

Expert Opinion

Amendment C339ggee Part 2: Flood Controls to the Greater Geelong Planning Scheme

City of Greater Geelong

Panel Hearing

22 May 2023





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| Report Author: | Warwick Bishop |
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1 STATEMENT OF ENGAGEMENT, QUALIFICATION, EXPERIENCE, AND EXPERTISE

I, Warwick Bishop, have prepared this report at the request of the City of Greater Geelong.

I am a Senior Principal Engineer and Director of Water Technology Pty Ltd. I have 30 years' experience as a consulting water engineer.

A copy of my Curriculum Vitae is provided in Appendix A.

The report is prepared as an independent and impartial report.

I have read and understood Planning Panels Victoria Practice Note 1 Expert Evidence and agree to be bound by it.

This report is given independently to assist the Panel in relation to the amendment. I accept my paramount duty is to the Panel and not to any individual party who is liable to pay my fees or otherwise.

I have relied upon many documents in formulating my opinion. A non-exhaustive list of those documents is included in Section 6 of this report.

With my qualifications and experience, I believe I am well qualified to provide an expert opinion in relation to Amendment C339ggee to the Greater Geelong Planning Scheme Part 2: Flood Controls.

I note that Water Technology was engaged by the Corangamite Catchment Management Authority (CCMA) to undertake the investigation "Flood Risk Management Study – Lower Barwon River and Lower Moorabool River", completed in 2019. I had no direct or significant involvement in this previous work.



2 REPORT AUTHOR

Warwick Alistair Bishop

Senior Principal Engineer, Director
Water Technology Pty Ltd
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Qualifications:

- Bachelor of Engineering (Civil) with Honours, University of Melbourne, 1993
- Master of Engineering Science (Water), Monash University, 2000

Affiliations:

- Fellow, Institution of Engineers Australia, Chartered Professional Engineer
- Member, River Basin Management Society
- Member, Society for Sustainability and Environmental Engineering of Engineers Australia
- Member, Stormwater Victoria
- Member, Australian Water Association
- Member, International Association for Hydraulic Research

Area of Expertise

Key areas of expertise relevant to this report are summarised below.

- Assessment of drainage and flood related issues;
- Expert witness for drainage and flood related issues at environmental effects panels, planning panels and civil hearings.

Statement of Expertise

With my qualifications and experience, I believe that I am well qualified to provide an expert opinion on drainage and flood matters relative to Amendment C384 to the Melbourne Planning Scheme.

A copy of my CV is provided in Appendix A.



3 REPORT CONTRIBUTORS

Johanna Theilemann

Senior Principal Engineer
Water Technology Pty Ltd
15 Business Park Drive
Notting Hill, VIC 3168

Qualifications

Bachelor of Engineering (Environmental) with Honours, RMIT University, 2003
Graduate Certificate River Health Management, Melbourne University, 2011

Affiliations

Member, Institute of Engineers Australia
Chartered Professional Engineer
Registered Professional Engineer, Victoria
National Engineers Register

Areas of Expertise

Key areas of expertise relevant to this report are summarised below:
Hydrologic and Hydraulic modelling of Riverine Floodplains
Project Manager of Lower Barwon and Lower Moorabool Flood Investigation
Flood risk and hazard assessments
Flood Emergency management

Scope of Contribution

Johanna assisted in the preparation of the report, including data review and figure preparation, under my supervision.



4 GLOSSARY

| TERM | DEFINITION |
|-------------------------------------|--|
| Annual Exceedance Probability (AEP) | The probability of exceedance of a given discharge within a period of one year. Can be expressed as a percentage (e.g. 1% change in any one year) or 1 in 100 [years] (e.g. a probability of 1 in 100). This report will generally use AEP terminology. |
| Average Recurrence Interval (ARI) | The average or expected period between exceedances of a given discharge expressed in years. This is a another method of expressing the magnitude of a particular event in probabilistic terms (e.g. a “100 year ARI flood” can also be described as a flood with an AEP of “1%” or “1 in 100” or ARI 100 Year). The ARI of a flood event is a statistical estimate that gives no indication of when a flood of that size or larger will occur next. |
| Catchment | The area of land contributing stormwater runoff to a particular site or point under consideration. It always relates to a particular location and includes the catchments of tributary streams as well as the main stream. |
| Consequence | Outcome or impact of an event. |
| Drainage System | A system of gully [street or field] inlets, pipes, overland flow paths, open channels, culverts, and detention basins used to convey runoff to its receiving waters. |
| Freeboard | The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation. |
| Flood | The covering of normally dry land by water that has escaped or been released from [i.e. has exceeded the capacity of] the normal confines of any lake, or any river, creek, or other natural watercourse, whether altered or modified; or any reservoir, canal, or dam. A flood can be caused by excessive rainfall, storm surge, dam break or a tsunami. |
| Flood Frequency Analysis (FFA) | Flood frequency analysis is a technique that uses historical records of annual peak flow data to estimate the probability and magnitude of flood events at specific river locations. It involves calculating statistical information such as mean, standard deviation, skewness, and recurrence intervals, and constructing frequency distributions that show the likelihood of various flows as a function of return periods or exceedance probabilities. |
| Floodplain | A floodplain is defined as the extent of land inundated by the Probable Maximum Flood. |
| Hazard | A source of potential harm. |
| Hydraulic Design | The component of drainage design that involves the determination of velocities, heads and water levels as storm runoff passes through the drainage system. |
| Hydrologic Design | The component of drainage design that involves determination of stormwater runoff, either discharge or volume. |
| Laser Airborne Depth Sounder (LADS) | Laser airborne depth sounding is a means of bathymetric survey that uses a pulsed laser mounted on a fixed-wing aircraft to collect bathymetric survey in coastal waters up to 70 metres in depth and in areas that are too shallow or otherwise navigationally hazardous for standard hydrographic survey vessels. |



| TERM | DEFINITION |
|-------------------------------------|--|
| Light Detection and Ranging (LiDAR) | Is a method for determining levels on a surface with a laser and measuring the time for the reflected light to return to the receiver. It is commonly captured from a plane, helicopter or drone to produce accurate descriptions of topographic levels. |
| Local Authority | Any local or regional external authority—whether government or non-government, including local governments and the State Government—that has a legal interest in the regulation or management of a given activity, or the land on which the activity is occurring, or is proposed to occur. Reference to “the local authority” shall also imply the plural. |
| Local Government | The local city or shire council with jurisdiction over the land in which the activity in question is occurring, or is proposed to occur. |
| Manning's 'n' Roughness Coefficient | A measure of the surface roughness of a conduit or channel to be applied in the Manning's equation. |
| Probable Maximum Flood (PMF) | The Probable Maximum Flood is the flood that can be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. It is derived from the probable maximum precipitation, which is an estimate of the physical upper limit to storm rainfall over a drainage basin. |
| Rainfall Intensity | The rate at which rain falls, typically measured in mm/hour. Rainfall intensity varies throughout a storm. This variation is called a temporal pattern. |
| Risk | The chance of something happening that will have an impact on objectives. It is measured in terms of a combination of the consequences of an event and their likelihood. |
| Runoff | That part of rainfall which is not lost to infiltration, evaporation, transpiration, or depressions in the ground. For the purposes of investigating or studying a flood it is the amount of rainfall that drains along the surface and into the “drainage system” or directly into receiving waters. Local runoff is that which occurs locally to a point in question (i.e. within a lot) and has not yet reached a drainage system. |
| Storm Tide | The total water level from the ocean including the astronomical tide, barometric pressure effect, wind, and wave setup |
| Surface Water or Inundation | Any water collecting on the ground or in an open drainage system or receiving water body. In this report we use these terms to discuss water before it is categorised into flood, stormwater or other. |



5 SCOPE OF THIS REPORT

In relation to Amendment C339 to the Greater Geelong Planning Scheme, I have been engaged to act as an independent expert on flooding and drainage issues relevant to the Amendment.

I have been asked to review the material provided to me and prepare an expert witness statement in respect to Amendment C339 to the Greater Geelong Planning Scheme. Specifically, I have been instructed to:

- Review the materials for the Amendment listed in Section 6;
- Prepare an expert witness statement for the Panel hearing on behalf of City of Greater Geelong; and
- Consider the Planning Panels Victoria Guide to Expert Evidence in preparing my statement for the Panel.

A copy of my instructions is provided in Appendix B.



6 BASIS OF THIS REPORT

This report is based on a review of Amendment C339ggee Part 2: Flood Controls to the Greater Geelong Planning Scheme supporting information and technical reports, including:

- Lower Barwon and Lower Moorabool Flood Investigation, March 2019.
- Bellarine Peninsula Corio Bay Local Coastal Hazard Assessment Inundation Report, December 2015.
- Greater Geelong Planning Scheme.
- Planning Practice Note 12: Applying the Flood Provisions in Planning Schemes, A guide for councils (2015)
- City of Greater Geelong Council Minutes, 28 July 2020, 14 December 2021, 27 September 2022 and 28 March 2023.
- Proposed Controls and Maps for Amendment C339, including:
 - Explanatory Report (not dated).
 - C339 maps (April 2021).
 - Amendments to Schedule to Clause 44.04.
 - Amendments to Schedule to Clause 44.03.
- Relevant guidelines, including:
 - Guidelines for Development in Flood Affected Areas, DELWP (February 2019).
 - Guidelines for Development in Flood Prone Areas, CCMA (Sept 2022)
- Submissions received in respect to Amendment C339 to the Greater Geelong Planning Scheme.

This report has been prepared in accordance with the relevant procedures and practice notes applied by Planning Panels Victoria on Expert Evidence. I have read the “Guide to Expert Evidence” and am aware of my overriding duty to assist the Panel on matters relevant to my expertise.



7 INTRODUCTION

I have been instructed by the City of Greater Geelong Council to provide expert evidence in relation to relevant drainage and flooding matters associated with the proposed Amendment C339ggee Part 2: Flood controls (hereon referred to as Amendment C339) to the Greater Geelong Planning Scheme.



8 BACKGROUND

Amendment C339 seeks to update the flood overlay maps and related schedules within the Greater Geelong Planning Scheme to incorporate the most up-to-date information on flood risk and ensure new or updated developments are designed appropriately, considering flood risk under existing and future conditions. The proposed changes include:

- Amend the Schedule to Clause 44.03 Floodway Overlay to include floodway objectives, statement of risk, permit requirements, applications requirements, and decision guidelines, and renumber the schedule to Schedule 1;
- Amend the Schedule to Clause 44.04 Land Subject to Inundation Overlay to include inundation objectives, statement of risk, permit requirements, applications requirements and decision guidelines, and renumber to Schedule 1;
- Apply the Floodway Overlay Schedule 1 (FO1) and Land Subject to Inundation Overlay Schedule 1 (LSIO1) to properties identified in the Lower Barwon and Lower Moorabool Flood Investigation (Dec 2018);
- Delete the Floodway Overlay (FO) and Land Subject to Inundation Overlay (LSIO) from properties or parts of properties identified in the Lower Barwon and Lower Moorabool Flood Investigation (Dec 2018);
- Amend the application of the Floodway Overlay Schedule 1 (FO1) and Land Subject to Inundation Overlay Schedule 1 (LSIO1) to include all other land currently identified as Flood Overlay (FO) or Land Subject to Inundation Overlay (LSIO).
- Apply the Land Subject to Inundation Overlay Schedule 2 (LSIO2) to properties identified in the Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment (Dec 2015);
- Insert new Planning Scheme Maps 32LSIO-FO and 64LSIO-FO.
- Amend Planning Scheme Maps 15LSIO-FO, 16LSIO-FO, 20LSIO-FO, 21LSIO-FO, 22LSIO-FO, 23LSIO-FO, 24LSIO-FO, 27LSIO-FO, , 29LSIO-FO, 31LSIO-FO, 32LSIO-FO, 36LSIO-FO, 46LSIO-FO, 47LSIO-FO, 48LSIOFO, 49LSIO-FO, 50LSIO-FO, 52LSIO-FO, 53LSIO-FO, 54LSIO-FO, 55LSIO-FO, 56LSIO-FO, 65LSIO-FO, 66LSIO-FO, 67LSIO-FO, 68LSIO-FO, 69LSIO-FO, 70LSIO-FO, 77LSIO-FO, 78LSIO-FO, 79LSIO-FO, 80LSIO-FO, 81LSIO-FO 82LSIO-FO, 83LSIO-FO, 86LSIO-FO and 88LSIO-FO, and;
- Amend the Schedule to Clause 72.03 to include new planning scheme maps in the Greater Geelong Planning Scheme.



9 FLOOD MODELLING ASSUMPTIONS

9.1 Introduction

The following reports supporting the flood overlay map and schedule updates have been reviewed with the key modelling assumptions summarised in the following Section. This relates to the following studies:

- Lower Barwon and Lower Moorabool Flood Investigation, March 2019
- Bellarine Peninsula Corio Bay Local Coastal Hazard Assessment Inundation Report, December 2015

9.2 Lower Barwon and Lower Moorabool River Flood Investigation (Water Technology, 2019)

An overview of the modelling and assumptions within the Lower Barwon and Lower Moorabool Flood Investigation (Water Technology, March 2019) are presented below:

9.2.1 Modelling Methodology

A Direct Inflow approach was applied for the hydrology, with design storm hydrographs extracted from a hydrological (RORB¹) model and using Flood Frequency Analysis. Design flood hydrographs were then introduced to a hydraulic (MIKEFLOOD²) model for the simulation of riverine flooding. The RORB rainfall-runoff model was developed for parts of the catchment (Waurin Ponds Creek and Armstrong Creek) but was not calibrated to any historical streamflow or flood level information as no suitable historical streamflow or flood level information was available within these parts of the study area. A flood frequency analysis was completed for the three key gauges on the Barwon and Moorabool Rivers within the upper reaches of the study area to determine peak flow and volume for the range of modelled design floods.

I consider this method is appropriate and in accordance with industry practice for flood investigations. Overview and discussion on specific methods is provided in Section 10.

9.2.2 Modelling Parameters

Model Software: The 2017 version of MIKEFLOOD was used, which is considered appropriate.

Topography: A 1 m LiDAR dataset captured by the Department of Environment, Land, Water and Planning (DELWP) in January 2017 was processed to remove large depressions in the terrain (i.e. excavation sites during construction; underground car park entrances, etc.). Bathymetry made available from Corangamite CMA was also used in the development of the model. A mesh with variable shape sizes was applied to best represent the ground surface. The two-dimensional (2D) mesh was supplemented with detailed linear features called dike lines, representing roads, channel banks and levees.

These data sources and methods are inline with standard practice for flood studies.

¹ RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce the hydrograph. It was developed within the Water Group, Department of Civil Engineering at Monash University and is widely used by industry across Australia.

² MIKEFLOOD is a one and two-dimensional hydraulic modelling software package, developed by the Danish Hydraulic Institute and widely adopted by industry across the world.



Roughness³: Planning Scheme Land Use zoning was used with standard Manning’s “n” roughness coefficients presented in Table 1 to apply consistent roughness values over the hydraulic model. These values are consistent with standard industry practices.

Table 1 Manning’s “n” Roughness coefficient

| Land Use type | “n” value |
|---|-----------|
| Residential – urban | 0.1 |
| Rural – Agricultural | 0.4 |
| Road – Sealed | 0.02 |
| Road Unsealed | 0.03 |
| Open space – minimal vegetation | 0.05 |
| Open space or waterway – dense vegetation | 0.07 |
| Open space – void of vegetation | 0.03 |
| Open water with submerged vegetation | 0.020 |

Timestep: 1 second for the two-dimensional (2D) timestep⁴ and 1 second for the one-dimensional (1D) timestep. These timesteps are within a range that I would expect for this type of hydraulic model.

Boundary Conditions: The downstream boundary conditions are in the form of constant tailwater levels at the mouth of the river at Barwon Heads. Water levels of 1.56 m AHD and 1.82 m AHD were adopted using the 10% AEP Storm Tide Level and 1% AEP Storm Tide Level respectively. The boundary conditions are applied in a slightly conservative form (constant rather than time varying) however this is common practice in flood studies.

Rainfall Conditions: Australian Rainfall & Runoff 2016 using the Intensity Duration Frequency (IDF) of the centroid of the catchment (for RORB catchments only). This is an appropriate source of rainfall data.

Losses⁵: Initial and continuing losses were applied to the RORB model using Monte Carlo⁶ analysis with variable initial losses as summarised in Table 2. The method used to apportion rainfall losses is considered appropriate.

Table 2 Initial Losses and Runoff Coefficients

| Design Storm (ARI) | Equivalent Design Storm (AEP) | Initial Loss (mm) | Continuing Loss (mm/hr) |
|--------------------|-------------------------------|-------------------|-------------------------|
| 5 years | 18.1% | 6.4 - 12.0 | 3 |
| 10 years | 9.5% | 7.7 - 8.6 | 3 |
| 20 years | 4.9% | 5.8 - 8.5 | 3 |
| 50 years | 2.0% | 6.7 – 12.6 | 3 |
| 100 years | 1.0% | 6.7 - 12.0 | 3 |

³ In a hydraulic model “Roughness” and the “roughness coefficient” represent the hydraulic impact that different types of ground surface (or material) has on overland or pipe flows. For example, a rough surface such as rock, will tend to slow velocities and cause deeper flow levels than a smooth surface such as concrete which will tend to increase velocities and lower levels.

⁴ The computational timestep is the numerical increment on which parameters such as depth and velocity are calculated. Fine resolution models require small timesteps for stability. A 1 second timestep means there are depths calculated every second across the whole model, this results in significant computational effort for models that simulate design floods over hours or days.

⁵ In flood modelling, the losses refer to the amount of rainfall that is not converted to overland flow and hence is “lost”. This includes rain that is intercepted by trees and buildings before it hits the ground, along with rain that infiltrates the soil or is trapped in shallow surface ponds or puddles.

⁶ Monte Carlo analysis is a simulation method that uses random variables to calculate the possible outcomes of a complex system. It is used to predict the effect of uncertainty in losses on design flood predictions.



9.2.3 Model Simulations

The flood model was run for the following design storms and scenarios:

- Historic Calibration scenarios from 1995,2001,2011 and 2016.
- Sensitivity scenarios that adjusted the losses, roughness values, and blocking out of building footprints.
- Design storms (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP flood events and PMF).
- Climate change scenarios for selected AEP including increased rainfall intensities and/or sea level rise.

This range of calibration and design flood simulations is consistent with standard flood study practice.

9.3 Bellarine Peninsula Corio Bay Local Coastal Hazard Assessment Inundation Report, Cardno (2015)

A model overview and assumptions of the Bellarine Peninsula Corio Bay Coastal Hazard Assessment (Cardno, 2015) are presented below.

9.3.1 Modelling Methodology

The modelling for this study was carried out using a mixture of static (“bathtub”) and dynamic modelling. In static modelling, the relevant sea-level, normally the 1% AEP storm tide, plus the relevant sea level rise, is applied to the topography and any area with a land-surface elevation less than the applied sea level is considered as inundated. This is a conservative approach in that it will overestimate the extent of inundation. Static modelling does not include consideration of whether water is able to flow from the ocean into a given locality and does not always include consideration of features such levees. It also does not consider the time it might take for sufficient water to flow into an area to reach the same level as the ocean (given peak sea levels occur for a short time at the peak of the tide). For these reasons, static modelling should only be applied in situations where the inundation is hydraulically simple, the topography is not complicated and the flow paths are short.

Dynamic modelling simulates the movement of water through the environment by accounting for flow paths, resistance to flow of various surfaces and the time variation of sea-level and river flows. Dynamic methods were applied to higher priority locations and where flow paths are more complex. In this study the SOBEK model from Deltares (formerly Delft Hydraulics) was used for dynamic modelling, this is an industry-standard model for flooding and inundation.

9.3.2 Modelling Parameters

Model Version: SOBEK. This is an appropriate tool for flood modelling.

Topography: The topographic and bathymetric data used to generate the models was based primarily on the airborne-laser survey undertaken as part of the Future Coasts program of DELWP. The topography data set utilised LiDAR (2007) and bathymetry was sourced from the LADS (2009). The accuracy and implications for the project of using these data sets are discussed in more detail below. Information on the stormwater drainage pipe network was provided by the relevant local council. Details of the various models, their spatial coverage, grid sizes and inputs are contained in Cardno (2015).

The modelling utilised variable grid sizes ranging from 4 to 40 metres across 9 study areas.

The topographic and bathymetric data sets are considered appropriate for the study.

Model Simulations: The model was run for the 1 % AEP storm-tide case in combination with a number of sea-level rise scenarios to determine the likely extent of inundation. Noting that this amendment is based on the 1% AEP + 0.8 m SLR (Sea Level Rise) Scenario. These scenarios are consistent with those applied in other detailed coastal hazard assessments in Victoria in recent years.



Table 3 Design Storm-tide level (m AHD)

| | 0m SLR | 0.2m SLR | 0.5m SLR | 0.8m SLR | 1.1m SLR | 1.4m SLR |
|--------------------------------|--------|----------|----------|-------------|----------|----------|
| Stingaree Bay to Geelong | 1.03 | 1.23 | 1.53 | 1.83 | 2.13 | 2.43 |
| Portarlington to Point Edwards | 1.09 | 1.29 | 1.59 | 1.89 | 2.19 | 2.49 |
| Point Lonsdale | 1.75 | 1.95 | 2.25 | 2.55 | 2.85 | 3.15 |
| Port Arlington to Point Henry | 1.03 | 1.23 | 1.53 | 1.83 | 2.13 | 2.43 |
| Breamlea | 1.75 | 1.95 | 2.25 | 2.55 | 2.85 | 3.15 |
| Queenscliff | 1.20 | 1.40 | 1.70 | 2.00 | 2.3 | 2.6 |

Uncertainty:

As noted in the Cardno (2015) assessment, this project has some inherent uncertainties that must be Considered. Each assessment has its own uncertainty with the project report providing a comprehensive list of project-related uncertainties which are noted in the Cardno report. The levels of uncertainty and measures applied to address, where possible, these uncertainties are considered appropriate.



10 FLOOD MODELLING AND MAPPING REVIEW CONSIDERATIONS

The modelling techniques applied for the two studies used to inform the amendment are considered appropriate for mapping urban, rural, and coastal design flood extents and the development of planning flood overlays. Discussion on key aspects of the modelling approach for the different areas is provided below.

10.1 Hydrological Modelling Methodology

The models were based on the Australian Rainfall and Runoff 2016 methodology utilising a combination of RORB and FFA inflows.

The flood frequency analysis was undertaken for three gauges within the catchment; Barwon River at Pollocksford, Barwon River at Geelong and Moorabool River at Batesford. The approach included the adoption of annual series records from the respective gauges fitting flows to the range of flood probability models. Sensitivity analysis has undertaken on varying periods of record to understand the impact of storages and limited data.

Comparison of the analysed flows against previous assessment and regional estimates was undertaken and demonstrated a good data fit.

A hydrologic model of the Waurn Ponds Creek catchment was developed to determine design flow hydrographs at several locations within the Waurn Ponds Creek catchment to be used as inflow boundary conditions in the hydraulic model. The rainfall-runoff program, RORB, was utilised for this study. The adopted methodology was based on the 2016 Australian Rainfall and Runoff guidelines at the time. A Monte Carlo method was adopted utilising a probabilistic approach whereby a large number of potential combinations of parameters and catchment conditions are run through the hydrological model to determine appropriate design flow estimates. In this instance 10,000 model runs were simulated, with varying initial losses and temporal patterns, to produce a probabilistic distribution of design flows. This allowed design peak flows for a range of design floods to be determined. A Monte Carlo approach results in less uncertainty than a traditional deterministic approach, as a range of input parameters were considered in the determination of design flows that address uncertainties in the input parameters.

The Waurn Ponds Creek catchment is ungauged, therefore the adopted design flows were validated against a range of other flow estimate methods including regional estimates and an existing RORB model developed by Corangamite CMA (Catchment Management Authority) (2008). Figure 1 shows the resultant peak flow estimates at the gauge locations and at Barwon Heads Road on Waurn Ponds Creek.



| Design AEP (%) | Barwon River at Pollocksford | | Moorabool River at Batesford | | Barwon River in Geelong (McIntyre's) | | Wauron Ponds Creek at Barwon Heads Road bridge | |
|----------------|------------------------------|-------------------|------------------------------|-------------------|--------------------------------------|-------------------|--|-------------------|
| | Peak Flow (ML/d) | m ³ /s | Peak Flow (ML/d) | m ³ /s | Peak Flow (ML/d) | m ³ /s | Peak Flow (ML/d) | m ³ /s |
| 50% | 9,180 | 106 | 3,221 | 37 | 9,999 | 116 | 916 | 11 |
| 20% | 24,063 | 279 | 8,771 | 102 | 25,983 | 301 | 1,643 | 19 |
| 10% | 38,004 | 440 | 14,012 | 162 | 41,559 | 481 | 2,312 | 27 |
| 5% | 54,149 | 627 | 20,071 | 232 | 60,343 | 698 | 3,168 | 37 |
| 2% | 78,702 | 911 | 29,222 | 338 | 90,367 | 1,046 | 4,640 | 54 |
| 1% | 99,568 | 1,152 | 36,926 | 427 | 117,198 | 1,356 | 5,897 | 68 |
| 0.50% | 122,294 | 1,415 | 45,236 | 524 | 147,736 | 1,710 | 7,273 | 84 |
| 0.20% | 155,267 | 1,797 | 57,048 | 660 | 194,022 | 2,246 | 10,014 | 116 |
| PMF | 1,453,594 | 16,824 | 827,971 | 9,583 | 395,615 | 4,579 | 64,714 | 749 |

Figure 1 Design Flows - Lower Barwon and Lower Moorabool Flood Study

10.2 Hydraulic Model Mesh

The hydraulic model utilised a MESH to represent the floodplain surface. The mesh was developed iteratively, starting with a coarse mesh for more efficient modelling (faster runs), with iterative refinements to provide improved connectivity through the various floodplains, accurate flood extents and achieve better calibration. The compromise between run-time and model resolution is key to the model development. The 2D mesh can be supplemented with detailed linear features called dike lines, representing roads, channel banks and levees.

The mesh is developed by digitising essential hydraulic and topographical features by way of polylines and/or polygons, such as waterways, channels, roads, and levees that will dictate the triangulation of elements within the domain. Mesh resolution parameters (e.g. maximum element size) are also defined for specified areas, thereby enforcing finer elements where needed to represent smaller drainage lines and larger elements within Lake Connewarre and Reedy Lake for example. Several linear structures such as roads and levees that had potential to act as hydraulic controls, were added to the 2D domain using “dike” structures. Dikes in the model are polylines that control the flow through specific geometry which can be sampled from the detailed LiDAR information. The location and crest levels of these features were extracted from the LiDAR and overtopping is calculated in the model via weir equations.

The developed model mesh provides an appropriate balance between accuracy and practicality.

10.3 Hydraulic Modelling Methodology.

The approach adopted for the hydraulic model is a 1D/2D MIKE FLOOD coupled model, using flexible mesh and GPU (Graphical Processor Unit) technology. The hydraulic model covers the Lower Barwon River, Lower Moorabool River and Wauron Ponds Creek as well as the surrounding floodplains.

Topography and bathymetry data sets were used to develop the model in either 1D or 2D numerical schemes. Survey of all hydraulic structures impacting flood levels and extents, were included in the model.

The final hydraulic model had the following set-up:

- Moorabool River from the Batesford streamflow gauge to the confluence with the Barwon River is represented a detailed 2D model.
- Wauron Ponds Creek is represented by a 1D branch laterally linked to the 2D floodplain from the upstream boundary of the model to the confluence with the Barwon River.



- Barwon River from Pollocksford streamflow gauge to Shannon Ave bridge is represented by a detailed 2D model.
- From Shannon Ave to the northern part of Connewarre Lake, the Barwon River is represented by a 1D model laterally linked to the the2D floodplain.
- Several hydraulic structures in the floodplain were included in the model via linked 1D branches.
- The mesh was developed iteratively, starting with a coarse mesh for more efficient modelling (faster runs), with iterative refinements to provide improved connectivity through the various floodplains, accurate flood extents and achieve a better calibration. The compromise between run-time and model resolution was key to the model development. The 2D mesh was also supplemented with detailed linear features called dike lines, representing roads, channel banks and levees.

The modelling process involved the following stages:

- Model development and calibration
 - The historical events of November 1995, January 2011, April 2001, and September 2016 were used for calibration and validation process.
 - A review of the current rating curve at Geelong, including comparison to historic and hydraulic model rating curves, which has concluded that the current rating curve is appropriate and suitable for continued adoption across the range of flow rates up to the 1% AEP.
- Sensitivity tests.
- Design flood simulations.
 - 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2%, and PMF.

The calibration, validation and sensitivity assessments were completed using an iterative process and all outcomes from these stages informed the final design flood simulations.

The hydraulic model method is considered appropriate for the purposes of this study.

10.4 Hydraulic Model Calibration

The hydraulic model calibration results demonstrated the ability of the model to represent the flood behaviour within Geelong for the November 1995, April 2001, January 2011, and September 2016 flood events. The modelling demonstrated that the events were quite different in nature with November 1995 being a much larger and more damaging flood.

Modelling identified that the peak flow in the Barwon River in Geelong for the November 1995, April 2001, January 2011, and September 2016 flood events was approximately 1040 m³/s, 322 m³/s, 404 m³/s and 271 m³/s respectively. These flow estimates represent the flow in the Barwon River and the surrounding floodplain at the Barwon River at Geelong (McIntyre Bridge) gauge.

The model results for the calibration and verification floods replicated the observed flood behaviour through the town accurately; this was confirmed by a comparison of modelled to observed flood marks, aerial images as well as previous modelling. The model is considered appropriate for use for design flood modelling and mitigation options investigations.

10.5 Model Outputs

Results were produced for the following design floods (50%, 20% 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1%), producing maximum depth, velocity, velocity x depth, Flood Hazard using AR&R Safety criteria for vehicles, Flood Hazard using AR&R Safety criteria for people and water surface elevations.



Flood Planning layers were adopted in line with the Corangamite CMA delineation requirements which identify the following:

- Floodway Overlay (FO) - 1% AEP flood depths ≥ 0.3 m,
- Floodway Overlay (FO) - 1% AEP high hazard area (velocity ≥ 3.0 m/s)
- Floodway Overlay (FO) - 1% AEP Depth multiplied by Velocity ≥ 0.3 m²/s
- Land Subject to Inundation Overlay is defined by the extent of the 1% AEP design flood (existing conditions) that is not part of the FO.

These outputs are considered to be appropriate to inform the planning scheme amendment.

It is noted that floodplain authorities are starting to incorporate climate change scenarios in flood-related planning layers. The justification for this in large riverine catchments is not clear compared to smaller urban catchment. Hence I believe the approach taken here is appropriate (to use existing conditions hydrology). Sea level rise (incorporating climate change predictions) is taken into account for the coastal inundation modelling within the planning layers. This is also considered appropriate.



11 VICTORIAN PLANNING POLICY

11.1 Land Subject to Inundation Overlay (LSIO) and Floodway Overlay (FO)

The Victorian Planning Practice Note 12, “Applying the Flood Provisions in Planning Schemes - A guide for councils” (2015), outlines the process for incorporating flood related information into planning schemes. This makes the distinction between “mainstream” and “stormwater” flooding. The flood risk information in this amendment pertains to mainstream flooding and hence is appropriate to be represented by LSIO and FO mapping and schedules.

The LSIO and FO mapping defines the inundation extent and floodway area for the predicted 1% AEP riverine flooding along the Moorabool River, Barwon River and Waurn Ponds Creek as defined by the Lower Barwon and Lower Moorabool River Flood Investigation (Water Technology, 2019). The definition of these overlays and the related schedules is consistent with the processes outlined in Practice Note 12.

The use of the LSIO and FO responds to the State Planning Policy, Clause 13.03-1S (20/03/2023) strategies which includes the following:

Identify land affected by flooding, including land inundated by the 1 in 100 year flood event (1 per cent Annual Exceedance Probability) or as determined by the floodplain management authority in planning schemes.

It is appropriate for Council and the CCMA to identify areas prone to flood risk using the latest and best available information and that this should be implemented in the planning scheme.

11.2 LSIO1

The LSIO1 defines areas on the floodplain fringe, within the 1% AEP design flood extent, that are of low hazard and do not meet the criteria for floodway as applied to the FO2 overlay. The LSIO1 applies to areas of floodplain inundation associated with riverine flooding, as opposed to the LSIO2 (described below) which relates specifically to inundation driven by coastal inundation mechanisms. Figure 2 below shows a typical arrangement of LSIO and FO in a floodplain context. This highlights how LSIO applies to the floodplain fringe whilst FO covers the main flow path within the floodplain. In this amendment the LSIO is located where maximum 1% AEP design flood depths are less than 0.3 m and hazard is low.

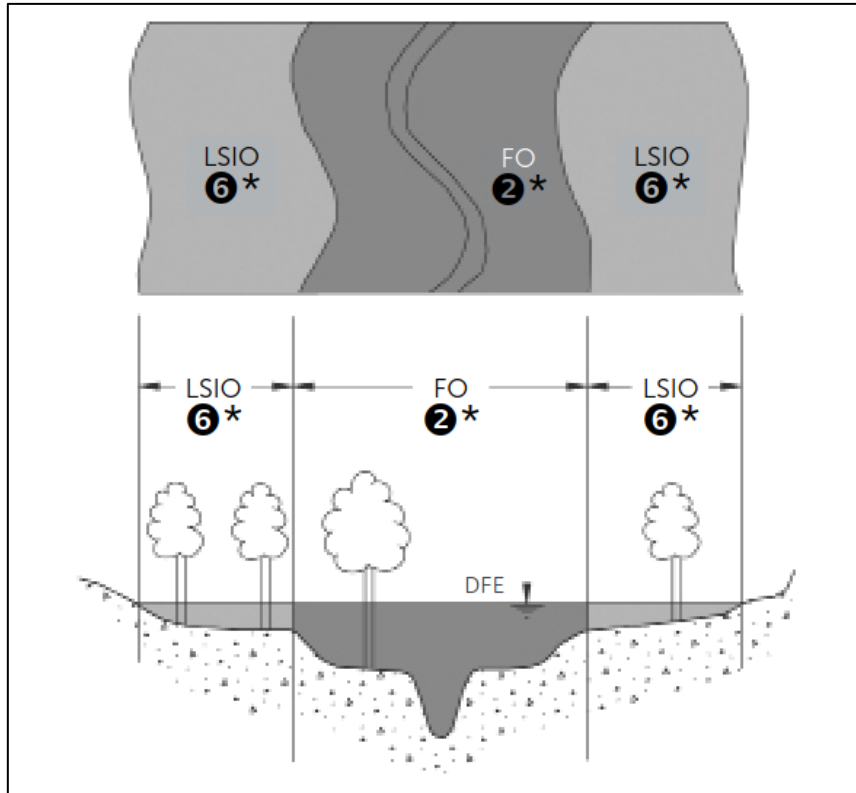


Figure 2 Typical Delineation of LSIO and FO on the floodplain (Source Fig 2.2 from Practice Note 12)

11.3 LSIO2

The LSIO2 is being used to define inundation under a predicted 1% AEP, 0.8 m sea level storm tide by 2100 as defined by the mapping provided by the Bellarine Peninsula Corio Bay Local Coastal Hazard Assessment Inundation Report, Cardno (2015).

In accordance with the C394 Geelong Planning Scheme Amendment the basis of the LSIO 2 includes:

The definition of the LSIO2 is based on the mapping from Cardno (2015) for the 1% AEP storm event with 0.8 m sea-level rise. As stated in the agenda for the Council Meeting of 26 November 2019, some minor changes were incorporated in the mapping. These include the removal of some isolated areas of flooding where there is not an overland flowpath from the ocean and the flooding is due to backflow up the stormwater drainage system. Council are committed to installing backflow-preventing valves on these pipes and hence this flood will be prevented.

The use of the LSIO2 responds to the State Planning Policy, Clause 13.01-2S (20/03/2023) strategies which includes the following:

Plan for sea level rise of not less than 0.8 metres by 2100 and allow for the combined effects of tides, storm surges, coastal processes, and local conditions such as topography and geology when assessing risks and coastal impacts associated with climate change.

and

Ensure that land subject to hazards is identified and appropriately managed to ensure that future use and development is not at risk.

It is appropriate for Council and the CCMA to identify areas prone to flood risk using the latest and best available information and that this should be implemented in the planning scheme.



11.4 FO1

The CCMA has developed the FO1 in conjunction with Council, using the H1 classification:

- Depth of flooding ≥ 0.3 m;
- Velocity ≥ 3 m/s; and
- Depth multiplied by Velocity ≥ 0.3 m²/s

This is a standard definition of flood hazard. I note this is different to the original hazard classification used in the Lower Barwon and Lower Moorabool Flood Investigation (2019), which applied a depth threshold of 0.5 m for flood hazard. Since this time the CCMA has updated the flood hazard criteria they apply to floodplains, based on the hazard criteria published in the Guidelines for Development in Flood Prone Areas (DELWP 2019). The FO mapping included in the proposed amendment was updated to incorporate this revised flood hazard criteria.

Within the planning scheme the purpose of the Floodway Overlay includes:

- *To identify waterways, major floodpaths, drainage depressions and high hazard areas which have the greatest risk and frequency of being affected by flooding.*
- *To ensure that any development maintains the free passage and temporary storage of floodwater minimises flood damage and is compatible with flood hazard, local drainage conditions and the minimisation of soil erosion, sedimentation and silting.*

Hence the two key aspects to be addressed by the FO are:

- Hydraulic function of floodways (conveyance and storage); and
- Flood hazard (safety)

The first point – hydraulic function of floodways – is to ensure that key flow paths and areas of temporary flood storage in waterways and floodplains are protected. This is to ensure that people, places and the environment are not adversely affected, upstream or downstream, by any potential development.

The second point relates more to safety of occupants of the land and their safe access to the land (under flooded conditions).

I consider this second part of the FO to be somewhat problematic in the way it is implemented in the SPPF at present. This is not unique to this amendment or to the Greater Geelong Planning Scheme.

At present the threshold commonly used to define floodway with respect to flood hazard is a maximum 1% AEP design flood depth of either 0.3 m or 0.5 m (H1 or H2 classification as documented in ARR 2019). This reflects the site hazard for existing conditions. In greenfield or undeveloped areas, this reflects the “pre-development” site flood hazard. Where the FO is applied, this appropriately triggers a referral to the relevant floodplain authority to assess development against established floodplain criteria (afflux, access safety etc).

When considering any proposed development, a floodplain authority should consider flood hazard and site/access safety under “developed” (mitigated) conditions. This can be problematic for greenfield sites where feasible and practical mitigation measures exist for areas that are covered by the FO (for example areas of floodplain with 0.5 m depth and low velocity). The FO specifically precludes subdivision that creates lots that are entirely within the FO. Hence it may not be possible to apply for a subdivision that would address and mitigated the hazard that drives the FO in the first place. This presents a “catch-22” situation. In this circumstance it may be necessary to seek a planning scheme amendment to remove the FO before a development proposal can be put forward. This is not an efficient way to manage land-use.



I note that in the proposed schedule the last point describing when a permit is not required says to:

- *Construct any buildings and/or works (other than earthworks) on land that has been filled above the 1% AEP flood level in accordance with the requirements of a planning permit for subdivision, restriction or Section 173 agreement, or other planning permit issued for the land.*

This makes reference to permits for subdivision of land within the FO. The preconditions for this situation are extremely limited due to the restriction on subdivision under this overlay. These items seem in conflict.

Notwithstanding the above, I support the application of the FO1 overlays as presented in the proposed amendment as they should result in an improvement in overall floodplain management outcomes. I consider the issues raised above would only arise in rare cases and are not intractable.

11.5 Victorian Floodplain Management

In 2016, the Department of Environment, Land, Water and Planning (DELWP) released the Victorian Floodplain Management Strategy. This document aims to set the direction for floodplain management in Victoria.

The Victorian Floodplain Management Strategy sets out a systematic approach to evaluating Victoria's flood risks. It also provides a systematic approach to sharing information between the individuals, communities, government agencies and other organisations responsible for managing the various aspects of flood risk. Most importantly, it clarifies which agency is accountable for each aspect of floodplain management.

Relevant to this amendment are the following sections:

Policy 13a The 1% Annual Exceedance Probability flood will remain the design flood event for the land use planning and building systems in Victoria.

Policy 13b The strategic planning framework must give due consideration to flooding and its impacts on land use potential.

Policy 13c LGAs with areas at risk of a 1% Annual Exceedance Probability flood must ensure that their Planning Scheme contains:

- the objectives and strategies for managing the risk in the Municipal Strategic Statement
- the appropriate zone and overlays.

Accountability 13a LGAs are accountable for ensuring that their Planning Schemes correctly identify the areas at risk of a 1% Annual Exceedance Probability flood, and contain the appropriate objectives and strategies to guide decisions in exercising land use controls regarding flooding.

Action 13b The CMAs and Melbourne Water will work with LGAs to ensure that Planning Schemes use the planning controls that align with their flood risks.

The updating of LSIO and FO layers in the Greater Geelong Planning Scheme in accordance with this amendment is consistent with the above policies.



12 SUBMISSIONS


I have responded to issues raised by submissions related to Amendment C339, as relevant to my expertise, in Table 4. Please note that I have grouped similar flooding and drainage issues together, where appropriate.

I understand that 40 submissions were received relating to the Lower Barwon and Lower Moorabool Study area, 2 relating to the LSIO2 (sea level rise inundation), 4 relating to the proposed LSIO and FO schedules, 5 location specific and 4 government Authority submissions.

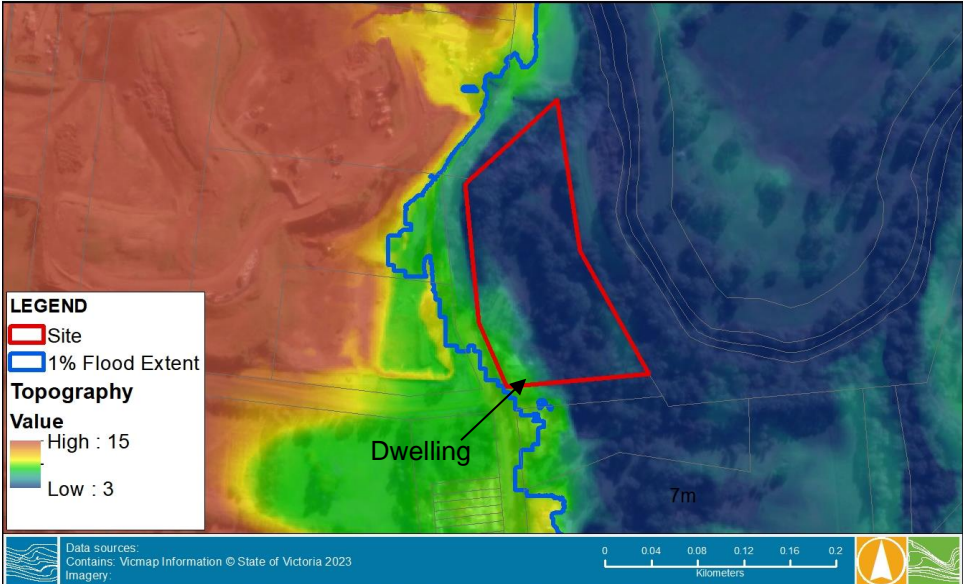

Table 4 Summary of Matters Raised in Submissions

| Concerns Raised | Comments |
|---|--|
| <p>Submitters indicating no prior history of flooding</p> <p>For example, “Lived at current address for 23 years and lake down the road has never flooded my house”</p> | <p>The nature of extreme flooding is that, whilst long-term statistics can often be reliably derived, specific floods are irregular and unpredictable. For this reason, the absence of historic flooding over long periods does not preclude the probability of an extreme flood sometime in the future. While some areas may not have experienced flooding for a long time, others may experience multiple extreme floods over a relatively short period. For example, parts of Central Victoria have experienced two ~ 1% AEP (or 100 year probability) floods over an 11 year period (2011 and 2022).</p> <p>The methods that have been applied to develop the design flood extents are rigorous and appropriate to inform the proposed overlay maps.</p> |
| <p>Submitters raised questions relating to newly developed estates in the Lower Barwon and Moorabool Flood Study area including Fyansford Green and Heights Estate.</p> | <p>The flood modelling undertaken for the Lower Barwon and Lower Moorabool River Flood Study has based on best available information at the time. During 2016 and 2017, when the study was commencing, several developments along the edge of the Moorabool River were underway. As part of approved works, these developments filled some low-lying areas within the floodplain to facilitate safe development. At this time, the filling works had not been completed. As a result, the ground level information on which the modelling is based did not show these areas to have been raised. Hence the modelling showed them to be inundated during the 1% AEP event. It has subsequently been verified that these areas are no longer at risk, with filling activities now completed and the low-lying areas being above the 1% AEP flood level in this area. To reflect this, I understand that Council has removed these areas from the proposed overlay extents. Specific responses to these submissions have been provided in following sections.</p> |
| <p>Submitters identified the potential increase in insurance premiums or difficulty to obtain insurance coverage because of properties now being either designated as flood prone or within an overlay such as the SBO, LSIO or FO.</p> | <p>Implications for insurance premiums should not be a reason to withhold or restrict information on known flood risks. Overall, communities are more resilient to flooding when good flood information is available and planning processes take this into account. Insurers will utilise a range of information to guide their assessment of flood risk. They will seek to use the best available information on flooding, irrespective of whether it is expressed in an overlay.</p> |
| <p>Submitters raised concerns regarding the potential reduction in property values because of the overlay.</p> | <p>Flood related overlays do not dictate land use or sterilise land from potential future development. Underlying flood risk exists regardless of any overlay. I believe it is better for the community and existing or future landowners to have awareness of potential flood risk over their properties, so they can make informed decisions.</p> |
| <p>Application of the proposed LSIO2.</p> | <p>The LSIO2 has been defined through the outputs of a detailed coastal hazard assessment. This study took into account the impacts of sea level rise in accordance with state planning policy. This allows for a minimum of 0.8 m sea level rise in 2100.</p> |

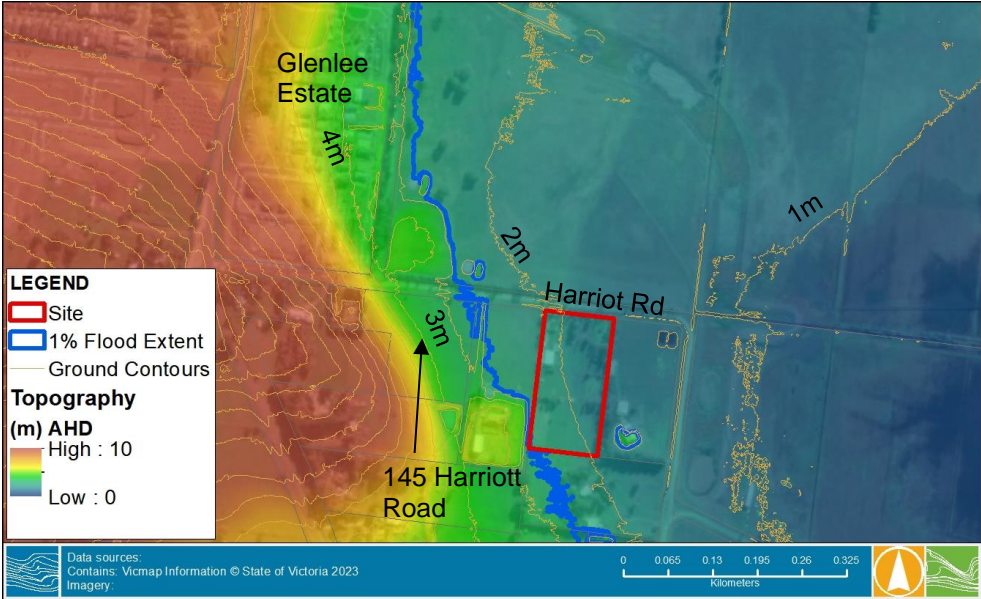


| Concerns Raised | Comments |
|--|--|
| <p>Inappropriate drainage infrastructure & Council's responsibility to upgrade its infrastructure (planning scheme shifts responsibility towards householder and/or future developers)</p> | <p>Piped drainage systems are typically not designed to cater for the 1% AEP design flood. This is standard engineering practice. There is usually a minor drainage system (typically piped) for up to the 10% AEP design storm, with larger flows designed to travel overland, often through the street network. This is only for local drainage. Council drains are not designed to convey mainstream flood flows. Where riverine flooding is predicted to occur through existing residential areas, this is not a failure of the council drains. It is more likely a legacy of prior decisions to build in areas that were not known to be flood prone at the time.</p> |
| <p>Submission 51 – 93 Bailey Street, Belmont. Floodplain on opposite side of creek is lower. Block has never had water on it.</p> | <p>The subject lot slopes substantially from the street east towards the creek. The rear of the property is approximately 1.5 m lower than the frontage. This area is on the edge of the Waurm Ponds Creek floodplain. The Figure below shows the levels at the rear of the property are similar to the low-lying land on the opposite side of the creek. The overlay is a reliable indication of potential flood extent.</p>  <p>LEGEND Site Topography (m) AHD High : 9 Low : 4 1m Contours</p> <p>Data sources: Contains: Vicmap Information © State of Victoria 2023 Imagery:</p> <p>0 0.02 0.04 0.06 0.08 0.1 kilometers</p> |

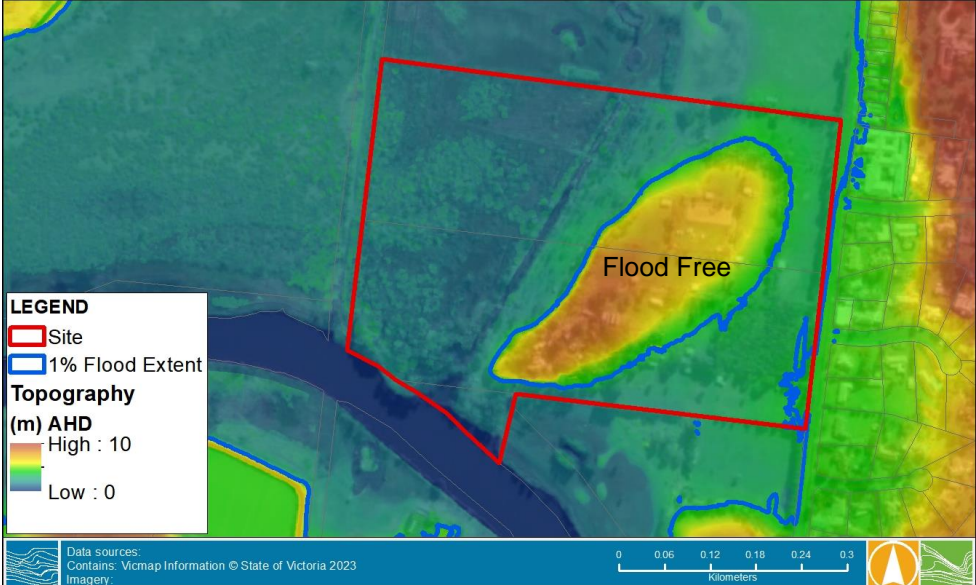


| Concerns Raised | Comments |
|---|---|
| <p>Submission 64 – 45 Lower Paper Mills Rd Fyansford.</p> <p>Property has high ground which has never been flooded (even in the 1995 flood) with a 100 year old Victorian house that has never been flooded.</p> | <p>This property is on the edge of the Moorabool floodplain. Whilst the dwelling (location indicated in the figure below) could be considered to be on the floodplain fringe, the depth criteria determine the land to be within the FO.</p> <p>The overlay will allow for any future planning application to be referred to the floodplain authority and appropriate consideration be given to the flood risk at the site.</p>  |
| <p>Submission 78 - The Heights Estate at 355 Church Street, Herne Hill.</p> <p>Subdivision of land at 355 Church Street, Herne Hill has occurred in accordance with endorsed plans which includes the area of land now proposed for a Flood Overlay. The planning permit for the subdivision of this land was supported by the Heights Development Flood Impact Assessment 2017 developed by BMT WBM. The Assessment determined that the subject land is not flood prone under development conditions.</p> | <p>The Lower Barwon and Lower Moorabool Flood Study was based on topographic survey collected in January 2017. At this time “The Heights” estate had commenced some earthworks, but filling of this area had not been completed. Hence raised ground levels resulting from the development were not incorporated into the hydraulic modelling. The 1% AEP design flood level in this area is around 8.3 m AHD. Approved plans provided to council indicate that ground levels within Salisbury Circuit and the sections shown to be flooded under the exhibited overlay have been raised to at least 9.4 m. The figure below shows the modelled and current topography.</p> <p>Lots within the Heights Estate are now higher than the applicable design flood level and would not be subject to inundation in a 1% AEP design flood. The exhibited overlay does not align with the likely flooding extent at this location. It is therefore appropriate that the mapping be clipped to the extent of filling within the Heights development.</p>  |

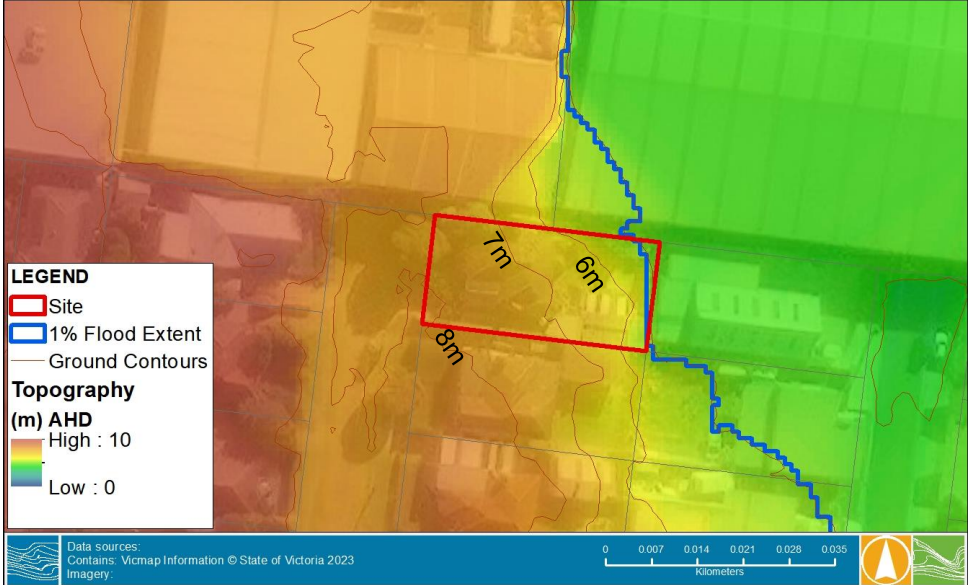


| Concerns Raised | Comments |
|---|--|
| <p>Submission 104 – 1-5 Factories Road South Geelong. Amendment needs to be clearer on the impact of the controls. Inconsistency in permitting fill in other parts of the floodplain.</p> | <p>The Schedules to the overlays essentially reinforce the principles already stated in the planning scheme and floodplain management documents (such as the State Guidelines for Development in Flood Affected Areas). They also provide a list of cases in which a permit is not required. This provides for more streamlined planning and should reduce the number of flood-related referrals to the CCMA. The most significant change is that some areas previously covered by LSI0 have been reclassified as FO. The controls related to FO are very similar to LSI0. The main difference is that sub-division is generally not permitted for areas entirely covered by FO.</p> <p>Historic patterns of fill in different floodplain areas is not directly relevant to the proposed overlays. Where historic filling has occurred, this has been included in the topography and floodplain models. Floodplain management knowledge and practices have evolved over time. Responsible authorities are obligated to apply appropriate floodplain management policies and practices into the future.</p> |
| <p>Submission 124 – 135- 143 Harriott Road Charlemont. 145 Harriott Road has almost been excluded from the LSI01 and F01 and our property is the same elevation as it? Can I have more information on why the line extends where it does, why not follow the road line? The eastern section of Glenlee Estate is the same height as the farming lots on the south side of Harriott Road.</p> | <p>Relatively small changes in ground elevation can have a significant impact on the extent and depth of flooding in a floodplain area. In flat areas, changes in ground levels are often difficult to detect by eye. Whilst the area in question may seem quite flat, the figure below demonstrated there is significant change in ground elevation along Harriott Road. The submission site is all below the 3 m contour, whereas most of the lot to the west is above the 3 m contour. The Glenlee Estate land is higher again, mostly above the 4 m contour.</p> <p>The flood overlays are guided by the flood modelling which follows the topographic contours (blue line in figure below).</p>  |

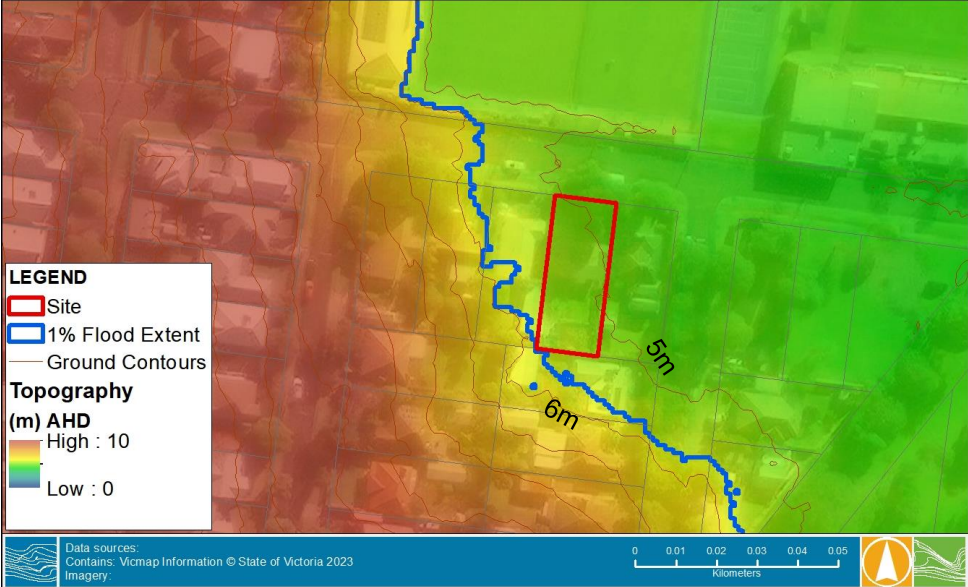


| Concerns Raised | Comments |
|---|--|
| <p>Submission 147, 372-410 Wilsons Road St Albans Park.</p> <p>Do not agree with the area identified as LSIO1 on this property. It is elevated compared to the rest of the property and above the flood level.</p> | <p>The figure below shows colour-shaded topography, with the site outlined in red. This confirms that the area within the relevant lot proposed as LSIO1 on the amendment mapping is above the floodplain. Whilst it is not common for land that is not directly impacted by flooding to be included in a flood overlay, there are instances where this can be justified. Particularly when access to a site that is not flood prone is subject to significant flood hazard.</p> <p>In this instance I consider it is important that any permit application for the site should trigger a referral to the CCMA so that appropriate conditions can be applied that related to safe flood access.</p>  <p>LEGEND</p> <ul style="list-style-type: none">Site1% Flood ExtentTopography (m) AHD<ul style="list-style-type: none">High : 10Low : 0 <p>Data sources: Contains: Vicmap Information © State of Victoria 2023 Imagery:</p> <p>0 0.06 0.12 0.18 0.24 0.3 kilometers</p> |



| Concerns Raised | Comments |
|---|---|
| <p>Submission 152 – 8 Merralyn Street, Belmont.</p> <p>Only a small area of lot is covered by proposed overlays in NE corner. Area is within existing easements on the land and hence can not be built over.</p> <p>Impact of other works/developments on flooding in general.</p> | <p>The figure below shows colour-shaded topography, with the site outlined in red. The topography contours are also shown with levels marked. The applicable 1% AEP flood height at this location is just under 5 m AHD. The figure below shows this site slopes relatively steeply from east to west and most of the site is between 6 m and 8 m AHD, with well over a metre of freeboard above the flood level. The area and depth of flooding in the rear of the lot is minor and is unlikely to have any impact on future development of the lot. The flood overlay(s) on this property could be removed without any detrimental impacts to flood risk management and could potentially save on unnecessary planning referrals in the future.</p>  <p>LEGEND</p> <ul style="list-style-type: none"> Site 1% Flood Extent Ground Contours <p>Topography (m) AHD</p> <ul style="list-style-type: none"> High : 10 Low : 0 <p>Data sources: Contains: Vicmap Information © State of Victoria 2023 Imagery:</p> <p>0 0.007 0.014 0.021 0.028 0.035 Kilometers</p> |

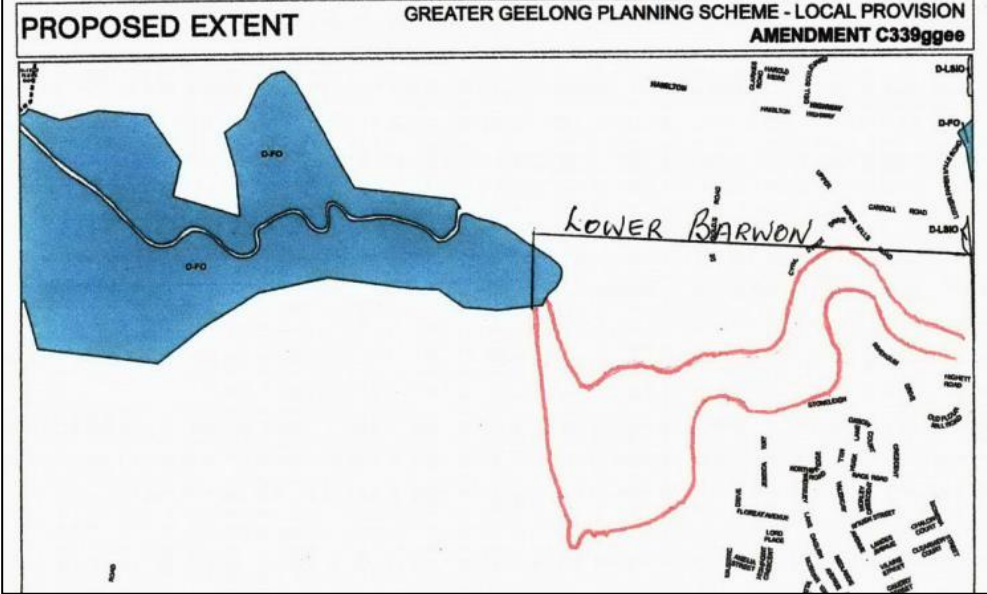
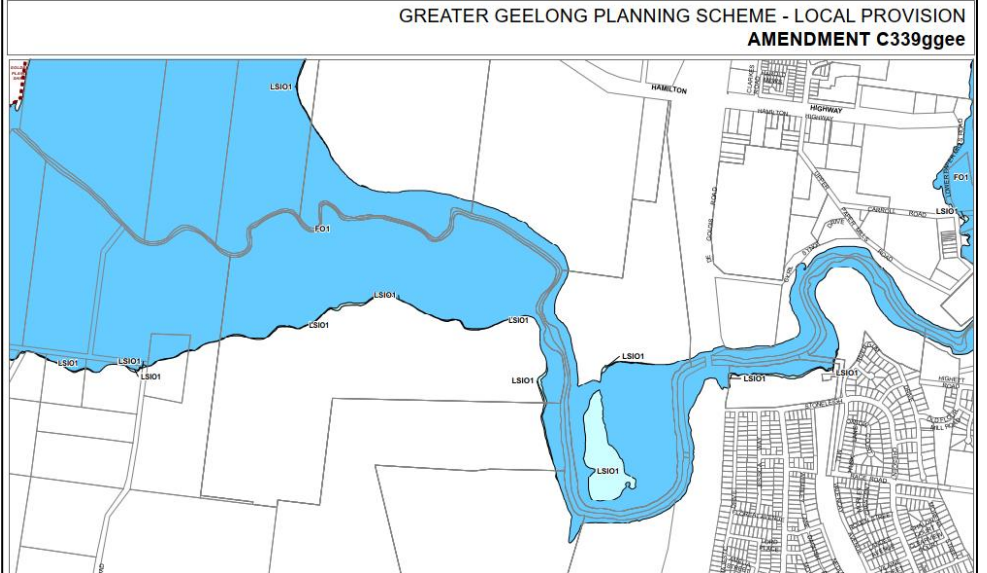


| Concerns Raised | Comments |
|--|--|
| <p>Submission 265 - 7 Sommers Street Belmont.</p> <p>Impacts of vegetation and “greening” on flood mitigation? Why has overlay changed from LSIO to FO1 when extent is the same? Is the application of “worst-case” events to determine overlays used by other planning bodies and appropriate? Overlays will increase cost of property maintenance and insurance. Propose area stays in LSIO1.</p> | <p>The figure below shows colour-shaded topography, with the site outlined in red. The topography 1 m contours are also shown with levels marked. The applicable 1% AEP flood height at this location is around 5.7 m AHD. The figure below shows this site slopes from south to north. The lowest part of the property is at the street frontage, around 4.7 m AHD which would result in maximum flood depths of up to 1 m which places this land in a high flood hazard category. The depth of potential flooding in the street for access to this property reinforces the high hazard.</p> <p>The application of the 1% AEP design flood for planning purposes is entirely consistent with planning policy and practice across Victoria and is the same as that used for other planning scheme amendments. Matters related to flood insurance have been covered in previous sections.</p>  |

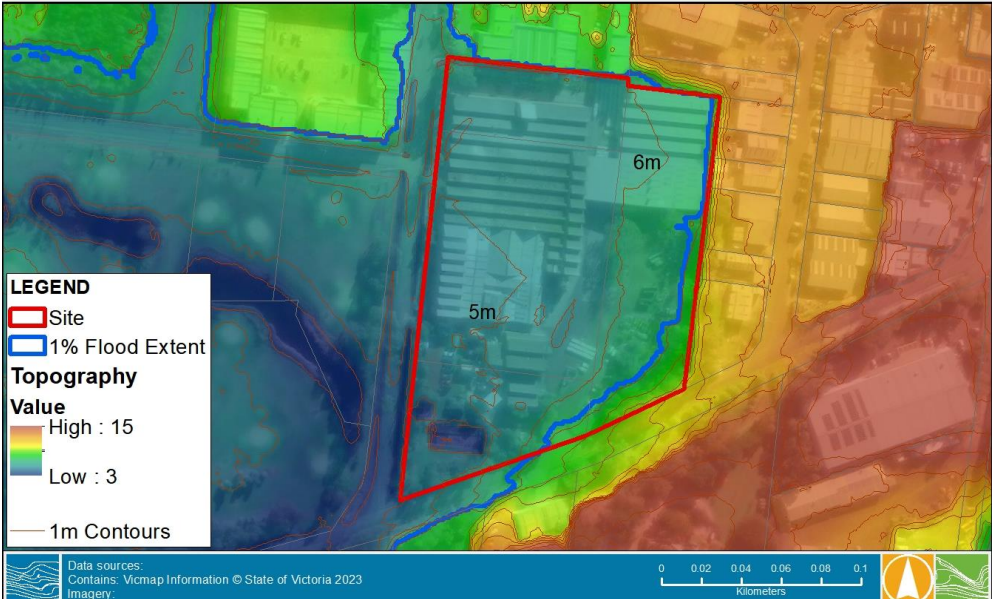


| Concerns Raised | Comments |
|--|---|
| <p>Submission 269 – 12-14 The Parade Fyansford.</p> <p>Seek clarification on the impact of surrounding development on flood levels and mapping.</p> | <p>The Lower Barwon and Lower Moorabool Flood Study was based on survey data collected in January 2017. Ground levels on the subject property are understood to range between 7.1 – 7.6 m AHD. The 1% AEP design flood level and corresponding flood extent on which the overlays are based is around 8.15 m AHD in this area. The topographic data is shown in the figure below, with the site boundary highlighted.</p> <p>At the time of the flood study the “Gen Fyansford” estate had commenced earthworks, but filling of this area had not been completed and fully developed ground levels were not included in the modelling or mapping. A detailed review of construction plans indicates that flood protection works within the estate do not extend to the subject property. The Gen Fyansford estate is filled above the applicable 1% AEP flood level to provide flood protection to all residential lots. Whilst it is acknowledged that the existing flood modelling within this section of the floodplain does not account for filling of the Gen Fyansford estate, the impact of filling is likely to be localised and only provide flood immunity to the areas shown to be filled above the applicable flood level.</p> <p>Having regard to this it is considered that the LSI01 and FO1 extent at this location be clipped to the area of fill within the development. Noting that, as the site has not been filled, the overlay should remain on that land.</p> <div data-bbox="480 835 1453 1294"> </div> <div data-bbox="480 1301 1453 1337"> <p>Data sources: City of Greater Geelong Contains: Vicmap Information © State of Victoria 2020 Imagery: Geelong Imagery 01 OCT 2019</p> </div> |

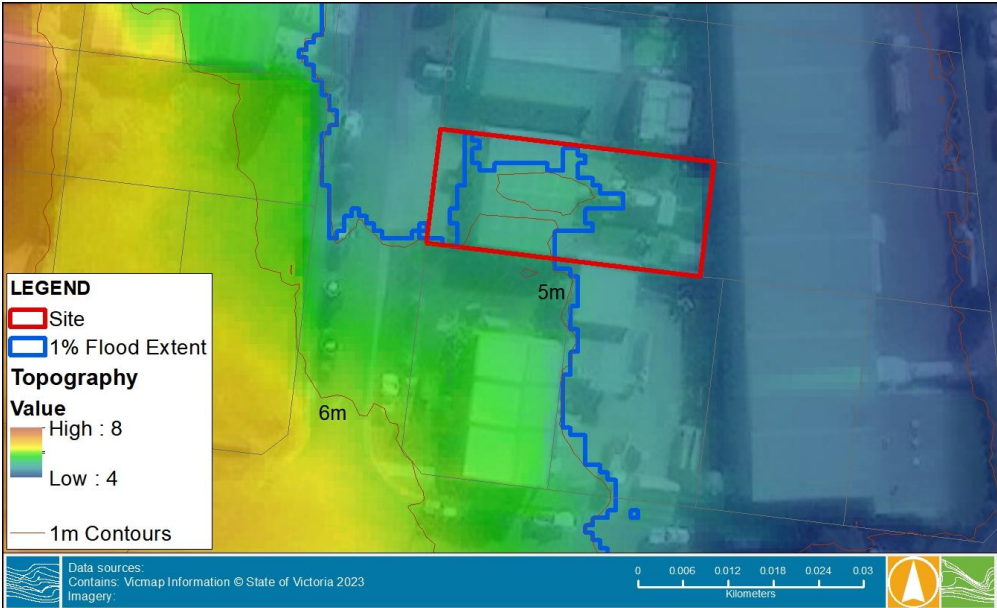


| Concerns Raised | Comments |
|---|---|
| <p>Submission 303 - Ceres. Concern regarding the reduction in flood extent based on experience of previous flooding.</p> | <p>It appears there may have been some mis-labelling of maps and resulting lack of clarity regarding what is proposed in the area highlighted by the submitter. The updated amendment maps show that the existing FO mapped area will be deleted, however it will be replaced by FO1 and LSIO1 areas that cover the area of concern highlighted. This is highlighted in the two figures below.</p> <p>Area of concern</p>  <p>Proposed overlays in this area.</p>  |



| Concerns Raised | Comments |
|---|--|
| <p>Submission 358 - 13 Bridge Street, Newtown. Request that FO1 is not applied to the land and existing overlays are retained.</p> | <p>The figure below shows colour-shaded topography, with the site outlined in red. The topography 1 m contours are also shown with levels marked. The applicable 1% AEP flood height at this location is around 6.8 m AHD. The figure below shows this site slopes down from east to west. Most of the site is below 6 m AHD in elevation, which would result in maximum flood depths of greater than 0.6 m which places this land in a high flood hazard category. The application of the floodway overlay, rather than the land subject to inundation overlay is appropriate.</p> <p>From a practical perspective, apart from the recognition of higher site hazard and limitation on sub-division, the planning requirements for the LSIO and FO are similar. I would not expect the change to FO to have any impact on the development or operational potential of the land. This is determined by the flooding characteristics of the site which are not affected by the change in overlay.</p>  |




| Concerns Raised | Comments |
|--|--|
| <p>Submission 368 - 2 and 2A Tegwen Street Belmont.</p> <p>Land was filled when shed was built and is same level as the property on corner of Park and Tegwen Street (8 Park Street) and higher than Tegwen Street.</p> | <p>The figure below shows colour-shaded topography, with the site outlined in red. The topography 1 m contours are also shown with levels marked. The applicable 1% AEP flood height at this location is around 4.9 m AHD. The figure below shows this site slopes down from west to east. Approximately half the site is above 5 m AHD in elevation, and the rest is slightly below this level. Maximum depths across the site and in the street are generally less than 0.3 m which places this land in a low flood hazard category.</p> <p>The lidar survey suggests the site is slightly lower than 8 Park Street, which explains why the overlay does not extent onto that land.</p> <p>The survey levels used to develop the mapping are derived from lidar data. This is generally quite accurate and is appropriate for flood mapping purposes. There may be small differences between the lidar values and a high-accuracy local survey. If a planning application for the site is made, local detailed survey would be taken into account by the CCMA and Council in the assessment process.</p>  |

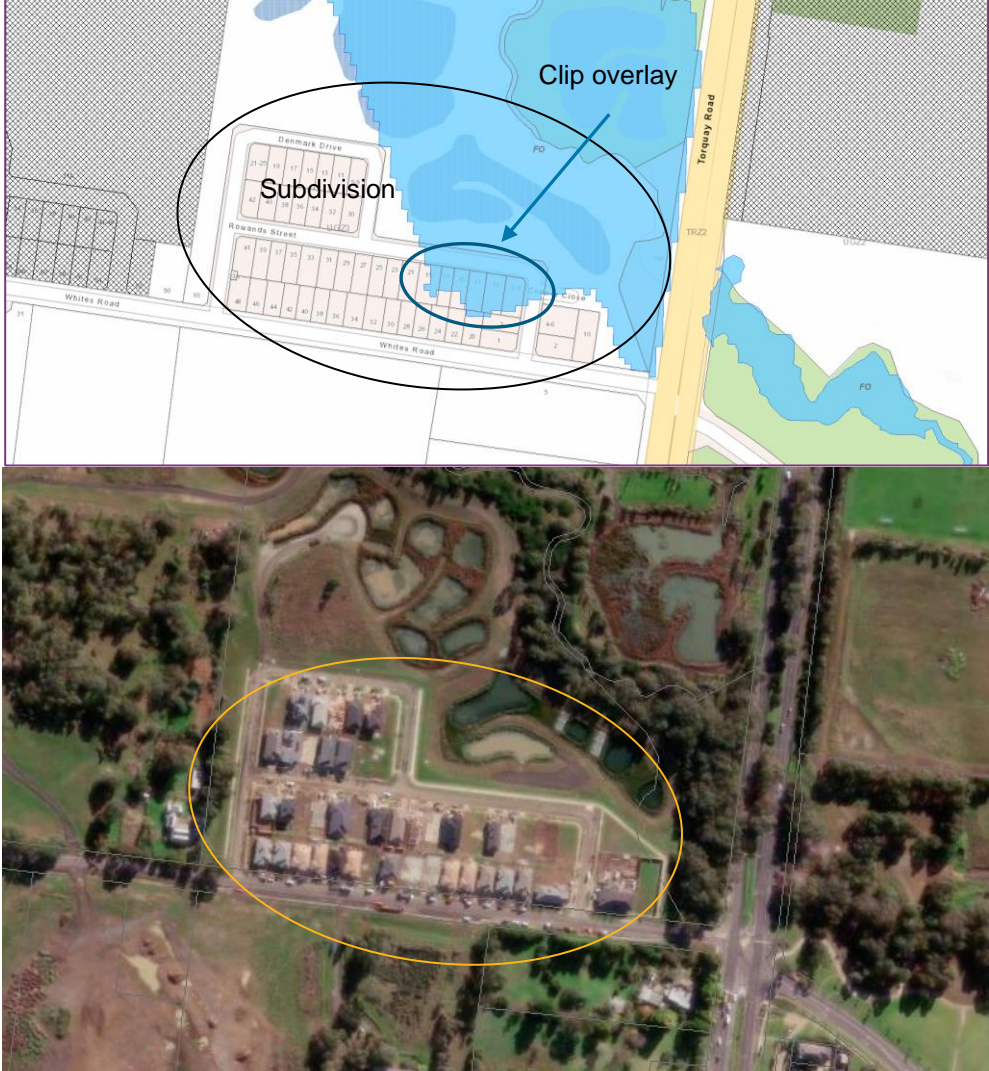


| Concerns Raised | Comments |
|---|---|
| <p>Submission 386 – 167-201 Lower Duneed Road Armstrong Creek.</p> <p>Does the flood level height on the land relate to the Barwon River or poor drainage to the river.</p> <p>Has the downstream development improved drainage?</p> | <p>The segment of overlay that covers this property is shown in the Figure below. This is the same in both the overlays to be deleted and new overlay maps. This area is not associated with any of the recent flood studies that have informed the amendment and the information source for this flood extent is unclear. I note that the site is outside the Armstrong Creek Urban Growth Area. Any future significant development of the land would likely be associated with a rezoning. Future development of the land would provide the opportunity to address and mitigate flood issues with the potential to reduce the area subject to the FO control. For the present, the proposed amendment will not result in any change the existing flooding-related planning constraints on the site.</p> <div data-bbox="491 573 1461 1211" style="border: 1px solid black; padding: 5px;"> <p style="text-align: right;">GREATER GEELONG PLANNING SCHEME - LOCAL PROVISION AMENDMENT C339ggee</p> </div> |
| <p>Submission 434 – 31-33 Salisbury Circuit, Fyansford.</p> <p>Property is not subject to flooding as it is part of a new estate designed to be protected from flooding.</p> | <p>This site is within the same area addressed in Submission 78. See response above.</p> |

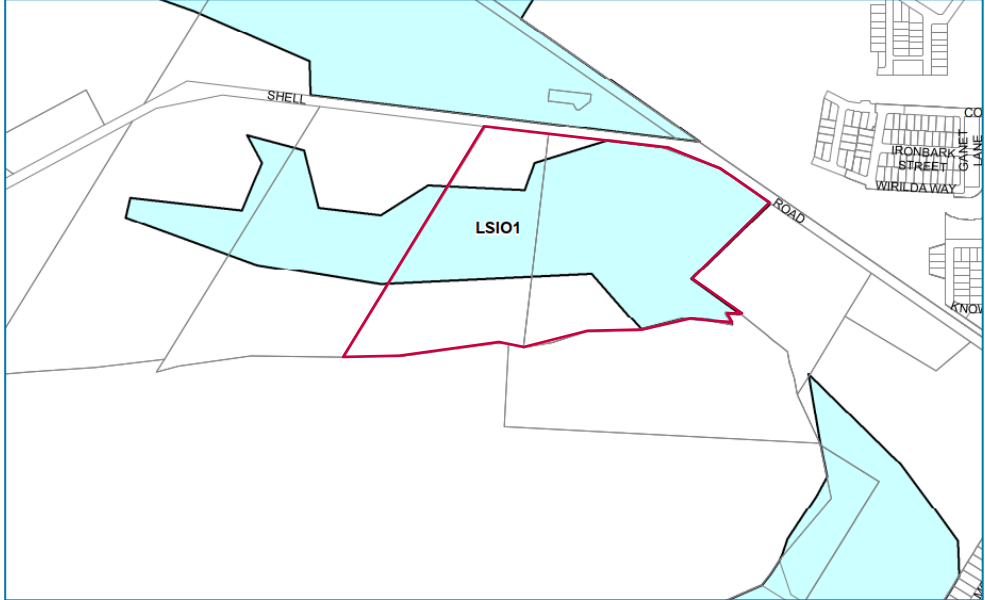


| Concerns Raised | Comments |
|---|--|
| <p>Submission 440 – 32 Monier Way, Fyansford .</p> | <p>The Lower Barwon and Lower Moorabool Flood Study was based on topographic data collected in January 2017. At this time the “Gen Fyansford” estate had commenced earthworks but extensive filling of this area had not been completed. The 1% AEP flood level and corresponding flood extent on which the Land Subject to Inundation Overlay is based is around 8.15 m AHD in this area. It is understood that ground levels within the lowest sections of the estate have now been raised. Approved plans provided to council indicate that ground levels within Monier Way and the sections shown to be flooded in the exhibited C339 overlay have been raised to 9.3 – 9.6 metres AHD along Monier Way.</p> <p>The figure below shows a side-by-side comparison of the existing and flood-study topography, highlighted where the lots have been filled.</p> <p>The Gen Fyansford land levels are now higher than the applicable flood level and the associated residential lots would not be subject to inundation in a 1% AEP design flood. It is therefore recommended that the overlay maps be clipped to the extent of filling within this area of development.</p>  <p>Legend Topography (m AHD) High : 17.615 Low : 1.105</p> <p>Existing Topography January 2017 Model Topography</p> <p>Data sources: City of Greater Geelong Contains: Vicmap Information © State of Victoria 2020 Imagery: Geelong Imagery 01 OCT 2019</p> <p>28/02/2022</p> |

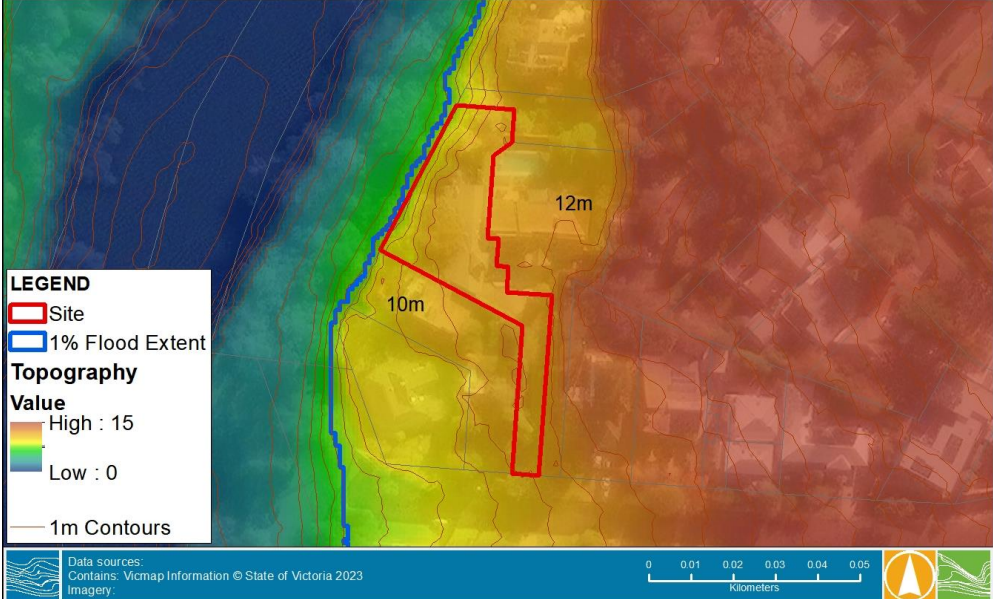


| Concerns Raised | Comments |
|---|---|
| <p>Submission 442 – 10 Whites Road Mount Duneed. Just developed 51 lot subdivision. The land has been filled and should not be covered by the FO1.</p> | <p>The proposed floodway overlay (FO1) covering part of this site is not changed from the present FO within the planning scheme. It is clear from VicPlan data and aerial imagery that the subdivision described by the submitter has been constructed (see figures below). Pending a check to ensure fill levels are appropriate to ensure this area is protected from flooding, the overlay in this area can be clipped to remove the new residential lots.</p>  |
| <p>Submission 455 -9, 11, 13, 21, 23 & 25 Balcombe Road Newtown. Land should be rezoned to residential from UFZ.</p> | <p>As I understand, no objection is raised to the proposed LSIO1 and FO1. The re-zoning of the land from UFZ to a residential zone (or any other zone change) is not part of this amendment as I understand. From a floodplain management perspective I agree that UFZ does not appear to be an appropriate control to apply to the filled land along Balcombe Road.</p> |



| Concerns Raised | Comments |
|--|---|
| <p>Submission 469 – 592-670 Shell Road Point Lonsdale.</p> <p>Overlay shape does not follow the natural contours of the land.</p> | <p>The area in question is displayed in the figure below, showing the proposed LSIO1 overlay. Whilst the shape of the inundation area has been simplified (by “blocking” with straight lines), the area is generally consistent with the predicted inundation extent shown in the Bellarine Peninsula - Corio Bay LCHA (Cardno 2015).</p> <p>The purpose of flood-related overlays is to trigger referral to the appropriate floodplain management authority when an application for development is made. This process would then require the specific topographic details of the site to be taken into account. One of the application requirements specified in the proposed schedule to the LSIO1 is for:</p> <p><i>“Relevant ground levels, to Australian Height Datum, taken by or under the direction and to the satisfaction of a licensed surveyor.”.</i></p> <p>I therefore consider the proposed overlay covers an appropriate area to allow for the necessary referral process to occur and that sub-lot scale details of the flood extent are not necessary and can be determined as part of any future development application. In the case where more finely resolved map extents are provided in the overlay, the confirmation of levels and flood extent at the planning application stage is still required.</p>  |



| Concerns Raised | Comments |
|---|--|
| <p>Submission 492 – 110 Camden Road Newtown. Never seen flooding in 44 years. Only a small portion of the site is covered. Should be removed from overlay.</p> | <p>The figure below shows colour-shaded topography, with the site outlined in red. The topography 1 m contours are also shown with levels marked. The applicable 1% AEP flood height in the Barwon River at this location is around 7.3 m AHD. The figure below shows this site slopes down from east to west. The site is elevated on high ground above the river. The majority of the site is well above 9 m AHD in elevation. There is an insubstantial line of land along the western boundary the slopes steeply down and is close to the flood level. The access to the site from the south is also many metres above the flood height. It would be appropriate to remove this lot entirely from the flood overlay.</p>  <p>LEGEND Site 1% Flood Extent Topography Value High : 15 Low : 0 1m Contours</p> <p>Data sources: Contains: Vicmap Information © State of Victoria 2023 Imagery:</p> <p>0 0.01 0.02 0.03 0.04 0.05 Kilometers</p> |



Submission 562 - 40-70 Windsor Road, Newtown.

The application of the FO1 as proposed would prohibit any future subdivision of the land, which is considered unduly restrictive. Key concerns include:

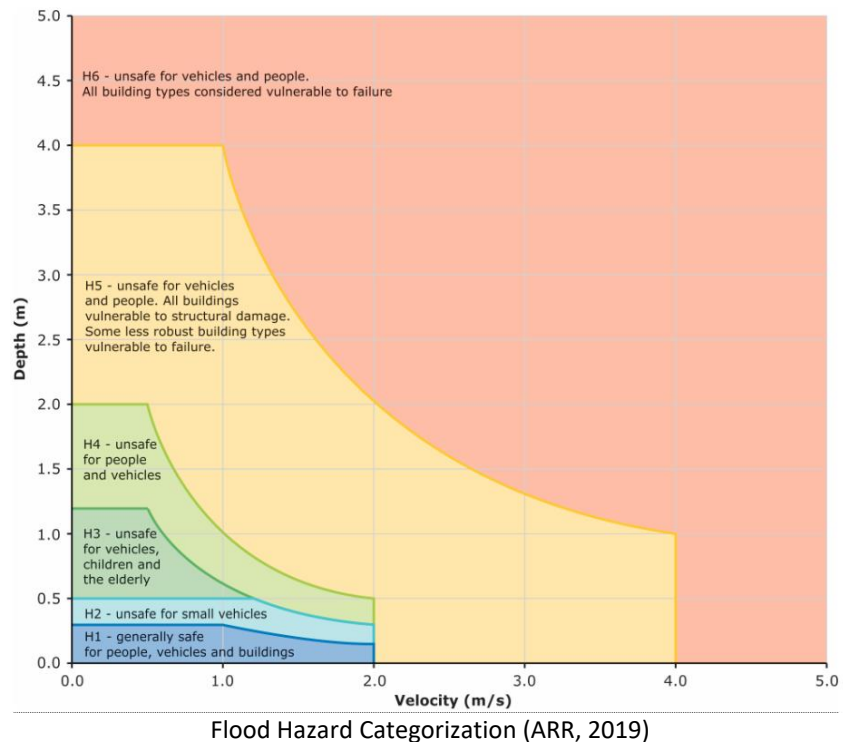
- The potential technical discrepancies, as per Lara flood study
- The disparity between evidence identifying the site as an area of flood fringe in c.1998 and the new interpretation of data which categorises it as a high risk floodway, noting that the 1% AEP from the previous studies is essentially the same.
- The discrepancy between the proposed reduction in extent of the LSIO immediately to the north of the subject site and the proposed introduction of the FO1, indicating a higher flood risk to the submitter.

Concerns raised in relation to the potential technical deficiencies in relation to the study as per the Lara Flood Study are not well founded. The Lara Flood Study was not abandoned. Rather, the Lara portion of amendment C339 was abandoned primarily due to challenges with the community engagement related to the number of properties impacted by flooding in that area. The Lower Barwon and Lower Moorabool Flood Study is an independent study that has been peer reviewed and applies a methodology which is consistent with industry best practice. It is endorsed by the CCMA and Council and is entirely appropriate and fit-for-purpose to inform flood-related planning overlays.

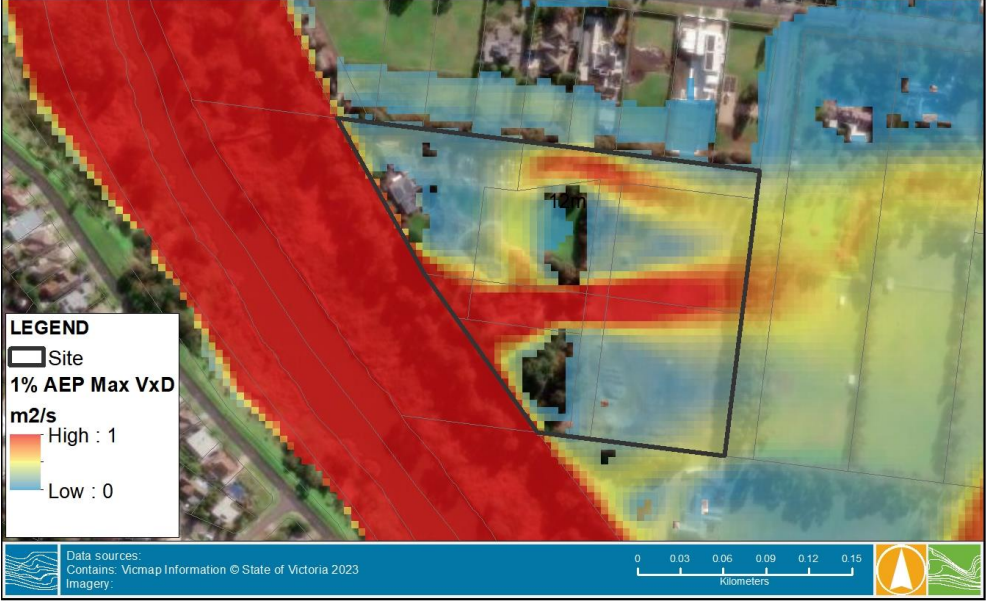
The Lower Barwon and Lower Moorabool River Flood Study is considered to be the best available flood information for the Barwon River. This information supersedes previous studies, mapping and advice including any definition of flood fringe from 1998. The definitions under which flood overlays define high risk areas have changed since 1998. Current delineation of FO and LSIO relies on the use of updated hazard criteria which was revised as part of the update to Australian Rainfall and Runoff Guide to Flood Estimation in 2019. The hazard categorisations establish thresholds related to vulnerability (see figure below). These thresholds are determined based on both depth and velocity of floodwaters. Within this amendment the H1 category has been used to define the LSIO areas, with the FO based on flood hazard categories H2 and above. This approach is accepted and used by several Catchment Management Authorities and Councils. The Figure below shows mapped hazard across the site which highlights the significant flood conveyance through the property related to the floodway classification.

Available 1% AEP flood information for the subject property at 40-70 Windsor Road, Newtown indicates that flood depths range between 0 and 2+ metres, with much of the site and its access inundated by depths above 1.0 metre. Modelled peak flood flow velocity varies across the site, with most areas experiencing velocities of less than 1m/s under 1% AEP design flood conditions.

The change (reduction) in flood classification to the north is not a discrepancy. This is related to permitted filling of this part of the floodplain which occurred in the last 20 years. It is desirable that current flood studies and mapping take into present conditions that reflect the current flood risk in order to best inform future floodplain management.





| Concerns Raised | Comments |
|-----------------|--|
| |  <p>LEGEND Site 1% AEP Max VxD m2/s High : 1 Low : 0</p> <p>Data sources: Contains: Vicmap Information © State of Victoria 2023 Imagery:</p> <p>0 0.03 0.06 0.09 0.12 0.15 Kilometers</p> |

Flood Hazard across Site (WT, 2019)



■ CONCLUSIONS

With respect to the proposed Amendment C339 to the Greater Geelong Planning Scheme and surface water management issues, I make the following conclusions:

- The models, input data, methods and assumptions applied in the constituent flood studies that have informed the overlay maps are considered appropriate for the proposed amendment.
- The adopted sea level rise and rainfall intensity value assumptions applied to the flood studies are appropriate for a 2100 planning horizon in the coastal inundation area.



13 DECLARATION

I confirm the following:

The factual matters stated in this report are, as far as I know, true;

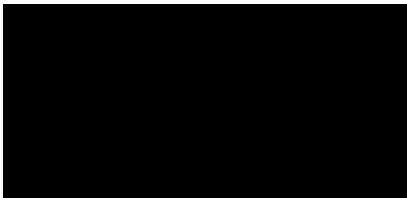
I have made all enquiries that I consider appropriate;

The opinions stated in this report are genuinely held by me;

The report contains references to all matters I consider significant; and,

I understand my duty to the Panel and have complied with that duty.

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.



Warwick Bishop
Senior Principal Engineer and Director

WATER TECHNOLOGY PTY LTD

22 May 2023





APPENDIX A CURRICULUM VITAE



PROFESSIONAL HISTORY

| | |
|-----------------|---|
| 2009 to present | Director, Senior Principal Engineer, Water Technology Pty Ltd |
| 2003-2009 | Senior Engineer, Water Technology Pty Ltd |
| 2001-2003 | Victorian Water Resources Manager, Lawson and Treloar Pty Ltd |
| 1997-2001 | Senior Engineer, Lawson and Treloar Pty Ltd |
| 1993-1997 | Engineer, Lawson and Treloar Pty Ltd |

SPECIALIST AREAS OF EXPERTISE

- Wetland, WSUD and water quality investigations
- Surface water investigations of urban and rural floodplains, rivers and wetlands
- Modelling of flooding, environmental flows, water quality and sediment transport
- Urban flood mapping, flood mitigation and stormwater treatment
- Integrated Water Management
- Investigations of estuary and coastal hydraulics
- Expert witness reports

RECENT MAJOR PROJECTS

STORMWATER PROJECTS (FLOODING, DRAINAGE AND WSUD) WATER TECHNOLOGY

Glen Eira WSUD Opportunities – Project director for an options study looking at the potential effectiveness of WSUD measures for flood mitigation. A local case study was undertaken with preliminary hydrologic and hydraulic modelling.

PNG LNG Condensate Fate Modelling – Project Director for hydrologic and hydraulic assessment of potential condensate spill scenarios for Gas Pipeline Development. One and two-dimensional models as well as mixing zone calculations were performed.

Buckland Park Development, Lower Gawler River – Detailed hydraulic investigation of a large new residential area in a floodplain environment. Development of flood mitigation measures including levees and channels.

Inverloch, Broadbeach Resort – Management of flooding issues related to a coastal development on the South Gippsland Coast. Hydrodynamics of the ocean, estuary, creek and township drainage systems have been taken into account to develop an overall flood risk assessment and appropriate land development level. Also included full drainage and WSUD design for the development.

Hoppers Lane (Werribee) – Development of a surface water management strategy for a mixed-use development including full WSUD treatment.

Keysborough South – Development of surface water management strategy for a large residential rezoning. This strategy has been adopted by Melbourne Water as input to their drainage scheme.

Stamford Park – Floodplain and wetland design for an industrial development adjoining a community park area for Knox Council.

The Strand Traralgon – Development of surface water models and WSUD design (wetlands) to provide treatment for a challenging site, constrained by existing drainage infrastructure and major easements.

Ocean View Lakes Entrance Stormwater Management Plan - Project director for development plan for a residential subdivision. Included design of wetland systems and retarding basin controls.

Cowes WEMP – Project Director in the development of a Water Efficiency Management plan for development in Cowes, use of probabilistic rainfall model PURRS.

Darebin Creek –1d Model (HEC-RAS) construction of waterway and analysis of bridge level assessment for Darebin Creek. Project Director.

Azola Waters, Pakenham – Functional design of Wetlands system for retirement village. Ongoing water quality assessment using various monitoring equipment. Project Manager/Director.

Cuttriss Street Flood investigation, Inverloch – Use of Mike Storm Pipe (Mouse) and two-dimensional (Mike21) linked model for urban storm water flooding. Project Director.

Brookfield Lakes, Bairnsdale, Stormwater Management Plan - Development plan for residential subdivision. Included design of wetland systems and retarding basin controls. Project Director.

Donga Road main drain catchments drainage study (City of Greater Geelong) - GIS analysis and hydraulic modelling of urban floodplain. Use of TUFLOW as predominate 2d/1d modelling package. Project Director.

STORMWATER PROJECTS (FLOODING, DRAINAGE AND WSUD) LAWSON AND TRELOAR

Sanctuary Lakes Water Quality – Management of a detailed water quality investigation including complex eutrophication modelling of the large lake system and analysis of the upstream wetlands

Sandhurst Estate – Management of hydrologic, hydraulic and water quality investigations for a large residential and golf course development in Melbourne's SE. This investigation included two-dimensional hydraulic analysis, a dynamic-pump system for lake top-up and eutrophication modelling in order to predict future water quality impacts.

Knox Golf Course – Development, calibration and application of a detailed MIKE 21 model of Monbulk Creek/Ferny Creek floodplain to assess flood impacts of a proposed golf course.

Oyster Cove Development, Coomera River QLD – Development of detailed MIKE 21 sub-models to calibrate roughness over residential developments.

Nerang River Floodplain – Major involvement in the development and application of a large, detailed 2-dimensional model of the Nerang River Floodplain. Analysis of impact of developments on flooding and investigation of mitigation options.

Heritage Golf and Country Club – Development of a MIKE 11 model to assess flood conditions in the Yarra River floodplain for design input.

Graceburn Creek, Healesville – development and application of a two-dimensional numerical model of a floodplain for risk assessment, regarding a proposed development. Believed to be the first application of two-dimensional hydraulic modelling on a floodplain in Victoria (1994).

FLOODPLAIN INVESTIGATIONS WATER TECHNOLOGY

Project Director for a hydraulic modelling study of the Pike River floodplain (SA MDB NRM Board). Development and calibration of a MIKE FLOOD model of the floodplain and use to inform the concept design of environmental regulators.

Project Director for a hydraulic modelling study of the South Australian Katfish Demonstration Reach (DEH). Development and calibration of a MIKE FLOOD model of the floodplain. This model was used to test a number of management scenarios.

Lyndhurst Drainage Strategy - Project Director of modelling waterway works for design of Retarding basins and wetlands for the Lyndhurst drainage scheme. Innovative use of linear waterways/wetlands for storage using two-dimensional hydraulic modelling.

Chowilla Floodplain Hydrodynamic Model – Supervision of the provision of detailed modelling services for this important floodplain system on the Murray River in South Australia, near the Victorian/NSW Border.

Port Fairy Flood Regional Study – A comprehensive review of flood risk to the township of Port Fairy and surrounding areas was undertaken. This included detailed hydrologic and hydraulic modelling, mapping and flood damages analysis. In addition, an extensive investigation of the potential impacts of climate change was undertaken.

Boggy Creek Wetland Review – Hydrologic and hydraulic review of translocated high-value wetland plots in Seaford adjacent to major road development. Working with ecologists to determine appropriate hydrologic regime.

Swan Hill Levee Audit – Investigation of the status of the existing town levee around Swan Hill through the use of a detailed two-dimensional hydraulic model. Assessment of levee system performance and recommendations for future flood mitigation works.

Beaufort Flood Study – Management of a comprehensive hydrologic and hydraulic study of the Beaufort township including investigation of 4 creeks that flow through the town. Resolution of complex design hydrology inputs to the township.

Dennington Flood Study – Detailed two-dimensional hydraulic model developed to describe inundation of the Merri River floodplain and provide planning information for future growth area near Warrnambool in south-west Victoria.

Applying Modelling Tools to Investigate Water Management in the Gunbower Forest – Project manager for the development of a detailed hydraulic model of Gunbower Forest. The model has been calibrated against a number of historic flood events and will be used to assess the effectiveness of a number of potential water management options. These options seek to improve the flooding regime of the forest through the use of environmental flow allocations. The required flooding is determined through a set of ecological objectives. Working closely with ecologists to determine hydrologic regime.

Hydraulic Modelling for Lindsay, Mulcra and Wallpolla Islands – This project involves the development of a linked one and two-dimensional model of these important floodplain and wetland environments that are included as one of the significant environmental assets or “icon sites” along the Murray River. This area has significant environmental values that suffer from reduced flooding due to river regulation. The hydraulic model will be used to test different management scenarios for floodplain improvement.

Murray River Regional Flood Study – Cobram to Tocumwal – Specialist modelling input is being provided for this project with an extensive one and two-dimensional model being developed including the Murray River channel and floodplain. The study area features many man-made controls such as levee banks and irrigation supply channels that dominate the topography. Once established the modelling will be used to develop flood management scenarios on a regional scale.

Investigations into Preferred Water Management Options in Gunbower Forest, 2D Modelling - Project management of the hydraulic modelling of the impact and effectiveness of proposed management options to improve watering of the wetlands and floodplain within Gunbower Forest.

Glenelg Hopkins CMA Rural Drainage Areas, Water Quality Impact Studies – Hydrologic and water quality analysis of four rural drainage areas specifically to examine the impacts of rural drainage on stream health of the main receiving waters.

Living Murray Hydraulic Investigation, Environmental flow for Barmah Millewa Wetland System – Project and technical management of this significant study within the Murray River system. The project involves the development and calibration of a detailed one and two-dimensional hydrodynamic model of the Barmah Millewa Forest for the purposes of determining the impact and effectiveness of various environmental flow management scenarios.

Lower Gawler Flood Mitigation Study – Detailed hydraulic modelling of the Lower Gawler River floodplain to investigate the effectiveness of various flood mitigation measures. A combined one and two-dimensional hydraulic model was employed.

Scoping Study for Best Management Options for Rural Drainage, Eumeralla and Nullawarre Drainage Areas – Major rural drainage study covering some 18,000 Hectares in south-west Victoria. Processing of ALS/Lidar survey data to assist in detailed hydrologic and hydraulic modelling. Investigation of water quality and environmental impacts of drainage practices and options for implementation of best management practices.

South Warrnambool Flood Study – Management of an urban hydraulic and flood mapping study of a major coastal township. Integration of a variety of survey data sources and a development of a two-dimensional hydrodynamic model.

Geelong Bypass Hydrology and Hydraulics – Management of the investigations of waterway requirements for this major freeway planning study. Numerous crossings analysed with a variety of techniques ranging from simple one-dimensional to fully two-dimensional models.

FLOODPLAIN INVESTIGATIONS LAWSON AND TRELOAR

Point Roadknight Drainage Investigation – Development of a detailed pipe and overland flow model for the assessment of flood extents and investigation of potential mitigation options.

Lake Burrumbeet and Burrumbeet Creek Floodplain Management Plan – Project and technical management of a comprehensive hydrologic and hydraulic modelling study. Assessment of economic, social and environmental impacts also determined.

Morambro Creek Surface Water Allocation – A rigorous hydrological approach was applied to a large catchment in south-east SA utilising a spatially distributed, GIS based hydrologic Model (SWAT). The results will be used in determining future allocation of water rights in the catchment.

Glass's Creek and Bell Street Flood Mitigation Studies – Detailed hydrology and hydraulic modelling has been undertaken in order to develop appropriate mitigation strategies for two densely developed urban areas in Melbourne. The two-dimensional overland flood models are coupled with detailed pipe network modelling to provide a robust and accurate analysis tool.

Princes Freeway (Pakenham Bypass), Cardinia Creek Crossing – Detailed hydrologic and hydraulic investigation of a proposed crossing of a particularly sensitive creek environment was undertaken. This involved fine-grid two-dimensional modelling.

Little Lang Lang River Waterway Mapping – A combined one and two-dimensional hydrodynamic model of this rural catchment was developed and results integrated into Melbourne Water's GIS system.

Albury-Wodonga Bypass Hydrology and Hydraulics – Development of a detailed two-dimensional hydraulic model for the assessment of alignment options. The development of detailed hydraulic performance criteria for alignment assessment was also undertaken.

City of Kingston, Flood Mitigation Assessment – Detailed flood modelling of various mitigation options. Utilising local catchment hydrologic and hydraulic models requiring detailed assessment at the block level combined with complex pump systems.

Breakwater Road Hydrology and Hydraulics – Review of hydrology and detailed hydraulic modelling of a proposed crossing of the Barwon River floodplain. An innovative hydraulic design was necessary in order to provide zero afflux within this sensitive floodplain area.

Shepparton Floodplain Management Investigation for Shepparton City Council – Project management of the hydraulic modelling aspects of the largest rural township flood study undertaken in Victoria.

Princes West Project - Detailed hydrologic and hydraulic assessment of the existing status of the Princes West freeway between Melbourne and Geelong via VicRoads. Crossing upgrades were designed for varying levels of immunity and various configurations.

Data Consistency Project Stages 7-10 – These projects involved detailed one and two-dimensional urban flood modelling of stormwater surcharges from the various main drain systems.

City of Kingston – Flood Mapping of various locations to supplement Melbourne Water Mapping. Development of local catchment hydrologic and hydraulic models requiring detailed assessment at the block level.

Data Consistency Project Stage 6 – This project involved detailed two-dimensional urban flood modelling of stormwater surcharges from the main drain system. This work formed a pilot study in which Melbourne Water were able to evaluate the benefits of applying two-dimensional modelling to urban areas.

Tambo River Geomorphic Investigation – The 1998 Tambo River event caused significant damage in the floodplain. Specialist two-dimensional hydraulic modelling was undertaken as part of an integrated study approach considering flooding, longer term geomorphological processes and potential waterway management options.

Tuppal and Bullatale Creek Flood Study – Development and calibration of an extensive model of the Tuppal/Bullatale Creek system as well as the Murray and Edward Rivers between Tocumwal and Deniliquin. This model was set-up for the subsequent analysis of floodplain management options through DLWC (NSW).

Strathmerton Route Investigation – Development and calibration of hydraulic models (ranging from steady state backwater to full two-dimensional unsteady models) for subsequent hydraulic design. Both Murray River and floodplain areas have been investigated.

Swan Hill Regional Flood Strategy – Extensive MIKE 11 modelling of Murray/Loddon River system upstream of Swan Hill to assess effects of proposed regional flood strategies.

Traralgon Floodplain Management Study for Shire of Traralgon – As for the Euroa Study, a comprehensive understanding of the flooding mechanisms is being gained through this state of the art fully two dimensional, dynamic flooding investigation.

Euroa Floodplain Management Study for Shire of Strathbogie – This Floodplain Management Study aimed initially at providing a comprehensive understanding of the damaging and complex flooding regime at Euroa, and subsequently at assessing potential flood protection measures (mitigation schemes, both structural and non-structural and flood warning systems). Full two-dimensional hydraulic modelling was undertaken.

Wangaratta Flood Study, Stage 2 – Application of MIKE 11 model to assess various flood mitigation measures.

Cairns Airport Drainage Study – Development and application of a detailed 2-dimensional model of the Cairns Airport and Lower Barron Delta in order to assess flood/cyclone hydrodynamic conditions at the Airport. Analysis of mitigation options.

Wangaratta Flood Study, Stage 1 – Development and calibration of a MIKE 11 model covering the extensive Ovens/King Rivers floodplain.

Yarra River, Melbourne – Development of a detailed MIKE 21 (two-dimensional) model of the Yarra River to investigate the hydraulic features of a small turning basin/wharf.

Gippsland Lakes System – One-dimensional model developed to analyse the potential impact of sea-level rise on lake levels.

Yarra River, Yarra Glen (VicRoads) – Set up and calibration of both one and two-dimensional models to investigate the impact of a proposed bridge replacement on flood levels.

Lower Loddon River Flood Study – development and calibration of MIKE 11 model covering an extensive floodplain network.

COASTAL/ESTUARINE INVESTIGATIONS WATER TECHNOLOGY

Gippsland Lakes Coastal Hazard Assessment – Project manager for a major hazard assessment project looking at impacts of sea level rise on coastal vulnerability throughout the Gippsland Lakes and Ninety Mile Beach.

Environmental Water Requirements of the Gippsland Lakes – Managed the input of scientific knowledge around hydrodynamics of the lakes and the freshwater/saltwater interface as well as the impacts of reduced freshwater inputs on these flow mechanisms.

Ecological Characterisation of the Gippsland Lakes – Provided hydrodynamic input to a broader characterisation project looking at the various habitats and bio-dependencies in the Gippsland Lakes.

Numerous Coastal Hazard Vulnerability Risk Assessments – assessing the change in risk to coastal inundation and stability due to sea level rise and the resulting change in coastal processes.

COASTAL/ESTUARINE INVESTIGATIONS LAWSON AND TRELOAR

Bass Strait – Three-dimensional model (Delft3D) development and calibration for pipeline design currents prediction.

Tropical Cyclone Thelma, Three-dimensional Current Model – This project involved the set-up and calibration of a three-dimensional hydrodynamic model of the Timor Sea and extraction of currents data.

Mooney Ponds Creek three-dimensional Water Quality Modelling – This project involved modelling of the detailed hydrodynamics of the fresh/salt-water interface in the Yarra River and how this effected the movement of pollutants from storm-water inflows.

Port Catherine Development, W.A. – Detailed three-dimensional hydrodynamic and water quality modelling of a proposed harbour development south of Perth.

Palm Springs Marina, Malaysia – Development of a two-dimensional model to assess effects of marina on local hydraulics.

Corio Bay Sediment Model Verification – Comparison of model predicted and recorded sediment plumes in Corio Bay during channel dredging.

Lake Illawarra/Botany Bay – Application of a two-dimensional water quality model to two large waterways. Long term water quality simulations performed and analysed for risk assessment.

South China Sea – Two and three-dimensional modelling to determine design currents for oil/gas pipelines.

Manila Bay – Analysis of flood behaviour, dredged sediment impacts and flushing characteristics of a proposed area of reclamation in Manila Bay, using one and two-dimensional models.

West Point Wilson hazardous chemicals storage facility – Environmental Effects Statement. Investigation of proposed facilities effect on nearby coastal processes.

East Coast Armaments Complex – Set up of two-dimensional current and wave models to investigate the impacts of proposed port facility.

Port Hedland – Set up and operation of numerical model to investigate Cyclone driven winds and wave set up.

Western Port – Two-dimensional model investigations of the dispersion of pollutants and the flushing characteristics of Western Port under tidal and wind driven currents.

Oil Spill Modelling/Response – Development of oil spill response procedures to perform real-time modelling of oil slick movements in Bass Strait and Western Port.

Western Port – Set up and calibration of a numerical model for the development of tidal and wind driven current fields as input to oil spill modelling.

Port of Geelong – Application of a two-dimensional numerical model to assess impact of a proposed dredging program on suspended sediment loads in Corio Bay.

Bass Strait – Numerical modelling of the flushing characteristics of Bass Strait over a typical year.

EXPERT WITNESS REPORTS

Adams Creek, Lang Lang – Expert evidence related to rural flooding and drainage issues

Donald, NW Victoria – Expert evidence and analysis of flooding issues related to channel networks on farmland in the Wimmera area

St Georges Road Northcote - Expert advice and modelling of an apartment development within SBO

Duncans Road South Werribee – Review of hydraulic conditions, flooding and drainage for a horticulture area. Provision of expert evidence report.

Nunawading – Expert evidence on flooding issues including modelling, for a multi-storey apartment building in a floodway zone

Hagen Park Bangholme – Expert advice and modelling of drainage issues in SE Melbourne

Noonan Grove Woodend - Expert advice and report on surface water management for a residential subdivision

Industrial Subdivision Shepparton/Mooroopna – Expert advice on drainage and flooding issues for land valuation purposes

Dandenong Valley, Scoresby – Expert modelling and report on flooding issues and development capability for land valuation

Coastal Development Paynesville – Expert report and evidence at VCAT on coastal hazard vulnerability for a residential subdivision

School Site Monbulk – Expert report on drainage issues in the Dandenong Ranges

Broken River, Stewarton – Expert modelling/report and evident at VCAT for a rural flooding issue

Toorak Road South Yarra – VCAT report and evidence in relation to redevelopment of a site within an urban area subject to flooding

Hopkins River Warrnambool – Flooding and coastal hazard vulnerability expert report and VCAT evidence

Apartment Development Port Fairy – Expert report on flooding issues associated with a proposed apartment complex

Port Fairy (2014) – Expert evidence to VCAT on coastal hazard and flooding for a proposed sub-division in Port Fairy.

Kerang East (2014) – Expert evidence to VCAT on flooding issues along Pyramid Creek arising from 2011 floods.

Woodend (2014) – Expert evidence to VCAT regarding flooding from Five Mile Creek and local stormwater impacts at a development site within Woodend.

Port Fairy Planning Scheme Amendment (2014) – Provided Expert Evidence on flooding to Planning Panels Victoria for Moyne Shire.

Victoria Street Richmond (2016) – Expert Evidence to VCAT on flooding issues related to a multi-storey apartment development next to the Yarra River.

Donnybrook/Woodstock PSP (2016) – Expert evidence to panel hearing in relation to drainage issues for a large greenfield development area.

Manningham (2016) – Provision of peer review of modelling and expert advice to City of Manningham regarding a planning scheme amendment to implement SBO layers into their planning scheme.

Amendment C121 Planning Panel - Leneva Baranduda Precinct – expert advice to the City of Wodonga

PUBLICATIONS

CONFERENCE PRESENTATIONS

BISHOP, W.A., McCOWAN, A. D., SUTHERLAND, R. J., WATKINSON, R. J. - “Application of Two-Dimensional Numerical Models to Urban Flood Studies”, 2nd International Symposium on Urban Stormwater Management, Melbourne 1995.

SOMES, N.L.G., BISHOP, W.A., WONG, T.H.F. - “Numerical Simulation of Wetland Hydrodynamics”, MODSIM 97 International Congress on Modelling and Simulation, Hobart.

BISHOP, W.A., COLLINS, N. I., CALLAGHAN, D. P., and CLARK, S. Q. - “Detailed Two-Dimensional Flood Modelling of Urban Developments”, 8th International Conference on Urban Storm Drainage, Sydney 1999.

SOMES, N.L.G., BISHOP, W.A., WONG, T.H.F. - “Numerical Simulation of Wetland Hydrodynamics”, Environment International, Vol. 25, No. 6/7 pp. 773-779, 1999.

BISHOP, W.A. – “Two-dimensional Modelling for Urban Flood Mapping and Drainage Analysis”, Proceedings, Victorian Flood Management Conference, 2001.

BISHOP, W.A. and CATALANO, C.L., “Benefits of Two-dimensional Modelling for Urban Flood Projects”, 6th Conference on Hydraulics in Civil Engineering, Hobart 2001.

McCOWAN, A.D., BERTON, F.M. and BISHOP, W.A. – “The Application of a Three-dimensional Variable Density Model to Assess Water Quality in an Urban Waterway”, 6th Conference on Hydraulics in Civil Engineering, Hobart 2001.

REHMAN, H.U., ZHANG, S.Y., BISHOP, W.A., BERKFELD, J., “Water Resources Assessment using Soil Water Assessment Tool - A Case Study”, in Proceedings of ICam Catchment Management Conference, University of Western Sydney, Australian Water Association, Sydney, 26-28 November 2003.

McMASTER, M.J., PROVIS, D.G., GRAYSON, R.B. & BISHOP, W.A., “Calibration and testing of a hydrodynamic model of the Gippsland Lakes” in Proceedings of MODSIM 2003, Townsville, Australia 14-17 July 2003.

BISHOP, W.A., WOMERSLEY, T.J. & TIERNEY, G, “Flooding Forests - the Hydraulics of Environmental Flows”, Proceedings, 4th Victorian Flood Management Conference, Shepparton 2005.

MUNCASTER, S.H., BISHOP, W.A. and MCCOWAN, A.D., “Design flood estimation in small catchments using two-dimensional hydraulic modelling –A case study”, 30th Hydrology and Water Resources Symposium, Launceston, TAS, December 2006.

BISHOP, W.A. and WOMERSLEY, T.J., “The use of hydraulic models to inform the management of flood dependent ecosystems on the River Murray, South-Eastern Australia”, 6th International Symposium on Ecohydraulics, Christchurch, February 2007.

MUNCASTER, S. H., BISHOP, W. A. and DUGGAN, S.J., “Making the best with what you have - Design flood estimation with and without observed data”, 5th Victorian Flood Management Conference, Warrnambool, October 2007

BISHOP, W.A., CHARTERIS, A.B., MUNCASTER, S.H., WOMERSLEY, T.J., “Impacts of Climate Change on Floodplain Management in Coastal Communities”, 5th Victorian Flood Management Conference, Warrnambool, October 2007.

BISHOP, W.A. and TATE, B. “The Use of Eco-Hydraulics in Managing the River Murray”, 17th QLD Water Symposium, Griffith University, November 2008.

BISHOP, W.A. and WOMERSLEY, T.J., “Port Fairy Regional Flood Study - Dealing with Risk in a Coastal Floodplain”, Joint 49th Annual Floodplain Management Authorities Conference (NSW) & 6th Biennial Victorian Flood Conference, Albury, February 2009.

BISHOP, W.A., RUSSELL, K.L. and LITTLE, M.J., “Impacts of Sea Level Rise on Flooding in an Estuarine Environment”, Climate Change 2010: Practical Responses to Climate Change Conference, Melbourne, 2010.

MARTIN, J.C., ARROWSMITH, C.L., and BISHOP, W.A., Hydraulic Implications associated with the Placement of Timber Snags in a Developing Anabranch. Proceedings of the Sixth Australian Stream Management Conference, Canberra, Australian Capital Territory, 2011.

BISHOP, W.A., LAW, S.E., NEWTON, J.L., GODFREY, M., “Integrated Water Management Opportunities for Inner Suburban Areas”, WSUD 2013, 8th International Water Sensitive Urban Design Conference, Gold Coast, November 2013.

WOMERSLEY, T.J., LEAHY, C., HUDSON, K., ANDERSON, B., KAZAZIC, E., BISHOP, W.A., & MAWER, J., “Proof of concept hydrodynamic model and marine and atmospheric forecast data integration for flood forecasting in the Gippsland Lakes”, 54th Floodplain Management Association Conference, 20-23 May 2014, Deniliquin RSL Club, Deniliquin, NSW

MCCOWAN, A.D., LAUHLAN-ARROWSMITH, C., BISHOP, W.A., “Estimating Future Coastal Inundation and Erosion Hazards”, Australian Coastal Councils Conference, March 2015

COUSLAND, T.J., and BISHOP, W.A., “Transport modelling to verify constructed wetland residence times”, Stormwater 16 – National Stormwater Association Conference, Gold Coast, QLD, September 2016.

CLARK, S., BISHOP, W., CUNNINGHAM, L., TATE, B., DALY, A., “Utilising Hydraulic Grade Line rather than water surface levels for Flood Planning Levels”, 13th Conference on Hydraulics in Water Engineering, Sydney, Nov 2017.

CLARK, S., CUNNINGHAM, L., TATE, B., DALY, A., BISHOP, W., “Flood Planning Levels: Incorporating residual risk considerations”, 13th Conference on Hydraulics in Water Engineering, Sydney, Nov 2017.



APPENDIX B INSTRUCTIONS



Warwick Bishop
Director | National Technology and Innovation Lead
Water Technology
51 Little Fyans Street
South Geelong VIC 3220

2 May 2023

Our Ref: C-A-339

Direct Ph: [REDACTED]

Dear Warwick,

Re: Amendment C339ggee Part 2 Panel Hearing - Expert Witness Instructions

I refer to Amendment C339ggee Part 2 (the Amendment) which seeks to implement new flood overlay mapping from the *Lower Barwon and Lower Moorabool Flood Investigation* and part of the *Bellarine Peninsula – Corio Bay Local Coastal Hazard Assessment* and also update schedules to the Floodway Overlay (FO) and Land Subject to Inundation Overlay (LSIO).

Your firm Water Technology prepared the *Lower Barwon and Lower Moorabool Flood Investigation* and also provided further technical advice to the City on certain complex submissions to the original Amendment C339ggee mainly in relation to Lara but also the Fyansford area which is part of the Lower Barwon/ Moorabool study area.

This letter is to brief you as an expert witness in the field of flood modelling and stormwater engineering for the upcoming Panel Hearing for Amendment C339ggee Part 2. The particulars of your brief are outlined in further detail below.

Background

At the Council meeting on Tuesday 28th March 2023 the following resolution was passed:

"That Council, having further considered submissions to Amendment C339ggee Flood Zones and Overlays, resolves to abandon the part of the Amendment which relates to the Lara Flood Study properties and refer remaining submissions to an independent Panel."

Consequently, the original Amendment C339ggee has been split with the abandoned part relating to the Lara Flood Study properties becoming Amendment C339ggee Part 1. Amendment C339ggee Part 2 has been created for the components relating to the Lower Barwon and Moorabool rivers and the Bellarine Peninsula Coastal Hazard flood studies and broader overlay schedule changes. C339ggee Part 2 has been referred to Planning Panels Victoria.

The below information relates to C339ggee Part 2:

Council is the Planning Authority for the Amendment which includes the following key elements:

- Implement new and revised FO1 and LSIO1 overlay mapping from the *Lower Barwon and Lower Moorabool Flood Investigation*
- Apply LSIO2 (Coastal inundation and hazard) to areas fringing the Barwon River estuary /Lake Connewarre identified in the *Bellarine Peninsula – Corio Bay Local Coastal Hazard Assessment* that weren't implemented by Amendment C394ggee.

- Amend Schedules to Clause 44.03 Floodway Overlay and 44.04 Land Subject to Inundation Overlay to include statement of risk, permit requirements, application requirements and decision guidelines, and renumber the schedules to Schedule 1;

Amendment C399ggee was exhibited from 15 July 2021 to 16 August 2021 with a total of 561 submissions received with 56 relating to what is now C339 Part 2. Of these submissions 50 objected to the amendment and 6 provided comment and/or supported the amendment. An additional late submission (objection) from Tract consulting was received on 19 April 2023. This was formally accepted on 26 April 2023 and subsequently sent to Panel for consideration.

Key issues raised in objecting submissions include: a lack of historical flooding; lack of consideration of recent development works and topography changes; increased insurance costs and devaluation of property.

On 14 December 2021, Council considered submissions to C399ggee and resolved to refer the “non-Lara” submissions to a Planning Panel and undertake further work on Lara related submissions. Council officers did not request a Panel at the time as we intended to do the work on the Lara submissions and refer them to the same Panel. However, the Lara component was subsequently abandoned at the Council meeting on Tuesday 28th March 2023.

Please note that Council’s position on submissions to C339ggee Part 2 is to not make any changes to the exhibited amendment maps with the exception of alterations to LSIO and FO mapping on the Moorabool River at Fyansford where new development has occurred since the original flood modelling.

The panel hearing is expected to be held on the week commencing 5th June 2023. This will be confirmed at the directions hearing today Tuesday 2nd May 2023.

Brief

The key objectives of your brief are to:

1. Review this letter and the documents referred to below and provide a fee proposal including an overall fee Hourly rates and disbursement should be included.
2. If possible, meet with me and other Council officers mid May 2023.
3. Review the flood assessments, exhibited amendment material, relevant background documents, key submissions and Council’s responses to submissions that relate to the *Lower Barwon and Lower Moorabool Flood Investigation*.
4. Prepare an overview of the *Lower Barwon and Lower Moorabool Flood Investigation*, which Water Technology completed.
5. Provide your opinion on the amendment particularly as it relates to your expertise as a flooding and stormwater engineering expert.
6. Compile the above into an expert witness report in accordance with the Planning Panels Victoria expert evidence guidelines and also have regard to:
 - 6.1 whether or not the Amendment addresses the VPP Practice Note:
 - 6.2 any other matters which you consider arise from the Amendment documentation and background material.
 - 6.3 the matters raised in submissions to the amendment.
 - 6.4 other expert witness reports prepared on behalf of other parties.



7. Provide a draft expert evidence statement for review by 9am **Fri 20 May 2023**.
8. Provide a final expert evidence statement for circulating by midday **Mon 22 May 2023**.
9. Present your evidence at the Panel Hearing on **5 June 2023** (to be confirmed after directions hearing).

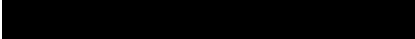
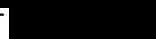
Documents

Relevant documents are on the [C339ggee Part 2 webpage](#) and include:

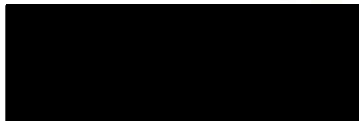
- Exhibited amendment documents including schedules and maps (under “Amendment Documents”);
- Council minutes of 28 July 2020, 14 December 2021, 27 September 2022 and 28 March 2023 (under “supporting documents) (note the minutes of Sep 2022 include a copy of Water Technology’s advice on complex submissions including Fyansford);
- Lower Barwon River and Lower Moorabool River Flood Risk Management March 2019 (under “supporting documents”);
- C339 Part 2 – Bellarine Peninsula Corio Bay Local Coastal Hazard Assessment Inundation Report Dec 2015 (under “supporting documents);
- C339 Part 2 – Council Delegated Authority Report – 40-70 Windsor Road Newtown Late Submission (under “supporting documents).

Copies of all relevant submissions are attached.

If you have any queries, please contact Allistair Krause, Strategic Planner by email  or telephone  or myself on

 or 

Yours sincerely



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