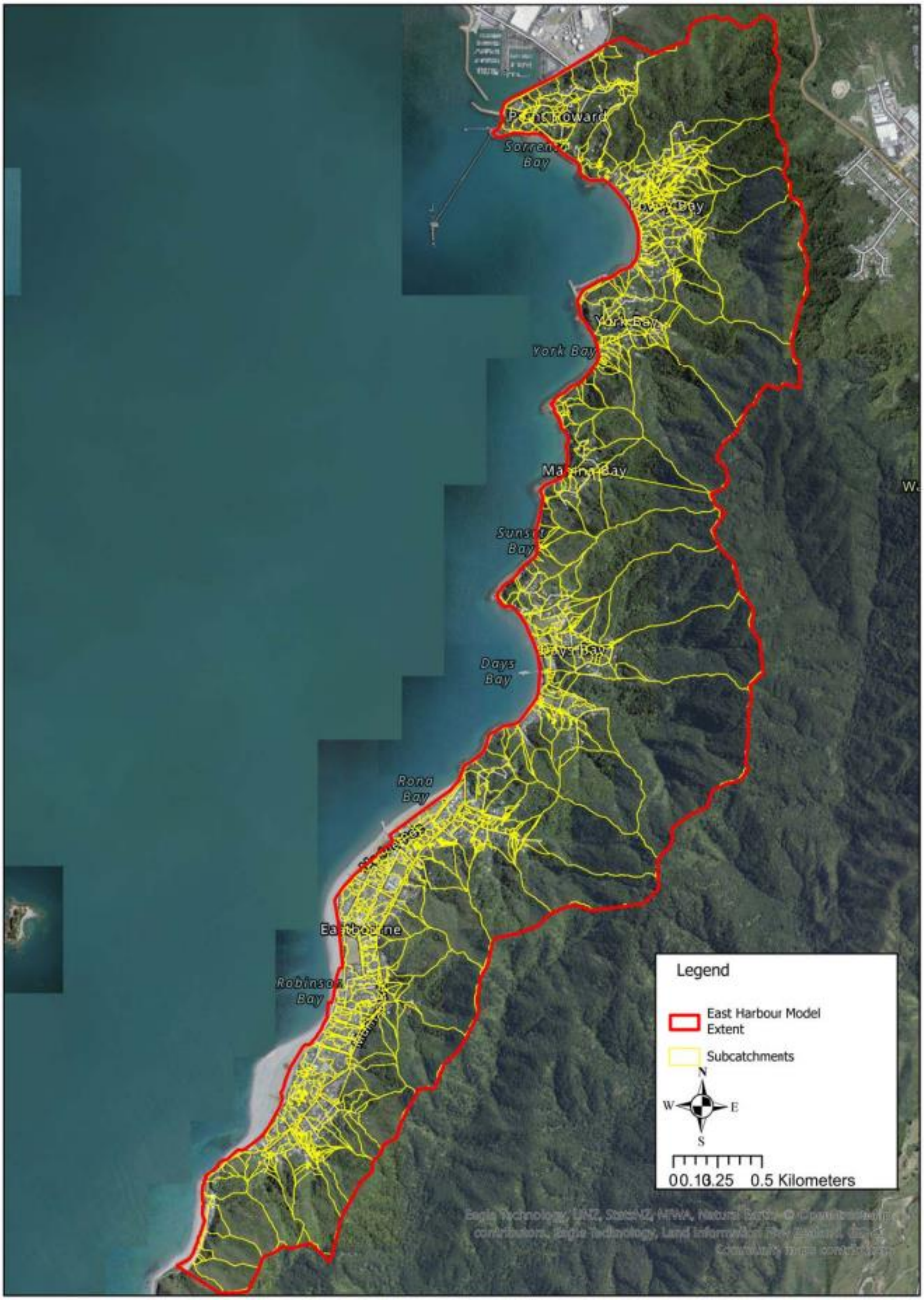


Figure 6 Delineated watershed sub-catchments

3.3.3. Rainfall

Rainfall depths for 63.3%, 50%, 20%, 10%, 5%, 2% and 1% Annual Exceedance Probability (AEP) events with for 10 minute to 12 hour durations were obtained from NIWA's (National Institute of Water and Atmosphere) HIRDS Version 4 software available as a web based programme at http://hirds.niwa.co.nz/ for the catchment centroid and are given in Table 1 below:

Table 1: Rainfall Depths of Different AEP Obtained from HIRDS Version 4

ARI (Year)	AEP (%)	Rainfall Depths (mm)							
Duration (hrs)		0.17	0.33	0.5	1	2	6	12	24
1.58	63.3	6.85	9.37	11.5	16.5	24.1	44.1	63.3	88.1
2	50	7.53	10.3	12.6	18.1	26.5	48.4	69.4	96.5
5	20	9.88	13.5	16.5	23.7	34.6	63.0	90.3	125
10	10	11.7	15.9	19.4	27.9	40.7	74.0	106	147
20	5	13.5	18.4	22.5	32.2	47.0	85.4	122	169
50	2	16.1	21.9	26.7	38.3	55.8	101	144	200
100	1	18.1	24.7	30.1	43.1	62.6	114	162	224

3.3.4. Rainfall – Runoff Model Parameters

The Soil Conservation Service (SCS) unit hydrograph methodology was used with an initial and constant loss approach in accordance with the *Quick Reference Guide for Design Storm Hydrology* (Cardno 2016). The parameters for this method were calibrated for the Wellington Region during the development of the Quick Reference Guide.
Key parameters of this approach are:

- Sub-catchment area;
- Initial Abstraction (represents the depth of rainfall that falls before runoff occurs, i.e. surface wetting and depression storage);
- Antecedent Moisture Conditions;
- Curve Number; and
- Time of Concentration.

The sub-catchment parameters for East Harbour catchment were estimated using an area weighted mean for the curve number and initial abstraction parameters.

The *Quick Reference Guide for Design Storm Hydrology*, (Cardno 2016) provides the equations for calculating the time of concentration for use in the Unit Hydrograph model. The time of overland flow has been applied over a maximum distance of 50m. The shallow concentrated flow equation has been applied over a maximum distance of 100m starting from the end of the overland flow component. The kerb flow equation has been applied from the point where the flow path enters the road as identified from the roughness layer or from the end of the shallow concentrated flow component. A minimum time of concentration of 5 minutes has been applied.

As the pipe networks and open channels have been included in the hydraulic model it was not necessary to use the time of open channel flow and time of pipe flow equations.

For building sub-catchments, the Time of Concentration has been set to 5 minutes.

3.4. Hydraulic Model

A coupled 1-D and 2-D hydraulic model has been developed in InfoWorks ICM to represent flow interchanges between the 1-D pipe network, 1-D open channels and the 2-D surface. The hydraulic model set up is shown in **Error! Reference source not found.**. Further detail on aspects of the set up are provided in the subsequent sub-sections, Sections 3.4.1 to 3.4.7.

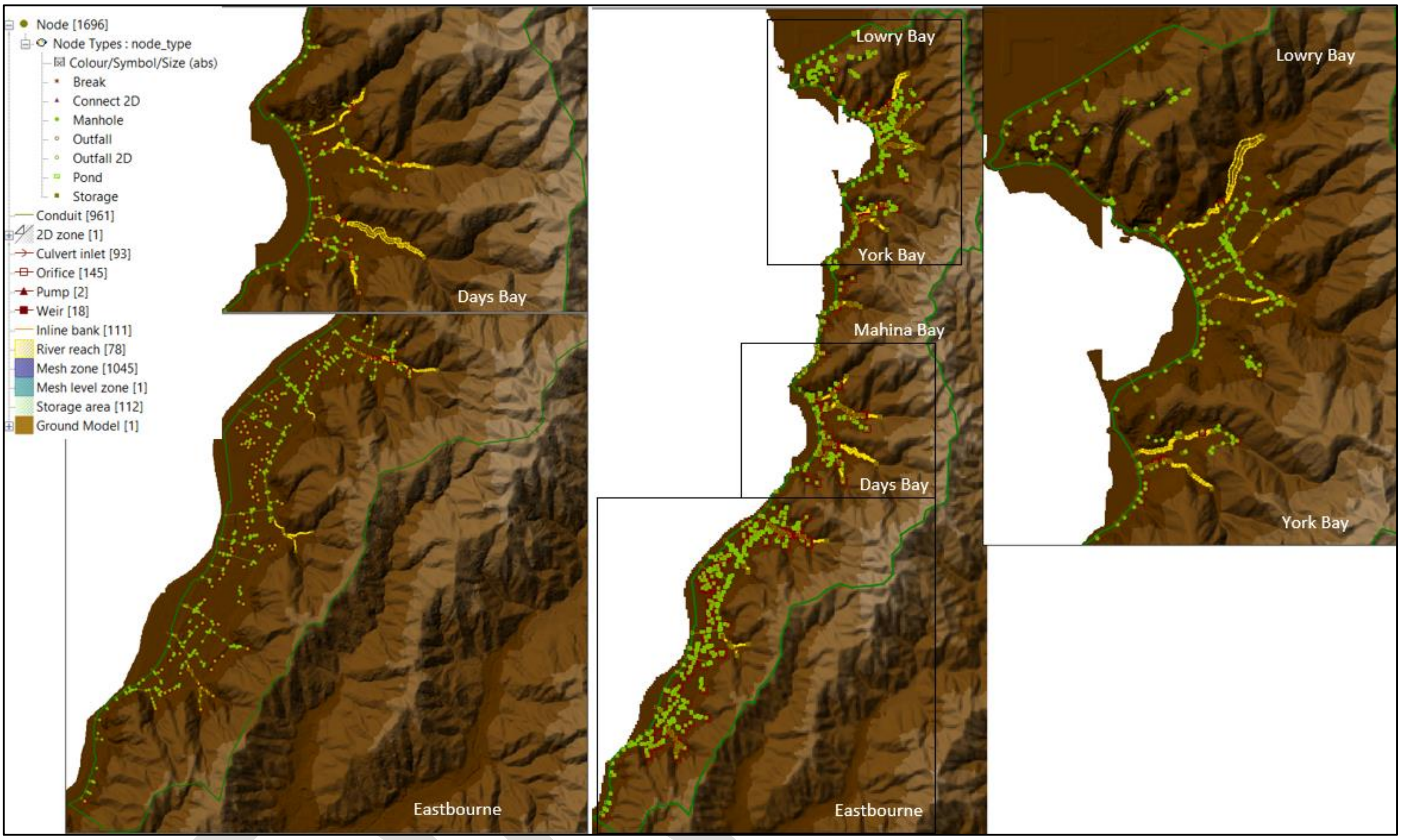


Figure 7 Final Extent of the Hydraulic Model (1-D and 2-D components). Note the 2D extent does not cover the entire catchment upper parts of the catchment are only represented in the hydrological model.

3.4.1. 2-D Model Extent

The 2-D model is used to describe overland flow within the catchment, minor open channels that were not included in the 1-D model, and the coastal/tidal zone.

The extent of the 2-D model and number of mesh elements in it is a significant factor that determines how quickly/slowly model can complete a simulation. For the East Harbour model the 2-D model extent was determined using rain on grid results as a first step (see figure 8). 2-D model extent was reduced from the study area extent to much smaller footprint only including those areas where flooding problems were revealed by the rain on grid results.

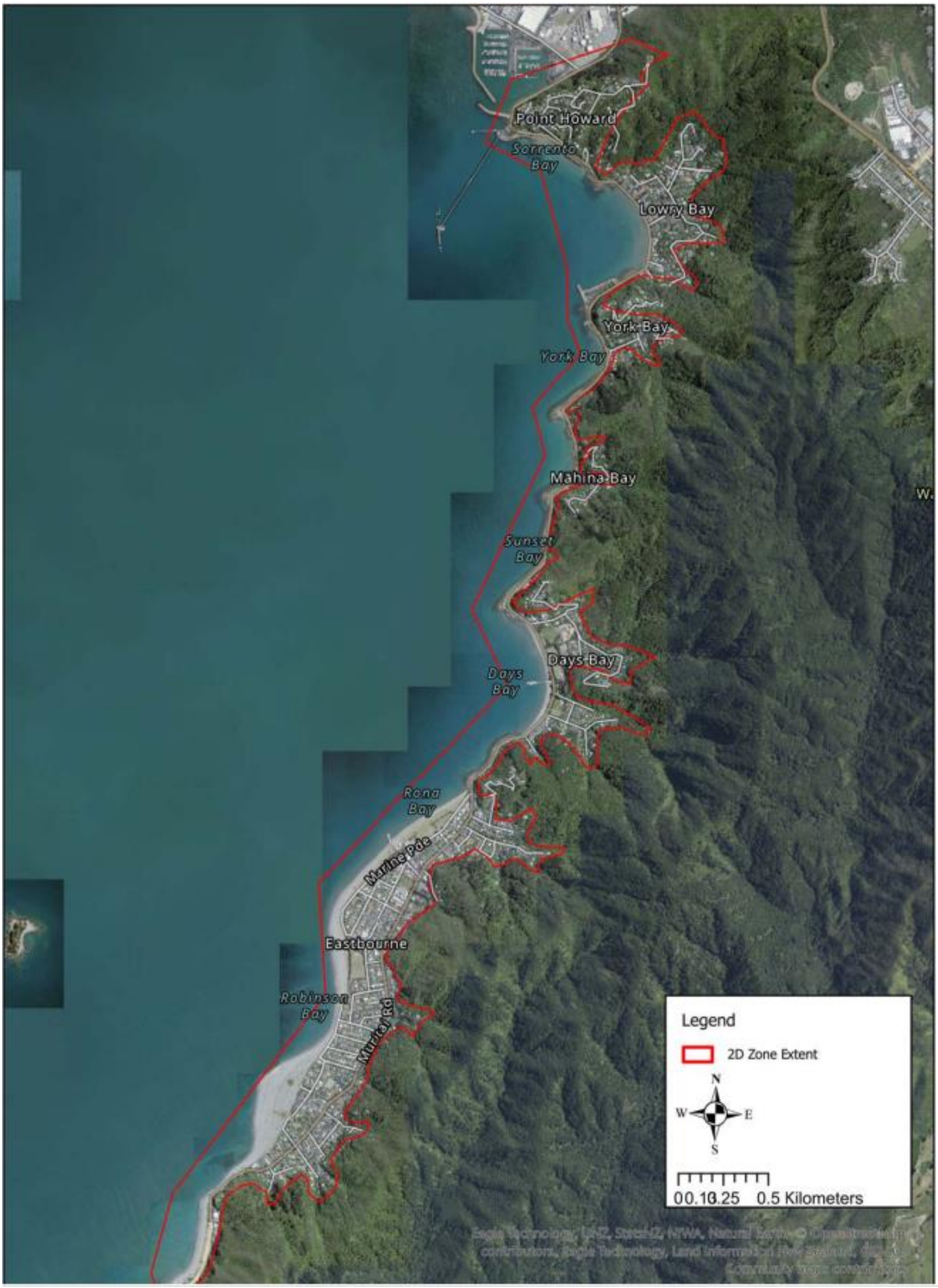


Figure 8 2-D model extent based on rain on grid results

Upstream areas, within the catchment where rain on grid modelling did not identify flooding issues, were excluded from 2-D model.

The DEM available for East Harbour only extended to the intertidal zone. To represent tidal zone in the model, the DEM was updated to include the bathymetry data from the Wellington Harbour.

3.4.2. Building Void Mesh Zone

Some large commercial buildings in Eastbourne and Days Bay assessed to be a barrier to overland flow paths and prevent surface flows from passing through, were excluded from the 2-D surface model by modelling them as voids. The final building voids used are shown in **Error! Reference source not found.**.

Figure 9 Building Voids layer

3.4.3. 1-D Pipe Network Model

The 1-D pipe network model is used to simulate the hydraulic processes in the stormwater network. The pipe network has been developed to a high level of detail and includes all stormwater drainage pits, pipes and manholes in the catchment that could be identified from the available GIS layers of the stormwater assets, apart from small diameter privately owned pipes.

3.4.1. Culvert Inlets

Culvert inlets have been modelled in ICM as square edged headwalls using parameters listed in Table 2.

Table 2 Culvert Inlet Parameters used in the model

	Round	Square
K	0.0098	0.0260
M	2	1
C	0.0398	0.0385
Y	0.67	0.81
Ki	0.5	0.30

3.4.2. 1-D Open Channels

Open channels have been modelled as one-dimensional open channels based on the aerial photography. In most cases the open channels required some editing with centerlines adjusted to align with low cells in the DEM and/or the ortho photography.

Cross section survey has not been undertaken for the open channels in this catchment as they are considered minor and thus do not warrant survey at this time. Cross section survey is recommended if the model is to be used for options analysis or detailed design near the modelled open channels. Some visual checks have been made to confirm the shape, roughness and extent of the channels.

Cross sections were extracted from the DEM approximately every 20m along the open channels, or at any significant change in gradient or cross section shape.

A total of 77 1-D reaches were modelled as 1-D open channels in the East Harbour model. These are shown in **Error! Reference source not found.**.

Figure 11 below illustrates how 1-D open channels are represented in ICM using RR links.

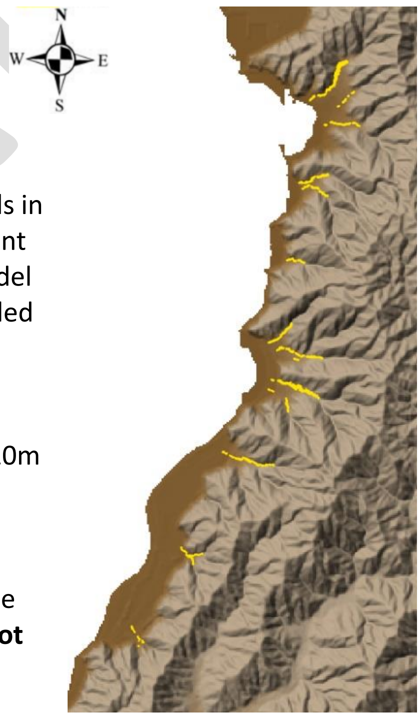


Figure 10 1-D Open Channels

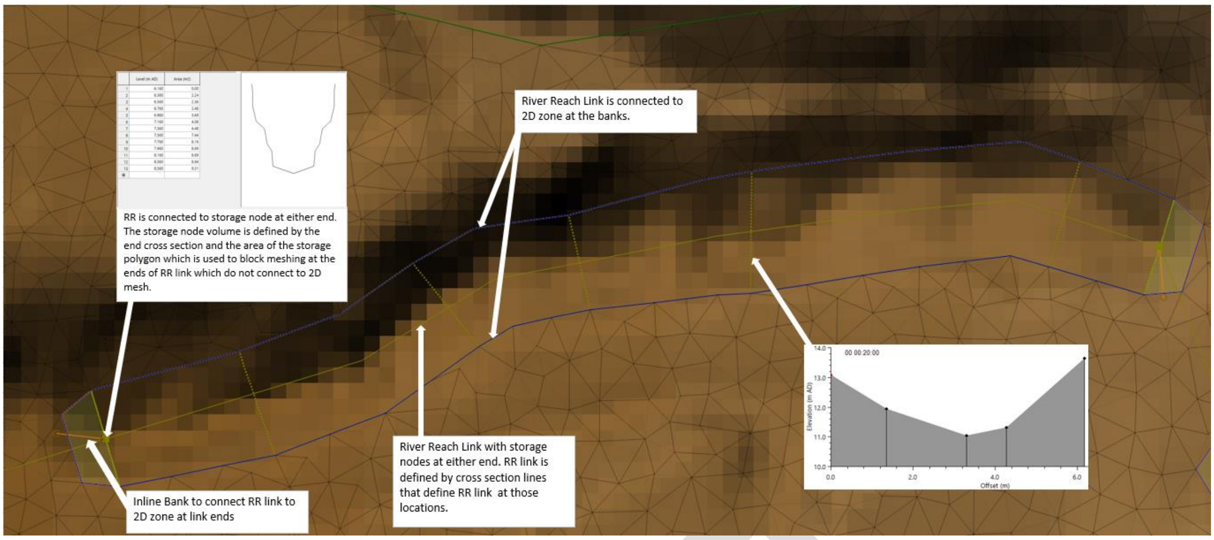


Figure 11 1-D Open Channel/River Reach link

3.4.3. Pump Stations

There are two stormwater pumping stations in the East Harbour area and both have been included in the model as 1D model components. The two pump stations are referred to as Heketara Street and Pukatea Street and are indicated in Figure 12.

Figure 12 Overall Site Layout

The following describes how the pumps have been schematised in the model:

- The pumps were added as pump links with characteristics based on as-built drawings. These drawings contained pump curves, storage volumes and invert levels for most pumps (Table 2). It was difficult to adequately represent pipework and fittings setup from the pump station to the outfall mains to where pump stations discharge so that pumps operate like what described in the manual. Therefore, the pumps were set up as fixed discharge pumps with capacities described in the operational manual.
- The total storage for each pump station was modelled as storage node with a defined volume based on the as-built drawings.
- Rising mains are short and were assumed as pump link discharging directly into gravity outfall pipe.
- Heketara Street pump station operational manual states pump start level as + 1.40 m and pump stop level as – 0.75 m. The same start and stop levels have been assumed for Pukatea pump station. The design report mentions that while during 100 yr flood event all three pumps would be required to run at Heketara St and both pumps at Pukatea St, during more frequent events not all pumps would be needed to keep up with inflow. Therefore, it was assumed that the second pump (at both pump stations) would be turned on at + 1.5 m and the third pump (at Heketara St) would be turned on at +1.6 m.

Table 3 below provides a summary of the two pump stations setup.

Table 3: Pump Station Pump Outputs and Start/Stop Levels

Pump Station	Heketara St	Pukatea St
Location	Heketara St	Pukatea St in Greenwood Park
No. of Pumps	3	2
Start/Stop (m aMSL)	Duty – 1.4 / -0.75 Assist – 1.5 / -0.75 Assist – 1.6 /-0.75	Duty – 1.4 / -0.75 Assist – 1.5 / -0.75
Pump Type	Fixed Discharge	Fixed Discharge
Name/Serial No	Flygt NP3202.185	Flygt NP3202.185
Capacity (l/s)	PS capacity - 585 l/s Pump 1 – 236 l/s Pump 2 – 198 l/s Pump 3 – 151 l/s	PS capacity - 434 l/s Pump 1 – 236 l/s Pump 2 – 198 l/s
Inlet Pipe Dia.	600 mm Dia	600 mm Dia
Discharge to	Beach overflow chamber 15 m away via 450 mm Dia rising main	Beach overflow chamber 13 m away via 450 mm Dia rising main

3.4.4. Soakage Chamber at 347 Muritai Rd

Adjacent to 347 Muritai Rd, there is a chamber unconnected to stormwater network. The dimensions of the chamber are indicated in Figures 13 below. The chamber receives runoff from the neighboring properties but its soakage capacity is unknown.

Figure 13 Soakage Chamber at 347 Muritai Rd

To represent this chamber in the model, a 1.89 m deep manhole of 3.5 m^2 floor area was used with flood type set to Gully 2D was used. The inlet parameters were set to mega pit, inline or recessed with double sump. To allow for soakage it was assumed that soakage capacity of the chamber is sufficient for runoff from 10 year ARI storm event which equals to 18 l/s. The soakage was represented by orifice connected to outfall with limiting discharge set to 0.018 m^3/s.

3.4.5. Private Soakage

Large areas of Eastbourne are low-lying with houses located in depressed areas that are lower than adjacent roads. In these areas there are no public stormwater drainage assets; private drainage plans indicate drainage pipes discharging to the back of these properties. Figure 14 below shows depressed areas and properties with assumed to private soak pits.

The private soak pits were not represented individually in the model. Lowest points in the depressed areas were used as drainage sumps to delineate subcatchments for these localities. To represent soakage, similar to how described above, an assumption that soakage capacity of these soak pits is sufficient for runoff from 10 year ARI storm events. The soakage was represented by orifice connected to outfall with limiting discharge set to peak flow associated with 10 year ARI storm. Such setup means that the model does not predict flooding at these locations for any event up to 10 year ARI storm. For storms of greater magnitude than that, the model will show flooding at these locations. This appears to be consistent with reality. Community engagement in the Eastbourne area has been carried out. No evidence of regular flooding at these locations has been collected.

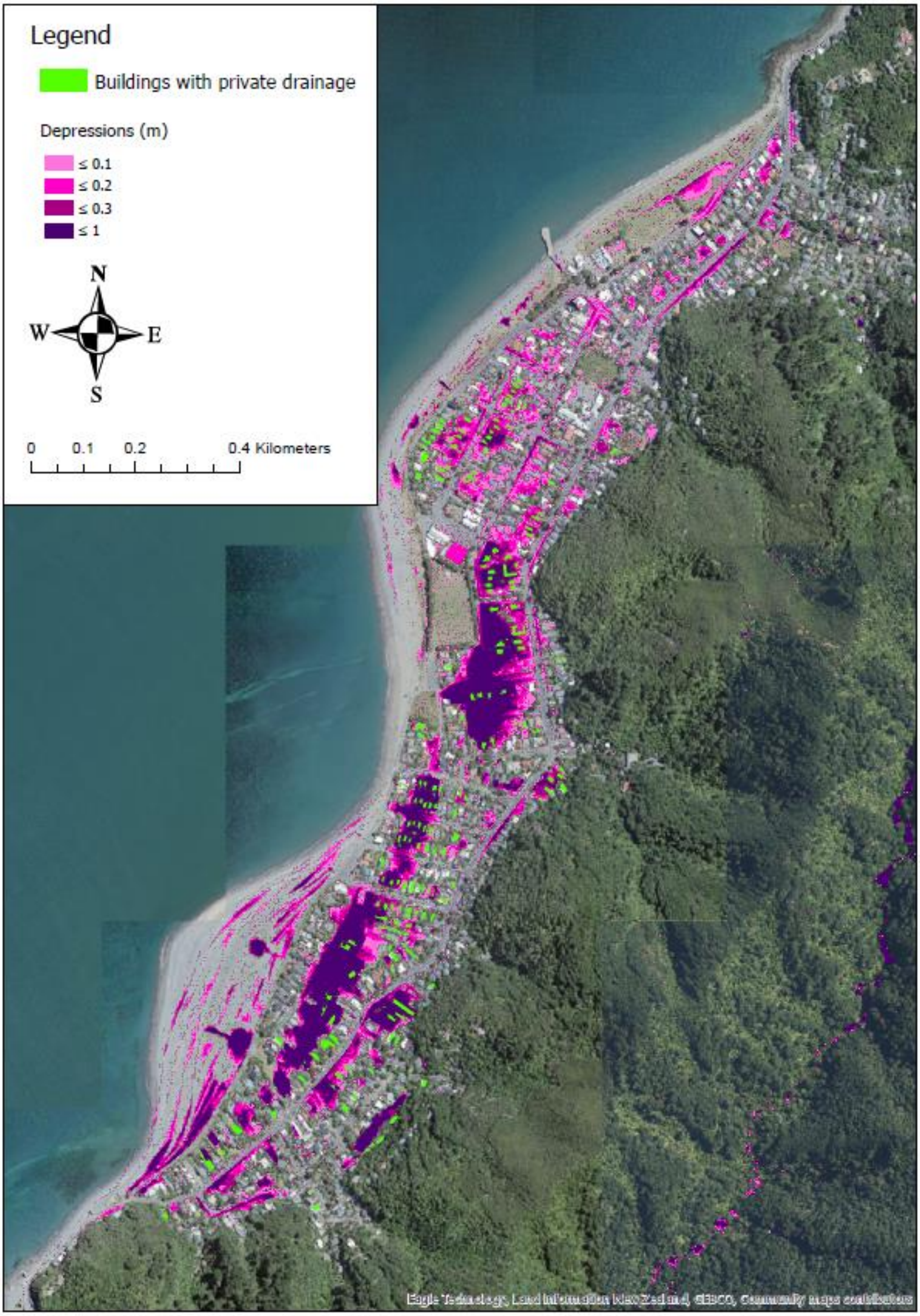


Figure 14 Depressed areas in Eastbourne and likely private soakage locations

3.4.6. 1-D/2-D Linkages

The East Harbour hydraulic model is made up of three model domains, the 1-D pipe network, the 1-D open channel network and the 2-D surface. Flow can be transferred between all three domains in all directions.

There are two key links between the 1-D pipe network and the 2-D surface. The first is at manholes and sumps in the network that have a Flood Type attribute of 2-D or Gully 2-D respectively. These nodes can transfer water with the 2-D mesh elements they are located in. For 2-D Flood Type nodes flow between the node and the 2-D mesh element is calculated using a weir equation where the circumference of the node (manhole) is given as the weir width. For Gully 2-D nodes, flow is calculated using a head discharge table.

The second link is where a pipe network outlet discharges directly onto the 2-D surface rather than an open channel. At these locations an Outfall 2-D node has been used in the model. Flow across Outfall 2-D nodes is calculated as a vortex control with a nominal head discharge relationship.

The link between the 1-D channel network and 2-D surface takes place at the bank lines used in the River Reaches and Inline Banks. Flow across the bank lines is calculated using an irregular weir equation.

3.4.7. Energy Losses

3.4.7.1. 1-D Pipe Network

Energy losses in the 1-D pipe network due to surface friction have been accounted for using the pipe materials information in the Wellington Water Ltd.'s GIS data for pipes where available. Wellington Water Ltd.'s materials attributes were mapped to the ICM roughness values as shown in **Error! Reference source not found.**4. The default for unknown pipe materials was set to Concrete (Normal).

Table 4 Pipe Manning's M Roughness Values

Materials Type	Manning's M Coefficient	Manning's n Coefficient
Cement Mortar	77	0.013
Ceramics	70	0.014
Concrete (Normal)	75	0.013
Concrete (Rough)	68	0.015
Concrete (Smooth)	85	0.012
Iron (cast)	70	0.014
Iron (wrought)	65	0.015
Plastic	80	0.013
Stone	80	0.013
Corrugated Metal	50	0.020
Asbestos Cement	77	0.013
Timber	68	0.015
Storm Boss	70	0.014
Nexus	70	0.014
Nova Flow	65	0.015

3.4.7.2. 1-D Channel Network

Energy losses in the 1-D channel network due to surface friction have been accounted for using the Manning's n Roughness Values specified in **Error! Reference source not found.**, taken from the Regional Specification, below.

All the natural stream in the network have been assigned a Manning's n value of 0.045 Winding natural streams with irregular cross section and some obstruction with vegetation and debris. Constructed open drains within urban area have been assigned a Manning's n value of 0.025.

Table 5 Typical 1-D Manning's n Roughness Values

Classification	Manning's n Coefficient
Open Channel	
Straight uniform channel in earth and gravel in good condition.	0.0225
Unlined channel in earth and gravel with some bends and in fair condition.	0.025
Channel with rough stony bed or with weeds on earth bank and natural streams with clean straight banks	0.03
Winding natural streams with generally clean bed but with some pools and shoals.	0.035
Winding natural streams with irregular cross section and some obstruction with vegetation and debris.	0.045

Irregular natural stream with some obstruction with vegetation and debris.	0.060
Very irregular winding stream obstructed with significant overgrown vegetation and debris	0.1

3.4.7.3. 2-D Network

Energy losses in the 2-D network due to surface friction have been accounted for using Roughness Zones to apply Manning's n roughness values across the 2-D Zone. The Roughness Zones have been adopted from the Regional Ground Roughness Coefficients report ((MWH, now part of Stantec 2017). **Error! Reference source not found.** and **Error! Reference source not found.** below show the roughness values applied to the different types of surface identified across the Wellington Region. As the residential parts of the Pauatahanui catchment lie within Porirua the roughness applied to residential properties was the Porirua Manning's n value of 0.16. The 2D zone default roughness value was set to the value for roads 0.02 to avoid the complex roughness polygon shapes required by roads.

Table 6 Manning's n Roughness Values Non- Residential Properties

Ground cover	Manning's n Coefficient	Comment
Roads and footpaths	0.02	Upper limit from Regional Specification (value indicated by Wellington Water)
River	0.05	"Winding with some weeds and large stones" in Ven Te Chow table (value indicated by Wellington Water)
Vegetation: alpine	0.05	Maximum value of "rock cut channel, jagged and irregular" in Ven Te Chow table
Vegetation: bare	0.04	"Rock cut channel, jagged and irregular" in Ven Te Chow table (value indicated by Wellington Water)
Vegetation: forest	0.1	"Medium to dense brush in summer" in Ven Te Chow table (value indicated by Wellington Water)
Vegetation: impervious	0.05	"Impervious" here means water-logged (value indicated by Wellington Water)
Vegetation: pasture	0.05	Maximum value of "high grass" in Ven Te Chow table (value indicated by Wellington Water)
Vegetation: scrub/flax	0.08	Maximum value of "light brush and trees in summer" in Ven Te Chow table (value indicated by Wellington Water)
Vegetation: urban open space	0.05	"Urban open space" can be any of forest/open field/landscaped garden/pavement
Recreational area, playing field	0.05	Upper limit from Regional Specification
Non-residential properties: pavement	0.02	Upper limit from Regional Specification because assumed to be poorly maintained or have plantings and dividing barriers
Non-residential properties: building	0.5	Upper limit from Regional Specification
Residential properties: pavement	0.02	In line with Regional Specification (value indicated by Wellington Water)

Residential properties: grass	0.04	In line with Regional Specification (value indicated by Wellington Water)
Residential properties: trees	0.15	Upper limit from Regional Specification
Residential properties: small fenced backyards	0.1	
Residential properties: building	0.5	Upper limit from Regional Specification

Table 7 Manning's n Roughness Values for Residential Properties

City	District Plan Zones	Average equivalent Manning's n Coefficient
Wellington	Inner residential	0.27
	Outer residential	0.23
Hutt City	General residential	0.21
	Hill residential	0.17
Porirua	None (general)	0.16

3.5. Boundary conditions

3.5.1. Rainfall Data

Rainfall inputs for design events were derived using the methodology outlined in SCS Rainfall Runoff Model Calibration: Standardised Parameters for Hydrological Modelling, March 2017 which recommends a nested rainfall profile for durations form 10 minutes to 12 hours.

The design rainfall was collected from the HIRDS v4 website for the East Harbour catchment for the point with the following coordinates:

- Latitude -41.27883367663434
- Longitude 174.9074807167053

The depth-duration rainfall from HIRDS v4 is provided in **Error! Reference source not found.** below.

Table 8 Design Rainfall Depths Used for the East Harbour catchment (based on historical data)

Duration		10 min	20 min	30 min	60 min	2 hrs	6 hrs	12 hrs	24 hrs
ARI (y)	**AEP (%)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**
1.58	**0.633**	6.85	9.37	11.5	16.5	24.1	44.1	63.3	88.1
2	**50**	7.53	10.3	12.6	18.1	26.5	48.4	69.4	96.5
5	**20**	9.88	13.5	16.5	23.7	34.6	63	90.3	125
10	**10**	11.7	15.9	19.4	27.9	40.7	74	106	147
20	**5**	13.5	18.4	22.5	32.2	47	85.4	122	169
30	**3.3**	14.6	19.9	24.3	34.9	50.8	92.3	132	183
40	**2.5**	15.5	21	25.7	36.8	53.6	97.3	139	192
50	**2**	16.1	21.9	26.7	38.3	55.8	101	144	200
60	**1.7**	16.6	22.6	27.6	39.5	57.6	104	149	206
80	**1.2**	17.5	23.8	29	41.5	60.4	110	156	216

100	**1**	18.1	24.7	30.1	43.1	62.6	114	162	224

For climate change scenarios, depth-duration rainfall data based on RCP 6.0 scenario is provided in Table 9 below.

Table 9 Design Rainfall Depths Used for the East Harbour catchment (based on RCP 6.0 scenario)

Duration		**10 min**	**20 min**	**30 min**	**60 min**	**2 hrs**	**6 hrs**	**12 hrs**	**24 hrs**
ARI (y)	**AEP (%)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**
1.58	**0.633**	7.41	10.1	12.4	17.8	26	47	66.8	92.3
2	**50**	8.15	11.1	13.6	19.6	28.6	51.6	73.4	101
5	**20**	10.7	14.7	17.9	25.7	37.5	67.5	95.9	132
10	**10**	12.7	17.3	21.1	30.4	44.2	79.5	113	155
20	**5**	14.7	20.1	24.5	35.2	51.1	91.9	130	179
30	**3.3**	16	21.8	26.5	38.1	55.3	99.3	141	193
40	**2.5**	16.9	23	28	40.1	58.3	105	148	203
50	**2**	17.6	23.9	29.2	41.8	60.7	109	154	211
60	**1.7**	18.2	24.7	30.1	43.2	62.6	112	159	218
80	**1.2**	19.1	26	31.7	45.4	65.8	118	167	229
100	**1**	19.8	27	32.8	47	68.2	122	173	237

To have a full understanding of modelled catchments response to the entire spectrum of rainfall durations, using above rainfall data, nested storm profiles were created as shown in Figure 15 below. The use of a nested storm means that one simulation event can represent a range of response times, including performance in different sub catchments as well as across the entire catchment.

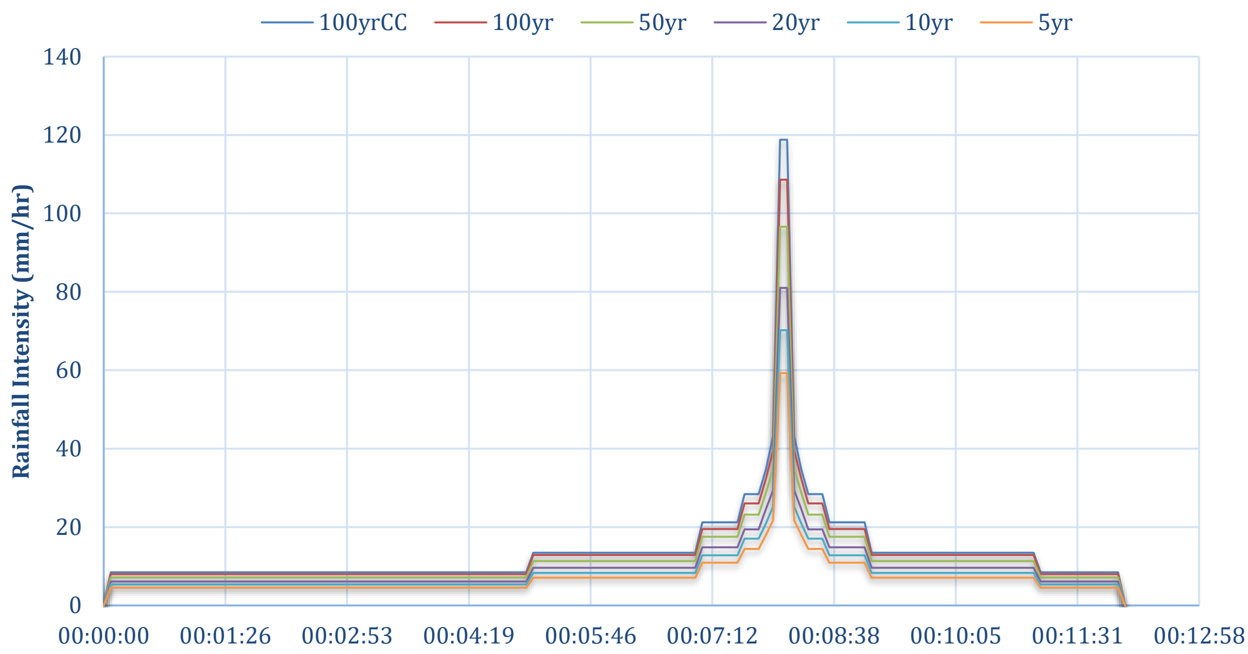


Figure 15 Nested storm events used in the model

3.5.2. Tide Data

Dynamic tide data was applied to the model in accordance with Wellington Water Ltd.'s *Regional Stormwater Hydraulic Modelling Specifications V4*, December 2013. An oscillating tide boundary with a peak at 1.105m RL (2.105m RL climate change scenario) was applied to the model. The peak tide was made to coincide with peak depth at 9:25 (see Figure 16), in areas most influenced by tide level i.e. low areas adjacent to the shore, predominantly in Eastbourne. This is one hour and twenty minutes after peak rainfall.

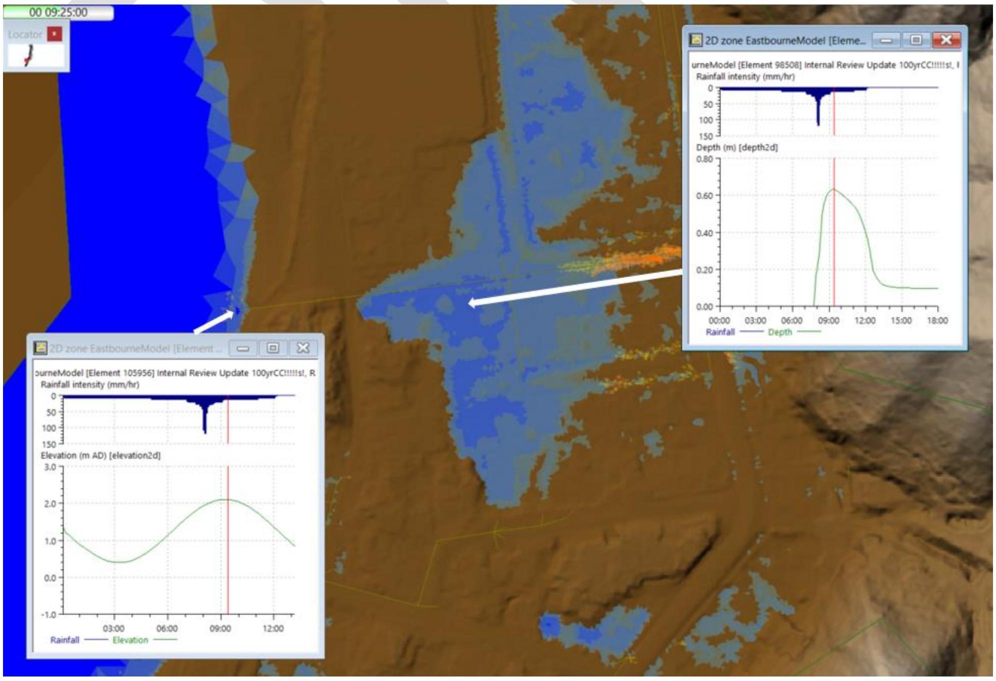


Figure 16 Peak tide and peak flood depth in Eastbourne

3.5.3. 2-D Zone

A normal boundary condition has been applied to the boundary of the 2-D zone.

3.5.4. Model Limitations

Computational models are only as accurate as the information input into them, and the data available to verify their accuracy. The primary sources of information for this investigation were asset data and LiDAR available at Wellington Water Ltd as well as limited site checks.

The constraints and limitations of the stormwater flood model are as follows:

- Manhole and pipe levels for a substantial amount of the network have been interpolated from available or surveyed data.
- Large parts of the model are based on LiDAR. Where the quality of the LiDAR is suspect or there have been changes made since the collection of LiDAR the model will not represent the real-life structures. Further information on the quality of LiDAR can be referred to in Ground Model Assessment Summary Report submitted by MWH, now part of Stantec, in April 2016 to Wellington Water.
- Building floor levels are not applied.
- Cross sections for most modelled open channels have been generated from the LiDAR data.
- Fences and walls that may constrict flow paths are not represented in the model.
- Some culvert structures in rural areas have an assumed diameter in the upper catchment.

3.5.5. Hydrological Model Assumptions

The following assumptions have been applied in the development of the hydrological model:

- The hydrological method specified by Wellington Water Ltd for use in the catchment is appropriate.
- The sub-catchments delineated and parameterised are appropriate and have been correctly parameterised.

3.5.6. Hydraulic Model Assumptions

The following assumptions have been applied in the development of the hydraulic model:

- The LiDAR generated ground model is an accurate representation of catchment topography;
- Manhole lid levels are adequately represented in the ground model;
- Pipes are sediment free;
- Inlets, outlets and sumps are sediment free;
- The network asset data is of a suitable standard for use in the model without additional survey.

3.6. Initial Model Testing

3.6.1. Layout Checks

The model has been built using aerial photography, topographic information, and GIS layers provided by Wellington Water Ltd. The stormwater network has been based on a combination of Porirua City Council GIS layers of the network assets and available as-built information. The extent of the 2-D simulation polygon (2-D Zone) was defined based on the topography of the East Harbour catchment and the reticulated stormwater network, ensuring that it covered all low-lying areas and extended upstream of all branches of the pipe network.

3.6.2. Instability Tests

Initial model testing was carried out using a 1% AEP nested design storm event.

3.6.3. Sensibility Check

Sensibility checks were carried out for the model. This included:

- Reviewing pipe grade and soffit levels;
- Reviewing open channel grades and bank line levels;
- Reviewing the total head of open channels and pipes; and,
- Reviewing the total flow in pipes and open channel.

3.6.4. Mass Balance Checks

By default, the ICM simulation engine undertakes mass balance checks at every simulation time step. If the cumulative Mass Balance error exceeds 0.01 m^3 at any individual time step the simulation is automatically terminated. This implies that any simulation that is completed is considered to have passed this check.

Volume balance information for each simulation is provided in the simulation log file. The volume balances for the two simulations used for initial testing are provided below (

).

Table 10 Volume Balance Summary for Initial Simulations

Design Storm Event	2-D Volume Balance	
	Mass Error Balance (%)	Total Mass Error (m^3)
1% AEP	0.0005	2.0745
10%AEP	0.0000	0.0109

4. Model Confidence

Several steps have been undertaken to provide confidence in the East Harbour catchment model. These include validating the model against measured rainfall events and analyzing the results of sensitivity testing. The following section details the steps taken to assess simulation results and provide confidence in the East Harbour catchment model.

4.1. Model Validation

Information available for validating East Habour catchment model is somewhat scarce with main source being Hutt City Council (HCC) database of reported flooding. In addition to that Wellington Water carried out public engagement using social pinpoint app whereby residents by accessing the app could see predicted flood extents and provide their commentary. Relatively few comments have been collected and some of the identified properties have already been recorded in HCC database.

Unfortunately, there is very little photographic evidence available for flooding events that occurred in East Harbour catchment. Likely reason for this is that the two very large storm events that occurred in February 2004 and April 2019 happened during nighttime at a time when residents were not prepared to take photographs. Even complaints registered with Hutt City Council were relatively few. It is likely that only residents who were seriously affected reported flooding at their properties.

The only available approach to validate East Harbour catchment model is to try and match predicted flooding with the locations identified by the resident on social pinpoint app and HCC database.

Validation results for each available data point is provided in detail in Appendix A. General overview is provided below.

4.1.1. Data

The model has been validated using three rainfall events that resulted in localised flooding reported by the residents. The three events were:

- February 16th 2004
- October 16th 2009
- April 7th 2019

There are no flow gauging sites available located within East Harbour catchment that can be used for validation purposes.

4.1.2. Rainfall Data

There are no rainfall gauges within East Harbour catchment itself for validation use. There are five adjacent active rainfall gauges of which Seaview WTP and Shandon Golf Club are the nearest. **Error! Reference source not found.** shows the location of the rainfall gauges in relation to the study area, while **Error! Reference source not found.** shows the rainfall records available at each site:

Table 11 Rainfall Records

Gauge	Distance	Record Length	Record Details
Shandon Golf Club	6.1 km	2000 – 2023	Incremental rainfall record. Maybe used for 2004 and 2009 flood events.
Seaview WTP	4.5 km	2018 – 2023	Incremental rainfall record. Maybe used for 2019 flood event.
Miramar Bowling Club	7.9 km	2016 – 2023	Incremental rainfall record. Maybe used for 2019 flood event.
Wainuiomata River	6.9 km	1901 – 2023	Incremental rainfall record. Events of interest. Maybe used for all events.
Lake Kohangatera	10.9 km	2007 - 2023	Incremental rainfall record. Maybe used for 2009 and 2019 flood events.

Figure 17 Rainfall gauge locations nearest to the study area

Not all gauges had data available for the validation events selected. Rainfall data from the available gauges associated with the three events are shown below in **Error! Reference source not found.**.

Table 12 Observed Rainfall Depths of Selected Storms at Different Gauging Sites

Event	Rainfall Depth (mm)						Adopted Rainfall Depth (mm)	Duration (hr)	ARI
	Shandon Golf Club	Seaview WTP	Miramar Bowling Club	Wainuiomata River	Lake Kohangatera	Radar			
16 /02/ 2004	161	-	-	157	-	-	157	12	80
16 /10/ 2009	43	-	-	58	13.5	41.7	58	12	1.58
7/04/ 2019	9.6	13	15	27	8	42.7	42.7	1	100

A comparison of the observed rainfall at the rainfall gauges was carried out to identify suitable rainfall for use in each validation event. Data available for each event is discussed below:

16 February 2004: Error! Reference source not found. shows that the rainfall depth observed for the 24 hours over the 15-17 February 2004 at Shandon Golf Club and Wainuiomata River sites was similar at between 192-211 mm (80 yr ARI storm over 12 hrs). For the purposes of validation, Wainuiomata River rainfall data was employed.

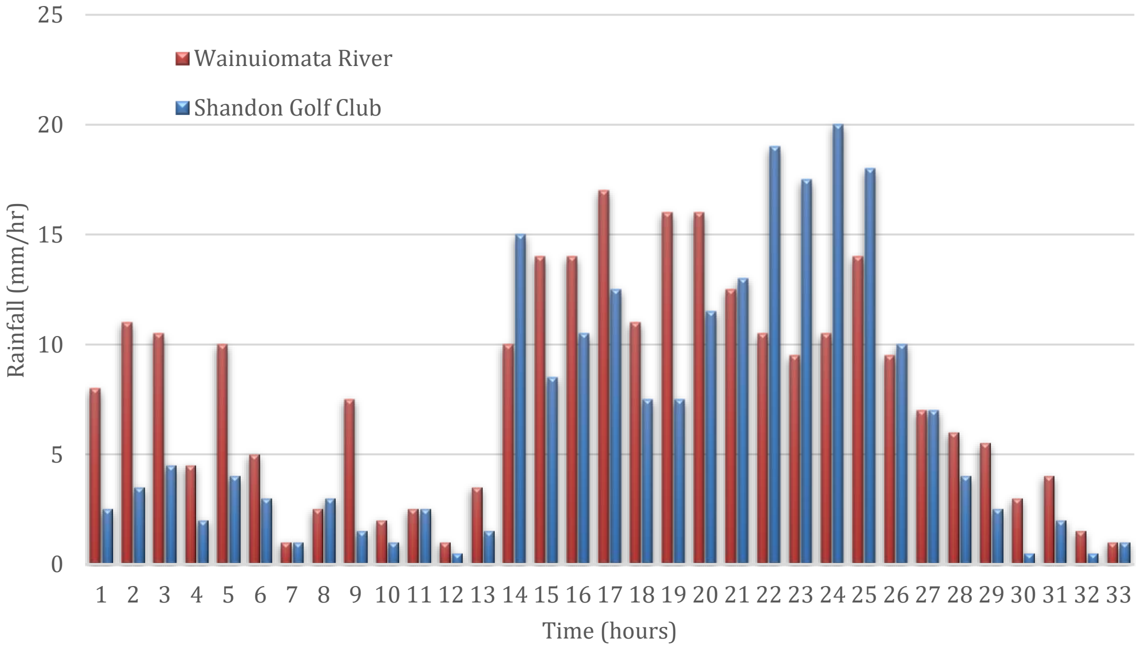


Figure 18 Temporal Pattern of 16 Feb 2004 Event Observed at Wainuiomata River and Shandon Golf Club Sites

16 October 2009: A rainfall depth of 58 mm over 12 hrs was observed at Wainuiomata river rainfall gauge for the 16 October 2009 event. This was a highest recording of all the gauges and can be categorised as less than 1.58 yr ARI storm. Temporal rainfall pattern of this event observed at Wainuiomata River was employed.

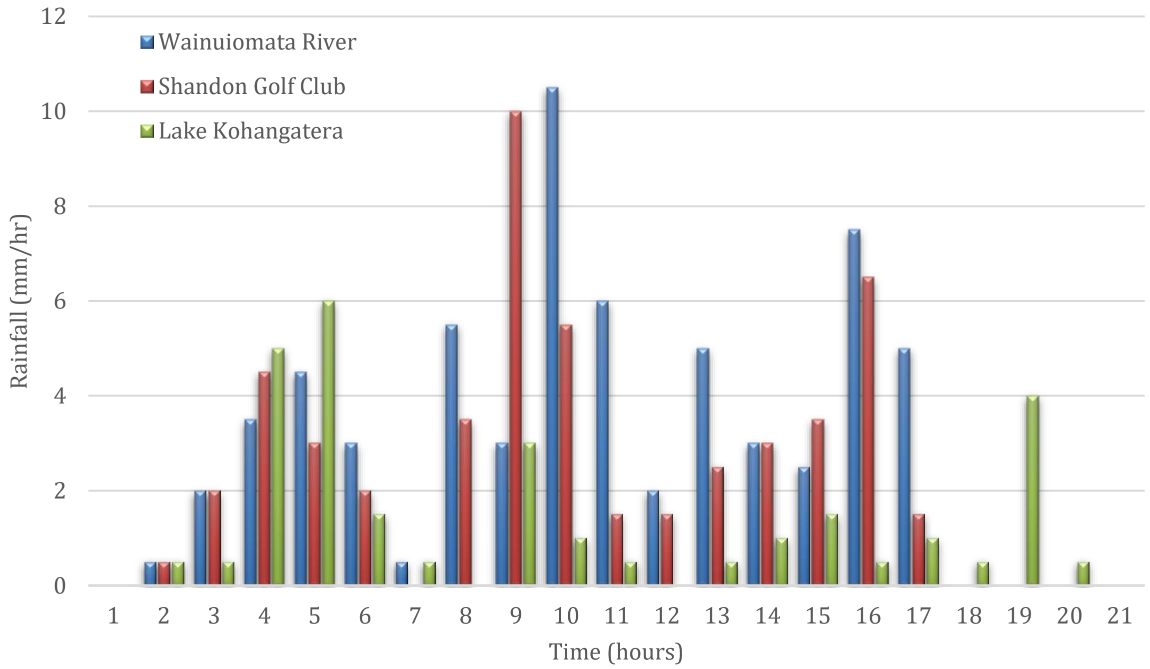


Figure 19 Temporal Pattern of 16 October 2009 Event Observed at Different Gauging Sites

7 April 2019 : For the 7 April 2019 event all the rain gauges with exception of Wainuiomata river indicated a minor event of less than 1.58 yr ARI. Wainuiomata river gauge with one hour maximum of 27 mm is categorised as 10 yr ARI storm. The rain radar data available for the East Harbour catchment estimates rainfall depth of 42.7 mm over a period of one hour. If this estimate is correct, then this event can be categorised as 100 yr ARI storm.

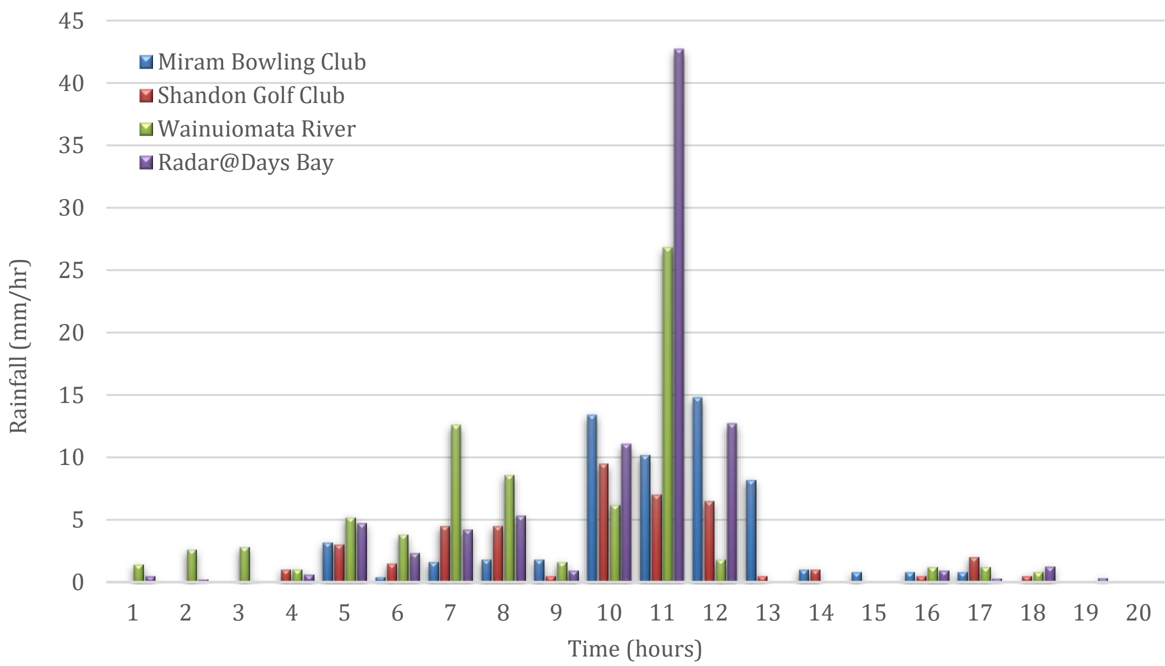


Figure 20 Temporal Pattern of 7 April 2019 Event Observed at Different Gauging Sites

4.1.3. Tidal Boundary

For the validation runs a dynamic tidal boundary was applied to the downstream tidal boundary of the model, based on the recorded levels in Wellington Harbour at Queens Wharf tidal gauge. Some smoothing of the raw data was carried out to reduce the instability at the downstream end of the model. Figures 21, 22 and 23 present rainfall and corresponding tide data for February 2004, October 2009 and April 2019 events respectively.

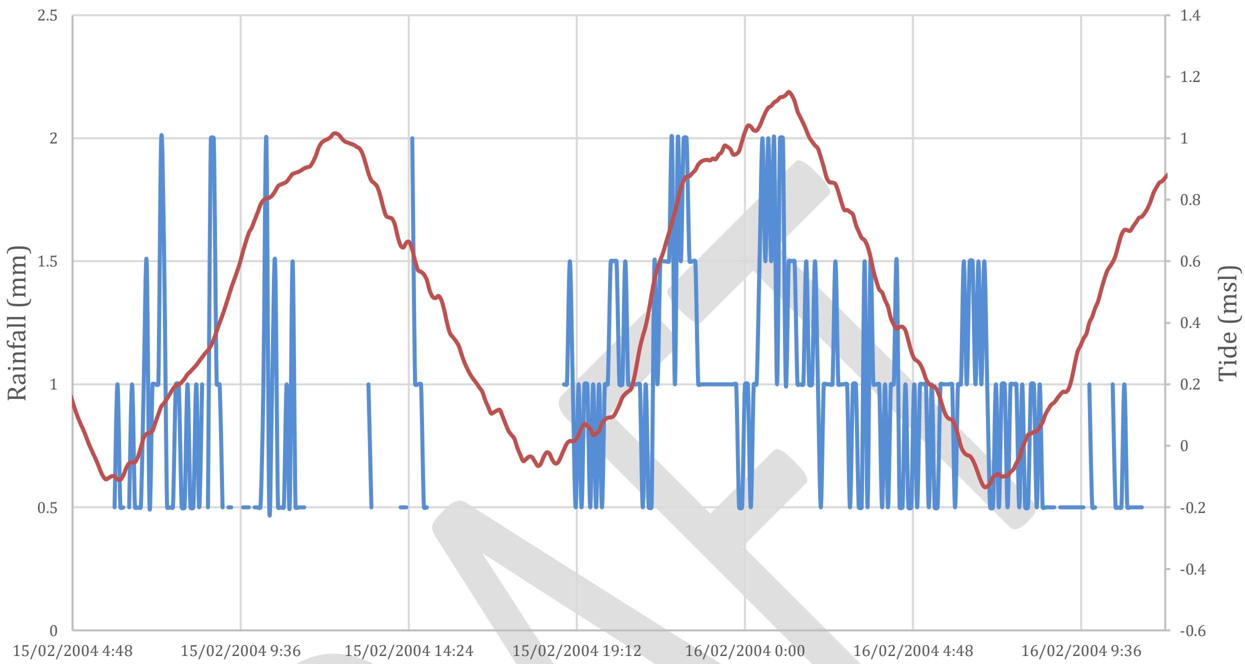


Figure 21 Validation Boundary Conditions (16th February 2004)

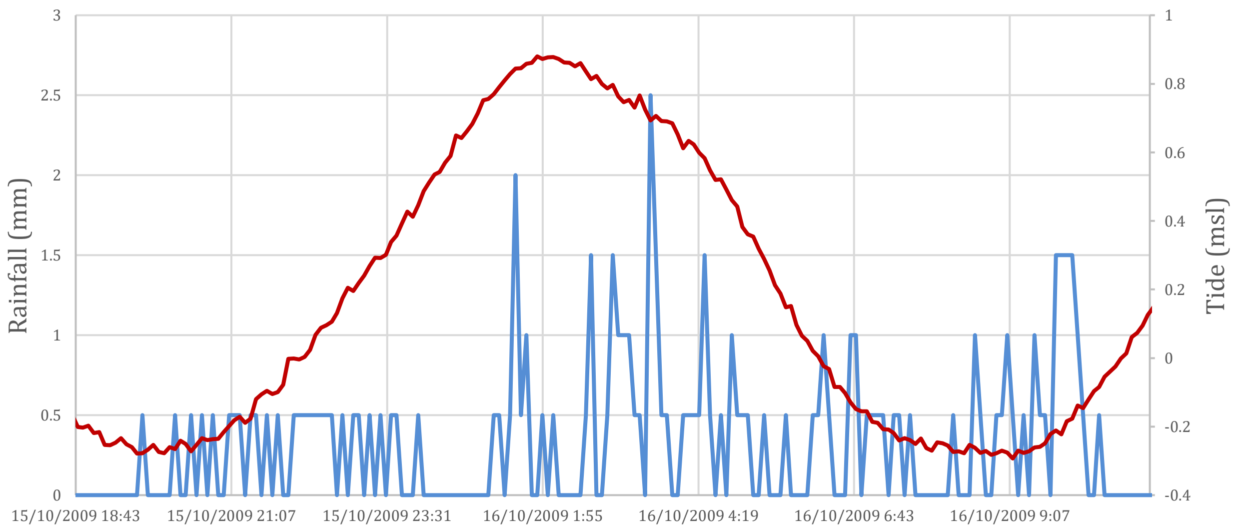


Figure 22 Validation Boundary Conditions (16th October 2009)

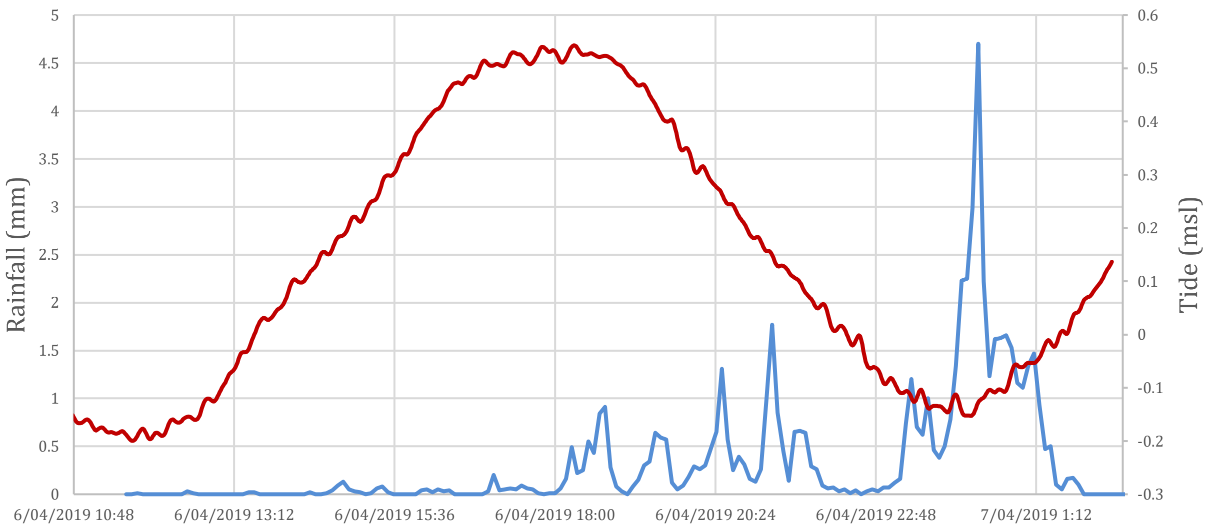


Figure 23 Validation Boundary Conditions (7th April 2019)

4.1.4. Flood Record Data

Townships in the East Harbour catchments, especially Eastbourne, have experienced several significant flooding incidents in recent history. Some anecdotal and photographic evidence is available from flooding events in 2004 (believed to be 15 February 2004), 16 Oct 2009, 7 Apr 2019. All available information has been collated in Figure 6. This information came from the following sources:

- HCC records of flooding investigations layer which indicates approximate extents of flooding experienced (unknown accuracy of these extents).
- a video record featuring flooding on Muritai Road, opposite Muritai Primary School which occurred on 16 Oct 2009 (Figure 7).
- Photograph depicting aftermath of 7 Apr 2019 storm event at 94 Muritai Road showing a line along the outside of the house, indicating the level the flooding had reached. From this image it appears the flooding had a depth of roughly 400mm (Figure 8).
- Additional information has been obtained from operators and from the public through engagement via social pinpoint site(Managing Flood Risks Eastbourne | Social Pinpoint (mysocialpinpoint.com)). Confirmed flooding locations are shown in Figure 6.

A summary of the recently reported flooding issues is contained in Table 12. This information has been obtained from HCC database as well as public engagement conducted by Wellington Water Ltd.

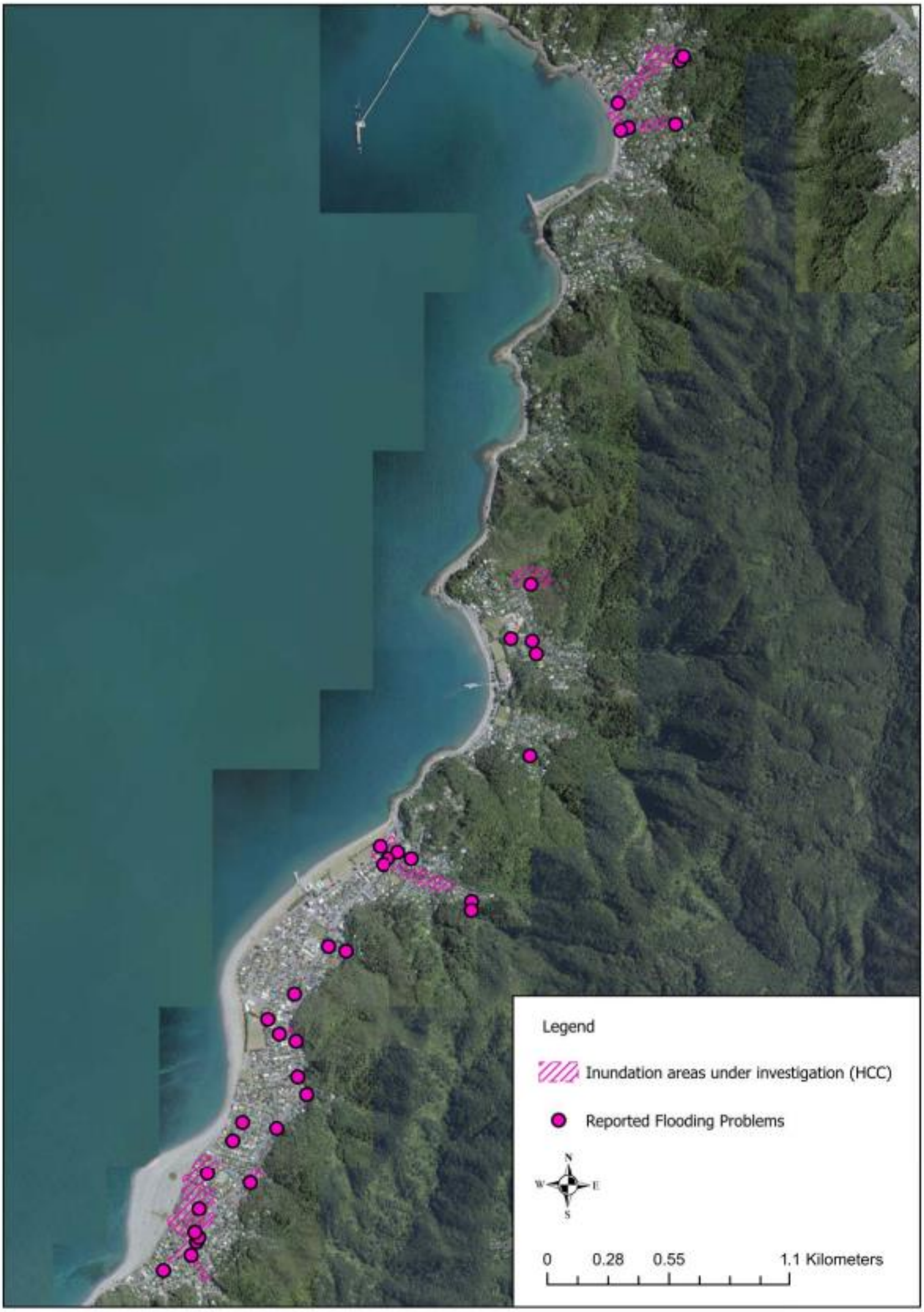


Figure 24 Reported flooding issues from 2004, 2009 and 2019 storm events

4.2. Hydrology Validation Setup

The East Harbour model hydrological settings were based on the hydrological parameters extracted from the GIS based Regional Surface Layers developed by MWH (now part of Stantec) for Wellington Water Ltd (MWH, 2017) and the Curve Numbers and Initial Abstraction layers developed by Cardno (2017). This model was used to model the rainfall depths of the three selected events.

Modelling results based on adopted hydrological settings indicate widespread flooding in Eastbourne at locations not identified by the reported flooding issues in Figure 23. This can be explained by the timing of the events i.e. peak rainfall occurring at night and the worst of the event not observed and reported by the residents unless real damage including inside dwelling has occurred. The other explanation for this is the presence of private soak pits, currently not represented in the model, as well as by the possibility that at depressed locations (abundant in Eastbourne) where older types of buildings were constructed on piles (majority in Eastbourne), the runoff would occupy the space of the house footprint resulting in higher permeability of the sub catchment then currently is assumed.

To try and achieve the best representation of hydrology in Eastbourne, validation scenarios have been setup to allow in depressed areas not serviced by public stormwater network for infiltration to occur. Lowest points in the depressed areas were used as drainage sumps to delineate subcatchments for these localities. To represent soakage, it was assumed that soakage capacity of these soak pits is sufficient for runoff from 10 year ARI storm events. The soakage was represented by orifice connected to outfall with limiting discharge set to peak flow associated with 10 year ARI storm. Such setup means that the model does not predict flooding at these locations for any event up to 10 year ARI storm. For storms of greater magnitude than that, the model will show flooding developing there. This appears to be consistent with reality as community engagement in the Eastbourne area has not produced any evidence of regular flooding at these locations.

4.3. Hydraulic Model Validation

4.3.1. Model setup for simulating February 2004 and August 2009 events

To model these events, the stormwater network had to be reconfigured in several places as network upgrades have been made since 2004. Figures 24 and 25 show components of the network (in white) removed to represent stormwater network configuration on the 15-16 February 2004.

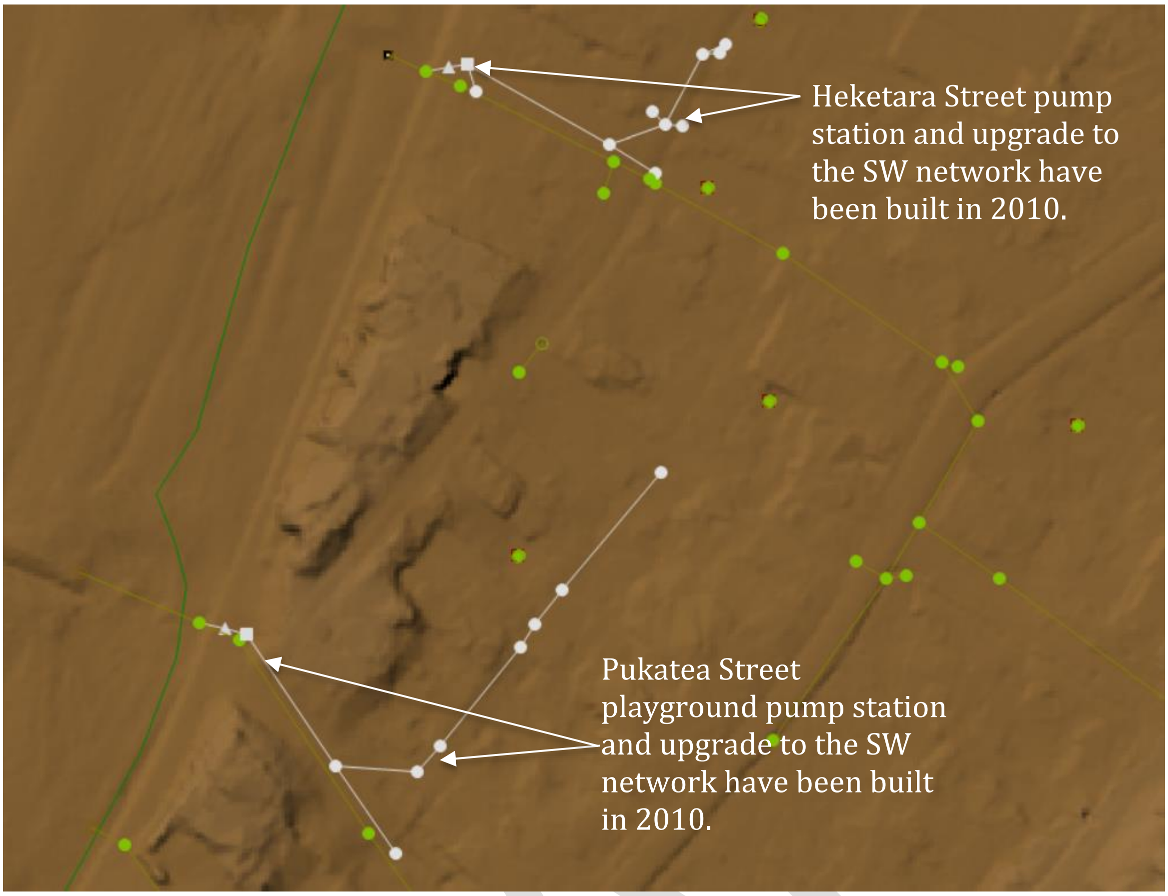


Figure 25 SW upgrades in Eastbourne built since 2004 event which were removed for the validation

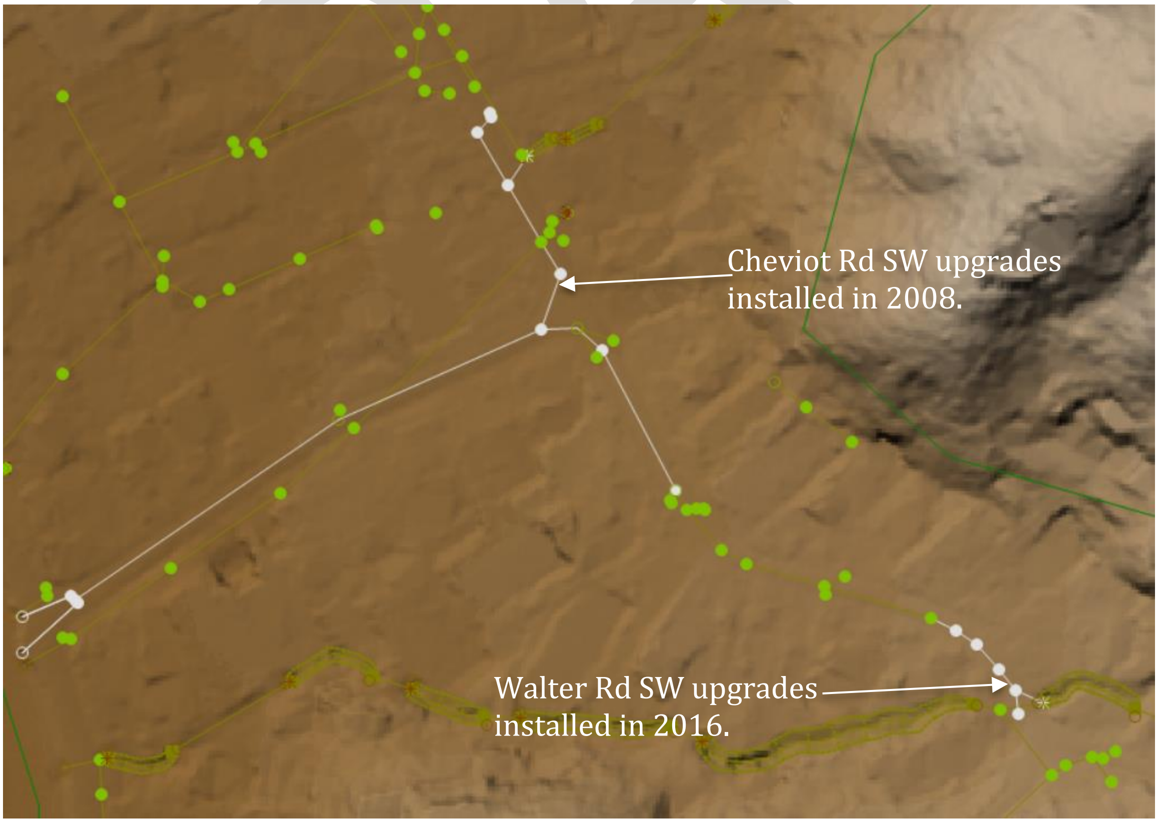


Figure 26 SW upgrades in Lowry Bay built since 2004 event which were removed for the validation

Also it was noted in accounts submitted by residents that outlets draining Rona St, Heketara St and Pukatea St catchments were blocked. This was represented by applying sediment depth to outlet links.

The rainfall for 15-16 February 2004 has two peaks and this is reflected in the observed hydrograph, with a lower initial peak occurring in the morning of 15th February, decrease in discharge before the hydrograph rises again with a second higher peak occurring around midnight. The initial model run started at 5am on the 15th February.

4.3.2. Model setup for simulating April 2019 event

There is no information available about the state of stormwater network during this event. To simulate this event the model was as Base without any modifications to the network.

4.3.3. Muritai Rd/Rona St Flooding

Residents' accounts from the area around Muritai Rd/Rona St as well as flood extent shown on HCC plans for the storm event in February 2004 suggest extensive flooding at this location had occurred. Taking into consideration the fact that peak of the event was at night when residents would have been sleeping or unable to fully assess the scale of the flooding, none of the reported accounts contradict model prediction for the same event at this location. Figure 26 below shows flooding predicted by the model as well as residents' accounts from this area.

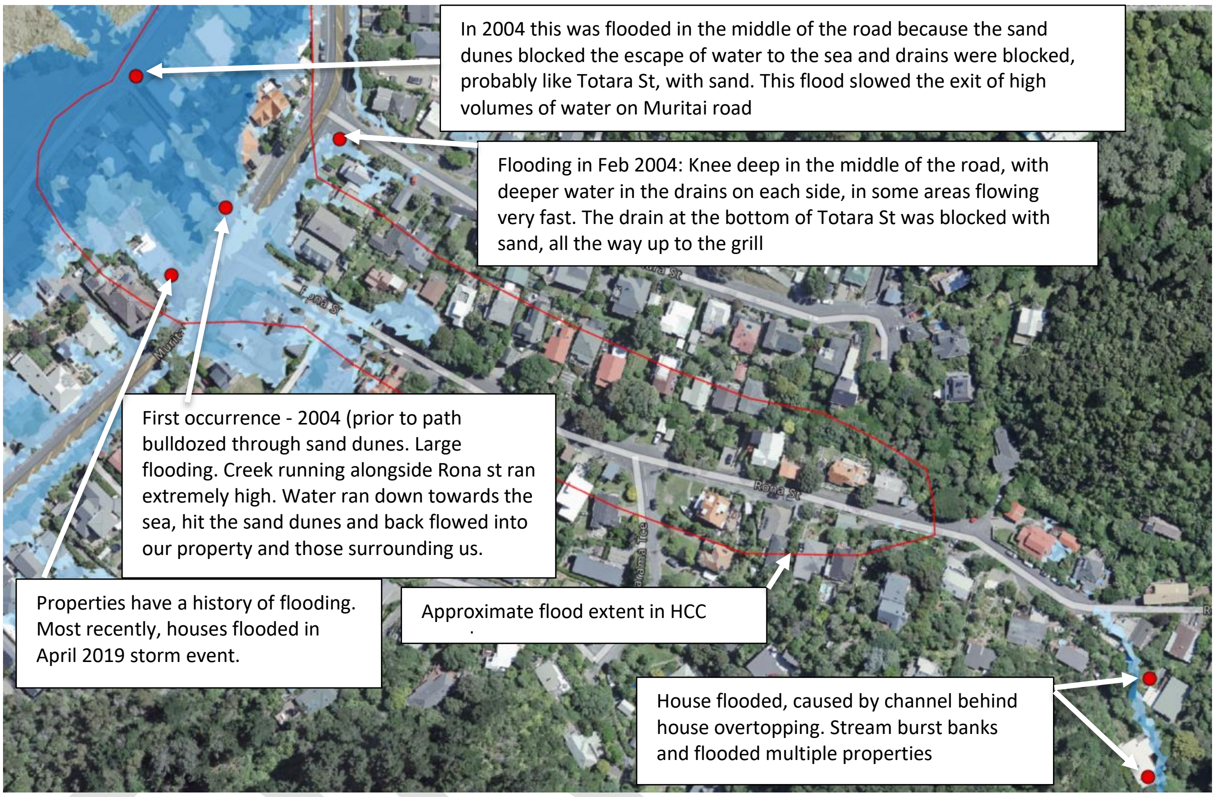


Figure 27 Flooding in the North of Eastbourne in February 2004 – Modelled and Observed

For the April 2019 flood event it is known that properties at 92, 94, and 96 Muritai Road, as well as 19 Marine Parade were affected. It is known that properties at 94 Muritai Rd and 19 Marine Parade had habitable floors flooded. The only photographic evidence from the aftermath of the event is of 94 Muritai Rd shown in Figure 27. A distinct line on the side of the house indicates peak water level during the event. It is difficult to precisely state the depth based on the image, but it is in a range of 500 to 600 mm. The model prediction at this location is 550 mm which is within the range.

It is possible to estimate floor height at 19 Marine Parade from Google Street View. It appears to be in 150 to 200 mm range. The model predicts peak flood depth at this location of approximately 350 mm. The model prediction appears to be consistent with the flood depth experienced during the event where habitable floors were flooded.

Figure 28 Flooding at 94 Muritai Rd during 7 April 2019 storm event

4.3.4. 153 to 167 Muritai Rd as well as Muritai School

Search for flooding evidence has produced a video from 16 October 2009 event depicting flooding along Muritai Rd between numbers 153 to 167 as well as Muritai School on the opposite side of the road. Of note is that storm event which occurred on 16 October 2009 appears to be relatively minor with return period of less than 1.58 year ARI. The actual magnitude of the event could have been greater in Eastbourne as the nearest rain gauge data available for this even is from Wainuiomata river which is around 7 km away and separated from our study area by a hill range. Nevertheless, the model approximately predicts the same flooding as was depicted in the video from the event (see Figure 28).

Hutt City records indicate that properties at 165 and 167 Muritai Rd have history of flooding. It can't be positively confirmed whether the cause of the flooding is due to blockage of culvert as indicated in the council records or due to insufficient capacity as appears to be the case based on the model prediction.

Figure 29 Flooding at 153 to 167 Muritai Rd and Muritai School in October 2009 – Modelled and Observed

Discussion 1

The flood extent predicted by the model for 153 to 167 Muritai Rd appears to be accurate and is corroborated by the image in the top right corner in Figure 29 where it shows flooding extend to around half of school grounds.

Discussion 2

Model prediction for flooding at Muritai School grounds appears to match the video evidence from the event as can be seen in Figure 30.

Figure 30 Flooding at 153 to 167 Muritai Rd during 16 October 2009 storm event

Figure 31 Flooding at Muritai School during 16 October 2009 storm event

4.3.5. Middle Eastbourne Flooding

Residents' accounts from the area of Middle Eastbourne which for the purposes of this discussion is defined by the extent shown in Figure 31, as well as flood extent shown on HCC plans mostly corroborate modelling predictions for February 2004. Some of the comments attribute flooding to blocked gutters or inappropriate location of sumps, this does not negate the fact that flooding would still be experienced during February 2004 event as predicted by the model.

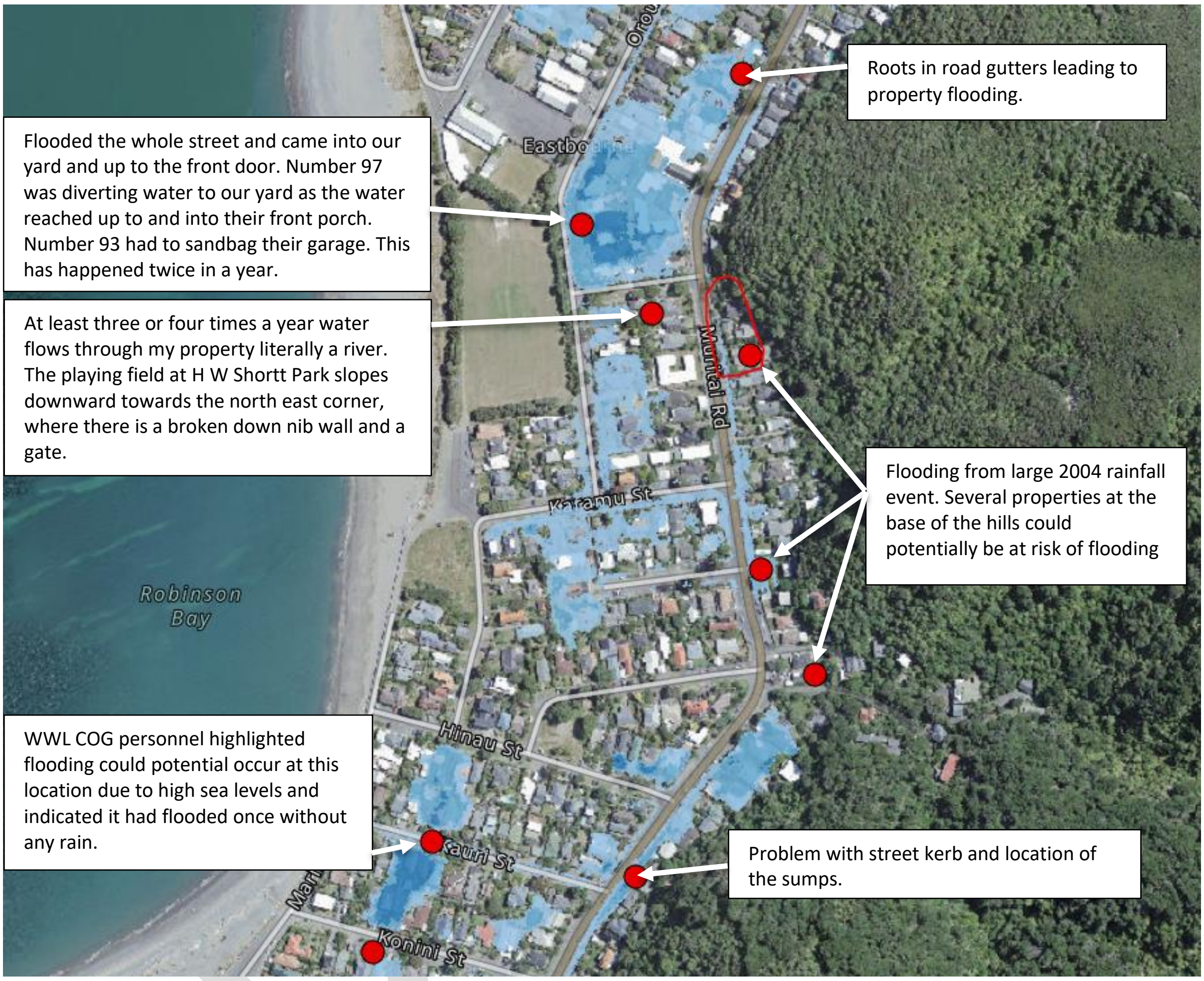


Figure 32 Flooding in the Middle of Eastbourne in February 2004 – Modelled and Observed

4.3.6. South Eastbourne Flooding

Residents' accounts from the area of South Eastbourne which for the purposes of this discussion is defined by the extent shown in Figure 32, as well as flood extent shown on HCC plans mostly corroborate modelling predictions for February 2004 event.

While there is no photographic evidence that can be used for the purposes of validation, HCC council records of historic flooding events as well as public feedback provided via Social Pinpoint App clearly validate most of the flooding predicted by the model for that event.

Figure 33 Flooding in the South of Eastbourne in February 2004 – Modelled and Observed

There were several comments provided that refer to 2017 event but not to 2004. This is expected as it's likely that residents did not live there in 2004. The reasoning for the flood provided in these comments is insufficient capacity of the drain. It is very likely that flooding experienced in 2004 before upgrades to Pukatea Street playground pump station stormwater network upgrade, would have been just as bad or worse.

Storm event in April 2019 was very intense in the North of Eastbourne around Rona St and ended up flooding several properties. In other parts of Eastbourne and along the coastline, rainfall was a lot less intense, and no flooding reports were registered other then what already has been described. Flooding predicted by the model based on April 2019 rainfall for this area is a lot less extensive than what was predicted for the 2004 event. As the peak of the event occurred just passed midnight, unless people were flooded inside their homes, it is unlikely they observed any flooding outside. It is therefore difficult to validate model prediction for this area based on April 2019 event.

Several locations where predicted flooding extent has not been explicitly corroborated by available records do require discussion which is provided below.

Discussion 1

Several properties including 438, 434, 426 and 424 Muritai Rd are located in depressed locations and are predicted by the model to have flooded during 2004 event or during even smaller events i.e. 10 or 5 year ARI storms. The reason for this is that these properties are not serviced by public stormwater network. It appears that these properties are connected to private soak pits which should provide some drainage and maintain these properties flood free at least during minor storm events.

Discussion 2
There is a significant depression at the foot of the hills at 19 Matipo St extending to 24 Karaka St to the north. The model predicts this location to have been severely flooded during 2004 event with depth reaching 1.7 m. Slightly shallower depth of 1.3 m is predicted for 10 year ARI storm. However, no records exist which would confirm this flooding.

As this location is sitting significantly lower than Matipo St and Karaka St, there is no gravity drainage for this location. The properties located there must rely on private soak pits or pumping solution. No information about this was available.

4.3.7. Days Bay Flooding

Residents' accounts from the area of Days Bay as well as flood extent shown on HCC plans mostly corroborate modelling predictions for February 2004 event as indicated in Figure 33.

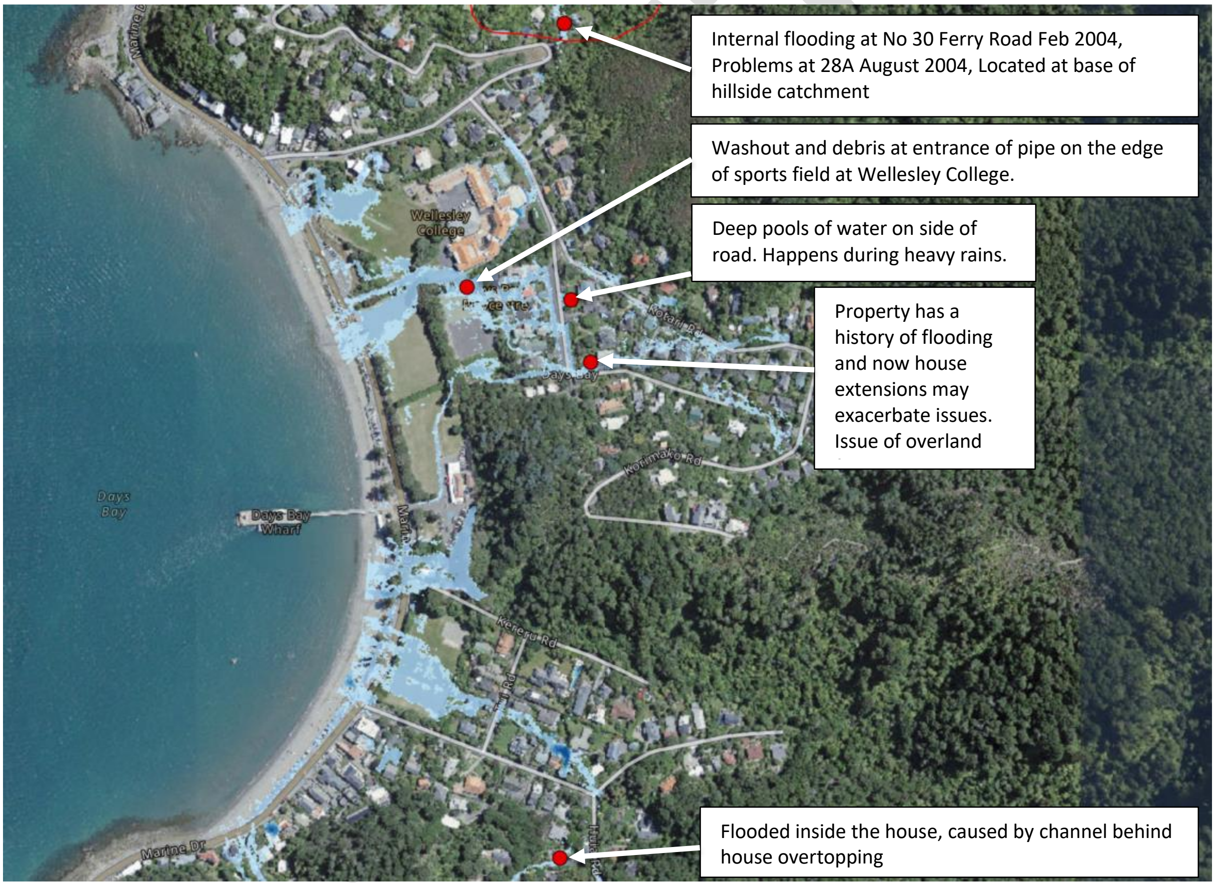


Figure 34 Flooding in Days Bay in February 2004 – Modelled and Observed

4.3.8. Lowry Bay Flooding

Residents' accounts from the area of Days Bay as well as flood extent shown on HCC plans mostly corroborate modelling predictions for February 2004 event as indicated in Figure 34.

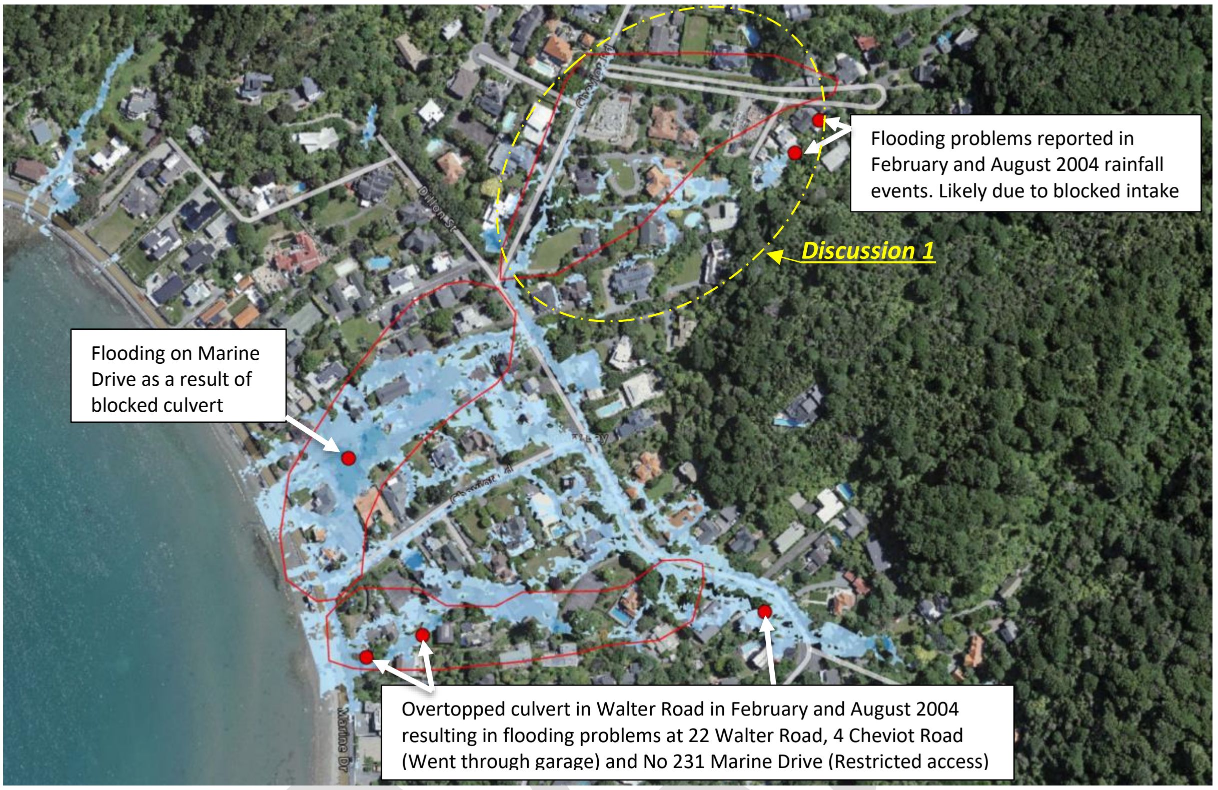


Figure 35 Flooding in Lowry Bay in February 2004 – Modelled and Observed

Discussion 1

The model does predict flooding at this location but seemingly of less severity. Only one of the identified locations appears to experience flooding. It is not clear what is meant by blocked intake in the provided comment. There's an intake to the north of Whiorau Rd which if blocked result in flooding of a few properties in addition to the ones identified. It could also be that by inlet is meant the open drain outlet which if blocked should have resulted in both locations experiencing flooding. The setup corresponding to flooding in Figure 34 did not have blocked inlet.

5. Conclusion

A coupled 1-D-2-D model was developed for the East Harbour stormwater catchment using InfoWorks ICM software. The model includes 1-D pipe network and 1-D open channel data based on data available at Wellington Water Ltd as well as a 2-D model generated from LiDAR data and Wellington Harbour bathymetry. Errors, omissions, and anomalies in the GIS data have been resolved using engineering judgment, as-built drawings and site inspections undertaken by Wellington Water Ltd staff.

The hydraulic model has been developed to a high level of detail and includes all the sumps and small diameter pipes that could be identified in the catchment. The ground model has also been developed to a high level of detail with mesh elements ranging in size from 2-4 m used in most locations. The hydrological model has been built to a comparable level, with sub-catchments delineated for each sump, open channel and building with a direct connection to the stormwater network.

The model is suitable for preparation of flood hazard maps, use in detailed design of remedial options, setting recommended building levels, assessment of development impacts and for testing the impacts of increased rainfall intensity and sea level due to climate change.

Where the model is to be used for detailed design of upgrades to the stormwater network, it is recommended that further site survey is undertaken by Wellington Water Ltd.

6. References

Capacity Infrastructure Services, 2013. Regional Stormwater Hydraulic Modelling Specifications.

Cardno, 2016. Quick Reference Guide for Design Storm Hydrology: Standard Parameters for hydraulic modelling.

Cardno, 2017. SCS Rainfall Runoff Model Calibration: Standardised Parameters for Hydrological Modelling.

MWH, now part of Stantec, 2017. Regional Surface Layers Prepared for Wellington Water Ltd.

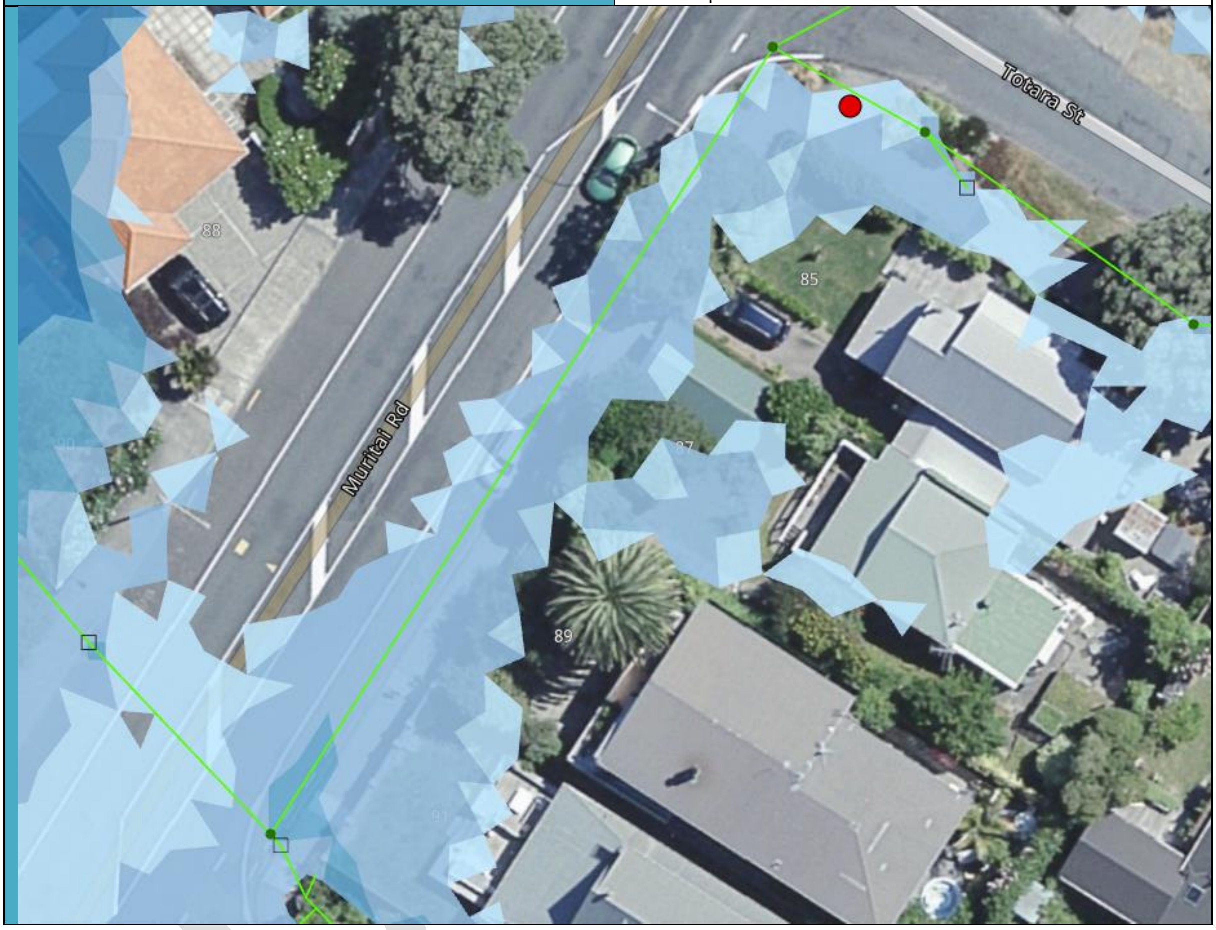
Appendix A – Data Flags

Flag Abbreviation	Flag Description
ASCO	From an as-constructed plan
AUTO	Automatically generated data
BRN	UMM Source Code
BS	UMM Source Code
CPLN	From a construction plan (not as-built)
CRS	UMM Source Code
DEF	Default values
DEM	Ground level from LiDAR Data
DEP	UMM Source Code
FTR	Future Model
GIS	GIS Import
GISI	Inferred in the GIS database
ICS	UMM Source Code
INF	Inferred
LL	Invert level of pipe from inlet/outlet lid level
MOD	UMM Source Code
PCOV	Invert level based on largest pipe diameter, node ground level and a nominal amount of cover
PIPE	Node invert level from pipe invert level or node diameters calculated form connected pipe diameter
SOFI	UMM Source Code
SUMP	UMM Source Code
SURV	Surveyed
UMM	UMM Source Code
UPG	Upgrade
USER	Set by the modeller
VAL	Validation Assumption

Appendix B – Validation Results

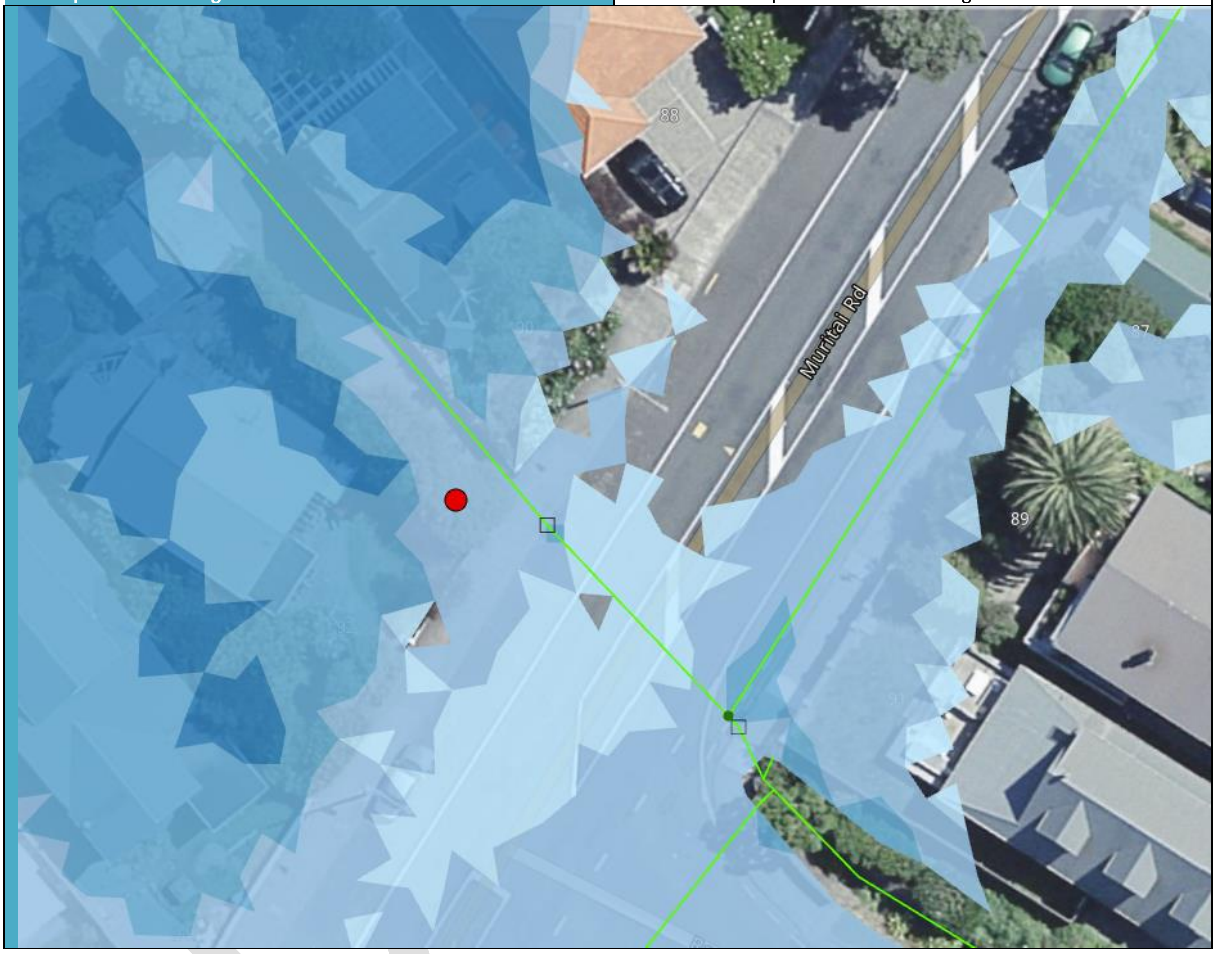
Intersection of Muritai Road and Totara Street, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Knee deep in the middle of the road, with deeper water in the drains on each side, in some areas flowing very fast. The drain at the bottom of Totara St was blocked with sand, all the way up to the grill
Description of flooding from model	The model doesn't predict quite as deep flooding as described at Totara St. However, it may be referring to other location to the south of Totara St, at Rona St intersection where flooding was knee deep at the middle of the road



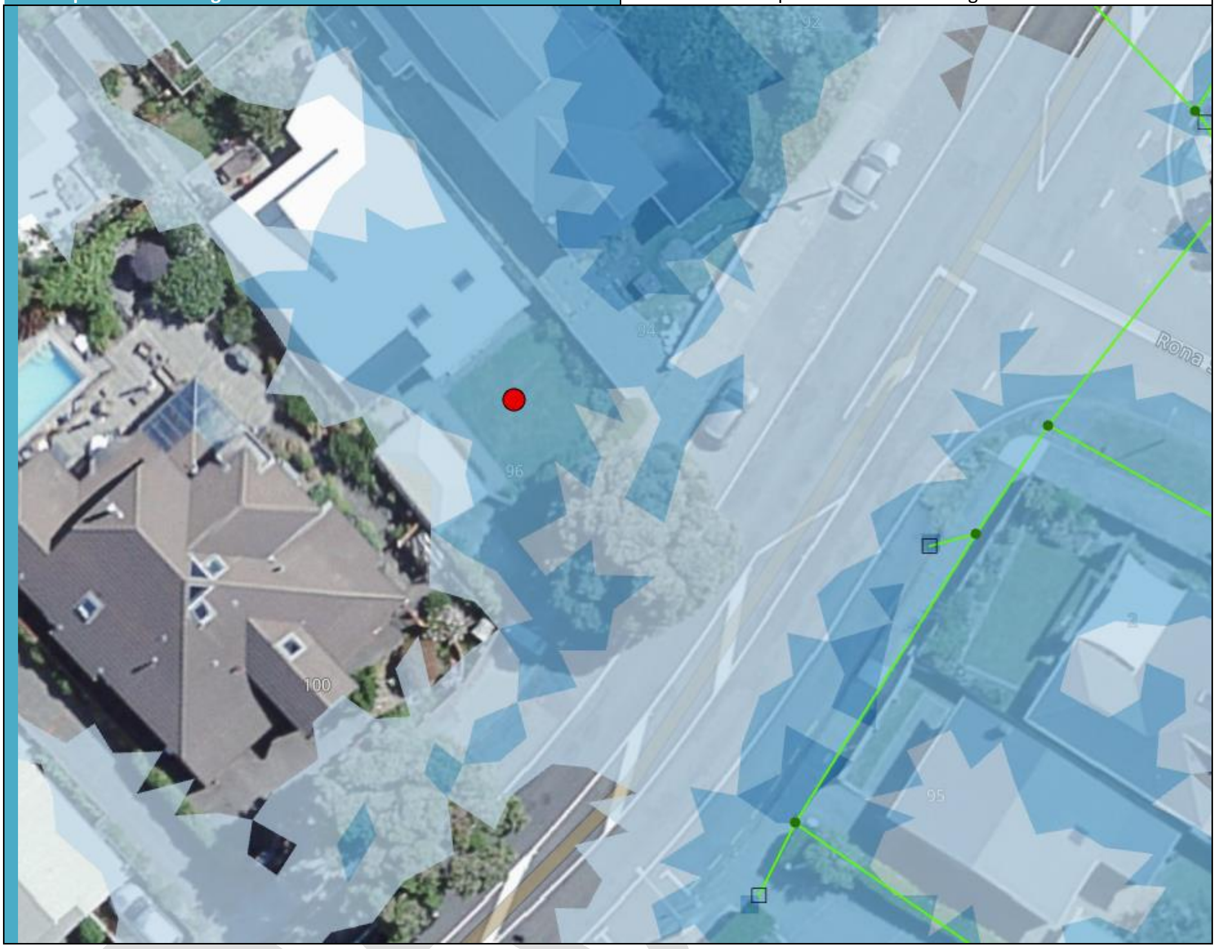
Intersection of Muritai Road and Rona Street, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	First occurrence - 2004 (prior to path bulldozed through sand dunes. Large flooding. Creek running alongside Rona st ran extremely high. Water ran down towards the sea, hit the sand dunes and back flowed into our property and those surrounding us.
Description of flooding from model	The model does predict similar flooding at this location.



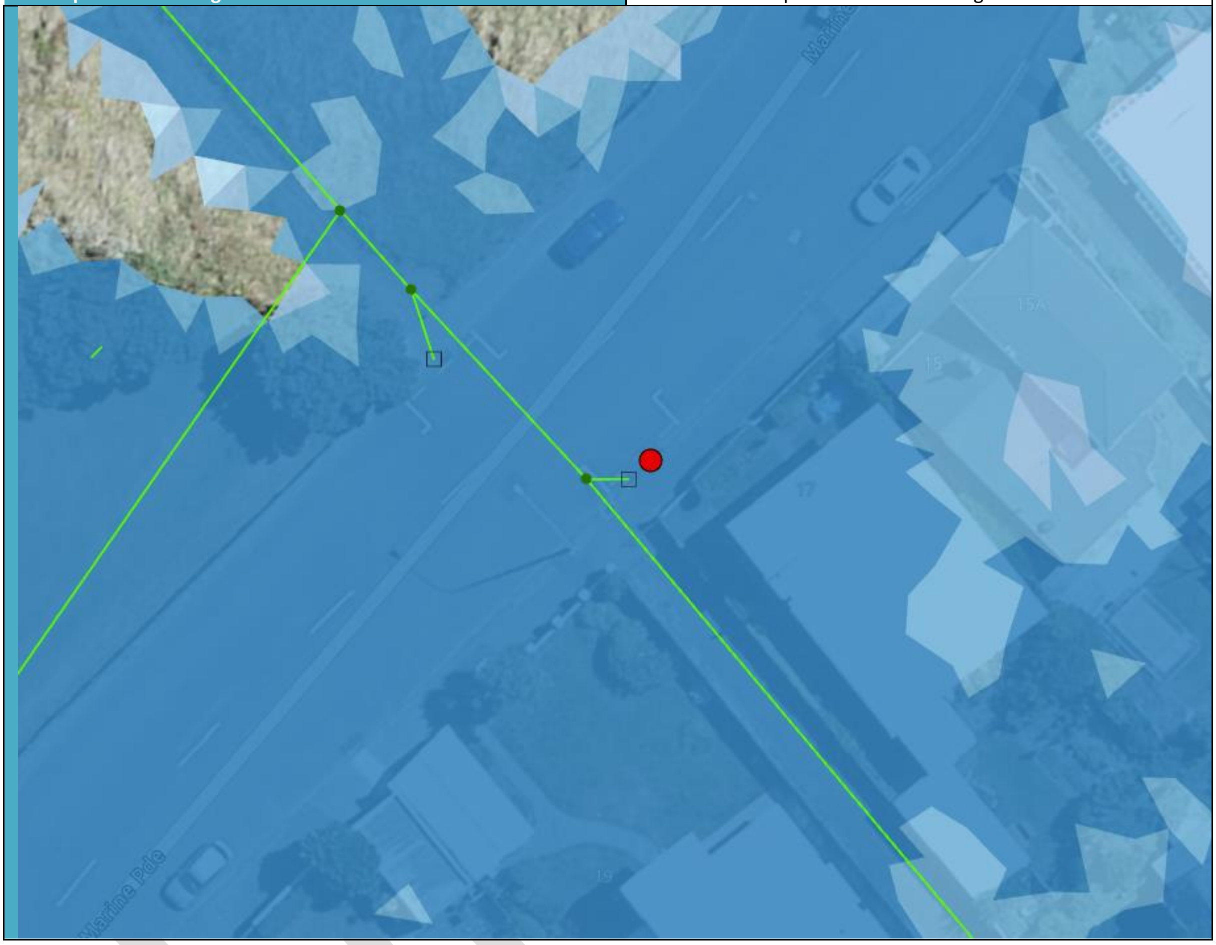
96 Muritai Road, Eastbourne

7 April 2019	
Description of flooding from Social Pinpoint/HCC database	Properties have a history of flooding. Most recently, houses flooded in April 2019 storm event.
Description of flooding from model	The model does predict similar flooding at this location.



Marine Parade, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	In 2004 this was flooded in the middle of the road because the sand dunes blocked the escape of water to the sea and drains were blocked, probably like Totara St, with sand. This flood slowed the exit of high volumes of water on Muritai road
Description of flooding from model	The model does predict similar flooding at this location.

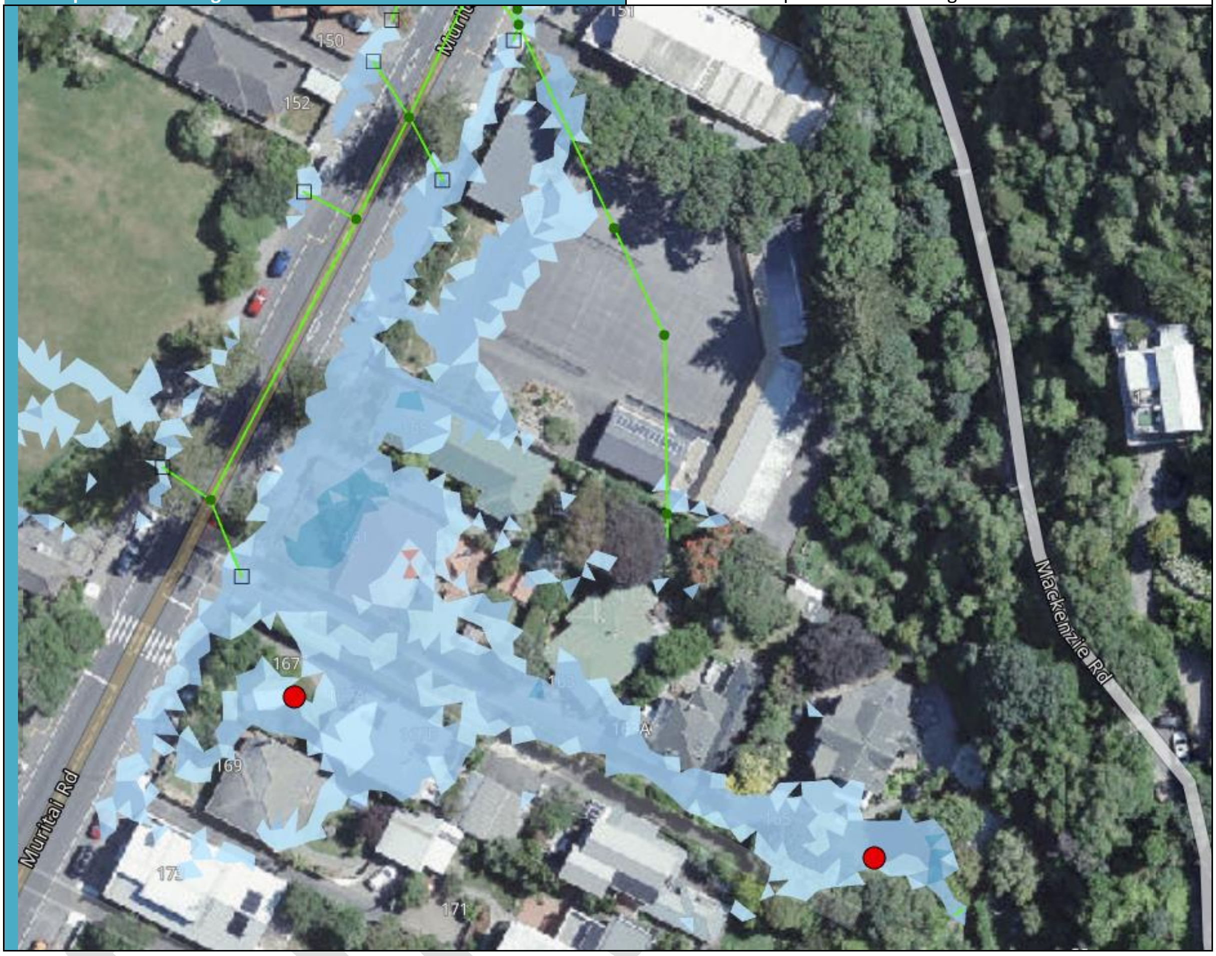


Upper Rona Street, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	House flooded, caused by channel behind house overtopping. Stream burst banks and flooded multiple properties
Description of flooding from model	The model potential flooding at this location. The severity of it would depend on the stormwater network inlet conditions. If it was blocked, the flooding could be significantly more obvious.

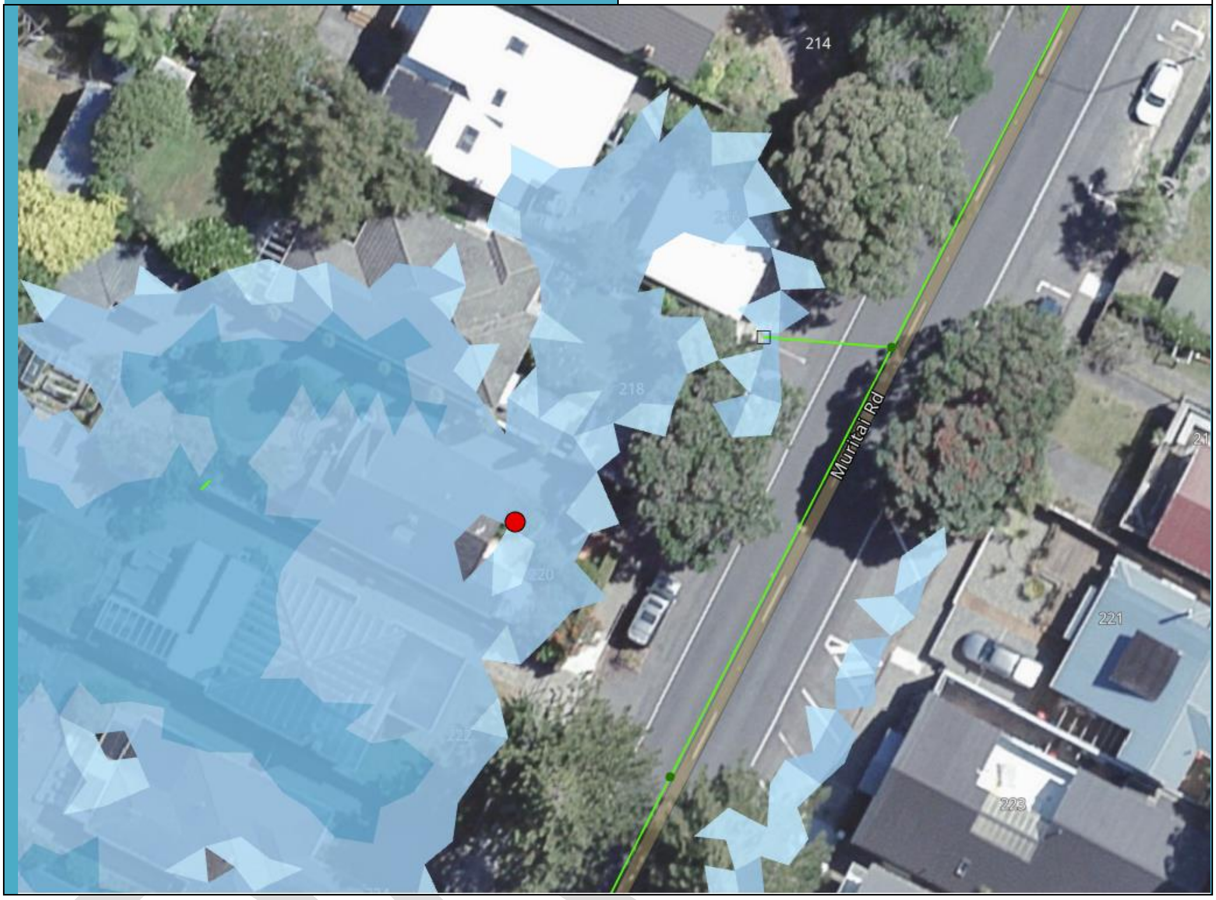
153-167 Muritai Rd, Eastbourne

16 October 2009	
Description of flooding from Social Pinpoint/HCC database	Property has a history of flooding. Culvert blocked and caused flooding
Description of flooding from model	The model does predict this flooding.



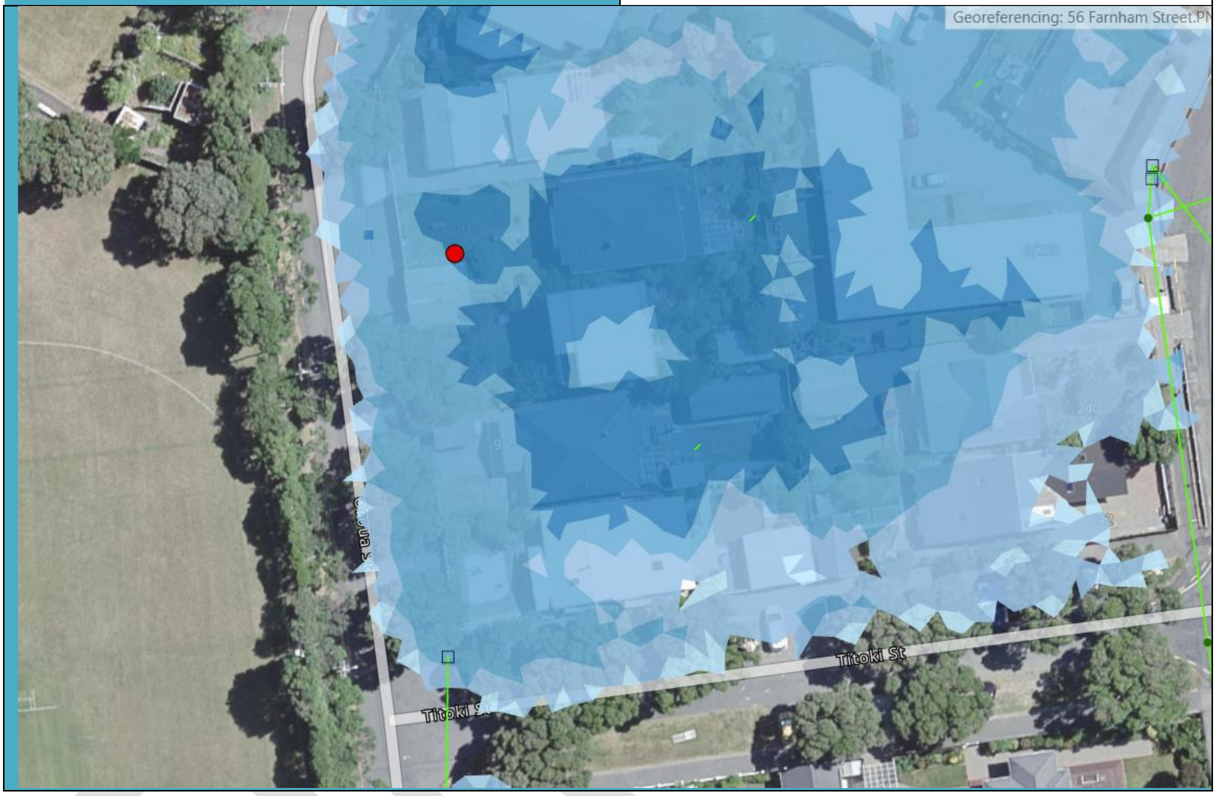
220 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Roots in road gutters leading to property flooding.
Description of flooding from model	The model does predict flooding at this location, but road gutters were unblocked. The flooding was caused by capacity limitation.



91 Oroua St, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooded the whole street and came into our yard and up to the front door. Number 97 was diverting water to our yard as the water reached up to and into their front porch. Number 93 had to sandbag their garage. This has happened twice in a year.
Description of flooding from model	Date when flooding occurred was not provided in the comment. It appears from other comments in this area that flooding is common. The model does predict flooding at this location during Feb 2004 event as well as other storm events.

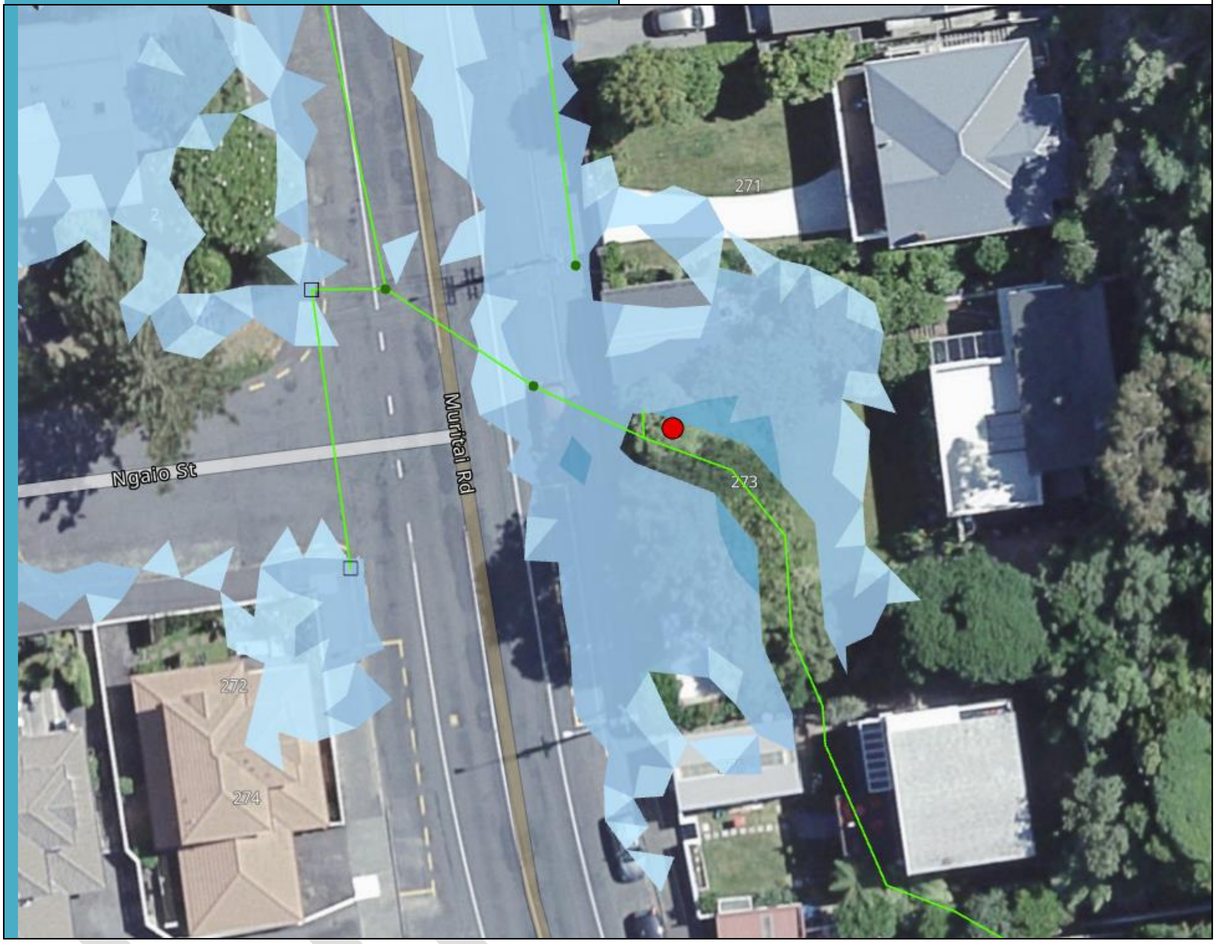


249 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooding from large 2004 rainfall event. Several properties at the base of the hills could potentially be at risk of flooding
Description of flooding from model	The model does predict flooding at this location during Feb 2004 event however flooding is predicted at the front of the property as the hill sub-catchments discharge to the curb drain. Rain on grid results do indicate shallow runoff over this properties flowing towards the road.

273 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooding from large 2004 rainfall event. Several properties at the base of the hills could potentially be at risk of flooding
Description of flooding from model	The model does predict flooding at this location during Feb 2004 event.

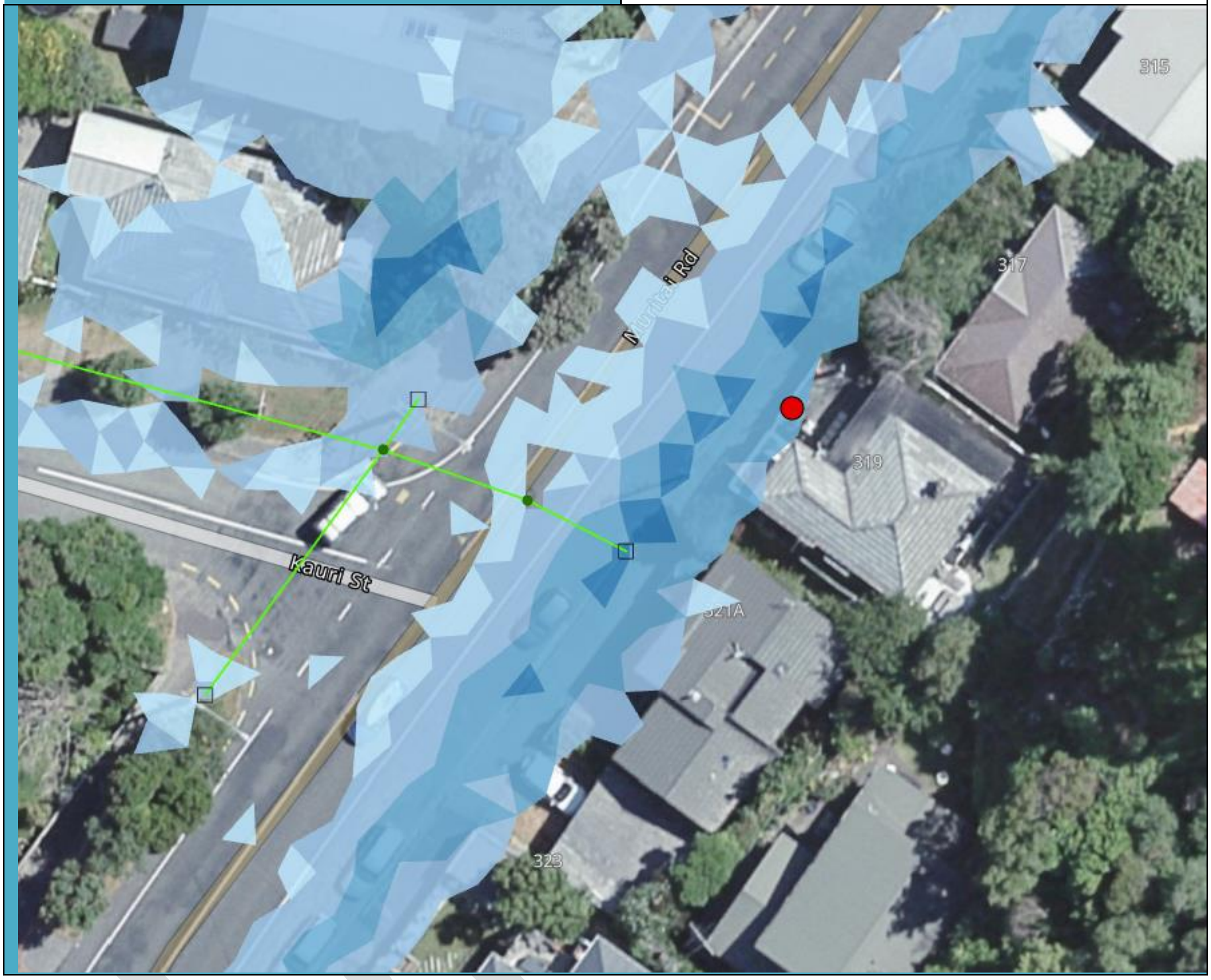


285 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooding from large 2004 rainfall event. Several properties at the base of the hills could potentially be at risk of flooding
Description of flooding from model	The model does not predict flooding at this location during Feb 2004 event however it does predict flooding here for April 2019 event and for 100 yr ARI storm events.

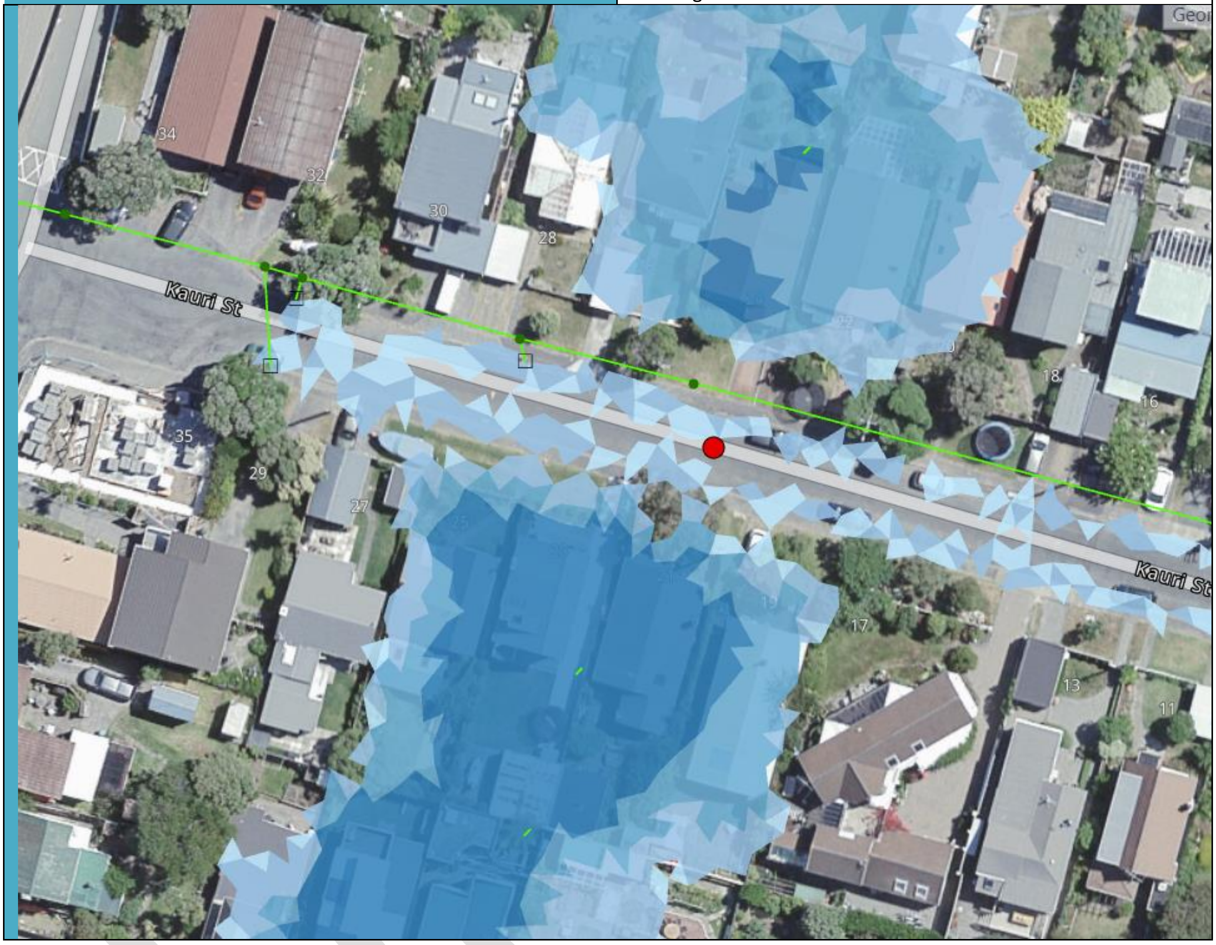
319 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Problem with street kerb and location of the sumps.
Description of flooding from model	The comment does not specify specific storm event. The model does not predict flooding at this location for all events including Feb 2004 event.



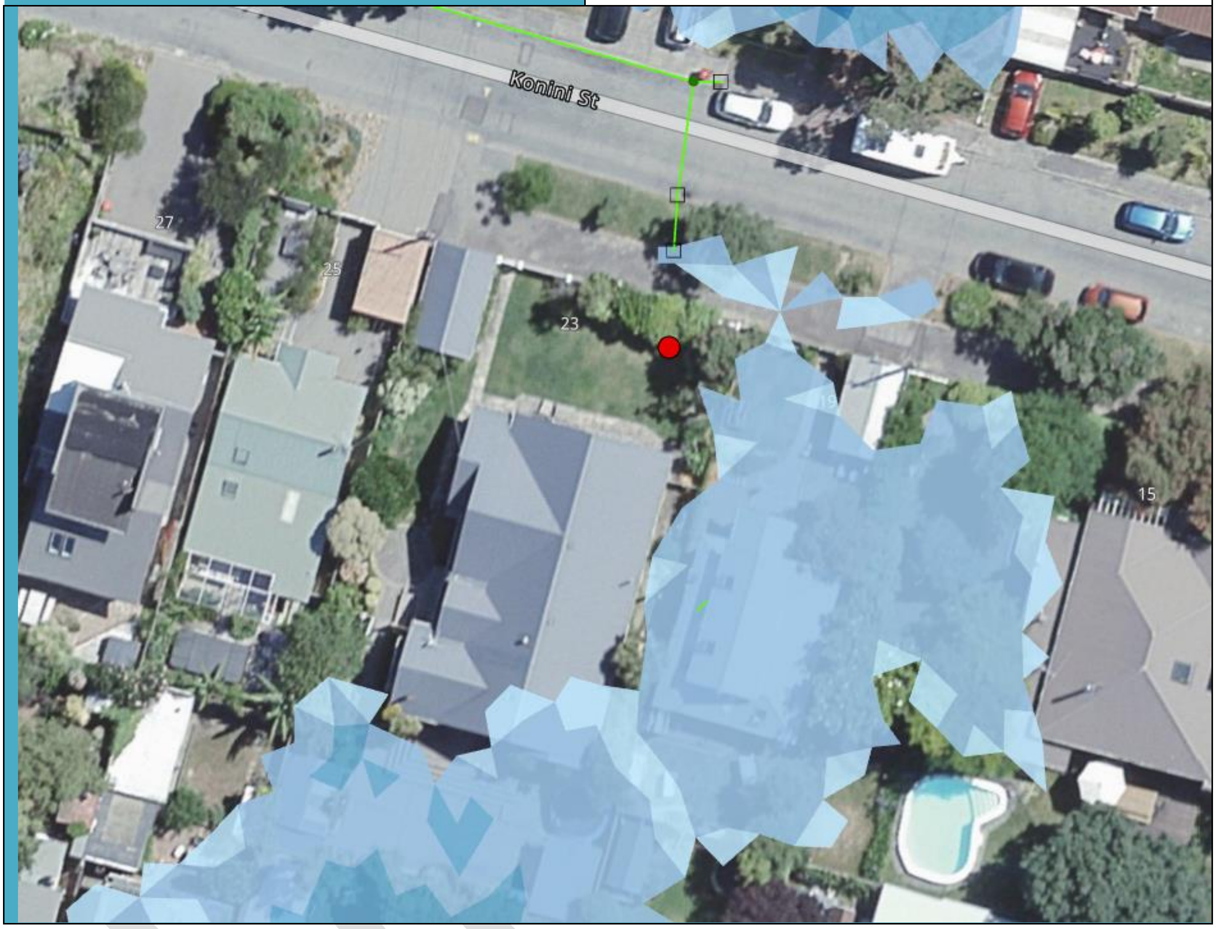
Kauri St, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	WWL COG personnel highlighted flooding could potential occur at this location due to high sea levels and indicated it had flooded once without any rain.
Description of flooding from model	Depression area. Does not easily drain. The model predicts flooding here for most events.



23 Konini St, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Floods the drain outside#23 every time there is decent/moderate rain. The flooding ranges from about 2m radius around the drain to covering the footpath. This is the only drain on the south side of the street
Description of flooding from model	Depression area. Does not easily drain. The model predicts flooding here for most events.

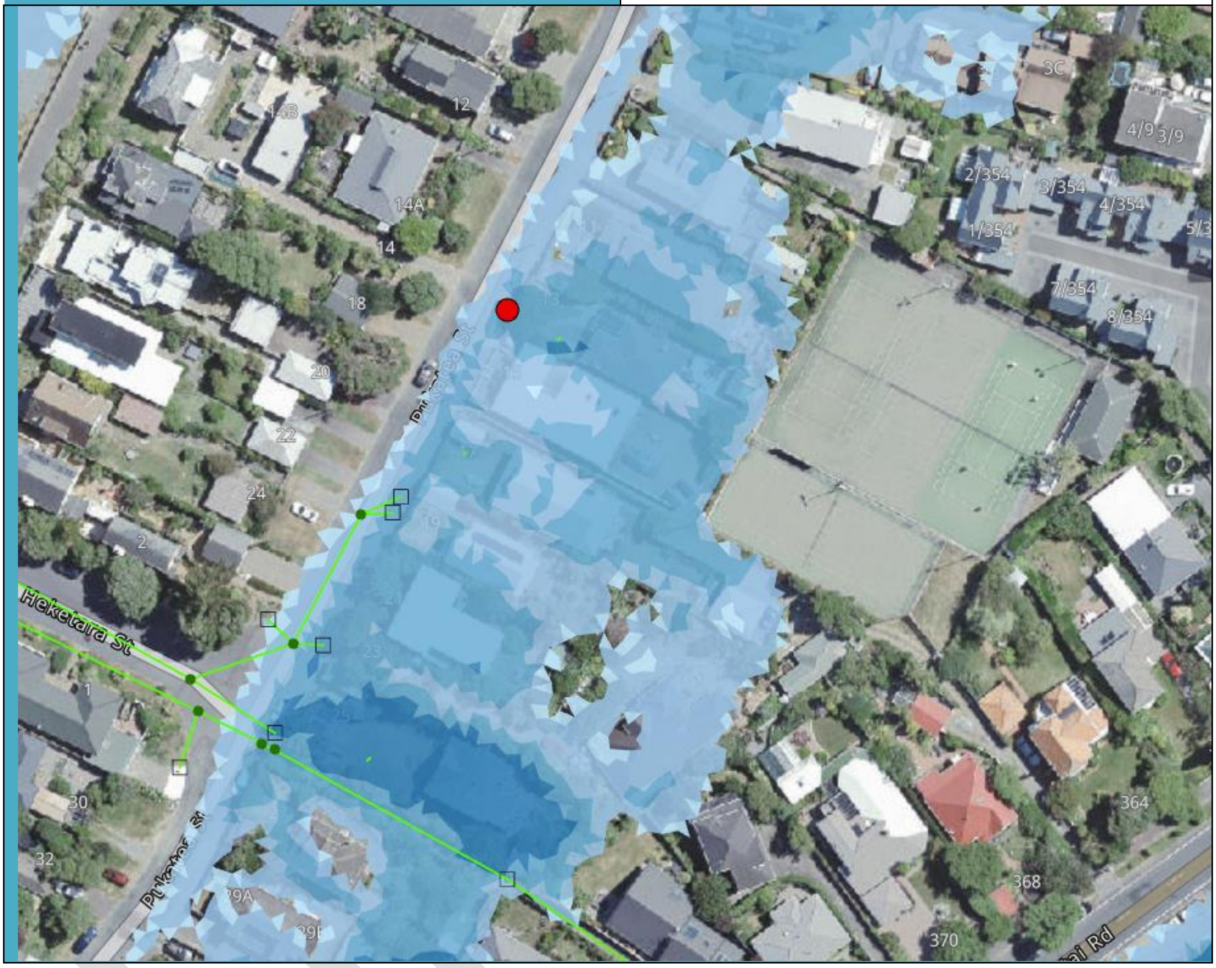


353 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooding from large 2004 rainfall event. Flooding as a result of runoff from Hills. A number of properties at the base of the hills could potentially be at risk of flooding
Description of flooding from model	The model does not predict flooding at this location for Feb 2004 event.

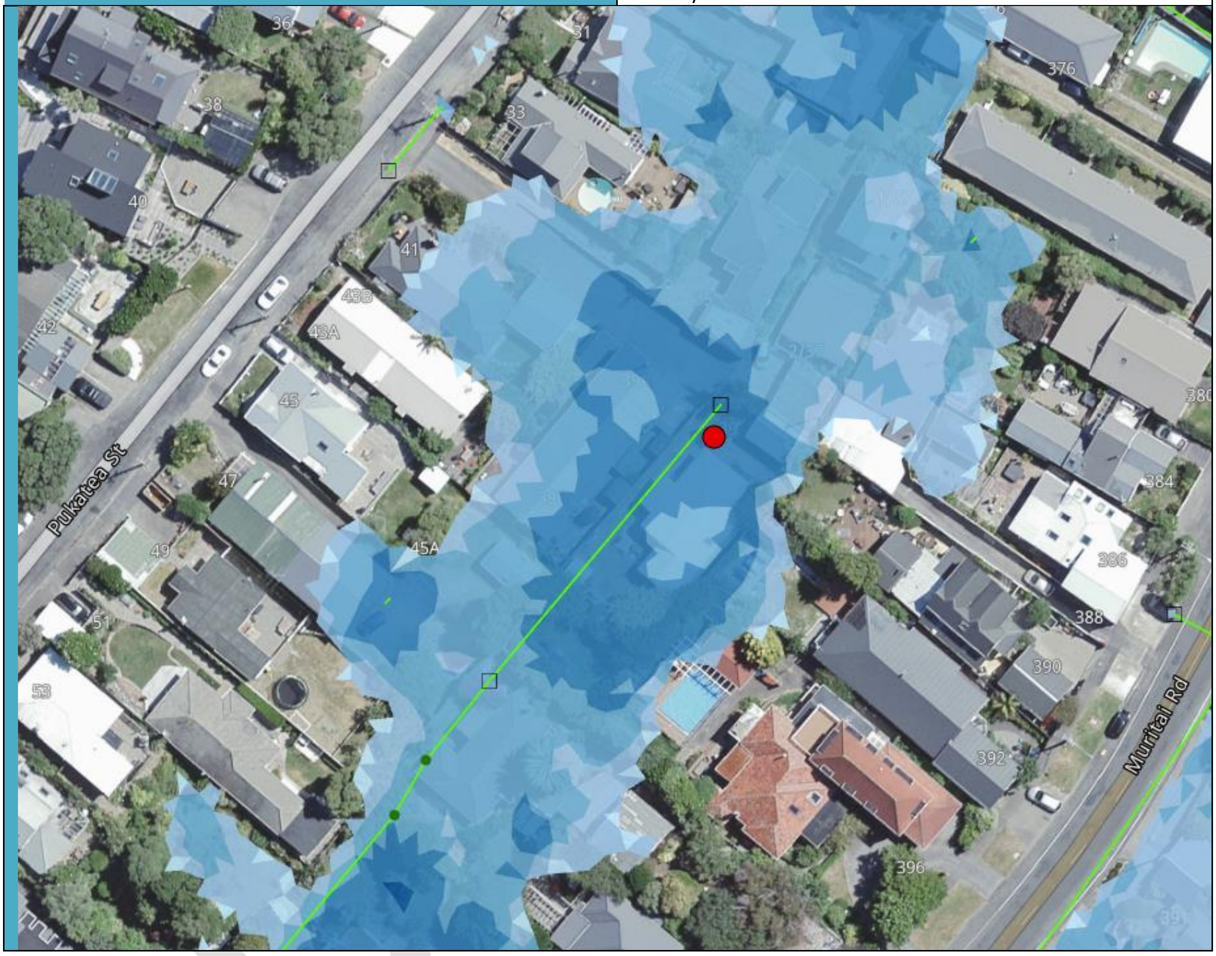
13 Pukatea St, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Some low properties flooded in this area in 2004.
Description of flooding from model	The model does not predict flooding at this location for Feb 2004 event.



39 Pukatea St, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Water flowed to our rental property from the Street. Drains were blocked and flooding extended through #37. The street was flooded from an under-road creek that overflowed 50m away. 0.5m water stayed until we managed to free the blockage on the beach
Description of flooding from model	The comment does not specify the event when the flooding occurred. The model does predict flooding at this location for Feb 2004 event as well as for other events with impact of varying severity.



Muritai Rd and Matipo St intersection, Eastbourne

7 April 2019	
Description of flooding from Social Pinpoint/HCC database	See comments provided on the plan.
Description of flooding from model	Rainfall associated with an event that generated flooding at several locations throughout Wellington in 2017 did not produce flooding consistent with what was reported in this catchment. There could be many reasons why this is so including outlet blockage etc. This is not known. One of the comments appears to be referring to 2019 event. The model does predict flooding at this location for 2019 storm.

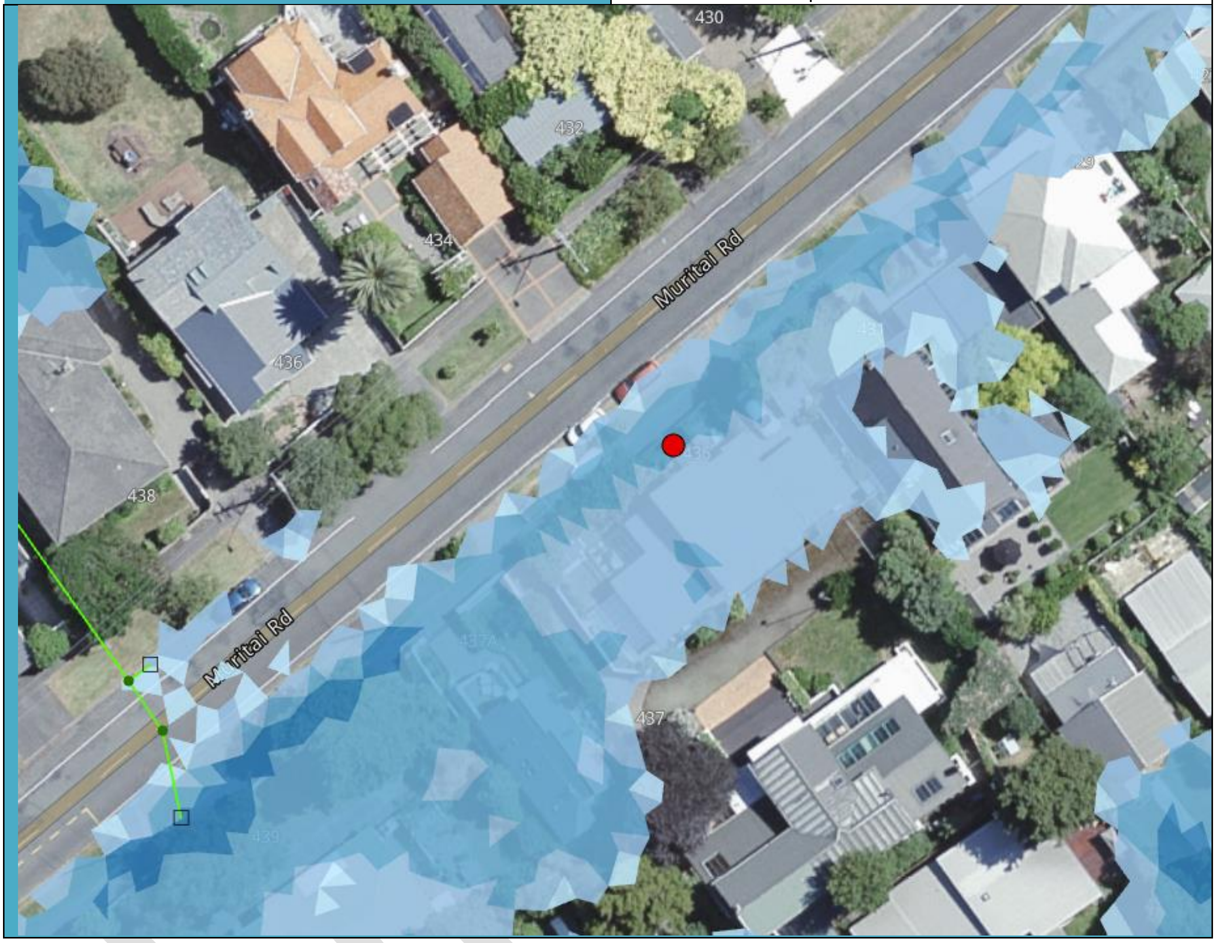
Property flooded in 2017 storm event believed to be due to insufficient pipe capacity.

Muritai Rd and Nikau St intersection, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Area identified as flooded from large 2004 rainfall event
Description of flooding from model	The model does predict flooding at this location for Feb 2004 storm.

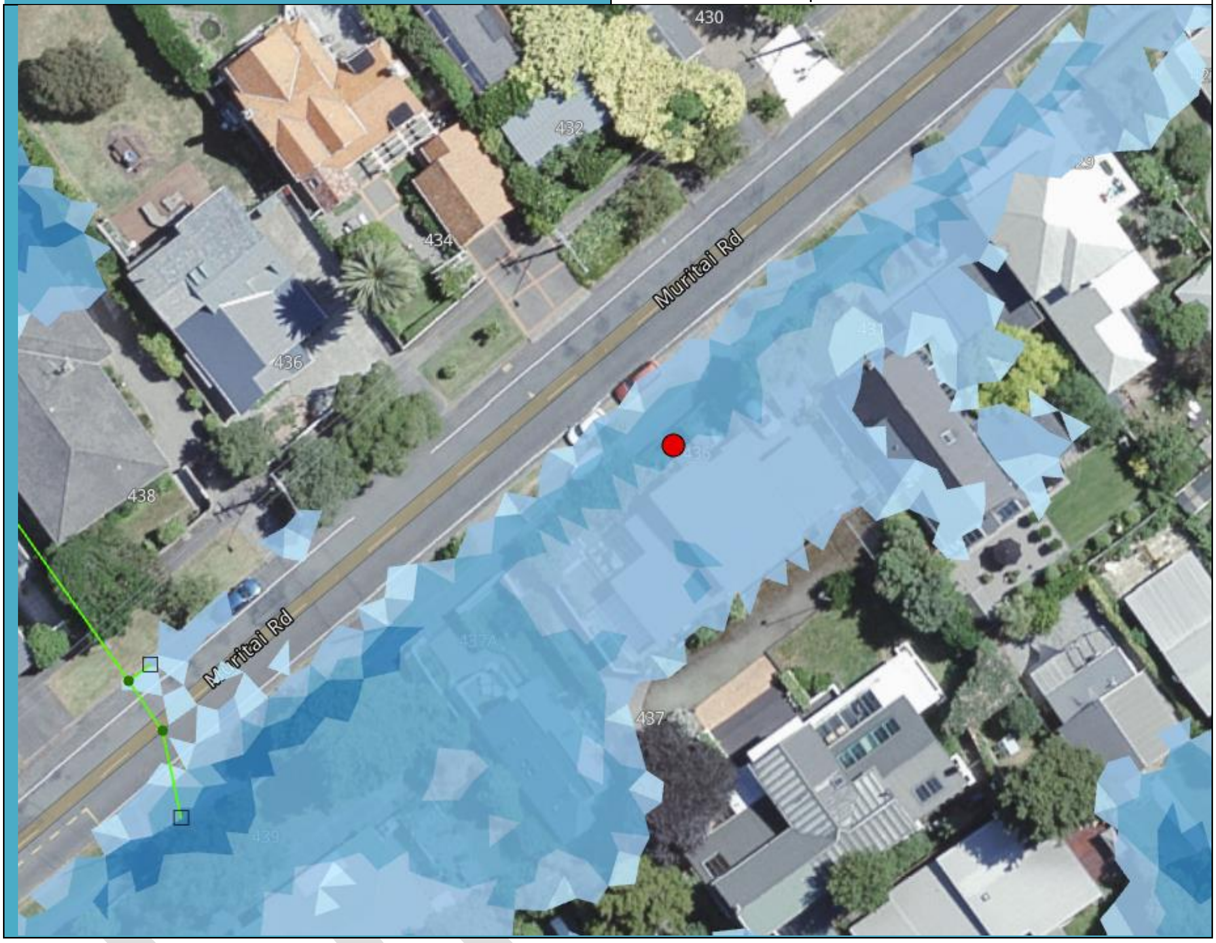
435 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Surface flooding on the street/gutter during heavy rainfall. Our front garden also fills up with rain during heavy rainfall events and can flood up to about 3 or 4 inches deep.
Description of flooding from model	The description does not mention the event when flooding occurred. The model does predict flooding at this location for Feb 2004 event but not April 2019 event.



435 Muritai Rd, Eastbourne

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Surface flooding on the street/gutter during heavy rainfall. Our front garden also fills up with rain during heavy rainfall events and can flood up to about 3 or 4 inches deep.
Description of flooding from model	The description does not mention the event when flooding occurred. The model does predict flooding at this location for Feb 2004 event but not April 2019 event.

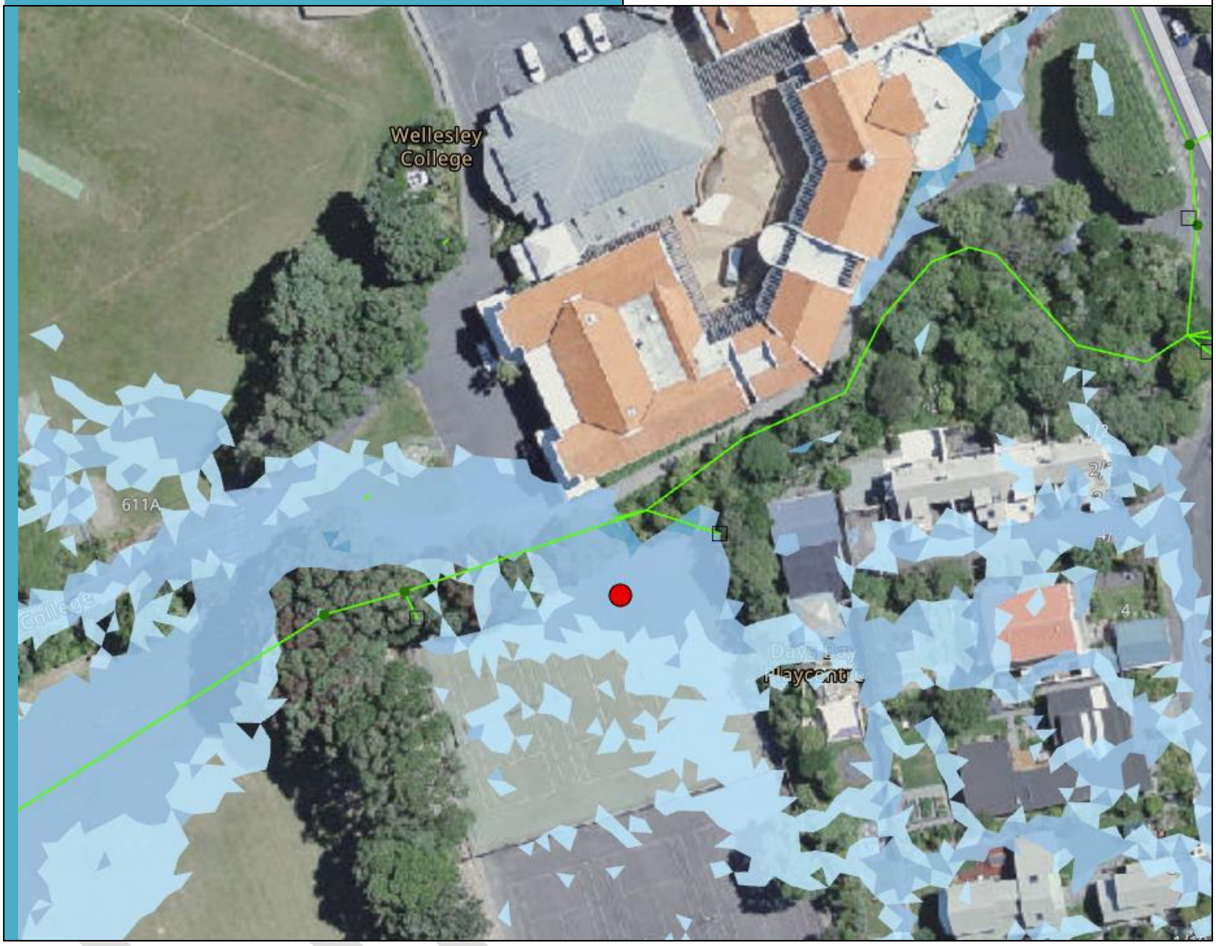


30 Ferry Rd, Days Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Internal flooding at No 30 Ferry Road Feb 2004, Problems at 28A August 2004, Located at base of hillside catchment
Description of flooding from model	The model does predict flooding at this location for Feb 2004 event.

Wellesley College, Days Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Washout and debris at entrance of pipe on the edge of sports field at Wellesley College.
Description of flooding from model	The comment does not specify the event when flooding occurred. The model does predict flooding at this location for Feb 2004 event.

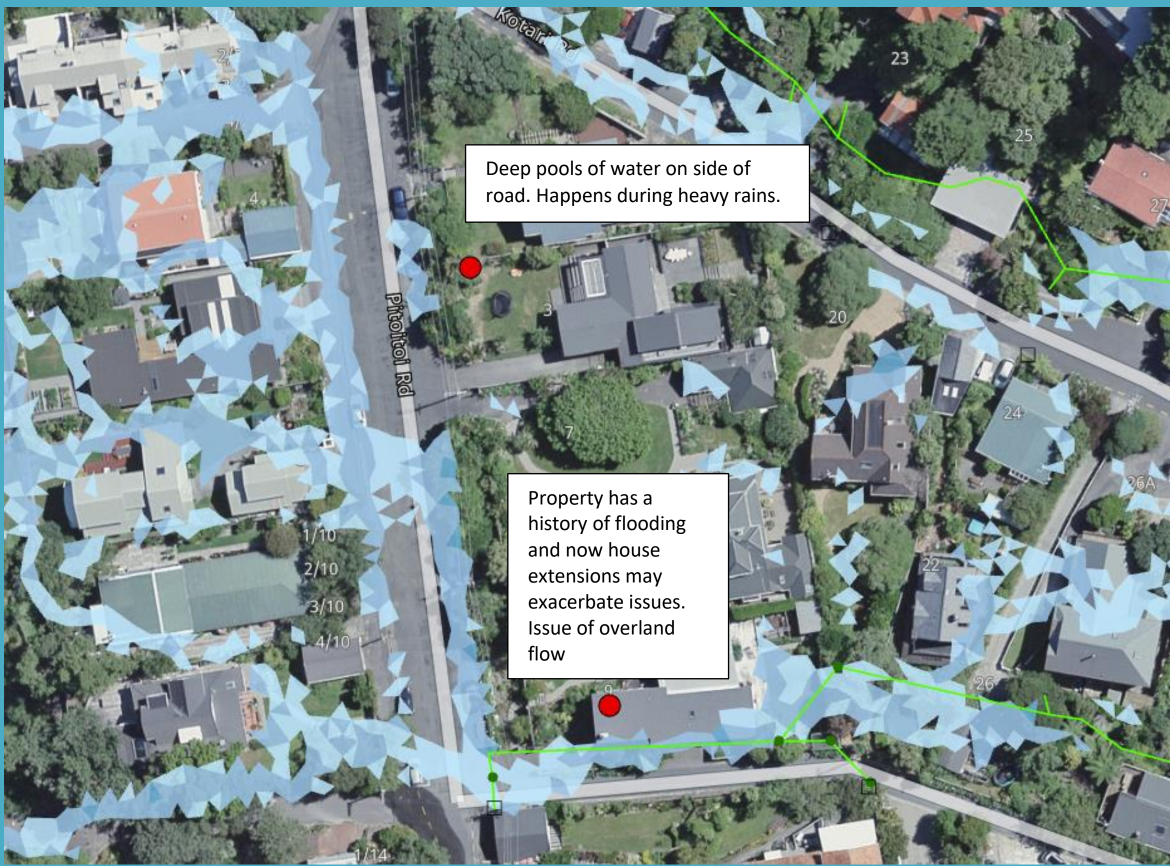


Wellesley College, Days Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Washout and debris at entrance of pipe on the edge of sports field at Wellesley College.
Description of flooding from model	The comment does not specify the event when flooding occurred. The model does predict flooding at this location for Feb 2004 event.

Pitoitoi Rd, Days Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	See comments on the plan below.
Description of flooding from model	The comment does not specify the event when flooding occurred. The model does predict flooding at this location for Feb 2004 and April 2019 events.

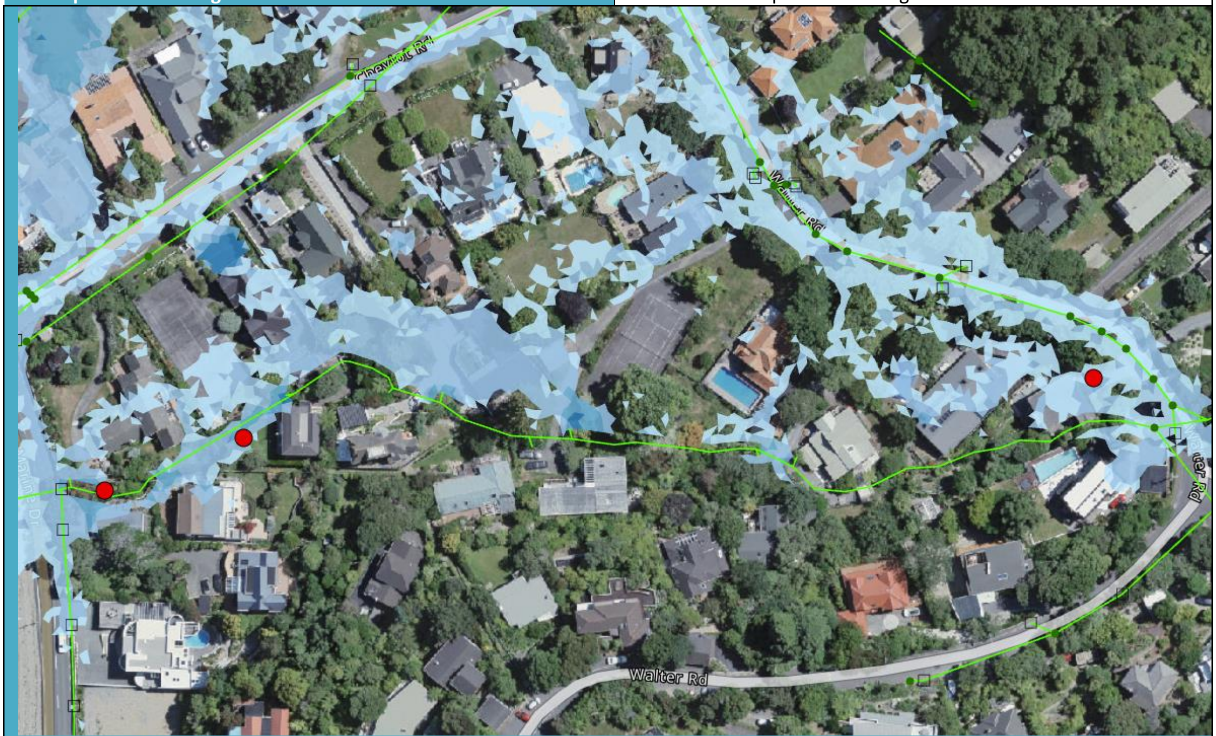


2 Huia Rd, Days Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooded inside the house, caused by channel behind house overtopping
Description of flooding from model	The comment does not specify the event when flooding occurred. The model does predict flooding at this location for Feb 2004 and April 2019 events.

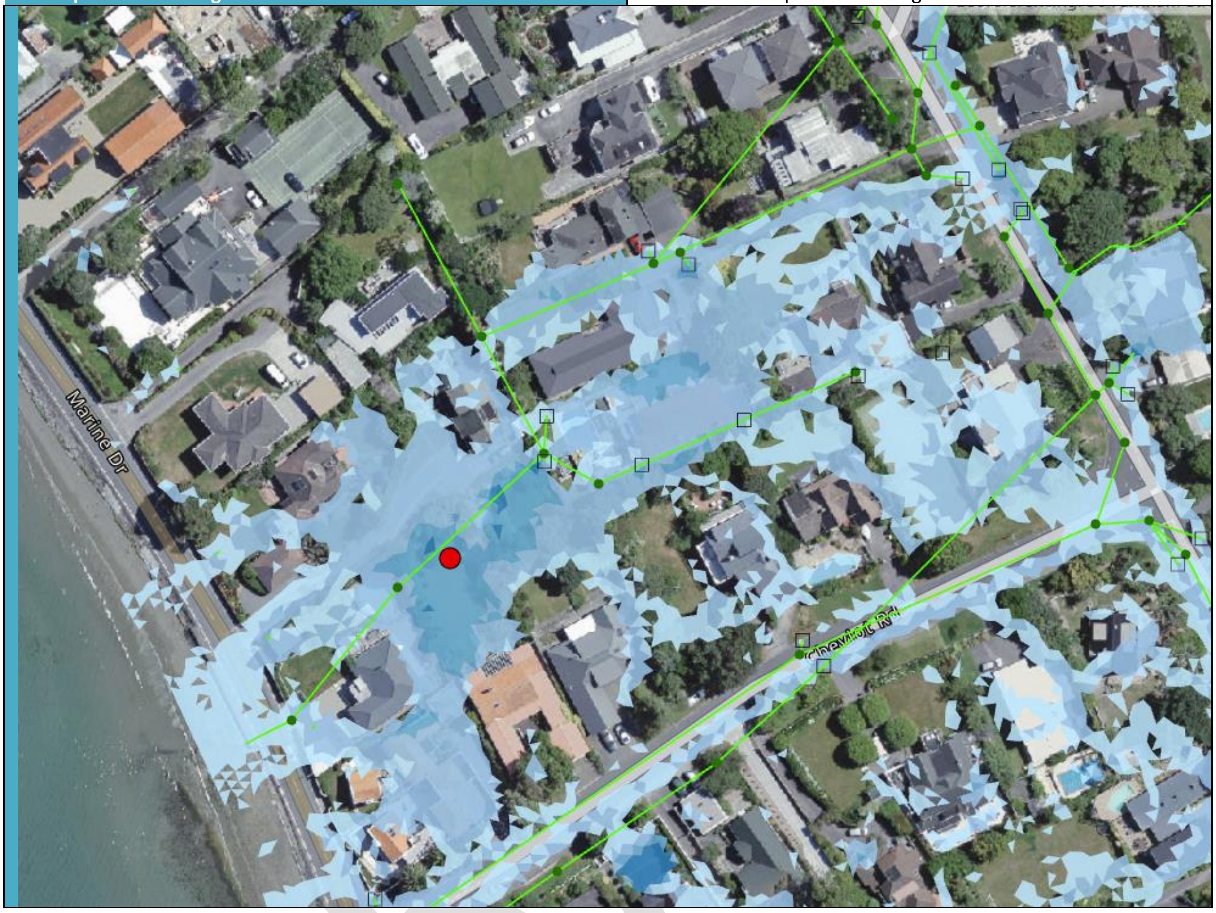
Walter Rd and Cheviot Rd, Lowry Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Overtopped culvert in Walter Road in February and August 2004 resulting in flooding problems at 22 Walter Road, 4 Cheviot Road (Went through garage) and No 231 Marine Drive (Restricted access)
Description of flooding from model	The model does predict flooding at this location for Feb 2004.



Marine Dr, Lowry Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooding on Marine Drive as a result of blocked culvert
Description of flooding from model	The model does predict flooding at this location for Feb 2004.



Whiorau Rd, Lowry Bay

15 February 2004	
Description of flooding from Social Pinpoint/HCC database	Flooding problems reported in February and August 2004 rainfall events. Likely due to blocked intake
Description of flooding from model	The model does predict flooding at this location but seemingly of less severity. It is not clear what is meant by blocked intake in the comment.