

Appendix E. Design Event Modelling Input Data and Model Peer Review

Figure E-1 Model Boundary Hydrographs – 20% AEP event

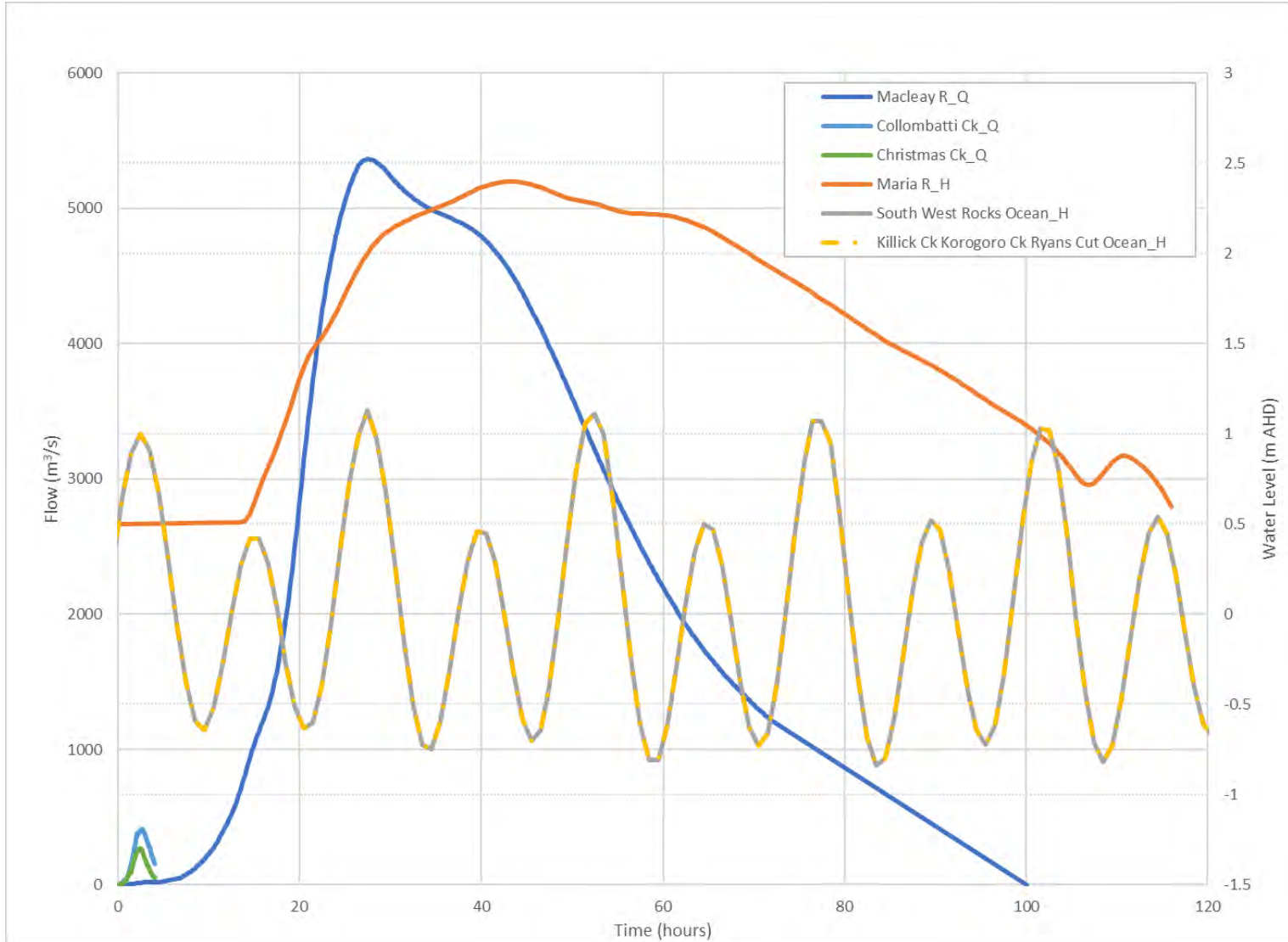


Figure E-2 Model Boundary Hydrographs – 5% AEP event

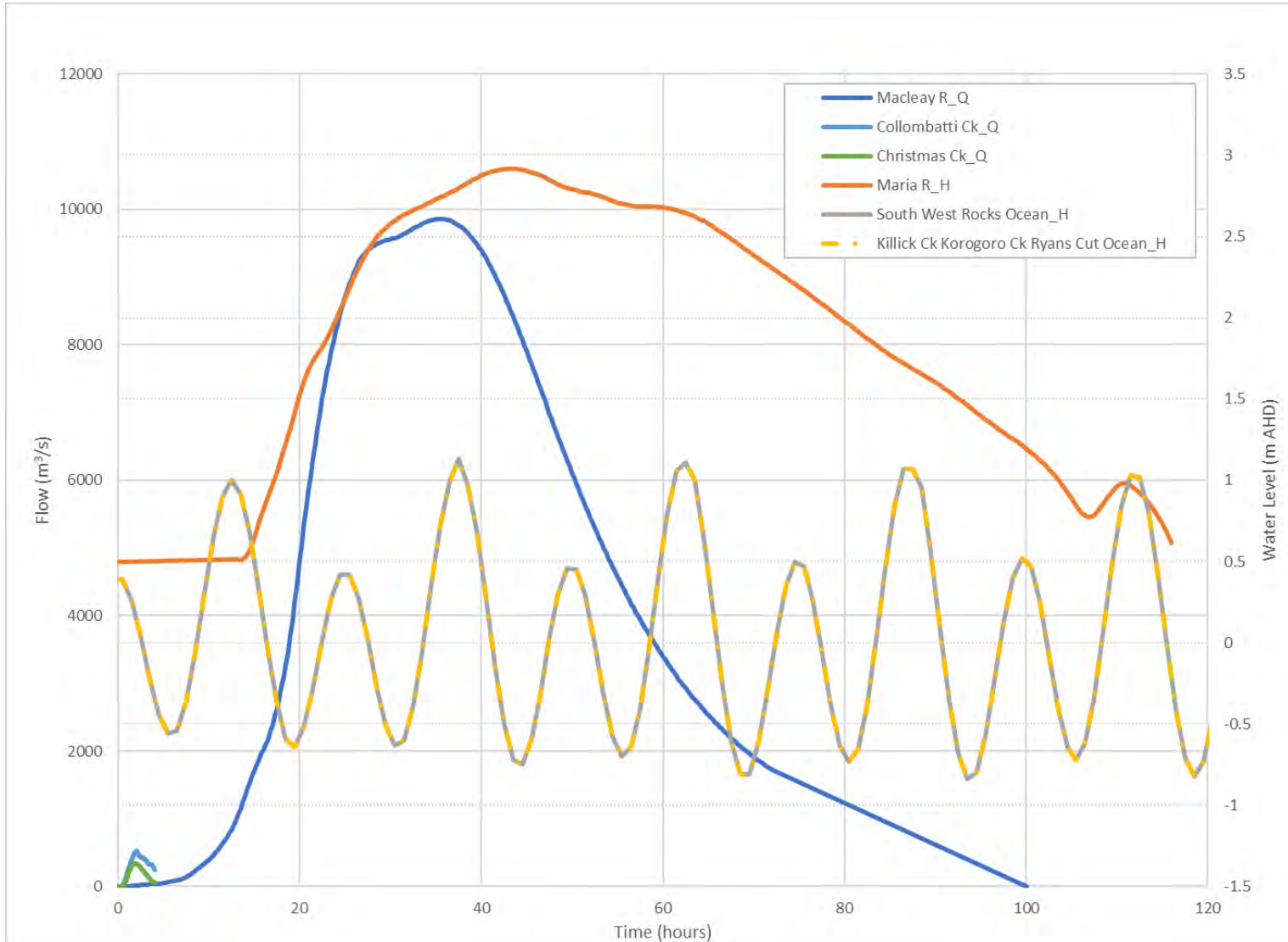


Figure E-3 Model Boundary Hydrographs – 1% AEP Macleay event

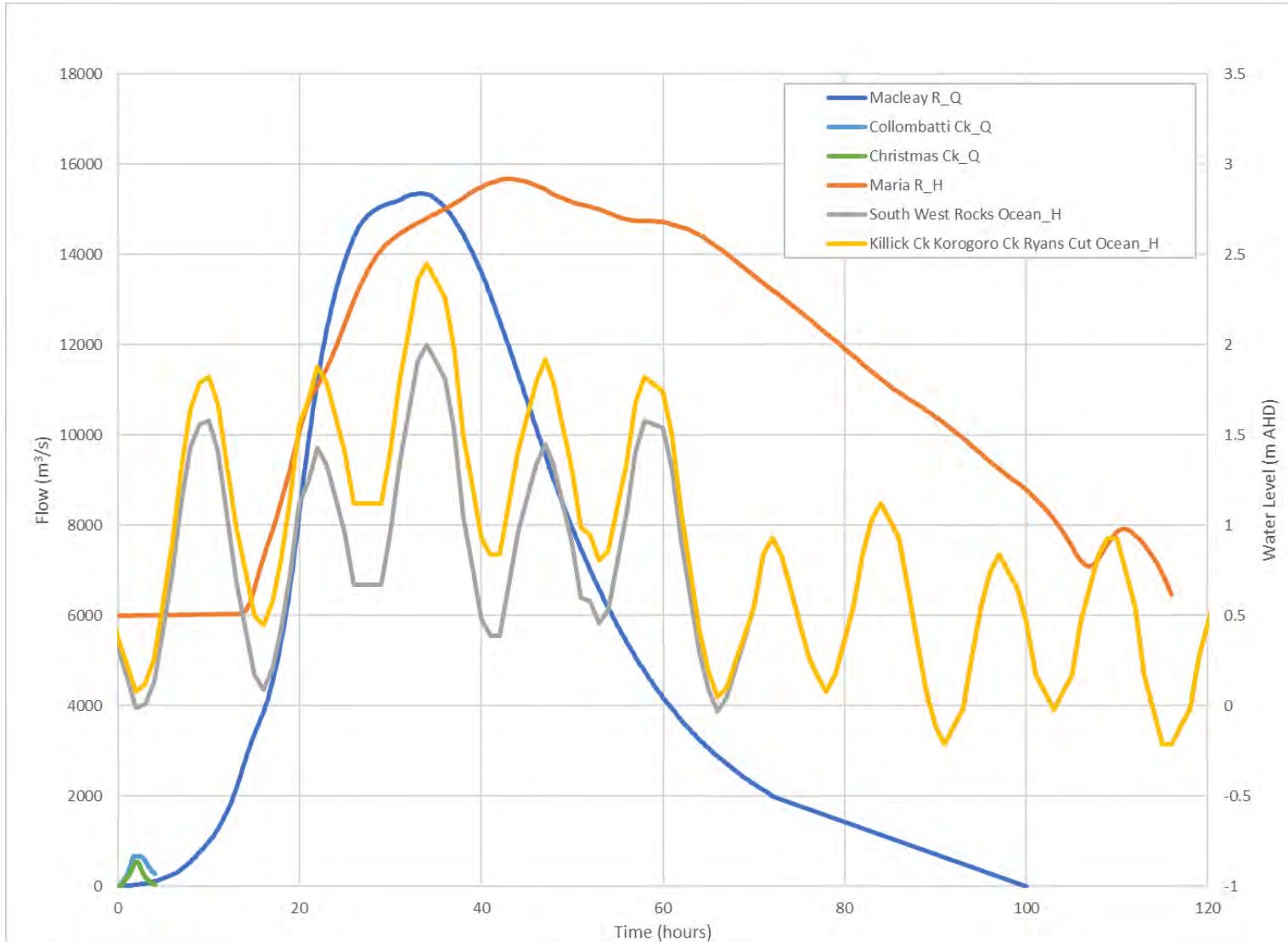


Figure E-4 Model Boundary Hydrographs – 1% AEP Maria event

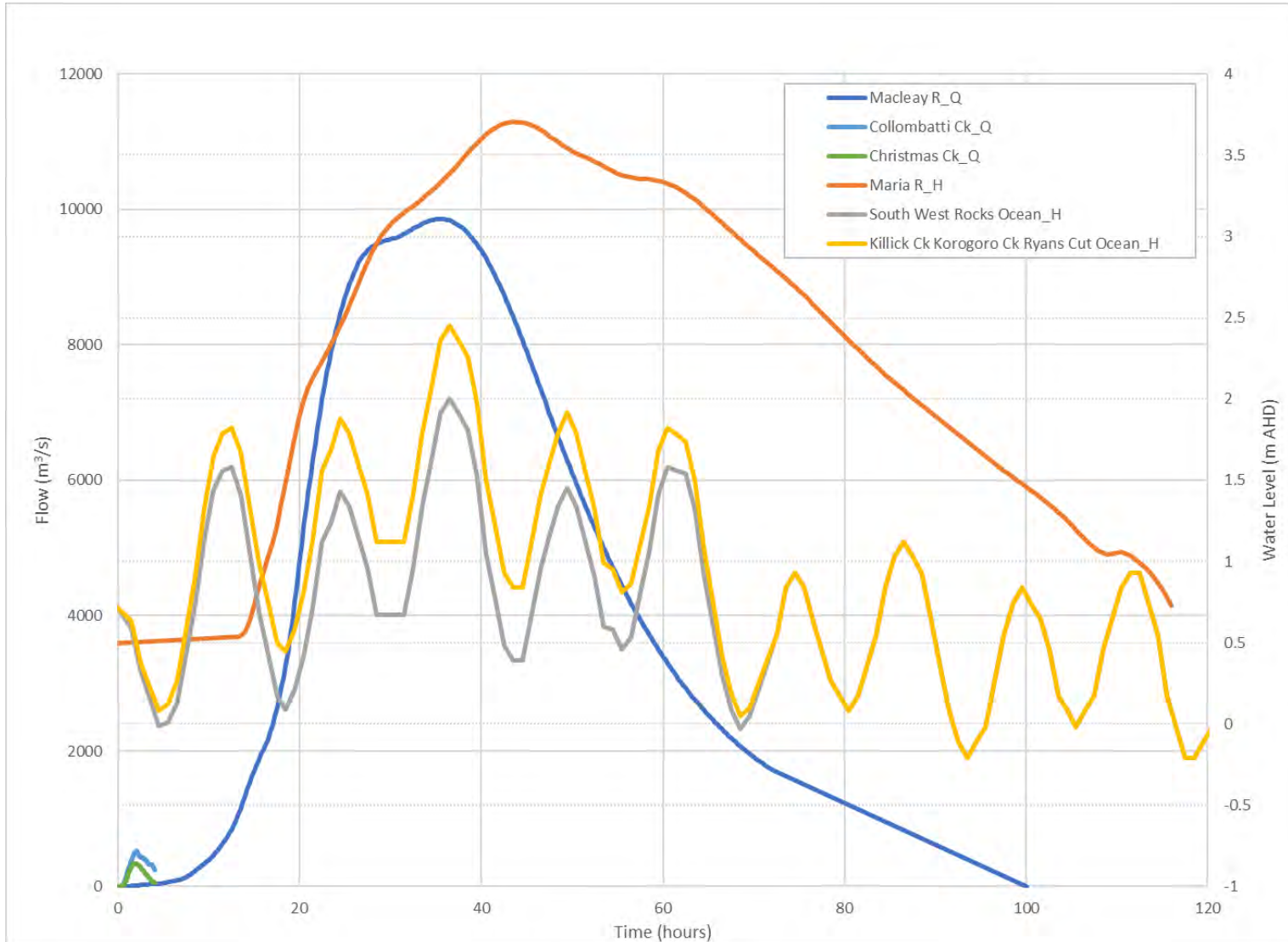


Figure E-5 Model Boundary Hydrographs – 1% AEP Ocean event

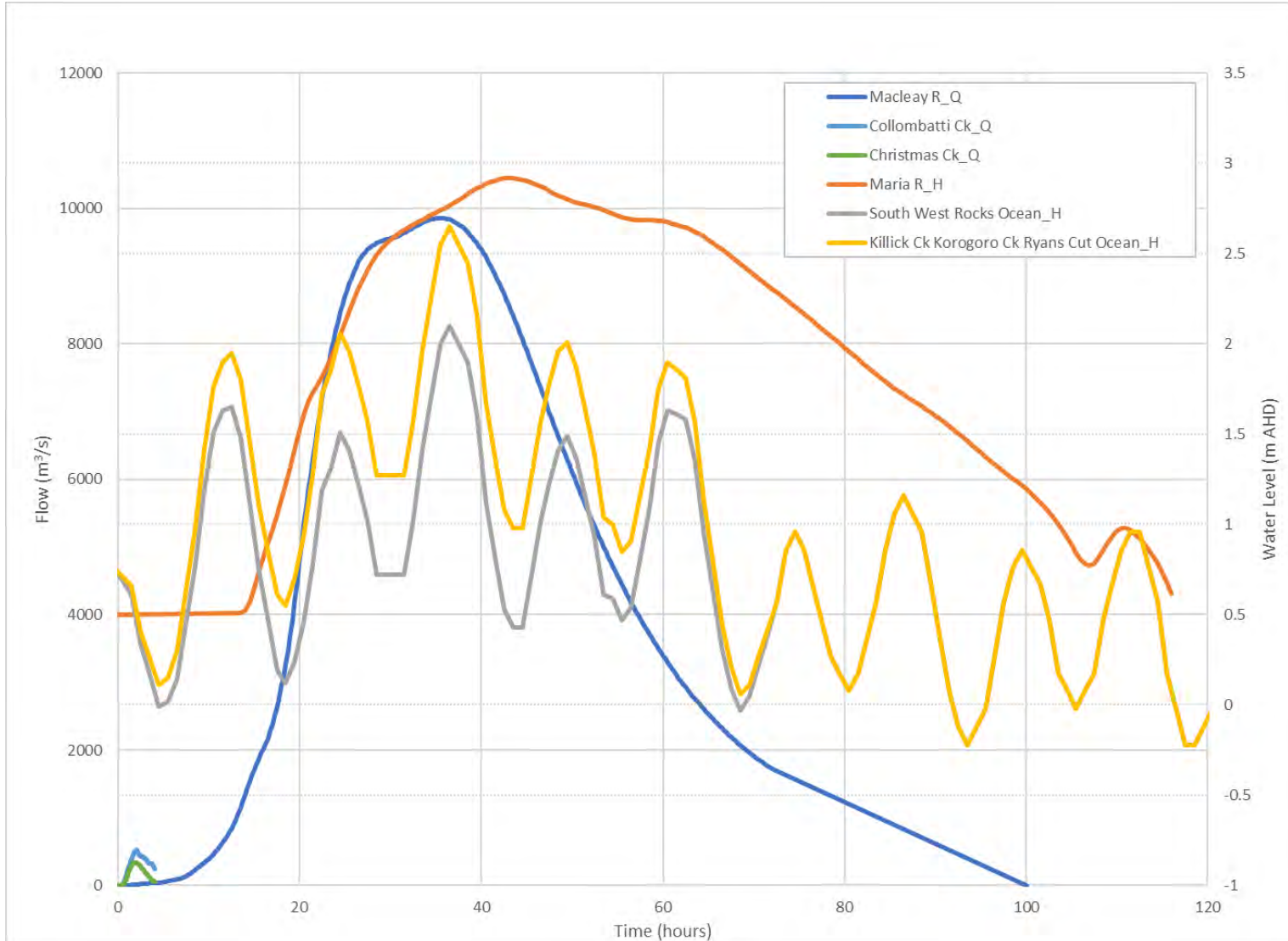


Figure E-6 Model Boundary Hydrographs – 1% AEP Low Ocean event

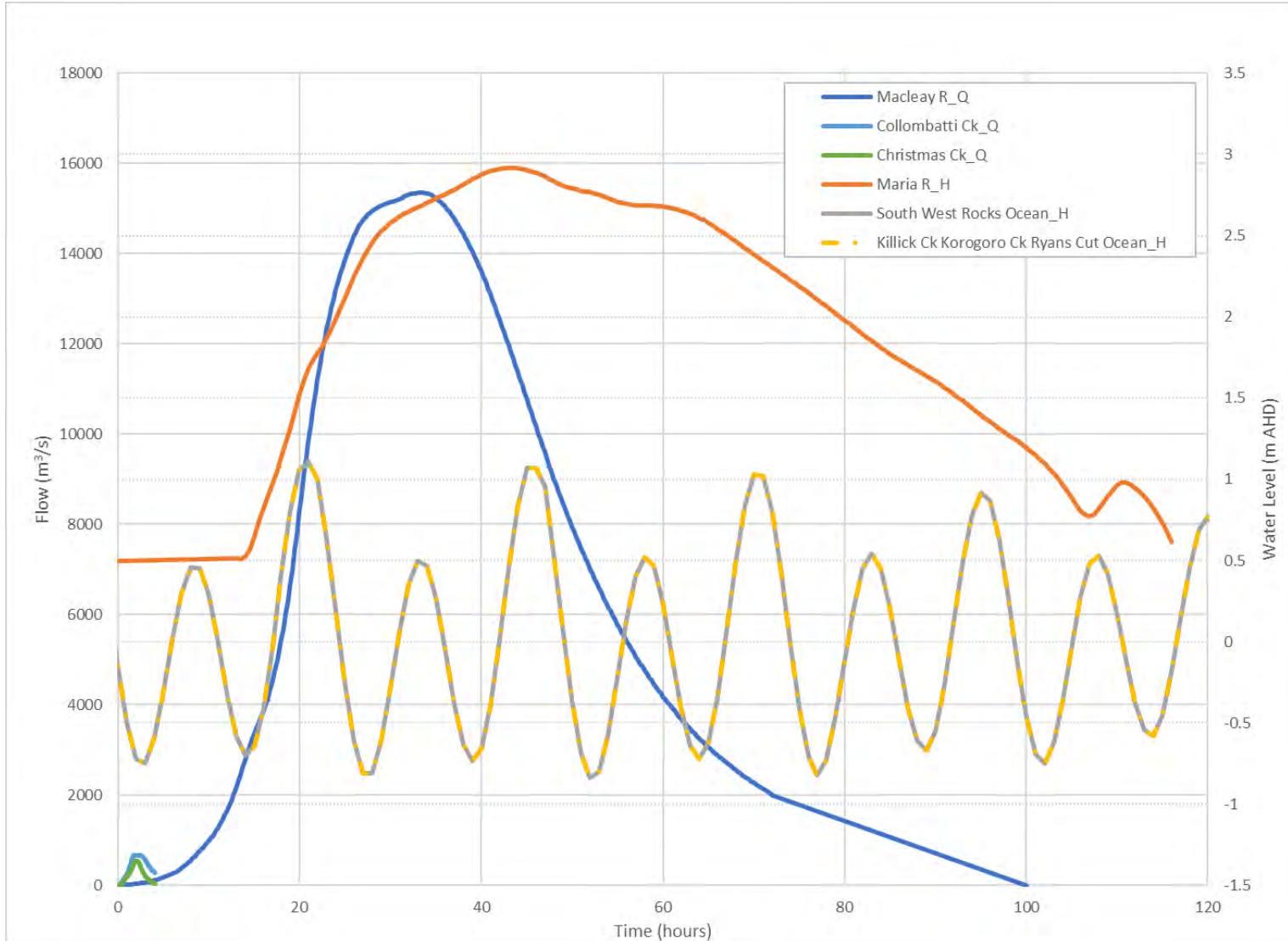


Figure E-7 Model Boundary Hydrographs – 0.2% AEP Macleay event

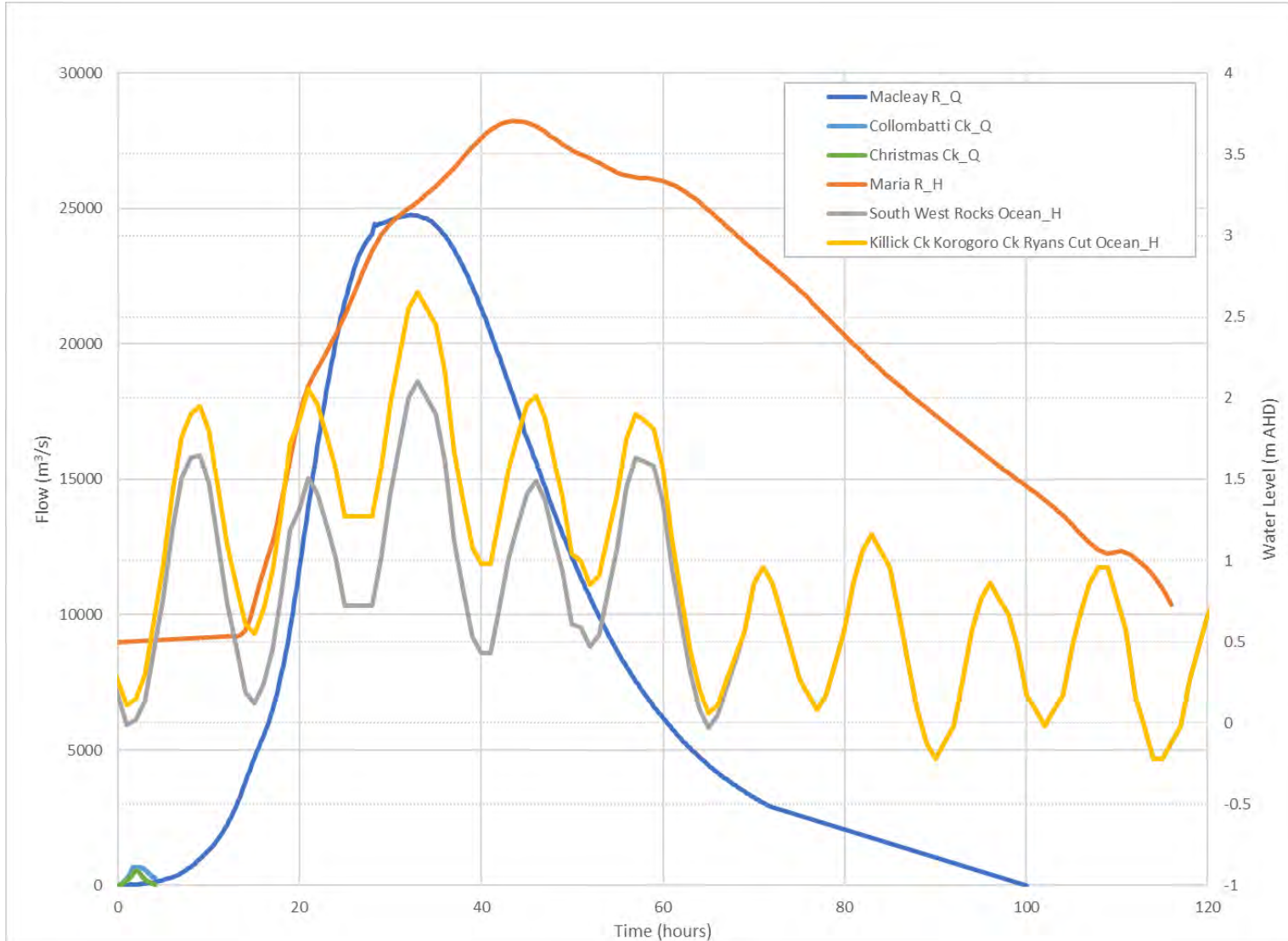


Figure E-8 Model Boundary Hydrographs – 0.2% AEP Maria event

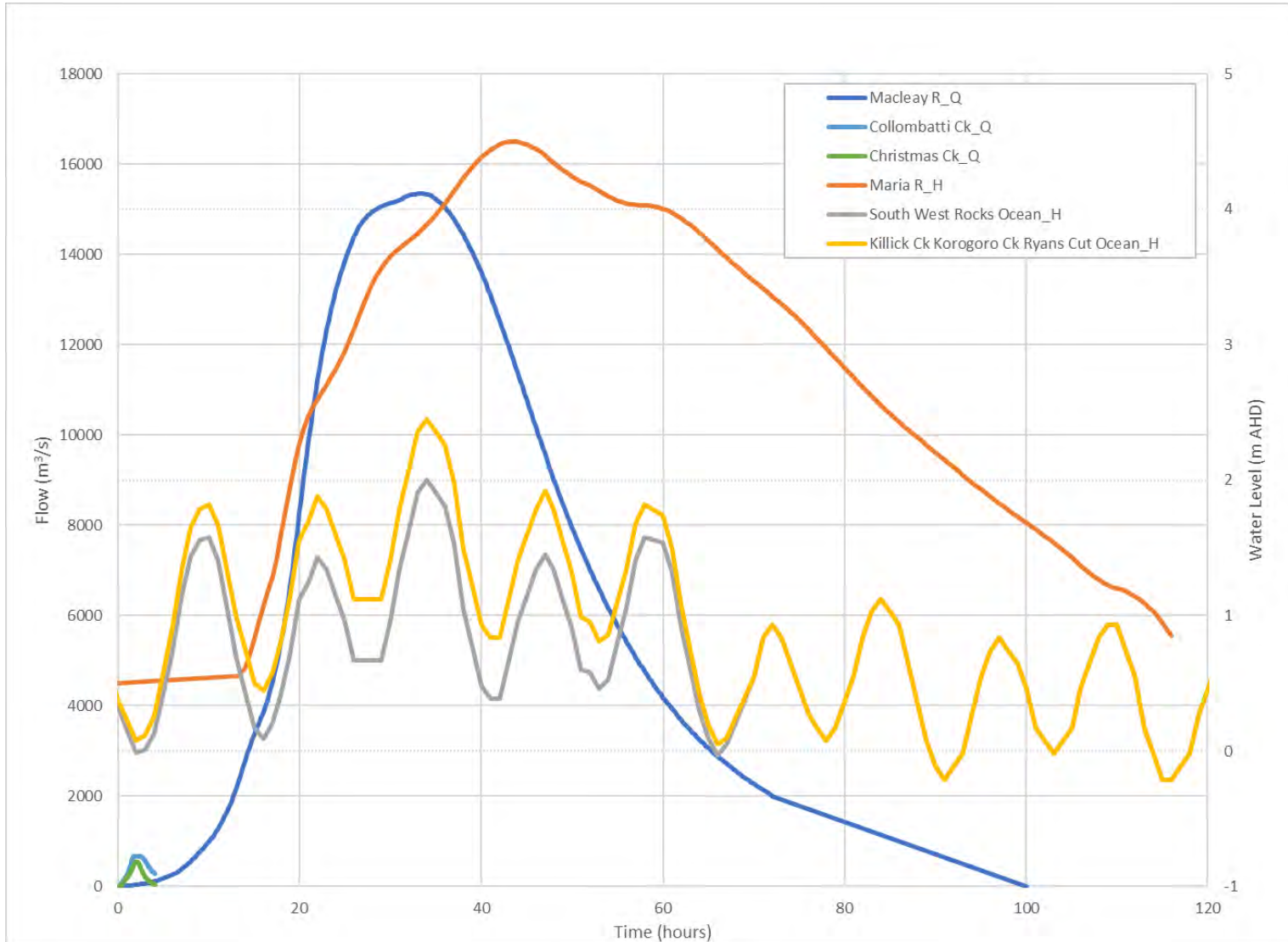


Figure E-9 Model Boundary Hydrographs – PMF Macleay event

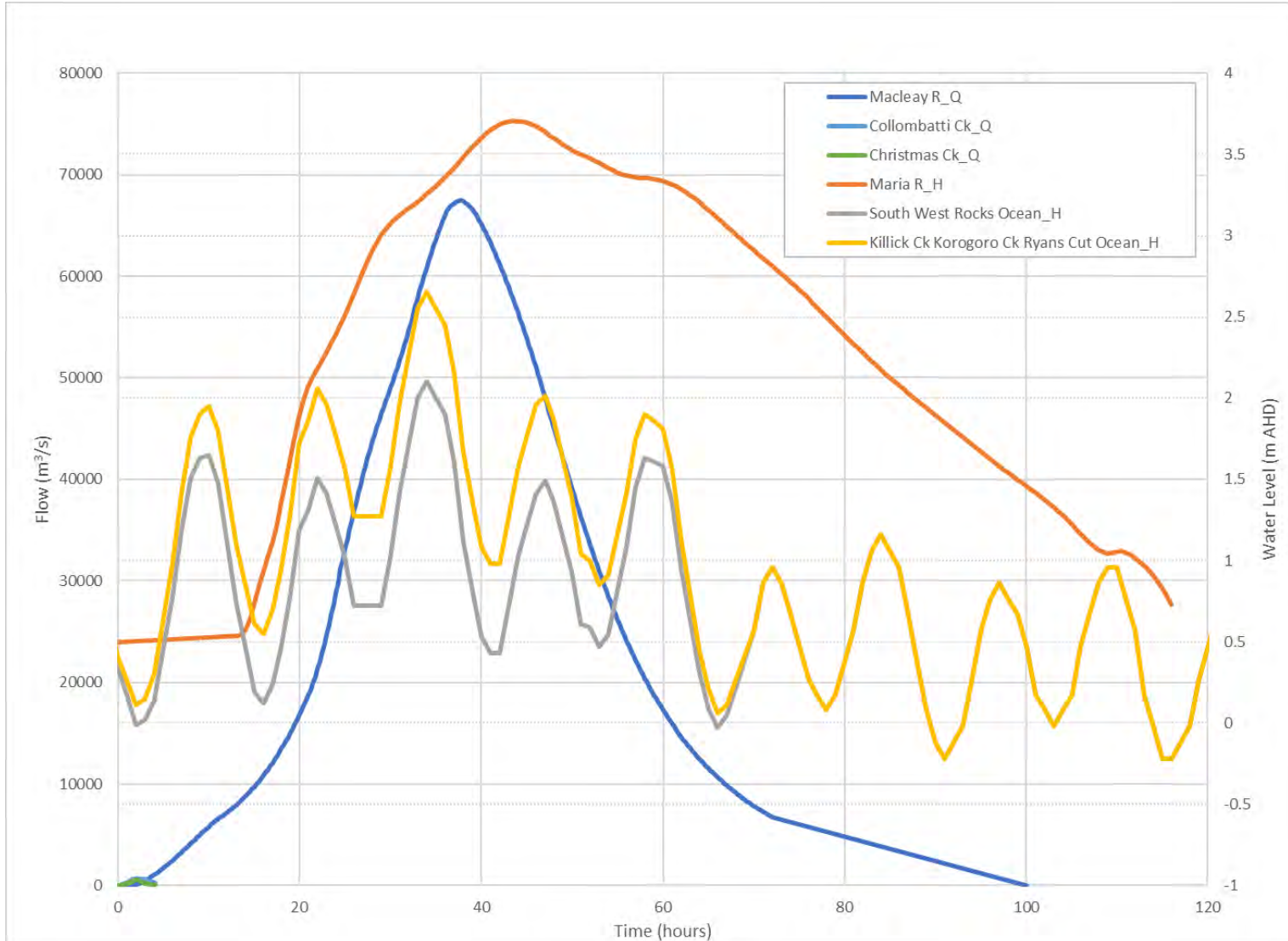


Figure E-10 Model Boundary Hydrographs – PMF Maria event

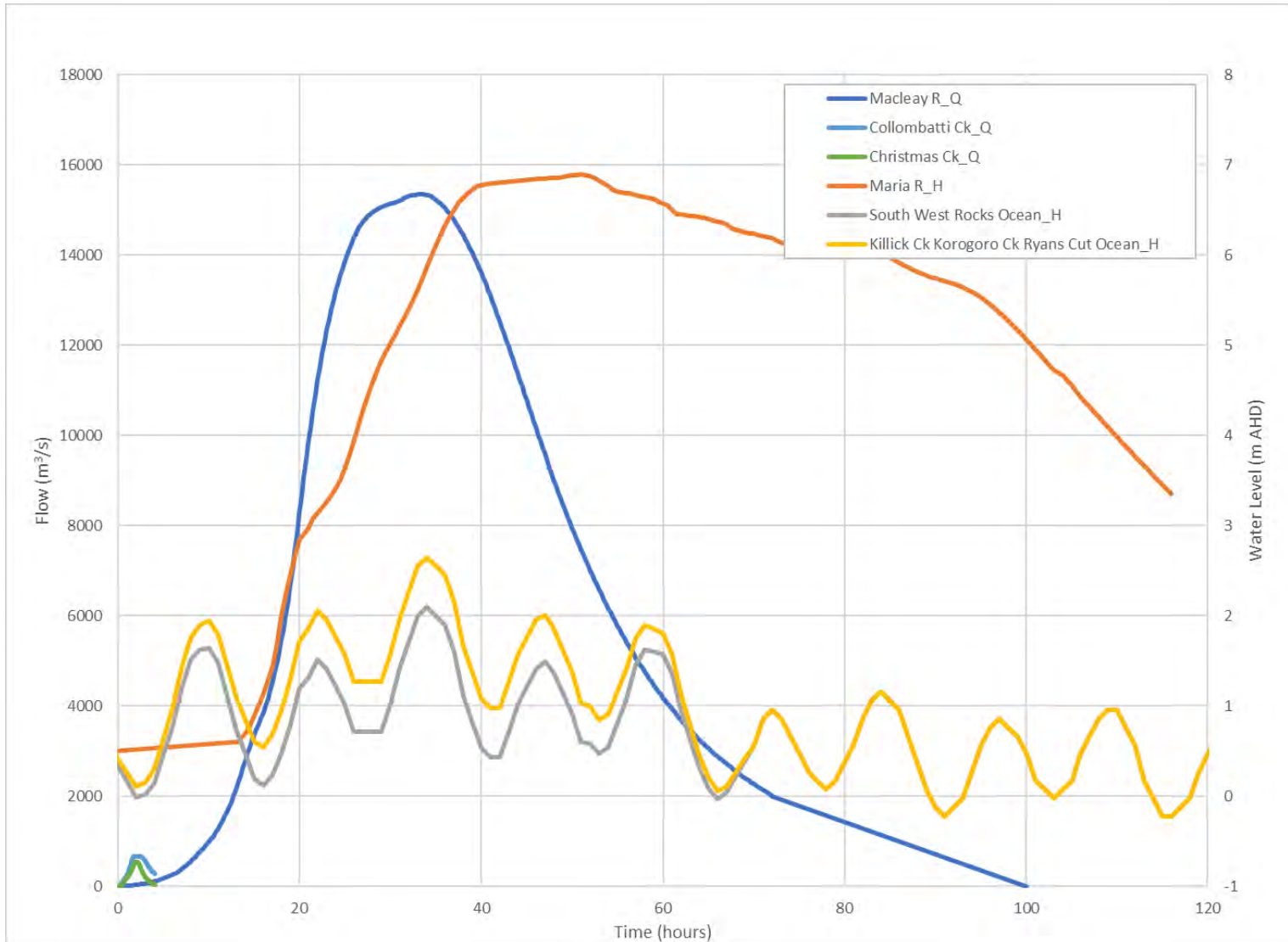


Table E-1 Summary of TUFLOW Hydraulic Model Data Sources and Assumptions

Parameter	Notes, Assumptions and Data Sources	Refer to Report Section
Configuration		
Model extent and structure	<p>Waterways and floodplain represented in a 2D/1D TUFLOW hydraulic model.</p> <p>The TUFLOW model covers the Lower Macleay floodplain, from upstream of Kempsey Railway Bridge (Greenhill) down to ocean outlet at South West Rocks, and from Grassy Head in the north to the Maria River floodplain south of Crescent Head, including a dynamic boundary allowing interflow between Macleay floodplain and Maria River/Hastings floodplain.</p>	Section 5.2.1
Model resolution	Main model domain consists of 20m model grid with 5m grids nested at floodplain villages and urban areas.	Section 5.2.2
Topography and bathymetry	<p>LiDAR ground surface elevation data captured 2009/2010, 2016.</p> <p>Main watercourse bathymetry based on hydrographic survey captured 2001 – 2005. Additional data surveyed for selected locations in 2018.</p> <p>Levee crest elevations based on survey collected by Council in 2014.</p> <p>Breaklines defined in the previous Kempsey CBD TUFLOW model were utilised for available areas (based on survey, LiDAR).</p>	Section 5.2.3
Waterway entrance bed scouring	<p>Main river entrance shoals assumed to be scoured down to bed elevations of -4.0 to -6.0m AHD, for the calibration events and design events up to 0.2% AEP. Validated with detailed coastal sediment transport modelling. Bed scoured condition for PMF event down to -8.5m AHD.</p> <p>Korogoro Creek, Killick Creek and Ryans Cut assumed scoured down to bed level of -1m AHD.</p>	Section 5.4.1, Section 6.4.1.8, Section 6.5.1.9, Section 7.1.7

	Coastal dunes assumed static (i.e. no scouring/breaching) for design events up to and including PMF.	
Minor channels and drains	<p>Selected minor channels and drains modelled as 1D channel features, mostly based on cross sections extracted from LiDAR.</p> <p>Seven Oaks Drain and other drains around Collombatti Creek based on cross section survey data.</p>	Section 5.2.4
Hydraulic structures	Key hydraulic structures were represented in the TUFLOW model, including culverts, floodgates and flood control structures. Details of these structures were obtained from Council GIS layers, work-as-executed plans (Pacific Highway upgrade and Kempsey Bypass) and survey.	Section 5.2.5
Bridges	Data on bridge crossings derived from previous hydraulic models, raw LiDAR data and work-as-executed plans (Pacific Highway upgrade and Kempsey Bypass).	Section 5.2.6
Surface hydraulic roughness	Adopted Manning's n values are based on widely-used parameter values from literature (Chow, 1959) and guidance from ARR 2019. Refer to main report for details and mapping.	Section 5.2.7
Other features	<p>Rowes Cut is represented in the calibration and design event modelling in its present, filled-in/silted form, based on LiDAR ground surface level data.</p> <p>Recently constructed roadworks in the design flood modelling include Pacific Highway upgrade road, bridge and drainage structures, Kempsey Bypass, Plummers Lane, South West Rocks Road.</p> <p>Yarrahapinni floodgates are removed and the tidal barrages breached in the design event modelling, as per the conditions in 2019.</p>	<p>Section 5.2.3</p> <p>Section 7.1.4</p> <p>Section 7.1.6</p>

Hydrology and model boundary inputs		
River inflows	<p>Macleay River calibration event and design flows adopted from Kempsey Hydraulic Model TUFLOW Update Final Report (WMAwater, 2016). These flows are based on WBNM hydrologic modelling of the Macleay catchment which has been calibrated based on flood frequency analysis of historic recorded Macleay River flows.</p>	<p>Calibration</p> <p>Section 4.2.1, Section 6.4.1.1, Section 6.5.1.1,</p> <p>Design events</p> <p>Section 7.1.1</p>
Local catchment hydrology	<p>Local inflows for sub-catchments over the Lower Macleay based on DRAINS/RAFTS hydrologic modelling.</p>	<p>Section 4.3, Section 7.1.2</p>
Ocean water level boundary	<p>Calibration event modelling adopts recorded ocean water levels at Coffs Harbour Marina.</p> <p>Design event modelling adopts design ocean water levels based on guidance in OEH (2015).</p> <p>Ocean boundary conditions are applied as time-varying water levels at all waterway ocean outlets and coastal frontages.</p>	<p>Calibration</p> <p>Section 6.4.1.4, Section 6.5.1.5</p> <p>Design events</p> <p>Section 7.2.3</p>
Maria River water level boundary	<p>Calibration event modelling based on recorded historic water levels on MHL water level gauge on Maria River at Green Valley.</p> <p>Design event modelling based on design flood levels in Maria River derived from Hastings River Flood Study modelling results (Patterson Britton and Partners, 2006).</p> <p>Maria River boundary conditions are applied as time-varying water levels. The water level difference between the Maria River and Macleay floodplain dictates the rate of inflow or outflow into the Macleay floodplain.</p>	<p>Calibration</p> <p>Section 6.4.1.4, Section 6.5.1.5</p> <p>Design events</p> <p>Section 7.2.2.2</p>

<p>Concurrent flood events</p>	<p>Various combinations of the different flooding mechanisms were modelled to define peak flooding conditions. These individual flooding sources include:</p> <ul style="list-style-type: none"> • Macleay River mainstream flooding • Local catchment rainfall-runoff • Overflows from the Maria River/Hastings River • Elevated ocean levels. <p>Refer to main report for details of combinations.</p>	<p>Design Events</p> <p>Section 7.2.3</p>
<p>Timing of concurrent events</p>	<p>Peak elevated ocean levels (high tide, storm surge) assumed to coincide with peak flooding at Kempsey.</p>	<p>Design Events</p> <p>Section 7.2.4</p>
<p>Floodplain initial water levels</p>	<p>Floodplain water levels assumed to be ponded up to 0.5m depth at main ponding locations at the start of the flood event.</p>	<p>Calibration</p> <p>Section 6.4.1.5, Section 6.5.1.4</p> <p>Design Events</p> <p>Section 7.1.3</p>
<p>Operation of hydraulic structures</p>		
<p>Main flood control structures</p>	<p>2001 calibration event</p> <p>Belmore and Kinchela flood control structures assumed open for duration of the flood event, in the absence of further historic information.</p> <p>2013 verification event</p>	<p>Section 6.4.1.7</p>

Project Name	Lower Macleay Flood Study
Model Reviewed	LM_20m_Hist_2001_Shift_Q_plus2p5hr_039 (2001 Calibration)
Report Reviewed	Model Development and Calibration Report (Revision A)
Date of Review	09/11/2018
Reviewer	Shilin Chen, Greg Rogencamp

1. Summary

This memo documents the review of the development and calibration of the Macleay River flood model. The Macleay River flood model was developed to assess flood behaviour on the lower Macleay River floodplain.

The model was calibrated to the 2001 flood event and verified to the 2013 flood event. A technical review was conducted on the flood model to assess the following:

- Modelling techniques used are appropriate for the intended purpose of the study and adhere to best-practice industry standards;
- Input parameters used are appropriate and adhere to best-practice industry standards;
- The overall flood model performance;
- The suitability of using the flood model for design flood simulations.

The review used check files generated by the flood model to assess the appropriateness of model schematization and input parameters. Flood gradient, flow hydrograph and mass balance outputs were checked to make sure they were sensible and within acceptable limits. The calibration model report was reviewed in conjunction with the model review to understand the accuracy and limitations of the input data.

In general, it was found that the Macleay River flood model is an adequate representation of observed flood behaviour. The schematization methods and input parameters are within the acceptable limits of industry standards.

Some minor schematization anomalies have been identified, which need to be rectified. It is not expected that these modifications would result in changes to the results that would warrant re-calibration. The calibration achieved is a good fit in terms of peak, timing and shape at the main water level gauges.

It is of the opinion of the reviewer that the model is suitable for taking into the next phase of simulating design flood simulations.

The review findings, comments and recommendations associated with each part of the model build are documented in detail in the following sections. Recommendations are highlighted in green throughout the document.

2. Hydraulic Model Review

2.1 Schematic

The Macleay River flood model was developed as a 1D/2D hydrodynamic TUFLOW model using version 2018. TUFLOW is an appropriate software choice for this study.

The Macleay River bed width ranges from approximately 100m to 350m. The grid size is 20m. A spot check of a number of river cross sections indicated the modelled waterway area using the 20m grid is similar to the actual surveyed waterway area. Therefore, the 20m grid size is appropriate.

The smaller channels on the floodplain have been represented as 1D networks which is appropriate for appropriate representation of smaller waterway areas.

2.2 Terrain Representation

The input geometry data were taken from the 2009/2010 1m, 2016 5m and 2009/2010 10m LiDAR data which would give a reasonable representation. Where available, bathymetric data was obtained and used to represent channel beds in the TUFLOW model. The vertical accuracy of the terrain sources should be documented in the report.

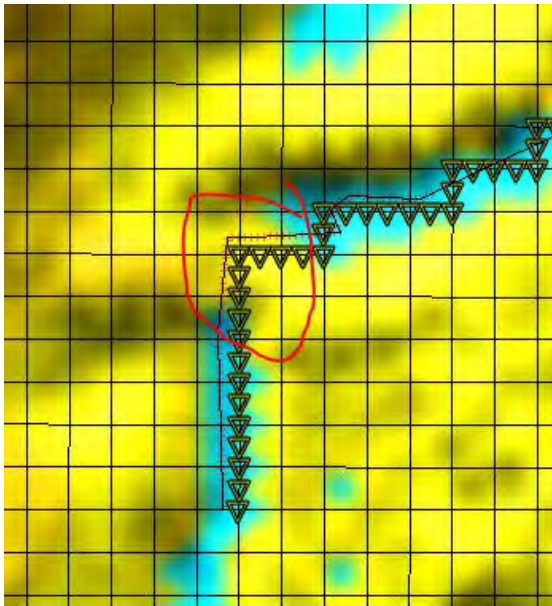
As the calibration event was in 2001, the Pacific Highway Upgrade was removed which is appropriate. Roads, levees, railways and smaller waterways have generally been represented with breaklines.

The grid is orientated south to north. It should ideally be orientated south-west to north-east, in the same orientation as the Macleay River. However, as the model has been calibrated using the south to north orientation, this is a minor issue.

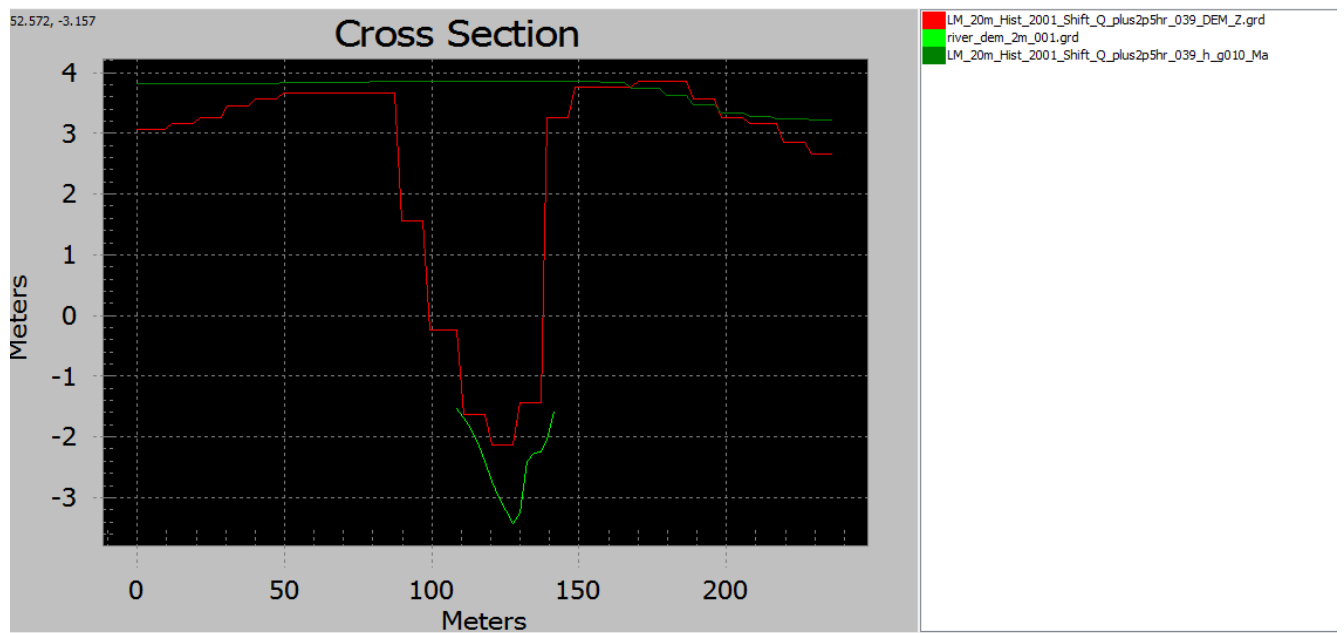
The terrain at the downstream mouth has been modified to account for scouring of the river entrance. This has been modelled as a static change in geometry. The static representation is appropriate as the timing and rate of rising and falling limbs of the observed versus modelled hydrographs at the South West Rocks and Smithtown gauges achieve a good match.

The railway line is only represented in Kempsey, with no representation of it as a ridge line outside this area. **The railway line needs to be represented as a ridge line across the entirety of the model code.**

At the Collombatti Creek catchment, the 'gully line' to represent the low-flow part of the channel has not been correctly read as it has not been set as a MIN or GULLY line. This has created an artificial wall, which is blocking the waterway (see image below). **The river line needs to be read in correctly.**



The Belmore River has been modelled in the 2D domain. It has a narrow bed of about 30m. It is recommended that a gully line be used to represent the bed to minimize the waterway area lost, as shown in the image below.



In general, the levees, railways and roads should have 'RIDGE' or 'MAX', and the channels and gullies should have 'GULLY' or 'MIN' in the tgc file. This is good modelling practice and will prevent any accidental mis-representations in the terrain.

2.3 Inflow Boundaries

Inflows into the model have been represented as QT lines for the upstream catchments, and SA polygons for the local flow. The results were checked at the upstream inflow locations and no abnormal flow behaviour was detected. The use of QT lines is acceptable.

2.4 Downstream Boundaries

The downstream boundaries are a tidal boundary taken from the recorded tide level at the Coffs Harbour gauge, and a water level boundary taken from recorded water levels at Green Valley gauge on the Maria River. This is considered appropriate for the calibration event.

2.5 Hydraulic Roughness

The roughness values used are within the industry accepted range and are similar to those used for other projects on the NSW east coast.

The adopted Mannings' n values were compared to those recommended in Australian Rainfall and Runoff (ARR) Project 15 Table 10-1. The comparison is shown below.

The most sensitive Mannings n value would be that of the river channels which match the ARR Project 15 guidance well.

In general, the adopted values fall within the recommended ARR range, with the notable exception of the high-density area. However, the roughness value of 1.0 in the Macleay River model is applied to individual buildings, and not a residential block which has both buildings and open space. Therefore, it is considered appropriate.

Land Use Type	ARR Project 5	Macleay River Model
Residential areas - high density	0.2-0.5	1.0
Residential areas - low density	0.1-0.2	0.1
Open pervious areas, minimal vegetation (grassed)	0.03-0.05	0.03-0.06
Open pervious areas, moderate vegetation (shrubs)	0.05-0.07	0.08
Open pervious areas, thick vegetation (trees)	0.07-0.12	0.12
Waterways/channels - minimal vegetation	0.02-0.04	0.021-0.035
Paved roads	0.02-0.03	0.02
Wetlands (emergent vegetation)	0.05-0.08	0.06
Estuaries/Oceans	0.02-0.04	0.03

The land-use delineation was spot checked and appear to be appropriate.

Connection Creek has been represented in the 1D domain and given a Mannings' n of 0.03 in the 1D. In the 2D domain, it has been assigned a Mannings' n of 0.025. This effectively represents the creek twice. **It is recommended that the Mannings' n of the creek in the 2D to be the same as the surrounding Mannings' n.**

2.6 Structures

2.6.1 Culverts and waterways

Culverts and smaller waterways were represented as 1D elements. All culverts had an entry loss of 0.5 and exit loss of 1. This is considered appropriate. The Mannings' n was set to 0.015 for the culverts and 0.03 for the channels which is appropriate and consistent with the Mannings' n values used in the 2D domain.

Spot checks of the culvert CU_77 is flowing backwards – possibly also because the upstream invert is nearly 1m higher than the downstream invert. The invert levels need to be confirmed.

2.6.2 Bridges

Bridges in the model have been represented with 2d_lfcsh files. A form loss in layer 1 of either 0.1 or 0.2 has been applied, with a total form loss of 1.56 across the three layers. The representation and form loss coefficient used is appropriate.

It is noted that the bridge just downstream of the railway bridge on Macleay River has not been given a form loss. This needs to be rectified.

It is noted that all bridges have been represented by a single 20m cell, indicating that every bridge is 20m wide. The modeler needs to confirm that this is the case, otherwise, if the bridge is say, 40m, the form loss needs to be applied across both cells.

A spot check of one of the bridges found that a form loss of 0.2 with velocity of 1.8m/s caused a head loss of approximately 40mm, which is consistent with first principal calculations.

2.6.3 Connection of 2D floodplain to 1D structures

The 1D structures and channels have been connected to the 2D domain using CN and SX connections. The connections are generally well placed. **It is noted that culvert "Willow FG" has no 1d/2d connection. This needs to be rectified.**

2.7 Model Performance

2.7.1 Mass Balance

A mass balance calculation ("volume in" versus "volume out plus volume remaining in the model") was performed. It was found that the volume error was -0.04% which is within the acceptable tolerance.

A broader mass balance calculation using rainfall and catchment area to calculate volume that should have gone into the model, versus actual volume going into the TUFLOW model found that there was a -1.8% difference. That is, the volume of water going into the model should have been 1.8% less. However, the calculation did not include continuing loss of rainfall. Therefore, the 1.8% difference is considered acceptable.

No errors were found in the TSMB1d2d or the TSMB1d result files.

The total negative depth was zero, indicating no mass errors within the model.

2.7.2 Calibration

The calibration event is a 1 in 13 AEP event. Ideally, a larger flood should be chosen as the calibration event. However, given the lack of reliable calibration points and catchment features available for the larger floods that occurred prior to 2001, calibrating to the 2001 event is acceptable.

The +/- 0.2m in difference between calibrated and observed peak flood depths along the river is considered a good calibration result. The shape and timing of the flood model hydrographs also match the observed hydrographs well.

2.7.3 Verification

The model verification achieved a difference between observed and modelled flood levels of less than +/- 0.2m at reliable flood marks which is considered acceptable. The rising limb matched the observed hydrograph well but the flood peak is elongated and the second peak on the falling limb is higher in the model than that observed.

This is likely to be a hydrological modelling issue, rather than hydraulic as noted in the report, and in general, the verification run showed that the Macleay River flood model is an adequate representation of observed hydraulic behaviour.

2.8 Mapping

The mapping produced is clear and of high quality.

For design event flood mapping, it is recommended that the limit of mapping be reconsidered to include areas at the upstream parts of the model, where inflows from the short-duration upper catchments are dominant and the gradient is steep (and not dominated by Macleay River flooding). Flood depths in these areas likely do not reflect actual flood depths.

Another minor comment is to ensure that all flood level labels on the map can clearly be seen and are not hidden behind another label.