Submission to the Inquiry into the 2022 Flood Event in Victoria

Victorian Upper House Parliamentary Inquiry

5-Jun-2023

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Cover photo

The photos and items appearing in my submission cover photo are (top left to right going clockwise)

1. Elderly woman at Maribyrnong Township being helped to safety by locals on 14-Oct-2022.
2. "Flood warnings a 'complete shemozzle': senior SES volunteer" article in The Age 19-Oct-2022.
3. Elderly man walking through flood waters along Raleigh Road, Maribyrnong on 14-Oct-2022.
4. "Proposed Dam Would Have Prevented Flood Damages, Says Hydrology Expert" front page article in The Age 16-Oct-2022 quoting myself.
5. SES rescue boat and flooded car in Maribyrnong Township 14-Oct-2022.
6. "Locals 'lost everything' after flood alert failed" front page article in The Age 6-Feb-2023, and (centre)
7. Elderly resident wading through floodwater at Rivervue Retirement Village in Avondale Heights on 14-Oct-2022 (courtesy of Channel 9 - A Current Affair).

Background

I have an extensive background in flood warning and emergency management, community flood preparedness and community flood alerting spanning almost 50 years.

This has included a very close association with the Maribyrnong River catchment and flood warning needs of the Maribyrnong community in the 31 years I worked at MMBW/Melbourne Water. Since leaving Melbourne Water at the end of 2003 I have maintained an interest in flooding concerns along the Maribyrnong River.

Appendix A contains a brief summary of that involvement, which is a key driver to why I am making such a detailed and comprehensive submission to this Parliamentary Inquiry.

Other work I have undertaken since 2003 has included:

- 2004-2006 Project manager - Shepparton Mooroopna Early Flood Warning and Emergency Management project for Greater Shepparton City Council and Goulburn Broken CMA.
- Critical review of May 2009 flood warnings in Northern New South Wales for NSWSES.
- Critical review of flood warnings component of the Neil Comrie AO, APM Review of the 2010–11 Flood Warnings & Response and 2012 North East Victoria Flood Review for the Victorian Government.
- Moyne River at Port Fairy Flood Warning Assessment Project for Glenelg Hopkins CMA.
- Flood Preparedness Review for Splendour in the Grass Event, North Byron Parklands, NSW in July 2013.
- Critical review of flood warnings for March 2012 Hawkesbury-Nepean flood, and
- Review of flood warnings for Maroochy River February 2022

Response to Terms of Reference

My submission addresses the following terms of reference (TOR) of the inquiry:

- TOR 1: Causes of and contributors to the Flood Event;
- TOR 2: Adequacy and effectiveness of early warning systems;
- TOR 5: Location, funding, maintenance and effectiveness of engineered structures, such as floodwalls, rural levees and culverts, as a flood mitigation strategy;
- TOR 7: The 2007 decision of the Minister for Planning to approve the construction of a flood wall around Flemington Racecourse and whether the growing impacts of climate change were considered;

The three key messages I wish to place before the Committee and will address in some detail are:

1. Melbourne Water was the primary cause for the flooding of Rivervue Retirement Village through a sequence of failures in their role as the Responsible Drainage and Floodplain Management Authority for Melbourne.

2. Melbourne Water's failed flood modelling, flood predictions and flood warnings for the Maribyrnong River community.

3. Arundel flood retarding basin being the only viable solution to the flooding problem on the Maribyrnong River by:
   (a) ensuring any future flood warning failures for the Maribyrnong don't cause a repeat of the disastrous flooding on 14-Oct-2022,
   (b) preventing the 50 or more villas at Rivervue Retirement Village, constructed on what has proven to still be an active floodplain, from flooding again in the future, and
   (c) enabling the controversial Flemington floodwall to be removed reducing the risk of flooding in the immediate area downstream to Kensington and West Melbourne.

TOR 1: Causes of and contributors to the Flood Event

1.0 Rivervue Retirement Village, Avondale Heights

While the causes of and contributors to the flood event given by the BoM in their submission, namely climate drivers, antecedent conditions and the heavy spring rainfall should be fairly obvious flood conducive factors, the primary cause and contributor to the flooding of 47 dwellings at the Rivervue Retirement Village in Avondale Heights was Melbourne Water.

Following a sequence of events spanning 10 years from 2006 to 2016 Melbourne Water failed to discharge its statutory duties as the Responsible Authority for Drainage and Floodplain Management in the Greater Melbourne Region.

1. Melbourne Water failed to object to the retirement village planning permit located substantively on a Land Subject to Inundation flood zoning, in support of Moonee Valley City Council's objection to the planning permit, namely Permit Application No. MV/16866/2004.
2. Melbourne Water did not even appear at the June 2006 VCAT hearing in support of the flooding conditions they were obliged to impose on the Planning Permit application, namely that Clause 39 (b) Earthworks "Any earthworks must be done such that the volume of cutting within the floodplain is equivalent or greater than the volume of filling. Before starting works, volume calculations must be submitted to Melbourne Water demonstrating that the volume of filling does not exceed the volume of cutting."
3. By not appearing at the 2006 VCAT hearing Melbourne Water lost the opportunity to challenge claims in Clause 58 by the two water engineering consultants supporting the proposed retirement village that,

   "the proposal would maintain or exceed the existing floodplain storage, any increase in flood level would be minimised or negated by the additional capacity provided by the proposed wetlands and risk to people would be minimised by habitable buildings being 600mm above the flood level and outbuildings/garages being 300mm above the same level" and ***"Melbourne Water's designated flood level was felt to be conservative based on modelling undertaken"*** by the principal consultant and ***"that in a flood, there may be some scouring near to the Cordite Avenue Bridge but nothing more than would be expected in a flood event without development on the review site."***

In Clause 59 the VCAT member damningly says due to *"the lack of objection by Melbourne Water, we find no basis to reject the proposal for reasons relating to impact on the operation of the floodway and floodplain."*

I have seen and closely examined a 1:1,000 scale topographic plan with 0.5 metre contour intervals of the subject land upstream of Canning Street and floodplain of the Maribyrnong River titled "Proposed Retirement Complex Canning Street Avondale Heights" dated May 2007 Drawing No. 07-015 PA03 and fail to understand how the lower dwellings of the retirement village on the floodplain could possibly be built without extensive fill that would contravene Melbourne Water's earthworks flooding conditions in the June 2006 planning permit application.

4. Melbourne Water approved TIGCORP'S so called (flood) "mitigations works" on 19-Sep-2011 and advised Moonee Valley City Council (in relation to Permit application MV/16866/2004) that:

   "All earthworks and finished floor levels shown on the development plans and civil drawings, including the wetland design, are in accordance with the flood levels and data outlined in the updated floodplain modifications report dated 21 December 2010, prepared by consultant [redacted] Pty Ltd Melbourne Water is satisfied that the submitted development plans and other relevant information satisfies the planning conditions 1(b), 6(a0, 25, 35, 35, 37, 39(b) and 41 outlined in the planning permit referenced MV/16866/2005 (Amended 15 August 2011)."

TIGCORP's submission to Melbourne Water's Maribyrnong Flood Review goes on to say,

"Endorsed and amended plans for Planning Permit MV 16866/2004 recognised the changes to the site.

These included the designs for the substantial retarding ponds and constructions on land close to the river corridor. These works were designed to confine the land areas subjected to flooding, to sections of the site outside of the areas approved for dwelling construction. These earthworks were completed in 2014-15 with finished survey plans provided to Melbourne Water (under Permit MV/16866/2004, Condition 39(c))."

Photo of Rivervue Retirement Village, showing the constructed retarding basins in the area of the site close to the river corridor land. Canning Street is seen at the right of photo.

TIGCORP's submission goes on to refer to their constructed "retarding basins" or "retarding ponds", to supposedly mitigate the risk of flooding in conjunction with Melbourne Water's flooding conditions in the 2006 VCAT planning permit, no less than 13 times.

It is inconceivable that Melbourne Water, Moonee Valley Council or any professional hydraulics consultant could endorse the view the constructed "retarding basins" at Rivervue provide any flood mitigation benefit in the event of a major riverine flood on the Maribyrnong River.

5. MVCC Planning Scheme Amendment C151

MVCC's submission to the Melbourne Water Maribyrnong Flood Review states,
"In January 2015, Melbourne Water requested Council undertake a Planning Scheme Amendment to update the LSIO and Special Building Overlay (SBO). Specifically, the amendment sought to implement updated flood overlay boundaries as a result of advanced methods of mapping and modelling carried out by Melbourne Water to determine land susceptible to flooding and overland flows. This work resulted in changes to Overlay maps within the Moonee Valley Planning Scheme and affected in the order of 1,900 properties by way of removal, application and revision of the Overlays."

MW's submission to their own review says nothing about this ***"advanced methods of mapping and modelling"*** that initiated MVCC Planning Scheme Amendment C151 later in 2015.

Moonee Valley Planning Scheme Amendment C151 Panel Report dated 30-Nov-2015 states that***, "The modelling undertaken by MW informing the application of the overlays is not entirely clear in the Amendment documentation."***

Melbourne Water did not even bother to attend the C151 panel hearing, they themselves had been the proponent of, to provide answers and clarification to the Panel Chair [redacted]. This was reminiscent how Melbourne Water failed to attend the VCAT hearing in 2006 to advocate for their flooding conditions for the retirement village planning permit application.

Moonee Valley Council's submission goes on to say ***"the panel recommended a reduction to the extent of the LSIO on Rivervue as a result of completed flood mitigation earthworks associated with the wetlands adjacent to the Rivervue Retirement Village. The works were to the satisfaction of Melbourne Water which altered the flooding profile of the site and subsequently led to the revised flood map".***

Figure 1. Existing view of Rivervue Retirement Village showing the 47 villas flooded after relocation of the LSIO in the 2015 Moonee Valley C151 planning panel process.

I have since discovered the ***"advanced methods of mapping and modelling carried out by Melbourne Water",*** spoken of earlier, did not extend to calibrating or otherwise considering Melbourne Water's recorded May 1974 flood level upstream of Canning Street.

This was conveyed to me personally by Melbourne Water on 15-Mar-2023 when I was told ***"Melbourne Water's data on the 1 in 100 flood levels for the Maribyrnong River upstream at Canning Street was 6 metres (AHD)."***

I replied saying, ***"Given that 6.0 m AHD is lower than Melbourne Water's recorded flood level upstream of Canning Street in May 1974, reference Figure 17 of the May 1974 Maribyrnong Flood Report, and the vast majority of the flooded floor levels at Rivervue, published last Friday in MW Flood Level Survey Data update, were higher than your current so-called "1 in 100 year flood level'."***

Back in June 2006 Melbourne Water's 100 year flood level upstream of Canning Street at the proposed retirement village location was 6.60 m AHD, grading up to 6.85 m AHD at the south western boundary of the retirement village 400 metres upstream.

Melbourne Water had indicated from an early stage that the 14-Oct-2022 flood was a similar magnitude to the flood 48 years earlier on the Maribyrnong in May 1974 which was always taken as about a 1 in 50 year average recurrence interval (ARI) flood, or slightly less.

I am in agreeance with Melbourne Water the Oct-2022 was another 1 in 50 year ARI flood, but in any case should never have been big enough to flood the 47 dwellings at Rivervue Retirement Village that were meant to have a 600 mm freeboard above the 100 year flood.

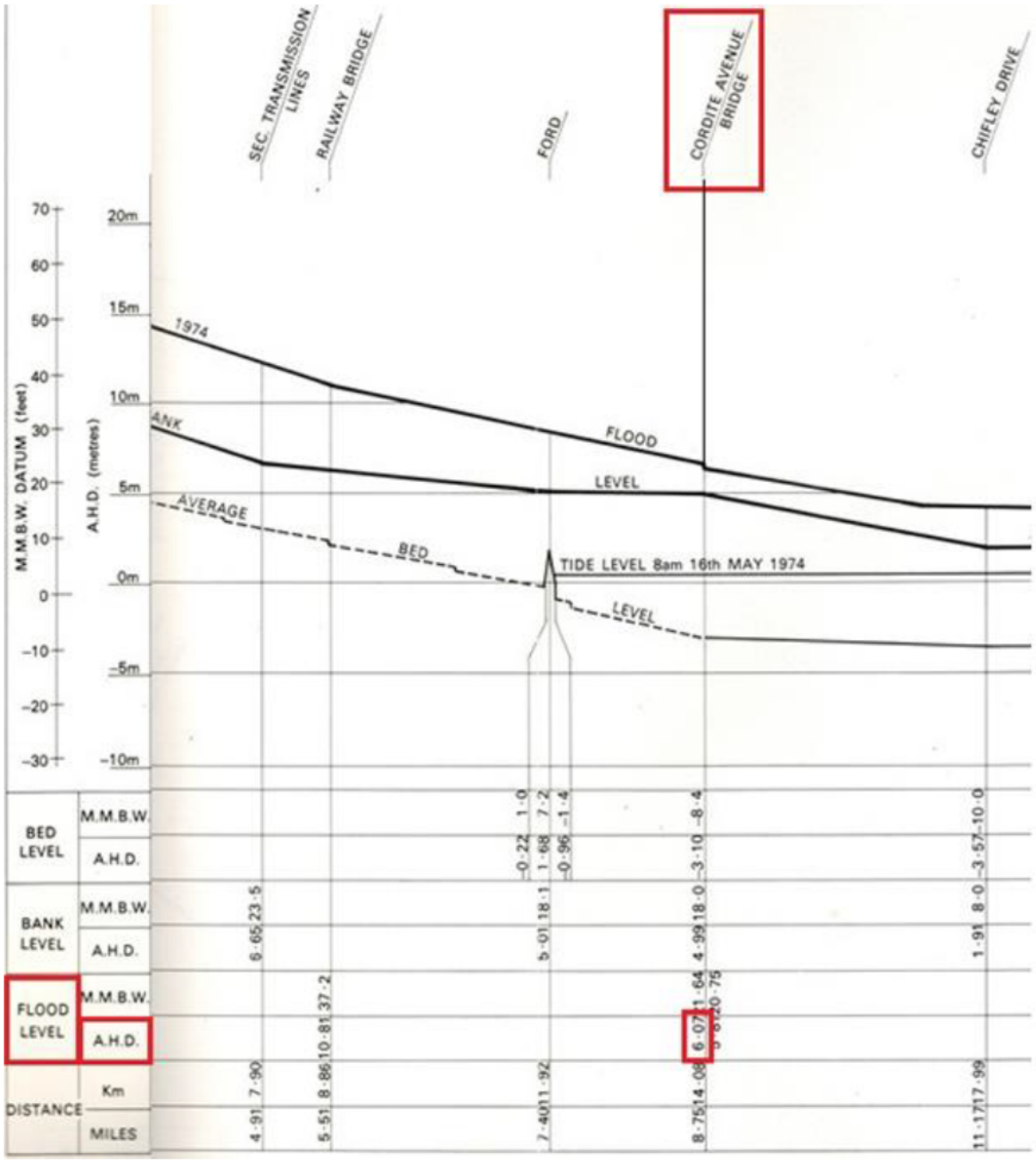


Figure 2. Copy of Figure 17 from the MMBW report on the Flood of May 1974 Maribyrnong River

Figure 2. is a cropped version of Figure 17 from the MMBW report on the Flood of May 1974 Maribyrnong River showing 6.07 m AHD was the recorded flood level on the upstream side of the Canning St/Cordite Ave Bridge, 7 cm higher than Melbourne Water's current 100 year flood level.

It had taken me 5 months to figure out why the 47 dwellings at Rivervue Retirement Village flooded but finding out Melbourne Water's 100 year flood level had been reduced from 6.60 m AHD to 6.00 m AHD, presumably as a result of the ***"advanced methods of mapping and modelling",*** went a long way to explaining it.

Below is a schematic describing the consequences of Melbourne Water's new 100 year flood level of 6.0 m AHD that meant Rivervue's owners were no longer required to provide the original 600 mm of freeboard after the LSIO was moved from the development footprint during the C151 planning amendment process.

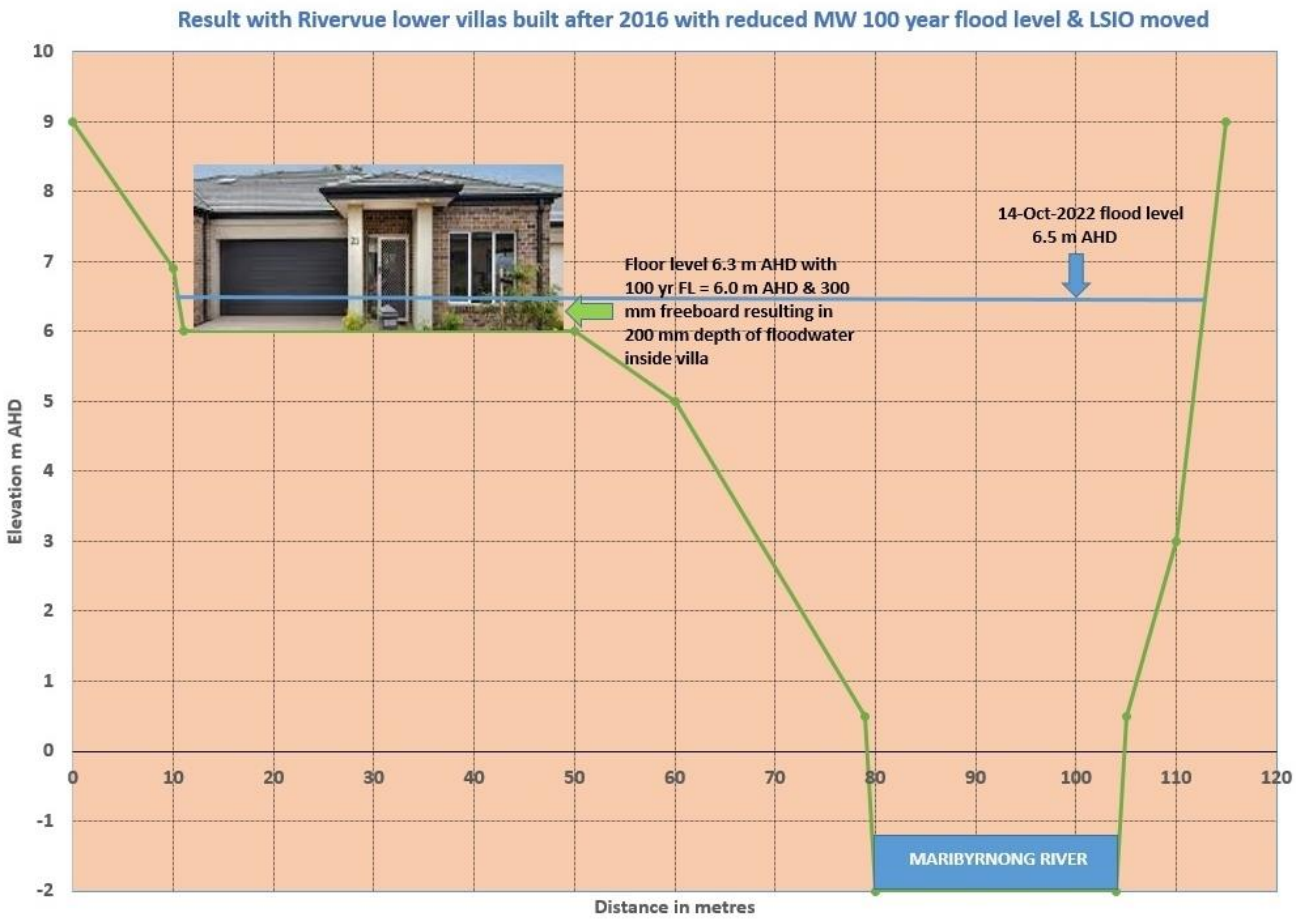


Figure 3. Typical example of Rivervue villa flooded on 14-Oct-2022

As Figure 3. shows, the cumulative effects of Melbourne Water's actions had created the "perfect storm", to coin a phrase, after their original 2006 VCAT flooding conditions 100 year flood level was lowered by 0.6 metres and the 600 mm freeboard required back in 2006 of 600 mm was lowered to the statutory minimum of 300 mm freeboard in accordance with the Victorian Building Regulations once the LSIO was removed.

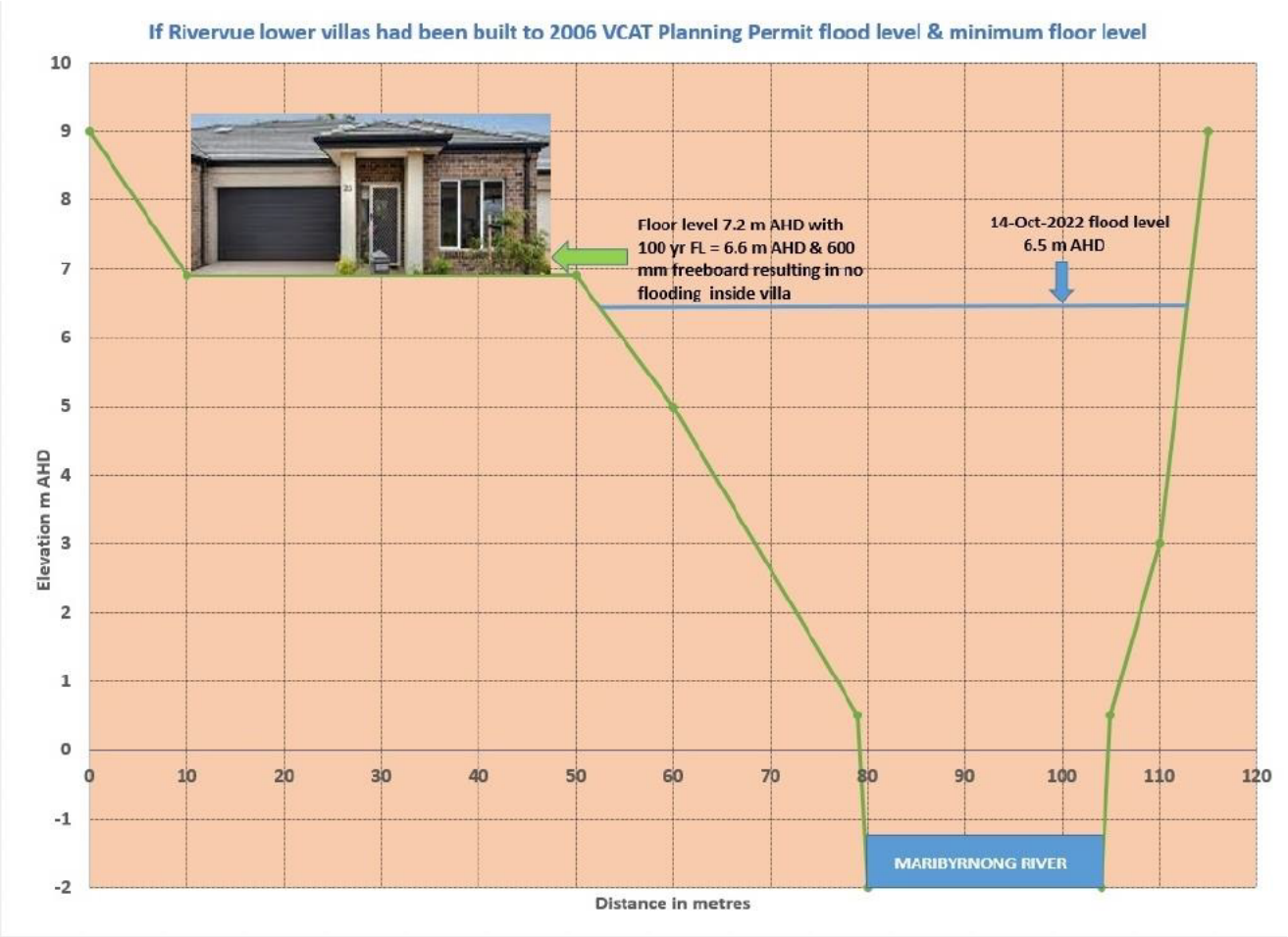


Figure 4. Example of what should have happened at the same Rivervue villa on 14-Oct-2022 had Melbourne Water not lowered the 100 year flood level and relocated the LSIO

Figure 4. shows what would have happened during the 14-Oct-2022 flood on the Maribyrnong at a typical Rivervue Retirement Village villa, subsequently built on the floodplain within the original LSIO, had Melbourne Water's flooding conditions for the planning permit in June 2006 been maintained.

To compound the misery of the flood victims at Rivervue Retirement Village Melbourne Water refused repeated requests by some residents for the floor level of their villas that I had been advised were surveyed by Melbourne Water contractors in the first week of November 2022.

This refusal by Melbourne Water to provide the flooded residents with the basic information of their floor level dragged on from mid-November until early March when I decided to go out and survey my friend's floor level at Rivervue Retirement Village myself.

On the 9-Mar-2023 my fellow ex-Melbourne Water colleague and good friend [redacted] and I set off to see if we could somehow survey the floor level of my friend's villa at Rivervue, almost 4 months after he first asked Melbourne Water to provide his floor level, we knew that had been surveyed.

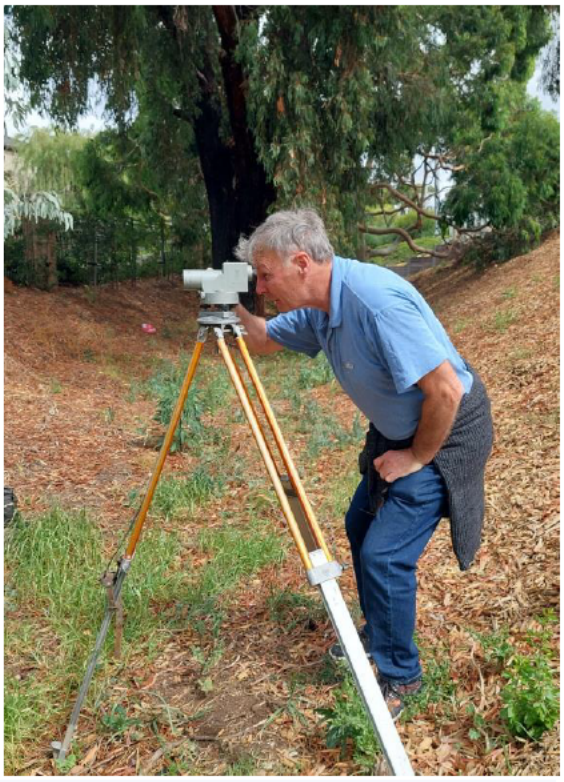


Photo 1 Me pointing to 3.0 m AHD survey datum on old MMBW crest level gauge (left) and Photo 2 [redacted] sighting the floor level of my flood victim friend's floor level at Rivervue Retirement Village.

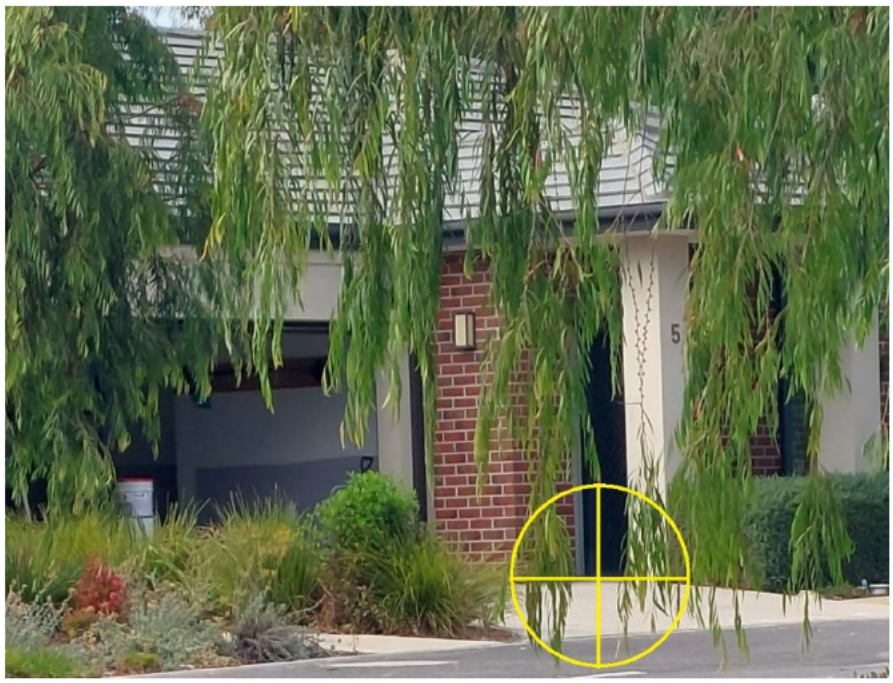


Photo 3 View my dumpy level sighted on my friend's floor level at Rivervue Retirement Village.

Our survey results confirmed that the floor level was around 6.4 m AHD, meaning it was 0.2 metres lower than Melbourne Water's 100 year flood level in 2006 and 0.8 metres lower than it should have been built according to the original Melbourne Water planning permit flooding conditions.

Most interestingly, Melbourne Water released the long-awaited flood level survey data for the 14-Oct-2022 Maribyrnong River flood, containing 53 floor levels for Avondale Heights (Rivervue Retirement Village), dated 9-Mar-2023. Of the 53 floor levels surveyed at Rivervue 48 were lower than Melbourne Water's 2006 VCAT 100 year flood level of 6.60 m AHD, with three of the four flood levels higher than the 2006 VCAT flood level.

Maribyrnong River Flood - Oct 2022

Flood Level Survey Data

OFFICIAL

9 March 2023 | 6

SUBURB	DEBRIS/FLOOD	FLOOR	NATURAL
AVONDALE HEIGHTS		6.36	6.24
AVONDALE HEIGHTS		6.36	5.99
AVONDALE HEIGHTS		6.36	6.23
AVONDALE HEIGHTS		6.45	5.95
AVONDALE HEIGHTS		6.35	5.97
AVONDALE HEIGHTS		6.45	6.28
AVONDALE HEIGHTS		6.45	6.12
AVONDALE HEIGHTS		6.45	6.33
AVONDALE HEIGHTS		6.45	6.36
AVONDALE HEIGHTS		6.45	6.17
AVONDALE HEIGHTS		6.45	6.28
AVONDALE HEIGHTS		6.46	6.19
AVONDALE HEIGHTS		6.45	6.16
AVONDALE HEIGHTS		6.45	6.25
AVONDALE HEIGHTS		6.46	6.18
AVONDALE HEIGHTS		6.45	6.31
AVONDALE HEIGHTS		6.44	6.25
AVONDALE HEIGHTS		6.46	6.26
AVONDALE HEIGHTS		6.45	6.31
AVONDALE HEIGHTS		6.45	6.26
AVONDALE HEIGHTS		6.44	6.26
AVONDALE HEIGHTS		6.45	6.32
AVONDALE HEIGHTS		6.50	6.45
AVONDALE HEIGHTS	6.5	6.96	6.80
AVONDALE HEIGHTS		6.68	6.59

Figure 5. Sample of the floor level and flood data released by Melbourne Water date 9-Mar-2023.

1.1 Conclusion and Recommendations

- My submission has outlined an appalling list of failures by Melbourne Water in discharging their statutory role as the Responsible Authority for Drainage and Floodplain Management in the Greater Melbourne Area.
- In doing so they have failed the residents of the 47 villas at Rivervue Retirements Village that were flooded above floor level from the Maribyrnong River on the 14-Oct-2022 by what was only about a 1 in 50 year average recurrence interval flood.
- Melbourne Water's own flood and floor level data surveyed about 3 weeks after the flood confirmed most of the flooded villas had been built between 0.7 metres to 0.9 metres lower than Planning Permit No. MV/16866/2004 approved by VCAT on 21-Jun-2006.
- Had the 47 villas at Rivervue Retirement Village been constructed with floor levels no lower than 7.2 m AHD, as was required by Melbourne Water's flooding conditions for the planning permit in 2006, none of the villas would have come close to having their floors flooded.
- I endorse the submission made by Moonee Valley City Council to the Melbourne Water Maribyrnong Flood Review which states,

  "During the 14 October 2022 flood, 47 properties at this site were flooded despite no indication from Melbourne Water that this would occur. VCAT approved the development application (based on advice from Melbourne Water) and the planning minister approved the adjustment of the Overlay based on the findings within the panel report.
  As a part of this current Review, the Panel should analyse development approvals, existing site levels prior to the development, approved levels, and site modification during the construction and as-constructed building levels. The Panel should also consider future facing modelling that factor climate change and the increased likelihood of more severe flood events in the future."

- In particular there is an urgent need for an independent hydraulic engineering expert to critically review TIGCORP'S consultant's updated floodplain modifications report dated 21-Dec-2010 on which Melbourne Water relied to approve the development on what was then a designated floodplain of the Maribyrnong River.
- The extent of the flooding at Rivervue Retirement Village on 14-Oct-2022 has shown beyond doubt that upwards of 50 villas are located on an active floodplain and subject to flooding in a 100 year (1% Annual Exceedance Probability) flood on the Maribyrnong River.
- Melbourne Water's surveyed flood levels at Rivervue Retirement Village for the 14-Oct-2022 flood ranged up to 6.66 m AHD, i.e., higher than the 100 year flood level of 6.60 m AHD Melbourne Water quoted back in June 2006.
- Given the anomalously high flood levels at Rivervue compared to the flood peak recorded downstream at the Maribyrnong Township gauge of 4.22 m AHD, well below the 100 year flood level there of 4.50 m AHD, any review of the hydraulic modelling of the Maribyrnong River by Melbourne Water should focus on whether the earthworks undertaken during TIGCORP's development of the site may have exacerbated the flood levels.
- Any review should place due emphasis on why Melbourne Water seemingly reneged on the flooding conditions it required for Permit Application No. MV/16866/2004 at the VCAT 1172 [21-June-2006] proceedings.
- Finally, if so-called "climate change", which is mentioned no less than 36 times in Melbourne Water's submission to their own review, is such an important issue to ensure ***"planning and development controls consider increased flood risks from climate change"*** Melbourne Water should be asked to explain how their 100 year flood level at Rivervue Retirement Village could have possibly been reduced from 6.60 m AHD in 2006 to 6.00 m AHD in 2015.

TOR 2: Adequacy and effectiveness of early warning systems

2.1 Flood warnings for the Maribyrnong River

My submission will focus on the adequacy and effectiveness of Melbourne Water's flood warnings for the Maribyrnong River issued between 8:24 am 13-Oct-2022 and 12:19 pm on 15-Oct-2022.

Figure 6. shows a map of Melbourne Water's Flood Warning Network of automatic real-time rain gauges and river level gauges from the 1986 MMBW Maribyrnong River Flood Mitigation Study report updated to show the current network. I will speak more of this report later in my submission.

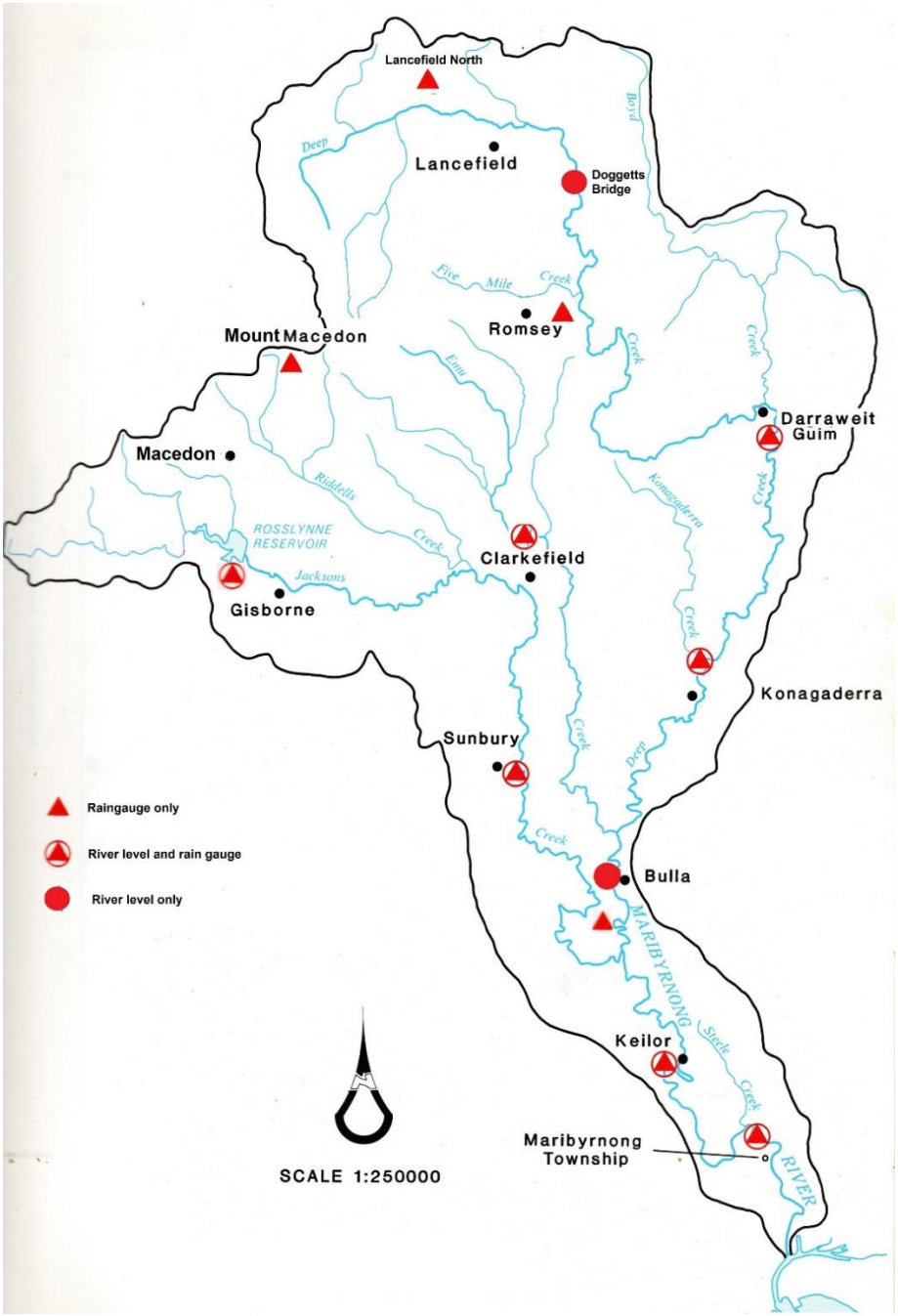


Figure 6. Melbourne Water Maribyrnong River Flood Warning Stations at October 2022

To fully appreciate the ineptness of Melbourne Water's flood warnings it is necessary to step through each flood warning individually.

Flood Warning #1 issued at 8:24 am Thursday 13-Oct-2022 went straight to a Major Flood Warning for the Maribyrnong River where it said,

"The Maribyrnong River catchment has recorded rainfall averaging about 34 mm since 09:00 AM Wednesday 12 October 2022. Rainfall totals of 15-30 mm are forecast for the catchment Thursday 13 October 2022."

What it didn't say was rainfall in the upper Deep Creek at Lancefield North had exceeded almost double the average catchment rainfall since 9am 12-Oct-2022 with 80 mm recorded since 6 am 12th October, and continuing to fall at the same steady rate.

Instead of the forecast rainfall of 15-30 mm for the remainder of Thursday close to 80 mm of additional rain was recorded at Lancefield North up until midnight Thursday 13-Oct-2022.

FW #1 went on to say *"The level of the Deep Creek at Darraweit Guim is currently at the Minor Flood Level (5.50 metres) and rising. If the rain occurs as forecast, it is expected to peak around the Major Flood Level (6.50 metres) around midday Thursday."*

It is important to note the Melbourne Water gauge at Darraweit Guim is 2.0 km downstream of the Darraweit township and 5.5 m on the gauge marks the trigger for break-out flows to begin on the west side of Deep Creek at the Melbourne Water gauge.

It is for this reason that it took about 5-6 hours longer to reach the Major Flood Level of 6.5 m on the Darraweit gauge than Melbourne Water predicted.

This initial flood warning provided no predicted flood level downstream in the Maribyrnong River other than to say "*Major flooding in the Deep Creek and Maribyrnong River catchment is expected to cause extensive inundation in the rural and/or urban areas, disruption to traffic, and may be isolation of some properties."*

Flood Warning #3 for the Maribyrnong was issued at 3:42 pm on Thursday 13th October 2022 with the somewhat confusing message,

"The Maribyrnong River catchment has recorded rainfall averaging about 56 mm since 09:00 AM Wednesday 12 October 2022. Rainfall totals of 60-100 mm are forecast for the catchment today (Thursday 13 October 2022)."

It contained no indication of how much more forecast rainfall was expected making it difficult to interpret how much of the 60-100 mm of rain was still expected to fall on Thursday and how much more rainfall was already included in the 56 mm of average rainfall since 9am Wed 12-Oct-2022.

In the end a further 30 mm of rain fell in the upper Deep Creek at Lancefield North by the end of Thursday 13-Oct-2022.

FW #3 went on to say,

"*The level of the Deep Creek at Darraweit Guim is currently at 6.15 metres, exceeding the Moderate Flood Level (6.10 metres). It is expected to peak around the Major Flood Level (6.50 metres) on Thursday evening (13 October 2022)."*

While FW #3 was issued at 3:42 pm 14-Oct-2022 when Melbourne Water's website says the level was close to 6.37 metres the FW only quoted the level almost 2 hours earlier at 1:51 pm 14-Oct-2022.

The level at Darraweit Guim would go onto peak at 7.22 metres just after 9 pm 14-Oct-2022, so the timing was about right but the predicted peak level 0.72 m too low.

For the Maribyrnong River FW #3 said,

"The level of the Maribyrnong River at Keilor is currently at 0.82 metres, and rising. It is expected to peak around the Moderate Flood Level (5.50 metres) on Friday morning (14 October 2022).

The level of the Maribyrnong River at Maribyrnong is currently at 0.15 metres, and rising. It is expected to peak around the Moderate Flood Level (2.40 metres) on Friday morning (14 October 2022).

Moderate to major flooding in the Deep Creek and Maribyrnong River catchment is expected to cause substantial inundation in the rural and/or urban areas, disruption to traffic, and may be isolation of some properties."

The peak level predictions for Keilor and Maribyrnong Township would prove to be manifestly low, 3.13 metres too low in the case of Keilor and 1.82 m too low in the case of Maribyrnong Township.

Flood Warning #4 for the Maribyrnong was meant to be issued by 8 pm Thursday 13-Oct-2022, or earlier if required, but wasn't issued until 8:24 pm Thursday 13-Oct-2022 with the heading still saying,

"Major Flood Warning for the Maribyrnong River" but the predicted peak level at Keilor remaining unchanged from FW#3 at ***"around the Moderate Flood Level (5.50 metres)"*** and the predicted peak level at Maribyrnong Township also remaining unchanged at ***"around the Moderate Flood Level (2.40 metres)".***

This was despite the level at Darraweit exceeding the Major Level [6.5 m] by 0.5 metres, according to the level of 7.00 metres at 7:52 pm given in the warning, but Melbourne Water's website said the level at 8:24 pm was actually 7.10 metres.

It is inconceivable how Melbourne Water's flood warning people could witness the river level on Deep Creek at Darraweit Guim approaching a new historical record flood level 0.5 to 0.6 metres higher than their predicted peak there almost 5 hours earlier and not increase their predicted peak flood level at Keilor and Maribyrnong Township and realise MAJOR FLOODING from Keilor downstream to Maribyrnong Township, Ascot Vale through to Kensington was going to result.

It was around this time, 8:52 pm Thursday 13-Oct-2022 to be precise, that I had been communicating my thoughts on the flood situation via Facebook Messenger to a friend who lives in Chifley Drive, Maribyrnong Township, who was well experienced with flooding in the 35 years or more she had lived there.

I expressed my concern with Melbourne Water's predicted flood peak for Keilor and Maribyrnong given that Deep Creek at Darraweit hadn't peaked at that time, nor had Konagaderra, Clarkefield or Sunbury, and it was still raining.

From my Facebook Messenger log went on to say, ***"another cause for worry is the level to flow (H-Q) relationship data Melbourne Water is quoting on their website for Deep Creek at Darraweit which is vastly different to the H-Q relationship at Darraweit we had 20 years ago. If the Melbourne Water flood prediction goes pear-shaped then I will do a detailed check on this anomaly with the H-Q relationship at Darraweit."***

By 11:00 pm 13-Oct-2022 the level on the Maribyrnong River at Bulla had exceeded the peak level of the May 1974 flood [6.22 metres] and was rising steadily, and yet this failed to ring any "alarm bells" with Melbourne Water that major flooding was imminent further downstream.
[Source" DELWP Water Monitoring website https://data.water.vic.gov.au/]

Flood Warning #5 was finally issued with a Major Flood Warning for Keilor and Maribyrnong Township at 2:25 am Friday 14-Oct-2022, see Figure 7. This warning should have been issued by 2:00 am Friday 14-Oct-2022 or earlier if required, according to FW #4 which read,

"The level of the Deep Creek at Darraweit Guim is currently at 6.67 metres, exceeding the Major Flood Level (6.50 metres) and falling."

Melbourne Water's submission to their own flood review says ***"At Darrweit [sic] Guim in Deep Creek the October 2022 flood event was close to 1% AEP (a flood event with a 1 in 100 probability in each year). The river levels were the highest ever recorded at 7.22 metres"*** but importantly Melbourne Water failed to mention this most vital piece of information in their FW #5.

At this time the best Melbourne Water could do with the peak level prediction at Keilor and Maribyrnong Township was,

"The level of the Maribyrnong River at Keilor is currently at 5.42 metres, exceeding the Moderate Flood Level (5.40 metres) and rising. It is expected to peak above the Major Flood Level (6.10 metres) on Friday morning (14 October 2022).

The level of the Maribyrnong River at Maribyrnong is currently at 0.72 metres, and rising. It is expected to peak above the Major Flood Level (2.90 metres) Friday morning (14 October 2022)."

Inexplicably Melbourne Water's FW #5 contains the exact same flooding consequences message as it did in FW #1, namely,

"Major flooding in the Deep Creek and Maribyrnong River catchment is expected to cause extensive inundation in the rural and/or urban areas, disruption to traffic, and may be isolation of some properties."

No indication was given this could be the highest flooding on the Maribyrnong River in over 100 years resulting in the inundation of hundreds of homes.

FW #5 concluded by saying, ***"The next warning will be issued by 8:00 AM EDT on Friday 14 October 2022."***

At this late stage of the flood questions could be asked why was Melbourne Water (1) unable to provide a more specific prediction for the peak levels on the Maribyrnong River at Keilor and Maribyrnong Township, (2) why did it take so long to issue a Major Flood Warning (for Keilor and Maribyrnong Township) and (3) why was their flood intelligence so poor they didn't ramp up the flood extent and urgency of their warning message?

Flood Warning - Maribyrnong River

IDV36300

Australian Government Bureau of Meteorology

Major Flood Warning for the Maribyrnong River

Issued at 2:25 am EDT on Friday 14 October 2022

by the Bureau of Meteorology, Victoria Regional Office on behalf of Melbourne Water

Flood Warning Number: 5

Maribyrnong River:

The Maribyrnong River catchment has recorded rainfall averaging about 44 mm since 09:00 AM Thursday 13 October 2022. Rainfall totals of 5 mm are forecast for the catchment Friday 14 October 2022.

Water levels of the Jacksons Creek, Deep Creek and the Maribyrnong River at various locations are rising in response to the rain.

Jacksons Creek:

The level of the Rosslynne Reservoir is currently at 51.24 metres, and steady. It is expected to peak around the Minor Flood Level (51.40 metres) Friday morning (14 October 2022).

Deep Creek:

The level of the Deep Creek at Darraweit Guim is currently at 6.67 metres, exceeding the Major Flood Level (6.50 metres) and falling. It is expected to drop below the Major Flood Level Friday morning (14 October 2022).

Maribyrnong River:

The level of the Maribyrnong River at Keilor is currently at 5.42 metres, exceeding the Moderate Flood Level (5.40 metres) and rising. It is expected to peak above the Major Flood Level (6.10 metres) on Friday morning (14 October 2022).

The level of the Maribyrnong River at Maribyrnong is currently at 0.72 metres, and rising. It is expected to peak above the Major Flood Level (2.90 metres) Friday morning (14 October 2022).

Major flooding in the Deep Creek and Maribyrnong River catchment is expected to cause extensive inundation in the rural and/or urban areas, disruption to traffic, and may be isolation of some properties.

The river heights at 02:03 AM Friday 14 October 2022 were:

Deep Creek at Doggetts Bridge, Lancefield: 2.95 metres, rising

Deep Creek at Darraweit Guim: 6.67 metres, falling

Deep Creek at Konagaderra: 10.48 metres, falling

Bolinda Creek at Clarkefield: 1.60 metres, falling

Deep Creek at Bulla: 7.61 metres, rising

Rosslynne Reservoir, Head Gauge: 51.24 metres, steady

Jacksons Creek at Sunbury: 3.55 metres, falling

Steele Creek at Keilor East: 0.77 metres, falling

Maribyrnong River at Keilor North: 9.00 metres, rising

Maribyrnong River at Keilor: 5.42 metres, rising

Maribyrnong River at Maribyrnong: 0.72 metres, rising

The next warning will be issued by 8:00 AM EDT on Friday 14 October 2022.

Figure 7. Flood Warning #5 issued at 2:25 am Friday 14-Oct-2022 – first Major Flood Warning for Keilor and Maribyrnong Township

Flood Warning #5 was reissued as Flood Warning #6 at 2:53 am 14-Oct-2022 to correct a minor inconsequential typo regarding the severity of flooding downstream of Rosslynne Reservoir in Gisborne.

Despite the Major Flood Level of 2.9 metres being reached at Maribyrnong Township around 6:35 am Friday 14-Oct-2022 the next flood warning (#7) wasn't issued until 8:10 am on Friday 14-Oct-2022 several hours after SES and Victoria Police had started door knocking residences in Maribyrnong Township to evacuate, stating:

"The level of the Maribyrnong River at Keilor is currently at 8.63 metres, exceeding the Major Flood Level (6.10 metres). It is expected to peak around 8.70 meters this morning (Friday 14 October 2022).

The level of the Maribyrnong River at Maribyrnong is currently at 3.46 metres, exceeding the Major Flood Level (2.90 metres). It is expected to peak around 3.8m this morning (Friday 14 October 2022)."

At this time the Maribyrnong River at Keilor was the highest level on record for over 100 years and it would have been reasonable to assume that with all the historical flood level correlation data Melbourne Water had between Keilor and Maribyrnong Township, that appear in numerous publications, they would have predicted a peak at Maribyrnong at least equivalent to the adopted May 1974 peak level at the Maribyrnong Township gauge of 4.2 metres.

But instead, Melbourne Water was somehow still only predicting a peak of 3.8 m at Maribyrnong Township.

Furthermore, FW #7 also belatedly said ***"The level of the Deep Creek at Darraweit Guim has peaked at 7.68 metres overnight. The water level is currently at 6.13 metres, exceeding the Moderate Flood Level (6.10 metres) and falling."***

The thing is though, Melbourne Water now say the peak level at Darraweit Guim was 7.22 metres and no mention has been made of this 7.68 m peak level at Darraweit.

In addition to the many other questions raised for Melbourne Water to answer from my critical assessment, they could add providing an explanation for the 7.68 m peak level initially reported for Deep Creek at Darraweit Guim.

Flood Warning #8 was issued at 2:16 pm on Friday 14-Oct-2022, about seven hours after the peak level of 8.64 metres and two hours after the peak level of 4.22 m was reach at Maribyrnong Township.

Inexplicably Melbourne Water's FW #8 failed to mentioned what level and time the peak was reached at Keilor and Maribyrnong Township, nor was it mentioned anywhere in the subsequent flood warnings #9, #10 or #11.

Apart from all the other failures and shortcomings of Melbourne Water's Maribyrnong River flood warnings, not mentioning what the peak level reached at Keilor and Maribyrnong Township, nor the time of the peaks, or quantifying when such a peak level was last reached breaches all best practice flood warning message construction guidelines.

2.2 Explanation for Melbourne Water's failed flood modelling, flood level under-predictions and belated Major Flood Warning for Maribyrnong River

2.21 Preliminary Discussion

As mentioned above, Melbourne Water's flood modelling of the Maribyrnong catchment failed to provide accurate peak level predictions downstream of Deep Creek from Darraweit Guim to Keilor and Maribyrnong Township and consequently resulted in belated and ineffectual warning of the major flood for the affected community. This prevented a timely and safe evacuation resulting in many residents being unable to save precious personal items, relocate cars to higher ground and/or raising household items above the impending flood level.

Melbourne Water's submission to their own flood review provides no explanation of what went so horribly wrong with their flood modelling and flood level predictions during the vital 10 hours and 6 minutes from 2:24 pm 13-Oct to 12-30 am 14-Oct-2022. It is unclear when Melbourne Water decided to set up an incident response team and staff an operations centre in a central location. Knowing when this was initiated is vital to understanding why Melbourne Water's response was so poor. All Melbourne Water have said is,

"In the afternoon of 13 October BOM advised Melbourne Water of revised rainfall forecast. At 2.24pm Melbourne Water prepared and sent to BoM a moderate flood warning for the lower Maribyrnong.
On 14 October at approximately 12.30am, Melbourne Water identified that the actual height in the Maribyrnong River exceeded the levels that models had predicted. Melbourne Water revised its projections in light of the real time data and contacted BoM and VicSES to upgrade the flood warning to 'exceeding major' at 2.16am (re-running models can take 30-90 minutes to run and a further 20- 45 minutes to process the information). This new warning was issued by BoM at 2.27am on 14 October."

I would like to make the immediate comment about Melbourne Water's statement that ***"re-running models can take 30-90 minutes to run and a further 20- 45 minutes to process the information".***

Back when I was in charge of Melbourne Water's flood warning operations (1989 to 2003) we would run the RTRORB (Real-Time RORB) program on the organisation's central computer system and have a peak flood prediction in a few minutes taking nothing like up to 90 minutes to re-run.

Furthermore, it took nothing like up to an additional 45 minutes to process the information and I'm gobsmacked to hear how long it takes Melbourne Water these days to run their flood forecasting modelling, and then make sense out of it.

I will have more to say later about the RTRORB program and how flood forecasting was done at Melbourne Water 20 plus years ago in Section 2.3.

2.22 What is a stage-discharge or level to flow (H-Q) relationship?

It is important to understand what is meant by a stage-discharge or level to flow (H-Q) relationship and the importance these have in the accuracy of catchment flood modelling and flood level predictions. These are commonly called rating curves or simply ratings in the flood business.

I have sourced what I believe to be an excellent example describing what rating curves are and the major errors that can occur in them that inevitably cause major under-estimation of flows in flood modelling studies, or worse still real-time flood forecasting.

The abstract starts of by saying, ***"Rating curves are the primary tool for converting water level data into flows. They are determined based on velocity measurements at a discrete location during different flow conditions and are generally developed by episodic flow metering during significant flow events. In the Pilbara region of Western Australia, the effect has been found to significantly underestimate the flow during larger flood events, sometimes by an order of magnitude."***

Reference: Does Your Rating Curve Hold Water: The Consequence of Rating Curve Errors Wark, Bob; Thomas, Louise GHD
https://www.ghd.com/en/expertise/resources/PDF/ANCOLD2014-Does-Your-Rating-Curve-Hold-Water---The-Consequences-of-Rating-Curve-Errors---WARK--THOMAS.pdf

This is the exact same thing that happened with the rating at Melbourne Water's Deep Creek at Darraweit Guim site that resulted in the historically high river levels generating spuriously low flood flow data and a peak flow value of 280 m3/sec that was more than two orders of magnitude too low.

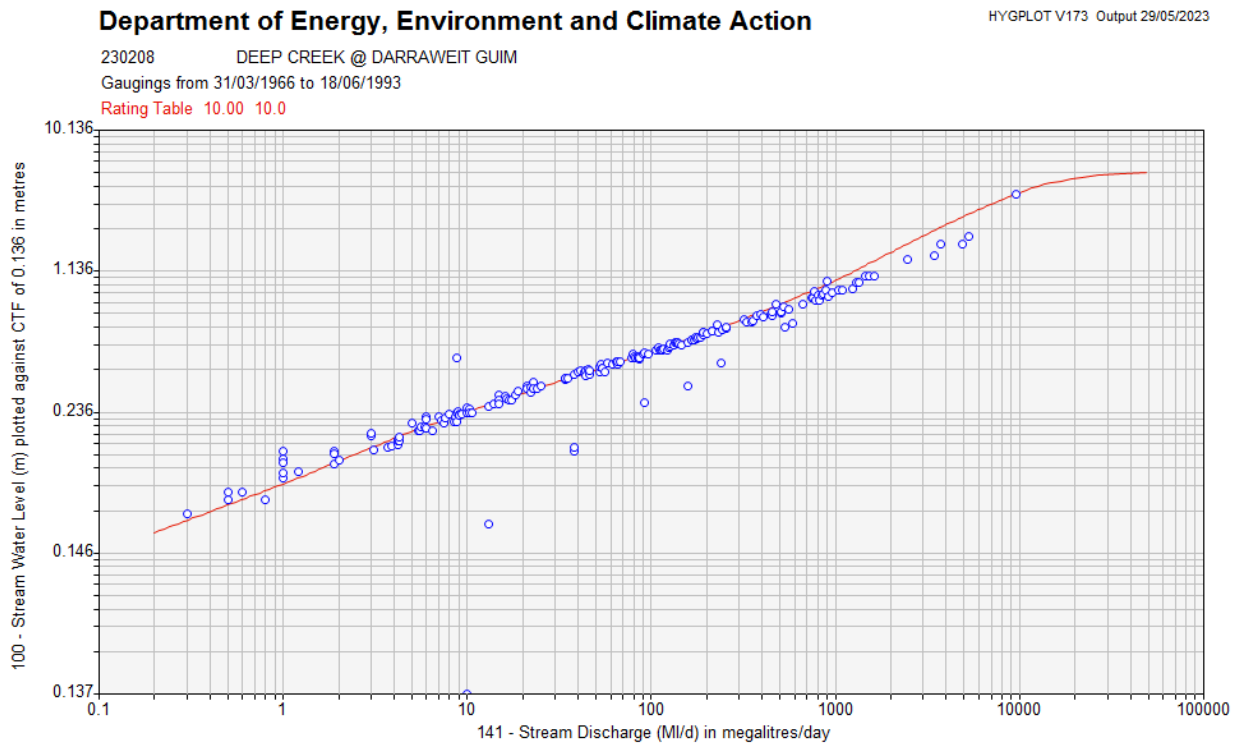


Figure 11: Rating curve for Deep Creek at Darraweit Guim [230208] [source: DELWP}

Figure 11 shows an example of a rating curve for the old SR&WSC site on Deep Creek upstream of Darraweit Guim [230208] that operated from 1966 to 1993 and had 209 stream gaugings carried out between 31-Mar-1966 and 18-Jun-1993 with a maximum gauging at 3.63 metres on 15-May-1974 of 9,540 ML/day.

The DELWP rating curve (red line) shows it passing through the gauging points on a statistical line of best fit from a low flow of 0.3 ML/day up to 1,000 ML/day before deviating up to maximum gauging of 9,540 ML/day and then flattening out with a relatively minor increase in level resulting in a significant increase in flow.

This is because the bankfull level at this site is around 3.63 metres on the gauge and after that flow starts to break out onto the floodplain which is used as the local soccer and football ground.

The SR&WSC hydrographers and technical staff would have known this and used historical flood data, cross sectional survey and analytical tools to estimate the stage-discharge relationship for river levels higher than 3.63 metres once large volumes of water had broken out on the floodplain.

I will be speaking more about this in Section 2.4 of my submission.

Figure 12 shows the rating table for Deep Creek at Darraweit Guim [230208] above 3.0 metres including the overbank flood flows upwards of 3.63 metres.

Department of Energy, Environment and Climate Action HYRATAB V195 Output 29/05/2023

Site 230208B DEEP CREEK @ DARRAWEIT GUIM

Rating Table 10.00 13/10/1990 to Present Interpolation = Log CTF = 0.1360

Converting 100 Stream Water Level (m) in metres
Into 141 Stream Discharge (Ml/d) in megalitres/day

G.H.	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
3.00	6490	6530	6570	6610	6650	6690	6730	6770	6810	6850
3.10	6890	6930	6970	7010	7050	7090	7140	7180	7220	7260
3.20	7300	7340	7390	7430	7480	7530	7570	7620	7660	7710
3.30	7750	7800	7850	7890	7940	7990	8030	8080	8130	8170
3.40	8220	8270	8320	8360	8410	8460	8510	8560	8600	8650
3.50	8700	8750	8800	8850	8900	8950	9000	9050	9090	9140
3.60	9190	9240	9290	9340	9400	9450	9500	9550	9600	9650
3.70	9700	9760	9820	9870	9930	9990	10000	10100	10200	10200
3.80	10300	10300	10400	10500	10500	10600	10600	10700	10800	10800
3.90	10900	10900	11000	11100	11100	11200	11300	11300	11400	11400
4.00	11500	11600R	11700R	11700R	11800R	11900R	12000R	12100R	12200R	12200R
4.10	12300R	12400R	12500R	12600R	12700R	12700R	12800R	12900R	13000R	13100R
4.20	13200R	13300R	13400R	13400R	13500R	13600R	13700R	13800R	13900R	14000R
4.30	14100R	14200R	14300R	14300R	14400R	14500R	14600R	14700R	14800R	14900R
4.40	15000R	15200R	15300R	15500R	15600R	15800R	15900R	16100R	16200R	16400R
4.50	16600R	16700R	16900R	17100R	17200R	17400R	17600R	17700R	17900R	18100R
4.60	18200R	18400R	18600R	18800R	19000R	19100R	19300R	19500R	19700R	19900R
4.70	20100R	20200R	20400R	20600R	20800R	21000R	21200R	21400R	21600R	21800R
4.80	22000R	22400R	22800R	23200R	23600R	24000R	24400R	24800R	25300R	25700R
4.90	26200R	26600R	27100R	27500R	28000R	28500R	29000R	29500R	30000R	30500R
5.00	31000R	31700R	32400R	33200R	34000R	34700R	35500R	36300R	37200R	38000R
5.10	38900R	39700R	40600R	41600R	42500R	43400R	44400R	45400R	46400R	47400R
5.20	48500R									

---------- Notes ----------
All rated data has been coded as reliable
except where the following tags are used...
R ... Rating table extrapolated

Figure 12. Rating Table for Deep Creek at Darraweit [230208] above 3.0 metres [source: DELWP]

2.23 Initial Concern for Melbourne Water's level to flow (H-Q) relationship for Deep Creek at Darraweit Guim

Earlier in my discussion of Melbourne Water's flood warnings I expressed the concern I had around 9 pm Thursday 13-Oct-2022 regarding the level to flow (H-Q) relationship data Melbourne Water was quoting on their website for Deep Creek at Darraweit Guim which was vastly different to the H-Q relationship at Darraweit contained in Melbourne Water's Flood Warning Manual we used 20 years ago.

Specifically, this concern was triggered after noting the flow Melbourne Water was reporting for the Deep Creek at Darraweit Guim at 9 pm 13-Oct-2022 for a level of 6.83 metres was only 240.3 m3/s.

A check of the Flood Intelligence Card for Deep Creek at Darraweit Guim from the September 2003 Melbourne Water Flood Warning Manual, see Figure 8., showed the flow should have been in excess of 440 m3/s, close to double the flow Melbourne Water was reporting.

12.2 Darraweit Guim - DG 3

DG 3 **Location:** Darraweit Guim

Watercourse: Deep Creek **Catchment:** Maribyrnong River

Highest Flood: **Date of Highest Flood:**

Zero Level of Staff Gauge: 230.83 m AHD

KEY Heights (metres)

Minor: 5.5 **Moderate:** 6.1 **Major:** 6.5

HEIGHT (m)	FLOW (cumecs)		REMARKS
5.5	150	123	Minor Flood level Road through Darraweit Guim cut, Homes in town centre threatened 5.8 hrs to Konagaderra
6.1	300	172	Moderate Flood Level 4.2 hrs to Konagaderra
6.5	440	210	Major Flood level 2.2 hrs to Konagaderra
7.22	700+	280	Flood Peak at Darraweit Guim around 9 pm 13-Oct-2022
	⇧ Sep 2003	⇧ Oct 2022	

Figure 8: Flood Intelligence Card for Darraweit Guim showing critical level and flow data
Source: Melbourne Water Flood Warning Manual Sep 2003

This massive discrepancy in the flow being reported by Melbourne Water was consistent with level to flow data contained on the schematic map of Deep Creek Catchment for Darraweit in the Melbourne Water Flood Warning Manual July 1996, which also indicated the level at 9 pm 13-Oct-2022 of 6.83 metres was in excess of the 100 year flood level, see below.

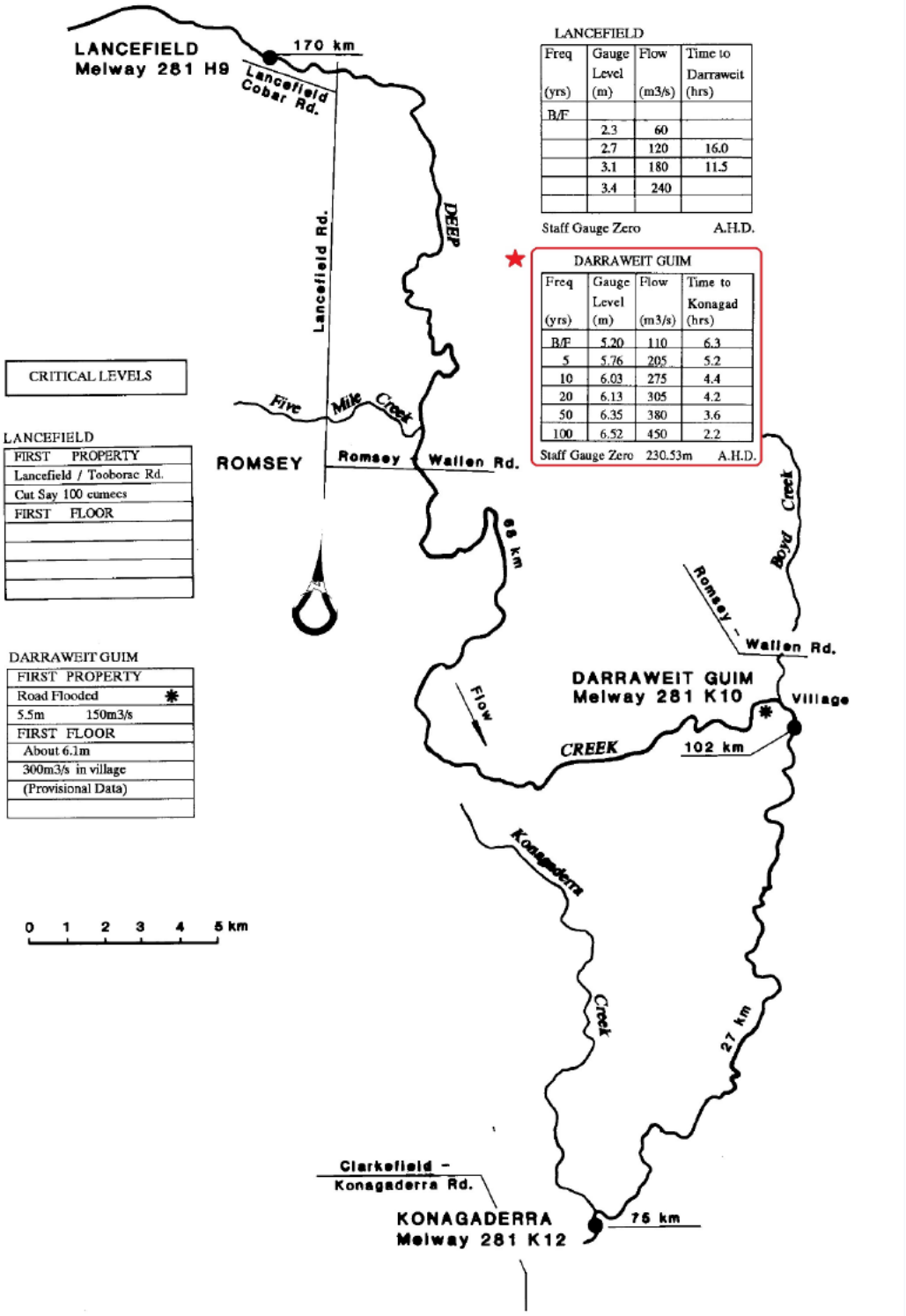


Figure 9: Schematic map of Deep Creek Catchment featuring Darraweit Guim
Source: Melbourne Water Flood Warning Manual July 1996

I then located the level-flow table for Deep Creek at Darraweit Guim (230100A) on the Excel spreadsheet used by Melbourne Water's flood warning system database 20 years ago and discovered to my horror a level of 6.83 metres was equivalent to a flow in excess of 583 m3/s, an order of magnitude 2.4 times what Melbourne Water was reporting for Darraweit at the time, see Figure 10 below.

RATEPTS_CurrentSites_ToMOSAIC - Excel

OFFICIAL

F4040

	A	B	C	D	E	Level (m)	Flow (m3/sec)		I
4069	230100	100	140	7	2	3	30.71	1	
4070	230100	100	140	7	2	3.1	32.25	1	
4071	230100	100	140	7	2	3.2	33.82	1	
4072	230100	100	140	7	2	3.3	35.41	1	
4073	230100	100	140	7	2	3.4	37.03	1	
4074	230100	100	140	7	2	3.5	38.68	1	
4075	230100	100	140	7	2	3.6	40.36	1	
4076	230100	100	140	7	2	3.7	42.06	1	
4077	230100	100	140	7	2	3.8	43.79	1	
4078	230100	100	140	7	2	3.9	45.54	1	
4079	230100	100	140	7	2	4	47.32	1	
4080	230100	100	140	7	2	4.1	49.12	1	
4081	230100	100	140	7	2	4.2	50.95	1	
4082	230100	100	140	7	2	4.3	55.13	1	
4083	230100	100	140	7	2	4.4	59.78	1	
4084	230100	100	140	7	2	4.5	64.71	1	
4085	230100	100	140	7	2	4.6	69.92	1	
4086	230100	100	140	7	2	4.7	75.43	1	
4087	230100	100	140	7	2	4.8	81.24	1	
4088	230100	100	140	7	2	4.9	87.37	1	
4089	230100	100	140	7	2	5	93.81	1	
4090	230100	100	140	7	2	5.1	100.6	1	
4091	230100	100	140	7	2	5.2	107.72	1	
4092	230100	100	140	7	2	5.3	121.62	1	
4093	230100	100	140	7	2	5.4	136.79	1	
4094	230100	100	140	7	2	5.5	153.52	1	
4095	230100	100	140	7	2	5.6	171.93	1	
4096	230100	100	140	7	2	5.7	192.17	1	
4097	230100	100	140	7	2	5.8	214.37	1	
4098	230100	100	140	7	2	5.9	238.7	1	
4099	230100	100	140	7	2	6	265.3	1	
4100	230100	100	140	7	2	6.1	294.35	1	
4101	230100	100	140	7	2	6.2	326.04	1	
4102	230100	100	140	7	2	6.3	360.54	1	
4103	230100	100	140	7	2	6.4	398.07	1	
4104	230100	100	140	7	2	6.5	438.82	1	
4105	230100	100	140	7	2	6.6	483.03	1	
4106	230100	100	140	7	2	6.7	530.93	1	
4107	230100	100	140	7	2	6.8	582.76	1	
4108	230100	100	140	7	2	6.99	693	1	

RATEPTS_CurrentSites_ToMOSAIC

Figure 10: Extract of Deep Creek at Darraweit Guim [230100A] official H-Q rating table points
Source: Melbourne Water RATEPTS_CurrentSites_ToMOSAIC.xls Excel database file 5-Dec-2001

I then told my friend who lived in Maribyrnong Township that ***"If the Melbourne Water flood prediction goes pear-shaped then I will do a detailed check on this anomaly with the H-Q relationship at Darraweit."***

My submission will now detail the checks I have undertaken since for the level to flow (H-Q) rating relationship for Deep Creek at Darraweit Guim after Melbourne Water's flood prediction did indeed go "pear shaped", as predicted by me some five and a half hours before Melbourne Water's first Major Flood Warning was issued for Keilor and Maribyrnong Township.

2.24 Melbourne Water's incorrect rating for Deep Creek at Darraweit Guim [230100A] and the consequences

By 2003 the stage-discharge rating for Deep Creek at Darraweit Guim [230100A] had been developed since 1975, using numerous streamflow gaugings along with cross section survey data at the site and downstream that identified bankfull conditions occurring when the gauge reached about 5.2 metres for a flow around 108 m3/sec.

Above 5.2 metres break-out flow occurs downstream on the right or western bank where water begins spilling out on the floodplain. The stage-discharge rating took account when it was extrapolated above 5.2 metres using historical flood data correlations with the SR&WSC site upstream of Darraweit Guim Township [230208], referred to in Section 2.22.

The May 1974 flood, and even bigger flood in September 1975, provided valuable input to the 230100A rating table extrapolation.

I will be speaking much more about the September 1975 flood in Section 2.4 of my submission.

Essentially Melbourne Water's stage-discharge rating for 230100A Deep Creek at Darraweit Guim remained substantively unchanged in the flood flow range above 5.2 metres from 1975 and was successfully used over 28 years encompassing half a dozen floods, and was in good working order when I left Melbourne Water at the end of 2003.

However, since 2003 it seems the flood intelligence, stage-discharge rating archives, station file histories and photographic records gathered for 230100A Deep Creek at Darraweit Guim by Melbourne Water, have been filed away somewhere apparently never to be seen again.

It appears Melbourne Water's latest hydrographic contractors have not had the benefit of all the station history and previous rating table information gathered from 1975 to 2003, and been unaware of the dramatic change in the stage-discharge rating above 5.2 metres, when Deep Creek is in full flood as it was back in October last year.

Melbourne Water provided a personal assurance as recently as 10-Mar-2023 that ***"The Maribyrnong River Gauging Stations are routinely updated using independent experts who use profiling equipment to undertake stream gauging. Melbourne Water regularly obtains stream gauging measurements at Darraweit Guim to ensure our stream rating table is kept current. Since 2003 there has been 20 revisions of the rating tables."***

However, my investigation of the stage-discharge rating Melbourne Water currently has for Darraweit Guim shows the rating must have been changed dramatically on one of those 20 revisions since 2003, by not taking account of the breakout floodplain flows above 5.2 metres.

Melbourne Water was asked to provide copies of those 20 different rating table revisions at Darraweit Guim since 2003, to enable the exact date of their error to be identified, but they declined.

Melbourne Water provided reasons for changes in the rating since 2003, ranging from additional vegetation growth, changes in channel conditions affecting the measured gauge cross section, to changing conditions upstream and downstream of the gauge. But my extensive experience and intimate knowledge of the Darraweit Guim gauging station tells me none of the factors suggested by Melbourne Water was ever going to explain the huge difference in the rating curve from 2003 to 2022.

Figure 13 below shows the dramatic difference in the stage-discharge rating at Darraweit Guim used by Melbourne Water during the October 2022 flood for calculating flows above 5.2 metres, compared to the rating at Darraweit used by Melbourne Water prior to 2004.

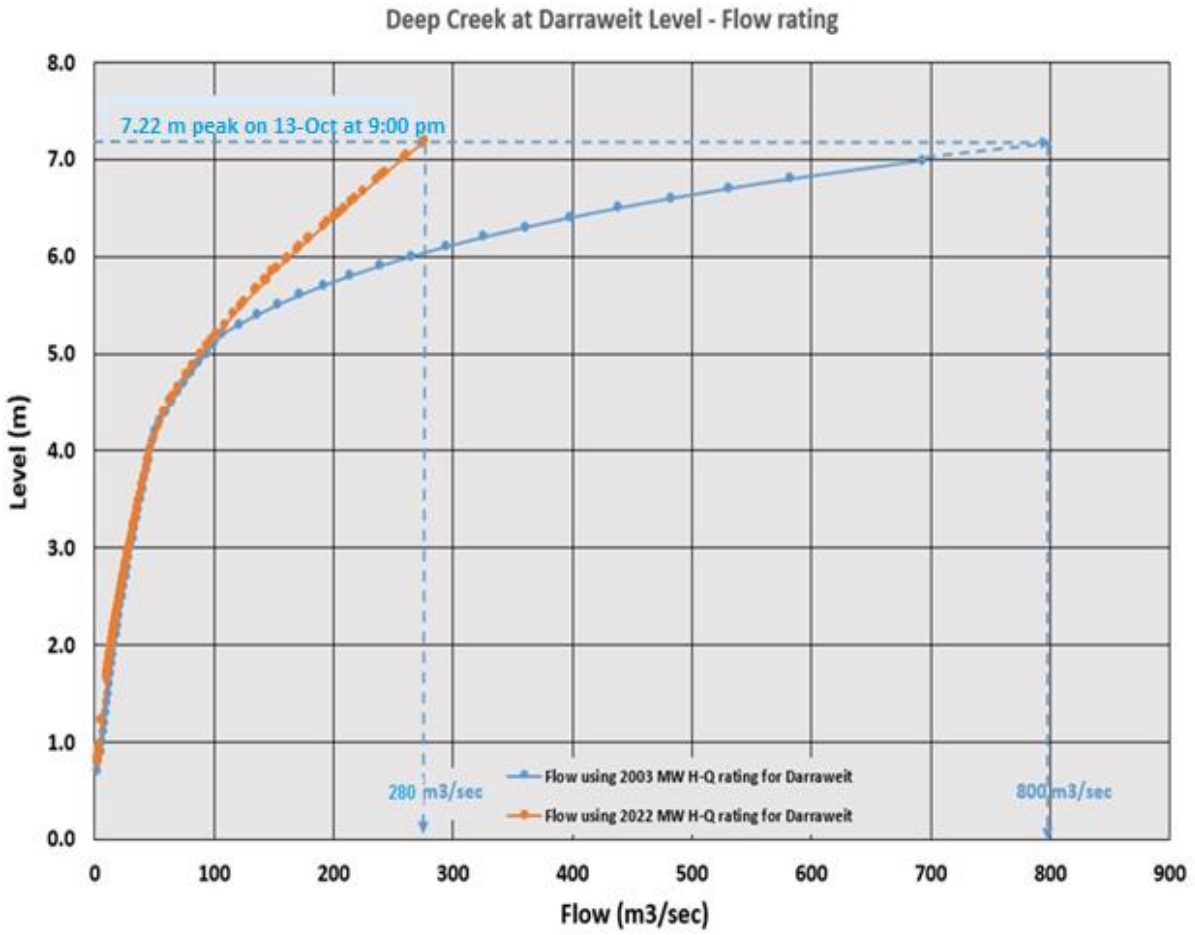


Figure 13. Melbourne Water's rating curve for Deep Creek at Darraweit Guim [230100A] in 2003 compared to what was used for the rating during the 13-14 Oct-2022 flood.

The consequences of Melbourne Water having the incorrect stage-discharge rating at Darraweit Guim for flows above 5.2 metres were wide-sweeping and disastrous for residents living adjacent to the Maribyrnong River from Avondale Heights to Maribyrnong Township and Ascot Vale down to Kensington and West Melbourne.

It meant Melbourne Water's flood warning staff monitoring the flood and carrying out the flood modelling of the Maribyrnong River had no idea of the magnitude of the flood at Darraweit, with their flood model only inputting half to a third of what the actual peak flow really was at Darraweit.

This in turn caused their model to produce much lower predicted flows downstream to Keilor, Melbourne Water's main flood gauge for estimating the peak flood level at Maribyrnong Township. This translated into much lower flood level predictions there and belated ineffectual warnings for the Major Flood, resulting in the shambolic emergency flood response by SES and Victoria Police.

Figure 14 shows the flood flows Melbourne Water was producing for Deep Creek at Darraweit Guim compared to the flood flows they would have produced with their rating 20 years ago, a peak of 280 m3/s in 2022 compared to around 800 m3/s using their 2003 rating. Also shown is the peak flow of 600 m3/s produced by Melbourne Water's RORB model, which is the subject of my next Section 2.3.

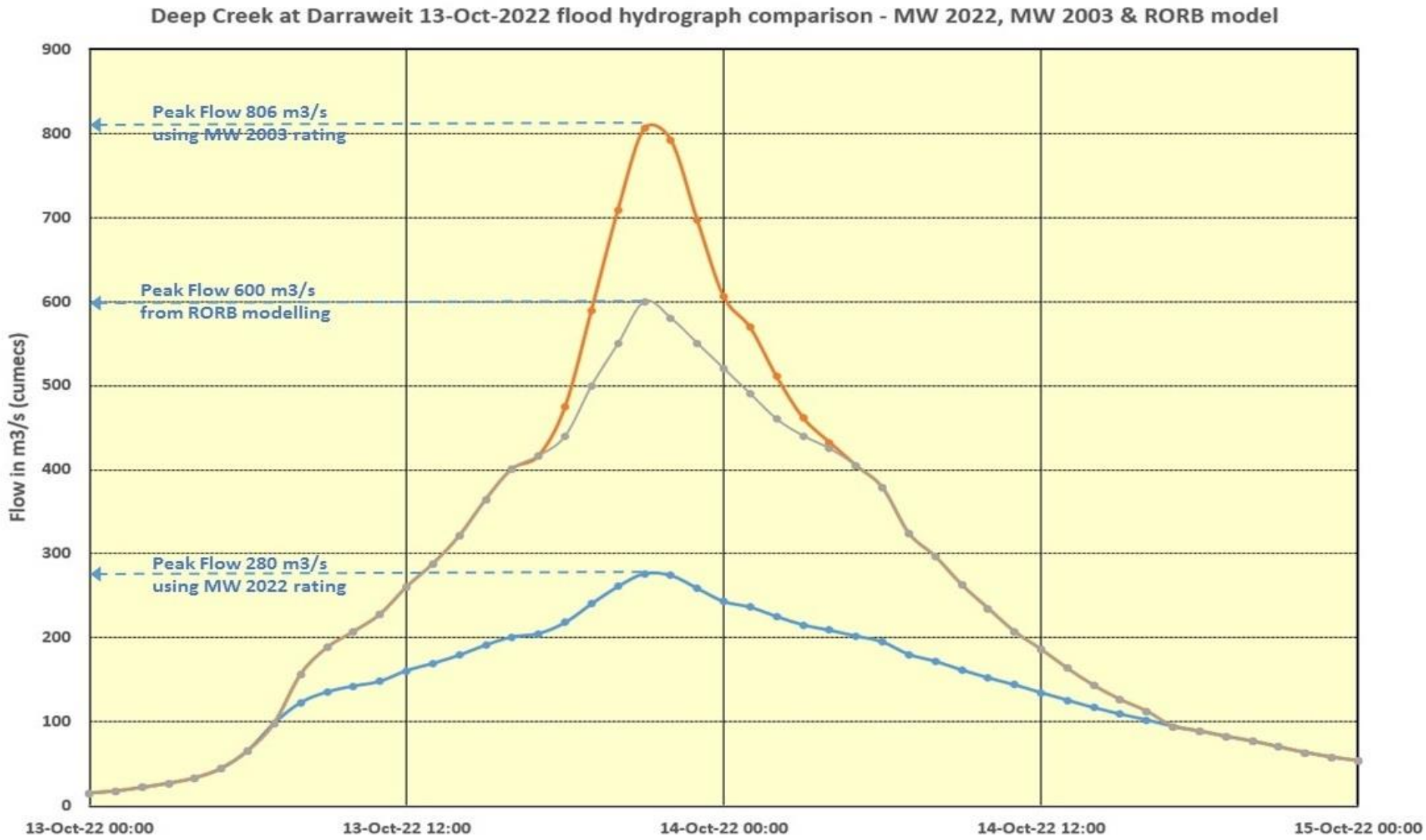


Figure 14. Comparison between flood flows for Darraweit Guim (1) using Melbourne Water's current rating, (2) MW's 2003 rating & (3) RORB model

2.3 RORB rainfall runoff catchment modelling for Maribyrnong October 2022 using 1986 MMBW model

2.3.1 Background

The 1986 MMBW Maribyrnong River Flood Mitigation Study used the RORB runoff routing program developed by Professor Eric Laurenson and Assoc. Professor Russell Mein at Monash University in the mid-1970s.

* The 'ROR' of 'RORB' stands for 'runoff routing'. The 'B' initially stood for the name of the Burroughs B6700 computer it was developed and maintained on at Monash University Clayton Campus.

The MMBW study team included Ron Sutherland, who was trained in the use of RORB at Monash University, configured a RORB model for the Maribyrnong catchment and used it to firstly calibrate the model parameters for a number of significant flood events and then model the catchment response to design rainfall with a range of different flood mitigations strategies, including flood retarding basins at Wildwood, upstream of Bulla, and Arundel, just upstream of Keilor.

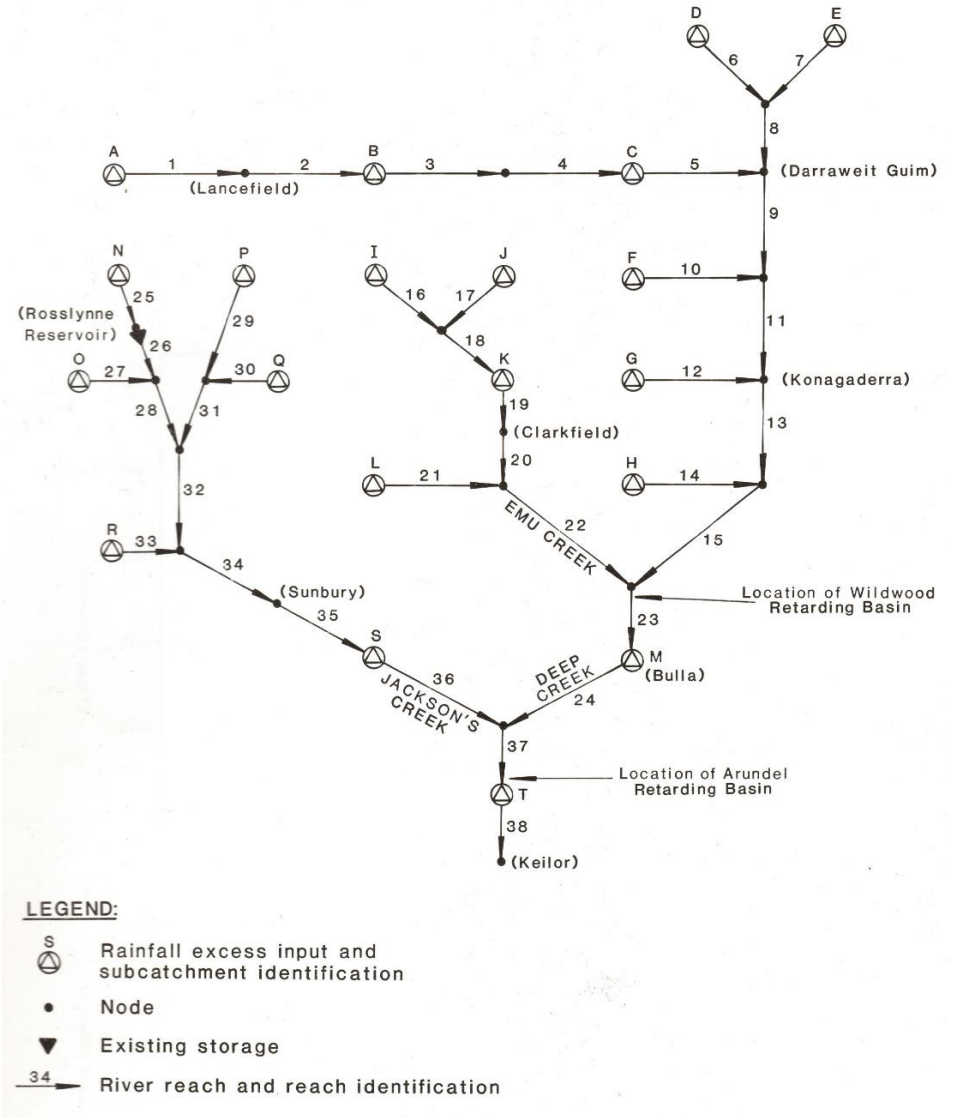


Figure 15 Schematic Representation of the 1986 MMBW RORB Model for Maribyrnong

In 1989 I conceived the use of the RORB model for real-time flood forecasting applications following a significant flash flood on the Diamond Creek in June of that year. The real-time RORB (RTRORB) computer model was written in-house by the MMBW under my direction.

It was subsequently used many times in the early 1990s during frequent flooding on Watts River downstream of Maroondah Reservoir at Healesville, and most notably in September 1993 when I used RTRORB to model and predict levels in the Upper Yarra Dam during the critical reconstruction period of the outlet tower, while at the same time carrying out real-time flood forecasting of the Major Flood on the Maribyrnong River.

In the early 1990s the head of the BoM's Australia-wide flood warning operations brought a group of visiting Chinese delegates into Melbourne Water's Head Office for me to demonstrate the cutting edge RTRORB real-time flood modelling technology. That is how highly regarded it was.

In early 1994 I supervised the Maribyrnong River RORB model study which used all available rainfall and flow data for significant floods on the Maribyrnong from the Sep 1975 flood to the Sep 1993 flood. This was to provide a better understanding of initial loss and continuing loss model parameters in relation to the antecedent catchment conditions and critical storm duration for the particular flood event.

RTRORB was also used very successfully for flood forecasting and flood warning in the late 1990s and early 2000s on the Bunyip River catchment.

2.3.2 RORB flood modelling for the 13-14 Oct 2022 flood event

Following Melbourne Water's self-confessed issues with their flood modelling for the Maribyrnong during the 13-14 Oct-2022 flood event I decided to run the 1986 MMBW RORB model for the Maribyrnong catchment using Melbourne Water's rainfall and flow data for the event.

Initially the 1986 MMBW RORB model was run using Melbourne Water's Oct 2022 rainfall and flow data up to 9 pm 13-Oct-2022 to determine the initial loss (mm) and continuing loss (mm/hr) likely to have been used by Melbourne Water's flood warning staff carrying out the flood modelling and flood predictions for the Maribyrnong flood event.

The RORB parameters for modelling Melbourne Water's rainfall and flow data up to 9 pm 13-Oct-2022 were: kc = 67.0, m = 0.8, Initial loss = 25.0 mm, Continuing loss = 2.5 mm/hr.

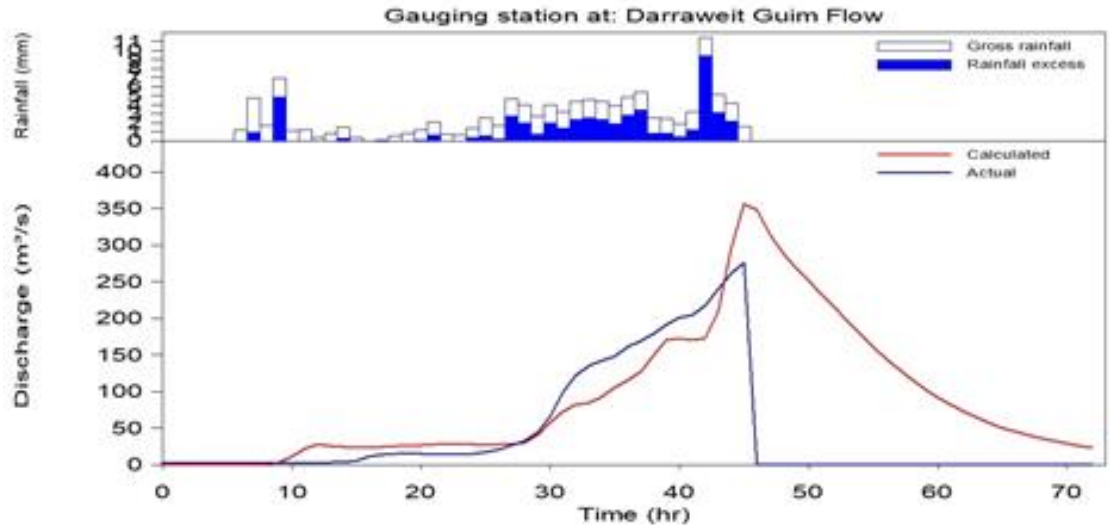


Figure 16. RORB modelled flow at Darraweit Guim (Calculated-red line) plotted against Melbourne Water's flow data for Deep Creek at Darraweit Guim on 13-14 Oct 2002 (blue line)

The 1986 MMBW RORB model was then run using Melbourne Water's same Oct 2022 rainfall and flow data up to 9 pm 13-Oct-2022 for all river level sites, but with Melbourne Water's erroneous high flow data for Deep Creek at Darraweit Guim substituted with the high flow data that would have been produced by Melbourne Water's 2003 stage-discharge rating.

The RORB parameters for modelling Melbourne Water's rainfall and flow data up to 9 pm 13-Oct-2022 with flows at Darraweit Guim calculated using Melbourne Water's 2003 rating were:

kc = 67.0, m = 0.8, Initial loss = 25.0 mm, Continuing loss = 0.0 mm/hr.

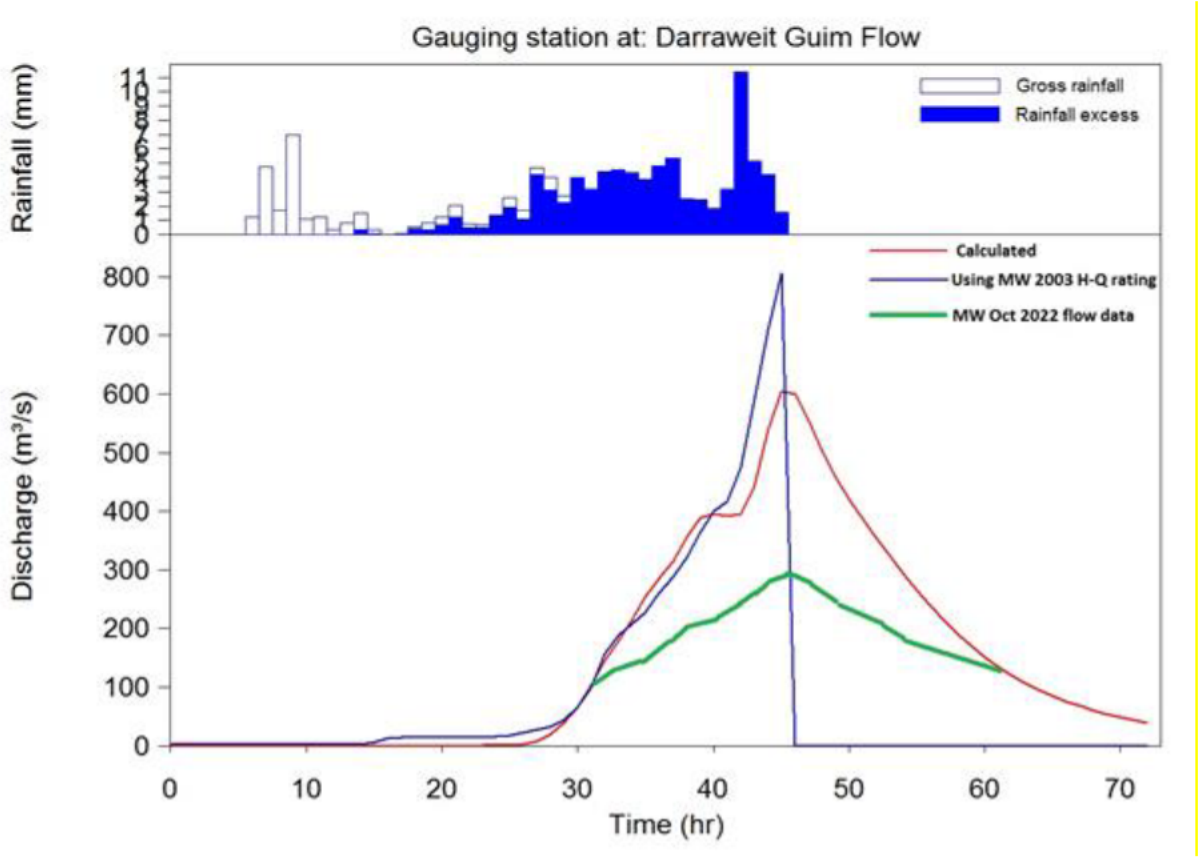


Figure 17. RORB modelled flow at Darraweit Guim (Calculated – red line) plotted against flow data for Deep Creek at Darraweit Guim using Melbourne Water's 2003 rating (blue line) with Melbourne Water's incorrect October 2022 flow data shown for comparison (green line)

The same RORB model run using Melbourne Water's rainfall and flow data up to 9 pm 13-Oct-2022, but with flows at Darraweit Guim calculated using Melbourne Water's 2003 rating, produced a flood peak and hydrograph downstream at Maribyrnong Township almost identical to what was recorded there a staggering 15 hours later.

This meant that by 9 pm Thursday 13-Oct-2022 Melbourne Water should have been able to provide a Major Flood Warning and predicted peak level with centimetres of the actual peak 5 hours and 25 minutes before they actually issued their first Major Flood Warning for Keilor and Maribyrnong Township at 2:25 am Friday 14-Oct-2022.

That is, had Melbourne Water been calculating the high flows on Deep Creek at Darraweit Guim using the same stage-discharge rating they were using back in 2003.

Figure 18 provides a visual impression of this.

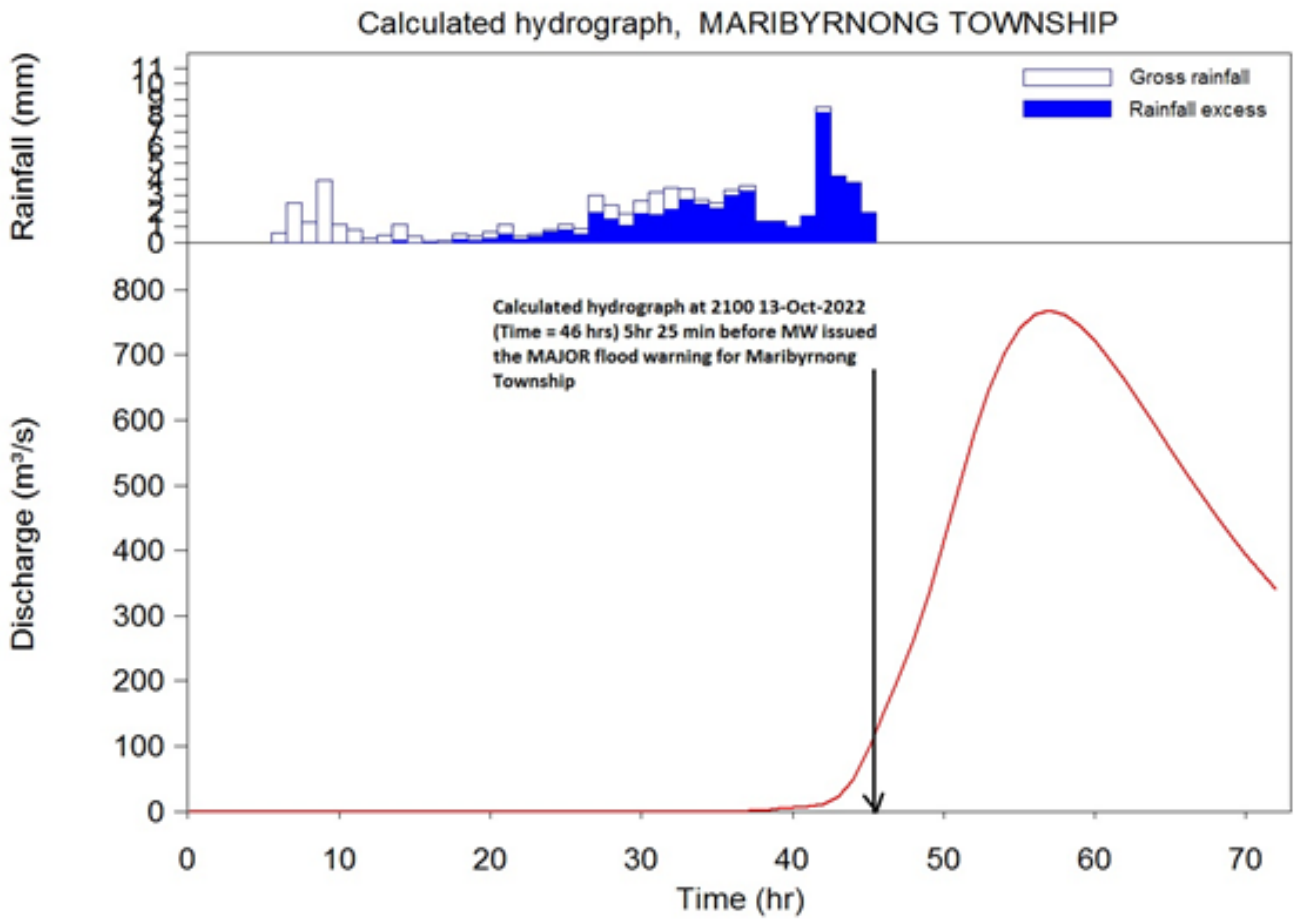


Figure 18. RORB calculated flow for the Maribyrnong River at Maribyrnong Township at 9 pm (21:00) Thursday 13-Oct-2022 almost identical in shape and actual flood peak level that was recorded

Finally, I ran the 1986 MMBW RORB model using Melbourne Water's Oct 2022 rainfall and flow data up to 6 pm 13-Oct-2022, again with the corrected flow data at Darraweit Guim using Melbourne Water's 2003 rating.

I did this to find out much additional warning of a Major Flood at Maribyrnong Township could have been given with 3 hours less rainfall and flow data.

The RORB parameters for this run remained the same as they were 3 hours later, namely kc = 67.0, m = 0.8, Initial loss = 25.0 mm, Continuing loss = 0.0 mm/hr.

By 6 pm 13-Oct-2022 the Deep Creek at Darraweit Guim was 475 m3/s (by Melbourne Water's 2003 rating) and rising fast toward the peak 3 hours later, but was only reporting 218 m3/s according to Melbourne Water's rating and flood model at the time on 13-Oct-2022.

Figure 19 shows the excellent fit the RORB model's calculated flow at Darraweit Guim was providing with the actual flow data (by Melbourne Water's 2003 rating).

Moving on to the calculated flood hydrograph on the Maribyrnong River at Maribyrnong Township it can be seen that at 6 pm 13-Oct-2022 the 1986 MMBW RORB model was predicting a flow of 514 m3/s there, which is equivalent to the Major Flood Level trigger of 2.9 metres on the Maribyrnong Township gauge.

This was almost 8 and a half hours before Melbourne Water issued the first Major Flood Warming for Keilor and Maribyrnong Township at 2:25 am Fri 14-Oct-2022.

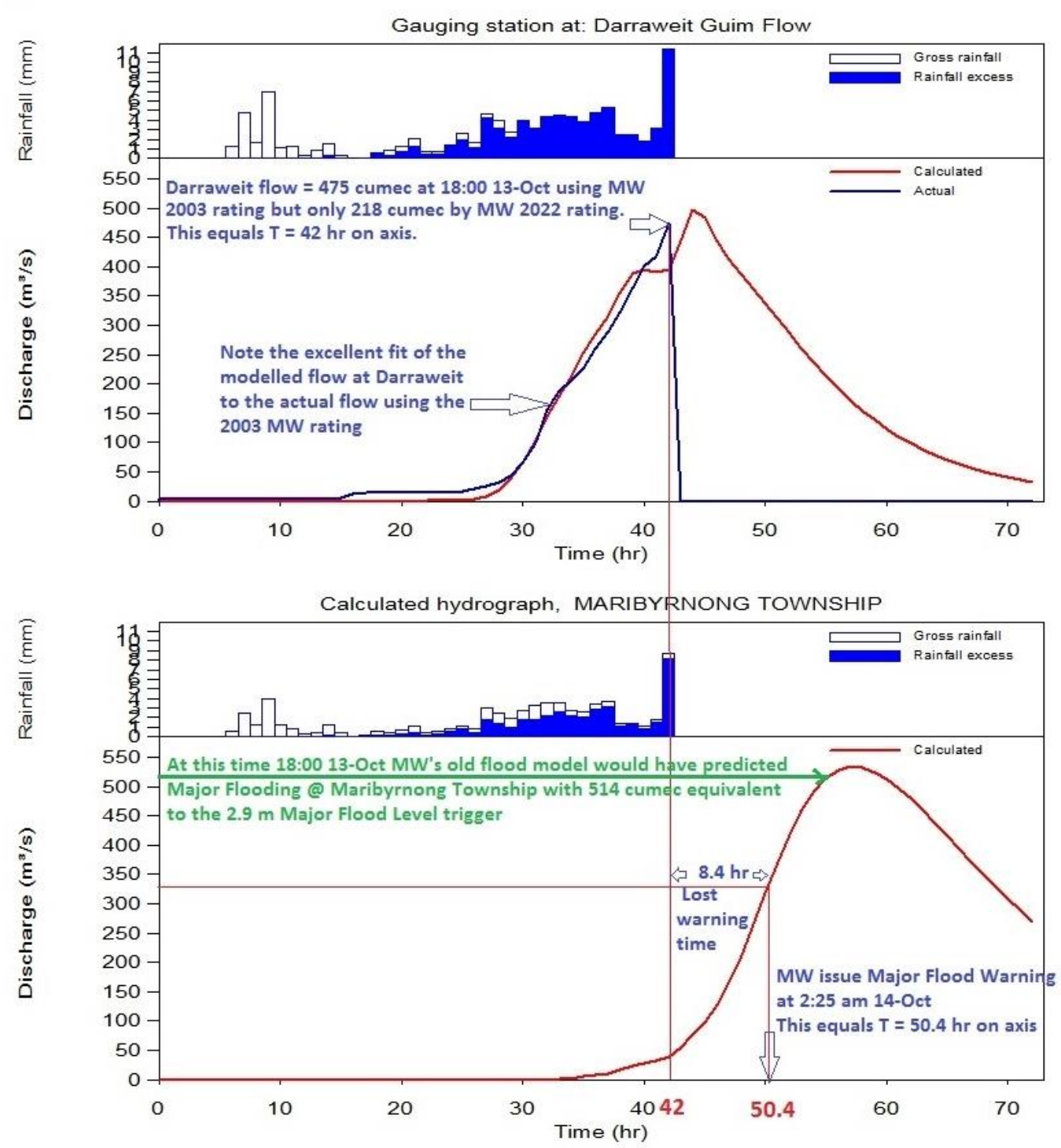


Figure 19. Deep Creek at Darraweit Guim and Maribyrnong Township using the RORB model with data to 6 pm (18:00) Thursday 13-Oct-2022

Earlier in this section I spoke of the Maribyrnong River RORB model study I undertook at Melbourne Water in April 1994 after the major flood on the Maribyrnong River in September 1993.

This was to gain a better understanding of the RORB model loss parameters in relation to the antecedent catchment conditions and critical storm duration for future real-time flood forecasting operations.

The RORB modelling I have undertaken and detailed in this submission has allowed me to compare how well the calculated continuing loss values for the October 2022 flood compared with my correlation graph produced almost 30 years ago and reproduced below as Figure 20.

From Melbourne Water's rainfall data, I have established the storm duration was around 36 hours, commencing at 6-7 am Wed 12-Oct-2022, continuing at a steady unbroken rate and tapering off around 9-10 pm Thu 13-Oct 2022.

I have plotted both the calculated continuing loss values obtained from (1) my RORB modelling using Deep Creek at Darraweit Guim flows calculated from Melbourne Water's 2003 rating of 0.0 mm/hr and (2) the continuing loss value of 2.5 mm/hr calculated from the RORB modelling using Melbourne Water's flow data for Deep Creek at Darraweit Guim, with the rating there in October 2022 most likely being as wrong now as it was back then.

As can be seen from Figure 20, my 0.0 mm/hr continuing loss for the 36 hour storm duration is consistent with the trend line of my almost 30 year old correlation graph, while Melbourne Water's continuing loss of 2.5 mm/hr plots virtually off the page and is obviously incorrect.

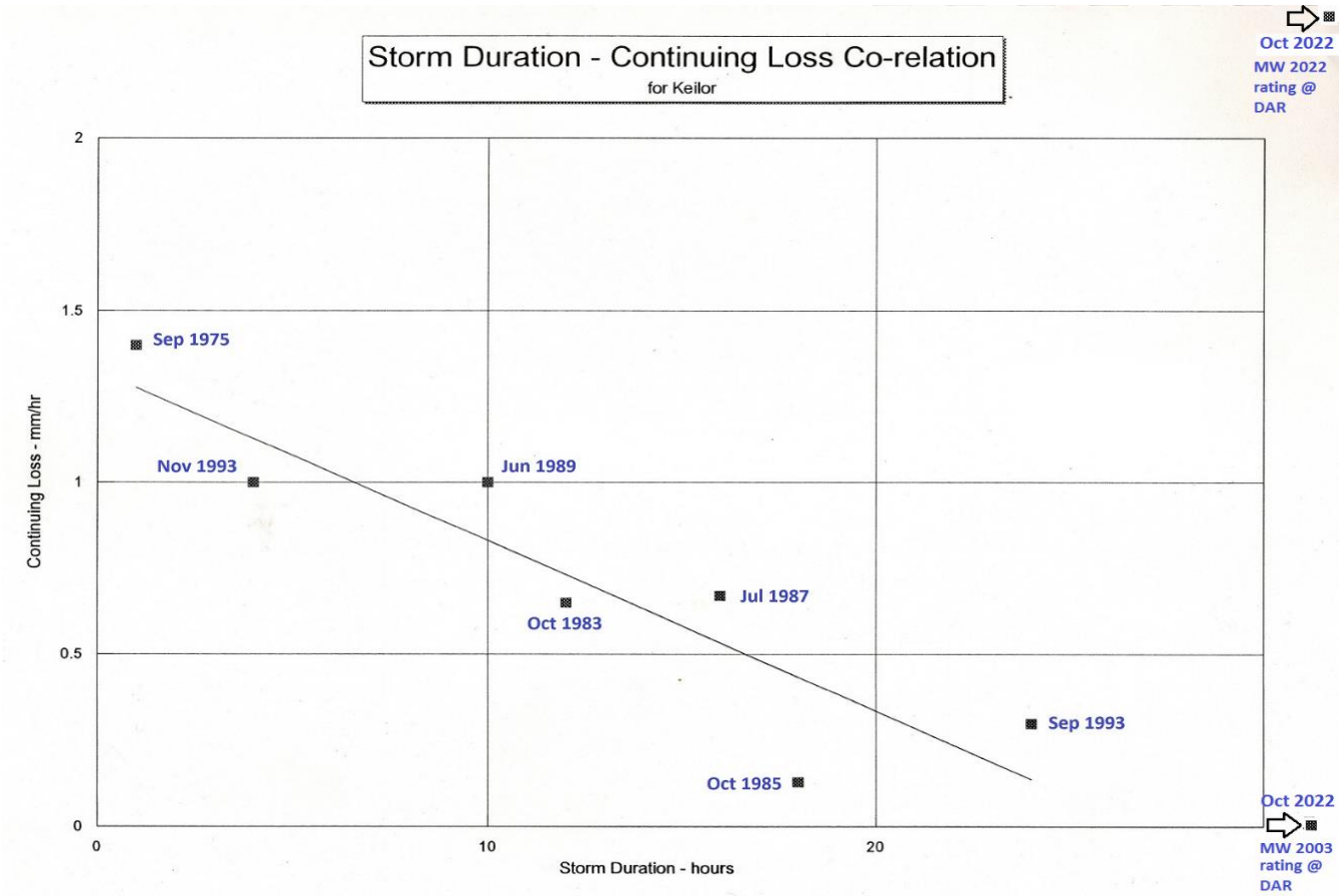


Figure 20. Storm Duration – Continuing Loss Co-relation graph for the Maribyrnong at Keilor {source: Maribyrnong River RORB Model Study, April 1994, Melbourne Water, Maribyrnong Region, Catchment and Drainage Branch}

2.3.3 Conclusion and Recommendations

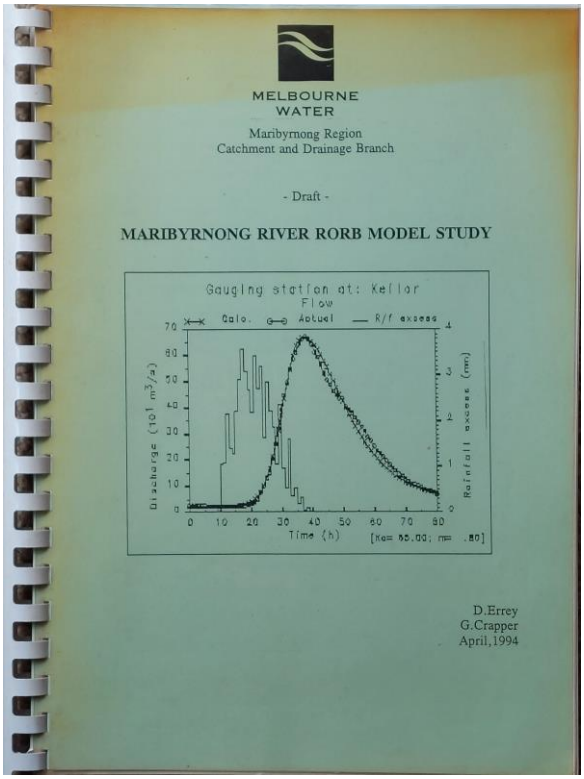
This section of my submission has shown that not only is the 1986 MMBW RORB model for the Maribyrnong River catchment still fit for purpose, it was able to:

- model the flood hydrograph shapes and peak flows very well using Melbourne Water's October 2022 rainfall data and flow data.
- prove conclusively Melbourne Water's peak flow for Deep Creek at Darraweit Guim was less than half the flow it actually was.
- show with the corrected flood flow data for Deep Creek at Darraweit Guim, using Melbourne Water's 2003 stage-discharge rating, the initial Major Flood Warning for Keilor and Maribyrnong Township could have been issued around 8 and a half hours earlier than it was.
- again, with the corrected flood flow data for Deep Creek at Darraweit Guim, showed that almost 5 and a half hour's additional warning time could have been provided for the peak flood level at Maribyrnong Township.
- disprove comments from so-called flood modelling experts that improved modelling tools and approaches since 1986, plus additional changes to the catchment since then, have somehow rendered the 1986 MMBW RORB model from being as valuable a modelling tool now as it was back in 1986.

Melbourne Water's flood modelling of the Maribyrnong Catchment on the 13th October 2022 showed they were incapable of selecting the best continuing loss value to use in the case of a long duration major rainfall event in the Maribyrnong catchment, as shown in my Figure 20.

I strongly recommend Melbourne Water finds a copy of the Maribyrnong River RORB Model Study report, I helped write 29 years ago, and adopt the continuing loss – storm duration correlation for future real-time modelling operations on the Maribyrnong River.

If Melbourne Water is unable to locate a copy of this report I would be pleased to provide them with one, refer to cover page on the right.


MELBOURNE
WATER

Maribyrnong Region
Catchment and Drainage Branch

- Draft -

MARIBYRNONG RIVER RORB MODEL STUDY

Gauging station at: Keilor
Flow

Calc. Actuel R/f excess

Discharge (10³ m³/s)

Rainfall excess (mm)

Time (h)

D.Errey
G.Crapper
April,1994

2.4 Review of Jacobs Post-Event Analysis discounting the Sep 1975 Deep Creek flood – and the consequences

After seven months of trying to work out why Melbourne Water hadn't discovered the source of their failed flood modelling, under-estimated flood level predictions and belated initial Major Flood Warning for the Maribyrnong River last October, I became aware of the Jacobs Group (Australia) P/L Maribyrnong Flood Event October 2022 – Post Event Analysis report commissioned by Melbourne Water. https://hdp-au-prod-app-mw-yoursay-files.s3.ap-southeast-2.amazonaws.com/2316/8324/2465/Maribyrnong-Flood-Event-Oct_2022_Post-event-analysis.pdf

After a brief read of Jacobs' Appendix A. Deep Creek and Maribyrnong River Flood Frequency Analysis, at A.2.1 Deep Creek at Darraweit Guim it became clear why Melbourne Water had not discovered the exceedingly large error in their calculated flood flow data at Darraweit on 13-Oct-2022.

Not only had Jacobs failed to acknowledge the existence of the huge flood on Deep Creek at Darraweit Guim on 18 September 1975, they also failed to mention anything about the major flood in May 1974 on Deep Creek at Darraweit.

While Jacobs refer to the flood on the Maribyrnong River at Keilor in May 1974 no less than 14 times in their report, a flood that was the highest for over 100 years, inexplicably they make no mention to the flow upstream on Deep Creek at Darraweit Guim in May 1974.

This is despite Jacobs saying, ***"In addition to gauged data, one historic event of 193 m^3/s in 1964 recorded in the "Blue Books"[24] was added to the annual maxima series."*** but exclude the much higher peak flows given on the same page for May 1974 and September 1975, refer Figure 21 below.

230208

MARIBYRNONG RIVER AT DARRAWEIT GUIM
MARIBYRNONG BASIN

INSTANTANEOUS MAXIMUM FLOW IN MEGALITRES PER DAY

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1963	-	-	-	-	-	-	-	-	-	2 830	137	34	-
1964	1	1	1	137	33	-	4 320	722	3 690	16 600	51	30	-
1965	14	1	1	46	19	46	1 900	3 340	1 680	34	26	61	3 340
1966	2	10	2	15	12	6	73	590	1 810	881	100	722	1 810
1967	15	-	-	3	7	13	10	223	166	22	2	0	-
1968	0	0	0	0	993	7 780	5 510	7 730	372	993	23	27	7 780
1969	3	21	24	27	66	51	509	1 000	1 650	98	10	10	1 650
1970	-	3	4 620	724	440	289	242	1 870	2 470	247	-	26	-
1971	18	76	2	34	301	276	122	905	550	1 420	6 830	157	6 830
1972	11	-	-	-	16	22	100	680	758	51	16	1	-
1973	470	1 550	86	76	100	964	1 520	2 040	2 740	1 520	164	46	2 740
1974	49	11	-	-	38 700	183	2 060	995	1 900	5 550	933	33	-
1975	5	1	3	5	17	20	186	670	46 500	8 330	2 140	44	46 500
1976	6	2	2	2	4	19	39	75	660	677	1 110	16	1 110
1977	216	35	18	2 000	32	2 040	2 250	494	486	31	5	3	2 250
1978	7	4	6	408	335	273	1 450	7 860	1 860	782	942	458	7 860
1979	38	67	9	17	31	27	43	653	5 340	7 130	58	9	7 130
1980	17	1	1	61	9	123	196	1 170	800	850	31	11	1 170
1981	3	0	0	1	32	1 270	5 400	5 090	523	203	7	4	5 400
1982	6	1	1	2	2	4	4	9	3	2	1	4	9
1983	1	0	3	14	159	115	3 740	2 440	6 880	5 580	213	522	6 880
1984	30	3	28	30	12	11	92	4 350	1 520	3 030	83	3	4 350
1985	1	0	-	6	58	35	75	4 670	2 010	4 130	1 900	2 880	-
1986	25	2	1	6	24	13	531	3 180	5 280	5 520	144	32	5 520
MAX:	470	1 550	4 620	2 000	38 700	7 780	5 510	7 860	46 500	16 600	6 830	2 880	

Instantaneous maximum flow: **46 500 ML/d** height: **5.180 m** gauge: 610 **18 September 1975**

Figure 21. Peak Flood Flows for Darraweit Guim from 1963 to 1986 [source: RWC "Blue Books" Volume 2]

The Jacobs report goes on to talk about data inconsistencies and yet includes the peak flow in 1964 of 193 m3/s for the DELWP gauge (230208) at Darraweit Guim, with a catchment area of 350 sq km, in the annual maximum flow for the Melbourne Water gauge (230100A), which has a catchment area of 500 sq km, used for their Flood Frequency Analysis for the 230100A gauge.

The use of the 193 m3/s peak flow in 1964 from the 230208 gauge, located upstream of Darraweit Guim Township, makes no allowance for the additional 150 sq km of catchment that flows into Deep Creek downstream of the township. On a proportional catchment area basis the peak flow in 1964 at the 230100A gauge should be more like 276 m3/s, i.e. a similar magnitude to the peak flow in October 2022, according to Melbourne Water.

Furthermore, the Jacobs report excluded all historical flood records for Deep Creek at Darraweit Guim (230208) from 1965 to 1974, and while they offer no reason for why they excluded the May 1974 peak flow they do attempt to give a reason for why they excluded the September 1975 peak flow of 537 m3/s, shown as 46,500 ML/day in Figure 21, saying,

"A significant high flow event with a peak of 537 m3/s was recorded only at the 230208 gauge in 1975 (almost double the peak of the October 2022 event, 280 m3/s). Confidence in this 1975 flow estimate at the 230208 gauge is low due to the following:

- ***Stage data for the same gauge (230208) does not indicate a high flow event of this magnitude occurred on this date (peak stage: 5.18 m). It is possible that the rating curve for the gauge is of low quality for theses stages."***

My Response

Jacobs assessment that the 5.18 metre peak level stage data for gauge 230208 on 18-Sep-1975 was not indicative of a major flood is a nonsense and completely baseless, see Figure 22 below. I challenge Jacobs to explain on what basis they decided the level hydrograph could not be a flood.

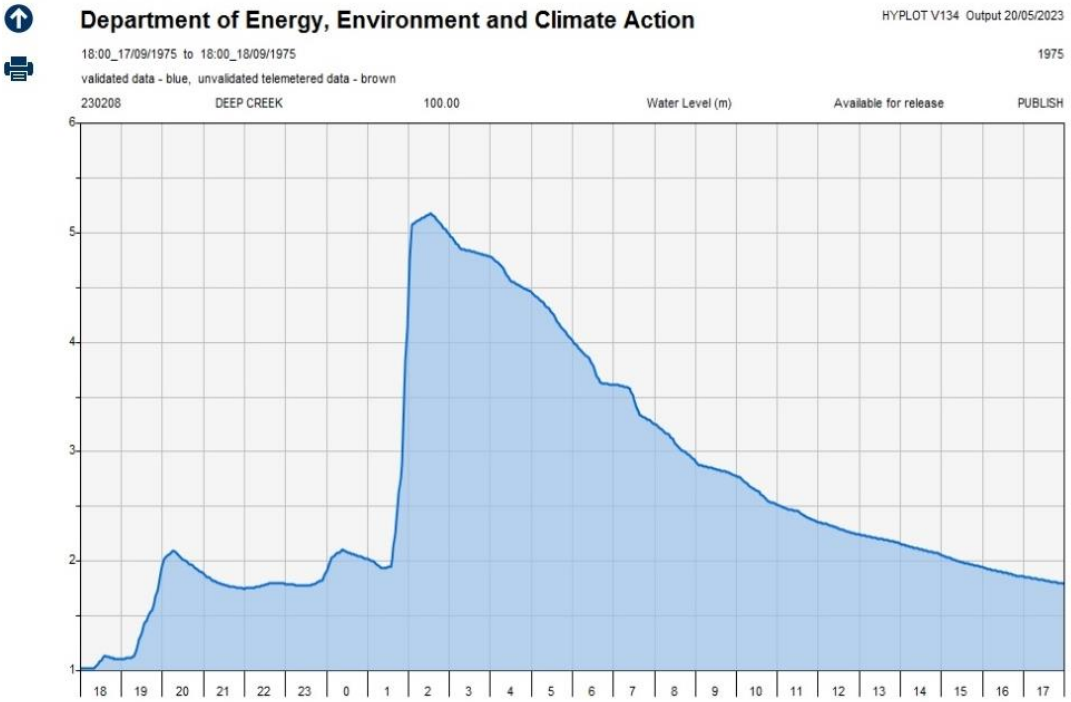


Figure 22. Deep Creek at Darraweit Guim [230208) gauge flood level hydrograph 17-18 September 1975

- ***"There is no evidence of a high flow event of a similar magnitude from a review of gauged records upstream and downstream along Deep Creek or the Maribyrnong River."***

My Response

There is a wealth of rainfall, level and flow gauge records, and other forms of information, for the 17-18th September 1975 flood event adjacent to the Deep Creek catchment.

Firstly, in the catchment immediately north of Deep Creek at Lancefield, namely 405236 Mollison Creek at Pyalong, on the 17-Sep-1975 the same super-cell that hit the top end of Deep Creek also impacted on Mollison Creek at Pyalong.

The extraordinary nature of the short-term rainfall and flash flooding in the region at that time is consistent with Mollison Creek rising by a staggering 20,000 ML/day (231 m3/s) in just 3 hours, which remains the highest flood on record at this location.

405238 MOLLISON CREEK @ PYALONG

bookmark this page

All data times are Eastern Standard Time

Real time data | Details | Reports | Data

Details

Site no.	405238
Zone	55
Easting/Northing	309638.000/5889623.000
Latitude	37°07'13.0"S
Longitude	144°51'26.2"E
Site commence	10/05/1966
Site ceased	
Zero gauge	247.867
Datum	AHD
Control	CONCRETE WEIR
Cease to flow level	1.000
Maximum gauged level	2.100
Maximum gauge date	16/09/1975
Catchment area	163 sq. km
Gaugings	294 gaugings have been performed between 15/06/1966 and 06/10/2022

Period of record

Variable		Start date	End date	Days	Data type	Max value	Max date	Min value	Min dat
10.00	Rainfall (mm) (Available for release)	17/11/1988	03/05/2023	12585	Daily total	83.8	30/01/2021	0.0	19/11/1
100.00	Water Level (m) (Available for release)	08/12/1972	03/05/2023	18408	Instantaneous value	3.605	17/09/1975	0.275	07/01/1
141.00	Discharge (Ml/d) (Available for release)	08/12/1972	03/05/2023	18408	Instantaneous value	20024.4	17/09/1975	0.0	08/12/1
820.00	EC@25C (µS/cm) (Available for release)	17/11/1988	11/08/1994	2093	Instantaneous value	1258.800	06/05/1992	42.900	18/07/1

Figure 23. Mollison Creek at Pyalong [405238) site details showing 17-Sep-1975 was the maximum flood on record {source: DELWP}

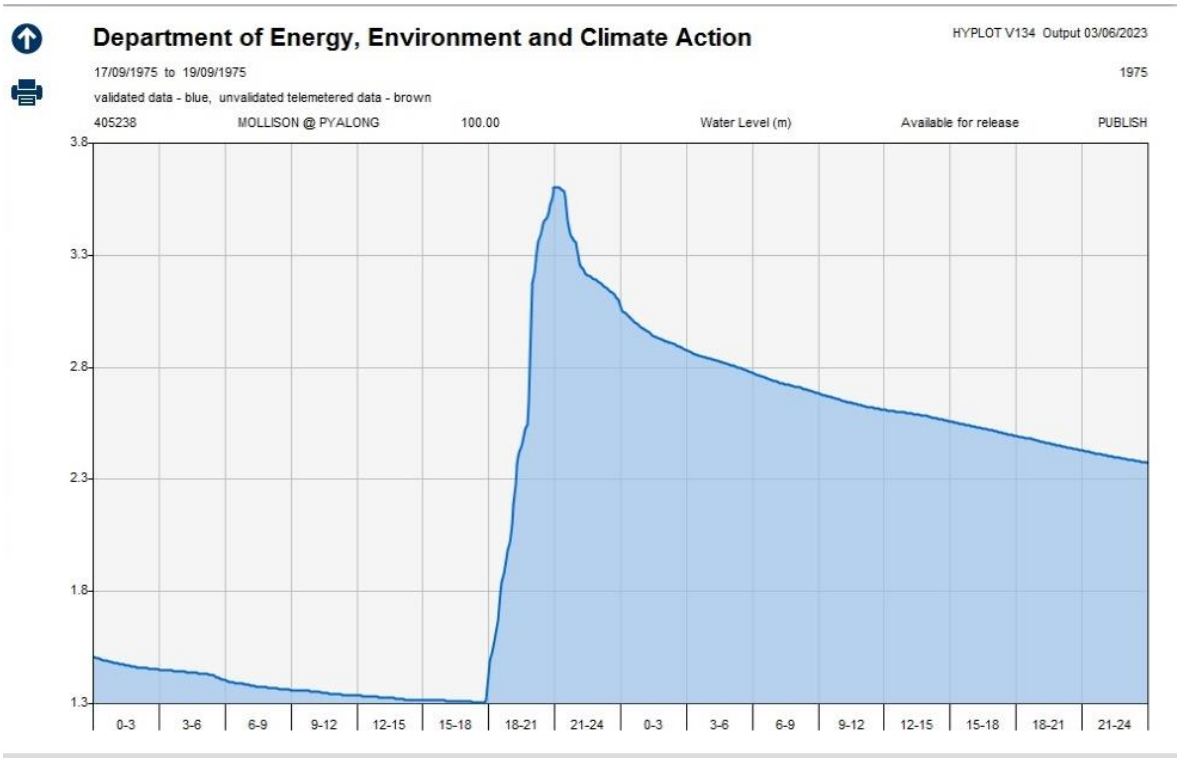


Figure 24. Mollison Creek at Pyalong [405238) flood level hydrograph 17-18 September 1975

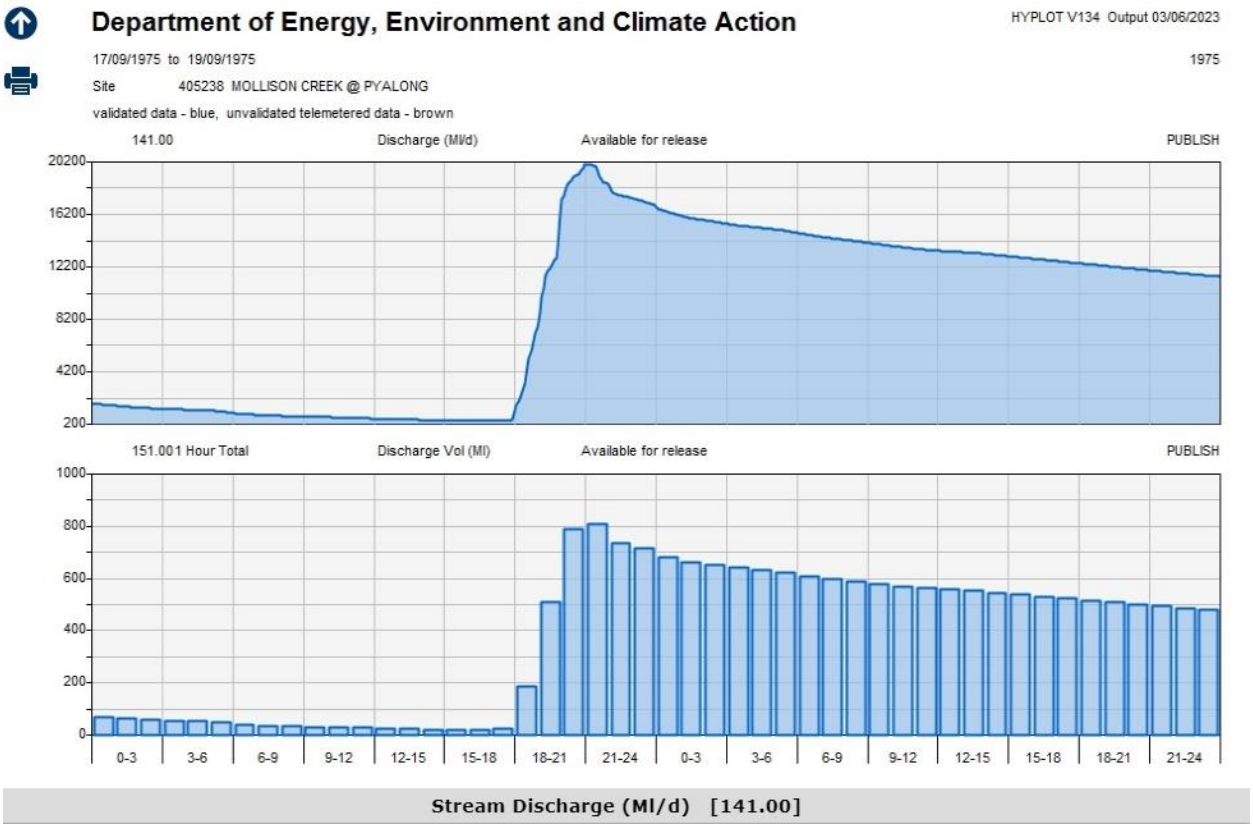


Figure 25. Mollison Creek at Pyalong [405238) flood flow hydrograph 17-18 September 1975

Secondly, the catchment immediately south of the Deep Creek, namely Emu Creek at Clarkefield, was only on the edge of the heavy rain but still recorded a dramatic rise in the level on 17-Sep-1975 with the peak flow there only marginally less than the May 1974 flood.

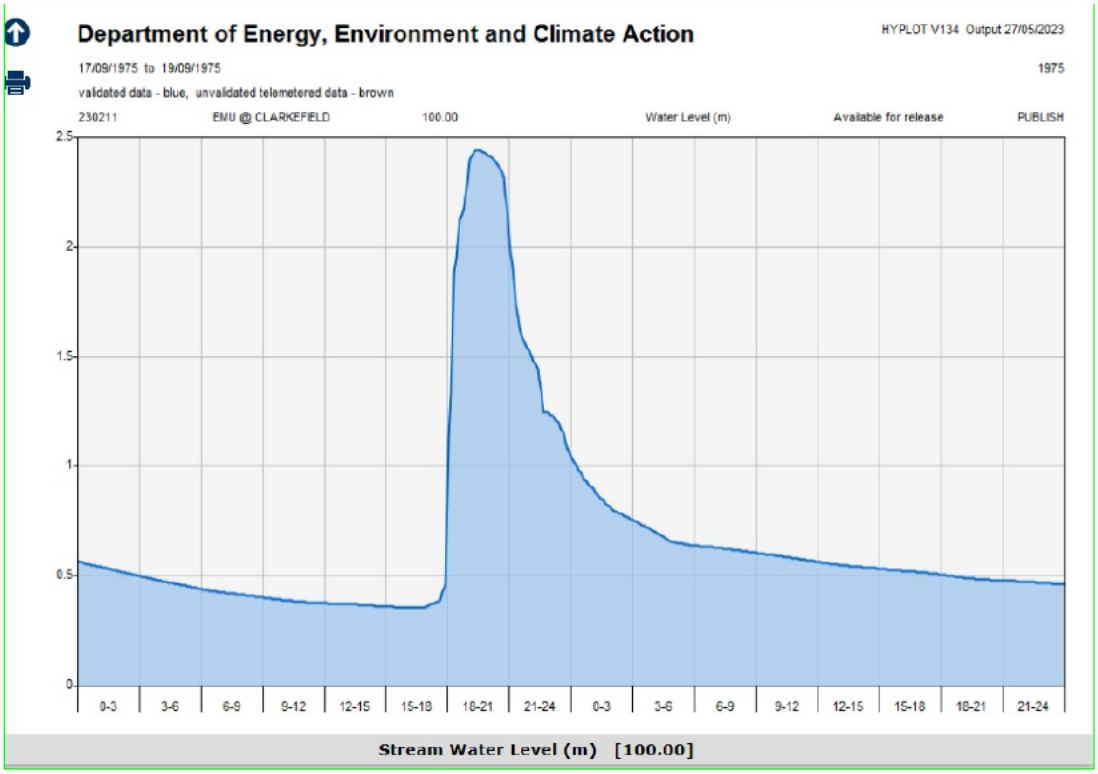


Figure 26. Emu Creek at Clarkefield [230211) flood level hydrograph 17-18 September 1975

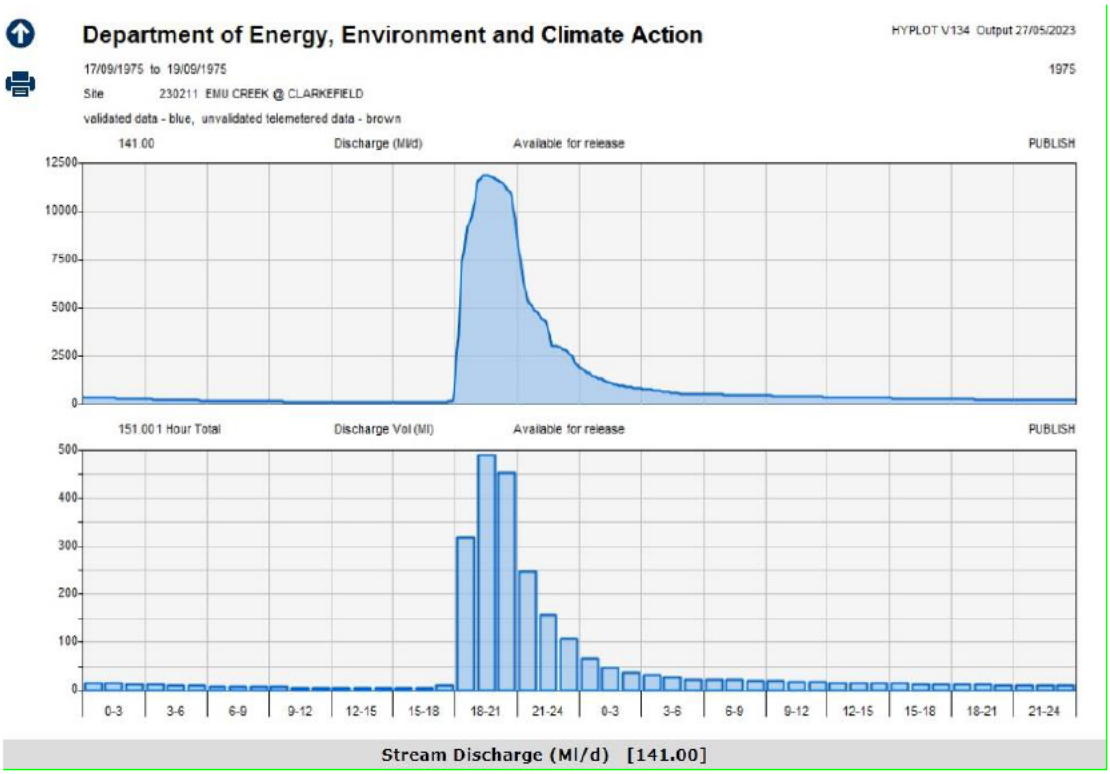


Figure 27. Emu Creek at Clarkefield [230211) flood flow hydrograph 17-18 September 1975

The MMBW Report on the Operation of the Flood Warning System During the Minor Floods at Maribyrnong in September and October 1975 details reported,

"It was about 4.00 p.m. that afternoon (17-Sep-1975) when the flood producing rain commenced on the catchment. At the time all that could be guessed from previous experience was that a frontal storm of this type can give 30 to 60 mm of rain average over the whole catchment."

The MMBW Flood Warning System had only been operating about a week at this stage and no real-time telemetry rain gauge or river level gauged were install on Deep Creek upstream from Darraweit Guim, where the heaviest of rain was centred in the upper reaches of Deep Creek between Hanging Rock at Newham and Lancefield.

The cover of the MMBW report on the September and October 1975 floods is shown below (left) and a isohyetal rainfall map for the 17-18th September 1975 storm (right) are shown below in Figure 28.

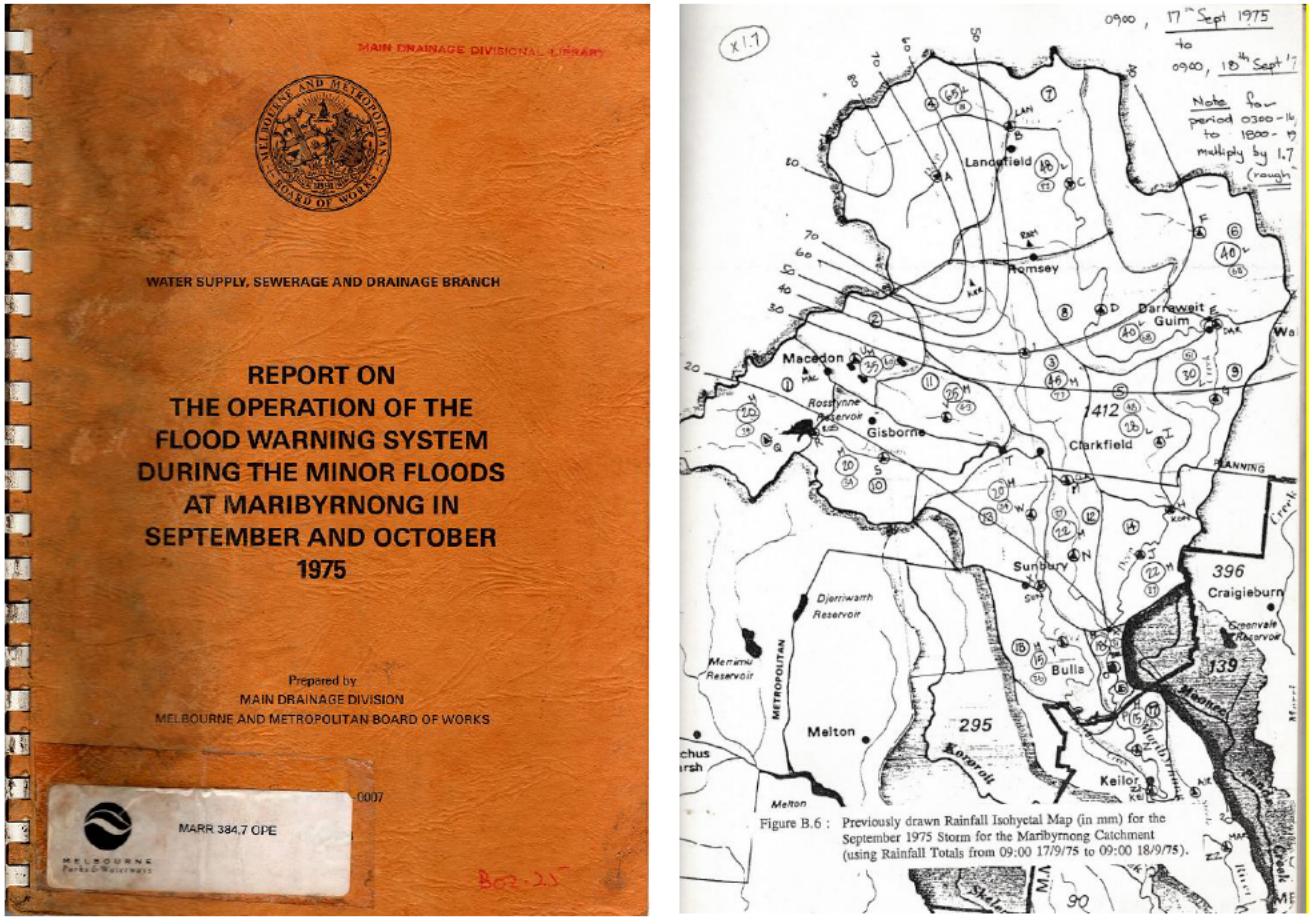


Figure 28. MMBW Report on the Operation of the Flood Warning System During the Minor Floods at Maribyrnong in September and October 1975 (left) and Isohyetal Rainfall map for the 17-18th September 1975 storm (right)

The report for the September flood went on to say,

"That afternoon all available alarms on the recently installed system of rainfall and river level gauges within the Maribyrnong River catchment were set on. The first information of problems within the catchment of the Maribyrnong River came in the news broadcast at about 9.00 p.m. on Wednesday 17th September.....The news related to local flooding at Lancefield. On receipt of this information the rainfall figures were checked by telephoning a rainfall observer at Lancefield. The rainfall reached nearly 38 mm after 9.00 p.m. but the bulk of it would have fallen that evening, i.e. 17th September."

It was subsequently found that most of that 38 mm of rain at Lancefield had fallen in just one hour.

"From that information it was clear that all staff involved in flood warning operations for the Maribyrnong River has to be alerted. …. At 4.30 a.m. on the morning of the 18th September, 1975, the first group arrived at the Head Office and examined data from the computer." "The first group had left to observe and follow the peak of the flood about 5.00 a.m. At about 6.30 a.m. an operations centre was set up on the 16th floor in the area where the computer is located. By this time the peak had passed Darraweit Guim."

I was one of the flood level observer teams following the peak on Deep Creek all the way from Darraweit Guim, see Photo 4, to Wildwood and Bulla, then cutting across to Jackson Creek at Holden Bridge, then onto the Maribyrnong River at Keilor. We eventually arrived at the Maribyrnong Township gauge around 4:30 pm Wednesday 18-Sep-1975 as the Maribyrnong was just breaking the bank and flooding the first low spot in Chifley Drive, with the flood going on to peak soon after around the Minor Flood Level.

Photo 4. Water-damaged photo of myself checking the 6 to 7 metre gauge at the Deep Creek at Darraweit Guim 230100A gauge around 7:30 pm 18-Sep-1975, about 4 hours after the flood wave from Lancefield had swept through.

- ***"There are no records of reported flooding in media reports for 1975."***

My Response

Had Jacobs undertaken a more rigorous approach to checking on the voracity of the September 1975 flood at Darraweit all they needed to have done was contact the publishers of the local Darraweit Community newsletter or the Lancefield and District Historical Society.

There they would have found that the September 1975 flood on Deep Creek from Darraweit Guim to Lancefield was arguably the biggest flood on Deep Creek since white settlement in the 1840s.

I was able to recently interview two elderly Lancefield residents who witnessed first-hand the exceptional flood on Deep Creek at Lancefield in the late afternoon of Tuesday 17-Sep-1975.

They both described the approaching sound of the flood wave on Deep Creek like that of a jet engine. The Deep Creek just a few kilometres upstream from them at Linehan's bridge overtopped the deck by about a metre and washed out the abutments on both side of the bridge.

The bridge was so badly damaged it was beyond repair and remains derelict to this day.

Here is a brief excerpt of my interview on video from 22-May-2023.
https://www.youtube.com/watch?v=3TNb6QRQLiU

Photo 5. Lancefield locals having a laugh at Melbourne Water's consultant Jacobs' assessment that the September 1975 flood on Deep Creek never happened.

- ***"For these reasons, the 1975 537 m3/s event was discounted from the FFA."***

My Response

Jacobs fail to say that the peak stage in September 1975 (of 5.18 metres on the 230208 gauge on Deep Creek at Darraweit Guim) would have to have been considerably higher than the maximum streamflow measured by SR&WSC hydrographers the previous year on 15-May-1974 of 9,540 ML/day (110 m3/s) at a gauge level of 3.63 metres. {source: RWC "Blue Books, Volume 2, page 229.

This gauged flow of 110 m3/sec was higher than 34 years of the annual maximum flow data listed in Table 9 of the Jacobs report which excluded the May 1974 and Sep 1975 peak flow data at Darraweit Guim.

- ***"There is no data available for the 230100A gauge for this date."***

My Response

Earlier in Appendix A.2.1 Jacobs say ***"A review of the data found inconsistencies in the gauged levels and flows recorded at the two locations",*** namely the Melbourne Water gauge (230100A) and the DEWLP (formerly RWC and before that SR&WSC) gauge (230108).

Somehow Jacobs declare it to be an inconsistency for the DELWP 230108 gauge at Darraweit Guim to show a peak flow of 537 m3/s in 1975, even though Melbourne Water's 230100A gauge had no data available in 1975 to compare it against.

One example of data inconsistency I found online says, ***"Data inconsistencies arise when the data that should be in one database ends up in multiple files, each with a different version of the same information."***

Missing level data at one site compared to otherwise good quality level data at a nearby site cannot be considered to be an inconsistency. In essence there is no way to discount the September 1975 peak level and flow data at the 230208 gauge on the basis of no data to compare it with at the 230100A gauge.

Conclusion and Recommendations

- How can Jacobs call the DEWLP's very high flow value in 1975 a data inconsistency when MW had no data available whatsoever for Darraweit Guim in 1975.
- Jacobs decided the DELWP's peak flow of 537 m3/s in 1975 must be wrong because Melbourne Water didn't have any flow data available in 1975.
- Jacobs failure to increase the peak flow in 1964 for the 230208 gauge to allow for the additional inflow from the 150 sq km catchment flowing downstream of 230108 gauge to the 230100A gauge, plus their exclusion of the major flood flows in May 1974 and September 1975 has grossly over-stated the flood frequency estimate for the October 2022 flood which is not anywhere near a 100 year (1% AEP) flood.
- The errors, data omissions and incorrect assumptions made in the Jacobs report for Melbourne Water, principally concerning the existence and magnitude of the 17-18th September 1975 flood on Deep Creek at Darraweit Guim, need to be brought to Melbourne Water's attention as a matter of urgency.
- Jacobs' blind faith in the accuracy of Melbourne Water's flood flow data at the Darraweit (230100A) gauge, coupled with their critical omission of the May 1974 flood data and discounting of the September 1975 flood has seriously compromised the accuracy, credibility and usefulness of their report.
- Jacobs has not been able to identify the source of Melbourne Water's failed flood modelling of the Deep Creek and Maribyrnong River on 13-14th October 2022.
- The Maribyrnong River Flood Review, being undertaken by an independent panel, will be severely compromised until such time as Melbourne Water's consultants Jacobs Group (Australia) are made aware of the extent and seriousness of the errors and omissions in their Maribyrnong Flood Event October 2022 – Post Event Analysis report, detailed in my submission.

2.5 Critical Review of Deep Creek at Bulla October 2022 flow data

It is incredulous that the peak level on Deep Creek at Bulla in October 2022 [8.205 m] was almost 2 metres higher than the peak level at Bulla in May 1974 [6.22 m] and yet both Melbourne Water and DELWP have the peak flow for Deep Creek at Bulla in Oct 2022 around 3,200 ML/day less flow than in May 1974.

There appears to be no basis for this wildly anomalous disparity in peak flows given the maximum measured flow in Deep Creek at Bulla was around 24,000 ML/day on 30-Jul-1987.

DELWP Rating Table 44.00 gives a flow of 30,500 ML/day for the equivalent level of the 6.22 m peak level in May 1974, 21,900 ML/day or 42% less flow carrying capacity of Deep Creek at Bulla in October 2022 compared to what it was in May 1974.

This is clearly a preposterous suggestion as anyone with a modest amount of hydrographic or hydraulic experience would concur.

Melbourne Water's consultant Jacobs makes virtually no mention of the 0ct-2022 flood event on the Deep Creek at Bulla in their Maribyrnong Flood Event October 2022 – Post Event Analysis report and makes no attempt to work out where the huge volume of water that hit Bulla, on its way to Keilor, originated from.

A simple check of flow volumes across the 3 days of the flood from 13-Oct-2022 to 16-Oct-2022 for Deep Creek at Darraweit Guim (DAR), Emu Creek at Clarkefield (CLA) and Deep Creek at Bulla (BUL) reveals the volume at Bulla, from BUL = CLA + DAR, shows 8,504 ML more than the combined volumes at Darraweit and Clarkefield.

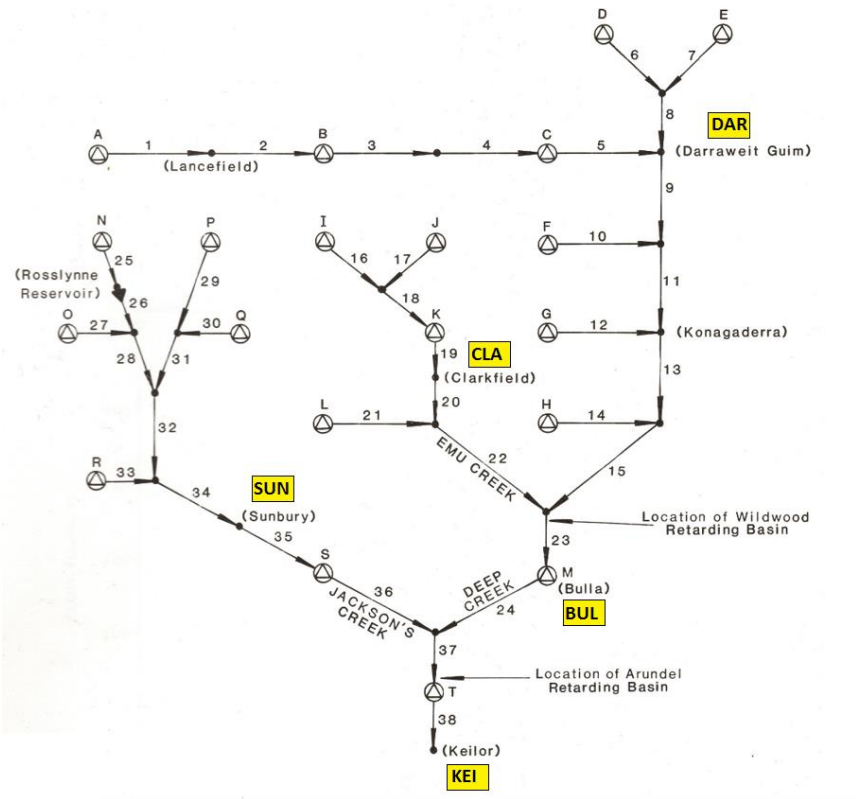


Figure 29. Map showing the five key flow sites for the volume checking process

So, assuming the volume at CLA is correct this means the flood volume should have been 8,504 ML more at Darraweit Guim, i.e. 35,665 ML instead of 28,155 ML.

A check of the flood volumes for Deep Creek at Bulla (BUL), Jacksons Creek at Sunbury (SUN) and Maribyrnong River at Keilor (KEI) from KEI – BL + SUN reveals that Bulla itself is missing 5,753 ML, consistent with my view the stage-discharge rating for Deep Creek at Bulla is significantly under-estimating the peak flow.

Adding the missing 5,753 ML at Bulla indicates the volume there should have been more like 49,922 ML instead of 44,169 ML.

Substituting this back into BUL = DAR + CLA then DAR = BUL – CLA shows the flow volume at Darraweit is actually 14,257 ML short of what it should be, again consistent with my detailed assessment of how under-estimated the peak flow at Darraweit Guim was in Section 2.2.4.

2.8 Conclusion and Recommendations

- As a matter of urgency Melbourne Water reinstates the stage-discharge rating for 230100A Deep Creek at Darraweit Guim to what it was pre-2004 and update it at a later time once they have completed a rigorous analysis of their flood modelling in October 2022 and in recognition that a major flood of the same order of magnitude as the 13-Oct-2022 flood did actually occur at Darraweit Guim on 18- Sep-1975.
- MW revise rating and flood flow calculations for 13-14 Oct-2022 for Deep Creek at Bulla in conjunction with Section 2.5 of my submission.
- MW carry out an independent review of the estimated peak flow for the Maribyrnong at Keilor extrapolated from the flood flow gaugings carried out by their hydrographic contractors on 14-Oct-2022.
- MW backdate the flood flow rating for the Maribyrnong River at Keilor and recalculate all flood data likely to have been affected by the construction of the concrete crump weir on the Maribyrnong in 1979. The Sep 1993 is in most need of this retrospective flood flow update with the flow likely to reduce from 690 m3/s to closer to 500 m3/s.
- I fully support the decision, announced on 5-Jun-2023 in the light of MW's flood warning performance in October last year, to transfer responsibility for riverine flood forecasts and warnings in Greater Melbourne to the BoM. It had become increasingly obvious that Melbourne Water's ability to carry out this important function had been compromised in recent years by the direction Melbourne Water was heading.

TOR 5: Location, funding, maintenance and effectiveness of engineered structures, such as floodwalls, rural levees and culverts, as a flood mitigation strategy

5.0 Arundel Flood Retarding Basin

I was a project team member of the 1976 MMBW Flood Mitigation in the Maribyrnong River Basin study and worked in the same group in Drainage Division that carried out the Maribyrnong River Flood Mitigation Study in 1985-86.

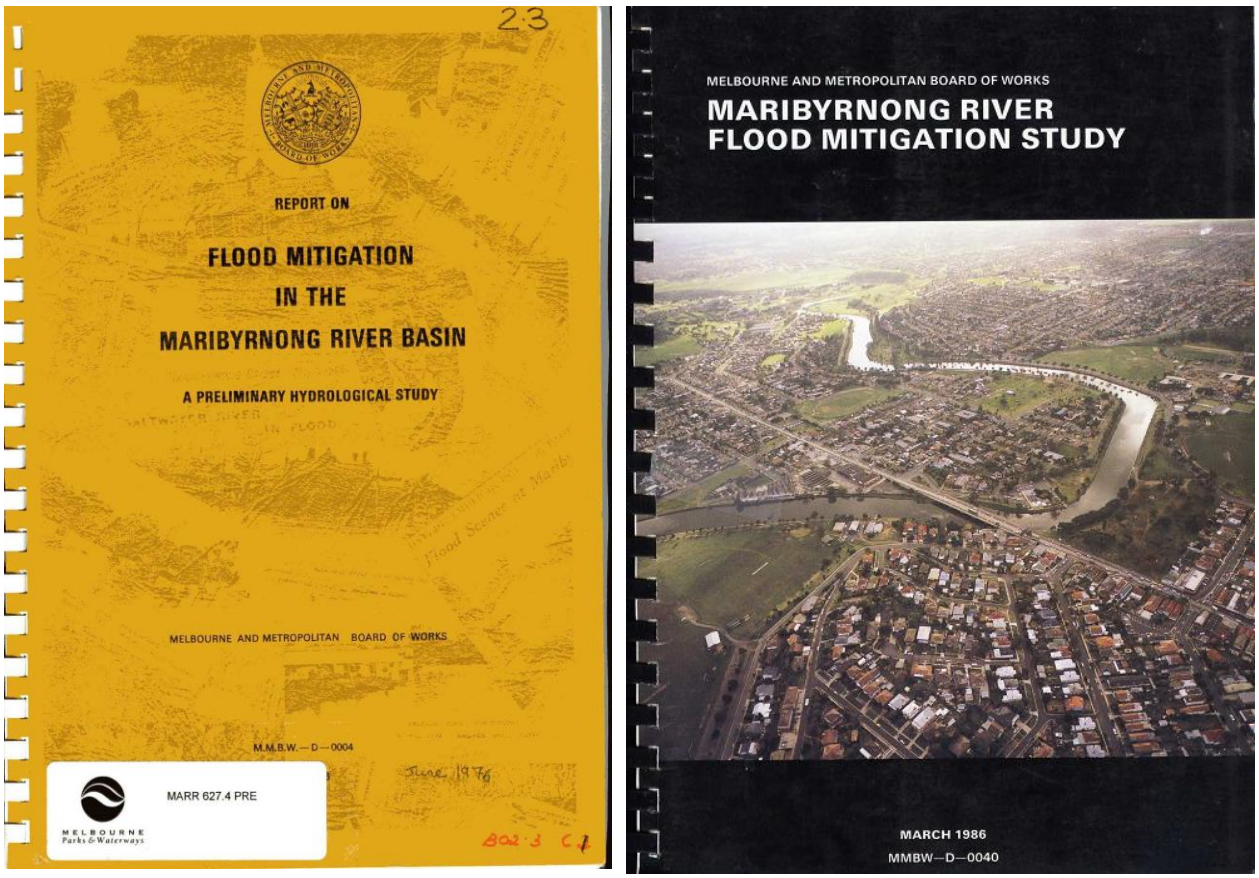


Figure 30 Cover pages of the 1976 MMBW Flood Mitigation in the Maribyrnong River Basin study report and 1986 Maribyrnong River Flood Mitigation Study report.

Consequently, I am well versed in the hydrological behaviour of the Arundel flood retarding basin and the unquestionable flood mitigation benefits Arundel would bring to the flood-prone communities adjacent to the Maribyrnong River downstream from Keilor.

In 1986 Arundel was the MMBW's preferred means of providing flood protection up to the 100 year average recurrence interval (ARI) flood, now commonly termed the 1% annual exceedance probability (AEP) flood, and in 2023 its benefits are even more compelling.

This is because development on the Maribyrnong River floodplain has continued to increase in the last 20 years, with a number of totally inappropriate planning permit approvals being granted in Maribyrnong Township.

As detailed in Section 1.0 of my submission, the approval process for the construction of a retirement village, located substantially on the floodplain of the Maribyrnong River upstream of Canning Street in Avondale Heights, is arguably the worst planning decision in the last 20 years.

The plight of the 70 elderly residents who have bought villas there since 2016 in good faith, only to be flooded last October by a 1 in 50 year ARI flood, is quite lamentable.

Melbourne Water has an obligation to provide these residents with an assurance they will never again be flooded by a similar, or slightly higher, magnitude flood.

The only viable solution to achieving this, and affording the retirement village residents with the same amenity that drew them to live there is the construction of the Arundel flood retarding basin on the Maribyrnong upstream from Keilor.

The Arundel basin is the answer for everyone who was flooded or adversely affected by the Maribyrnong River on 14-Oct-2022.

It would also enable the VRC to remove their floodwall along the Maribyrnong River at Flemington Racecourse and eliminate any perceptions real or otherwise that the floodwall exacerbated flooding during the 14-Oct-2022 flood.

I will mention more on the Flemington floodwall in Section 7 of my submission.

Returning now to the 1986 MMBW Maribyrnong River Flood Mitigation Study, one of the most comprehensive and outstanding engineering studies to come out the MMBW since the Thomson Dam Augmentation Project.

The report's number one flood mitigation recommendation for the Maribyrnong River was,

"The most cost effective means of providing protection (to the entire study area) is the construction of a retarding basin at Arundel.

- ***It is recommended that if the study area is to be protected from the one percent probability flow a retarding basin be constructed at Arundel at an estimated cost of $16.2 million."***

At this point I would like to address any concerns anyone may have that since 1986 improved modelling tools and approaches, along with changes in urbanisation, would necessitate a new study to essentially start from scratch, in addition to the so-called likely impacts of climate change.

My RORB modelling of the October 2022 flood on the Maribyrnong River, detailed in Section 2.3 of my submission, has shown the 1986 MMBW RORB model is just as good now as it was back then to effectively model major rainfall events likely to produce major flooding in the catchment.

As for climate change, all it will do is cause major flood events to occur more frequently with apparent increased severity and should not be an impediment for building the Arundel flood retarding basin, it simply means the basin might get to hold floodwater once or twice every 10 years instead of once or twice every 20 years and even more reason to build it.

5.1 Flood Retarding Basin upstream of Darraweit Guim

Back in 1976 MMBW investigated potential flood retarding basins, including two on Deep Creek upstream of Darraweit Guim in the vicinity of The Gorge, and one on Boyd Creek upstream of Willow Flat.

These basin storage sites did not afford viable flood mitigation benefits for the Maribyrnong River, but could however provide some flood mitigation benefits for Darraweit Guim, and provide some partial flood mitigation benefits in the Maribyrnong, such as reducing the size of the Arundel flood retarding basin.

Photo 6 Flood house at Darraweit Guim around 6:30 pm 13-Oct-2022

5.3 Conclusion and Recommendations

- A flood retarding basin on the Maribyrnong River upstream of Keilor at Arundel has long been the preferred flood mitigation option for flood-prone properties along the Lower Maribyrnong River. It is my recommendation that due consideration be given to fast-tracking the construction of the Arundel flood retarding basin.

- Consideration be given to carrying out a feasibility study for the construction of flood retarding basins upstream of Deep Creek and Boyd Creek.

TOR 7: The 2007 decision of the Minister for Planning to approve the construction of a flood wall around Flemington Racecourse and whether the growing impacts of climate change were considered;

There is much I would like to say about the VRC Flemington floodwall after being involved in the initial critical review of the consultant's hydraulic modelling of the Maribyrnong River in July 2003, when I was still working at Melbourne Water. However time constraints have prohibited me from doing so.

So instead I would like to endorse the concluding comments of Moonee Valley City Council's submission to Melbourne Water's Maribyrnong Flood Review, namely:

"3. Council's position on the Flemington Racecourse flood wall

Council's opposition to the Flemington Racecourse Flood Protection Wall remains as adopted at Ordinary Council meeting on 15 February 2005.
The resolution reads:

"Council Resolution: Moved, seconded that Council:

• Reiterates its opposition to the construction of a floodwall along the Maribyrnong River at the Flemington Racecourse based on expert commentary which raised doubts as to the accuracy of the modelling and methodology used in the analysis of the impacts of the floodwall on upstream areas.
• Write to the Minister for Planning and request a review of the decision to allow the Flemington Racecourse flood works, with particular emphasis being placed on undertaking a new analysis of the upstream effects of the proposed floodwall."

In reviewing Melbourne Water's reports provided to Moonee Valley, Council's consultant's findings remained unchanged due to errors and concerns with Melbourne Water's modelling. The 2005 report identified:
• A number of potentially quite serious issues in relation to the modelling work that has been carried out.
• The effects of the floodwall could be greater than predicted by GHD, and the effects of the proposed mitigation works may be somewhat less than predicted.
This advice was provided directly to Melbourne Water. Council then provided the expert commentary to the Minister for Planning who referred it to Melbourne Water.
Melbourne Water confirmed that its modelling was sound and issues raised by Moonee Valley City Council and other objectors did not support the need for additional modelling to be conducted."

Appendix A - Brief Summary of involvement with Maribyrnong

1. Co-author of the MMBW Flood of May 1974 Maribyrnong River Basin report MMBW-D-0001.

2. Developed first rainfall-peak flow catchment model for the Maribyrnong River in early 1975 that was included in subsequent flood warning manuals and computer flood forecasting tools.

3. Configured the stage-discharge rating tables for the automatic river level telemetry gauges in the Deep Creek and Maribyrnong catchment, prior to the commissioning of the MMBW flood warning system in early September 1975.

4. Involved in field reconnaissance and communications work on 18-Sep-1975 following the progression of the tsunami-like flood wave on Deep Creek from Darraweit Guim all the way downstream to Konagaderra, Wildwood, Bulla, Keilor and Maribyrnong Township as part of the first real-time flood operations of the MMBW flood warning system.

5. Co-author of the MMBW 1976 Flood Mitigation in the Maribyrnong River Basin study report MMBW-D-0004, June 1976.

6. Responsible for site selection of various real-time telemetry rain gauges and river level gauging stations in the Maribyrnong Catchment, including Deep Creek at (Upper) Lancefield (1976), Deep Creek at Konagaderra (1979), Lancefield North rain gauge (1999), Deep Creek at (Doggett's Bridge) Lancefield (1999), Mt Macedon rain gauge (1999) and Romsey (East) rain gauge (1999).

7. Responsible for the site survey and establishment of stage-discharge rating for Deep Creek at (Upper) Lancefield, (Doggett's Bridge) Lancefield and Deep Creek at Konagaderra.

8. Design of major concrete weir on Maribyrnong River at (Brimbank Park) Keilor in 1978 and development of stage-discharge rating.

9. Designed and supervised construction of concrete weir control on Jacksons Creek at Sunbury.

10. Conceived, designed and supervised Candy Pole historical flood marker on Maribyrnong River at Maribyrnong Township in 1988.

11. Conceived and helped develop real-time use of the RORB catchment model for flood forecasting in 1989.

12. Sep 1989 to Dec 2003 - Senior Engineer, Hydrology and Flood Warning in charge of hydrologic data quality integrity, including flow data stage-discharge ratings, production and update of Flood Warning Manual for Maribyrnong River (& Melbourne's other major rivers and waterways), co-ordination of Melbourne Water's 24/7 Flood Warning Service including training of flood warning duty officers and ongoing system response to rainfall, level and flow alerts and alarms.

13. Supervised and co-authored the Maribyrnong River RORB Model Study in April 1994 following the major flood in September 1993 to help improve model parameters for real-time catchment modelling of subsequent floods.

14. Developed property-specific flood charts for Maribyrnong Township households to aid Community Flood Awareness in conjunction with Maribyrnong City Council (2000) and the VoiceReach community telephone alerting system.

15. In July 2003 I was asked to undertake a review of the Maribyrnong River Hydraulic Model Final Report, carried out by consultants acting for the VRC in support of the construction of a flood wall at Flemington Racecourse. I will discuss my findings in more detail in addressing TOR 7.

16. Presented paper on Melbourne Water's Flood Warning System to Horsham Flood Conference in October 2003.

17. In November 2004 I was asked to provide an advisory role with the Maribyrnong Floodplain Committee, a community group opposing the VRC Flemington floodwall.

18. In December 2005 I made a submission to the Victorian Government's Draft Central Region Sustainable Water Strategy featuring a concept for a flood retarding basin on the Maribyrnong River upstream of Keilor, in conjunction with a multi-purpose low level water supply storage. I subsequently made presentations on this to the Maribyrnong Council, Moonee Valley Council and Western Water Community Reference Group, of which I was a member at the time.

19. In June 2006 I took Liberal Leader Ted Baillieu on an inspection of the Maribyrnong River retarding basin site at Arundel, with my concept plan being subsequently adopted by the Victorian Liberal-Nationals Opposition in the lead-up to the November 2006 State Election.

20. On 17-Nov-2022 I provided advice to Melbourne Water about the location of additional flood levels they could obtain along the Maribyrnong River at Keilor to provide an improved comparison between the October 2022 flood and May 1974 flood level records.

Photo 7. Myself at the Maribyrnong historical flood "Candy Pole" marker in 1992, featured in Melbourne Water's June 2001 edition of *Guidelines for Development in Flood-prone areas.*