Amendment C384 to the Melbourne Planning Scheme

Expert Witness Statement of Robert Campbell Swan - Flooding

Amendment C384

5 October 2022

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Contents

1. Name and Address

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2. Position

Principal Engineer, Flooding and Stormwater

3. Area of Expertise

My area of expertise is hydrology and hydraulics, particularly the areas relating to the flow of and characteristics of surface water and flood dynamics.

Specifically, I have:

a) Been the project manager, project director and technical director for more than 30 urban flood studies undertaken by Melbourne Water

b) Contributed to the development of Melbourne Water's flood mapping technical specifications for Flood Mapping

c) Undertaken modelling and assessment of the proposed drainage works at the Fishermans Bend precinct on behalf of Melbourne Water

d) Provided technical direction for the flood analysis of the Stations and Tunnels package of the Melbourne Metro Project, which included the Flinders Street Station and City of Melbourne.

e) Modelled the flooding at Southbank and managed the design of stormwater upgrades into the Yarra, including pump stations and pipe upgrades, for the City of Melbourne at Clarendon St/Normanby Road (Melbourne Convention and Exhibition Centre).

f) Developed flood planning layers used in various Planning Schemes, including City of Manningham, Moorabool Shire Council, Moyne Shire Council, Southern Grampians Shire and others.

g) Provided peer review for Melbourne Water on flood modelling for major infrastructure projects.

h) Modelled the Lower Yarra River as part of the Port Phillip Bay Channel Deepening Project to assess the impacts of that project on flood behaviour.

i) Undertaken hydraulic analysis of proposed upgrades of the Wesley College Boathouse and its impact on flood behaviour (Yarra River near Herring Island).

j) Assessed the flood risk from climate change for the One Queensbridge development, including assessment of Yarra river tidal flooding and stormwater flooding.

k) Am a member of the Victorian State Emergency Services expert hydrology panel to provide flood advice and analysis during flood related emergencies.

l) Developed drainage strategies for redevelopment areas in and around Melbourne for the Victorian Planning Authority, including East Village and Prahran Market

m) My qualifications are detailed in Appendix A

4. Instructions

My instructions were provided by Hall and Wilcox and included the following:

- prepare an expert witness statement addressing hydrology/flooding matters for the purpose of the Panel hearing. In addition to any matters that considered relevant, the witness statement should address whether:
  - the flood reports adopted an appropriate methodology;
  - the modelling and analysis has been appropriately undertaken;
  - the updated LSIO mapping is appropriate;
  - the LSIO3 is drafted appropriately and includes all matters you consider relevant in the Decision Guidelines; and
  - any of the listed Background Documents ought to be amended and/or removed from being referenced in the LSIO3.

I was additionally instructed to consider the following via email by Hall and Willcox:

- whether the approach adopted in the Good Design Guide with regard to reducing the required floor levels to the 2100 1% AEP if levees are provided could be considered at Southgate?

My instructions also included review of the documents associated with the proposed overlay and are included in Appendix B.

5. Documents Examined

I have examined the number of documents as part of my review. These have included:

- Technical Report 01: Australian Rainfall Runoff Sensitivity Analysis (Engeny Water Management dated 22 July 2020)
- Technical Report 02: Southbank Flood Modelling Update and Climate Change Scenarios (Water Modelling Solutions dated 21 April 2020)
- Technical Report 03: Southbank Stormwater Infrastructure Assessment: Final Report (BMT WBM dated August 2015)
- Technical Report 06: Lower Yarra River Flood Mapping (GHD dated 24 September 2020)
- Guidelines for Development in Flood Affected Areas (Department of Environment, Land, Water and Planning, 2019)
- Good Design Guide for Buildings in Flood Affected Areas in Fishermans Bend, Arden and Macaulay (City of Melbourne, Melbourne Water and City of Port Phillip, 2021)

6. Overview of Southgate Site and Flood Characteristics

The Southgate site consists of two parcels of land south of the Yarra River, as shown in Figure 6-1. These are:

- 3 Southgate Avenue, Southbank; and
- 16-60 City Road, Southbank.

Figure 6-1 – Southgate Site Location

Southgate Avenue is a Council owned road that bisects the site and provides access to various parking structures, loading bays and back of house operations areas. The level of Southgate Avenue as it traverses the site varies from 2.09mAHD to 3.1mAHD as shown in Figure 6-2. Southgate Avenue also services Quay West and The Langham Hotel (whose title is shown in purple in Figure 6-2). Along the Yarra River frontage, the pedestrian boulevard grades from a level of approximately 3mAHD at the eastern end of the site, down to 2.4mAHD at the western end of the site. There is a lower walkaway immediately adjacent to the Yarra at approximately 1m AHD in some sections.

The known flood conditions at the site are:

- Highest recorded flood level (1934) – approx. 1.96mAHD
- Present Day 1% AEP Yarra River Flood Level (Melbourne Water advice 11 Feb 2020) – 1.6mAHD
- Present Day 1% AEP storm surge in Port Phillip Bay – 1.12mAHD (+/- 0.1m) at Williamstown, 1.15mAHD (+/- 0.1m) at St Kilda (taken from CSIRO, 2009)
- Melbourne Water adopted Present Day 1% AEP storm surge flood level – 1.6mAHD

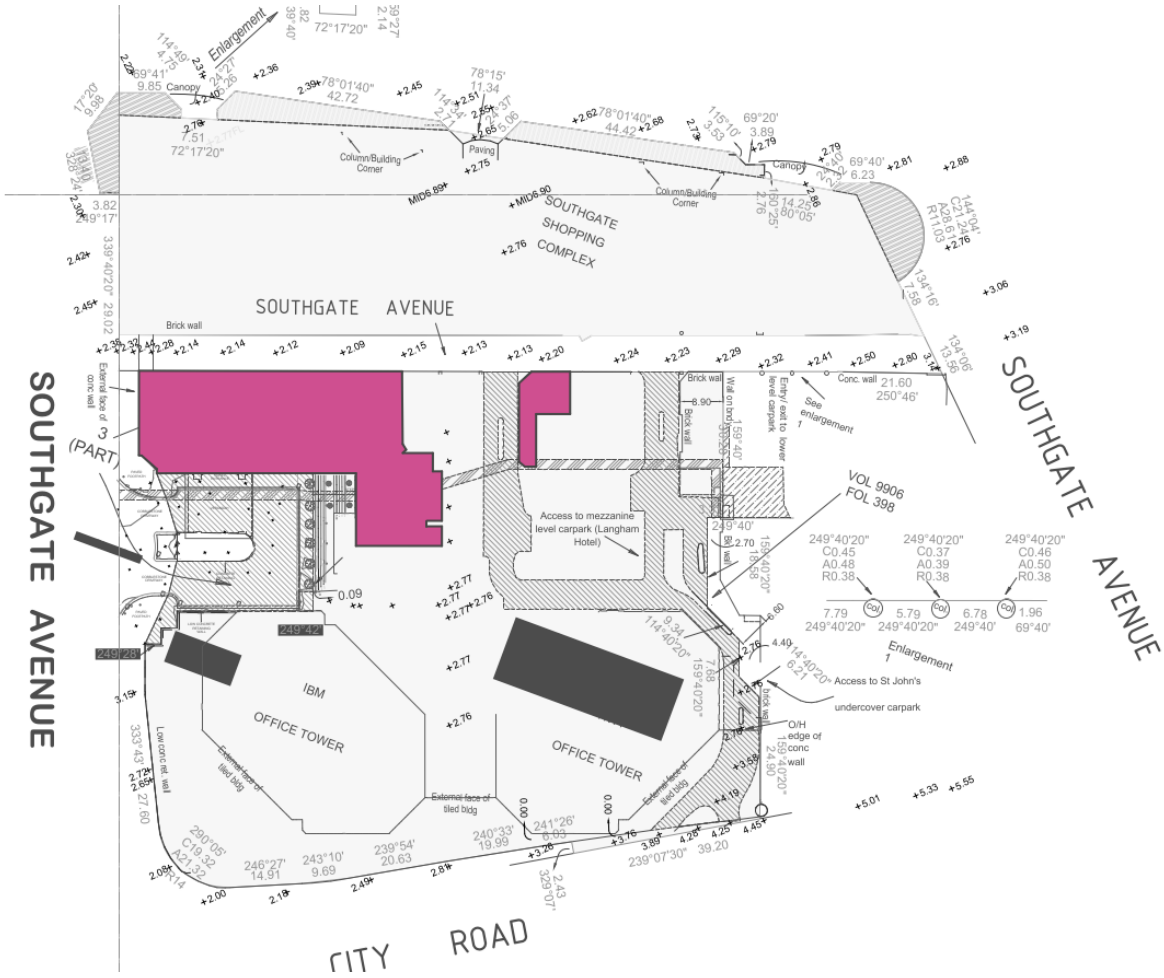


Figure 6-2 - Southgate Ground Floor Layout and Levels

The proposed overlays adopt a much higher flood level at the site. Melbourne Water has advised that under the GHD modelling at Southgate:

- The existing conditions 1% AEP flood level, advised 7 December 2021 – 2.88mAHD
- The 2100 1% AEP flood level, advised 7 December 2021 – 3.44 mAHD

The 2100 conditions include an increase in sea level of 0.8m and a 18.5% increase in rainfall intensity. Advice received from Melbourne Water in 2020 and 2021 regarding flood levels are shown in Appendix C.

7. Flood Modelling

The flood modelling methodology applied to derive the flood extents for the proposed LSIO overlays should be undertaken in accordance with industry guidelines such as Australian Rainfall and Runoff and Melbourne Water Flood Mapping Guidelines. At Southgate, the flood extents and levels are derived from the GHD Lower Yarra model[1] as it provides the higher flood

[1] Technical Report 06 of the exhibited amendment

levels when compared to the local stormwater flood levels in the BMT Southbank Stormwater Infrastructure Assessment[2].

As such, I have limited my review to the GHD Lower Yarra flood modelling for the purposes of this witness statement. The review is limited to an assessment of the procedures used to undertake the modelling against good industry practice and a review of the model schematisation and input data that is referred to in the report. This is because I do not have access to the model files.

7.1 Review of Modelling Approach

The lower Yarra River flood study was completed by GHD on behalf of Melbourne Water and reported in September 2020. My overall comments on the report are:

- There were some limitations placed on the study team by Melbourne Water with regard to the hydrological components of the project, which came from a previous Melbourne Water report. This appears to have caused the study's consultants some concern to the extent that the adopted flow rates were discussed in detail with Melbourne Water (Appendix A, pdf page 79 and Attachment 3). In my view, a proper review of the hydrological components for the project was warranted. As far as can be determined, that review did not occur.
- There has been no calibration undertaken for the model used to define the flood extents in the project. This is a major failing of the report, given that there is enough recorded data for the 1934 flood and contemporary flood events (2005 and 2014) that could have been used to validate that the model was appropriately representing the expected catchment behaviour. The failure to undertake model calibration and validation against real flood events means that the modelled flood flows and levels are subject to significant uncertainty. The lack of calibration is not consistent with good modelling practices recommended in ARR2019.
- The existing condition 1% AEP flood levels are significantly higher than the 1934 flood, which is the flood of record and has (up until now) been considered as representative of the 1% AEP flood for the mid and lower reaches of the Yarra River. GHD's modelled flood levels at Southgate are more than 800mm higher than those recorded in the 1934 flood event.
- The consideration of the joint probability of coincident tide and flood events is not analysed. ARR2019 provides an approach, but this has not been undertaken by the GHD team.
- The report details that the study team are concerned that they cannot replicate the 1934 flood levels and that the flood levels in the modelling appear to be too high. (Appendix A Section 7.1, pdf page 72)
- The main body of the report does not provide a clear understanding of the outputs of the model or the flows and levels for the modelled flood events at key locations. The details of the adopted flows are lacking and the mapping in the report appendices does not provide sufficient granularity to properly assess the results. I also note that in the provided mapping, the legend for the flood levels is incorrect.

[2] Technical Report 03 of the exhibited amendment

- The overall modelling approach is not consistent with that generally in use for large scale river flood modelling projects in Victoria, where calibration data is available. I have modelled of major rivers such as the Murray at Echuca and Swan Hill, the Goulburn River at Shepparton and the Broken River at Benalla. In each case, the models were calibrated and validated against known flood records to ensure that they were representative of the expected flood behaviour.
- The approach to modelling is also not consistent with flood modelling of rivers through major urban centres across Australia, completed within the last ten years. These studies include flood analysis of the Hawkesbury-Nepean through western Sydney, the Torrens River through Adelaide, the Brisbane River through Brisbane and the Swan River through Perth. All these models were calibrated and validated to known flood events, to ensure the models provided an appropriate representation of flood behaviour.

7.2 Review of Model Inputs

For two-dimensional modelling, such as that undertaken for the Lower Yarra River, there are a number of inputs that must be considered when developing the model. These fall into two key categories:

1. Boundary Conditions – these are usually measured or derived data that represent water behaviour. In this model, there are two main types of boundary conditions:
    a. Flow Inputs – these are where flows have been introduced to the model. Normally these occur at the 'upstream' end of the model.
    b. Water Levels – these represent the tidal time series and act as the control on flows leaving the model. These are usually applied at the downstream end of the model. In this case, the tidal boundary is time varying and represents the water level in Port Phillip Bay.
2. Model Parameters – these are the physical parameters of the model that are intended to reflect the physical conditions of the model area. These typically include:
    a. Hydraulic Roughness - an estimate of the resistance to flow of a surface. Higher roughness will tend to increase the water level and slow the flow velocity.
    b. Topography – a digital representation of the ground surface. The model topography is defined by both level and resolution. Higher resolution models have more elevation points in a given area.
    c. Bridges and Structures – models require the physical information for bridges and structures, such that their effect on flow can be included.

7.2.1 Boundary Conditions

7.2.1.1 Inflow Boundaries

Due to the scale of the final model, the assumed flows are not particularly clear at the mapping boundary. This is because the model was extended well beyond the project area by the GHD study team, in an attempt to deal with some of the higher than expected levels generated in their initial testing. Although some reduction in level is asserted, the model is still returning results significantly higher than historical levels.

The modelled inflows are included as hydrographs in Appendix C of the GHD report. However, there is no clear flow rates presented for the lower Yarra River, downstream from Dights Falls. The timings of the flows indicate that large flood events on the Moonee Ponds Creek and the Maribyrnong River will have little to no impact on flooding in the Yarra. It is of some concern that the modelling assumes 1% AEP floods simultaneously in the Yarra River, Moonee Ponds Creek and Maribyrnong River. This would appear to be unlikely, given the spatial and temporal variability of rainfall across a catchment of this size. This assumption would tend to increase flood levels in the Yarra River, due to elevated tailwater conditions at the Maribyrnong and Moonee Ponds Creek. I have not assessed the magnitude of this change.

Based on the hydrographs, it is apparent that the expected flows through the lower Yarra are in the order of 1100 m^3/s under existing conditions and approximately 1300 m^3/s under climate change conditions, assuming a 18.5% increase in rainfall intensity.

7.2.1.2 Tidal Boundaries

The tidal boundaries adopted in the modelling are not consistent with the expected tidal behaviour in the Yarra River and recorded storm surge events. The modelling has correctly adopted a tidal level that varies over time and includes a storm surge component, but the storm surge does not decay over time after it reaches its peak storm tide level. The areas indicated as extension with typical tide curve should return over time to averaging around mean sea level (or MSL +sea level rise).

To demonstrate the issue, Figure 7-1 below shows the recorded 2009 tidal surge event in magenta (approximately equivalent to a 20% AEP event) plotted against the tidal series used by GHD (as per Appendix C of their report).

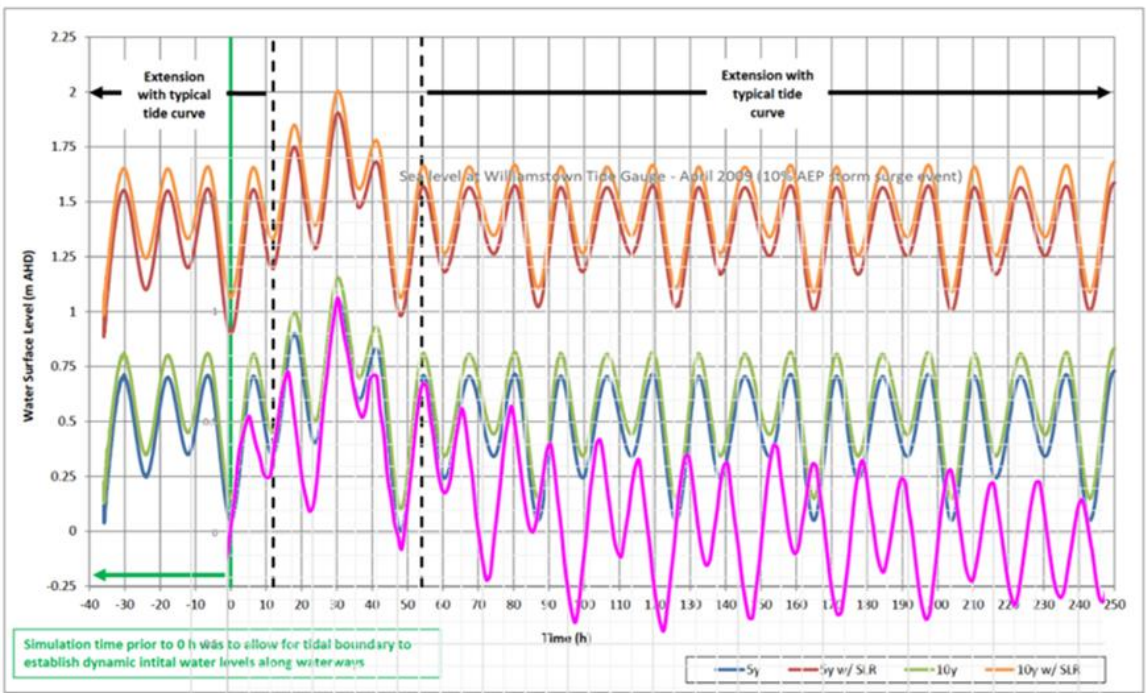


Figure 7-1 – Comparison of GHD model tide condition with real 2009 tide

Based on the real tide data, there are some issues that become immediately apparent; firstly, the real tides revert back to a more normal tidal cycle relatively quickly after the conclusion of the surge event. The lower tide levels will enable greater flow capacity in the river, as the average tailwater level is lower over the entire tidal cycle. This decay characteristic is typical of all storm surges. The recorded 1934 tide levels show that 24 hours after the peak of the tide, the high tide level was approximately 0.5 metres, which is only slightly elevated above the normal high tide level. At 48 hours post the peak, the high tide level had returned to 0.3 mAHD, well within the normal tidal range.

Secondly, the tides used by GHD appear to have the wrong timing, in that over the 240 hours after the start of the event, there is an additional ½ cycle in the real data (one additional high and low tide). This also can impact the timing of the flood peak.

The tidal cycle also does not show the normal Melbourne diurnal tidal characteristics, that has 4 distinct elements each cycle - Higher High Water, Lower High Water, Higher Low Water and Lower Low Water. As the GHD series has been copied from the edges of the storm surge series and repeated, these characteristics of the tide are lost.

The use of this elevated sea level in the modelling has significant impacts on the expected flood levels in the lower Yarra. In their modelling, GHD has adopted a timing that matches the peak of the tide to when flows are 30% of the total peak of the flood event. The peak of the flood occurs more than 50 hours after the peak of the tide, at which time the tidal levels should be significantly lower.

Effectively, the GHD results for the existing conditions have an inbuilt sea level rise component of approximately 0.5-0.6 metres under present day conditions and 1.3-1.4 m rise under the 2100 conditions, in the absence of storm surge at the time of peak flood flows in the Yarra. This is well in excess of the required 0.8 m sea level rise required to be considered under the Victorian Coastal Strategy and by Melbourne Water's own guidelines.

7.2.2 Model Parameters

7.2.2.1 Roughness

The values used in the model for roughness appear to be reasonable and within the range of those expected for urban areas.

7.2.2.2 Topography and Bathymetry

The GHD model has adopted a 10 m grid cell size using topography data collected in 2013. The biggest unknown in the modelling is the definition of the Yarra River channel, which is subject to bed scour under high flow conditions (as per Melbourne Water's memo in Appendix A of the report). The effect of this scour would be increase the carrying capacity of the Yarra River and lower peak flood levels. However, as the model was not calibrated to real flood events (for example, the 1934, 2005, 2009 and 2014 events), it is unclear if the model definition of the river is correct.

The Yarra River bathymetry has been constructed using a variety of data sources, all taken at different times, with unknown quality control. As discussed above and in Appendix A of the

report, the river is known to have bed scour under high flow conditions. The report provides some guidance that the scoured bathymetry may provide some reduction in flood level. It appears that the final model bathymetry did not include any consideration of the effect of bed scour. If scour does occur, as is indicated in the appendix, then the model will be overpredicting the expected flood level.

The modelling has adopted the sub-grid sampling (SGS) methodology available in Tuflow. This method provides some extra definition of topographic features that are smaller than the main grid cell size and would otherwise not be considered. It is noted that GHD recommended some changes to the SGS parameters to improve accuracy, but that these made the model unstable. I do not anticipate that this will have had a significant impact on model results.

7.2.3 Bridges and Structures

GHD introduced bridges and other structures into the model. The methodology used to define these structures appears sound, but somewhat complicated.

7.3 Model Calibration

As part of standard practice for floodplain models, the model should be calibrated to known events when data is available. ARR2019 (and the previous draft version, released in 2016) Book 6, Section 4.3.2 provides the following advice with regard to calibration and validation of hydraulic models:

> *Model calibration and validation provides an overall check of the reliability of a model. That is, how well the final site-specific model is representing the flow conditions in the physical system to be modelled. Ideally, calibration and validation is a two stage process, as follows.*
>
> *Model calibration is the process of comparing model results against measured flood levels and extents and adjusting model parameters to obtain a "best-fit". For flood studies, model calibration is typically carried out on the largest flood for which reliable water level data is available. In studies where more frequent flooding may be important, the model should also be calibrated against measurements taken from a more frequent flood event. During the calibration process, model parameters (typically bed-friction coefficients) are adjusted and the model re-run until the results give the best reproduction of the measured data.*
>
> *In the first instance, the calibration process is also used to identify any inconsistencies in the model terrain data and boundary conditions. If after repeated efforts, it is not possible to obtain a reasonable representation of the measured data or, if this can only be achieved by the use of physically unrealistic input parameters, then it will be necessary to look more closely at: the assumptions made in the selection of the generic mathematical model, the appropriateness of the selected modelling package for reproducing the flow conditions under consideration, and the reliability of the boundary conditions that have been applied to the model.*

Model Validation is the process whereby the calibrated model is used to simulate an independent flood event to provide a check on the reliability of the calibration process. The flood event will typically be somewhat lower than the calibration case and, in some cases, the results may be used to further refine the calibration process.

This is the case for the Lower Yarra, with flow data available at the Chandler Highway at Fairfield and a continuous tidal record available at Williamstown. Historically, the 1934 flood event is been considered equivalent to the 1% AEP flood event in the Lower Yarra, which has the highest recorded levels in terms of both storm surge level and Yarra River flow (noting that the storm surge peak occurred before the River flow peak). The 1934 event has been the subject of significant analysis, with estimates of flood flow and tide levels available in reports from the MMBW (Adams, 1987). Despite the flow and tide series data being available, no calibration has been attempted for any recorded storm event, including for 1934. The lack of calibration is not consistent with good practice approaches described in ARR2019.

More recent Lower Yarra River flood events occurred in 2005 and 2009. The Bureau of Meteorology in their severe weather report for the 2005 event indicated that this was the first time since 1934 that the Yarra River had broken its banks at Collingwood. The flood level at Spencer Street was recorded at 1.37mAHD in the 2005 event. In the 1934 event, the level at Spencer Street was 1.61mAHD.

At page 205 of the GHD report, a comparison of flood levels is provided for the existing conditions assumed 1% AEP flood levels at various locations, testing the impact on levels where various model parameters have been altered. Location HL33 is at Princes Bridge and HL28 is at Spencer Street. These are reproduced below:

ID	1934 Flood Level	4400_v24_OR Model (refined version of Lower Yarra River flood mapping model)				4400_v26 Model (extended version of 4400_v24_OR model)			
		Current - Kc=145 w/o ARFs & n = 0.015	Kc=180 w/ ARFs & n = 0.015	Current - Kc=145 w/o ARFs & n = 0.020	Kc=180 w/ ARFs & n = 0.025	Current - Kc=145 w/o ARFs & n = 0.020	Kc=180 w/ ARFs & n = 0.020	Current - Kc=145 w/o ARFs & n = 0.025	Kc=180 w/ ARFs & n = 0.025
HL28	1.61	2.50	1.85	2.06	2.24	2.60	2.01	2.72	2.19
HL29	6.79	6.38	4.88	5.40	5.88	6.72	5.31	7.01	5.79
HL30	4.66	5.03	3.83	4.31	4.76	5.36	4.21	5.69	4.66
HL31	5.27	-	-	-	-	-	-	-	-
HL32	3.22	4.05	3.10	3.49	3.85	4.34	3.42	4.65	3.78
HL33	2.06	3.48	2.56	2.84	3.09	3.61	2.76	3.80	3.02

It can be seen that in all cases, at both Princes Bridge and Spencer Street, the model significantly over predicts the recorded 1934 flood levels, thought to be greater than the 1% AEP event. The level is also significantly higher than that recorded in 2005 at Spencer Street.

The lack of calibration and the apparent overprediction of flood levels in nominal 1% AEP events means that the extent of the overlay is likely to be overestimated, and, more importantly, the levels used to assess development controls will also be overestimated.

7.4 Impact of Tide Assumptions on Flooding

To assess the impact of the approach adopted by GHD, I created a model of the Lower Yarra River. This model is not intended to replace the GHD model, but rather to provide guidance on the expected impact of the assumptions adopted by GHD. The model development is described in Appendix D. For clarity, I will refer to my model as the HARC model.

As described in Appendix D, the HARC model adopts flow boundaries as described in the GHD report. I also ran the model for the 1934 flood data, as described in the Adams report, to provide an initial calibration to known levels. I consider this model suitable to assess the impact on flood levels caused by correcting the tidal cycle issues in the GHD report. The HARC model has been run with a range of model tidal boundary conditions and inflow conditions. I have reproduced the relevant description tables from Appendix D. Table 7-1 describes the assumed tidal boundaries and Table 7-2 is the modelled flow and tidal boundary combinations. The labels that are used in the graphs and figures in this evidence statement are named as per Table 7-2.

Table 7-1 - Modelled tide details

Tidal Boundary Name	Description	Peak Level
1934	A tidal boundary digitised from the Adams report from 28 November 1934 to 2 December 1934. The boundary was continued after 2 December based on the tidal cycle from 2 December.	1.33 mAHD (estimated as greater than a 1% storm tide event).
2009 Tide	A tidal signal that represents the 2009 storm tide event at Williamstown. Data was sourced from the National Tidal Centre at 1 hour intervals. This tide includes the expected reduction in storm surge over time.	1.09 mAHD (approx. 2% AEP event, according to McInnes et al CSIRO, 2009).
2009 Adjusted	The tidal signal from 2009, with the storm surge component adjusted higher from +/- 12 hours either side of the peak, to achieve a peak tide level of 1.15 mAHD, the same as the GHD peak level. This tide includes the expected reduction in storm surge over time	1.15 mAHD (upper range confidence estimate of the 1% AEP event, according to McInnes et al CSIRO, 2009).
GHD Tide	An approximation of the tide signal used in the GHD report. There is no additional decay of the storm surge component.	1.15 mAHD.
Climate Change Tide	This is the adjusted 2009 tide, with a increase in level and surge representing the future climate conditions (sea level rise of 0.8 m and additional wind). This tide includes the expected reduction in storm surge over time	2.00 mAHD (equivalent to a 5% AEP event at 2100, according to McInnes et al CSIRO, 2009).
GHD Climate Change	This is the GHD tide series with 0.8 m sea level rise and the storm surge adjusted to match the 2.00 m level, as per the GHD report.	2.00 mAHD (equivalent to a 5% AEP event at 2100, according to McInnes et al CSIRO, 2009).

Inflow boundaries were adopted from hydrographs in the GHD report for the Yarra River. These are reflective of the expected existing conditions, climate change (2100) and 1934 flood flows.

Table 7-2 - Modelled Boundary Combinations

Model Name	Tidal Boundary	Yarra Boundary
Yarra	2009 Tide	Yarra (peak flow 1100 m^3/s)
Tide 115	2009 Adjusted	Yarra (peak flow 1100 m^3/s)
GHD	GHD Tide	Yarra (peak flow 1100 m^3/s)
Climate Change	Climate Change	Yarra CC (peak flow 1290 m^3/s)
GHD_CC	GHD Climate Change	Yarra CC (peak flow 1290 m^3/s)
1934	1934	Yarra 1934 (peak flow 1130m^3/s)

It should be noted that the results of the HARC model are lower than the equivalent GHD model under all conditions. The HARC model also slightly overestimates the 1934 results at Princes Bridge, but to a lesser degree than the GHD model. Figure 7-3 shows the modelled flood levels at Princes Bridge.

Table 7-3 - Modelled Water Levels at Princes Bridge (HARC model)

Model Scenario	Modelled Maximum Water Level (mAHD)
Yarra	1.99
Tide 115	1.99
GHD	2.20
Climate Change	2.79
GHD Climate Change	2.98
1934	2.17

A long section comparing the flood levels along the Yarra for the HARC model is shown in Figure 7-2. The flood levels just upstream of Princes Bridge in each case are also shown in Figure 7-3.

The only change between the various model runs for the same inflow hydrograph (existing or climate change) is the tide boundary. The adoption of the GHD tides in the modelling contributes to an increase in flood levels of approximately 0.2m at Princes Bridge, when compared to the realistic tidal series. For the climate change case, this is seen in the difference between the blue and red lines in Figure 7-2 and Figure 7-3, where the red line is the result from the model using the GHD tide series and the blue line uses the corrected tidal boundary, adjusted for climate change. The effect of the incorrect tide is in the model is increased levels along the entire lower Yarra reach modelled, from Spencer Street to AAMI Park. This in turn would lead to larger flood extents than predicted along the entire lower Yarra.

Inherently, the flood levels in and around Southgate are a function of the time that the modelled water level exceeds the top of the Yarra River embankment. This analysis indicates that the GHD levels are likely to be at least 200mm too high when considering a reasonable tidal cycle, notwithstanding any other errors in the model. This then significantly increases the time when water overtop the Yarra River embankments, leading more water spilling into the Southbank precinct and higher flood levels. When translated to a flood extent, the area covered by the extent is much larger under the incorrect tide.

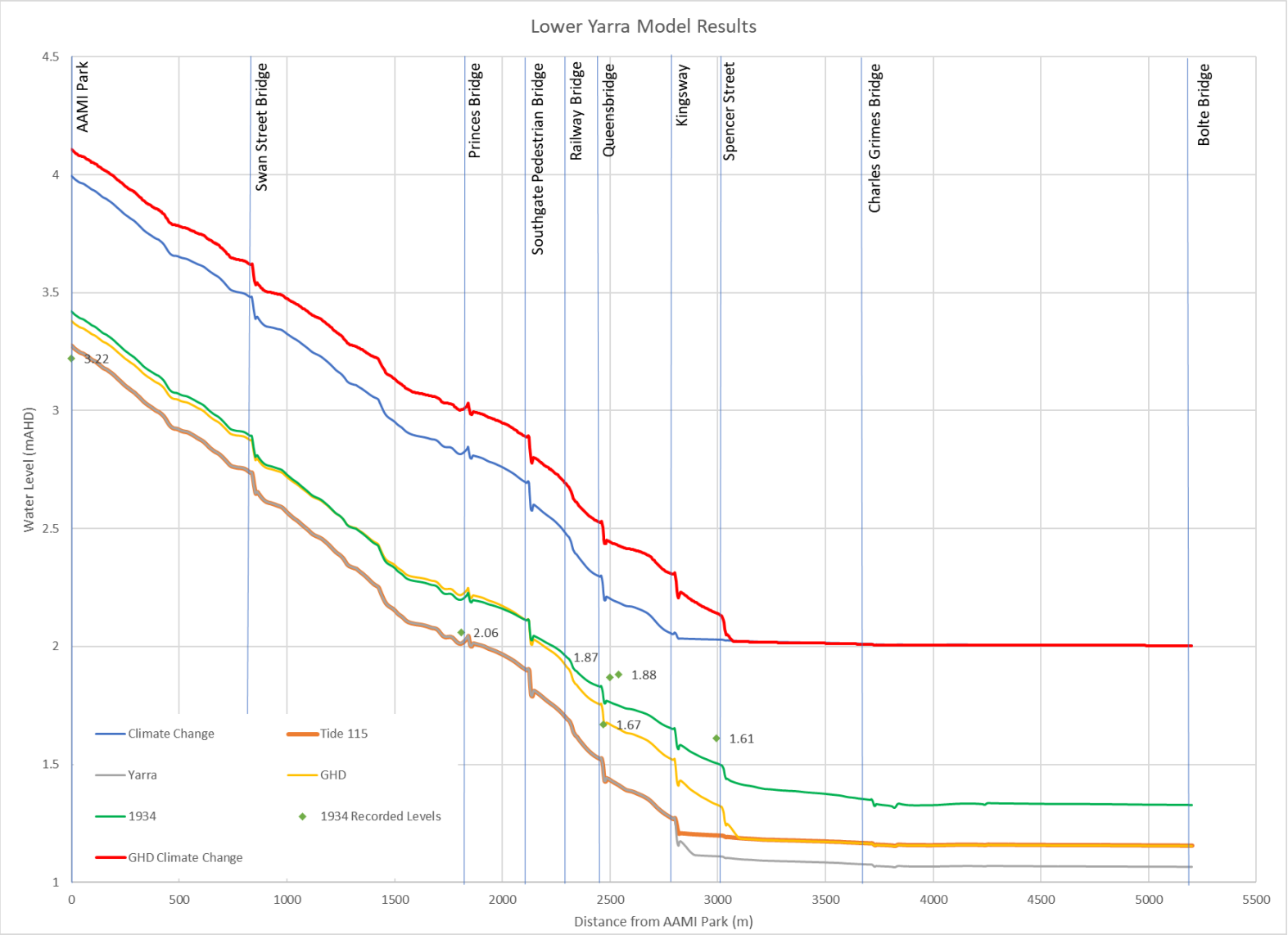


Figure 7-2- Modelled water levels, Lower Yarra River

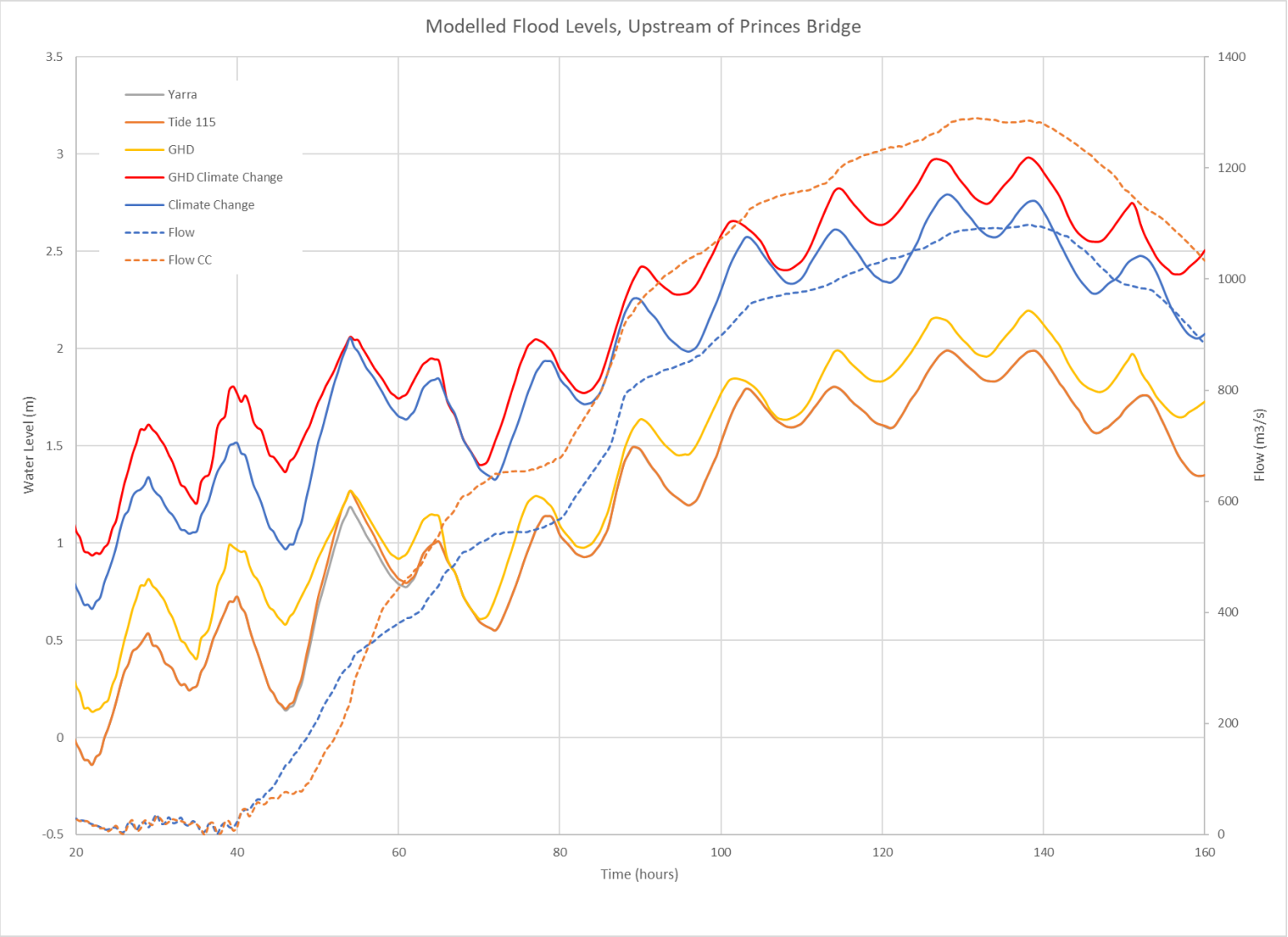


Figure 7-3 – Modelled water levels, upstream of Princes Bridge

I note that in the modelling I have undertaken, I have not been able to replicate the high water levels indicated in the GHD results under any combination of input conditions. This is likely due to the differences in the assumed bottom bathymetry, the assumed losses at bridge and structures, and potentially the adopted inflows or Mannings values. However, the HARC model did adopt a reasonable estimate of the 1934 conditions and returned levels in the vicinity of Southgate that were a slight overestimate of levels upstream of Princes Bridge and a close approximation of the recorded level at Queens Bridge.

Although in this evidence I have mostly considered the implications of the adopted boundary at Southgate, it should be noted that the differences continue along the lower Yarra. This will lead to an overestimate of both flood extents and levels along the lower Yarra. At Spencer Street, the assumption leads to a change in the timing of the peak flood level that is no longer consistent with the 1934 reports, where the peak water level was experienced at the peak of the tide as opposed to the peak of the flow.

7.5 Flood Modelling Conclusions

In my view, the lower Yarra River flood modelling is likely to significantly overestimate the expected flood levels and extents that would be experienced both in the present day and future conditions. This is because:

- The GHD model incorrectly adopts a tidal boundary level that does not reflect the expected tides under storm tide condition.
- The GHD model was not calibrated to any historic events and does not reflect the expected timing of combined storm and flood flows in the estuary, such as experienced in 1934.
- The GHD existing conditions 1% AEP levels significantly overestimates the largest recorded floods in the last 100 years at Spencer Street and Princes Bridge.
- Data was available to calibrate the model to a contemporary flood events. I consider the lack of calibration to be outside of what would be considered good practice flood modelling on a river such as the Yarra.
- When compared to an identical model that used an historical tidal surge recorded in 2009, adopting the GHD tide assumptions results in a flood level 300 mm higher than expected at Spencer Street, and 200mm at Princes Bridge.
- The GHD model overestimates flood extents and levels in the Lower Yarra. The use of these levels in a planning context, especially in developed areas such as at the Southgate site will result in poor decision making around floor levels and flood risk.

8. Is the LSIO mapping appropriate?

I have considered if the LSIO mapping is appropriate for the area around Southgate and the lower Yarra. In this case, it is considered that the mapping is likely to significantly overestimate the extent of flooding through this area under the future climate conditions. From a risk perspective, the adoption of an overlay that is likely to be larger than the real flood extent is considered acceptable provided it is not significantly outside the realms of likely inundation.

In this case, whilst I can accept the adoption of the larger overlay to ensure flood risk is considered through potentially vulnerable areas, the adoption of the modelled flood levels for planning decision making cannot be supported for the reasons described in section 7 above.

9. Is the LSIO3 drafted appropriately and includes all matters considered relevant in the Decision Guidelines

It should be noted that I am not a qualified town planner but I have worked in floodplain planning for more than 20 years. I have significant experience in floodplain risk management, including the development of flood response management plans and in the design and assessment of flood mitigation works at both an individual property and catchment scale.

My comments on the drafting of the schedule are related to the implications of the wording on development and the engineering responses that can be adopted.

9.1 Objectives

The objectives of the overlay are clear and generally reasonable. The last objective is

> *"To ensure development simultaneously achieves safe access and egress, good urban design and equitable access."*

In my view, in many locations in the lower Yarra floodplain, this objective would be very difficult to meet, especially under the elevated flood levels from the GHD report. The objective does not acknowledge that for existing buildings that are to be refurbished or where the site constraints are such that 'safe' access above the future flood level cannot be provided (due to local streets being inundated) that these sites cannot meet this objective, even though they may able to be designed such that they can meet the other objectives of the scheme.

At Southgate, the existing access to the ground floor is at the same level as the pedestrian boulevard along the Yarra (approximately 2.7mAHD) and along Southbank Avenue at 2.1mAHD. These link to existing underground accessways to carparks and loading bays. Safe access criteria will not be able to be achieved at Southgate for vehicular access.

This objective would be appropriate for new development where the streetscape can be easily redesigned as space allows. For tight and highly constrained spaces and where there are significant connections to existing infrastructure, the objective may not be able to met at all. At Southgate, the site configuration is such that the access to the underground parking areas is from Southgate Avenue, which would not meet the safe access criteria defined by Melbourne Water. The objectives should recognise that the constraints of redevelopment in these highly urbanised areas and provide for these sites to use measures that reduce the overall flood risk.

In communications on a number of recent projects between HARC and Melbourne Water, we have been advised that Melbourne Water is not applying any discretion on relaxing access criteria to sites (pers. comm). This means redevelopment that would otherwise reduce flood risk and meet the other objectives of the scheme are not able to proceed.

9.2 Statement of Risk

The statement of risk is reasonable. It would be preferable to add that the flood warning times for the Lower Yarra River are likely to be in the order of at least 24-48 hours.

9.3 Application Requirements

The application requirements are reasonable.

9.4 Decision Guidelines

The decision guidelines are generally reasonable. In my view however, a major issue with the guidelines is that the floodplain management authority is not required to consider the decision guidelines specified in the schedule. In recent times, Melbourne Water as the floodplain management authority, has advised that they no longer apply any discretion to the criteria described in the *Guidelines for Development in Flood Affected Areas* (the Department of Environment, Land, Water and Planning, 2019) (pers. comm). This is despite these guidelines clearly stating that:

> *These guidelines provide an assessment framework and method to assist decisions on development in flood affected areas. In principle, development should not intensify the harmful impacts of flooding.*
>
> *The purpose of the guidelines is to provide a clear, consistent and transparent process for managing land use and development in flood affected areas in Victoria. They are intended to be used with the land use planning and development system. Usually the information in the guidelines is sufficient to guide decision making. However, the guidelines cannot cover all the circumstances and aspects of flood behaviour. (Introduction, page 5)*

And

> *Floodplain managers have discretion to vary from the guidelines, considering local circumstances, the nature of the development proposal and the flood risk. (Introduction, page 5)*

In my view, the guidelines are mainly aimed at new development or for smaller scale developments on an individual site basis. The decision-making framework for a highly developed area such as that found in the City of Melbourne should not be the same as for a two-lot subdivision in the middle suburbs of Melbourne. Without having a clear decision making framework to deal with complexities involved with redeveloping or refurbishing sites such as Southgate, the current strict application of the DELWP guidelines adopted by Melbourne Water can lead to sterilisation of otherwise useful land.

The outcome of this strict application is that a site may not be not redveloped or improved due to being unable to meet one of the DELWP criteria (such as access) and would be objected to by the floodplain management authority. The redevelopment of these sites may otherwise reduce the overall flood risk to people and property, due to the design response adopted for that

site. This could include a range of flood risk reduction measures such as flood barriers, emergency response plans and other design and engineering responses. Paradoxically, the application of the guidelines in this manner may lead to existing buildings with a higher flood risk not being updated or have only minor refurbishments that would not trigger a planning permit referral under the overlay. This would lead to an increase in overall flood risk to the community, which is not consistent with the overlay objectives.

The decision guidelines do not appear provide any discretion for decision makers to identify sensible, risk based responses to the change in flood levels that is predicted to occur between present day and future flooding. A redevelopment of an existing building today will have a different flood risk over it lifetime to a building constructed in 50 years time. The ability to encounter a flood at a 1% AEP level as modelled at 2100 is, by the definitions adopted , rarer than a 1% event in every year prior to 2100.

The decision guidelines consider connections to the streetscape and activation of the frontage, but, as discussed above, these are not required to be considered by the floodplain management authority. There are engineering controls that can assist in this approach, including automatic flood barriers to provide temporary relief in the event of a flood. However, in my experience, Melbourne Water has typically not allowed these type of barriers to provide primary flood protection, regardless of the site circumstances. Consideration should be given to including a statement in the decision guidelines to explicitly allow these responses for constrained sites as appropriate, subject to an overall reduction in community flood risk.

9.5 Precinct Wide Approaches

The decision guidelines also do not require consideration of proposed precinct scale flood protection works. These works are proposed for both the Fishermans Bend and Arden Precincts, and are required as part of both their structure plans. We note that in the BMT report into flooding through Southbank, the City of Melbourne was advised that in the long term, precinct scale works would be required to manage flood risk from the Yarra River. It advised that these works would

> *"… require significant capital works across local government area boundaries and involving multiple state government agencies.*
>
> *The form of these capital works is likely to be hard defences such as sea walls or a tidal barrage or a combination of the two. Given the scale of these works, in terms of investment and the potential impacts, it is recommended that a feasibility study is carried out at an early stage. (Executive Summary, page iii)*

I agree with this approach. Whilst the planning scheme is a useful tool to manage risk, for areas with significant existing infrastructure and a future flood risk that has not yet been realised, the adoption of precinct scale mitigations will likely provide the best balance between total community cost and net benefit in relation to flood risk reduction and societal cost (enjoyment, access, activation). Assuming the 1934 flood levels are indicative of the current 1% AEP levels, there is still between 30 and 40 years before sea level rise impacts would cause overtopping at Southgate. The adoption of flood protection levees along the Southbank promenade from

Princes Bridge to the Charles Grimes Bridge (linking with the required Fishermans Bend precinct levee) would be a logical mitigation measure at a precinct scale.

9.6 Other considerations

In my view, it would be prudent to adopt a Local Floodplain Development Plan (LFDP) for the Lower Yarra area. This plan could provide greater detail on decision making criteria for areas in the lower Yarra floodplain and provide addition guidance and policy transparency for both the floodplain management authority (Melbourne Water) and the public, including developers. A LFDP would be able to address some of the gaps in the decision criteria described above, especially where existing buildings and redevelopment are concerned. This could include how decisions are made regarding access provisions along existing roads and under what circumstances the access, floor level or other conditions would be amended from the standard approach.

I have not attempted to draft such a LFDP, but would consider that it would provide significantly better guidance to the public and would explicitly provide for decision guidelines from the floodplain manager to be appropriately crafted for the area. This type of approach is fully consistent with the DELWP Guidelines for Developments in Flood Prone Areas. Local Floodplain Development Plans are incorporated into a number of planning schemes, including for areas such as Shepparton and Skipton. The Skipton Local Floodplain Development Plan enables development in some areas designated as Floodway Overlay that would otherwise not be considered. This is to ensure that the main commercial area of the township is able to redevelop appropriately, even though properties may not meet the access and flood safety criteria that would be typically applied.

10. Background Documents in the Schedule to Clause 72.08

In general, the background documents associated with the Scheme are reasonable. However, there are two documents where consideration should be given to removing them from the associated documents. These two documents are:

- Planning for Sea Level Rise Guidelines (Melbourne Water. February 2017)
- Lower Yarra River Flood Mapping (GHD dated 24 September 2020)

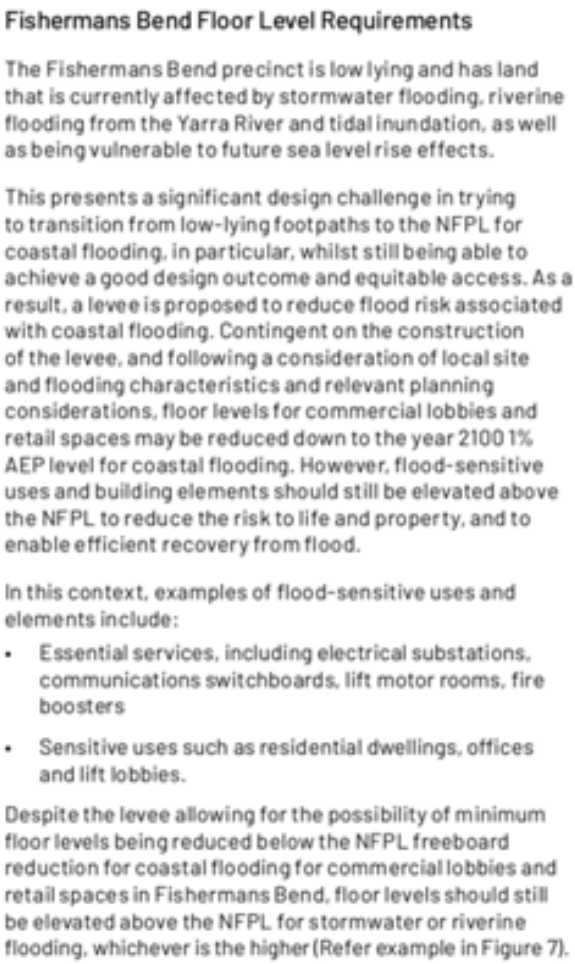
The reason for excluding the planning for sea level rise guideline is that the document is not technically consistent with other data sources regarding the expected sea level rise conditions in Port Phillip Bay. The document adopts levels at St Kilda that are not appropriate for the Yarra River, including additional consideration of wave action and setup.

The exclusion of the GHD report is for the reasons described in section 7 above. Whilst the report may be a reasonable representation of flooding under the conditions modelled, they do not appear to be consistent with the actual existing behaviour of the Yarra River in a current day 1% flood events. Without calibration of the model for a floodplain like the Yarra, and the likelihood that the levels are significantly overestimated, the use of the report as a background document that properly describes the flood behaviour of the Yarra cannot be supported.

Additionally, the document does not provide any sufficient details of expected flood levels or flows at key locations along the floodplain, again limiting its use as a planning document.

11. Reduction in required floor levels due to levees

The Good Design Guide adopts a flood protection level that is lower than usual nominal flood protection level under certain circumstances. An extract is shown in Figure 11-1.



Fishermans Bend Floor Level Requirements

The Fishermans Bend precinct is low lying and has land that is currently affected by stormwater flooding, riverine flooding from the Yarra River and tidal inundation, as well as being vulnerable to future sea level rise effects.

This presents a significant design challenge in trying to transition from low-lying footpaths to the NFPL for coastal flooding, in particular, whilst still being able to achieve a good design outcome and equitable access. As a result, a levee is proposed to reduce flood risk associated with coastal flooding. Contingent on the construction of the levee, and following a consideration of local site and flooding characteristics and relevant planning considerations, floor levels for commercial lobbies and retail spaces may be reduced down to the year 2100 1% AEP level for coastal flooding. However, flood-sensitive uses and building elements should still be elevated above the NFPL to reduce the risk to life and property, and to enable efficient recovery from flood.

In this context, examples of flood-sensitive uses and elements include:

- Essential services, including electrical substations, communications switchboards, lift motor rooms, fire boosters
- Sensitive uses such as residential dwellings, offices and lift lobbies.

Despite the levee allowing for the possibility of minimum floor levels being reduced below the NFPL freeboard reduction for coastal flooding for commercial lobbies and retail spaces in Fishermans Bend, floor levels should still be elevated above the NFPL for stormwater or riverine flooding, whichever is the higher (Refer example in Figure 7).

Figure 11-1 - Fishermans Bend Floor Level Requirements

This approach could be applied for other areas of the lower Yarra floodplain, such as Southgate. I would be supportive of this approach. I also note that there is no reason that the levees could not be designed such that they provide protection from riverine flooding – indeed it is the combination of a riverine flood and a coastal tidal flood that causes the peak elevated levels in the Yarra shown in the overlay.

I note that the reduction is down to the adjacent 2100 coastal flood level (2.27mAHD). This is below the existing floor levels at Southgate, and would meet safe access criteria along

Southgate Avenue. However, should the area be protected by precinct wide levees in some form, there is a strong argument that even adopting the 2100 coastal inundation level is an excessive response to the risk of riverine flooding.

For example, in other areas that are protected by 1% AEP levees, areas on the dry side of the levee are not routinely included in flood overlays or considered as subject to flooding, unless they are otherwise impacted by local stormwater flooding. An example is Castle Creek levee at Euroa. The BMT Southbank Stormwater Infrastructure Assessment recommends that the local drainage network be fitted with non-return valves and pumps to ensure that the infrastructure is functional under elevated Yarra river levels and does not provide a pathway for river water to impact low lying areas via backflow.

It is acknowledged that levees can fail, and the DELWP guidelines advise that the emergency management plan for impacted communities should be developed with this in mind.

12. Findings and Conclusions

Based on my investigations, it is my opinion that:

- The GHD flood modelling that forms the basis for the Lower Yarra has not been completed to a standard that provides sufficient certainty for its use in determining flood levels in the Lower Yarra, as shown in the proposed LSIO3 maps. This is because:
  - The model adopts a tidal signal boundary condition that is inconsistent with expected storm surge behaviour, resulting in an elevated levels in the Yarra
  - Testing indicates that the use of the GHD tidal boundary can overestimate flood levels at equivalent times by more than 200mm, and change the expected flood timings, such as those experienced in the 1934 flood event.
  - The model has not been calibrated to the 1934 event or to other contemporary flood events in the Yarra, including 2005, despite information being available for those events. The GHD results indicate that the adopted model is overpredicting the 1934 flood levels by at least 800mm at Princes Bridge and 400mm at Spencer Street
  - I consider the lack of calibration of the Yarra River model to be inconsistent with good modelling practice as described in ARR2019.
- The LSIO3 flood extents are likely to be larger than would be experienced in the 1% AEP flood at 2100.
- Adopting a larger flood extent for planning controls is not necessarily a bad planning outcome. However, using the information from the GHD report to determine future floor levels by the floodplain management authority cannot be supported, given the identified issues. The setting of floor levels that are significantly higher than would be reasonable expected is poor planning outcome, and may make it difficult to meet the objectives of the LSIO.
- The safe access provisions of LSIO3 as proposed in the objectives, are unlikely to be met by many existing properties, including Southgate, through no fault of the property owner, given that they connect to the existing street network.

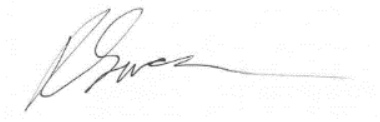
- The decision criteria of the LSIO are generally reasonable, but are not required to be considered by the floodplain management authority. This means that the balancing of flood risk and design response can be severely limited, especially as Melbourne Water has indicated that they will not apply discretion to the DELWP guidelines.
- I believe there is a need for the development of a Local Floodplain Development Plan as part of the overlay to address the significant local constraints of a heavily urbanised and built-up area such as the Southgate site and the wider lower Yarra. This LFDP would provide additional guidance and clarity on how flood risk can be controlled to meet the objectives of the LSIO. It should consider a range of options, including flood protection devices to provide primary protection, flood warning and evacuation, streetscape and access concerns, especially on low-lying streets and potentially a progressive nominal flood protection level for existing buildings. This should not be considered an exhaustive list. The plan should aim to ensure reduced flood risk through the lower Yarra, acknowledging that avoidance is not the only response to risk.
- There is a clear need for a wider flood mitigation scheme for the lower Yarra that is not reliant on planning controls to provide flood protection. Such schemes are proposed for the Arden Precinct and Fishermans Bend. This would significantly reduce flood risk to the area and can be planned and implemented before the risk materialises as a result of sea level rise.
- I would support a reduction in adopted flood levels for development controls as a result of a levee adjacent to the river providing flood protection above the 1% AEP flood level. This is similar to the approach taken at both the Fishermans Bend and Arden Precincts.

13. Limitations

The hydraulic modelling I have undertaken that is described in this statement is preliminary and intended to assess that impacts of the erroneous tidal boundary adopted in the GHD modelling. In particular, the dimensions of bridge structures have been estimated based on topography, aerial and land imagery and data available from VicRoads online bridge structure database. Although I have undertaken a preliminary calibration to the 1934 flood events, the model results presented should be considered indicative of Yarra flood levels only. The model is suitable for the comparison of changes in flood level as a result of various boundary assumptions.

14. Declaration

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.



Robert Campbell Swan

5 October 2022

Appendix A CV of Robert Campbell Swan

Rob Swan

Principal Flood & Stormwater Engineer

Rob has over twenty years' experience in the areas of hydrology and hydraulics, flood analysis, water quality and environmental assessment. He has significant project management experience and has worked on a number of large multi-disciplinary infrastructure projects. Prior to joining HARC, Rob was Cardno's National Technical Director for Water.

Rob is an expert in floodplain management and the simulation and modelling of large flood events. He is a member of the Victorian State Emergency Service Expert Hydrologist Panel and has performed in an operational capacity in emergency flood response. Rob has significant experience in the intersection of the planning system and flood analysis and their interaction to provide community benefit and appropriate management of natural assets.

Qualifications

Bachelor of Engineering, 2000

Diploma of Project Management, 2016

Affiliations

Fellow of the Institute of Engineers Australia (FIEAust)

Expertise

One and two-dimensional numerical model development and application for the study of flooding and water quality

Flood Emergency Response and Planning

Drainage Scheme Development and Application

Planning Scheme Amendments

Hydraulic and hydrologic investigations of urban and rural floodplains

Water quality investigations of shallow lakes and Water Sensitive Urban Design

Floodplain management and planning

Expert Witness Services and Planning Panels

Employment History

Hydrology and Risk Consulting (HARC), Australia

February 2021 – current

Cardno / Lawson and Treloar, Australia

January 2003 – December 2020

Melbourne Water Corporation, Australia

November 2000 – December 2002

Recent Project Experience

Floodplain Management and Modelling

Rob has extensive experience developing, calibrating and using flood models for strategic and statutory planning, infrastructure investigations and design. He has worked in this sector for a range of private and government projects, including on major infrastructure projects.

- **Melbourne Water Flood Planning Panel** (2014 – 2020) – Rob was the project director and key client liaison for projects undertaken as part of this panel arrangement. This included more than 20 individual projects with a total value in excess of $2.5M. The projects were varied and included flood mapping, advice on pump station and infrastructure design, expert witness advice and development of planning layers. Flood mapping projects were completed across Melbourne, including areas such as Pakenham, Hume, Riddles Creek and Nunawading,
- **Clifton Springs and Drysdale Flood Mapping and Mitigation Project** (2020) – Rob was the project director for this project undertaken on behalf of the City of Greater Geelong. The project included mapping and analysis of both historical and expected flooding in the Clifton Springs and Drysdale on the Bellarine Peninsula. The project was expanded to include an assessment of potential integrated water cycle management options in the catchment.

- **City of Manningham Flood Mapping and Planning** (2011-2018) – Rob was the project director and manager for the City of Manningham flood mapping projects and the following flood planning layer development project. Rob ensured that the project delivered high quality mapping outcomes that were suitable for use by Melbourne Water and Council. Rob acted as the expert witness for the Panel hearing and provided advice to reduce the number of objectors prior to the panel hearing.
- **Benalla Rural City Flood Information** (2016-2020) - Rob was the lead for the Rural City of Benalla for a number of projects, including the detailed investigation of large scale flood mitigation options. This included presenting to three community forums with over 300 total attendees and providing summary documents to Council for distribution to residents. The outcome of this work was the Benalla Flood Information Portal, which provides advice on flood risk to all residents of Benalla. Rob led this follow up project and launched the portal alongside Council and VicSES in late 2017.
- **SES Expert Hydrologist 2012 Broken Creek Flood Event -** Rob provided hydrological and hydraulic analysis as part of the incident response to flooding on the Broken Creek. His work included public meetings and liaison, flood impact prediction, hydrological assessment and flood impact assessment. Rob is a current member of SES's expert hydrology panel.
- **Port Fairy Coastal Hazard Mapping Project** (2016-2020) – Rob was the project director and key technical lead for this project which expanded the assessment of coastal inundation at Port Fairy from a static analysis to a fully dynamic assessment for a number of riverine and coastal event combinations. The project will define the future development boundaries for the township of Port Fairy.
- **Bellarine Coastal Hazard Vulnerability Assessment** (2012-2016) - The Bellarine Peninsula - Corio Bay LCHA study area includes the entire Bellarine Peninsula and the northern side of Corio Bay, from Point Wilson in the north, to Breamlea in the south. The study provided a comprehensive understanding of the extent of coastal hazards and their impacts on the coastal environments within the study area. It assessed coastal inundation, while considering the effects of climate change, as well as combined incidence of catchment flooding and coastal inundation. Rob was the technical lead for the inundation modelling portions of the project, including the consideration of ocean storm surge and tidal flood events.

Major Infrastructure Projects

- **North East Link Project Early Works (DP48)** (2019-2020) – Rob was the project lead for design Package 48 of the North East Link Early Works Project. This project included the flood analysis of the proposed early works design at Borlase Reserve and the design of temporary drainage works for the realignment of Banyule Creek. The design package was delivered under significant time constraints to meet the project construction requirements.
- **North East Link Early Works Construction** (2020) Rob managed the response to flooding for the construction phase of the North East Link Early Works program. This included assessment of flood impacts from temporary works and the development of construction flood management plans, based around the trigger levels and actions.
- **Melbourne Metro Project Stations and Tunnels** (2018–20) Rob was a technical adviser to the Stations and Tunnels design team and provided technical review for flood mapping and analysis of the flooding associated with the city stations and tunnel portals. This included mapping of urban flooding through the CBD and in the Arden Street precinct. Analysis was also required of the major riverine flooding associated with the Yarra and Maribyrnong Rivers and Moonee Ponds Creek.
- **Western Distributor Tender Design** (2016-17) - Rob was the design lead for flooding for the Western Distributor Tender Design. The project is a $5.5 Billion tunnel and freeway upgrade and included crossings of 4 major waterways. The analysis of a new bridge crossing of the Maribyrnong River included consideration of PMP and climate change flooding and the navigational requirements of commercial and recreational craft on the river.
- **Second Bridge Crossing, Murray River at Echuca** (2012-2017) Rob provided design and technical advice to VicRoads on the required bridge and culvert requirements for the proposed second crossing of the Murray and Campaspe Rivers at Echuca. This advice included flood impact assessment, mitigation sizing, preliminary costing, water quality and

quantity assessment and community consultation. Rob prepared the technical reports and provided expert advice to the Planning Panel considering the application.

Urban Planning, Development and Integrated Water Cycle Management

- **Shepparton East Growth Area** (2019) – Project Director for the drainage, IWM and flood strategy for the Shepparton East Growth Area. The project was undertaken for the VPA to provide appropriate engineering inputs into future land use planning.
- **Benalla West Drainage Strategy** (2019) – Project Director for the Benalla West Drainage Strategy, which defines the future strategy for the next 30 years of development in Benalla. This include consideration of flood behaviour and conceptual drainage design.
- **East Village Bentleigh Development Drainage Strategy** (2018) – Project director for the development of the future drainage strategy for the East Village development at Bentleigh, including consideration of the main drainage flood impacts, development of the required drainage strategy and integration of water sensitive urban design drainage elements into the comprehensive development plan.
- **Sandown Racecourse Flood Management Strategy** (2020) – on behalf of the Melbourne Racing Club, Rob developed the flood management and drainage strategy to facilitate the future redevelopment of Sandown Racecourse. The proposed strategy incorporates the naturalisation of Mile Creek, significant flood storage and optimises the availability of open space throughout the site.

Water Balance, Water Quality and WSUD

- **Cannon Hills Development and Golf Course, Brisbane** (2018 - 2020) – Rob was the technical director and project lead for the assessment of this development which included water harvesting from a tidal creek for irrigation purposes. Rob assessed the complex interactions between surface hydrology, tidal levels and irrigation demands to optimise the availability of water for irrigation, whilst ensuring appropriate turnover to minimise blue green algal growth and ensuring that fish refuges remained wet at all times.
- **Melbourne Desalination Plant Outfall** (2013/14) – Rob was a project lead for the investigation and modelling of the saline plume discharge from the Melbourne Desalination plant. This modelling determined the area of environmental impact that was used to define the operating licence for the plant. Subsequent testing has indicated that the highly detailed 3D model was very accurate in its estimation of the area of impact.
- **Sanctuary Lakes Algal Bloom Modelling** (2004-5) – Rob was the project lead for the analysis of the expansion of the 60 hectare lake to 120 hectares. The analysis used modelling to assess the performance of the lakes under a range of scenarios and incorporated the use of a process driven water quality model to quantify potential algal growth. Since the modelling was completed, there has not been an algal bloom in the lakes system.
- **Johnstone Park Raingarden Geelong** (2017) **–** Rob was the project director for this project which incorporated a tiered raingarden and a 250Kl stormwater reuse tank in the heritage listed Johnstone Park. The design required heritage approvals and was created to be sympathetic to the original park design.

Awards

- 2011 Harold Davies Award for Technical Excellence, Runner-up

Publications

Swan, R, Guest, R, Sommerville, H, and Haywood, J. (2018) *ARR 2016 – Adopting a Practical Methodology for Catchment Scale Urban Flood Mapping Projects*. Proceedings of the 2018 Floodplain Management Australia National Conference, May 29 to June 1, 2018

Veldema, A and Swan, R (2016) *Adaptive Floodplain Planning - from modelling to implementation*. Proceedings of the 4th National Conference of Stormwater Australia, August-September 2016

Veldema, A and Swan, R (2015) *Transforming Flood Mapping Outputs to Decision Making Inputs*. Proceedings of the 36th National Hydrology and Water Resources Symposium, December 2015

Swan, R, Provis, D and Bicknell, P (2015) *Ocean Inundation, climate change and policy planning – is the Flood approach suitable?,* Proceedings of the 36th National Hydrology and Water Resources Symposium, December 2015

Swan, R, and Thompson, A (2013) *Representing flood mechanisms in the Koo Wee Rup Flood Protection District,* Presented at the 8th Victorian Flood Conference, February 2013

Thompson, A and Swan, R, (2013) *Flood Mapping without Drainage Asset Data,* Presented at the 8th Victorian Flood Conference, February 2013

Swan, R, and Thomson, R (2011) *Direct Rainfall - Verifying the technique across two States,* Proceedings of the 34th IAHR World Congress and the 33rd National Hydrology and Water Resources Symposium and the 10th National Conference on Hydraulics in Water Engineering, June 2011

Swan, R. (2010) *Direct Rainfall - Loss Modelling Approaches,* Presented at the 7th Victorian Floodplain Management Conference, October 2010

Swan, R and Provis, D. (2010) *Ocean versus River - Coastal Interfaces, Climate Change and Flood Analysis,* Presented at the 7th Victorian Flood Conference, October 2010

Swan, R, Watkinson, R and Wong, M. (2007a) *Dealing with Hydrological Uncertainty: A New Modelling Approach,* Presented at the 5th Victorian Floodplain Management Conference, October 2007

Swan, R, Howells, L, Bonello, D, Watkinson, R, Robertson, J. (2005) ***Flood Studies and Extreme Events - Modelling, Mitigation and Assessment at Fairfield, Victoria*****,** Presented at the 4th Victorian Floodplain Management Conference, October 2005

Swan, R. (2004) *Application of Australian Runoff Quality Draft Chapter 6 - A 'model' approach?,* Proceedings of the 6th International Conference on WSUD - Cities as Catchments (WSUD 2004), December 2004

Swan, R. and Collins, N. (2004) *Integrated High Order Water Quality and Hydrodynamic Analysis - An Essential Tool for Lake Management,* Proceedings of the 8th National Conference on Hydraulics in Water Engineering, July 2004

Appendix B Instructions

16 September 2022

Our ref: MLL JXT 205484

Robert Swan
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Dear Rob

Amendment C384 to the Melbourne Planning Scheme Application of the Land Subject to Inundation Overlay

1 Introduction

1.1 We act on behalf of ESR Real Estate (Australia) Pty Ltd (**ESR**), submitter 30 to Amendment C384 to the Melbourne Planning Scheme (**Amendment)** and is one of the owners of 3 Southgate Avenue, Southbank and 16-60 City Road, Southbank (**Southgate**).

1.2 The purpose of the Amendment is to "*implement updated flood modelling undertaken for local catchments within the City of Melbourne by introducing and applying new **schedules** to the Land Subject to Inundation Overlay (**LSIO**) and Special Building Overlay (SBO) and making other consequential changes to the Melbourne Planning Scheme*".

1.3 On 7 October 2021, Melbourne City Council (**Council**) acting as the planning authority placed the Amendment on exhibition and sought feedback from stakeholders.

1.4 Specifically, the Amendment proposes the following changes:

Amendment	Proposed changes
Amendment C384 to the Melbourne Planning Scheme	▪ Amend the wording in Schedules 1 and 2 to the LSIO; ▪ Introduce a new Schedule 3 to the LSIO; ▪ Introduce new Schedules 1, 2 and 3 to the SBO ▪ Introduce new background documents to the Schedule to Clause 72.08 ▪ Amend the mapping associated with the LSIO and SBO.

1.5 On 29 November 2021, ESR lodged a submission to Council outlining its position in relation to the Amendment.

1.6 On 2 August 2022, Council considered the submissions received and resolved to refer all submission onto a Planning Panel.

1.7 A Panel hearing is listed to commence on 17 October 2022 and run until 28 October 2022.

2 The Land

2.1 ESR is part owner of the following properties which make up Southgate (approximately 2 hectares):

(a) 3 Southgate Avenue, Southbank; and

(b) 16-60 City Road, Southbank.

Figure 1 - Aerial image

2.2 Currently the Land:

(a) is within the Capital City Zone - Schedule 3 (Southbank); and

(b) is subject to the following overlays:

(i) Design and Development Overlay (partially):

(A) Schedule 1 (Urban Design in Central Melbourne);

(B) Schedule 10 (General Development Area- Built Form); and

(C) Schedule 60 (Special Character Areas- Built Form (Southbank));

(ii) Parking Overlay (Schedule 1: Capital City Zone - Outside the Retail Core);

(iii) Specific Controls Overlay (Schedule 25 - Southgate Redevelopment Project). This provides site specific approval to the redevelopment proposal and exempts the land from the application of other planning controls.

Figure 2 - Zoning map

3 Amendment C384

3.1 Council has partnered with Melbourne Water to update flood mapping for areas experiencing increased growth and urban development. The new modelling used to arrive at new LSIO and SBO boundaries incorporates climate change factors, such as increased rainfall intensity and sea level rise, that are predicted to influence inundation.

3.2 Specifically, the Amendment seeks to update flood mapping (SBOs and LSIOs) to reflect new flood modelling that incorporates Australian Rainfall and Runoff 2019 standards for climate change:

(a) an 18.5% increase in rainfall intensity by 2100;

(b) for Moonee Ponds Creek and the Lower Yarra River, a boundary condition inclusive of a starting water surface level of a 10% Annual Exceedance Probability (**AEP**) tidal level plus a 0.8 metre sea level rise in 2100.

3.3 In relation to Southgate, based on the new modelling, the Amendment proposes to include part of the land within the new LSIO - Schedule 3 (Moonee Ponds Creek and Lower Yarra River Waterways):

Figure 3 - Current extent of LSIO

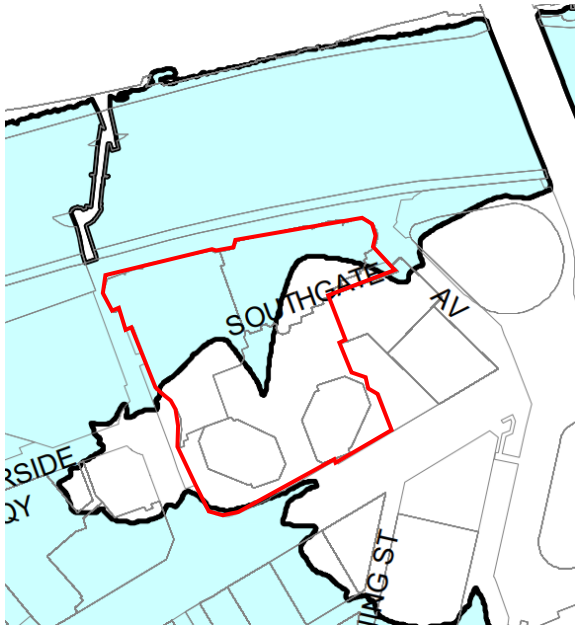

Figure 4 - Proposed LSIO extent under C384

3.4 A new Schedule 3 (Moonee Ponds Creek and Lower Yarra River Waterways) to the LSIO (**LSIO3**) is to apply to Southgate. The objectives of LSIO3 are to:

(a) identify land in areas that may be inundated by the combined effects of the 1% Annual Exceedance Probability (AEP) flood event incorporating an 18.5% increase in rainfall intensity due to climate change by the year 2100;

(b) protect life, property, public health, assets and the environment from flood hazard;

(c) minimise the impact of development on flood extent, depth and the flow velocity;

(d) ensure new development is suitably designed to be compatible with local drainage characteristics and identified flood hazard; and

(e) ensure development simultaneously achieves safe access and egress, good urban design and equitable access.

3.5 The Amendment is supported by a number of background and technical reports, which are proposed to form part of the Schedule to Clause 72.08, including:

(a) Technical Report 01: *Australian Rainfall Runoff Sensitivity Analysis* (Engeny Water Management dated 22 July 2020)

(b) Technical Report 02: *Southbank Flood Modelling Update and Climate Change Scenarios* (Water Modelling Solutions dated 21 April 2020)

(c) Technical Report 03: *Southbank Stormwater Infrastructure Assessment: Final Report* (BMT WBM dated August 2015)

(d) Technical Report 04: *Elizabeth Street Melbourne Flood Modelling Report (Water Technology, dated August 2017) including the Memorandums* dated 9 April 2020 and 13 February 2020

(e) Technical Report 05: *Arden Macaulay Precinct & Moonee Ponds Creek Flood Modelling* (Engeny Water Management dated August 2020)

(f) Technical Report 06: *Lower Yarra River Flood Mapping* (GHD dated 24 September 2020)

(g) Technical Report 07: *Hobsons Road Catchment Flood Mapping Update (Venant Solutions dated 17 June 2020) including the review response* dated 22 April 2020

(h) Technical Report 08: *Fishermans Bend Flood Mapping* (GHD dated November 2020)

(i) Technical Report 09: *Overlay Delineation Report* (Engeny Water Management dated 27 October 2020)

(j) *Planning for Sea Level Rise Guidelines* (Melbourne Water. February 2017)

(k) Guidelines for Development in Flood Affected Areas (Department of Environment, Land, Water and Planning, 2019)

(l) *Good Design Guide for Buildings in Flood Affected Areas in Fishermans Bend, Arden and Macaulay* (City of Melbourne, Melbourne Water and City of Port Phillip, 2021).

4 Southgate's planning background

4.1 On 24 December 2021, the Minister for Planning approved and gazetted Amendment C390 to the Melbourne Planning Scheme which introduced the Specific Controls Overlay to facilitate the Southgate Redevelopment Project (**Project**) by introducing an incorporated document titled '*Southgate Redevelopment Project – 3 Southgate Avenue, Southbank – September 2021*' (I**ncorporated Document**).

4.2 Prior to the approval and gazettal of Amendment C390, the Minister for Planning sought advice from Melbourne Water in relation to flooding. On 14 August 2020, Melbourne Water advised in an email to Michael Cawood (project engineer) that:

(a) *"The applicable adjacent flood level associated with the Yarra River for a storm event with a 1% chance of occurrence in any given year is 2.0 metres to Australian Height Datum (**AHD**).*

(b) *Southgate will be affected by a rise of 0.8 metres in the mean sea level of Port Phillip Bay by 2100 and therefore this property will be affected by flooding from the Bay in the future.*

(c) *Historically, Melbourne Water has adopted a 1 in 100 year flood level of 1.6 metres to AHD for Port Phillip Bay. A future sea level rise of not less than 0.8 metres by 2100 will translate to a level for Port Phillip Bay of 2.4 metres to AHD."*

(d) Southgate's architectural drawings should address the following:

(i) *"the finished floor levels of the new sections of the building, including lift lobbies and entrances to the basement, should be set no lower than 3.0 metres to AHD, to provide 600mm of flood protection above the applicable 2100 year flood level of 2.4 metres to AHD associated with coastal inundation;*

(ii) *concessions to the finished floor levels of the retail, storage & transitions areas down to 2.6 metres to AHD can be considered, where the natural surface levels of the property and design constraints associated with the existing building limit the ability to achieve a finished floor level of 3.0 metres to AHD. This level provides a minimum 600mm flood protection from the adjacent Yarra River flood level.*

(iii) *where protection to the retail areas at 2.76 metres to AHD is provided through existing floor levels, it is recommended that these levels are not further reduced.*

(iv) *The finished floor levels of areas containing electrical fittings e.g. substations, gas meters, fire controls etc. should be set no lower than 3.0 metres to AHD, unless otherwise accepted by the relevant utility authorities/service providers in relation to the risk of flood damage."*

4.3 The Incorporated Document provides that:

> "*The use and development of the land must be in accordance with the detailed development plans endorsed under the conditions of the Incorporated Document and must be generally in accordance with the 'Incorporated Plans' prepared by Fender Katsalidis Architects, titled 'Massing and Development Envelope Plans' and dated 28 January 2021*"

4.4 The Massing and Development Envelope Plans show finished floor levels at approximately RL 3m, in accordance with Melbourne Water's advice. On that basis, the Minister for Planning approved and gazetted Amendment C390.

4.5 In order to commences works, the Project must comply with a number of conditions under the Incorporated Document. Condition 2(e) of the Incorporated Document provides that detailed development plans must provide:

> "*Design details at 1:50 scale (or as otherwise agreed with the Minister for Planning) of the lower podium levels including the interfaces to the public open space to demonstrate careful consideration of the building canopies, entries, active frontages, and services. Drawings should demonstrate finished material and detail that respond to the human scale and the function and character of the threshold from private to public land. Any level changes to the ground floor interface resulting from Melbourne Water requirements should have regard to balancing activation and flood mitigation*." [our emphasis]

4.6 On 7 December 2021, Melbourne Water advised that the applicable flood level for Southgate under the Amendment C384 modelling was 3.44m. Given that Southgate is in a riverine environment, a freeboard allowance of 600mm would also be required meaning finished floor levels for the Project would need to be raised to 4.06m to satisfy Melbourne Water.

4.7 We understand that Southgate has yet to submit detailed development plans under the Incorporated Document to the Minister for Planning for her consideration.

5 Panel hearing

5.1 Keys dates for the Panel hearing are as follows:

(a) by 3 October – Council and Melbourne Water to circulate Part A Submission and expert evidence;

(b) by 6 October – Submitter parties to circulate expert evidence;

(c) by 11 October – Council and Melbourne Water to circulate Part B Submission;

(d) on 17 October – Hearing commences;

(e) by 12pm on 21 October – ESR to circulate its written submission and, if required, expert witness slides and responses to 'like' evidence; and

(f) on 24 and 28 October - ESR is listed to present its evidence and submissions.

6 Counsel and experts

6.1 Tiphanie Acreman of counsel has been engaged to appear on behalf of ESR at the Panel hearing.

6.2 In addition to your hydrology/flooding evidence, ESR is likely to call expert witnesses in relation to architecture/urban design and planning.

7 Your instructions

7.1 Our client has instructed us to engage you to undertake the following work:

(a) review all materials enclosed in your brief;

(b) prepare an expert witness statement addressing hydrology/flooding matters for the purpose of the Panel hearing. In addition to any matters that you consider relevant, your witness statement should address whether:

(i) the flood reports adopted an appropriate methodology;

(ii) the modelling and analysis has been appropriately undertaken;

(iii) the updated LSIO mapping is appropriate;

(iv) the LSIO3 is drafted appropriately and includes all matters you consider relevant in the Decision Guidelines; and

(v) any of the listed Background Documents ought to be amended and/or removed from being referenced in the LSIO3.

(c) if instructed, attend the Panel hearing to observe any opposing hydrology/flooding evidence;

(d) if instructed, advise on the merits and technical issues raised in any opposing expert hydrology/flooding evidence; and

(e) appear at the Panel hearing to present your evidence in relation to hydrology/flooding matters.

7.2 Please provide your fee proposal to this office, addressed to:

Duncan Scott
Project Director
Duncan.Scott@esr.com

7.3 Your expert witness report should be prepared in accordance with the *Planning Panels Victoria Guide to Expert Evidence*.

7.4 Please note that your evidence is due to be filed and served **on 6 October 2022**. As such, we would appreciate a draft of your witness statement **by 29 September 2022**.

7.5 Please advise us as soon as possible as to whether you require any further information in relation to the Amendment and its supporting documents.

8 Confidentiality

8.1 This letter and enclosed documents and all future communications between us and between you are confidential (**Confidential Information**), and are subject to a claim for privilege and must not be disclosed without our consent or the consent of our client.

8.2 The duty of confidentiality will continue beyond the conclusion of your instructions.

8.3 If you are obliged by law to disclose Confidential Information, it is not a breach of this engagement if you first give written notice to us of that obligation, if you can do so without breach of any law.

8.4 You must return all documents and other media, including copies, which contain Confidential Information to us. You must delete all electronically stored material immediately when requested to do so by us.

8.5 You must take all steps necessary to maintain Confidential Information and notes in strictest confidence.

9 Change of opinion

9.1 If for some reason, you change your opinion after delivering your report, please advise us as soon as possible. If that change is material, a supplementary report will need to be prepared, which explains the reasons for the change in your opinion.

Please contact Meg Lee on (03) 9603 3312 or Jamie Truong on (03) 9603 3427 should you have any queries.

Yours faithfully

Hall & Wilcox

Encl.

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Volume 1 - Documents regarding the Land

No	Document	Date
1	Planning Property Reports	-
2	Planning Scheme Controls and Extracts	-
3	Title search information	-

Volume 2 - Amendment C384 documents

No	Document	Date
4	Authorisation documents:	
	a. Council officer report, including attachments	3 August 2021
	b. Letter from DELWP authorising amendment	18 August 2021
5	Exhibited ordinances and maps:	October 2021
	a. Explanatory Report	
	b. Instruction Sheet	
	c. Clause 44.04 (Land Subject to Inundation Overlay - Schedule 1)	
	d. Clause 44.04 (Land Subject to Inundation Overlay - Schedule 2)	
	e. Clause 44.04 (Land Subject to Inundation Overlay - Schedule 3)	
	f. Clause 44.05 (Special Building Overlay - Schedule 1)	
	g. Clause 44.05 (Special Building Overlay - Schedule 2)	
	h. Clause 44.05 (Special Building Overlay - Schedule 3)	
	i. Clause 72.08 Schedule	
	j. Overlay maps	
6	Exhibited background reports:	
	a. Technical Report 01: *Australian Rainfall Runoff Sensitivity Analysis* (Engeny Water Management)	22 July 2020
	b. Technical Report 02: *Southbank Flood Modelling Update and Climate Change Scenarios* (Water Modelling Solutions)	21 April 2020
	c. Technical Report 03: *Southbank Stormwater Infrastructure Assessment: Final Report* (BMT WBM)	August 2015
	d. Technical Report 04: *Elizabeth Street Melbourne Flood Modelling Report* (Water Technology, dated August 2017) including the Memorandums	9 April 2020 and 13 February 2020
	e. Technical Report 05: *Arden Macaulay Precinct & Moonee Ponds Creek Flood Modelling* (Engeny Water Management)	August 2020
	f. Technical Report 06: *Lower Yarra River Flood Mapping* (GHD)	24 September 2020
	g. Technical Report 07: *Hobsons Road Catchment Flood Mapping Update* (Venant Solutions) including the review response	17 June 2020 and 22 April 2020

No	Document	Date
	h. Technical Report 08: *Fishermans Bend Flood Mapping* (GHD)	November 2020
	i. Technical Report 09: *Overlay Delineation Report* (Engeny Water Management)	27 October 2020
	j. *Planning for Sea Level Rise Guidelines* (Melbourne Water)	February 2017
	k. *Guidelines for Development in Flood Affected Areas* (Department of Environment, Land, Water and Planning)	2019
	l. *Good Design Guide for Buildings in Flood Affected Areas in Fishermans Bend, Arden and Macaulay* (City of Melbourne, Melbourne Water and City of Port Phillip)	2021

Volume 3 - Southgate approvals documents

No	Document	Date
7	Amendment C390 documents:	
	a. Explanatory report;	December 2021
	b. *Southgate Redevelopment Project – 3 Southgate Avenue, Southbank – September 2021*	September 2021
	c. Minister's reasons for intervention	21 November 2021
8	Letter from Melbourne Water regarding applicable flood levels	14 August 2020
9	Email from Melbourne Water regarding applicable flood levels	7 December 2021
10	Design plans referenced in the Incorporated Document:	
	a. Master Planning & Urban Context Report by Fender Katsalidis	April 2020
	b. Massing & Development Envelope Plans prepared by Fender Katsilidis	28 January 2021

Volume 4 - Submissions to Council and referral of submissions

No	Document	Date
11	ESR's submission	29 November 2021
12	Council's consideration of submissions: a. Officer report and attachments b. Council meeting minutes	2 August 2022

Volume 5 - Panel documents

No	Document	Date
13	Letter from PPV giving notice of directions hearing	12 August 2022
14	Panel directions and hearing timetable (v1)	6 September 2022

No	Document	Date
15	Panel hearing timetable (v2)	14 September 2022

Volume 6 - Other strategic documents

No	Document	Date
16	Background/strategy documents provided by Council: a. Health and Wellbeing Action Plan 2021 b. Asset Plan 2021-31 c. Built Environment Climate Change Adaptation Action Plan 2022 – 2026 d. The Climate Change Adaptation Strategy Refresh (2017) e. Climate Change Mitigation Strategy (2018) f. Docklands Waterways Strategic Plan (2009-2018) g. Elizabeth Street Catchment Integrated Water Cycle Management Plan h. Local Government Climate Change Adaptation Roles and Responsibilities under Victorian Legislation (2020) i. Maribyrnong Waterfront (2020) j. Melbourne Flood Management Plan (2018) k. Moonee Ponds Creek Strategic Opportunities Plan (2019) l. Municipal Integrated Water Management Plan (2017) m. Planning Practice Note 12 – Applying the Flood Provisions in Planning Schemes, June 2015 n. Review of the 2021-2011 Flood Warnings and Response o. Yarra River – Birrarung Strategy (2019)	5 September 2022

Rob Swan

From: Meg Lee <Meg.Lee@hallandwilcox.com.au>
Sent: Tuesday, 27 September 2022 3:17 PM
To: Rob Swan
Cc: Jamie Truong
Subject: C384 - comparison with Fishermens Bend [HW-Active.FID3592730]

Hi Rob

Further to your instructions in this matter, are you able to comment in your evidence on whether the approach at Fishermens Bend is something that should be considered (in your expert opinion) at Southgate ?
I note in the Good Design Guide the following extract in relation to Fishermens Bend, indicating that the construction of a levee will reduce the applicable freeboard requirements in that location.

Fishermans Bend Floor Level Requirements

The Fishermans Bend precinct is low lying and has land that is currently affected by stormwater flooding, riverine flooding from the Yarra River and tidal inundation, as well as being vulnerable to future sea level rise effects.

This presents a significant design challenge in trying to transition from low-lying footpaths to the NFPL for coastal flooding, in particular, whilst still being able to achieve a good design outcome and equitable access. As a result, a levee is proposed to reduce flood risk associated with coastal flooding. Contingent on the construction of the levee, and following a consideration of local site and flooding characteristics and relevant planning considerations, floor levels for commercial lobbies and retail spaces may be reduced down to the year 2100 1% AEP level for coastal flooding. However, flood-sensitive uses and building elements should still be elevated above the NFPL to reduce the risk to life and property, and to enable efficient recovery from flood.

In this context, examples of flood-sensitive uses and elements include:

- Essential services, including electrical substations, communications switchboards, lift motor rooms, fire boosters
- Sensitive uses such as residential dwellings, offices and lift lobbies.

Despite the levee allowing for the possibility of minimum floor levels being reduced below the NFPL freeboard reduction for coastal flooding for commercial lobbies and retail spaces in Fishermans Bend, floor levels should still be elevated above the NFPL for stormwater or riverine flooding, whichever is the higher (Refer example in Figure 7).

Kind regards

Meg Lee (she/her) | Partner

T +61 3 9603 3312 | F +61 3 9670 9632 | M +61 404 070 549
Meg.Lee@hallandwilcox.com.au | professional profile

Hall&Wilcox
smarter law
www.hallandwilcox.com.au

My working days are Monday - Friday

Appendix C Melbourne Water Flood Information at Southgate

11 February 2020

Mark Allan
MA Civil Design Pty Ltd
55 Sir Garnet Road
Surrey Hills VIC 3127

Dear Mark,

Proposal: Extension works at Southgate
Site location: 16-60 City Road Southbank 3006

Melbourne Water reference: MWA-1163098
Date referred: 21/01/2020

Thank you for your application regarding the proposed development at the above property. Melbourne Water has reviewed the proposal and provides the following advice for your consideration.

This property is affected by any incremental mean sea level rise associated with climate change predictions above the current Port Phillip Bay level of 1.6 metres. The flood level for Port Phillip Bay in 2040, rises 200mm to a level of 1.80 metres (AHD), with a further increase of 600mm by 2100, to 2.4 metres AHD.

When a property is affected by a flooding overlay or is 'land designated as land liable to flooding', Melbourne Water is a Referral Authority for buildings and works for planning and building permit applications. Melbourne Water has reviewed the submitted information/plans and has the following development requirements:

1. Any proposed ground floor residential areas (including areas with access to lifts/stairs) must be constructed with finished floor levels set no lower than 3 metres to Australian Height Datum (AHD), which is 600mm above the applicable flood level of 2.4m to AHD.

2. Retail ground floor areas must be constructed with finished floor levels set no lower than 2.4 metres to Australian Height Datum (AHD).

Advice

Melbourne Water assesses development applications in accordance with the adopted 'Guidelines for Development in Flood Affected Areas' (DELWP). Under these guidelines, development in or adjacent to a floodplain may only be acceptable where the new development is protected from flooding, has safe access to and around the development and does not interfere with the passage and storage of floodwaters.

This advice is valid for a period of three months from the date of this letter.

Melbourne Water ABN 81 945 386 953
990 La Trobe Street Docklands VIC 3008
PO Box 4342 Melbourne VIC 3001 Australia
T 131 722 F +61 3 9679 7099
melbournewater.com.au

The above information is only preliminary and forms no contractual agreement between your company and Melbourne Water. Melbourne Water reserves the right to alter any or all of this information at any time.

For enquiries in relation to this application please contact our Customer Service Centre on 131 722.

Regards,

Segujja Kakembo
Development Planning Services

Rob Swan

From: Michael Cawood
Sent: Tuesday, 7 December 2021 6:11 PM
To: Nikolas Karageorge
Cc: duncanscott@ara-group.com; Dev Connect; Stacey Rees
Subject: RE: Southgate redevelopment and amendment C384 - meeting sought please - MWA-1163098

Thank you Nic. Both Duncan and I very much appreciate the opportunity to talk with you and Stacey about the project and to work through with you what are likely to be challenging issues in relation to flood.

The following flood level information was provided prior to today's meeting
:

Description	Applicable Flood Level
Current/Today 1% AEP flood level (Yarra River)	2.88 m AHD
2100 1% AEP Climate Change Flood Level	3.44m AHD
Sea Level Rise 1% AEP Flood Level	2.4m AHD

My query during our meeting related to the 2.88m AHD level in the first row in the table above. However, my reading of the GHD Lower Yarra Flood Modelling report (and yes, it is a dense document that is not easy to digest – and therein may lie the answer to the clarification sought) has left me with a number of questions. An explanation of the following would be very useful. The first bullet is what I was aiming at during our meeting while the other bullets will assist our understanding of the current requirements. In all, somewhat more expansive than the verbal request. Trust that is OK.

- The scenario that delivers the 2.88m AHD level;
- The rationale for that level being adopted ahead of the 1934 flood level at Southbank – it is just on 1m higher than 1934 and with 600mm freeboard requires a minimum floor level just shy of 500mm higher than recent approvals and builds in the area;
- How that level (2.88m AHD) is used in the permitting/approvals process given amendment C384 and the intention to begin using the 2100 1% AEP climate change flood level of 3.44m AHD (derived from modelling the 1% AEP Yarra flood with the 18.5% climate change driven increase in rainfall plus the 1% AEP sea level rise tide (with lower Kc)) to drive minimum floor levels;
- Why the modelled tidal level has not regressed to oscillate around mean sea level after the storm surge has passed. Figure 23 in Appendix C of the GHD report shows the tide level remaining some 600mm higher than what would normally be expected. That would have a substantial influence on modelled peak flood levels through the lower Yarra and around Southbank.

As always, happy to talk if and as required.

Seasonal greetings and best regards
Mike

Michael Cawood | HARC
Principal - Flood and Emergency Risk Management
P: 03 8691 3728 | M: 0418 568 904

From: Nikolas Karageorge <Nikolas.Karageorge@melbournewater.com.au>
Sent: Tuesday, 7 December 2021 4:35 PM
To: Michael Cawood <michael.cawood@harc.com.au>
Cc: duncanscott@ara-group.com; Dev Connect <DevConnect@melbournewater.com.au>; Stacey Rees <Stacey.Rees@melbournewater.com.au>
Subject: RE: Southgate redevelopment and amendment C384 - meeting sought please - MWA-1163098

Good afternoon,

Thank you for the meeting earlier this afternoon.

Michael, you asked a question about the current/1% AEP flood level and I just wanted to make sure I convey your query as accurately as possible so if you could put that in writing to me via an email reply it would be very helpful.

Currently the applicable reference number is MWA-1163098 but I will be requesting a new reference number shortly and let you know what that is as it's created.

If there are any documents or proposed conditions that you believe might be of assistance to Melbourne Water, please feel free to send them on as it would be a great help.

Let me know if you have any further questions via email or my contact numbers below.

Kind regards,

Nikolas Karageorge | Area Manager, Development Planning Services | **Melbourne Water** | T: +61394735187 M: 0436 304 476 | 990 La Trobe Street, Docklands 3008 | PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au

We thank you for your support as our Organisation closes to take a break from service on 1st - 2nd November and 24th December 2021 - 7th January 2022 inclusive.

Statutory Developer Services provides the essential regulatory water decisions for Metropolitan Melbourne's urban and greenfield development sector. If you are the applicant and have a complaint regarding your project, you can contact my manager **Stacey Rees** to discuss.

For more information about how we're recruiting for 25 additional staff members and transforming to respond to the significant increase in complexity and demand for our Services, *and our New Year processing break*, please see our dedicated website:
Developers | Melbourne Water

We acknowledge the Victorian Traditional Owners and their Elders past and present as the original custodians of Victoria's land and waters and I pay my respects to their Elders past and present and to the ongoing living culture of Aboriginal and Torres Strait Islander Peoples.

Enhancing Life and Liveability.

From: Stacey Rees
Sent: Tuesday, 7 December 2021 9:10 AM
To: Michael Cawood <michael.cawood@harc.com.au>; Dev Connect <DevConnect@melbournewater.com.au>
Cc: Duncan Scott (APM Australia) <duncanscott@ara-group.com>
Subject: RE: Southgate redevelopment and amendment C384 - meeting sought please - MWA-1163098

Good Morning Michael, ahead of the meeting today we have sought to confirm the latest flood level information for the site on your behalf. Please find the information below, for discussion at the meeting.

Description	Applicable Flood Level
Current/Today 1% AEP flood level (Yarra River)	2.88 m AHD
2100 1% AEP Climate Change Flood Level	3.44m AHD
Sea Level Rise 1% AEP Flood Level	2.4m AHD

Kind Regards,

Stacey Rees | Development Planning Service Manager, Development Planning Services | Waterways and Catchment Operations | **Melbourne Water |** T: (03) 8615 5054 | 990 LaTrobe Street, Docklands 3008 | PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au

Please note that I work part-time (Tuesday, Wednesday and Friday).

Statutory Developer Services provides the essential regulatory water decisions for Metropolitan Melbourne's urban and greenfield development sector. If you are the applicant and have a complaint regarding your project, you can contact my manager Rachel Lunn to discuss.

For more information about how we're recruiting for 25 additional staff members and transforming to respond to the significant increase in complexity and demand for our Services, *and our New Year processing break*, please see our dedicated website:
Developers | Melbourne Water

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Enhancing Life and Liveability.

From: Michael Cawood <michael.cawood@harc.com.au>
Sent: Wednesday, 1 December 2021 3:53 PM
To: Stacey Rees <Stacey.Rees@melbournewater.com.au>; Dev Connect <DevConnect@melbournewater.com.au>
Cc: Duncan Scott (APM Australia) <duncanscott@ara-group.com>
Subject: RE: Southgate redevelopment and amendment C384 - meeting sought please - MWA-1163098

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Good afternoon Stacey and thank you for the quick reply and offer to meet with us to discuss the redevelopment proposal.

Duncan Scott and I would like to be involved in the meeting with you and Nik. Were you proposing a video meeting or face-to-face? Duncan and I can do either. We were thinking that an hour should be enough but would be good if there was opportunity to extend beyond that if needed. Based on current commitments, suggested timing is either:

- After 3pm on Monday
- Between 11am and 2pm on Tuesday
- Before 1030am on Wednesday

Hopefully there is a time within those periods where we can meet.

Regards
Mike

Michael Cawood | HARC
Principal - Flood and Emergency Risk Management
P: 03 8691 3728 | M: 0418 568 904

From: Stacey Rees <Stacey.Rees@melbournewater.com.au>
Sent: Wednesday, 1 December 2021 3:03 PM
To: Michael Cawood <michael.cawood@harc.com.au>; Dev Connect <DevConnect@melbournewater.com.au>
Cc: Duncan Scott (APM Australia) <duncanscott@ara-group.com>
Subject: RE: Southgate redevelopment and amendment C384 - meeting sought please - MWA-1163098

Hi Michael,

Thanks for your email.

Myself and Nik Karageorge (the relevant Area Manager) are happy to meet with you to talk through the development plans and permit application, and the implications of the new adopted flood levels and PS Amendment C384. We have some availability this Friday, or otherwise next week. Who would be attending the meeting on your/the developers end?

As discussed with Rob, at a high level, Melbourne Water's decision making criteria (e.g. application of the DEWLP guidelines, position on flood gates etc) has not changed. What has changed in this case is the adopted flood level.

I appreciate that this site will certainly present some difficulties due to the surface levels and interface points. If the proposal seeks to depart from the standard requirements of the guidelines we would encourage the developer to submit a flood risk assessment as part of their application outlining and justifying where/how/why such departures were being sought.

Kind Regards,

Stacey Rees | Development Planning Service Manager, Development Planning Services | Waterways and Catchment Operations | **Melbourne Water |** T: (03) 8615 5054 | 990 LaTrobe Street, Docklands 3008 | PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au

Please note that I work part-time (Tuesday, Wednesday and Friday).

We thank you for your support as our Organisation closes to take a break from service on 24th December 2021 - 7th January 2022 inclusive.
We are currently recruiting additonal staff resources to respond to the growth in Development Service demands across Melbourne. For information about what we're doing and our current service level expectations, please see our website Melbourne Water service processing times | Melbourne Water.

We acknowledge the Victorian Traditional Owners and their Elders past and present as the original custodians of Victoria's land

and waters and I pay my respects to their Elders past and present and to the ongoing living culture of Aboriginal and Torres Strait Islander Peoples.

Enhancing Life and Liveability.

From: Michael Cawood <michael.cawood@harc.com.au>
Sent: Friday, 26 November 2021 1:24 PM
To: Stacey Rees <Stacey.Rees@melbournewater.com.au>; Dev Connect <DevConnect@melbournewater.com.au>
Cc: Duncan Scott (APM Australia) <duncanscott@ara-group.com>
Subject: Southgate redevelopment and amendment C384 - meeting sought please

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Good afternoon Stacey and further to your conversation with Rob Swan on Tuesday.

The purpose of this intentionally short email is to provide some background to a redevelopment project at Southgate and to request a meeting to work through what is being planned and what flood related constraints will be applied to the site now that amendment C384 is under consideration.

Background

Southgate is a mixed use retail and commercial office precinct located adjacent to Hamer Hall on the southern side of the Yarra River between the river and City Road. The precinct contains approximately 10,000sq. m of retail premises over three levels all fronting the Yarra River, facing north and two office towers to the rear of the site providing over 70,000sq. m of commercial office space. The entire site is situated above an existing 2-level basement parking facility. The site is dissected by Southgate Avenue which runs east-west at the ground / Promenade level and divides the ground level into two distinct sections, the retail premises to the north of Southgate Avenue and the existing car park entry points, loading zones, infrastructure services, plant rooms and general back of house support areas to the south. Adjoining the Southgate Precinct is the Langham Hotel, Quay West apartments and St John's Lutheran Church which all share access from Southgate Avenue and also provision of some services.

Melbourne Water provided an initial response and advice in relation to an application for development at the site on 11 February 2020 (Melbourne Water reference: MWA-1163098). In view of amendment C384, we are uncertain as to whether we can rely on the flood planning and minimum floor levels provided in that advice as a basis for driving the plans for redevelopment.

Proposed Redevelopment

ARA Australia, the owner and managers of Southgate are proposing to undertake a staged redevelopment of significant portions of the site over the next five years by:

- Predominantly redeveloping the retail areas along the northern section of the site at the ground / promenade level. This will initially involve fully developing the east side of the site with new retail tenancies, whilst retaining and / or refurbishing the west side retail tenancies that are situated under the adjoining Langham Hotel strata title (under separate title ownership to Southgate)
- Provision of additional retail tenancies at Level 2 facing a new, elevated, north facing 2,000sq.m public park along the northern boundary of the site,
- Relocation of the loading facilities by the introduction of a basement loading facility serviced by two truck lifts accessed off the eastern end of Southgate Avenue, and
- Development of an additional 42,000sq.m (NLA) commercial office tower above the retail levels.

The redevelopment proposal has been the subject of a collaborative working party involving the City of Melbourne, the Department of Environment, Land, Water and Planning (DELWP) and other government or authority related entities (Including Melbourne Water) since late 2018. The proposal was submitted for planning approval in mid-2020. Planning approval for the redevelopment is anticipated to be received before the end of the 2021 year which will see ARA commence the leasing, design and procurement phases of the project during 2022. Construction is anticipated to commence in 2023 and continue until mid to late 2026.

Current floor and entry levels are set at 2.76mAHD and are proposed to remain at these levels. This is particularly important given the strata titling arrangement on the west side of the site where the adjoining owned Langham Hotel's title protrudes above the Southgate retail areas below. These existing levels are above the (current) minimum requirement of 2.4mAHD for retail areas.

A key urban design outcome for this development is the connectivity between the existing public and private spaces, the back-of-house services and the access ways that service other adjoining properties and activities which must be maintained in order to achieve a high quality design and liveability outcome. These may not always be fully compatible with the minimum floor level requirements sought by Melbourne Water. While engineering measures such as flood barriers do provide a solution, we understand that Melbourne Water does not normally accept such measures to provide direct flood protection as opposed to freeboard. It would be good to have an understanding of the extent to which Melbourne Water's approach to these types of flood risk mitigation and flood protection measures will be flexible on constrained sites such as this one at Southgate.

While there are a set of plans covering the staged development works as outlined above, I have not attached them to this email. The file is quite large. Further, I believe that a face-to-face explanation of the plans and proposed staged works will assist understanding of what is proposed, the constraints that govern the whole site and what can be done to achieve redevelopment.

Action Sought

A meeting with yourself and perhaps other senior members of Melbourne Water's Development Services Team to present the current redevelopment plans and discuss the proposal in some detail in order to gain clarity on:

- How the proposed redevelopment will be assessed from a flood risk perspective given that amendment C384 is responding to an intention to increase flood planning levels within the precinct;
- The flood levels the proposed redevelopment will be required to respond to given that the anticipated life of the project is of order 30 to 40 years, much less than the planning horizon to which we understand the proposed flood levels respond ;
- The minimum floor levels required by Melbourne Water for the redeveloped retail and office areas, at lift (people and truck) and stairwell entries, and at other openings to above ground areas as well as to the basement car parks and loading areas;
- Melbourne Water's likely flexibility for what is a significantly constrained site on the incorporation of engineering measures such as flood barriers to achieve the flood risk mitigation sought.

We look forward to meeting with you.

Best regards
Mike

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Appendix D Model Description

1. Lower Yarra Modelling

In order to assess the impact of the change in tidal conditions, HARC has developed a model of the lower Yarra River and floodplain, from the Morell Bridge to approximately 2km downstream from the Bolte Bridge. This model is a simplified version of the model used by GHD and is suitable for the comparison of changes in model parameters. The model has been calibrated to the 1934 flood event and has adopted flow rates from GHD's report.

The following sections describe the model development, calibration, assumed boundary conditions and the results of the analysis.

1.1 Model Development

1.1.1 Topography

The model topography was generated from the 1 m Lidar ground surface DTM, captured in 2019 as part of DELWP's coordinated imagery program. This data has a vertical accuracy of +/- 0.1 m and is considered the most appropriate data available for the project. It should be noted that bridges over water are removed from the DTM, but bridge abutments are generally well captured. The data was sampled at a 6 m grid resolution for modelling purposes.

1.1.2 Yarra River Bathymetry

The bathymetry of the Yarra was not available to this project. To provide an appropriate definition of the river bathymetry, the river bed was lowered to minus 5 mAHD for a width of between 40 and 80 metres, depending on the location, with additional depth changes to 10 and 16 metres downstream from the Charles Grimes Bridge. These depths and widths were based on the figure and text provided in Melbourne Water's memo to the Citylink project, found in Appendix A of GHD's report, and the provided cross sections in the GHD report.

It is acknowledged that the bathymetry is a rough approximation of the actual Yarra bed conditions and this is an area of uncertainty in the model. However, as we have undertaken a preliminary calibration of the model to the 1934 event, we have some idea of the model accuracy compared to a real event. Figure 1-1 shows the model topography and bathymetry.

1.1.3 Model Roughness

For the purposes of the modelling, which aims to compare changes in boundary conditions, only four hydraulic roughness zones were defined. These are shown in Table 1-1.

Table 1-1 - Adopted Mannings Roughness

Land Use	Mannings Roughness
Roads	0.025
River	0.025
Buildings	0.3
All other areas	0.05

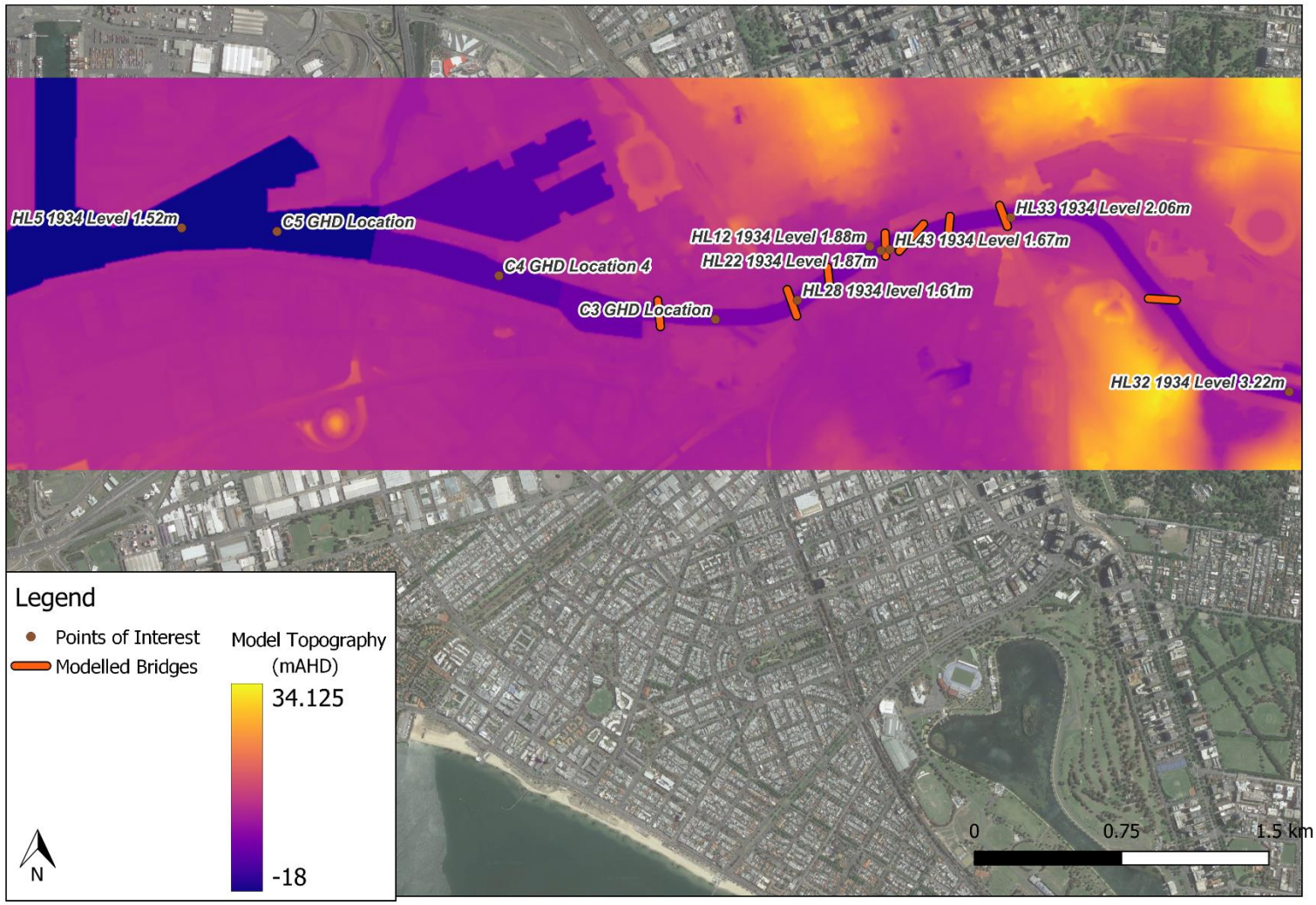

Figure 1-1 - Model Topography

1.1.4 Tidal Boundary Conditions

The modelling has adopted five different tidal boundaries as part of the assessment. These are described in Table 1-2.

Table 1-2 - Modelled tide details

Tidal Boundary Name	Description	Peak Level
1934	A tidal boundary digitised from the Adams report from 28 November 1934 to 2 December 1934. The boundary was continued after 2 December based on the tidal cycle from 2 December.	1.33 mAHD (estimated as greater than a 1% storm tide event).
2009 Tide	A tidal signal that represents the 2009 storm tide event at Williamstown. Data was sourced from the National Tidal Centre at 1 hour intervals	1.09 mAHD (approx. 2% AEP event, according to McInnes et al CSIRO, 2009).
2009 Adjusted	The tidal signal from 2009, with the storm surge component adjusted higher from +/- 12 hours either side of the peak, to achieve a peak tide level of 1.15 mAHD, the same as the GHD peak level	1.15 mAHD (upper range confidence estimate of the 1% AEP event, according to McInnes et al CSIRO, 2009).
GHD Tide	An approximation of the tide signal used in the GHD report, that has an elevated mean sea level.	1.15 mAHD.
Climate Change Tide	This is the adjusted 2009 tide, with a increase in level of and surge to match the GHD peak level, representing the future climate conditions (sea level rise of 0.8 m and additional wind)	2.00 mAHD (equivalent to a 5% AEP event at 2100, according to McInnes et al CSIRO, 2009).
GHD Climate Change	This is the GHD tide with 0.8 m sea level rise and the storm surge adjusted to match the 2.00 m level, as per the GHD report	2.00 mAHD (equivalent to a 5% AEP event at 2100, according to McInnes et al CSIRO, 2009).

These boundary conditions are shown in Figure 1-2, normalised to start at the same time. It should be noted that as the 1934 event data ends at 112 hours, the series has been infilled to provide a limited tide sequence for the remaining 48 hours. This tide does not include the lower low water that would have been experienced and is therefore considered to be conservative.

The tide timing has been developed to allow enough time prior to the surge event to stabilise the model. The peak tide level occurs at the time the Yarra River inflow hydrograph reaches approximately 30% of its peak value (as occurred in 1934).

1.1.5 Bridges

The model has accounted for the losses at bridge structures using layered flow constriction shapes. Each crossing of the river has been included based on estimates of the pier width and channel blockage percentage while the pier shape was used to define the pier loss coefficients. The soffit level and structural depths have also been estimated, based on a combination of topographic information, some plan details and photography. While there is some uncertainty in these estimates, the head losses across the bridges appear reasonable. The majority of the

bridges existed in 1934 in a form similar to current conditions. Any new bridges (post 1934) would have been designed such that they had little impact on flow behaviour.

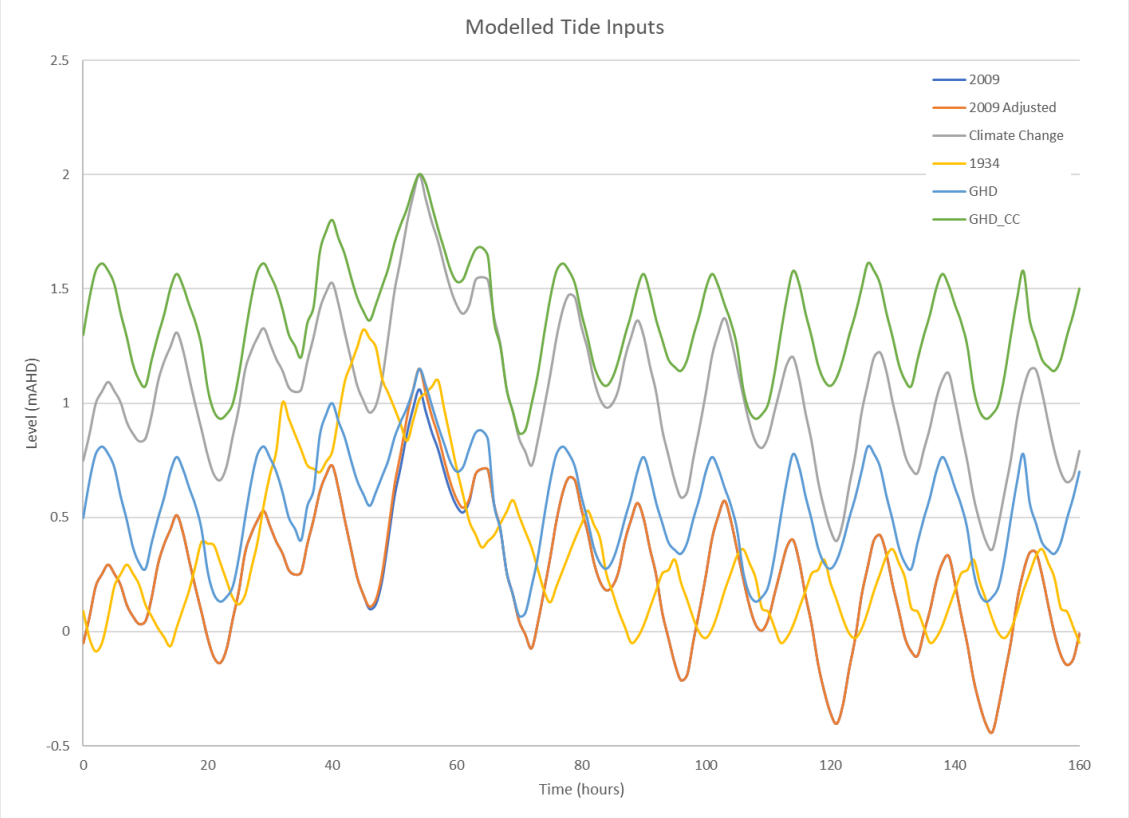

Figure 1-2- Tidal Boundaries used in the modelling

1.1.6 Inflow Boundaries

As the GHD model was significantly extended to beyond the Chandler storage basin, it is impossible to adopt the exact flows used in that model. In Appendix B of the GHD report, Yarra River inflows are presented for the test model, that had a boundary downstream from Dights Falls. These flows are generated from the RORB model adopting aerial reduction factors and a k_c of 180, which was the model identified in the GHD report as providing the flows used in their assessment. We have extracted two time series from that Appendix, one representing 100yr 72hr storm flows under current condition and one where the rainfall intensities have been increased by 18.5% to account for an RCP8.5 pathway at 2100.

We have also developed an estimate of the 1934 hydrograph, based on the Adams report. This hydrograph is somewhat oddly shaped, but adopts a static peak flow at 1130 m^3/s for more than 24 hours, and is suitable for this assessment. The adopted inflow boundaries are shown in Figure 1-3.

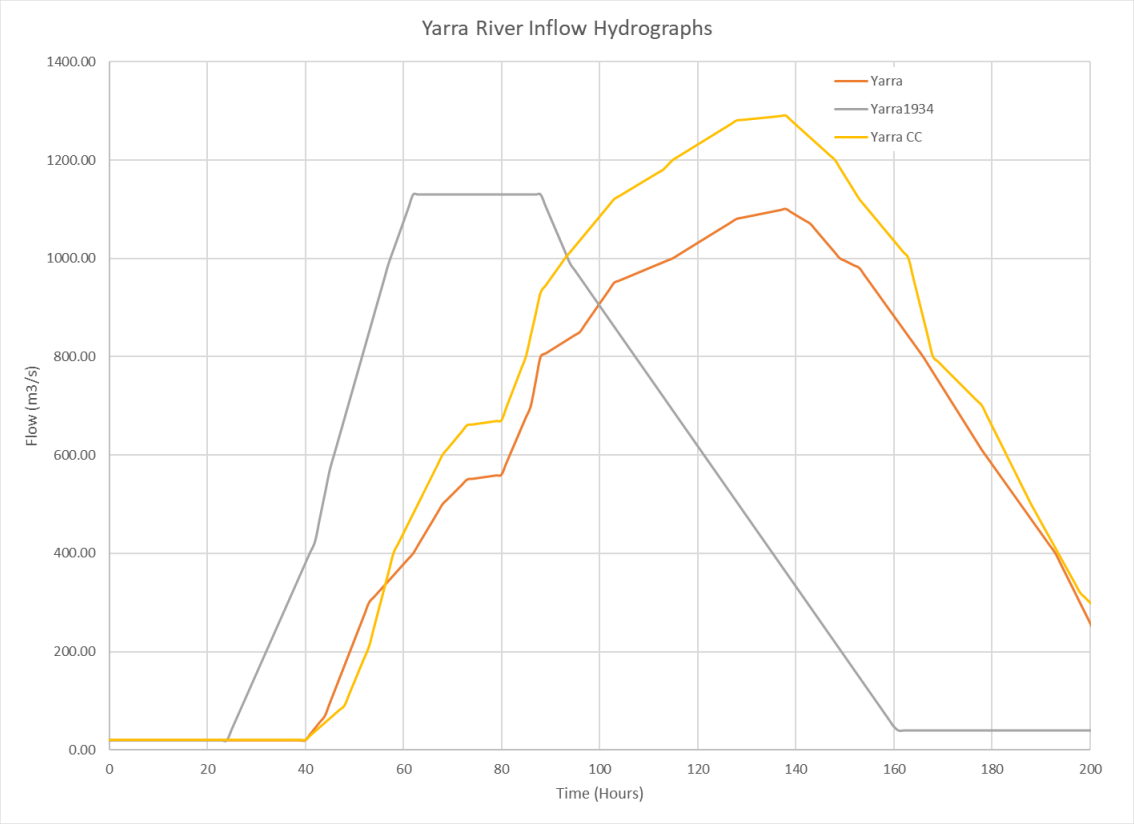

Figure 1-3 - Yarra River Inflow Boundaries

1.2 Modelled Events

Table 1-3 provides the combinations of boundary conditions modelled as part of this project.

Table 1-3 - Modelled Boundary Combinations

Model Name	Tidal Boundary	Yarra Boundary
Yarra	2009 Tide	Yarra (peak flow 1100 m^3/s)
Tide 115	2009 Adjusted	Yarra (peak flow 1100 m^3/s)
GHD	GHD Tide	Yarra (peak flow 1100 m^3/s)
Climate Change	Climate Change	Yarra CC (peak flow 1290 m^3/s)
GHD_CC	GHD Climate Change	Yarra CC (peak flow 1290 m^3/s)
1934	1934	Yarra 1934 (peak flow 1130m^3/s)

1.3 Timing of Flows

As per the GHD report, the models have adopted the peak of the tide event occurring once the inflow hydrograph reaches 30% of the peak flow. This occurs at approximately 54 hours in both inflow cases. The 1934 event is based on real data, where time zero is midnight on 28th November.