REPORT

Tonkin+Taylor

Blue-Green Networks – Te Ararata Creek - Walmsley Rd Bridge

Flood Hazard and Risk Assessment

Prepared for
Auckland Council Healthy Waters
Prepared by
Tonkin & Taylor Ltd
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Document control

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October 2024	1	Final	J. Rix / N. Flores Lim	L. Dowson	C. Bauld
November 2024	2	Additional consideration of coastal, temporary pedestrian bridge and Watercare pipe.	J. Rix / N. Flores Lim	L. Dowson	C. Bauld

Distribution:

Auckland Council Healthy Waters 1 PDF copy

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1 Introduction

Auckland Council Healthy Waters has engaged Tonkin & Taylor Ltd (T+T) to undertake a Flood Hazard Risk Assessment for the proposed Te Ararata Walmsley Road bridge replacement project (the Project) to support a resource consent application under the Severe Weather Emergency Recovery (Auckland Flood Resilience Works) Order 2024.

The primary reason for flooding in the Te Ararata area was in relation to blockage, and Healthy Waters has identified a combination of interventions within the Te Ararata catchment (overall referred to as the Te Ararata Project) to collectively address this issue in the catchment.

The first package of works within the overall Te Ararata Project is for the Walmsley Road bridge replacement which is the subject of this report. The Project seeks to increase flow capacity beneath Wamsley Road by reducing the blockage risk in Te Ararata Creek from the existing culvert structure.

A detailed project description is provided in the Assessment of Effects on the Environment (AEE).

1.1 Purpose

The purpose of this report is to present flood hazard information and a hazard risk assessment in relation to the project to support the resource consent application.

Noting that the overall purpose of the works is to address flood risk by reducing blockages, the location of the works is within a flood plain and coastal inundation zone and an overland flow path passes through the works area (refer Figure 1.1). Therefore, given the location of the works, this assessment has been prepared to assess the specific matters of control set out in the Severe Weather Emergency Recovery (Auckland Flood Resilience Works) Order 2024, being:

- *(a) The risks from natural hazards to people, property, infrastructure, and the environment, and measures to avoid or mitigate those risks.*
- *(b) The risk of flood resilience works increasing risks from existing natural hazards or creating new natural hazards, and measures to avoid or mitigate that risk.*

There are no works planned that will impact the overland flowpath, and therefore there is no further discussion regarding the overland flowpath. The following section discusses the flood hazard, including commentary on coastal inundation levels in Section 2.2.4.

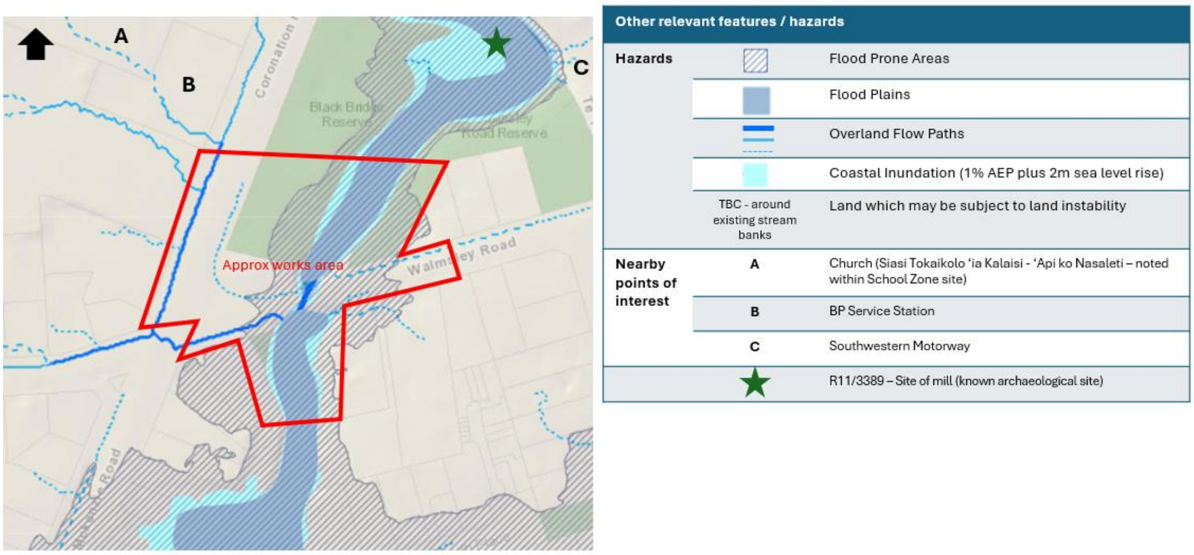

Figure 1.1: Approximate works area and Auckland Council hazard overlays.

2 Flood Hazard

The Te Ararata catchment (~550 ha) is located on the southern side of Māngere Inlet. It is a largely urban catchment and the area downstream of Moyle Park was one of the worst impacted areas of Auckland following the January 2023 floods.

2.1 January 2023 Flood

Figure 1 in Appendix A shows the observed flood extent from January 2023 and also identifies the 288 flood affected properties (including empty sections). Further investigations and hydraulic assessments have identified four categories of effects to properties in the area, as described in Table 2.1[1].

Table 2.1: Number of flooded properties by category within the Te Ararata study area

Property Effect	Definition	No. properties affected
Intolerable risk to life	Intolerable risk to life was assessed using a rapid risk assessment methodology where the flood level from the January 2023 event was likely in excess of 0.5 m above floor level and the house was surrounded by floodwaters. Refer Figure 1 in Appendix A.	43
Near- intolerable risk to life	Rapid risk assessment methodology indicated that the flood level was likely close to, but less than 0.5 m above floor level. Further investigations may reveal that some exceeded 0.5 m. Refer Figure 1 in Appendix A.	55
Property flood depths >0.5m	Total number of properties (i.e. not buildings) affected by floodwaters greater than 0.5 m in the January 2023 event within in the study area. (includes the 43 intolerable and 55 near tolerable properties). Refer Figure 1A in Appendix A.	195 (176 allowing for 19 empty sections)
Flood affected properties	Properties surrounded by floodwater of any depth (includes all previous categories).	288

Following the January 2023 rainfall event, a hydraulic assessment of the event was carried out which revealed that the flood extents, flood level and risk to life was greater than expected for the rainfall experienced. There was evidence of partial blockage at Walmsley Bridge and Mahunga Culverts and further investigations revealed the significant role that blockage has on the floodplains of Te Ararata Creek.

The flood-prone area[2] caused by a total blockage of the Mahunga Drive culverts is presented in Figure 2.1. A similar flood extent is likely for complete blockage of the Walmsley Road bridge. If there was near total blockage of either of these bridges in a 1% AEP event, there is potential for upstream flood levels to reach 6.65 mRL, which is between 1.2 m and 1.4 m above the observed January 2023 flood levels and approximately 2 m above the predicted 1% AEP flood level (T+T,

[1] This assessment was undertaken as a geospatial analysis and is not taken to the same level of detail as the formal flood categorisation work being undertaken by Healthy Waters, which is still underway at the time of writing.

[2] The flood prone area is based on 215 mm rainfall (less than the new 1% AEP 24 hour rainfall depths) which would inundate nearly 100 ha (1 km^2) of upstream area. The flood prone area has not been reassessed with new rainfall statistics, however it is likely to show a similar flood extent.

2019). The flood-prone area covers nearly 1 km^2 and there are 1,114 property parcels, 1,253 buildings and 1,502 unique addresses[3] exposed to the resulting flooding.

The January 2023 event resulted in an intolerable risk to life at 43 properties. However, modelling suggests that the intolerable risk could have been more than 1,000 properties if there had been complete blockage.

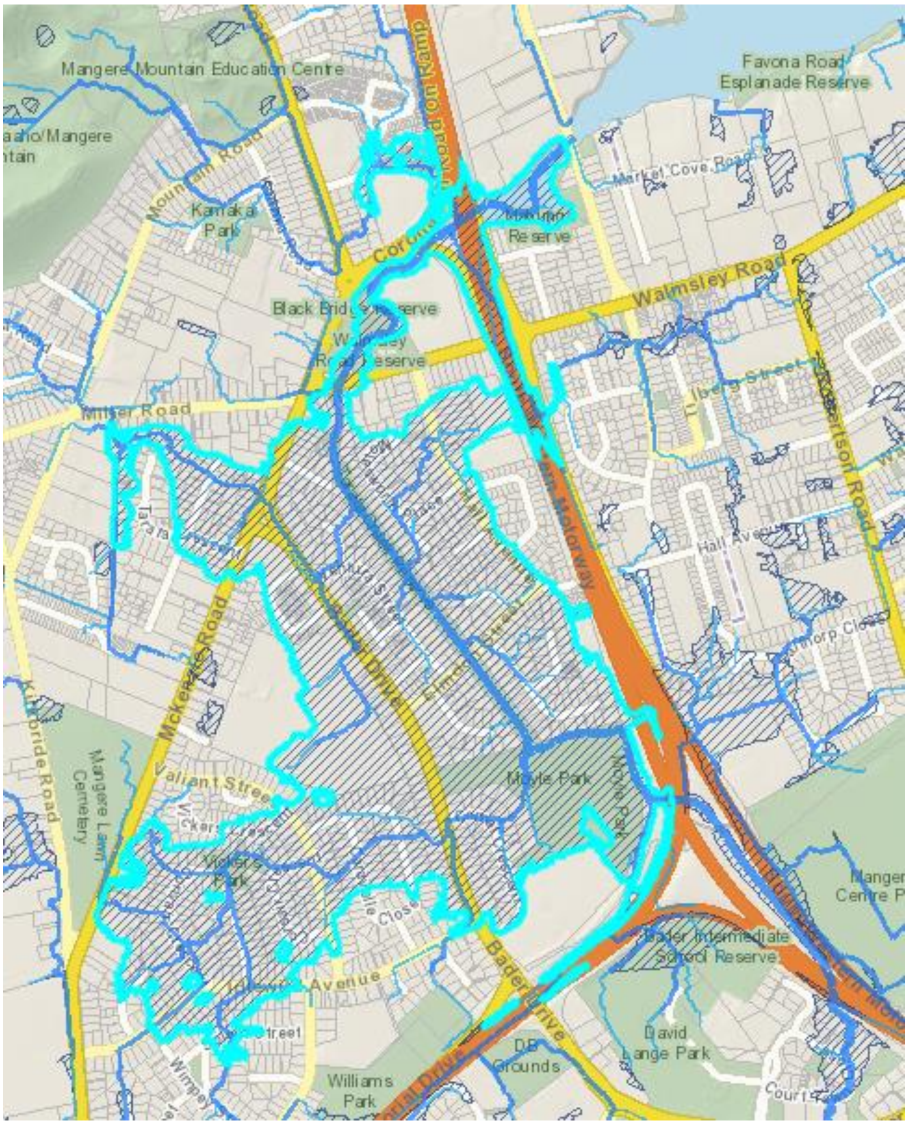

Figure 2.1: Flood prone area upstream of Walmsley Road and Mahunga Road culverts.

2.2 Impact of Bridge Design on Flood Levels

This section identifies the impact of the proposed bridge on flood levels. The following sub-sections discuss the changes in likelihood of blockage, and the impacts on upstream and downstream water levels. Section 3 identifies the consequences of the changes as part of the risk assessment.

[3] Estimates vary due to the information sources regarding property parcels, addresses and buildings. There are major subdivisions progressing in the area causing regular updates to property boundaries, addresses and building footprints. Different sources of address information provide different answers (e.g. 1,502 based on AC_Site GIS layer).

2.2.1 Changes in likelihood of blockage at Walmsley Bridge

The Walmsley Bridge upgrade project will increase the available cross section area from approximately 17 m^2 to approximately 60 m^2 and the maximum width increases from 2.3 m (twin 2.3 m culverts) to ~17 m (see Figure 2.2). The increased bridge span will significantly reduce the blockage likelihood, whilst also significantly increasing conveyance potential.

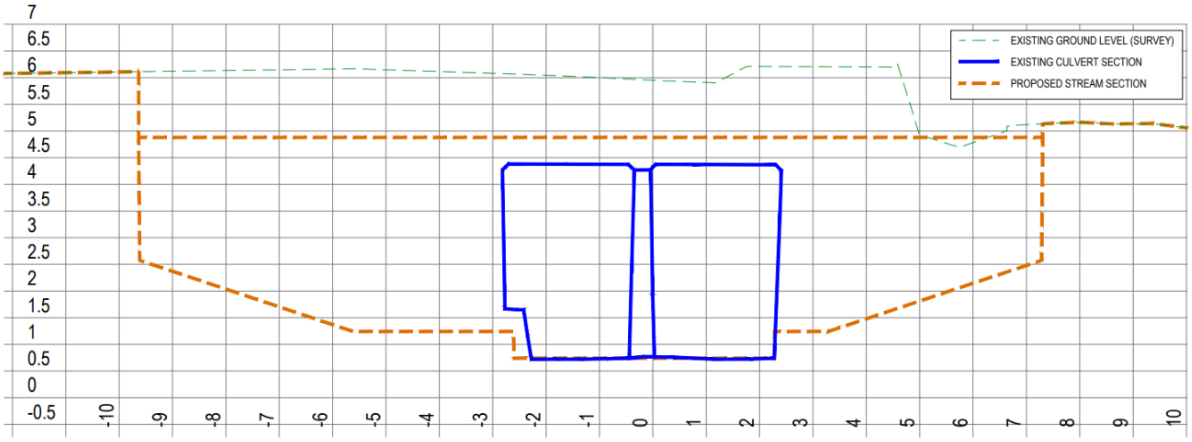

Figure 2.2: Comparison of the existing culverts and proposed bridge cross sections.

The key positive outcome of the bridge replacement works is that it will reduce blockage likelihood of Te Ararata Creek at Walmsley Road and increases conveyance potential. These works also contribute towards improving flood resilience within the Te Ararata catchment alongside other anticipated works as part of the overall Te Ararata Project.

2.2.2 Upstream and Downstream Flood Levels

In extreme rainfall events, widening the Walmsley Road opening will decrease upstream water levels, although it has potential to increase downstream flood levels. A hydraulic model (refer Section 2.2.3) was used to evaluate the changes in water level as a result of the bridge widening. The model was also used as an assessment tool to support bridge design decisions.

The model was used to assess the 1% AEP flood hazard and flood risk for a pre-development scenario (i.e. existing bridge) and post-development scenario (i.e. new widened bridge) for this assessment. Note that the scenarios assume no blockage.

The flood hazard and risk assessment has been carried out using a temporal design storm approach in accordance with Auckland Regional guidance (TP108). This is a common approach for carrying out flood hazard and flood risk assessments, although importantly, it does not relate to actual flood events (e.g. January 2023 floods in Auckland).

2.2.2.1 Catchment Model

Auckland Council’s catchment model has evolved for use across the Māngere Inlet area to support a wide variety of projects since it was developed in 2019 (T+T, 2019). The model has been refined, updated, reviewed and approved for use over the last 5 years as new information has become available, primarily to support Kāinga Ora (through LEAD alliance) and Auckland Council projects. Details of the modelling, including the baseline model details and post-development assessment details can be found in Appendix B.

2.2.3 Model Results

The floodplains associated with the 24 hour 1% AEP pre-development and post-development scenarios are presented in Figure 2.2 and Figure 2.3 respectively and are suitable for the effects assessment. Figure 2.4 shows the water level difference between the pre-development and post-development scenarios. Changes in flood levels along Te Ararata Creek are shown in Figure 2.5 and summarised at key locations in Table 2.2[4].

Table 2.2: Comparison of water level results at key locations along Te Ararata Creek (mRL NZVD2016)

Location	Baseline water level (mRL)	Post-development water level (mRL)
Elmdon Culvert	4.29	4.19
Walmsley Culvert	3.86	3.74
SH20 Off ramp Bridge (Coronation Road)	2.69	2.72
SH20 Bridge	2.43	2.46
Mahunga Culvert	1.99	2.01

The results show the small changes in floodplain and flood levels as a result of the bridge widening, noting that the works will completely remove the blockage risk.

There is approximately 100 mm - 200 mm reduction in water level upstream of Walmsley Road bridge and 20 – 30 mm increase downstream. The effect of the small downstream increase is discussed in Section 3.

[4] The results are shown for a 250 mm, 24-hour rainfall scenario. Due to the evolving nature of extreme rainfall analysis approaches and statistical outputs, there are a range of credible 24-hour estimates. This work has not been published although there is general consensus that historically developed 24-hour rainfall depths (e.g. TP108, 1999) are likely low for the present day climate. It is understood that 250 mm represents a pragmatic upper estimate and has been adopted for Table 2.2. For comparative purposes, the TP108 24-hour rainfall was 187 mm.

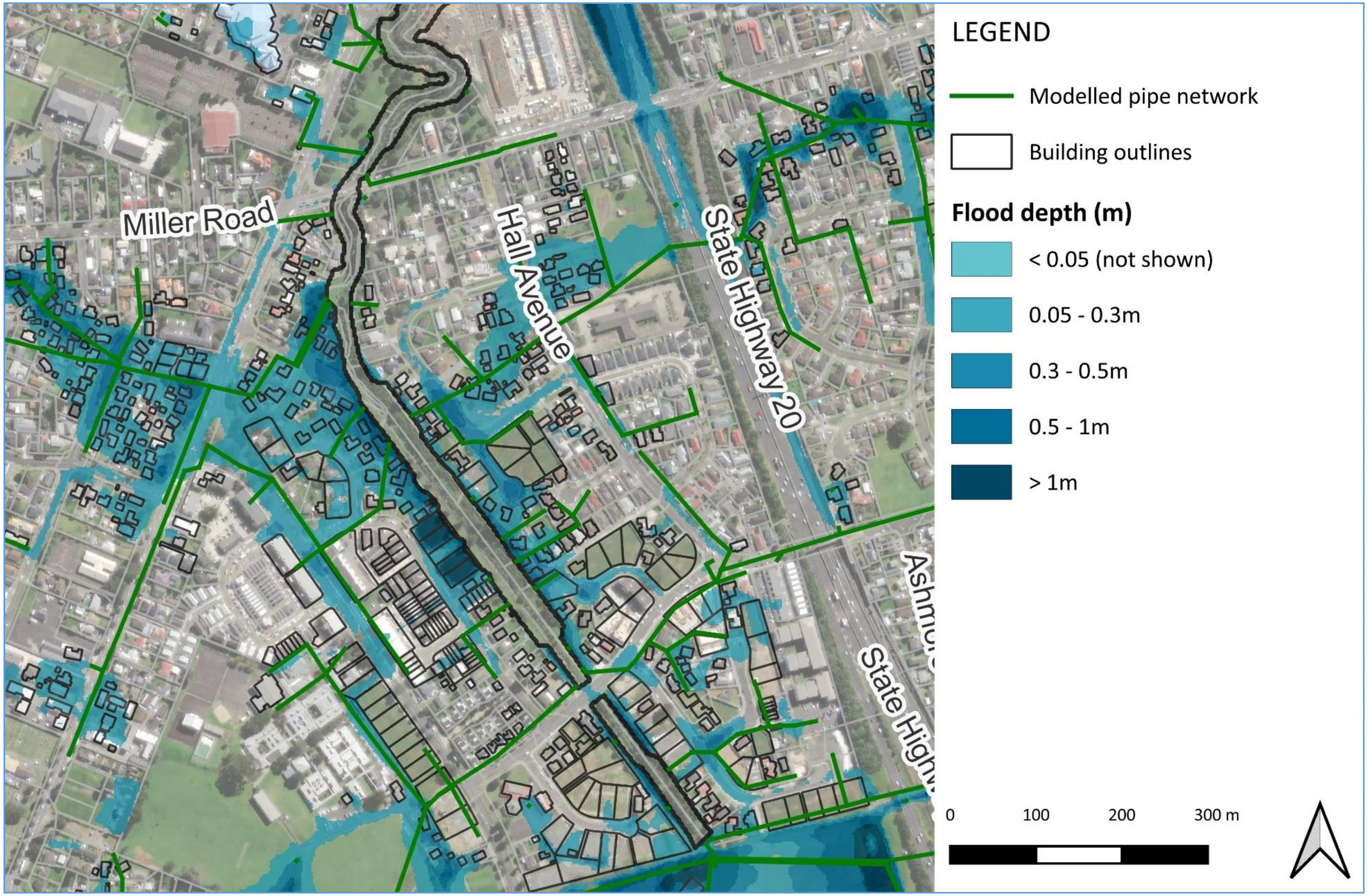

Figure 2.3: 1% AEP pre-development flood depth (250 mm 24-hour rainfall depth).

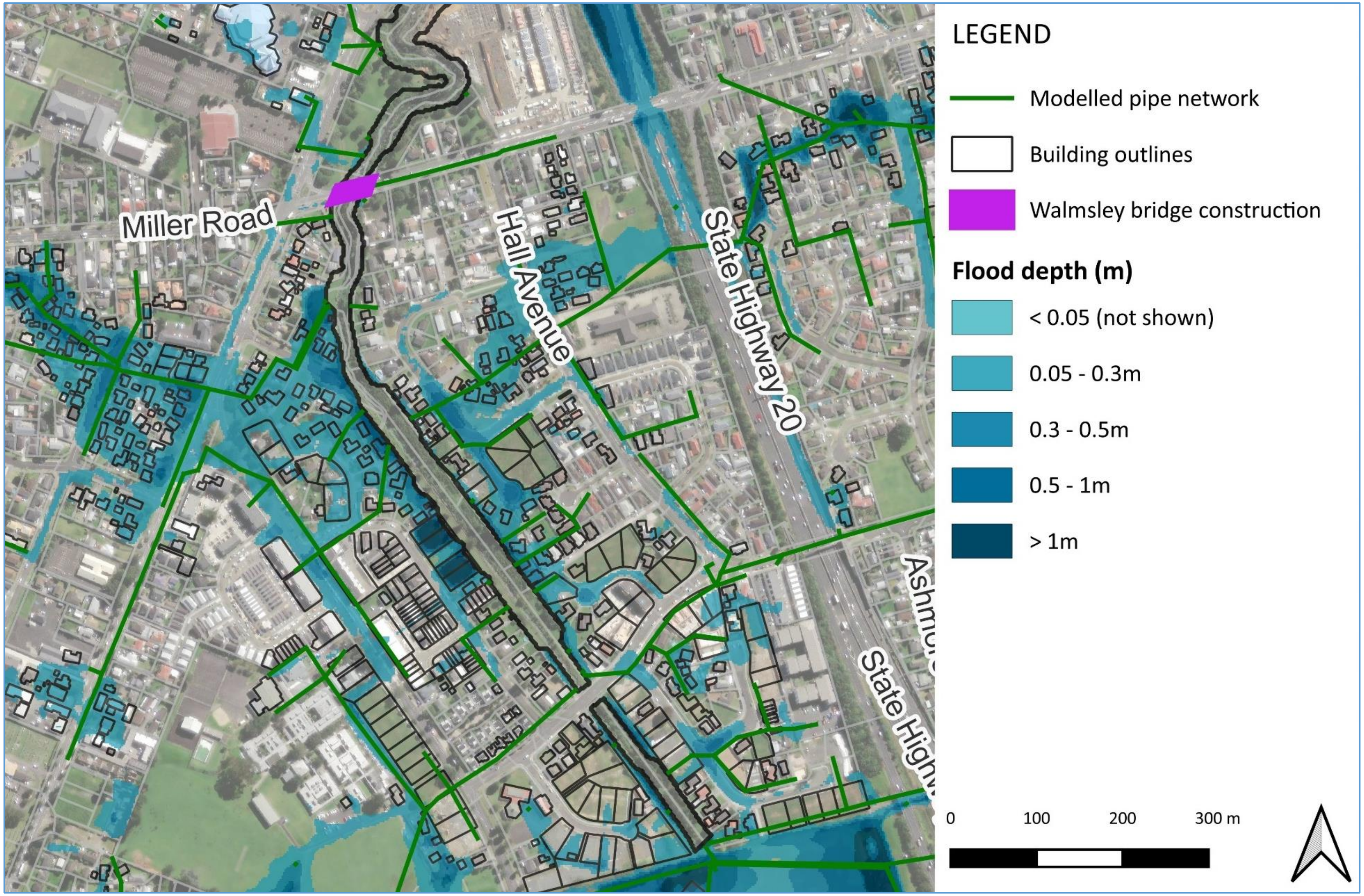

Figure 2.4: 1% AEP post-development flood depth (250 mm 24-hour rainfall depth).

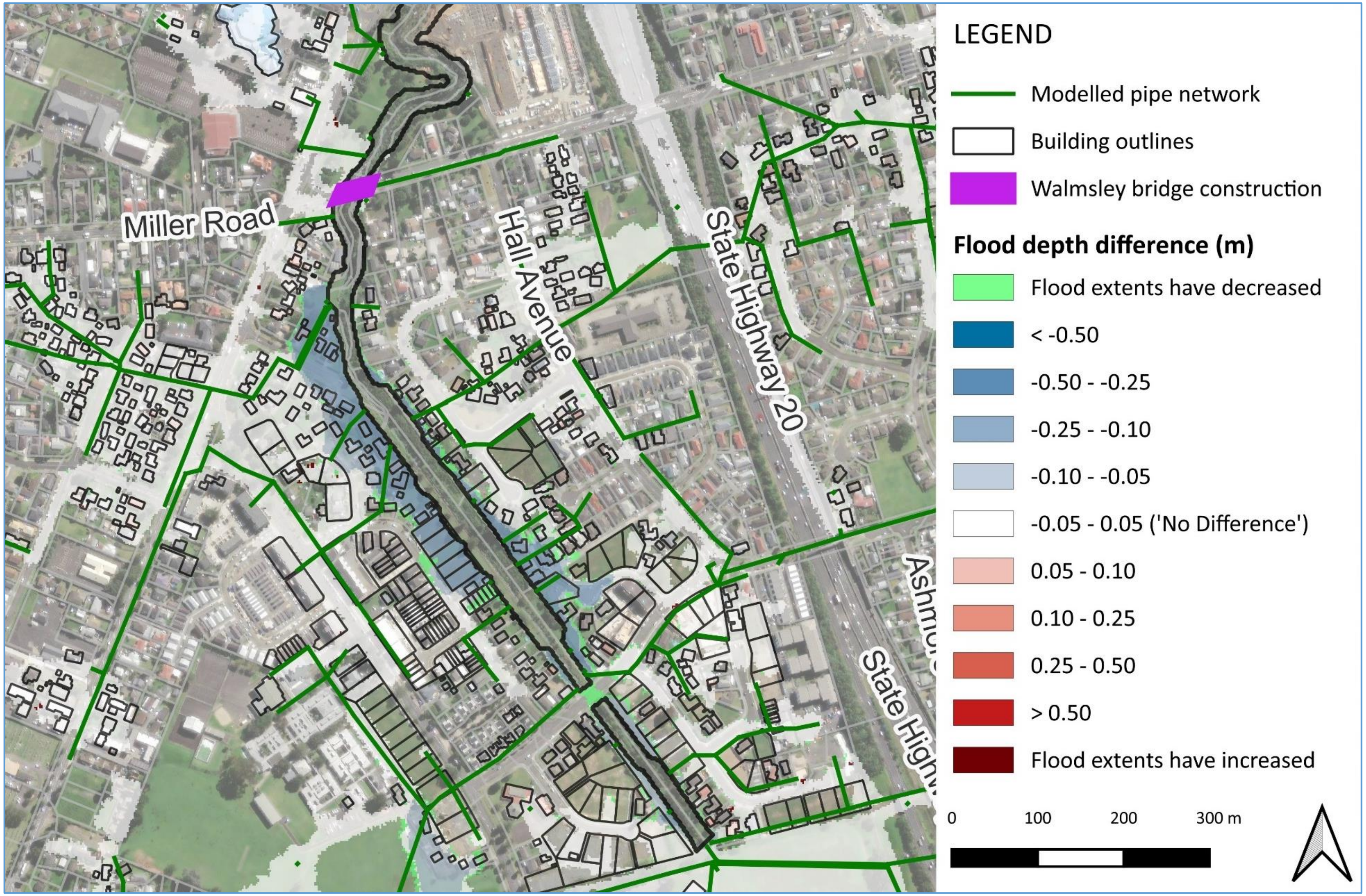

Figure 2.5: 1% AEP Flood depth difference (250 mm 24-hour rainfall depth post-development minus pre-development).

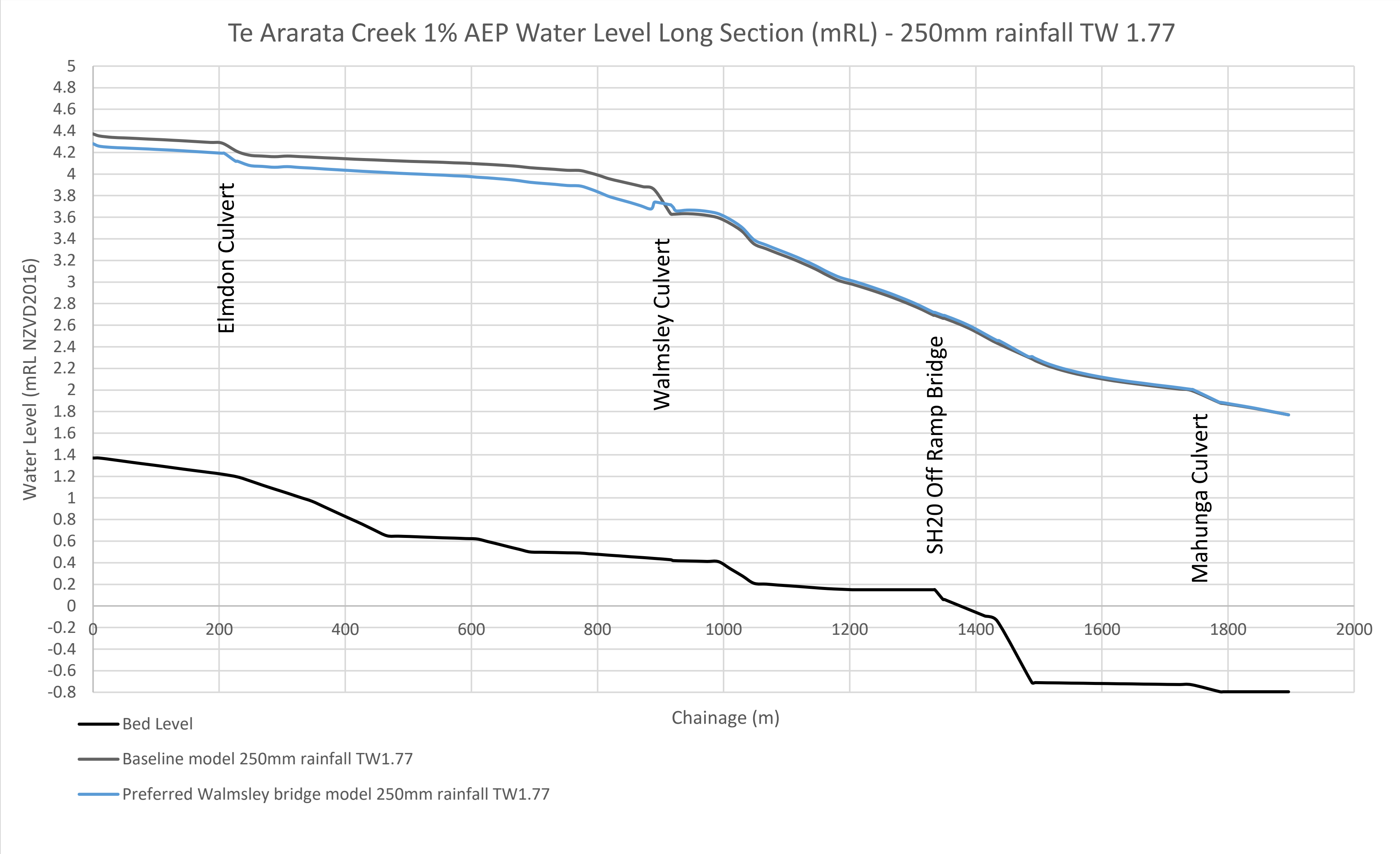

Figure 2.6: Te Ararata Creek flood levels for the 1% AEP pre-development and post-development scenarios.

In addition to the scenarios presented above, the model was also used to predict flood levels to support the bridge design for a variety of additional rainfall depths[5]. Table 2.3 presents predicted flood levels for a variety of rainfall depths at the Walmsley Road location.

Table 2.3: Pre-development (baseline) model water levels at Walmsley Road for a variety of 1% AEP rainfall depths

24-hour rainfall depth (mm)	Water level at Walmsley Road (mRL NZVD2016)		Land use[A]	TP108 nested rainfall distribution	Tailwater condition
	Pre-development (baseline)	Post-development			
187	3.61	3.52[D]	MPD	Existing, 0°C	MHWS-10[B]
217	3.87	3.76[D]	MPD	2.1°C	MHWS-10 + 1 m SLR[C]
247	4.06	3.95[D]	MPD	3.8°C	MHWS-10 + 1 m SLR[C]
250	3.86	3.74	MPD	Existing, 0°C	MHWS-10
295	4.25	4.12	MPD	2.1°C	MHWS-10 + 1 m SLR[C]
332	4.49	4.34	MPD	3.8°C	MHWS-10 + 1 m SLR

Note A: Hydrological land use, altered via percent impervious.

Note B: Mean high water spring tide exceeded 10 percent of the time (MHWS-10). This is 1.77 mRL in NZVD2016.

Note C: SLR = sea level rise.

Note D: These flood level results relate to a similar bridge design to the consent design, but is not exactly the same. The results are considered a good indication of likely reduction from the proposed design.[6]

2.2.4 Coastal Inundation Levels

The Port of Onehunga tidal levels are shown in Table 2.4 and the 1% AEP extreme sea-level in the Manukau Harbour adjacent to the project is ~2.73 m RL (Auckland Council technical report TR2020/024)[7].

Table 2.4: Port of Onehunga tidal levels

Datum	MHWS	MHWN	MLWN	MLWS	MSL	HAT	LAT
CD	4.18	3.33	1.45	0.56	2.43	4.54	0.12
AVD-46	**1.979**	**1.129**	**-0.751**	**-1.641**	**0.229**	**2.339**	**-2.081**
NZVD2016	1.695	0.845	-1.035	-1.925	-0.055	2.055	-2.365

[5] Refer footnote 4 (page 5) for discussion.

[6] Model reference for further information: MPDXXCC001AEPTWX_B2024_WB06 where XX and X refer to different scenarios inputs.

[7] Sites 17 and 18 from the following report: Roberts, R., N Carpenter and P Klinac (2020). Auckland's exposure to coastal inundation by storm-tides and waves. Auckland Council technical report, TR2020/24. Recorded levels are 3.00 m and 3.02 m to AVD-46 (converted to 2.716-2.736 m NZVD2016). https://www.aucklandcouncil.govt.nz/environment/what-we-do-to-help-environment/Documents/coastal-inundation-in-auckland.pdf.

The underside of the Walmsley Road bridge (~4.9 m RL, refer Figure 2.2) is situated approximately 2.9 m above MHWS and approximately 2.2 m above the 1% AEP extreme sea level.

The underside of the Watercare pipe girders (4.57-4.73 m RL) is situated approximately 2.6 m above MHWS and approximately 1.8 m above the 1% AEP extreme sea level. Refer to Section 4.4 of the AEE for further information about the Watercare pipe bridge.

The underside of the temporary pedestrian bridge (~4.4 m RL) is situated approximately 2.4 m above MHWS and approximately 1.7 m above the 1% AEP extreme sea level. Refer Sections 4.5 of the AEE for further information about the temporary pedestrian bridge.

3 Natural hazard risk assessment

The following assessment has focused on the specific matters for control as set out in Section 1.1.

3.1 The risks from natural hazards to people, property, infrastructure, and the environment, and measures to avoid or mitigate those risks

The Walmsley Road Bridge replacement will significantly reduce risks from flooding to people, property, infrastructure and the environment by:

- Reducing the likelihood of blockage, which has the potential to affect over 1000 properties. The reduced likelihood of blockage occurs because:
  - The available cross section area increases from approximately 17 m^2 to approximately 60 m^2.
  - The maximum width increases from 2.3 m (twin 2.3 m culverts) to ~17 m.
- Upstream of Walmsley Road bridge, flood levels are reduced by between 100 mm - 200 mm, which reduces flood risk.
- Contributing towards the flood resilience strategy within the Te Ararata catchment (alongside other planned catchment wide projects).

Notwithstanding these positives, the modelling has shown that there is a small increase in flood levels (20 mm - 30 mm) downstream of Walmsley Road, however there are no identified flood effects associated with the increase. This is because the increase is small, the floodplain lies within a well-defined floodplain located in public property (largely within Black Bridge and Walmsley Road Reserve) and the increase does not alter the risk profile to either the SH20 bridge or the Coronation Road offramp bridge. On the basis that there are no identified downstream effects, the downstream risk remains the same.

The underside of the Walmsley Road bridge, temporary pedestrian bridge[8] and the Watercare pipe bridge[9] are all located above the post-development 1% AEP flood level (~3.74 m RL) and coastal inundation levels (up to 2.73 m RL).

The Wamsley Road bridge (in either its current or proposed form), Watercare pipe and proposed temporary pedestrian bridge do not provide an impediment to coastal inundation. Therefore, the coastal inundation extents and levels will remain the same and there are no changes to the risks.

There are no changes to the overland flowpath as a result of the project and therefore no changes to the risks.

[8] Underside of the temporary pedestrian bridge estimated level 4.4m RL, refer Sections 4.4 and 4.5 of the AEE for further information about the Watercare pipe bridge and pedestrian bridge.
[9] 4.57-4.73 m RL from drawing reference 148654.33 S04-01 (rev A).

3.2 The risk of flood resilience works increasing risks from existing natural hazards or creating new natural hazards, and measures to avoid or mitigate that risk

There have been no increases in risks as a result of the project, therefore no additional measures to avoid or mitigate risks are considered necessary.

4 Applicability

This report has been prepared for the exclusive use of our client Auckland Council Healthy Waters , 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.

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Appendix A Flood Hazard and Flood Risk

Te Ararata Creek

Figure 1

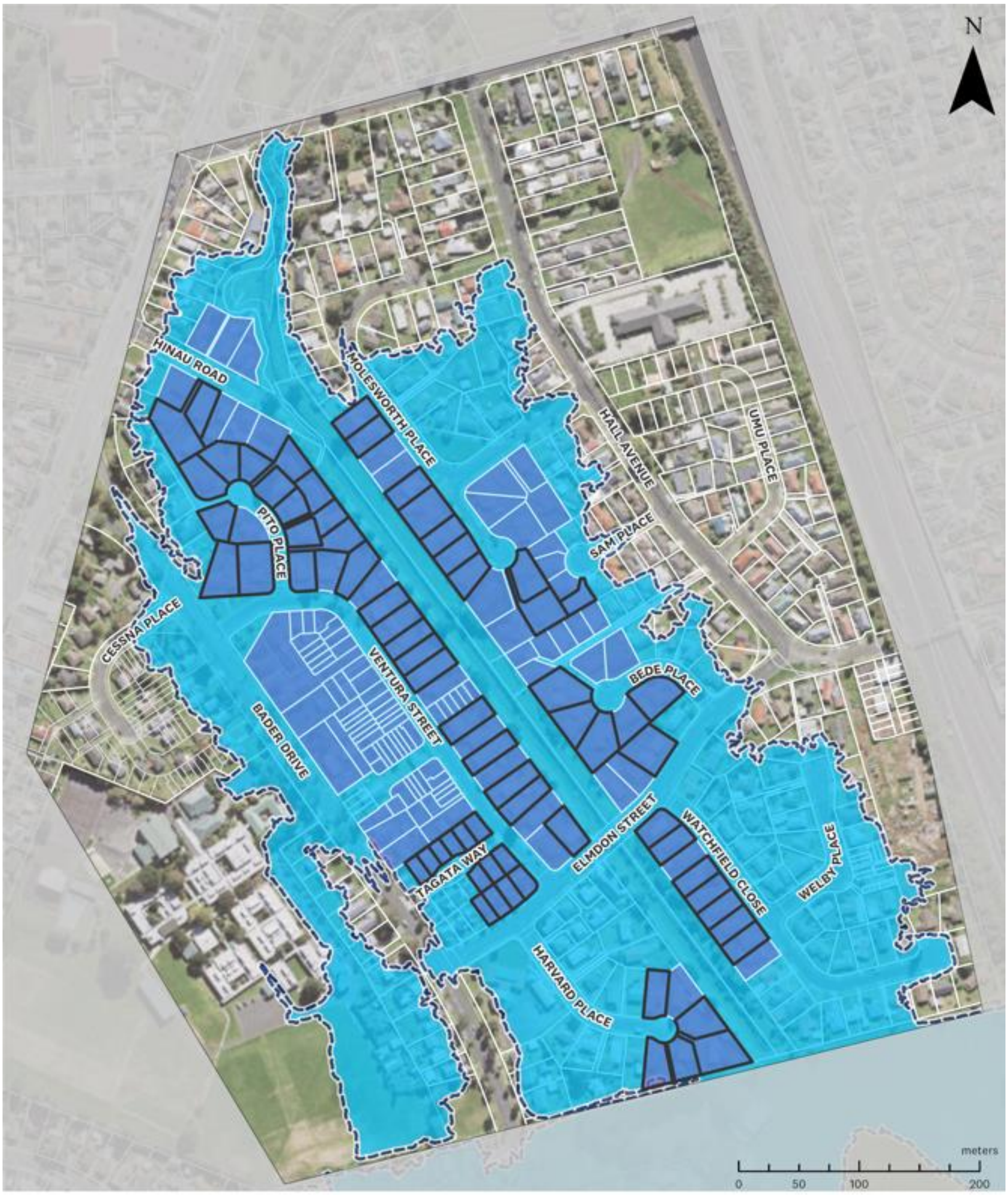
Estimated flood extent on January 27, 2023

Property at intolerable risk during January 27, 2023 flood

Unknown

Empty lot

Kāinga Ora property



Te Ararata **Figure 1A**

Estimated flood extent on January 27, 2023

Property that experienced flood depths in excess of 0.5m in January 27, 2023 flood

Kāinga Ora property

Te Ararata

Figure 2

Estimated flood extent on January 27, 2023

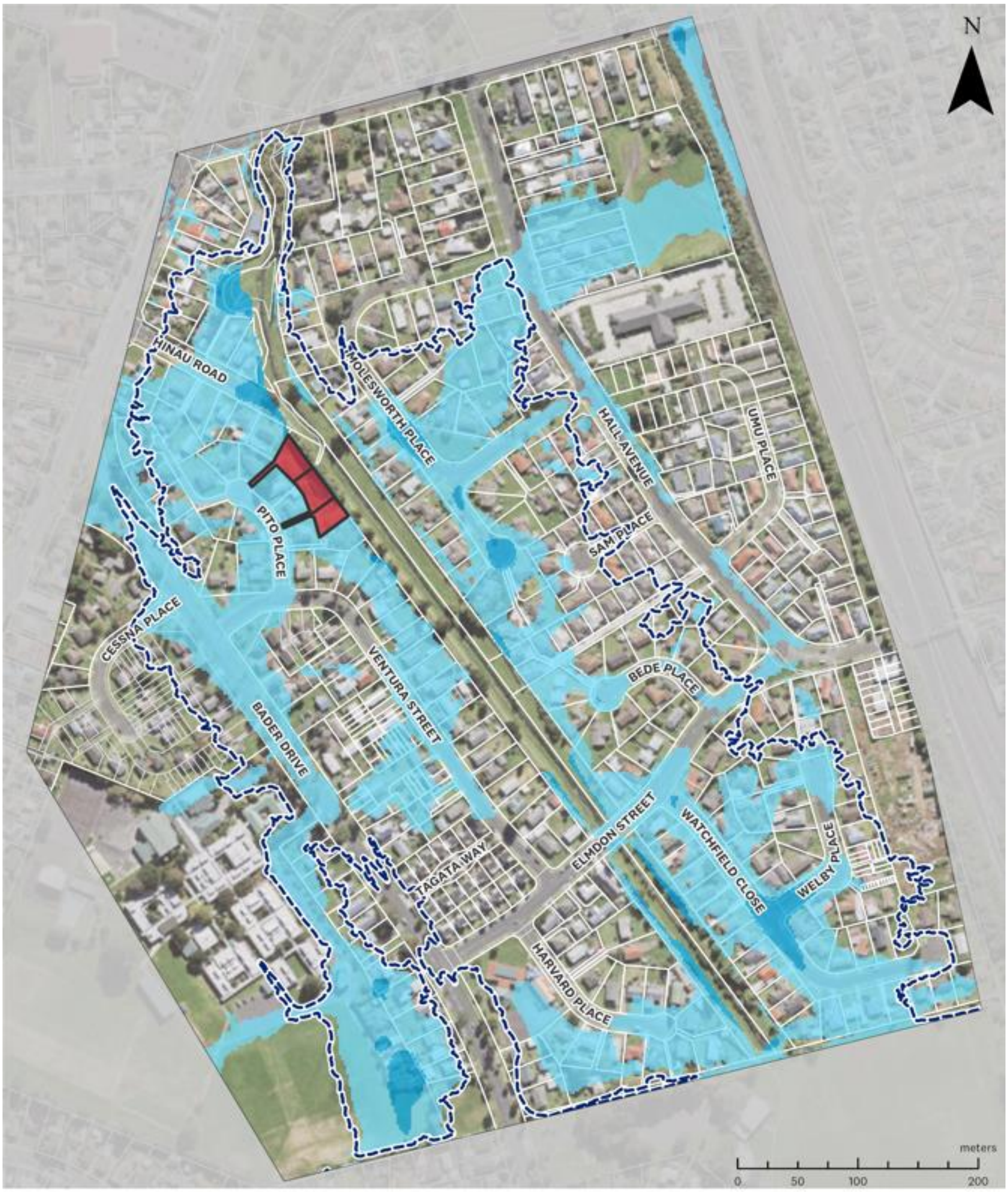
Risk to life intolerable

Future scenario flood extent - no blockage

Kāinga Ora property

≤ 0.5 m

> 0.5 m



Te Ararata

Figure 3

Estimated flood extent on January 27, 2023

Risk to life intolerable

Kāinga Ora property

Future scenario flood extent - debris control & downstream conveyance improvements

Value

≤ 0.5 m

> 0.5 m

Appendix B Model Build Report

1 Introduction

The Te Ararata catchment was one of the worst affected areas of Auckland following the January 2023 floods. The Te Ararata catchment (~550 ha) is located on the southern side of Māngere Inlet. It is a largely urban catchment and the area downstream of Moyle Park was impacted during the January 2023 floods. After the January 2023 floods, 288 properties were identified as flood affected (including empty sections).

An upgrade to the Walmsley Road bridge/culverts is proposed as one of three projects in the Te Ararata catchment that fall under the Blue Green Networks (BGN) programme. Whilst the current culverts are not undersized, they are at risk to blockage and cause mild backwater effects and a resulting increase in flooding upstream. The project is therefore intended to reduce the likelihood of blockage and improve flood conveyance in the Te Ararata Creek. Hydraulic modelling was undertaken to support the bridge design and to assess the effects resulting from the proposed bridge upgrade.

This report describes the methodology of the hydraulic modelling to support the Te Ararata BGN project.

Figure 1.1 shows the location of the proposed works and Auckland Council's existing flood hazard information[1].

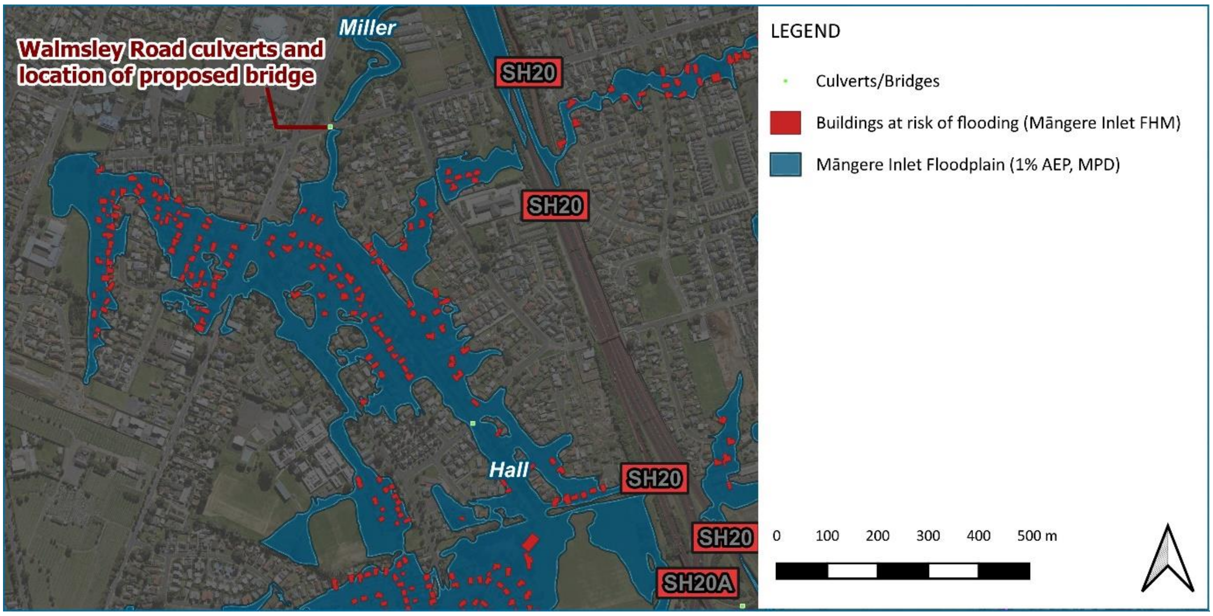


Figure 1.1: Location of proposed works and Auckland Council's existing flood hazard information Model source: Māngere Inlet hydraulic model from FHM (T+T, 2020).

1.1 Model purpose

The purpose of the hydraulic model is to support resilient infrastructure design (of the bridge) and to assess the benefits of the proposed works on flooding in the Te Ararata catchment. Note that not all scenarios used to support the bridge design are covered in this report.

2 Te Ararata catchment and hydraulic model history

Te Ararata creek is located within Auckland's Māngere area. Auckland Council have undertaken hydraulic modelling and Flood Hazard Mapping (FHM) for the Māngere Inlet catchment, completed in 2019[1].

The Māngere Inlet hydraulic model has been subsequently updated as new information has become available and used to assess options for large scale Kāinga Ora development projects across the catchment, including new infrastructure. These projects and associated hydraulic modelling have been undertaken by the LEAD Alliance for Kāinga Ora.

The Te Ararata model is a cut-down version of the Māngere Inlet catchment hydraulic model, as shown in Figure 2.1 below.

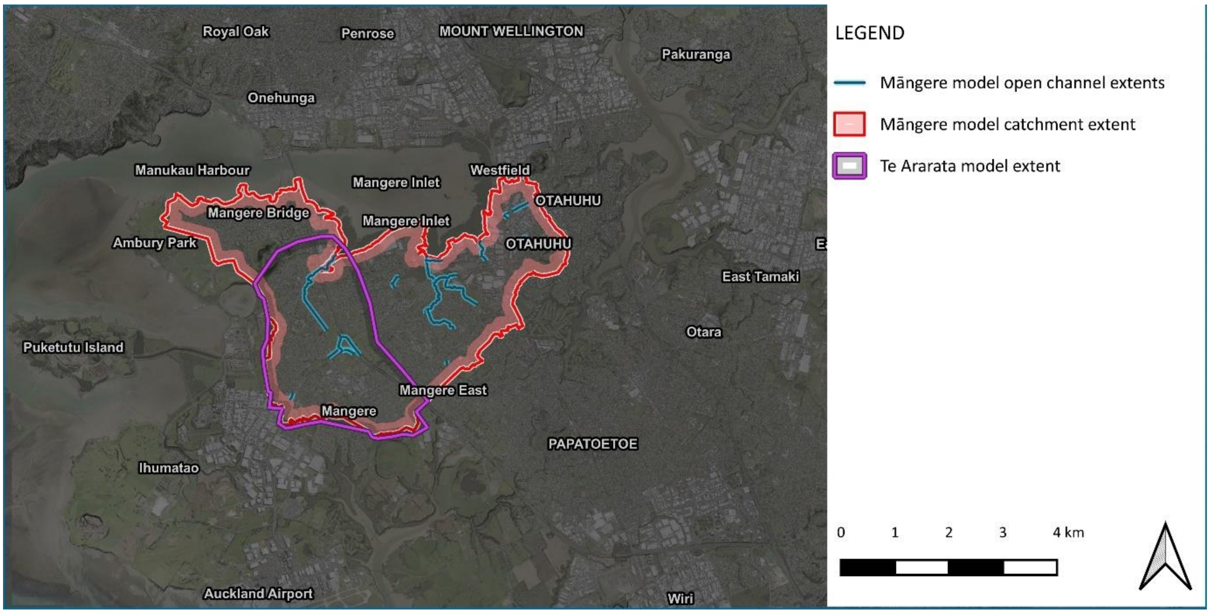


Figure 2.1: Māngere Inlet hydraulic model and Te Ararata model extents.

The 'baseline' Te Ararata model used for the BGN project was the latest model peer reviewed by Auckland Council at the time of commencing the work. The model was provided to Tonkin & Taylor Ltd (T+T) by LEAD Alliance.

Details of the 'baseline' model provided by LEAD are as follows:

- **Model folder:** R002_TA-B_MPD100yrCC3pt8_B2022.
- **Model couple file**: *R002_TA-B_MPD100yrCC3pt8_B2022.couple.*
- **Source:** Provided on 24/07/2024 via internal transfer link.

Updates made to this model to support the BGN work by T+T are described in Section 3.

[1] *Māngere Inlet FHM Model Build and System Performance*, Tonkin & Taylor Ltd, June 2020.
Spatial data sourced from Tonkin + Taylor's 2017/2019 FHM mapping, project ref: 28456.1000.

Figure 2.2 below shows the key features of the model. The existing culverts at Walmsley Road (and location of proposed works) is named "Walmsley Road culvert".

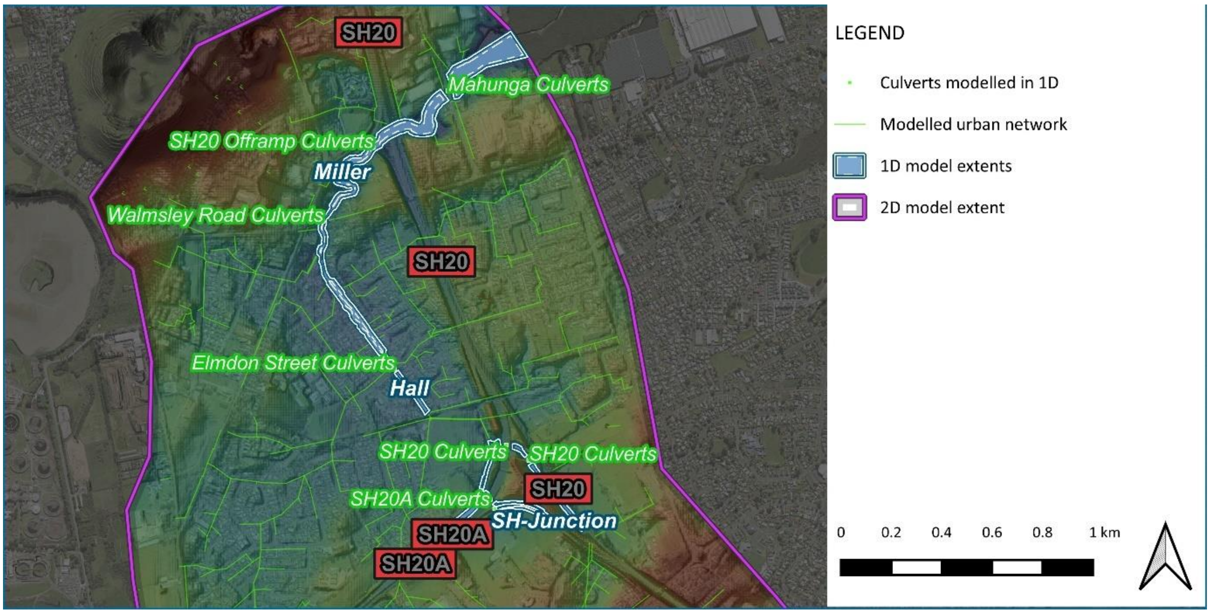


Figure 2.2: TeArarata_B2024 model schema.

3 Pre-development hydraulic model

Table 3.1 presents a summary of changes made to the baseline Te Ararata hydraulic model to represent the pre-development scenario (i.e. the existing Walmsley Road culverts). Additional information references are provided from the relevant section of the table.

Table 3.1: Te Ararata BGN Baseline model summary and changes to LEAD model

Model element	Model summary	Update details (changes to LEAD model)
Model name	Te Ararata Baseline model, "**TeArarata**"	• LEAD model name updated for baseline model year.
Model version	***TeArarata_B2024***	• LEAD model name updated to match the Auckland Council Modelling Specification (2023).
Software	MIKE by DHI, 2020 release.	• Unchanged from LEAD model.
Datums	**Horizontal:** New Zealand Transverse Mercator (NZTM) (NZGD2000). **Vertical:** Auckland Vertical Datum 1946 (AVD46).	• Unchanged from LEAD model.
Extent	Cut-down version of the Māngere Inlet hydraulic model. Bordered by SH20 to the east. Refer Figure 2.1 and Figure 2.2.	• Unchanged from LEAD model.

Model element	Model summary	Update details (changes to LEAD model)
Schema	Te Ararata creek represented as Hall and Miller branches represented as 1D open channel. Other waterways are also represented in 1D open channel. Refer Figure 2.2.	• Branches: – Hall – Miller – SH-Junction2 have been adjusted in the 1D open channel in the LEAD model to match the correct lateral link extents. Refer Section 3.1.1 for further information.
Topography	Branches converted from 1D to 2D (Hall, Kirkbride, Miller, SH-Junction, SH-Junction1, SH-Junction2, SH20 and SH20A) have topographical data from the following sources: • 2013 cross section survey (BECA) • 2016 LiDAR	• Unchanged from LEAD model.
Roughness	Spatially varying roughness applied in model. This is based on land use.	• Unchanged from LEAD model.
Hydraulic structures	There are various structures represented in the river model: 1 Elmdon Street culverts, located on Hall Branch (**1D culverts**) 2 Walmsley Road culverts, located on Hall Branch (**1D culverts**) 3 Mahunga Road Culverts, located on Miller Branch (**1D culverts**) 4 Various culverts along SH20 and SH20A interchange Culverts (**1D culverts**) 5 SH20 Pedestrian Bridge (**1D culverts**) 6 SH20 Offramp Bridge, located at State Highway 20 exit 10 (**1D culverts**) Culverts may be represented by multiple barrels. Refer Figure 2.2.	• Unchanged from LEAD model.
Urban network	The stormwater network is represented in the hydraulic model. Pipes greater than 300 mm are included, as well as smaller pipes where required for connectivity. Refer Figure 2.2.	• Unchanged from LEAD model.
Hydrology	Catchment inflows distributed through the urban model using TP108 methodology. Total rainfall depth (over 24 hours) for the 1% AEPA storm (current climate) is **187 mm**. Maximum probable development ('MPD') land use scenario is represented. This considers an increased (maximum probable) impervious percentage for each land use, i.e. runoff is higher than for the existing development ('ED') scenario	Total rainfall depth (over 24 hours) for the 1% AEP storm (current climate) is 250 mm. This rainfall depth was provided by Auckland Council in October 2024 and requested to be used to reflect updated hydrology including rainfall statistics of the January 2023 storms. Further information provided in Section 3.1.2 regarding rainfall.

Model element	Model summary	Update details (changes to LEAD model)
Downstream boundary	Constant tidal tailwater boundary of **2.05 mRL** (AVD46). The tidal boundary corresponds to mean high water spring tide exceeded 10 percent of the time (**MHWS-10**).	• Unchanged from LEAD model.
Climate change	**Rainfall:** Total rainfall depths are increased and hyetograph intensities adjusted to account for future climate scenarios. Two scenarios are considered: • 2.1°C temperature increase to year 2090: 1% AEP rainfall increased 16.8% • 3.8°C temperature increase to year 2110: 1% AEP rainfall increased 32.7% **Sea level rise:** Tidal boundary is increased by 1 m to account for sea level rise under future climate scenarios. Tidal boundary with climate change considered is **3.05 mRL** (AVD46).	• Unchanged from LEAD model.
Initial conditions	Initial conditions are set equal to the downstream tidal boundary condition.	• Unchanged from LEAD model.
Model connections	**Runoff:** Rainfall converted to runoff is 'loaded' directly into the urban network model. **Urban/river/floodplain:** 3-way coupled model with connections between urban stormwater network, open channel 1D extents, and 2D floodplain.	• Unchanged from LEAD model.

Note A: AEP = annual exceedance probability.

3.1 Schema

The Baseline Te Ararata BGN model represents the existing or 'pre-BGN-project' scenario. The 1D cross sections in the provided LEAD model did not fully represent the 1D extent. The open channel was therefore modified by T+T to better represent the 1D and 2D extents. This was applied for the Hall, Miller, and SH20Junction2 branches in the 1D model. An example of cross section inconsistency with the extent is shown in Figure 3.1 below.

Figure 3.1: Te Ararata model – Example of old 1D cross sections not matching 1D extent from provided LEAD model.

3.2 Rainfall

Design rainfall across the Auckland Region is currently being reviewed and updated by Auckland Council following the January (and February) 2023 storm events. Under instruction by Auckland Council (8/10/24), we have adopted a 24-hour 1% AEP baseline rainfall depth of 250 mm (no reference), which is consistent with the rainfall used for the risk categorisation work. The 1% AEP baseline rainfall depth does not make allowances for climate change. T+T has not reviewed the 250 mm rainfall depth.

A comparison of 1% AEP rainfall depths in the received Te Ararata model from LEAD Alliance (based on TP108, 1999) and the revised 1% AEP rainfall depths (AC, 2024) are provided in Table 3.2.

Table 3.2: Rainfall depth comparisons

Scenario	24 hr rainfall depth (mm)	
	TP108 (1999)	AC Healthy Waters, 2024
Existing	187	250
2.1 degrees climate change scenario relative to “Existing” scenario above.	217	295
3.8 degrees climate change scenario relative to “Existing” scenario above.	247	332

4 Walmsley Bridge hydraulic model – post-project scenario

Table 4.1 presents a summary of changes made to the Walmsley Road Bridge ('WB08') hydraulic model to represent the post-development scenario (i.e. the proposed Walmsley Road Bridge) Additional information references are provided from the relevant section of the table.

Table 4.1: Te Ararata - Walmsley Road Bridge (post-scenario) model summary

Model element	Model summary	Changes from Baseline Model ('B2024')
Model name	• Te Ararata preferred Walmsley Bridge option model	• Updated for post-project model
Model version	• ***TeArarata_B2024_WB08***	• Updated for post-project model. • Note that model versioning is implemented independently between pre-/post-project (B2024/B2024_WB08) scenarios.
Software		• Unchanged from BASE
Datums		• Unchanged from BASE
Extent		• Unchanged from BASE
Schema	Walmsley Road culverts removed and replaced with the bridge section provided by Blue-Green Networks project team and confirmed by Auckland Council to be the preferred bridge sections ('Walmsley Bridge – Draft Civil Design*', October* 2024*).*	• River network outside of Walmsley Road project extent is unchanged from B2024 model.
Topography		• Unchanged from BASE (refer also Hydraulic Structures)
Roughness		• Unchanged from BASE
Hydraulic structures	1D culvert through existing Walmsley Road culverts are removed. The bridge is then represented as a single span. The soffit of the proposed bridge used consists of the existing but is not reached in the baseline model runs, i.e. no vertical hydraulic restriction occurs.	• Structures outside of proposed Walmsley Road bridge are unchanged from the B2024 model. • Bridge design as per drawing number 1017033.2002-027 'Walmsley Bridge – Draft Civil Design', October 2024.
Urban network		• Unchanged from BASE
Hydrology		• Unchanged from BASE
Downstream boundary		• Unchanged from BASE
Climate change		• Unchanged from BASE
Initial conditions		• Unchanged from BASE
Model connections		• Unchanged from BASE.

4.1 Hydraulic structures

The Walmsley Road bridge is represented in the Te Ararata model for the 'post-project' scenario. The preferred Walmsley Road Bridge cross sections were provided by the BGN project team and confirmed as the preferred option by Auckland Council (Drawing number 1017033.2002-027 'Walmsley Bridge – Draft Civil Design', October 2024).

A summary of modifications to the baseline model is listed below.

- Remove existing Walmsley Road culverts.
- Shifting the existing model cross sections to allow inputting the proposed bridge channel.
- Inputting channel cross sections aligning with the bridge sections provided the Blue-Green Networks project team.
- Inputting bridge structure into the 1D network with cross section matching bridge sections provided the Blue-Green Networks project team.

The bridge sections provided the Blue-Green Networks project team are reproduced in Figure 4.1 and the location of changes in the model is illustrated in Figure 4.2.

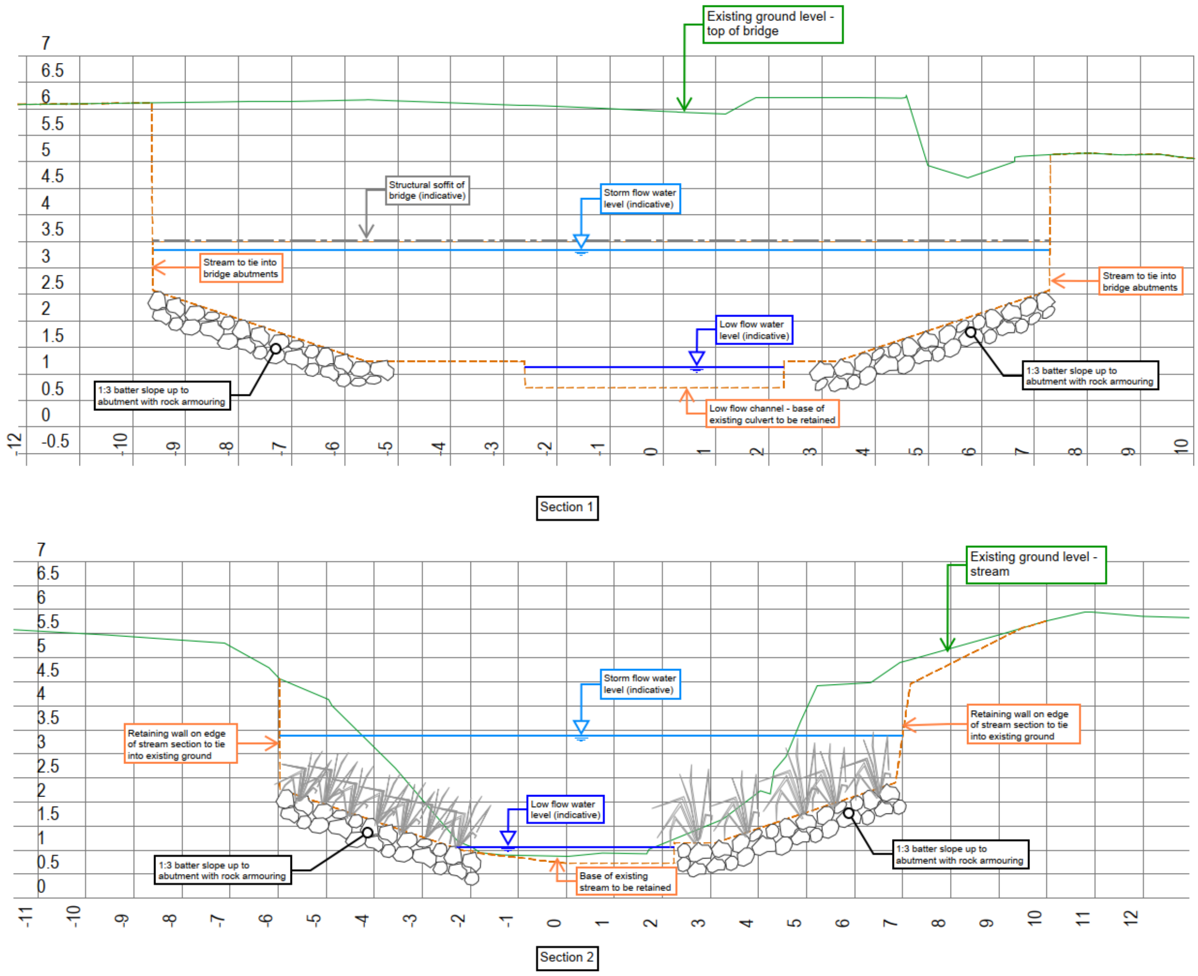


Figure 4.1: Walmsley Road Bridge preferred cross sections. Section 1 presents a cross section through the Walmsley Road Bridge, Section 2 presents cross sections immediately downstream of the bridge. Note that soffit levels presented are not refering to the bridge soffit. Levels presented are in NZVD2016.

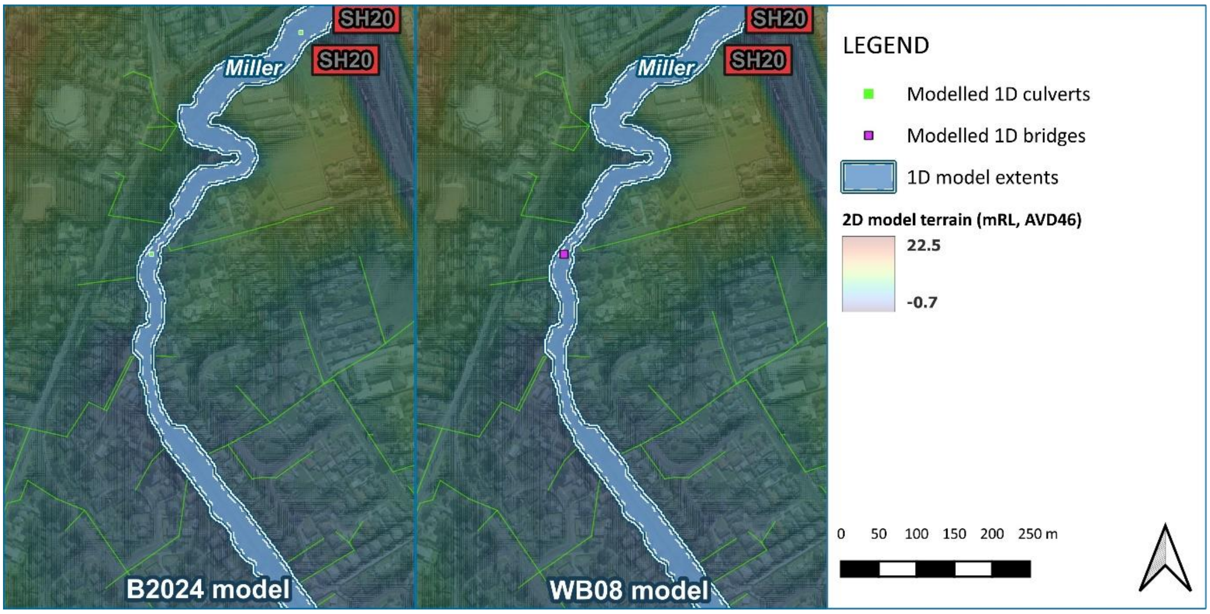


Figure 4.2: WB08 model differences from TeArarata_B2024 model.

5 Modelled scenarios

The scenario naming convention for the hydraulic model generally follows the Auckland Council 2023 Stormwater Modelling Specifications. Details of the naming convention are described below.

- **Part 1 - Hydraulic model details**:
  - Model name, project scenario, model version
  - E.g. *TeArarata_B2024_WB08*
- **Part 2 – Boundary condition details**:

Table 5.1: Boundary condition ID's in hydraulic model scenario naming

Boundary condition	ID in model name	Details
Hydrological land use	**ED**	Existing development
	MPD	Maximum probable development
Rainfall climate change	**HCLM**	"Historic climate", i.e. existing climate or 0°C of warming
	21CC	2.1°C temperature increase from climate change
	38CC	3.8°C temperature increase from climate change
Storm event	**001AEP**	1% AEP[A] (24-hour duration) storm
Tailwater condition	**TWA**	MHWS-10[B] (2.05 mRL, AVD46)
	TWB	MHWS-10 + 1 m SLR[C] (3.05 mRL, AVD46)
	TWC	MLWS[D] (-0.78 mRL, AVD46)

Note A: AEP = annual exceedance probability

Note B: MHWS-10 = Mean high water spring tide exceeded 10 percent of the time.

Note C: SLR = sea level rise.

Note D: MLWS = mean low water spring tide.

  - E.g. *MPD21CC001AEPTWA*

- **Example:**
  - The proposed Walmsley Bridge model with a fully developed catchment, 1% AEP storm under current climate and a ‘low’ tide level would be denoted as:

    TeArarata_MPD38CC001AEPTWB_B2024_WB08

Table 5.2 below details selected modelled simulations carried out in support of the project. Note that not all of the scenarios are presented to support the consent application.

Table 5.2: Te Ararata Blue Green Networks model simulation matrix

No.	Project scenario	Land use[A]	Rainfall CC[B]	Storm event	Tailwater condition
1	Existing (‘Baseline’)	MPD	Existing, 0°C	1% AEP[C] (250 mm 24-hour rainfall)	MHWS-10[D]
2	Existing (‘Baseline’)	MPD	2.1°C	1% AEP (295 mm 24-hour rainfall)	MHWS-10 + 1 m SLR[E]
3	Existing (‘Baseline’)	MPD	3.8°C	1% AEP (332 mm 24-hour rainfall)	MHWS-10
4	Existing (‘Baseline’)	MPD	3.8°C	1% AEP (332 mm 24-hour rainfall)	MHWS-10 + 1 m SLR
5	Walmsley Road Bridge (‘WB08’)	MPD	Existing, 0°C	1% AEP (250 mm 24-hour rainfall)	MHWS-10
6	Walmsley Road Bridge (‘WB08’)	MPD	2.1°C	1% AEP (295 mm 24-hour rainfall)	MHWS-10
7	Walmsley Road Bridge (‘WB08’)	MPD	2.1°C	1% AEP (295 mm 24-hour rainfall)	MHWS-10 + 1 m SLR
8	Walmsley Road Bridge (‘WB08’)	MPD	3.8°C	1% AEP (332 mm 24-hour rainfall)	MHWS-10
9	Walmsley Road Bridge (‘WB08’)	MPD	3.8°C	1% AEP (332 mm 24-hour rainfall)	MHWS-10 + 1 m SLR

Note: Model versions *TeArarata_MPD38CC001AEPTWB_B2024* and *TeArarata_MPD38CC001AEPTWB_B2024_WB08.*

Note A: Hydrological land use, altered via percent impervious.

Note B: Rainfall CC = climate change scenario applied to rainfall, in terms of temperature increase.

Note C: AEP = annual exceedance probability. 24-hour duration as per TP108 methodology.

Note D: Mean high water spring tide exceeded 10 percent of the time. This is 2.05 mRL in AVD1946.

Note E: SLR = sea level rise.

6 Model limitations and assumptions

The accuracy of model outputs is limited to the quality and availability of data inputs to the model. The Te Ararata hydraulic model has been developed from a catchment-wide scale model for the purpose of assessing relative effects. Site-specific assessment is recommended for any use case that differs from the model purpose.

Listed below are a summary of limitations or assumptions that end users of the model will need to consider when interpreting and using the results.

- It is understood that LEAD Alliance and Auckland Council carry out quality assurance checks on the hydraulic models in development. Additional quality assurance checks were not carried out on the received LEAD model prior to commencing this project.
- For limitations and assumptions associated with the original Māngere Inlet FHM or LEAD hydraulic models, end users should refer to the appropriate documentation for these projects.
- The soffit of the proposed Walmsley Road bridge is set to 5.16 mRL. This allows for 540 mm freeboard above the most extreme modelled water level at Walmsley bridge (nested distribution hyetograph with a rainfall depth of 332 mm, ~4.62 mRL AVD46 for the MPD 1% AEP with 3.8°C climate change storm, MHWS-10 tailwater with 1 m sea level rise). Any later changes to the bridge design or additional model scenarios will require users to confirm that the soffit of the proposed bridge is not reached (and therefore does not affect hydraulic performance).

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