Murray Lower Lakes Model Development

Stage 1 and 2 Modelling

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Author	Dr Mitchell Baum
Checked By	Dr Ian Teakle
Approved By	Dr Ian Teakle
Project Manager	Dr Mitchell Baum

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Contents

Tables

Figures

1 Background

1.1 Introduction

The Department for Environment and Water (DEW) is in the process of updating their suite of hydrodynamic models representing the South Australian River Murray between "Lock 7" and the Coorong barrages. As product of the model updates, the DEW intends to produce updated flood inundation maps for a range of River Murray flood flows.

1.2 Existing Modelling Tools

Whilst the reaches of the River Murray between "Lock 7" and Wellington are sufficiently represented in existing MIKE+ models, the DEW considers TUFLOW FV to be the most suitable platform to undertake the same flood modelling for the Lower Lakes between Wellington and the barrages.

Initial investigations have concluded that it is not feasible to amend the existing 2011 TUFLOW FV Lower Lakes model that the DEW owns for this purpose. Rather, the DEW has proposed a new mesh build and calibration to deliver a modern TUFLOW FV model. This model will be initially applied for a series of flood scenarios to produce corresponding inundation extents.

1.3 This Project

Due to current capacity limitations within the DEW and BMT's longstanding involvement in building, calibrating and applying TUFLOW FV models for the Lower Lakes and Coorong region, BMT has been scoped to undertake the model development and subsequent scenario modelling.

Stage 1 includes the hydrodynamic TUFLOW FV model development and model calibration/validation against water level measurements within Lake Alexandrina and Lake Albert.

The Stage 2 scope involves modelling for a spectrum of different River Murray inflow events and subsequent reporting on flood water levels.

2 Hydrodynamic Model Development

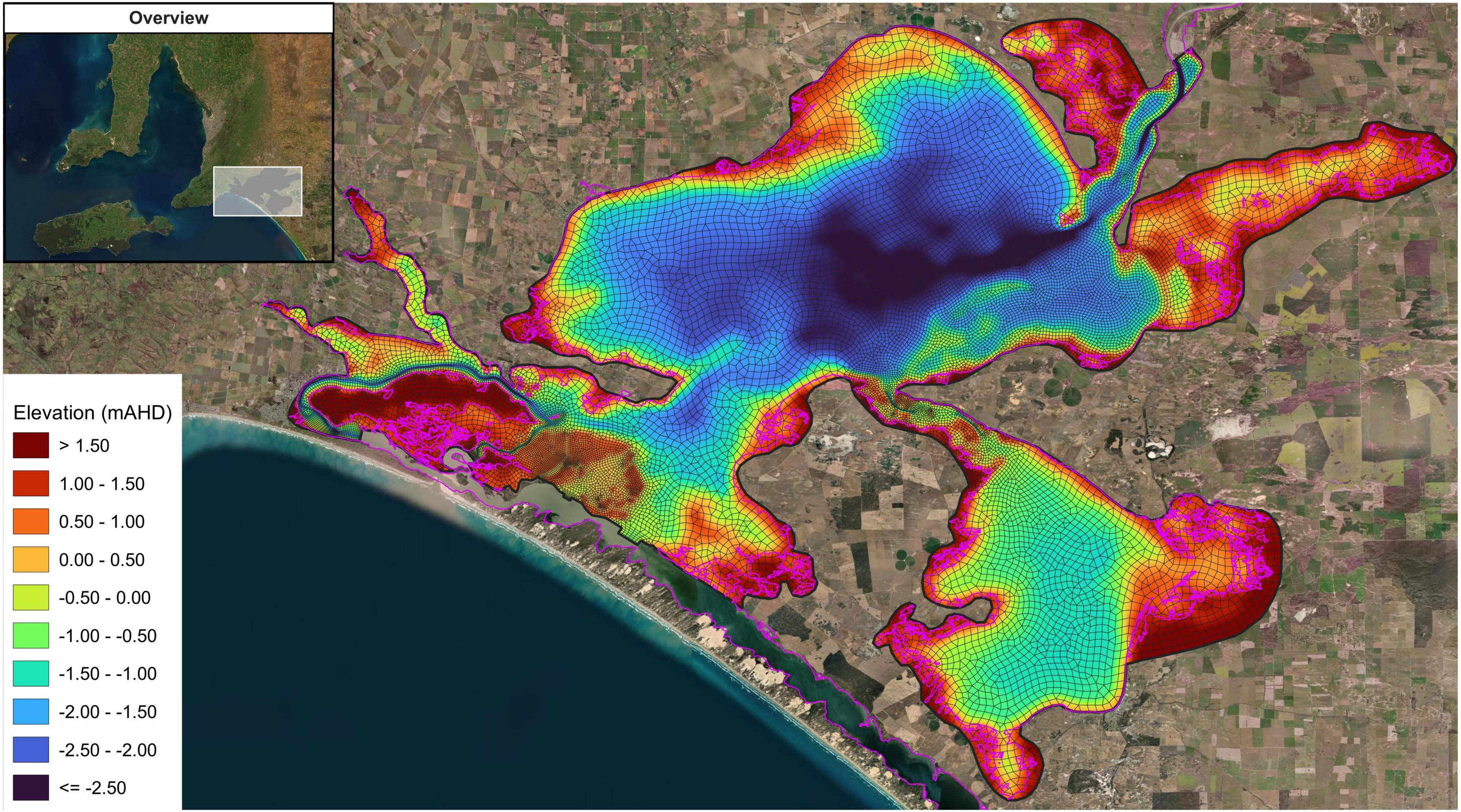
2.1 Overview

A two-dimensional hydrodynamic TUFLOW FV model of Lake Alexandrina and Lake Albert (hereafter referred to as the Murray Lower Lakes (MLL)) has been developed. This model addresses limitations of the existing DEW MIKE+ models and outdated RMA-style TUFLOW FV model meshes and provides the capability to integrate the with existing TUFLOW FV models situated adjacent to the MLL (e.g., the various Coorong hydrodynamic models).

The model domain has been expanded to include the both the 2022/23 and 1956 flood extents, with the build also incorporating state-of-the-art development features such as GIS integration and the ability to run simulations on GPU cards.

2.2 Mesh Development

A modern TUFLOW FV model mesh was developed using flexible and unstructured cell elements. The model consists of over 19,670 cells with a mean cell size of approximately 260 m. Cell sizes as small as 30 m are used to resolve key channels and bathymetric features. The MLL model domain and mesh is presented in Figure 2.1.



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DEW 1956 Flood Extent

Title:

Murray Lower Lakes TUFLOWFV Hydrodynamic Model Mesh

Figure: **2.1**

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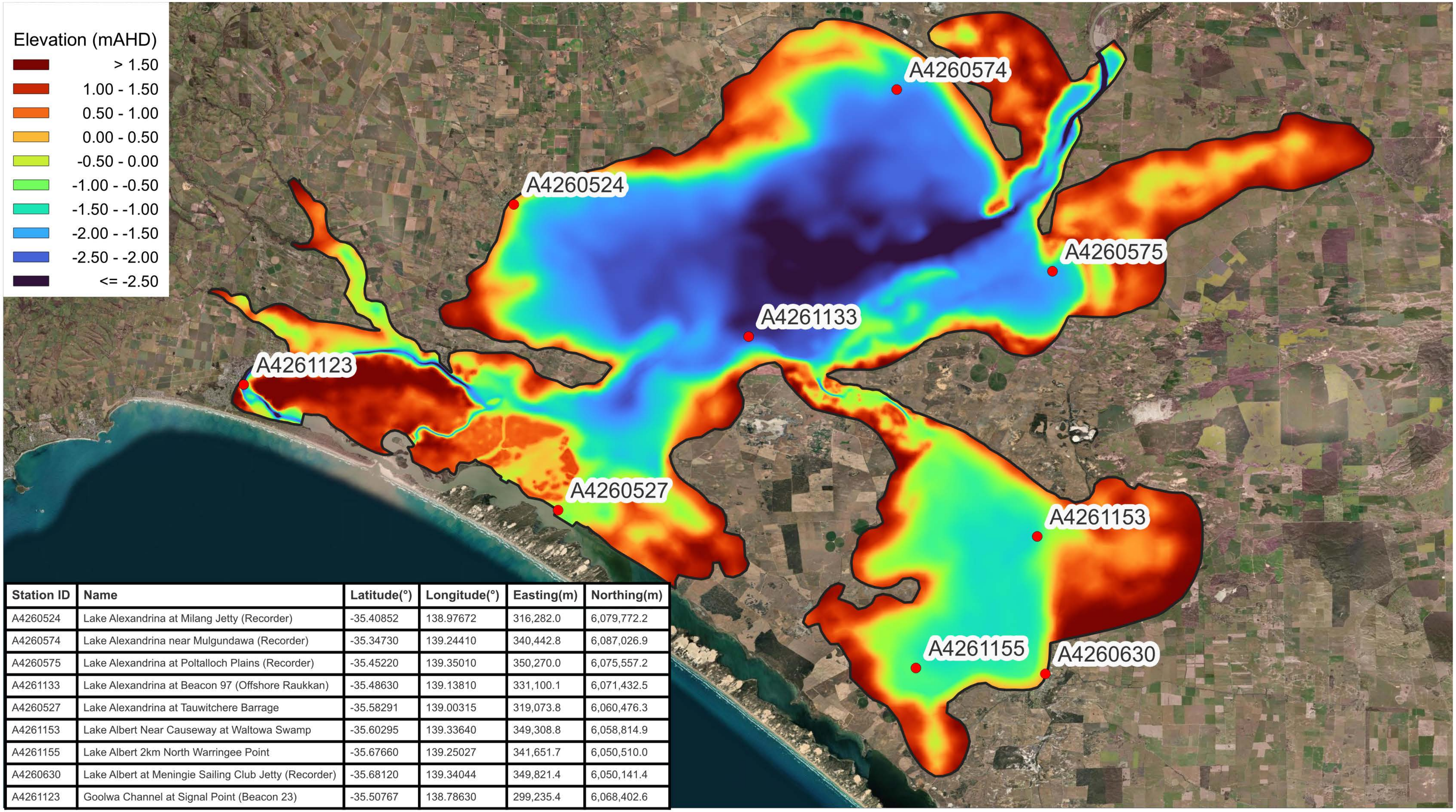
2.3 Bathymetry

In increasing order of hierarchy, the following DEW datasets (provided 04/10/2024) were accommodated into the TUFLOW FV model build:

- LL_2024_DEM_resamp2m_Clip.tif
- 2008_DEM_clipped_below_wellington.tif

From inspection of the 2024 LiDAR dataset, it was determined that elevations ≤ -0.16 mAHD were generally erroneous and were subsequently defined using the 2008 DEM. Elevations between the two datasets were in good agreement at this threshold, ensuring a smooth transition between the composite datasets.

The model bathymetry is presented in Figure 2.2. The model bathymetry is stamped onto the node vertical coordinate in the .2dm mesh file, however *ZLN* polygons are used to improve the bathymetric representation in the ~5 km vicinity upstream of the Ewe Island barrage. This setup is captured in the model repository.



Station ID	Name	Latitude(°)	Longitude(°)	Easting(m)	Northing(m)
A4260524	Lake Alexandrina at Milang Jetty (Recorder)	-35.40852	138.97672	316,282.0	6,079,772.2
A4260574	Lake Alexandrina near Mulgundawa (Recorder)	-35.34730	139.24410	340,442.8	6,087,026.9
A4260575	Lake Alexandrina at Poltalloch Plains (Recorder)	-35.45220	139.35010	350,270.0	6,075,557.2
A4261133	Lake Alexandrina at Beacon 97 (Offshore Raukkan)	-35.48630	139.13810	331,100.1	6,071,432.5
A4260527	Lake Alexandrina at Tauwitchere Barrage	-35.58291	139.00315	319,073.8	6,060,476.3
A4261153	Lake Albert Near Causeway at Waltowa Swamp	-35.60295	139.33640	349,308.8	6,058,814.9
A4261155	Lake Albert 2km North Warringee Point	-35.67660	139.25027	341,651.7	6,050,510.0
A4260630	Lake Albert at Meningie Sailing Club Jetty (Recorder)	-35.68120	139.34044	349,821.4	6,050,141.4
A4261123	Goolwa Channel at Signal Point (Beacon 23)	-35.50767	138.78630	299,235.4	6,068,402.6

Legend

● Water Level Sites

Title:

Lake Alexandrina and Lake Albert Bathymetry and Water Level Sites

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2.4 GIS Specifications

To facilitate ease of spatial model inputs, the model has been developed to integrate GIS functionality where appropriate. The model mesh has been deliberately developed without material and nodestring definitions contained within the .2dm mesh file itself, where these are alternatively defined by GIS shapefiles.

2.5 Boundary Conditions

2.5.1 Inflows

Inflows into the Murray Lower Lakes system are solely based on riverine inflows from the Murray River and are imposed that the northern bounds of the model at Wellington. Analysis of the original DEW boundary condition (*Wellington_Q_Sal.csv*) revealed that the flow peak was truncated to approximately 120,000 ML/d, while flows further upstream at Overland Corner (A4260528) peaked at approximately 180,000 ML/d. After further investigation by DEW, this truncation was an artefact of a data outage at the Lock 1 (A4260903) gauge.

While Lock 1 gauge data suffered an outage over this period, field measurements were collected – with sufficient resolve over the peak hydrograph flows. Using a 6-day translation of the Lock 1 field measurements, these data were used to replace flows from 01/10/2022 – 01/03/2023. Here, peak flows of ~177,300 ML/d were applied after resampling to a 1-day frequency.

2.5.2 Meteorological

Meteorological forcing has been updated to use the Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia (BARRA2) system (Su et al., 2022). This BARRA2 dataset provides deterministic reanalysis on a 12 km horizontal grid over Australia from 1979 to present.

Due to the relatively small domain size relative to the BARRA2 grid resolution, the TUFLOW FV model was forced using a global timeseries with a 1-hour temporal resolution. The meteorological BARRA2 variables defined in the TUFLOW FV model setup include:

- Wind speed
- Air temperature
- Relative humidity
- Shortwave radiation
- Longwave radiation.

2.5.3 Initial Conditions

Measured water level, temperature and salinity were prescribed as initial model conditions in the TUFLOW FV model. Due to low lake water levels over the 2010/11 validation period, a spatially varying water level condition was applied to reflect the differing water levels between Lake Albert and Lake Alexandrina.

2.5.4 Downstream Structures

The downstream barrage structures served as a critical parameter in the model performance in terms of the predicted water levels in the MLL system.

Under the original DEW configuration, the barrage "fraction open" was defined using automated logic based upon water levels either side of the barrage, where the downstream water levels were defined using Goolwa Channel at Beacon 12 (A4261036) water levels at all barrages. Noting the significant water level differences downstream of the individual barrages, a significant improvement in predicted MLL water levels was achieved by supplying the measured downstream water levels at each respective barrage.

Further, it was identified that water levels were generally underpredicted during the main 2022/23 flow event, where the barrage "fraction_open" was underpredicted by the automated logic. To assess the efficacy of this water-level defined proxy for the "fraction open", the model results were compared against the operational logs (*Barrage_OpenBays_Hourly.csv*) in Figure 2.3. To define the "fraction_open" from the operational logs, the number of open barrage gates (including the number of log stops for Goolwa) was assessed relative to the total capacity at the barrage locations.

In order to improve the predictive skill of the model and facilitate improved definition of the barrage structure matrices, the "fraction_open" property was defined based on this derived operational timeseries. Further, this structure matrix function was expanded to accommodate upstream water levels up to 2.0 m (noting that water levels peaked at 1.62 mAHD at the Goolwa Ferry crossing during the 1956 event (DEW, n.d.)). Improved model performance was further achieved by removing the weir submergence calculation from the structure matrices, whereby the model relies on flux limiting from the TUFLOW FV shallow water equations in the event that submergence occurs. An example of the final barrage configuration is shown as follows:

```
! Tauwitchere Barrage
Structure == nodestring,5
    Name == Tauwitchere
    Flux function == Matrix
    Flux file == ../../bc_dbase/BarrageMatrix/BCW_Matrix_Tauwitchere_002.csv
    Control == Timeseries
        Control parameter == FRACTION_OPEN
        Control file == ../../bc_dbase/BarrageLogic/FO_Tauw_Proccessed.csv
        Control update dt == 24.0 ! hrs
    End control
End Structure
```

It is also noted that the barrage calculator flows were also compared against the River Murray inflows and MLL outflows from the calibrated TUFLOW FV model with the "fraction_open" timeseries parameterisation. It was identified that the barrage calculator underestimated the flows from the 2022/23 event, with total volumes approximately 25% lower than estimated by the TUFLOW FV simulation (refer Figure 2.4). This underprediction is particularly evident during the December 2022 – January 2023 peak of the flood.

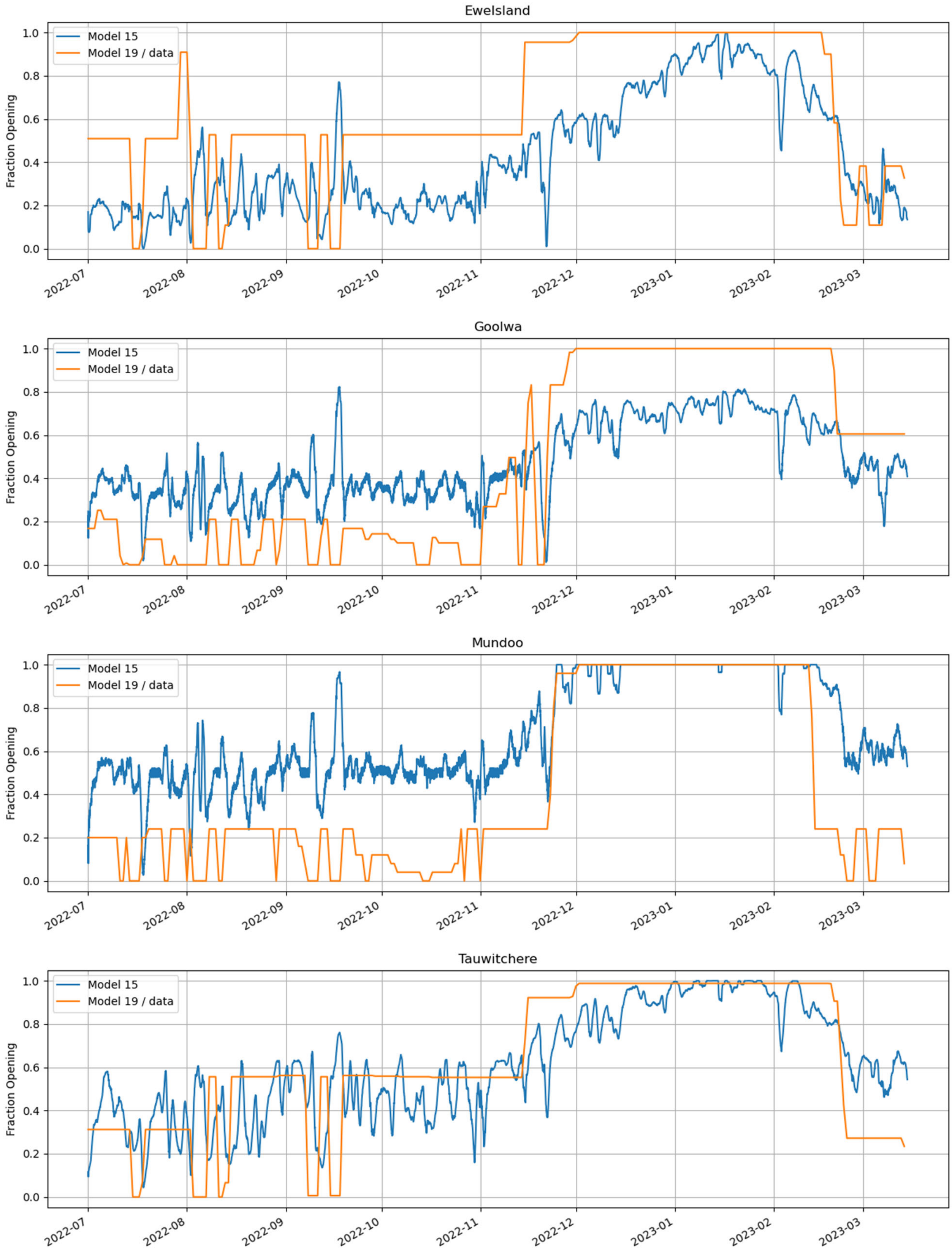

Figure 2.3 Barrage fraction open timeseries comparisons using the original water level proxy with moving average applied (blue), and the timeseries inferred from the barrage operation logs (orange)

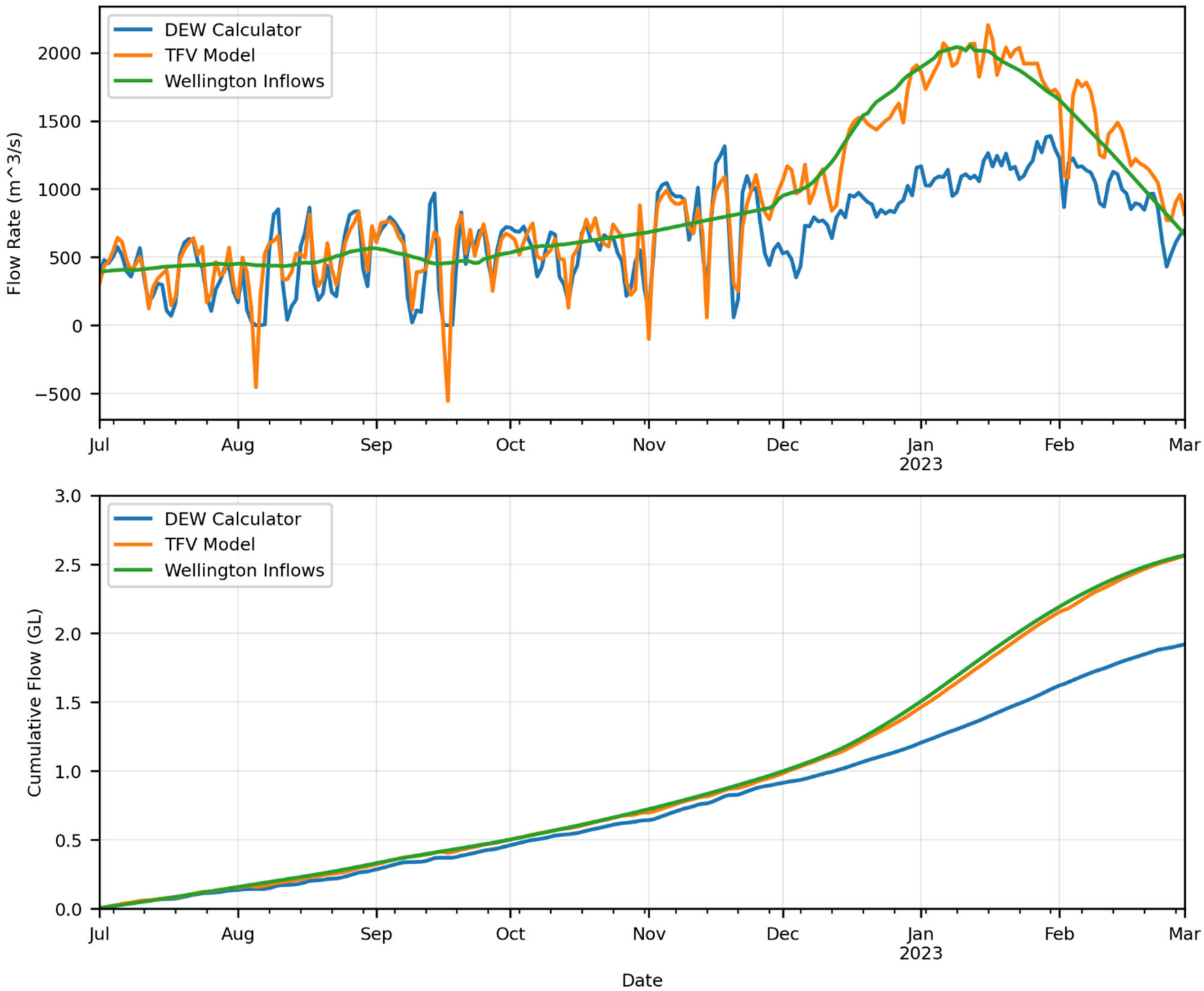

Figure 2.4 Comparison of cumulative flow timeseries from Wellington Murray River inflows and downstream barrage outflows (DEW Calculator and TFV Model). Top: flow rate; bottom: cumulative flow volume.

2.6 Bed Roughness

The new TUFLOW FV MLL model build applies the material polygons from the original DEW *LL_mesh_LakeCycling_v101.2dm* mesh and corresponding material properties from the original *LL_flood_2020_2023_test.fvc* control file. Note that some materials defined in the control file were not actively implemented in the provided mesh file and were subsequently discarded from the presented model setup.

2.7 TUFLOW FV Executable

Using the original DEW structure configuration (“fraction_open” parameterised by automated logical based on target upstream water levels) and the 2023.1 TUFLOW FV executable, it was identified that the structure dynamics were not working as intended. This has subsequently been resolved with a patch, where these amendments will be captured in a future release.

After shifting to the alternative timeseries defined barrage structure configuration, all subsequent modelling including the final model setup was performed using the 2023.1 TUFLOW FV release executable.

2.8 Model Speed Testing

Under the final model configuration, testing on BMTs CPU supercomputer cluster provided a runtime ratio of ~860 (single node, 16 threads @2.0 GHz with 16 GB RAM).

2.9 Model Git Repository

The final model builds have been pushed to DEW's BitBucket repository under the `bmt-dew` branch. Stage 1 and 2 modelling is captured in a separate subfolders as indicated below:

- Stage 1: `lower-lakes-tuflow-fv-model/TUFLOWFV/runs/bmt_stage1`
- Stage 2: `lower-lakes-tuflow-fv-model/TUFLOWFV/runs/bmt_stage2`

3 Model Calibration and Validation

3.1 Simulation Periods

Due to the comprehensive data acquisition collected over the 2022/23 flood event and the magnitude of the event itself, the model was calibrated for a simulation period spanning 01/07/2022 – 15/03/2023.

A model validation period was nominally defined for the 2010/11 flood event, with the respective simulation duration ranging from 02/09/2010 – 01/07/2011.

The Murray River inflow hydrograph and respective modelled periods are shown in Figure 3.1.

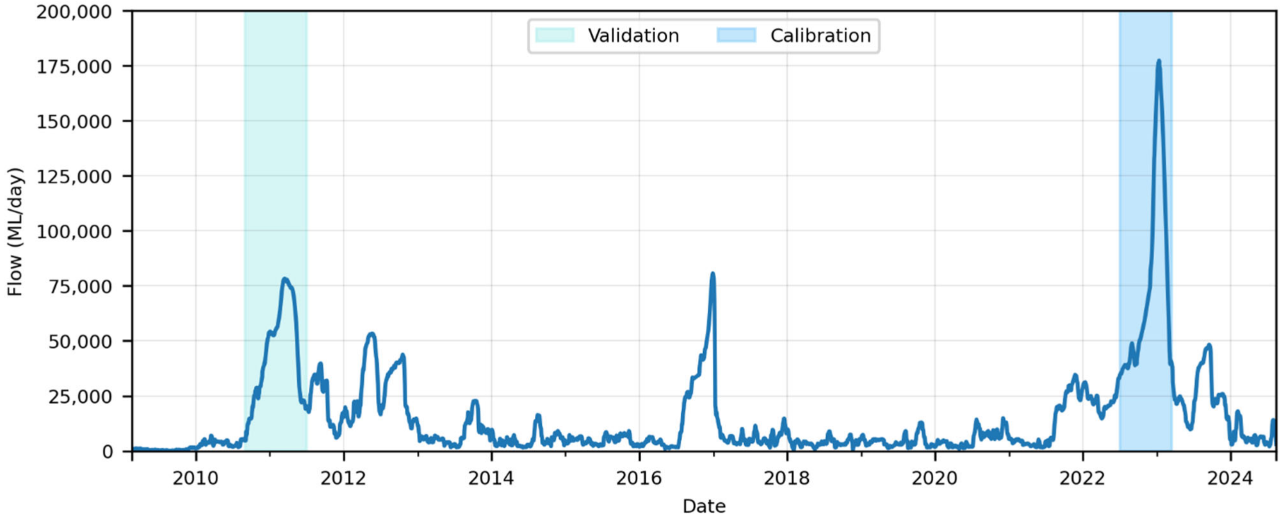

Figure 3.1 River Murray Inflow Hydrograph with Modelled Calibration and Validation Periods

As a necessary step to sufficiently parameterise the downstream boundary conditions for the subsequent Stage 2 modelling, a pseudo 1956 event was represented by proxy of scaling the 2022/23 flood event flow rate to match the reported peak 1956 flow rate (341 GL/day, refer https://www.environment.sa.gov.au/topics/river-murray-floods/lower-lakes-and-barrages). The scaling approach was necessary due to the limited data available for the 1956 event. Calibration of the pseudo 1956 event required suitable scaling of the barrage downstream water levels which are primarily dependent on barrage flow rate during large flow events.

3.2 Model Assessment

3.2.1 Reporting Locations

The location of DEW water level measurement gauges used in the model assessment are presented in Figure 2.2.

3.2.2 Model Skill Score Metrics

The relevant model error metrics used for performance assessment are described below and were applied to all timeseries comparisons.

- Mean Absolute Error (MAE)

  The mean absolute error (MAE) is a measure of the average magnitude of errors between pairs of observations. The MAE will always be smaller or equal to the root mean square error (RMSE - see below) and is considered to be a better measure of the average error magnitude as the errors are equally weighted and influence from outliers is minimised (Willmott and Matsuura, 2005).

- Root Mean Square Error (RMSE)

  The RMSE was used to quantify the absolute error in the model. This parameter gave an indication of the expected error in the calibration overall. The process of squaring the differences of the model and observed data gives higher weight to the largest (Willmott and Matsuura, 2005).

- R-squared (R^2)

  The R-squared value is a measure of how close the model and observed data can be represented by a linear regression line. The R-squared value is always between 0 and 1.0 with the higher R-squared value indicating a better model fit.

- Index of Agreement (IOA)

  The Index of Agreement (IOA) was originally developed by Willmott (1981) and subsequently modified in Willmott et al. (1985). It was developed so that the model's ability to reproduce the variance in the measured data themselves could be taken into consideration.

  Following Willmott (1981) and Willmott et al. (1985), the IOA can vary from 0 to 1 with higher values indicating better model predictive skill. A value above 0.5 is generally considered to indicate satisfactory model performance.

3.3 Calibration Results

To evaluate the efficacy of the MLL TUFLOW FV model, results are compared against several locations in both Lake Albert and Lake Alexandrina (locations formerly shown in Figure 2.2), with a daily average applied to both measured and modelled data. The model skill scores are presented in Table 3.1, with timeseries for Lake Albert and Lake Alexandrina presented in Figure 3.2 and Figure 3.3, respectively. As an alternative representation of the timeseries data, quantile-quantile plots are also presented in Annex A.

Table 3.1 Calibration period water level station skill scores

Location	Statistic			
	MAE (m)	RMSE (m)	R^2 (-)	IOA (-)
A4261155 Lake Albert 2km North Warringee Point	0.04	0.05	0.94	0.97
A4260630 Lake Albert at Meningie Sailing Club Jetty (Recorder)	0.03	0.00	0.94	0.98
A4261153 Lake Albert Near Causeway at Waltowa Swamp	0.03	0.04	0.97	0.99
A4261133 Lake Alexandrina at Beacon 97 (Offshore Raukkan)	0.02	0.03	0.98	0.99
A4260524 Lake Alexandrina at Milang Jetty (Recorder)	0.03	0.04	0.98	0.99
A4260575 Lake Alexandrina at Poltalloch Plains (Recorder)	0.02	0.03	0.98	0.99
A4260527 Lake Alexandrina at Tauwitchere Barrage	0.03	0.04	0.95	0.98
A4260574 Lake Alexandrina near Mulgundawa (Recorder)	0.02	0.03	0.98	1.00
Mean	0.03	0.03	0.97	0.99

The MLL TUFLOW FV model demonstrates a very high degree of correlation with the measured field data. The broad flood peak in January 2023 well represented at each location. The second peak in February 2023 corresponds to the highest flood peak at some locations, which appear to correspond with a wind and tidal surge event. This mechanism is very well represented at each location, particularly noting the Poltalloch Plains and Mulgundawa recorders (Figure 3.3).

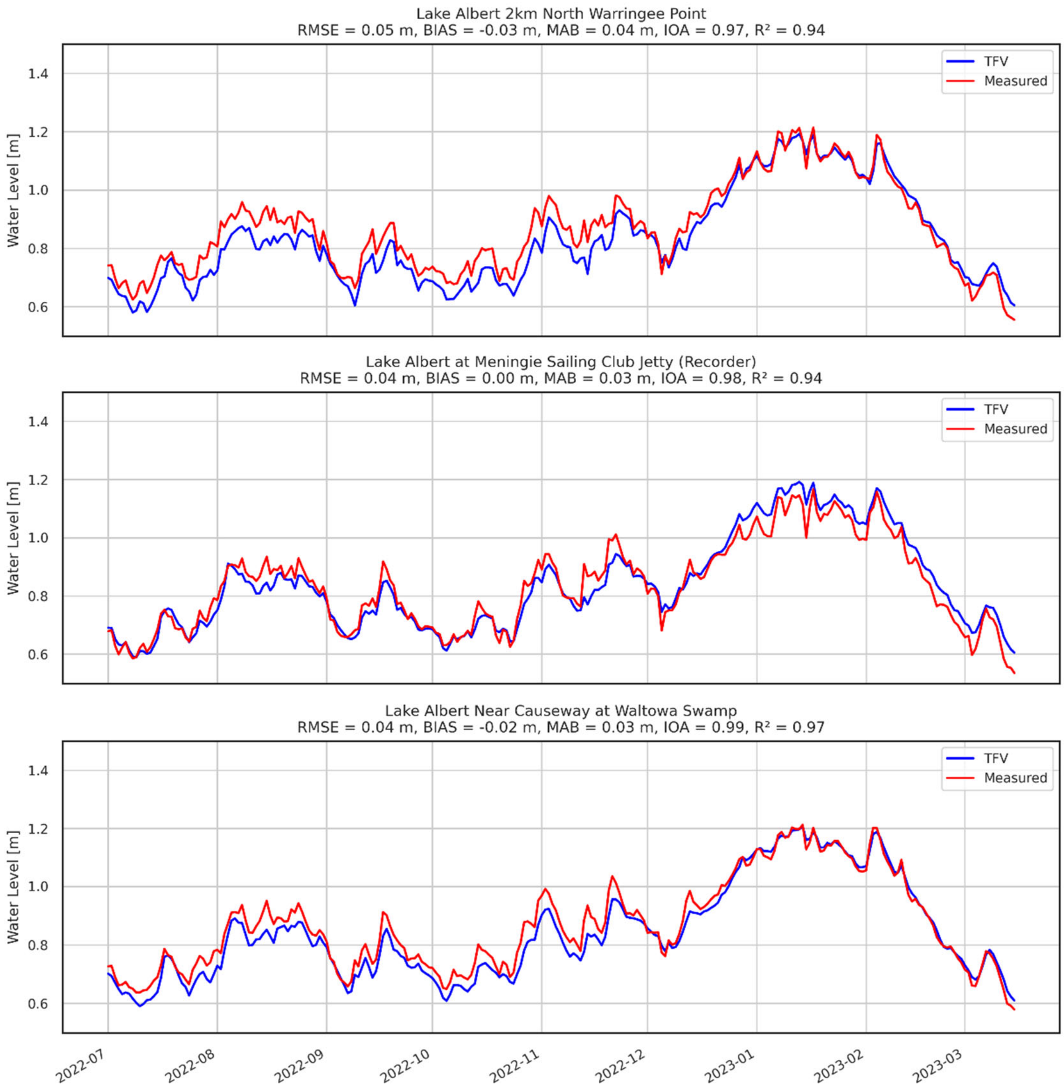

Figure 3.2 Modelled Lake Albert water level timeseries over the 2022/23 calibration period

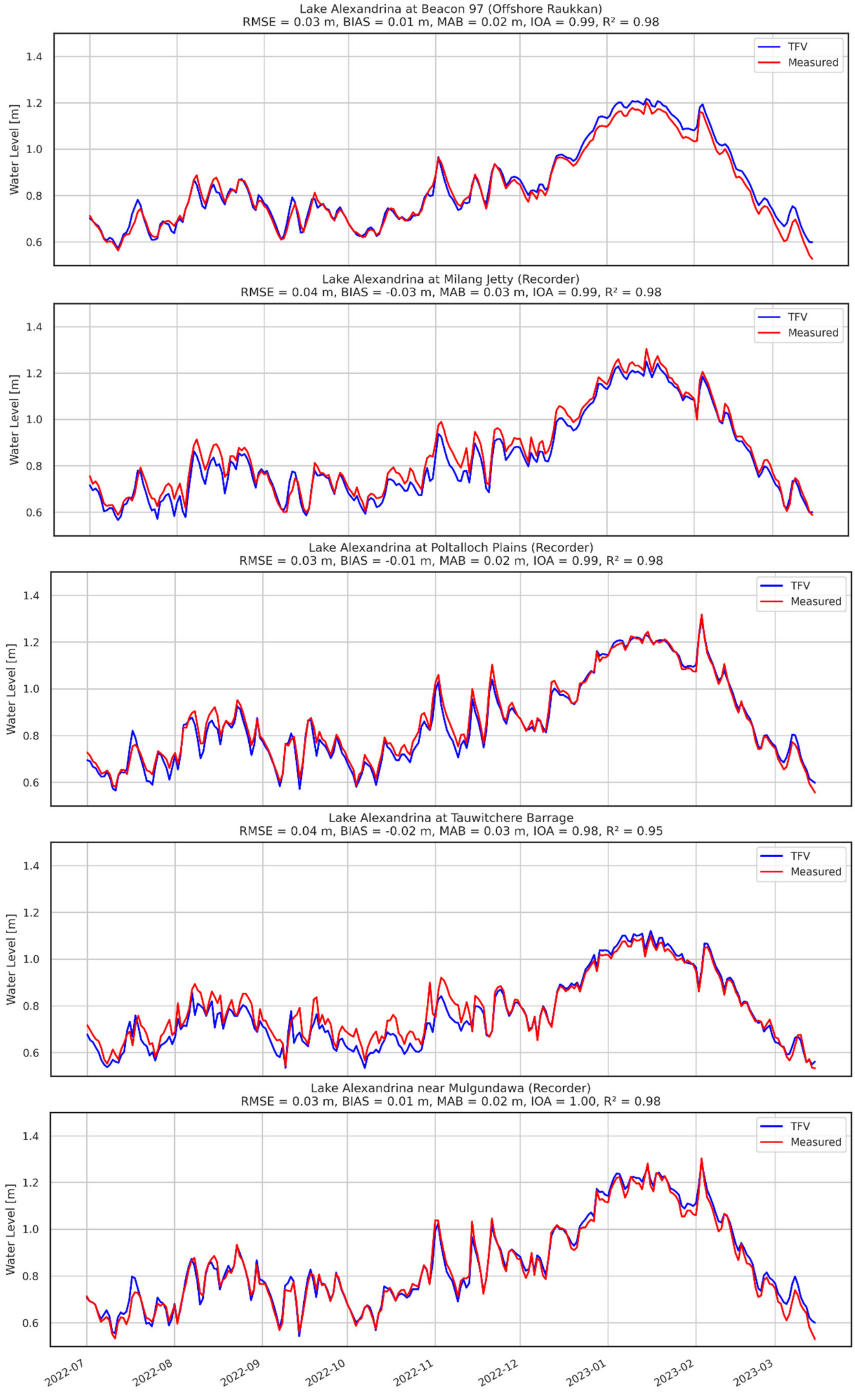

Figure 3.3 Modelled Lake Alexandrina water level timeseries over the 2022/23 calibration period

3.4 Validation Results

Model skill scores over the 2010/11 model validation period are presented in Table 3.2, with the Lake Albert and Lake Alexandrina timeseries presented in Figure 3.4 and Figure 3.5, respectively.

Table 3.2 Validation period water level station skill scores

Location	Statistic			
	MAE (m)	RMSE (m)	R^2 (-)	IOA (-)
A4261155 Lake Albert 2km North Warringee Point	0.07	0.09	0.32	0.73
A4260630 Lake Albert at Meningie Sailing Club Jetty (Recorder)	0.07	0.09	0.32	0.75
A4261153 Lake Albert Near Causeway at Waltowa Swamp	0.07	0.09	0.33	0.73
A4261133 Lake Alexandrina at Beacon 97 (Offshore Raukkan)	0.07	0.08	0.36	0.75
A4260524 Lake Alexandrina at Milang Jetty (Recorder)	0.07	0.09	0.33	0.74
A4260575 Lake Alexandrina at Poltalloch Plains (Recorder)	0.07	0.09	0.41	0.78
A4260527 Lake Alexandrina at Tauwitchere Barrage	0.07	0.10	0.30	0.68
A4260574 Lake Alexandrina near Mulgundawa (Recorder)	0.07	0.09	0.45	0.80
Mean	0.07	0.09	0.35	0.75

It is noted that due to the low initial lake levels at the Meningie Sailing Club recorder, the modelled water levels appear to show large positive bias until the model cell water levels achieve inundation (Figure 3.4). As a whole, the MLL model appears to underperform up until December 2010. This appears to be due to premature connectivity between Lake Alexandrina and Lake Albert, which were cut-off at the beginning of the simulation period. Once both the lake systems achieve parity with a water level of ~0.75 mAHD, the model performance shows significant improvement.

While the December 2010 water level peak is much more discrete than the 2022/23 flood event, the model shows good performance in resolving the peak water levels in both lake systems, particularly noting the sharp increases in water level at the Poltalloch Plains and Mulgundawa recorders within Lake Alexandrina as shown in Figure 3.5

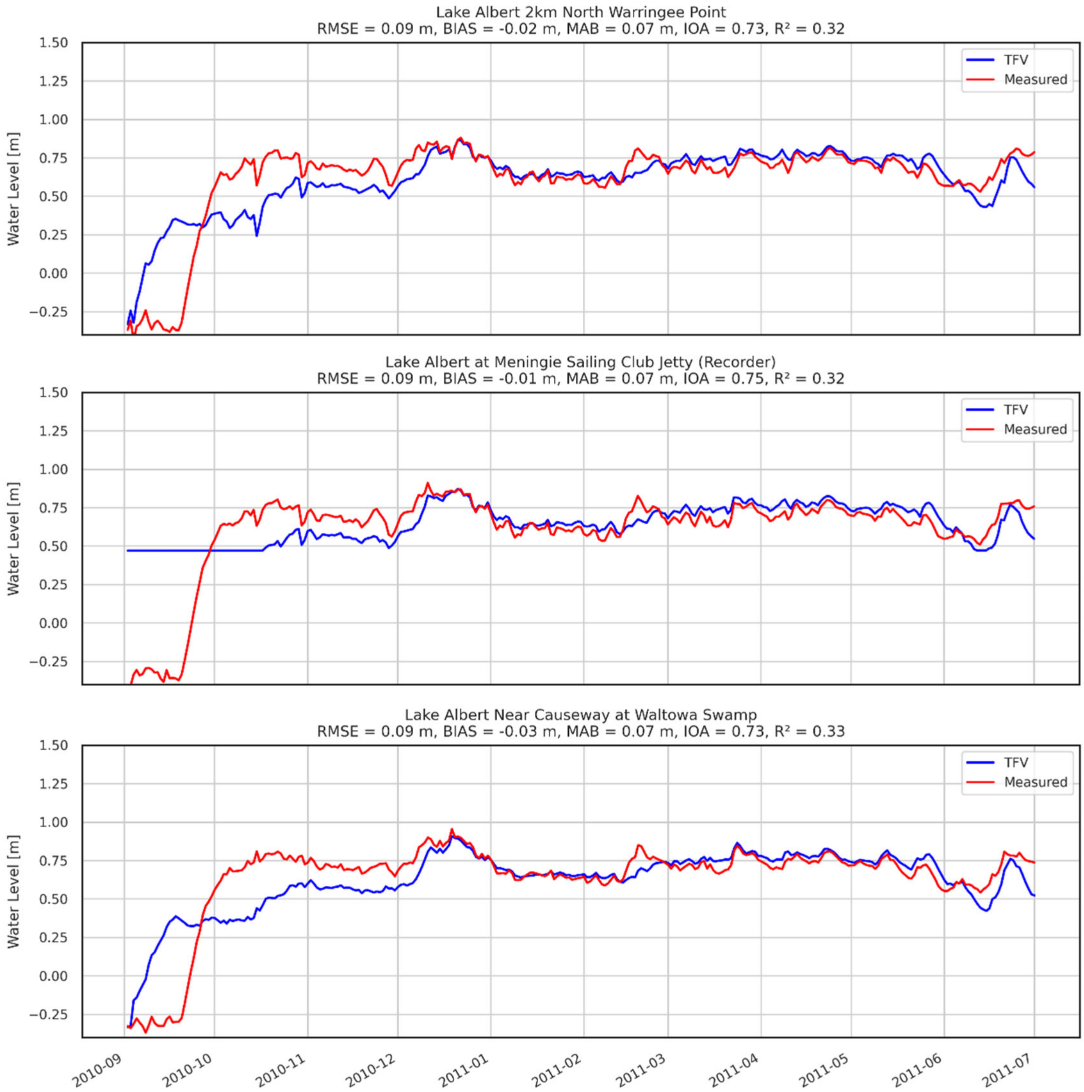

Figure 3.4 Modelled Lake Albert water level timeseries over the 2010/11 validation period

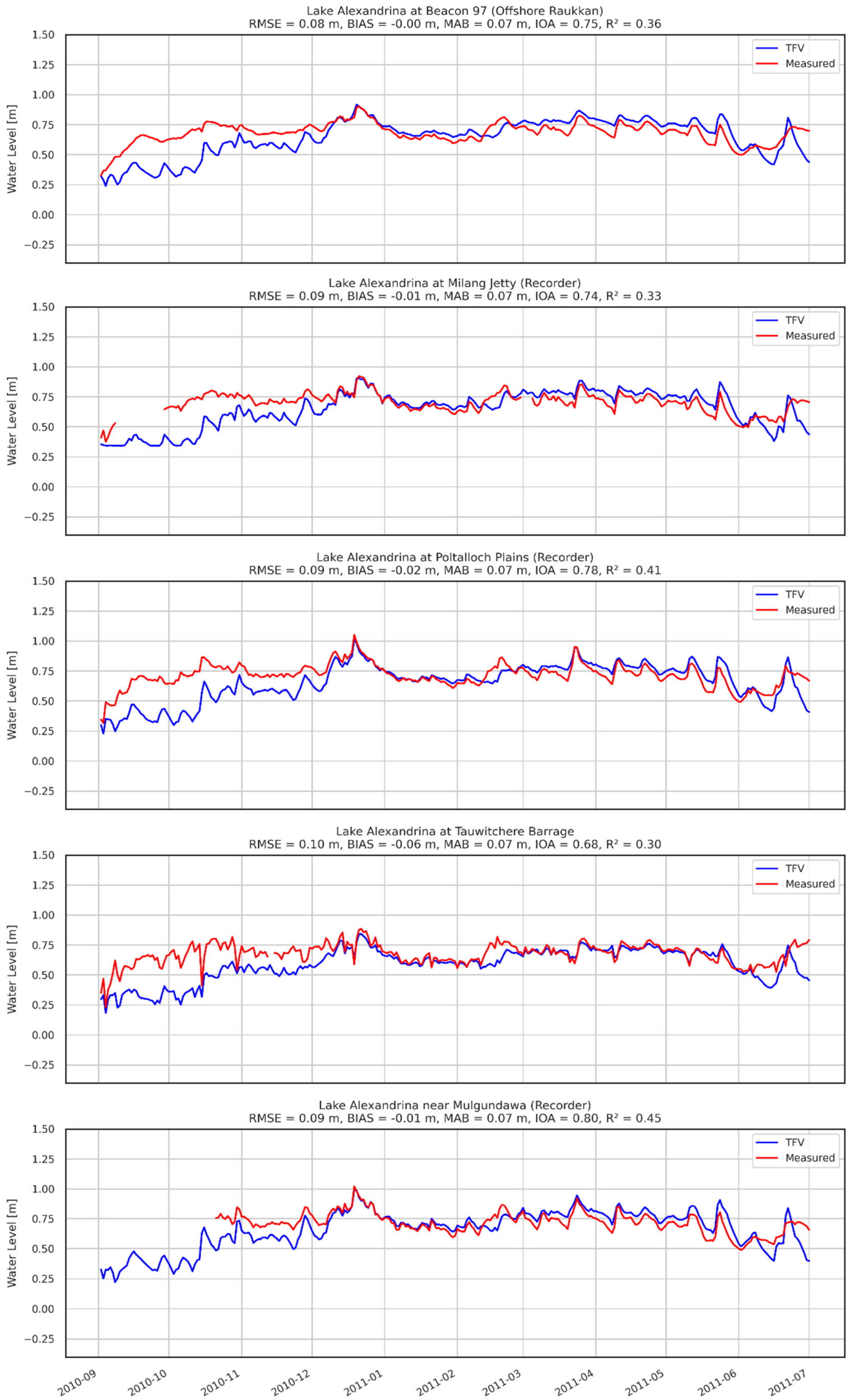

Figure 3.5 Modelled Lake Alexandrina water level timeseries over the 2010/11 validation period

3.5 Pseudo 1956 Flood Event

Mindful of the intention to apply the MLL model for flood inundation scenario modelling, with flows up to the 1956 flood event, a calibration exercise has been conducted to adjust the barrage downstream water levels to achieve the 1.62 mAHD water levels measured at the Goolwa ferry crossing at the peak of the event (DEW, n.d.).

This approach uses a simple scale coefficient, where over several simulation iterations this coefficient was refined. For the pseudo-1956 flood event (2022/23 event upscaled to the 341 GL/d peak River Murray inflows), a downstream scaling coefficient of 1.6 was derived. Timeseries illustrating the Goolwa water levels are presented in Figure 3.6.

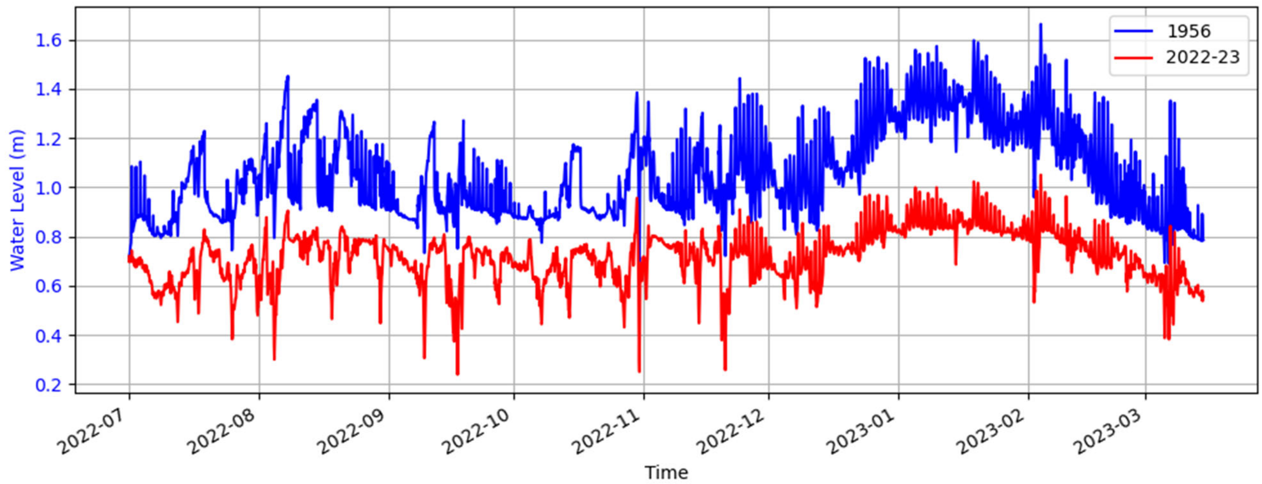

Figure 3.6 Modelled Goolwa water levels for the pseudo 1956 flood event and unscaled 2023/23 flood event

It should be noted that the scaled downstream methodology also lends the model to amplified signatures from within the Coorong (e.g., ocean surge events and strong wind events), subsequently having potential to overstate these hydraulic mechanisms.

Further, it was also identified that while the water levels at Goolwa matched the measured flood peak, water levels in Lake Alexandrina and Lake Albert were notably higher than the Goolwa water levels Figure 3.7.

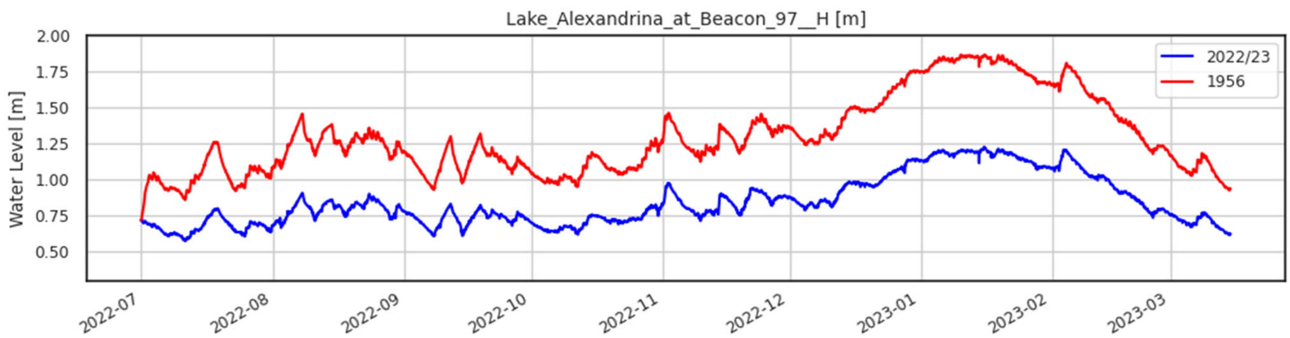

Figure 3.7 Modelled water levels at Lake Alexandrina Beacon 97 during the pseudo 1956 event

4 Stage 2 Flood Scenarios

Flood scenarios for River Murray inflows ranging 100 – 341 GL/day were modelling using the updated MLL TUFLOW FV hydrodynamic model. The model configuration is summarised in Section 4.1, with results presented in Section 4.2.

4.1 Scenario Parameterisation

The 2022/23 flood event was used as proxy for developing the boundary conditions for the various flood scenarios. Here, the River Murray inflow hydrographs were scaled to achieve defined scenario peak flows. For scenarios exceeding the peak 2022/23 flows, the downstream barrage water levels were linearly scaled, with the 2022/23 event and pseudo 1956 event (refer Section 3.5) providing the respective lower and upper scaling bounds. Scenarios defined by flows lower than the 2022/23 flood event adopted the 2022/23 water levels.

The barrage downstream water level and River Murray inflow scaling coefficients used for each of the flow scenarios are captured in Table 4.1.

Table 4.1 Barrage downstream water level and River Murray inflow scaling coefficients for the respective inundation scenarios

Peak Flow (GL/d)	Barrage Downstream Water Level	River Murray Inflows
100	1.00	0.56
120	1.00	0.68
140	1.00	0.79
160	1.00	0.90
180	1.01	1.02
200	1.08	1.13
250	1.27	1.41
300	1.45	1.69
341	1.60	1.92

The barrage “fraction_open” timeseries for the 2022/23 hindcast event were applied consistently for each of the scenarios. It is noted as limitation of this approach, that barrage operations would likely be different across the spectrum of events. Similarly, the use of the same barrage downstream water levels for flows less than the 2022/23 event could present an overestimate of the tailwater condition.

4.2 Results

Peak lake water levels at each of the DEW water level gauge locations (illustrated in Figure 2.2) are presented in Table 4.2. In order to filter out short term water level variations which may be driven by fluctuations in the scaled downstream barrage water level boundary condition or response to strong wind events the results have been low-pass filtered with a 48-hour moving average.

Table 4.2 Summary of peak scenario water levels at DEW gauge locations

Location	Peak 48-hr Moving Average Water Level (mAHD)								
	100 GL/d	120 GL/d	140 GL/d	160 GL/d	180 GL/d	200 GL/d	250 GL/d	300 GL/d	341 GL/d
A4261155 Lake Albert 2km North Warringee Point	1.10	1.11	1.14	1.17	1.20	1.30	1.49	1.70	1.86
A4260630 Lake Albert at Meningie Sailing Club Jetty (Recorder)	1.09	1.11	1.14	1.17	1.20	1.30	1.50	1.70	1.86
A4261153 Lake Albert Near Causeway at Waltowa Swamp	1.10	1.12	1.15	1.18	1.21	1.30	1.51	1.71	1.87
A4261133 Lake Alexandrina at Beacon 97 (Offshore Raukkan)	1.12	1.14	1.16	1.19	1.23	1.31	1.51	1.71	1.87
A4260524 Lake Alexandrina at Milang Jetty (Recorder)	1.15	1.16	1.19	1.21	1.25	1.32	1.53	1.72	1.88
A4260575 Lake Alexandrina at Poltalloch Plains (Recorder)	1.21	1.23	1.24	1.26	1.29	1.36	1.53	1.73	1.88
A4260527 Lake Alexandrina at Tauwitchere Barrage	1.07	1.08	1.09	1.10	1.12	1.19	1.40	1.61	1.77
A4260574 Lake Alexandrina near Mulgundawa (Recorder)	1.20	1.21	1.23	1.25	1.28	1.35	1.55	1.74	1.90
A4261123 Goolwa Channel at Signal Point (Beacon 23)	0.86	0.87	0.87	0.88	0.89	0.94	1.10	1.25	1.40
Mean	1.10	1.11	1.13	1.16	1.19	1.26	1.46	1.65	1.81
Maximum	1.21	1.23	1.24	1.26	1.29	1.36	1.55	1.74	1.90

5 Suggested Updates

As outcome of the MLL model development exercise, it has been identified that the MLL model performance is critically dependent upon the barrage parameterisation. In particular, the downstream water levels in the Coorong play a key role in the head differential and subsequent barrage flows. For the purposes of delivering a fit-for-purpose model suitable for the scoped application of a flood inundation assessment, the barrages were defined based on a “fraction_open” timeseries defined by barrage operations. This method provides an accurate depiction of the barrage configuration for hindcast modelling, however it is rigid in its ability to extend to accommodate alternative arrangements. This is further compounded by the dependency of a fixed water level condition at the downstream side of the barrages, where similarly this would be a variable dependent upon the upstream flow conditions. These limitations were discussed with DEW during an interim modelling update on 25th November 2024.

As an alternative approach, it was proposed to recommission the Coorong Rapid model to capture the water levels downstream of the barrages. This approach has the potential to provide significant flexibility in the model setup and application to non-hindcast scenario modelling where downstream barrage tailwater levels are dependent variables (e.g., oceanic surge events, sea level rise and flood events). The integration of the Coorong Rapid and Murray Lower Lakes models will help produce a powerful modelling tool for management of these respective systems, with added flexibility over existing approaches

6 Summary

A two-dimensional hydrodynamic model has been developed for the Murray Lower Lakes region including Lake Alexandrina and Lake Albert. The model is based on the TUFLOW FV software and was built with the primary intent of flood inundation assessment.

The modelling scope was undertaken in two stages. Under Stage 1, the Murray Lower Lakes model mesh was re-built to encompass the DEWs mapped 1956 flood extents, using recently acquired LiDAR and bathymetric datasets. Through model testing it was identified that the predicted lake levels demonstrated a high degree of sensitivity to the barrage tailwater levels. To address these sensitivities, the model was parameterised directly with a barrage fraction-open timeseries to directly represent actual historical barrage operations in the model hindcast. Under this configuration, the model demonstrated a high level of model accuracy for the 2022/23 calibration flood event. The model was also validated against a smaller 2010/11 flood event. To facilitate extrapolation of the model to larger flows, the downstream barrage tailwater condition was also appropriately scaled to replicate measured water levels for a pseudo 1956 flood event (by proxy of scaling 2022/23 flows).

Stage 2 modelling considered the water level response for a range of different River Murray inflow events for flow rates ranging 100 GL/d up to 341 GL/d. These events were synthesised by scaling the River Murray inflows and Coorong barrage tailwater conditions, relative to the 2022/23 event. Peak water levels at key DEW gauge locations and water level GIS outputs were derived for each simulation event. As an important outcome of this investigation, it was identified that water level gradients across the Murray Lower Lakes system were significant, with the model predicting that water levels in Lake Alexandrina were in the order of ~0.3 m higher than the Hindmarsh Island Ferry Crossing measurements for the 1956 flood flow magnitude.

Due to the sensitivity of the model results to barrage downstream water level, which is in turn dependent on ocean water level, barrage flows, Coorong hydrodynamics and Mouth morphology, BMT recommends the integration of the Lower Lakes model with the Coorong (rapid configuration) model. As a further extension of an integrated model system the model barrage fraction-open parameterisation could be reviewed to respond appropriately to a combination of ocean and river flow conditions. These updates will facilitate improved flexibility in the model schematisation and better capture the feedback between the Murray Lower Lakes and Coorong systems.

Model updates for both the Stage 1 and Stage 2 modelling have been captured in DEWs “lower-lakes-tuflow-fv-model” Git repository.

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Annex A Water Level Quantile-Quantile Plots

A.1 Calibration Period

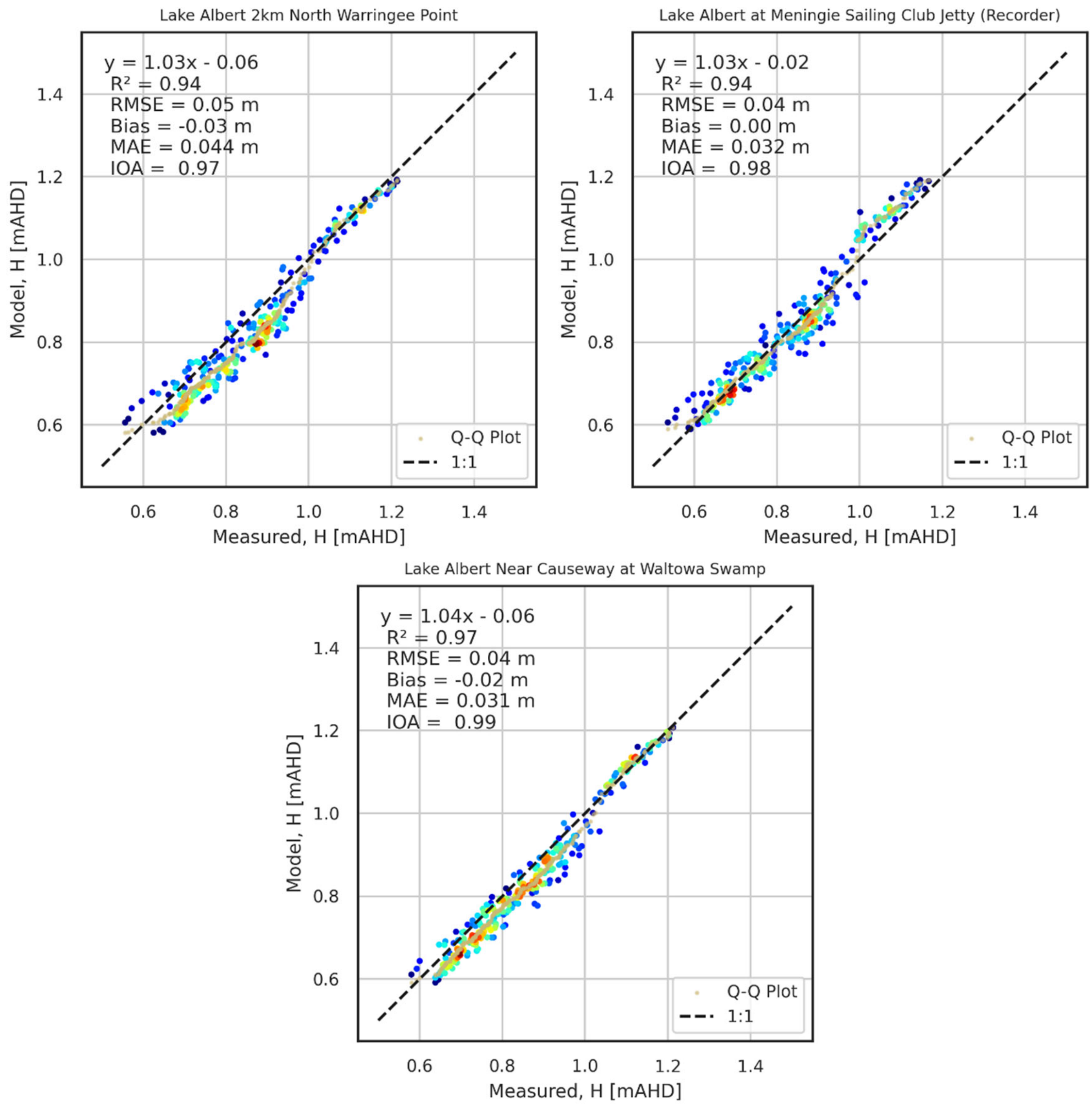


Figure A.1 Modelled Lake Albert water level quantile-quantile plot over the 2022/23 calibration period

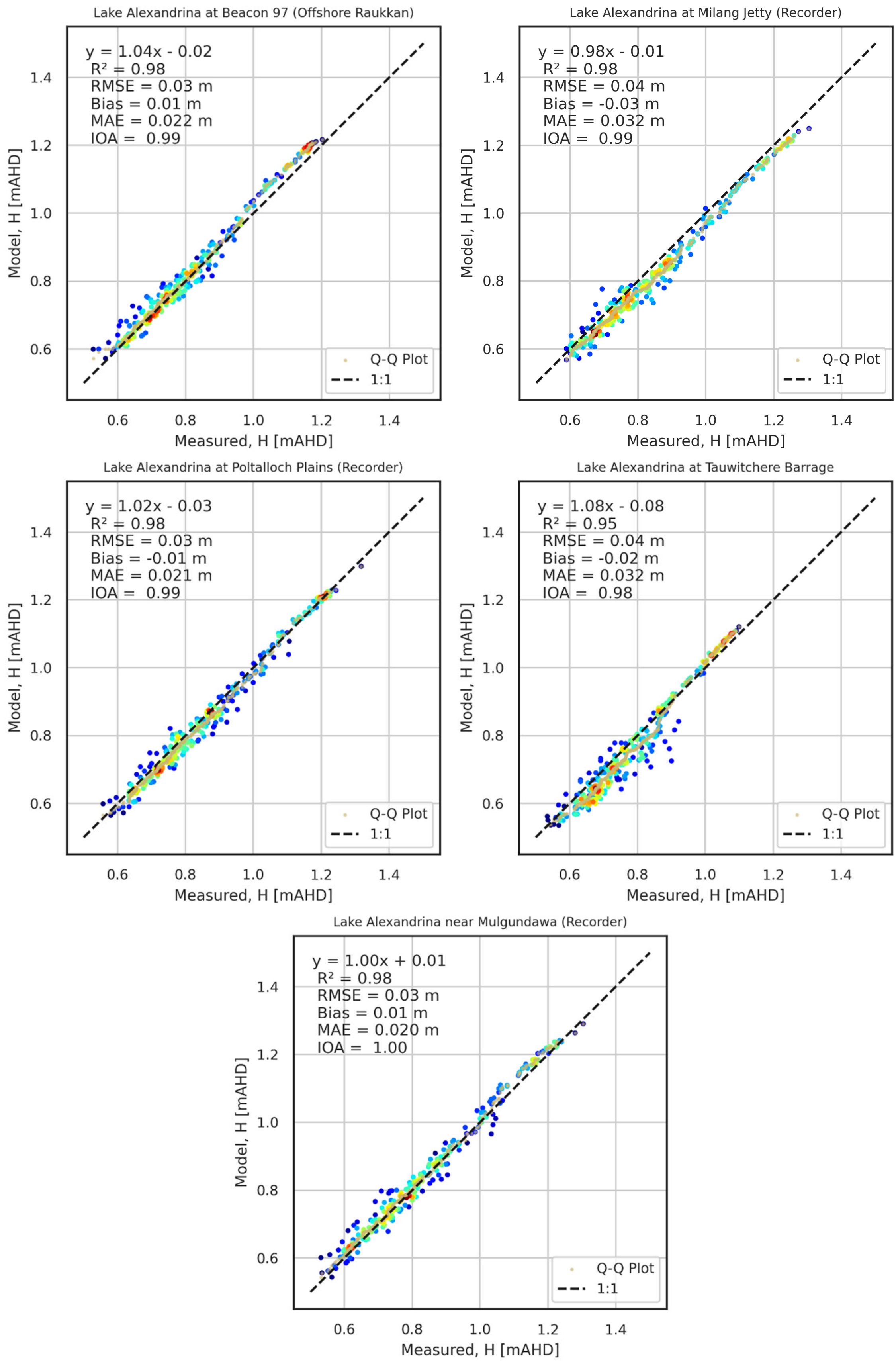


Figure A.2 Modelled Lake Alexandrina water level quantile-quantile plot over the 2022/23 calibration period

A.2 Validation Period

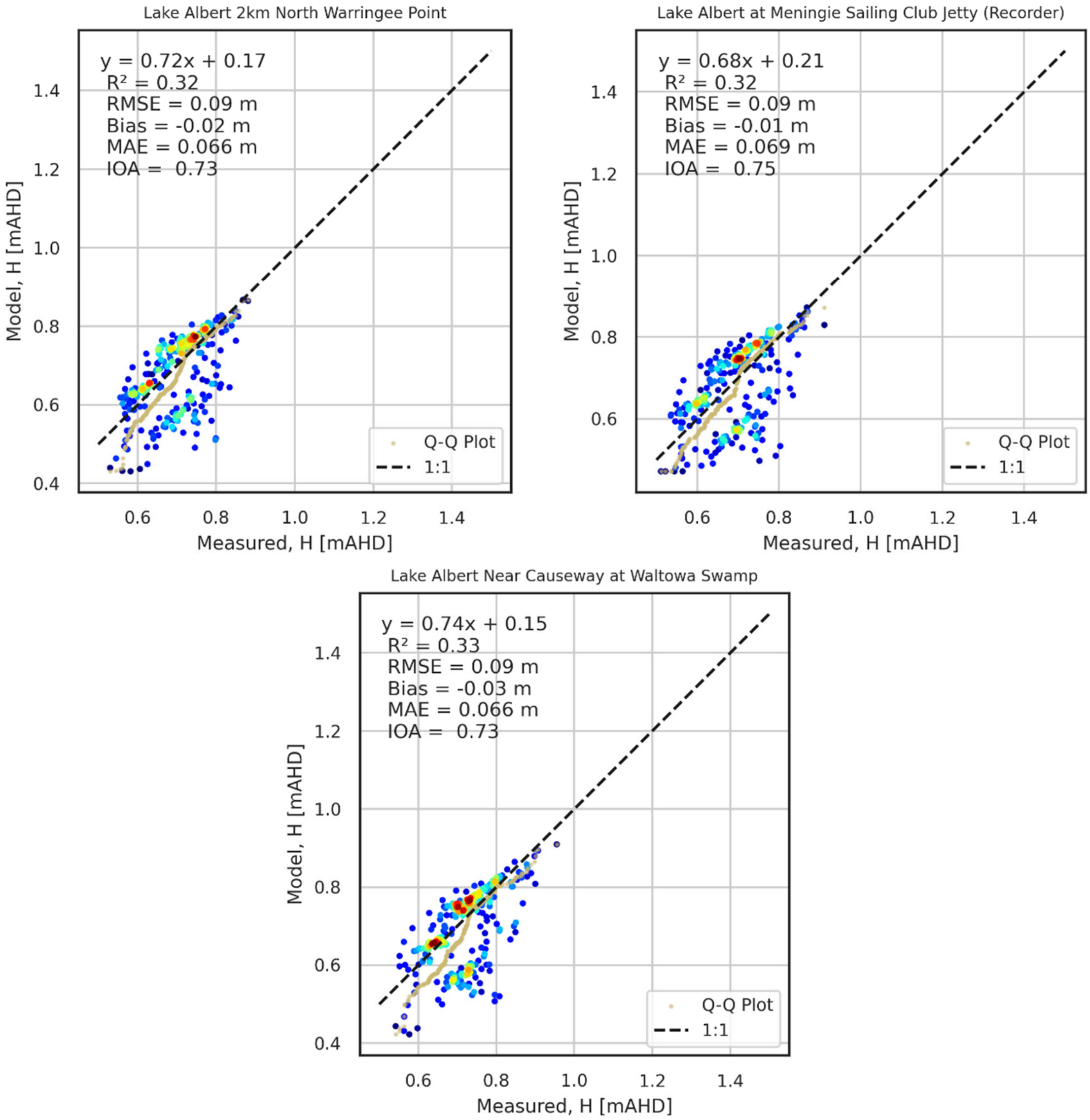


Figure A.3 Modelled Lake Albert water level quantile-quantile plot over the 2010/11 validation period

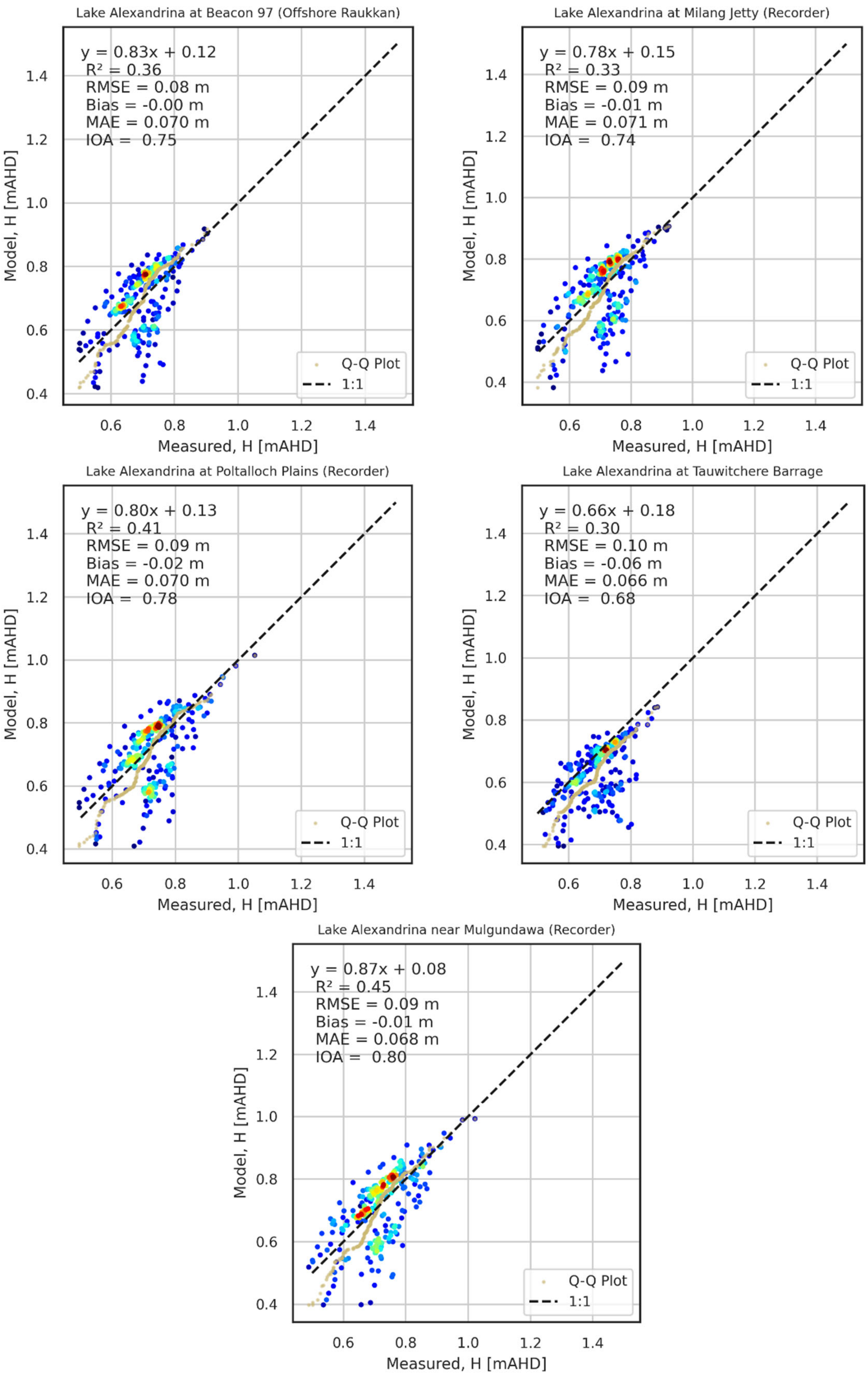
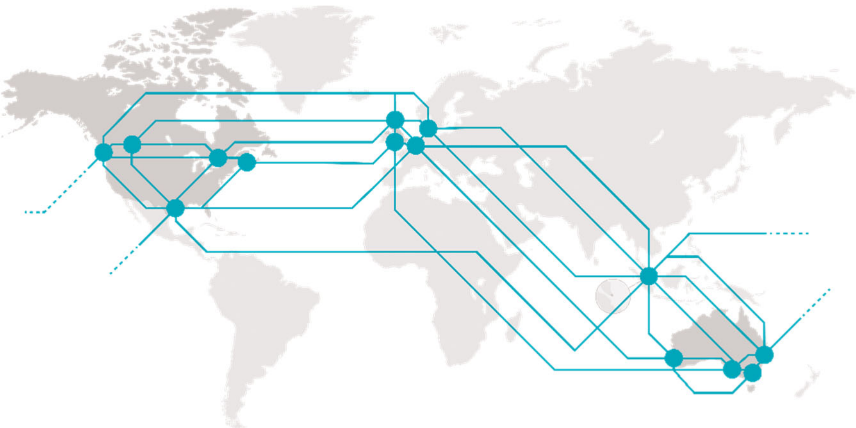


Figure A.4 Modelled Lake Alexandrina water level quantile-quantile plot over the 2010/11 validation period



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Level 5
348 Edward Street
Brisbane
QLD 4000
Australia
+61 7 3831 6744

Registered in Australia
Registered no. 010 830 421
Registered office
Level 5, 348 Edward Street,
Brisbane QLD 4000 Australia

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