REPORT

Brightwater and Wakefield flood model - December 2024 updates

Mount Heslington catchment

Prepared for
Tasman District Council

Prepared by
Tonkin & Taylor Ltd

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Document control

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1 Introduction

1.1 Purpose and scope of work

Tonkin & Taylor Ltd (T+T) was engaged by Tasman District Council (TDC) to make refinements to the Brightwater and Wakefield hydraulic flood model as outlined in the "Variation Order 3 Rintoul Place Brightwater – flood model refinements" dated 27 September 2024.

The purpose of these refinements was to incorporate new local survey and services data and adjust Mt Heslington catchment parameters to achieve better alignment between the modelled August 2022 event and TDC staff's understanding and observations of flooding in this area. The focus of the alignment was on Rintoul Place and Fairfield Street, Brightwater.

We note up front that as per previous work, the focus of this model remains on the stormwater catchments and flooding around Brightwater and Wakefield townships. The main river systems are included as tailwater boundaries rather than the primary purpose of the model. The model could readily be adapted in future if accurate river flood hazard maps were required.

This report documents changes made as part of updating from model version 007 to version 009.

1.2 Previous work

The TUFLOW stormwater flood model for Brightwater & Wakefield (v007) was originally developed in 2020 and updated in March 2024. Table 1.1 summarises existing reports that the current work builds on.

Table 1.1: Previous reports

Report name	T+T ref.	Date	Model version	Description
Brightwater and Wakefield TUFLOW model build, v1	1004543.3000	March 2020	003	Original TUFLOW model build report
Updates to Brightwater and Wakefield stormwater flood model, v1	1004543.3001	March 2024	007	Model updates including updated LiDAR and landcover datasets, upgrade to pipe network representation, additional bridges, recalibration of Mt Heslington catchment
Brightwater and Wakefield flood mitigation options screening, v1	1004543.3001	March 2024	007	Original screening of mitigation options

1.3 August 2022 event

The rain event in August 2022 caused flooding of the road in Rintoul Place, but private properties remained largely free from flooding as shown in oblique aerial Photograph 1.1 below. The return period for the August 2022 is estimated by TDC staff to be greater than a 10% annual exceedance probability (AEP) event (potentially 2% AEP).

Photograph 1.1: Flooding in Rintoul Place during the August 2022 event (source: TDC)

There was no attempt to model the August 2022 rainfall event as part of this model update, using rain radar or rainfall gauge data. Instead, the design (HIRDS v4) design rainfall for the present day 10% AEP and 1% AEP events were modelled to generate flood extents for a lesser and larger event. These were then compared with the August 2022 flood observations, to check that the August 2022 flood observations fell somewhere between the modelled 10% AEP and 1% AEP events.

1.4 Key issue

The August 2022 event is thought to have had an AEP greater than 10% in Brightwater, and flooding was observed to have been largely contained to the road reserve within Rintoul Place. However, the existing model (v007) indicates flooding of several residential properties in Rintoul Place during a present day 10% AEP event. Thus, it appears that the model over-predicts flood extents and depths in this area.

2 Model refinements

Based on initial review of the above issue, it was determined that improvements may be required to the DEM (informed by improved survey in places) and to surface roughness and infiltration rates applied to the Mount Heslington catchment.

The previous model (version 007) was updated as described in the following sections. At the completion of these updates, the updated model is version 009.

2.1 Survey

A site visit was conducted by Bryan Scoles (TDC hazard scientist) to ground truth the local topography, drainage paths, and culverts immediate upstream of Rintoul Place and around the railway embankment (stopbank) adjacent to Mt Heslington Stream (12 Fairfield Street, Brightwater). This topographical data was used to refine the ground surface (DEM) used in the flood model.

2.1.1 Additional pipe network

Two additional 350 mm diameter culverts crossing State Highway 6 upstream of Rintoul Place were located and inverts surveyed during the site visit by Bryan Scoles. These culverts are currently missing from TDC’s asset register and consequently were not included in the previous flood model. The location of these additional culverts are shown in Figure 2.1 below.

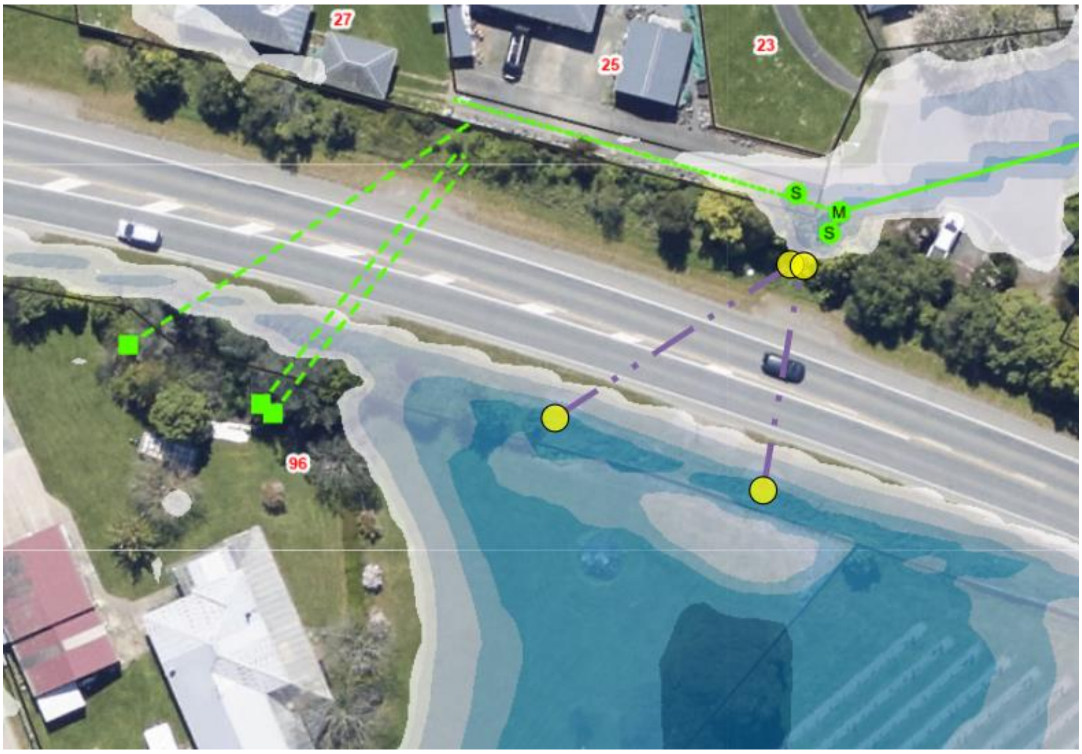

Figure 2.1: Location of newly added culverts shown in purple line (supplied by TDC, 4 September 2024). Rintoul Place properties shown to the north

The addition of these pipes to the model resulted in minimal changes to flood depths in the modelled 10% AEP present day event as the pipes only conveyed approximately 0.4 m^3/s (total between both pipes). It should be noted that the culvert outlets are immediately upstream of a wooden fence, which is not included in the flood model. In the 2022 event water was likely temporarily detained behind this fence until breaking through as shown in Photograph 2.2 below.

Photograph 2.2: Rintoul Place downstream of 350 mm culvert outlets - August 2022 (source: TDC)

2.1.2 Topography changes

Spot heights alongside the road were captured and provided by TDC, as well as inverts of the roadside drainage channel. These were included in the model, though generally these spot heights matched closely with what was included in previous modelling (based on LiDAR).

2.1.3 Stopbank at 12 Fairfield St

The previous model showed an outbreak of Mt Heslington Stream on the true left bank at 12 Fairfield Street. TDC advised of a known low point along the stopbank crest that may not be included in the model DEM. Aerial photographs show large trees at this location, and there was therefore concern that the LiDAR data may not be sufficiently accurate along the stopbank crest.

Surveyed spot heights along the crest of the stopbank were therefore obtained by TDC (survey by Bryan Scoles) and incorporated into the model. Crest elevations have been raised by up to 1.5 meters at a low point along the left bank, shown in Figure 2.2 below.

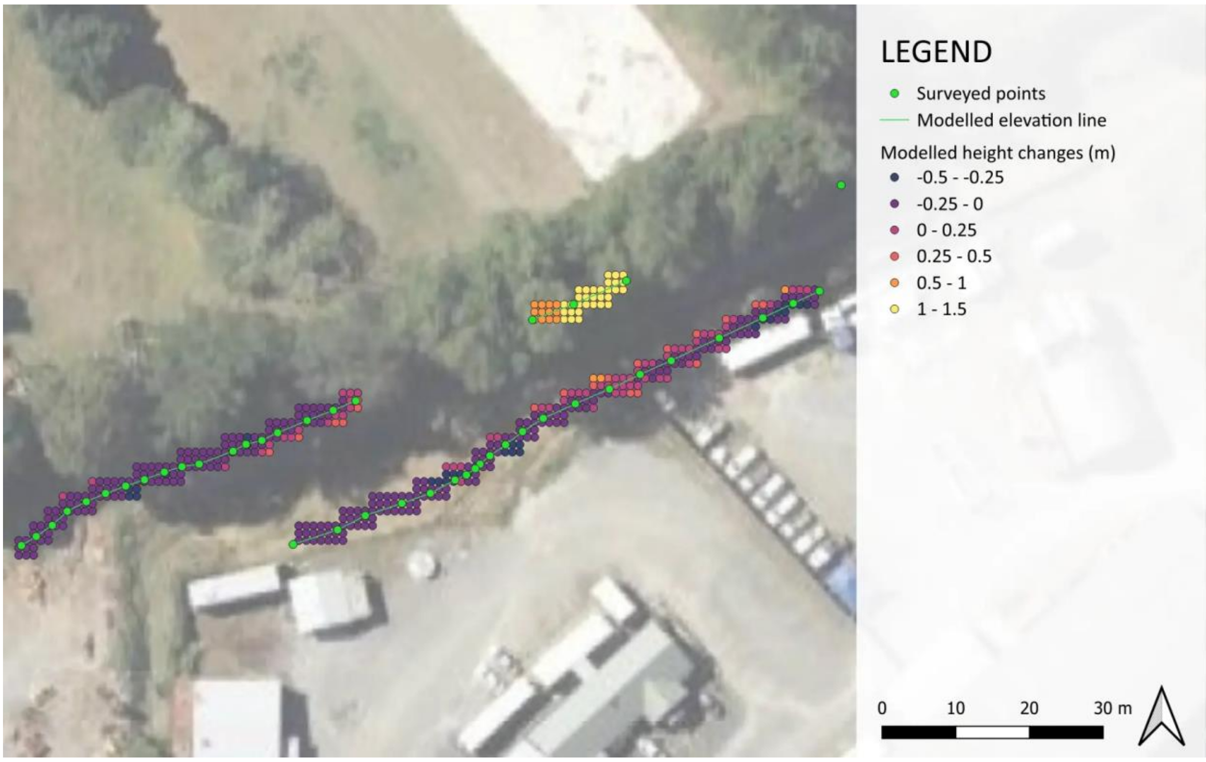

Figure 2.2: Elevation changes in the model from TDC survey of Mt Heslington Stream

2.2 Surface roughness values

Land cover information was sourced as per previous modelling from the New Zealand Land Cover Database v5 (LCDB5). Land cover mapping is shown below in Figure 2.3.

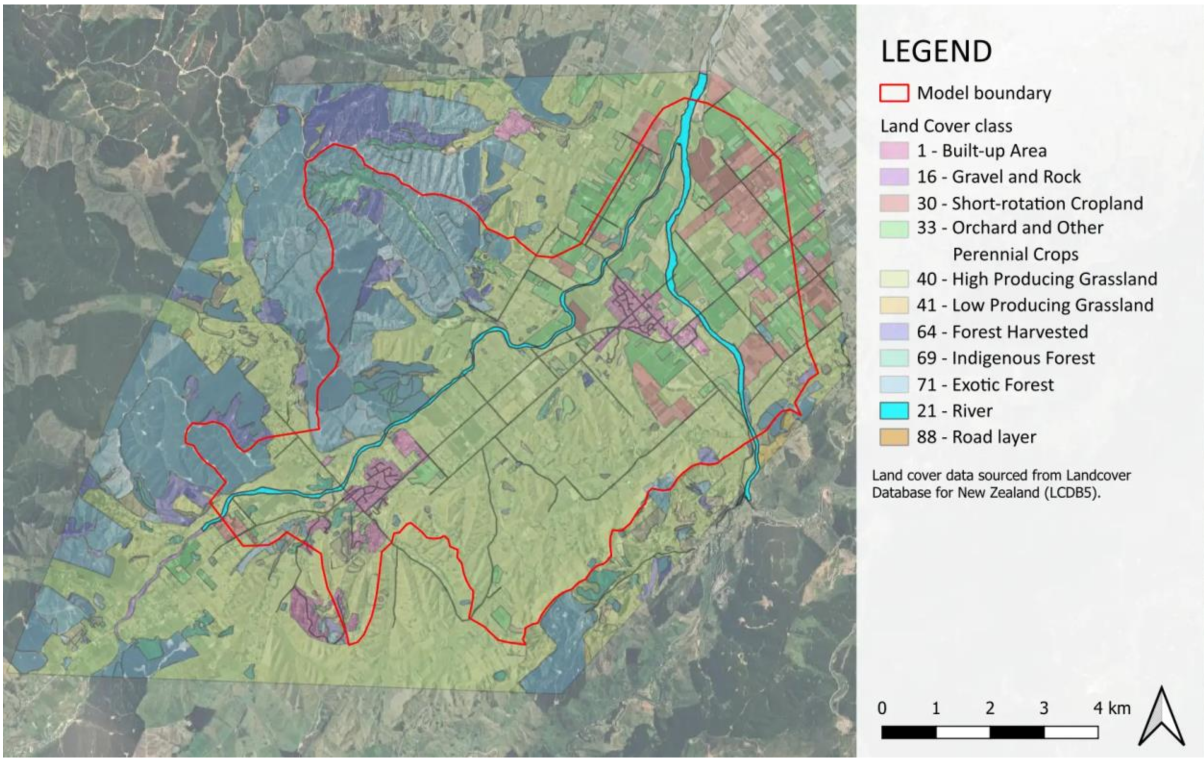

Figure 2.3: Modelled landcover as per LCDB5

A significant portion of the land cover in the lower Mt Heslington catchment (immediately upstream of Brightwater) is classed as "short-rotation cropland' and "Orchard and perennial crops" in the Landcover Database for New Zealand (LCDB5). Manning's n roughness values of 0.1 and 0.05 respectively were originally applied to these two cover types (model version 003). As part of model version 007 updates in March 2024, these values were reduced as part of increasing modelled flow rates arriving at Brightwater School to values that better aligned with TDC staff's understanding of flooding in that area.

For these updated runs in version 009, Manning's n roughness values were applied as shown in Table 2.1 below. These values are in line with what T+T typically applies to these land cover classes in models used in other parts of New Zealand. Using these more typical values for surface roughness and adjusting soil infiltration rates (as described in the following section) was considered a more straightforward and defendable approach to matching modelling results with flood observations.

Manning's n values for all other cover types remain unchanged.

Table 2.1: Modified Manning's n values

LCDB5 Class code	Land cover name	Modelled Manning's n value	
		Model version 007	Model version 009
30	Short-rotation Cropland	0.10	0.04
33	Orchards, Vineyards or Other Perennial Crops	0.05	0.08
40	High Producing Exotic Grassland	0.05	0.03
41	Low Producing Grassland	0.09	0.035
64	Forest - Harvested	0.16	0.10

LCDB5 Class code	Land cover name	Modelled Manning's n value	
		Model version 007	Model version 009
69	Indigenous Forest	0.15	0.12
71	Exotic Forest	0.15	0.10

2.3 Infiltration rates

The Land Resource Inventory (LRI) dataset classes soils in the Brightwater and Wakefield catchments as being predominantly "well drained".

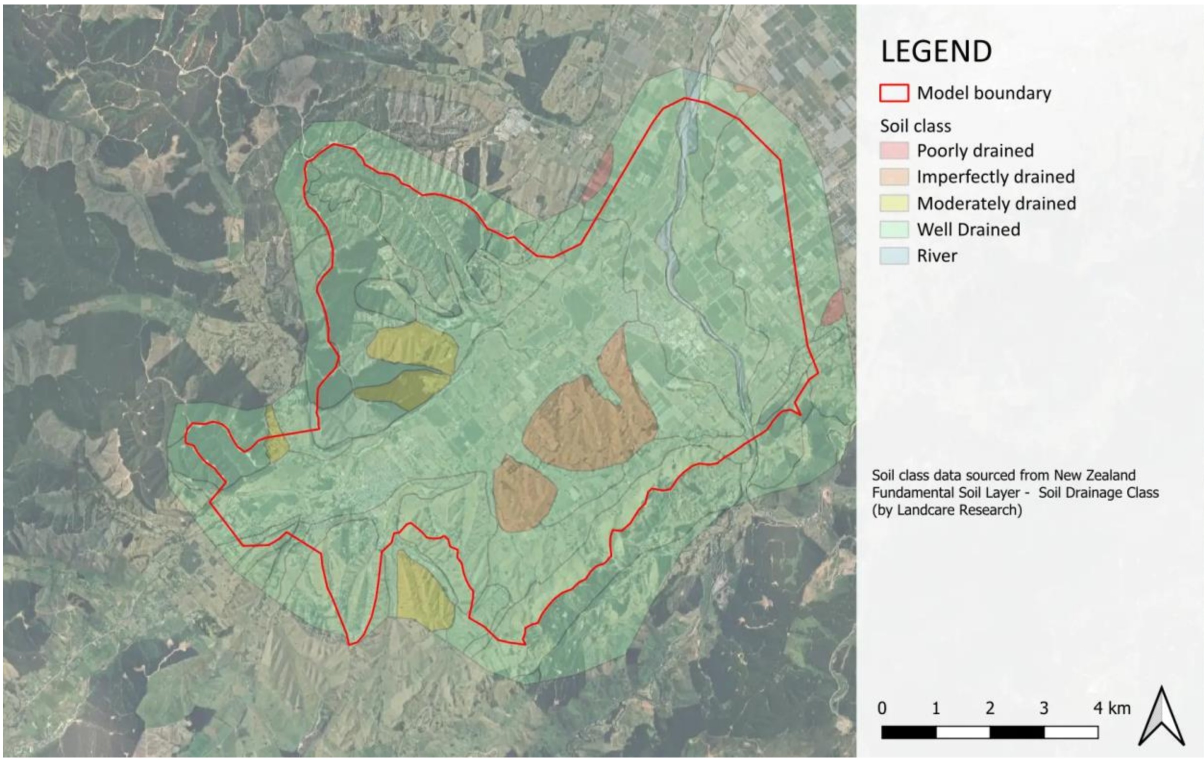

Figure 2.4: Soil drainage classes across the model domain (source: LRI)

In order to increase modelled flows closer to expected values as part of the update to model version 007, the change in surface roughness outlined above was paired with a reduction in the soil infiltration rate to 0.5 mm/hr for the majority of the catchment. While this infiltration rate was lower than would be typical for well drained soils, the use of this value resulted in modelled flows into Brightwater that were closer to flow rates estimated using other methods (e.g. Henderson-Collins 2018 regional flood estimation).

As part of this version 009 model update, the soil infiltration rate was recalibrated using observations (surveyed flood levels and photographs provided by TDC) from the August 2022 event. Infiltration rates ranging from 0.5 to 18 mm/hr were tested in the model until the modelled 10% AEP event displayed no overtopping of State Highway 6 upstream of Rintoul Place while also matching photographs of flooding within Brightwater School (as per the observations presented in Section 1.4).

We note that the model does not explicitly account for groundwater levels and flows. It is considered likely that at times the depth to groundwater is relatively shallow in this catchment, and significantly restricts infiltration rates during extreme events. There remains an opportunity to obtain groundwater information to allow for further refinement of the model to match observed flooding events

The model uses an Initial Loss/Continuing Loss (ILCL) method which infiltrates water based on an initial infiltration rate then decays to a constant rate over time. The model loss rates used for version 009 are shown in Table 2.2, based on soil classes shown in Figure 2.4 above.

Table 2.2: Modelled soil infiltration parameters

Soil Class	Initial loss (mm/hr)	Continuing loss (mm/hr)
Well drained	0	15
Moderately drained	0	7.5
Imperfectly drained	0	3.25
Poorly drained	0	1.625

The use of these infiltration rates has resulted in a decrease in modelled flood extent and modelled flows in the lower Mt Heslington catchment compared to the previous modelling results (007). The updated modelling results were shared with TDC staff, who confirmed acceptance of the infiltration rates and resulting flood maps.

3 Updated model (version 009)

3.1 Model parameters

Table 3.1 below summarises key model parameters following the refinements detailed in the previous section to the Brightwater and Wakefield updated baseline flood model (v009).

Table 3.1: Model parameters

Model Parameter	Value/approach used in model version 009
Model version	TUFLOW 2023-03-AC
Model cell size	2 m cell in the urban drainage area varying to 16 m in the upper catchments. Model makes use of TUFLOW's quadtree and sub-grid sampling features.
Extent	Wakefield and Brightwater urban areas and surrounding floodplain. Refer to Brightwater Wakefield modelling report 9 March 2024 for more information.
Timestep	The TUFLOW GPU model utilises an adaptive timestep based on a maximum Courant number of 1.
Viscosity	Default Wu viscosity coefficients for C3D and C2D (7.0, and 0.0 respectively).
Ground surface/topography	A digital elevation model (DEM) based on LIDAR survey flown in 2022 and modified by new survey data in places.
Hydrology	NIWA's High Intensity Rainfall Design System (HIRDS V4) storm rainfall and hyetographs to generate 10 and 100 year ARI inflow time series and rainfall hyetographs for input to the hydraulic model. A HEC-HMS model was used to generate inflow time series to the modelling area.
Boundaries	Flows from five upstream catchments; Waititi, pigeon Valley, Eighty Eight Valley, Gibbs and Wairoa have been entered into the model through lumped catchment hydrology and introduced to the model as point sources at the model boundary.

Model Parameter	Value/approach used in model version 009
	The downstream boundary for the model is on the Waimea River below the confluence of the Wai-iti and Wairoa Rivers. At this boundary, a Q-H relationship is automatically applied by TUFLOW based on a Manning's formulation of the cross-section and assumed channel slope of 0.01 m/m. Refer to Brightwater Wakefield modelling report 9 March 2024 for more information.
Land use roughness	Surface roughness values adopted in the model were based on land use as categorised in Landcare Research's Land Cover Database version 5.0 (LCDB5), released in Jan 2020.
Soil infiltration	Soil infiltration values were used as shown in Table 2.2, selected from infiltration testing.
Hydraulic structures	Primary (piped) flow in the catchment was represented in the model by modifying the DEM to replace stormwater pipes with open channels with equivalent hydraulic performance (termed "simulated pipes"). Only pipes larger than 225 mm in diameter were represented. Additionally, where water was artificially ponding behind road embankments and satellite imagery or local knowledge indicated that culvert or road bridge existed a circular pipe with 900 mm diameter was modelled at seven locations including: - SH6 between Telenius Road and Roughton Lane - Telenius Road - Higgins Road near Barton Lane - Higgins Road near Mount Heslington Road - Barton Lane near Higgins Road - Bridge Valley Road - Pigeon Valley Road Refer to Brightwater Wakefield modelling report 9 March 2020 for more information.

3.2 Model run matrix

The updated (v009) baseline model was run for the 10% and 1% AEP events, each for 6hr and 48hr durations, and each for both present day and 2090 RCP8.5 time horizons. The results have been provided in WaterRIDE format to TDC (13 November 2024). These results supersede results previously provided by T+T. A model run matrix is included in Table 3.2 below.

Table 3.2: Model run matrix

Annual exceedance probability (AEP)	Climate scenario	Rainfall duration	waterRIDE result filename
10%	Present day	6 hour	BrightwaterWakefield_Q10_6h_009_QPC
		48 hour	BrightwaterWakefield_Q10_48h_009_QPC
	2090 RCP8.5	6 hour	BrightwaterWakefield_2090_RCP8.5-Q10_6h_009_QPC
		48 hour	BrightwaterWakefield_2090_RCP8.5-Q10_48h_009_QPC
		6 hour	BrightwaterWakefield_Q100_6h_009_QPC

Annual exceedance probability (AEP)	Climate scenario	Rainfall duration	waterRIDE result filename
1%	Present day	48 hour	BrightwaterWakefield_Q100_48h_009_QPC
	2090 RCP8.5	6 hour	BrightwaterWakefield_2090_RCP8.5-Q100_6h_009_QPC
		48 hour	BrightwaterWakefield_2090_RCP8.5-Q100_48h_009_QPC

4 Recommendations for future refinements

The modelling results provided to TDC are highly dependent on the model parameters and assumptions outlined in Section 3. The performance of the model could be improved by undertaking the following additional tasks:

- Model calibration – calibration of the model to known data points is recommended where possible to provide greater confidence in model outputs. There are no rainfall gauges or flow monitoring sites located within the Brightwater and Wakefield urban area. It is recommended that Council considers the installation of water level monitoring devices to capture data to improve our understanding of flooding and for use in model calibration.
- Terrain survey - as specific areas of the model become the focus of further investigation, it is recommended that TDC considers the quality of terrain data used in the model, both in terms of the date it was captured and whether it is out-of-date, and the quality of the data to represent key hydraulic features (e.g., whether the LiDAR survey DEM accurately captures ground conditions, especially in areas of dense vegetation and water surfaces).
- Land use characteristics – as above, where specific areas of the model become the focus of further investigation, it is recommended that land use characteristics, such as roughness zones and impervious areas, are revisited to capture out-of-date information and refine the city-wide estimates made in this report.
- Building floor level survey at properties in known flood hazard areas will help to better quantify the effects of flooding.
- Field data collection of other hydrological parameter such as soil infiltration characteristics (e.g., double ring infiltrometer testing) would help to validate soil loss parameters used in the model.

The Brightwater and Wakefield flood model was created to assist TDC in identifying flood hazard in the urban drainage areas of Brightwater and Wakefield (at a catchment wide scale), as well as being used to conceptualise flood mitigation measures and assessing their effectiveness. While the model is appropriate for these purposes, caution should be taken when using model outputs for other means beyond this purpose.

We recommend that TDC communicate the model purpose, assumptions and limitations of the results when sharing them to others.

5 Applicability

This report has been prepared for the exclusive use of our client Tasman District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

The accuracy of the model outputs is limited to the quality of the data inputs to the model. The model is fit for purpose for broad-scale planning measures and for the testing of stormwater mitigation options. However, caution should be taken when using the model outputs for other means beyond this primary purpose.

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