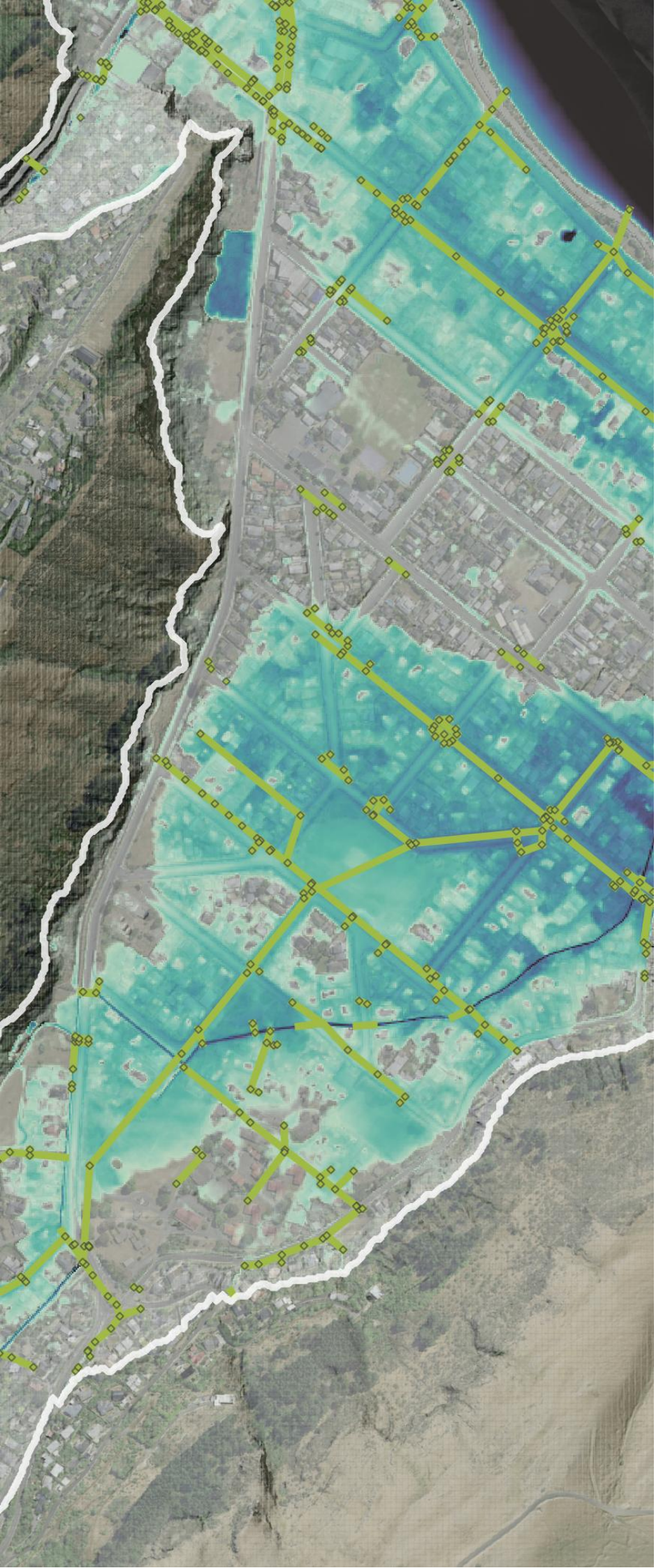

Sumner Flood Modelling

TUFLOW HPC
Model Build Report

Date 8/8/2025

Excellence Heart Innovation

SUMNER FLOOD MODELLING – MODEL BUILD REPORT

Project number	J000832
Version number	3.0
Date	8/8/2025
Project Manager	Chusit Apirumanekul
Author	Chusit Apirumanekul
Additional technical contributors	Craig Martell, Dominic Lo

VERSION	DATE	DESCRIPTION	AUTHOR	REVIEWED
1.0	12/07/2024	Draft model build report for peer review	Chusit Apirumanekul	
1.1	25/12/2025	Draft model build report after peer review for initial design event simulations	Chusit Apirumanekul	Julian Fyfe
2.0	7/5/2025	Model build report after post peer review updates and design event simulations	Chusit Apirumanekul	Brad Scarfe
2.1	13/6/2025	Model build report after close-out peer review comments and CCC comments	Chusit Apirumanekul	Brad Scarfe
3.0	8/8/2025	Model build report after CCC comments on inclusion of irregular culvert and CCC filename and conventions.	Chusit Apirumanekul	Brad Scarfe

EXECUTIVE SUMMARY

Sumner is a coastal catchment to the South-East of Christchurch. It is separated from the city by hill ridges with flat topography compared with surrounding terrains. The Sumner flood model was initially built in 2018 as part of the LDRP044 project and calibrated against a March 2014 storm event. This model was further developed by GHD and Christchurch City Council (CCC) using the DHI MIKE Flood software suite with more information between 2020 and 2022. The existing MIKE model required improvements due to changes in catchment characteristics and the availability of higher quality input data and Awa Environmental (Awa) updated this model in the TUFLOW HPC software, which is the focus of this reporting.

The objectives of this study are to:

- review existing data and information including existing models to support model updates;
- develop a new TUFLOW model for the existing development (2024) state based on existing models and the updated information;
- validate the 2024 TUFLOW model using the March 2014 event, which was previously used to calibrate the existing MIKE model;
- run the 2024 TUFLOW model for design events and produce deliverables as described in the user deliverables requirements spreadsheet; and
- provide CCC with a flood simulation capability suitable for a range of purposes, in line with the flood modelling Schema.

A range of model purposes for which this model can be used are:

- building design (especially floor level setting);
- Building Consent requirements;
- other network infrastructure and earthworks planning and design (especially stormwater management infrastructure);
- definition of flood risk extents (e.g. high flood hazard area) and other District Plan requirements;
- expert evidence for establishing consents and supporting plan changes;
- input into rules, assessment matters, policies and consenting outcomes relating to waterway and flood management;
- ongoing operation of existing consents (e.g. CSNDC);
- planning and preparation for emergencies including response and recovery plans for Civil Defence groups; and
- multi-hazard planning and input into the Coastal Hazards Adaptation and Planning Programme.

The previous modelling studies and data received to input into the model update are outlined in this report. Some key model characteristics are outlined below.

- 1D (one-dimensional) – 2D (two dimensional) coupling approach was applied for this model. The 1D components include stormwater network assets (pipes, culverts and pits) which are linked with the 2D domain. Open channels were modelled in the 2D domain.

- Coordinate system: New Zealand Transverse Mercator 2000.
- Vertical datum: NZVD 2016.
- The model was validated against the March 2014 storm event using observed flood level and results from the existing MIKE Urban model. The result variance from measured water levels was between 70 and 470 mm, with an average difference 240 mm (see Table 9).
- TUFLOW HPC (Heavily Parallelised Compute) version 2023-03-AE.
- TUFLOW's Quadtree and SGS features were applied in the model.
- A simplified approach to groundwater was applied using an initial groundwater level layer to approximate the MIKE approach outlined in the CCC flood modelling schema.
- 62 design runs where completed and a design run log is provided.

The updated and validated TUFLOW model was to simulation 62 design events outlined in *Appendix E – Design run log* for use by CCC's Stormwater Asset Planning team.

The model is considered a detailed, robust and validated model in line with good practice for flood models in New Zealand at the time of development. The validated TUFLOW model was developed into a design base model and design simulations have been completed to replace Councils master model results for reference by the Stormwater Asset Planning team.

The following recommendations made to be considered in a model backlog of future improvements. These do not impact the model's ability to deliver on the stated purposes, but are suggestions to consider if issues are found in specific locations or for specific events.

- High resolution cell size (0.5 m) along Sumner Stream if issues are found in low flow modelling results.
- The stormwater network in the CCC Spatial Open Data Portal contains missing information which is necessary for modelling purpose (invert levels of pipes and catchpits). Current model applied assumptions to fill those gaps and accurate surveyed information (pipes along Arnold St, pipes near the intersection between Marriner St and Wakefield Ave) will help improving the accuracy of model results. Specific assessment of model data quality and data capture plan is recommended.
- Flows from upstream catchments were produced by RORB models which do not consider the stormwater networks. There are some stormwater networks in RORB catchments which have not been considered. It was also observed that some RORB delineated catchments do not follow the terrain suggesting that further improvements could be made to the upstream catchment flows estimation.
- The use of the Schema based initial groundwater levels approach in this model is a good advancement. A sensitivity test to adding horizontal hydraulic conductivity would help with understanding if any additional improvements to soil representation and groundwater approaches are warranted.
- Consider local catchment measurements of infiltration to better balance the role of surface run off and groundwater exchange in streams and low lying areas. The main types of non-impervious land cover should be considered including parks, open spaces and residential properties.
- Improve kerb line representation as outlined in Section 3.3.5 Road and Kerb Lines.

TABLE OF CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The Sumner flood model was initially built in 2018 as part of the LDRP044 project and calibrated against a March 2014 storm event. This model was further developed by GHD and Christchurch City Council (CCC) using the DHI MIKE Flood software suite with more information between 2020 and 2022.

The existing MIKE model required improvements due to changes in catchment characteristics and the availability of higher quality input data. To address this, Awa Environmental (Awa) has been engaged by CCC to update the existing MIKE-based model and carry out a range of validation and design simulations for reference by the Stormwater Asset Planning. It was decided that the model update would be completed in TUFLOW HPC.

1.2. OBJECTIVES

The objectives of this study are to:

- review existing data and information including existing models to support model updates;
- develop a new TUFLOW model for the existing development (2024) state based on existing models and the updated information;
- validate the 2024 TUFLOW model using the March 2014 event, which was previously used to calibrate the existing MIKE model;
- run the 2024 TUFLOW model for design events and produce deliverables as described in the user deliverables requirements spreadsheet; and
- provide CCC with a flood simulation capability suitable for a range of purposes, in line with the flood modelling Schema.

1.3. MODEL PURPOSE

CCC (2025) provides draft user requirements for Council catchment-wide flood models and typical internal model users:

- Operations;
- Consent Compliance;
- Asset Management;
- Technical Services and Design;
- Transport;
- Planning, including CHAP; and
- Civil Defence and Emergency Management;

CCC (2025) also lists a range of primarily functions that modelling supports. These are relevant to the purpose of the Sumner model and include these functions:

- building design (especially floor level setting);
- Building Consent requirements;
- other network infrastructure and earthworks planning and design (especially stormwater management infrastructure);
- definition of flood risk extents (e.g. high flood hazard area) and other District Plan requirements;
- expert evidence for establishing consents and supporting plan changes;
- input into rules, assessment matters, policies and consenting outcomes relating to waterway and flood management;
- ongoing operation of existing consents (e.g. CSNDC);
- planning and preparation for emergencies including response and recovery plans for Civil Defence groups; and
- multi-hazard planning and input into the Coastal Hazards Adaptation and Planning Programme.

2. STUDY LOCATION OVERVIEW

2.1. CATCHMENT AND MODEL EXTENT

Sumner is a coastal catchment to the South-East of Christchurch. It is separated from the city by hill ridges with flat topography compared with surrounding terrains.

In previous models, MIKE 21 and RORB model boundaries were aligned for simplicity (green area) covering the flat area. The TUFLOW model extent was delineated from the 2020 LiDAR and the model extent was extended slightly further uphill (red polygon) based on the catchment topography. This causes overlapping between TUFLOW and Mike 21 model boundaries. To avoid duplication of generated surface runoff between RORB model catchment and TUFLOW 2D domain, rainfalls were applied only on the previous model extent (Mike 21) based on peer review and CCC approval.

On the coastal area, the model boundary was extended down to the 6m RL CDD to ensure the model boundary will remain inundated under the extreme low tide condition based on the requirements in the Citywide Flood Modelling (LDRP097) Model Schematisation 2020 Update – Avon/Estuary, Heathcote and Sumner – Rev 7 (Schema rev7). Figure 1 shows the TUFLOW model extent for the Sumner catchment and model boundaries adopted in previous studies (MIKE 21 and RORB).

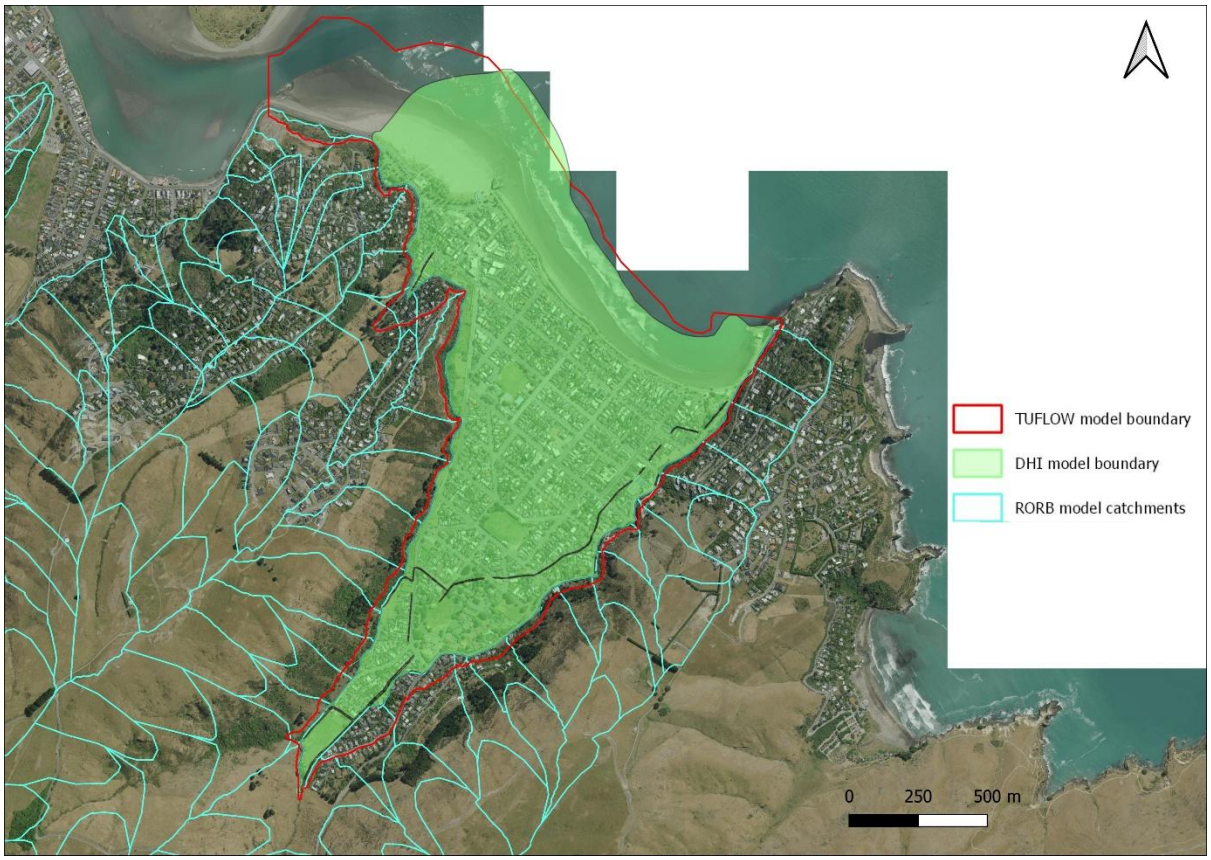

Figure 1. Sumner catchment TUFLOW and previous model extents.

2.1.1. PREVIOUS STUDIES

Substantial input information was provided to Awa to support model development. The input information was reviewed by Awa to assess and fill gaps for TUFLOW modelling purposes. Table 1 summarises the previous modelling work referenced in this study.

Table 1. Summary of previous models used in this study.

PREVIOUS STUDIES	DESCRIPTION
MIKE 1D-2D coupled model by GHD (version 3 Aug 2021)	MIKE-based models were calibrated to a March 2014 storm event. The TUFLOW model was validated against the same storm event using inputs from the MIKE21 and MIKE11 models.
RORB model outputs by GHD (version 19 Mar 2020)	RORB model calibrated to the March 2014 event.
RORB model outputs by Beca (version 18 Oct 2024)	GHD RORB model with updated HIRDS rainfall data

2.2. EXISTING LAND COVER

Existing land covers were classified into eight categories as shown in Figure 2. Land cover and impervious areas were mapped using machine learning method by Lynker and the Christchurch 0.075 m aerial imagery from 2023.

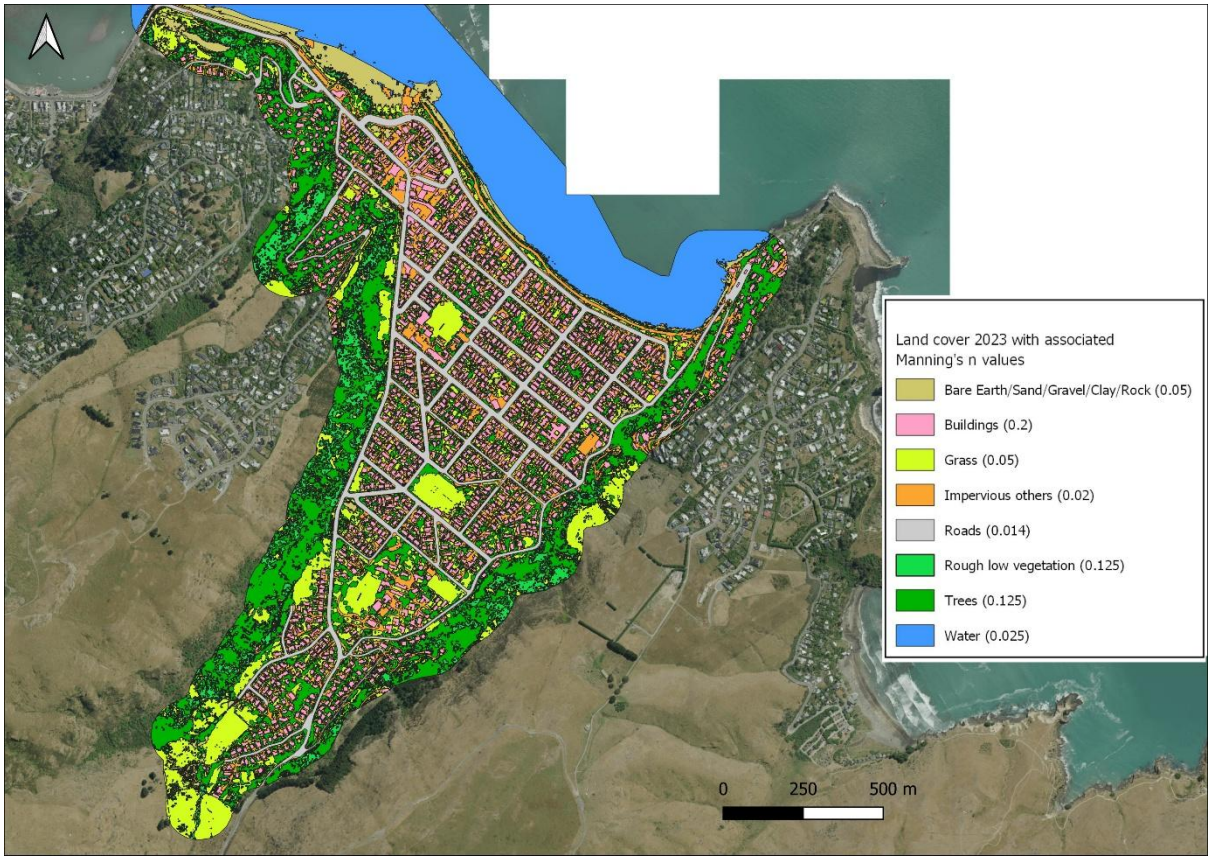

Figure 2. Existing land cover and associated roughness coefficients (Manning's n values).

2.3. STORMWATER SYSTEM

The stormwater network included in the TUFLOW model comprised elements from different sources including CCC's Spatial Open Data Portal, the existing MIKE Urban models, and assumptions based on engineering judgement.

The stormwater assets included in previous MIKE Urban models (2014 and 2020 versions) are significantly fewer than those captured in the CCC Spatial Open Data Portal. Table 2 compares the numbers of different asset types that constitute the TUFLOW and MIKE Urban models. The shows the increased detail in the latest model update reported here.

Table 2. Stormwater assets included in the TUFLOW model compared with the Mike Urban model.

STORMWATER NETWORKS	TUFLOW MODEL	MIKE URBAN MODEL
Nodes/Manholes	249	162
Catchpits	429	
Outlet	33	18
Pipes	636	166

Pipes and catchpits less than 300 mm in diameter were included in the TUFLOW model based on advice from CCC. Figure 3 contrasts the stormwater network included in the TUFLOW, model which corresponds to baseline (2024) conditions, with the stormwater network modelled in Mike Urban.

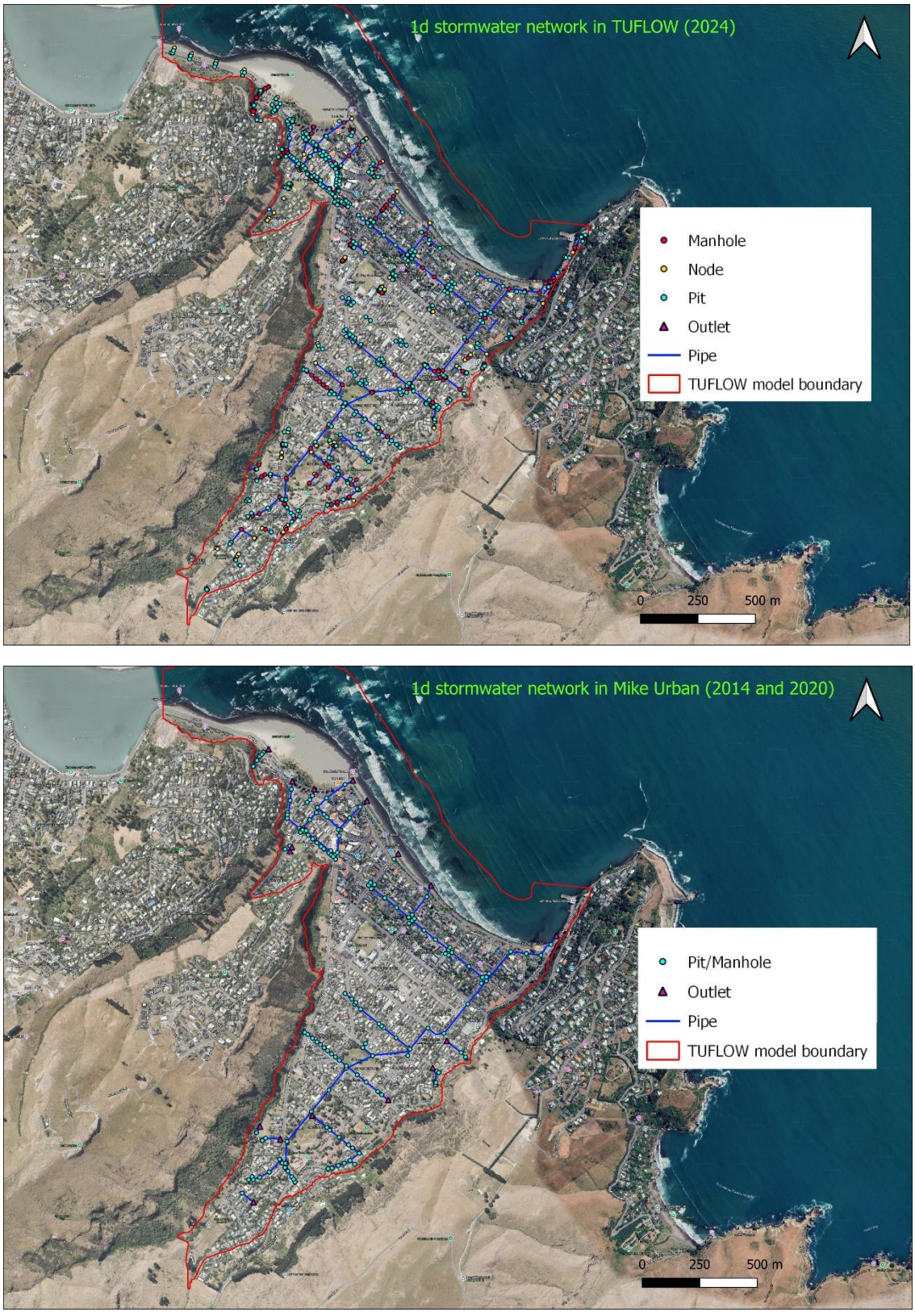

Figure 3. Stormwater networks included in TUFLOW model (top) and MIKE Urban model (bottom).

3. FLOOD MODEL BUILD

3.1. MODEL OVERVIEW

The following section defines the conceptual approaches that were used to represent the real-world characteristics of the Sumner catchment. The CCC flood modelling Schema (rev 7; GHD, 2020) explains the methods, practices and standards used for the MIKE-based modelling system and it forms the basis for this TUFLOW model build where applicable. Table 3 summarises the key details of the TUFLOW model.

Table 3. TUFLOW model overview.

ITEM	DETAILS
Purpose	Provide CCC with the simulation capability to understand changes in the catchment and growth scenarios, and to plan for development, in line with the flood modelling Schema (GHD, 2020).
Software	TUFLOW HPC (Heavily Parallelised Compute) version 2023-03-AE.
Modelling approach	1D (one-dimensional) – 2D (two dimensional) coupling approach was applied for this model. The 1D components include stormwater network assets (pipes, culverts and pits) which are linked with the 2D domain. Open channels were modelled in the 2D domain.
Coordinate system	New Zealand Transverse Mercator 2000.
Vertical datum	NZVD 2016. Original information was provided in the Christchurch Drainage Datum (CDD). The CDD was converted to the Lyttelton1937 and then converted to the New Zealand Vertical Datum 2016 (NZVD 2016). Refer to Section 3.4 for more details.
Validation	The TUFLOW model was developed to represent the existing development state as of 2024. The model was validated against the March 2014 storm event using observed flood level and results from the existing MIKE Urban model.
Design event model runs	57 model runs were initially scoped. A number of additional scenarios were added where 16 % increases in rain were applied to make a total of 62 design runs. The log of simulations is in *Appendix E – Design run log.*

3.2. MODEL INPUT DATA

Various types of information was provided to Awa. The information was reviewed and the findings were discussed with CCC to agree on which information should be used for the model. Table 4 below details the key data.

Table 4. Data used for the model build.

DATA / INPUT	DESCRIPTION	SOURCE
Terrain	• 2020 LiDAR with 1 m resolution in raster format.	Provided by CCC in Feb 2024
Open channel	• Reclassified LiDAR for Sumner stream with 1 m and 0.1 m resolution in raster format. • Reclassified LiDAR coverage extended 15 m from the centre of Sumner stream	Provided by LandPro in May 2024
	2014 Surveyed cross sections in MIKE 11 model • V012_SUMN_PostEQ_ED2014_Blockage.nwk11 • V09_SUMN_PostEQ_ED2014.xns11	2014 Mike 11 model (version 3 Aug 2021) provided by GHD in Mar 2024
	• Sumner stream topographical survey in Aug 2014 (RPS 1047 Sumner Main Drain Sections Aug 2014.pdf)	Provided by CCC on 31 May 2024
	• Upstream Rivers and Tributaries Earthquake Repairs Sumner Stream & Richmond Hill Stream (LDRP 28 Sumner and Richmond Hill Streams Final Condition Assessment Report - Rev B.pdf dated 2 Dec 2015) for ground-truthing of the survey.	Provided by CCC on 31 May 2024
Seawall	• Point elevations along the seawall available in the MIKE21 model.	2014 MIKE 21 model (version 3 Aug 2021) provided by GHD
Building footprints	• Building classification was included in the land cover 2023 raster format from Lynker.	Provided by CCC on 9 May 2024
1D stormwater networks	• Information on pipes, manholes and pits were mainly obtained from the CCC Spatial Open Data Portal, representing the 2024 stormwater network.	https://opendata-christchurchcity.hub.arcgis.com/ downloaded on 13 Jun 2024
	• Information from MIKE Urban was used when the information on 1D stormwater assets (such as diameter of pipe, invert level and etc) is missing. • All culverts in the model are sourced from the MIKE11 model.	2014 Mike Urban and MIKE11 models (version 3 Aug 2021) provided by GHD

DATA / INPUT	DESCRIPTION	SOURCE
Culverts and bridges along Sumner stream	• Surveys of culverts and bridges along Sumner stream from Wakefield Ave to the coastal outfall (upstream and downstream cross-section dimensions, length of structure) conducted by GHD in Nov 2020	Provided by GHD on 1 May 2024
Kerb line	Kerb line along roads • Export_Surface Water Channels.zip (Surface Water Channel_LineString.shp)	RAMM (exported on 1 Feb 2024) and provided by CCC on 10 Jun 2024
Groundwater / infiltration	• Soil drainage classes in shapefile format • Associated constant infiltration rates and porosity from the Citywide Flood Modelling (Schema Rev 7) Model Schematisation 2020 Update report	• Soil drainage class provided by GHD (Nov 2023) • Schema Rev 7 report by GHD (July 2022)
	• 85th percentile groundwater depth layer	• Provided by CCC in June, September and December 2024
Land cover / Roughness	• Citywide land cover based on 2023 aerials (Lynker Analytics, 2024) was used to define roughness values. The dataset has eight classifications.	• Provided by CCC on 9 May 2024
Imperviousness	• Baseline – raster layer of imperviousness percentage for 2023 (ImperviousRasters.gdb) • Future – raster layer of imperviousness percentage for 2073 and 2103 (ImperviousRasters.gdb). Two impervious rasters (mitigated and unmitigated) were provided for each time horizon. The mitigated impervious raster represents the 10-year and 50-year ARI storm events while the unmitigated impervious raster represents the 200-year ARI storm event.	Provided by CCC on 29 Oct 24
Rain	• March 2014 rainfall (30-min interval) from MIKE 21 Model (Mar2014_CalibrationRainfall_30mi_mmday_spline_inclUB.dfs2) for validation purpose. • 100-m resolution	2014 MIKE 21 model (version 3 Aug 2021) provided by GHD
	• Design rainfall (citywide rainfall) in dfs2 format for future scenarios • 500-m resolution	Provided by Beca on 13 Sep 2024

DATA / INPUT	DESCRIPTION	SOURCE
Tide	• Gauged tide level from NIWA • Tide input data from MIKE 21 model (Citywide_Mar14_Gauged_Levels_NIWA.dfs0- Item 966699)	2014 MIKE 21 model (version 3 Aug 2021) provided by GHD
	• Tidal levels for design events generated using a spreadsheet calculator created by GHD (Generate sea water level boundary conditions v2.xlsx)	Provided by GHD on 21 Jun 2024
Flows from hill sub-catchments (RORB models)	• RORB generated flows calibrated to March 2014 event. • RORB outputs were converted to MIKE format (SUMN_ED2020_20200319_SUMN_RORB_MARCH2014.dfs0)	2014 MIKE 21 model (version 3 Aug 2021) provided by GHD on 20 Mar 2024
	• RORB flows for design events. The Citywide RORB modelling applied an Areal Reduction Factor (ARF) of 0.95.	Provided by Beca on 24 Oct 2024
Observed flooding during March 2014 storm event	Flood extent and flood level from March 2014 storm event • 2014_ChChFlood_Extent.zip (5 Nov 2018) • Surveyed_Flood_Levels.zip (2 May 2014) • March2014_FloodingObs.gdb.zip (5 Nov 2018)	Provided by CCC on 11 Apr 2024
Other information / documentations	• Schema Rev 7 report (model methodology and practice for MIKE-based model; GHD, 2020) • LDRP044 by AECOM (past MIKE modelling work) • Model logs (MIKE and RORB models) and technical memos from GHD (summary of past works)	Provided by CCC in Feb 2024
	• Citywide Sumner Flood Model Calibration Sensitivity Testing (technical memo dated 3 Nov 2021).	Provided by CCC on 31 Jan 2025

3.3. MODEL SCHEMATISATION

Details of the TUFLOW model components are described below.

3.3.1. HYDROLOGICAL APPROACH AND MODEL BOUNDARY CONDITIONS

HILL SUB-CATCHMENTS

In previous models, flows from RORB models were attached to the Mike Urban nodes (1D network) which were coupled with MIKE21 (2D component). In this study, upstream flows generated by RORB

models were attached to the TUFLOW model boundary in the 2D domain. Therefore, RORB flow connections and the TUFLOW model extent were adjusted to ensure that generated RORB flows can enter the stormwater networks. Figure 4 shows the TUFLOW model extent, and the updated RORB flow connections and sub-catchment boundaries. Appendix A summarizes the modifications of RORB flow locations and TUFLOW model extents based on peer review and CCC feedback.

RAIN ON GRID BOUNDARIES

As per the previous MIKE21 model, direct rainfall (rain-on-grid approach) was applied to the model extent depicted by the light green area in Figure 4. Design rainfalls were provided by Beca in February 2024 in DFS2 format. The design rainfall events are triangular storms with a peak at 70% of the total storm duration, applied in a grid of spacing 500 m with units set to mm/day. Refer to Appendix M of the Schema rev 7 report for the definition of the triangular hyetograph.

For TUFLOW, there is no interpolation between time steps when a gridded rainfall approach is applied (TUFLOW, 2023), and thus the design storm was divided into individual rainfall depth grids for each 5-minute time step (mm/5mins).

At the coastline, the model boundary was extended approximately 150m from the seashore. This is to ensure that the DEM extended to the 6 m RL CDD, and the model boundary remained inundated under the extreme low tide condition. Tidal levels were applied along the model edge at the seashore (dotted light blue line in Figure 4).

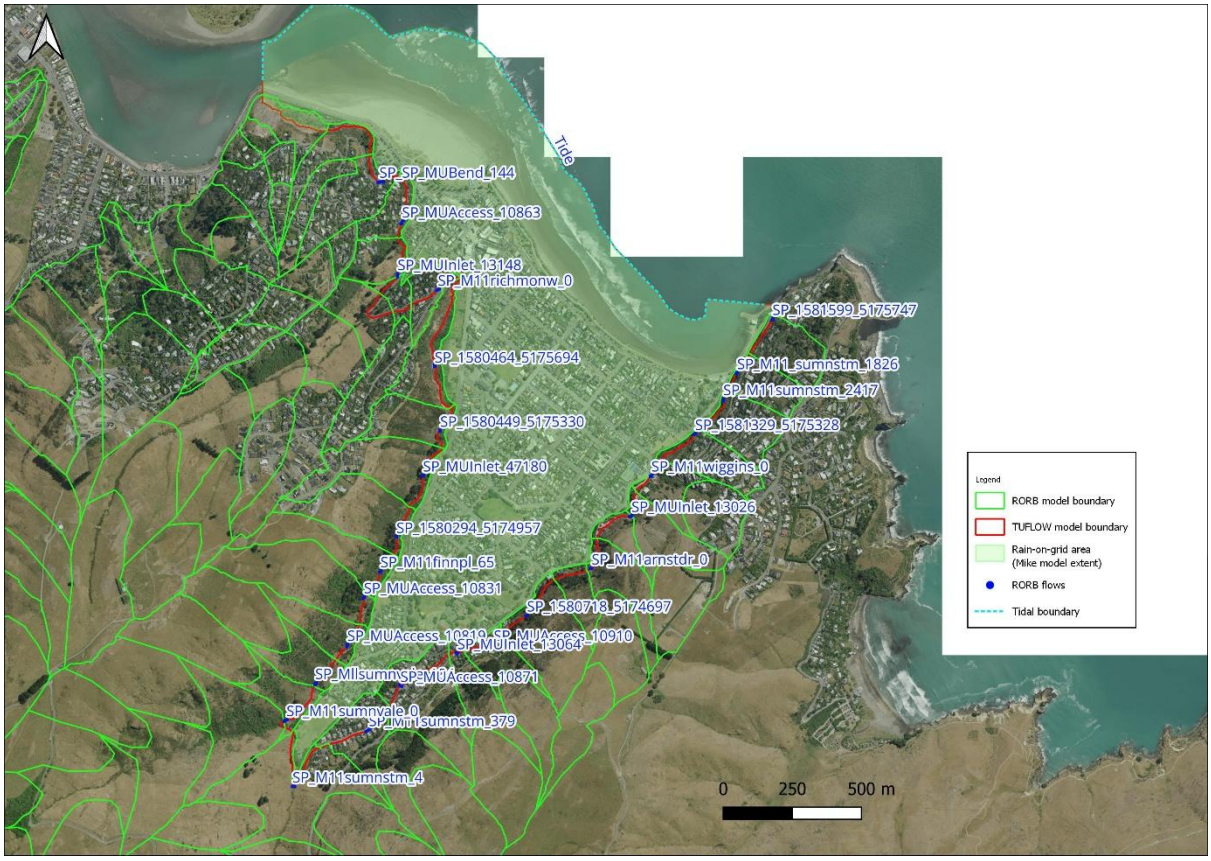

Figure 4. TUFLOW model extent with boundary conditions (RORB flows and tidal boundary).

3.3.2. GRID CELL APPROACH

Open channels are modelled in the 2D domain using sub-grid Sampling (SGS) approach. SGS uses multiple points for grid cell elevations in a single cell for more accurate representation of the topography and hydraulic conveyance in the 2D domain. The SGS approach was applied for more accurate representation of the topography such as open channels and small drainage ditches to help with hydraulic conveyance.

The traditional approach (non-SGS) applies a single elevation per cell centre and cell face as shown in Figure 5. With SGS, all four cell faces would be active for the same water level compared with only two faces without SGS providing additional resolution in each cell.

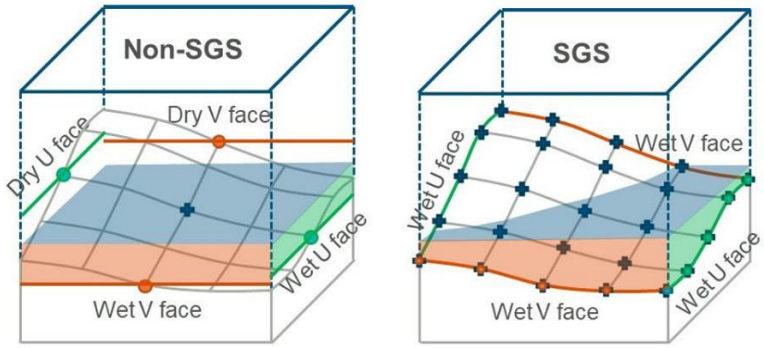

Figure 5. Non-SGS (traditional) (left) vs SGS approach (right). Source: TUFLOW Classic and HPC 2020-01 Release Notes.

The number of points at which the elevation datasets within a single cell are sampled can be defined in an HPC model. For instance, with a 4 m cell size and a 1 m SGS sample distance, the DEM is inspected using a regular 1 m grid, so 16 elevation points are used to define the volume vs elevation relationship within the 2D cell, and 4 points are used for defining the area-elevation relationship for the cell faces.

This study applies a 1 m SGS sample distance based on the resolution of the 2020 LiDAR. Over the Sumner stream channel, finer SGS sample distance is applied based on the resolution of the terrain of 0.1 m.

The benefit of SGS increased when cells have a variety of elevations within each cell. It also mitigates effects where cells are misaligned with the water flow direction (particularly in open channels) producing more realistic flow patterns without significant impacts on simulation run time.

A Quadtree mesh (nesting of the grid cell) has also been configured in the model to allow higher resolution of grid cell size over key focus areas and lower resolution in topographically or hydraulically simple locations. The Quadtree feature allows recursive quad-tree cell subdivision (division of square cells into four equal-sized cells) to increase resolution in selected areas. Quadtree feature allows combination of different computation cell sizes in 2D domain. The Quadtree levels adopted for Sumner catchment are as followed:

- 2-m cell resolution in general
- 1-m cell resolution for roads, kerbs and the Sumner stream.

The Quadtree nesting grid approach was also applied which allows larger cell sizes for computational efficiency where topographic and hydraulic complexity is low, and allowing higher resolution of grid cell size over focus areas.

3.3.3. MODEL TERRAIN

Model terrain was derived from the 2020 LiDAR. Additional information, such as surveyed cross sections of Sumner stream in 2014, survey points along the seawall, and kerb lines, was incorporated into the DEM to improve the accuracy of terrain geometries. The model terrain used in the TUFLOW model represents the 2024 baseline condition. No building footprint elevation adjustments were made.

The point elevations along the seawall were extracted from the MIKE21 model. The DEM was elevated along the seawall using the point elevations to ensure the actual elevation of seawall was represented.

Along the coastal line, the terrain was extended downward to 6m RL CDD at a 2% slope, creating bathymetry under the sea level where no data was available. The terrain in CDD was then converted to NZVD 2016.

To address the issues of mismatch between 1D inlet/outlet elevations and DEM elevations, the TUFLOW function using ‘2d_zsh_R.shp’ was applied to lower the DEM elevation to match the invert

levels of 1D elements. Terrain elevation at 1D inlet/outlets connections with 2D domain were lowered with in a range from 50mm to 100mm to ensure that inlet/outlet levels are above the ground elevations and to reduce instability (flow fluctuations).

Awa compared the 2020 LiDAR with the past DEMs and we found that the 2020 LiDAR elevations are higher than the DEM (2012 LiDAR) used in the MIKE model calibrated to March 2014. The higher 2020 LiDAR elevation caused higher simulated water levels compared with the simulated water levels by MIKE models for March 2014. More details are explained in Section 4.1.

Figure 6 shows the final terrain used in the TUFLOW model

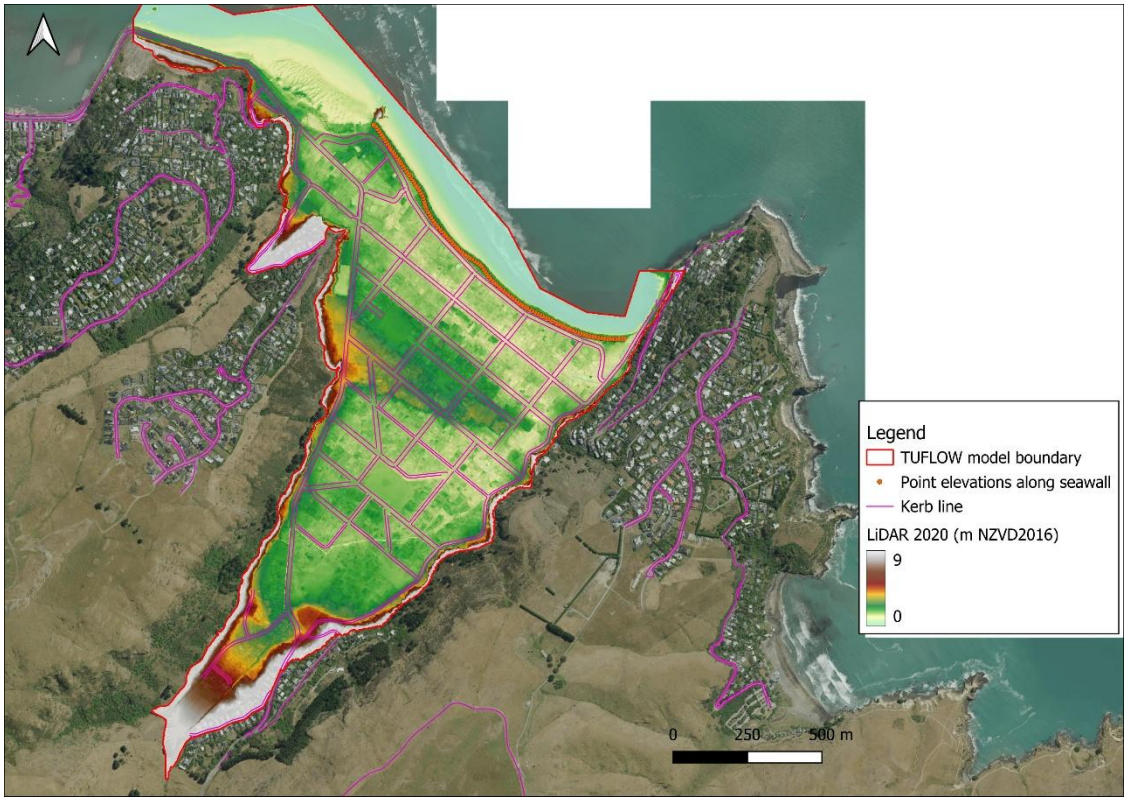

Figure 6. Digital Elevation Model (DEM) used in TUFLOW model.

3.3.4. STREAM OPEN CHANNEL

Although the Sumner Stream open channel was modelled as a 1D component in the previous MIKE11 model, Awa opted to model the open channel as a part of 2D domain in TUFLOW. Surveyed cross sections of the Sumner stream collected in 2014 was the main information used to modify the open channel terrain. 2024 LiDAR was incorporated into the DEM where surveyed cross sections were not available. There are some inconsistencies among the cross-section data (Apirumanekul, 2024). In some parts of Sumner stream, the 2024 reclassified LiDAR and surveyed cross sections from 2014 have narrower width compared with the surveyed information from field measurement of private structures along Sumner stream taken in Nov 2020. Cross-sections surveyed in 2014 were used if there were inconsistencies. A technical memo on the assessment different sources of information for Sumner Stream for open channel modelling in TUFLOW is appended in Appendix B.

In summary, the 2024 reclassified LiDAR was mainly used to represent Sumer Stream and the surveyed cross sections from 2014 were used when there are some consistencies between the 2024 reclassified LiDAR and surveyed cross sections in 2014. For instance, the stopbank on the left bank of Sumner Stream along Heberden Ave near Scarborough Park is incorporated in the model DEM using TUFLOW terrain modification function (2d_zsh).

Using this combination of different data for Sumner stream, has improved the accuracy of Sumner stream geometry representation in the model terrain over the MIKE model. The Quadtree approach applied over the open channel with 1-m cell resolution together with the SGS technique for better simulation of open channel flows.

3.3.5. ROAD AND KERB LINES

Road and kerb lines were modelled in 2D domain applying the SGS technique with 2-level nesting (Quadtree), refining grid cell size to 1 m over the road. To represent the drainage capacity of kerb lines, the terrain along the kerb lines was lowered by 100mm to collect and direct rainwater away from road to the pits. Figure 7 shows the modified terrain along the kerb line on St Leonard Square.

Figure 7. Kerb line along St Leonard Square (Google Street View).

Figure 8 displays the Quadtree areas (including road) and kerb lines for Sumner model. The kerb line layer provided by CCC (exported from RAMM on 1 Feb 2024) contains some gaps such as overlapping of kerb line and disconnected kerb line at intersections. This may cause water to be diverted away from the kerb lines in some areas depending on the topography. This potentially can

underestimated flows from 2D surface to the stormwater networks. Improvements by realigning of kerb lines to avoid overlapping and discontinuities are recommended in the future.

Figure 8. Modelling of road and kerb lines in the TUFLOW model and Quadtree level 2 (1 m) converge on the road.

3.3.6. BUILDING FOOTPRINT

Building footprints were obtained from the land cover 2023 by Lynker. Manning's n value of 0.2 was applied over the building footprints to represent high flow resistance of buildings following the Schema rev 7 report.

Roughness value (Manning's n coefficient) of 0.2 was applied for building footprints based on the Schema Rev 7.

3.3.7. LAND COVER AND IMPERVIOUSNESS

Land cover and impervious areas were mapped using the machine learning method by Lynker and the Christchurch 0.075m aerial imagery from 2023. The 2023 Land cover was classified into 8 types as shown in Table 5 below. This landcover was used for baseline and design runs.

Figure 2 shows the land cover by Lynker (2023) with associated roughness values from the Schema Rev 7 report. The Schema rev report classifications differ from the 8 classifications by Lynker and during the peer review process with CCC matching between the classifications was agreed with the 2023 land cover classifications (Figure 2).

Roughness values (Manning's n coefficients) for 8 land use classifications were from the Schema rev 7 report.

Table 5. Land cover classifications for 2023.

CATEGORY NAME	DESCRIPTION
Water	Water bodies including river, pond, lake and ocean
Bare earth/gravel/sand	Tilled land, bare earth, loose gravels and sand beaches
Grass	Open space without trees and shrubs
Scrub/shrub	Shrub species, rushes, low profile vegetation
High vegetation	Taller trees of all species
Other impervious	Driveways, carparks, footpaths and other paved areas
Road	Sealed and unsealed
Building	Commercial and residential

Impervious surfaces (raster format) were provided by CCC for baseline (2023) and future time horizons (2073 and 2103). It is assumed that the impervious rasters for 2073 and 2103 represent the time horizons of 2074 and 2124 for design events, respectively.

In TUFLOW, fraction of imperviousness can be defined in overlying material type (land cover classification). This fraction is used to define the amount of water that is infiltrated from surface into the ground. The soil infiltration was calculated using the infiltration rates defined for each soil drainage classification (section 3.3.8).

There were two source files for land cover and imperviousness: the 2023 land cover layer was provided in vector format (shapefile), while the imperviousness rasters were provided in raster format (2m cell size). TUFLOW incorporates the percentage of imperviousness in the land cover classification in a single materials layer. To combine the two inputs into a TUFLOW-consumable format, Awa mapped the spatially distributed imperviousness from impervious rasters to each polygon in the land cover classification layer. This means that the classification of each material in the materials layer comprises unique combinations of land cover values plus a percentage imperviousness value.

3.3.8. INFILTRATION AND GROUNDWATER CAPACITY

The Schema rev 7 report (GHD, 2020) describes the infiltration methodology for MIKE21 models, and consideration of basic groundwater simulation. This TUFLOW model applied the same infiltration methodology, adapted to TUFLOW HPC, as summarized below.

- Infiltration using the constant rate of 75% of the final infiltration rate plus 25% of the initial infiltration rate from Horton's parameters for each soil type.
- Leakage to the saturated zone was assumed negligible as the slow leakage rate has little impact within the typical timescales of the flood events.
- Initial water volume was assumed null to represent unsaturated zone moisture using only porosity parameter.

For the TUFLOW model, soil infiltration is applied by defining a soil classification with associated porosity, initial moisture and loss parameters. The Initial Loss/Continuous Loss (ILCL) approach was

applied to the Sumner model. Figure 9 shows the soil classifications in the Schema rev 7 report and these soil classifications were used for defining infiltration related parameters.

The ILCL approach combined with a ground water initial water level estimates the amount of water infiltrated to the ground and if the ground becomes saturated, infiltration stops. The amount of infiltrated water to the ground depends on the impervious fraction of overlying layers (land cover/materials), depth to groundwater, porosity and the initial moisture content of soil. The 85th percentile groundwater levels at different scenarios were supplied by CCC and used to define initial groundwater conditions in the TUFLOW model.

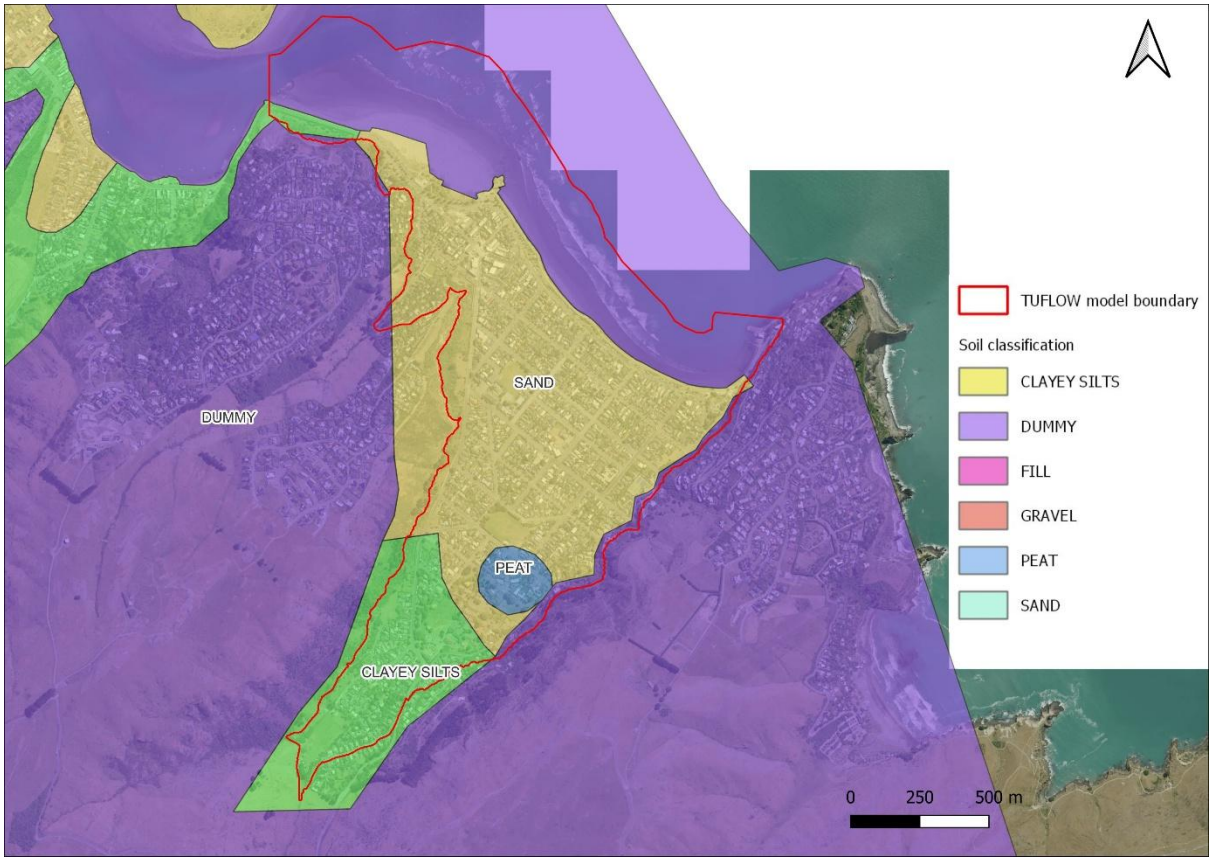

Figure 9. Soil classification based on the Schema rev 7 report for infiltration and groundwater capacity in TUFLOW model.

The following parameters were applied in accordance with recommended values related to the infiltration and groundwater capacity in the Schema rev 7 report.

- Initial loss = zero (null leakage to saturated zone).
- Initial soil moisture = zero (null initial water volume).
- Continuous loss (mm/hr) = constant infiltration rates for each soil type as defined in Table 6.
- Porosity = porosities for each soil type as defined in Table 6.

Note that the TUFLOW TSOILF file has horizontal hydraulic conductivity parameter empty, which equates to 0 mm/hr . This means groundwater acts as a limiting factor on infiltration, rather than groundwater moving through the catchment.

To date sands have been considered to have high infiltration rates consistent with the gravel drainage class. With the limits of Waterways, Wetlands and Drainage Guide knowledge, it is suggested that gravels and sands both coincided best with the same drainage class of 4.65 mm/hr infiltration rate (P. Tim, E-mail communication, August 18, 2024). It is noted though that these are low infiltration rates to increase runoff response for short term rain events.

Table 6. Parameters for infiltration and groundwater capacity for each soil type (March 2014 re-validation) from the Schema rev 7 report.

SOIL CLASSIFICATION	SOIL DRAINAGE CLASS	CAPILLARY RISE (M)	POROSITY (%)	INFILTRATION RATE (MM/HR)
Gravel (C)	Free draining	0.0125	14%	4.65
Sand (M)	Moderately drained	0.135	15%	3.85
Clayey Silts(F)	Imperfectly drained	1.055	10%	3.35
Peat (P)	Poorly drained	0.5	15%	2.55
Fill (X)	Very poorly drained	0.025	15%	1.025
Dummy (W)		0	0%	

3.3.9. FOOTBRIDGES AND DRIVEWAYS ALONG SUMNER STREAM

Previous MIKE-based modelling included culverts, footbridges and driveways along Sumner stream as culvert structures in MIKE 11. Field measurements for these structures along Sumner stream, from Wakefield Ave to the coastal outfall, were conducted by GHD in Nov 2020 (Costa R.D. and Marshall M, 2021).

In the TUFLOW model, the footbridges and driveways along Sumner stream were modelled as bridges based on their flow obstruction characteristics, using 2d_lfcsh layer, as shown in Figure 10 below. Initially, these private driveways and footbridges were modelled as culverts in the 1D component of TUFLOW, similar to the MIKE 11 modelling approach. However, the flows through these driveways/footbridges show some flow fluctuations (instability issues) which are caused by culvert width being wider than the Sumner stream width. This instability issue was discussed with the TUFLOW support team, who suggested to use bridge structures (layered flow constrictions) in TUFLOW.

Figure 10. Samples of private driveways and footbridges along Sumner stream (From Costa and Marshall, 2021).

Four flow constriction layers are used to model the driveways/footbridges along Sumner stream. Each layer has its own percentage blockage and form loss coefficient. The top (fourth) layer assumes the flow is unobstructed, representing flow over the top of a bridge while the first layer represents the flow beneath the bridge deck (Figure 11).

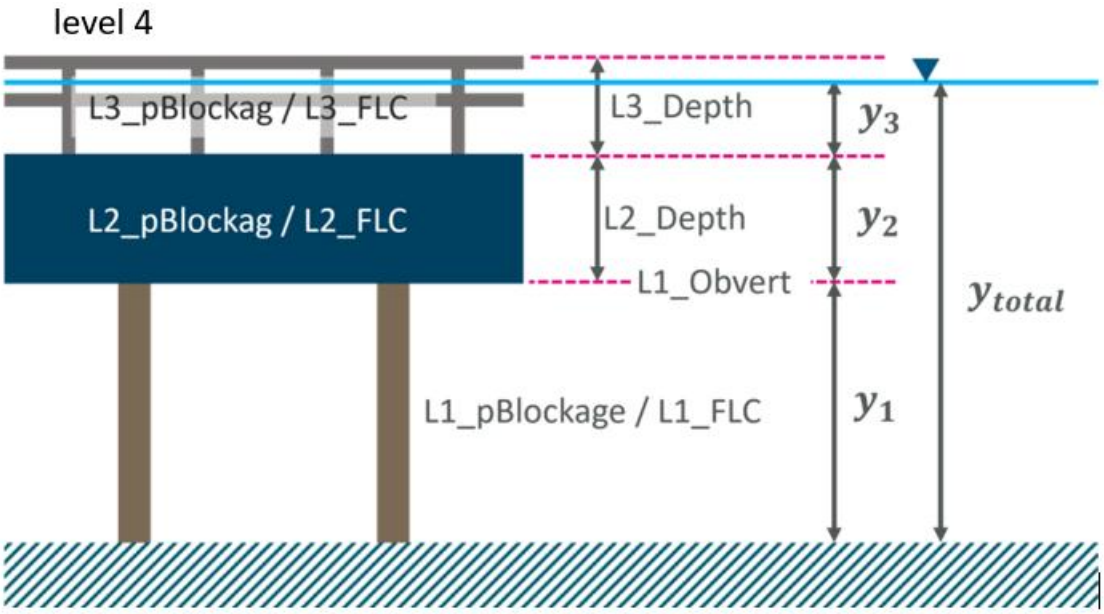

Figure 11. Layered flow constriction for modelling of bridges (driveways/footbridges) along Sumner stream.

Parameters of each layer (depth of each level, percentage of blockages of each driveway/footbridge) were estimated from the photos taken during field measurements in Nov 2020 (Costa R.D. and Marshall M, 2021). For instance, high percentage blockage (80%) of L3 is applied for driveways with a metal fence with 0.3m depth doe L2 (refer to bottom photo in Figure 10).

Flows through driveway/footbridge using the layered flow constrictions do not create instability issues and the results show good agreement with flows upstream and downstream of the driveway/footbridge.

3.3.10. 1D STORMWATER NETWORK

The 1D networks included in previous MIKE Urban models (2014 version and 2020 version) are considerably smaller than the available information in CCC Open Data Portal, which represents the current state (2024) of the stormwater networks. All network assets in CCC Open Data Portal were included in the TUFLOW model (Figure 3).

Awa reviewed the existing stormwater networks in the CCC Open Data Portal and it is observed that there are gaps which are consistent with the information in MIKE Urban models. The gaps in the 1D stormwater networks were discussed with CCC for validation and to identify supplemental information to fill the gaps. Appendix C includes samples of gaps in the 1D stormwater networks together with comments from CCC and Awa's approach to addressing the gaps.

Overall findings from the investigation of the 1D stormwater network data gaps are summarized in Table 7 below.

Sumps that are not connected to the CCC stormwater network in the CCC Spatial Open Data Portal are not included in the model

Table 7. Gaps in 1D stormwater networks with improvements.

GAP IN STORMWATER NETWORK	CCC COMMENTS / AWA'S UPDATES ON STORMWATER NETWORKS
Drop of invert level at downstream pipe (disconnection between 2 pipes)	• Validation with photos from SCIRT and update accordingly • No change has been made if they are reasonable based on CCC comments
Downstream pipe diameter is smaller than the upstream pipe diameter	• Increase pipe diameter based on information in CCC Open Data Portal • No change if there is no information from CCC (assumed that information from CCC Open Data Portal is correct). This is likely to have less impact as the pipe diameter is small (less than 300mm).
Pipe invert levels are above ground elevation	There is no information in the CCC Open Data Portal. Most of these pipes are stand-alone (no connection to other pipes). For pipes with diameter less than 0.5m, pipe invert levels were changed to be 0.5 m below ground elevation to allow for minimum ground coverage. As most of these are stand-alone pipes, it is likely to have minimal impact on the modelling.
Invert levels of outlets are below ground elevations	• Validation with photos from SCIRT and it was observed that outlets are in rock band and LiDAR might not be accurate. Ground elevations were adjusted to match outlet levels. • Adjust invert levels of outlets to match CCC Open Data Portal. • Adjust outlet invert levels to ground level if there is no information in CCC Open Data Portal.
Pipe has unrealistically low ground coverage (50-100mm)	For pipes with diameter less than 0.5m, pipe invert levels were lowered from ground level by 0.5m.
Pipe with steep gradient	No information is available from CCC Open Data Portal. Adjust invert levels to be 0.5 m below ground level.

3.4. DATUM CONVERSION

CDD is based on the Lyttelton Vertical Datum 1937 with CDD having an offset of 9.043 m higher than the Lyttelton 1937. The Lyttelton 1937 was converted to the NZVD2016 using the offset raster from

Land Information New Zealand (LINZ)[1]. Below equation shows how CDD can be converted to NZVD2016.

NZVD2016 = CDD -9.043- Lyttleton 1937 offset

The Lyttelton 1937 to NZVD2016 conversion raster was obtained from the Land Information New Zealand (LINZ) Data Service[2]. For accurate conversion, LINZ suggests that the conversion raster grid must be downloaded in terms of NZGD2000 and then converted into a surface using bilinear interpolation (resampling to a small grid cell size, 1m in this case).

The asset data and terrain in CDD will then be selected and converted to NZVD2016 using the above equation.

3.5. PEER REVIEW

The TUFLOW model was peer reviewed by Tonkin and Taylor between August and October 2024. CCC also provided feedback on model configurations and model parameters during the peer review process, mainly in regard to conformance with the Schema rev 7 report. Sensitivity tests on some key parameters were conducted during the peer review process. Table 8 summarises the sensitivity tests with recommendations. Details of comments and responses from the peer reviews are included in Appendix D.

Table 8. Summary of sensitivity tests during peer review.

SENSITIVITY TESTS	RESULTS	RECOMMENDATIONS
Single precision vs double precision	• Increased depths 90-100mm in localised areas near the coast.	• If there is any difference in results between single precision and double precision, it is recommended to use the double precision executable (communication with TUFLOW Support on 26 Sep 2024). Sumner TUFLOW model applied the double precision approach.
Default viscosity coefficient (0.1) vs viscosity coefficient of 0.2	• Decreased depths 50-150mm in localised areas near the coast.	• An upper limit of Manning's n value was used in the Wu viscosity coefficient. The viscosity coefficient of 0.2 was applied in TUFLOW as the Manning's n value for building footprint is 0.2.
0.5-m cell size vs 1-m cell size over Sumner stream	No impact on flood depth.	It was agreed to use 1-m cell size over Sumner stream (2 level of

[1] The Christchurch Drainage Datum (CDD) was converted to Lyttelton Vertical Datum 1937 and then converted to New Zealand Vertical Datum 2016 (NZVD2016) using conversion factors from LINZ online data conversion (https://data.linz.govt.nz/layer/103958-lyttelton-1937-to-nzvd2016-conversion-raster/)

[2] https://data.linz.govt.nz/layer/103958-lyttelton-1937-to-nzvd2016-conversion-raster/

SENSITIVITY TESTS	RESULTS	RECOMMENDATIONS
		nesting) to reduce model simulation time.
Extension of terrain around coastal area to 6 m RL (CDD)	• Increased depths 150-1000mm in localised areas near the coast.	• It was agreed to extend the DEM down to 6 m RL (CDD).
Constant pit capacities in Schema rev 7 report vs depth-discharge relation curves for pit capacities from Kapiti Coastal District Council	Decreased depths 90-100mm in localised areas.	It was agreed to retain constant inlet capacity from Schema rev 7 report. Kapiti pit database was used initially as a TUFLOW format schema database was not available.
Raising elevation by 150 mm over building footprints with low roughness (n=0.016) vs no terrain modification with Manning's n = 0.2	Decreased depths in building areas by 70-130mm	It was agreed to use approach stipulated in the Schema rev 7 report (no change in terrain with Manning's n value of 0.2)

4. MODEL RESULTS

4.1. MARCH 2014 MODEL VALIDATION EVENT

The TUFLOW validation model was set up using the following configuration.

- Baseline geometries (LiDAR in 2020, land cover in 2023, stormwater network in 2024).
- Hydrological inputs from the March 2014 event were used as inputs to the TUFLOW baseline model.
- The March 2014 rainfall was extracted from the MIKE 21 model.
- Upstream catchment flows were generated from RORB models prepared by GHD, calibrated to the March 2014 event. The calibrated flows were generated using initial loss (IL) of 30 mm and continuing loss (CL) of 2.5 mm/hour. RORB-generated flows were attached to the TUFLOW model extent as model boundary conditions.

The technical memorandum on Citywide Sumner Flood Model Calibration Sensitivity Testing (3 Nov 2021) provided suggestions for improving the model calibration. The suggestions were considered for the TUFLOW model builds.

The general approach of flexible meshing is similar between MIKE and TUFLOW models (allowing mixed mesh sizes throughout the model domain with finer grid size over the areas of interests). The MIKE model applies flexible mesh using mixed triangular and quadrangular mesh element shapes while the TUFLOW quadtree approach uses the nesting grid with quadrangular shape. The TUFLOW baseline model outputs show good agreement with MIKE model results, while the TUFLOW model results provide greater definition of flood extents due to the inclusion of updated model inputs and the application of SGS and quadtree approaches. Figure 12 compares flood extent and flood depth maps between TUFLOW and MIKE model results for the March 2014 event.

To validate the TUFLOW model results against the March 2014 event, simulated water levels from TUFLOW baseline model were compared with the observed levels (CDD) and the corresponding MIKE model levels of March 2014 event. It was observed that TULOW simulated water levels are overestimated, ranging from 90 mm to 470 mm with the average of 240 mm difference. The DHI simulated results are slightly overestimated within a range of 0-230 mm with the average of 65 mm difference as shown in Table 9. Differences can be explained by different modelling parameters and methodologies used in the modelling software and the updated model inputs (DEM 2020 and inlet capacities). Note that DHI model was calibrated to observed information for the Sumner stream and the TUFLOW model used both parameters from DHI model and the Schema Rev 7 report without the additional calibration as this was out of the scope.

To have better understanding on the overestimation of the TUFLOW results, Awa did further analysis and found that the terrain used in MIKE model (2012 LiDAR) was lower than the 2020 LiDAR used in the TUFLOW baseline model. Awa checked different LiDAR from LINZ and we found the following;

- The change from 2015 to 2018 LiDAR suggests that the elevation went down 100-200 mm approximately as confirmed by GHD findings (P. Tim, E-mail communication, March 17, 2025 See Appendix F). It is noted that there is no 2012 LiDAR provided on LINZ but the 2015 LiDAR produced the same argument.

- The change from 2015 to 2020 LiDAR suggests that the levels went up 100-200 mm approximately.

Figure 13 shows a comparison of 2015, 2018 and 2020 LiDAR at random locations to assess the change of the elevation that have impacts on simulated model results.

It is also noted that TUFLOW model used baseline inputs (2020-2023) while MIKE-based models were set up and calibrated using the historical information. The validation of March 2014 event is only for high-level sense check of TUFLOW baseline model results. The validation of TUFLOW model against the March 2014 event was considered adequate for design runs given these limitations including the historical event. The model now includes significantly more details also than the previous DHI model so results are not expected to be exactly the same. As with all catchment scale models, care is to be taken when looking at results in specific locations, or using the base model for other applications.

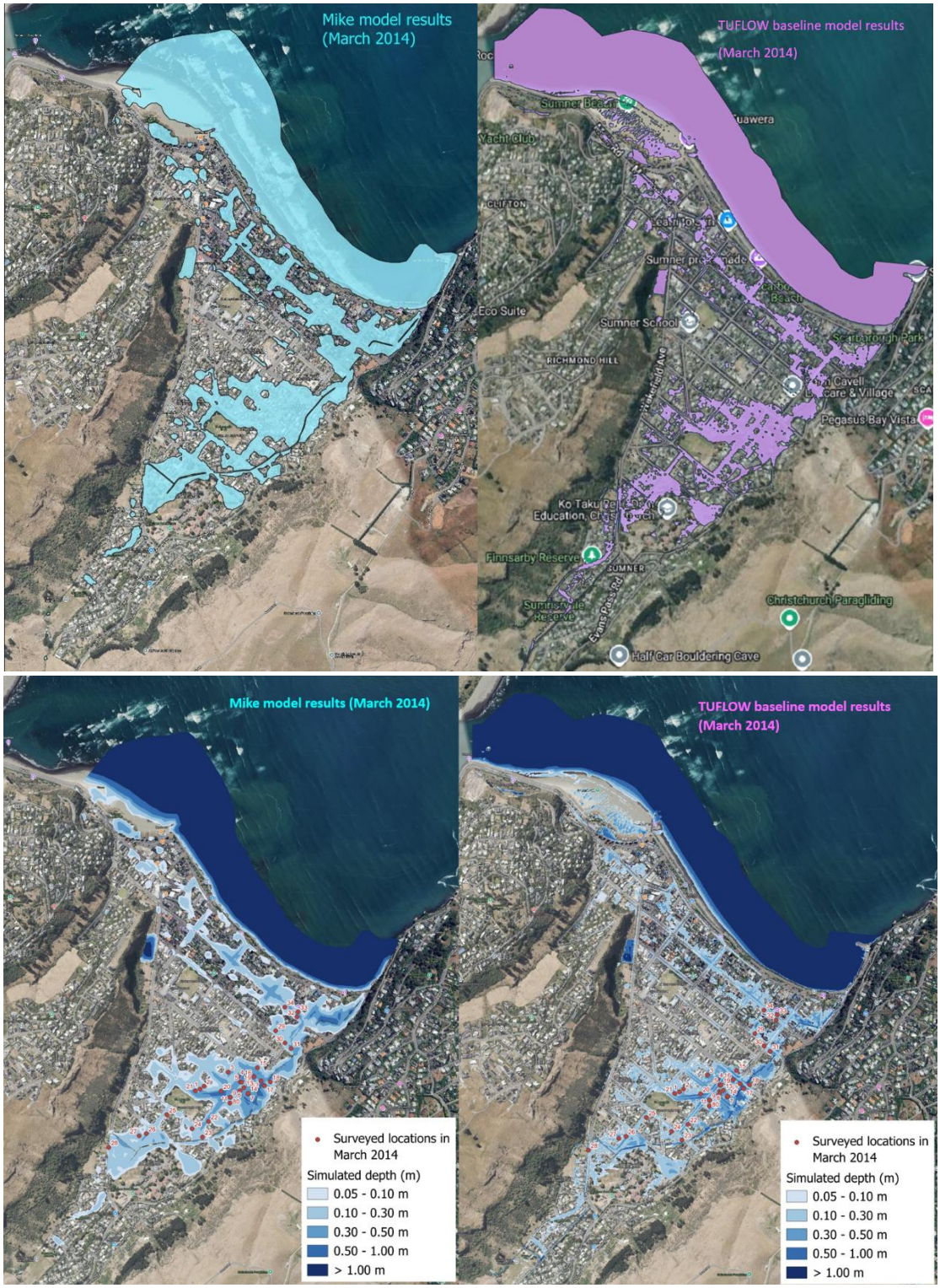

Figure 12. Comparison between TUFLOW baseline model results and MIKE model results for the March 2014 storm event - flood extent (top) and flood depth with surveyed locations (bottom).

Table 9. Comparison of TUFLOW results and DHI results against the observed information in March 2014 for validation purpose.

								Difference in water level (m)				Difference in depth (m)	Difference in DEM (m)
ID	X	Y	Survey source	Date	Surveyed level (m CDD)	DHI simulated water level (m CDD)	TUFLOW simulated water level (m CDD)	DHI level minus observed level	TUFLOW level minus observed level	DHI simulated depth (m)	TUFLOW simulated depth (m)	DHI depth minus TUFLOW depth	DHI terrain minus LiDAR2020 (m)
1	1580716	5175084	Watermark	5-Mar-14	11.53	11.58	11.75	0.05	0.22	0.27	0.30	-0.03	-0.06
2	1580734	5175097	Watermark	5-Mar-14	11.57	11.58	11.75	0.01	0.18	0.16	0.07	0.09	-0.15
3	1580842	5175160	Watermark	5-Mar-14	11.51	11.55	11.75	0.04	0.24	0.30	0.35	-0.05	-0.13
4	1580887	5175140	Watermark	5-Mar-14	11.55	11.55	11.75	0	0.20	0.36	0.06	0.30	-0.22
5	1580898	5175116	Watermark	5-Mar-14	11.51	11.55	11.75	0.04	0.24	0.38	0.37	0.01	-0.05
6	1580896	5175077	Watermark	5-Mar-14	11.49	11.55	11.75	0.06	0.26	0.35	0.43	-0.08	0.01
7	1580932	5175061	Watermark	5-Mar-14	11.5	11.55	11.75	0.05	0.25	0.39	0.51	-0.12	0.12
8	1580852	5175047	Watermark	5-Mar-14	11.51	11.56	11.75	0.05	0.24	0.23	0.22	0.01	-0.11
9	1580852	5175047	Watermark	5-Mar-14	11.51	11.56	11.75	0.05	0.24	0.23	0.22	0.01	-0.11
10	1580852	5175047	Watermark	5-Mar-14	11.51	11.56	11.75	0.05	0.24	0.23	0.22	0.01	-0.11
11	1580850	5175021	Watermark	5-Mar-14	11.54	11.56	11.75	0.02	0.21	0.26	0.27	-0.01	-0.04
12	1580990	5175121	Watermark	5-Mar-14	11.45	11.53	11.75	0.08	0.30	0.39	0.53	-0.14	0.02
13	1580913	5175091	Woods	7-Mar-14	11.55	11.55	11.75	0	0.20	0.29	0.28	0.01	-0.06
14	1580932	5175065	Woods	7-Mar-14	11.52	11.55	11.75	0.03	0.23	0.38	0.55	-0.16	0.10
15	1580974	5175180	Woods	7-Mar-14	11.47	11.55	11.75	0.08	0.28	0.29	0.37	-0.08	0.07
16	1580958	5175139	Woods	7-Mar-14	11.48	11.55	11.75	0.07	0.27	0.43	0.48	-0.05	0.00
17	1581005	5175099	Woods	7-Mar-14	11.46	11.5	11.75	0.04	0.29	0.30	0.37	-0.06	-0.08
18	1581032	5175116	Woods	7-Mar-14	11.46	11.49	11.74	0.03	0.28	0.22	0.15	0.07	-0.08
19	1580903	5175115	Woods	7-Mar-14	11.51	11.55	11.75	0.04	0.24	0.31	0.38	-0.07	0.01
20	1580811	5175075	Woods	7-Mar-14	11.35	11.56	11.75	0.21	0.40	0.51	0.49	0.01	-0.09
21	1580695	5175076	Woods	7-Mar-14	11.51	11.58	11.75	0.07	0.24	0.35	0.29	0.06	-0.07
22	1580754	5174938	Woods	7-Mar-14	11.55	11.62	11.78	0.07	0.23	0.18	0.03	0.15	-0.14
23	1580727	5174868	Woods	7-Mar-14	11.67	11.67	11.81	0	0.14	0.16	0.08	0.08	-0.18
24	1580680	5174906	Woods	7-Mar-14	11.72	11.67	11.82	-0.05	0.10	0.14	0.15	-0.02	-0.11
25	1580566	5174969	Woods	7-Mar-14	11.74	11.97	11.91	0.23	0.17	0.06	0.03	0.03	0.02
26	1580474	5174884	Woods	7-Mar-14	11.88	11.9	11.95	0.02	0.07	0.29	0.27	0.02	-0.20
27	1580442	5174874	Woods	7-Mar-14	11.86	11.91	11.95	0.05	0.09	0.23	0.20	0.02	-0.09
28	1580305	5174822	Woods	7-Mar-14	11.88	12.04	12.09	0.16	0.21	0.18	0.23	-0.05	0.05
29	1581056	5175346	Woods	7-Mar-14	11.2	11.28	11.48	0.08	0.28	0.21	0.22	-0.01	-0.03
30	1581098	5175291	Woods	7-Mar-14	11.28	11.31	11.48	0.03	0.20	0.21	0.15	0.06	-0.09
31	1581125	5175266	Woods	7-Mar-14	11.11	11.32	11.58	0.21	0.47	0.34	0.35	0.00	-0.16
32	1581152	5175408	Woods	7-Mar-14	11.16	11.22	11.44	0.06	0.28	0.26	0.16	0.11	-0.09
33	1581157	5175431	Woods	7-Mar-14	11.11	11.28	11.44	0.17	0.33	0.27	0.20	0.06	-0.02
34	1581097	5175452	Woods	7-Mar-14	11.14	11.24	11.44	0.1	0.30	0.23	0.17	0.06	-0.06

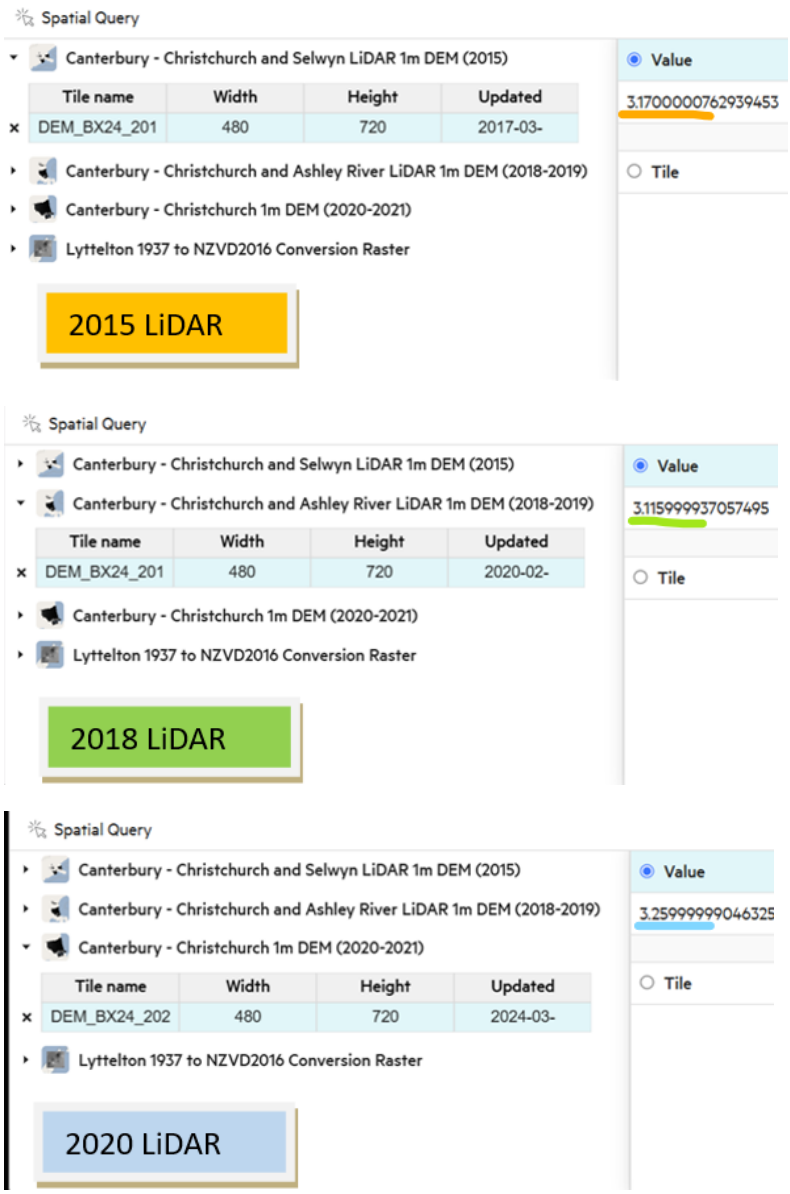

Figure 13. Comparison of different DEMs used in the models to support the TUFLOW model validation for March 2014.

5. CONCLUSIONS

The existing 1D-2D coupled DHI formal model for Sumner catchment was upgraded to TUFLOW HPC software with new and more detailed information. It is considered a detailed, robust and validated model in line with good practice for flood models in New Zealand at the time of development. The model is consider fit for purpose for the stated model purposes in *Section 1.3.*

The updated and validated TUFLOW model was able to be converted to a design base model and subsequently was successfully used to simulate 62 design events (outlined in *Appendix E – Design run log*) for use by CCC's Stormwater Asset Planning team.

Based on the analysis of model results and peer reviews' comments, the following recommendations made to be considered in a model backlog of future improvements. These do not impact the model's ability to deliver on the stated purposes, but are suggestions to consider if issues are found in specific locations or for specific events.

- High resolution cell size (0.5 m) along Sumner Stream if issues are found in low flow modelling results.
- The stormwater network in the CCC Spatial Open Data Portal contains missing information which is necessary for modelling purpose (invert levels of pipes and catchpits). Current model applied assumptions to fill those gaps and accurate surveyed information (pipes along Arnold St, pipes near the intersection between Marriner St and Wakefield Ave) will help improving the accuracy of model results. Specific assessment of model data quality and data capture plan is recommended.
- Flows from upstream catchments were produced by RORB models which do not consider the stormwater networks. There are some stormwater networks in RORB catchments which have not been considered. It was also observed that some RORB delineated catchments do not follow the terrain suggesting that further improvements could be made to the upstream catchment flows estimation.
- The use of the Schema based initial groundwater levels approach in this model is a good advancement. A sensitivity test to adding horizontal hydraulic conductivity would help with understanding if any additional improvements to soil representation and groundwater approaches are warranted.
- Consider local catchment measurements of infiltration to better balance the role of surface run off and groundwater exchange in streams and low lying areas. The main types of non-impervious land cover should be considered including parks, open spaces and residential properties.
- Improve kerb line representation as outlined in Section 3.3.5 Road and Kerb Lines.

6. REFERENCES

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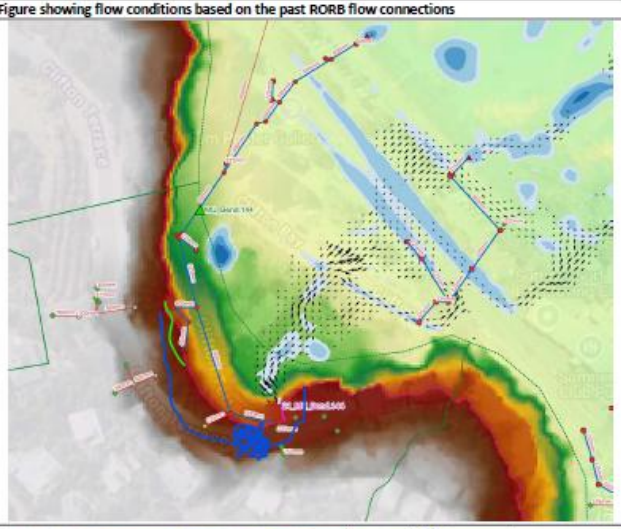
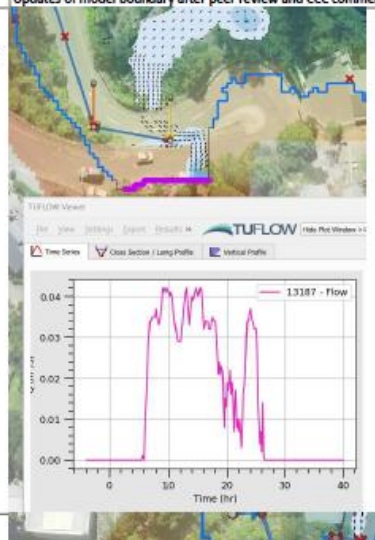
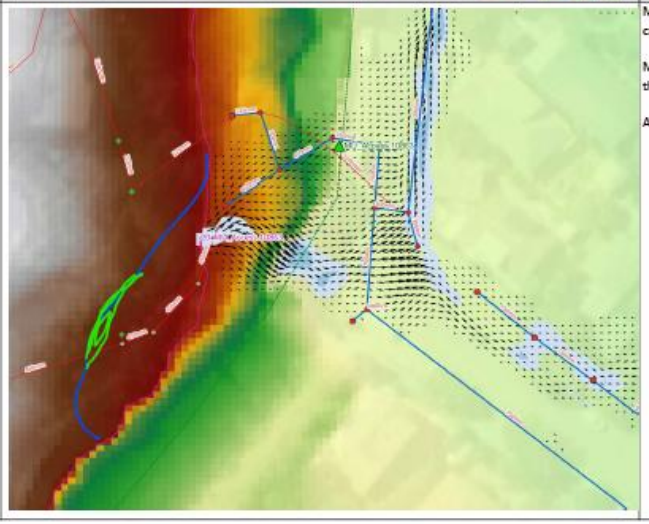
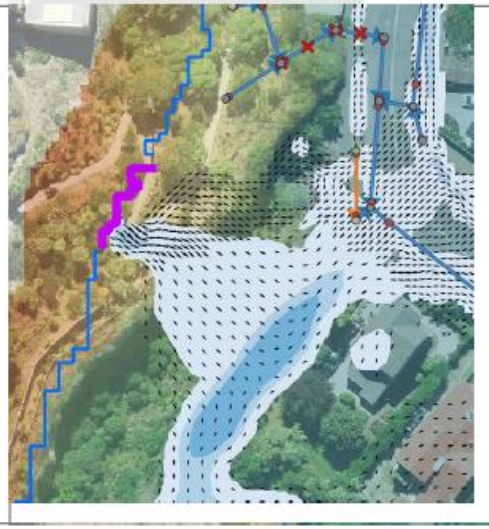
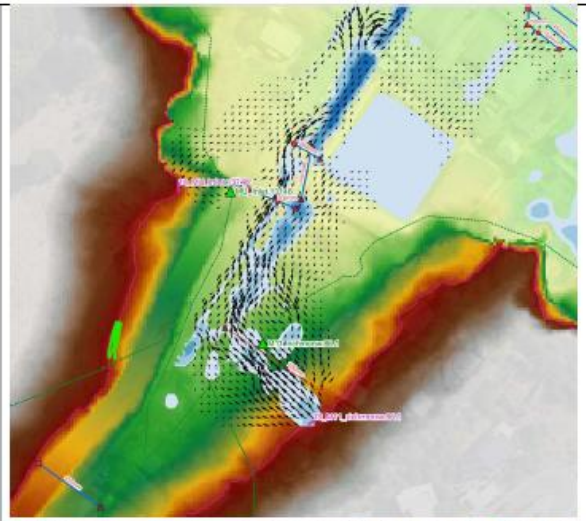
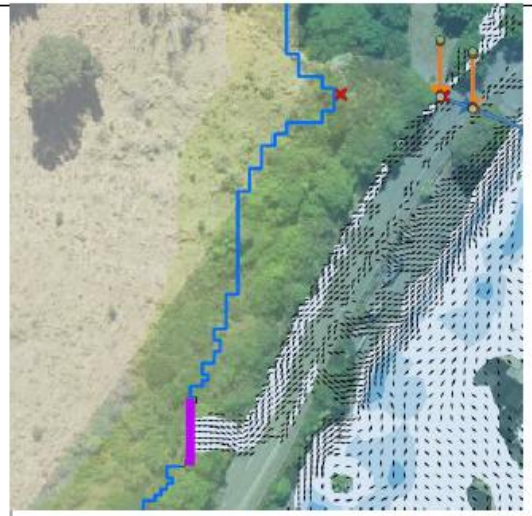
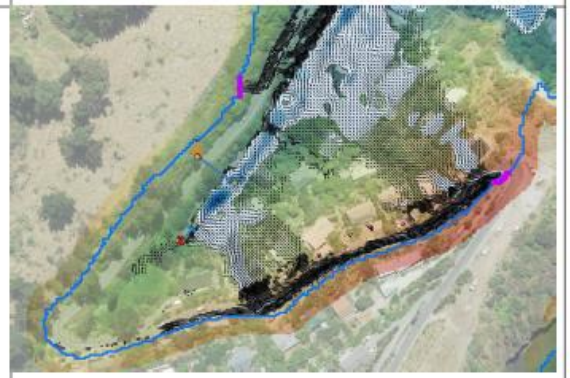
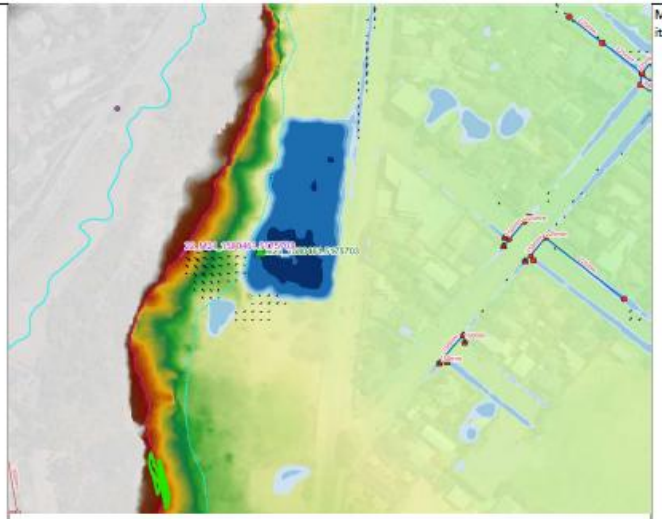
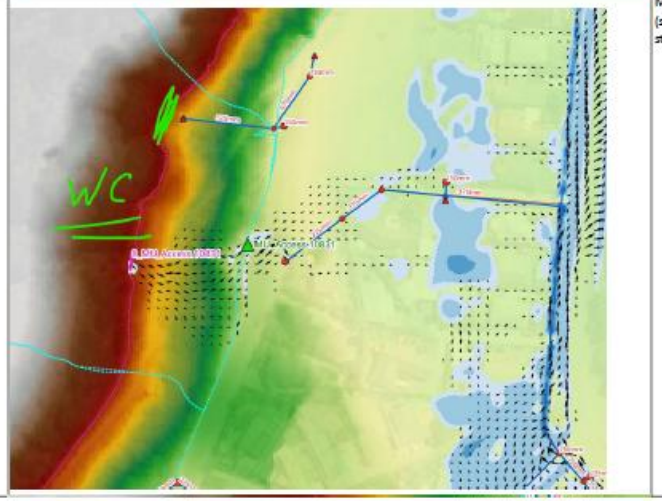
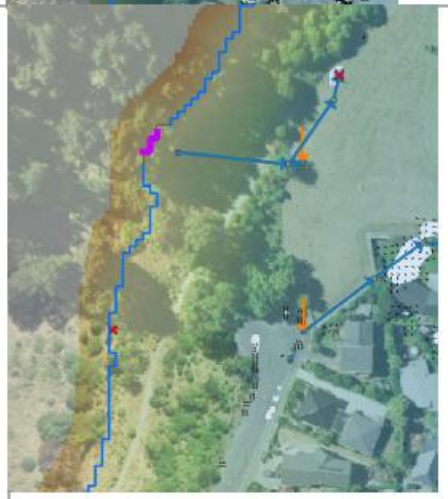
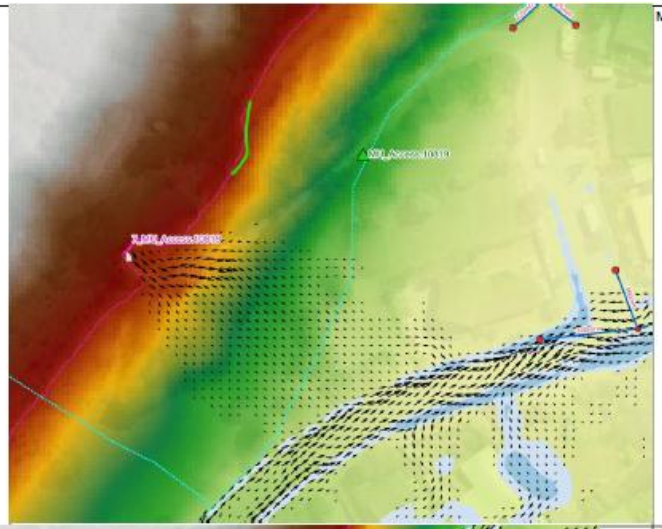
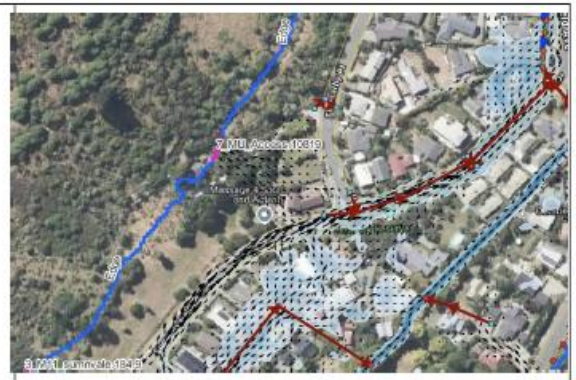
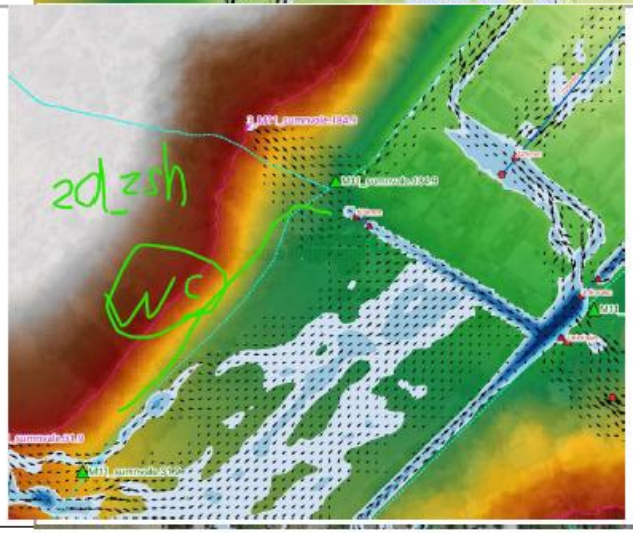
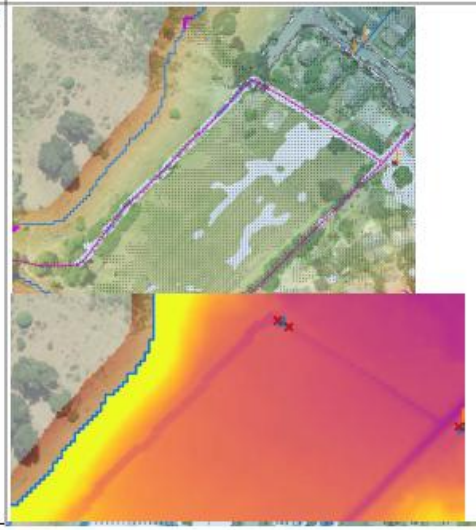
APPENDIX A - MODIFICATION OF RORB FLOW CONNECTIONS

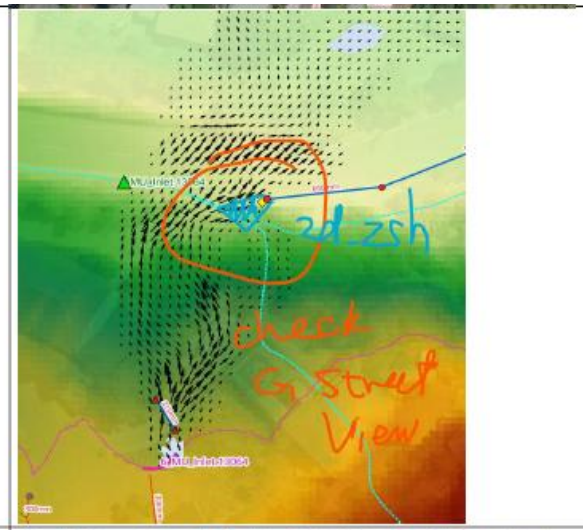
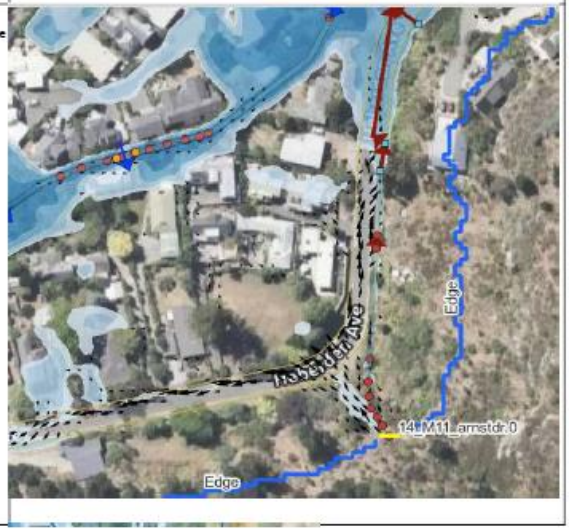
RORB flow connections	Figure showing flow conditions based on the past RORB flow connections	Suggestion for modification of RORB flows and TUFLOW boundary	Updates of model boundary after peer review and CCC comments
21_MU_Bend.144		Move boundary (blue line) following the Clifton Terrace terrain. Move flow boundary to green line to ensure that 450mm pipe could capture the flow.	
20_MU_Access.10863		Move boundary (blue line) to the west to ensure that the 450mm could capture flows. Move flow boundary to green line to ensure that 450mm pipe could capture the flow. Add stormwater to the model (red pipes, pits and manholes).	

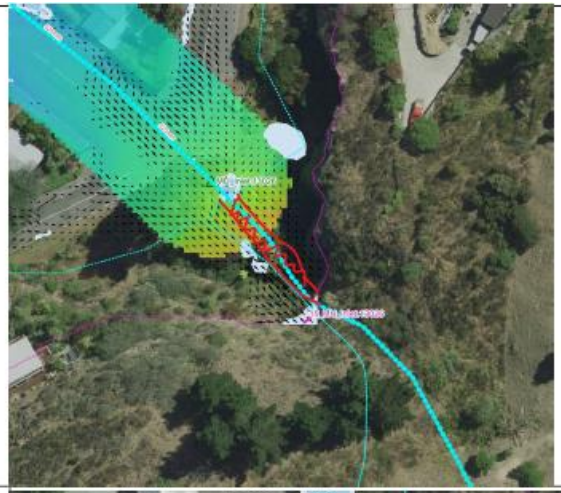
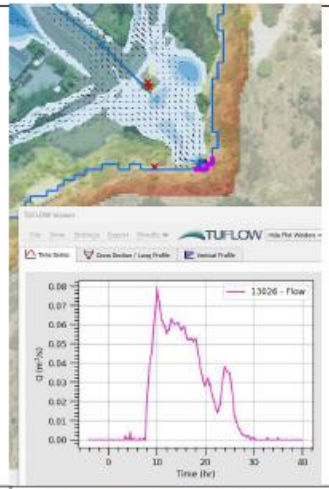
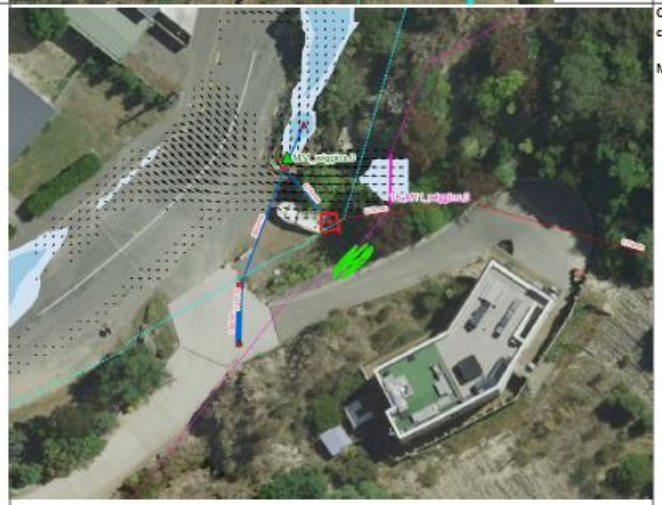
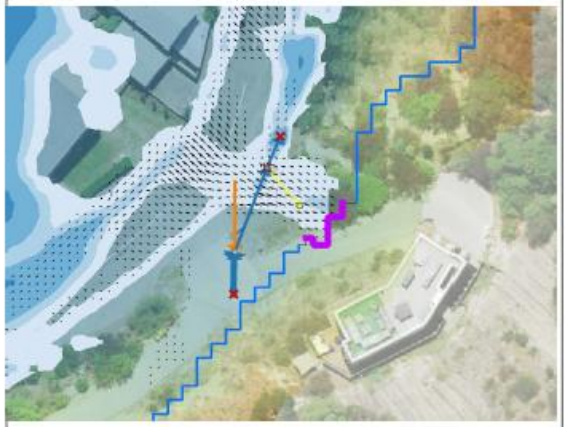
18_MU_Inlet.13148		Move flow boundary to green line to let flow follow the street.	
19_M11_richmonw.86.1		Extend model boundary (blue line) following the street terrain. Mode flow boundary to green line to let flow follow the street terrain.	

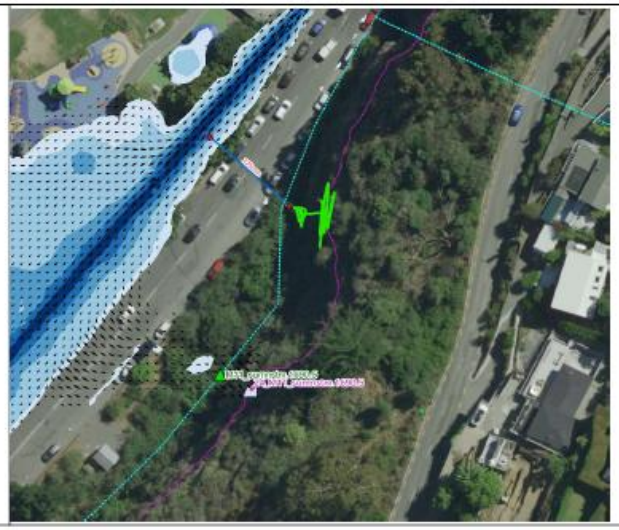
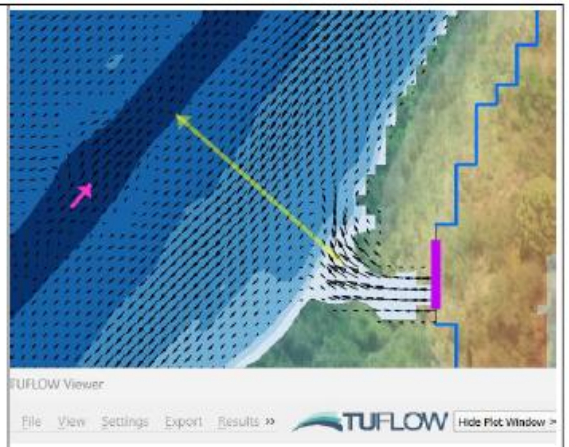
22_M21_1580461.5175703		Move flow boundary to green line to let flow follow the terrain and let's see if it fill the pond.	
8_MU_Access.10831		Move flow boundary to green line to let flow follow the water course (stormwater network in this case). FYI, watercourse include drain and stormwater network).	

7_MU_Access.10619		Move flow boundary to green line to let flow follow the terrain.	
3_M11_sumnvale.184.9		Include watercourse (thick dotted pink line) in the terrain using 2d_zsh. Refer to email for details of watercourse.	

4_M11_sumnstm.379.5		Extend model boundary (blue line) following the street terrain. Mode flow boundary to green line to let flow follow the street terrain.	
5_MU_Access.CCCGIS.10871		Move flow to green line to let flow follow the street.	

6_MU_Inlet.13064		There is a structure (little yellow polygon) at the pit (red square) to collect flow to the SW network. Add 2d_zsh to modify the terrain to ensure that the flow is collected to the SW network.	
14_M11_arnstdr.0		Check which RORB upstream catchments were included for flow at M11_arnstdr.0. See if flows should be separated (by area ratio) for flow at the watercourse. See attach eml file for RORB details.	

15_MU_Inlet.13026		Check if watercourse is included in the terrain. Chusit to check reclassified LiDAR. If not, include 2d_Zsh (red lines).	
16_M11_wiggins.0		Change mahole (red circle) to pit to ensure that it collect flows from external catchment. Move flow boundary to green line.	

24_M11_sumnstm.1690.5		Move flow to green line to let flow be collected at inlet (red triangle).	

APPENDIX B - SUMNER STREAM GEOMETRY

MEMO

TO:	Jarad Sinni and Peter Christensen	DATE:	20 Aug 2024
FROM:	Chusit Apirumanekul	PROJECT NO.:	J000832
COPY:	Craig Martell		
SUBJECT:	Assessment of different sources of information for Sumner Stream for open channel modelling in TUFLOW		

BACKGROUND

Existing DHI flood model simulated the open channel using 1D component. Awa proposed to model the open channel in 2D component using Sub-Grid Sampling (SGS) approach in TUFLOW. Christchurch City Council (CCC) provides the reclassified LiDAR, with 0.1m resolution using aerial images and interpolation techniques, providing more accurate representation of open channel geometry. The objectives of the assessment are to compare different data of Sumner Stream, listed below, and recommend the appropriate input for 2D open channel modelling for Sumner Stream.

1. Cross sections in MIKE 11 model (calibrated to March 2014 event)
2. Surveyed cross sections along Sumner Stream in August 2014
3. Reclassified LiDAR in 2023

METHODOLOGY

MIKE11 model used both surveyed cross sections in 2014 and LiDAR information in 2011 for 1D simulation. It is confirmed that the surveyed cross sections in August 2014 were included in MIKE11 model.

MIKE Zero was used to convert M11 XS to 2D surface with 0.5m resolution. The 2D surface was linearly interpolated between 2 cross sections and the alignment of the 2D surface depends on the shape of the M11 river network. The M11 converted 2D surface was then compared with the reclassified LiDAR.

FINDINGS AND DISCUSSION

1. OPEN CHANNEL ALIGNMENT.

Reclassified LiDAR can capture the alignment of open channel quite well as shown in the left picture of Figure 1. The M11 converted 2D surface (orange area) was compared with the reclassified LiDAR (blue/green area) and it can be observed that the reclassified LiDAR can have good representation of open channel course.

Accuracy of the M11 converted 2D surface depends on the quality of surveyed cross sections (locations and levels of left bank, right bank and riverbed) and the accuracy of river network digitization. During the development of M11 model, the river network was not accurately digitized due to limited information at

that time. This resulted in misalignment of the open channel when converting to 2D surface. It is concluded that the reclassified LiDAR has better representations of open channel alignment.

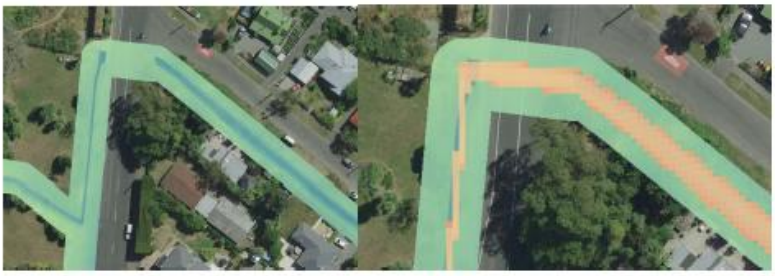


Figure 1 Comparison between reclassified LiDAR and (blue/green area) and M11 converted 2D surface (orange area) for assessing the alignment of open channel

2. REPRESENTATION OF CHANNEL CROSS SECTION

Cross sections from the survey in Aug 2014, M11 converted 2D surface and reclassified LiDAR were compared at different locations along the Sumner Stream. The comparison is carried out to evaluate the quality of the reclassified LiDAR and M11 converted 2D surface compared with the surveyed cross sections. Figure 2 to Figure 4 shows the comparison of cross sections at chainage 725.9, 1516.4 and 2367.2 (upstream to downstream).

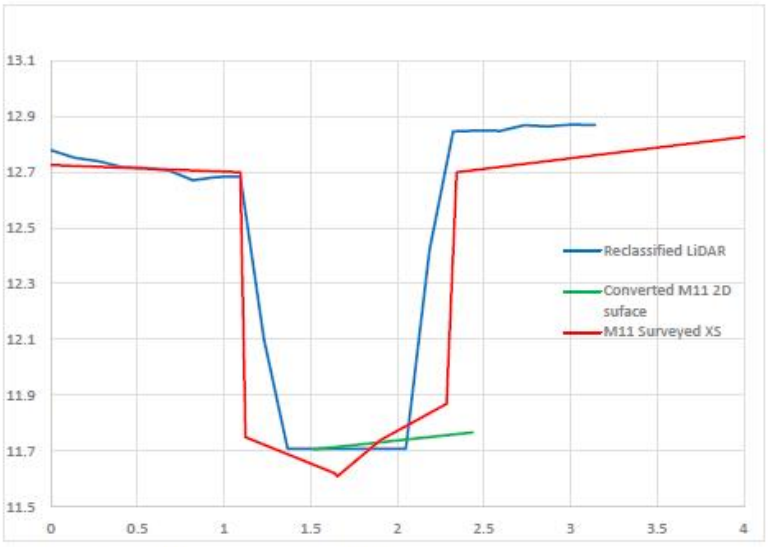


Figure 2 Comparison of cross sections at chainage 725.9

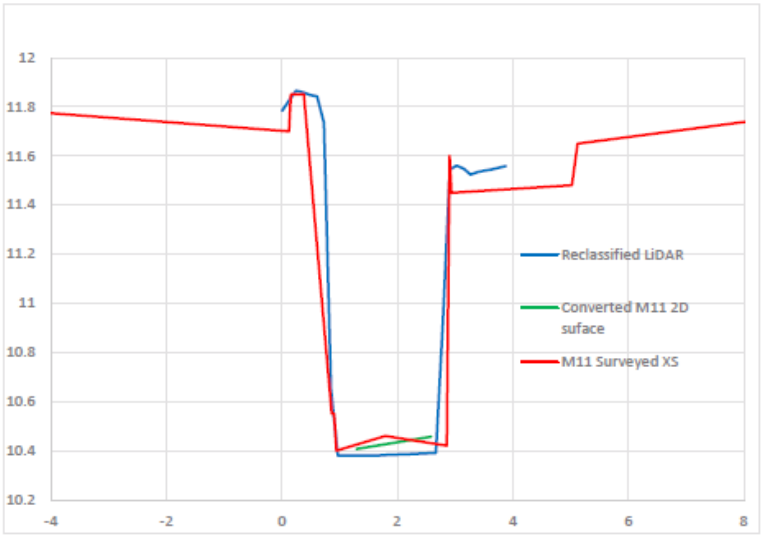


Figure 3 Comparison of cross sections at chainage 1516.4

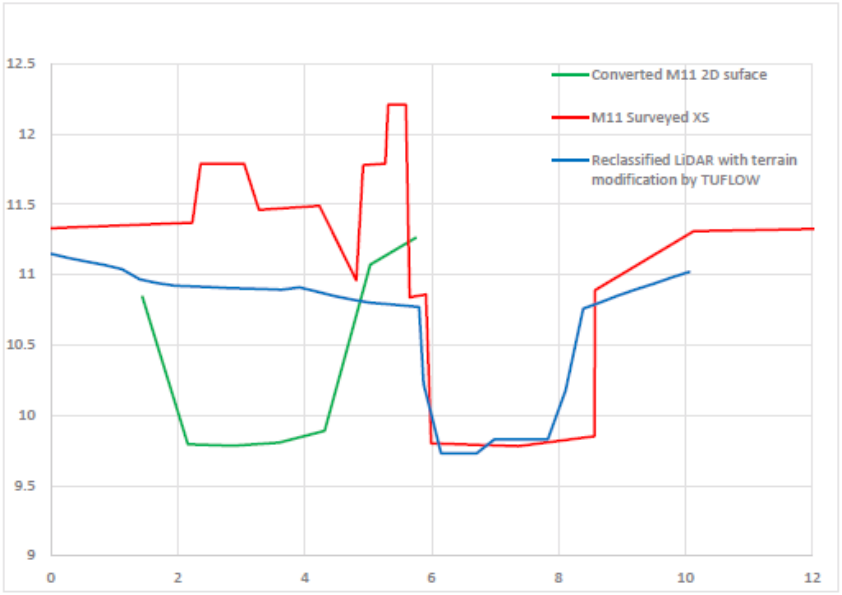


Figure 4 Comparison of cross sections at chainage 2367.2

The comparison at 3 random locations along Sumner Stream shows that reclassified LiDAR shows good agreement with the surveyed cross sections in terms of channel width and riverbed level. However, the reclassified LiDAR does not include the vertical wall on the left bank at chainage 2367.3, due to the limited quality of LiDAR data and obstructions of big trees.

To incorporate the vertical wall on the left bank, information from the surveyed cross sections in 2014 (top level and width of the vertical wall) were used to modify the reclassified LiDAR as shown Figure 5. TUFLOW has a function to modify the 2D model terrain (DEM). Top levels along the vertical walls were extracted from surveyed cross sections and the vertical wall was raised along the Sumner stream (Figure 5). This modification of reclassified LiDAR can represent the actual condition of the vertical wall on the left bank.

It is found that the M11 converted 2D surface has significant deviation of channel alignment (green cross section in Figure 4 and Figure 5). This is due to the fact that interpolation between two cross sections can only be done linearly. Inaccurate digitization of M11 river network is one of the reasons on channel misalignment.

It is also observed that most of riverbed levels from reclassified LiDAR are similar to the surveyed riverbed levels in Aug 2014.

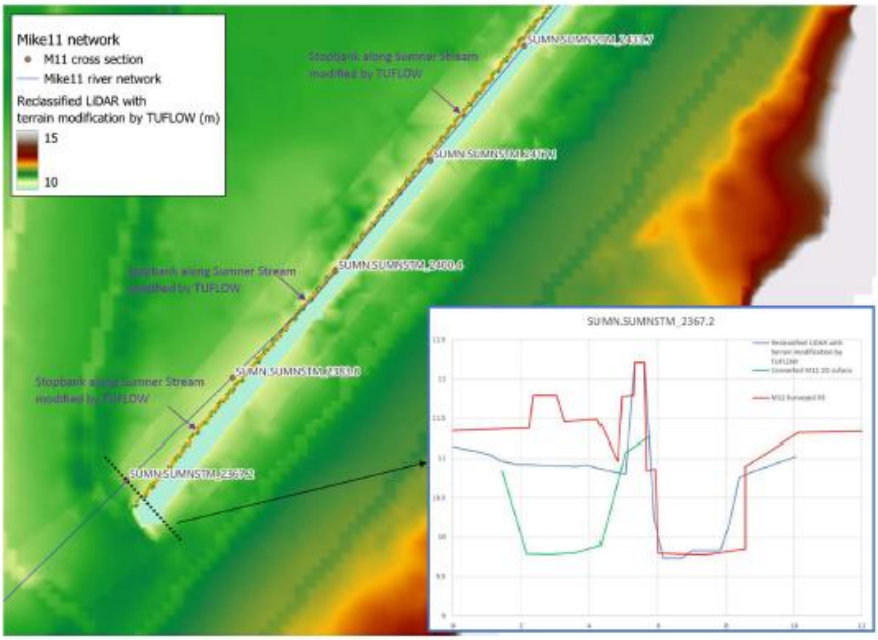


Figure 5 Inclusion of vertical wall along Sumner Stream by TUFLOW to improve quality of the reclassified LiDAR (blue cross section) compared with the surveyed cross section (red cross section)

CONCLUSION AND RECOMMENDATIONS

- M11 converted 2D surface (based on surveyed cross sections in 2014 and LiDAR 2011) has an issue on the open channel alignment. This issue could be from the inaccurate digitization of Sumner Strem in M11 river network.
- Reclassified LiDAR can represent Sumner Stream alignment and geometry (width and depth)
- Reclassified LiDAR has some issues on capturing the details of channel (such as vertical wall) if there is any obstruction (big tree). However, the geometry of the channel can be well represented due to the good interpolation techniques. Information from the surveyed cross sections in 2014 were used to modify the reclassified LiDAR to fill this gap using TUFLOW DEM modification function.

It is recommended to use the reclassified LiDAR with the surveyed cross-sections incorporated where reclassified LiDAR have issues to capture details of channel.

awa

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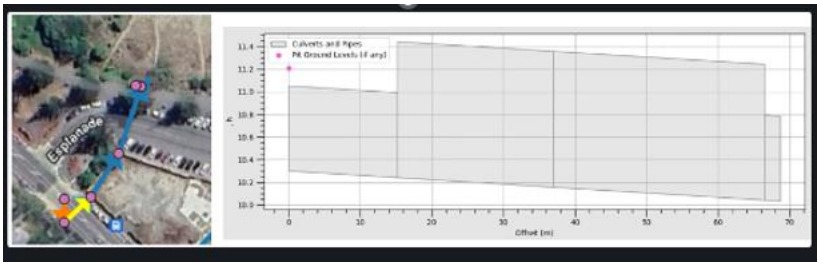
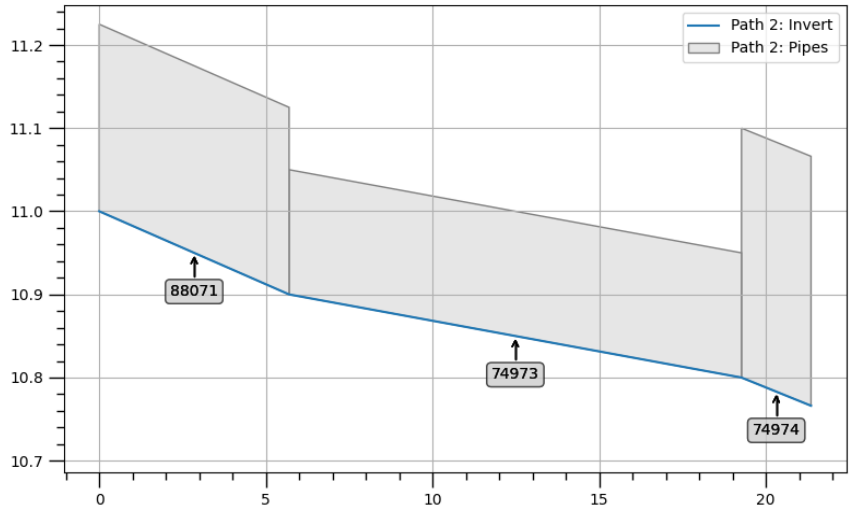
APPENDIX C - NETWORK GAPS

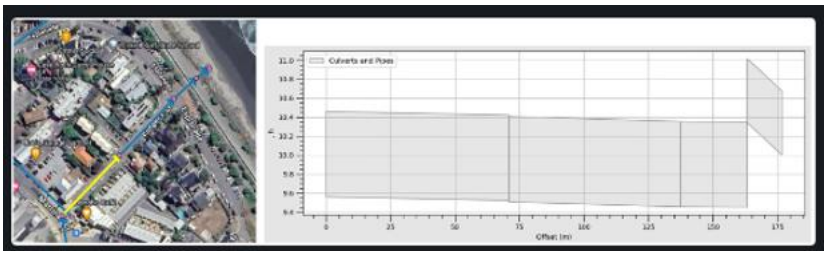
SAMPLES OF GAPS IN 1D NETWORKS IN MIKE URBAN MODEL AND CCC OPEN DATA PORTAL

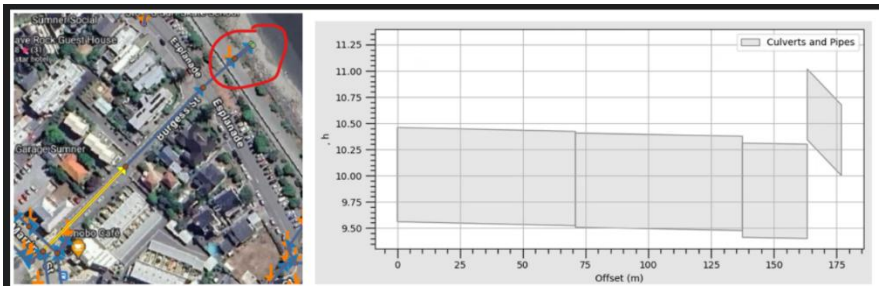
Decrease in downstream pipe diameter and inconsistency in pipe diameters.





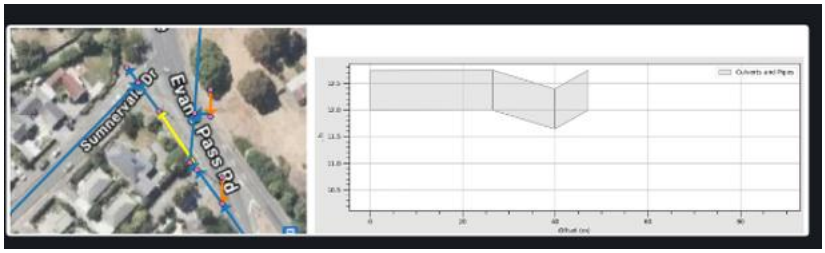
Mismatch invert level of outlet

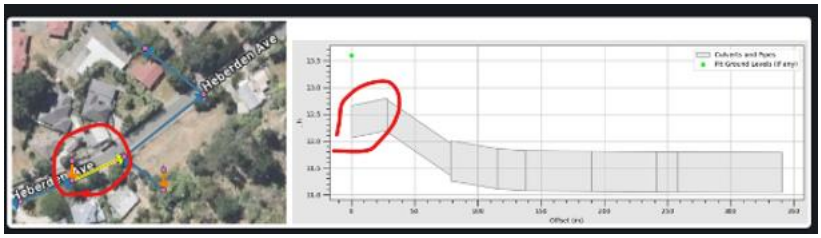




Outlet pipe invert levels higher than LiDAR

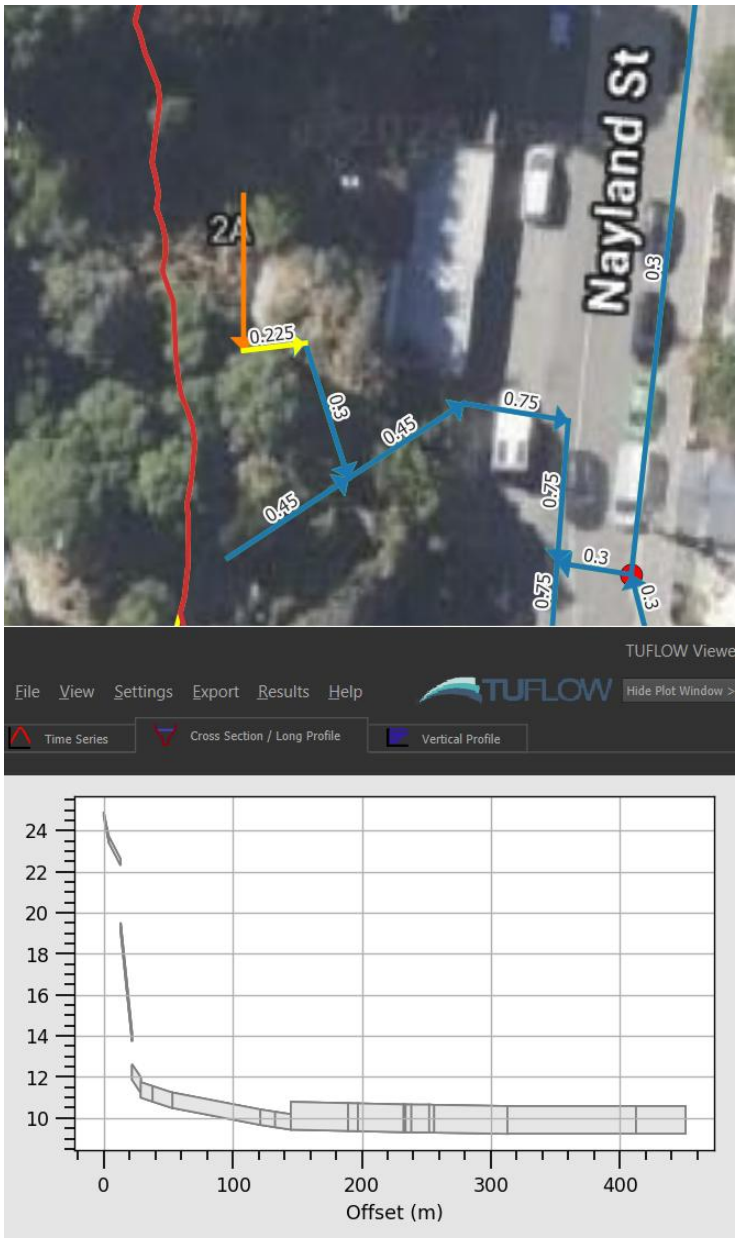
Negative slope





Disconnected pipes/significant drop of pipe invert

Pipe with steep slope




Sumner_1d_gap_DS_pipe_drop
Sumner_1d_gap_DS_dia_less_than_US_dia
Sumner_1d_gap_US_IL_below_DS_IL
Sumner_1d_gap_Pipe_outlet_below_ground
Sumner_1d_gap_small_cover
Sumner_1d_gap_Pipe_above_ground
Sumner_1d_gap_steep_gradient
Sumner_1d_data_gaps_log_V2
SUMNER_1d_data_gaps_log_pipes
model extent

CCC comments on 1D gaps with Awa response/update

Drop of invert level at downstream pipe (disconnection between 2 pipes)

fid	id	type	us_invert	ds_invert	width_or	height_or	number_o	awa_note	issue	source	st_length_shape_	CCC comment	Awa comment
1	27499	C	12.627	12.466	0.225	0	1	-0.012m IL drop to DS pipe	Y	OpenGIS2024		photo does seem to show small drop	After rechecking, the drop is only 0.012m. We will not change the invert level as the drop is
2	27578	C	10.3	10	0.225	0	1	0.20m IL drop to DS pipe	Y	OpenGIS2024		check GIS inverts, they are different to yours (even accounting change in datum)	Update the IL based on CCC open GIS data
3	27632	C	23.4	22.298	0.3	0	1	3.23m IL drop to DS pipe	Y	OpenGIS2024		see photo	Confirm by photo. Suggest to use IL from open GIS data as it was recorded as accurate survey.
4	27639	C	19.069	13.728	0.45	0	1	1.86m IL drop to DS pipe	Y	OpenGIS2024		see photo	Confirm by photo. Suggest to use IL from open GIS data as it was recorded as accurate survey.
5	27640	C	26.341	22.502	0.45	0	1	3.43m IL drop to DS pipe	Y	OpenGIS2024		see photo 3 and 5, I'm not sure!	Confirm by photo. Suggest to use IL from open GIS data as it was recorded as accurate survey.
6	58160	C	10.15	10.14	0.225	0	1	0.65m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
7	58161	C	10.14	10.12	0.225	0	1	0.63m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
8	58165	C	10.37	10.36	0.225	0	1	0.55m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
9	58166	C	10.89	10.87	0.225	0	1	0.5m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
10	58168	C	10.92	10.9	0.225	0	1	0.57m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
11	58169	C	10.545	10.535	0.225	0	1	0.605m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
12	58170	C	10.9	10.83	0.225	0	1	0.29m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
13	58171	C	10.34	10.32	0.3	0	1	0.39m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
14	58172	C	10.975	10.9	0.225	0	1	0.56m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
15	58174	C	10.81	10.79	0.225	0	1	0.59m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
16	58176	C	10.94	10.93	0.225	0	1	0.63m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
17	58180	C	11.23446	11.16	0.225	0	1	0.77m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
18	58182	C	11.1	10.89	0.3	0	1	0.5m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
19	58183	C	11.46	11.36	0.225	0	1	0.26m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
20	74929	C	11.2	10.8	0.225	0	1	0.66m IL drop to DS pipe, pipe partially above ground, no minimum cover	Y	OpenGIS2024		No photo. But no inverts in GIS so check your invert interpolation/assumptions	Use upstream IL of downstream pipe for missing downstream IL
21	74932	C	11.72	11.42	0.15	0	1	0.32m IL drop to DS pipe, pipe partially above ground,	Y	OpenGIS2024		No photo. Check GIS inverts, different to model. Although GIS inverts in this area look wrong, may have to make some sensible assumptions	Updated the US IL assumed 0.3m below ground level (LIDAR 2020). DS IL is assumed to be same as US IL of downstream pipe.
22	87774	C	11.25	11	0.15	0	1	0.40m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to larger pipe, so seems reasonable	No further comment
23	88082	C	11.917	11.895	0.375	0	1	0.55m IL drop to DS pipe	Y	OpenGIS2024		No photo, but connecting inlet to large pipe, so seems reasonable	No further comment
24	88090	C	11.87	11.57	0.15	0	1	0.47m IL drop to DS pipe, pipe partially above ground, 0.47m IL drop	Y	OpenGIS2024		No photo. Check u/s invert, different to GIS. D/s connects to larger pipe, so reasonable	Recheck the IL from GIS and they are correct. Use IL from GIS. No further comment.
25	94614	C	11.35	11.305	0.225	0	1	0.21m IL drop to DS pipe	Y	OpenGIS2024		No photo. Not a big drop.	No further comment
26	94622	C	10.97	10.9	0.3	0	1	0.37m IL drop to DS pipe	Y	OpenGIS2024		No photo. Connecting to larger pipes	No further comment
27	94644	C	11.26	11.23	0.15	0	1	0.70m IL drop to DS pipe	Y	OpenGIS2024		No photo. Connecting to larger pipes	No further comment

CCC comments on 1D gaps with Awa response/update

Invert levels of outlets are below ground elevations

fid	id	type	us_invert	ds_invert	width_or_	height_or_	number_o	awa_note	issue	source		Awa comment
1	27556	CU	9.45	9.3	0.75	0	1	pipe outlet below LiDAR	Y	OpenGIS2(	levels don't match GIS data	Adjust invert level of pipes to match GIS data (above the ground)
2	27580	CU	9.66	9.5	0.225	0	1	pipe outlet below LiDAR	Y	OpenGIS2(	levels don't match GIS data	Adjust invert level of pipes to match GIS data (above the ground)
3	27611	CU	10.711	10.6	0.225	0	1	pipe outlet below LiDAR	Y	OpenGIS2(	levels don't match GIS data	Use invert level from upstream pipe
4	32963	C	12.4	11.34676	0.175	0	1	pipe outlet below LiDAR, steep gradient	Y	OpenGIS2(	No GIS data	Use ground level from LiDAR for outlet.
5	65917	CU	10.342	10	0.675	0	1	pipe outlet below LiDAR	Y	OpenGIS2(	Look at street view. Outlet possibly in rock bank. LiDAR may be inaccurate. See photos	Noted. Use invert level from GIS data. Can be updated in the future.
6	65918	CU	10.342	10	0.675	0	1	pipe outlet below LiDAR	Y	OpenGIS2(	Look at street view. Outlet possibly in rock bank. LiDAR may be inaccurate. See photos	Noted. Use invert level from GIS data. Can be updated in the future.

Figure 2. Burgess Street outfall in May 2014

CCC comments on 1D gaps with Awa response/update

Downstream pipe diameter is smaller than the upstream pipe diameter

fid	id	type	us_invert	ds_invert	width_or_d	height_or_	number_of	awa_note	issue	source	CCC comment	Awa comment
1	27457	C	10.9	10.9	0.225	0	1	diameter < US pipe diameter	Y	OpenGIS2024	I can't find anything about this. It does look wrong though, as the larger pipes u/s and d/s were constructed in 2019, whereas the 225 was constructed in 2002.	Assume use diameter from GIS. It is likely to have insignificant impact.
2	27467	C	11.05	11	0.225	0	1	diameter < US pipe diameter	Y	OpenGIS2024	I can't find anything about this. It does look wrong though, as the larger pipes u/s and d/s were constructed in 2019, whereas the 225 was constructed in 2002.	Assume use diameter from GIS. It is likely to have insignificant impact.
3	39798	C	10.3	10	0.15	0	1	diameter < US pipe diameter	Y	OpenGIS2024	I can't find anything about this.	Assume use diameter from GIS. It is likely to have insignificant impact.
4	74973	C	10.9	10.8	0.15	0	1	diameter < US pipe diameter	Y	OpenGIS2024	Doesn't look right but assume GIS is correct based on construction dates. Can re-visit if causes issues in results.	Assume use diameter from GIS. It is likely to have insignificant impact.
5	94618	C	10.97	10.965	0.225	0	1	diameter < US pipe diameter	Y	OpenGIS2024	Check GIS pipe sizes, as DS > US	Recheck and confirm that DS > US. No further comment
6	94629	C	11.06	11.02	0.3	0	1	DSIL below DS pipe IL, diameter < US pipe diameter	Y	OpenGIS2024	I can't find anything about this.	Assume use diameter from GIS. It is likely to have insignificant impact.
7	94643	C	10.2	9.5	0.225	0	1	diameter < US pipe diameter	Y	OpenGIS2024	I can't find anything about this. But based on grade the pipe capacities may be similar?	Assume use diameter from GIS. It is likely to have insignificant impact.

CCC comments on 1D gaps with Awa response/update

Pipe has small ground coverage (50-100mm)

fid	id	type	us_invert	ds_invert	width_or_	height_or_	number_o	awa_note	issue	source	CCC comment	Awa comment
1	39092	C	17.6	17.59	0.15	0	1	small cover (0.05m)	Y	OpenGIS2(	levels don't match GIS data	Use LiDAR minus by 0.5m for invert level
2	73759	R	9.88	9.85	2.4	1.1	1	small cover (0.1m)	Y	OpenGIS2(	levels don't match GIS data	Use LiDAR minus by 0.5m for invert level
3	73760	R	9.85	9.83	2.4	1.1	1	small cover (0.1m)	Y	OpenGIS2(	levels don't match GIS data	Use LiDAR level for culvert invert level

CCC comments on 1D gaps with Awa response/update

Pipe invert levels are above ground elevation

fid	id	type	us_invert	ds_invert	width_or	height_or	number_o	awa_note	issue	source	CCC comment	Awa comment
1	27367	C	15.658	12.938	0.6	0	1	pipe partially above ground	Y	OpenGIS2024	See SCIRT photo.	
2	27598	C	25.93676	19.2	0.45	0	1	pipe above ground	Y	OpenGIS2024	No inverts on GIS. But on very steep hill, so need to consider this when comparing to ground levels.	Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
3	40577	R	10.97	10.91	3.57	1.05	1	pipe above ground	Y	OpenGIS2024	No inverts on GIS. But connects two open drains, so what ground level are you comparing to?	This is culvert. We use Invert levels from Mike 11. Suggest to use Information from Mike 11.
4	40608	C	11.24	11.24	1.2	0	1	pipe above ground	Y	OpenGIS2024	No inverts on GIS. But connects two open drains, so what ground level are you comparing to?	This is culvert. We use Invert levels from Mike 11. Suggest to use Information from Mike 11.
5	43146	C	12.7	11.25	0.225	0	1	pipe above ground	Y	OpenGIS2024		There are invert levels from GIS pipes. Use invert levels from GIS pipes.
6	45582	C	12.8	11.82	0.3	0	1	pipe partially above ground	Y	OpenGIS2024		Use invert levels from US and DS pipes
7	45867	R	9.98	9.89	2.45	0.9	1	pipe above ground	Y	OpenGIS2024		This is culvert. We use Invert levels from Mike 11. Suggest to use Information from Mike 11.
8	46989	C	22.66676	22.06676	0.9	0	1	pipe above ground	Y	OpenGIS2024		USIL and DSIL use ground levels from LIDAR (seems to be culvert under the road).
9	46990	R	13.1	12.68	1	1	1	pipe above ground	Y	OpenGIS2024		This is culvert. We use Invert levels from Mike 11. Suggest to use Information from Mike 11.
10	47328	C	14.28	12.8	0.1	0	1	pipe partially above ground	Y	OpenGIS2024		Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
11	47329	C	14.28	12.8	0.1	0	1	pipe partially above ground	Y	OpenGIS2024		Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
12	47330	C	14.28	12.8	0.1	0	1	pipe partially above ground	Y	OpenGIS2024		Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
13	47331	C	14.28	12.8	0.1	0	1	pipe partially above ground	Y	OpenGIS2024		Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
14	74934	C	11.8	11.6	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
15	74939	C	11.24	11.24	1.2	0	1	pipe above ground	Y	OpenGIS2024		This is culvert. We use Invert levels from Mike 11. Suggest to use Information from Mike 11.
16	74942	C	11.82	11.8	0.15	0	1	pipe above gorund	Y	OpenGIS2024		Assume USIL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
17	74943	C	11.8	11.3	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		Assume IL to be ground level minus by 0.5m. Assume DSIL to be ground level minus by 0.5m.
18	74948	C	12.41	12.25	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		GIS values exist and are below DEM. Both USIL and DSIL set to GIS (10.897, 10.711).
19	74962	C	11.8	11.6	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m (11.30, 11.42). **Note DSIL is HIGHER.** Further drop DSIL to be DEM minus 0.7 m (11.22)
20	74979	C	13.11	12	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m
21	77252	C	12.5	12.3	0.15	0	1	pipe above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. USIL set to DEM minus 0.5 m (11.96). DS node is a T-junction connected to 77254, a node with USIL that is above ground
22	77255	C	12.55	12.5	0.15	0	1	pipe partially above ground	Y	OpenGIS2024	All of these either don't have inverts in GIS, or the inverts are different to the model	Three connected pipes with no USIL or DSIL, connected at a T-junction with a high point in DEM. Setting in/out to be DEM minus 0.5 m, and junction at 11.84, so that pipes are (11.86, 11.84), (11.99, 11.84), and (11.84, 11.76)
23	77256	C	12.55	12.5	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		
24	77257	C	12.5	12.3	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		
25	87586	C	11.4	11.35	0.3	0	1	pipe above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. DEM at DS is higher. DS is connected to 87585 with USIL 11.35. USIL set to DEM minus 0.3 m, DSIL set to DEM minus 0.5 m
26	87590	C	23.91	23.45	0.3	0	1	pipe above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m
1	87775	C	11.13	10.8	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		Two connected pipes, T-junction downstream connected to 80883 with USIL from cGIS of 10.673. DSIL for both pipes set to 10.673, USIL set to DEM minus 0.4 m
28	87776	C	11.24	10.68	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		
29	88088	C	12.38	12.021	0.15	0	1	pipe above ground	Y	OpenGIS2024		cGIS values exist and are below DEM. Both USIL and DSIL set to cGIS (12.018, 12.021)
30	88089	C	12.25	12.073	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		cGIS values exist and are below DEM. Both USIL and DSIL set to cGIS (12.083, 12.073)
31	88091	C	12.19	11.963	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		cGIS values exist and are below DEM. Both USIL and DSIL set to cGIS (12.052, 11.963)
32	88094	C	12.4	12.073	0.15	0	1	pipe partially above ground	Y	OpenGIS2024		cGIS values exist and are below DEM. Both USIL and DSIL set to cGIS (12.133, 12.073)
33	91090	C	26.97	26.35676	0.315	0	1	pipe above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m
34	91167	R	10.85	10.85	3.63	1.1	1	pipe above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m
35	91168	C	12.47	12.26676	0.3	0	1	pipe above ground	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m
36	1	C	11.82	11.8	0.675	0	1	pipe above ground, not showing on aerial	Y	OpenGIS2024		No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m
37	74929	C	11.2	10.8	0.225	0	1	0.66m IL drop to DS pipe, pipe partially above	Y	OpenGIS2024		No USIL or DSIL from cGIS. DS is a T-junction connected to 58161 with USIL from cGIS of 10.14. DSIL set to 10.14, USIL set to DEM minus 0.5 m
38	74932	C	11.72	11.42	0.15	0	1	0.32m IL drop to DS pipe, pipe partially above	Y	OpenGIS2024		cGIS values exist and are below DEM. Both USIL and DSIL set to cGIS (10.897, 10.711)
39	88090	C	11.87	11.37	0.15	0	1	0.47m IL drop to DS pipe, pipe partially above	Y	OpenGIS2024		cGIS values exist and are below DEM. Both USIL and DSIL set to cGIS (11.625, 11.37)

CCC comments on 1D gaps with Awa response/update

Pipe with steep gradient

fid	id	type	us_invert	ds_invert	width_or_	height_or_	number_o	awa_note	issue	source	CCC Comment	Awa Comment
1	32963	C	12.4	11.34676	0.175	0	1	pipe outlet below LiDAR, steep gradient	Y	OpenGIS2024	No inverts on GIS.	No USIL or DSIL from cGIS. Both set to DEM minus 0.5 m

CCC comments on 1D gaps with Awa response/update

Upstream invert level is lower than downstream invert level

fid	id	type	us_invert	ds_invert	width_or_	height_or_	number_o	awa_note	issue	source	CCC comment	Awa Comment
1	27379	C	11.851	11.735	0.45	0	1	IL below DS pipe IL	Y	OpenGIS2024	d/s pipe doesn't have invert levels in GIS	from cGIS - DSIL 11.735. no USIL of DS pipe.
2	27443	C	11.2	11.084	0.45	0	1	IL below DS pipe IL	Y	OpenGIS2024		from cGIS - DSIL 11.084, USIL of DS pipe 11.094. keep value as-is
3	27444	C	11.239	11.19	0.45	0	1	IL below DS pipe IL	Y	OpenGIS2024		from cGIS - DSIL 11.19, USIL of DS pipe 11.2. keep values as-is
4	28168	C	10.4	10.32	0.225	0	1	IL below DS pipe IL	Y	OpenGIS2024	model levels don't match GIS data	cGIS values exist and are are below DEM. Set both USIL and DSIL to cGIS values
5	65479	C	12.78	11.78	0.45	0	1	IL below DS pipe IL	Y	OpenGIS2024	model levels don't match GIS data	cGIS values didn't exist at the time the snapshot was taken. USIL of DS pipe 12.01. set DSIL to DEM minus 1 m.
6	65916	C	9.411	9.4	0.9	0	1	IL below DS pipe IL	Y	OpenGIS2024		cGIS values exist. DSIL is 9.4. Both downstream connections are from cGIS and are 10.342. Defer to cGIS values
7	65919	C	12.069	9.4	0.15	0	1	IL below DS pipe IL	Y	OpenGIS2024	model levels don't match GIS data. But still a concern due to the difference in levels. I can't find anything about it though.	cGIS values do not exist. Node IL is 9.4 (see 65916 above) but connections downstream are from cGIS and are 10.342. Setting DSIL to 10.342
8	94623	C	11.02	11.01	0.3	0	1	IL below DS pipe IL	Y	OpenGIS2024		cGIS values exist. DSIL is 11.02, downstream connections are from cGIS and are 11.22 and 11.04 respectively. Keep cGIS values in all cases.
9	94629	C	11.06	11.02	0.3	0	1	IL below DS pipe IL, diameter < US pipe diameter	Y	OpenGIS2024		cGIS values exist. DSIL is 11.02, downstream connection is from cGIS and is 11.11. Keep cGIS values.
10	94631	C	10.82	10.75	0.3	0	1	IL below DS pipe IL	Y	OpenGIS2024		cGIS values exist. DSIL is 10.75, downstream connection is from cGIS and is 10.77. Keep cGIS values.
11	94638	C	10.95	10.91	0.3	0	1	IL below DS pipe IL	Y	OpenGIS2024	d/s pipe doesn't have invert levels in GIS	cGIS values exist. DSIL is 10.91, downstream connection is from cGIS and is 10.95. Keep cGIS values.
12	94642	C	11.72	11.645	0.225	0	1	IL below DS pipe IL	Y	OpenGIS2024		cGIS values exist. DSIL is 11.645, downstream connection is from cGIS and is 11.68. Keep cGIS values.

APPENDIX D - SELECTED PEER REVIEW FEEDBACK

The first peer review contained a number of useful comments and analysis that are reported here as background for the model build. After the model was updated further minor feedback was received but not reported here.

Sumner TUFLOW model supplied by Awa 15/07/2024
TUFLOW version 2023-03-AE-iDP-w64

Issue Description
NO ISSUE
MINOR ISSUE - Likely to have only a minor impact on results and is somewhat subjective - Consider fixing if model is being re-run for other reasons
MAJOR ISSUE - An error or omission that will noticeably affect results (local or wider) - Must be fixed

Peer reviewer's comments

Item	Comment	Issue	Modeller's response (30 Aug 2024)	Meeting discussion/agreement (12 Nov 2024)	Agreed actions	T
OVERVIEW						
File naming, structure and management	Scenario provided for review is "SUMNER_B0101". Its unclear the basis for this naming convention. Suggest this is documented in the report and a model log spreadsheet is developed for future tracking purposes, i.e. what does the "B0101" mean? File naming not aligned with recommended naming conventions in the Citywide Flood Modelling Model Schematisation document. The GIS shapefiles (e.g. 2d_zsh_Seawall_L.shp) have no version control. Suggest adding a "_V00X" to the shapefile names so if they change, can be tracked across versions. "quadtree_v2_CZ.qcf" naming is random, is there a v17, suggest changing to a naming convention that can be tracked more easily. "Sumner_GWL_Capillary_Mar2014_CDD" layer naming suggests this is in CDD datum Please confirm that model is in CDD and not in NZVD 2016 Its not clear what events the result files relate to. Suggest the outputs should have names that give the user more information. e.g. the outputs for the modelled March 2014 event should have "March2014" in the output name. Consider adding additional version controls to the TUFLOW code and shapefiles. e.g. "_Cal" to denote calibration, "_Des" to denote design runs etc. Assuming the model will be used for testing various things in the future (e.g. pipe upgrades) the model should be set up with naming convention now to make this process easier to follow and track.		File naming of the final TUFLOW model will follow the instructions in the '20240124 Data system report.pdf' shared by CCC on 24 April 2024 (attached in the email). Refer to Section 2.4.1 for file naming convention which allows adding free description of model run (e.g. _Cal for calibration, run event). This version of TUFLOW refers to CDD. After peer reviews, we will convert model to NZVD 2016.	Agree	Follow instructiongs for file naming.	
Model log	Not provided - Suggest a model log is developed in a spreadsheet to track versions. Relates to previous comment regarding tracking of shapefiles and naming convention		Model log will be provided for all model runs.	Agree	Provide model logs for all model runs.	
Scenarios	NA - no scenarios used for this model version					
Model extent	No glass walling for the scenario results provided (March 2014). Will need to be checked again when other events are simulated					
Timestep	Adaptive timestep					
Calculation parameters	Model uses TUFLOW HPC but also forces iDP (Double Precision). As per guidance from TUFLOW for HPC version: (https://wiki.tuflow.com/TUFLOW_General_Discussion#What_is_the_difference_between_single_and_double_precision_and_when_should_I_use_them.3F) *"It uses cell-averaged water depth as the primary variable within the solver, rather than using water surface elevation as the primary variable and computing water depth on the fly from surface elevation minus bed elevation. This means that precision issues associated with applying a very small rainfall and/or modelling high elevations are not applicable in HPC. Unless testing shows otherwise, the single precision version of TUFLOW should be used for all HPC simulations. An error message will be triggered if TUFLOW HPC is used with double precision unless HPC DP Check == OFF is specified within the TCF."* Its unclear why Double Precision has been forced in the model. There are some specific cases where iDP can be used with HPC but its unclear if those cases apply. Single precision (iSP) is much faster and is recommended by TUFLOW when using HPC.		TUFLOW manual (TUFLOW Manual.2018-03.pdf) recommends iDP for direct rainfall models where large amounts of flows are predicted (refer to page 11-16). We re-run the model with iSP mode. Figure 1 shows the difference in maximum flood depth between iSP model and iDP model. Using iSP model results in increased flood depth by 100mm at the lower part of the model domain (Figure 1). The iDP model required 12.4 hours to complete the model run while the iSP model took 4.1 hrs to finish the model run. To be confirm by peer reviewer on the modelling approach (iSP or iDP).	Agree to use iSP approach as it takes less times to run the models with conservative results. Suggest to consult with TUFLOW on iSP vs iDP.	After consulting with TUFLOW, double precision can be used for very small incremental infiltration during simulation times (e.g. 0.00000xx) as single precision might not pick up the small value. For longer simulation time, those small amounts might add up over time and create some differences in the results. TUFLOW suggested to do a sensitivity test and use double precision if there is the difference. CCC to confirm if single precision should be used.	
	An upper limit to manning's used in the Wu viscosity calculation was introduced in 2023-03-AA TUFLOW to limit the computed viscosity in regions of unusually high roughness. This only affects the viscosity calculation, the momentum equation will continue to use the original roughness value as defined in the materials file. The default limit is 0.1 Several of the materials have roughness > 0.1 and so may be affected by this default. Suggest running a sensitivity run, increasing the default (using Viscosity Coefficients == command).		Upper limitting of roughness value was increased to 0.2 using the Viscosity Coefficient == command as indicated in the TUFLOW Release Note 2023-02-AA version. Viscosity Coefficient == <C3D, C2D, Upper limitting n> Default values for C3D and C2D are 7 and 0, respectively. Increasing upper limiting roughness value to 0.2 results in reduced flood depth, ranging from 50mm to 250mm, in the lower part of the model domain (Figure 2). Awa will use lowered roughness as suggested in the roughness section. Upper limiting of roughness value will be 0.2 as the suggested roughness for building is 0.2 based on the Citywide Flood Modelling Model Schematisation document. Viscosity Coefficient can be updated after discussion with CCC on the roughness for buildings.	Agree to use upper limitation of n = 0.2.	Update the model.	
Runn						
Method	Lumped catchment inflows & Rain on grid within model domain					
Lumped catchments	Lumped catchments from existing RORB model (supplied by CCC) - Assume review of the RORB model is outside scope of T+T review.					
Rainfall	March 2014 event from MIKE model - Assume review of the data is outside scope of T+T review Time varying grided rainfall is applied to an area inside the model domain. The gridded rainfall is applied to an area slightly smaller than the model domain to avoid double up of RORB lumped inflows. Between the gridded rainfall area and the model domain boundary, the model results could be visually misleading as no rainfall is being applied. Consider outputting only the TUFLOW results within gridded rainfall area using TUFLOW's command to specify a defined output area (i.e. instead of outputting results for the whole domain)		Agree. We will defint output zone for model domain where rains are applied. Frequency of output interval and output types will be discussed and confirmed by CCC.	Agree	Update the model.	
Soil losses/infiltration	TUFLOWs ILCL method with porosity Initial loss = 0, Constant loss = variable based on soil type 5 soil types used across the domain defined by grid "Sumner_Soil_Drain_ID" Soil type in lower catchment is shown in report as "SAND" however in the Sumner_Soil_Drain_ID grid its being defined as type 5 which is GRAVEL. Please check Porosity = variable based on soil type Assume review of ILCL rates, porosity and groundwater depth is outside scope of T+T review		We confirmed that soil type for lower catchment is sand (Figure 2 of Appendix L in the Citywide Flood Modelling Model Schematisation document). GHD provided shape file of soil drainage class (Selected_SoilsMegered01.shp) which have an identical drainage class for both Sand and Gravel. It was confirmed by GHD that sand was considered to have high infiltration rates consistent with drainage class 5. Due to limites of Waterway, Wetlands and Drainage Guide (WWDG) knowledge and 1-5 drainage class mapping, GHD have not distinguished gravels from sands within class 5.	Not ideal. To be improved in the future.	Use the values in the schema report.	

	Suggest setting impervious area for stream channels and water as 100%		Agree. The revised model updated the imperviousness for channels and water to 100%.	Agree	Update the model.
Groundwater depth	Groundwater depth - spatial varying grid - "Sumner_GWL_Capillary_Mar2014_CDD" layer name suggests this is in CDD datum. Please confirm that model is in CDD and not in NZVD 2016.		It is confirmed that CDD datum is used for groundwater level layer. Note that groundwater level was used as initial condition for groundwater using groundwater depth and ground elevation from LiDAR 2020 in CDD datum.	Agree.	To convert model to NZVD2016.
Sense check					
Validation	RORB model was calibrated to March 2014 event - Assume review of the RORB model calibration is outside scope of T+T review				
2D MODEL					
Cell size	Overall cell size (1 to 2 m) suitable for purpose Consider using a smaller quadtree nest for the Sumner Stream. Because a finer resolution DEM is available for the stream (0.1m) there is opportunity to use a smaller cell size. The stream is currently being modelled at a 1 m cell size which results in a SGS target distance of 0.5 m (sample frequency input of 3). Sumner stream appears to be around 2-3 m wide. Suggest using a nest level of 3 for the stream giving a cell size of 0.5m and 4-5 cells across the stream width. SGS target distance would then be 0.25 m which makes better use of the 0.1 m resolution DEM.		We did the sensitivity test on usinng a nest level of 3 for the stream. The impact of increasing nest level over Sumner stream was carried out by comparing maximum flood depths (0.5m grid minus by 1m grid). Difference flood depth (refer to Figure 3) shows that reducing cell size over the Sumner Stream to 0.5m only have impacts on depth along Sumner Stream. This is considered insignificant. It is suggested to run the model with 1m resolution over Sumner Stream due to shorten model simulation times (12.4 hrs for 1m grid vs 25.1 hrs for 0.5m grid).	High resolution could be used for low flow modelling (to be included in the report).	Add suggestion on using high resolution in the final report.
Terrain	Assume review of the LiDAR DEM is outside scope of T+T review. Though it is noted that at the DEM levels along the coast have not been extended down to a level of 6 m RL (CDD) as per the Citywide Flood Modelling Model Schematisation document. "Sumner_LiDAR2020_CDD_GHD_202208121" layer name suggests this is in CDD datum. Please confirm that model is in CDD and not in NZVD 2016.		It is confirmed that LiDAR DEM is in CDD datum. It will be converted to NZVD 2016 after completion of peer review. LiDAR DEM at the coastal area was extended down to a level of 6mRL (CDD) as per the schema report rev 7. Model was re-run with the extended LiDAR DEM. Difference in depth (revised LiDAR DEM minus by original LiDAR DRM) was calculated to assess the impact of DEM extension in the coastal area. Difference depth map (Figure 4) shows that extension of LiDAR DEM down to 6m RL results in increasedflood depth in the coastal areas. Refer to Figure 4 for impact of LiDAR DEM coastal extension. Suggest to extend DEM down to 6m RL.	Agree to extend the model to 6mRL	Update the model.
Terrain modifications	Please explain in the report the function of the "2d_zsh_CHANNEL_CZ_R.shp" and "2d_zsh_SX_R.shp" layers - Assuming its for fixing elevations where 1D inlets/outlets are connected. State what assumptions have been used e.g. set terrain elevation at 50mm below 1D invert level.		These shape files are used to set elevations of inlet and outlet to the ground elevations from reclassified LiDAR. We will include in the assumption in the report.		We will include the assumptions in the final report.
Roughness	See comment regarding Wu eddy viscosity. Consider using depth varying roughness for buildings, with low roughness at shallow water depth to represent quick runoff from building roofs, and higher roughness at deeper depths to represent slow flood flow through the building. Roughness for "trees" (0.125) while in line with the schema appears high compared to roughness for "rough low vegetation" (also 0.125). At shallow water depths, the only resistance to flow from trees are the tree trunks. Suggest using a lower value for trees.		CCC suggests to do sensitivity tests on the roughness for buildings. The options include using high roughness (0.2) over building footprints and raising ground elevation by 150mm with lowered roughness to 0.02. Depth varying roughness could be included in the sensitivity test after CCC approval. Noted that more information is required to set up depth varying roughness relation. Agree on the lowered roughnesses for vegetation. Below are the suggested roughnesses which will also be applied to Sytx model. CCC is reviewing these suggested roughness values. - n = 0.035 for grass - n = 0.04 for rough low vegetation - n = 0.07 for tree - n = 0.03 for bare earth/sand/gravel/clay/rock Note that current roughness value for buildings is 0.2 based on the the Citywide Flood Modelling Model Schematisation document. CCC have indicated that they would like Awa to consider developing a TUFLOW schematisation for development of future TUFLOW model. This changed method will be captured in the schematisation report.	Use schema report value. For Styx, to discuss more in details (to be added in decision)	Update the model using roughness from the schema report.
Initial conditions	dry				
Wet/dry depth	0.002				
Boundary	tidal boundary				
STRUCTURES					
Hydraulic structures	Many minor structures along the stream have been excluded where the stream DEM continues. Think this approach is probably reasonable.		We already included private driveways/bridges along the Sumner Stream.		
Head losses	No issues identified				
1D/2D linking	No issues identified				
PIPE NETWORK					
Pipes	Pipe network modelling has a number of variations from the Citywide Flood Modelling Model Schematisation document, such as the inclusion of catchpits and pipes less than 300 mm diameter. Have these been done in agreement with CCC? Pipe data has come from a number of sources including CCC Spatial Open Data Portal, the existing Mike Urban model, and assumptions. Data sources for diameter and invert levels at each pipe would ideally be recorded within the model GIS. There are a number of empty pipes in the upstream areas of the catchment, where they fall outside of the rain on grid extent and away from the catchment inflows. Schematisation may need to be modified in some of these locations to capture more flow in the 1D network (see tab '1DNetworkIssues')		CCC agreed to include all storm networks available in CCC Spatial Open Data Portal. We work with CCC to fill data gaps in the storm networks and source of information will be included in the attribute of GIS files. For gaps in pipe networks, we are updating the pipe networks based on the updated information from CCC. Refer to '1DNetworkIssues' for initial Awa responses.	This will have impacts on hydrological modelling. Suggest to consider in the future improvement.	Awa to check pipe diameters of stormwater network outside model domain to consider if those networks will have impacts in the model domain or not. Refer to Figure 1 in the 'Figure_V2' spreadsheet for the diameters of stormwater networks outside the model domain (raning from 150-450mm). Awa to put inclusion of pipe network in the data decision spreadsheet.
Nodes	Report states the node types are being checked, is this still ongoing? Non-default Km losses have been applied to R type manholes. Why have these values been chosen?		Node types are beining checked and updated based on the updated information from CCC. DHI recommendation suggested Mouse Classic K value of 0.5 for Avon model and a more recent recommendation for Weighted Inlet Energy K of 0.25 for Heathcote model. The suggested K factors were applied to all nodes. However, the recent report by GHD, 'Investigation of Manhole Minor Loss K Factors on Riccarton Main Drain' on 18 July 2024, provided a chart with a range of K factors for different bend angles (0-45 deg). Further analysis on K factor will be carried out in future works. We will apply defaults Km losses factors for C and R type manholes.	Use the default values.	Update the model using default values.
1D/2D linking	Missing 1D/2D link identified at pipe 39167 (see tab '1DNetworkIssues') Where do pit inflow curves come from (Wollington Water) ? Pit flows are not consistent with the inlet max flows recommended in the Citywide Flood Modelling Model Schematisation document.		Node types are beining checked and updated based on the updated information from CCC. Pit capacities were adopted from Kapiti Coastal District Council (KCDC) TUFLOW flood model as initial model set up. Maximum inlet flows from the Citywide Flood Modelling Model Schematisation document will be used to define pit capacities with constant (max) flow rates. CCC have indicated that they would like Awa to consider developing a TUFLOW schematisation for development of future TUFLOW model. The changed method in pit capacity will be captured in the schematisation report.	Prefer to use values in the schema report. Awa did a sensitivity test on the pit capacities.	Awa to share the result of sensitivity test on sump capacity. Using inlet capacity from schema report has impacts in the downstream area near the coast. Refer to Figure 2 in the 'Figure_V2' spreadsheet for difference in flood depth (inlet capacity from schema report minus by inlet capacity from KCDC model). Awa will use inlet capacity from the schema report as suggested by CCC.
RESULTS					
Errors/warnings	Cannot review - please provide LOG files with next issue of model		To be provided after addressing gaps in 1D network and agreements on peer reviews.		To be provided.

Mass balance	Cannot review - please provide LOG files with next issue of model		To be provided after addressing gaps in 1D network and agreements on peer reviews.		To be provided.
Run duration	Appears reasonable				
Output grids and timeseries	Consider what resolution output grids are required (currently set at 2m) - suggest Awa confirms with CCC. Consider what timestep outputs are required - suggest Awa confirms with CCC.		Awa will discuss with CCC to decide on output cell size and frequency of output interval.		Awa to discuss with CCC on output cell size and frequency of output interval.
Max depths	Appear reasonable				
Max water level	Appear reasonable				
Max velocity	High velocities at tidal boundary, recommend checking cause of this		We checked possible causes of high velocities at the coastal area. Roughness value of 0.025 is set for coastal area. It is found that high velocities occur when tidal level is low (Figure 5). Slope of the bathymetry is around 2%. During low tide, high velocity in the coastal area could be expected due to low roughness and the geometry of the sea bed slope. This is likely to have insignificant impact to the onland floodings due to high elevation of road with sea wall along the road.		No further action.
VALIDATION					
Calibration	Model calibrated to March 2014 - please provide reporting on calibration results with next issue		Awa will discuss with CCC for their comments. Model validation will be included in the final report.		Awa will discuss with CCC on validation of baseline model.
Sensitivity testing	None provided at this time		Some results for sensitivity tests suggested by peer reviewers are included in the 'Figure' spreadsheet. DHI model has an instability issue when using the raised ground elevation to represent building footprints. CCC suggested to do a sensitivity test on modelling of buildings (high roughness n =0.2 for buildings vs raised elevation by 150mm with lower rougness n = 0.02) using TUFLOW model. Simulations for both approaches are similar without instabiliy issue. Figure 6 shows flood depth difference map for sensitivity test on building roughness. Other sensitivity tests (if required) will be discussed with CCC.		Awa will discuss with CCC on sensitivity tests (if required).

Figures for 1st peer review

Figure 1 Difference in water depth (iSP minus by iDP) under March 2014 event

Figure 2 Difference in water depth (Viscosity coefficient = 0.2 minus by default viscocity) under March 2014 event

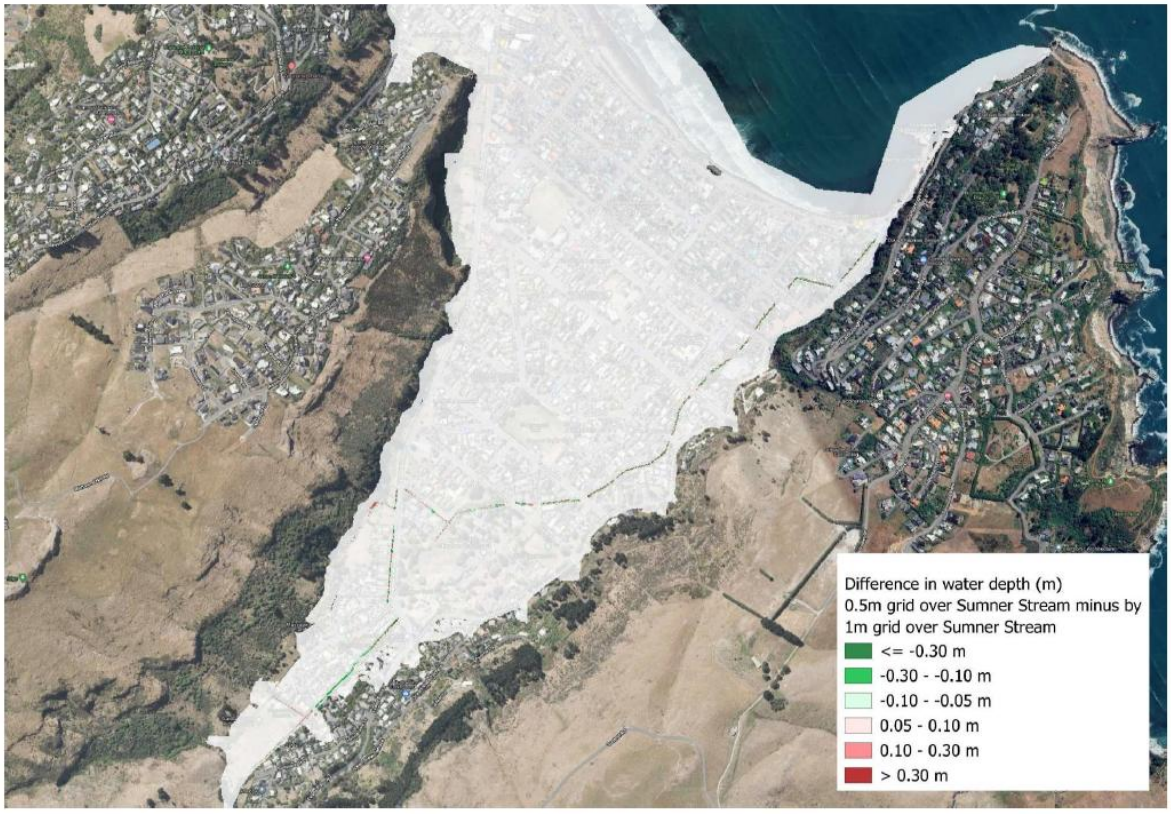


Figure 3 Difference in water depth (0.5m grid over Sumner Steam minus by 1m grid over Sumner Stream) under March 2014 event

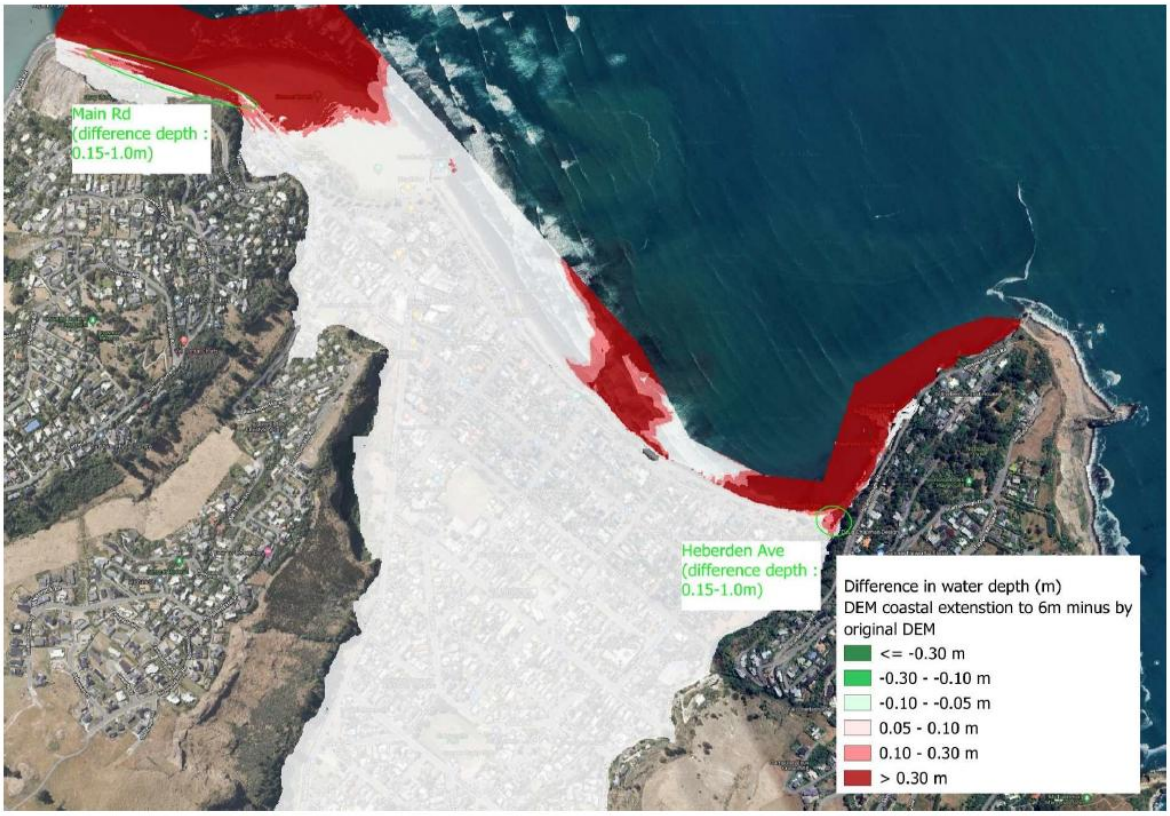


Figure 4 Difference in water depth (DEM coastal extension to 6mRL minus by original DEM) under March 2014 event

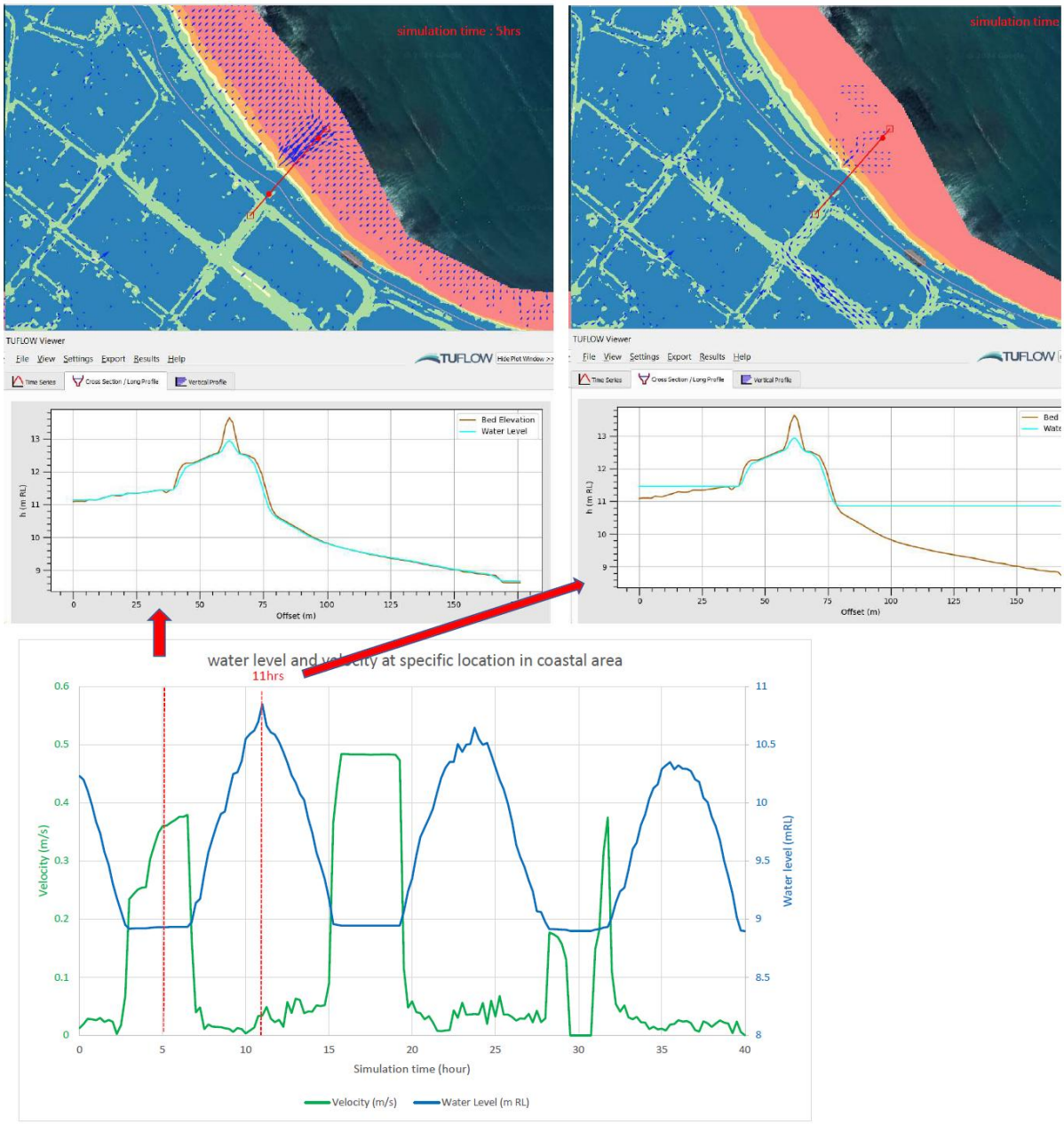


Figure 5 Investigation of high velocity in the coastal area

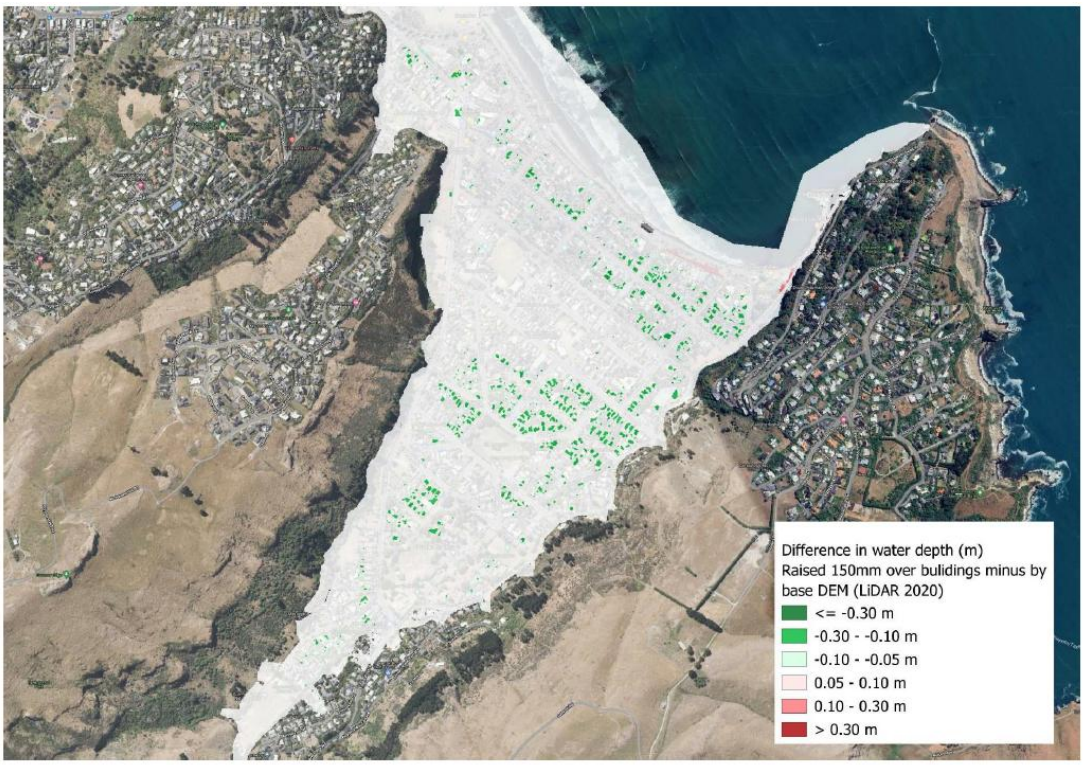


Figure 6 Difference in water depth (raised 150mm over buildings with n = 0.02 minus by original DEM with n = 0.2 over buildings) under March 2014 event

Figures for 2nd peer review

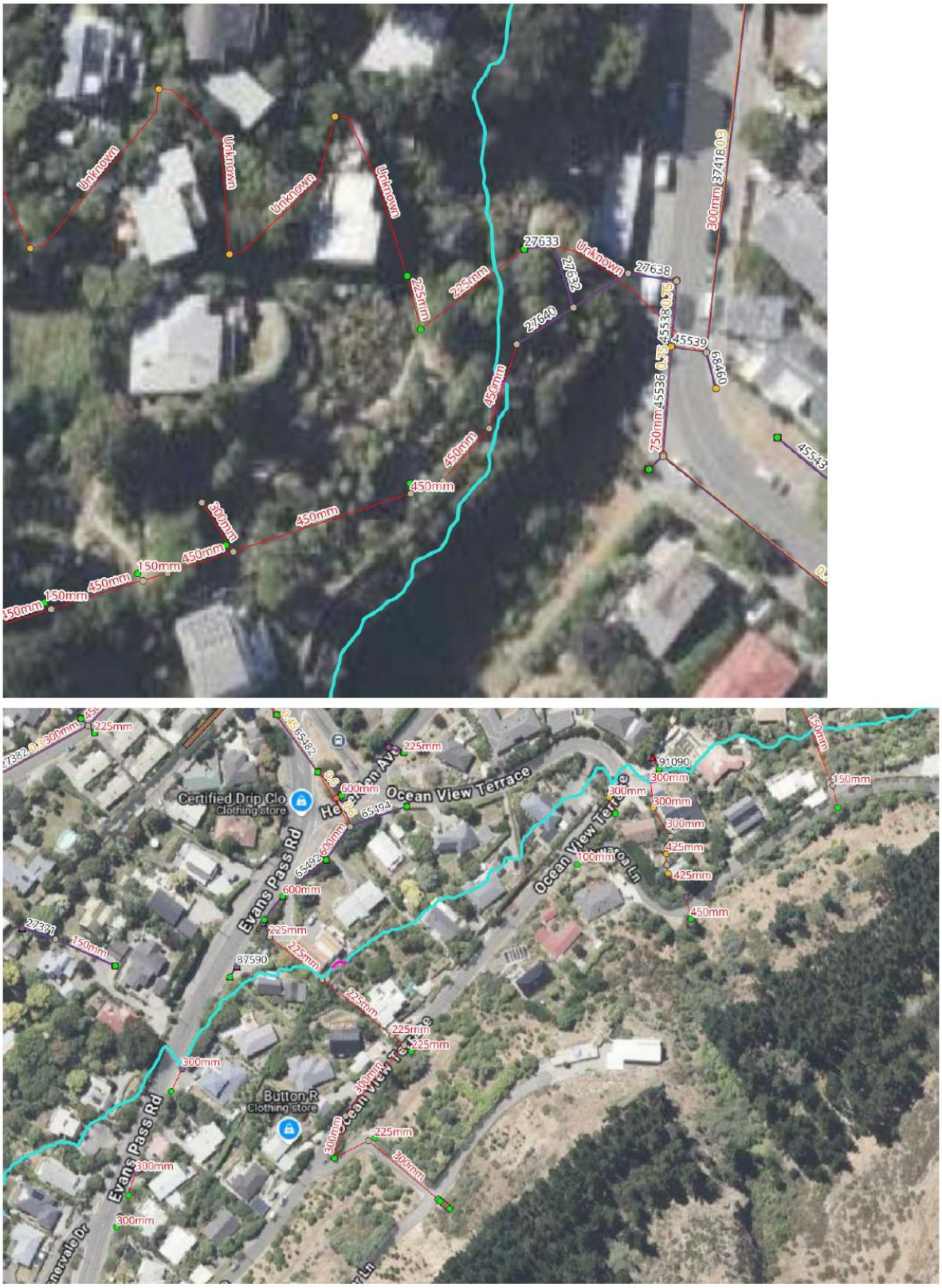


Figure 1 stormwater networks with diameters outside the model domain

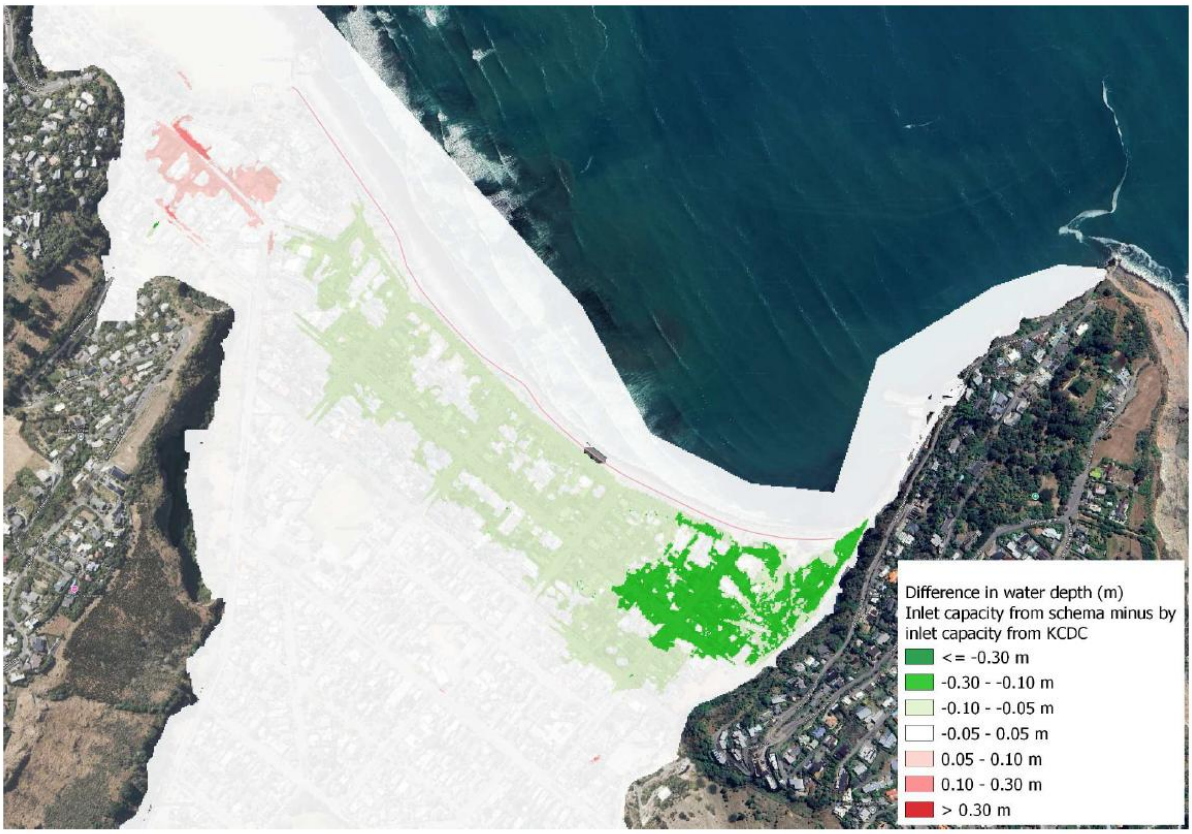


Figure 2 Difference in water depth (inlet capacity from schema report minus by inlet capacity from KCDC) under March 2014 event

APPENDIX E – DESIGN RUN LOG

The follow pages outline the 62 design simulations completed.

The file naming convention used is:

> *<MODEL VERSION>_<CATCHMENT>_<DEVELOPMENT YEAR>_<RAINFALL ARI>_<RAINFALL DURATION>_<TIDE ARI>_<SEAL LEVEL RISE SCENARIO>_<RAINFALL CLIMATE SCENARIO>_<DATA_TYPE>_WILDCARD if required*

For example:

> *V4_SUMN_ED2024_R0010ARI_24hr_T1p43ARI_SLR0p0_R2024_D_WILDCARD*
> *V4_SUMN_FD2124_R0200ARI_12hr_T28p57ARI_SLR1p0_R16pct_V_WILDCARD*

DESIGN RUNS, SCENARIO PARAMETERS AND RESULTS FOLDER NAMES

NO	TIME HORIZON	ARI RAIN EVENT (ARI)	STORM DURATION	ARI TIDE EVENT (ARI)	SEA LEVEL RISE (M)	RAINFALL CLIMATE SCENARIO	TUFLOW RESULT NAME
1	ED2024	1p43	024HR	10	0p0	R2024	V4_SUMN_ED2024_R1p43ARI_024HR_T0010ARI_SLR0p0_R2024
2	ED2024	10	30MIN	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_30MIN_T1p43ARI_SLR0p0_R2024
3	ED2024	10	002HR	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_002HR_T1p43ARI_SLR0p0_R2024
4	ED2024	10	006HR	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_006HR_T1p43ARI_SLR0p0_R2024
5	ED2024	10	012HR	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_012HR_T1p43ARI_SLR0p0_R2024
6	ED2024	10	024HR	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_024HR_T1p43ARI_SLR0p0_R2024
7	ED2024	10	036HR	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_036HR_T1p43ARI_SLR0p0_R2024
8	ED2024	10	048HR	1p43	0p0	R2024	V4_SUMN_ED2024_R0010ARI_048HR_T1p43ARI_SLR0p0_R2024
9	ED2024	7p14	024HR	50	0p0	R2024	V4_SUMN_ED2024_R7p14ARI_024HR_T0050ARI_SLR0p0_R2024
10	ED2024	50	30MIN	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_30MIN_T7p14ARI_SLR0p0_R2024
11	ED2024	50	002HR	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_002HR_T7p14ARI_SLR0p0_R2024
12	ED2024	50	006HR	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_006HR_T7p14ARI_SLR0p0_R2024
13	ED2024	50	012HR	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_012HR_T7p14ARI_SLR0p0_R2024
14	ED2024	50	024HR	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_024HR_T7p14ARI_SLR0p0_R2024
15	ED2024	50	036HR	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_036HR_T7p14ARI_SLR0p0_R2024
16	ED2024	50	048HR	7p14	0p0	R2024	V4_SUMN_ED2024_R0050ARI_048HR_T7p14ARI_SLR0p0_R2024
17	ED2024	20	024HR	200	0p0	R2024	V4_SUMN_ED2024_R0020ARI_024HR_T0200ARI_SLR0p0_R2024
18	ED2024	200	30MIN	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_30MIN_T28p57ARI_SLR0p0_R2024
19	ED2024	200	002HR	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_002HR_T28p57ARI_SLR0p0_R2024
20	ED2024	200	006HR	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_006HR_T28p57ARI_SLR0p0_R2024
21	ED2024	200	012HR	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_012HR_T28p57ARI_SLR0p0_R2024
22	ED2024	200	024HR	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_024HR_T28p57ARI_SLR0p0_R2024

NO	TIME HORIZON	ARI RAIN EVENT (ARI)	STORM DURATION	ARI TIDE EVENT (ARI)	SEA LEVEL RISE (M)	RAINFALL CLIMATE SCENARIO	TUFLOW RESULT NAME
23	ED2024	200	036HR	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_036HR_T28p57ARI_SLR0p0_R2024
24	ED2024	200	048HR	28p57	0p0	R2024	V4_SUMN_ED2024_R0200ARI_048HR_T28p57ARI_SLR0p0_R2024
25	ED2024	50	024HR	500	0p0	R2024	V4_SUMN_ED2024_R0050ARI_024HR_T0500ARI_SLR0p0_R2024
26	ED2024	500	30MIN	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_30MIN_T71p43ARI_SLR0p0_R2024
27	ED2024	500	002HR	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_002HR_T71p43ARI_SLR0p0_R2024
28	ED2024	500	006HR	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_006HR_T71p43ARI_SLR0p0_R2024
29	ED2024	500	012HR	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_012HR_T71p43ARI_SLR0p0_R2024
30	ED2024	500	024HR	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_024HR_T71p43ARI_SLR0p0_R2024
31	ED2024	500	036HR	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_036HR_T71p43ARI_SLR0p0_R2024
32	ED2024	500	048HR	71p43	0p0	R2024	V4_SUMN_ED2024_R0500ARI_048HR_T71p43ARI_SLR0p0_R2024
33	FD2074	7p14	024HR	50	0p45	R2074	V4_SUMN_FD2074_R7p14ARI_024HR_T0050ARI_SLR0p45_R2074
34	FD2074	50	30MIN	7p14	0p45	R2074	V4_SUMN_FD2074_R0050ARI_30MIN_T7p14ARI_SLR0p45_R2074
35	FD2074	50	002HR	7p14	0p45	R2074	V4_SUMN_FD2074_R0050ARI_002HR_T7p14ARI_SLR0p45_R2074
36	FD2074	50	006HR	7p14	0p45	R2074	V4_SUMN_FD2074_R0050ARI_006HR_T7p14ARI_SLR0p45_R2074
37	FD2074	50	012HR	7p14	0p45	R2074	V4_SUMN_FD2074_R0050ARI_012HR_T7p14ARI_SLR0p45_R2074
38	FD2074	50	024HR	7p14	0p45	R2074	V4_SUMN_FD2074_R0050ARI_024HR_T7p14ARI_SLR0p45_R2074
39	FD2074	50	048HR	7p14	0p45	R2074	V4_SUMN_FD2074_R0050ARI_048HR_T7p14ARI_SLR0p45_R2074
40	FD2074	50	024HR	500	0p45	R2074	V4_SUMN_FD2074_R0050ARI_024HR_T0500ARI_SLR0p45_R2074
41	FD2074	500	048HR	71p43	0p45	R2074	V4_SUMN_FD2074_R0500ARI_048HR_T71p43ARI_SLR0p45_R2074
42	FD2124	20	024HR	200	1p0	R16pct	V4_SUMN_FD2124_R0020ARI_024HR_T0200ARI_SLR1p0_R16pct
43	FD2124	200	30MIN	28p57	1p0	R16pct	V4_SUMN_FD2124_R0200ARI_30MIN_T28p57ARI_SLR1p0_R16pct
44	FD2124	200	002HR	28p57	1p0	R16pct	V4_SUMN_FD2124_R0200ARI_002HR_T28p57ARI_SLR1p0_R16pct
45	FD2124	200	006HR	28p57	1p0	R16pct	V4_SUMN_FD2124_R0200ARI_006HR_T28p57ARI_SLR1p0_R16pct
46	FD2124	200	012HR	28p57	1p0	R16pct	V4_SUMN_FD2124_R0200ARI_012HR_T28p57ARI_SLR1p0_R16pct
47	FD2124	200	024HR	28p57	1p0	R16pct	V4_SUMN_FD2124_R0200ARI_024HR_T28p57ARI_SLR1p0_R16pct

NO	TIME HORIZON	ARI RAIN EVENT (ARI)	STORM DURATION	ARI TIDE EVENT (ARI)	SEA LEVEL RISE (M)	RAINFALL CLIMATE SCENARIO	TUFLOW RESULT NAME
48	FD2124	200	048HR	28p57	1p0	R16pct	V4_SUMN_FD2124_R0200ARI_048HR_T28p57ARI_SLR1p0_R16pct
49	FD2124	50	024HR	500	1p0	R2124	V4_SUMN_FD2124_R0050ARI_024HR_T0500ARI_SLR1p0_R2124
50	FD2124	500	30MIN	71p43	1p0	R2124	V4_SUMN_FD2124_R0500ARI_30MIN_T71p43ARI_SLR1p0_R2124
51	FD2124	500	002HR	71p43	1p0	R2124	V4_SUMN_FD2124_R0500ARI_002HR_T71p43ARI_SLR1p0_R2124
52	FD2124	500	006HR	71p43	1p0	R2124	V4_SUMN_FD2124_R0500ARI_006HR_T71p43ARI_SLR1p0_R2124
53	FD2124	500	012HR	71p43	1p0	R2124	V4_SUMN_FD2124_R0500ARI_012HR_T71p43ARI_SLR1p0_R2124
54	FD2124	500	024HR	71p43	1p0	R2124	V4_SUMN_FD2124_R0500ARI_024HR_T71p43ARI_SLR1p0_R2124
55	FD2124	500	048HR	71p43	1p0	R2124	V4_SUMN_FD2124_R0500ARI_048HR_T71p43ARI_SLR1p0_R2124
56	FD2124	20	024HR	200	1p2	R2124	V4_SUMN_FD2124_R0020ARI_024HR_T0200ARI_SLR1p2_R2124
57	FD2124	200	30MIN	28p57	1p2	R2124	V4_SUMN_FD2124_R0200ARI_30MIN_T28p57ARI_SLR1p2_R2124
58	FD2124	200	002HR	28p57	1p2	R2124	V4_SUMN_FD2124_R0200ARI_002HR_T28p57ARI_SLR1p2_R2124
59	FD2124	200	006HR	28p57	1p2	R2124	V4_SUMN_FD2124_R0200ARI_006HR_T28p57ARI_SLR1p2_R2124
60	FD2124	200	012HR	28p57	1p2	R2124	V4_SUMN_FD2124_R0200ARI_012HR_T28p57ARI_SLR1p2_R2124
61	FD2124	200	024HR	28p57	1p2	R2124	V4_SUMN_FD2124_R0200ARI_024HR_T28p57ARI_SLR1p2_R2124
62	FD2124	200	048HR	28p57	1p2	R2124	V4_SUMN_FD2124_R0200ARI_048HR_T28p57ARI_SLR1p2_R2124

DESIGN RUNS AND TUFLOW CONTROL FILE NAMES

RUN	RUN COMMAND FOR TCF (REFER TO NOTE SPREADSHEET FOR EVENT AND SCENARIO DESCRIPTION)
1	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 1p43ARI -s3 024HR -e1 0010ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
2	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0010ARI -s3 30MIN -e1 1p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
3	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0010ARI -s3 002HR -e1 1p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
4	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0010ARI -s3 006HR -e1 1p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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7	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0010ARI -s3 036HR -e1 1p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
8	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0010ARI -s3 048HR -e1 1p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
9	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 7p14ARI -s3 024HR -e1 0050ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
10	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0050ARI -s3 30MIN -e1 7p14ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
11	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0050ARI -s3 002HR -e1 7p14ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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19	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0200ARI -s3 002HR -e1 28p57ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
20	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0200ARI -s3 006HR -e1 28p57ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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RUN	RUN COMMAND FOR TCF (REFER TO NOTE SPREADSHEET FOR EVENT AND SCENARIO DESCRIPTION)
23	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0200ARI -s3 036HR -e1 28p57ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
24	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0200ARI -s3 048HR -e1 28p57ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
25	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0050ARI -s3 024HR -e1 0500ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
26	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0500ARI -s3 30MIN -e1 71p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
27	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0500ARI -s3 002HR -e1 71p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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31	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0500ARI -s3 036HR -e1 71p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
32	TUFLOW_iDP_w64.exe -b -s1 ED2024 -s2 0500ARI -s3 048HR -e1 71p43ARI -e2 0p0 -s4 R2024 V4_SUMN_ED~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
33	TUFLOW_iDP_w64.exe -b -s1 FD2074 -s2 7p14ARI -s3 024HR -e1 0050ARI -e2 0p45 -s4 R2074 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
34	TUFLOW_iDP_w64.exe -b -s1 FD2074 -s2 0050ARI -s3 30MIN -e1 7p14ARI -e2 0p45 -s4 R2074 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
35	TUFLOW_iDP_w64.exe -b -s1 FD2074 -s2 0050ARI -s3 002HR -e1 7p14ARI -e2 0p45 -s4 R2074 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
36	TUFLOW_iDP_w64.exe -b -s1 FD2074 -s2 0050ARI -s3 006HR -e1 7p14ARI -e2 0p45 -s4 R2074 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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42	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0020ARI -s3 024HR -e1 0200ARI -e2 1p0 -s4 R16pct V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
43	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0200ARI -s3 30MIN -e1 28p57ARI -e2 1p0 -s4 R16pct V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
44	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0200ARI -s3 002HR -e1 28p57ARI -e2 1p0 -s4 R16pct V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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48	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0200ARI -s3 048HR -e1 28p57ARI -e2 1p0 -s4 R16pct V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf

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50	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0500ARI -s3 30MIN -e1 71p43ARI -e2 1p0 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
51	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0500ARI -s3 002HR -e1 71p43ARI -e2 1p0 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
52	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0500ARI -s3 006HR -e1 71p43ARI -e2 1p0 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
53	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0500ARI -s3 012HR -e1 71p43ARI -e2 1p0 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
54	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0500ARI -s3 024HR -e1 71p43ARI -e2 1p0 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
55	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0500ARI -s3 048HR -e1 71p43ARI -e2 1p0 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
56	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0020ARI -s3 024HR -e1 0200ARI -e2 1p2 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
57	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0200ARI -s3 30MIN -e1 28p57ARI -e2 1p2 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf
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59	TUFLOW_iDP_w64.exe -b -s1 FD2124 -s2 0200ARI -s3 006HR -e1 28p57ARI -e2 1p2 -s4 R2124 V4_SUMN_FD~s1~_R~s2~_~s3~_T~e1~_SLR~e2~_~s4~.tcf

APPENDIX F – CHANGE IN DEM ELEVATIONS

Chusit Apirumanekul

From: Tim Preston <Tim.Preston@ghd.com>
Sent: Monday, 17 March 2025 11:24 pm
To: Christensen, Peter
Subject: RE: Sumner - datum

Ok;

- My 'summary of CCC work' memo Oct-23, timeline, shows that Victor updated the mesh levels to match LiDAR-2018, so if AWA are using the CCC version then differences should reflect 2020 minus 2018 which I would expect to be <50mm 99% of the time
    - Pdf pg 6/97 also notes Victor moving from negative bathymetry, (which GHD used to allow the exact specification of individual cell levels) to positive bathymetry, which suggests a fundament new approach by Victor
    - My email attached to above (pdf pg 31), suggests that Victors z values were likely taken from a 'Z4' Citywide raster generated by GHD using the 2018 LiDAR
    - Pdf pg 49/97 records the specifics of Victors 'flip' to positive bathymetry
    - Pdf pg 77/97 records Victor initial work on LiDAR_2018
    - Pdf pgs 79+80/97 record probably the last of Victors work on the z-levels, lists the filename, basically GHD's Z4 with a couple of minor areas of change/update
- Inspection of various DFSU files, (N:\NZ\Christchurch\Projects\51\12523229\01.Document Transfer\Incoming\20230808 Sumner handover Victor Tim\Citywide Sumner Model\Model\SUMN_ED2020_ARIDesignRuns\01Data\M21\A_Mesh) dated in Victors era, show all of them had positive bathymetry
- The associated setup M21FM file (..20230808 Sumner handover Victor Tim\Citywide Sumner Model\Model\SUMN_ED2020_ARIDesignRuns\02Setup\50ARI\V12_50ARI_03hr\M21) uses specified bed level change - [DEPTH], type = 1, whereas GHD used the undocumented but Antoinette recommended [DEPTH], type = 2 (type 1 is presumably at least mainly ok with positive level DFSU data
- The GHD model log indicates that we largely preserved the AECOM mesh levels – as per their delivery thereof in 2018. We have little build documentation from AECOM, but based on history this mesh should have been based on the post EQ LiDAR – ie: 2011/12 era. I am 85-90% confident (from memory) that the 2015 LiDAR was not updated into the Sumner model during the AECOM era
- Therefore depending which starting file AWA have used for the mesh, it should be either based on ex GHD/AECOM 2011/12 LiDAR or ex Victor 2018 LiDAR
- GHD also have a 2018 minus 2012 change raster. Some rough spot checks around Sumner indicate significant changes like -100 to -200mm. So the 2018 LiDAR indicates the land has dropped since 2012.
    - N:\NZ\Christchurch\Projects\51\12523229\04.GIS\Data\CHCH_LiDAR_Comparison.gdb\CHCHDEM2018 minusZ1_Difference
- On further study the AWA email seems to confirm that they used the ex GHD DFSU, so that should be the 2011/12 LiDAR which we noted as being higher than 2018, (but we have no change comparison wrt 2020 LiDAR).
- I am 80% sure during our Sumner efforts, that we 'validated' the AECOM mesh against the 2011/12 LiDAR dataset and were able to match 99% of the values to <1mm, and the 1% of differences we were able to identify the AECOM 'manual work' about half of which we since 'undid'.

Conclusion;
AWA seem to find that their DHI mesh is (ex GHD/AECOM 2011/12 LiDAR) 'lowered than' 2020 LiDAR however GHD have found that their DHI mesh is higher than the 2018 LiDAR (I presume as a result of further land settlement during the Chch aftershocks and/or the Kaikoura 2016 EQ)
I would seek clarification from AWA as to the direction of their minus as their email grammar and screen shot leave room for doubt

- if they actually did 2020 LiDAR, minus DHI model, and then found mainly negatives, then we are all in agreement (ie: the DHImodel2012 is higher than 2020LiDAR - agreed)
- however, if they actually did DHI model minus 2020 LiDAR, then a mystery remains (ie: AWA say DHImodel2012 is lower than 2020LiDAR, and we don't agree)

1

In the event of disagreement, I would suggest referring AWA back to the raw LIDAR data sources (2012 vs 2020), and doing differencing between the LiDAR data sets to see if they confirm their observed change pattern at that source
They will likely want our 2011/12 LiDAR data file for that purpose if they go that way

Regards

Tim Preston
BE Civil, MComm
Senior Water Engineer

My typical working hours are
Mon-Fri 8:30am-6:00 pm
I am typically on secondment in CCC offices Wed & Thurs
For communication about CCC secondment work and calendar appointments @CCC during these hours, please use tim.preston@ccc.govt.nz
I generally monitor both GHD and CCC email addresses and Teams communications throughout the day

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From: Christensen, Peter <Peter.Christensen@ccc.govt.nz>
Sent: Monday, 17 March 2025 6:12 pm
To: Tim Preston <Tim.Preston@ghd.com>
Subject: Re: Sumner - datum

Yes, please spend some time looking into it

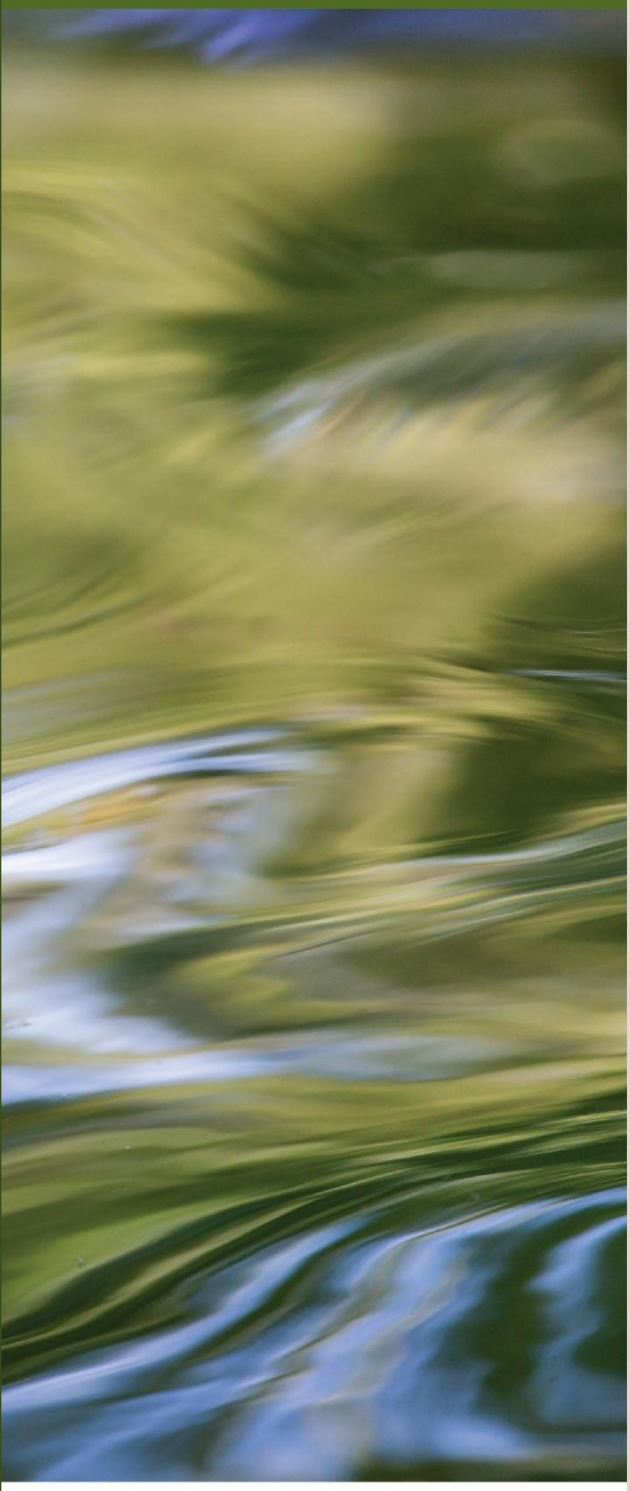
Get Outlook for Android

From: Tim Preston <Tim.Preston@ghd.com>
Sent: Monday, March 17, 2025 4:41:29 PM
To: Christensen, Peter <Peter.Christensen@ccc.govt.nz>
Subject: RE: Sumner - datum

Nothing 'off the cuff' Peter
The DHI negatives for depth correction are fairly well known, but don't seem to be the concern either
The model build log should clearly state the source of the mesh levels in terms of LiDAR version(s)
If the mesh was GHD version it would have been something prior to 2020 LiDAR as we stopped working on it before that LiDAR was produced I'm pretty sure
I don't recall but its possible that Victor's work might have moved the levels forward to 2020 LiDAR (without QA)
I also have some loose recall that Victor might have changed (or tried to change) the DHI setup so as to put mesh levels in as positives (different to our methodology)

I could spend 15-20 minutes digging into the records and narrow down the options if you'd like

Regards



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Prepared by Awa Environmental Limited

For Christchurch City Council