

MEMORANDUM

To [REDACTED] | City of Ballarat
From [REDACTED] | Water Technology
Date 18 June 2026
Subject Ballarat 11 Waterways Amendment C217ball – Beveridge Williams Consolidated Response
Our ref 26010601_M01_V01_BevWil.docx

1 SCOPE OF MEMORANDUM

Water Technology was engaged by the City of Ballarat to provide a consolidated technical response to submissions for the C217ball amendment from Beveridge Williams in relation to the following sites:

- [REDACTED], Canadian.
- [REDACTED], Bonshaw (River Gum Rise Estate).

The response is to key issues across the Beveridge Williams submissions. The follow key issues included:

- Completeness and representation of the drainage infrastructure.
- Treatment of terrain resolution (topographic resampling).
- Representation of waterbodies and roughness assumptions.
- Application and justification of climate change scenarios.
- Model assumptions, limitations and overall fitness for planning purposes.



2 TECHNICAL RESPONSE

Responses to the key issues submitted by Beveridge Williams for their two sites related to Amendment C217ball are as follows.

2.1 [REDACTED], Canadian

2.1.1 Completeness and representation of the drainage infrastructure

The stormwater drainage infrastructure within the Canadian Creek & Tributaries hydraulic model is comprised of infrastructure sourced from various sources. The bulk of the stormwater drainage network within the models was based on Council's drainage asset database and was supplemented with As Constructed plans. Where gaps were found in Council's database, historic plans were then requested (and provided if available).

The absence of invert levels in the stormwater drainage infrastructure details in Council's database was rectified by a hierarchical process, such as:

1. Representation of the invert levels based on available design plans.
2. Representation of invert levels based on LiDAR elevations (specific to inlets and outlets).
3. Estimation of invert levels based on standard design grade slopes, ground cover requirements and inlet/outlet constraints.

This method of representing stormwater infrastructure within municipal or catchment wide models is standard practice and regularly adopted.

The extent of the stormwater drainage infrastructure within the hydraulic models was limited to the riverine extents. Inflows from the hydrological models were applied directly to the waterways, or in some instances into drainage infrastructure. Inclusion of the stormwater drainage infrastructure outside of these areas was not necessary as it would not impact the outcomes of the study. An overview of the stormwater drainage infrastructure included in the Canadian Creek & Tributaries hydraulic model (specific to Elsworth and Butt Street) is shown below in Figure 1.

A comparison with the raw dataset from the City of Ballarat, as shown in Figure 2, highlights that the main culvert underneath Butt Street is not included in the base dataset. This main culvert has been captured and modelled in the Canadian Creek & Tributaries model. As noted above, assets located outside of the riverine or study extent were not included in the hydraulic model. This is evident for infrastructure in Marli Close.

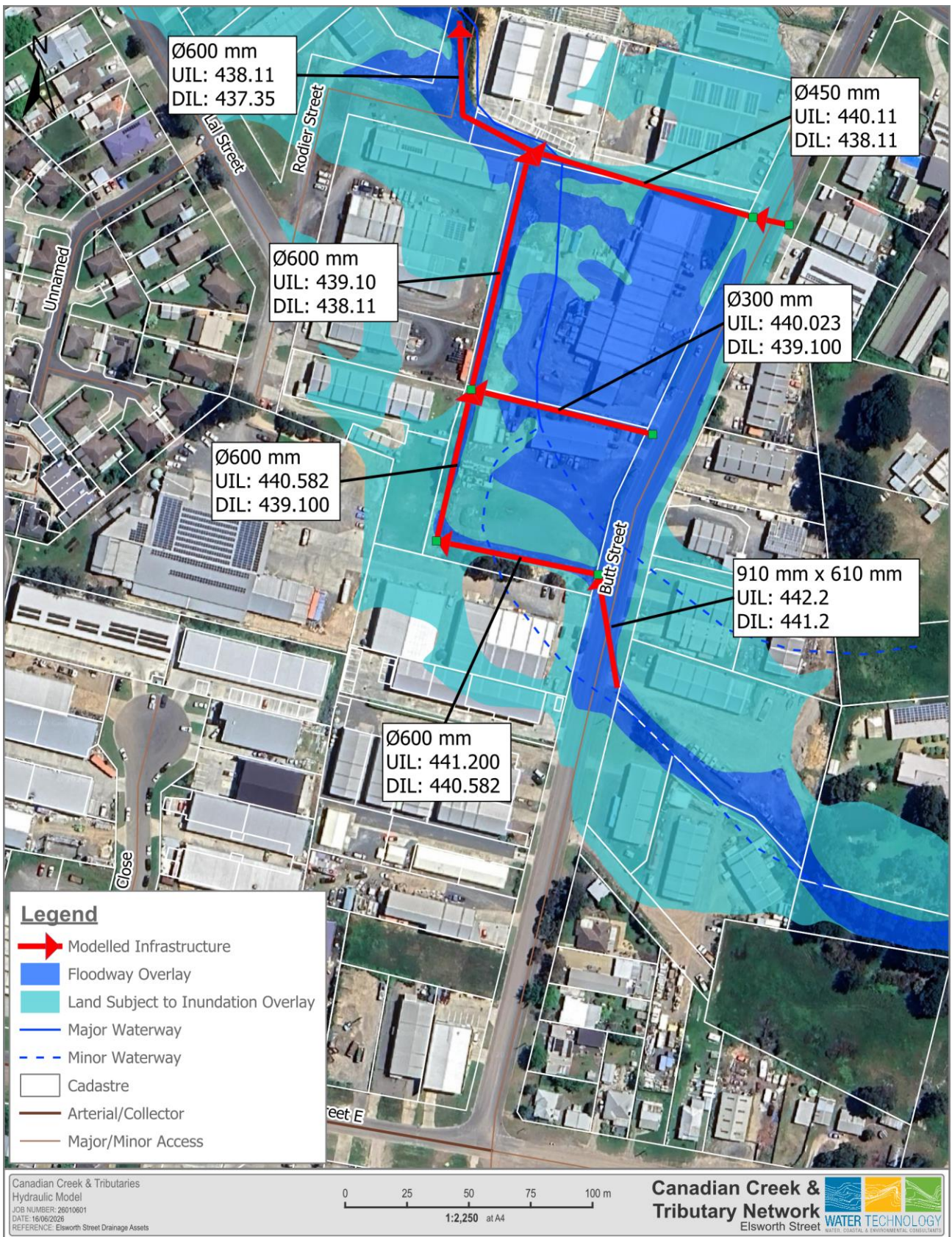


Figure 1 Canadian Creek & Tributaries Drainage Infrastructure – Elsworth/Butt Street (UIL – upstream invert level, DIL – downstream invert level)

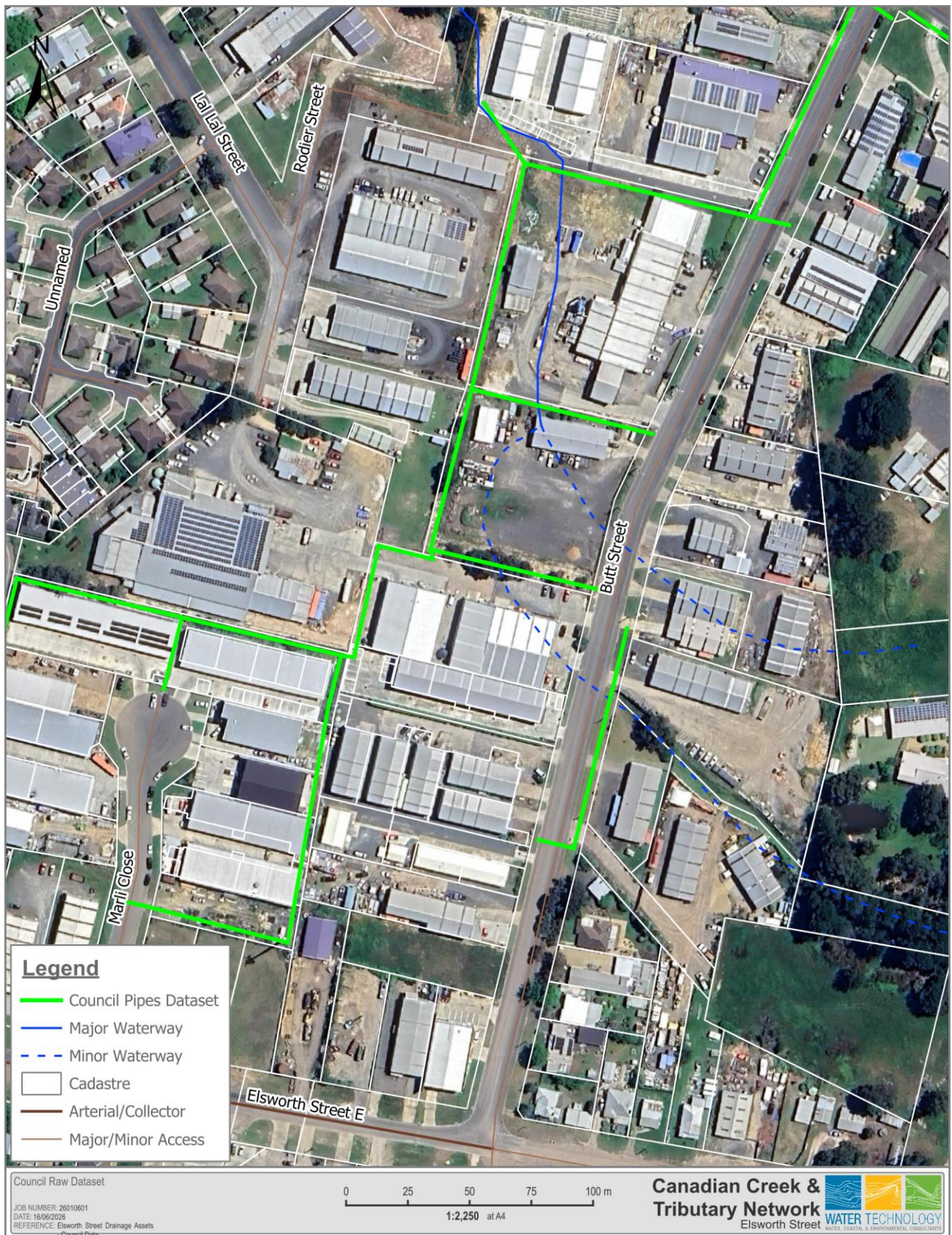


Figure 2 Council's Raw Pipe Dataset



2.1.2 Treatment of terrain resolution (LiDAR resampling)

The Canadian Creek & Tributaries modelling completed in 2024 was commissioned to update the hydraulic model terrain and reflect development that had occurred since the study was first conducted in 2018. The 2018 study utilised LiDAR data with a 2-metre grid cell size, which was resampled to 5-metres in the hydraulic model, whereas the most recent study features to a 1-metre grid cell size dataset that was resampled to 3-metres in the hydraulic model.

Resampling topographic data for hydraulic modelling is an industry wide standard approach, undertaken to achieve suitable model run times and output file sizes while balancing the trade-off between accurate representation of streamflow paths. The Canadian Creek & Tributaries hydraulic model featured input terrain data with a 1-metre grid cell size, which was resampled to 3-metres for the hydraulic model. A 3-metre grid cell size is common for catchment/municipal wide flood studies. There are trade-offs with when adopting a topographic resolution coarser than the underlying LiDAR data given the Canadian Creek & Tributaries flood model has numerous open channel drains as it approaches the Ballarat CBD; however, to rectify this, the open channels in the hydraulic model closer to the CBD were modelled as 1-dimensional channels. This 1D representation was based on cross-sections of the channels.

Specific to the abovementioned site, the overland flow paths from the upper catchment to Butt Street does not include a 1D channel. A comparison of the input terrain data (1-metre) and modelled terrain (3-metre) is shown below to demonstrate that while some accuracy in the terrain characteristics is lost, it is a common issue in large flood models and does not invalidate the results.

Figure 3 below provides an overview of the cross-section locations where the comparison has been undertaken and features the 1-metre topographical dataset. Comparison cross-sections for each location are presented in Figure 4, Figure 5, Figure 6 and Figure 7.



Figure 3 Overview of terrain comparison cross-sections

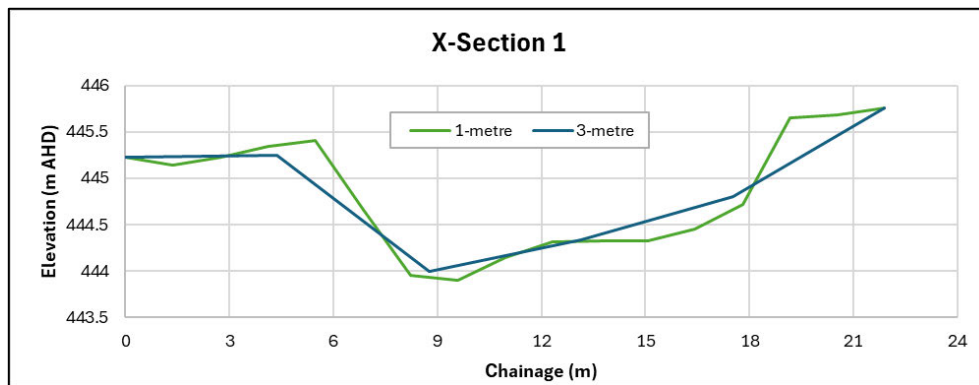


Figure 4 Terrain Comparison – Cross-Section 1

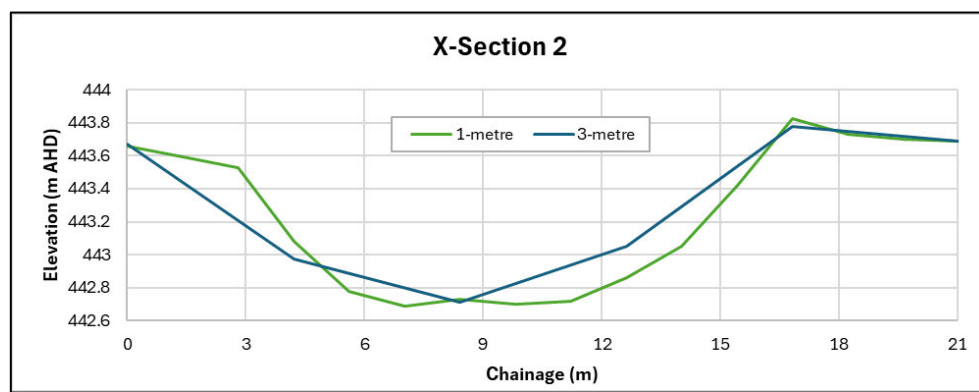


Figure 5 Terrain Comparison – Cross-Section 2

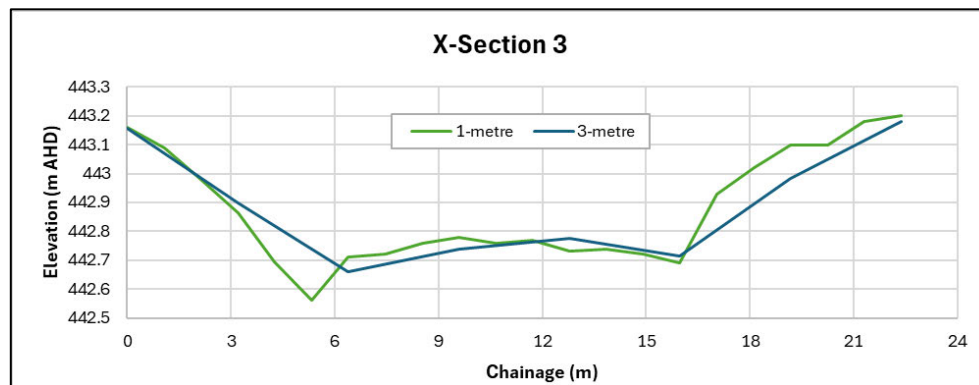


Figure 6 Terrain Comparison – Cross-Section 3

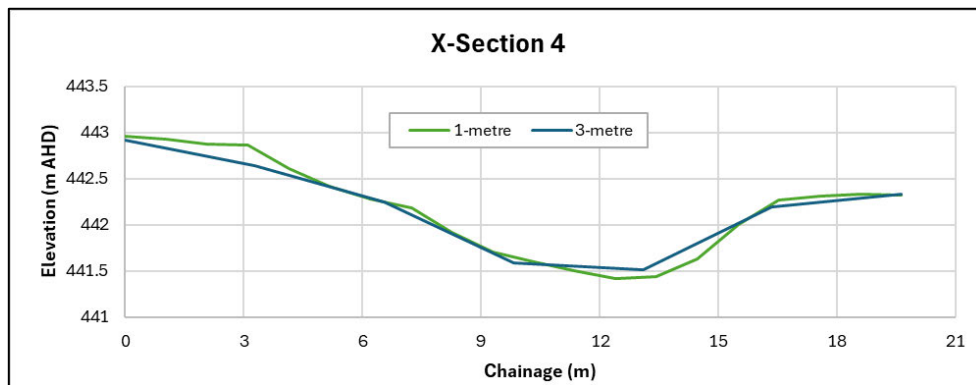


Figure 7 Terrain Comparison – Cross-Section 4

2.1.3 Representation of waterbodies and roughness assumptions

Representation of waterbodies, ponds and basins did not adopt all the same Manning's (n) value. Where aerial imagery indicates basins holding water, they were assigned a roughness value of 0.03; and where aerial imagery showed dry basins, they were assigned a roughness value of 0.035.

2.1.4 Application and justification of climate change scenarios

It is acknowledged the adoption of the current climate change recommendations would align the study to current industry standards which were amended in July 2024. However, hydrological modelling for this study (and those part of the Ballarat 11 Waterways) was completed in 2019 and therefore adopted the best practice of the time (now referred to as ARRV4.1).

The following has been quoted from Australian Rainfall and Runoff Version 4.2¹

Key differences from the 2019 Climate Change Considerations chapter (ARRV4.1) include:

- *Recognition that global temperatures have increased over the historical period used to derive design rainfall information.*
- *A recommendation to adjust 2016 Intensity-Frequency-Duration (IFD) curves to present (i.e. current climate) conditions*
- *Provision of information to support a range of approaches to decision-making*
- *Provision of guidance across the range of Annual Exceedance Probability (AEP) considered in ARR up to and including the Probable Maximum Precipitation (PMP)*
- *Provision of uncertainty estimates*
- *Consideration of additional factors that influence design flood estimates; that is, changes in rainfall losses, temporal patterns, and sea level rise.*

The recommendation to proceed with RCP8.5 for the design horizon 2100 was considered carefully in conjunction with the City of Ballarat and the Corangamite Catchment Management Authority. Adoption of this

¹ Wasko, C., Westra, S., Nathan, R., Jakob, D., Nielson, C., Evans, J., Rodgers, S., Ho, M., Babister, M., Dowdy, A., Sharples, W., (Editors), 2024 Chapter 6: Climate Change Considerations, Scope and Philosophy, Book 1 in Australian Rainfall and Runoff - A Guide to Flood Estimation, Commonwealth of Australia, © Commonwealth of Australia (Geoscience Australia), Version 4.2, 2024



climate change scenario for the proposed planning controls reassures the study's relevance until revised hydrological modelling can be completed. This was based on the factor of which rainfall depths are increased to account for climate change (or global warming levels) under ARR4.2.

Under the climate change scenario adopted for this study (Canadian Creek & Tributaries 2024), the 1% AEP storm event was increased by a factor of 1.184 (18.4%) for the 2100 RCP8.5 scenario. Climate change modelling under the current standard, ARR4.2, requires scaling of rainfall data to reflect current climate levels by accounting for the increase in global warming level since the baseline IFD representation period (1961-1990). Rainfall depths are then subject to further scaling to represent future climate conditions.

Should the latest climate change considerations be applied to the Canadian Creek & Tributaries hydrologic model, current day representation of rainfall IFD's would be comparable to the RCP8.5 2100 event that has been modelled. Should planning controls be delineated using ARR4.2 recommendations it would be for the year 2100 and would likely entail a 34% to 86% in rainfall intensity.

An overview of IFD factors for ARR4.2 climate scenarios and the adopted climate scenario IFD scaling for the 1% AEP event are provided in Table 1.

Table 1 Climate change IFD scaling

Duration	SSP3		SSP5		RCP8.5
	2030 (current day)	2100 (future climate)	2030 (current day)	2100 (future climate)	Adopted Scaling
<1hr	1.18	1.66	1.20	1.86	1.184
1.5hr	1.17	1.59	1.18	1.77	
2hr	1.16	1.55	1.17	1.71	
3hr	1.14	1.5	1.16	1.64	
4.5hr	1.13	1.45	1.14	1.58	
6hr	1.12	1.42	1.13	1.54	
9hr	1.12	1.39	1.13	1.5	
12hr	1.11	1.37	1.12	1.47	
18hr	1.10	1.34	1.11	1.43	
>24hrs	1.10	1.32	1.11	1.41	

2.1.5 Model assumptions, limitations and overall fitness for planning purposes.

The Canadian Creek & Tributaries flood study includes several assumptions around stormwater infrastructure representation, which employs approaches commonly used in flood studies. The limitations surround the resolution of the modelled terrain and the narrow channels located in the catchment are addressed by modelling them in a 1-dimensional domain, therefore allowing their narrow nature to be accurately captured. Beyond the 1-dimensional channels, overland flows in the upper catchment do lose some quality in representation in the terrain dataset which may result in some inaccuracy of the models' overland flows paths; however, this too is a common issue in large scale flood modelling. These limitations do not invalidate the results produced from the model, but they are taken into consideration when delineating planning control extents.



2.2 [REDACTED], Bonshaw (Rivergum Rise Estate)

2.2.1 Completeness and representation of the drainage infrastructure

Stormwater drainage within Ploughman's Arms Estate was primarily left out of the hydraulic model as inflows were applied to the wetland system at the southern end of the estate, fronting Ross Creek road. As noted in the submission, the construction of the stormwater drainage infrastructure within the River Gum Rise Estate has not been included in the hydraulic model as it was constructed post 2023.

The inclusion of stormwater drainage infrastructure within River Gum Rise Estate would likely influence levels during frequent storm events; however, under the current model arrangement of inflows and the planning controls been based on the 1% AEP 2100 event, it will likely have minimal impact on the overland flows modelled.

It is acknowledged that the stormwater infrastructure within River Gum Rise has altered the existing drainage conditions of the site, which will likely affect the represented inflows in the Bonshaw Creek hydrologic and hydraulic models.

Rerunning of the hydrologic and hydraulic models is necessary given the extents of the proposed planning controls can be amended to match the current infrastructure arrangement. Further discussion on the amendment of the overlays is discussed in Section 2.2.2 below.

2.2.2 Treatment of terrain resolution (LiDAR resampling)

It is acknowledged that the LiDAR dataset used to represent the base terrain of the Bonshaw Creek model features elevations is not reflective of the River Gum Rise Estates current terrain. Works on this site have been in progress since early 2025 and have altered the terrain between Joses Lane and Ploughman's Arms Estate.

A review of the 2019 LiDAR dataset aerial imagery indicates that previously present overland flow paths from the Ploughman's Arms Estate basin are likely no longer present. In conjunction with the works on River Gum Rise Estate, it is also understood that works on Ross Creek Road were also completed.

A combination of these factors is likely to change the modelled flood extents around Ross Creek Road and Joses Lane. However, remodelling of the Bonshaw Creek to accommodate for these changes is not recommended. Instead, adjustments to the planning control layers on Ross Creek Road, Joses Lane and the newly constructed road reserve of Figwood Grove can be made.

Due to the uncertainty of the civil works completed at the spillway of Ploughman's Arms Estate and the planning controls on Carthew Road, it is advisable they are maintained but removed from the residential properties.

2.2.3 Representation of waterbodies and roughness assumptions

Not applicable for this submission.

2.2.4 Application and justification of climate change scenarios

Please refer to response in Section 2.1.4.

2.2.5 Model assumptions, limitations and overall fitness for planning purposes.

Not applicable for this submission.



3 CAPABILITY STATEMENT

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- Expert in hydrological and hydraulic modelling;
- Expert witness for drainage and flood related issues at environmental effects panels, planning panels and civil hearings.