STATE EMERGENCY SERVICE

TASMANIAN STRATEGIC FLOOD MAP
MERSEY STUDY AREA MODEL CALIBRATION

REPORT

MARCH 2023

Level 1, 119 Macquarie Street
Hobart, TAS, 7000

Tel: (03) 6111 1726
Fax: (02) 9262 6208
Email: wma@wmawater.com.au
Web: www.wmawater.com.au

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Project Tasmanian Strategic Flood Map Mersey Study Area Model Calibration	**Project Number** **120038**
Client STATE EMERGENCY SERVICE	**Client's Representative** Chris Irvine
Project Manager Fiona Ling	

Revision History

Revision	Description	Distribution	Authors	Reviewed by	Verified by	Date
0	Draft report for review	Chris Irvine, SES	Sarah Blundy, Evmen Wong	Daniel Wood	Fiona Ling	SEP 22
1	Final report	Chris Irvine, SES	Sarah Blundy, Evmen Wong	Daniel Wood	Fiona Ling	NOV 22
2	Report with minor revisions	Chris Irvine, SES	Sarah Blundy, Evmen Wong	Daniel Wood	Fiona Ling	MAR 23

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LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ALS	Airborne Laser Scanning
AMS	Annual Maximum Series
ARF	Areal Reduction Factor
ARR	Australian Rainfall and Runoff
ATP	Areal Temporal Patterns
AWAP	Australian Water Availability Project
AWS	Automatic Weather Station
Bureau/BoM	Bureau of Meteorology
C	Lag parameter in WBNM
CFEV	Conservation of Freshwater Ecosystem Values (DPIPWE)
CL	Continuing Loss
DEM	Digital Elevation Model
DNRE	Department of Natural Resources and Environment (formerly DPIPWE)
DPIPWE	Department of Primary Industries, Water and Environment
DRM	Direct Rainfall Method
DTM	Digital Terrain Model
FFA	Flood Frequency Analysis
FLIKE	Software for flood frequency analysis
FSL	Full Supply Level
GIS	Geographic Information System
GEV	Generalised Extreme Value distribution
GPS	Global Positioning System
HSA	Human Settlement Area
ICM	Infoworks ICM software (Innovyze)
IDW	Inverse Distance Weighting
IL	Initial Loss
IFD	Intensity, Frequency and Duration (Rainfall)
LiDAR	Light Detection and Ranging
mAHD	meters above Australian Height Datum
PERN	Catchment routing parameter in RAFTS
Pluvi	Pluviograph – Rain gauge with ability to record rain in real time
QAQC	Quality assurance and quality control
R	Channel routing parameter in WMAWater RAFTS WBNM hybrid model
RAF	RAFTS Adjustment Factor
RAFTS	hydrologic model
SCE	Shuffled Complex Evolution
SES	State Emergency Service
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydrodynamic model)
WBNM	Watershed Bounded Network Model (hydrologic model)

1. INTRODUCTION

Flooding occurs regularly throughout Tasmania; the Bureau of Meteorology describes numerous major flood events that have occurred since the early 1800s. Following the 2016 Tasmanian floods, the need for state and local governments, communities and emergency response agencies to better understand flooding in Tasmania was identified. Improved flood intelligence would allow for targeted and appropriate investment in flood recovery and increased community resilience to future flood events. The Independent Review into the Tasmanian Floods of June and July 2016 found that there were gaps in flood studies and flood plans over Tasmania, both in comprehensiveness and currency.

The objectives of the Tasmanian Strategic Flood Mapping Project are to assist flood affected communities to recover from the 2016 floods through a better understanding of flood behaviour, and to increase the resilience of Tasmanian communities to future flood events. The targeted outcomes of the project are that post-flood recovery will be informed by up-to-date flood risk information, ownership of flood risk is appropriately allocated, flood risk can be included in investment decisions, and responsibility for flood mitigation costs can be appropriately allocated.

The Tasmanian Flood Mapping Project aims to address the objectives and outcomes by:

- providing communities with access to a high resolution digital terrain model that can be used for flood modelling, through collection of LiDAR data over Tasmania
- developing state-wide Strategic Flood Maps to support flood risk assessment and post event analysis and
- partnering with Local Government to deliver detailed flood studies and evacuation planning for communities with highest flood risk that do not have a current flood study.

This project addresses the second component of the Tasmanian Flood Mapping Project, the development of state-wide Strategic Flood Maps.

This report describes the calibration of hydrologic and hydrodynamic flood models for the Mersey study area.

2. STUDY AREA

The Mersey River study area is situated in northern Tasmania. The study area covers the Mersey River and Don River as well as some very small coastal catchments between the Don and Forth rivers. The Mersey River flows close to Latrobe and through Devonport, making this one of the most populous study areas in the state. The Mersey River forms part of the Mersey-Forth power scheme with 3 major hydro-electricity dams located in the catchment. Water from Lake Parangana is diverted through a tunnel to the Forth River via Lemonthyme Power Station.

The Mersey River forms on the central plateau of Tasmania in the Walls of Jerusalem National Park. This area is sometimes known as 'the land of a thousand lakes' with many natural lakes and tarns, steep terrain and alpine scrub. The alpine landscape gives way to dense eucalypt forest around lakes Rowallan and Parangana. The lower catchment has large areas of agricultural land interspersed with natural and plantation forests.

The study area is partially covered by two different irrigation schemes with a small area around Mole Creek and Chudleigh within the Greater Meander Irrigation Scheme, and areas south of Latrobe within the Sassafras - Wesley Vale Scheme. Many of the tributaries of the Don River and lower Mersey River have chains of small irrigation dams along their length.

The study area has a population of approximately 30,000 including the third largest city in Tasmania - Devonport, and major populations centres at Latrobe, Sheffield, Railton and Spreyton.

Large floods in the study area include the August 1970 and June 2016 flood events.

The Mersey study area has an area of 1915 km^2; 1750 km^2 of this comprises the Mersey River catchment, with the Don River making up most of the remainder of the area. The Mersey study area and the available gauge information are shown in Figure 1. Landuse in the Mersey study area is shown in Figure 2.

3. AVAILABLE DATA

3.1. Historic Flow Data and Level Data

There are eight flow gauges with data available in the Mersey study area, four of these are on the Mersey River itself (as shown in Table 1) and four are on tributaries or separate rivers within the study area (Table 2). These gauges are owned by Hydro Tasmania, DNRE (formerly DPIPWE), and BOM. Some data was supplied by these organisations or the SES for this project and some was downloaded directly from Water Data Online (BoM, 2021b) or the Tasmanian Water Information Web Portal (DPIPWE 2020).

Table 1: Flow gauges on the Mersey River

Gauge attribute	Mersey River Above Arm	Mersey River at Liena	Mersey River at Kimberley	Mersey River at Shale Road
Gauge number	153-1	60-1	22-1	447-1
Gauge abbreviated name	Mersey Arm	Mersey at Liena	Mersey at Kimberley	Shale Road
Start date	01/12/1953	27/07/1950	08/03/1921	01/11/1962
End date	Current	Current	21/11/2002*	Current
Latitude	-47.71	-41.55	-41.39	-41.27
Longitude	146.22	146.22	146.49	146.42
High flow rating quality	Good	Good	Unknown	Poor
Used for calibration	Yes	Yes	No	Yes
Assumed local datum 0m in AHD	426.337	282.600	N/A	4.293
Highest Gauged Level (m local datum)	2.97 (230 m^3/s)	2.74 (350 m^3/s)	Unknown	3.37 (622 m^3/s)
Highest recorded stage height (m local datum)	3.20	4.90	Not available	10.42
Highest recorded flow (m^3/s)	270	957	1364	2001
Highest recorded stage height date	23/04/1960	06/06/2016	Not available	6/06/2016
Highest recorded flow date	23/04/1960	06/06/2016	24/08/1970	24/08/1970

* Mersey at Kimberley is still a current BOM Flood Warning site however timeseries of stage heights or flows are not available publicly and were not supplied for this project.

Table 2: Flow gauges on rivers in the study area other than on the Mersey River

Gauge attribute	Arm River A/B Mersey River	Fisher River U/S Lake Mackenzie	Mole Creek D/S Sassafras Creek	Don River US Old Bass Hwy
Gauge number	624-1	16201-1	3703-1	16200-1
Gauge abbreviated name	Arm a/b Mersey	Fisher River	Mole Creek	Don River
Start date	12/01/1972	12/05/1972	18/06/2008	21/07/1967
End date	Current	Current	Current	Current
Latitude	-41.68	-41.69	-41.53	-41.19
Longitude	146.21	146.39	146.53	146.31
High flow rating quality	Good	Poor	Very poor	Poor
Used for calibration	Yes	No – results presented for illustration only	Yes – levels only	No – results presented for illustration only
Assumed local datum 0m in AHD	402.28	1136.4	204.50	3.70
Highest Gauged Level (m local datum)	1.79 (49 m^3/s)	0.76 (10 m^3/s)	0.94 (4 m^3/s)	1.85 (35 m^3/s)
Highest recorded stage height (m local datum)	2.20	2.16*	4.00	3.70
Highest recorded flow (m^3/s)	107	153*	41	97
Highest recorded stage height date	06/06/2016	05/06/2016	06/06/2016	14/01/2011
Highest recorded flow date	06/06/2016	05/06/2016	06/06/2016	24/08/1970

*Note: Peak flows and stage at Fisher River are estimated as the recorder cut out at approximately 1.5 m and 40 m^3/s during the June 2016 event.

3.1.1. Calibration Event Data Availability

Four events of the 13 flood events selected by the Bureau as calibration events for this project were selected for use in calibration in the Mersey study area (Table 3). Two of these events, August 1970 and June 2016, were very large across the study area, and were the largest or second largest events on record at many gauges. August 2007 was only a significant event in the upper catchment, being the 2nd and 3rd largest event on record at Arm above Mersey and Fisher U/S Lake Mackenzie. At other gauges throughout the catchment August 2007 was not in the top 10 events on record, therefore while this event was run for the entire catchment it was only calibrated to Arm above Mersey and Fisher Upstream Lake Mackenzie. Similarly, January 2011 event was 2nd-4th largest on record at Don River, Mole Creek, Fisher River and Shale Rd gauges. However, this event was not as significant in the upper catchment; for example it was less than a 1EY event at Arm above Mersey. Therefore, this event was only calibrated to the sites where it was significant.

During the June 2016 flood event, the recorder at Fisher River upstream of Lake MacKenzie cut out during the initial rise of the event, at higher flows than had ever been recorded before. Estimated flows and levels for this event are available on Water Data Online so these have been compared to modelled flows, but due to the uncertainty in the estimation this has not been used for calibration. The shape of the hydrograph at the Arm River above Mersey gauge for June 2016 is also suspect, with the gauge flatlining and then dropping off sharply towards the end of the event. These flows were treated with scepticism during calibration and given less weight than other sites.

In addition to the information at the stream gauges, lake levels and spillway flows at the Hydro Tasmania dam locations were used for calibration (see Section 3.3). As so many calibration points were available, calibration was done by looking across the entire study area, with the allowance that flows would be overestimated at some sites and underestimated at others, and that the rainfall and loss distribution is not perfect.

Table 3: Summary of the largest events in the Mersey study area

Event name	Used for calibration	Event peak flow (m^3/s) (location)
1970_Aug	Yes	318 (Mersey ab Arm)
1970_Aug	Yes	940 (Mersey at Liena)
1970_Aug	No	1364 (Mersey at Kimberley)
1970_Aug	Yes	2001 (Mersey at Shale Road)
1970_Aug	No – Rating poor	97 (Don River)
2007_Aug	No – event too small	13 (Mersey ab Arm)
2007_Aug	No – event too small	328 (Mersey at Liena)
2007_Aug	No – event too small	445 (Mersey at Shale Road)
2007_Aug	Yes	80 (Arm a/b Mersey)
2007_Aug	No – Rating poor	41 (Fisher River)
2007_Aug	No – event too small	25 (Don River)
2011_Jan	No – event too small	29 (Mersey ab Arm)
2011_Jan	No – event too small	305 (Mersey at Liena)
2011_Jan	Yes	788 (Mersey at Shale Road)
2011_Jan	No – event too small	12 (Arm a/b Mersey)
2011_Jan	No – Rating poor	41 (Fisher River)
2011_Jan	No – Rating poor	20 (Mole Creek)
2011_Jan	Yes – Level only	194 (Don River)
2016_Jun	Yes	175 (Mersey ab Arm)
2016_Jun	Yes	961 (Mersey at Liena)
2016_Jun	Yes	1227 (Mersey at Shale Road)
2016_Jun	Yes, but data quality suspect	107 (Arm a/b Mersey)
2016_Jun	No – estimated observed	153 (Fisher River)
2016_Jun	No – Rating poor	41 (Mole Creek)
2016_Jun	Yes – Level only	91 (Don River)

3.1.2. Rating Curve Quality

While the rating quality at many of these gauges is likely good, the largest calibration events are significantly above the highest gaugings and therefore well into the extrapolated range. At many sites, the observed peak for at least one calibration event is over twice the highest gauged flow (Mersey at Liena, Mersey at Shale Road, Arm above Mersey, Don River) and in some cases it is up to 10 times the highest gauged flow (Fisher River, Mole Creek), therefore at sites with very good rating curves, peak flows could easily be ± 20% in error. Additionally, at quite a few of these sites (Mersey at Liena, Arm above Mersey, Mersey above Arm) the highest gaugings were conducted in the 1960s, 1970s or 1990s so have not been verified in up to 60 years.

There were three gauges in this study area that were rerated as part of the Rating Revision Report (WMAWater, 2021c), however the revised ratings were not used at these locations due to various issues described in their sections below.

3.1.2.1. Mersey above Arm River

The rating at the Mersey above Arm River gauge is believed to be good quality with the highest gauging only 15% lower than the highest recorded flow. Additionally, as this site is located only a short way downstream of Rowallan Dam it is likely that the Rowallan Dam spillway and power station rating curves may have been used to verify the rating, which are likely to be more certain than typical stream gauges.

3.1.2.1. Mersey River at Liena

The rating at this gauge is believed to be good. The highest gauging is only approximately one third of the flow of the highest recorded flow. However, as this gauge is located only a short distance downstream of Paranagana Dam, it is likely that spill flows from the dam have been used to verify the rating.

3.1.2.2. Mersey River at Kimberley

Mersey River at Kimberley is a flood warning gauge operated by the Bureau. A revised rating was created for this gauge however, unfortunately, it has not been possible to source the historic stage height data at this site so the new rating could not be applied. Due to the lack of information on stage height, the quality of the rating for the flow data provided is unknown.

3.1.2.1. Mersey River at Shale Road

A revised rating was created for Mersey River at Shale Road; however, it was found to be unusable due to discrepancies in the site coordinates. Therefore, the DNRE flow data has been used. There are many different ratings applied by DNRE at this site across its history (24 ratings). While we were not able to obtain detailed information on the different ratings, it is clear from the event data that the rating curves have varied significantly at this site. The peak level for the 1970 event of 8.94 m (local datum) has an associated flow of 2000 m^3/s however the same stage height

has less than half this flow (990 m^3/s) for the June 2016 event. There was a notable shift in low flow levels in 1981 which suggests a significant change in the control at the gauge or datum used, which would impact the entire rating curve. However, even with a 0.6 m offset, the rating produces high flows for the 2016 event are still almost half those of 1970. As we are using a DTM from a fixed moment in time, we cannot replicate any real differences in the flow behaviour at this site. Comparing flows for more recent events with the Hydro Tasmania gauge upstream (Mersey at Liena) suggests that rated flows are underestimated for these events.

3.1.2.1. Arm above Mersey River

The rating at Arm above Mersey is believed to be good quality with a weir providing a stable control with predictable stage to flow behaviour. However, the highest gauging is at less than half the peak of the June 2016 event, so there is still uncertainty in the highest flow recordings.

3.1.2.2. Fisher River U/S Lake Mackenzie

The rating at Fisher River u/s of Lake Mackenzie is considered to be poor. Despite having a weir to provide a stable control, the isolated location of this site means that it has never been gauged during high flows. The highest gauging is at less than 10% of the estimated peak of the June 2016 event.

3.1.2.3. Mole Creek d/s Sassafras Creek

The rating at Mole Creek was deemed to be very poor for high flows. Flows are only gauged up to 4 m^3/s but rated flows for calibration events are much larger (up to 40 m^3/s) and modelled flows even larger – up to 150m^3/s; so potentially the highest gauging is at approximately 1-5% of the true maximum flows. This gauge has only existed since 2008 but has had 6 rating curves in that time, indicating that it has a very unstable control (Diagram 1). At the top end, these ratings vary by more than 50% suggesting that the rating extrapolations are highly uncertain. Additionally, simple volume balance estimations of flows at this gauge suggest that the rating is very significantly underestimating peak flows.

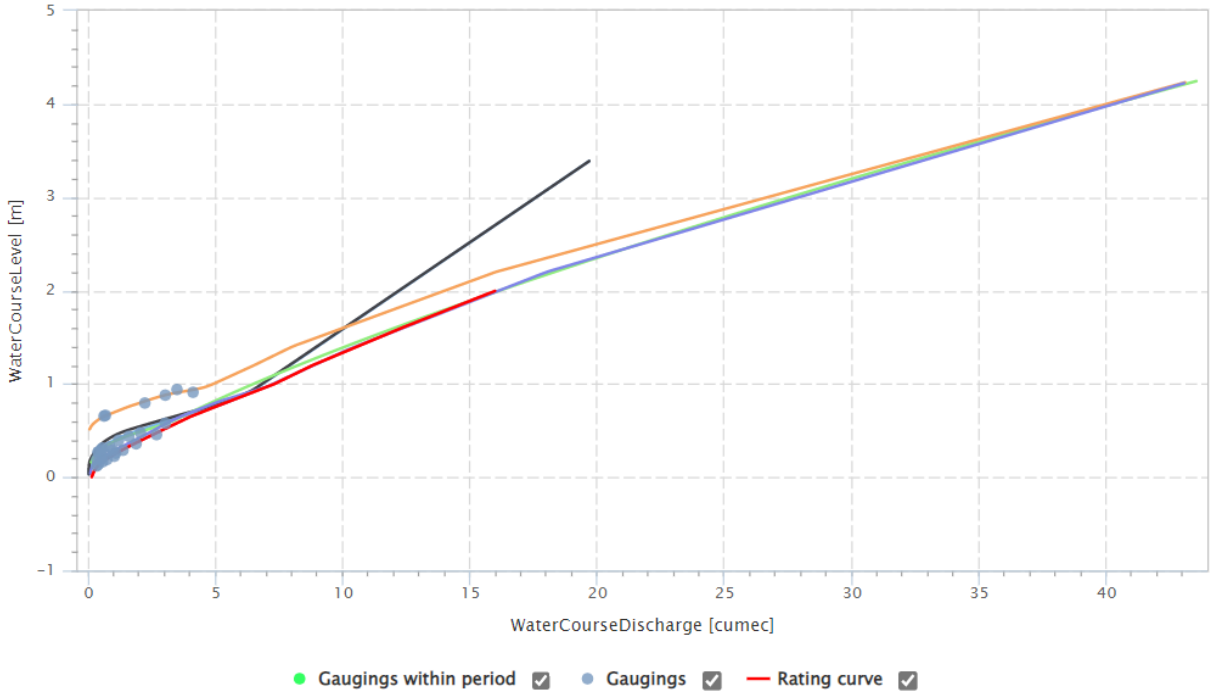

Diagram 1: Ratings and gaugings at Mole Creek downstream Sassafras Creek showing significant changes in the 14 year record (Source Water Data Online (BOM 2021b))

3.1.2.1. Don River upstream Old Bass Highway

Don River upstream Old Bass Highway is in an area where there has been significant changes to the DEM provided for this project between the time that the rating revision variation was undertaken and the current modelling stage (Diagram 2). Therefore, as this DEM was updated due to issues unfortunately this rating cannot be used.

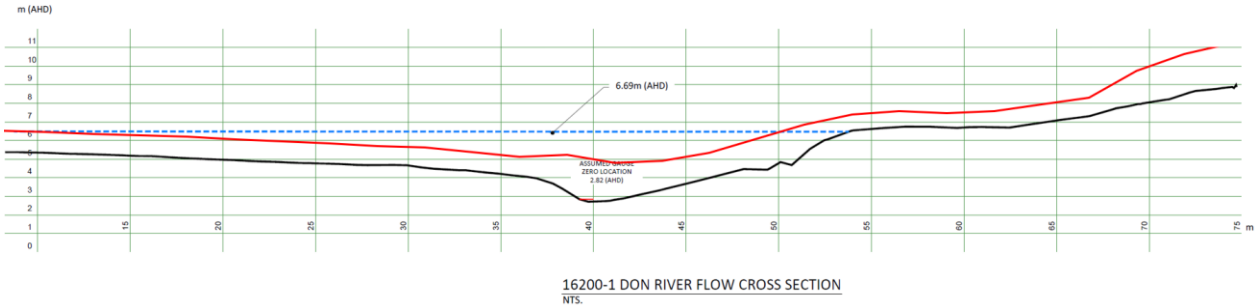

Diagram 2: Don River cross section with DEM used for re-rating (black) and updated DEM (red)

The DNRE rating at Don River is also highly uncertain for high flows, with large variability across different rating curves and large extrapolations from the highest gaugings. The rating curve used for the 1970 event (light blue in Diagram 3) is completely different from the rating for the smaller event in 2007 (orange) and also very different from the 2011 and 2016 events (purple), therefore our model will have inconsistent behaviour across the events compared to observed. Therefore, more emphasis has been given to the levels at Don River and less to matching the flows.

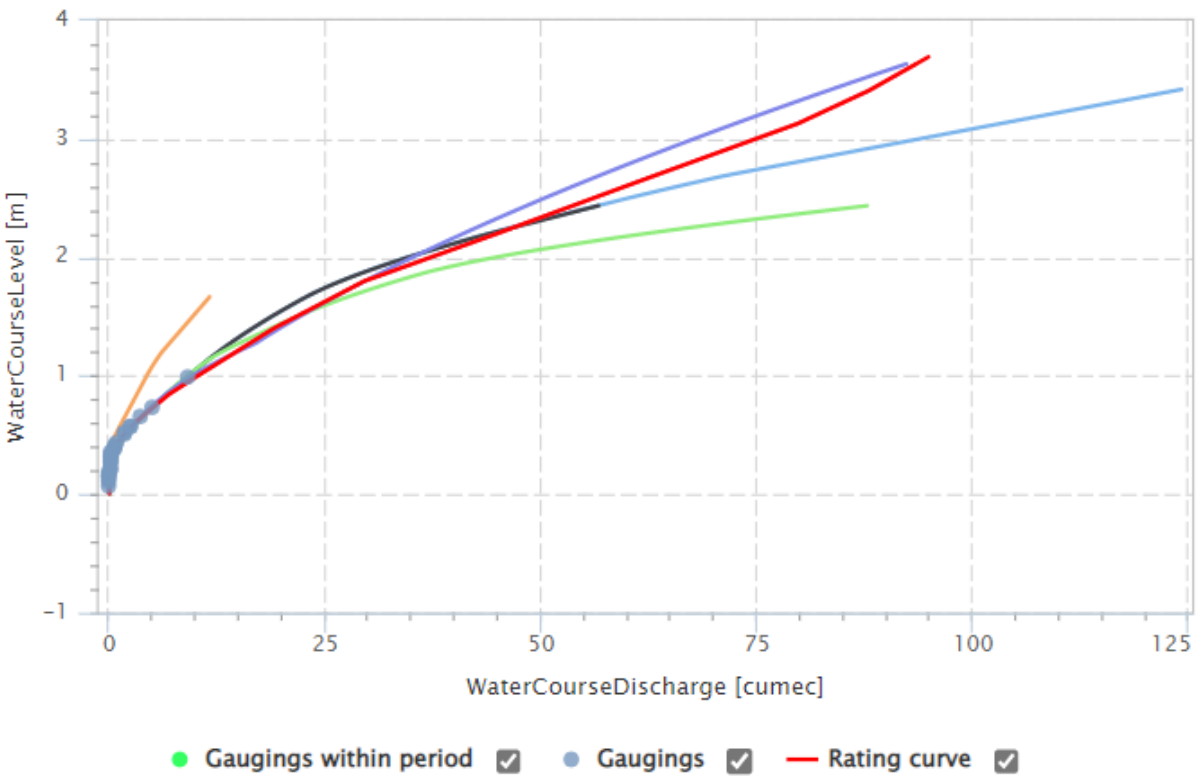

Diagram 3: Ratings and gaugings at the Don River (Source Water Data Online (BOM 2021b))

3.2. Historic Rainfall Data

Rainfall data was provided by Bureau of Meteorology as part of the initial project data. The data provided included sub-daily rainfall timeseries data from four different sources: Automatic Weather Station (AWS) data, pluvio data, rolling accumulated rainfall from the Bureau's flood warning network, and 10 minutely accumulation from the Bureau's flood warning network. The datasets were in different formats and required processing to a common format before they could be used to produce rainfall inputs to the model. Rainfall data was also provided by Hydro Tasmania for this project. Rainfall data was provided for 13 events identified by the Bureau of Meteorology for use as calibration events for this project, although not all 13 events have data available or were significant events in the Mersey study area (see Data Review Report WMAwater (2020) for details on calibration events).

The AWS and pluvio data were found to be the most consistently reliable data. Where multiple data sources were available at the same site, AWS or pluvio data were prioritised for use over the event or accum data. Data that was recorded less frequently than at 3 hour intervals was excluded from the analysis.

A summary of the rain gauges and rainfall totals for this study area is shown in Table 4.

Rainfall across the study area was highly variable for the August 1970 event with totals over 400 mm near Lake Mackenzie and less than 150 mm near Kimberley, Latrobe and Devonport (Figure 3). This variation occurs in a distance of about 30 km, so modelled flows and volumes will be sensitive to this steep rainfall gradient. The only sub-daily gauge within the catchment was

Fisher U/S Lake Mackenzie, however this shows very similar temporal pattern to surrounding gauges, so timing of the rainfall should be relativity well understood for this event.

Similarly, the June 2016 event had large spatial variations in rainfall but a fairly consistent temporal pattern across the study area. Rainfall totals ranged from around 400 mm near Lake Mackenzie to just less than 150 mm on the coast (Figure 6). Unlike for 1970, June 2016 also had lower rainfalls in the upper catchment around Lake Rowallan. As there are no gauges between Lake Mackenzie and Sheffield available for this event it is possible the incredibly high rainfall from Lake Mackenzie extends north with very high rainfalls in the tributaries that deliver flows to the Mersey River between the Liena and Shale Road gauges, notably to including the catchment of the Mole Creek gauge.

The August 2007 event had high rainfalls in the upper catchment, with totals upstream of Lake Rowallan and Lake Mackenzie greater than 200 mm, however relatively unremarkable rainfall downstream of Liena (Figure 4). This is consistent with flows described in Section 3.1.1 where flows recorded at gauges in the lower catchment are relatively insignificant, so are not included as full calibration events for this study area.

January 2011 had low rainfalls (less than 100 mm) on the Mersey River upstream of Parangana Dam, but high rainfalls (~300 mm) near Lake Mackenzie and throughout the mid and lower catchment (Figure 5). This means flows on Mersey River above Liena were not significant however the tributaries like Fisher River and Mole Creek and the Don River in the lower part of the study area had large flows (see Section 3.1.1). There is better coverage of rain gauges in the middle and lower catchment for this event, with operational daily gauges at Liena and Mole Creek giving more confidence in the spatial distribution between Lake Mackenzie and Sheffield than was available for the June 2016 event. There was far more variability in rainfall temporal pattern across this event than the other events with only some gauges experiencing very intense rainfall on the morning of the 14th of January.

The gauges in and around the Mersey study area, are shown in Figure 1.

Table 4: Available Rainfall Information

	August 1970	**August 2007**	**January 2011**	**June 2016**
Number of Sub-daily Stations Available within the study area	1	5	5	6
Number of daily Stations Available within the study area*	13	10	9	6
Number of sub-daily surrounding gauges ~15km	6	9	10	13
Number of daily surrounding gauges ~15km*	20	16	14	16
Rainfall Totals	130-410 mm	50-200 mm	60-320 mm	130-400 mm
Approx duration of rainfall event (hours)	48	60	72	36

*The number of daily gauges does not include daily gauges co-located with an active sub-daily gauge

The daily and sub-daily rain gauge data were used to create rainfall surfaces for each of the selected calibration events using an inverse distance weighting method. The method is described in detail in WMAwater 2021 and is summarised below.

1. Daily rainfall data from all gauges within Tasmania was extracted for each of the seven calibration events from 2000 – 2018
2. Rudimentary QAQC and infilling of daily record was undertaken
3. Daily rainfall surfaces for each event were fitted using all daily and available pluviograph data, using Inverse Distance Weighting (IDW)
4. Sub-catchment rainfall depths were calculated from all grid cells within the sub-catchment using areal weighted averages
5. Daily data in each sub-catchment was disaggregated using the temporal pattern from gauge assigned using Thiessen polygon method.

The rainfall surfaces for the selected calibration events are shown in Figure 3 to Figure 6.

For events prior to 1971, the AWAP gridded rainfall depths were used as described in WMAwater 2021a, due to lower coverage of rain gauges.

3.3. Dam Information

There were four dams included in the list in the Data Review Report (WMAwater, 2020) to be included in the models, however Fisher Forebay is a very small dam with inflows largely only via canal flow, so it has not been modelled for this project.

The remaining dams are shown in Table 5. Hydro Tasmania provided spillway flows, storage and spillway rating curves and lake levels for this project. As spillway rating curves are typically more accurate at high flows than the stream gauges, spill flows were used during calibration and given higher weighting than gauges with large uncertainties.

Mackenzie Dam had not been constructed for the 1970 calibration event. As there is no simple way to remove the dam from ICM, two external hydrologic models were created to assess the impact of the dam on modelled flows; one with the dam as constructed with a starting level of FSL and one with no dam. This showed a small difference in flows from the dam location itself and very small changes once the Fisher River meets the next major tributary, the Little Fisher River (Diagram 4). Therefore, while this dam is in the final hydrodynamic model only small variations are likely to be caused by this.

Lake Mackenzie diverts water from the Fisher River into the Fisher Canal and through Fisher Power Station. This diversion has not been modelled as the intent of this project is to model flood flows not routine hydro diversions. This means that spill flows and flows in the Fisher River down to the Fisher Power Station will be overestimated by the amount being diverted, however there is no infrastructure or settlements in this area that are impacted by this.

Parangana Dam has two power stations, a mini hydro to release flows down the Mersey River and Lemonthyme Power Station which diverts flows through a tunnel into the Forth River. As at Lake Mackenzie, the intent of this project is not to model all Hydro Tasmania's operations and

therefore these flows were not explicitly modelled. Lemonthyme Power Station capacity is approximately 43 m^3/s and observed spills from Parangana were in the order of 900 m^3/s so this could make up to a 5% impact on peak flows downstream.

Rowallan Power Station was also not explicitly modelled; however it releases water immediately downstream of the dam so should not impact on peak flows. Some influence of the power station can be seen in the spill flows hydrograph at Mersey above Arm, which is immediately downstream of the dam.

There are a large number of small dams in the lower catchment which are not explicitly modelled. These are particularly dense on tributaries of the Don, Dasher and Minnow rivers.

Table 5 Information on dams in the Mersey study area

Name	Storage FSL (mAHD)	Active Storage Volume at FSL (ML)*	Year constructed
Rowallan Dam	487.68	120,640	1967
Mackenzie Dam	1120.75	18,975	1972
Parangana Dam	381.00	2,600	1968

*Storage volumes were supplied by Hydro Tasmania as “active” volume which is understood to be volume above the intake for power station or canal outflows so it is not the total volume of water in the storage.

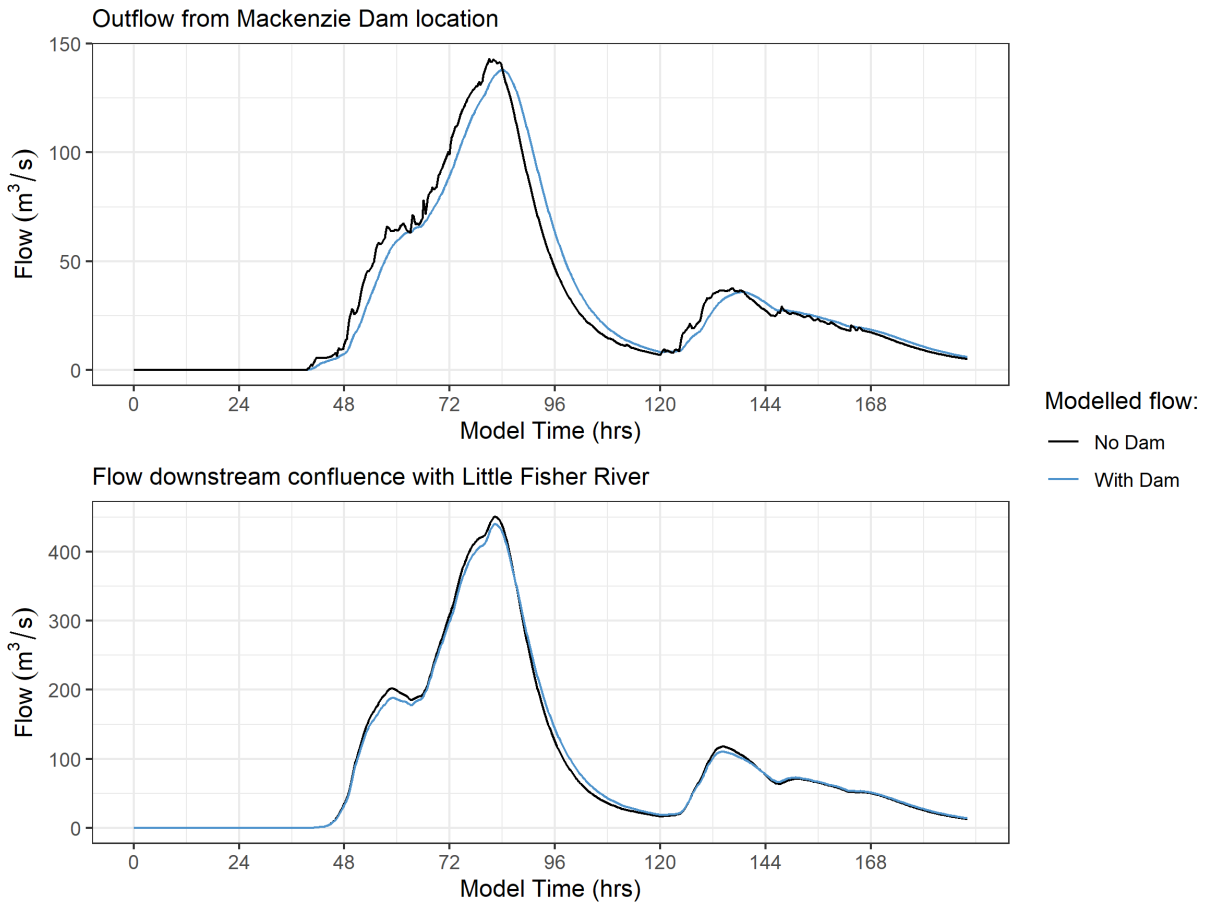

Diagram 4: Modelled flows for the 1970 event in the external hydrological model with Mackenzie Dam modelled starting at FSL and without Mackenzie Dam (as it was not yet constructed). Flows are shown both immediately downstream of the dam location and downstream of the next significant tributary (Little Fisher River).

3.4. Flood Levels and Extents

Flood survey levels and extents within the Mersey study area were available from the 2016 surveyed flood extents program conducted after the June 2016 flood event. This information was used to verify the modelling results for the June 2016 event.

No other information was available for the verification of modelled flood levels and extents.

4. METHODOLOGY OVERVIEW

The hydrological and hydrodynamic model calibration methodology has been outlined in the Hydrology Methods Report (WMAwater, 2021a) and the Hydrodynamic Methods Report (WMAwater, 2021b). Details on the methods are only included in this report where they deviate from the methods described in these reports or are specific for this catchment.

The modelling method includes the following steps:

- Data preparation
  - Extraction and collation of rainfall data for identified calibration events
  - Gridding rainfall data across each catchment
  - Extraction of flow data for identified calibration events at each flow site, and assessment of suitability of this data for calibration
- Hydrologic modelling
  - Identification of flow gauge locations
  - Identification of dam and diversion locations
  - Sub-catchment delineation in GIS
  - Inclusion of dam storage and spillway ratings where required and available
  - Event calibration for routing and losses using automated external RAFTS modelling tool. Output event sub-catchment rainfalls, routing parameters and event losses for input to ICM model
  - Running event calibration through ICM RAFTS model to provide sub-catchment pickups for direct input into ICM hydrodynamic model
  - As required, revise hydrologic parameters within ICM-RAFTS to obtain good match to historic flood information provided
  - Once a good match is achieved, provide ICM-RAFTS modified hydrologic parameters back to the external hydrologic model to ensure consistency
  - As required, confirm the response between the external hydrologic model and ICM hydrodynamic model is consistent to enable design event analysis
- Hydrodynamic modelling in ICM
  - Importing base DEM
  - Setting roughness values, referencing calibrated PERN value from hydrologic model
  - Meshing
  - Incorporation of structures
  - Setting up rainfall inputs (depth and temporal pattern), losses and dam/diversion outflows from the hydrologic model
  - Calibration model runs
  - Compare model results with hydrologic model runs and calibration points
- Model iteration
  - Adjust routing parameters values in both external and ICM RAFTS hydrologic model, based on results of hydrodynamic model calibration
  - Rerun hydrologic models for calibration events
  - Set roughness values in hydrodynamic model
  - Rerun hydrodynamic model for calibration events

5. HYDRODYNAMIC MODEL SETUP

5.1. Digital Elevation Model (DEM)

The base dataset that was used for the digital elevation model (DEM) of the hydrodynamic model was the SES state-wide 10 m DEM merged with 2 m DEM subsets at known gauges and levees (where available). 2 m DEM subsets were available at all known gauges (refer Table 1) and levees (refer Diagram 9).

The merged DEM was then clipped to the study area with a buffer zone to ensure 100% active mesh area in the model. Where no terrain information was available in the tidal zones, a ground level of -10 mAHD was applied in GIS to the clipped DEM. The resulting DEM is shown in Diagram 5.

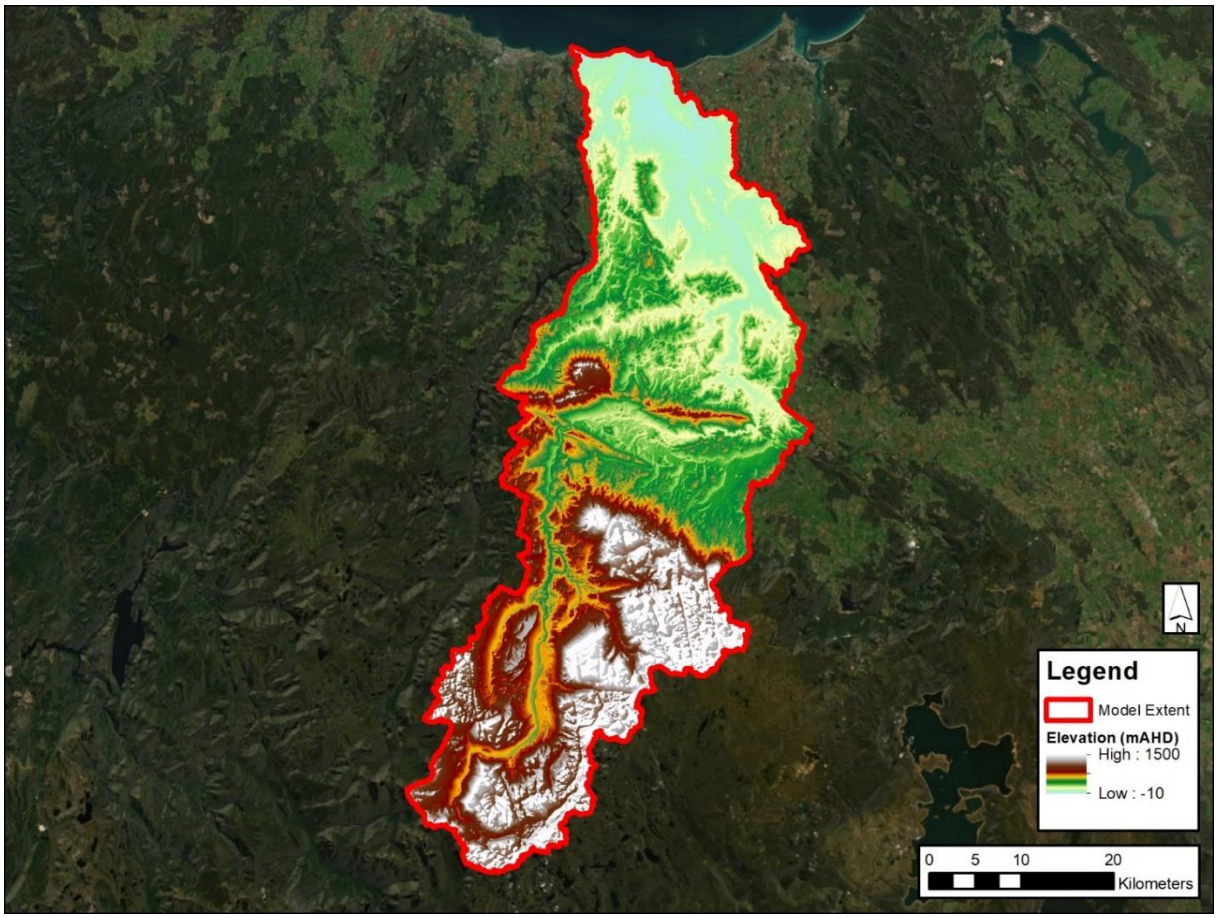

Diagram 5: DEM of the Mersey study area

The SES state-wide 10 m DEM consists of a 'Default DTM' that is state-wide and a 'LiDAR DTM' that covers the areas where LiDAR data was available at the time, as shown in Diagram 6. The majority of the Mersey study area is covered by the good quality 'LiDAR DTM'.

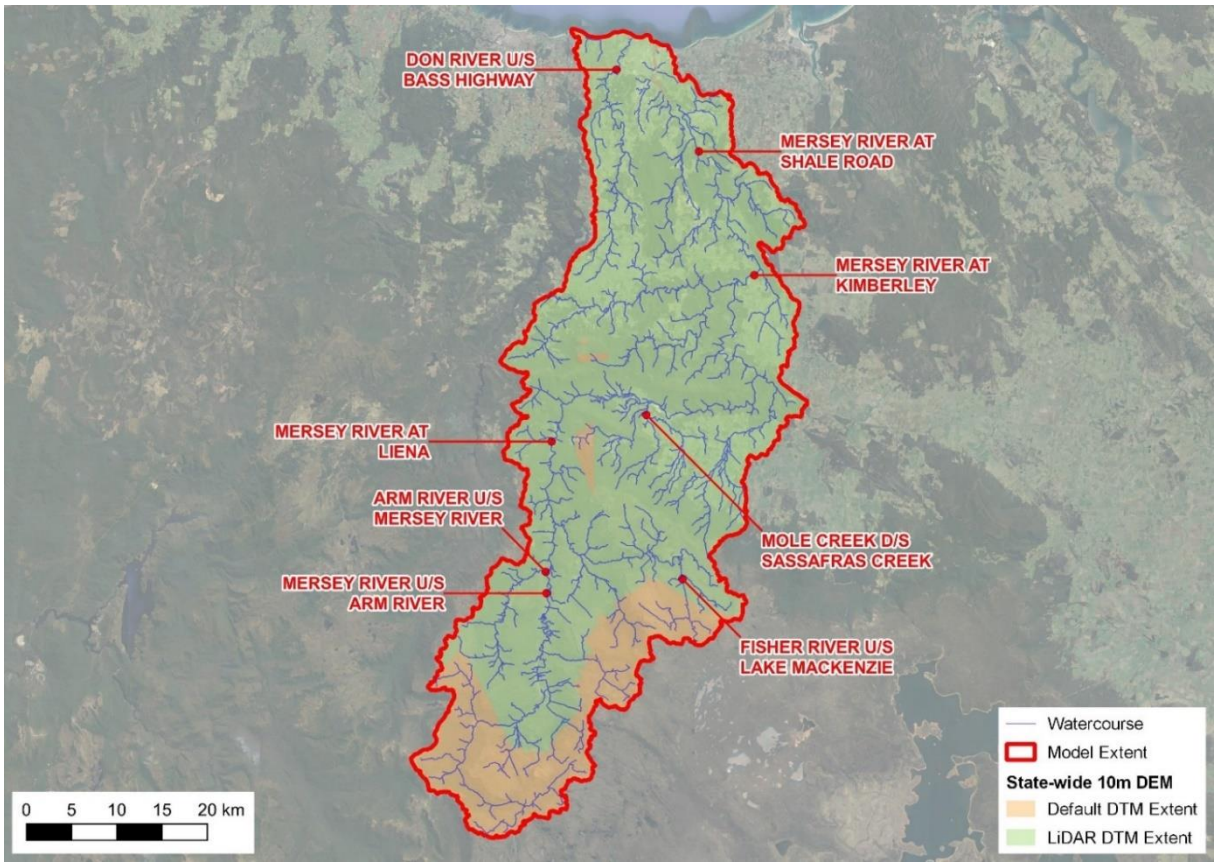

Diagram 6: 'Default DTM' extents for the Mersey study area

A review of the DEM was undertaken:

- The DEM adopts a value of -10 mAHD for the section of Mersey River between the mouth of the river and approximately 1.55 km downstream of Frogmore Lane in Latrobe.
- Along Caroline Creek and Mersey River, a breach was incorrectly applied to the DEM between the cement plant in Railton and approximately 1.5 km downstream of Frogmore Lane in Latrobe. The breach was 'filled in' using the surrounding DEM.
- At the Don River u/s Bass Highway gauge, the quality of the DEM was poor due to the presence of river channel and bank vegetation artefacts. As improved topographic information was not available, the DEM was not modified. Refer to Section 6.3.11 for further discussion.
- At Bass Highway at Don River and Bass Highway at Mersey River, the roadway was not adequately removed from the DEM. As improved topographic information was not available, the DEM was modified to allow for the free flow of water (and the bridge was not explicitly modelled). Refer to Section 6.4 for further discussion.

5.2. Roughness

The base dataset that was used for the roughness of the hydrodynamic model was the SES state-wide roughness grid. This dataset was converted to a set of polygons for each land use and linked to a corresponding friction value (as detailed in the Hydrodynamic Modelling Methods Report). The polygons were then cleaned in GIS to ensure that the geometry was valid before being imported into the hydrodynamic model.

It is noted that, at this stage, the roughness values for streams vary greatly with sections of Manning's n of 0.1 crossing streams in many locations. This issue is an artefact of the simplification of the roughness layer when it is converted into triangles. Where the issue was severe, a continuous zone of single roughness of 0.05 for all upper streams was utilised.

During the calibration process, the channel roughness at Mersey River at Arm River, Mersey River at Liena, Mersey River at Kimberley, and Mersey River at Shale Road was decreased from the default of 0.05 to 0.03.

The resulting roughness layer is shown in Diagram 7.

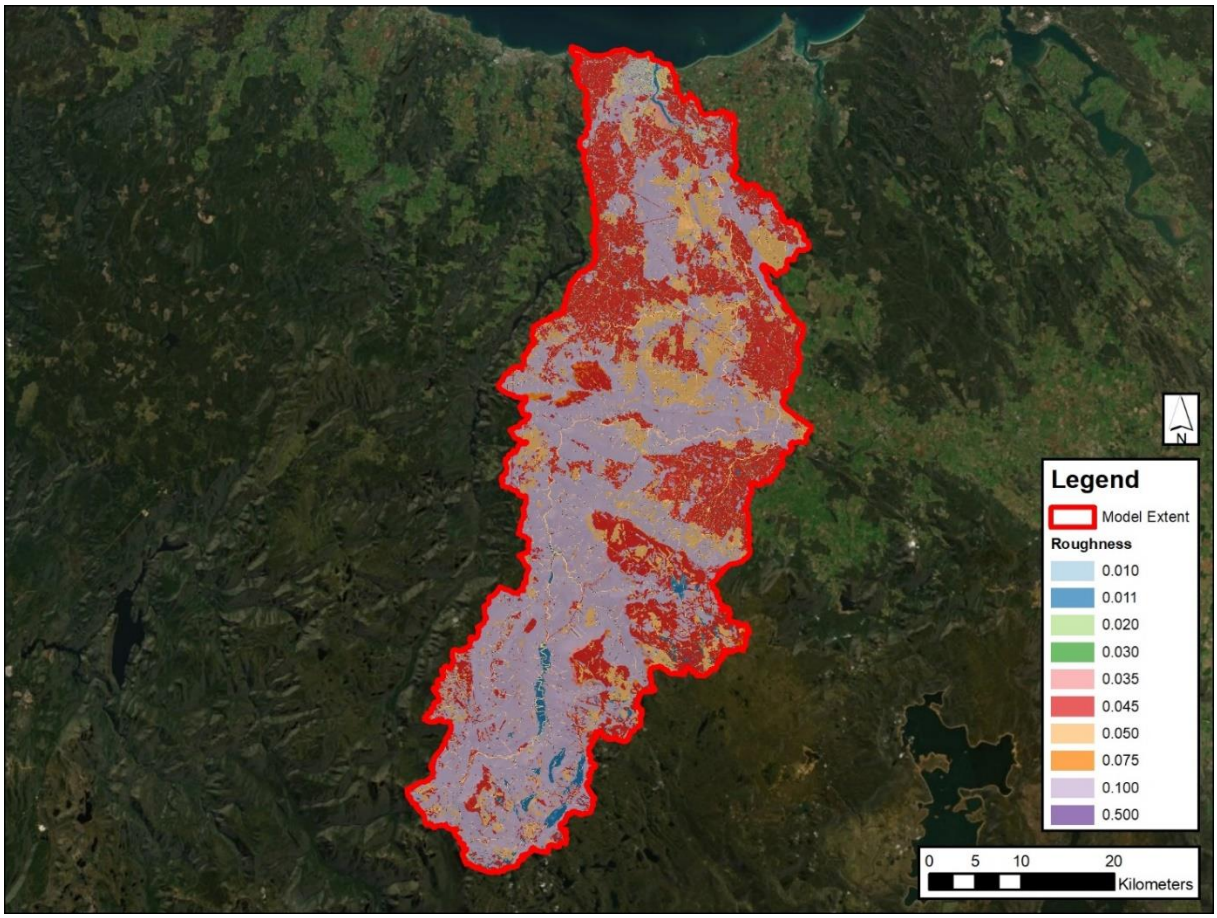

Diagram 7: Roughness layer for the Mersey study area

5.3. Meshing

Meshing in the hydrodynamic model was undertaken using mesh zones, with the following rules:

- Base mesh zone – the default mesh size, set to a maximum of 2500 m² and a minimum of 400 m²
- Stream mesh zones – set as an independent mesh zone with a maximum mesh size of 400 m^2 and a minimum of 100 m^2
- Upper stream mesh zones – streamlines of strahlar order 2-5 and strahlar order 6-8 were buffered by 10 m and 20 m either side of the centre line. These zones were then set to a maximum mesh size of 150 m² and a minimum of 100 m². This process was done to ensure

that the meshing process did not result in artificial blocking of the flow paths along the upper streams.

- Human Settlement Areas – set as an independent mesh zone with a maximum area of 100 m^2 and a minimum of 25 m^2
- Gauge/levee mesh zones – set as an independent mesh zone with a maximum area of 25 m^2 and a minimum of 10 m^2

The use of a 10 m^2 to 25 m^2 mesh zone at gauges and levees is a slight deviation from the standard methods (25 m^2 to 100 m^2), however, was found to improve the outcomes of the modelling.

The resulting mesh zones are shown in Diagram 8.

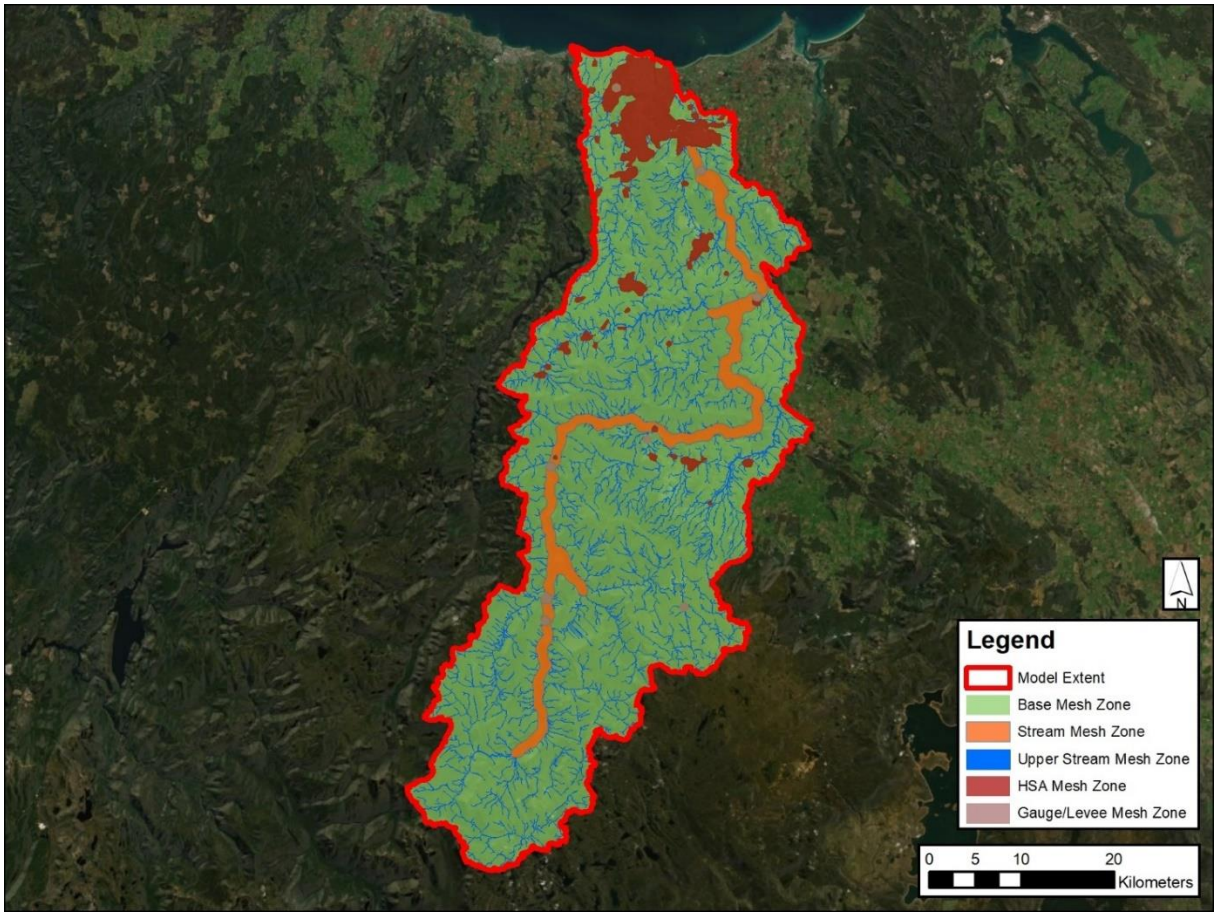

Diagram 8: Mesh zones for the Mersey study area

5.4. Structures

Within the study area, 13 significant bridges were identified from the SES state-wide bridge database and these were modelled in the hydrodynamic model in the 2D domain using linear 2D bridge structures. Further discussion on this process is provided in the Hydrodynamic Modelling Methods Report (WMAwater, 2021b).

The bridges modelled included:

- Mersey Forest Road at Mersey River
- Olivers Road at Mersey River
- Liena Road at Mersey River
- Union Bridge Road at Mersey River
- Kellys Cage Road at Mersey River
- Dynans Bridge Road at Mersey River
- Railton Road at Mersey River
- Railway at Mersey Road
- Lamberts Road at Mersey River
- Merseylea Road at Mersey River
- Native Plains Road at Mersey River
- Frogmore Lane at Mersey River
- Railway at Don River

No other significant structures were identified in the study area. As noted in Section 5.1, Bass Highway at Mersey River and Bass Highway at Don River were approximated with a channel carved in the 2D domain to allow the free flow of water.

The locations of the modelled structures are shown in Diagram 9. The locations of the known levees are also shown.

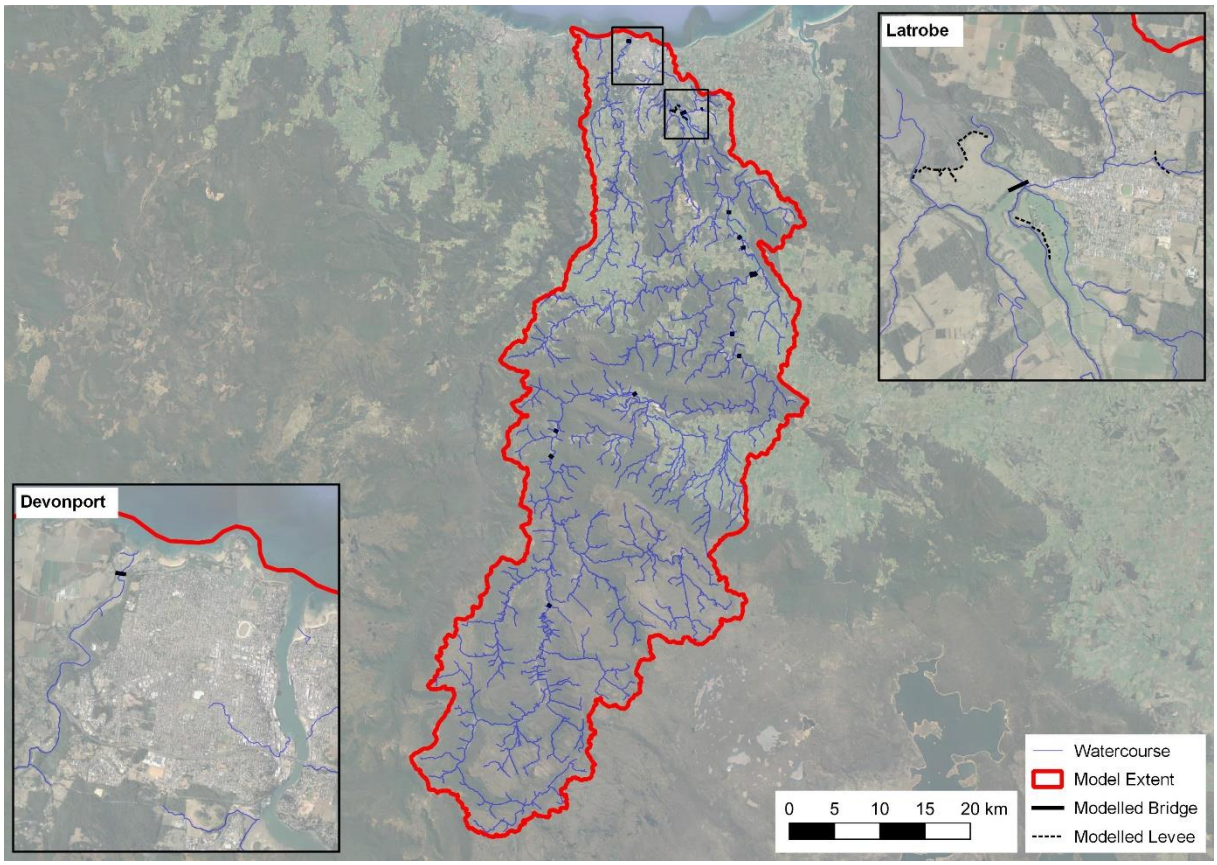

Diagram 9: Modelled structures and known levees in the Mersey study area

5.5. Dams

The storage and spillway elements of Lake Rowallan, Lake Mackenzie, and Lake Parangana were modelled in the hydrodynamic model as 1D elements using the storage and spillway rating curves supplied for the project (refer Section 3.3). These elements were then linked to the 2D domain.

5.6. Downstream Boundaries

Downstream boundaries were applied at the base of the model to provide interaction with the tidal zone. Synthetic tide data was provided by the Bureau of Meteorology (BoM) for the calibration events and was used to set a varying tide level. This data was extracted off the coast of Devonport at 10 min time increments and was imported into ICM as a time varying boundary condition. Diagram 10 shows an example of the synthetic tide data that was extracted for the June 2016 event.

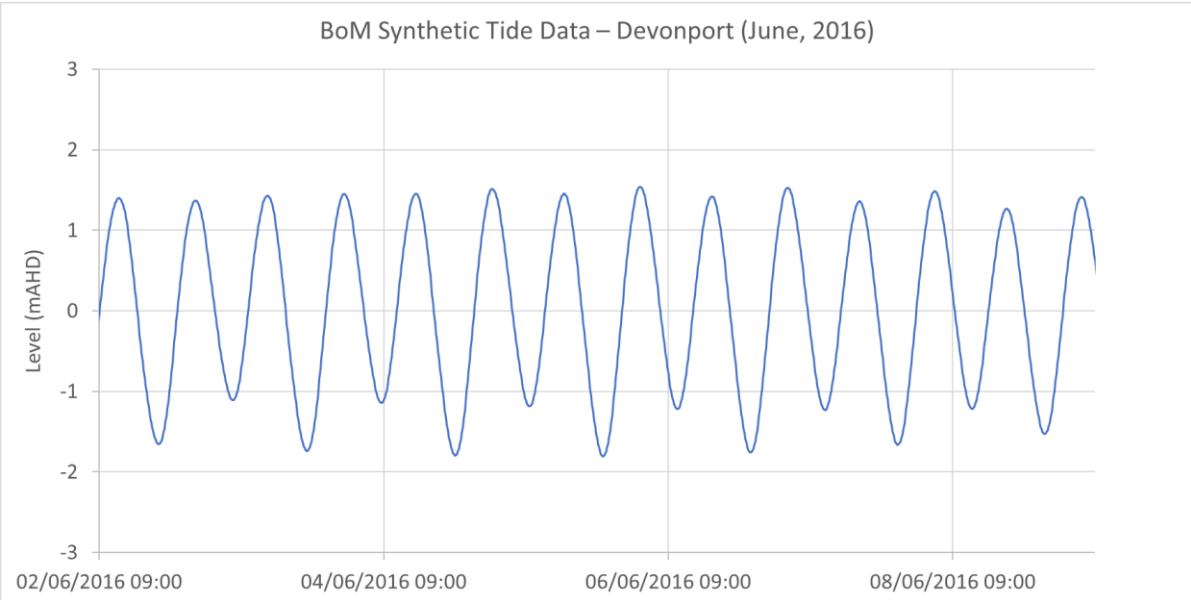

Diagram 10: Synthetic tide data off the coast of Devonport (June, 2016)

5.7. Flow Application for Hydrodynamic Modelling

Two approaches were used for application of flow in ICM:

- ICM-RAFTS sub-catchment routing, applied to each sub-catchment in the model at the downstream end of the sub-catchment
- Direct rainfall to model overland flow (short duration events).

The reason for using two approaches is to enable the model to be run efficiently for longer durations by limiting the number of cells wet, focusing on the major tributary flooding while also ensuring the local areas in the upper tributaries are mapped for short duration flooding.

The two flow scenarios sit within the same ICM hydrodynamic model as alternative flow condition scenarios (base and direct rainfall). For the calibration events, only the ICM-RAFTS approach is used, where the rainfall information is derived from rainfall files created by the hydrologic model.

For the design events, an envelope of the ICM-RAFTS approach and the design rainfall approach will be used. Rainfall and temporal pattern information derived from the ARR datahub will be used to establish the design rainfall and temporal pattern information for the ICM-RAFTS approach and a synthetic, duration independent storm will be used to assess a range of storm durations and temporal patterns in a singular rainfall event for the design rainfall approach.

5.7.1. ICM-RAFTS Sub-catchment Routing

For the ICM-RAFTS sub-catchment routing, the RAFTS model within ICM was used to calculate the hydrologic routing at each sub-catchment. Rainfalls, model information and model parameters developed through the external hydrologic model were imported into ICM through the open data input tool.

The information imported into ICM included:

- Sub-catchment name
- Slope
- PERN
- RAF
- Initial and Continuing Loss
- Sub-catchment rainfalls (for calibration events)

Each sub-catchment is connected directly to the 2D mesh surface at the downstream end of the catchment. The resulting RAFTS sub-catchment model setup is shown in Diagram 11. Figure A 1 and Figure A 2 show the hydrological soil groups used to distribute the CL and the average PERN used for each sub-catchment.

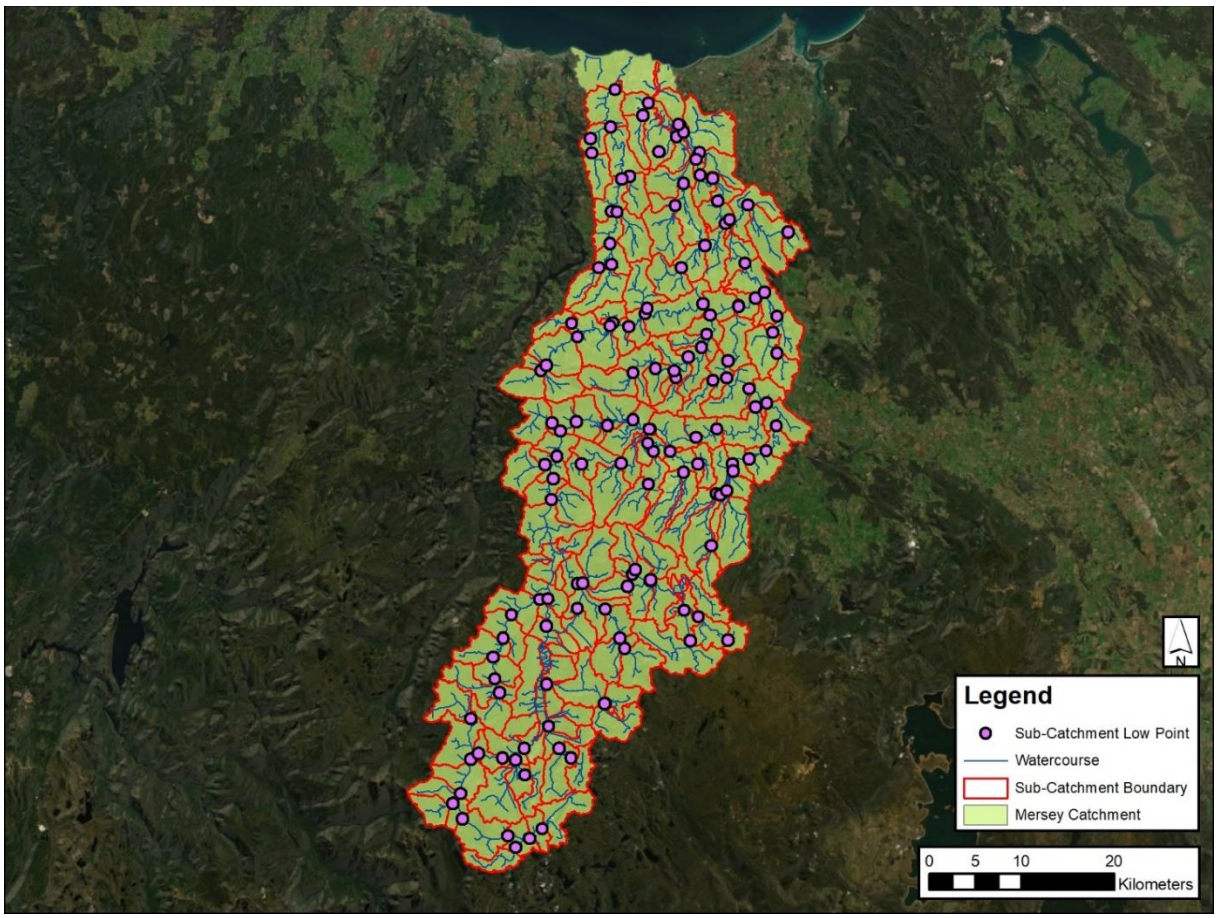

Diagram 11: RAFTS sub-catchment model setup for the Mersey study area

6. CALIBRATION RESULTS

Mapping of the peak flood depths from the calibrated hydrodynamic model for each calibration event is shown in Figure 7 to Figure 10.

6.1. Sub-catchment Routing and Loss Parameters

The ICM model was run with the routing and loss parameters derived from the external hydrologic model and the calibration process was undertaken for each calibration event.

To prevent the overfitting of parameters, a single IL and scaling to the default CLs (based on the soil types as described in the Hydrology Methods Report (2021a)) was used across the entire study area. It is acknowledged that there are some locations where flows are under or overestimated (for example, Lake Rowallan and Lake Mackenzie). Varying losses across the catchment could improve the fit at some of these locations, however, the poor fit is just as likely due to uncertainties in the recorded flows (Section 3.1.2) and distribution of rainfalls (Section 3.2) as to the actual loss behaviour of the catchment.

An RAF of 2 was assumed based on initial model runs with an RAF of 1, which indicated that the routing within the sub-catchment component of the model was faster than the recorded catchment responses. A comparison of the selected RAF of 2 and a RAF of 1 at the Mersey River gauges for the June 2016 calibration even is shown in Diagram 12 to Diagram 14.

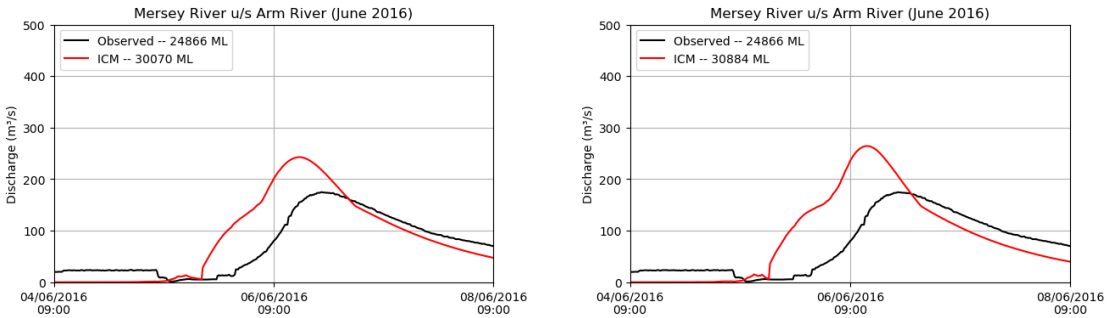

Diagram 12: Flow comparison at Mersey River u/s Arm River (left: RAF 2, right RAF 1)

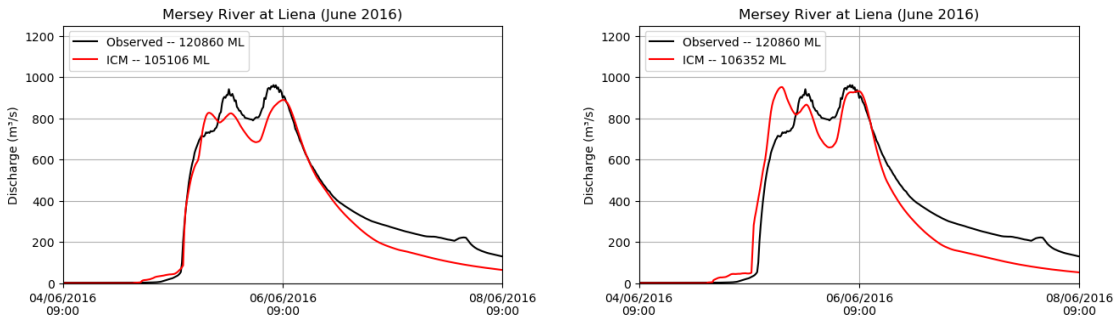

Diagram 13: Flow comparison at Mersey River at Liena (left: RAF 2, right: RAF 1)

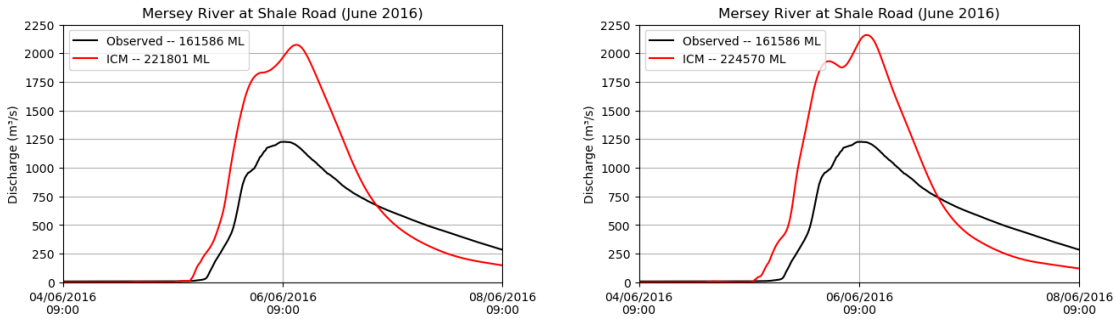

Diagram 14: Flow comparison at Mersey River at Shale Road (left: RAF 2, right: RAF 1)

Upon completion of the calibration process, the external hydrologic model and the ICM model were compared to ensure that the modelled flows are consistent. This is shown in Appendix C.

6.2. Initial Conditions

Prefilling of the ICM model was not found to be necessary to achieve a reasonable calibration to the locations of interest. On occasion it is necessary to prefill hydraulic models to manage the loss of flood volume due to local depression storage. This scenario however may result in filling of floodplain storage and as such should only be considered where necessary. To ensure there was no incidental filling of floodplain storage in this model it has been run without prefilling.

6.3. Gauge Results

As discussed in Section 3.1.1, the August 1970 and June 2016 calibration events were very large across the study area and were assessed at the gauges and lakes where historic event information was available. The August 2007 and January 2011 calibration events were only significant at selected locations in the study area and were only assessed at these locations.

The gauges and lakes on the Mersey River are shown in the following sections. The gauges and lakes on the Mersey River tributaries and separate rivers are then shown.

Comparisons of the gauge and modelled rating curves are shown in Appendix D.

6.3.1. Lake Rowallan

Significant spills were recorded at Lake Rowallan during the August 1970 and June 2016 events. Lake Rowallan discharges into Mersey River via the hydro power station and spillway. As discussed in Section 3.3, power station flows were not modelled as they were deemed to be a small proportion of flood flows even at peak capacity (approximately 25 m^3/s) and discharge immediately downstream of the dam where spill also flows.

The modelled and observed spills at Lake Rowallan are shown in Table 6 and Diagram 15 to Diagram 16. The modelled spills show a poor match to the observed, with peak flow overestimated in August 1970 and June 2016.

It is noted that the observed spills for August 1970 are instantaneous daily values and therefore, the observed peak flow may be greater than shown. The results at Lake Rowallan for August 1970 should be read in conjunction with the results at Mersey River u/s Arm River.

Table 6: Calibrated parameters and results at Lake Rowallan

Statistic	August 1970	June 2016
IL (mm)	20	0
Average CL (mm/h)	1.60	1.93
RAF	2	2
Modelled Peak (m^3/s)	316	242
Observed Peak (m^3/s)	137*	128
Peak % difference	+131%	+89%
Modelled Volume (ML)	30,962	29,574
Observed Volume (ML)	-	16,786
Volume % difference	-	+76%

* Instantaneous daily value

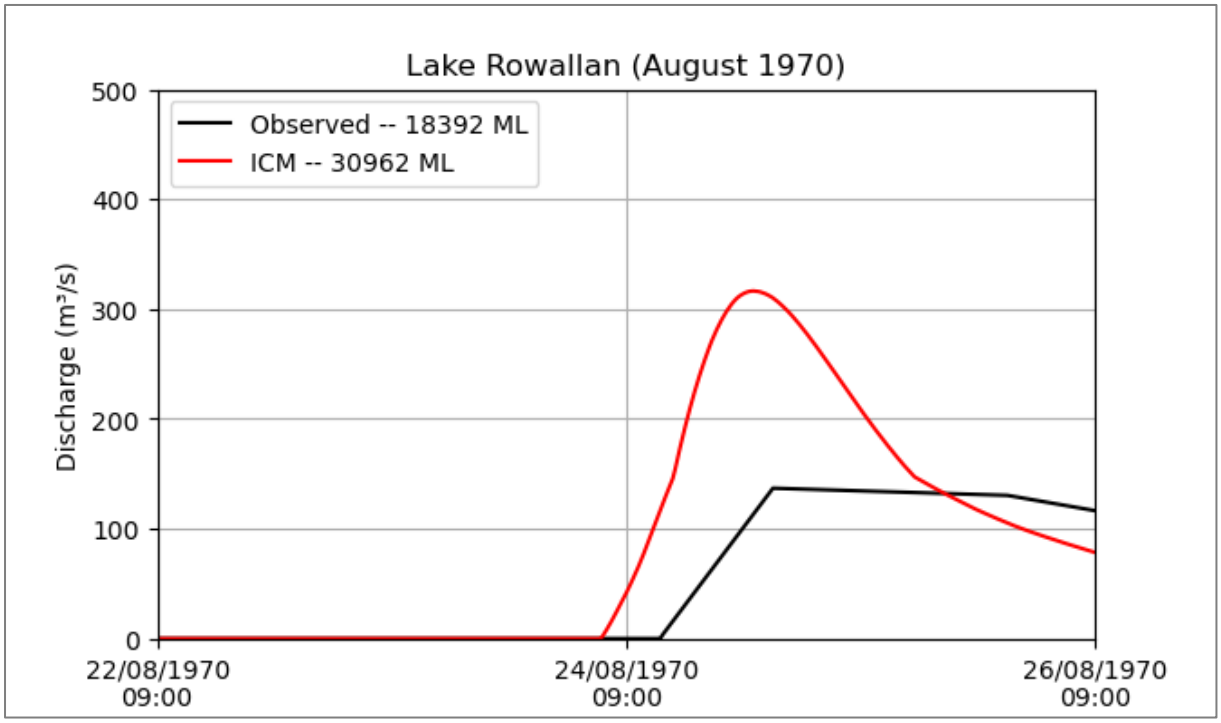

Diagram 15: August 1970 flow comparison at Lake Rowallan

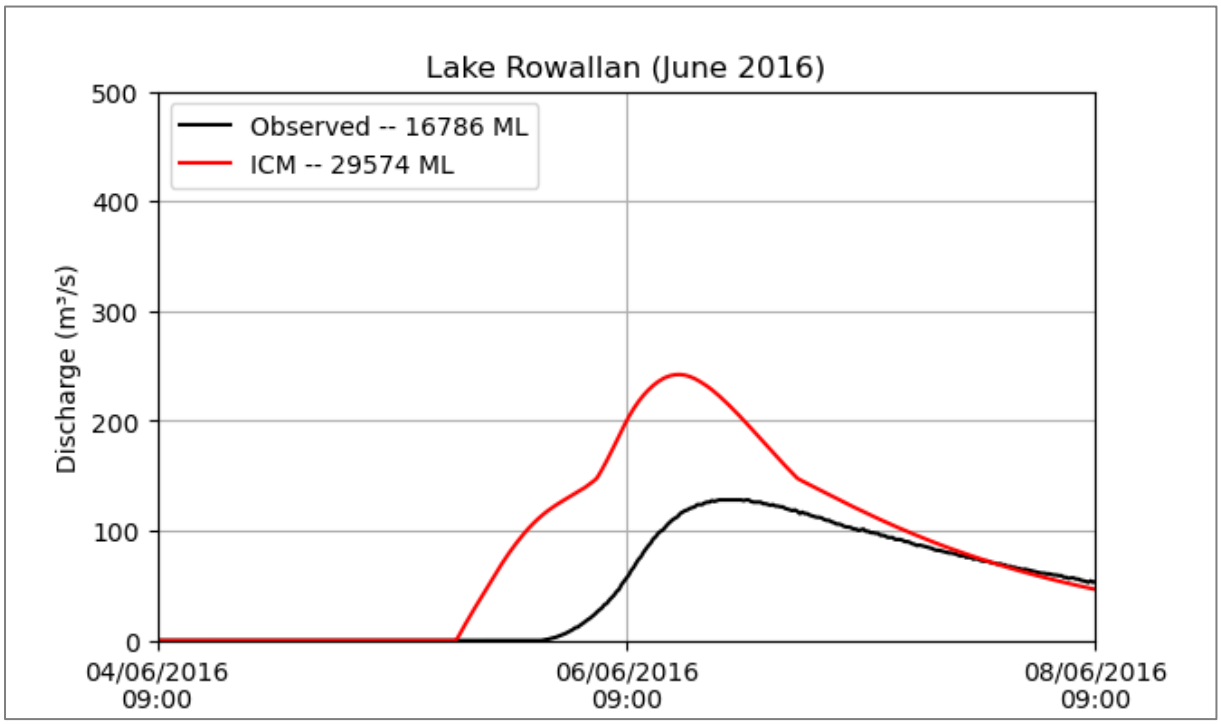

Diagram 16: June 2016 flow comparison at Lake Rowallan

6.3.2. Mersey River u/s Arm River

Significant flows were recorded at Mersey River u/s Arm River during the August 1970 and June 2016 events. This site is located just downstream of Lake Rowallan.

As noted in Section 3.1, the supplied rating curve was given a high flow rating quality of “good”, with the highest gauging above that of August 1970 and June 2016 (2.97 m compared to 2.83 m and 2.74 m respectively).

Differences between the modelled and supplied rating curves were observed during model calibration and the channel roughness at this location was decreased (Section 5.2). This resulted in a good agreement between the slope of the modelled and supplied rating curves at high flows (Figure D 1).

The supplied DEM does not appear to contain the full river bathymetry at this location, and it is acknowledged that the change to the channel roughness may be partially or fully compensating for this (rather than an actual change to the channel roughness). A gauge zero of 426.337 mAHD was provided for this gauge from Hydro Tasmania. The rating curve comparison suggests that the DEM has insufficient detail to align precisely with the provided gauge zero.

The modelled and observed flows and levels at Mersey River u/s Arm River are shown in Table 7 and Diagram 17 to Diagram 20. The modelled flows and levels show a poor match to the observed, with peak flow and level overestimated in August 1970 and June 2016. This is consistent with the results at Lake Rowallan. As this site is directly downstream of Rowallan Dam, power station operations up to ~25 m^3/s can be seen in the observed record which were not modelled.

Table 7: Calibrated parameters and results at Mersey River u/s Arm River

Statistic	August 1970	June 2016
IL (mm)	20	0
Average CL (mm/h)	1.62	1.94
RAF	2	2
Modelled Peak (m^3/s)	318	243
Observed Peak (m^3/s)	189	175
Peak % difference	+68%	+39%
Modelled Volume (ML)	32,896	30,070
Observed Volume (ML)	25,363	24,866
Volume % difference	+30%	+21%
Modelled peak (mAHD)	430.58	430.16
Observed peak (mAHD)	429.16	429.08
Peak difference (m)	+1.41	+1.08

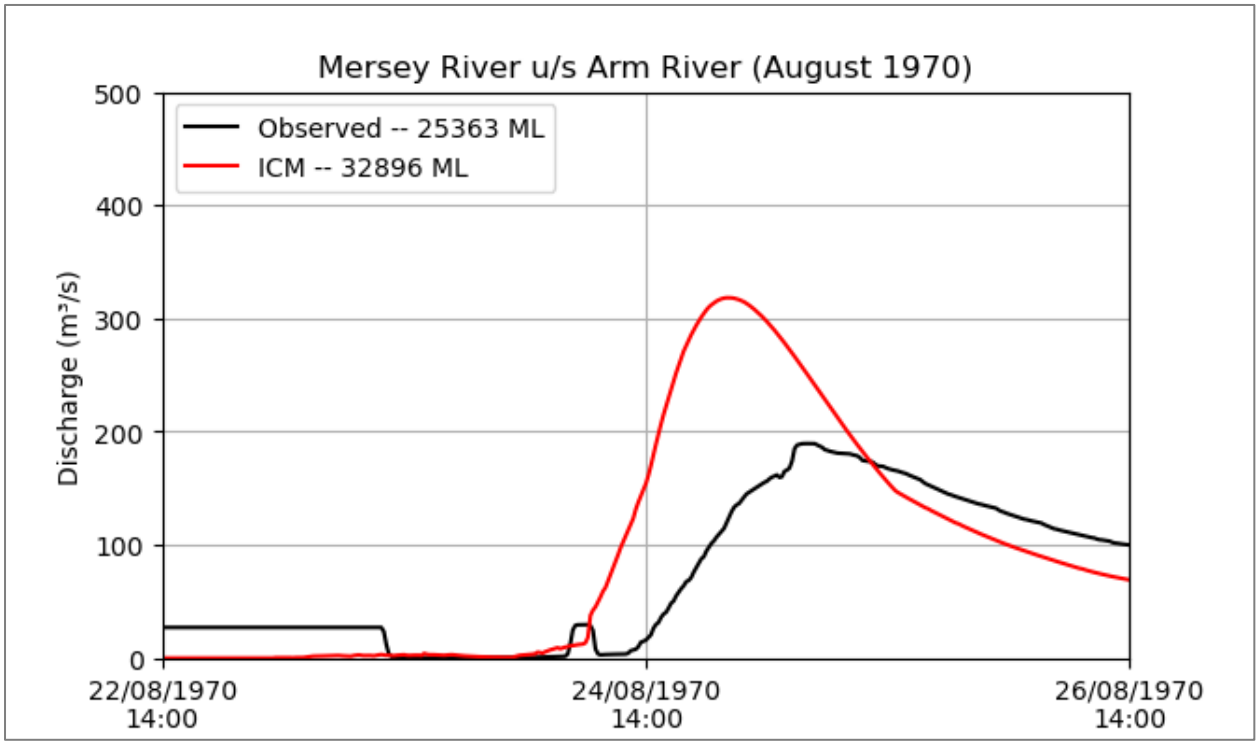

Diagram 17: August 1970 flow comparison at Mersey River u/s Arm River

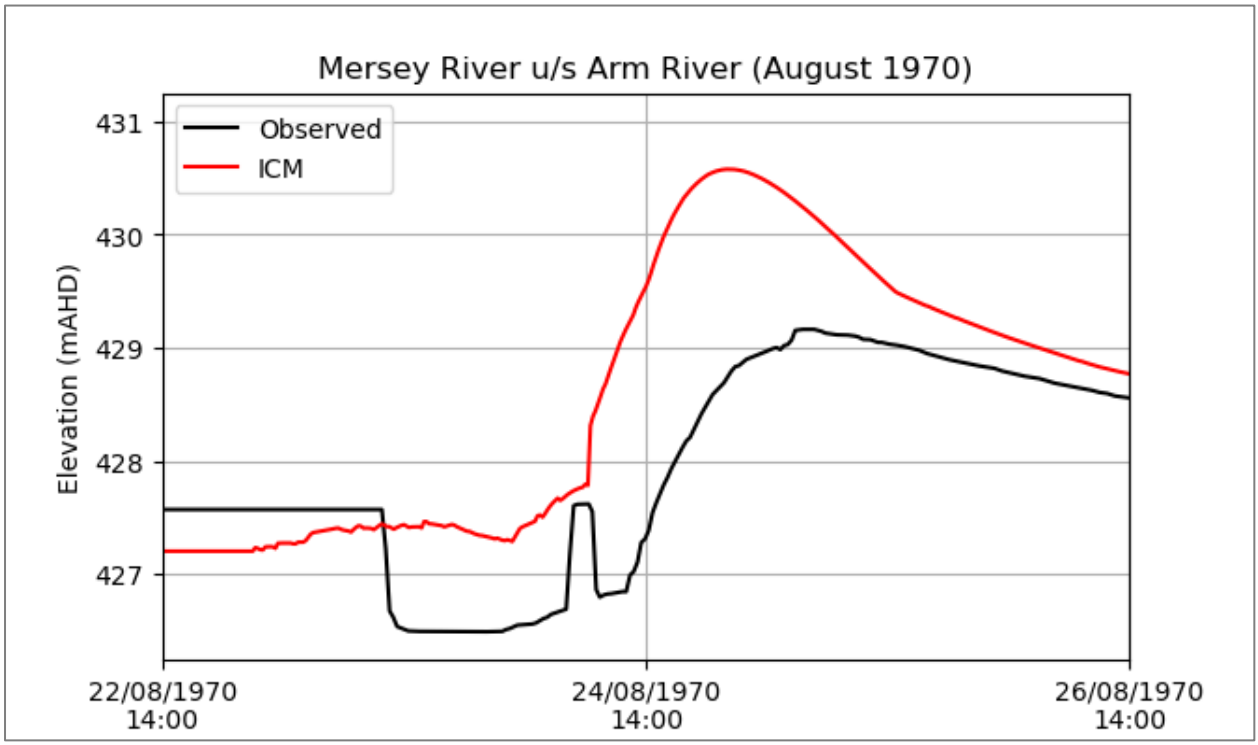

Diagram 18: August 1970 water level comparison at Mersey River u/s Arm River

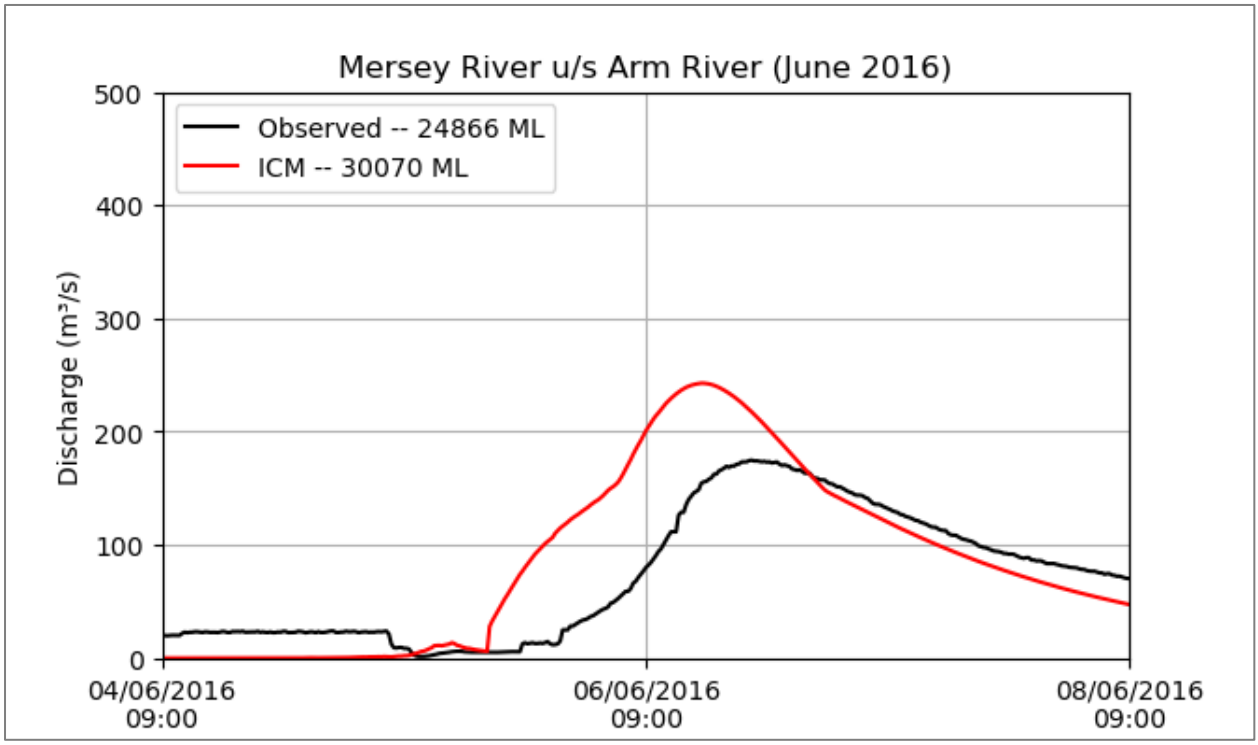

Diagram 19: June 2016 flow comparison at Mersey River u/s Arm River

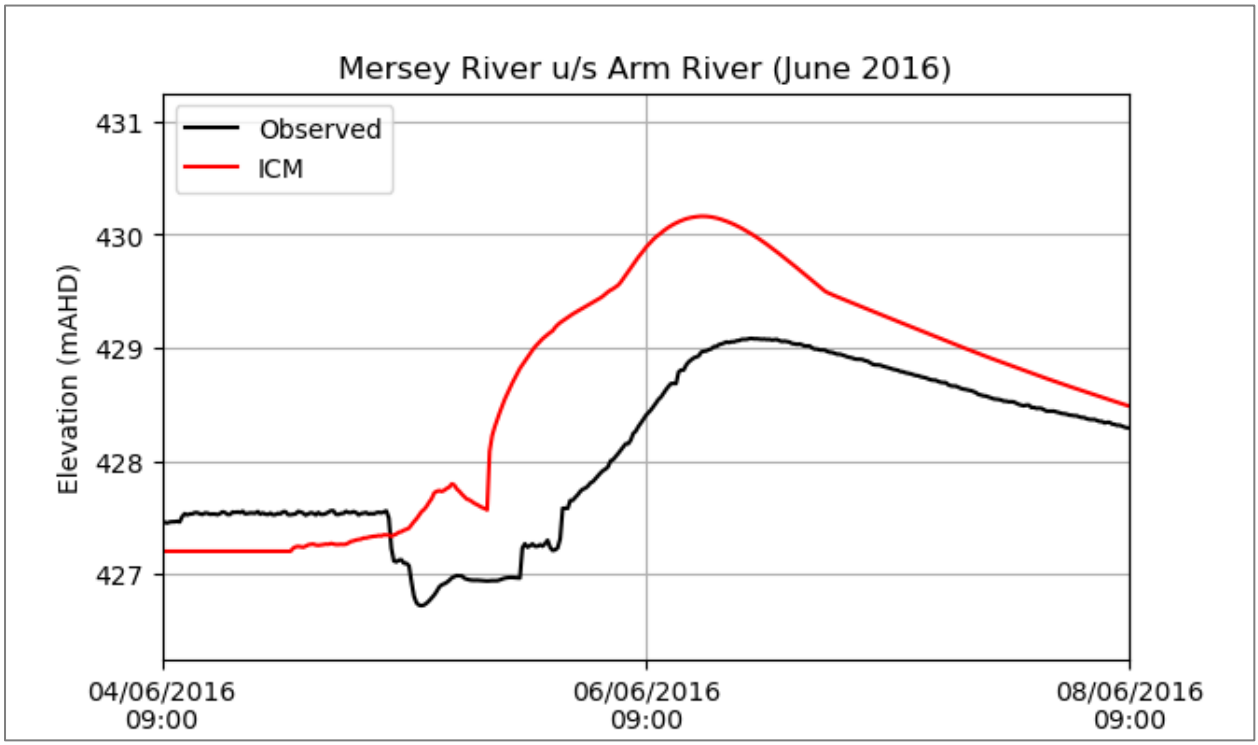

Diagram 20: June 2016 water level comparison at Mersey River u/s Arm River

6.3.3. Lake Parangana

Significant spills were recorded at Lake Parangana during the August 1970 and June 2016 events. Lake Parangana discharges into Mersey River via the mini-hydro power station and spillway and can discharge into Forth River via a tunnel to the Lemonthyme Power Station in Forth River. As discussed in Section 3.3, power station flows were not modelled as they were deemed to be a small proportion of flood flows even at peak capacity (approximately 5 m^3/s and 45 m^3/s respectively).

The modelled and observed spills at Lake Parangana are shown in Table 8 and Diagram 21 to Diagram 22. The modelled spills show a fair match to the observed, with peak flow overestimated in August 1970 and underestimated in June 2016.

It is noted that the observed spills for August 1970 are instantaneous daily values and therefore, the observed peak flow may be greater than shown. The results at Lake Parangana for August 1970 should be read in conjunction with the results at Mersey River at Liena.

Table 8: Calibrated parameters and results at Lake Parangana

Statistic	August 1970	June 2016
IL (mm)	20	0
Average CL (mm/h)	1.45	1.74
RAF	2	2
Modelled Peak (m^3/s)	946	823
Observed Peak (m^3/s)	874*	912
Peak % difference	+8%	-10%
Modelled Volume (ML)	94,860	97,526
Observed Volume (ML)	-	104,512
Volume % difference	-	-7%

* Instantaneous daily value

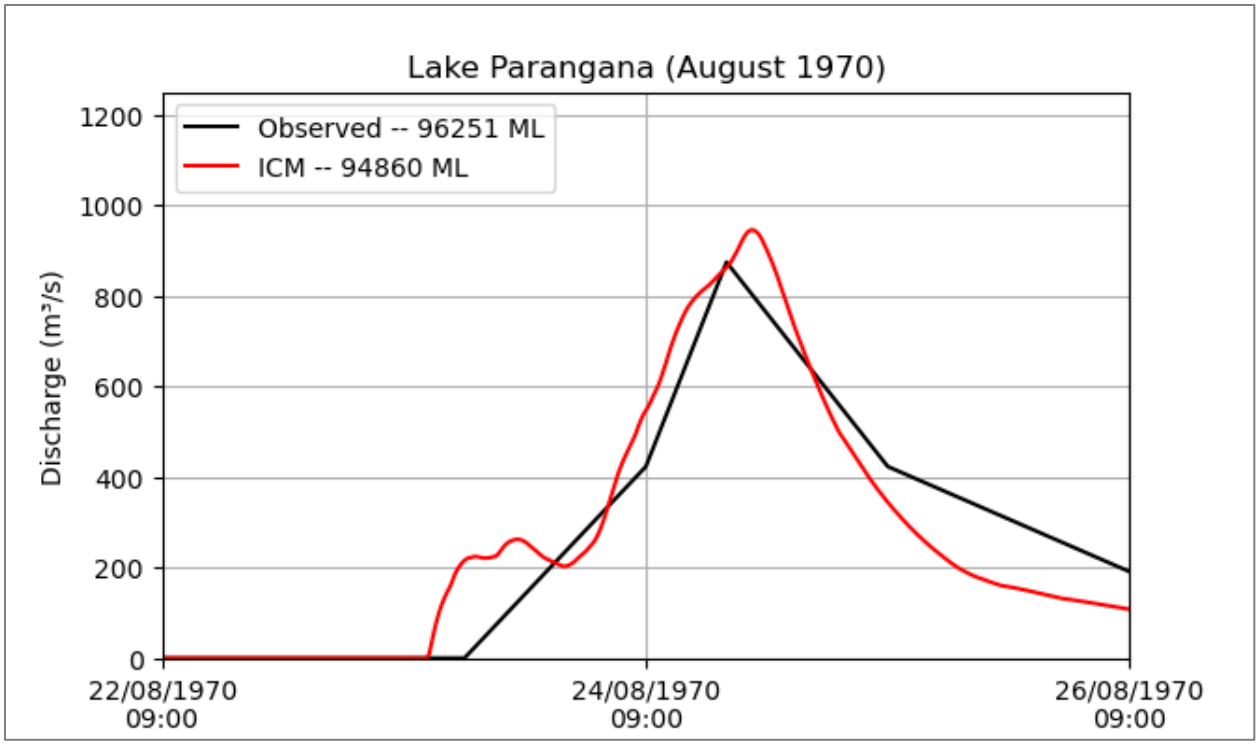

Diagram 21: August 1970 flow comparison at Lake Parangana

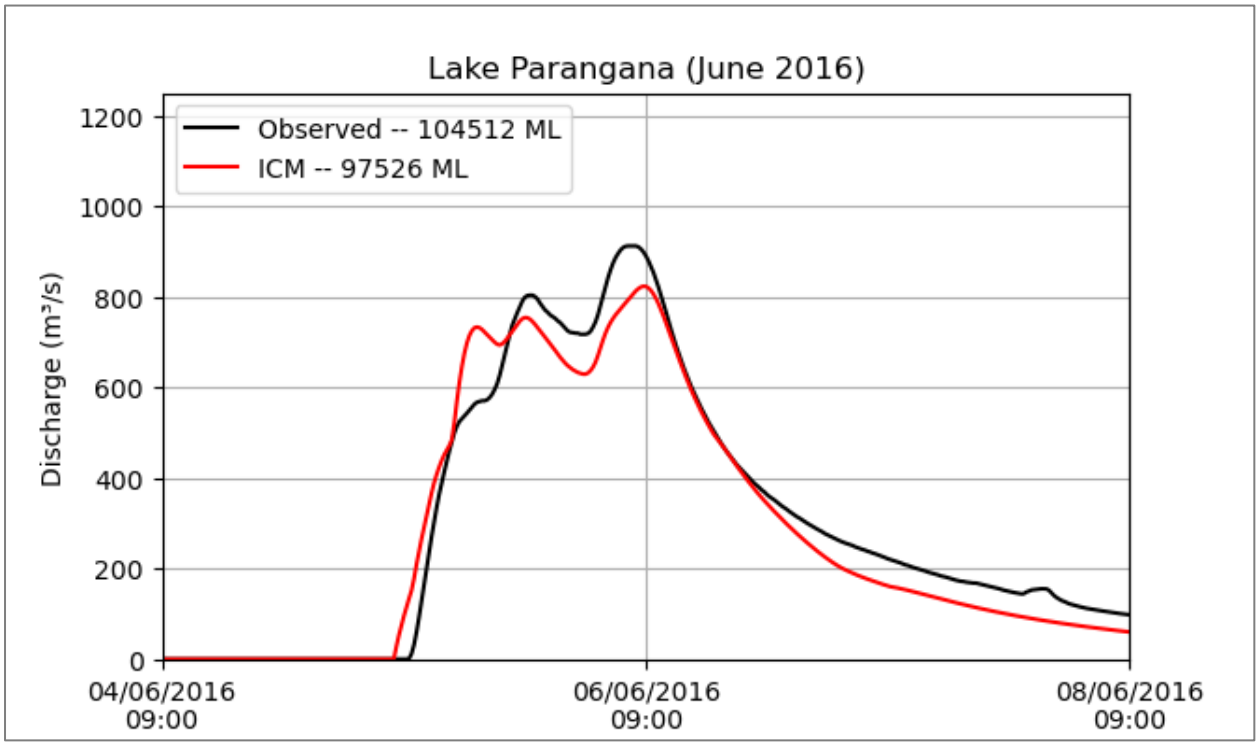

Diagram 22: June 2016 flow comparison at Lake Parangana

6.3.4. Mersey River at Liena

Significant flows were recorded at Mersey River at Liena during the August 1970 and June 2016 events. This site is located downstream of Lake Parangana.

As noted in Section 3.1, the supplied rating curve was given a high flow rating quality of “good”, with the highest gauging about half that of August 1970 and June 2016 (2.74 m compared to 4.78 m and 4.94 m respectively).

Differences between the modelled and supplied rating curves were observed during model calibration and the channel roughness at this location was decreased (Section 5.2). This resulted in a good agreement between the slope of the modelled and supplied rating curves at high flows (Figure D 2).

The supplied DEM does not appear to contain the full river bathymetry at this location, and it is acknowledged that the change to the channel roughness may be partially or fully compensating for this (rather than an actual change to the channel roughness).

The modelled and observed flows and levels at Mersey River at Liena are shown in Table 9 and Diagram 23 to Diagram 26. The modelled flows and levels show a fair match to the observed, with peak flow and level overestimated in August 1970 and underestimated in June 2016. This is consistent with the results at Lake Parangana.

A gauge zero was not provided for this gauge by Hydro Tasmania, so an assumed gauge zero of 282.6 mAHD was assumed. This gauge zero was inferred from the DEM of the hydrodynamic model.

Table 9: Calibrated parameters and results at Mersey River at Liena

Statistic	August 1970	June 2016
IL (mm)	20	0
Average CL (mm/h)	1.44	1.73
RAF	2	2
Modelled Peak (m^3/s)	1,005	889
Observed Peak (m^3/s)	940	961
Peak % difference	+7%	-8%
Modelled Volume (ML)	97,912	105,106
Observed Volume (ML)	102,017	120,860
Volume % difference	+4%	-13%
Modelled peak (mAHD)	287.71	287.47
Observed peak (mAHD)	287.38	287.54
Peak difference (m)	+0.33	-0.07

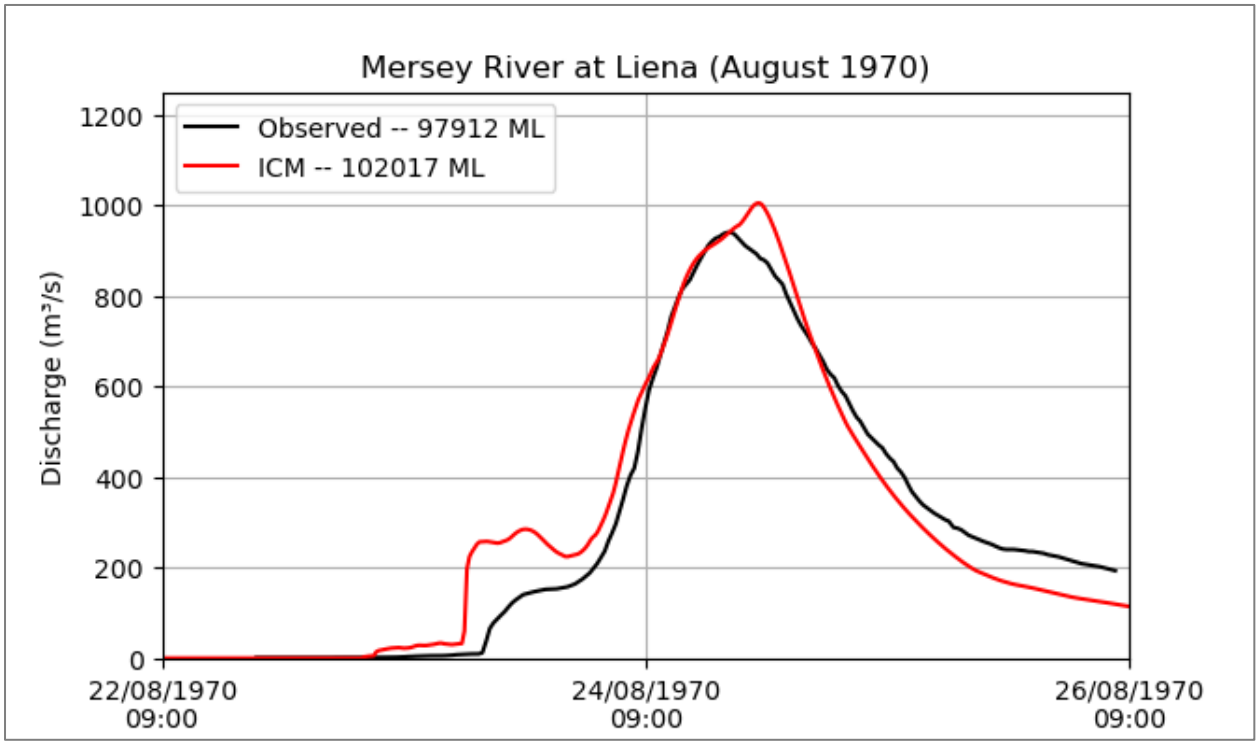

Diagram 23: August 1970 flow comparison at Mersey River at Liena

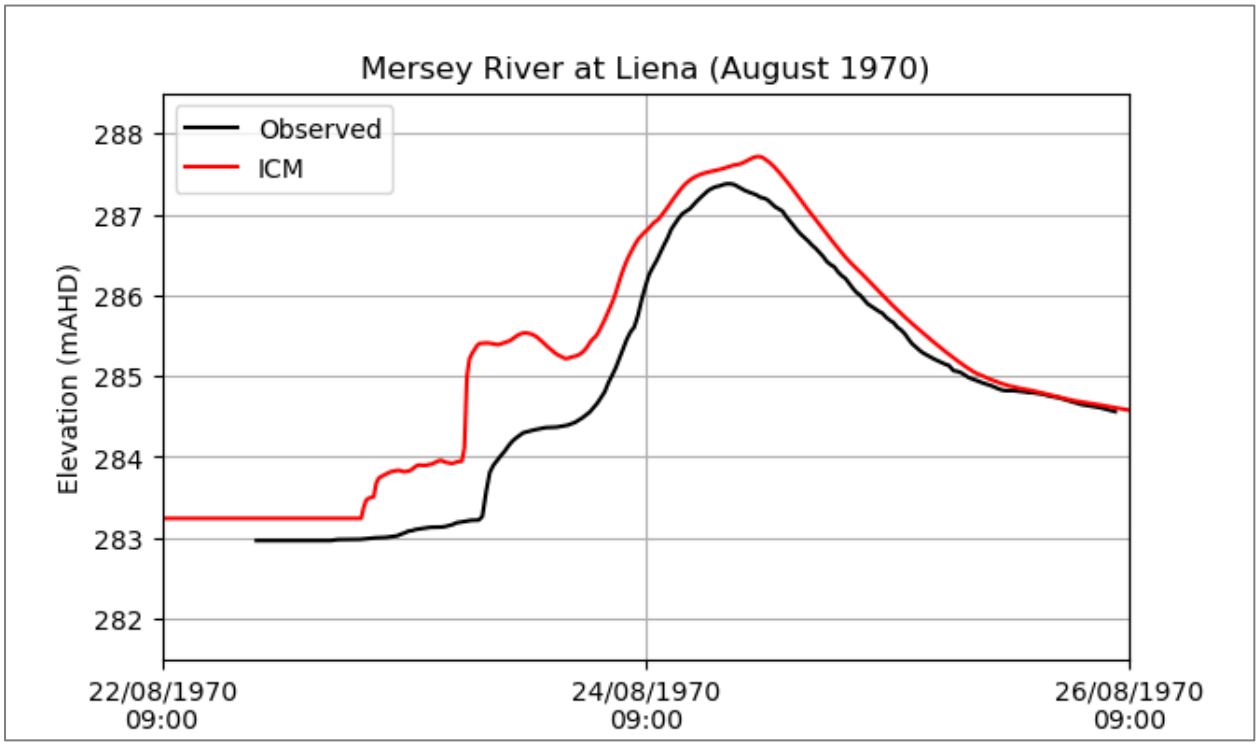

Diagram 24: August 1970 water level comparison at Mersey River at Liena

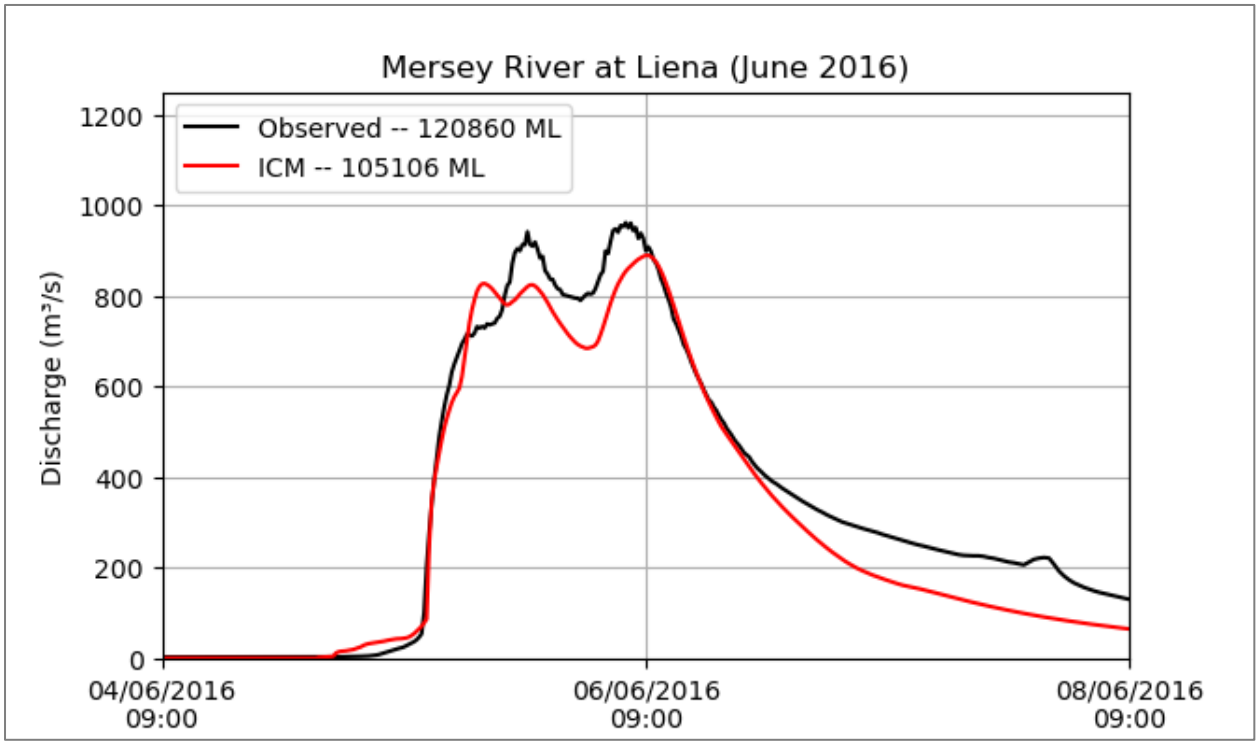

Diagram 25: June 2016 flow comparison at Mersey River at Liena

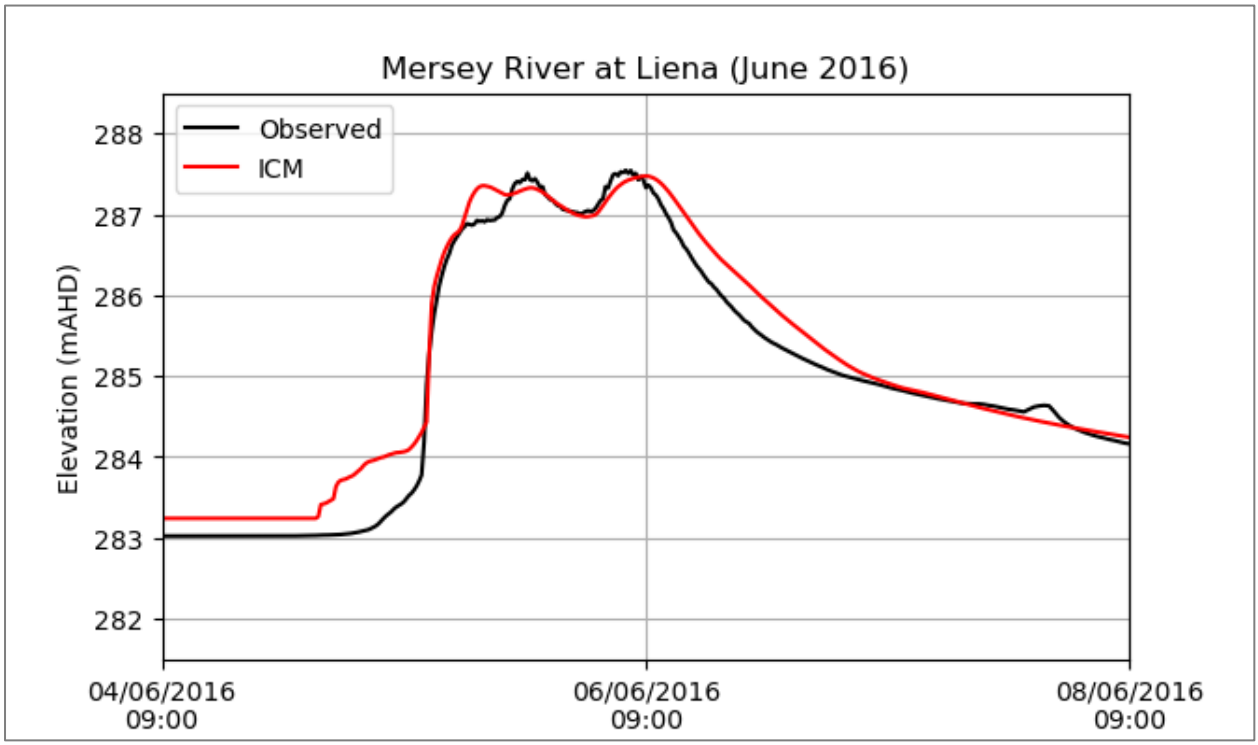

Diagram 26: June 2016 water level comparison at Mersey River at Liena

6.3.5. Mersey River at Kimberley

Model calibration at Mersey River at Kimberley was not undertaken as observed flows and levels were not provided for most of the calibration events. To provide a frame of reference for this location, the modelled flows and levels for the August 1970 and June 2016 events are shown in Table 10, and Diagram 27 to Diagram 30.

In keeping with the other Mersey River gauges, the channel roughness at this location was decreased (Section 5.2). Like the other Mersey River gauges, the supplied DEM does not appear to contain the full river bathymetry at this location.

It is noted that observed flows were provided for August 1970. However, no other data was provided to enable a review of the observed rating curve and therefore, the observed flows were treated with suspicion. It is recommended that the results at Mersey River at Liena and Mersey River at Shale Road are referred to for August 1970.

It is also noted that observed flows and levels were not provided for June 2016. It is recommended that the results of the June 2016 flood level survey comparison near Mersey River at Kimberley are referred to for June 2016.

Table 10: Parameters and results at Mersey River at Kimberley

Statistic	August 1970	June 2016
IL (mm)	20	0
Average CL (mm/h)	1.49	1.78
RAF	2	2
Modelled Peak (m^3/s)	1,650	1,900
Observed Peak (m^3/s)	1,364*	-
Peak % difference	+21%	-
Modelled Volume (ML)	164,079	207,580
Observed Volume (ML)	151,590*	-
Volume % difference	+8%	-
Modelled peak (mAHD)	54.30	54.49
Observed peak (mAHD)	-	-
Peak difference (m)	-	-

* Data quality suspect

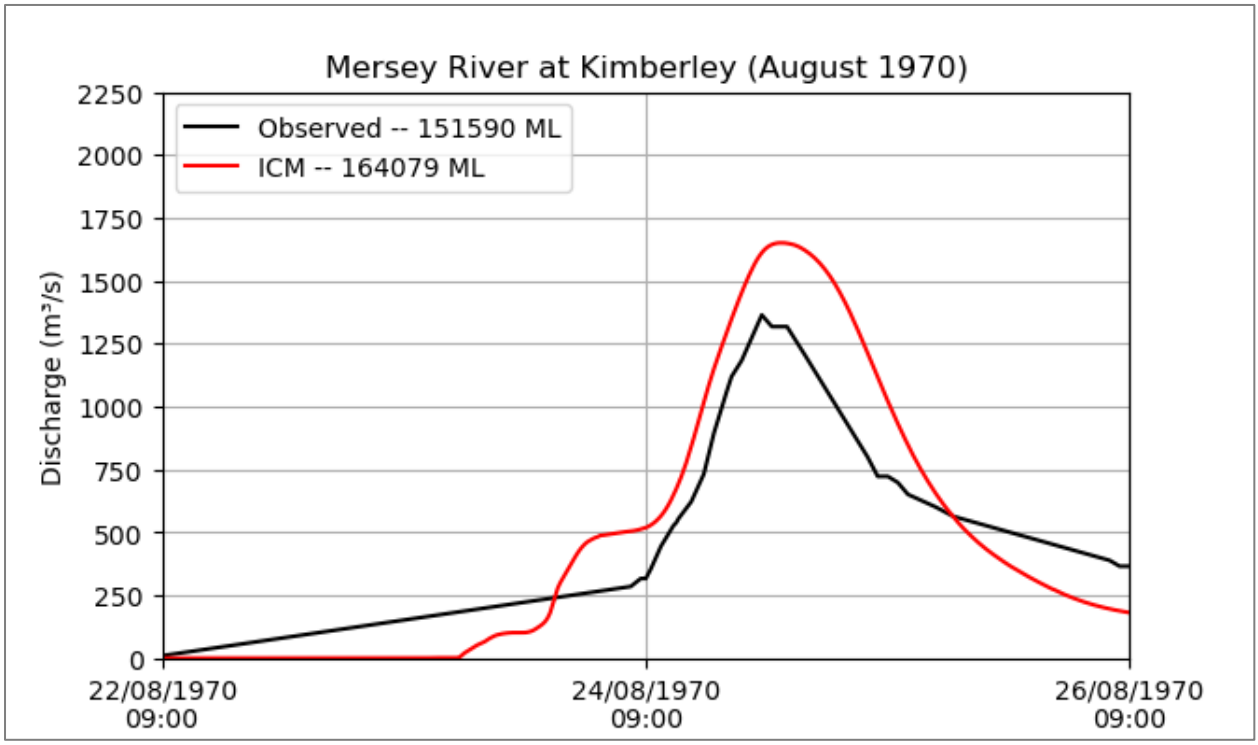

Diagram 27: August 1970 flows at Mersey River at Kimberley

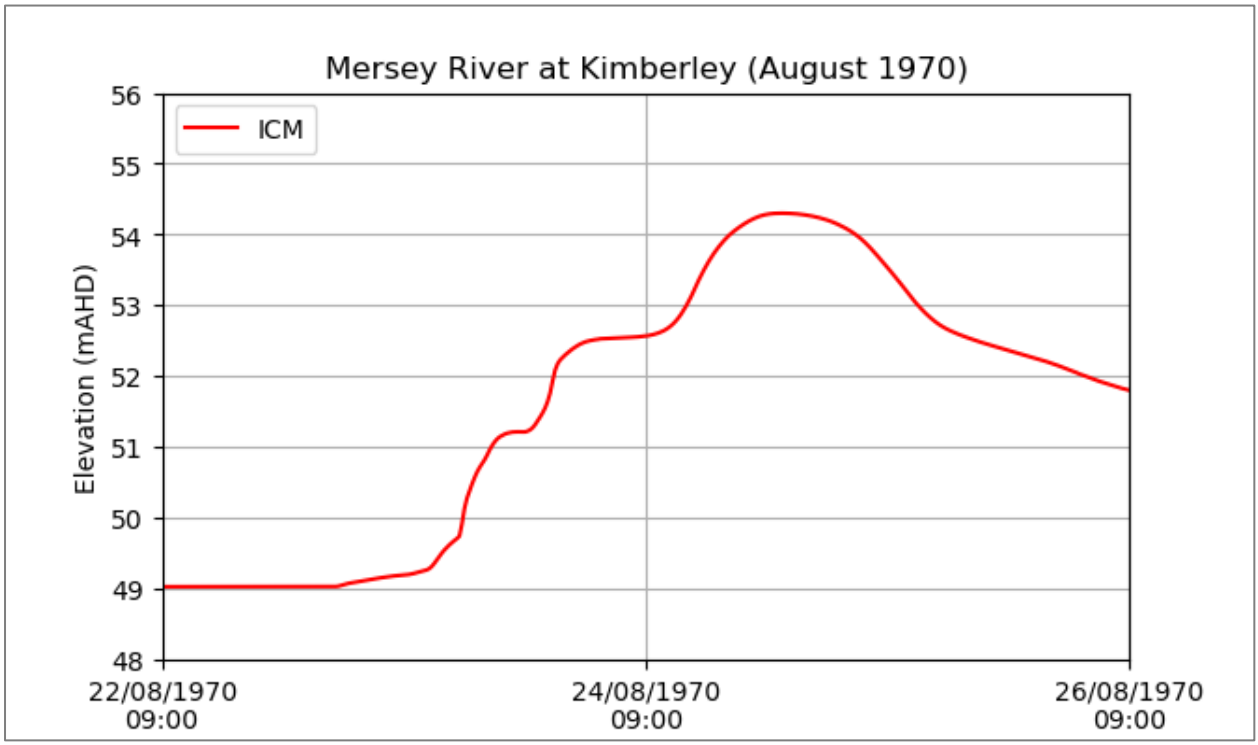

Diagram 28: August 1970 water levels at Mersey River at Kimberley

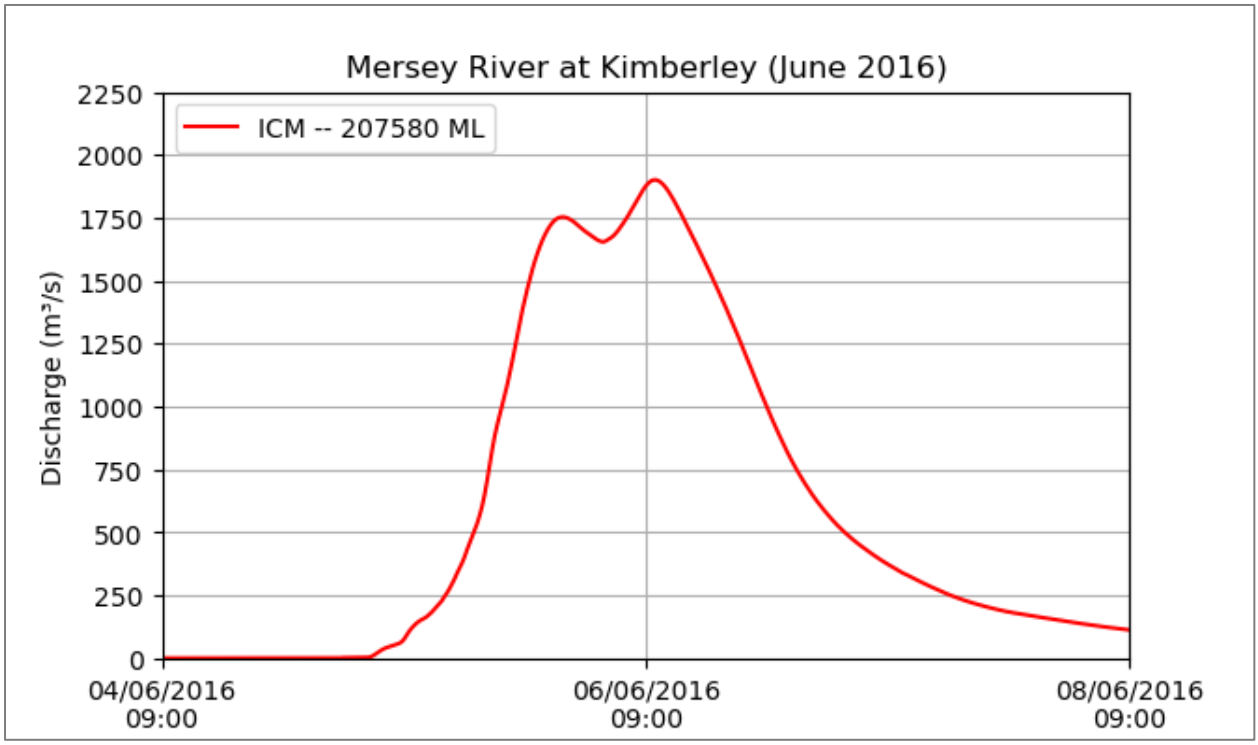

Diagram 29: June 2016 flows at Mersey River at Kimberley

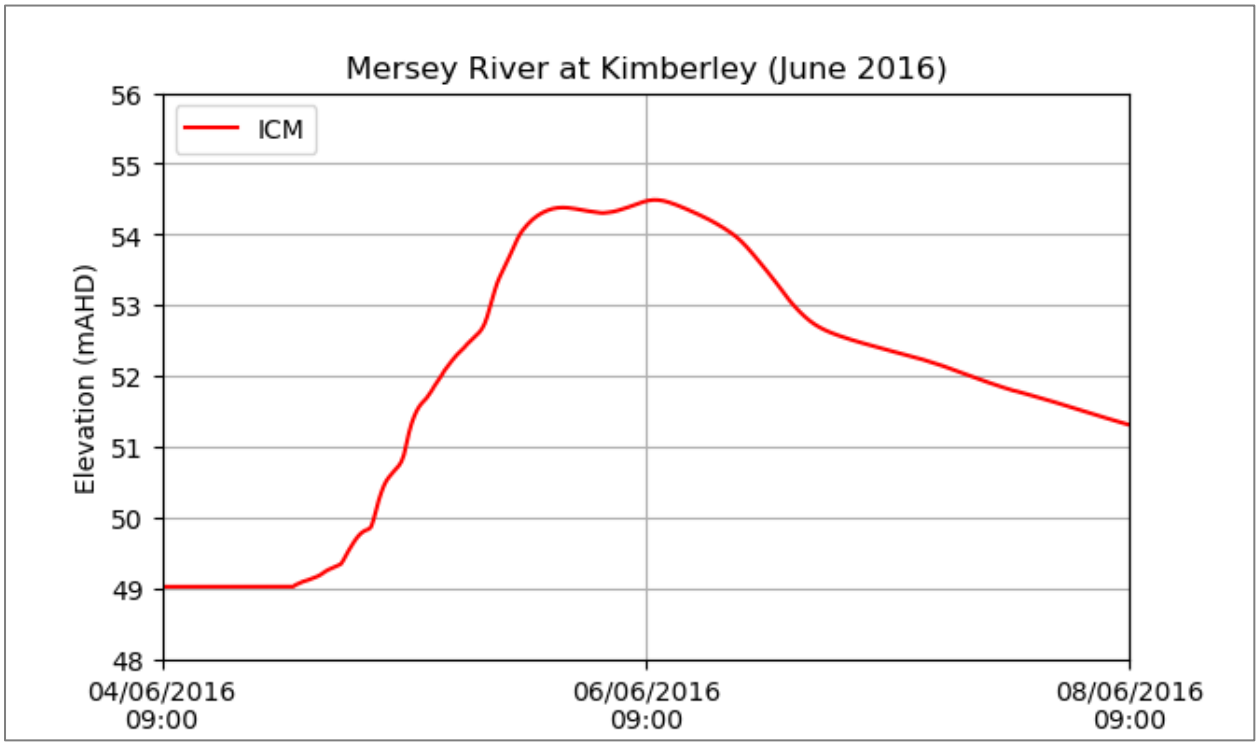

Diagram 30: June 2016 water levels at Mersey River at Kimberley

6.3.6. Mersey River at Shale Road

Significant flows were recorded at Mersey River at Shale Road during the August 1970, January 2011, and June 2016 events.

Due to uncertainty in the site's rating at high flows (Section 3.1.2), model calibration was attempted to levels only. The flows for the August 1970, January 2011, and June 2016 events have been presented below for illustration only.

In keeping with the other Mersey River gauges, the channel roughness at this location was decreased (Section 5.2). However, this was not able to reconcile the differences between the modelled and supplied rating curves at high flows (Figure D 3). Like the other Mersey River gauges, the supplied DEM does not appear to contain the full river bathymetry at this location.

The modelled and observed flows and levels at Mersey River at Shale Road are shown in Table 11 and Diagram 31 to Diagram 36. The modelled levels show a fair match to the observed, with peak level overestimated in August 1970, January 2011, and June 2016. This is relatively consistent with the results at Mersey River at Liena.

A gauge zero of 4.293 mAHD was provided for this gauge from the DNRE database. As discussed in Section 3.1.2 there was a shift in the low flow levels at this gauge in 1981 by ~0.6 m so levels for the 1970 event may be inconsistent with the current gauge zero and/or the current DEM.

Table 11: Calibrated parameters and results at Mersey River at Shale Road

Statistic	August 1970	January 2011	June 2016
IL (mm)	20	16	0
Average CL (mm/h)	1.50	5.72	1.80
RAF	2	2	2
Modelled Peak (m^3/s)	1706	850	2073
Observed Peak (m^3/s)	2001*	788*	1227*
Peak % difference	-15%	+57%	+69%
Modelled Volume (ML)	165,952	57,327	221,801
Observed Volume (ML)	197,540*	79,829*	161,586*
Volume % difference	-16%	-28%	+37%
Modelled peak (mAHD)	14.54	12.74	15.19
Observed peak (mAHD)	13.23	11.95	14.71
Peak difference (m)	+1.31	+0.80	+0.48

* Data quality suspect

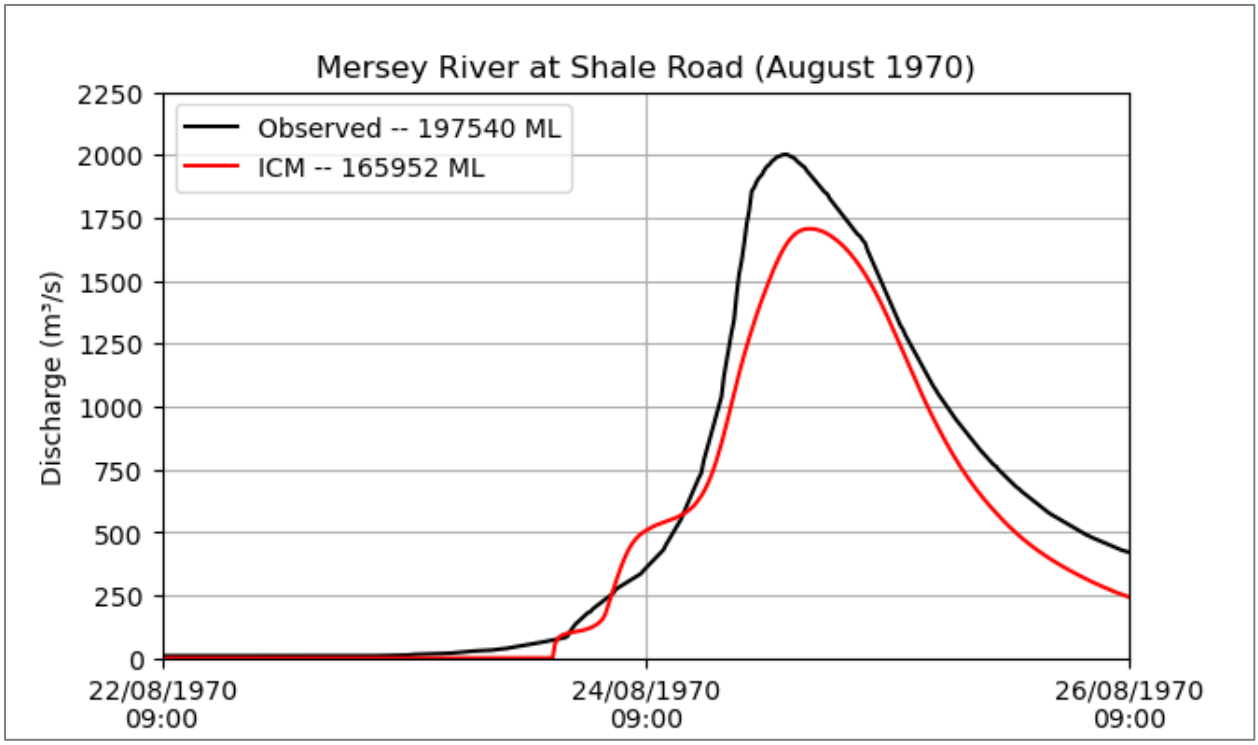

Diagram 31: August 1970 flow comparison at Mersey River at Shale Road

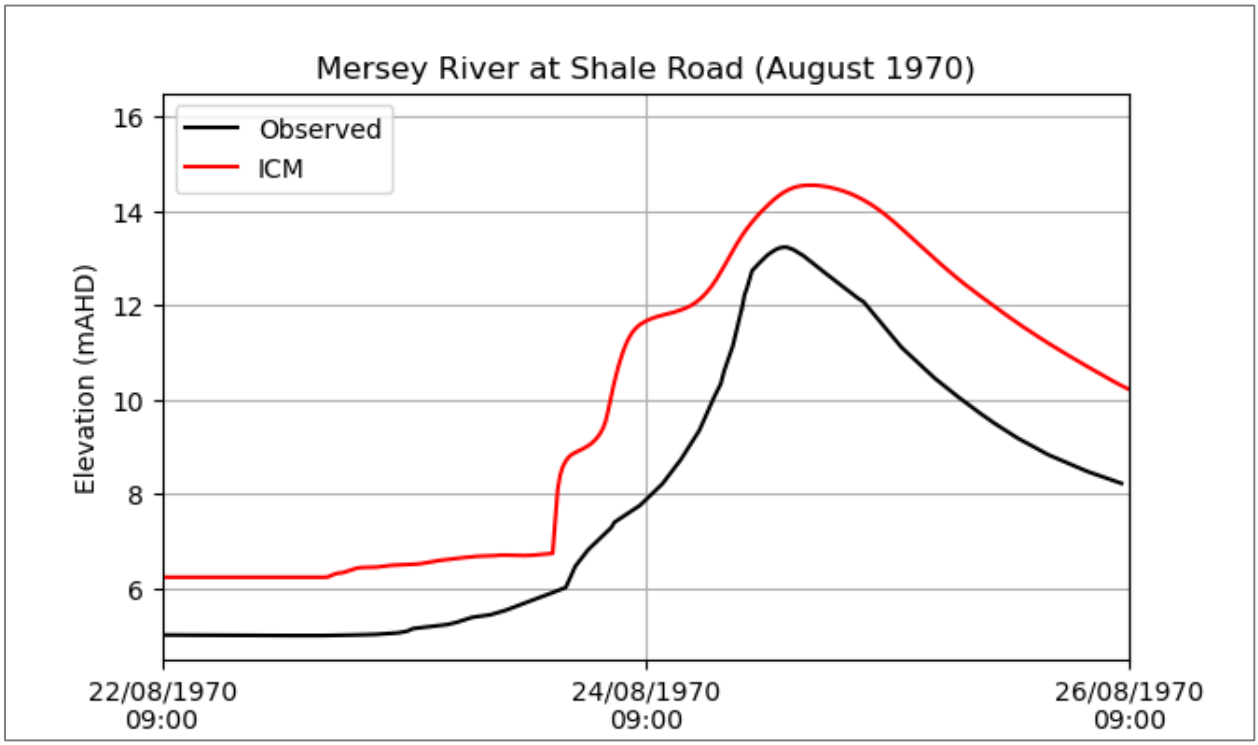

Diagram 32: August 1970 water level comparison at Mersey River at Shale Road

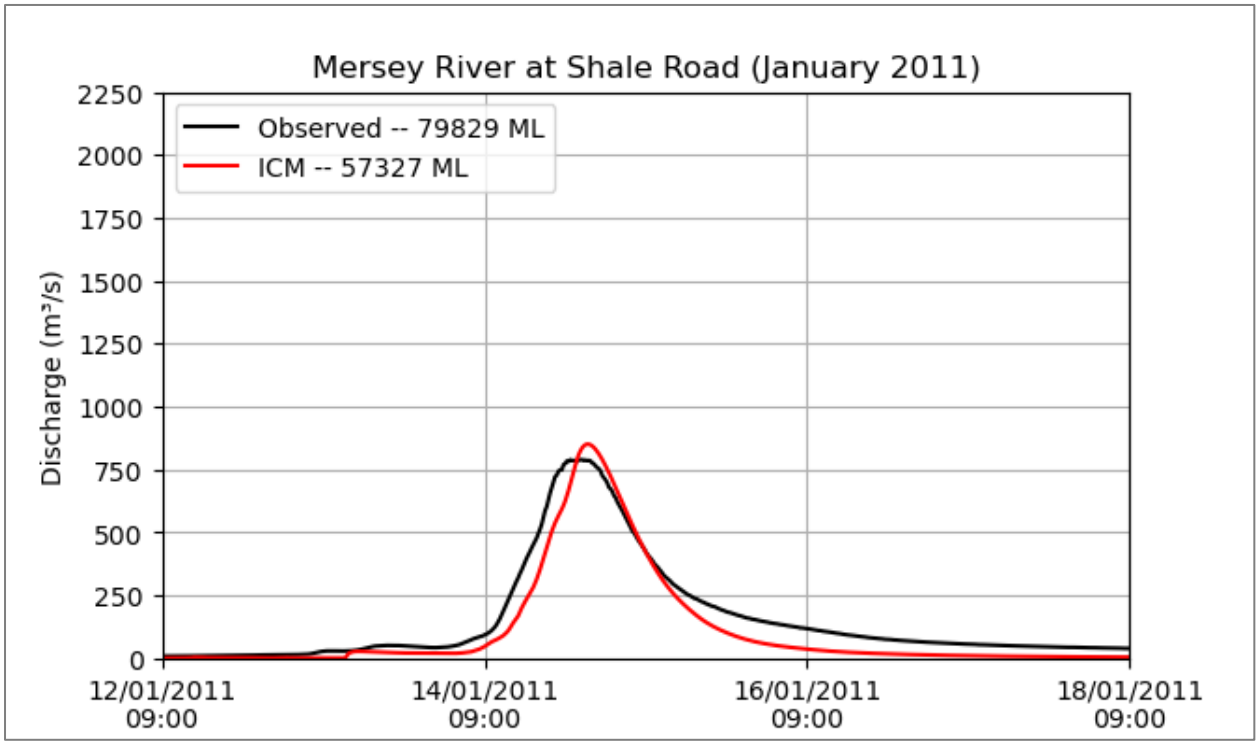

Diagram 33: January 2011 flow comparison at Mersey River at Shale Road

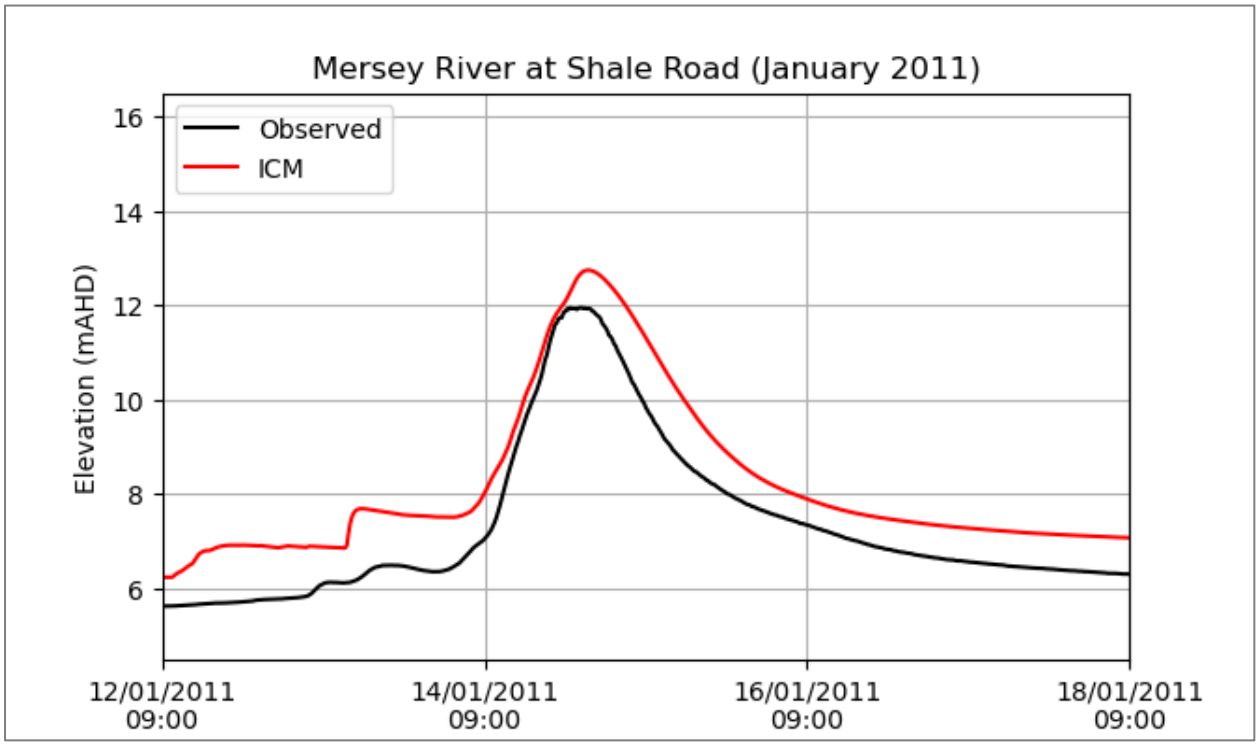

Diagram 34: January 2011 water level comparison at Mersey River at Shale Road

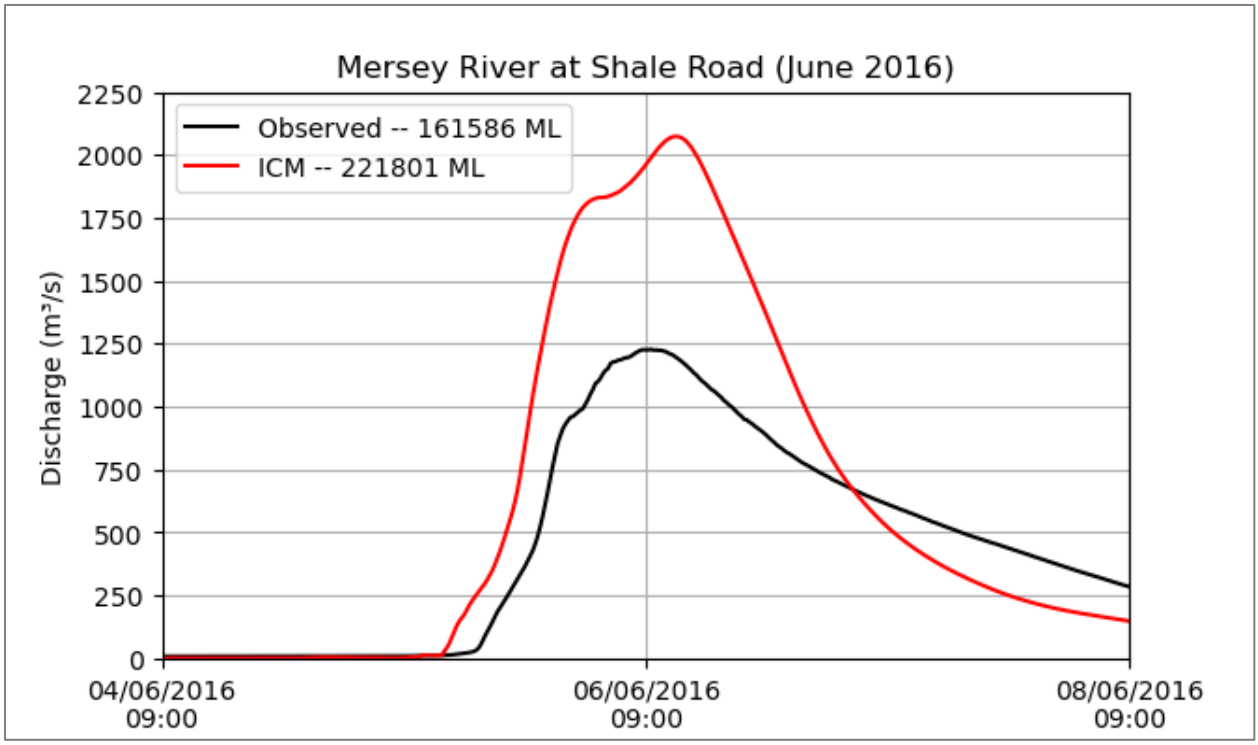

Diagram 35: June 2016 flow comparison at Mersey River at Shale Road

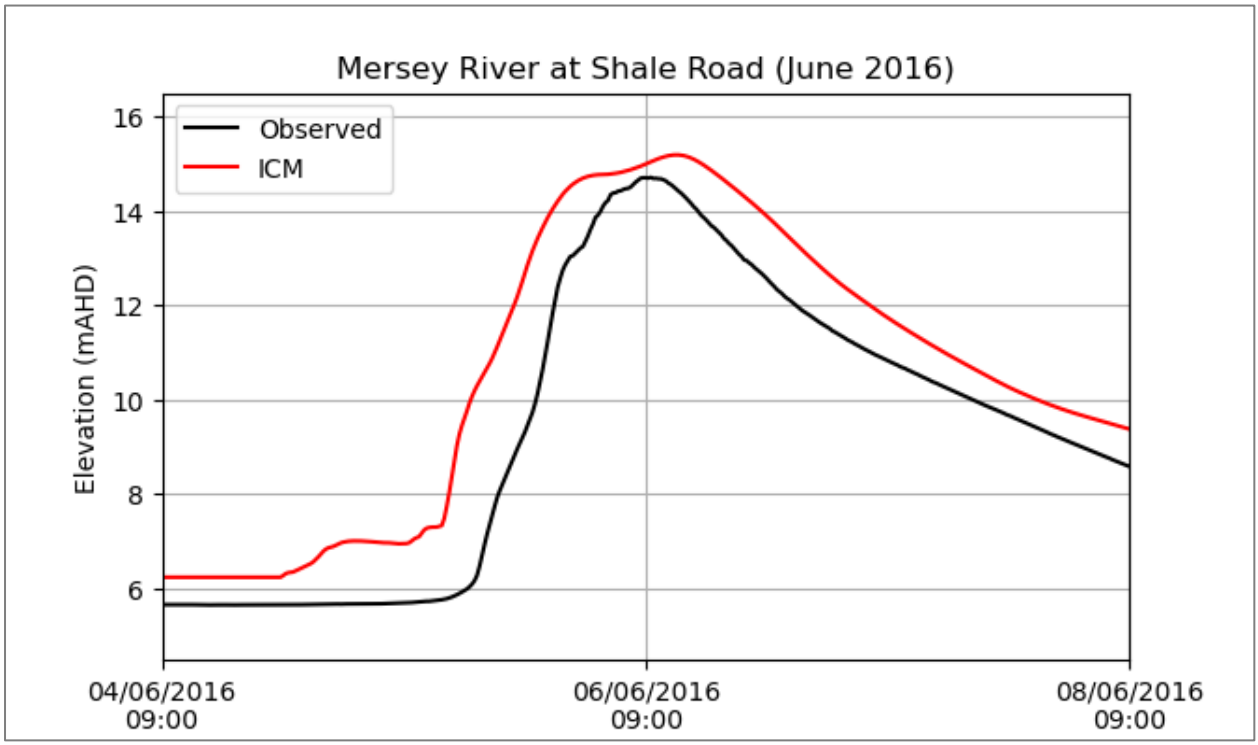

Diagram 36: June 2016 water level comparison at Mersey River at Shale Road

6.3.7. Arm River u/s Mersey River

Significant flows were recorded at Arm River u/s Mersey River during the August 2007 and June 2016 events. This site was established in 1972 and thus was not active during the August 1970 event.

As noted in Section 3.1, the supplied rating curve was given a high flow rating quality of “good”, with the highest gauging about half that of August 2007 and June 2016 (1.79 m compared to 2.04 m and 2.19 m respectively).

No significant differences between the modelled and supplied rating curves were observed during model calibration and therefore, no changes were made to the default model. There is a good agreement between the slope of the modelled and supplied rating curves at high flows (Figure D 4).

It is noted that the weir control for this location is not explicitly modelled, and the supplied DEM does not appear to contain the full river bathymetry at this location (with the DEM estimated to be just above weir flow). This may explain the differences between the modelled and supplied rating curves at low flows (which was not the subject of model calibration).

The modelled and observed flows and levels at Arm River u/s Mersey River are shown in Table 12 and Diagram 37 to Diagram 40. As noted in Section 3.1.1, the observed flows and levels around and after the peak of June 2016 are suspect.

The modelled flows and levels show a good match to the observed, with a good match to the peak flow and level of August 2007 and potentially June 2016. There is a poor match to the shape of June 2016 however, with a double peak in the modelled hydrograph compared to a single peak in the observed.

A gauge zero of 402.28 mAHD was provided for this gauge from Hydro Tasmania.

Table 12: Calibrated parameters and results at Arm River u/s Mersey River

Statistic	August 2007	June 2016
IL (mm)	33	0
Average CL (mm/h)	0.60	2.26
RAF	2	2
Modelled Peak (m^3/s)	79	112
Observed Peak (m^3/s)	80	107*
Peak % difference	0%	+5%
Modelled Volume (ML)	10,273	9,880
Observed Volume (ML)	15,004	10,699*
Volume % difference	-32%	-8%
Modelled peak (mAHD)	404.29	404.45
Observed peak (mAHD)	404.32	404.47*
Peak difference (m)	-0.03	-0.02

* Data quality suspect

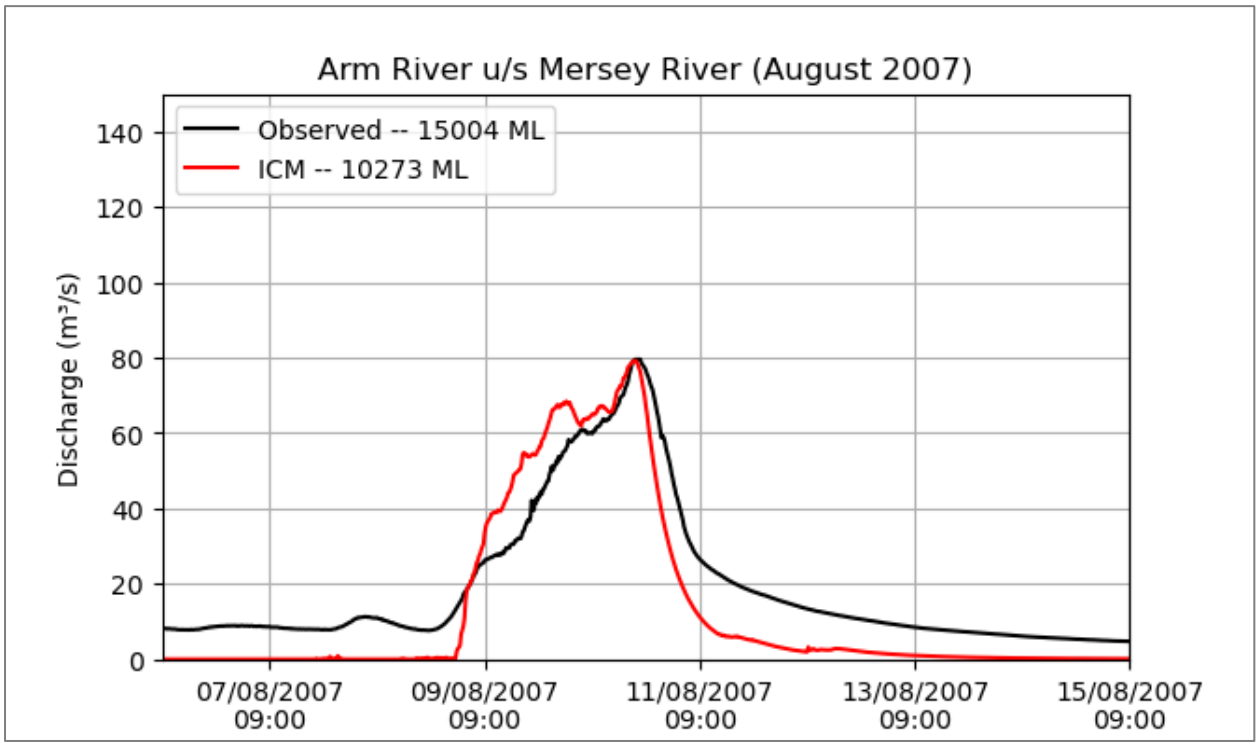

Diagram 37: August 2007 flow comparison at Arm River u/s Mersey River

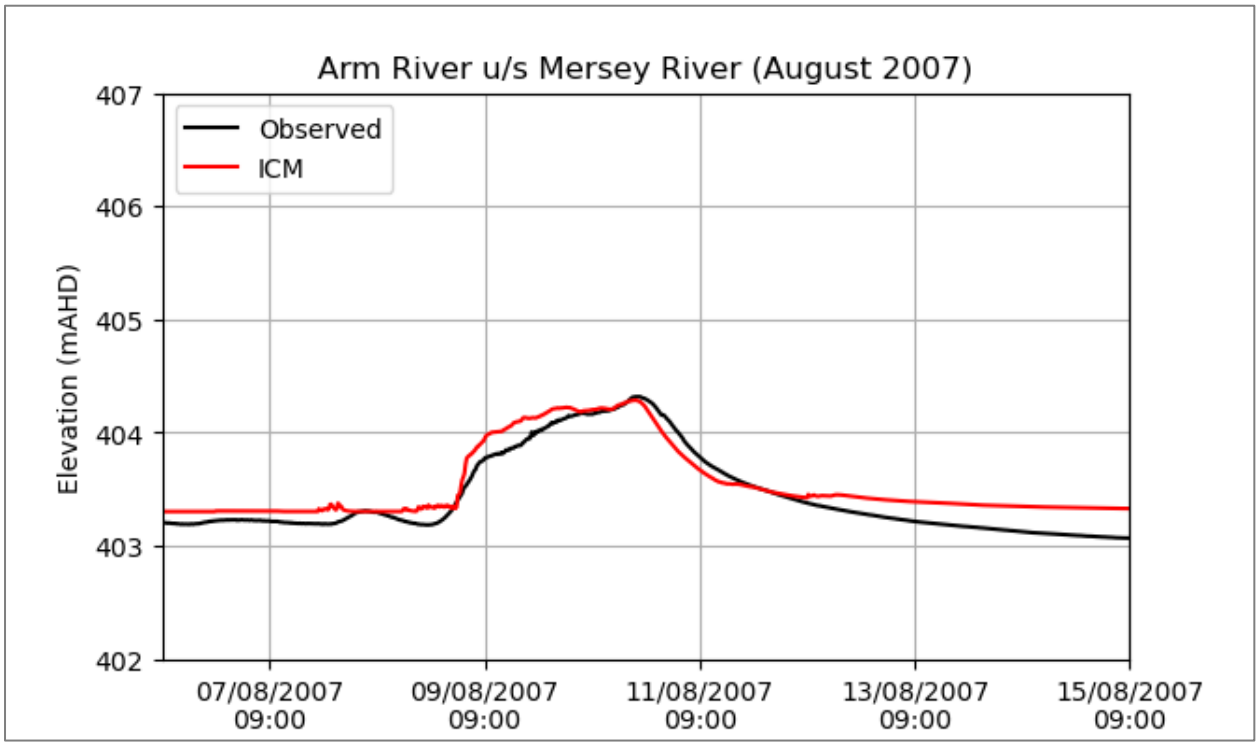

Diagram 38: August 2007 water level comparison at Arm River u/s Mersey River

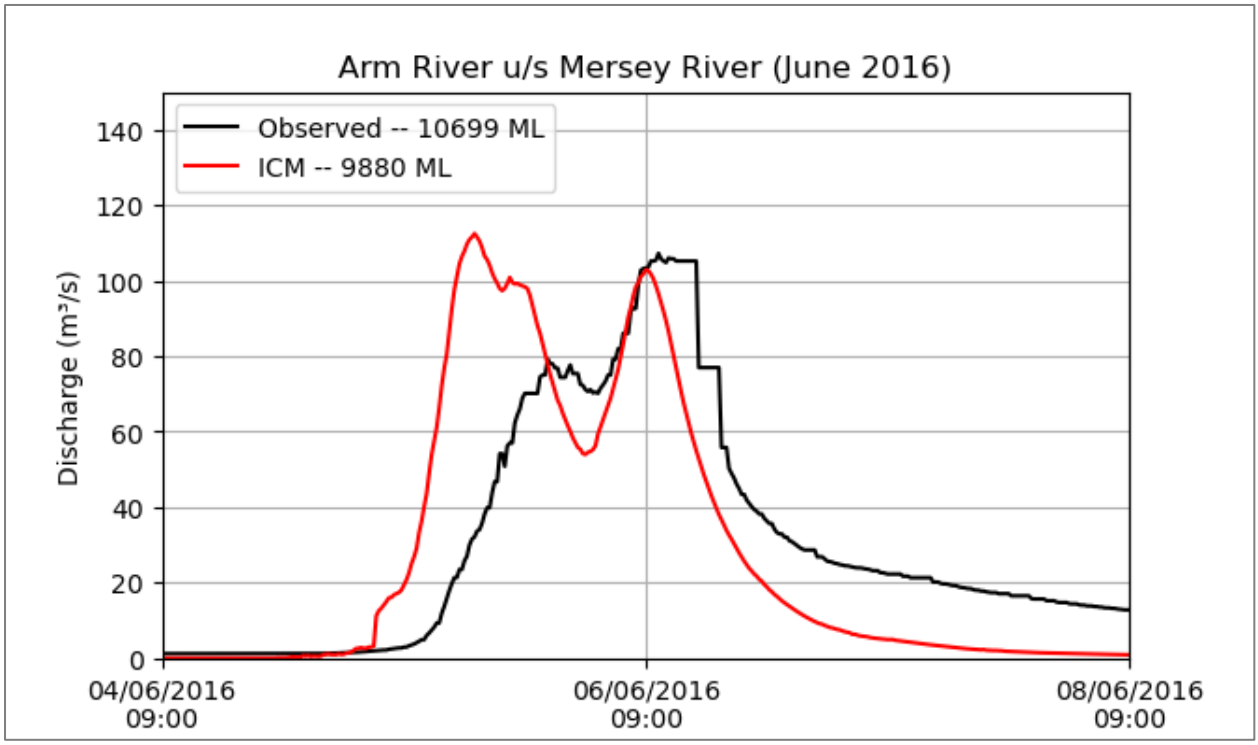

Diagram 39: June 2016 flow comparison at Arm River u/s Mersey River

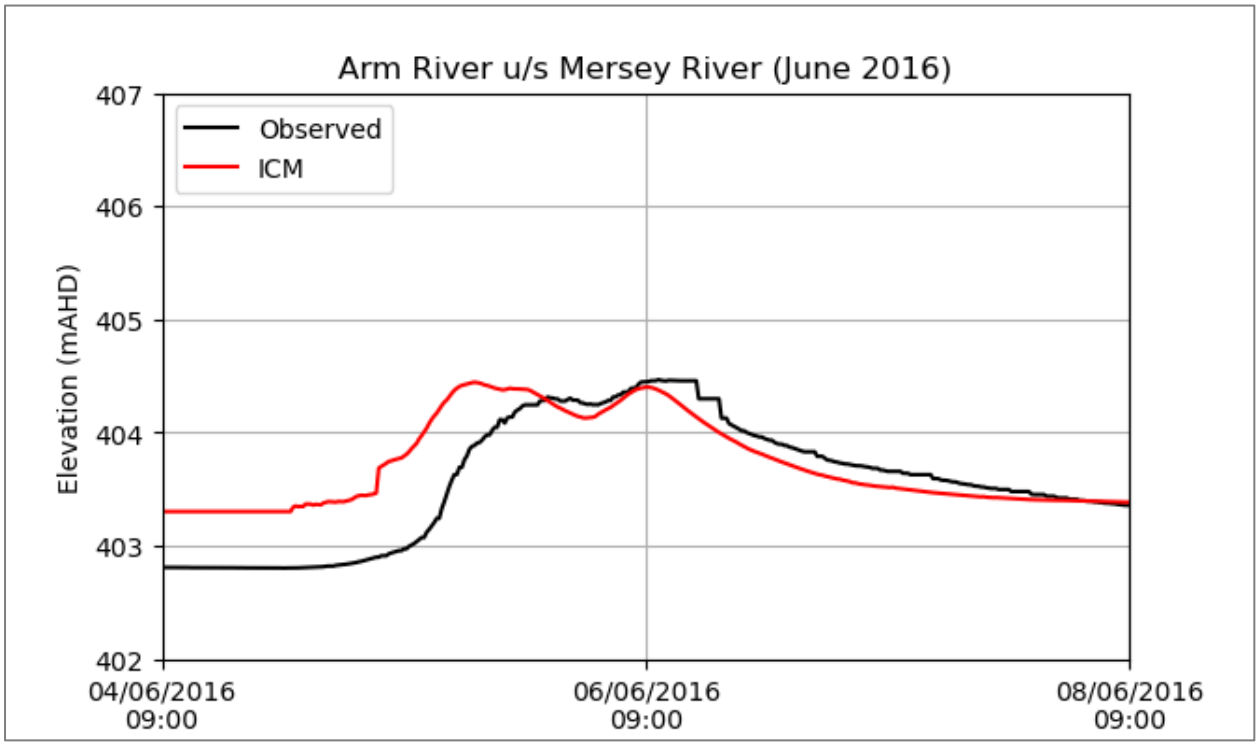

Diagram 40: June 2016 water level comparison at Arm River u/s Mersey River

6.3.8. Fisher River u/s Lake Mackenzie

Significant flows were recorded at Fisher River u/s Lake Mackenize during the August 2007, January 2011, and June 2016 events. This site was established in 1972 and was not present during the August 1970 event. It is believed that this gauge was overtopped during the June 2016 event and both the levels and flows available on Water Data Online are estimate only.

Due to the uncertainty in the site's rating at high flows (as discussed in Section 3.1.2), sites with higher quality data were given preference during model calibration. Flows have presented below for illustration only, however observed flows were not used for comparison as it is likely the rating is underestimating true flows. The modelled results have been compared to levels.

The modelled and observed flows and levels at Fisher River u/s Lake Mackenzie are shown in Table 13 and Diagram 41 to Diagram 46. As noted in Section 3.1.1, the observed flows and levels around the peak of June 2016 are suspect.

The modelled levels underestimated observed peak levels in August 1970, January 2011, and June 2016. There are very steep rainfall gradients in this area of the catchment which means any uncertainties in rainfall distribution can have a significant impact on modelled flows.

A gauge zero was not provided for this gauge by Hydro Tasmania, so a gauge zero of 1136.4 mAHD was assumed. This gauge zero was inferred from the DEM of the hydrodynamic model.

Table 13: Calibrated parameters and results at Fisher River u/s Lake Mackenzie

Statistic	August 2007	January 2011	June 2016
IL (mm)	33	16	0
Average CL (mm/h)	0.35	4.18	1.32
RAF	2	2	2
Modelled Peak (m^3/s)	43	73	105
Observed Peak (m^3/s)	41*	41*	153*^
Peak % difference	+6%	+76%	-31%
Modelled Volume (ML)	5,340	4,164	10,583
Observed Volume (ML)	8,874*	4,998*	17,050*^
Volume % difference	-40%	-17%	-38%
Modelled peak (mAHD)	1137.43	1137.58	1137.87
Observed peak (mAHD)	1137.97	1137.98	1138.56^
Peak difference (m)	-0.54	-0.40	-0.69

* Data quality suspect

^ Observed data believed to be estimated as gauge overtopped

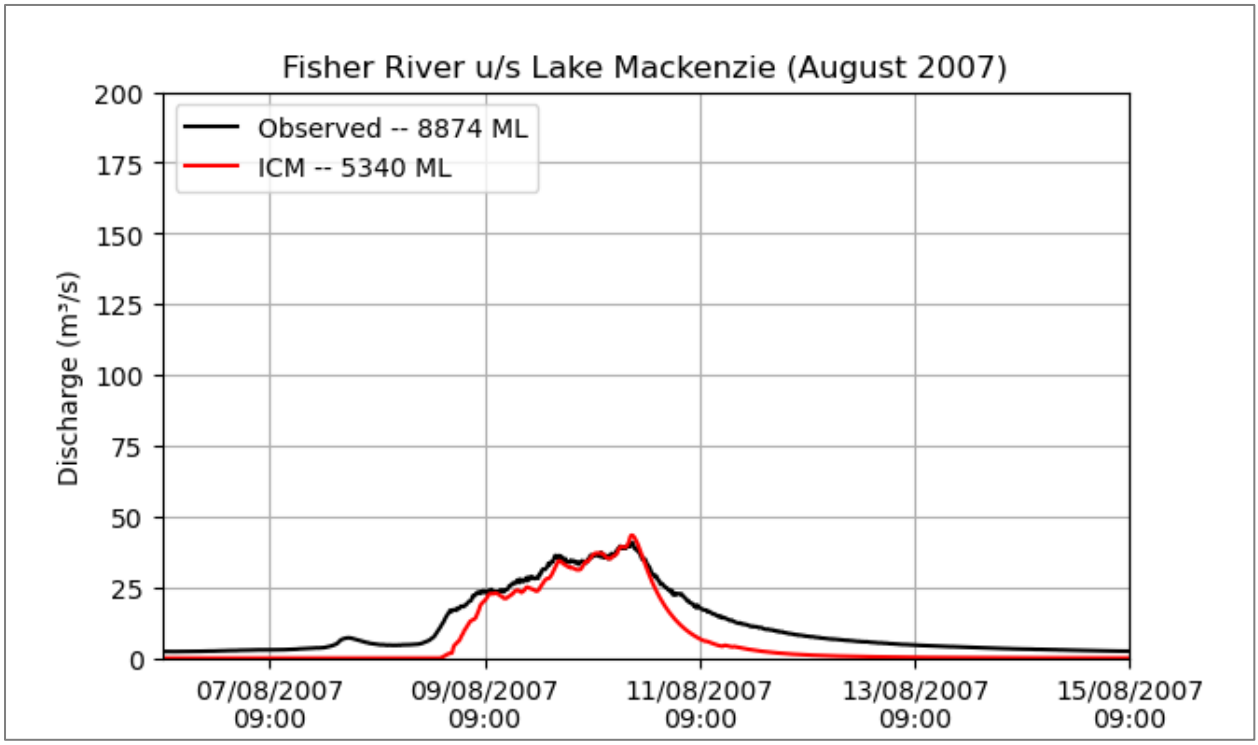

Diagram 41: August 2007 flow comparison at Fisher River u/s Lake Mackenzie

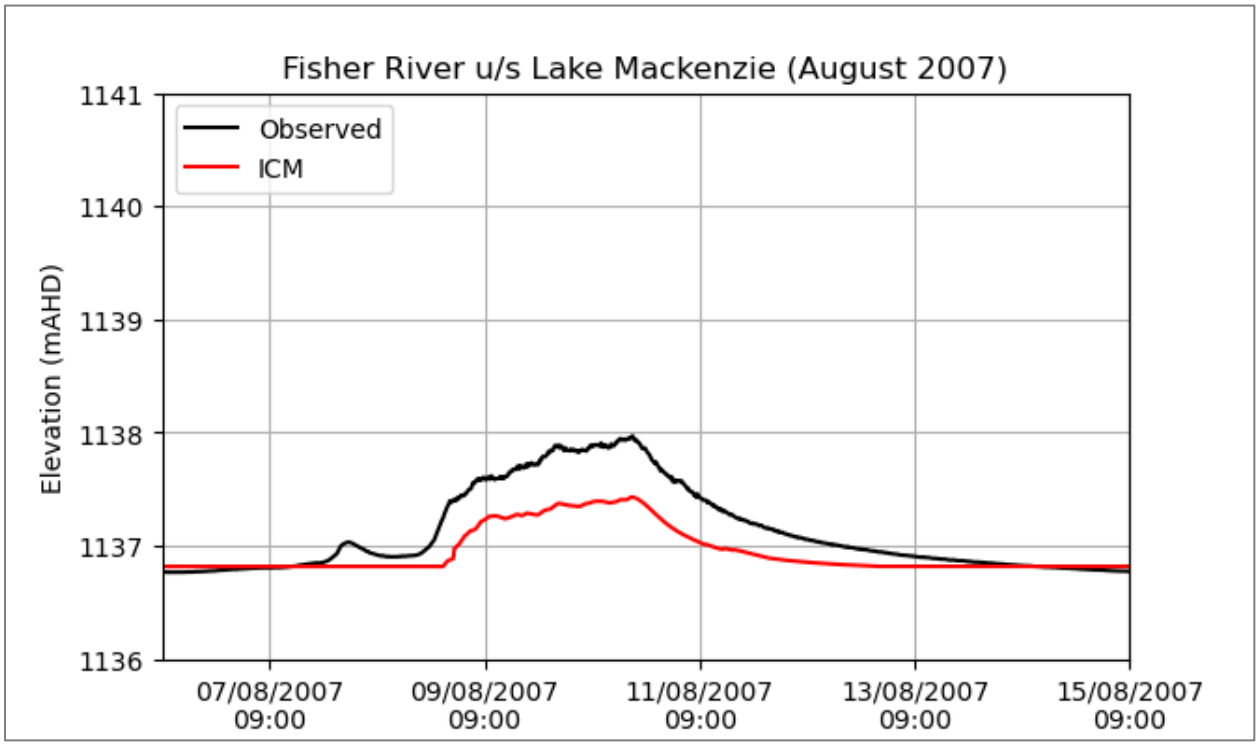

Diagram 42: August 2007 water level comparison at Fisher River u/s Lake Mackenzie

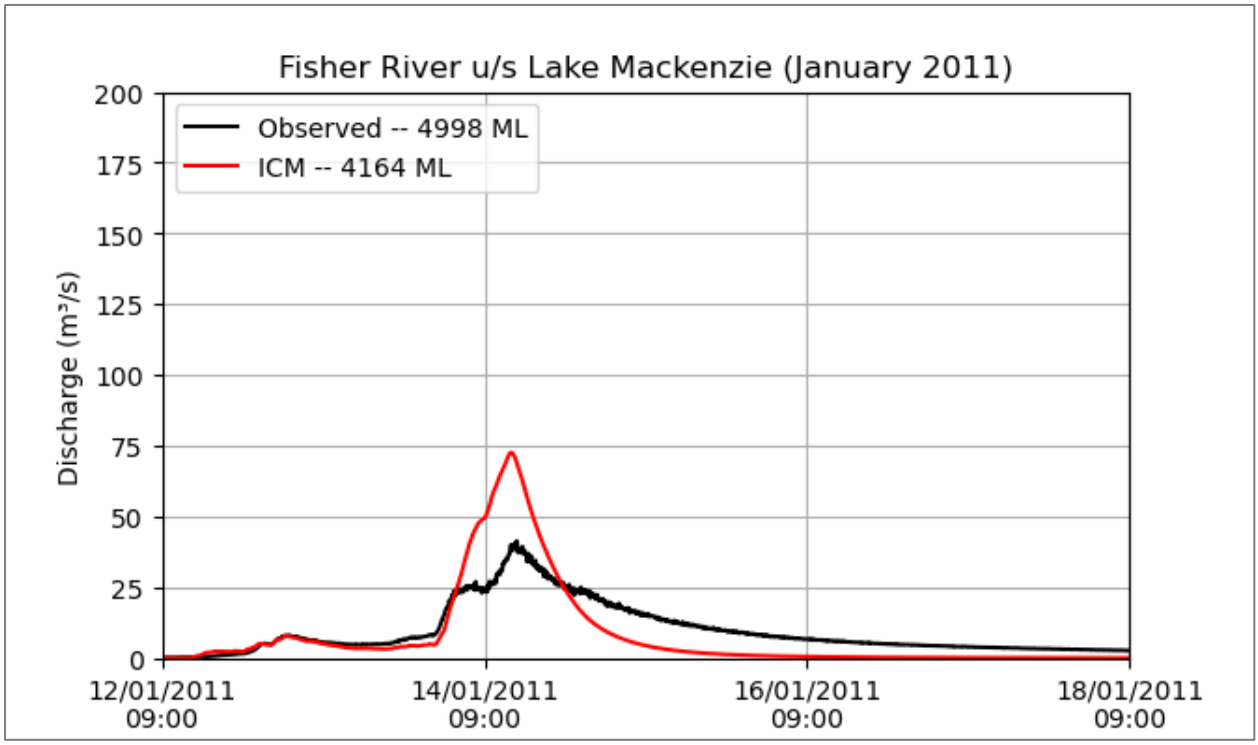

Diagram 43: January 2011 flow comparison at Fisher River u/s Lake Mackenzie

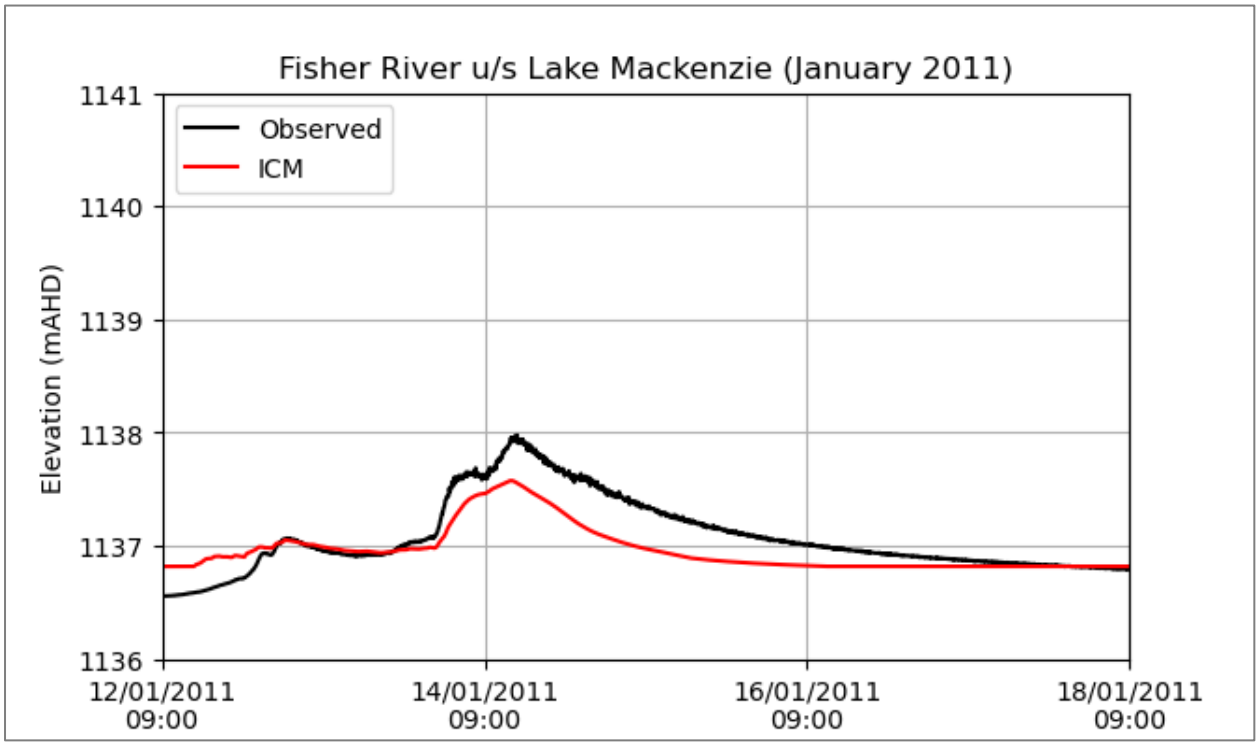

Diagram 44: January 2011 water level comparison at Fisher River u/s Lake Mackenzie

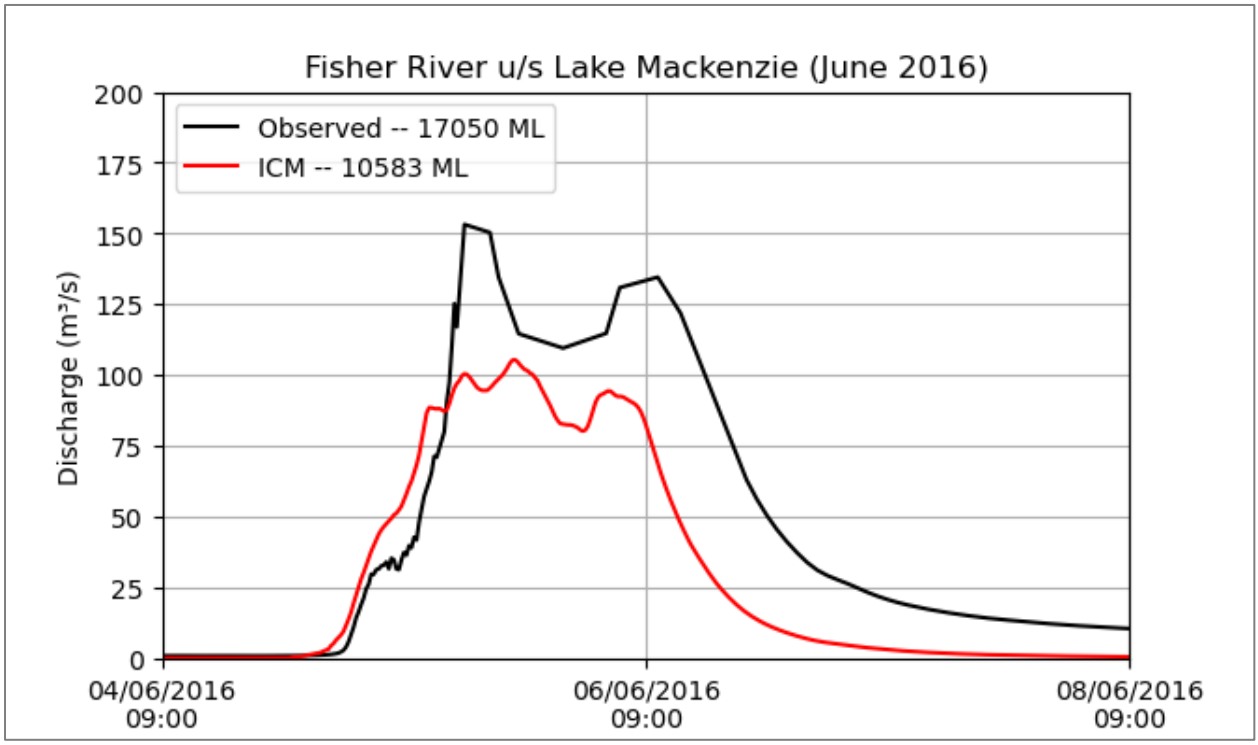

Diagram 45: June 2016 flow comparison at Fisher River u/s Lake Mackenzie

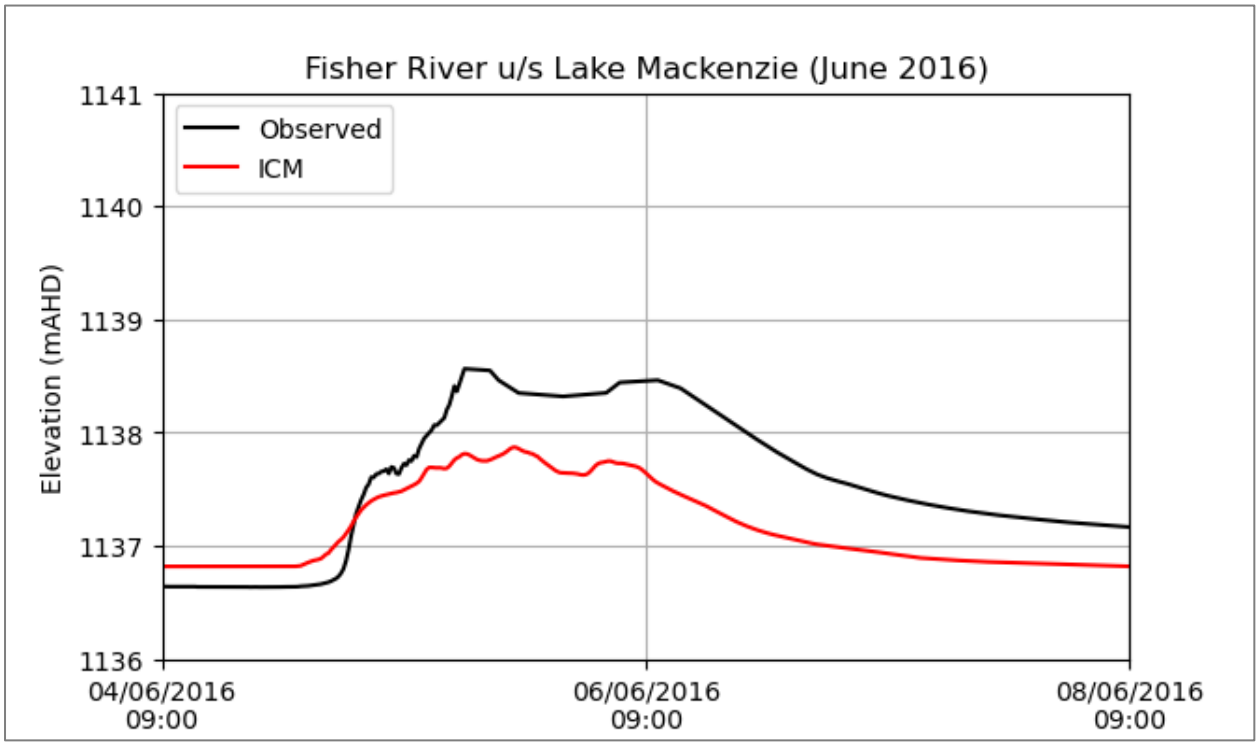

Diagram 46: June 2016 water level comparison at Fisher River u/s Lake Mackenzie

6.3.9. Lake Mackenzie

Significant spills were recorded at Lake Mackenzie during the August 2007 and June 2016 event. Lake Mackenzie was not dammed at the time of the August 1970 event and a low starting level meant that significant spills were not recorded during the January 2011 event.

Lake Mackenzie discharges into Fisher River via the spillway and can discharge into Fisher River via a series of tunnels and canals to the Fisher Power Station, approximately 13 km downstream of Lake Mackenzie. As discussed in Section 3.3, power station flows were not modelled as they were deemed to be a small proportion of flood flows even at peak capacity (approximately 8 m^3/s).

The modelled and observed spills at Lake Mackenzie are shown in Table 14 and Diagram 47 to Diagram 48. The modelled spills show a poor match to the observed, with peak flow underestimated in August 2007 and June 2016. This is consistent with the results at Fisher River u/s Lake Mackenzie and potentially also due to rainfall coverage. As discussed in Section 6.1 calibration was applied broadly across the entire study area and therefore no targeted changes were made to improve performance at Lake Mackenzie.

Although Lake Mackenzie was not yet dammed by the August 1970 event, it is reiterated that the dam storage and spillway was not removed from the model during the model calibration of downstream locations. As discussed in Section 3.3, Lake Mackenzie was deemed to have a negligible effect on flood flows at downstream locations.

Table 14: Calibrated parameters and results at Lake Mackenzie

Statistic	August 2007	June 2016
IL (mm)	33	0
Average CL (mm/h)	0.26	0.98
RAF	2	2
Modelled Peak (m^3/s)	43	198
Observed Peak (m^3/s)	99	286
Peak % difference	-57%	-31%
Modelled Volume (ML)	2,678	19,063
Observed Volume (ML)	11,046	26,977
Volume % difference	-76%	-29%

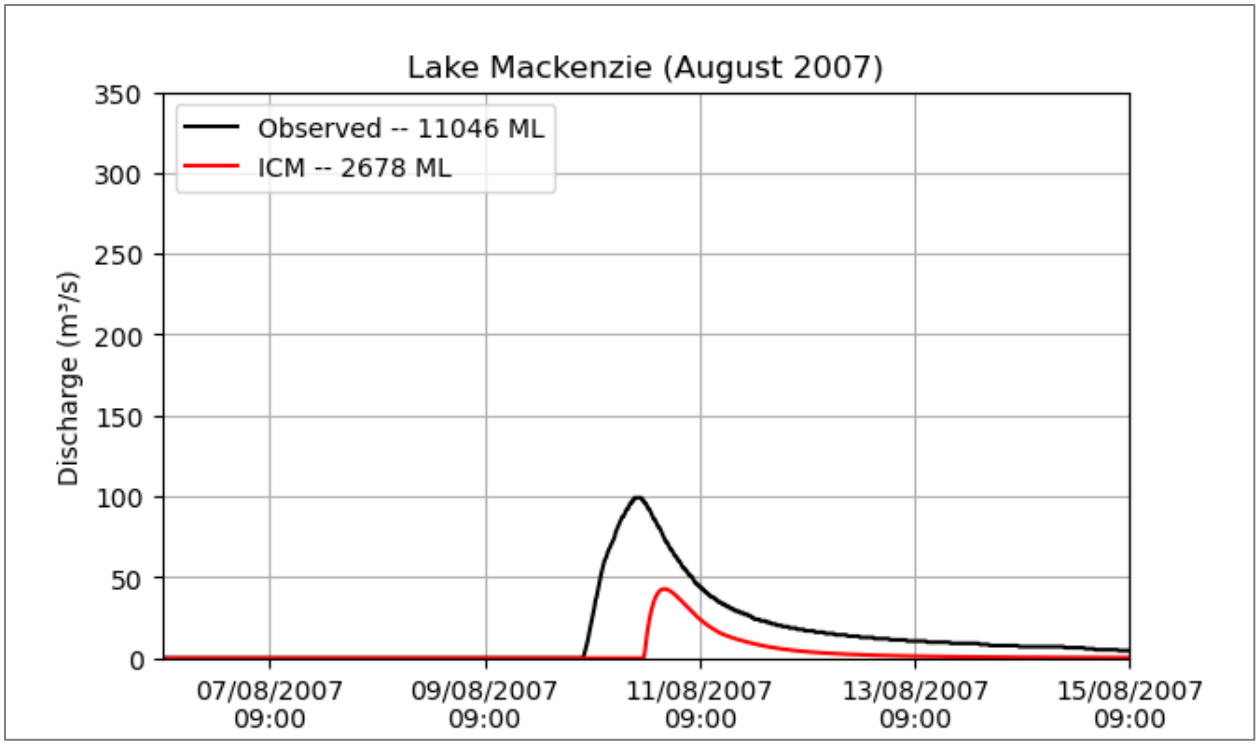

Diagram 47: August 2007 flow comparison at Lake Mackenzie

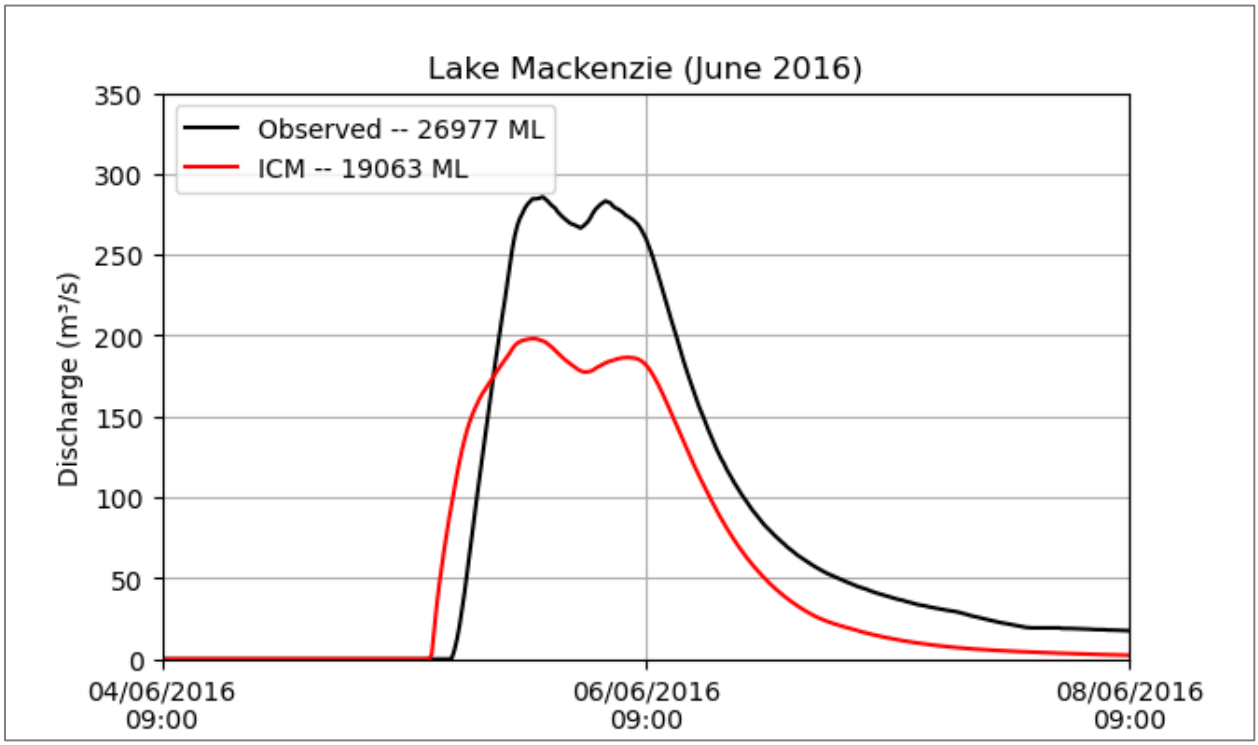

Diagram 48: June 2016 flow comparison at Lake Mackenzie

6.3.10. Mole Creek d/s Sassafras Creek

Significant flows were recorded at Mole Creek d/s Sassafras Creek during the January 2011 and June 2016 events. This site was established in 2008 and thus was not active during the August 1970 and August 2007 events.

Due to the uncertainty in the site's rating at high flows (as discussed in Section 3.1.2), model calibration was attempted to levels only. The flows for the January 2011 and June 2016 events have been presented below for illustration only.

The modelled and observed flows and levels at Mole Creek d/s Sassafras Creek are shown in Table 15 and Diagram 49 to Diagram 52.

The modelled levels show a fair match to the observed, with peak level overestimated in January 2011 and June 2016. There is also a poor match to the shape of June 2016 event, with the model showing the first of two peaks more significant than the second while the observed showing a higher second peak. As discussed in Section 3.2 this is an area with extremely high rainfall gradients which are likely contributing to differences in observed and modelled peaks.

A gauge zero was not provided for this gauge from the DNRE database, so a gauge zero of 204.5 mAHD was assumed. This gauge zero was inferred from the DEM of the hydrodynamic model.

Table 15: Calibrated parameters and results at Mole Creek d/s Sassafras Creek

Statistic	January 2011	June 2016
IL (mm)	16	0
Average CL (mm/h)	5.38	1.70
RAF	2	2
Modelled Peak (m^3/s)	144	160
Observed Peak (m^3/s)	20*	41*
Peak % difference	+621%	+294%
Modelled Volume (ML)	4,642	12,918
Observed Volume (ML)	3,855*	4,752*
Volume % difference	+20%	+171%
Modelled peak (mAHD)	209.15	209.33
Observed peak (mAHD)	207.94	208.55
Peak difference (m)	+1.21	+0.78

* Data quality suspect

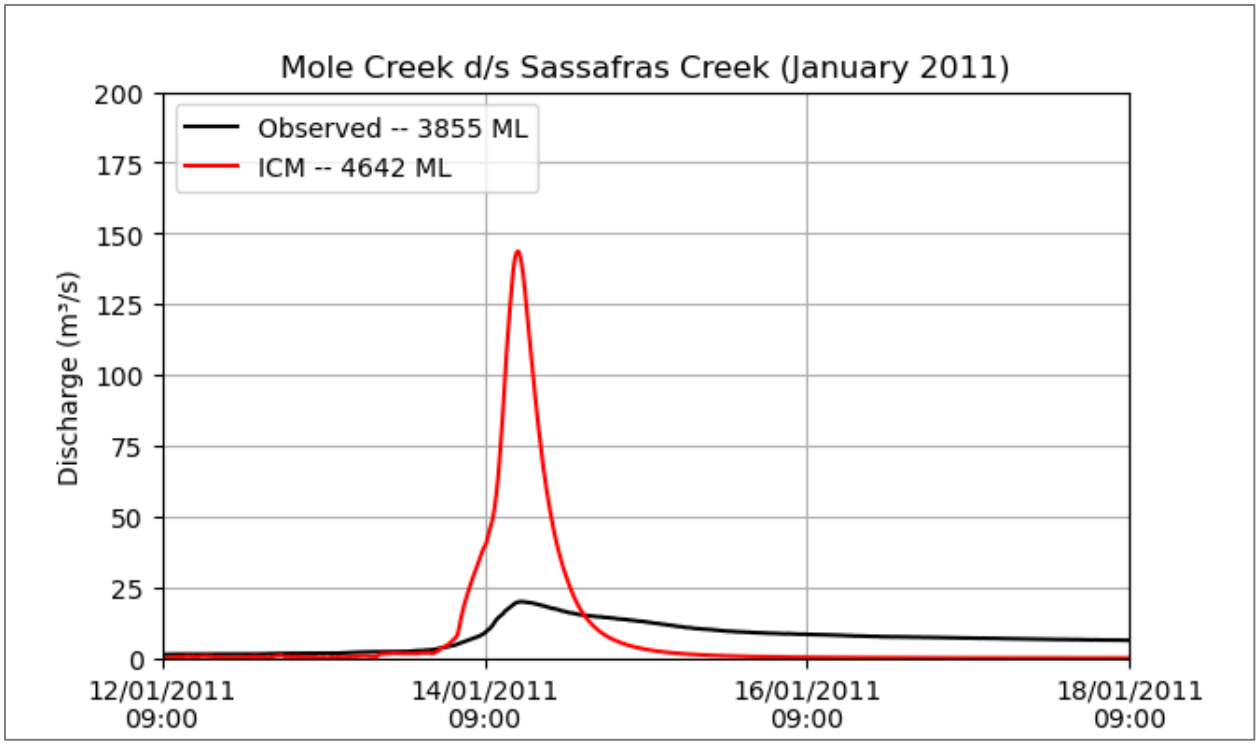

Diagram 49: January 2011 flow comparison at Mole Creek d/s Sassafras Creek

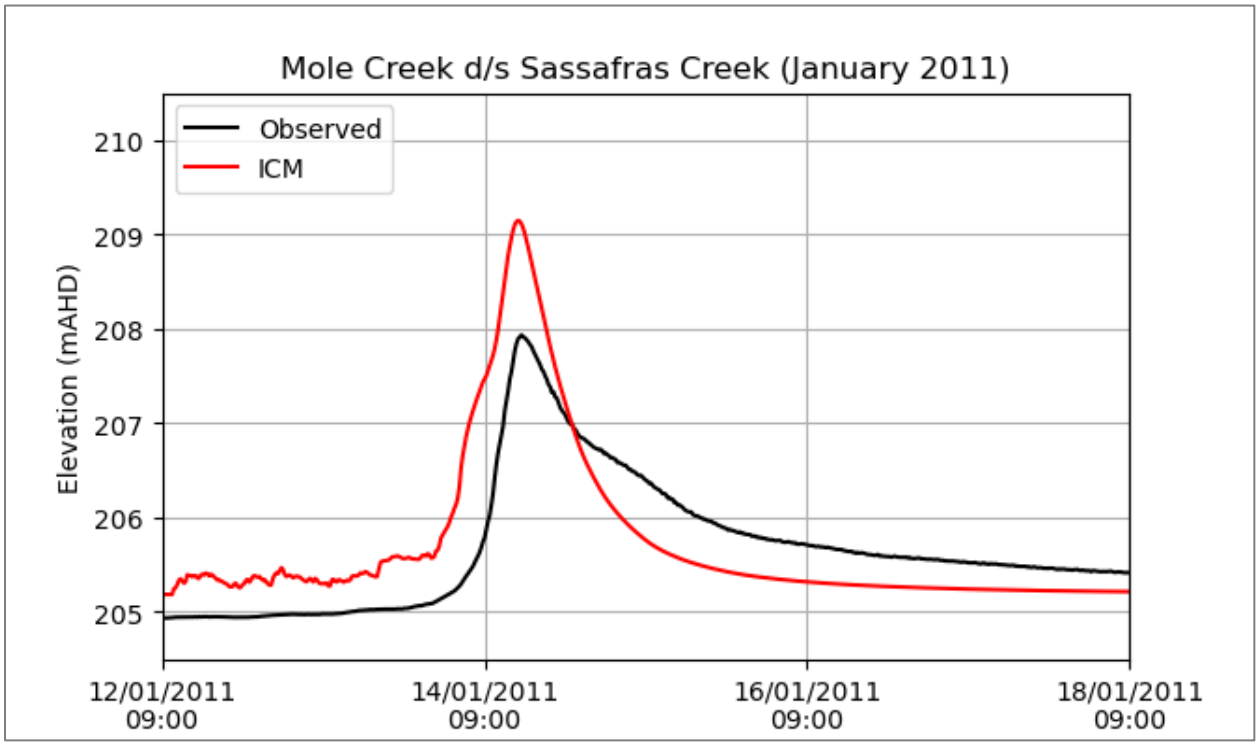

Diagram 50: January 2011 water level comparison at Mole Creek d/s Sassafras Creek

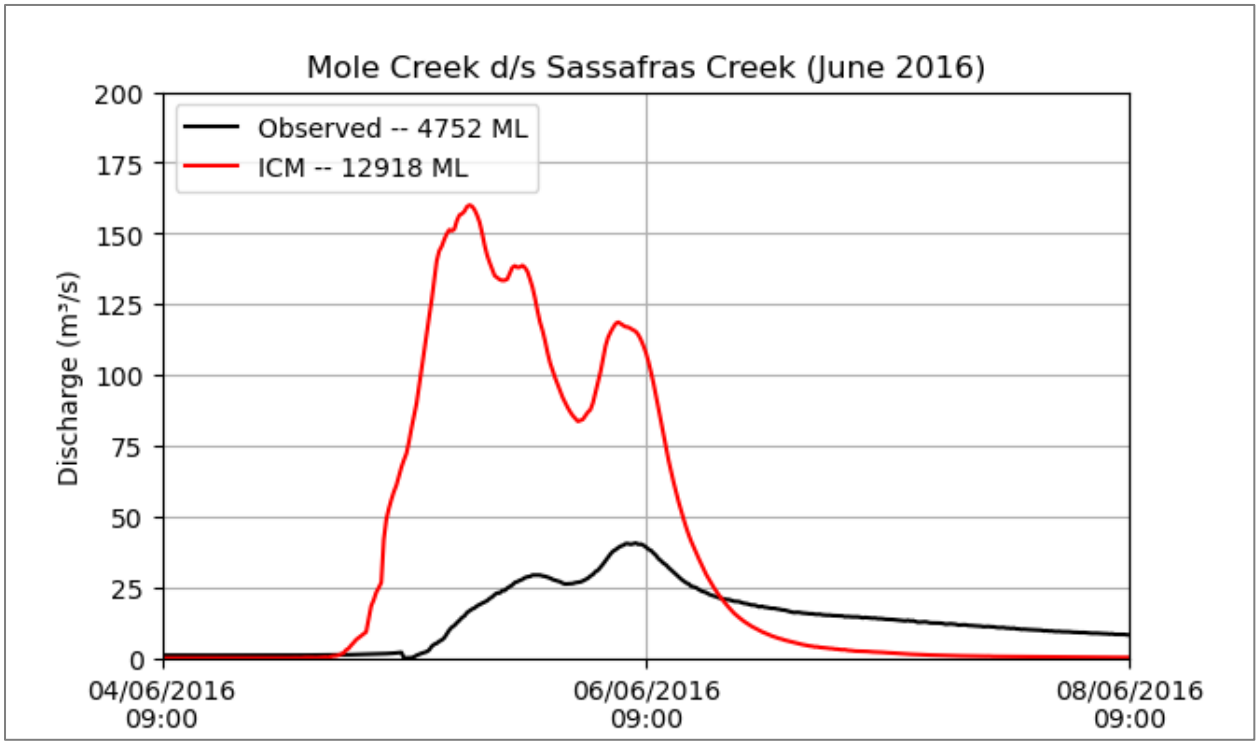

Diagram 51: June 2016 flow comparison at Mole Creek d/s Sassafras Creek

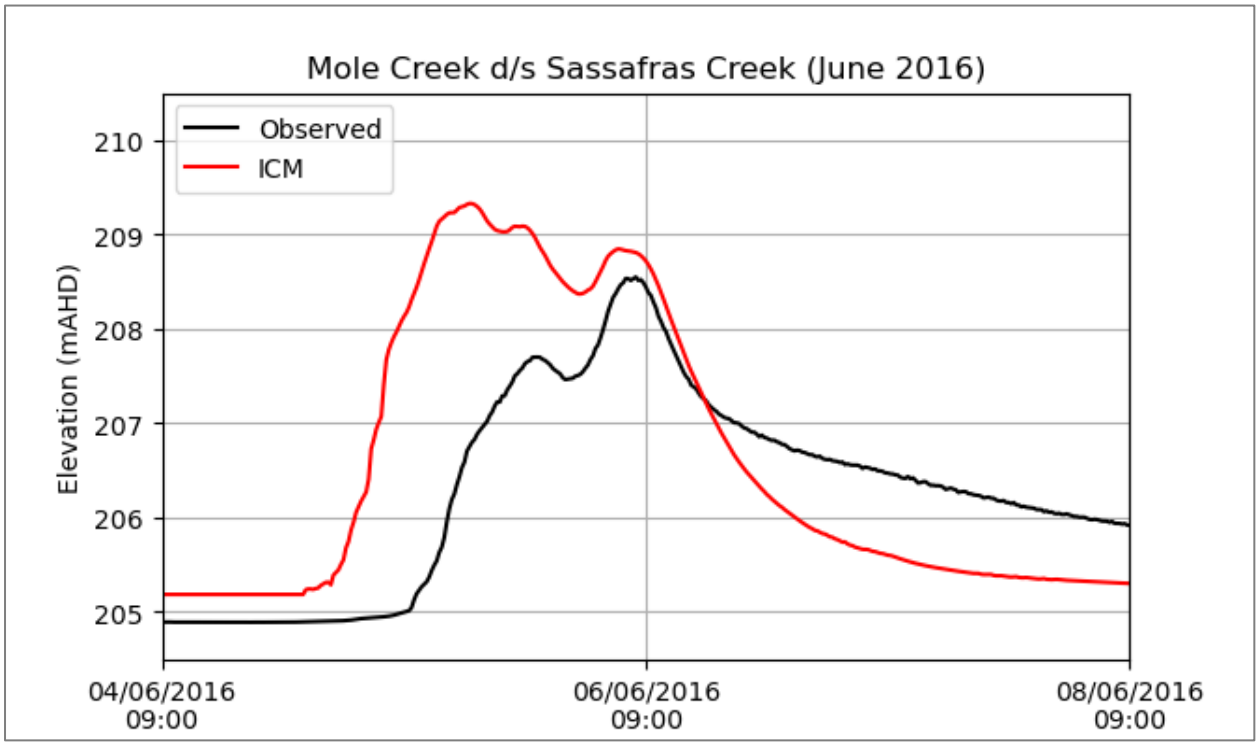

Diagram 52: June 2016 water level comparison at Mole Creek d/s Sassafras Creek

6.3.11. Don River u/s Bass Highway

Significant flows were recorded at Don River u/s Bass Highway during the August 1970, January 2011, and June 2016 events.

Due to the uncertainty in the site's DEM and rating at high flows (as discussed in Section 3.1.2), model calibration was not attempted at this gauge. The levels and flows for the August 1970, January 2011, and June 2016 events have been presented below for illustration only.

The modelled and observed flows and levels at Don River u/s Bass Highway are shown in Table 16 and Diagram 53 to Diagram 58. As noted in Section 5.1, the quality of the DEM at the gauge was poor due to the presence of channel and bank vegetation artefacts. This was found to extend some distance upstream and downstream of the gauge and therefore, the DEM was not able to be reasonably modified.

The results at the gauge have been presented as is to enable further discussion. It is recommended that that the DEM and results at the gauge be reviewed, should improved topographic information be available and if future detailed analysis is undertaken.

The modelled levels show a poor to fair match to the observed, with peak level overestimated in August 1970, underestimated in January 2011, and overestimated in June 2016. There is also a poor match to the shape of June 2016, with a double peak in the modelled hydrograph compared to a single peak in the observed.

A gauge zero of 3.7 mAHD was provided for this gauge from the DNRE database.

Table 16: Calibrated parameters and results at Don River u/s Bass Highway

Statistic	August 1970	January 2011	June 2016
IL (mm)	20	16	0
Average CL (mm/h)	2.01	7.65	2.42
RAF	2	2	2
Modelled Peak (m^3/s)	132	85	159
Observed Peak (m^3/s)	97*	94*	91*
Peak % difference	+36%	-10%	+75%
Modelled Volume (ML)	8,563	5,469	14,278
Observed Volume (ML)	10,559*	9,811*	9,294*
Volume % difference	-19%	-44%	+54%
Modelled peak (mAHD)	7.20	6.87	7.36
Observed peak (mAHD)	6.78	7.38	7.29
Peak difference (m)	+0.42	-0.51	+0.07

* Data quality suspect

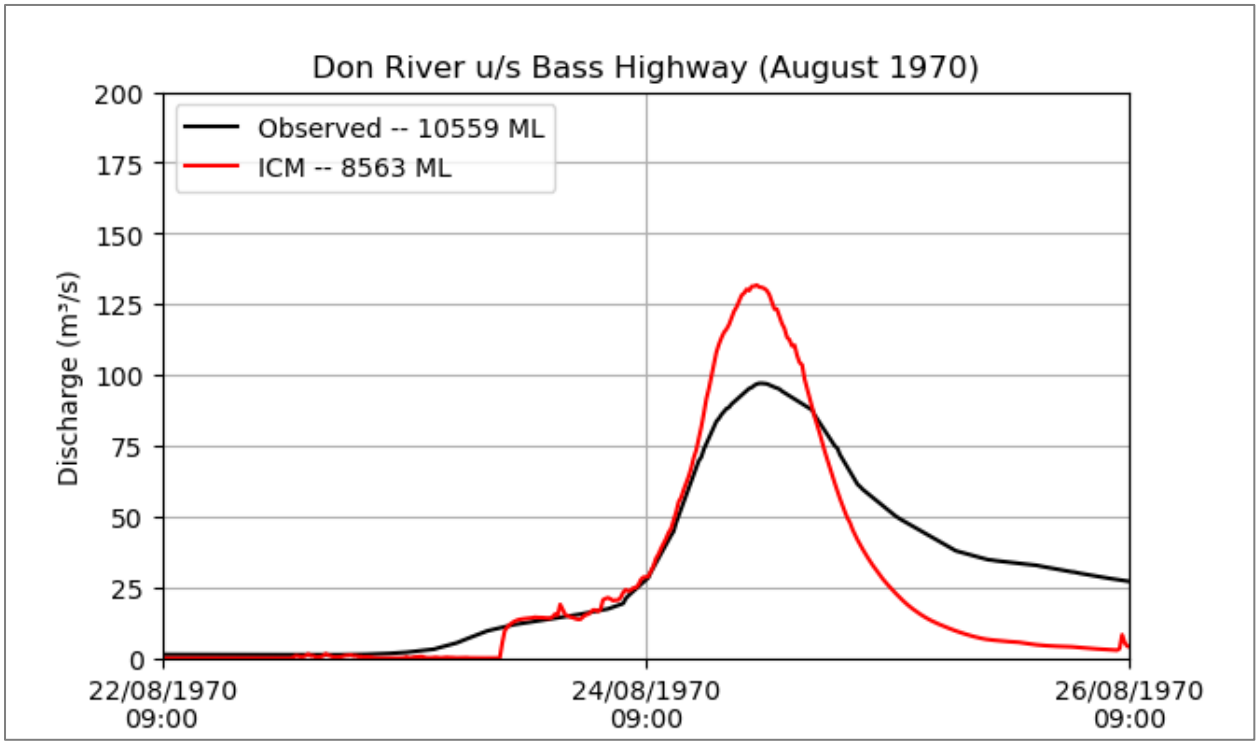

Diagram 53: August 1970 flow comparison at Don River u/s Bass Highway

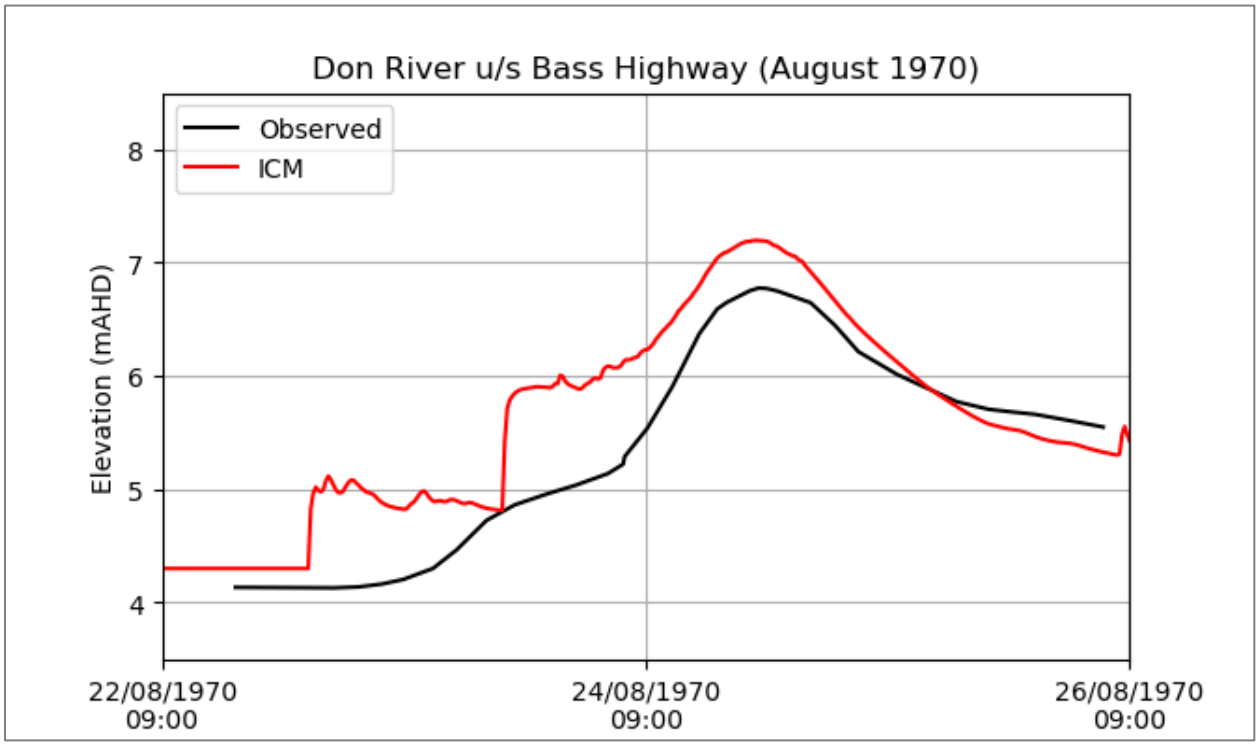

Diagram 54: August 1970 water level comparison at Don River u/s Bass Highway

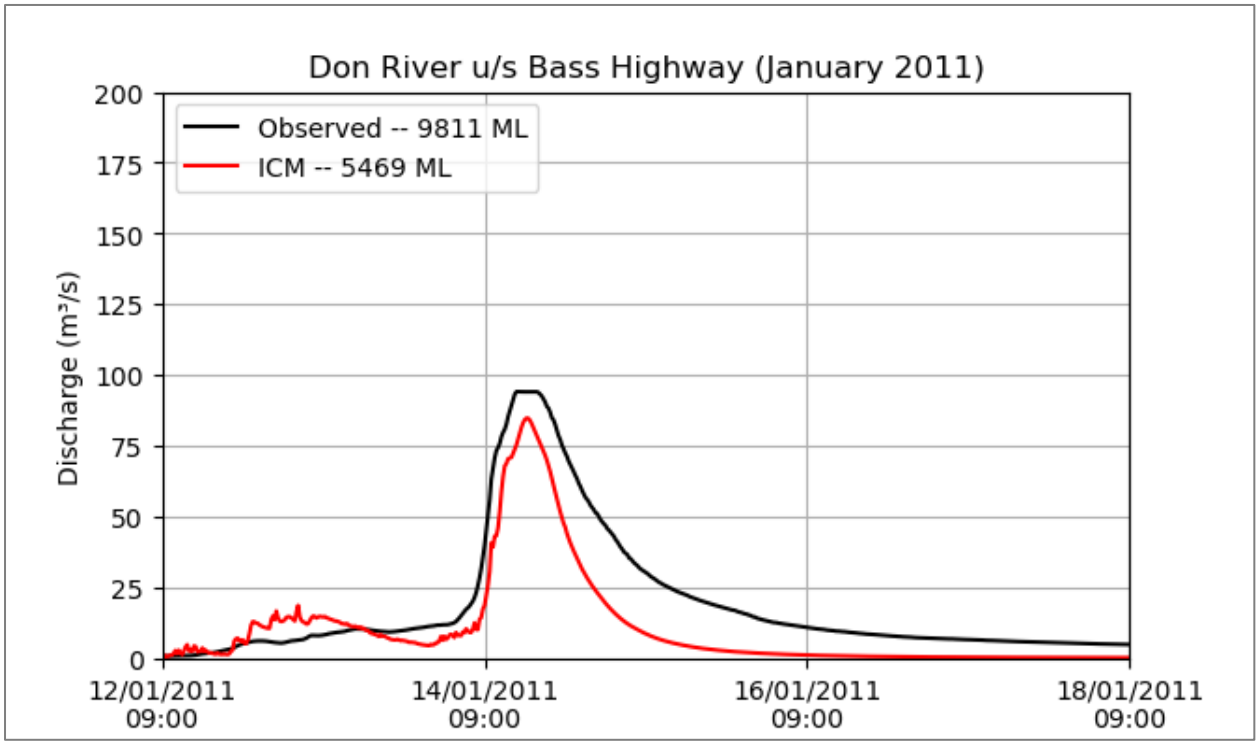

Diagram 55: January 2011 flow comparison at Don River u/s Bass Highway

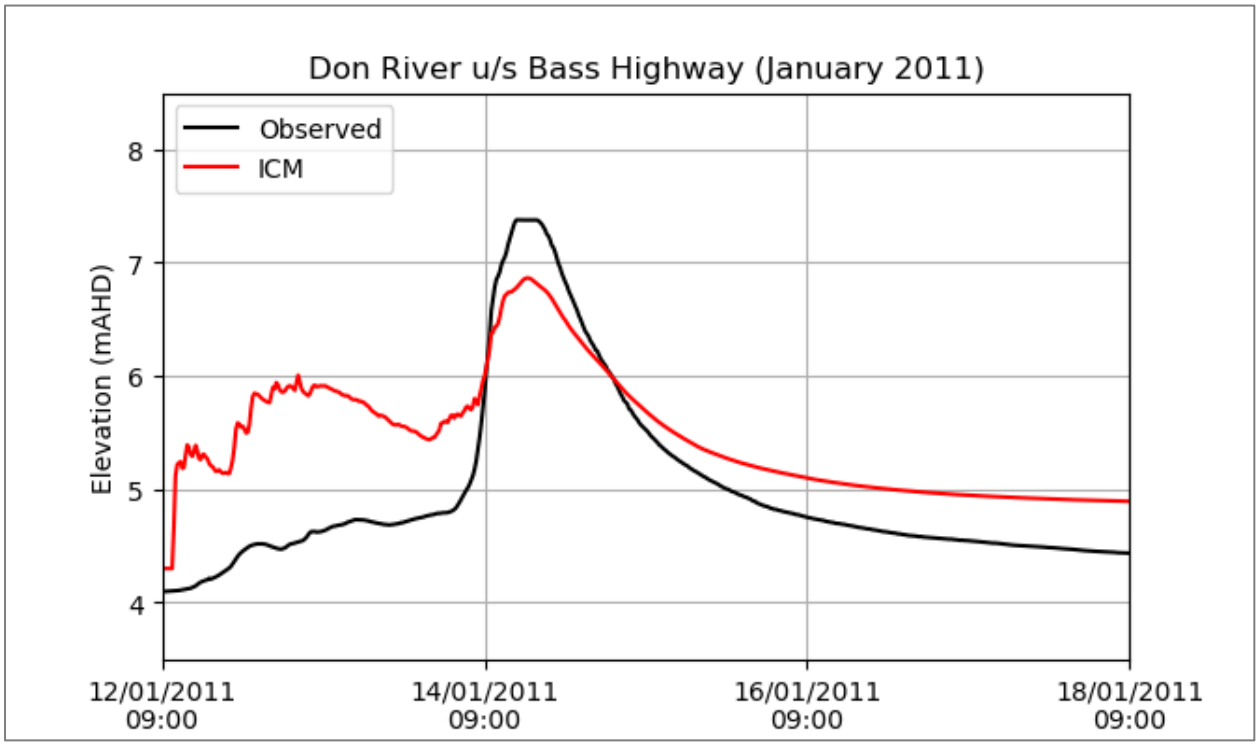

Diagram 56: January 2011 water level comparison at Don River u/s Bass Highway

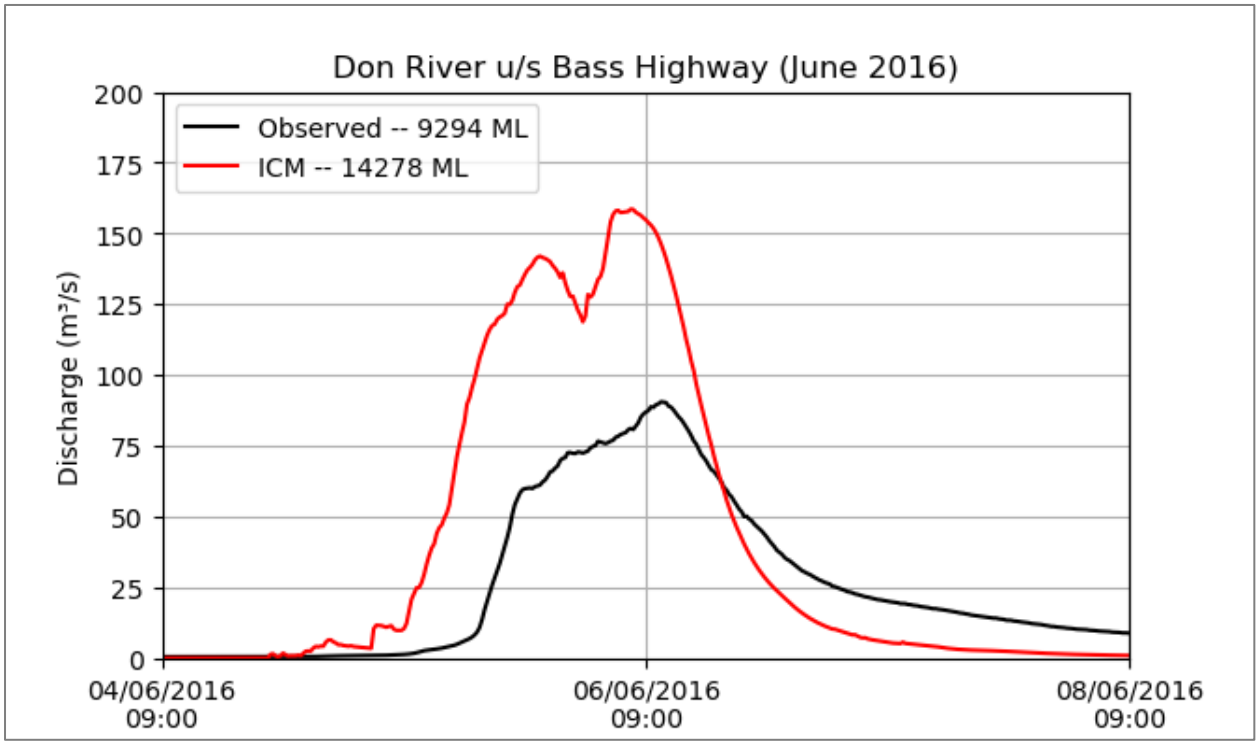

Diagram 57: June 2016 flow comparison at Don River u/s Bass Highway

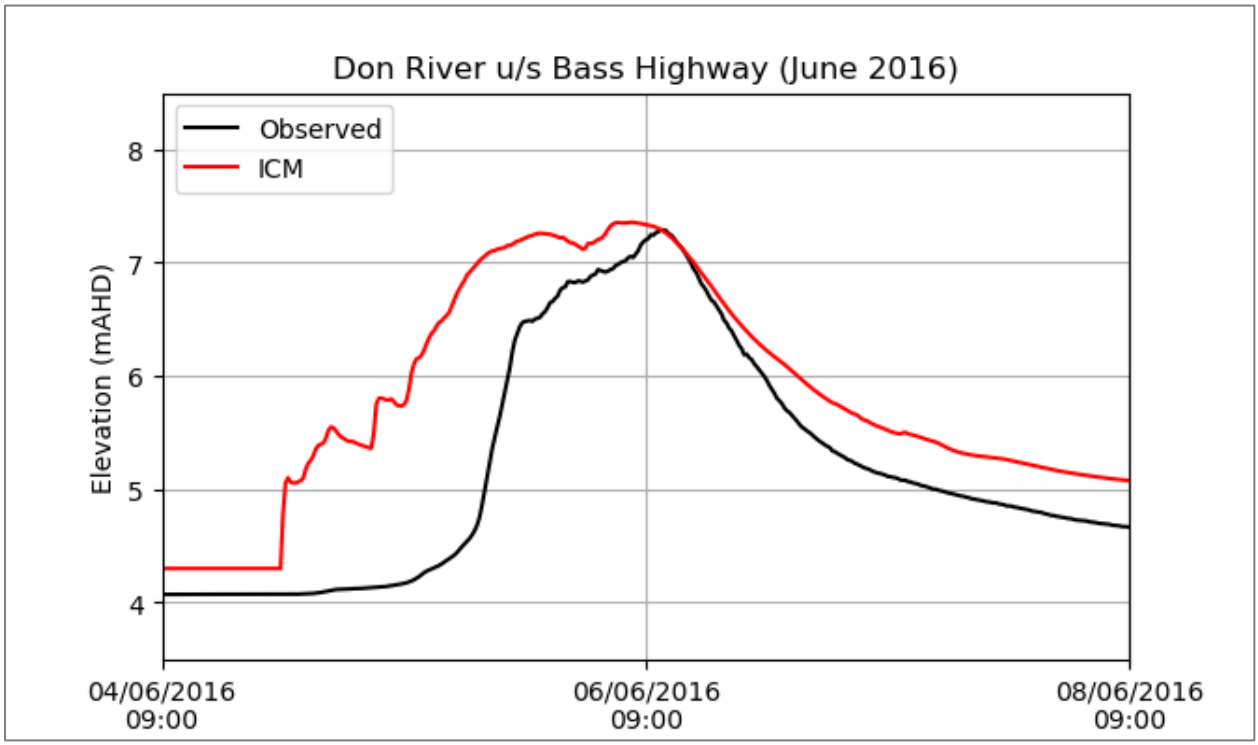

Diagram 58: June 2016 water level comparison at Don River u/s Bass Highway

6.4. June 2016 Flood Survey

As part of the Tasmanian flood recovery program following the 2016 floods, the Tasmanian Government collected flood extents survey around impacted areas of Tasmania. The survey utilised damage locations, debris marks and witness accounts to survey the full extent of the June 2016 flood.

Within the Mersey study area, 143 points were surveyed as part of the June 2016 flood survey, with 107 points available for comparison against the hydrodynamic model (downstream of the model inflows). Figure 11 shows the surveyed and modelled flood extents for the June 2016 event. It is noted that where there are a limited number of points along a reach, then the accuracy of the surveyed flood extent is likely to be poor beyond the immediate vicinity of the points.

Survey information was available along Mersey River and Don River, covering key areas such as Mersey River near Kimberley, Mersey River near Latrobe, Mersey River at Bass Highway, Don River at Bass Highway, and Don River at Railway. Survey information was also available along some of Mersey River tributaries such as Redwater Creek, Dasher River, Mole Creek, and Lobster River. Survey information was not available in the upper reaches of the Mersey River.

Diagram 59 to Diagram 63 show the modelled and surveyed flood extents and levels at key areas. The following points are of note:

- At Mersey River at Kimberley, the modelled levels show a poor match to the survey, with levels typically overestimated (by as much as 2 m at Railton Road and 3 m at the railway). This is most likely due to the supplied DEM in this area being based on LiDAR data captured after the June 2016 event and reinstatement of the railway embankment (which was washed out during the event). The provision of stage height data at Mersey River at Kimberley is recommended to enable a further review of the model at this location. It is noted that this data is not likely available for the June 2016 event (as the gauge was also washed out), however, is likely available for the August 1970 event.
- At Mersey River at Latrobe and Mersey River at Bass Highway, the modelled levels show a fair match to the survey, with levels typically underestimated (by as much as 0.4 m at Frogmore Lane and 0.2 m at Bass Highway). As noted in Section 5.1, the DEM adopts a value of -10 mAHD for the section of Mersey River between the mouth of the river and approximately 1.55 km downstream of Frogmore Lane.
- At Don River at Bass Highway, the modelled levels show a fair match to the survey, with a good match to the levels downstream of the highway, but a slight underestimation upstream (as much as 0.5 m). As noted in Section 5.1, the highway was not explicitly modelled.
- At Don River at Railway, the modelled levels show a fair match to the survey, with a good match to the level upstream of the railway, but a slight underestimation downstream (as much as 0.5 m). There is a discrepancy in the survey however, with the level upstream of the railway being less than downstream.

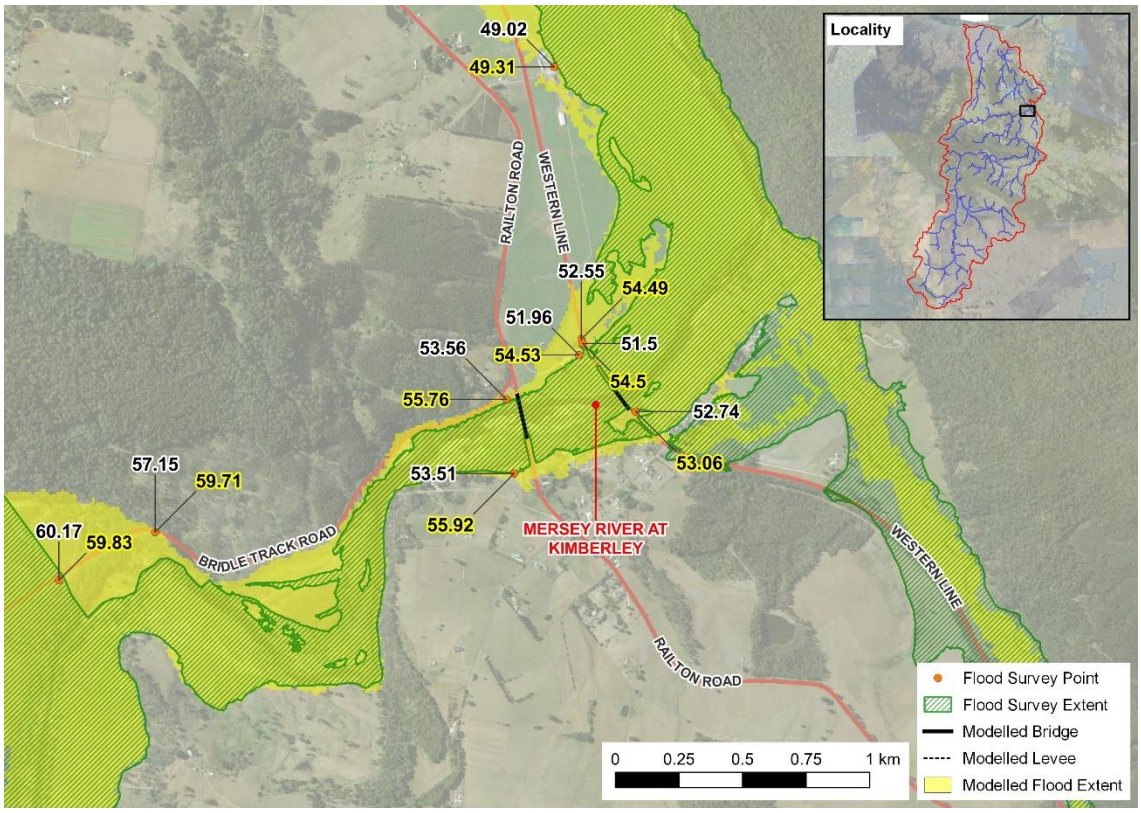

Diagram 59: Comparison to June 2016 flood survey along Mersey River near Kimberley. Modelled levels highlighted in yellow.

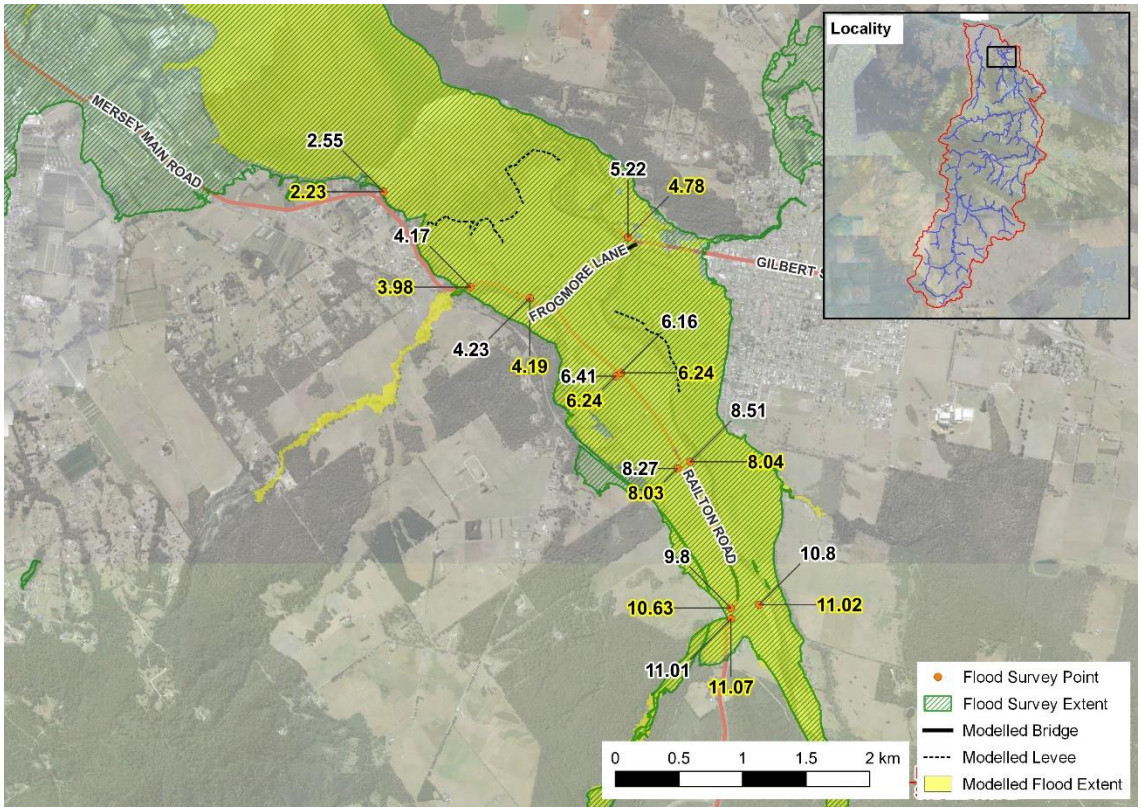

Diagram 60: Comparison to June 2016 flood survey along Mersey River near Latrobe. Modelled levels highlighted in yellow.

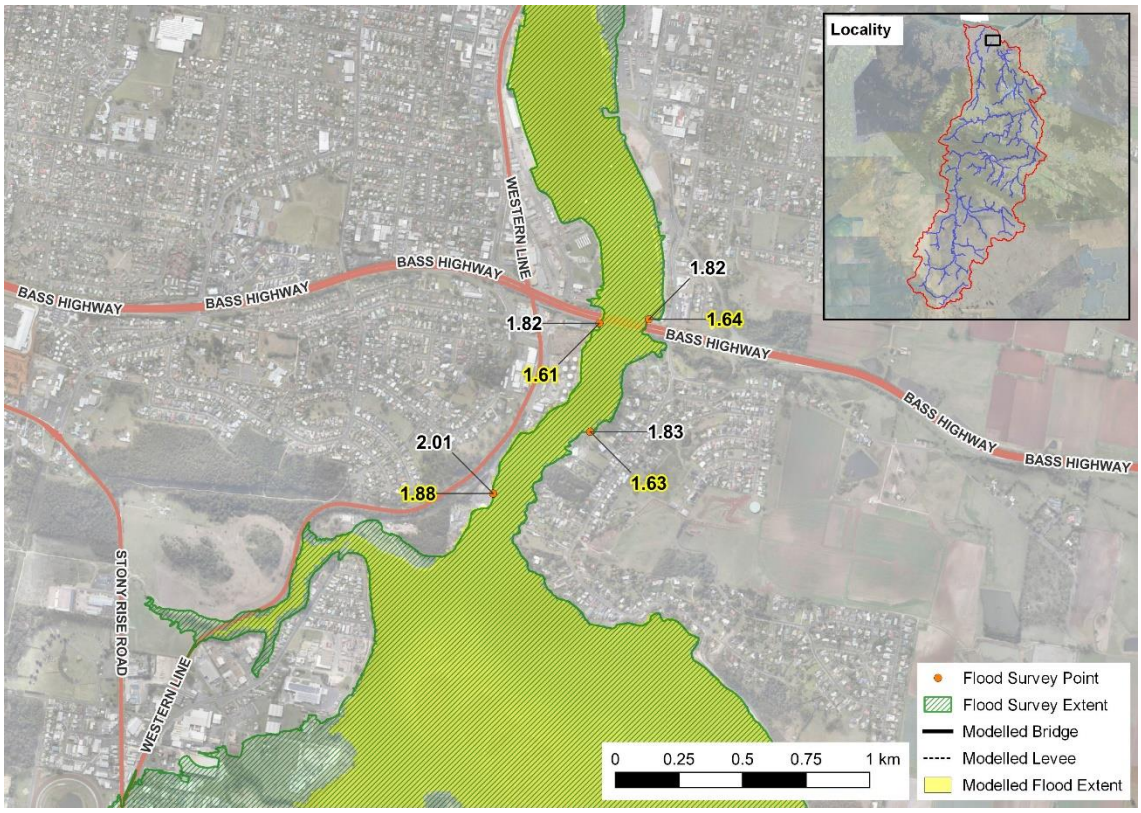

Diagram 61: Comparison to June 2016 flood survey along Mersey River at Bass Highway. Modelled levels highlighted in yellow.

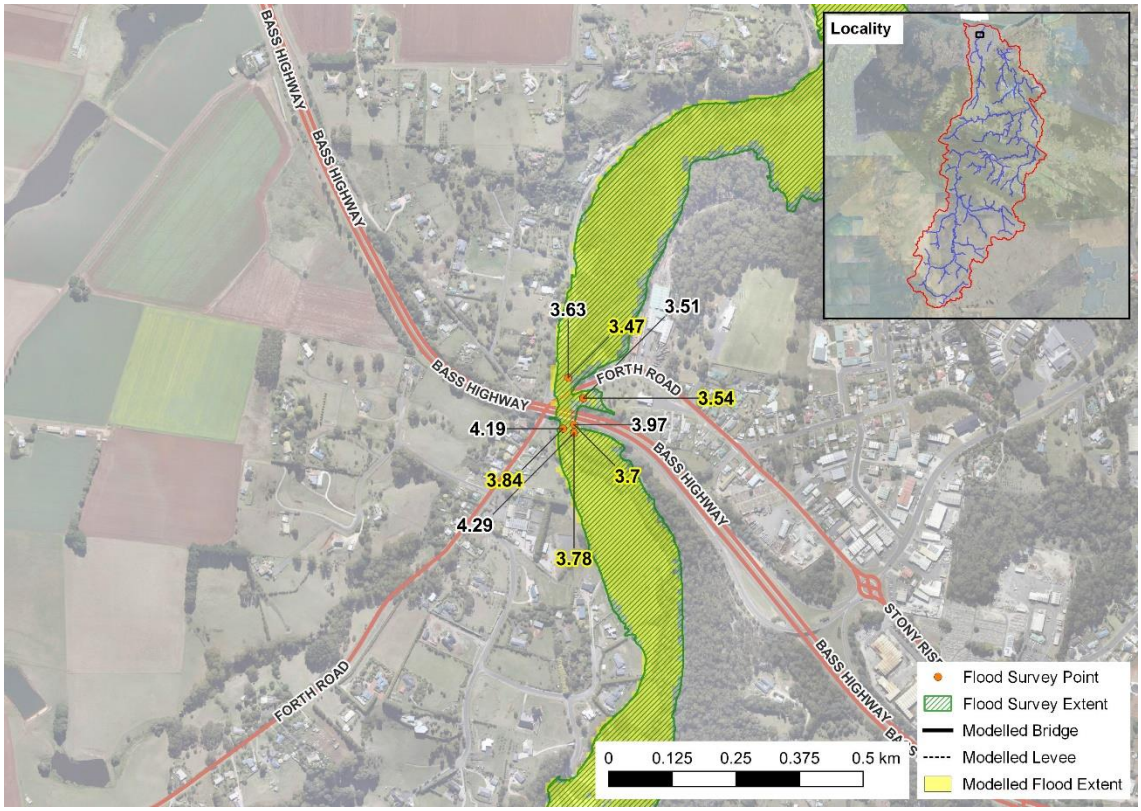

Diagram 62: Comparison to June 2016 flood survey along Don River at Bass Highway. Modelled levels highlighted in yellow.

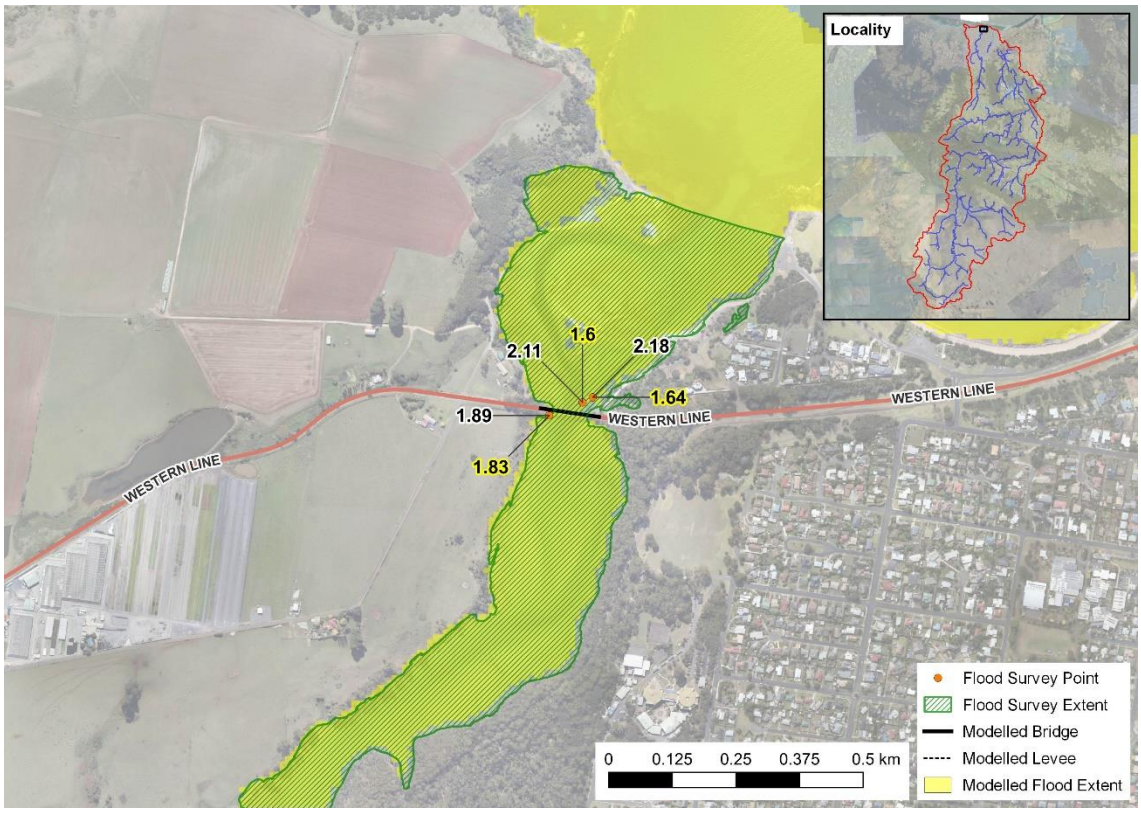

Diagram 63: Comparison to June 2016 flood survey along Don River at Railway. Modelled levels highlighted in yellow.

6.4.1. Summary of Levels

Diagram 64 shows the difference between the modelled and surveyed levels, with the upper and lower limits based on the uncertainty of the survey and DEM. There is generally a good agreement between the surveyed and modelled levels for the June 2016 event, with almost all points falling within the upper and lower limits. The flood survey points at Mersey River at Kimberley are highlighted in red. At Mersey River at Kimberley, the modelled levels show a poor match to the survey, with levels typically overestimated (by as much as 2 m at Railton Road and 3 m at the railway).

During the event, the area experienced significant damage to infrastructure and landform (Diagram 65) which likely had a large influence on the recorded flood levels in the area. As the LiDAR for the area is based on the post flood event (with remediation) topography it is considered the variation in observed and modelled levels is due to a poor representation of the landform that was present during the event.

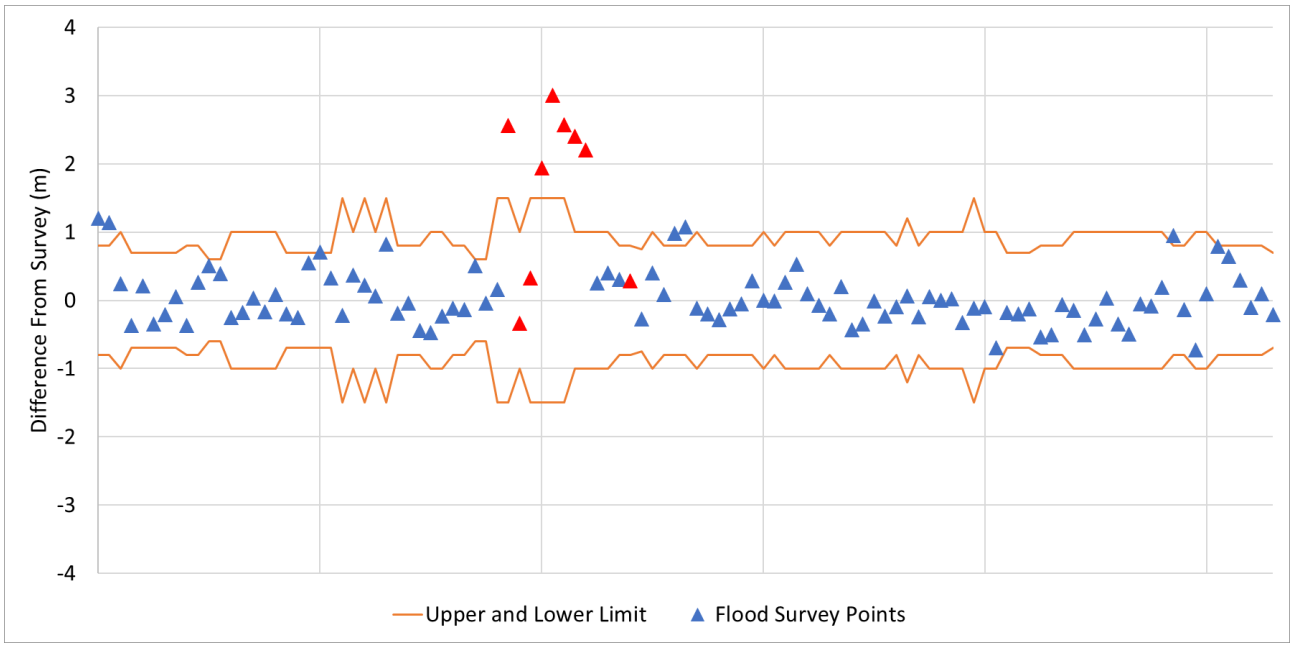

Diagram 64: Comparison to June 2016 flood survey across the Mersey study area. Flood survey points at Mersey River at Kimberley highlighted in red.

Diagram 65: Rail bridge over Mersey River at Kimberley after the 2016 flood event

6.5. Comparison to Previous Studies

Latrobe Council commissioned Entura to undertake a structural flood mitigation options assessment for the township of Latrobe (Entura, 2018). This project involved the hydraulic modelling of the June 2016 event for a 12 km section of the Mersey River through Latrobe (using the recorded hydrograph at Mersey River at Shale Road as the inflow hydrograph) and the subsequent development and assessment of structural flood mitigation options.

Other previous studies include the Mersey River Flood Study undertaken by Entura in 2011 and the Latrobe Flood Plain Study undertaken by Hydro-Electric Commission (HEC) in 1994 (HEC, 1994). The report for the Entura 2011 study was not able to be sourced. The HEC 1994 study involved the hydraulic modelling of the August 1970 event.

The following items are of note:

- The peak flows for the August 1970 and June 2016 events at Mersey River at Shale Road were given an original estimate of 1270 m^3/s and 1280 m^3/s respectively in the Entura 2018 study. The peak flow for the June 2016 event was later increased to 1790 m^3/s during the hydraulic modelling, due to a poor match to surveyed flood levels with the original estimate.
- The peak flow for the August 1970 event at Mersey River at Shale Road was given an estimate of 2000 m^3/s in the HEC 1994 study.

Table 17 compares the peak flow estimates from the Entura 2018 study, the HEC 1994 study, and the present study for the August 1970 and June 2016 events. The peak flow estimates from the Entura 2018 study and the HEC 1994 study at Kimberley and Liena were calculated using a scaling factor by catchment area. Modelled levels from the previous studies were not available for comparison. Depth mapping only was provided for the Entura 2018 report.

Table 17. Peak flow estimates for the August 1970 and June 2016 events

Location	Catchment Area (km^2)	Scaling Factor* (-)	Peak Flow for Aug 1970 (m^3/s)			Peak Flow for Jun 2016 (m^3/s)	
			Entura 2018	HEC 1994	Present Study	Entura 2018	Present Study
Mersey River at Liena	760	0.53	670	1060	1005	680 / 950	890
Mersey River at Kimberley	1440	0.91	1155	1820	1650	1165 / 1630	1900
Mersey River at Shale Road	1610	-	1270	2000	1705	1280 / 1790	2075

* Calculated as the ratio of the catchment area to the power of 0.85 (as presented in HEC 1994)

Based on this table and the results presented in Section 6.3.6, it is believed that:

- For the August 1970 event, the estimate of 2000 m^3/s in the HEC 1994 study is more likely (when compared to that of the Entura 2018 study)
- For the June 2016 event, the later estimate of 1790 m^3/s in the Entura 2018 study is more likely (when compared to that of the original estimate)

6.6. Identified Issues

The following issues have been identified, which should be investigated further if future detailed analysis is undertaken:

- Eight flow gauges were used in model calibration and verification. While the rating quality at some of these gauges is likely good, the largest calibration events are significantly above the highest gaugings and therefore well into the extrapolated range. At many sites, the observed peak for at least one calibration event is over twice the highest gauged flow and, in some cases, it is up to 10 times the highest gauged flow. Even at sites with very good rating curves, peak flows could easily be 20% in error. Additionally, at many of these sites the highest gaugings were conducted in the 1960s to the 1990s, so have not been verified in up to 60 years. Stage height data was not available for the Mersey River at Kimberley site, and this should be sought if further studies are undertaken.
- The following issues were observed in the DEM. If further modelling is undertaken in this catchment, the DEM should be refined if possible.
  - The supplied DEM does not contain full river bathymetry throughout much of the study area. Channel roughness was adjusted to obtain improved calibration results at gauges, and this may be partially or fully compensating for this issue. This has impacted the ability of the model to represent observed flood levels and extents. If available, the representation of the rivers and channels that that are frequently submerged should be updated with improved bathymetry data.
  - Comparisons of rating curves derived from the model with supplied ratings suggests that the DEM has insufficient detail to align precisely with the provided gauge zero at some gauge sites.
  - The DEM adopts a value of -10 mAHD for the section of Mersey River between the mouth of the river and approximately 1.55 km downstream of Frogmore Lane in Latrobe.
  - Along Caroline Creek and Mersey River, a breach was incorrectly applied to the DEM between the cement plant in Railton and approximately 1.5 km downstream of Frogmore Lane in Latrobe. The breach was ‘filled in’ using the surrounding DEM.
  - At the Don River u/s Bass Highway gauge, the quality of the DEM was poor due to the presence of river channel and bank vegetation artefacts.
  - At Bass Highway at Don River and Bass Highway at Mersey River, the roadway was not adequately removed from the DEM. As improved topographic information was not available, the DEM was modified to allow for the free flow of water (and the bridge was not explicitly modelled).

7. UNCERTAINTY ASESSMENT

Significant flows were recorded in areas of the catchment area for four of the 13 flood events selected by the Bureau as calibration events for this project: August 1970, August 2007, January 2011 and June 2016. The August 1970 and June 2016 events were very large across the whole study area. August 2007 was only significant in the upper catchment, whilst January 2011 was only significant in the lower catchment.

Data was available at eight gauges within the study area.

Within the Mersey study area, 107 points surveyed as part of the June 2016 flood survey were available for comparison against the hydrodynamic model results.

The uncertainty assessment for the modelling is shown in Table 18 and Appendix B.

Table 18: Uncertainty assessment for Mersey River study area model

Category	Quality statement
Hydrology – rainfall input quality	The quality of the rainfall data is generally fair to good. Between one and six pluviographs were operating in the study area during the calibration events. There were between six and thirteen daily rainfall stations operating for the calibration events. Given the large area, and the known high variations in rainfalls over the area, this introduces a high degree of uncertainty in the spatial and temporal distribution of rainfall for some events.
Hydrology – observed flows	Eight flow gauges were used for model calibration and validation. The qualities of the ratings are considered to be good at Mersey above Arm, Mersey at Liena and Arm above Mersey gauges. At the other gauges, the ratings are considered to be very poor to poor. The rating was unavailable at Mersey above Kimberley. The largest calibration events at all gauges are significantly above the highest gaugings and therefore well into the extrapolated range. At many sites, the observed peak for at least one calibration event is over twice the highest gauged flow and at some gauges it is up to 10 times the highest gauged flow. The highest gaugings were conducted in the 1960s-1990s at many gauge sites.
Hydrology – calibration events	The August 1970 and June 2016 events were large over the whole study area and were the largest or second largest events on record at many gauges. August 2007 event was only a significant event in the upper catchment, being the 2nd and 3rd largest event on record at Arm above Mersey and Fisher U/S Lake Mackenzie. January 2011 event was 2nd-4th largest on record at Don River, Mole Creek, Fisher River and Shale Rd gauges.
Hydrology – calibration results	The hydrology calibration was considered to provide an excellent match to observed hydrographs at Lake Parangana, Mersey at Liena, and Arm u/s Mersey. The fit at Mersey at Kimberly was considered good for the August 1970 event. The hydrology calibration gave a poor fit to observed hydrographs for all events at the remaining sites.

Category	Quality statement
DTM definition	The base dataset that was used for the digital elevation model (DEM) of the hydrodynamic model was the SES state-wide 10 m DEM merged with 2 m DEM subsets at the gauges. Overall, the DTM definition was considered to be poor to fair, noting that there was insufficient detail to be able to represent the gauge sites, and that there were vegetation and other artefacts in the data.
DTM waterways	No bathymetric data was available and waterway definition was based on the LiDAR to water surface. This resulted in a poor representation of waterways in the model.
Hydrodynamic – calibration results, peak levels	The hydrodynamic model results provided a good to excellent fit to peak levels at Don River u/s Bass Highway, Mersey at Liena, and Arm u/s Mersey gauge sites. The model gave a poor fit to observed levels at Mersey above Arm, Mersey at Shale Road, and Fisher u/s Lake Mackenzie gauges.
Hydrodynamic – calibration results, flood extents	Flood extents were available for the June 2016 flood. These were derived from 143 surveyed flood points within the study area. The comparison between modelled flood extent and that derived from the survey was generally very good to excellent, other than around Kimberley where it was poor. This may be due to the damage to the Kimberley Rail Bridge and embankments during this event, as the bridge is assumed to be intact in the model throughout the event.
Hydrodynamic – calibration results, flood depths	107 flood depth points from the June 2016 flood survey were available for comparison against the hydrodynamic model results. Comparison of the model results with the surveyed depths was fair to excellent, and was within the bounds of uncertainty of the survey and DEM. The exception was around Kimberley where there was a poor fit to surveyed flood depths.

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WMAwater (2021d): Tasmanian Strategic Flood Map, Addition Calibration Event Rainfalls, November 2021.

Figures

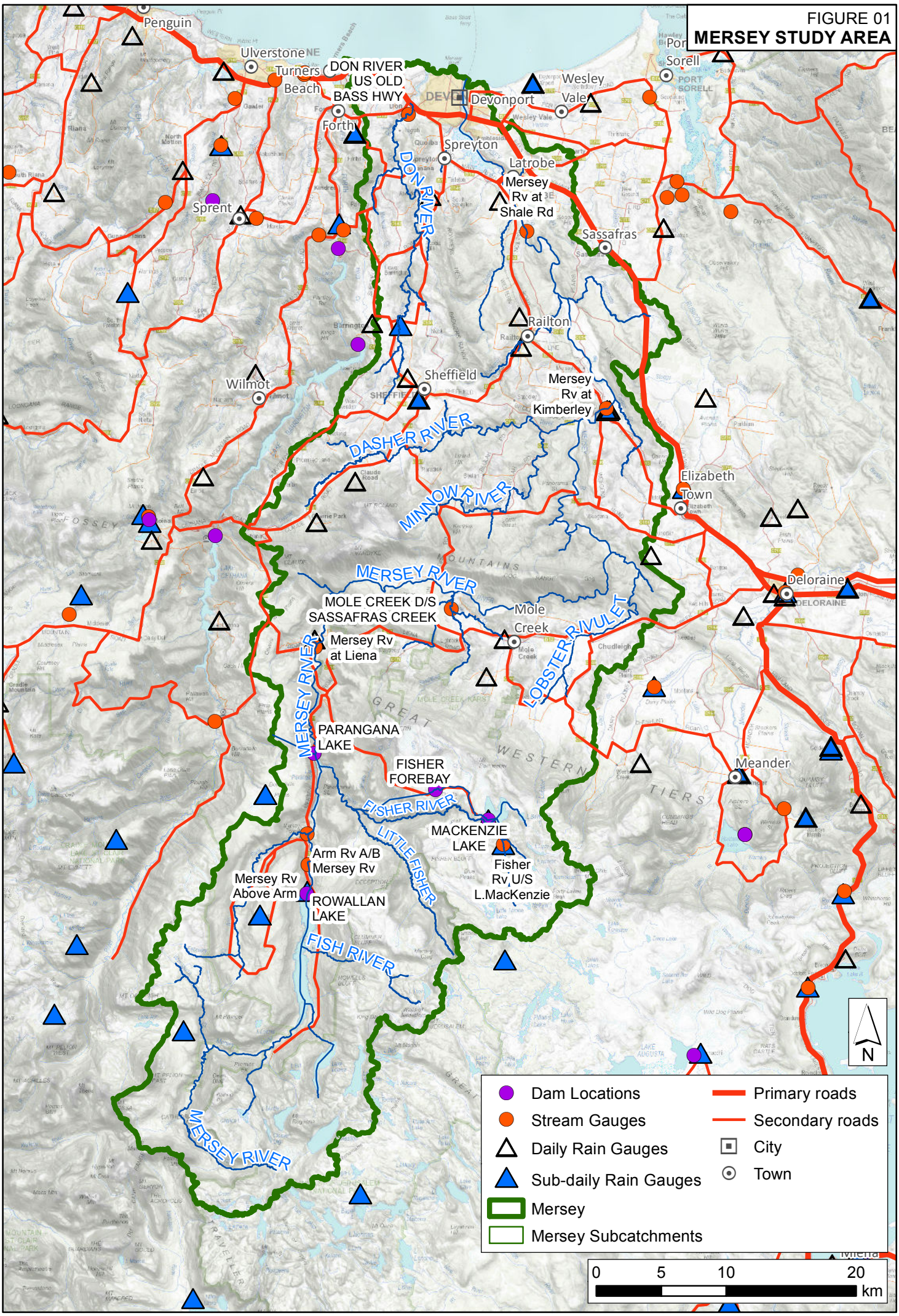

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FIGURE 02
MERSEY STUDY AREA LAND USE

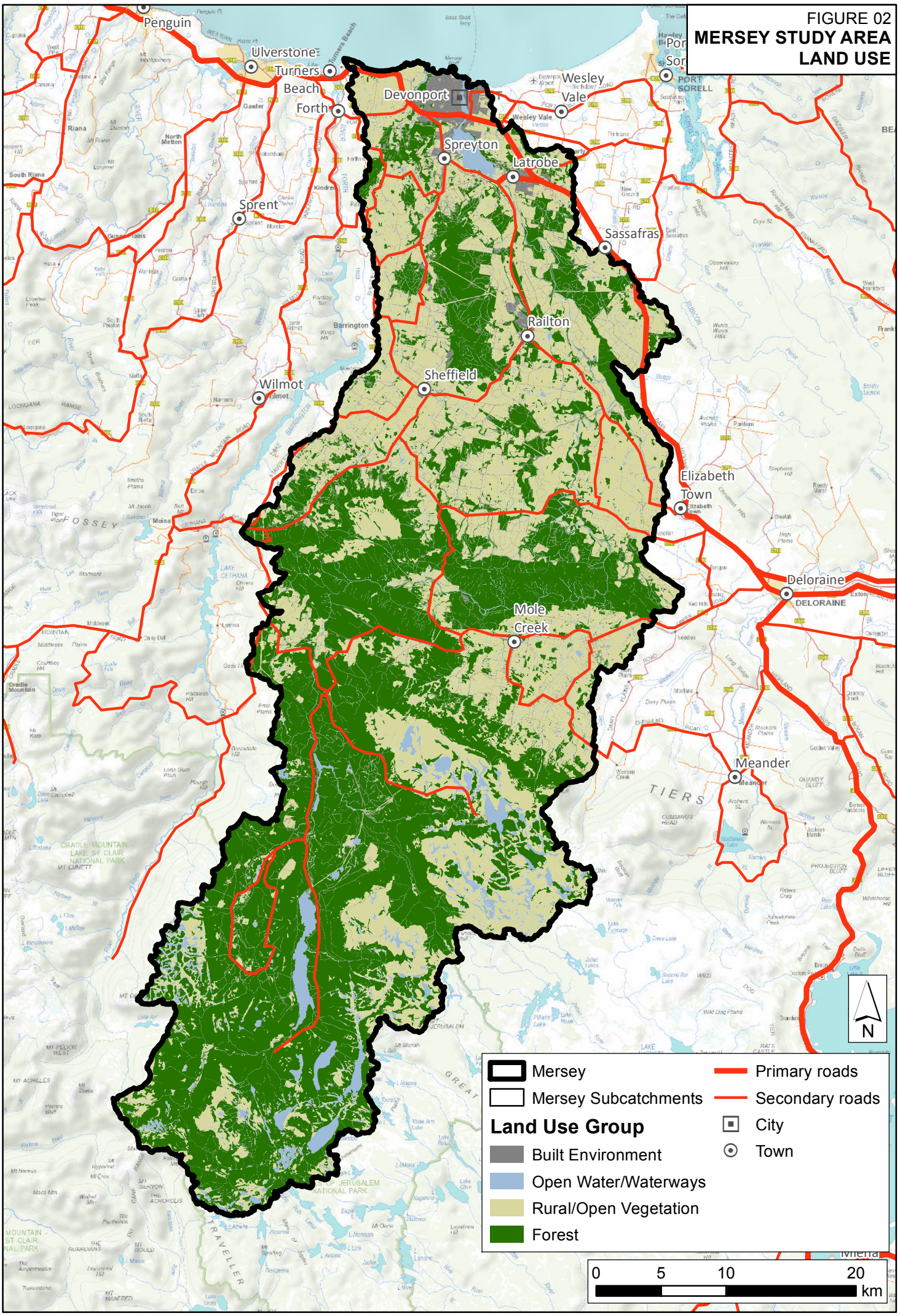

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FIGURE 03
MERSEY STUDY AREA
RAINFALL 1970_AUG

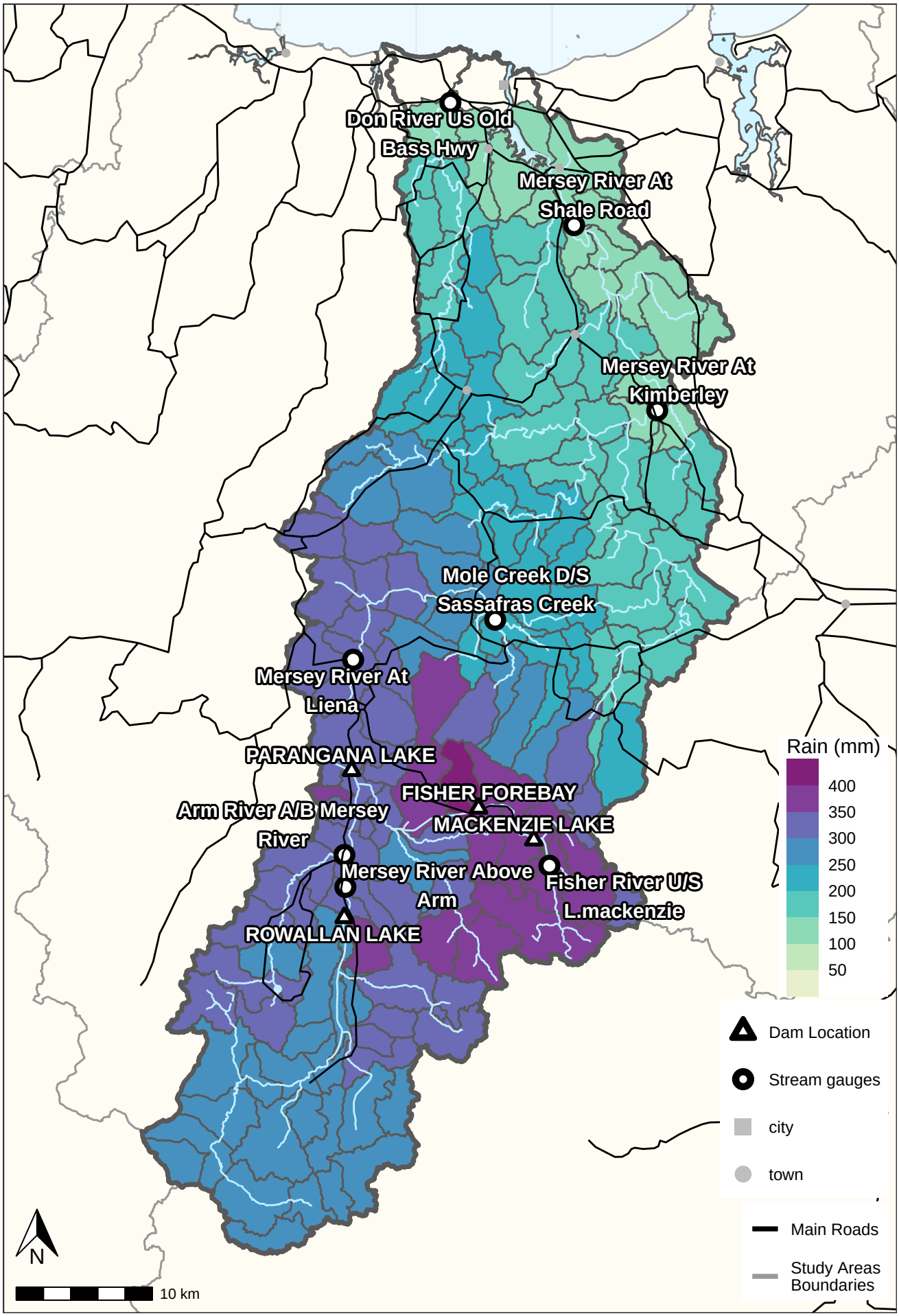

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FIGURE 04
MERSEY STUDY AREA
RAINFALL 2007_AUG

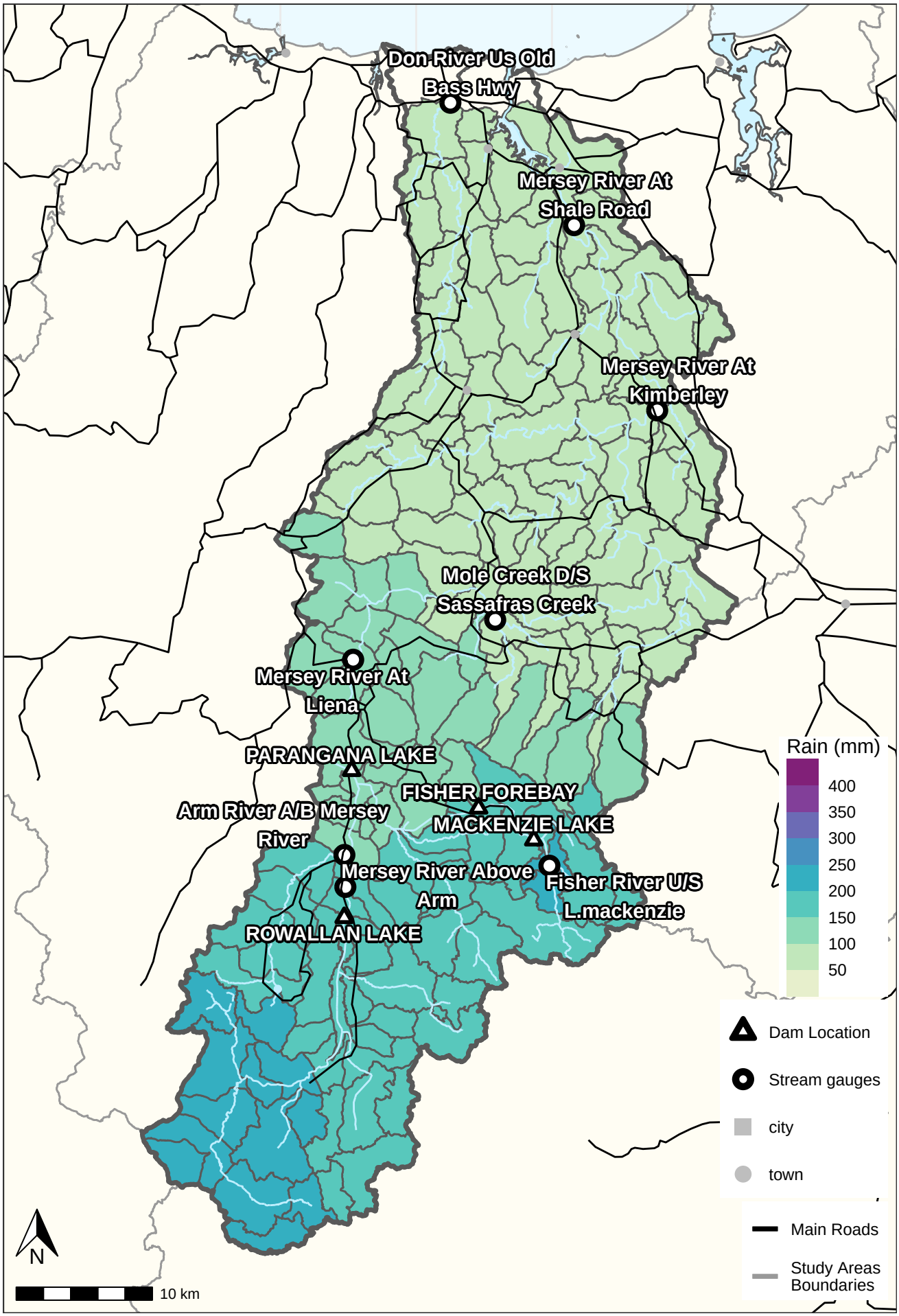

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FIGURE 05
MERSEY STUDY AREA
RAINFALL 2011_JAN

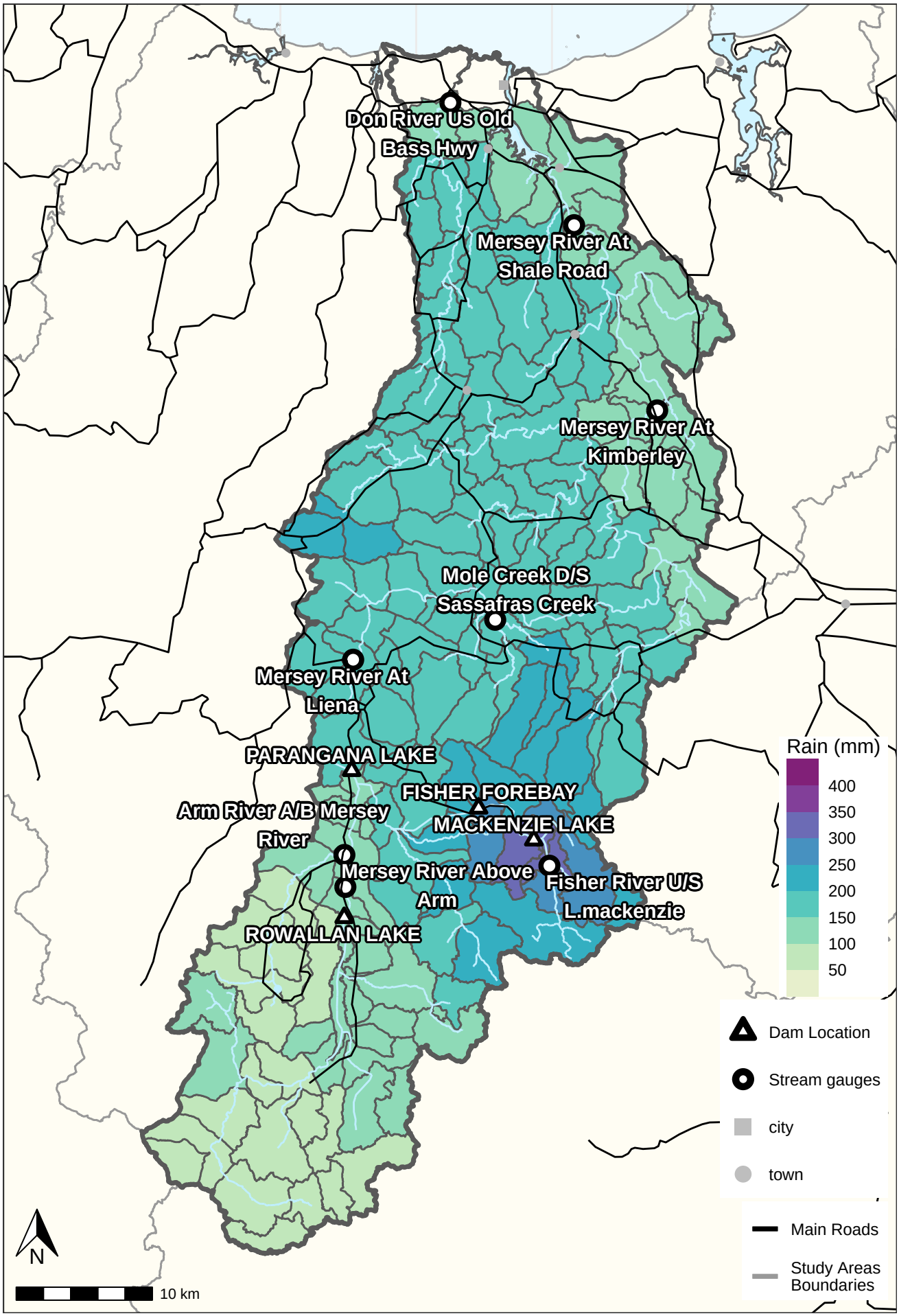

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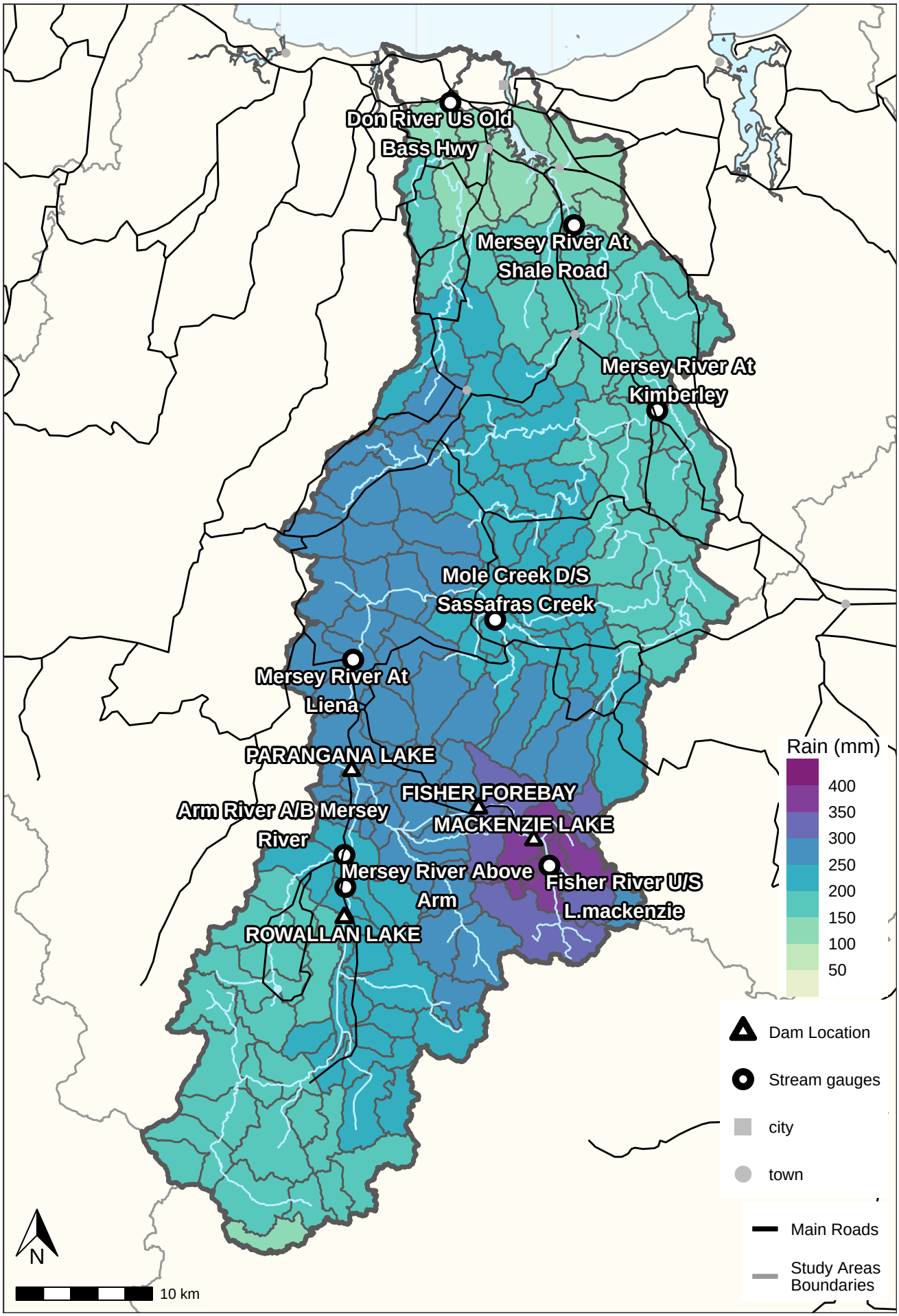
FIGURE 06
MERSEY STUDY AREA
RAINFALL 2016_JUN



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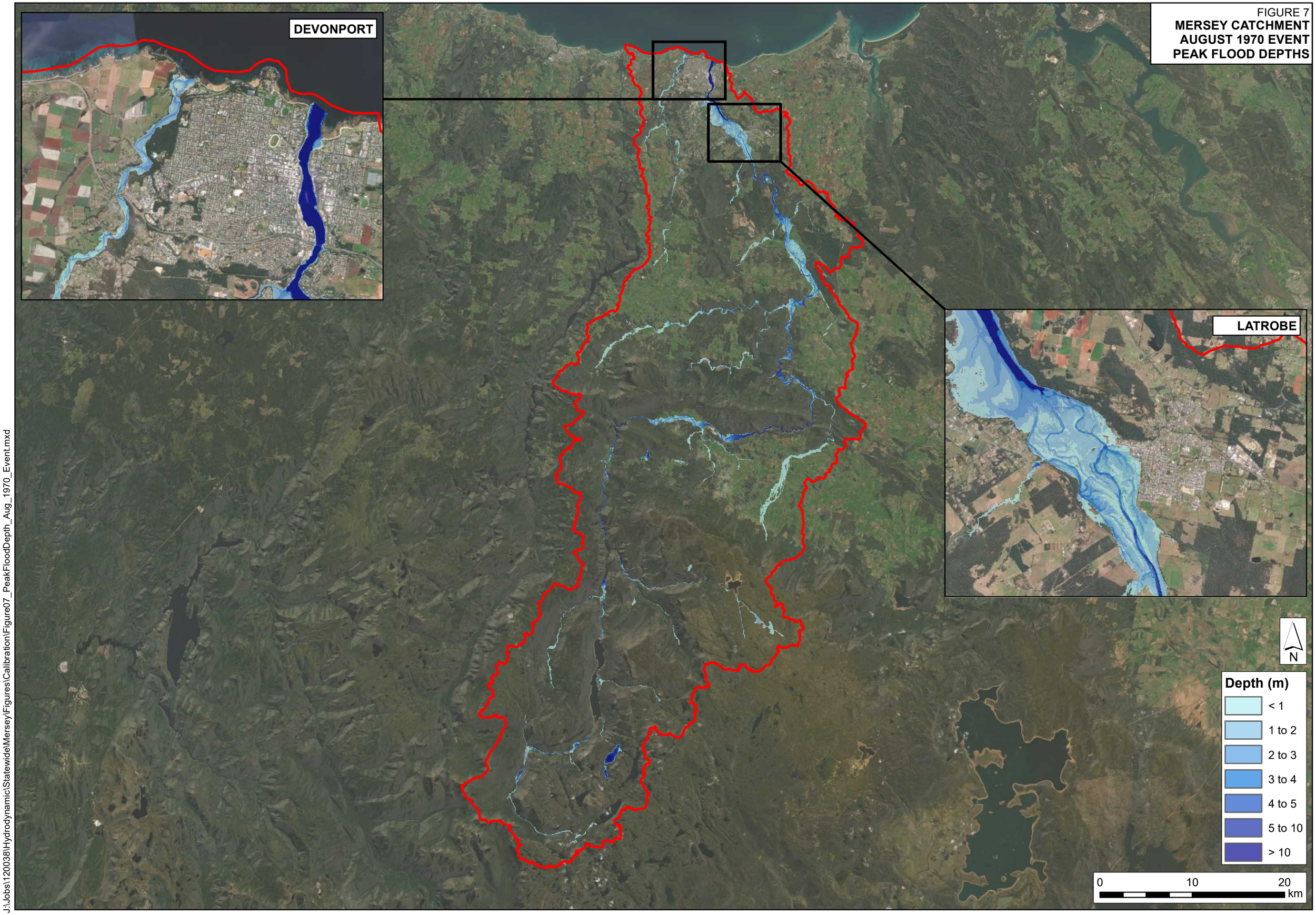

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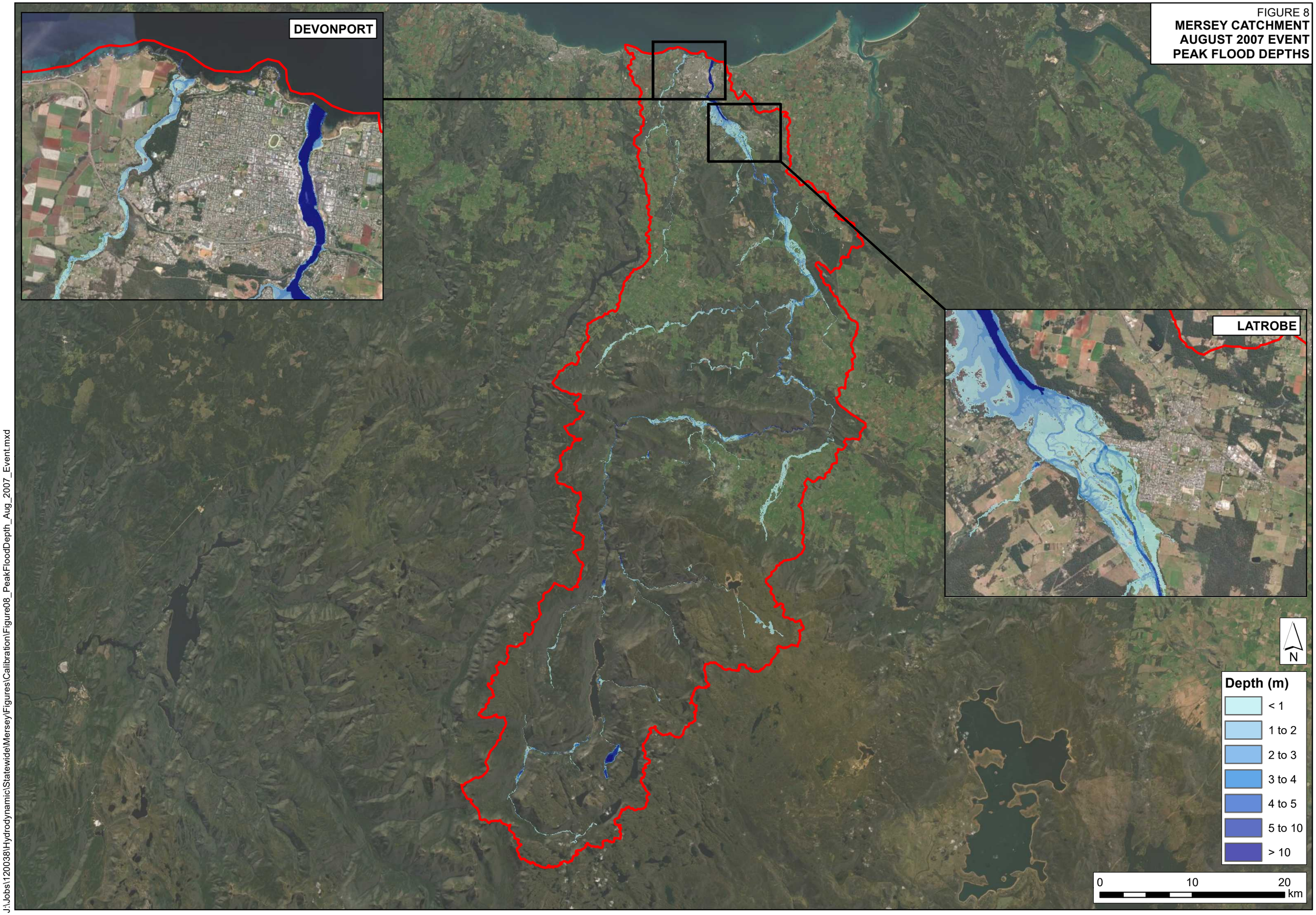

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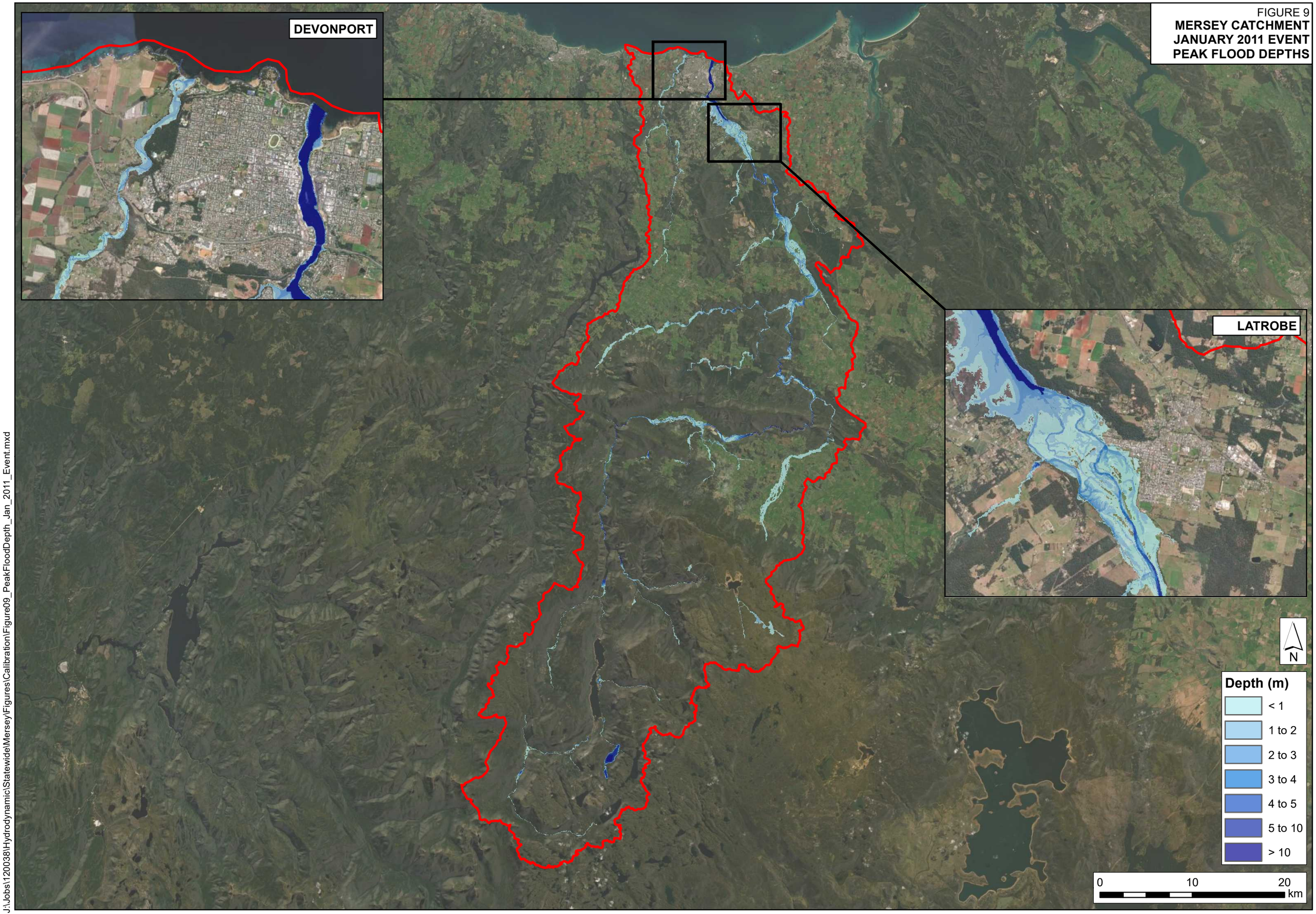

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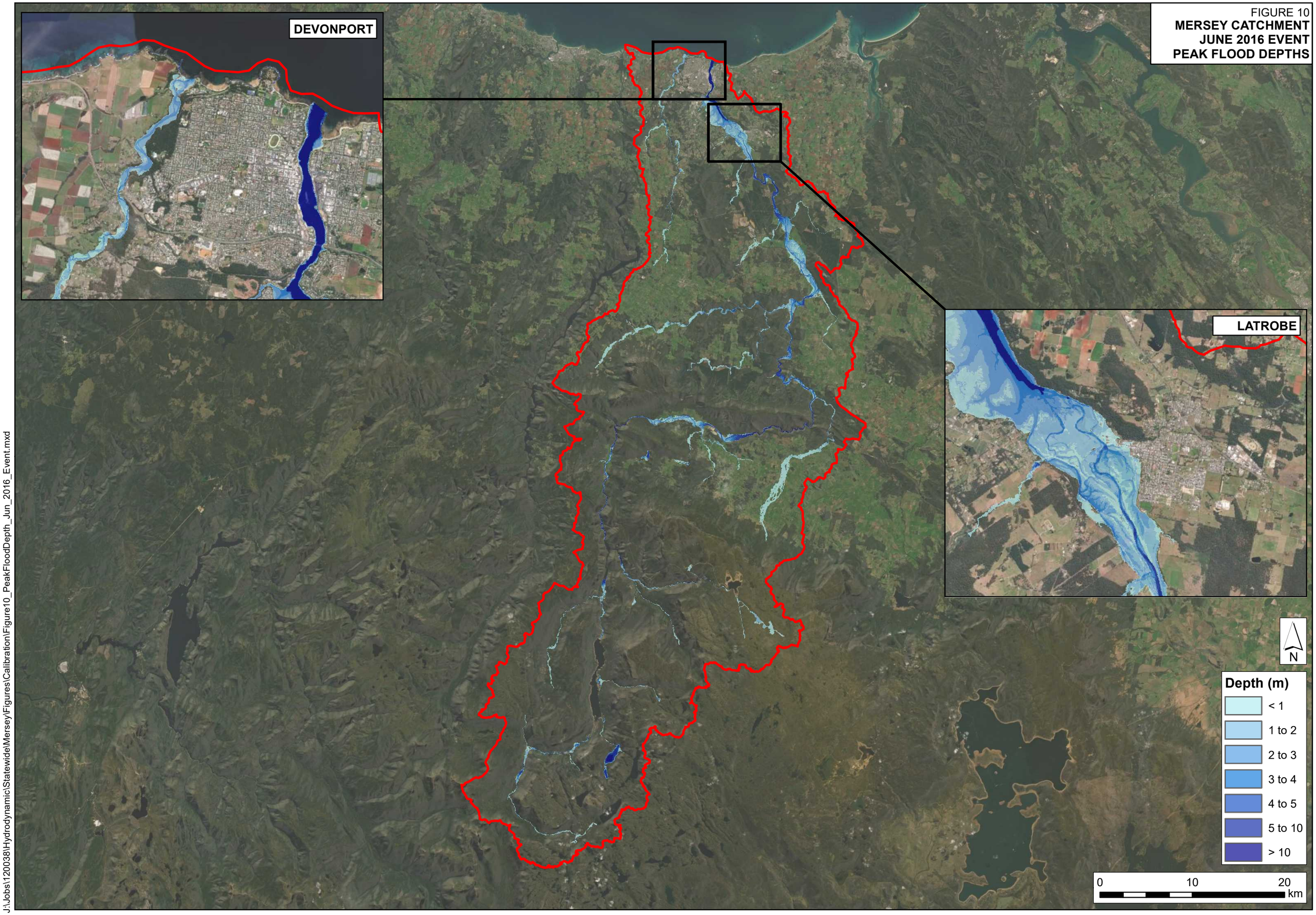

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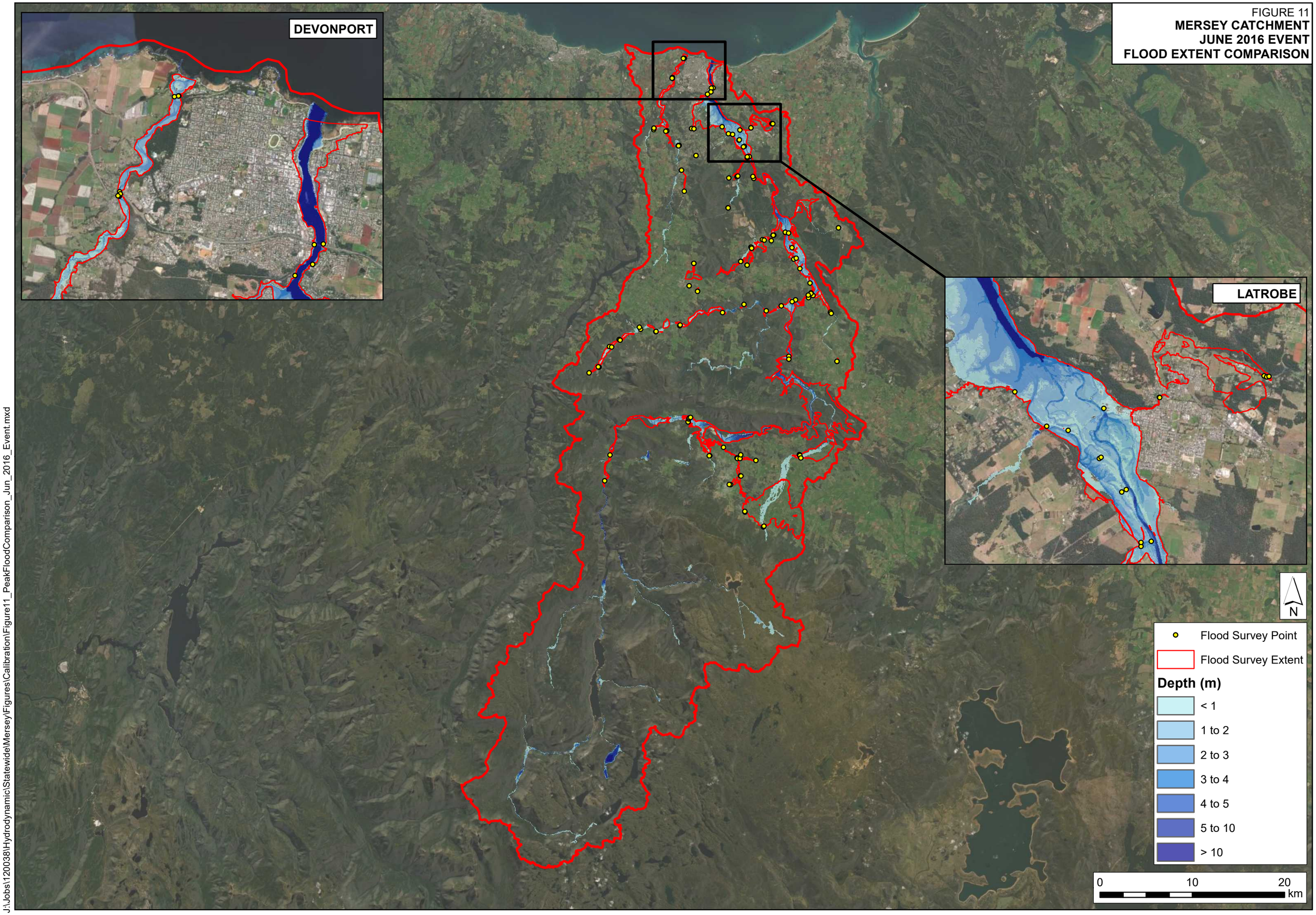

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Appendix A

APPENDIX A. AVALIABLE DATA

A.1. Sub catchment data

FIGURE A1

HYDROLOGICAL SOIL GROUP MAPPING

DOMINANT SUBCATCHMENT SOIL INFILTRATION RATE

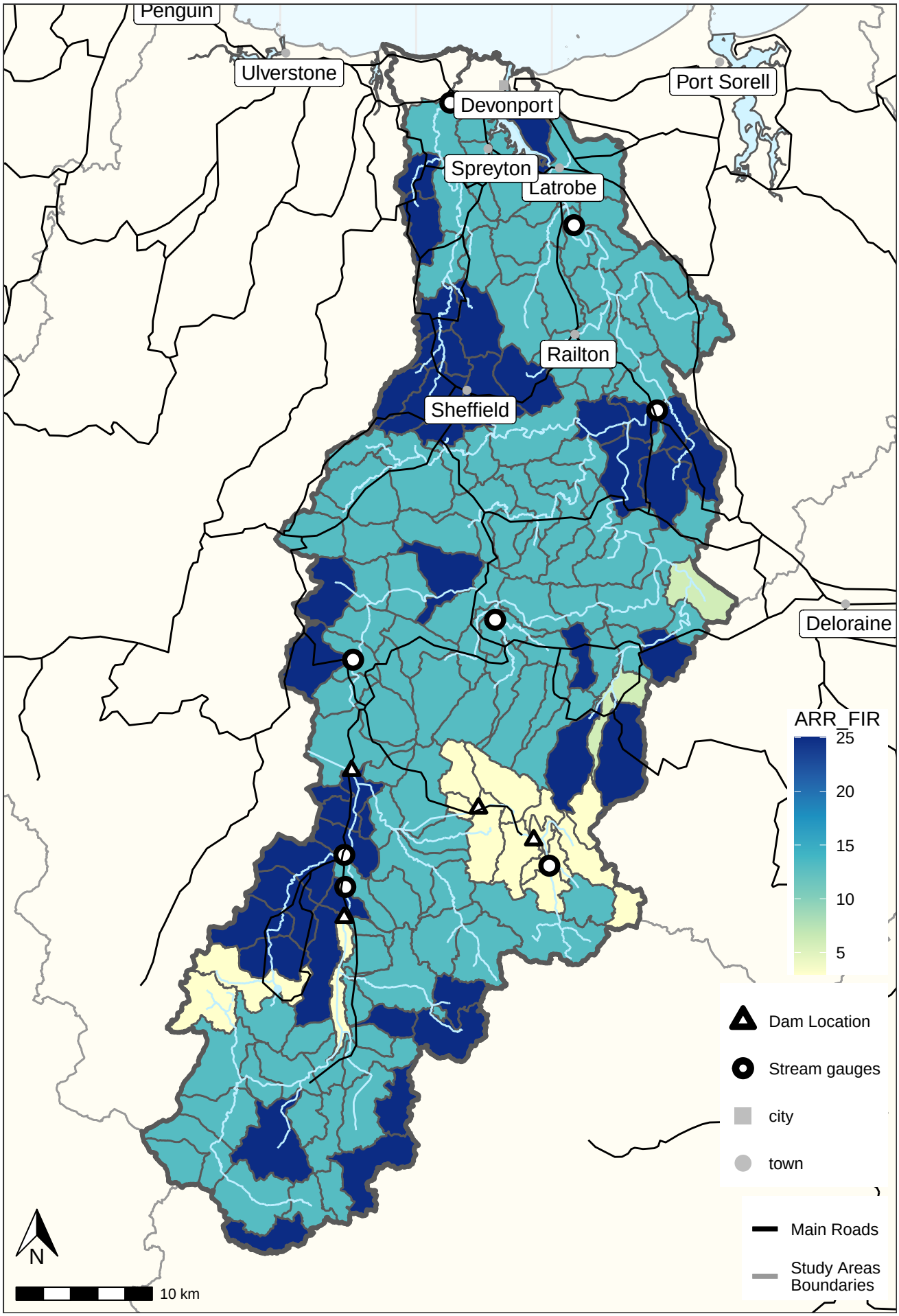

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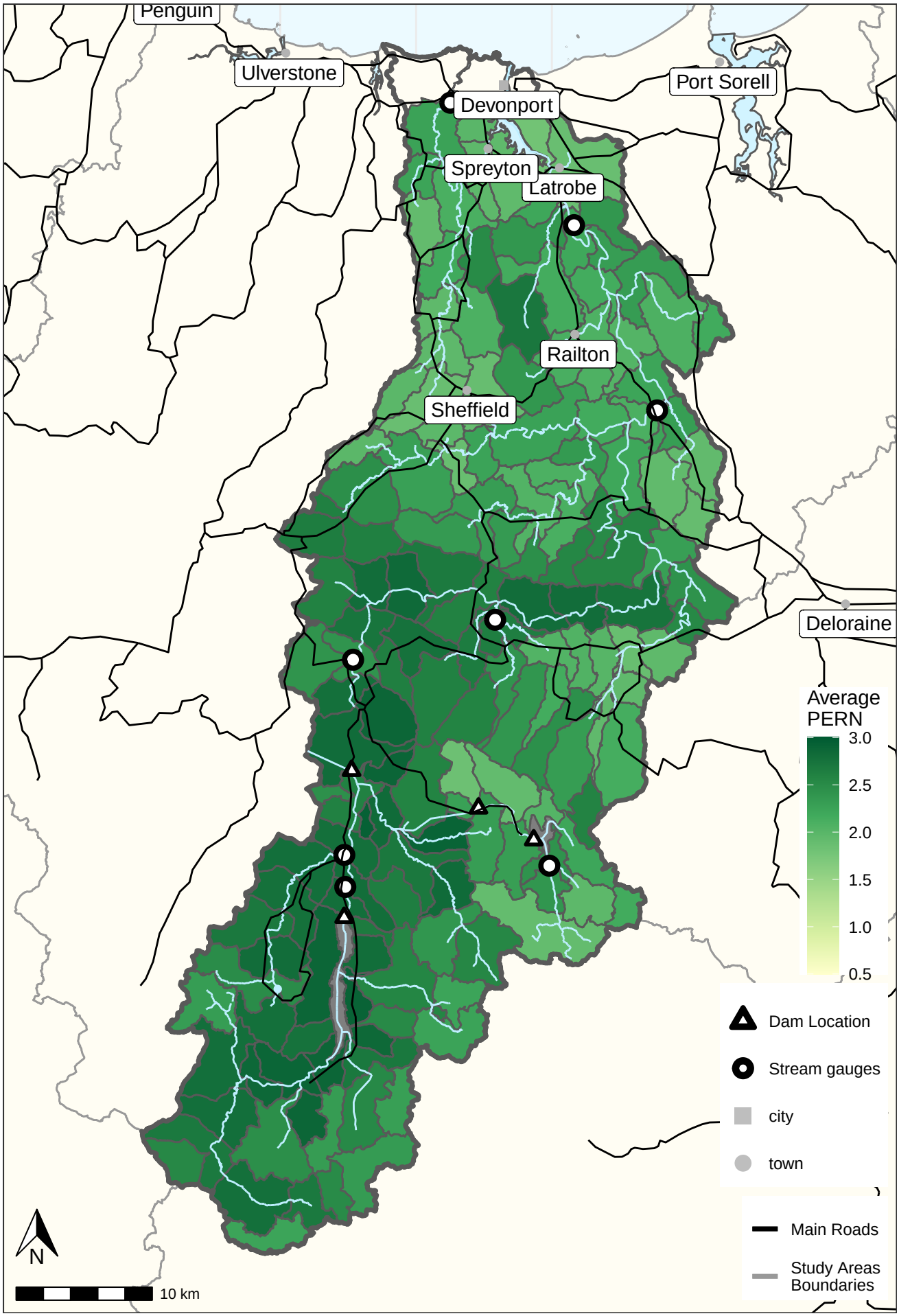
FIGURE A2

MERSEY STUDY AREA

SUBCATCHMENT AVERAGE PERN



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Appendix B

APPENDIX B. UNCERTAINTY ANALYSIS

B.1. Hydrologic Model Uncertainty

Table B 1 shows the calibration event rating. Green shading is used to highlight relevant statements.

Table B 1: Hydrology calibration event rating

Category	Rating				
	Poor	Fair	Good	Very good	Excellent
Rainfall input quality	Nearest pluvi > 15 km from catchment in unrepresentative location	Nearest pluvi > 15km from the catchment in similar climate area	Pluvi within the catchment or within 15km	1 pluvi within or very near catchment for each 300km2 of catchment area	1 pluvi within catchment for each 150km^2 of catchment area (spaced out)
	No daily rainfall sites within 15 km of catchment	No daily rainfall sites within 10 km of catchment	One daily rainfall site within 10 km of catchment in similar climate area	multiple gauges within 15km in different directions	multiple gauges within 10km in different directions
	Known high rainfall gradients (from BoM or investigation of surrounding gauges)	Known rainfall gradients for calibration events	No known large spatial variation in event rainfall relative to gauges	Event rainfall known to be generally spatially uniform if catchment is large, or well represented by raingauges	Event rainfall known to be spatially uniform if catchment is large, or well represented by raingauges
Observed flows	Highest gauging within channel and flow breaks out of channel at high flows.	Rating or gauging info unavailable, but flow contained in channel.	Calibration event is out of channel, good set of gaugings but no gaugings out of channel	Calibration event is out of channel, site has been gauged out of channel during different rating period (with changes at top end)	Calibration event is out of channel, site has been gauged during applicable rating period out of channel
	Rating extrapolated with no consideration for shape of cross section	Rating extrapolated with no consideration for shape of cross section	Rating shows consideration to shape of cross section	Rating shows consideration to shape of cross section	Rating shows consideration to shape of cross section
Calibration events	Smaller than 20% AEP	Between 20% and 10% AEP	Between 10% and 5% AEP	Between 5% and 2% AEP or within largest 4 events on record	Larger than 2% AEP or within largest 2 events on record

Table B 2 shows the hydrology calibration quality rating. The following shading is used to highlight relevant statements:

- Blue – Lake Rowallan, Mersey above Arm, Mersey at Shale Road, Fisher u/s Lake Mackenzie, Lake Mackenzie, Don River u/s Bass Highway
- Green – Mersey at Kimberley
- Orange – Lake Parangana, Mersey at Liena, Arm u/s Mersey

Table B 2: Hydrology calibration quality rating

Category	Rating				
	Poor	**Fair**	**Good**	**Very good**	**Excellent**
Hydrology calibration results – peak flow	Peak varies by more than 30%	Peak within 30% of observed	Peak within 20% of observed	Peak within 15% of observed	Peak within 10% of observed
Hydrology calibration results – hydrograph volume	Volume varies by more than 30%	Volume within 30% of observed	Volume within 20% of observed	Volume within 15% of observed	Volume within 10% of observed
Hydrology calibration results – hydrograph shape	Poor match to shape – modelled event routing does not match observed	Modelled and observed hydrographs have some similarities in shape	General characteristics of the modelled and observed hydrograph shape match in either rising limb or falling limb	Shape of the event generally matches well in rising and falling limbs	Shape of the event matches well including rising and falling limbs and recession

B.2. DTM Uncertainty

The overall study area DTM quality rating is shown in Table B 3 with green shading.

Table B 3: DTM rating

Category	Rating				
	Poor	**Fair**	**Good**	**Very good**	**Excellent**
DTM definition	Low resolution	Low resolution	High resolution at HSA/gauges	High resolution in HSA	High resolution in >60% of catchment
	Minimal Ground Control Points (GCP)	Minimal GCP	Reasonable GCP coverage	Good GCP coverage	Good GCP coverage
DTM waterways	Bathymetrical data unavailable	Bathymetrical data poor – e.g. LiDAR with estimated bathymetric information	Bathymetrical data reasonable	Bathymetrical data good	Detailed bathymetrical survey data available

B.3. Hydrodynamic Model Uncertainty

The hydrodynamic calibration event rating is shown in Table B 4 with relevant statements highlighted in green.

Table B 4: Hydrodynamic calibration event rating

Category	Rating				
	Poor	**Fair**	**Good**	**Very good**	**Excellent**
Calibration flood levels	Water level gauge data not available	Water level gauge data available	Water level gauge data available	Water level gauge data available	Water level gauge data available
		gauge zero level inferred	gauge zero level is known	gauge zero level is known	gauge zero level is known
		Sporadic water level gauge data available for event, low confidence in data	Reasonable confidence in gauged levels based on review of historic data	Good confidence in gauged levels based on review of historic data	Gauge is known to be regularly calibrated and of good quality (e.g. BOM flood warning sites)
Calibration flood depths	No survey extent available	Survey extent available with high uncertainty – few survey points and mostly interpolated	Survey extent available with medium uncertainty – survey points in critical areas, significant areas interpolated	Survey extent available with reasonable certainty – many survey points and limited interpolation	Survey extent available with survey points in all critical areas and limited interpolation

The hydrodynamic calibration event rating is shown in Table B 5. The following shading is used to highlight relevant statements:

- Blue – Mersey above Arm, Mersey at Shale Road, Fisher u/s Lake Mackenzie
- Grey - Don River u/s Bass Highway, Mersey at Liena
- Orange – Arm u/s Mersey
- Green – Mersey River near Kimberley
- Mauve – Mersey River near Latrobe and Bass Highway, Don River at Railway

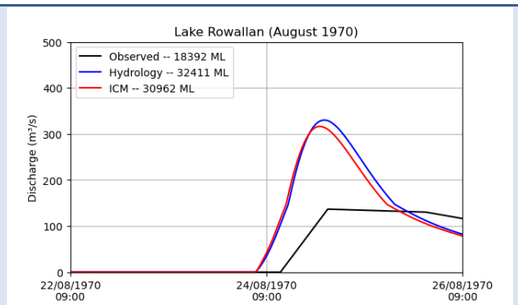
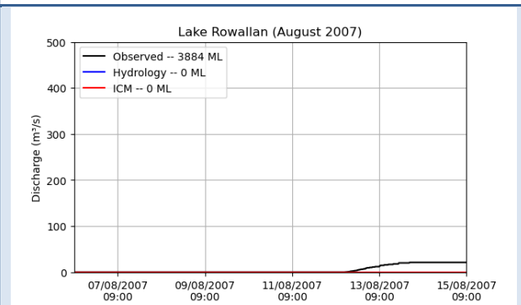
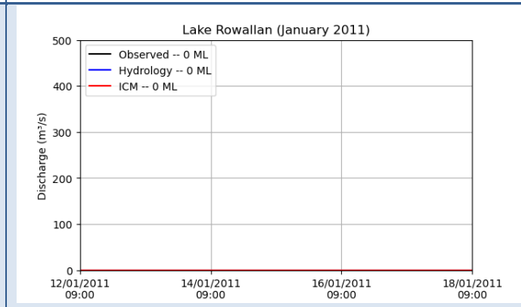
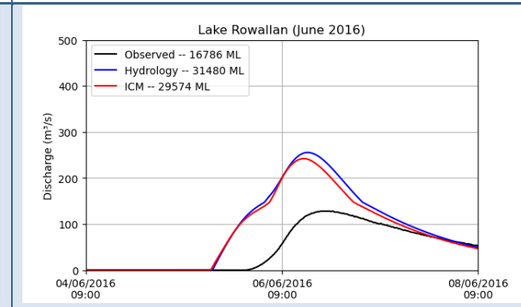
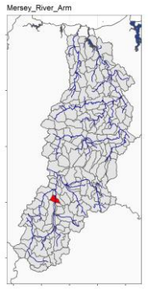
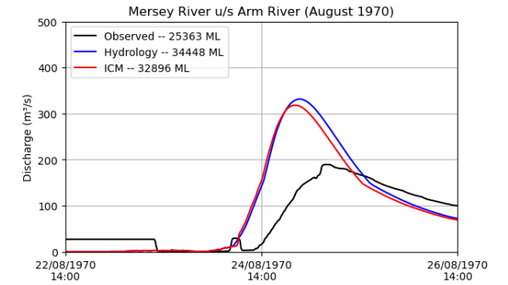
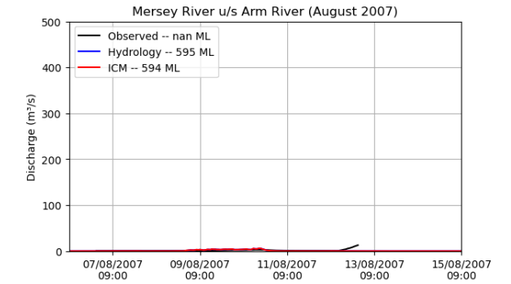
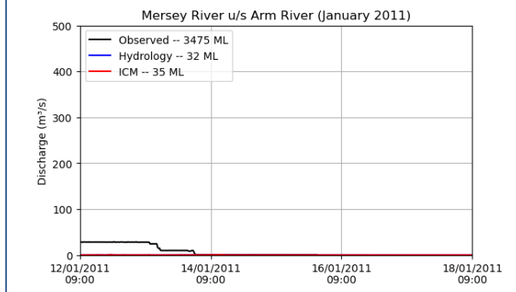
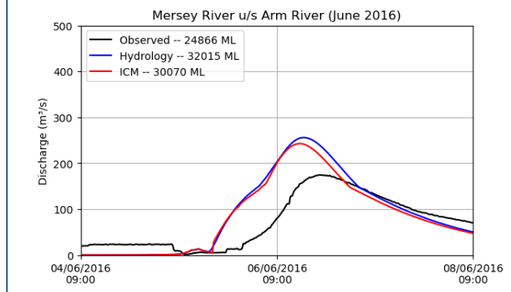
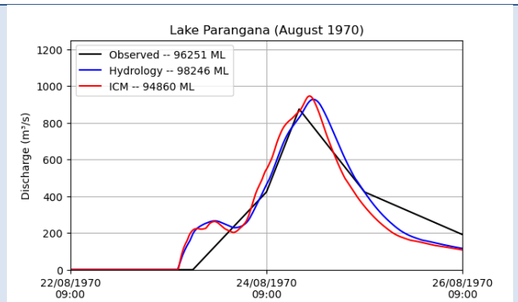
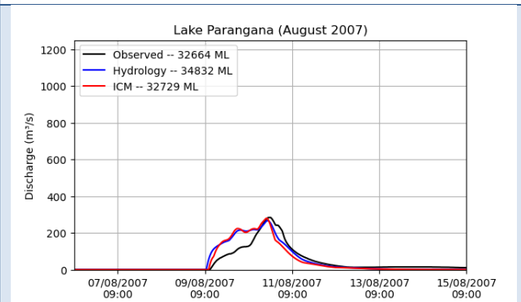
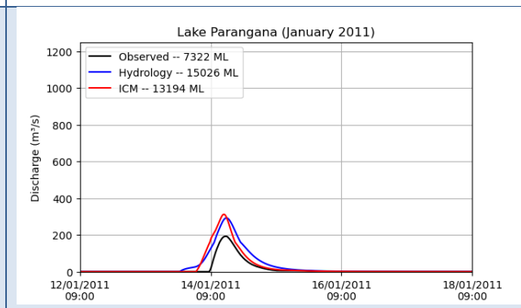
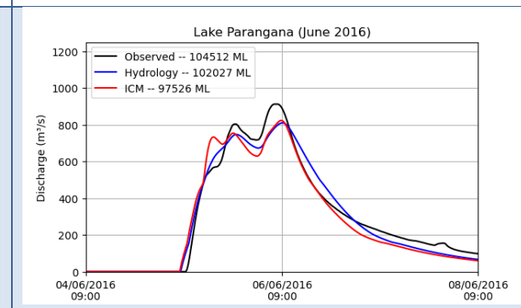
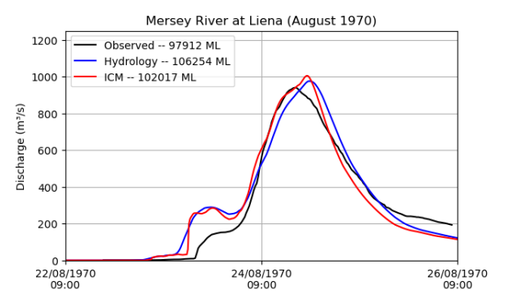
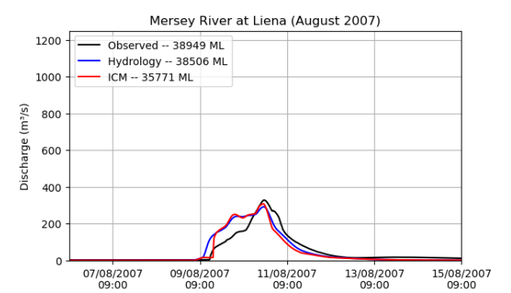
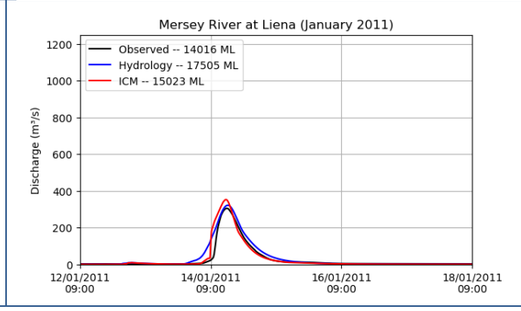
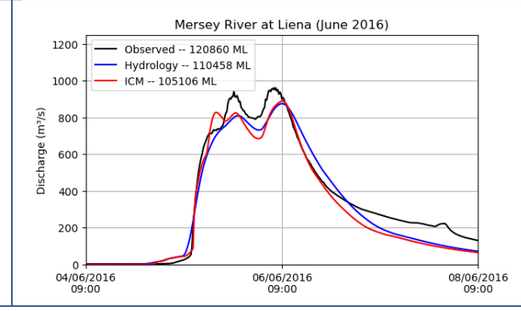
Table B 5: Hydrodynamic calibration quality rating

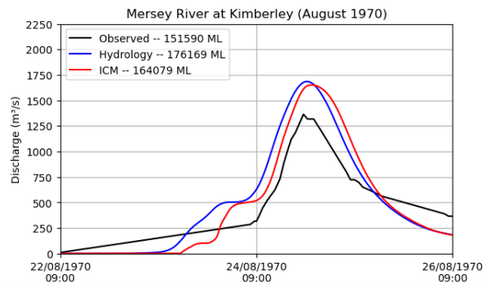
Category	Rating				
	Poor	**Fair**	**Good**	**Very good**	**Excellent**
Hydrodynamic calibration - peak levels	Peak level > +/- 1m of observed	Peak level within +/- 0.5m of observed	Peak within +/-0.5m of observed	Peak within +/-0.3m of observed	Peak within +/- 0.3m of observed
Hydrodynamic calibration – flood extents	Extent > 50m difference from observed	Extent lies within +/- 50m of recorded	Extent lies within +/- 20m of recorded	Extent lies within +/- 10m of recorded	Extent lies within +/- 5m of recorded
Hydrodynamic calibration - depths	Depth more than +/- 1m difference from Survey	Depth within +/- 1 m of Survey	Depth within +/- 0.5m of Survey	Depth within +/- 0.3m of Survey	Depth within +/- 0.3m of Survey

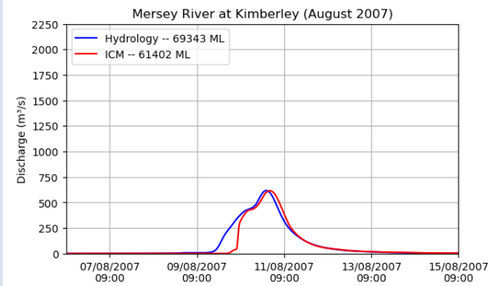
Appendix C

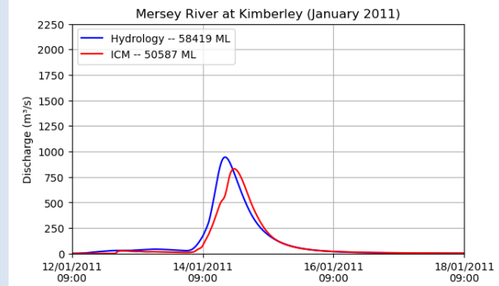
APPENDIX C. EXTERNAL HYDROLOGY MODEL AND ICM HYDRODYNAMIC MODEL COMPARISON

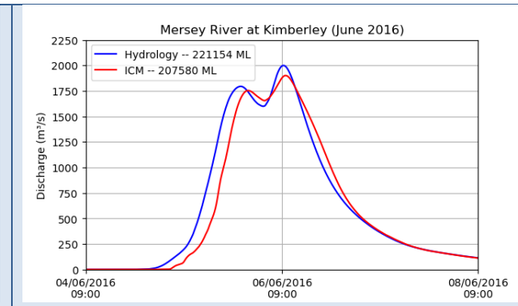
Figure C 1: Event hydrographs

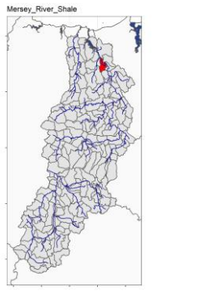
Catchment	August 1970	August 2007	January 2011	June 2016
Lake Rowallan				
				
Lake Parangana				
				

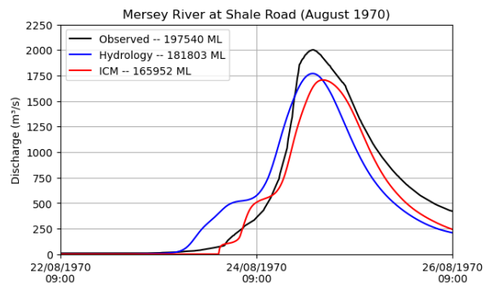


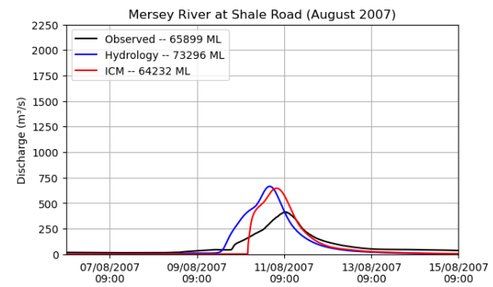


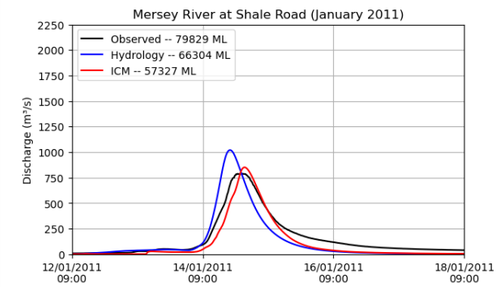


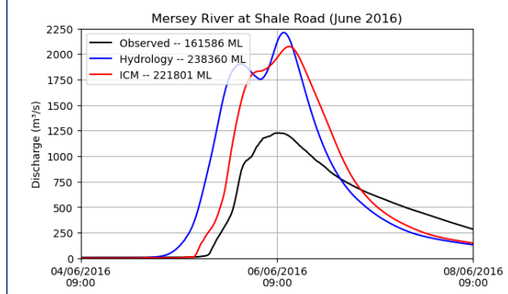


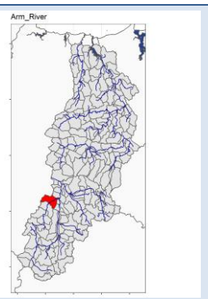












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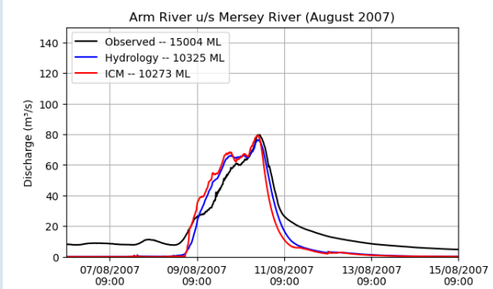

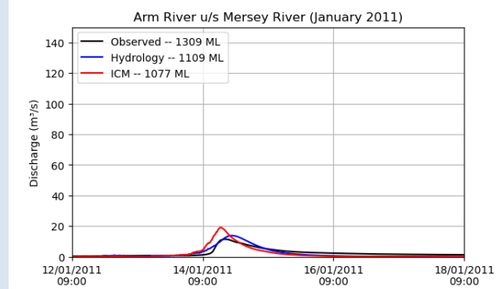

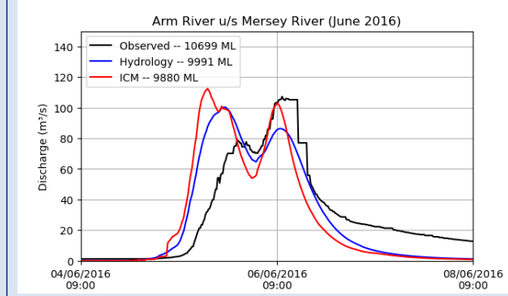

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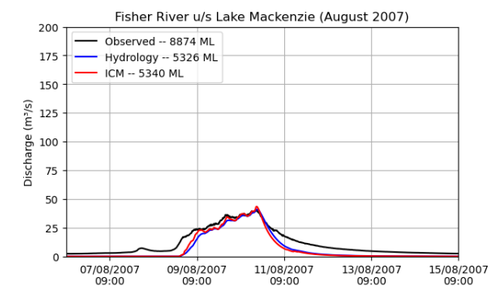
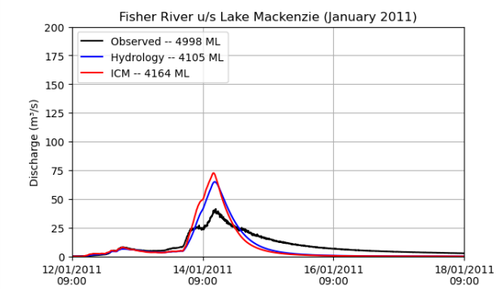
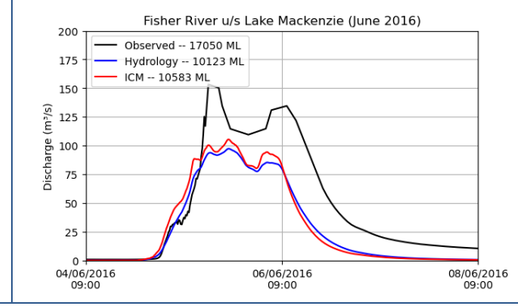
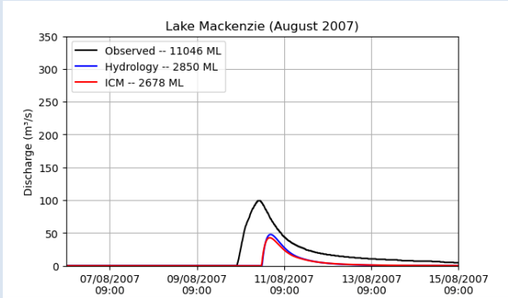
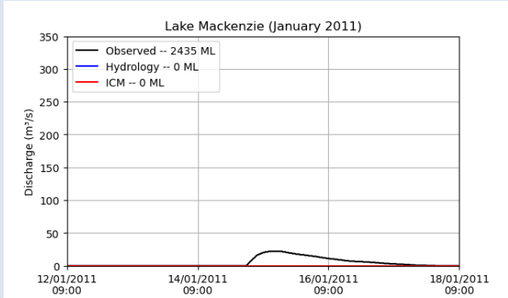
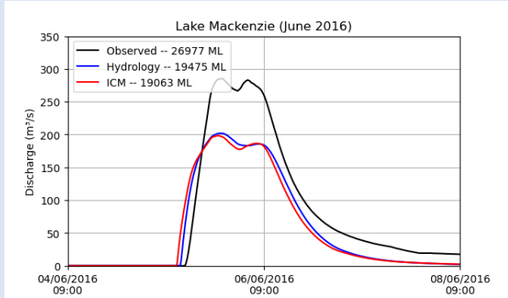
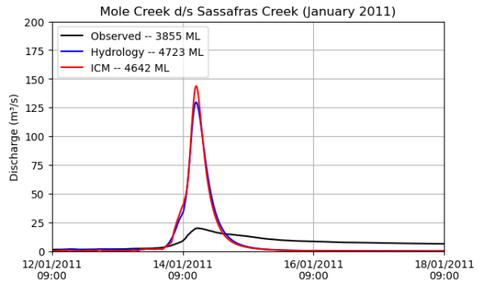
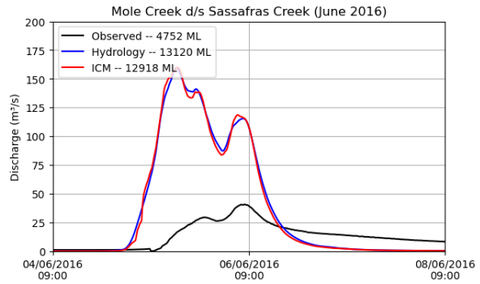
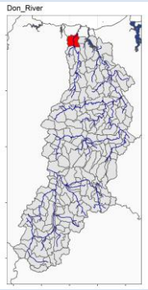
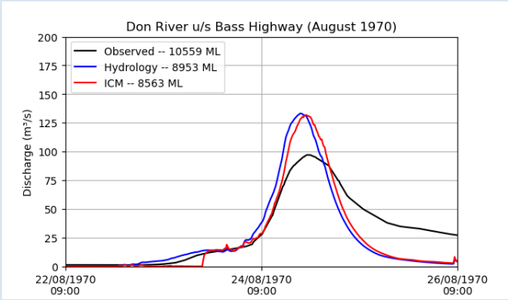
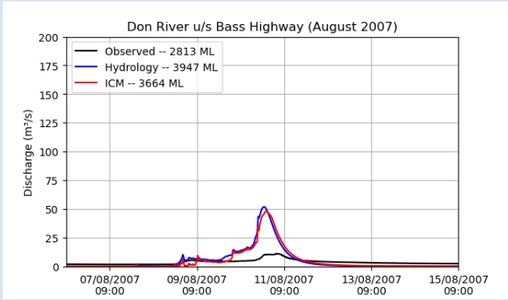
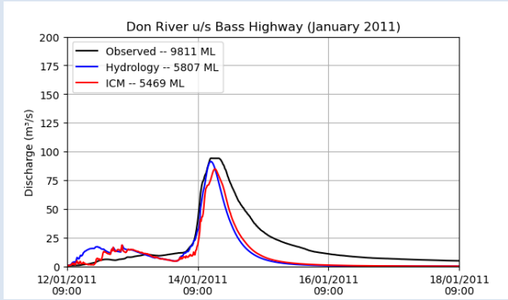
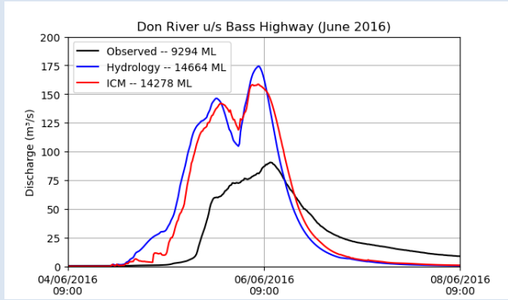
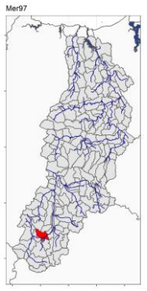
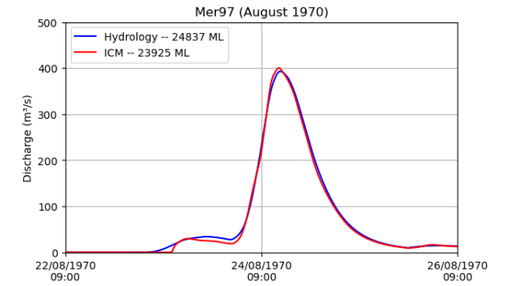
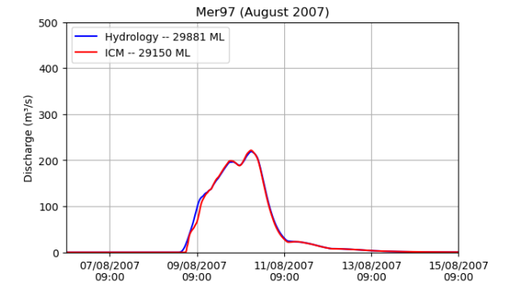
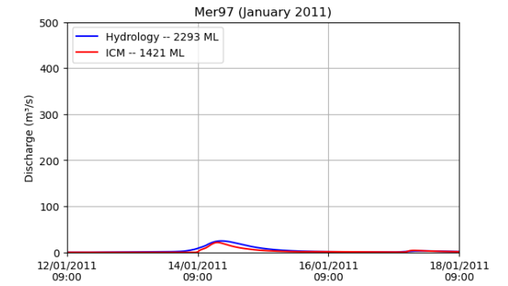
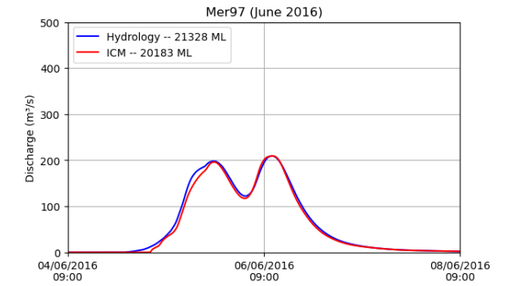
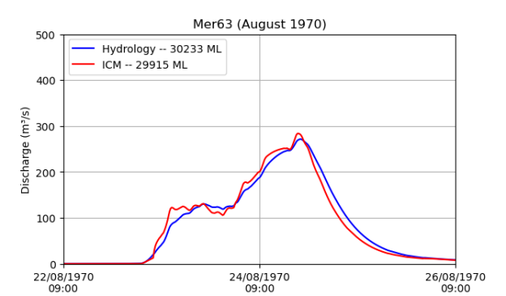


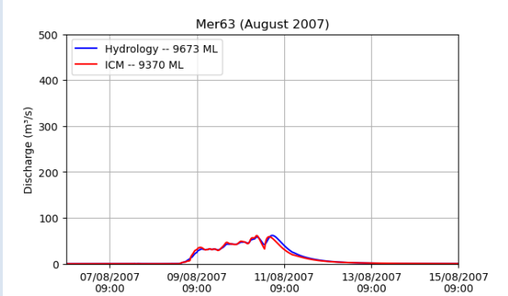


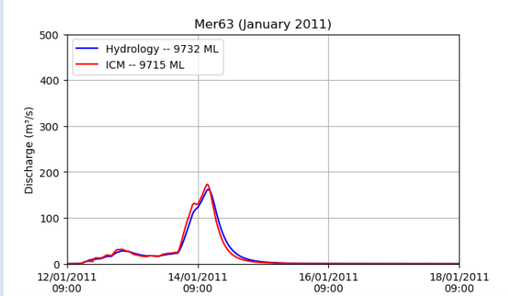


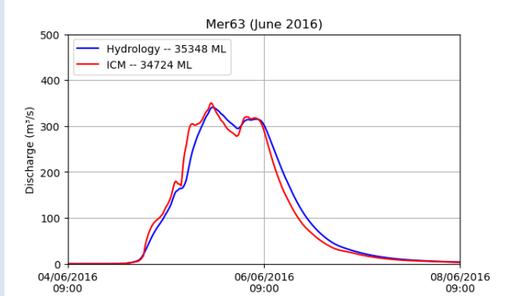
Lake Mackenzie	Site not yet established			
	Site not yet established	Site not yet established		
				
				

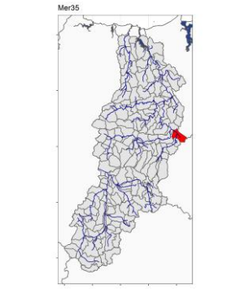

Mer63

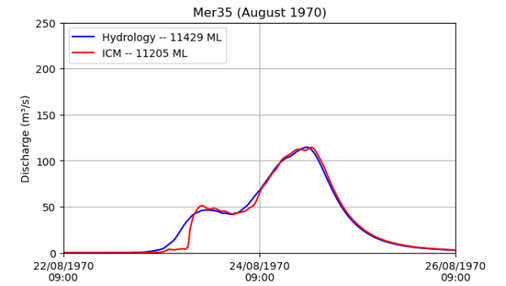

Mer63 (August 1970)
Hydrology -- 30233 ML
ICM -- 29915 ML
Discharge (m³/s)
22/08/1970 09:00
24/08/1970 09:00
26/08/1970 09:00

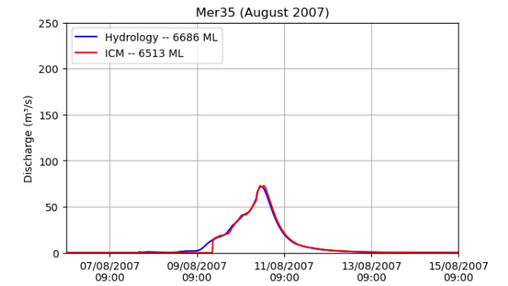

Mer63 (August 2007)
Hydrology -- 9673 ML
ICM -- 9370 ML
Discharge (m³/s)
07/08/2007 09:00
09/08/2007 09:00
11/08/2007 09:00
13/08/2007 09:00
15/08/2007 09:00

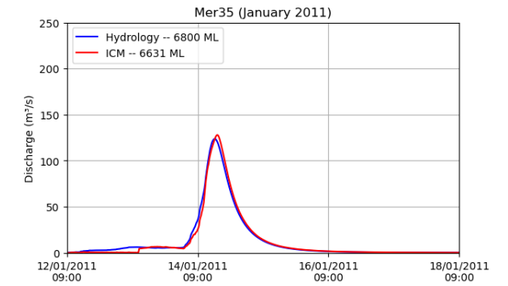

Mer63 (January 2011)
Hydrology -- 9732 ML
ICM -- 9715 ML
Discharge (m³/s)
12/01/2011 09:00
14/01/2011 09:00
16/01/2011 09:00
18/01/2011 09:00

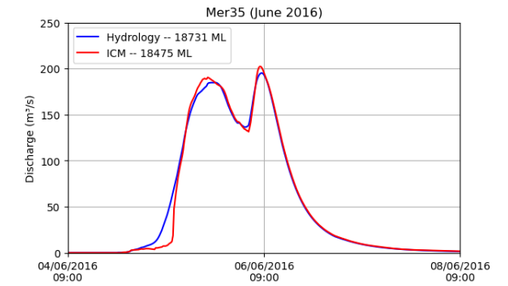

Mer63 (June 2016)
Hydrology -- 35348 ML
ICM -- 34724 ML
Discharge (m³/s)
04/06/2016 09:00
06/06/2016 09:00
08/06/2016 09:00

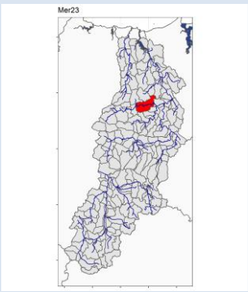

Mer35

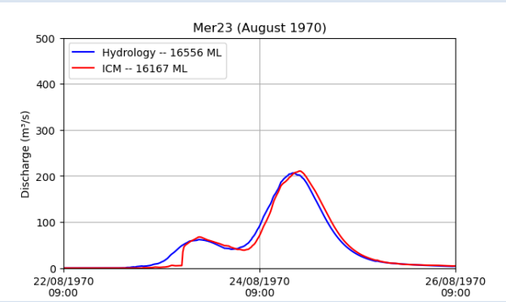

Mer35 (August 1970)
Hydrology -- 11429 ML
ICM -- 11205 ML
Discharge (m³/s)
22/08/1970 09:00
24/08/1970 09:00
26/08/1970 09:00

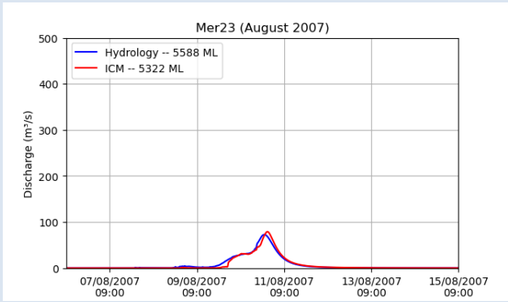

Mer35 (August 2007)
Hydrology -- 6686 ML
ICM -- 6513 ML
Discharge (m³/s)
07/08/2007 09:00
09/08/2007 09:00
11/08/2007 09:00
13/08/2007 09:00
15/08/2007 09:00

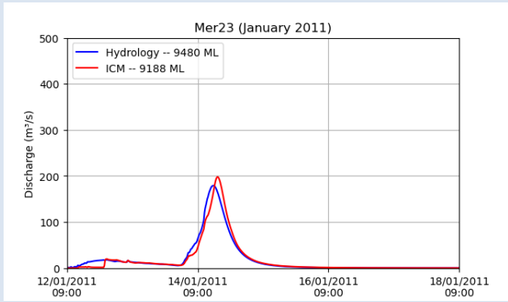

Mer35 (January 2011)
Hydrology -- 6800 ML
ICM -- 6631 ML
Discharge (m³/s)
12/01/2011 09:00
14/01/2011 09:00
16/01/2011 09:00
18/01/2011 09:00

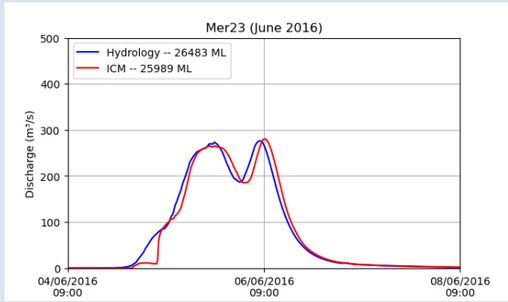

Mer35 (June 2016)
Hydrology -- 18731 ML
ICM -- 18475 ML
Discharge (m³/s)
04/06/2016 09:00
06/06/2016 09:00
08/06/2016 09:00


Mer23

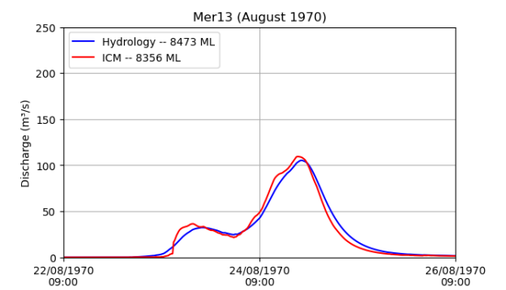

Mer23 (August 1970)
Hydrology -- 16556 ML
ICM -- 16167 ML
Discharge (m³/s)
22/08/1970 09:00
24/08/1970 09:00
26/08/1970 09:00

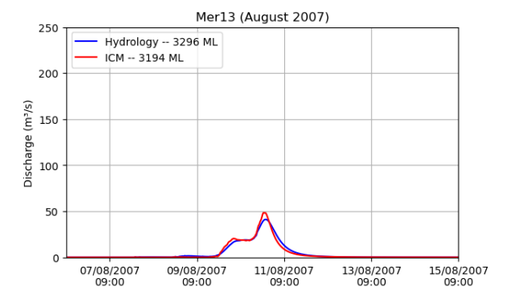

Mer23 (August 2007)
Hydrology -- 5588 ML
ICM -- 5322 ML
Discharge (m³/s)
07/08/2007 09:00
09/08/2007 09:00
11/08/2007 09:00
13/08/2007 09:00
15/08/2007 09:00

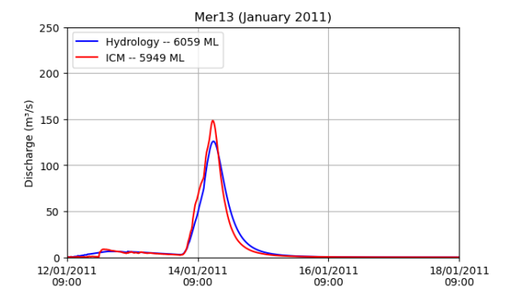

Mer23 (January 2011)
Hydrology -- 9480 ML
ICM -- 9188 ML
Discharge (m³/s)
12/01/2011 09:00
14/01/2011 09:00
16/01/2011 09:00
18/01/2011 09:00

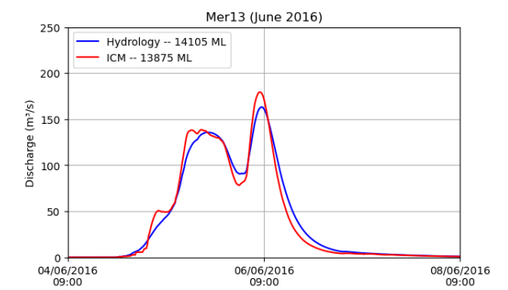

Mer23 (June 2016)
Hydrology -- 26483 ML
ICM -- 25989 ML
Discharge (m³/s)
04/06/2016 09:00
06/06/2016 09:00
08/06/2016 09:00


Mer13

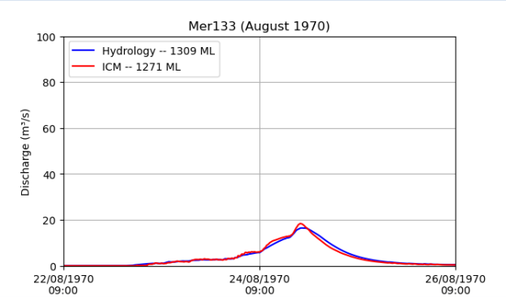

Mer13 (August 1970)
Hydrology -- 8473 ML
ICM -- 8356 ML
Discharge (m³/s)
22/08/1970 09:00
24/08/1970 09:00
26/08/1970 09:00

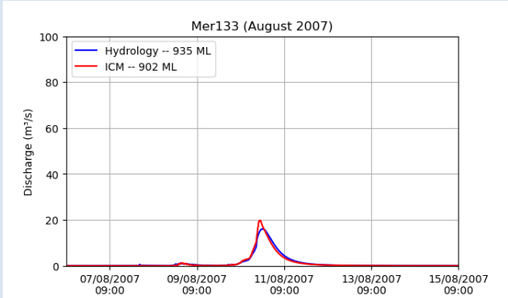

Mer13 (August 2007)
Hydrology -- 3296 ML
ICM -- 3194 ML
Discharge (m³/s)
07/08/2007 09:00
09/08/2007 09:00
11/08/2007 09:00
13/08/2007 09:00
15/08/2007 09:00

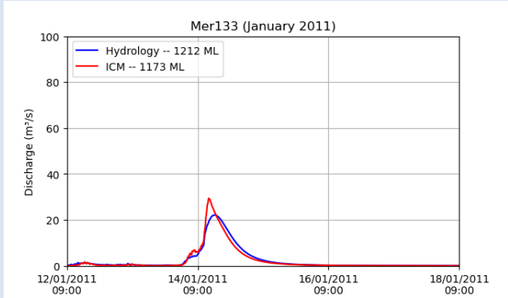

Mer13 (January 2011)
Hydrology -- 6059 ML
ICM -- 5949 ML
Discharge (m³/s)
12/01/2011 09:00
14/01/2011 09:00
16/01/2011 09:00
18/01/2011 09:00

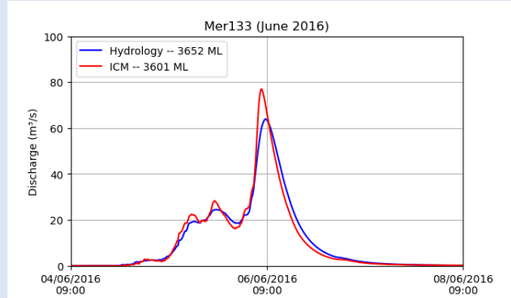

Mer13 (June 2016)
Hydrology -- 14105 ML
ICM -- 13875 ML
Discharge (m³/s)
04/06/2016 09:00
06/06/2016 09:00
08/06/2016 09:00

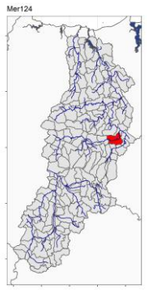

Mer133

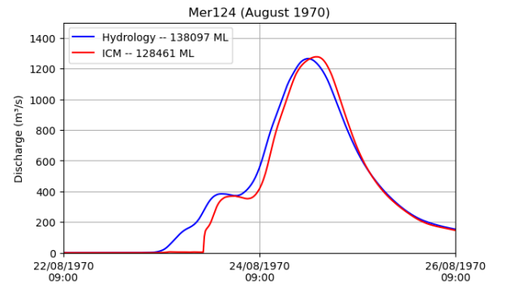

Mer133 (August 1970)
Hydrology -- 1309 ML
ICM -- 1271 ML
Discharge (m³/s)
22/08/1970 09:00
24/08/1970 09:00
26/08/1970 09:00

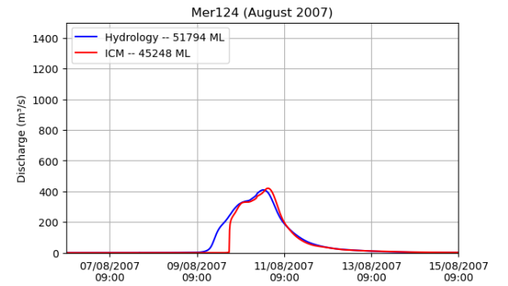

Mer133 (August 2007)
Hydrology -- 935 ML
ICM -- 902 ML
Discharge (m³/s)
07/08/2007 09:00
09/08/2007 09:00
11/08/2007 09:00
13/08/2007 09:00
15/08/2007 09:00

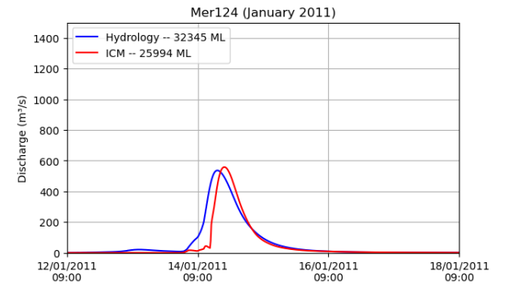

Mer133 (January 2011)
Hydrology -- 1212 ML
ICM -- 1173 ML
Discharge (m³/s)
12/01/2011 09:00
14/01/2011 09:00
16/01/2011 09:00
18/01/2011 09:00

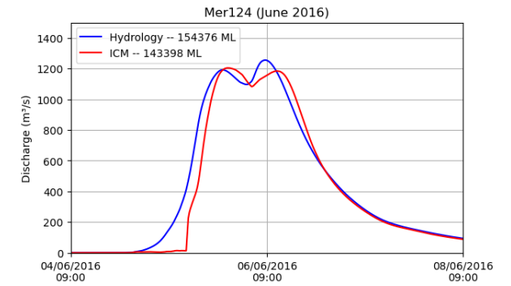

Mer133 (June 2016)
Hydrology -- 3652 ML
ICM -- 3601 ML
Discharge (m³/s)
04/06/2016 09:00
06/06/2016 09:00
08/06/2016 09:00


Mer124


Mer124 (August 1970)
Hydrology -- 138097 ML
ICM -- 128461 ML
Discharge (m³/s)
22/08/1970 09:00
24/08/1970 09:00
26/08/1970 09:00


Mer124 (August 2007)
Hydrology -- 51794 ML
ICM -- 45248 ML
Discharge (m³/s)
07/08/2007 09:00
09/08/2007 09:00
11/08/2007 09:00
13/08/2007 09:00
15/08/2007 09:00


Mer124 (January 2011)
Hydrology -- 32345 ML
ICM -- 25994 ML
Discharge (m³/s)
12/01/2011 09:00
14/01/2011 09:00
16/01/2011 09:00
18/01/2011 09:00


Mer124 (June 2016)
Hydrology -- 154376 ML
ICM -- 143398 ML
Discharge (m³/s)
04/06/2016 09:00
06/06/2016 09:00
08/06/2016 09:00

Appendix D

APPENDIX D. RATING CURVE COMPARISON

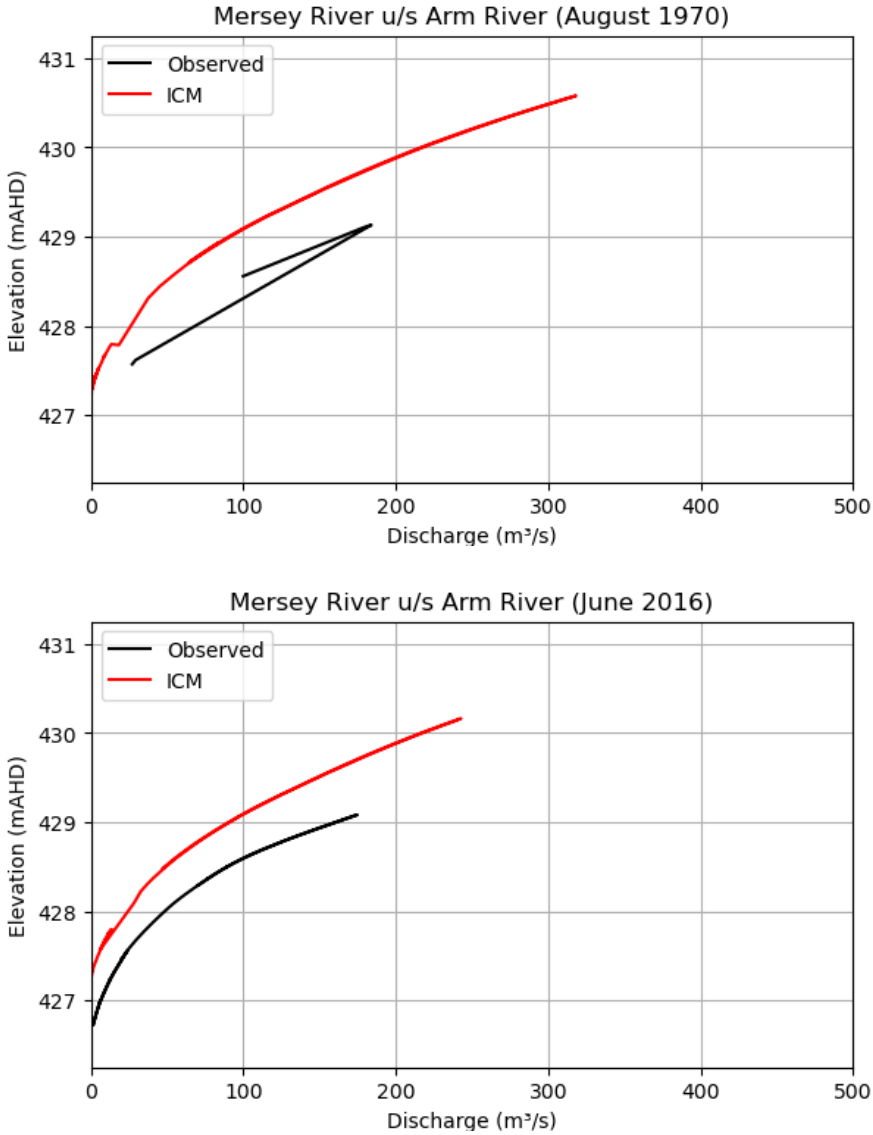


Figure D 1: Rating curve comparison at Mersey River u/s Arm River

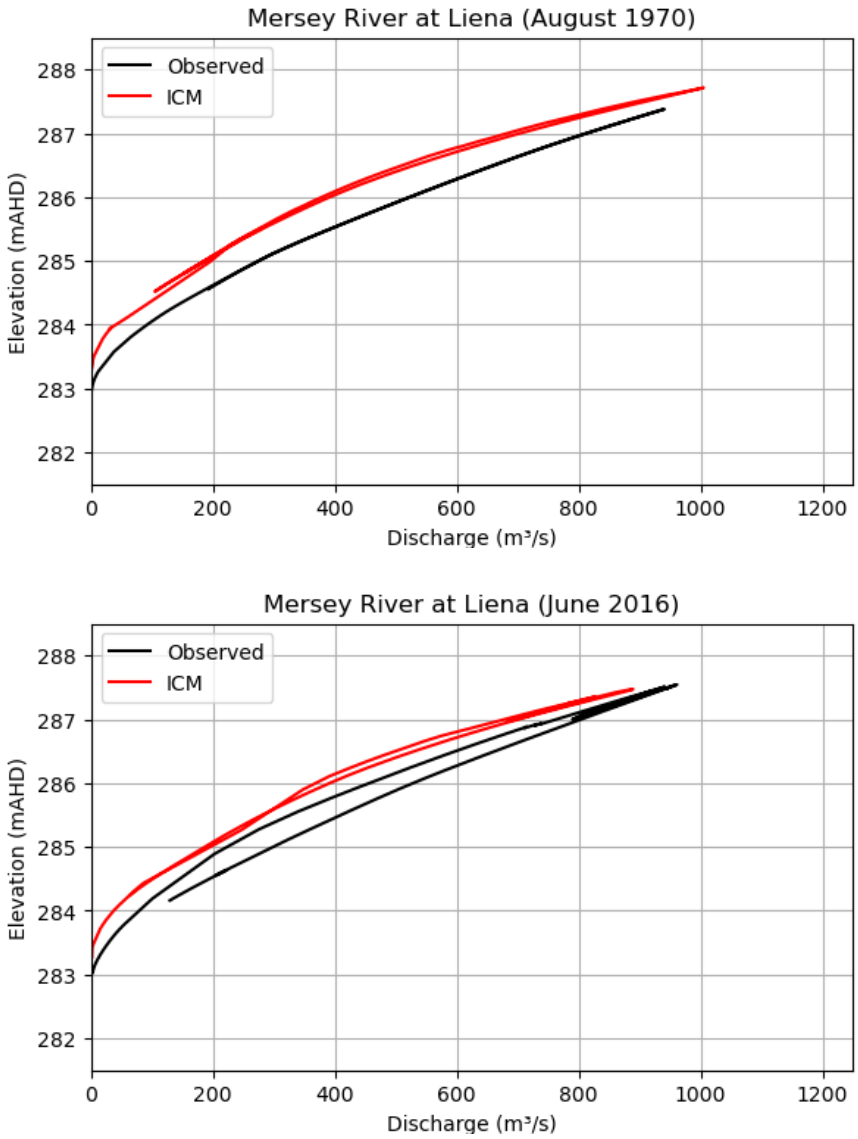


Figure D 2: Rating curve comparison at Mersey River at Liena

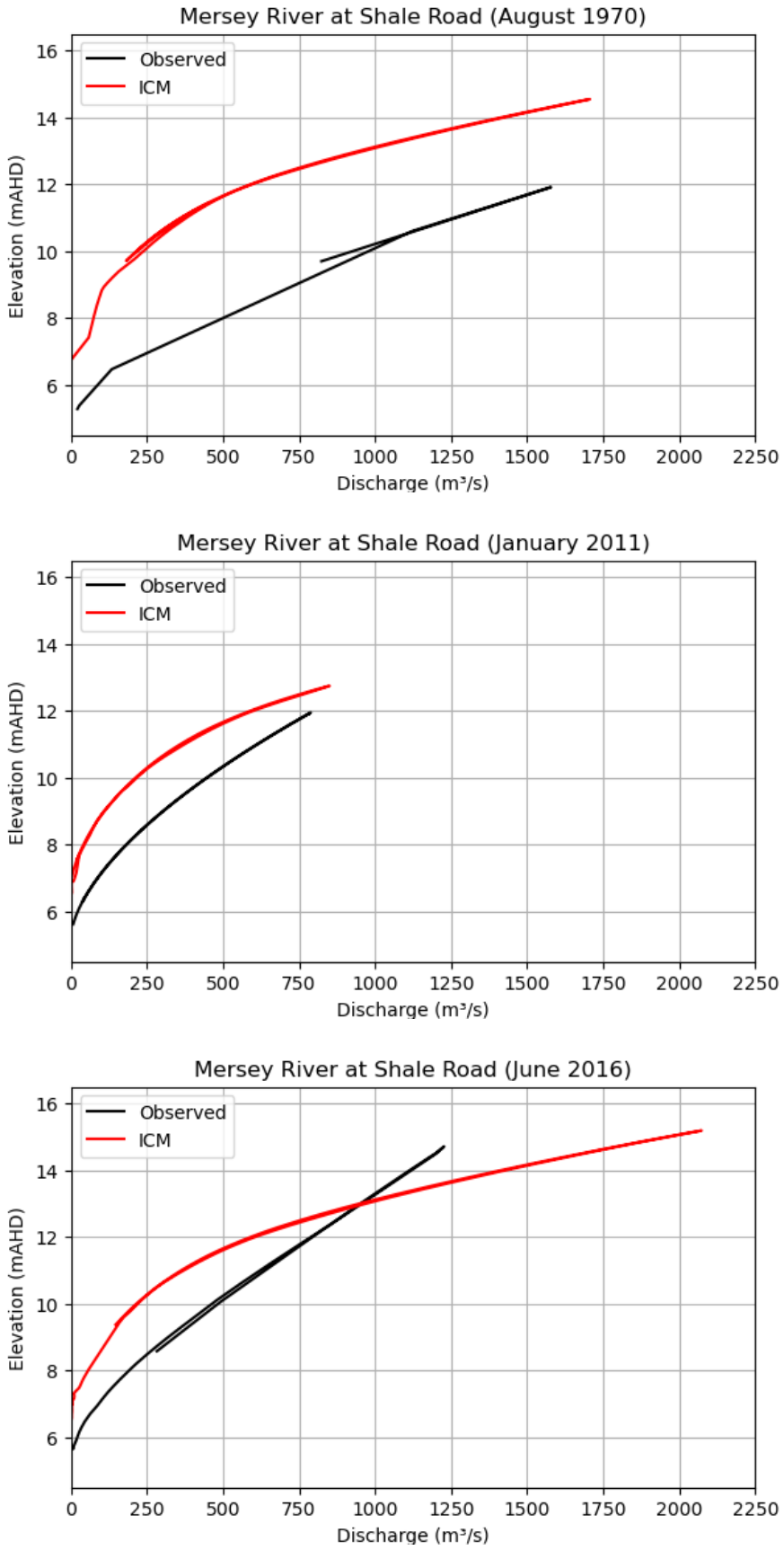


Figure D 3: Rating curve comparison at Mersey River at Shale Road

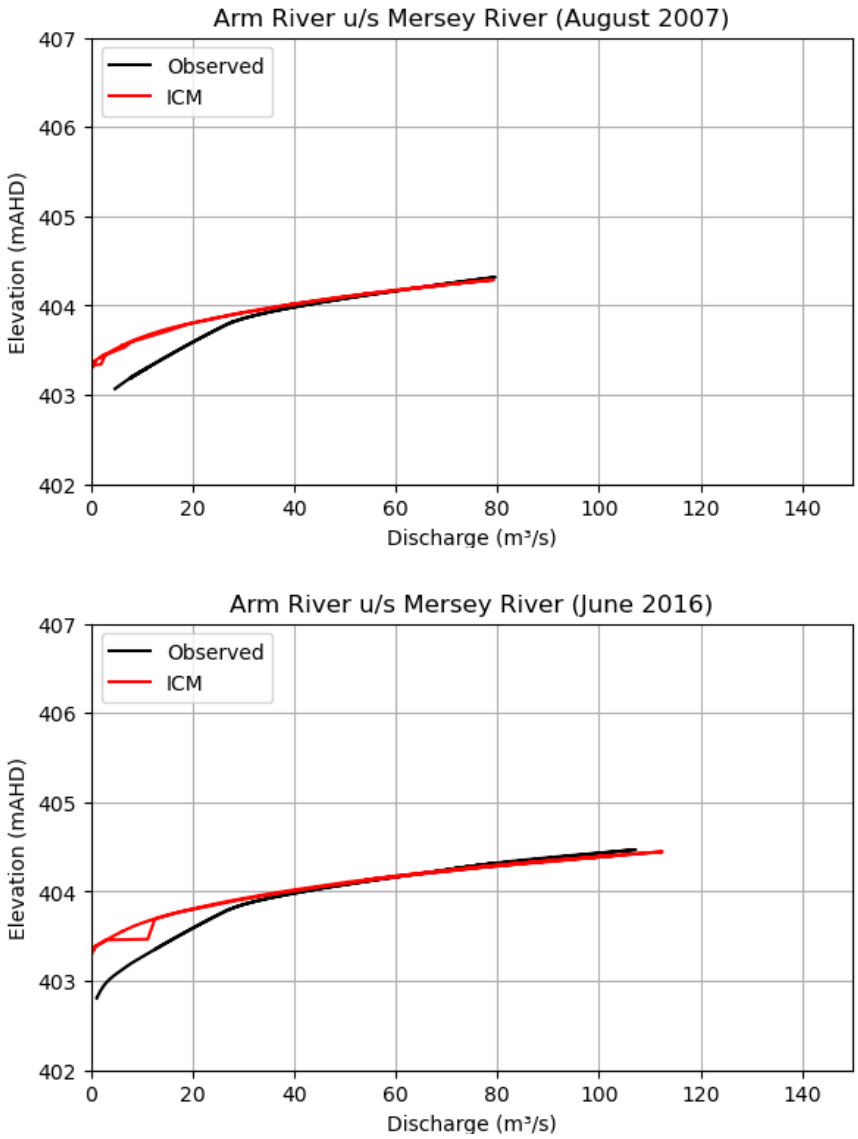


Figure D 4: Rating curve comparison at Arm River u/s Mersey River

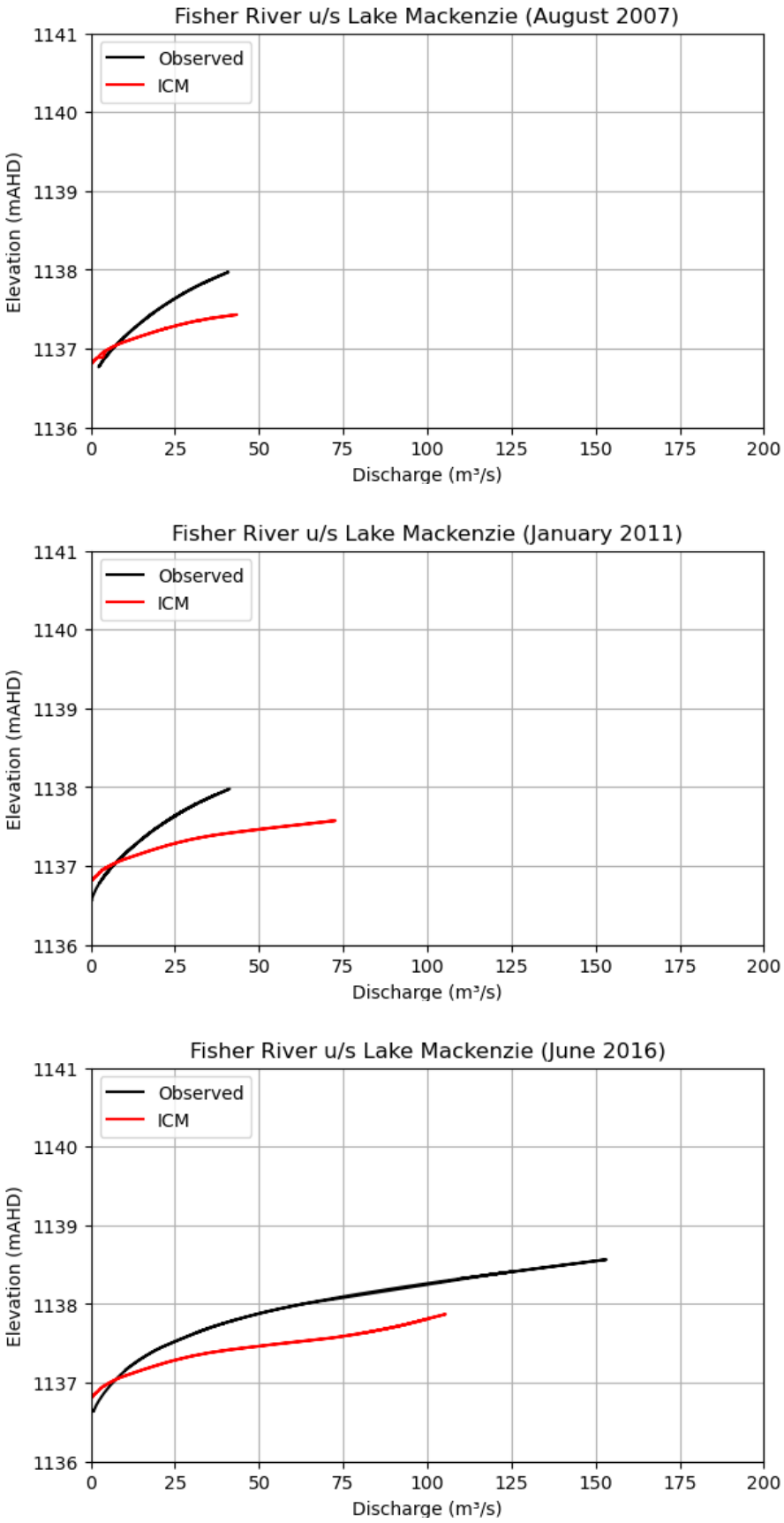


Figure D 5: Rating curve comparison at Fisher River u/s Lake Mackenzie

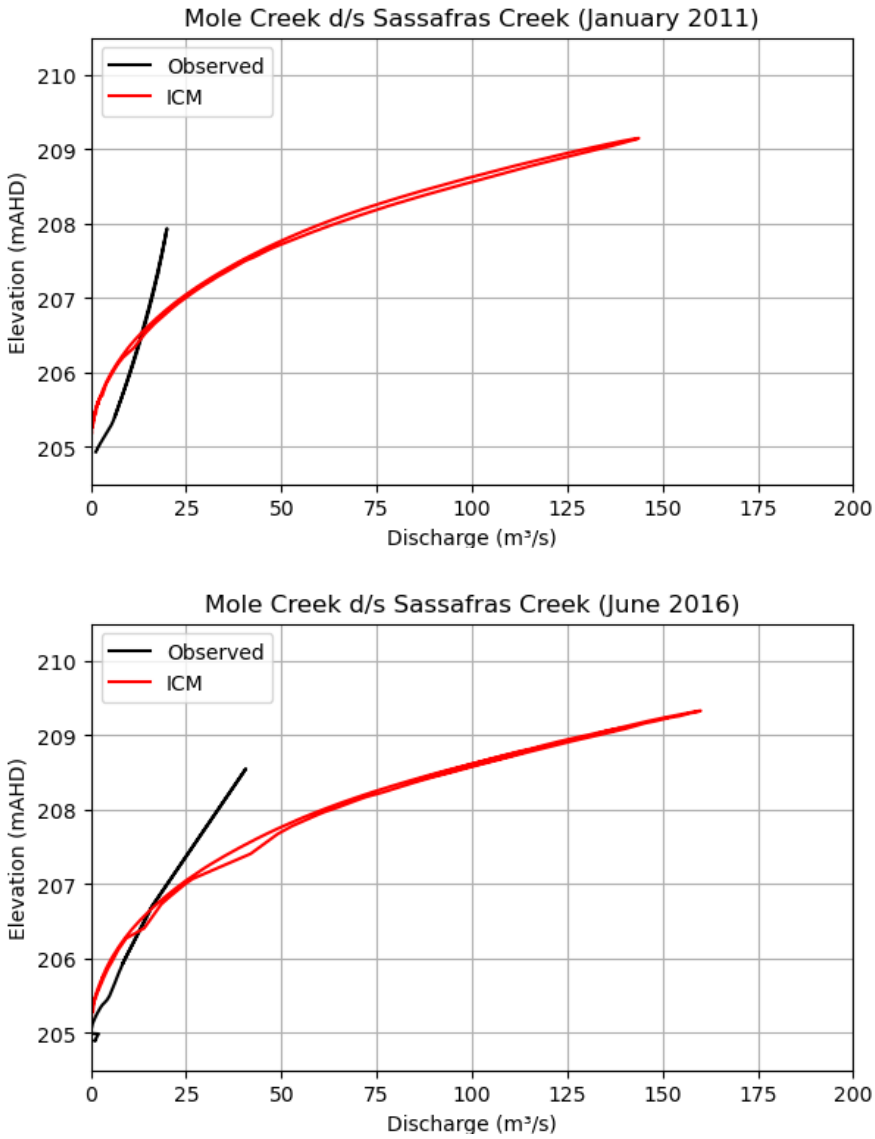


Figure D 6: Rating curve comparison at Mole Creek d/s Sassafras Creek

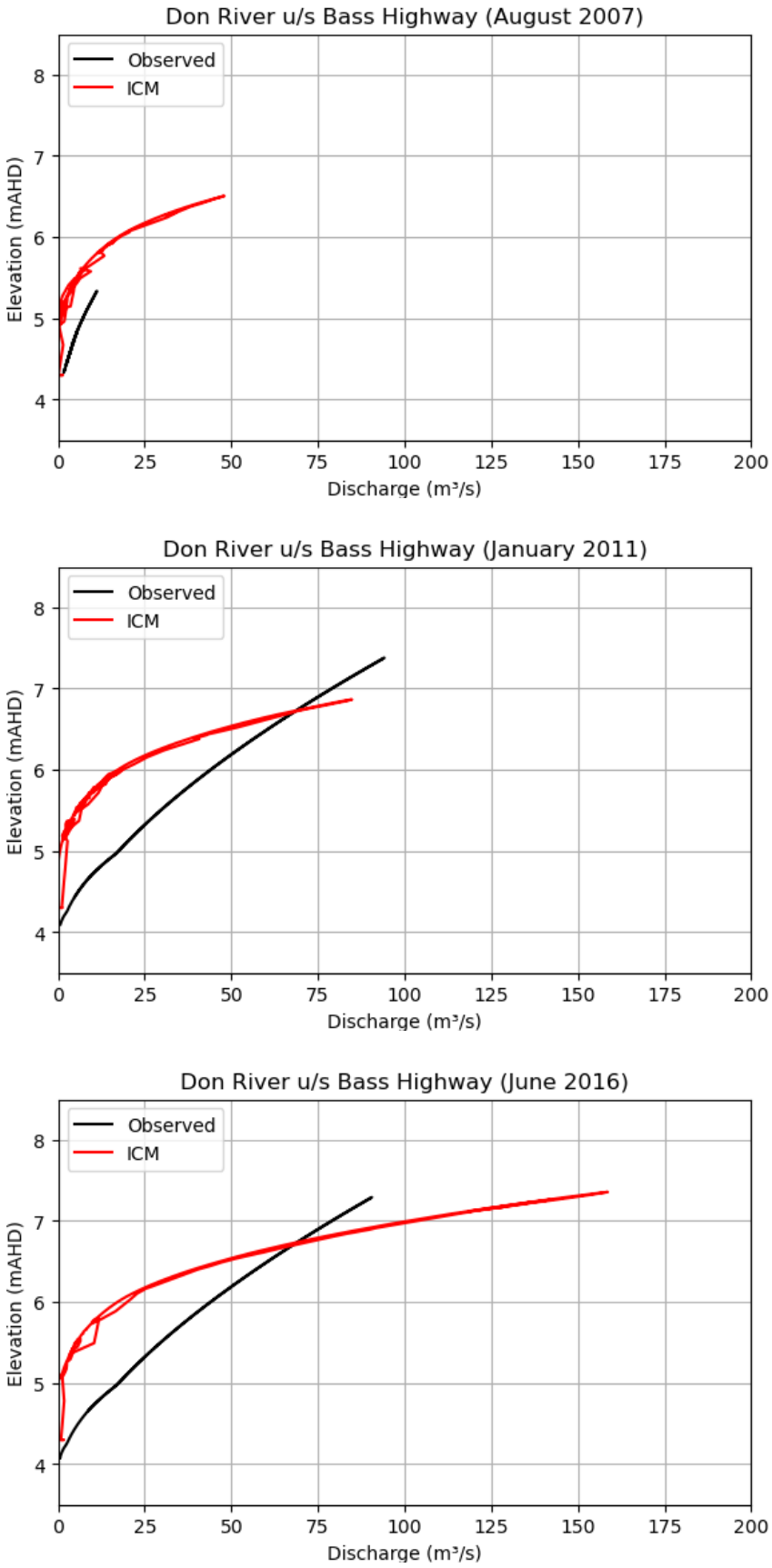


Figure D 7: Rating curve comparison at Don River u/s Bass Highway