RESTORE BLUE

Independent Review: Logan and Albert Rivers Flood Study

Report No 2026/01, April 2026

By G P Smith & R J Nathan

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Executive summary

Restore Blue Advisory Services Pty Ltd was engaged by Logan City Council to undertake an independent review of the Logan and Albert Rivers Flood Study Finalisation Project.

This review report has been prepared by Mr Grantley Smith and Professor Rory Nathan to document the findings of their independent, technical review of the WRM flood study.

Neither Mr Smith nor Professor Nathan have had any previous involvement in the development of the Logan and Albert Rivers Flood Study, nor any of the other flood studies prepared by Council for the floodplains in the Logan City Council local government area.

The findings presented in this report are the independent opinion of Mr Smith and Professor Nathan.

The investigations undertaken for the flood study delivered by WRM can be divided into the following five major steps:

1. Collation of information on past floods, where focus was largely given to events that have occurred over the past 50 years based on continuously recorded rainfall and streamflow data.
2. Development of a hydrologic model (XP-RAFTS) to estimate *peak streamflows* from recorded rainfall events at specific locations in the Logan/Albert catchment.
3. Development of a hydraulic model (TUFLOW) to estimate *flood levels* from streamflows.
4. Statistical analysis of peak streamflows from continuously gauged records.
5. Processed information on rainfalls to derive streamflows (using XP-RAFTS) and inundation levels (using TUFLOW) for "design floods" of varying severity ranging from frequent to the "probable maximum flood", which includes floods with a "1 in 100" chance of being equalled or exceeded in any one year (referred to here as 1 in 100 Annual Exceedance Probability). old terminology used

These five major steps were investigated and reported by WRM over a number of years. WRM was initially engaged in 2019 and a delivered a major flood study update in 2021. They were subsequently engaged to update this study with a validation of catchment and floodplain models against the February 2022 flood which was delivered in the 2023 report. The *Logan and Albert Rivers Flood Study Finalisation Project* report (WRM 2025, the WRM Report), which is the subject of this review, includes minor updates to the 2023 report. The 2025 report relies solely on modelling completed for the 2023 report.

There are several key strengths to the investigations undertaken by WRM, namely the attention given to the review and extrapolation of the "rating curves" used to estimate flood flow rates for a given flood level at gauging sites, the detailed assessment of five very large historic floods, and the rigour and attention to detail when schematising the XP-RAFTS catchment and TUFLOW floodplain models.

so any data that was previously wrong has been included without checking

However, a key shortcoming of the investigation is that no consideration was given to large historic floods that occurred before systematic streamflow records began (e.g. the 1887 and 1947 floods). Considering all available records, the information on large floods that have occurred over a 140-year period suggests that the derived design flood levels for present day catchment and floodplain conditions have been over-estimated. A preliminary statistical assessment undertaken as part of this review indicates that the 1 in 100 AEP peak flow rate estimate at the Yarrahappini gauging site would be in the order of 25% lower if these earlier historical floods had been considered. Estimating the impact of these historic floods on flood levels across the floodplain would require further detailed analysis and modelling which lies outside the scope of this review.

This over-estimation is also potentially (partly, or possibly wholly) offset by the fact that the impacts of climate change were underestimated in the WRM Report since it was largely completed before recent (August 2024) updates to the assessment of climate change in Australian Rainfall and Runoff (the national flood guidelines) were finalised.

The most recent version of the Australian Rainfall and Runoff guideline takes advantage of internationally peer-reviewed evidence published over the past 15 years on the past and ongoing impacts of climate change. The latest guideline recommends that flood estimates for present-day and near-term climate conditions (up to 2030) need to account for the ~1.2°C of global warming that has *already occurred* over the past few decades. Preliminary calculations accounting for this past global warming indicate that the degree of overestimation in the 1 in 100 AEP peak flows in the WRM Report at Yarrahappini reduces from around 25% to around 20%.

Did they see tide levels at Fort Denison for the past 100 years? NO

When considering future floods, the most recent Australian Rainfall and Runoff guideline is based on evidence that climate change is accelerating faster than previously assumed. While WRM increased 1 in 100 AEP flows by approximately 11% to account for climate change impacts to 2090 using guidelines valid at the time of the study, preliminary calculations suggest that 1 in 100 AEP flows in this region will increase by 32% in 2090. These preliminary estimates are provided here for indicative purposes only, and would need to be updated by more defensible estimates based on detailed modelling consistent with Australian Rainfall and Runoff guidance.

MY, opinion is do not use "climate change" as an excuse. Let nature tell us each year and go on "recorded history only"

Thus, while the WRM design flood flow estimates may be conservatively high for present-day conditions, the published information on flood levels may be appropriate for longer-term planning needs as flood risks will continue to increase due to climate change.

The preliminary assessments undertaken for this review indicate that the 1 in 100 AEP flood levels at the Yarrahappini gauge, when adjusted to account for the earlier historic floods (in 1887 and 1947) and global warming up to current (and near-term) climate conditions, may be over-estimated by approximately 1.6 m. This degree of over-estimation is expected to reduce further downstream as the floodplain widens, and inspection of the modelling results suggests that the 1 in 100 AEP flood levels in the more populated downstream areas may have been over-estimated by approximately 1m or more. Any revision of the flood levels that may be required for floodplain planning purposes to account for earlier historic floods and revised climate change impacts would require a significant reworking of the flood study models.

LCC employed new data collection (LIDAR) why study old data just use what is actual today to get today's result

There remain a number of other aspects of the work documented in this review which could be improved to provide better confidence in the flood study results, most notably the approaches used to calibrate the hydrologic and hydraulic models, and the treatment of design downstream boundary conditions governed by storm surge and sea levels.

Council should carefully consider these issues with the flood study outputs in ongoing floodplain risk management and planning. It is suggested that flood risk maps published for local planning schemes, including zones and overlays for lands subject to inundation, should focus on a narrow range of flood risks relevant to development controls (these are typically based on 1 in 100 AEP flood levels), where information on rarer floods (e.g. the Probable Maximum Flood) are only held by agencies responsible for assessing life-safety risks.

The use of mixed terminology is alarming as it id 1% AEP or 1 in 100 year, they are different!!

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1 Introduction

Restore Blue Advisory Services Pty Ltd was engaged by Logan City Council to undertake an independent peer review of the Logan and Albert Rivers Flood Study (EOI Reference: RIP/20/2026).

This review report has been prepared by Mr Grantley Smith and Professor Rory Nathan to document the findings of their independent, technical review of the flood study.

Neither Mr Smith nor Professor Nathan have had any previous involvement in the development of the Logan and Albert Rivers Flood Study, nor any of the other flood studies prepared by Council for the floodplains in the Logan City Council local government area.

The findings presented in this report are the independent opinion of Mr Smith and Professor Nathan.

This review report is comprised of the following sections:

1. Introduction – provides an introduction to the review process and reviewer's credentials
2. Catchment and floodplain – briefly describes the floodplain, lists major historical floods and reports on the reviewer's inspection of the floodplain in February 2026
3. Overview of the review – lists the review scope, the reports reviewed, and supporting information provided by Council.
4. Review findings – reports the review findings in response to the review scope
5. Conclusion – provides a summary of the review findings

References to external documents and information independently sourced as part of the review are provided as footnotes.

1.1 Information provided for the review

The following version of the report was nominated by Council for the review:

"Logan and Albert Rivers Flood Study Finalisation Project" prepared for Logan City Council by WRM Water & Environment Pty Ltd noted as report number: 2045-01-B1 Revision 1, dated 31 October 2025 (*the WRM Report*).

We understand that flood study analysis reported in the WRM Report relies on work completed over numerous years in several stages. A timeline and description of work components relied upon in the WRM Report, as supplied by Council, is provided in Appendix A.

Further, we understand that the bulk of the technical work completed for the WRM Report was completed in 2023 (Logan and Albert Rivers Flood Study Finalisation Project 2023). We understand that the WRM Report published in 2025 did not include additional model simulations beyond the 2023 report.

While the focus of the review is the flood study methodology, modelling analysis and modelling outcomes reported in the WRM Report, Council also provided the following information and datasets:

Where are the other studies by Cardno Davies overseen by Water Engineers Lou Kaminos & Nernadrah Singh?

- Copies of previous peer review reports:
  - Water Technology (2020) *Peer Review Summary Report Logan and Albert Rivers Flood Study Update 2019,* noted as version 01, issued 5 May 2020.
  - (DCPM P/L, 2020) *Review of Logan and Albert Rivers Flood Study issued by WRM and dated 24th March 2020*.
- Example TUFLOW floodplain design model configuration files, excluding model result files
- Example TUFLOW model verification files for the 2022 flood, inclusive of model result files
- XP-Rafts hydrological model files
- Flike flood frequency analysis files
- Gold Coast Storm Surge Study (GHD, 2013)
- Oblique aerial photos from the 2017 flood

Some of these files are not applicable

- Information providing (partial) clarification of the assignment of the design downstream model boundary condition
- Information describing the delivery timeline of the Logan and Albert Rivers flood study report
- Information describing the consultant's inspections of the catchment and floodplain to support the study
- A copy of the addendum report by WRM addressing the previous peer review reports:
  - WRM (2021) *Logan Albert Rivers Flood Study Addendum Report***.** Report prepared for Logan City Council. Report Number 0936-11-J1 dated 16 April 2021

1.2 Reviewers

A short introduction to the reviewers is provided below, with more comprehensive CV's provided in Appendix B.

Grantley Smith, Restore Blue, Sydney

In his 30+ years as a professional engineer, Grantley has developed his skills on a broad range of projects providing assessment and solutions for water engineering and water resources investigations. He is a team leader with a proven track record for leading multi-disciplinary teams delivering practical solutions to environmental investigations. He has particular expertise in the selection and application of appropriate physical and/or numerical models to support design solutions, planning, management and forecasting across the water spectrum.

Grantley has specialist expertise in water resources management and floodplain management through a hands-on career investigating catchment processes. He is acknowledged by his peers as an expert in modelling catchments and floodplains and was instrumental in the pioneering use of 2D hydrodynamic models for floodplain flow prediction and inundation mapping. His experience gained through direct participation in the evolution of floodplain modelling has provided him with an outstanding knowledge of the application and interpretation of appropriate models to support environmental planning, management and forecasting for floodplains. Grantley is a lead author and key contributor to reports supporting the 2019 revision of Australian Rainfall and Runoff, contributing to guidelines for appropriate use of numerical models (ARR Project 15 – two dimensional modelling guidelines) and flood hydraulics (ARR Book 6). He is also the lead author of the guideline on flood hazard assessment supporting the national best practice manual Managing the floodplain - a guide to best practice in flood risk management in Australia (AEMI Handbook 7). His skills include the simplification of technical data and modelling outputs in to forms readily communicated to non-technical stakeholders.

Professor Rory Nathan, University of Melbourne, Melbourne

Professor Rory Nathan is a hydrologist who has focussed much of his career in industry evaluating flood risk for public and private sectors. He has been involved in flood estimation as a consultant and researcher over a forty-year period. He is co-editor and leading author of the Australian Rainfall and Runoff, and most recently this has included co-authoring the updated climate change chapter (2024), the provision of guidance on the use of Monte Carlo and ensemble-based methods (2019), the derivation of Probable Maximum Floods (1999 and 2019), and the guidance relevant to the reconciliation of design estimates with multiple lines of evidence.

Professor Nathan is recognised internationally for his expertise, and this has included providing advice on extreme floods, on the characterisation of uncertainty, and on joint probability approaches for assessment of risks to floodplains, dams and nuclear power industry in the US, Canada and the UK. He has published over 300 papers in refereed journals and conference proceedings, and since 2016 this has included around 60 papers in leading international journals on flood estimation (as listed in his Curriculum Vitae). He has undertaken numerous expert advisory and review roles for government, legal, and private entities. In 2000 he was recognised as national "Civil Engineer of the Year" by Engineers Australia, and as the 2018 Munro Orator he is recognised as being one of Australia's most influential engineers eminent in the field of water resources.

Bit of a joke here. Probable Maximum Flood only a few people have witnessed this but the Account can be found in Genesis 6-14, Noah and family's account. There is no such possiblility unless all the ice on earth melted and the oceans rose to encompass this.
No one that I know of is using the Monte Carlo method as it ytakes a lot of manpower to set up and keep track of.
AR&R is the Australian Standard but like all the others eg QUDM it is "cover me butt" calculations so no one can get sued.

2 Catchment and floodplain

2.1 Catchment description

As noted in the WRM report, the Logan River catchment has a total area of 3,856 km^2. The catchment has its headwaters in the McPherson Ranges along the Queensland/New South Wales border and flows generally north-easterly into Moreton Bay at Jacobs Well.

The greater catchment is delineated into four (4) major tributaries:

- Logan River (2,260 km^2)
- Teviot Brook (694 km^2)
- Slacks and Scrubby Creeks (121 km^2), and
- Albert River (781 km^2)

The topography of the catchment varies from steep hills, valleys and mountainous terrain in the upper catchment near the border to wide, flat floodplains in the middle and lower reaches of the river. Areas of the upper, southern parts of the catchment are largely intact forest with some rural pasture development, middle parts of the catchment have pasture and rural residential development, transitioning into peri-urban and urban residential and commercial development in the lower catchment where the major centres of Logan City and Beenleigh are located.

The Wyalarong Dam on Teviot Brook and Maroon Dam on Burnett Creek are major infrastructure features influencing the passage of flows through the upper catchment, while numerous elevated road and rail embankments crossing the lower floodplain also influence the passage of flows through the floodplain in major flood events.

No mention here of development in the catchment as this is one of the greatest influences

2.2 Major historical floods

The Australian Bureau of Meteorology (BOM)[1] notes major historical floods have occurred in the catchment in the following years:

- January 1887
- January 1947
- January 1974
- February 1976
- April 1990
- January 2013
- March 2017
- February 2022

How can you compare these 'EVENTS' as they all have different origins, charateristics and base data?

Figure 2-1 notes that the January 1887 flood is the largest on record with respect to gauged heights followed by the January 1974 and January 1947 floods. The severity and cost of flooding in the

[1] https://www.bom.gov.au/qld/flood/brochures/logan_albert/logan_albert.shtml

catchment, particularly on the lower more urbanised areas of the floodplain, have long been an issue for the community[2].

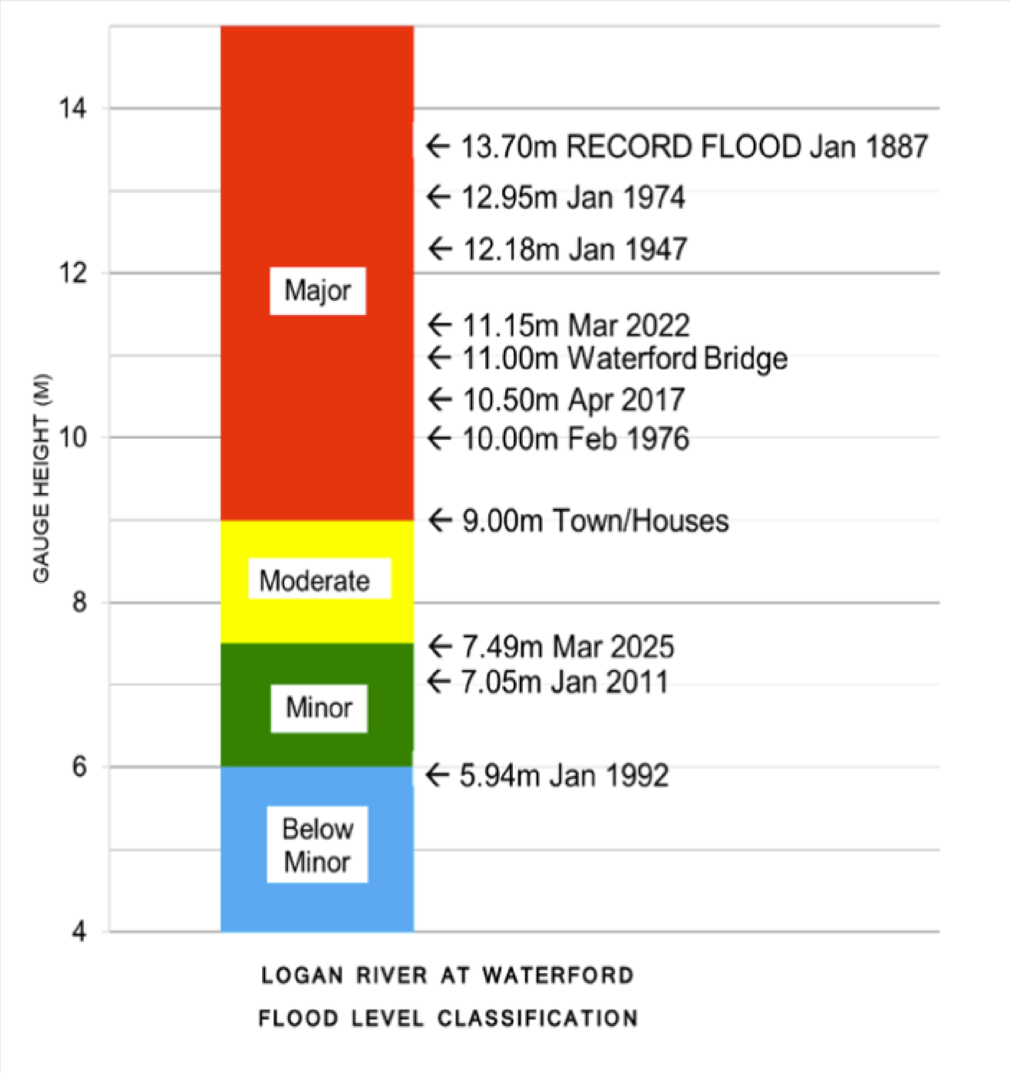

Figure 2-1: BOM classification of historical floods on the Logan River at Waterford

2.3 Site Inspection

Mr Smith and Professor Nathan inspected the lower Logan and Albert River floodplains on 17 February 2026 with Council floodplain officers. The site inspection afforded the opportunity to observe the floodplain first hand and visit sites where official flood height measurements have been recorded for historical floods.

The site inspection focussed on the lower floodplain and visited sites at MacLean Bridge, Logan Village, Luscombe, Beenleigh and Waterford.

[2] https://trove.nla.gov.au/newspaper/article/168902546; https://trove.nla.gov.au/newspaper/article/63003005; https://www.abc.net.au/news/2024-01-21/1974-floods-changed-brisbane-southern-queensland-forever/103367964;

a) **Flood memorial at MacLean bridge**

b) **Flood memorial at Maclean Bridge showing three largest floods on record**

c) **Flood gauge at Logan Village**

d) **Flood marker on River Road near Waterford State School**

Figure 2-2: Photographs of historical flood heights and gauges from 17 February 2026 site inspection

3 Overview of the review

3.1 Scope as per the brief

The review scope calls for a technical review of the flood study modelling approach, the application of that approach, and the flood model outputs and findings.

The flood study review brief requested by Council is reproduced below for the purposes of clarity. Section 4 of this report provides the review findings summarised against each of the points raised in the review scope.

1. *Consistency of methods applied with the national design flood estimation guideline "Australian Rainfall and Runoff " (ARR) and industry standards documents such as ARR Project 15 – two dimensional modelling guidelines*

2. *The hydraulic modelling approach including software and model schematisation (model resolution, model boundary type, key model parameters and calibration methodology).*

3. *Confirm process of catchment walk overs support modelling.*

4. *Review of the topographic methodology supporting the modelling.*

4-6 5. *The key input data sources (bathymetry survey sources and currency, structure data, land use data).*

6. *The key design inputs and resultant design flows (design rainfall and temporal patterns, rainfall-runoff losses, ground roughness, major structures, river discharge, tidal / storm surge boundaries and coincident events).*

7. *The flood frequency analysis (statistical analysis of historic events) and comparison with the model representation of historical events.*

8. *Consistency of application of climate change methods with ARR.*

9. *Commentary on the fitness-for-purpose of resulting design flood levels for application in land use planning and development control.*

10. *Determine and advise on the study's Probable Maximum Flood (PMF) frequency and PMF error bounds including any potential compounding effects.*

11. *Commentary on whether the flood study was completed using AI, Monte Carlo analysis or pilot/experimental methodologies.*

WHY do we start at 2019?????

3.2 WRM flood study time line relative to Australian Rainfall and Runoff guidelines

The national best practice guideline, Australian Rainfall and Runoff (ARR), has evolved through a series of reviews and updates throughout its history. A major review of ARR was published in 2016 and updated in 2019 (ARR V4.1) with a subsequent significant update addressing the influence of climate change on design rainfalls (ARR V4.2) published in August 2024.

Flood study analysis reported in the WRM Report relies on work completed over numerous years in several stages. A timeline and description of work components relied upon in The WRM Report, as supplied by Council, is provided in Appendix A. A graphic comparing the flood study stages to ARR publications is provided in Figure 3-1.

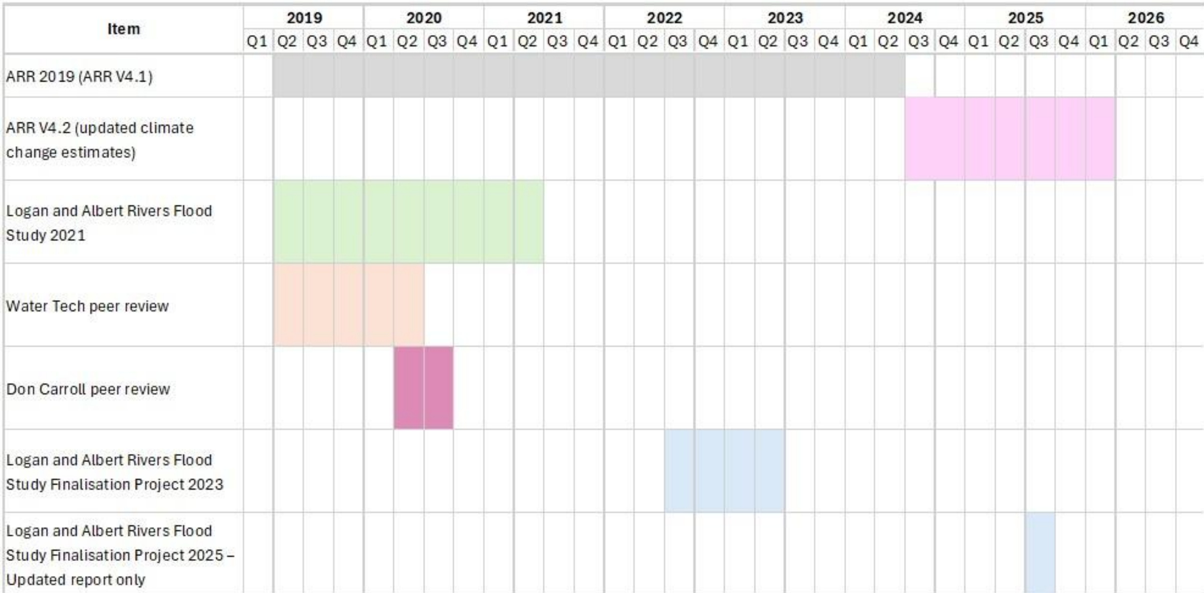

Figure 3-1: Flood Study timeline compared to ARR Publications

Note that the bulk of the technical work completed for the study (Logan and Albert Rivers Flood Study Finalisation Project 2023) was completed using ARR V4.1. We understand that Logan and Albert Rivers Flood Study Finalisation Project 2025 (the WRM Report - the subject of this review) did not include additional model simulations. Note that the WRM Report was finalised after ARR V4.2 (updated climate change estimates) was published. Note also that we have not reviewed the 2023 report.

3.3 Previous flood study peer reviews

Two previous peer reviews were conducted during the compilation of the WRM Report.

3.3.1 Water Technology Pty Ltd peer review

Water Technology Pty Ltd were appointed by Council in 2019 to provide detailed peer review of the Logan and Albert Rivers flood study methodology and models in stages in parallel to the work being undertaken by WRM. The Water Technology review findings were summarised in the following report:

> Water Technology (2020) *Peer Review Summary Report Logan and Albert Rivers Flood Study Update 2019,* noted as version 01, issued 5 May 2020.

The peer review was conducted at four (4) different stages as the study progressed, these being:

- Review Point 1: Model schematisation
- Review Point 2: Historic flood calibration
- Review Point 3: Design flood modelling
- Review Point 4: Review of Draft Flood Study Report and GIS Maps

Water Technology provided detailed review comments in a series of memorandums. Their review advice included feedback on a range of modelling issues including suggested improvements in the overall modelling approach, both the hydrologic and hydraulic model schematisation, the foundational datasets applied in the models, the flood frequency analysis of historical gauge data used to benchmark the models, the model calibration, and the design model outputs.

Section 4 of Water Technology (2020) provides a series of recommendations that were first provided to Council in a memorandum dated 30 April 2020. These recommendations and conclusions of the peer review are reproduced below:

While a range of recommendations have been made in connection with the peer review, WT considers that the considerable increases in peak flood levels that are now estimated to occur compared to the previous 2014 study are concerning and should be specifically addressed. Accordingly, we recommended that a range of further works be undertaken in this regard and provided the following additional comments:

This keeps coming up "higher levels"

- *We note that the differences in water surface levels are likely to be larger given that the discharges applied in the hydraulic model are lower compared to the FFA estimates. That is, the hydraulic model discharges should be aligned with the FFA estimates as opposed to the hydrologic flows as the hydraulic model is the determinant factor for water surface levels;*

- *It appears that the differences in water surface levels is primarily associated with the discharge estimates from the FFA. That is, it is discharge related with the former 2014 study adopting what appears to be a lower 1% AEP FFA estimate compared to the current 1% AEP FFA estimate which is approximately 1000m3/s higher at Yarrahappini;*

- *Given the above, we recommend that a critical review of all design discharge estimates be undertaken across the Logan/Albert River catchment to ensure that current estimates are fully supported and given the implications for since development and future development across the* *catchment. This review should also consider the corresponding discharge estimates for the Logan River and Teviot Brook catchments as have been noted, along with the Albert River. The review should additionally provide more in-depth discussions and comparisons between the 2014 and current 2020 study as to why the large differences have arisen. We consider that such a critical review should be undertaken and documented separately, and prior to finalisation of the study;*

- *An assessment should be undertaken to quantify the differences in design flood planning levels between the 2014 and current 2020 study, with a key focus on quantifying the extent and degree to which previous development approvals and building floor levels may now be compromised of affected;*

- *Given the sensitivity of the model boundary conditions and recommendations from QCoast 2100, we recommend that Council considers including a joint probability analysis be undertaken in accordance with the ARR2019 guidance; and*

- *Given the implications of the higher flood levels that will likely result from this study, and noting that the detailed model appears to provide lower flood levels compared to the fast model, consideration should be given as to the effects of hydraulically analysing the full suite of 1% AEP durations and temporal patterns using the detailed model and post-processing for either the average or median water surface level grids.*

WT consider that the above aspects must be addressed before the Logan Albert Rivers Flood Study Update project can be finalised and subsequently adopted by Council. These matters remain outstanding as at the time of preparation of this subject report.

3.3.2 Don Carroll peer review

Don Carroll was subsequently engaged by Council to provide a second independent review. The review findings by Mr Carroll are provided in a memorandum entitled *Review of Logan and Albert Rivers Flood Study issued by WRM and dated 24th March 2020* (DCPM P/L, 2020).

A key finding of the Carroll review is reproduced below:

The reviewer supports the key recommendation made by WaterTech (sic) *that given the differences between this study (2020) and the 2014 Flood Study, that a critical review of design discharges for the Logan Albert Rivers should be undertaken. This review should include reference to historical flood levels and flood modelling work undertaken by the BoM and the Gold Coast City Council and earlier studies. In addition to the specific technical recommendations outlined in this review including an addendum report addressing the differences between this study (2020) and the 2014 Flood Study , the 2020 WRM flood study should first be updated to incorporate the findings of critical design peak discharges review.*

The Carroll review also notes that following the Water Technology (2020) review:

"Several issues remained outstanding including refinement of Yarrahappini rating curves, matching flood frequency estimates with hydrologic model inflows, increased hydrologic model design flows at Yarrahappini (compared to 2014 estimates) and increased 1% AEP levels (in the order of 0.85 to 1.6 meters higher for key gauge locations) compared to the 2014 flood study levels despite close agreement

between the 2014 and 2020 flood frequency analyses. This last aspect is the most concerning to Logan City Council and this reviewer."

On the subject of the joint probability of ocean and catchment flooding, Mr Carroll recommends that *"… the joint probability analysis could be done in the next round of flood study updates, given the sensitivity analysis undertaken in the WRM report."*

3.3.3 Response to the peer reviews

Council engaged WRM to respond to the Water Technology and Don Carroll review recommendations. The *Logan Albert Rivers Flood Study Addendum Report* WRM (2021) includes a further consideration of the catchment hydrology and flood frequency analysis. The addendum report examined the impacts of various changed assumptions and design inputs on modelled flows, and while this is useful in some respects, it did not address the root cause of the shortcomings in the flood frequency analysis as outlined further in Section 4.7 of this review.

Here is the statement that needs to go to the Mayor

4 Review findings

4.1 Consistency of methods applied with the national design flood estimation guideline "Australian Rainfall and Runoff" (ARR) and industry standards documents such as ARR Project 15 – two dimensional modelling guidelines.

4.1.1 ARR

Our review found that the following aspects of the WRM Report are not fully consistent with the current version of ARR (v4.2, 2024):

1. Treatment of floods which occurred before the period of gauged records
2. Design rainfalls applied to represent present day (2020) and near-term (to 2030) flood risks
3. Design rainfalls applied to represent future (2090) flood risks
4. Lack of independence between results based on flood frequency analysis and rainfall-based modelling
5. Joint probability of design downstream boundary conditions applied to estimate present day (2020) and future (2090) design flood conditions

Note that points 1, 4 and 5 above are also not fully consistent with ARR version 4.1, which was the ARR version current at the time the flood study modelling was finalised.

Further commentary on the inconsistencies with versions 4.1 and 4.2 of ARR is provided in the following sections.

4.1.2 ARR Project 15

Our review found that in general the development of the two dimensional TUFLOW floodplain model has followed the principles of the national best practice guideline *ARR Project 15 - Two dimensional modelling in Urban and Rural floodplains*[3]. The TUFLOW model schematisation is considered sound, but there are some shortcomings with the approach used to calibrate the model and parameterise the model for design flood estimation as discussed below.

[3] https://arr.ga.gov.au/arr-guideline/revision-projects/project-list/projects/project-15

4.2 The hydraulic modelling approach including software and model schematisation (model resolution, model boundary type, key model parameters and calibration methodology).

4.2.1 Software

The flood study has been completed using three software packages:

FLIKE flood frequency analysis software which is used to derive the statistical relationship between the magnitude of flood peaks and their annual exceedance probability (AEP). Such analyses provide valuable information on how often a flood of a given size can be expected to occur.

XP-RAFTS – a catchment rainfall-runoff model which is used to estimate how streamflows respond to rainfalls during flood events, where the results are most commonly shown as graphs ("hydrographs") that show how streamflows rise and fall over the time when flood conditions occur.

TUFLOW – a two dimensional floodplain model which simulates how floodwaters spread across land, where the results are most commonly provided as time varying, two dimensional maps of water surface level, water depth, flow velocity and flows across the floodplain.

When applied appropriately in combination, these software packages are considered fit-for-purpose to meet the requirements of best practice estimation of design floodplain flow behaviour. Note, however, that there are some shortcomings with the application of the software for design flood estimation as discussed below.

4.2.2 Model schematisation

XP-RAFTS

The XP-RAFTS model covers an area of 3879 km^2 and consists of 268 sub-catchments. While this degree of discretisation is more than required to defensibly represent routing behaviour across the catchment, the approach is consistent with common industry practice. Model configuration is suitable for capturing differences in flood response across the sub-catchments upstream of the gauging stations, and is well suited to satisfying the upstream boundary conditions for the TUFLOW model.

TUFLOW

The TUFLOW model domain extent has been defined to cover the Logan/Albert floodplain area in the Logan City Council LGA over a total area of 453 km^2.

Two TUFLOW models have been configured for the floodplain:

1) A 20m grid resolution (fast) model
2) A 10m grid resolution (detailed) model

the WRM Report notes:

- ***'Fast Model'*** *– This model was configured with a grid cell size of 20 m. The purpose of this model is to allow the selection of critical design storms and then minimise the number of design event simulations is required to be run using a finer 'detailed model'.*

- ***'Detailed Model'** – This model was configured with a grid cell size of 10 m. The purpose of this model is to run the critical design storms selected using the 'Fast Model' to obtain the design outputs.*

- *A grid cell size of 10 m is considered to be most suitable for generating the design outputs for this study. However, the 'Fast Model' (with a 20 m grid) was required for this study to more efficiently implement the 'ensemble' method of design event modelling described in AR&R 2019.*

The reviewers agree that this is a pragmatic approach to dealing with the many model simulations required to implement the 'ensemble' method of design event modelling described in AR&R 2019.

The 10m model resolution of the 'detailed' model is considered suitable for a floodplain model of this scale and complexity.

The TUFLOW model has been configured with (24) inflow boundaries at the upstream extremities of the model. Inflow time series have been derived from the XP-RAFTS model. Where the XP-RAFTS model domain overlaps the TUFLOW model domain (72) local inflow boundaries have been applied. Using this approach, local flows are initially applied to the lowest point within a representative surface area polygon, then gradually applied over a larger area within the surface polygon as the discharge increases. This is considered a reasonable approach to representing local inflows to the model.

The downstream model boundary has been configured as a water level boundary. Time varying boundaries of recorded water level have been used for historical calibration and verification events. This boundary configuration is a recommended standard modelling approach that provides control over modelled flood volumes.

The downstream boundary is located downstream of a natural constriction in the floodplain topography near Riedel Road. This is an appropriate location for the downstream boundary.

Comments on the foundational source data for the model topography and bathymetry are provided in Section 4.5 below.

Comments on the configuration of hydraulic structures in the model are provided in Section 4.6 below.

4.2.3 Calibration methodology

The adopted calibration approach involves the joint fitting of the hydrologic (XP-RAFTS) and hydraulic (TUFLOW) models. With this approach, flows estimated by XP-RAFTS are input to TUFLOW, where the expectation is that the approach allows "*the suitability of the discharges estimated by the hydrologic model to be confirmed, as well as testing the performance of the hydraulic model*" (the WRM Report, p20).

While this approach is endorsed by ARR Project 15 as an applicable modelling approach (amongst others), the approach is considered by the reviewers as less than ideal as it prevents the identification, and treatment, of errors from different sources to be dealt with in an appropriate manner. For example, the estimation of areal rainfalls across a catchment (in space and time) from rainfall gauge point observations is a source of considerable uncertainty, yet with the adopted approach the influence of any associated errors may well be transferred to the hydraulic model rather than the hydrologic model. Similarly, any errors in identifying spatially-varied rainfall loss parameters might be transferred to the hydraulic model in a joint calibration, where in fact they are better identified as a limitation of the hydrologic model.

This is where LCC should have provided WRM 'as constructed' data from all subdivisions

The reviewers consider a better approach is to evaluate the performance of the hydrologic model separately from the hydraulic model; to this end, gauged flow inputs should be used as input to the hydraulic model where they are available, and the performance of the hydrologic model should be assessed using streamflow observations that are not materially affected by tailwater influences.

Hydrology

Rainfall isohyet mapping for calibration events was based solely on the availability of point gauge observations. While in concept this is a reasonable approach given the number of gauges potentially available, in practice the approach is vulnerable to the changing presence/absence of individual gauges, which varies from one event to another. It is thus preferable to take advantage of the AWAP (now AGCD)[4] gridded rainfall product developed by the Bureau of Meteorology as the daily gridded rainfall fields reflect both long-term spatial structure and event-specific station signals. The SILO product developed by the Queensland government[5] also uses information on long-term spatial structure though in a different manner to AWAP, and is a suitable alternative to AWAP. While such gridded rainfall products introduce different sources of bias, overall they provide more accurate estimates of daily rainfall fields than from event-based point observations alone, and they are a valuable source of information that can reduce the uncertainties involved in the calibration of historic flood events.

This where the Monte Carlo data is superior

Calibration of the XP-RAFTS model to four historic events was based on optimising a single set of routing parameters, combined with event-specific loss parameters. While it is appropriate to adopt a single set of routing parameters, it is not clear why loss parameters were assumed to be uniform across the whole catchment rather than varying by sub-catchment, particular as losses were varied by sub-catchment to derive the design floods. Given the variation in topography and land-use (and incident rainfalls) it is reasonable to expect that loss parameters may vary by sub-catchment, and it would have been preferable to investigate this where suitable gauging information was available. This point is acknowledged in the WRM Report Section 5.2 where it is stated that *“calibration of the models for individual events can be improved by adopting a set of variable loss rates within the catchment for each of the different events”*, however the rationale for not doing so is not provided.

The model was validated using information from the February 2022 flood, where it is stated (the WRM Report, Section 2.2) that *“No model parameters were adjusted as this was a validation event only.”* While it is understood that routing parameters in the XP-RAFTS model were not adjusted, given how this event was used in the study, it would be reasonable to adjust the loss parameters as these vary from one event to another. In concept, the rationale used to adopt the event-specific storage levels in Wyaralong Dam is equally applicable to loss parameters, as the losses represent antecedent storage conditions in the catchment at that time. The report should clarify how losses were treated in this validation event to better understand how well the model is performing.

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[4] https://www.bom.gov.au/climate/austmaps/about-agcd-maps.shtml

[5] https://www.longpaddock.qld.gov.au/silo/

Hydraulics (TUFLOW)

As noted above, the reviewers preferred approach to model calibration is to apply measured flows at the upstream boundaries of the hydraulic model where they exist to separate the sources of calibration error from the hydrologic model.

Calibration of the TUFLOW model is described in the WRM Report Section 7. The primary aim of the hydraulic model calibration is to demonstrate that the model can reliably reproduce the observed flow behaviour on the floodplain for historical floods. A reliably calibrated model can then be confidently used to predict design flood behaviour on the floodplain.

The WRM Report, Section 7 notes that the model was calibrated to the following historical events:

- January 1974
- April 1990
- January 2013
- March 2017

Inflows to the TUFLOW hydraulic model were generated from the calibrated XP-RAFTS model with the noted issues with the XP-RAFTS model (see above review section on hydrology calibration) transmitted to the TUFLOW model.

TUFLOW model calibration primarily involved fine-tuning the applied values of hydraulic roughness in the model. Adjustment of the model roughness parameters variously influences the relative split of flow volume carried in the main river and creek channels and on the overbank floodplain, the flood surface gradients and the associated timing of flood flow propagation down the floodplain.

The calibration exercise included comparing the simulated model results to available historical data records including:

- Time series hydrographs of water levels measured at flow gauging stations (all events)
- Surveyed flood debris marks (1974, 2013, 2017)
- Flood inundation extent (2013, 2017)

The model results presented in the WRM Report demonstrate a reasonable calibration has been achieved in terms of matching peak water levels, hydrograph volume (rising limb and falling limb of hydrographs) and flood timing through the floodplain for the different historical calibration events.

The calibration results presented for the different events show that the shape and timing of the historical event hydrographs have been reasonably matched with the flood peak typically matched to within +/- 6 hours. Peak flood levels at flood gauges are generally matched within +/- 0.3m.

Flood debris survey marks have more variable results. This is not unexpected since individual debris marks can be an inaccurate (compared to gauged data) representation of the flood peak for a range of reasons including the debris settling before or after the peak of the event or the debris being moved after the event.

In particular, the January 1974 event is not well reproduced by the model. For example, the WRM Report Figure 7.4 shows that the model generally underestimates the peak water surface profile for the 1974 event. This is perhaps understandable since the main river channel bathymetry and the floodplain topography have likely changed significantly since the 1970s with significant amounts of newer development in the catchment and on the floodplain. This is unfortunate since the 1974 flood is recorded as being significantly larger than the subsequent floods in the 2000's.

The model was also validated against the February 2022 flood event to time series hydrographs of water levels measured at flow gauging stations, surveyed flood debris marks and flood extent. The validation exercise involved running the calibrated model without further adjustment of the model parameters. The February 2022 flood, which is the most recent historical flood modelled, is the largest flood to have occurred in the lower floodplain since 1974 (see review Figure 2-1) and occurred in the period circa the most recent LiDAR and bathymetry survey. In these respects, the February 2022 validation event is perhaps the most relevant event to judge model performance by.

The validation results for the February 2022 event presented in the WRM Report Section 7.7 demonstrate an acceptable match of the recorded water level hydrograph peak levels, hydrograph shape, and flood extent as compared to surveyed debris marks. Based on the peak water levels at the flow gauging stations and the match with the majority of the surveyed debris marks as presented in the WRM Report Figure 7.27, the model accuracy might be inferred as generally within +/- 0.3m for this event, which is within the general range anticipated by the reviewers for a model of this scale. The modelled peak water surface profiles presented in the WRM Report Figures 7.38 to and 7.39 also demonstrated that the model is producing observed peak flood surface slopes with acceptable accuracy.

Overall the TUFLOW model calibration in considered an acceptable basis for use in predicting design flood behaviour, noting that the model accuracy is likely to be in the range +/- 0.3m.

4.2.4 Key model parameters

<u>Hydrology</u>
As noted above, the XP-RAFTS model was calibrated to historic flood events using a single set of routing parameters and a uniform set of loss parameters for the whole catchment. When the XP-RAFTS model was used to estimate design floods (i.e. floods with a specified annual exceedance probability), the same set of routing parameters found from calibration were adopted, whereas the loss parameters were varied by sub-catchment to yield flows that matched the flood frequency analysis results. Further discussion on this is provided in Section 4.6.1.

<u>Hydraulics</u>
The main model parameter that requires adaptation and fine-tuning in the TUFLOW model to ensure that the model is adequately reproducing observed floodplain flow behaviour is the 'hydraulic roughness' quantified in TUFLOW as Manning's "n".

The WRM Report Section 6.5 describes the detailed approach used to set the Manning's "n" parameter in various parts of the model. The Manning's "n" values were set primarily based on land use mapping. This is a reasonable approach regularly applied in contemporary floodplain modelling. The WRM Report Tables 6.1, 6.2, and 6.3 summarise the various parameter values adopted for the 10m grid and 20m grid models. These adopted values are within the expected ranges.

4.3 Confirm process of catchment walk overs support modelling.

The WRM Report does not contain any direct references to catchment site inspections by the consultant.

The following information was provided in response to enquiries made to WRM via Council officers for this review:

20 or 50 Site visits JOKE JOYCE!!! in 3856sq kms

> *"No job-specific site visits were undertaken as part of this project, as it was a finalisation study using models that had already been developed during previous work. Despite this, it is worth noting that the primary reviewer of the project at WRM personally undertook 20 site-specific flood damage inspections throughout the Logan and Albert River catchments immediately following the 2017 flood event. These inspections included assessments of key bridge crossings and observations of post-flood channel characteristics at multiple locations.*
>
> *Additionally, immediately following the 2022 flood event, WRM staff undertook more than 50 site-specific flood inspections across the Logan and Albert River catchments, observing post-flood characteristics and the extent of flooding at numerous locations within the LCC local government area."*

In response to an enquiry about the on-ground checking of model results reported in WRM (2021)[6] the consultant advised that:

> *"the consultant felt it wasn't warranted because of the significant number of site inspections undertaken by the same consultant following the 2017 flood event."*

Based on these responses it can be inferred that WRM staff directly involved in the modelling reported in the WRM Report have spent a significant amount of time in the catchment and floodplain both pre- and post-flood events gaining first-hand knowledge of flood behaviour.

4.4 Review of the topographic methodology supporting the modelling.

Successful reproduction of observed historical flow behaviour in a two dimensional (2D) numerical floodplain model, and the subsequent estimation of design flood behaviour, fundamentally relies on a suitable representation of the physical features and volume of the floodplain in the model's foundational digital elevation model (DEM).

The DEM for a 2D model is typically constructed using measured ground survey data from a range of sources that are either remotely measured e.g. LiDAR or photogrammetry, or directly sampled on-ground by surveyors typically using a global positioning system (GPS).

The topographic data used to build the Logan and Albert Rivers TUFLOW model is described in the WRM Report Section 3.2 Topographic data and Section 6.3 Topography.

[6] Logan and Albert Rivers Flood Study 2021

The WRM Report Section 6.3 describes the topographic data used as the foundational dataset for the floodplain model as a mosaic of LiDAR sourced terrain data on overbank floodplain areas, combined with boat mounted depth soundings and ground surveyed cross sections in the river and creek channels.

The LiDAR data was provided in both a point cloud and as regularised elevation points in one metre horizontal intervals that were resampled on either a 10m or 20m grid for use in the model. LiDAR data from a range of different surveys were sampled (see the WRM Report Section 6.3.1) to attain full coverage of the floodplain. Specific floodplain features that might influence the passage of flows down the floodplain such as creek channels, and elevated road and rail embankments were defined using "z-shapes".

Several different LiDAR and bathymetry datasets of various vintages (surveyed at different times) were available. The WRM Report Section 6.3 notes that historical datasets closest in vintage to the time of the flood were used to simulate historical flood events. The most recently measured datasets were used in the design event model.

The topographic methodology applied to develop the applied model DEM is considered sound, and the sources and accuracy of the underlying data, are considered suitable to support the flood study TUFLOW model.

LIDAR is good for open areas but not for areas containing buildings.see comment below

4.5 The key input data sources (bathymetry survey sources and currency, structure data, land use data).

Take IKEA carpark, it floods but the lidar image would show the roof not the actual ground profile so has LCC adjusted all these sites? My guess NO.

4.5.1 Topography

Comments on bathymetry and topography data and methodology are described in Section 4.4.

4.5.2 Hydraulic Structures

Development in the catchment and on the floodplain variously influences the passage of flood flows down the catchment. In numerous locations, built infrastructure crossing the floodplain interrupts and influences the downstream passage of flood flow.

The WRM Report Section 6.6 Hydraulic Structures notes that the following structures have been included in the model:

- 216 culverts, made up of 128 Reinforced Concrete Pipes and 88 Reinforced Concrete Box Culverts; and
- 80 bridge structures.

The locations of these structures are presented in the WRM Report Appendix B.

Culverts in the TUFLOW model were modelled as 1D structures embedded within the 2D model domain and bridges were represented in the hydraulic model using two-dimensional 'layered flow constrictions'. These methods are considered suitable for representing the various hydraulic structures in the model.

4.5.3 Land use data

Land-use mapping based on Google Earth aerial photographs and land capability classifications from local council planning schemes were used to assess fraction impervious, hydraulic roughness and catchment slopes in the hydrologic (XP-RAFTS) model. These are considered appropriate sources of information for configuration of this model.

Land use mapping has also been interpreted as the basis for setting Manning's "n" hydraulic roughness in the TUFLOW model. The process for setting the roughness parameters and the adopted Manning's "n" values are described in the WRM Report Section 6.5. Land use mapping used as the basis for the hydraulic roughness grids in the model are presented in the WRM Report Appendix B.

The method applied to develop the spatial hydraulic roughness maps is considered appropriate.

4.6 The key design inputs and resultant design flows (design rainfall and temporal patterns, rainfall-runoff losses, ground roughness, major structures, river discharge, tidal / storm surge boundaries and coincident events).

4.6.1 Design peak catchment flows (design rainfall and temporal patterns, rainfall-runoff losses)

The key design inputs used to derive rainfall-based flood estimates include rainfall depths of a given exceedance probability, areal reduction factors, temporal and spatial patterns of rainfall, and the routing and loss parameters for the XP-RAFTS model.

The sources of information used to obtain the design rainfalls, and their associated areal reduction factors and their temporal and spatial patterns, are appropriate.

Two different approaches were adopted to select XP-RAFTS model parameters. As discussed in the above Section 4.2.3, catchment routing parameters were obtained from calibration to historic flood events, which is an appropriate approach. With loss parameters, estimates of uniform losses relevant to selected historic events were also obtained from calibration, but these were not used for design purposes. Instead, the design loss parameters were obtained by adjusting the loss parameters "until a good match" (the WRM Report Section 9.6) was achieved with the flood frequency results. While it could be argued that this is a reasonable approach, the problem is that by forcing the XP-RAFTS model to match flood frequency results the modelling cannot be regarded as providing an independent line of evidence for flood behaviour. A better approach is based on model reconciliation rather than matching[7], whereby model parameters and associated design assumptions are only minimally adjusted within bounds that are supported by alternative lines of evidence to ensure that any differences can be explained by the uncertainties inherent in both methods. Such an approach affords some degree of

[7] The process of reconciling model parameters with independent flood frequency results is discussed in Section 3.3.3 of Book 5, and Chapter 7 Book 7 of the Australian Rainfall and Runoff guideline.

independence between the rainfall-based and statistical methods, and the process of reconciling estimates provides the opportunity to question the assumptions used in both methods.

The lack of independence between the rainfall-based and statistical methods (i.e. between XP-RAFTS and flood frequency results) is a particular issue in this study as it is considered that the flood frequency results are over-estimated. The reasoning for this is discussed further in Section 4.7, but if the flood frequency results are over-estimated, then it follows that the adopted XP-RAFTS design inputs have produced flood estimates which are also over-estimated.

4.6.2 Design event downstream boundary – tidal / storm surge boundaries and coincident events - present day (2020)

This has the issue that it starts at a higher level and does not allow for tidal influence

The WRM Report Section 10.3.6 notes that a fixed water level boundary at the 2020 mean high water springs (MHWS) tide level was applied to the downstream model boundary for design floods up to and including the 1 in 20 (5%) AEP event.

Similarly, the report notes in Section 10.3.7 that for events from the 1 in 50 AEP event to the 1 in 2000 AEP event inclusive, a time varying 1 in 20 AEP storm surge boundary was adopted. For the Probable Maximum Precipitation Design Flood (PMPDF) event, a time varying 1in 100 AEP storm surge boundary was adopted. The combinations of catchment flood design event and ocean storm event are further summarised in the WRM Report Table 10.2. No reference to the guidance relied upon by WRM to select these boundary combinations is provided in the report. However, these boundary combinations are similar to those recommended in Table 8.1 of the superseded NSW guideline *Floodplain Risk Management Guide Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways* (NSW OEH, 2015)[8].

Further, the WRM Report Table 10.2 notes design peak storm surge levels for the 1 in 20 AEP event at 1.88m AHD and the 1 in 100 AEP storm surge at 2.07m AHD. The source of these adopted levels is not referenced, but the reviewer's understand that they were sourced from the Gold Coast City Council Storm Tide Study (GHD, 2013)[9] (pers comms Logan City Council 20 Feb 2026). Table 18 of GHD 2013 notes the design storm surge levels for the Logan River mouth for 2010 as 1.80m AHD for the 1 in 20 AEP event and 1.94m AHD for the 1 in 100 AEP storm surge event. An explicit reason why the levels used in the WRM Report differ from the GHD 2013 report is not provided.

Given that historical flooding in the Logan and Albert rivers has often been the result of cyclonic activity, it could be reasonably anticipated that future floods might be associated with cyclones that would include storm surge. This is recognised by ARR in Chapter 5 of Book 6 which recommends a full joint probability analysis of catchment and ocean storm flooding be conducted for coastal floodplains in south east Queensland.

The reviewers also note that the Water Technology reviewers recommended a joint probability analysis following the ARR 2019 (v4.1) guideline be completed. The lack of such a joint probability assessment is a non-compliance with the ARR guidance.

There are a number of scenarios here that influenece the start level. It looks like pick the highest for ease.

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[8] https://www.environment.nsw.gov.au/sites/default/files/2024-07/modelling-catchment-flooding-oceanic-inundation-150769.pdf

[9] https://www.goldcoast.qld.gov.au/files/sharedassets/public/pdfs/planning-amp-building/technical-flood-reports/ghd-storm-tide-study.pdf

In lieu of a full joint probability assessment, the WRM Report completed a model sensitivity assessment of model results to the adopted downstream boundary condition. The first figure in the WRM Report Appendix F1, summarised in the WRM Report Section 10.8.2, demonstrates that changes in the downstream boundary might propagate as far upstream as Ferry Road, some 5 km upstream of the downstream model boundary. In the reviewers opinion, this is further evidence that a full joint probability assessment should be completed.

4.7 The flood frequency analysis (statistical analysis of historic events) and comparison with the model representation of historical events.

Flood frequency analyses were undertaken in the WRM Report at four sites with long continuous streamflow records (Teviot Brook, Logan River, and two sites on the Albert River) to derive relationships between flood magnitude and exceedance probability. Such analyses are of crucial importance as the estimates of flood risk are firmly grounded on observations of flood behaviour over a long period of time. While there are uncertainties associated with rating curve extrapolations and changing catchment conditions, these can be explicitly considered in the analyses; in general, it is expected that such uncertainties are small compared to the uncertainties associated with rainfall-based modelling. While the analyses used appropriate procedures to derive estimates of flood risk, the key weakness of the WRM Report analyses is that no account was given to large floods that were known to occur prior to the collection of continuous streamflow records. It is stated (the WRM Report Section 8.2) that *"No historical flood data (pre-dating the period of record) was available at any of the selected gauge sites for the study. It is of note that … the AWA (1997) study included some historical data, however this data was not available for use in this study."* However, information on the levels of floods in January 1887 and January 1947 at Maclean Bridge, Waterford, and Eagleby is published by the Bureau of Meteorology[10]. While these locations don't coincide exactly with the gauging sites used, such data has the potential to be of considerable value and any decisions made to either adopt or reject such data need to be thoroughly documented[11].

The reviewer's undertook a high level assessment of the implications of including the historical January 1887 and January 1947 in the frequency analysis. Some indication of the potential value of this historical flood data can be assessed by transposing the flood level recorded at Maclean's Bridge to the Yarrahappini gauge site. The TUFLOW modelling undertaken for historic and design events (e.g. WRM Report Figures 7.38 and 10.10) indicate that the flood levels at the Yarrahappini gauge are consistently around 6.0m higher than those at Maclean's Bridge. Using this difference (and accounting for the gauge level datum) suggests that the 1887 flood level at Yarrahappini was 21.14 m to gauge height (GH), and the corresponding flood level in 1947 was 19.57 mGH. Using the derived rating curve informed by TUFLOW modelling (the WRM Report Figure 3.8) these levels correspond to peak flows at Yarrahappini of around 4000 m^3/s in 1887, and 3080 m^3/s in 1947.

The potential value of this information can be seen by comparing results of the flood frequency analysis undertaken with and without the historical floods included. If we assume that all information on flood peaks recorded at the Yarrahappini gauge between 1969 and 2025 is accurate, then the 1 in 100 AEP flood is estimated to be 4966 m^3/s. If we then include the 1887 peak flow and assume that no flood

[10] https://www.bom.gov.au/qld/flood/brochures/logan_albert/logan_albert.shtml

[11] Section 2.3.8, Book 3, Australian Rainfall and Runoff.

greater than the 1947 event occurred between 1888 and 1946, then the estimate of the 1 in 100 AEP flood[12] is estimated to be 4030 m³/s, i.e. around 25% lower. In terms of flood levels, this corresponds to a reduction of around 1.9 m at the Yarrahappini gauging site. This degree of over-estimation is expected to reduce further downstream as the floodplain widens, and inspection of the modelling results in Figure 10.10 of the WRM Report suggests that the 1 in 100 AEP flood levels in the more populated downstream urban areas have been over-estimated by approximately 1m or more depending on the location on the floodplain.

The result of the frequency analysis is shown below, where for illustration purposes it is assumed that the 1887 flood is twice as uncertain as the top six floods recorded since 1973.

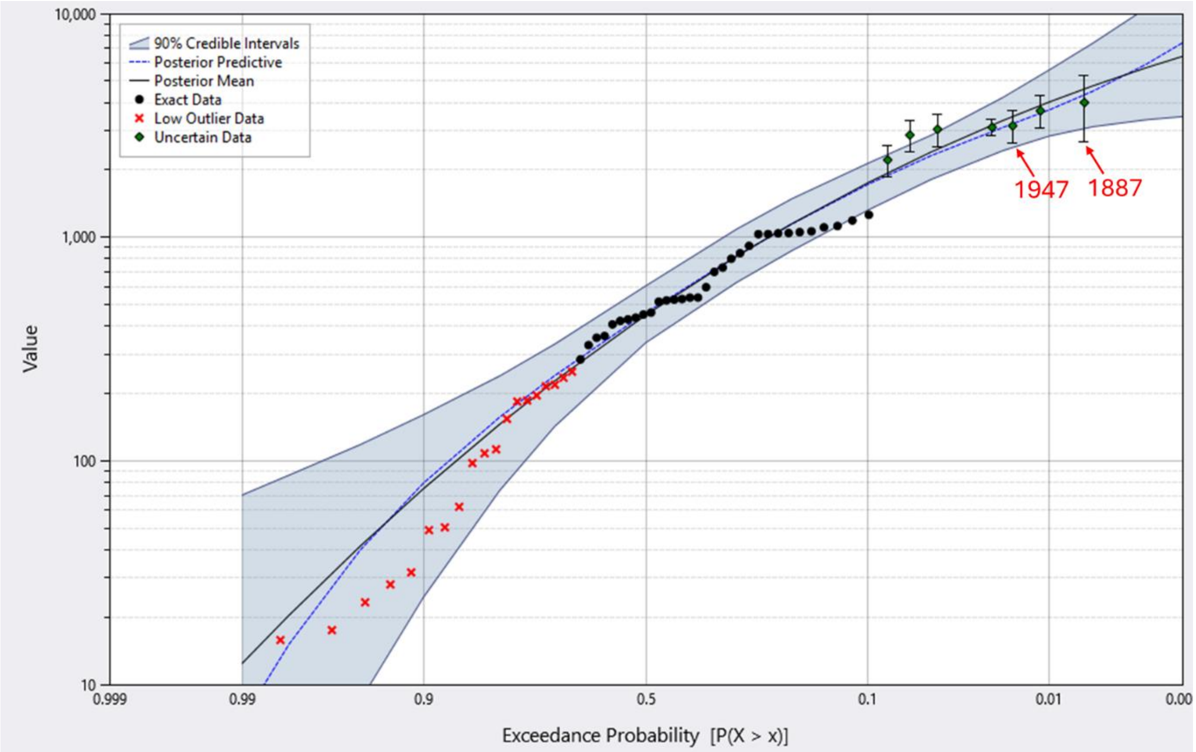

Figure 4-1: Flood frequency analysis of peak flood records at Yarrahappini gauge including the 1887 and 1947 flood events

It needs to be stressed that the foregoing analysis is provided solely to illustrate the potential importance of taking into account the 1947 and 1887 events, and it would be necessary to undertake more careful analysis of such historical information before these estimates can be relied upon. The estimate of the 1 in 100 AEP flood level at Maclean's Bridge provided in the WRM Report Table 10.6 is around 2.5m higher than the 2022 event, and around 0.8m higher than the 1887 event. The WRM estimate of the present-day 1 in 100 AEP event is around 0.8m higher than the largest flood recorded in 140 years, and this highlights an apparent inconsistency with historic evidence that is not addressed in the report. The design estimates derived by WRM suggest that the AEP of the 1887 flood is

[12] The frequency analysis was undertaken using BestFit, which is a freely available alternative to FLIKE that can be downloaded from https://www.rmc.usace.army.mil/Software/RMC-BestFit/. A comparison of BestFit with FLIKE was documented by Szemis, J., Pedruco, P., Ladson, T., & Nathan, R. (2024). Flike versus RMC-BestFit FFA Software – which one should I use? *Proceedings, Hydrology and Water Resources Symposium*, pp 434–443.

approximately a 1 in 50 AEP flood event. If the WRM estimates are correct then it would be expected that *another* flood similar in size to the 1887 event would have occurred at least once sometime in the past 140 years. Whilst not improbable, the fact that this has not occurred deserves careful investigation and discussion, and without specific counter-factual evidence to the contrary it is appropriate to conclude that the flood estimates are over-estimated. It is worth noting that the Water Technology and Carroll peer reviews also expressed concern that the 1 in 100 AEP flood levels were considerably higher than previous estimates, without expressly identifying the potential reason for the increase in levels.

The above analysis ignores the influence of Wyaralong Dam, which is consistent with the assumptions made in the WRM Report. While this may be a defensible assumption, it would be useful to investigate whether there is a correlation that needs to be explicitly considered between water levels in the dam and flood events, or whether it would be sufficient to assume dam water levels are at full supply prior to all floods of significance.

4.8 Consistency of application of climate change methods with ARR

The WRM Report assessed the impacts of climate change on flood levels using information provided in version 4.1 of Australian Rainfall and Runoff. The ARR guidelines for the assessment of climate change were updated in August 2024 (ARR version 4.2) (i.e. prior to the *Logan and Albert Rivers Flood Study Finalisation Project 2025*) to take advantage of the latest science. The key difference between versions 4.1 and 4.2 of these guidelines is that flood estimates for present-day and near-term climate conditions (up to 2030) need to account for the ~1.2°C of global warming that has *already occurred* in recent decades. The implications of this for the Logan-Albert catchment is that the rainfalls used to derive estimates of the current (i.e. present day and near-term) design floods need to be increased by around 10%.

Higher temperatures does not necessarily indicate higher rainfall, there is frequency and other inputs that could be altered

The relationship between rainfalls and flood flows and levels is highly non-linear, and while a rigorous estimate of the impact of climate change needs to be obtained by following the updated procedures in version 4.2 of Australian Rainfall and Runoff, a preliminary estimate can be made using the peer reviewed results obtained for 467 catchments around Australia[13]. This science has been incorporated into a tool recently developed for the federal Department of Climate Change Energy, the Environment and Water[14], and suggests that an increase of 10% in rainfalls for a hydroclimate region similar to the Logan-Albert catchment results in an increase in 1 in 100 AEP flood flows (based on median rates of change in rainfall intensities) of around 15%. By 2100, this increase rises to around 32%.

These figures are based on the last 200 years not the 4.5 billion of earth's history

In approximate terms, this means that climate change partly offsets the possible over-estimation of *current* flood levels discussed above, and indeed suggests that the present-day estimates of the 1 in 100 AEP flood provided by the WRM Report might represent a reasonable estimate of future flood risks in the year 2100.

The evidence used to assess the increases in flood risk due to past and future global warming[11,12] leads to the expectation that flood peaks used in the frequency analysis by the WRM Report also exhibit non-

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[13] Wasko, Conrad, Guo, Danlu, Ho, Michelle, Nathan, Rory, & Vogel, Elizabeth. (2023). Diverging projections for flood and rainfall frequency curves. *Journal of Hydrology*, *620*(129403).

[14] Ho, M., Wasko, C., Nathan, R., and Westra, S (2026): *Ready reckoner for flooding under climate change*. Report and Excel tools developed for the Department of Climate Change, Energy, and the Environment and Water. February, 2026.

stationarity. Non-stationarity in climate refers to the dynamic nature of climate drivers, where historical weather patterns are not necessarily representative of current conditions. This concept indicates that climate variables, such as temperature and rainfall, are changing over time, driven by global warming. Some indication of the possible influence of this can be determined by increasing all flood peaks recorded prior to 1975 by 15% (as determined using the abovementioned tool[12]), and those after this date are increased by a factor that linearly decreases to zero in 2025. That is, it is assumed that floods are increased by a factor that gradually increases back in time to account for the changing influence of global warming. Repeating the analysis undertaken for Figure 5-1 with all flood peaks adjusted in this manner, suggests that the degree of overestimation in the current 1 in 100 AEP flood peak reduces from approximately 25% to 20% (or in flood level terms, from approximately 1.9m to 1.6m).

Note that increases in flood levels are highly non-linear as the flood flows pass downstream into the widening floodplain. Inspection of the TUFLOW modelling results in WRM Report Figure 10.10 suggests that the 1 in 100 AEP flood levels in the more populated downstream areas are likely to remain over-estimated by approximately 1m or more, even with the relative reduction in flood peaks for climate change discussed above. The quantification of these issues with the flood study results would require a significant reworking of the flood study models.

4.8.1 Sea level Rise

For the assessment of coastal flooding, the Queensland government has formally adopted an allowance for sea level rise of 0.8m by 2100 compared to the baseline period from 1986-2005[15] based on climate change scenario RCP 8.5.

Adopting the median year of 1995 as representative of the baseline, 0.8m of sea level rise to the year 2100 equates to an average annual sea level rise of 7.6 mm/year.

The WRM report Section 10.3.5, page 178 notes:

as stated before look at Fort Denison tides

> *The mean high water springs (MHWS) tide level was obtained from Department of Transport and Road (TMR) Queensland Tide Tables (TMR, 2020), and was adjusted by 0.8m to account for sea level rise in the 2090 future climate scenario.*

The WRM report Section 10.3.6 notes:

> *A fixed MHWS boundary condition was adopted for these events. A MHWS level of 0.99 mAHD was adopted for the current climate condition. A MHWS level of 1.79 mAHD was adopted for the 2090 climate change scenario.*

On the basis that the MHWS level of 0.99m AHD is representative of 2020 tide statistics (Department of Transport and Road (TMR) Queensland Tide Tables (TMR, 2020)), and assuming the average annual sea level rise of 7.6 mm/year as per RCP 8.5 holds over the 70 year period from 2020 to 2090, the sea level rise to 2090 would equate to 0.53 m, which is 0.27 m less than the 0.8 m sea level rise allowance applied in the WRM Report.

Further, we understand that Council has formally adopted RCP4.5 for climate change planning (rather than the more conservative RCP 8.5).

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[15] https://www.qld.gov.au/environment/coasts-waterways/plans/hazards/sea-level-mapping

Sea level rise projections estimated using the NASA sea level projection tool[16] for 2090 for SSP2-4.5 provide a sea level rise estimate of 0.46 m for Brisbane Bar (see Figure 4-2) which is 0.34 m less than the 0.8 m sea level rise allowance applied in the WRM Report.

Based on this analysis, the downstream tailwater levels adopted in the WRM Report for events up to the 1 in 20 AEP event for 2090 are overestimated by between 0.27 m and 0.34 m, which is significant in the context of floodplain planning.

The WRM report Section 10.3.7 notes:

> *A time varying 5% AEP storm surge tidal boundary was adopted for these events, with the peak of the storm surge adjusted so that it coincides with peak of the flood wave at Reidel Road. The peak 5% AEP storm surge level adopted for the current climate is 1.88 mAHD. The peak for the 2090 climate change scenario (RCP4.5) is 2.53 mAHD.*

Again, the source of these levels is not referenced, but it is assumed that they are sourced from GHD (2013). Table 18 of GHD (201)3 has storm surge estimates for the 1 in 20 (5%) AEP event at the Logan River mouth of 2.28 m AHD for 2060 and 2.70m AHD for 2100. Interpolating these values for 2090 provides a value of approximately 2.6 m AHD. On this basis it appears that the 2090 storm surge value adopted in the WRM Report is underestimated.

[16] https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

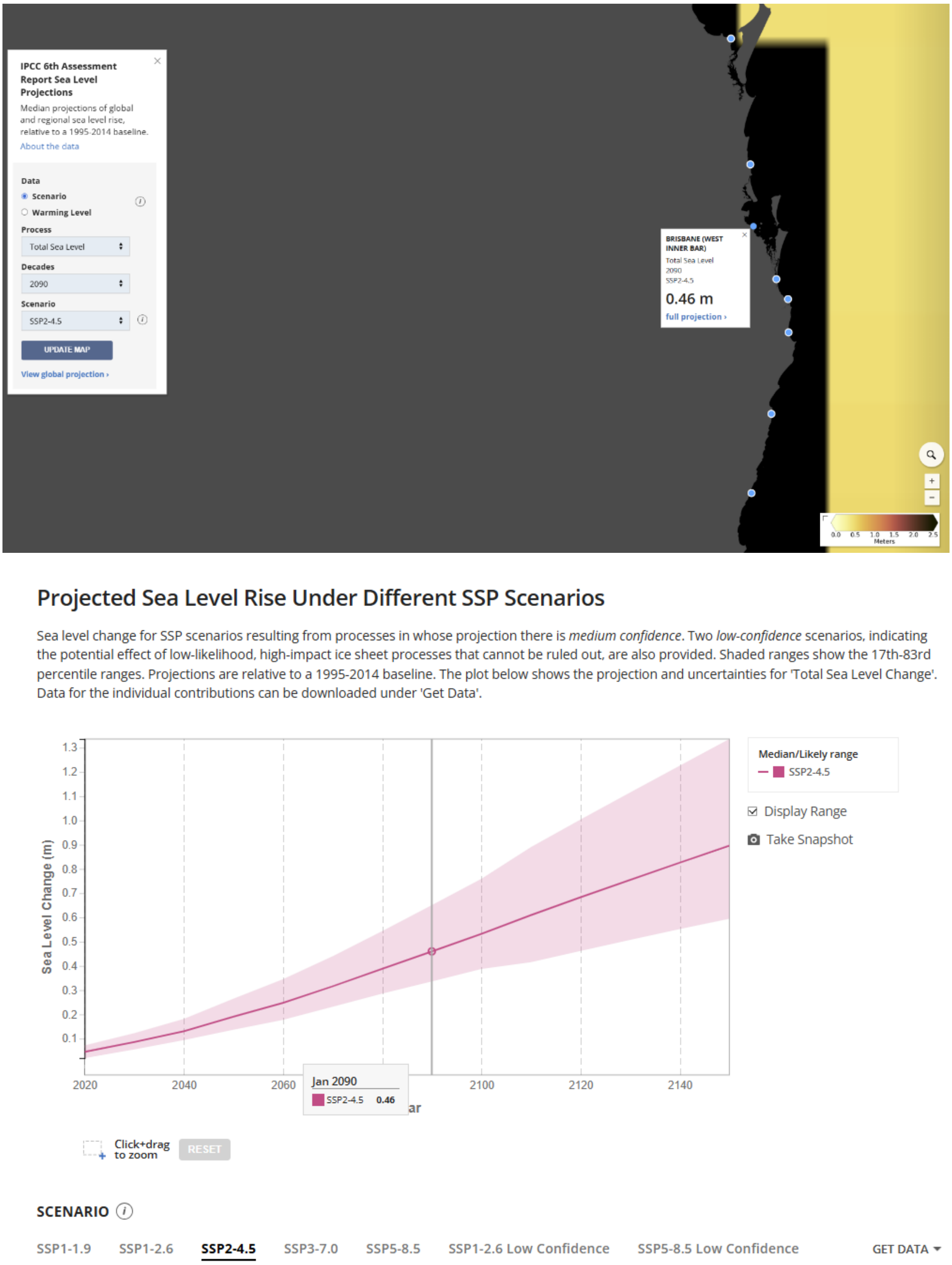

Figure 4-2: Sea level rise projection SSP2-4.5 for 2090

4.9 Commentary on the fitness-for-purpose of resulting design flood levels for application in land use planning and development control.

Our review has found that while the overall approach of the WRM Report flood study is sound, the following aspects of the study are inconsistent with the current version of ARR (v4.2, 2024):

1. Design rainfalls applied to represent present day (2020) catchment conditions
2. Design rainfalls applied to represent future (2090) catchment conditions
3. Joint probability of design downstream boundary conditions applied to estimate present day (2020) and future (2090) design flood conditions

Further, the flood model results as presented are dependent on several key assumptions that are not fully consistent with the available evidence as inferred using version 4.1 of ARR, particularly with regard to the catchment hydrology. In particular:

- The study failed to give consideration to information on documented historic floods that occurred prior to systematic gauging records, and this omission has led to design flood level estimates for present day catchment and climate conditions that are likely to be significantly over-estimated.
- These over-estimates are partially offset by the lack of account given to global warming that has already occurred, and to the underestimation of the future impacts of climate change (noting that the relevant guidelines have been revised since the study was undertaken).
- The approach used to match the results of rainfall-based (XP-RAFTS) modelling to the flood frequency results reduces the level of independence between the two sets of estimates, and consequently reduces confidence in the results.
- The study has not adequately documented the assumptions and approach adopted to account for storm surge levels in Moreton Bay and insufficient consideration has been given to the joint probabilities between storm surge and catchment floods.

But because global temperatures will continue to rise at an increasing rate, the question of whether the design levels derived by WRM are “fit for purpose” is not as straightforward to address as it has been in the past. As a general approximation, the risk of flooding is likely to double by the end of this century. That is, by 2100 we can expect a flood of the magnitude of the February 2022 event to occur twice as often as it has in the past. Or in other words, given that there is a 22% chance that a house located in the 1 in 100 AEP flood zone will be inundated at least once in 25 years (the typical period of a house mortgage), by 2100 this probability will increase to 44%.

In simple terms, this level of risk is similar to placing the life-savings of a householder on the outcomes of a coin-toss: there is almost a 50:50 chance that a house will become inhabitable one or more times over the period of a typical mortgage. Many people, if properly informed, are likely to find this level of risk intolerable, and it is increasingly likely that such housing stock will become uninsurable for practical purposes. It is thus appropriate that flood planning levels need to account for both near-term risks as well as future risks, and on this basis it could be argued that an over-estimate of the present-day 1 in 100 AEP flood levels are fit for longer-term planning purposes in representing flood risk in 2100. The extent to which this is a defensible argument depends on exactly the degree of over-estimation involved across the flood-prone areas of most interest, and in the risk tolerance of the community.

Council should carefully consider these shortcomings in the flood model outputs in ongoing floodplain risk management and planning, noting that industry is only recently coming to terms with the implications of global warming so there is little established practice to guide the process.

4.10 Determine and advise on the study's Probable Maximum Flood (PMF) frequency and PMF error bounds including any potential compounding effects.

RUBBISH AREA, AS IT CANNOT BE DETERMINED

The Probable Maximum Flood (PMF) is a hypothetical flood estimate relevant to a specific catchment whose magnitude is such that there is negligible chance of it being exceeded. The PMF represents a notional upper limit of flood magnitude, and is differentiated from the Probable Maximum Precipitation Design Flood (PMPDF) in that the assumptions adopted in its estimation are slightly more conservative (i.e. more extreme) than those used for the PMPDF. This point is noted here as the study purports to have provided estimates of the PMPDF, not the PMF, though the practical difference between the two estimates is likely to be negligible for this catchment.

The concept of the PMF has been an important element in design flood standards for dams and other critical infrastructure assets (such as nuclear power plants) in the United States and Australia over the past 60 to 70 years. The PMF is also used in some jurisdictions to define the extent of flood-prone land, though in these reviewers' experience the PMF is only used to inform such purposes in Queensland and NSW, but not in other Australian States. In this regard it is worth noting that the Queensland Flood Commission of Inquiry recommended[17] that for "*urban areas or areas where development is expected to occur: councils with the requisite resources should develop a flood map which shows 'zones of risk' (at least three) derived from information about the likelihood and behaviour of flooding*"

The "zones of risk" relevant to floodplain planning is typically focussed on 1 in 100 AEP events; that is, on areas of the floodplain where the risk of flooding in any given year is 1% (i.e. 1 in 100). While most householders do not think in terms of such probabilities of exceedance, the important point to note – and this is highlighted in the Queensland Flood Commission of Inquiry recommendations – is that all houses in a floodplain are vulnerable to flooding, regardless of whether they are located below or above the specified flood planning level. Flood planning levels merely represent a threshold of flooding risk that is deemed tolerable by the community, where houses above a specified flood planning level are less likely to flood than houses located below this level. In general there is no such thing as house located on a floodplain that can be considered entirely "safe" from flooding.

Strictly speaking the methods used to derive PMFs are not amenable to estimating the associated exceedance probabilities, but we can be confident that the AEP of a PMF is many times rarer than 1 in 100. The recommended annual exceedance probability for the PMPDF (which is slightly higher, i.e. less rare, than the corresponding PMF) is around 1 in 800,000 based on regional information[18], though it should be noted that more rigorous estimates based on site-specific studies[19],[20] imply that the annual

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[17] Recommendation 2.13a, Queensland Floods Commission of Inquiry, Final report, March 2012.

[18] Figure 8.3.2, Book 8, ARR

[19] Nathan, R., Jordan, P., Scorah, M., Lang, S., Kuczera, G., Schaefer, M., & Weinmann, E. (2016). Estimating the exceedance probability of extreme rainfalls up to the probable maximum precipitation. *Journal of Hydrology*, *543*, 706–720.

[20] Lang, S., Nathan, R., Shea, D. O., Scorah, M., Zhang, J., Kuczera, G., & Schaefer, M. (2019). Estimating Extreme Rainfall Probabilities for Large Catchments in Northern Australia. *2019 ANCOLD Conference. Auckland,10th-11th October,2019*.

exceedance probability of the PMF is more like 1 in a million, or even 1 in 10 million. The uncertainties around these estimated exceedance probabilities are very large, and are at least an order of magnitude (e.g. the uncertainty around the 1 in a million estimate will exceed a range between 1 in 100,000 and 1 in 10 million).

To place these risks in a floodplain planning context, it is estimated that just over two million homes, or one in six (17%), of Australia's 11.7 million residential properties are identified as being affected by varying levels of flood risk[21] (given the historical and regional flood map information sources used, it is reasonable to assume that the threshold relevant to "flood risk" considered here is 1 in 100 AEP). The bulk of flood-risk properties are concentrated in the larger east coast states, led by Queensland (40%) and New South Wales (30%).

Even given the large range of uncertainty in the risk of the PMF, it is hard to see their relevance to planning controls in a floodplain. That is, if one in six households across Australia are already vulnerable to 1 in 100 AEP floods, it is hard to conceive of a rationale that would support adoption of a planning level to accommodate risks that are a thousand-, or million-fold rarer. Knowledge of the PMF may be relevant to emergency services or other agencies responsible for managing life safety risks at the societal level (e.g. the design of dams to prevent failure in the event of flooding or earthquakes), but such extreme risks are not relevant to the management of infrastructure and housing in the floodplain.

In line with the recommendations of the Queensland Flood Commission of Inquiry, it would be prudent to publish flood maps for a range of exceedance probabilities as this would enable the community to appreciate flood inundation risks over a range relevant to other hazards that they are familiar with. For example, maps showing flood extents associated with AEPs of 1 in 50, 1 in 100, and 1 in 500 would provide information on flood hazards relevant to risks that are considered by insurers when setting premiums. Conversely, publishing maps of the flood extent associated with the PMF represent risks that are at least a thousand-fold less likely, and it is considered that such information is more likely to be alarming rather than helpful, as the risks involved are wholly disproportionate to engineering and design standards adopted for general civil infrastructure.

4.11 Commentary on whether the flood study was completed using AI, Monte Carlo analysis or pilot/experimental methodologies.

There is no evidence in the flood study report that Artificial Intelligence (AI), Monte Carlo analysis or pilot/experimental methodologies were applied in the flood study methods. While it is considered that there would be advantages to adopting Monte Carlo procedures to provide additional confidence in the results[22], the use of the more simple ensemble approach (as adopted by the WRM Report) is considered acceptable. The reviewers are not aware of any study in Australia that has relied upon AI for deriving design floods, and there is currently no evidence that such methods have any utility for such purposes.

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[21] PropTrack Climate Council Property Value Flood Risk Report (Creagh, E., et al. (2025): Property Value Flood Risk Report: how floods are impacting Australian property values. Proptrack and Climate Council).

[22] As is discussed in Section 3 of Book 4, ARR

5 Conclusions

Our review found that the general approach used in the study is in line with industry practice as it existed at the time of the study. The investigation as reported can be divided into the following five major steps, which are endorsed:

1. Collation of information on past floods, where focus was largely given to events that have occurred over the past 50 years based on continuously recorded rainfall and streamflow data
2. Development of a hydrologic model (XP-RAFTS) to estimate *peak streamflows* from recorded rainfall events at specific locations in the Logan catchment
3. Development of a hydraulic model (TUFLOW) to estimate *flood levels* from streamflows
4. Statistical analysis of peak streamflows from continuously gauged records
5. Processed information on rainfalls to derive streamflows (using RAFTS) and inundation levels (using TUFLOW) for "design floods" of varying severity ranging from frequent to the "probable maximum flood", which includes floods with a "1 in 100" chance of being equalled or exceeded in any one year.

Our review found that the development of the two dimensional TUFLOW floodplain model followed the principles of the national best practice guideline *ARR Project 15 - Two dimensional modelling in Urban and Rural floodplains*. The model resolution and schematisation are suitable to simulate the spread of flood flows across the floodplain.

Similarly, the approach used to schematise the XP-RAFTS catchment runoff model is consistent with common industry practice. The XP-RAFTS model configuration is suitable for capturing differences in flood response across the sub-catchments upstream of the gauging stations, and is well suited to satisfying the upstream boundary conditions for the TUFLOW model.

While these two models as configured have been shown to adequately reproduce the observed behaviour of historical flood events, there are shortcomings with their application to support design flood estimation.

The design flood model results as presented are dependent on several key assumptions that are not fully consistent with the available evidence as inferred using version 4.1 of Australian Rainfall and Runoff (relevant at the time of the execution of technical work supporting the study), particularly with regard to the catchment hydrology. In particular:

- The study failed to give consideration to information on documented historic floods that occurred prior to systematic gauging records, and this omission has led to design flood level estimates for present day catchment and climate conditions that are likely to be over-estimated.
- These over-estimates are partially offset by the lack of account given to global warming that has already occurred, and to the underestimation of the future impacts of climate change (as noted below the relevant guidelines were revised after the modelling work was undertaken).
- The approach used to match the results of rainfall-based (XP-RAFTS) modelling to the flood frequency results reduces the level of independence between the two sets of estimates, and consequently reduces confidence in the results.
- The study has not adequately documented the assumptions and approach adopted to account for storm surge levels in Moreton Bay and insufficient consideration has been given to the joint probabilities between storm surge and catchment floods.

Further, our review found that the following aspects of the study are inconsistent with the current version of ARR (v4.2, 2024), which was released after the modelling was undertaken for the WRM report:

1. Design rainfalls applied to represent present day (2020) catchment conditions
2. Design rainfalls applied to represent future (2090) catchment conditions
3. Joint probability of design downstream boundary conditions applied to estimate present day (2020) and future (2090) design flood conditions

The issue of climate change considerably complicates how best to manage long-term floodplain risks. Climate change is no longer an abstract concept that lies in the distant future. We now have unequivocal evidence that greenhouse gas emissions have warmed global surface temperatures above pre-industrial levels, and this warming has caused an increase in many drivers of flood risk, including an intensification of extreme rainfall events and the elevation of average and extreme sea levels. While we were once solely reliant on climate models to inform our understanding of changing flood risks, the impacts of global warming on extreme rainfalls and floods in Australian catchments are already being observed and measured.

While this review has found that the flood levels reported in the WRM Report were over-estimated based on gauging records, changes to the national flood guidelines in 2024 (ARR V4.2) highlight the need to account for the gradual increases in floods that have occurred due to global warming over the past few decades, as well as into the future. These increases are expected to partially offset the degree of over-estimation inherent in the original study. As a general approximation, the risk of flooding is likely to double by the end of this century. It is thus appropriate that flood planning levels need to account for both near-term risks as well as future risks, and it could be argued that an over-estimate of the current flood levels are fit for longer-term planning purposes. The extent to which this is a defensible argument depends on the degree of over-estimation involved across the flood-prone areas of most interest, and in the risk tolerance of the community.

Further, Council specifically requested our opinion on the frequency and error bounds including any potential compounding effects of the Probable Maximum Flood (PMF). We note that the AEP of a PMF is approximately ten thousand times rarer than 1 in 100. The uncertainties around these estimated exceedance probabilities are very large, Accordingly, it is suggested that flood risk maps published for local planning schemes, including zones and overlays for lands subject to inundation, should focus on a narrow range of flood risks relevant to development controls (e.g. floods with a 1 in 100 chance of being exceeded in any one year), where information on rarer floods (e.g. the Probable Maximum Flood) are held by agencies responsible for assessing life-safety risks.

Totally agree with the conclusion that LCC has provided WRM rubbish and we all know "crap in=crap out".
Yes to 1% AEP level shown, that leads to insurance companies saying "well it has been 50 years since last Q100 so we do not expect another flood for 50 years so we will give you flood insurance.
Maximum Flood is a joke.
Use todays levels and only adjust if the previous year is higher.
Refine to use auctual accurate datasets not assumed or interpreted.
Use 'As Constructed' data for point nodes not estimated ones.
Allow for two tide events, HAT and LAT to determine innundation amounts
Use today's data not yesterdays. Yesterdays occurred under different circumstances

Appendix A Flood study delivery timeline

The information below on the flood study timeline was provided by Council on 20 February 2026.

Logan Albert Rivers Flood Study Delivery Timeline.

Study Name	Report Number	Delivery Date and Updated Data	Comments
Logan and Albert Rivers Flood Study 2021	0936-11-F3	16 April 2021	Council commissioned the flood study in May 2019. Model calibration was undertaken as part of this study. Note: Two TUFLOW models were set up, referred to as the 'Fast Model' and the 'Detailed Model'.
Peer Review of Logan and Albert Rivers Flood Study by Water Technology Pty Ltd	19020079_R01_V01	05 May 2020	Council commissioned this peer review study in May 2019.
Review of Logan and Albert Rivers Flood Study issued by WRM and dated 24th March 2020 (by Don Carroll)		19 August 2020	Council commissioned this peer review study on 11th June 2020.
Logan and Albert Rivers Flood Study Finalisation Project 2023	0936-13-G3	24 May 2023	Validation of the model against the 2022 event was undertaken as part of this study. The topography was also updated using LiDAR survey data flown in December 2021 and provided to LCC in July 2022. Implemented the TUFLOW TCF command *Grid Output Origin == model origin* command. This report was used for the draft planning scheme public consultation in 2025 (was held from September 1 to October 31, 2025).
Logan and Albert Rivers Flood Study Finalisation Project 2023 – Updated report only	2045-01-B1	31 October 2025	Updated Table 7.1, Table 10.3 and Section 10.8.4 to correct a few typos.

Appendix B CVs

Grantley Smith

In his 30+ years as a professional engineer, Grantley has developed his skills on a broad range of projects providing assessment and solutions for water engineering and water resources investigations. He is a team leader with a proven track record for leading multi-disciplinary teams delivering practical solutions to environmental investigations. He has particular expertise in the selection and application of appropriate physical or numerical models to support design solutions, planning, management and forecasting across the water spectrum.

Grantley has specialist expertise in water resources management through a hands-on career investigating catchment processes. He is acknowledged by his peers as an expert in modelling catchments and floodplains and was instrumental in the pioneering use of 2D hydrodynamic models for floodplain flow prediction and inundation mapping. His experience gained through direct participation in the evolution of floodplain modelling has provided him with an outstanding knowledge of the application and interpretation of appropriate models to support environmental planning, management and forecasting for floodplains. Grantley is a lead author and key contributor to reports supporting the revision of Australian Rainfall and Runoff, most recently contributing to guidelines for appropriate use of numerical models and flood safety. He is also the lead author of the guideline on flood hazard assessment supporting the national best practice manual Managing the floodplain - a guide to best practice in flood risk management in Australia (AEMI Handbook 7). His skills include the simplification of technical data and modelling outputs in to forms readily communicated to non-technical stakeholders.

Qualifications and affiliations

BE Hons (Civil Engineering), UQ
MEngSc (Water Engineering), UNSW
CPEng, FIEA (Chartered Professional Engineer, Fellow Engineers Australia)
NPER, RPEQ (National Professional Engineers Register, Registered Professional Engineer Queensland)
Past Chair: Engineers Australia Sydney Water Panel

Professional history

2022 -	Co-Founder and CEO Restore Blue
2020-2022:	Director – Industry Research, UNSW WRL
2012-2020:	Principal Engineer & Manager, UNSW WRL
2009-2011:	Senior Project Engineer, UNSW WRL
1999-2009:	Principal Engineer NSW State Manager, DHI Water and Environment, Australia
1990-1999:	Engineer/Senior Engineer, Lawson and Treloar, NSW

Expertise

- Project management
- Hydrological processes and modelling
- Water resources management
- Surface water/groundwater interactions
- Flow forecasting
- Blue Carbon Wetlands
- Hydrodynamic and water quality modelling
- Wetland hydrology
- Environmental flow delivery
- Estuarine processes
- Hydraulic structures

Grantley Smith T +61 (0) 410 309 243 | e: grantley.smith@restoreblue.org

Summary of relevant experience

Wetland restoration
Blue Heart Blue Carbon Pilot Project, QLD
Tomago Wetlands, NSW
Yarrahappini Wetlands, NSW
Chowilla floodplain baseline, SA
Chowilla floodplain options, SA
Koondrook Forest, NSW
Gunbower Forest, VIC
Macquarie Marshes, NSW

Rivers and flooding
Hydraulic and cost benefit assessment of the impact of climate change on the Hunter Valley Flood Mitigation Scheme, NSW
Newcastle city-wide floodplain risk management plan, NSW
Lower Hunter River floodplain, NSW
Ironbark Creek floodplain, NSW
Middle Creek flood and sediments, NSW
Woy Woy flooding, NSW
Darling River, Bourke - Louth, NSW
Dark Creek flooding, NSW
River Murray environmental flow easements, NSW
Haslam Creek hydraulic investigation, NSW
Frenchs Creek FPMS, NSW
Warrah Creek flooding, NSW
Blackman's Swamp Creek FS, NSW
Mawson Lakes channel, SA
Flood damage assessment, Czech Republic
Bohle River flood study, QLD
Onion Creek, Texas, USA
Tenterfield flood study, NSW
Brickfield Creek flood study, NSW

Flood hazard
Flood fatalities estimation
National Flood Hazard Guideline – AEM Handbook 7
Flood hazard – analysis methods

Hydrology and forecasting
Wollondilly/Wingecarribee, NSW
Shoalhaven (Tallowa Dam), NSW
SCA real-time forecasting system framework, NSW
Vistula River, Poland

Dams and structures
Somerset Dam, QLD
Lake Macdonald, QLD
Hume Dam gate operations, NSW
Copeton Dam fuse plug EIA, NSW
Tumut 3 turbine upgrade, NSW
Chaffey Dam break, NSW
Bethungra Dam break, NSW
Potts Hill reservoir, NSW
Cordeaux Dam break, NSW
Avon Dam break, NSW
Nepean Dam break, NSW

Water and wastewater
Sydney Water sewer sediment blockage analysis, NSW
Maldon odour control, VIC
Sydney Water two-phase, dynamic H2S model scoping, NSW
Industrial waste impacts, Sydney Water, SWOOS, NSW
Balickera pump station upgrade, NSW
Sydney Water SCAMPS, NSW
Northside storage tunnel, NSW
Shelly Beach H2S assessment, NSW

Coasts, estuaries and outfalls
Hunter River water quality model, NSW
Sydney desalination plant outfall, NSW
Newcastle Harbour extreme ocean water levels, NSW
Port Jackson model, NSW
SWC SOLP receiving waters, NSW
Illawarra outfall design and commissioning, NSW
Danish Olympic Sailing Team – Sydney Olympics, NSW
Cooks River dispersion study, NSW
Lake Illawarra entrance, NSW
Kikori River pipeline stability, PNG

Panels and review
Sydney Water – Review of SWOOS upgrade at Mill Stream
NSW Department of Planning – Warragamba Dam Wall raising expert review
TfNSW – Warragamba Dam Wall Raising evacuation model
VIC DELWP flood program - peer review
QLD CSG surface water review
Ord River irrigation scheme expansion
Lower Lakes acid sulphate review
NSW Rivers environmental restoration program, hydraulic modelling

Selected publications

Gissing, A., Hamilton, K., **Smith, G.,** & Peden, A. (2023, February 22). Vehicle-Related Causes of Flood Fatalities. *Oxford Research Encyclopedia of Natural Hazard Science* https://oxfordre.com/naturalhazardscience/view/10.1093/acrefore/9780199389407.001.0001/acrefore-9780199389407-e-438

Smith, G and Cox, R. (2019) ARR Book 6 Chapter 7. Safety Design Criteria

Smith GP, Modra BD, Felder S, Full-scale testing of stability curves for vehicles in flood waters. *J Flood Risk Management*. 2019; 12 (Suppl.):e12527. https://doi.org/10.1111/jfr3.12527

Smith, Grantley & Rahman, Priom & Wasko, Conrad. (2016). A comprehensive urban floodplain dataset for model benchmarking. *International Journal of River Basin Management*. 14. 1-23. 10.1080/15715124.2016.1193510.

Rahman, P, Sharma, A and **Smith, G** 2011 'Estimating design floods for gauged urban catchments under climate change conditions case study: Cooks River, Sydney', *Proceedings 34th IAHR World Congress,* 2011, Brisbane, Australia.

Shand, T D, **Smith, G P**, Cox, R J and Blacka, M J 2010 'Development of appropriate criteria for the safety and stability of persons and vehicles in floods', *Proceedings 34th IAHR World Congress,* 26 June-1 July 2011, Brisbane, Australia.

Shand, T D, Cox, R J, **Smith, G P** and Blacka, M J 2010 'Appropriate criteria for the safety and stability of people in stormwater design', *Proceedings Stormwater 2010,* Stormwater Industry Association, 8-12 November 2010, Sydney, Australia.

Van Kalken, T, Madsen, H, Skotner, C, Pedersen, C B and **Smith, G** 2007 'A functional decision support system for the optimisation of dam operations, NZSOLD 2007', *Dams - Securing water for our future*, 17-21 November 2007, Queenstown, NZ.

Sakal, A, **Smith, G P** and Klinting, A 2006 'Managing catchment inflows using real-time flow forecasting', *30th Hydrology and Water Resources Symposium*, Launceston, Tasmania.

Carr, R S and **Smith, G P** 2006 'Linking of 2D and pipe hydraulic models at fine spatial scales', online, *2006 7th International Conference on Urban Drainage Modelling and the 4th International Conference on Water Sensitive Urban Design*, Book of Proceedings, pages: 888 – 895.

Smith, G P and Carr, R S 2005 'Linked 2D overland and 1D pipe system modelling for urban flooding', *Proceedings - NZWWA 4th South Pacific Conference on Stormwater and Aquatic Resource Protection*, Auckland.

Green, J, **Smith, G P** and Varley, I 2005 'A guide to rainfall-runoff-routing model selection', *Proceedings - 29th International Hydrology and Water Resources Symposium*, Canberra.

Smith, G P and Green, J 2005 'Design flood loss estimation using a continuous modelling approach', *Proceedings - 29th International Hydrology and Water Resources Symposium*, Canberra.

Smith, G P, Perrens, S and Carr, R S 2003 'Calibration of overlapping hydrologic and hydraulic flood models to limited historical data', *Australian Journal of Water Resources*, IEAust, 6(2):151 – 158.

Smith, G P, Wilson, G E and Jorgensen, G 2001 'MIKE flood watch - A physically-based, real-time flood monitoring and flood forecasting system', *2nd Victorian Flood Management Conference.*

Carr, R S, **Smith, G P**, Lincoln Smith, M and Jack, C 1999 'Linking of hydraulic models with ecologic assessments', *8th International Conference on Urban Storm Drainage.*

Carr, R S, **Smith, G P** and Bacon, P 1999 'A time series modelling approach for assessment of environmental conditions', *8th International Conference on Urban Storm Drainage.*

Smith, G P, Lincoln Smith, M, Jack, C and Carr, R S 1997 'The way water moves - linking hydrology and river hydraulics with ecology', *24th Hydrology and Water Resources Symposium.*

Smith, G 1994 'A comparison of one and two-dimensional models as applied to a floodplain - the Hexham Swamp Inundation Study', online, *1994 International Conference on Hydraulics in Civil Engineering: 'Hydraulics Working with the Environment',* Preprints of Papers, p 25 – 30.

Smith, G P 1993 ‘A practical application of an unsteady, two layered model to stratified flow in an estuary’, *University of New South Wales, Australia, School of Civil Engineering, Civil Project Report.*

Treloar, P D, Roper, A M and **Smith, G P** 1993 ‘Lake Illawarra - numerical modelling of entrance processes’, *11th Australasian Conference on Coastal Engineering.*

Curriculum Vitae

Professor Rory Nathan

PROFESSORIAL FELLOW, UNIVERSITY OF MELBOURNE
DIRECTOR, RJN HYDROLOGY PTY LTD

QUALIFICATIONS

B.E.(Agr), University of Melbourne, 1980

M.Sc., D.I.C., University of London (Groundwater Modelling), 1984

Ph.D., University of Melbourne (Hydrological Regionalisation), 1990

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

Fellow, Institution of Engineers, Australia

Previously, Floods Committee, International Committee on Large Dams (ICOLD Aust. Rep.)

Previously, Hydrology Sub-committee, NSW Dams Safety Council

AWARDS

National Civil Engineer of the Year, 2000

W.H. Warren Medal (1992, 1998, and 2005) for best paper in Civil Engineering

G.N. Alexander Medal (1998) for best paper in Hydrology and Water Resources

Named as one of Australia's "Most Influential Engineers" by Engineers Australia (2009)

Munro Orator, an invited talk by "a person eminent in the field of water resources in Australia." (2018)

"Presidents Medal" awarded by President of Engineers Australia for key role in developing national flood guidelines (2019)

Summary of Competencies

Rory Nathan is one of Australia's leading hydrologists with an international reputation for the application of leading research to solving practical problems. He has around 40 years' experience in various organisations in Australia and overseas, covering academia, the public service, and consulting. He has made a substantial contribution to industry best practice in a range of engineering and environmental fields, particularly in the characterisation of flood risks, the assessment of climate change impacts, the investigation of farm dam impacts, the assessment of sustainable limits on the use of water resources, hydrologic model development and application, regionalisation, and stochastic hydrology. He has published over 120 research papers on engineering and environmental hydrology in refereed journals and books, and 150 papers in refereed conference proceedings.

Rory is also a member of the statutory Independent Expert Scientific Committee under the auspices of the federal Department of Climate Change, Energy, the Environment and Water, which advises state and federal government bodies on the environmental water impacts of coal seam gas and coal mining.

Research Activities

- Impact of climate change on flood risk estimation
- Impact of climate change on water resources and on the frequency, occurrence, and nature of hydrologic extremes.
- Evaluation of hydrologic stress under climate change
- Impact of climate change on environmental condition.
- Impact of climate change on reservoir yields
- Impact of farm dams and land-use change on streamflows
- Development of probabilistic flood forecasts using event-based models
- Assessment of utility of paleo-hydrological techniques to inform the assessment of catchment yields and water supply security under conditions of climate change (ARC Research project, with Melbourne Water and Dept Land, Water and Environment Planning)

Selection of Consulting and Industry Activities

- Member, Ministerial Advisory Council for flood mitigation manuals, Department of Local Government, Housing and Public Works (DLGPW) Queensland
- Technical reviews for Melbourne Water (Maribyrnong River flood study, Yarra River flood study, Afflux Practice Note, Greenvale Reservoir, Cardinia Dam), Victoria

- Member, Independent Hydroclimate Science Expert Panel to provide the Murray Darling Bains Authority with strategic advice on future hydroclimate approaches to meet policy and planning needs.
- Systematic review of science and revision of national guidelines on the impact of climate change on flood estimation for federal Dept of Climate Change Environment Energy and Water.
- Review of guidelines for Victorian government on assessing the impact of climate change on water engineering and treatment design
- Hydrologic review of the Victorian Murray Floodplain Restoration Projects for ecological benefits under climate change
- Review of BHP's guidelines on water management operations under climate change
- Assessment of the impact of climate change on delivery of environmental water in the Goulburn River catchment for the Victorian government
- Technical support and review of an assessment undertaken by Icon Water into the sustainability of Canberra water supplies under future climate change
- Assessment and review of the impact of climate change on sustainable yields for Yan Yean reservoir
- Review of analysis and reporting undertaken by CSIRO into the flood risk factors in the Northern Rivers region of NSW
- Provision of expert witness testimony for the Class Action proceedings heard by the NSW Supreme Court related to the 2011 Brisbane River floods
- Member Expert Review Panel for the raising of Wyangala and Dungowan Dams
- Expert advisor for two committees reporting to State Ministers (Vic and NSW) and Ministerial Council regarding the efficacy of environmental water delivery under the Murray Darling Basin plan.
- Technical review and support for assessment of Melbourne Water sewer drainage system using continuous simulation techniques under climate change
- Technical review and support for estimation of extreme rainfall risks (spanning AEPs of 10^{-2} to 10^{-6}) for several catchments in central and south-eastern Queensland, NSW, and Northern Territory (Burdekin River, Burnett River, Brisbane River, Hawkesbury-Nepean Rver, Lachlan River, Ord River)
- Provision of expert advice to Melbourne Water and Barwon Water on characterisation of potential changes to catchment yields and recharge processes, and to the Bushfire and Natural Hazards CRC on adequacy of current research capability for assessing bushfire impacts
- Undertaking of applied research into the impact of climate change on environmental outcomes for MDBA and Melbourne Water.
- Provision of technical advice and review to the Department of Environment, Land and Water on long term water resource assessment
- Specialist advisor/reviewer for estimation of extreme rainfalls to inform overtopping risks of major dams (WA, NT, Qld and NSW)

Awards:

1992 : *W.H. Warren Medal* for best paper in the discipline of civil engineering published in any of Engineers Australia's journals, conference proceedings or any other document recognised as a formal Engineers Australia publication.

1997 : Best Research Paper Award – *J. Irrigation & Drainage Engineering*, American Society of Civil Engineering.

1999 : *G.N. Alexander Medal* for best paper in hydrology and/or water resources published in an Engineers Australia publication.

: *W.H. Warren Medal* for best paper in the discipline of civil engineering.

2000 : national *Civil Engineer of the Year*, awarded by Engineers Australia to an "eminent civil engineer considered to have made a major contribution to the profession"

2005 : *W.H. Warren Medal* for best paper in the discipline of civil engineering (I am the only person to have won this three times).

2009 : Listed in Engineers Australia as one of Australia's "*most influential engineers*" (across all sectors of the industry), *Civil Engineers Australia*, June 2009.

2010 : Appointed as Ambassador to "2010 Year of Engineering Leadership", which involved writing articles and giving presentations to industry on the topic of technical leadership.

2017 : Recognised for "Outstanding Contribution in Reviewing" by *Journal of Hydrology (Elsevier)*.

2018 : Recognised as "Outstanding Reviewer" by *Journal of Hydrologic Engineering,* American Society of Civil Engineering.

2018 : Invited to give the *Munro Oration*, an invitation extended to "a person eminent in the field of water resources in Australia". This prestigious event is sponsored by the National Committee on Water Engineering, the Canberra Hydrological Society and the South Australian Hydrology Society.

2019 : Awarded the *President's Prize* as a one of the editorial team for Australian Rainfall and Runoff for their "major contribution in promulgating the contribution that the engineering profession makes to the general welfare of the Australian people".

Selection of papers relevant to assessing flood impacts (since 2016)

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Acharya, S., Nathan, R., Wang, Q. J., & Su, C. (2022). Temporal disaggregation of daily rainfall measurements using regional reanalysis for hydrological applications. *Journal of Hydrology*, *610*(May 2021).

Bahramian, K., Nathan, R., Western, A. W., & Ryu, D. (2021). Towards an ensemble-based short-term flood forecasting using an event-based flood model- incorporating catchment-average estimates of soil moisture. *Journal of Hydrology*, *593*. https://doi.org/10.1016/j.jhydrol.2020.125828

Bahramian, K., Nathan, R., Western, A. W., & Ryu, D. (2023). Probabilistic Conditioning and Recalibration of an Event-Based Flood Forecasting Model Using Real-Time Streamflow Observations. *Journal of Hydrologic Engineering*, *28*(4), 04023003. https://doi.org/10.1061/(ASCE)HE.1943-5584.0002236

Cahyono, B. K., Ummah, M. H., Andaru, R., Andika, N., Pamungkas, A., Handayani, H. H., Atmodiwirjo, P., & Nathan, R. (2025). Leveraging machine learning and open accessed remote sensing data for precise rainfall forecasting. *Communications in Science and Technology*, *10*(1), 135–147. https://doi.org/10.21924/cst.10.1.2025.1638

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Dykman, C., Sharma, A., Nathan, R., & Wasko, C. (2025). The contribution of floods to streamflow at yearly timescales: A global assessment. *Journal of Hydrology*, *657*, 133099. https://doi.org/10.1016/j.jhydrol.2025.133099

Dykman, C., Sharma, A., Wasko, C., & Nathan, R. (2023). Can annual streamflow volumes be characterised by flood events alone? *Journal of Hydrology*, *617*, 128884. https://doi.org/10.1016/j.jhydrol.2022.128884

Dykman, C., Sharma, A., Wasko, C., & Nathan, R. (2024). Pyraingen: A python package for constrained continuous rainfall generation. *Environmental Modelling & Software*, *175*, 105984. https://doi.org/10.1016/j.envsoft.2024.105984

Fox-Hughes, P., Su, C., Eizenberg, N., White, C., Steinle, P., Jakob, D., Black, M., Dowdy, A., Brown, A., Nathan, R., & Acharya, S. C. (2022). A review of early severe weather applications of high-resolution regional reanalysis in Australia. *Meteorological Applications*, *29*(4). https://doi.org/10.1002/met.2087

Fraehr, N., Wang, Q. J., Wu, W., & Nathan, R. (2023). Development of a Fast and Accurate Hybrid Model for Floodplain Inundation Simulations. *Water Resources Research*, *59*(6), e2022WR033836. https://doi.org/10.1029/2022WR033836

Fraehr, N., Wang, Q. J., Wu, W., & Nathan, R. (2024). Assessment of surrogate models for flood inundation: The physics-guided LSG model vs. state-of-the-art machine learning models. *Water Research*, *252*, 121202. https://doi.org/10.1016/j.watres.2024.121202

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Ho, M., Nathan, R., Wasko, C., Vogel, E., & Sharma, A. (2022). Projecting changes in flood event runoff coefficients under climate change. *Journal of Hydrology*, *615*, 128689. https://doi.org/10.1016/j.jhydrol.2022.128689

Ho, M., O'Shea, D., Wasko, C., Nathan, R., & Sharma, A. (2025). The impact of climate change on dam overtopping floods in Australia. *Hydrological Earth System Science*, *29*, 5851–5870.

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Jayaweera, L., Wasko, C., Nathan, R., Syktus, J., & Eccles, R. (2025). Evaluation and Projection of Extreme Rainfall from a Large Ensemble of High–Resolution Regional Climate Models in Australia. *Weather and Climate Extremes*, 100818. https://doi.org/10.1016/j.wace.2025.100818

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