STATE EMERGENCY SERVICE

TASMANIAN STRATEGIC FLOOD MAP MUSSELROE-ANSONS STUDY AREA MODEL CALIBRATION

REPORT

MARCH 2023

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Project Tasmanian Strategic Flood Map Musselroe-Ansons Study Area Model Calibration	**Project Number** **120038**
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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
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 Musselroe-Ansons study area.

2. STUDY AREA

The Musselroe-Ansons study area is situated in the far north-east of Tasmania. The study area includes three main rivers: Great Musselroe River, Little Musselroe River and Ansons River. The Icena is the major tributary to Great Musselroe River and Big Boggy Creek is the major tributary to the Ansons River. The study area also includes several smaller watercourses that discharge directly into the Tasman Sea. Approximately one fifth of the study area is in the Mt William National Park which covers most of the coast from Musselroe Bay to Ansons Bay, and an inland area in the Ansons River catchment.

The Ansons River’s headwaters rise in the south of the study area at Murdochs Hill, flowing north and meeting Big Boggy Creek approximately 7km upstream of where it discharges into Ansons Bay. The lower section of the river passes through steep sided river valleys. The Great Musselroe River rises in very steep terrain on the western slopes of the Blue Tiers, and soon flattens out flowing north to Musselroe Bay. Little Musselroe River catchment covers the northern end of the study area and the river flows through largely flat landscape to Little Musselroe Bay close to the north-eastern tip of Tasmania. The entire study area is scarcely populated and has a mixture of forested areas, mostly in the south, and large agricultural areas mainly in the north. There are only small communities in the study area, with no major population centres. There are small settlements at Rushy Lagoon and at several places along the coast such as Ansons Bay and Great Musselroe Bay, all with populations of less than 50 people each.

Large floods in the study area include the January 2004 and January 2011 flood events.

The Musselroe-Ansons study area has an area of 994 km^2. The Great Musselroe catchment covers 493km^2, and the Ansons covers 260 km^2. The Musselroe-Ansons study area and the available gauge information are shown in Figure 1. Landuse in the study area is shown in Figure 2.

3. AVAILABLE DATA

3.1. Historic Flow Data and Level Data

There is only one active gauge in the Musselroe-Ansons study area. This is the Ansons River downstream Big Boggy Creek Gauge. There was a historical gauge on the Great Musselroe River operating from late 1969 until 1989, however it was only operating for one of the 13 calibration events selected for this project, and that was not a significant event at this gauge. The Ansons River gauge is operated by DPIPWE, and gauge information is shown in Table 1. The largest event on record (Jan 2004) was added as an additional calibration event for this study area (WMAwater 2021d). The January 2011 event was the second largest on record.

Table 1: Flow gauges

Gauge attribute	Ansons River DS Big Boggy Ck
Gauge number	2214-1
Gauge abbreviated name	Ansons River gauge
Start date	23/05/1979
End date	Current
Latitude	-41.04
Longitude	148.21
High flow rating quality	Original DPIPWE rating considered poor for high flows. Theoretical rating developed using local hydraulic model.
Used for calibration	Yes
Assumed local datum 0m in AHD	7.06
Highest Gauged Level (m local datum)	1.97
Highest recorded stage height (m local datum)	5
Highest recorded flow (m^3/s)	470*
Highest recorded stage height date	28/01/2004
Highest recorded flow date	28/01/2004

* Based on original DPIPWE rating, not revised rating

3.1.1. Calibration Event Data Availability

Significant flows were recorded in the catchment area for only one of the 13 flood events selected by the Bureau as calibration events for this project, therefore an additional event was selected (WMAwater 2021d). The largest two events on record were used for calibration at the Ansons River gauge, with estimated AEPs rarer than 5% (Table 2).

Table 2: Summary of the largest events in the Musselroe-Ansons study area

Event name	Used for calibration	Event peak flow (m^3/s) (location)
2004_Jan	Yes	377 (Ansons River)
2011_Jan	Yes	347 (Ansons River)

3.1.2. Rating Curve Quality

There has only been one gauging above the confines of the weir structure since the early 1990s at the Ansons River gauge. This was just below 2 m local datum which is much lower than the peak levels for the two calibration events, which were between 4.5 m and 5.0 m local datum.

The DPIPWE rating covering the period including the calibration events was markedly different to the most recent rating (
Diagram 1), which applied from February 2017. There is a comment in the rating tables that cease to flow changed for the most recent rating, but there is no further information. The largest gauging since 2010 was at 11 m^3/s in 2016, and the largest gauging in the most recent rating period was 1.8 m^3/s.

To improve the quality of the high flow rating for Ansons River gauge, a theoretical rating was developed using a local hydraulic model (WMAwater, 2021c, Figure D 1). This rating has been used in calibration, noting that it was applied for the period prior to the most recent rating change, where it is possible that there was some change in the gauge site.

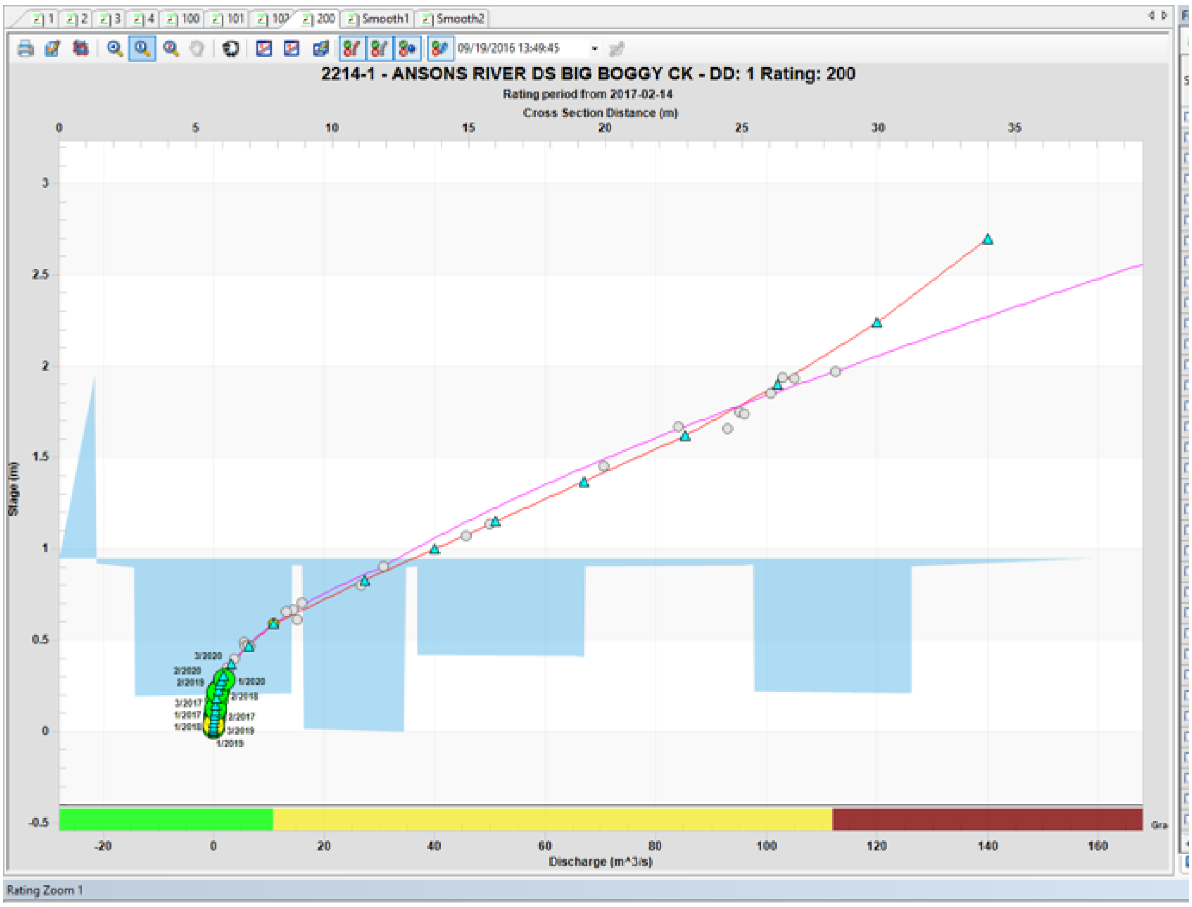

Diagram 1: Ansons River DS Big Boggy Creek DPIPWE ratings. Most recent rating in red.

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 (accum). 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 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 Musselroe-Ansons study area (see Data Review Report WMAwater (2020) for details on calibration events). Some study areas were identified as having insufficient coverage by these 13 events so additional calibration events were derived. This included the January 2004 event in this study area (WMAwater, 2021d).

The AWS and pluvio data were found to be more consistently reliable. 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.

There are two sub-daily rain gauges within the Musselroe-Ansons study area, however data at the Larapuna gauge is available for the 2011 event only. The other gauge is Swan Island which is off the coast in the far north-east of the study area. Therefore, St Helens Aerodrome, just over 15 km south of the study area has a significant influence on the temporal patterns derived over the study area. A steep rainfall gradient is observed during some high rainfall events in the study area, with coastal gauges and gauges inland to the west often recording very different totals, so the lack of sub-daily rain gauges may be problematic for modelling event totals or timing for this area. A summary of the rain gauges and rainfall totals for this study area is shown in Table 3. The gauges in and around the Musselroe-Ansons study area are shown in Figure 1.

Table 3: Available Rainfall Information

	January 2004	Jan 2011
Number of Sub-daily Stations Available within the study area	1	2
Number of daily Stations Available within the study area	4	2
Number of sub-daily surrounding gauges ~15km	0	0
Number of daily surrounding gauges ~15km	6	7
Rainfall Totals	170-230 mm	110-240 mm
Approx duration of rainfall event (hours)	72	48

*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 2021a 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 4.

3.3. Dam information

There are no major dams in this study area.

3.4. Flood Levels and Extents

There was no information about flood levels or extents provided for this study area. Calibration performance was therefore assessed at gauges only.

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 (if necessary)
  - Adjust routing parameters values in both external and ICM RAFTS hydrologic model if necessary, 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 the gauges (where available). 2 m DEM subsets were available at the gauge location (Refer to Table 1) in the catchment, with the SES state-wide 10 m DEM used at the remaining area. 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 (Diagram 2), was then imported into ICM via the grid import interface.

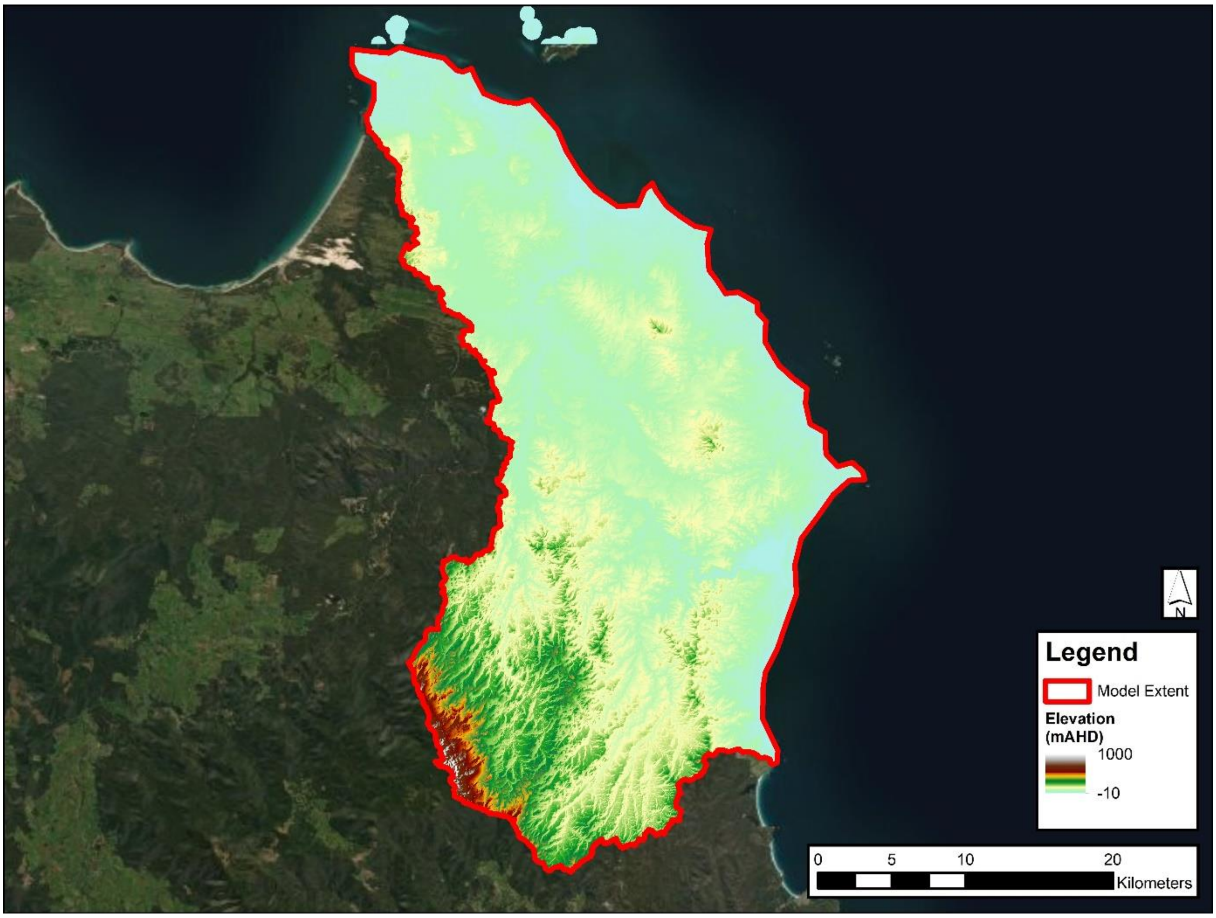

Diagram 2: DEM of the Musselroe-Ansons study area

The 'Default DTM' is understood to be based primarily on photogrammetric contour data and this was the basis for the DTM in a large area covering the lower reaches of the catchment (Diagram 3). The 'Default DTM' is therefore likely to be a poor representation of the topography of the area. Additionally, it is understood that the 'Default DTM' provided for the modelling was pre-processed to include the estimated bathymetry of watercourses. Review of the DEM highlighted that the channel is restricted where there are gaps in the LiDAR DTM and there are areas of significant floodplain storages where the Default DTM was used, which do not appear to match the aerial imagery. In particular there is a small gap (~200m) in the LiDAR DEM upstream of the Anson's gauge which had a narrower channel and higher ground level that impacted on modelled flows at the gauge site. Therefore, channel modifications were applied to lower and broaden the channel through the small area of the default DTM (Diagram 4). However, it is not practical within the scope of this study to improve the DEM over the whole part of the study area where the default DTM was used. Similar issues will therefore exist throughout that part of the study area (Diagram 5).

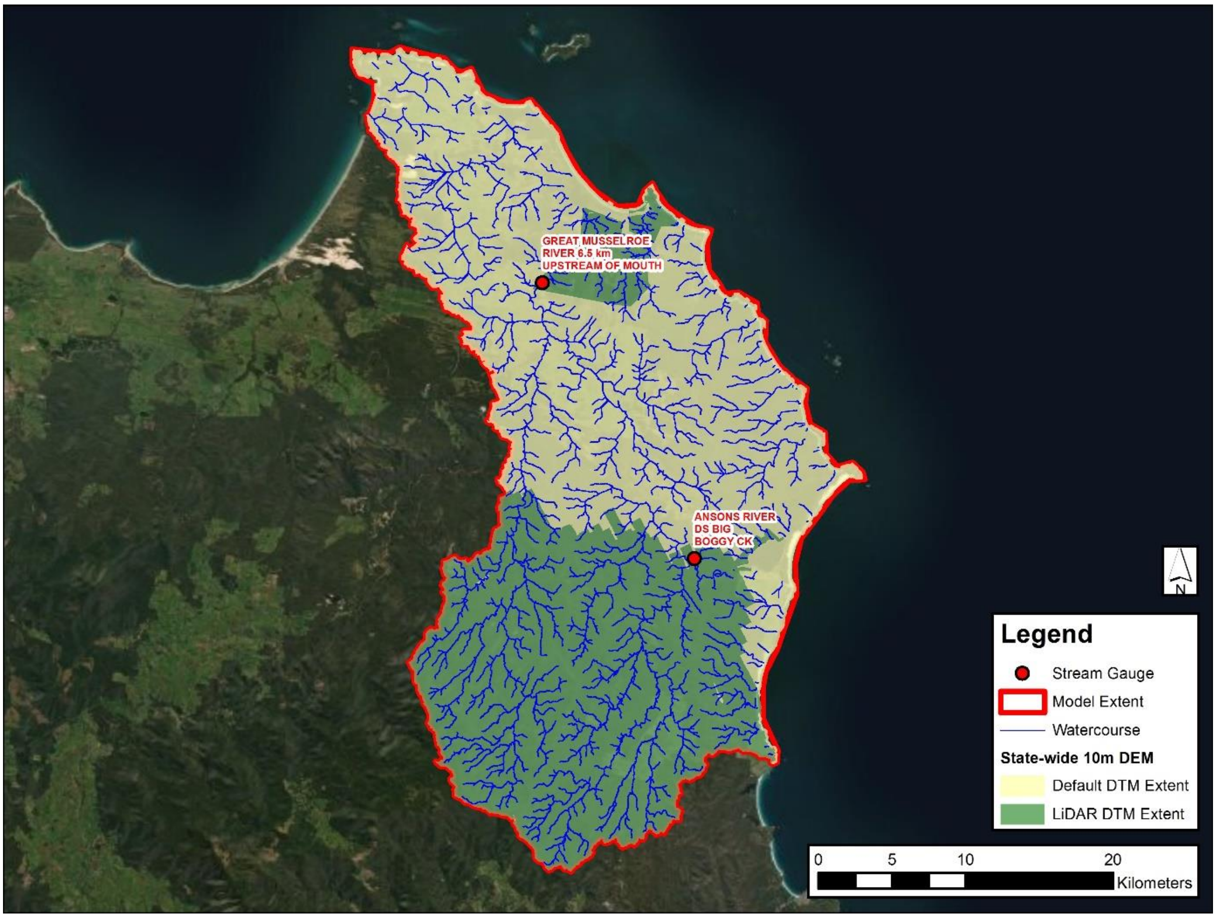

Diagram 3: ‘Default DTM’ extents for the Musselroe-Ansons study area

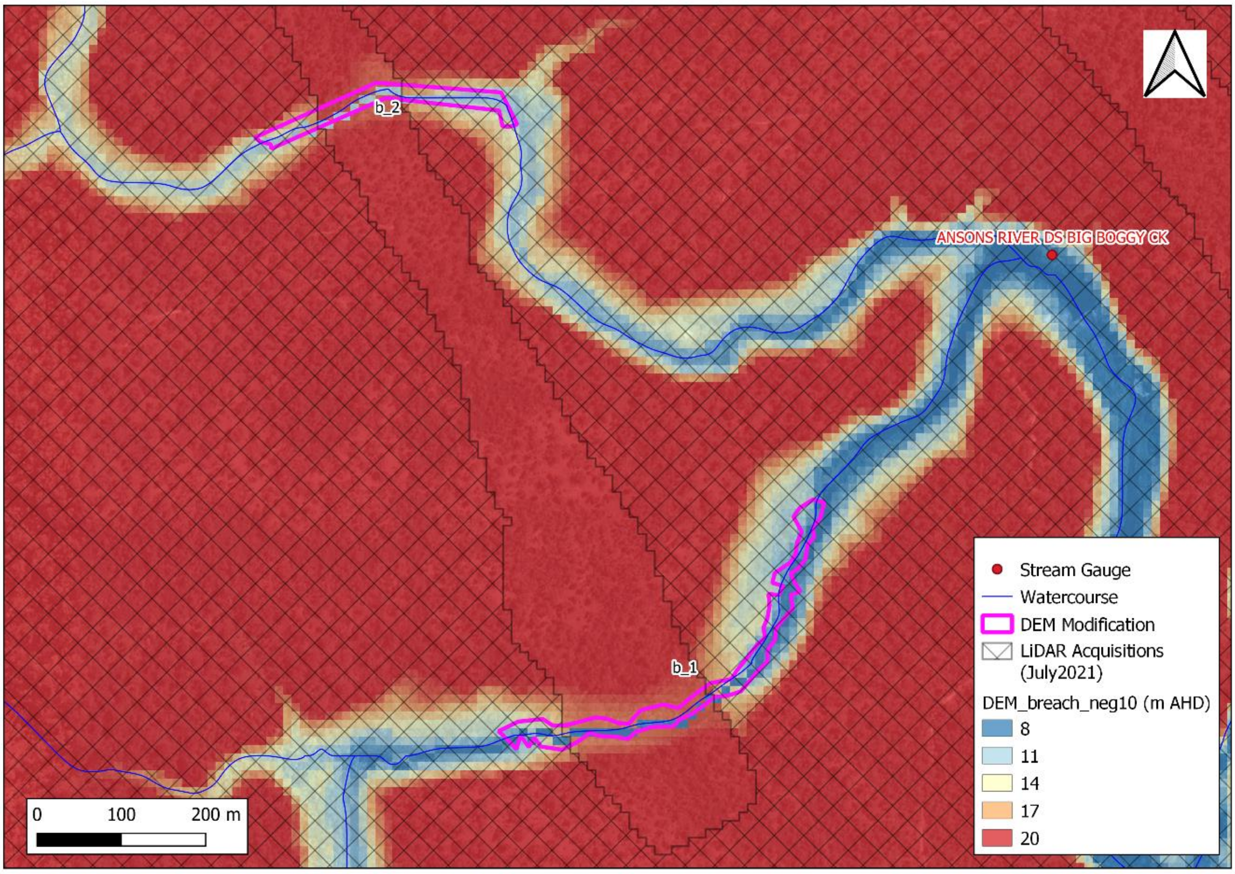

Diagram 4: DEM issues at upstream of the Anson's gauge with outline of area modified.

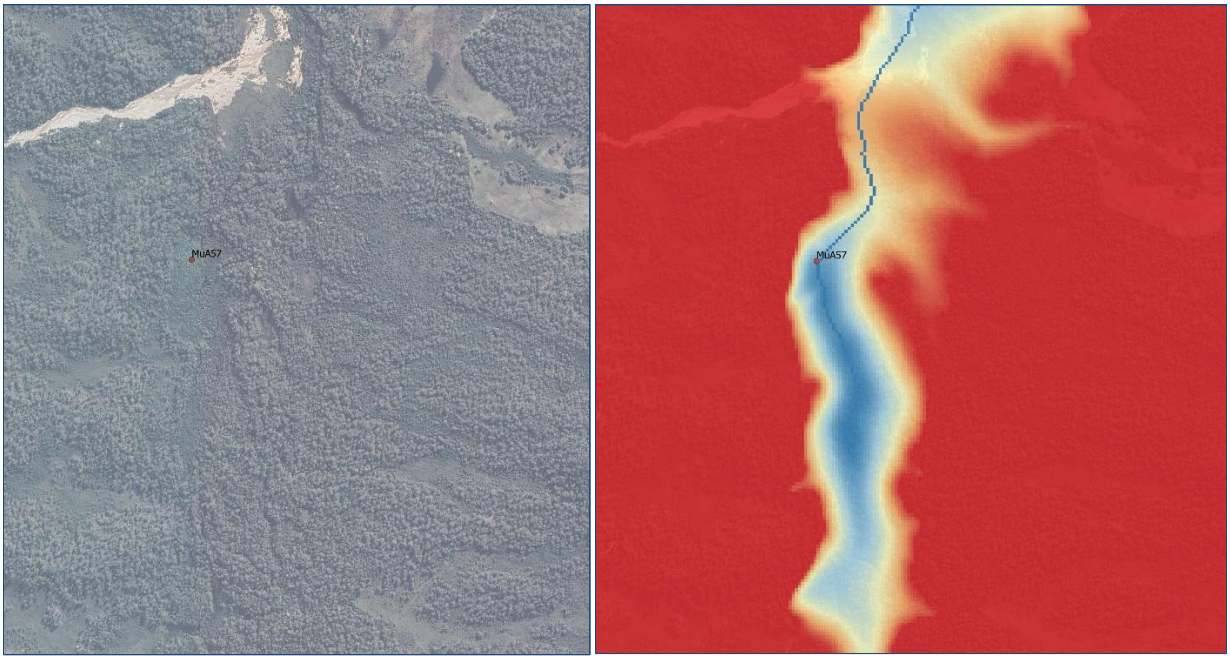

Diagram 5: Example of possible artificial storages in the default DTM area.

5.2. Roughness

The base information for the roughness grid was the roughness raster provided by SES for this project. The whole of state dataset was converted to a set of polygons for each land use zone in GIS, and the dataset was cleaned to ensure that the geometry was valid. This data was then exported as a csv file to link land use to friction values.

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 30 m buffered zone of single roughness of 0.05 for all upper streams was utilised. 0.05 was selected as in the upper reaches the computation of levels in triangles also results in artificial attenuation of flow and thus a slightly lower value than the norm was utilised.

The lagoon below Anson River gauge was identified as wetlands (0.035) in the provided land use zone. However, it was changed to the roughness of water bodies (0.011) after inspecting the area on Google imagery. In addition, the channel roughness was reduced from 0.05 (default) to 0.02, approximately 1 km above and 5.5 km below the Anson River gauge.

The roughness layer in ICM is shown in Diagram 6.

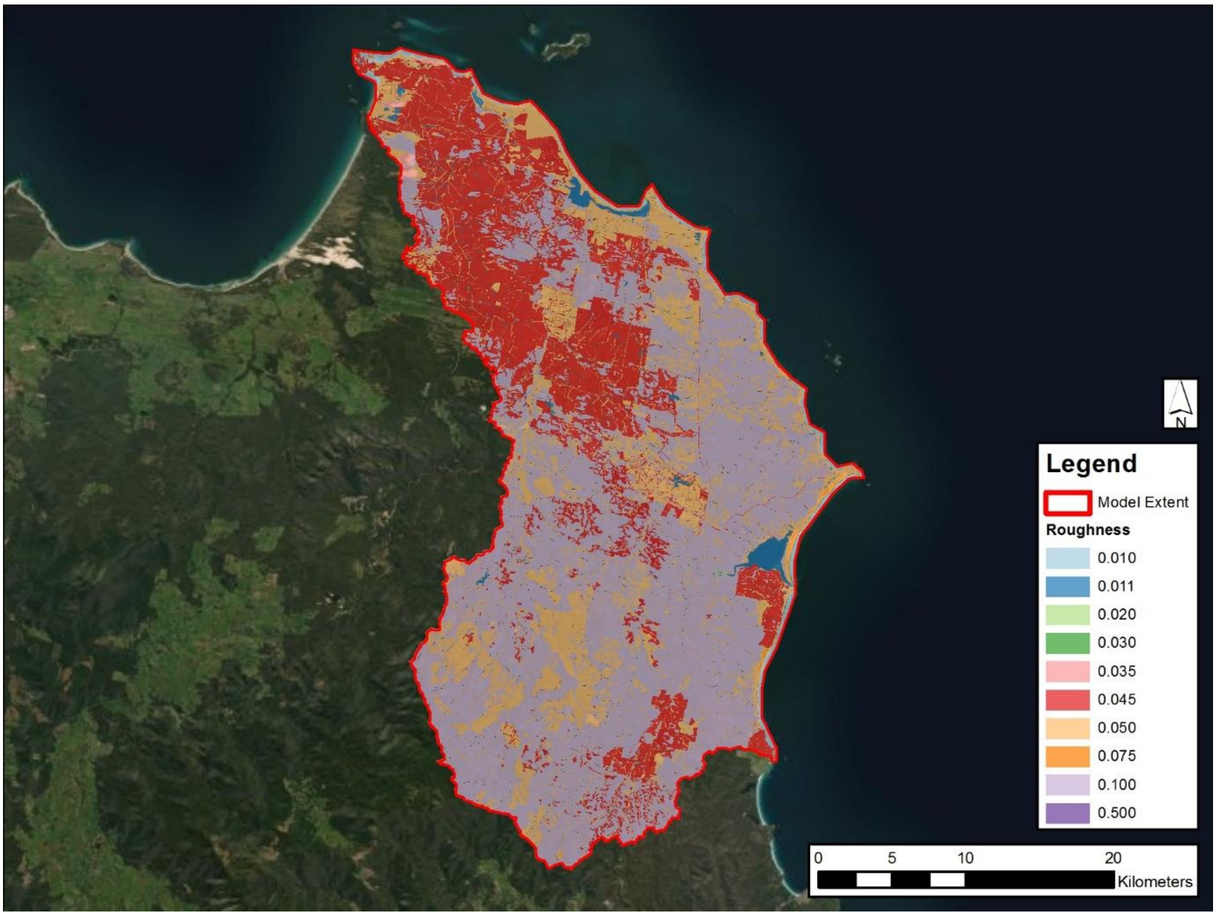

Diagram 6: Roughness layer for the Musselroe-Ansons study area

5.3. Meshing

Meshing in ICM was undertaken using zones, with the following rules:

- Base 2D zone – regional extent mesh size set to a maximum of 2500 m^2 with a minimum of 400 m^2
- Stream zone – set as an independent area with a maximum mesh size of 400 m^2 and a minimum of 100 m^2
- Human Settlement Area – set as an independent mesh zone with a maximum area of 100 m^2 and a minimum of 25 m^2
- Upper stream reaches – streamlines of Strahler order 2-5 were buffered by 10 m either side of the centre line with Strahler order 6-8 buffered by 20 m either side of the centre line and incorporated into the hydrodynamic model as a mesh zone. The mesh zones had a maximum area of 150 m^2. This process was undertaken to ensure that the meshing process did not result in artificial blocking of the flow paths along main stream lines.

Within the stream mesh zones, where LiDAR was present, upper stream mesh zone polygons were run through these zones (refer Diagram 7). This was done as there were some areas with very narrow channels in the stream mesh zone layers provided. Incorporation of the higher resolution upper stream mesh zones ensures more appropriate conveyance of flow through the zone. The resulting mesh zones for the Musselroe-Ansons study area are shown in Diagram 7.

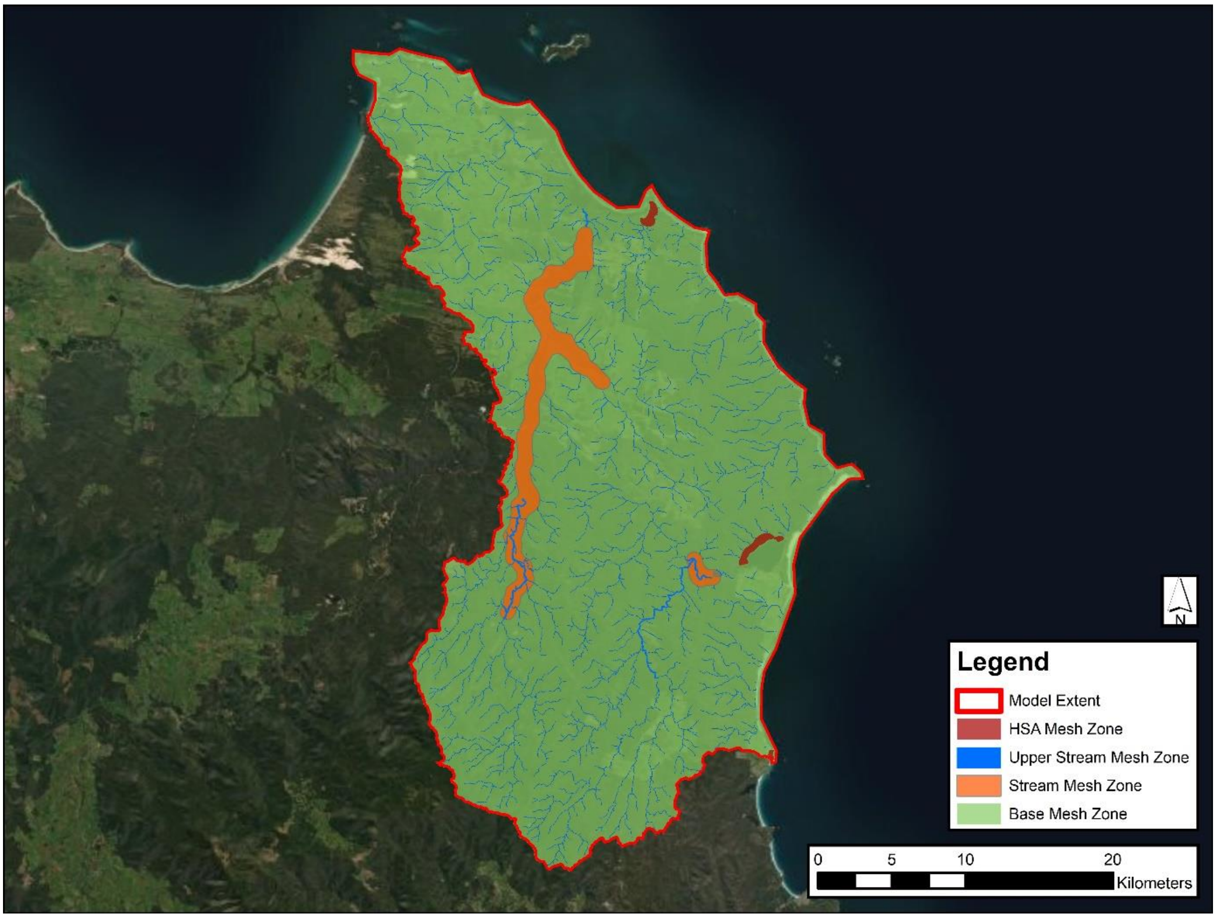

Diagram 7: Mesh zones for the Musselroe-Ansons study area

5.4. Structures

Bridges are represented within the ICM model as linear 2D bridge structures, using the SES state-wide bridge database for location and reach of associated structures.

For the Musselroe-Ansons study area 2 bridges longer than 30 m were identified and imported into the hydrodynamic model. These were at the following locations:

- Musselroe-Ansons River near Branxholm at Tasman Highway
- Musselroe-Ansons River at Derby Back Road

Further discussion on this process is provided in the Hydrodynamic Modelling Methods Report (WMAwater, 2021b).

No major culverts were identified.

5.5. Dams and Storage areas

There are no major dams in the study area that are explicitly modelled.

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 original 13 calibration events and this was used to set a varying tide level for these calibration events. This data was extracted off the coast of Eddystone Point at 10 min time increments and was imported into ICM as a time varying boundary condition. Synthetic tide data was not available for the January 2004 event as it was selected as a calibration event at a later stage (Section 3.2), therefore observed tide data from the Burnie gauge was used for this event (BOM 2021). Diagram 8 and Diagram 9 show examples of the observed and synthetic tide data for the January 2004 and the January 2011 events respectively.

Note that there is no calibration information to verify the function of the tailwater condition, thus no allowance for local storm effects was undertaken. It is considered that the synthetic tide and observed tide data are a reasonable estimation of tailwater levels for the purposes of this calibration assessment.

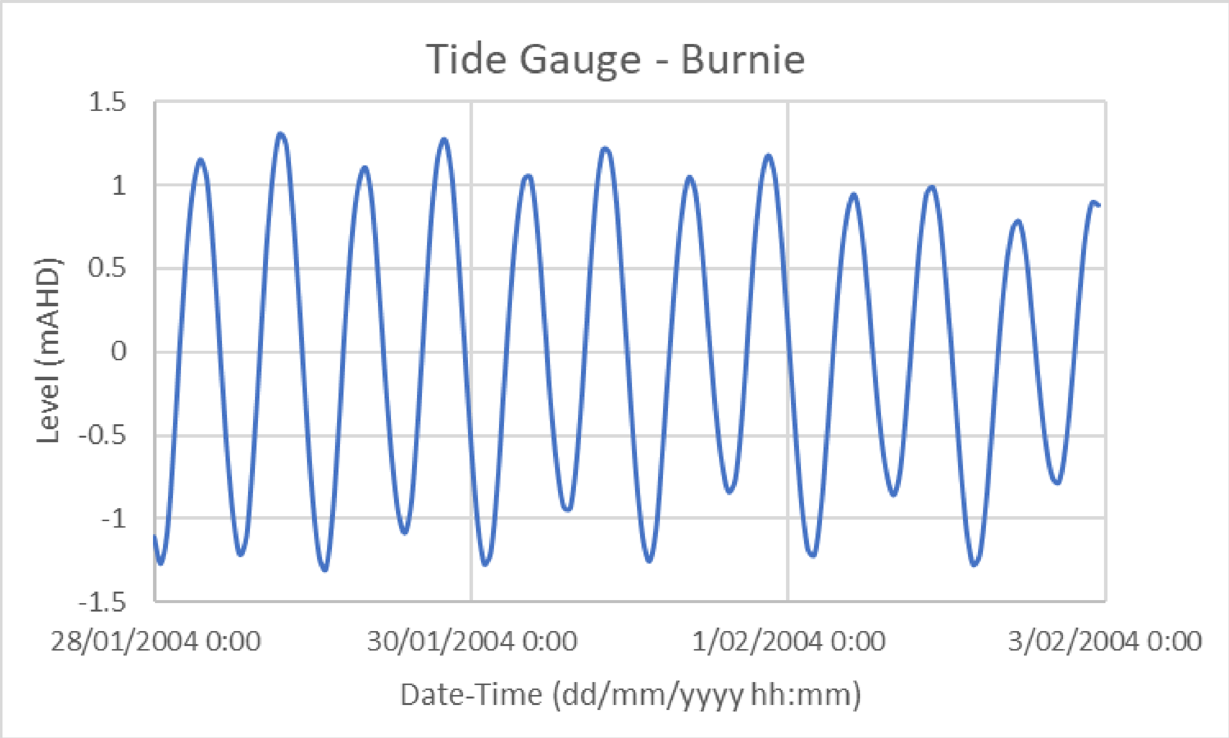

Diagram 8: Burnie Tide gauge data for the January 2004 calibration event

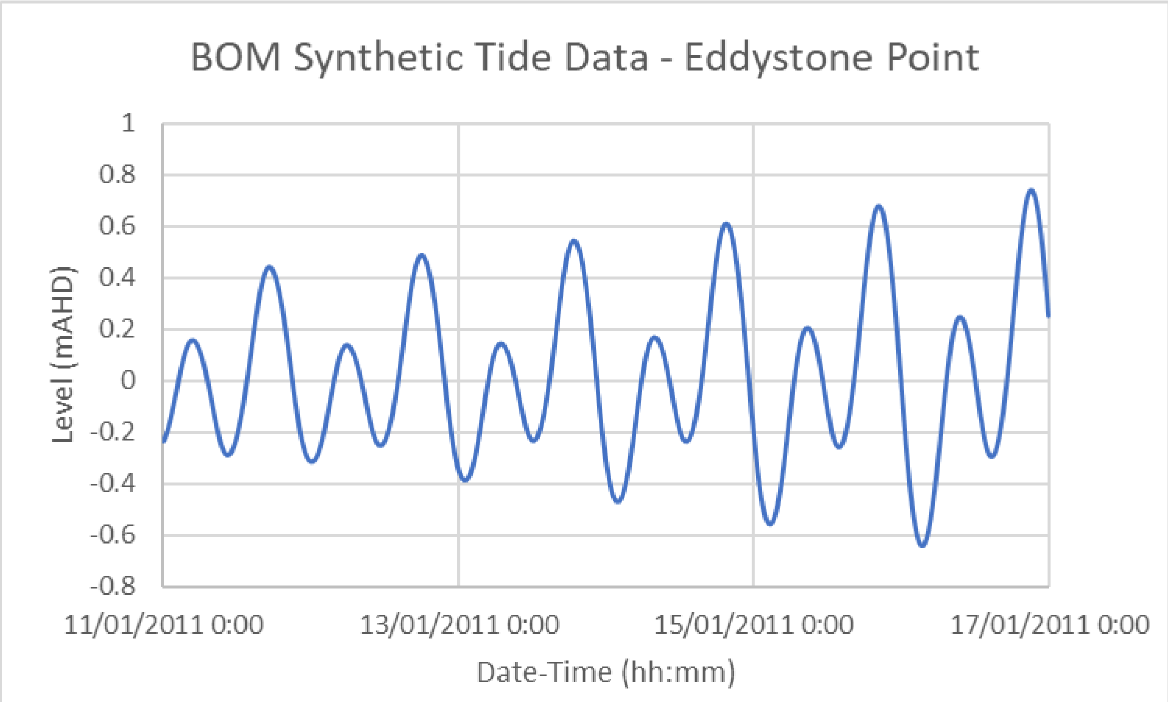

Diagram 9: Synthetic tide data off the coast of Eddystone Point for the January 2011 calibration event

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, 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 RAFTS sub-catchment model setup in ICM for the Musselroe-Ansons study area is shown in Diagram 10. 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.

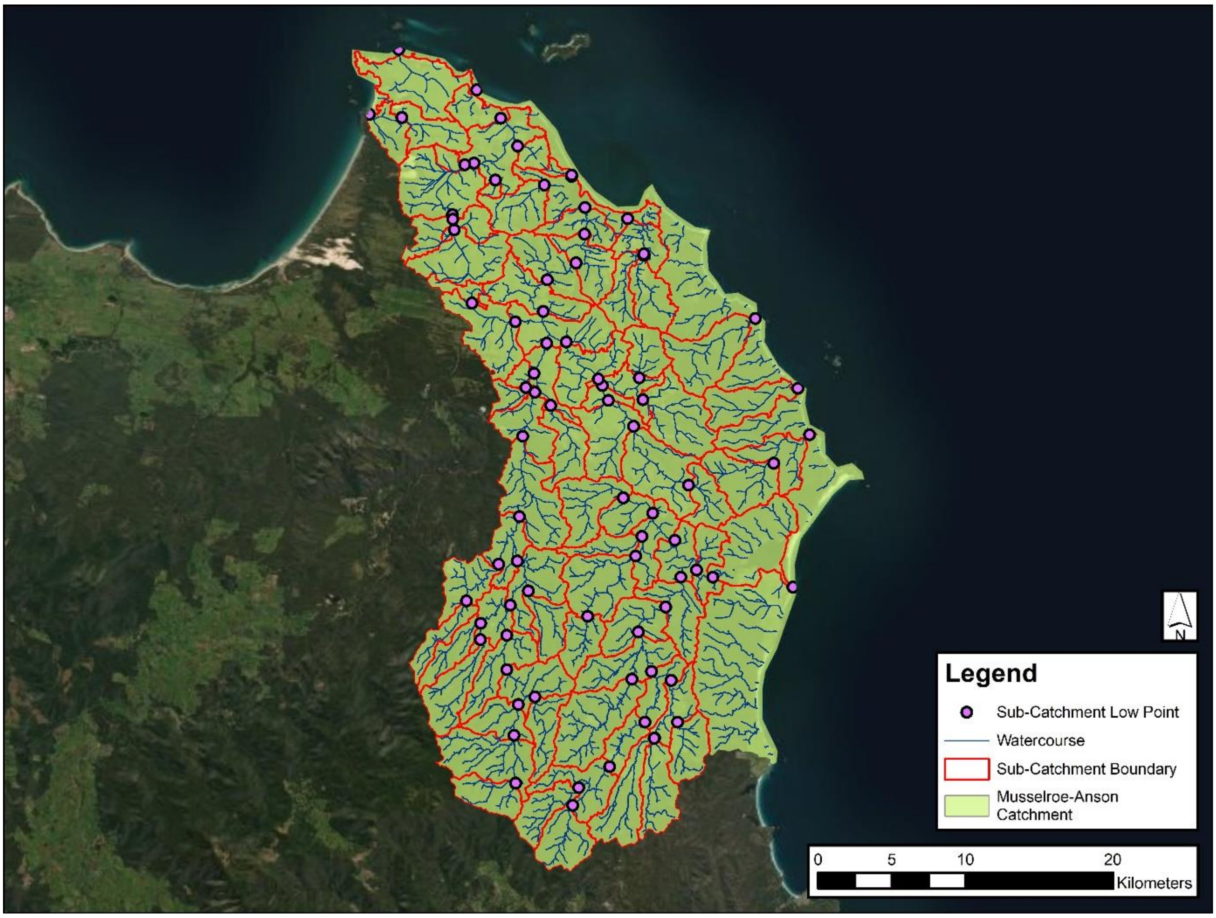

Diagram 10: RAFTS sub-catchment model setup in ICM for the Musselroe-Ansons study area

6. CALIBRATION RESULTS

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 for each calibration event.

The calibrated loss parameters are summarised in Section 6.3.

No changes were required to the RAF routing parameter from the external hydrologic model for this study area. Upon completion of the calibration assessment the external hydrologic model and the ICM model flow results were compared to ensure results were comparable. A summary of this review is presented in Appendix C.

6.2. Initial Conditions

Prefilling of the model was not undertaken for this study area. It is not proposed to pre-fill the model for design events based on the outcomes of this assessment. Without prefilling, some artificial depression storage occurs due to lumpiness in the DTM, however this does not impact on the core part of the hydrograph around the event peak.

6.3. Results

Mapping of the peak flood depths from the calibrated ICM model for each calibration event can be found in Figure 5 and Figure 6.

6.3.1. Ansons River ds Big Boggy Creek

The modelled peak flows for the two calibration events at the Ansons River ds Big Boggy Creek gauge show a good match to the recorded peak flow (Table 4). The modelled hydrograph also shows a good match in terms of timing however does not replicate the second peak in the January 2004 event, as shown in Diagram 11. This is likely to be due to the available rainfall data being unrepresentative of the rainfalls over the study area, noting that only one sub-daily raingauge was operating within the study area for this event. The model shows a good match to timing and shape to the recorded hydrograph in the January 2011 event, as shown in Diagram 12.

Table 4: Calibrated parameters and discharge at Ansons River ds Big Boggy Creek

Statistic	2004 Jan	2011 Jan
IL (mm)	59	75
Average CL (mm/h)	0	0.86
Modelled Peak (m^3/s)	409	370
Observed Peak (m^3/s)	377	347
Peak % difference	8%	7%
Modelled Volume (ML)	29,026	18,693
Observed Volume (ML)	37,775	18,448
Volume % difference	-23%	1%
Modelled peak (mAHD)	13.41	13.04
Observed peak (mAHD)	12.06	11.83
Peak difference (m)	1.35	1.21

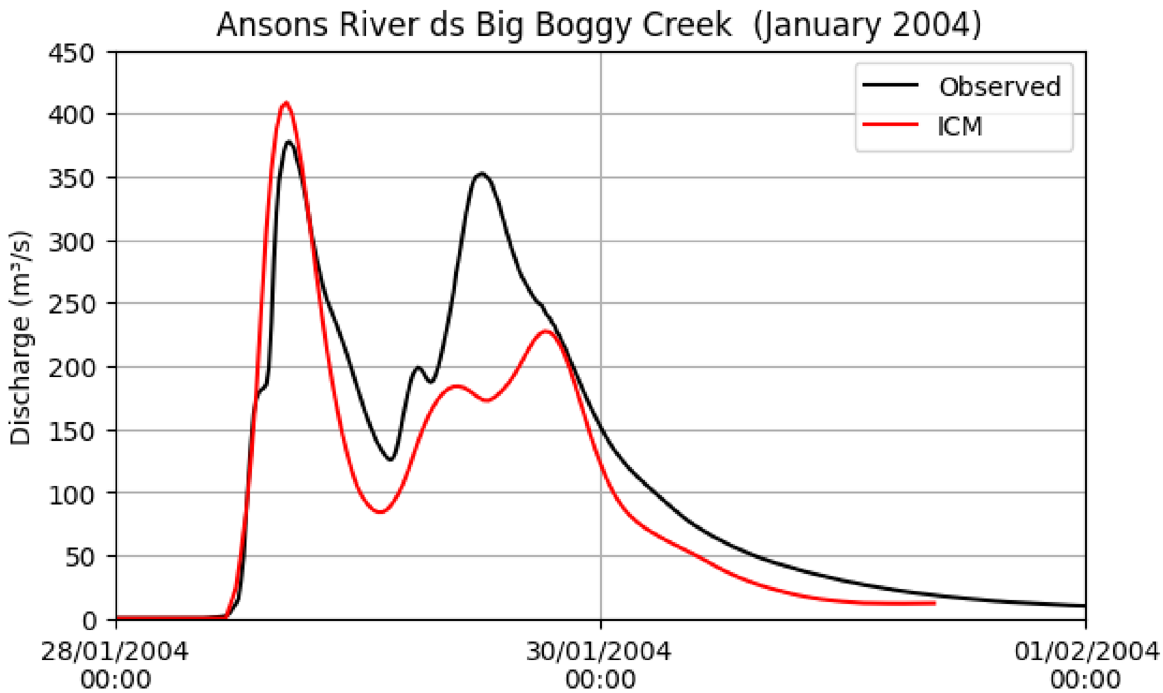

Diagram 11: January 2004 flow comparison at Ansons River ds Big Boggy Creek

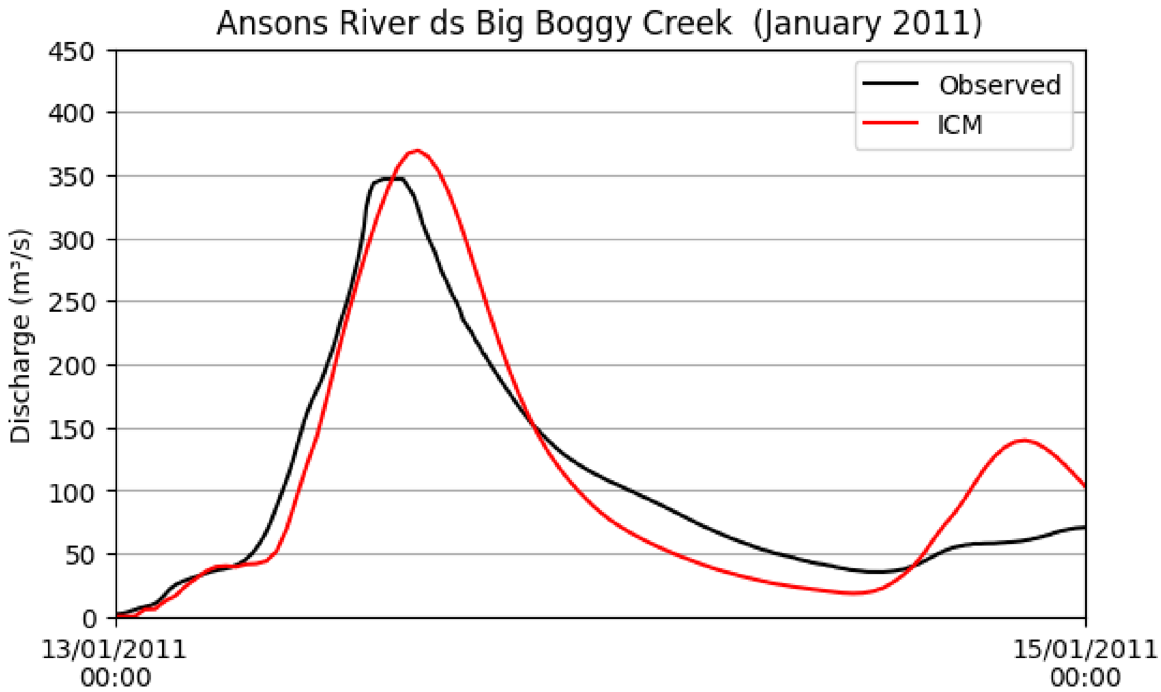

Diagram 12: January 2011 flow comparison at Ansons River ds Big Boggy Creek

Diagram 13 and Diagram 14 show the water level response for the calibration events at the gauge for the January 2004 and January 2011 events, respectively. A gauge zero was available from the DPIPWE database and this assumed gauge zero of 7.06 mAHD was used.

A poor match to level was achieved at this location. A review of the location shape and characteristics indicate the gauge is likely to be poorly represented in the mesh. In order to confirm this the 2011 event was run with a higher resolution mesh zone (50 m^2 maximum mesh size). The results of this assessment are presented in Diagram 15. From this review it is apparent that in this instance a smaller mesh size results in a much-improved replication of level at the gauge.

It is proposed that the higher resolution mesh zone at the gauge is utilised for design modelling to ensure a good replication of level at the gauge, noting that this mesh resolution is greater than the methodology prescribed (WMAwater, 2021b).

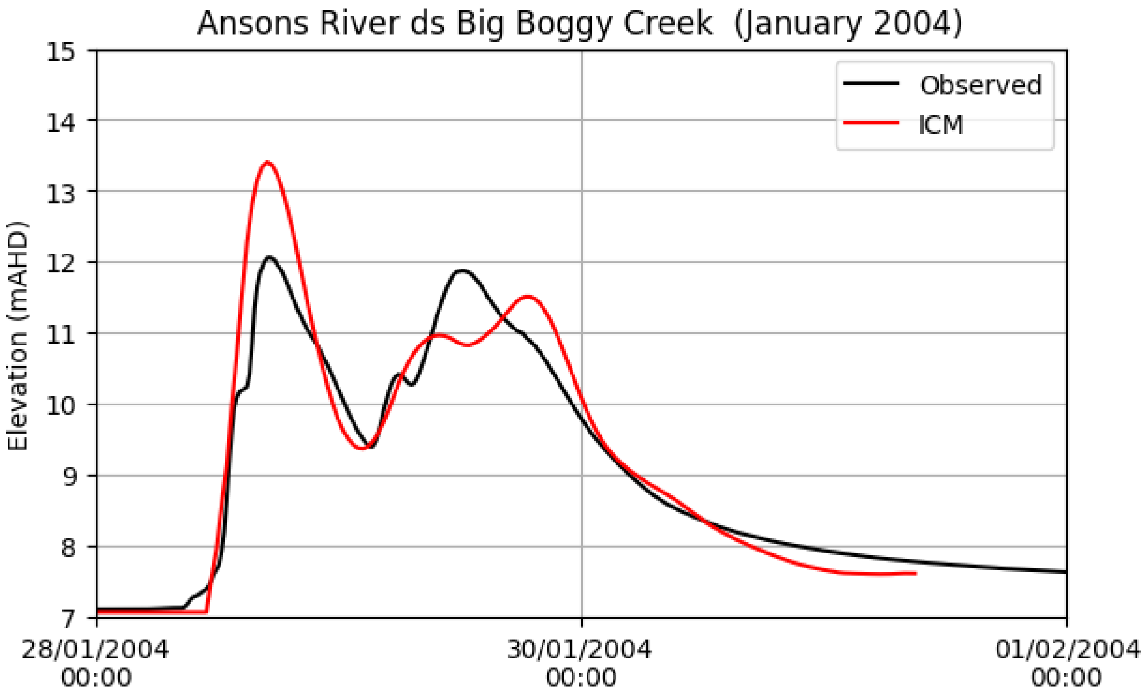

Diagram 13: January 2004 water level comparison at Ansons River ds Big Boggy Creek (assumed gauge zero)

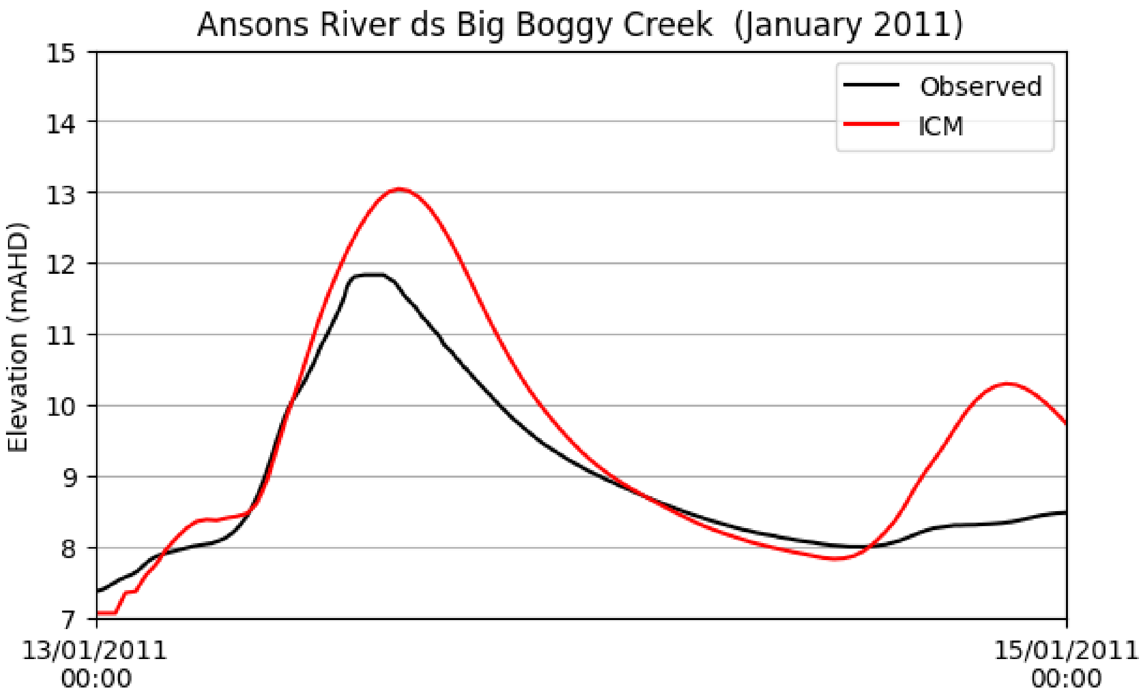

Diagram 14: January 2011 water level comparison at Ansons River ds Big Boggy Creek (assumed gauge zero)

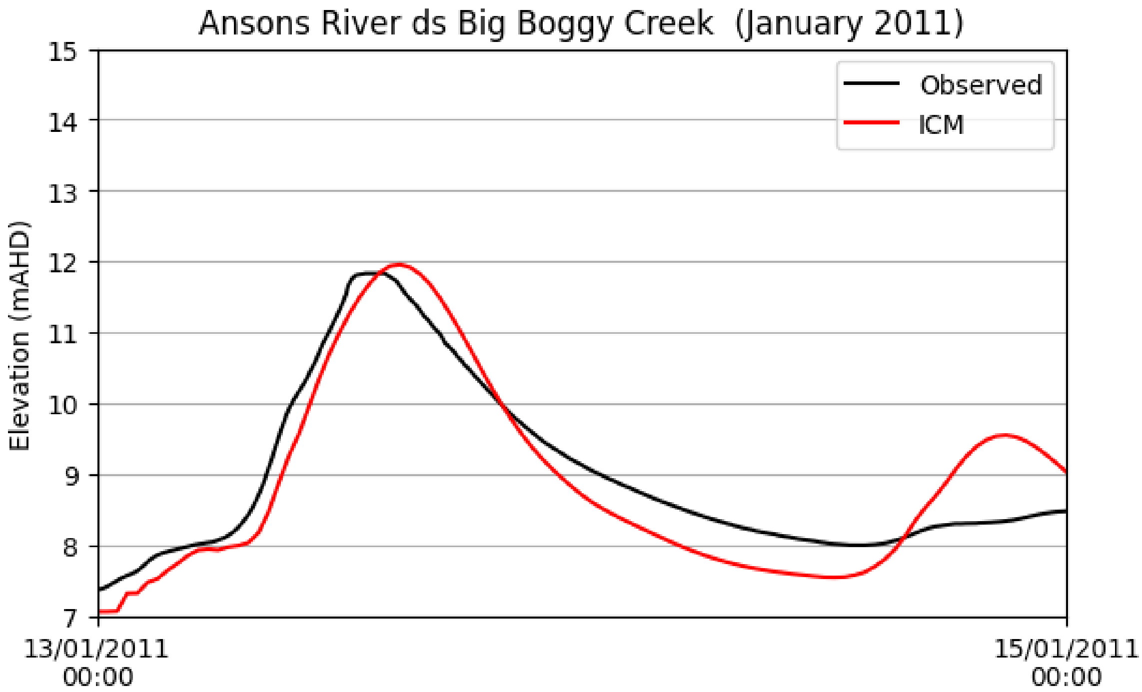

Diagram 15: January 2011 water level comparison at Ansons River ds Big Boggy Creek with higher mesh resolution (assumed gauge zero)

6.4. Identified Issues

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

- The DEM in a large area of the catchment is limited to the 'Default DTM' of the state-wide 10 m DEM. Based on the observations at the Ansons River gauge, it is expected that there will be a poor representation of flooding in these areas until such that time that improved topographic data is made available.
- The gauge is likely to be poorly represented at the default resolution of the mesh. It is proposed that the higher resolution mesh zone at the gauge is utilised for design modelling to ensure a good replication of level at the gauge. Whilst this will improve levels at the gauge site, the same issues are likely to be present in other modelled areas.
- There are known to be high rainfall gradients in large rainfall events in this study area and there is only a sparse rain gauge network. It likely that the calibration event rainfalls derived from the gauge data provide a poor representation of actual rainfalls over the study area. As the total modelled flow volume for the 2004 event is 23% lower than observed with no continuing loss, these rainfalls may be at least 25% lower than the true catchment average rainfall.

7. UNCERTAINTY ASESSMENT

Significant flows were recorded in the catchment area for one of the 13 flood events selected by the Bureau as calibration events for this project, in January 2011. An additional event in January 2004 was used for calibration in this study area.

Flow data was available at one gauge, Ansons River DS Big Boggy Creek, for the calibration events.

There were no flood extents or depths available in this catchment.

The uncertainty assessment for the modelling is shown in Table 5 and Appendix B.

Table 5: Uncertainty assessment for Musselroe-Ansons River catchment model

Category	Quality statement
Hydrology – rainfall input quality	The quality of the rainfall data is considered to be poor. There is only one sub-daily rainfall gauge with data available for the 2004 event and two for the 2011 event. There is known to be high rainfall gradients over the catchment.
Hydrology – observed flows	There have been some significant changes in the rating at Ansons River gauge site, and there are no high flow gaugings. The high flow rating was considered to be poor. A theoretical rating was developed using a local hydraulic model at Ansons River gauge and this rating has been used in calibration.
Hydrology – calibration events	The January 2004 and January 2011 events were the two largest on record at the Ansons River gauge.
Hydrology – calibration results	The hydrology calibration was considered to provide a very good match to peak flows at the Ansons River gauge. The modelled hydrograph did not capture the second peak of the 2004 event and the overall hydrograph fit was considered to be poor. This may be due to the sparse rainfall data available over the studyarea for this event.
DTM definition	The 2 m DEM provided by SES was utilised to inform levels within the catchment. In areas where discrepancies in the 2 m DEM were identified the 10 m DEM was used to inform a better approximation of ground level. The ‘Default DTM’, comprised primarily of photogrammetric contour data was the basis for the DEM in a large area covering the lower reaches of the catchment. The ‘Default DTM’ is likely to be a poor representation of the topography of the area.
DTM waterways	No bathymetric data was available and waterway definition was based on the LiDAR to water surface in areas where LiDAR data was available. Review of the DEM highlighted that the channel is restricted where in many areas covered by the Default DTM was used, which do not appear to match the aerial imagery.
Hydrodynamic – overall calibration results	The modelled water levels at the Ansons River gauge showed similar rates of rise to the observed, however the match to peak water levels was poor when modelled with the default mesh resolution.

Category	Quality statement
Hydrodynamic – calibration results, peak levels	Model calibration to peak levels at Ansons River gauge was considered to be poor, with differences of greater than 1 m when modelled with the default mesh resolution agreed for this project.
Hydrodynamic – calibration results, flood extents	No flood extents were available in this study area
Hydrodynamic – calibration results, flood depths	No flood depths were available in this study area

8. REFERENCES

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Figures

FIGURE 01
MUSSELROE-ANSONS STUDY AREA

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FIGURE 02
MUSSELROE-ANSONS STUDY AREA LAND USE

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FIGURE 3
MUSSELROE−ANSONS STUDY AREA
RAINFALL 2004_JAN

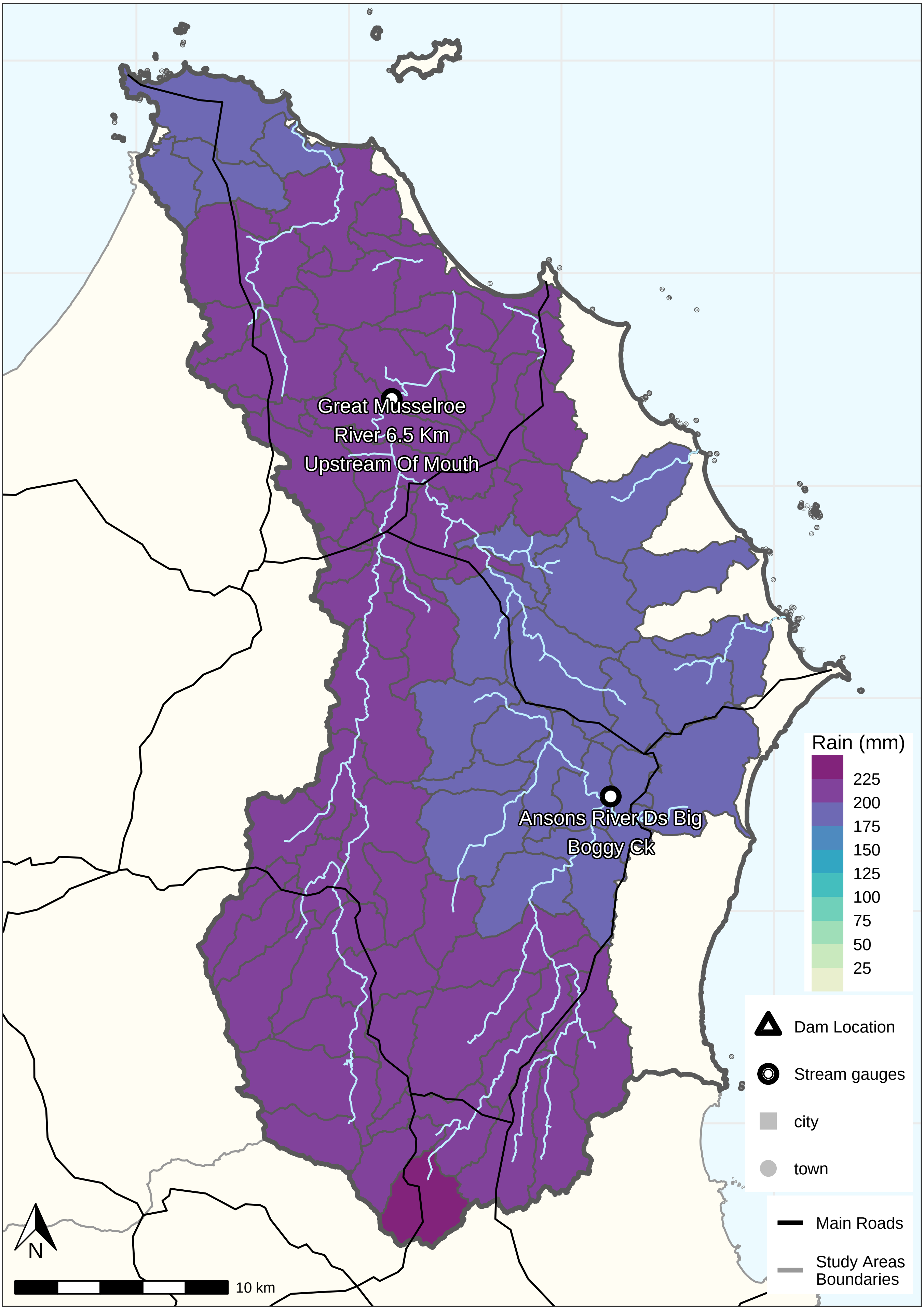

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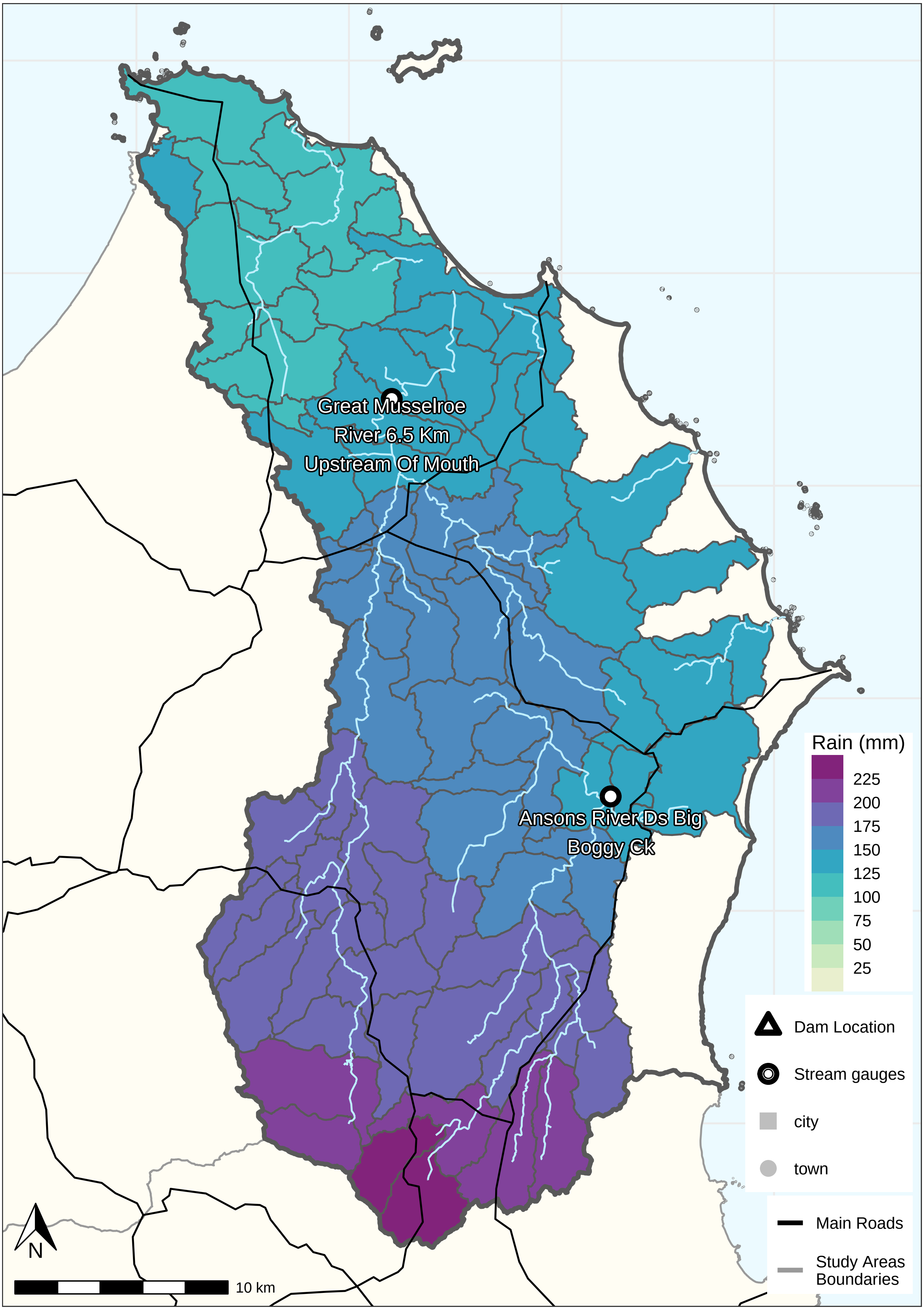
FIGURE 4
MUSSELROE−ANSONS STUDY AREA
RAINFALL 2011_JAN



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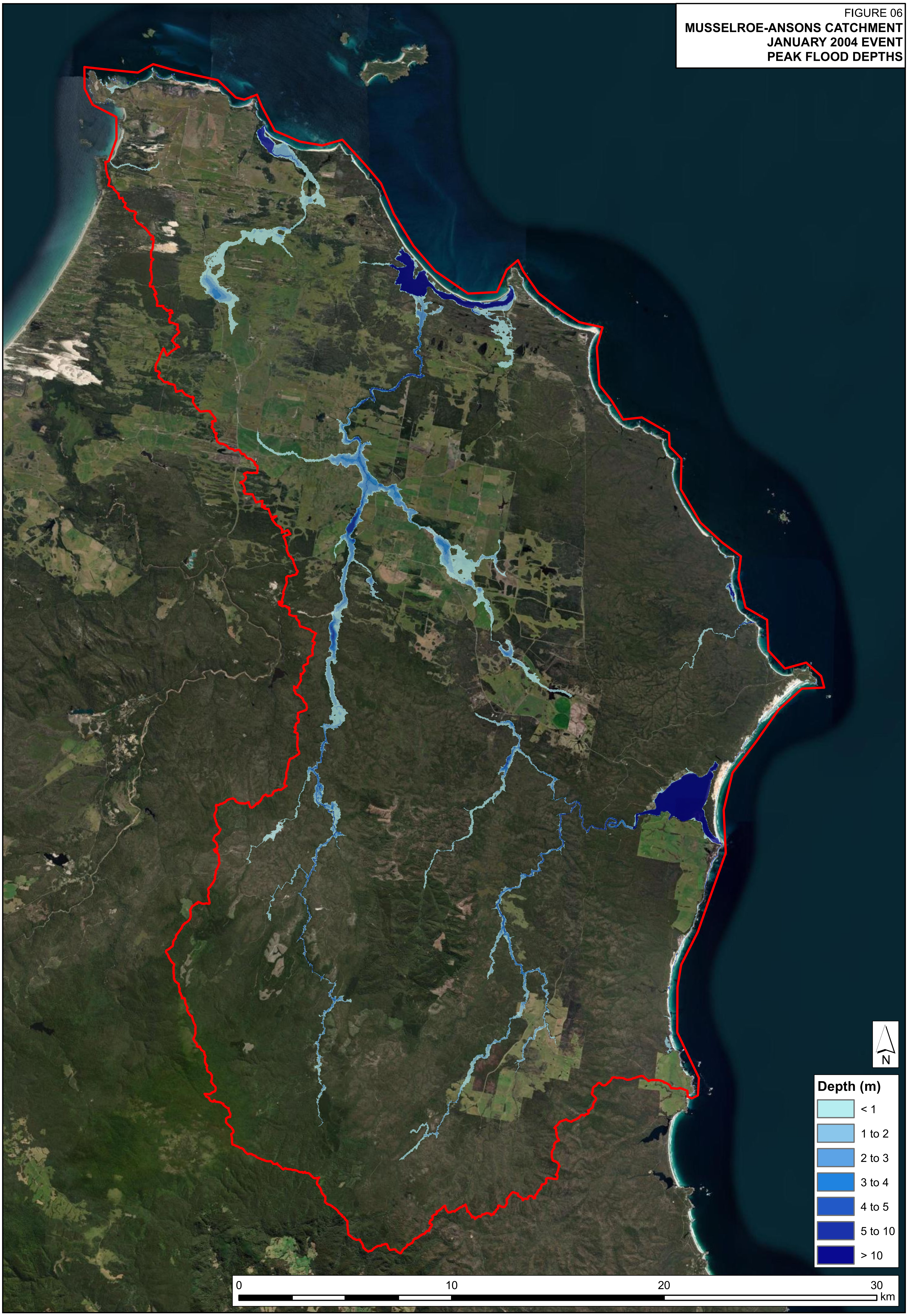

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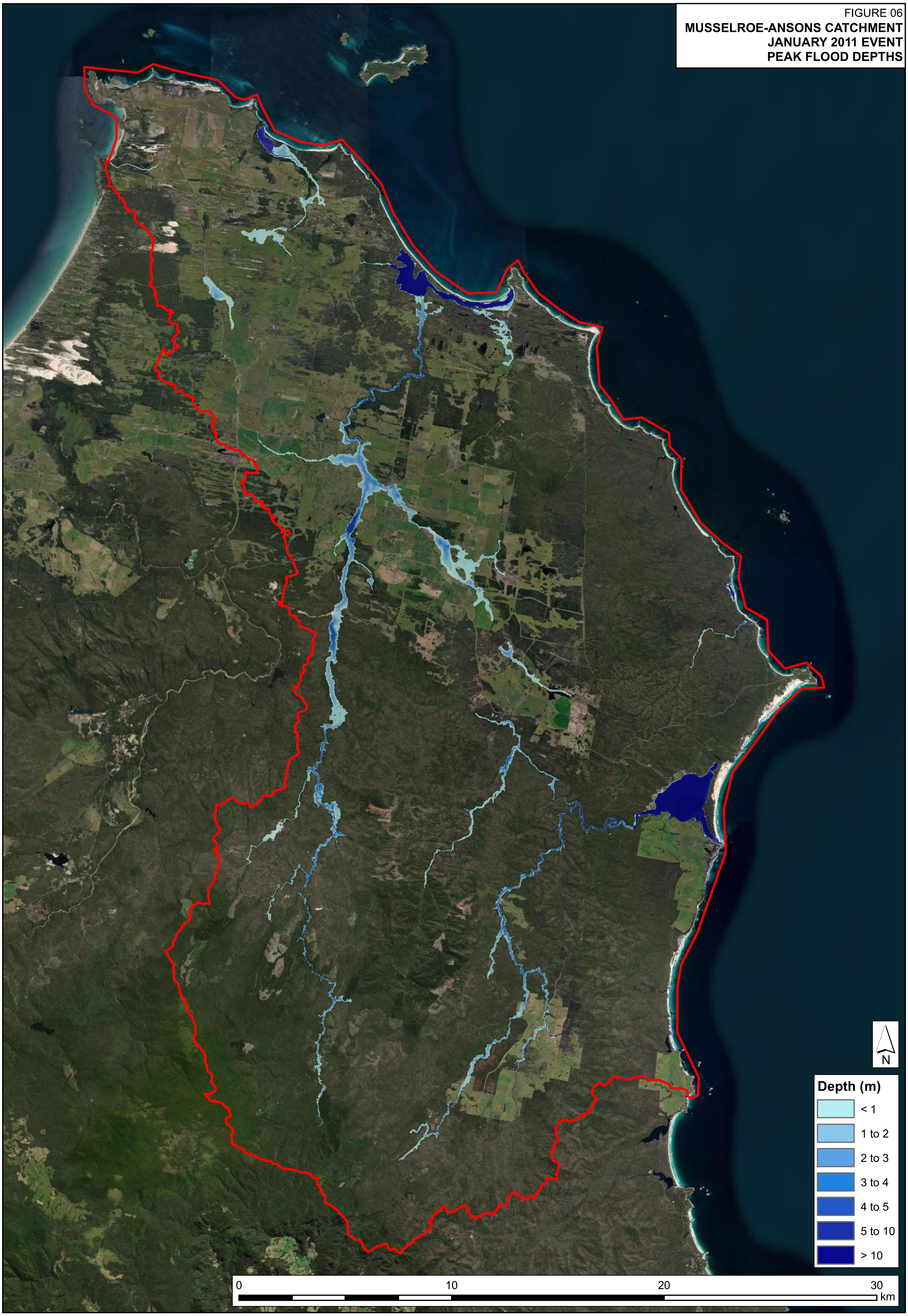
FIGURE 06
MUSSELROE-ANSONS CATCHMENT
JANUARY 2011 EVENT
PEAK FLOOD DEPTHS



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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

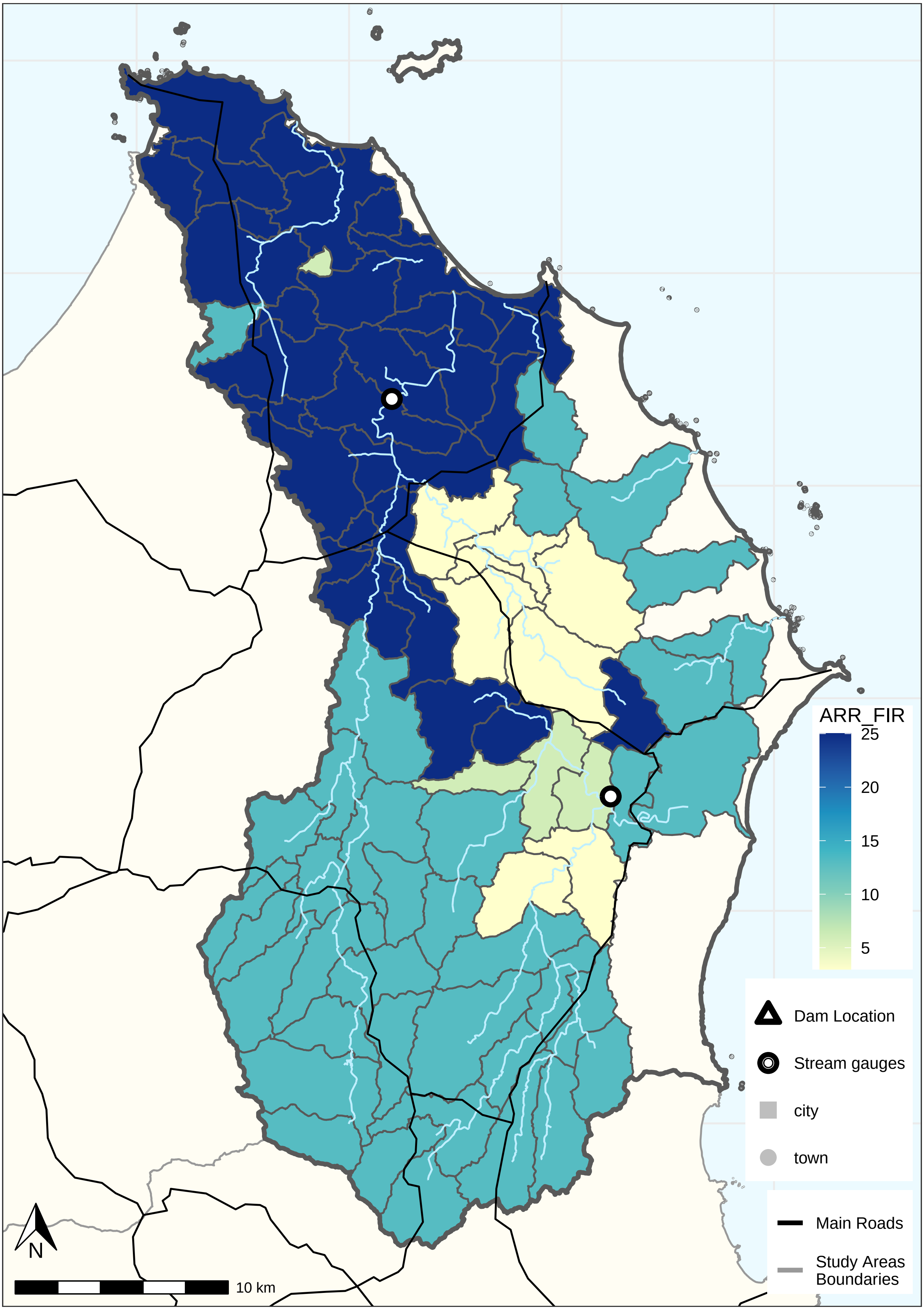

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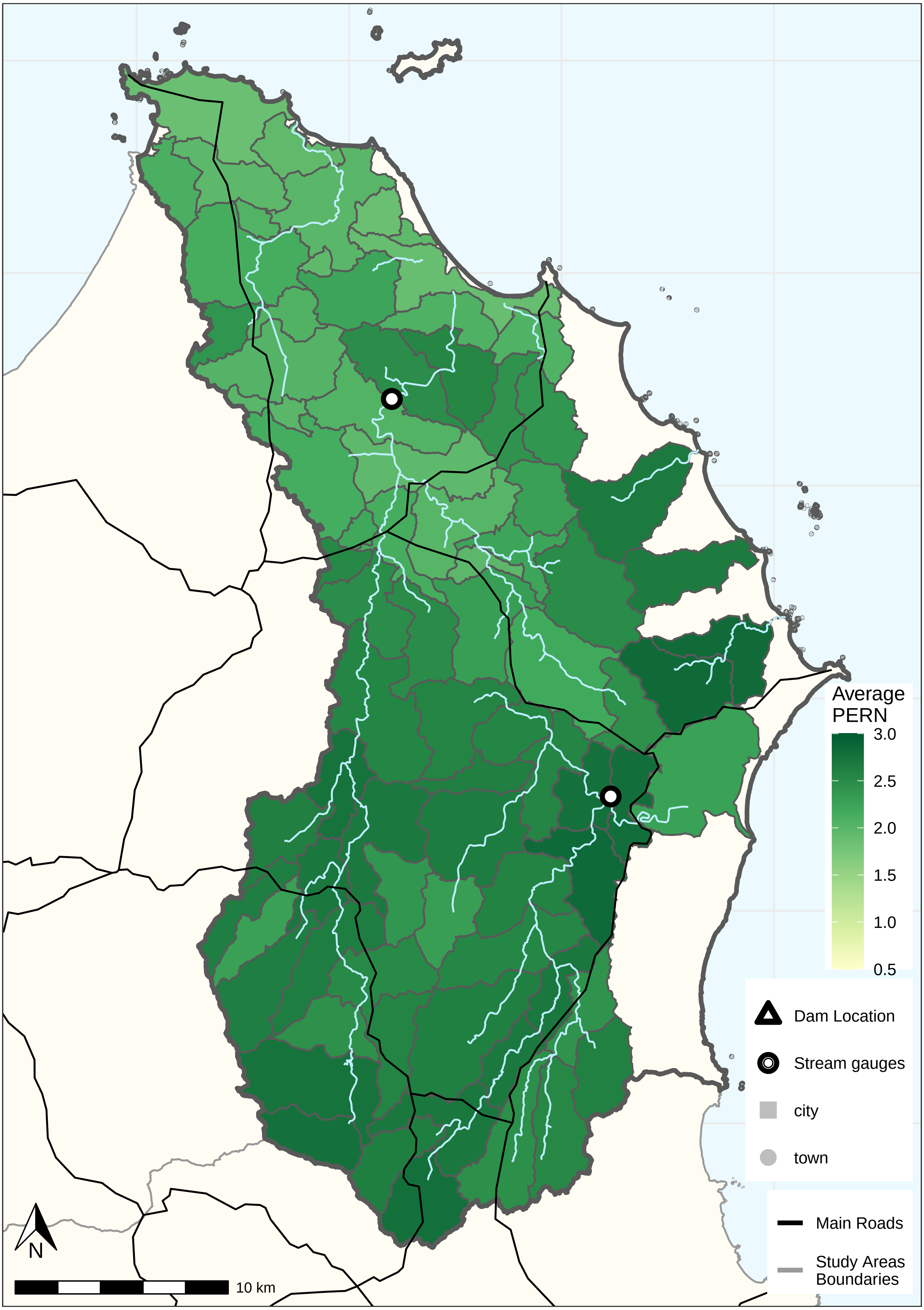
FIGURE A2

MUSSELROE−ANSONS 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. Green shading is used to highlight relevant statements:

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 Modelling 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, with relevant statements highlighted in green.

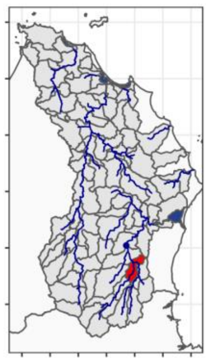
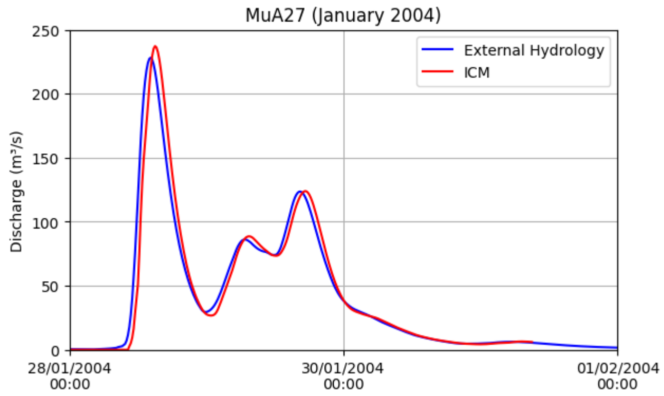
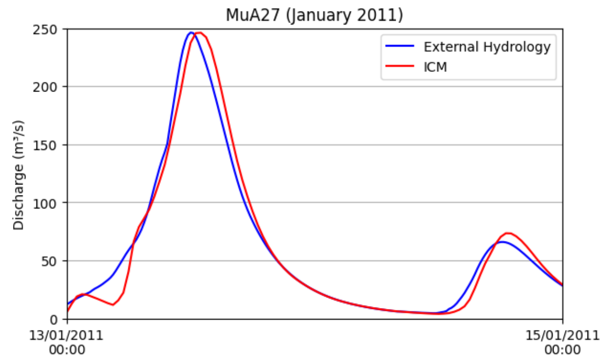
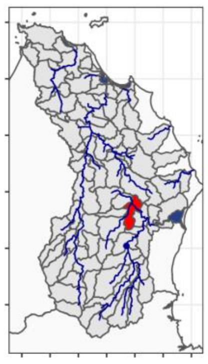
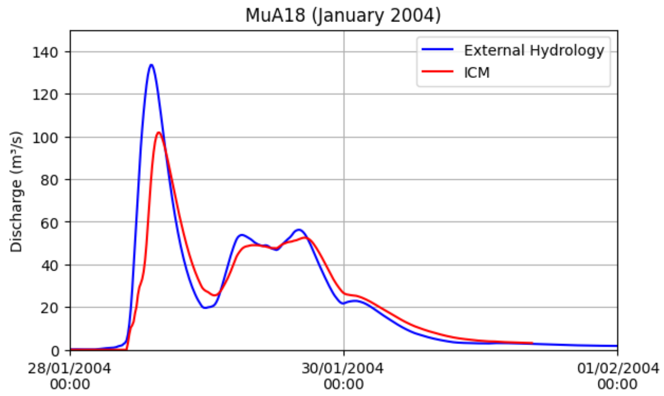
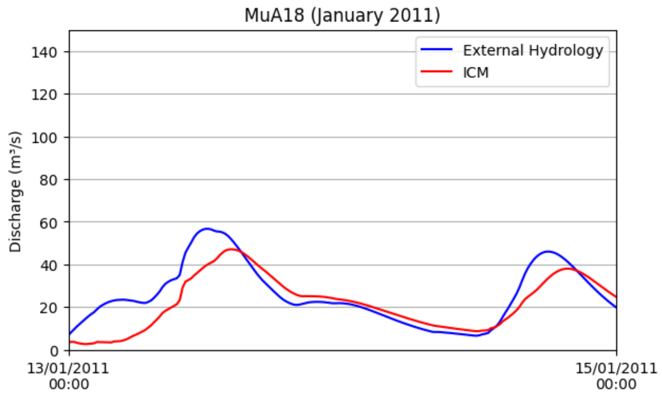
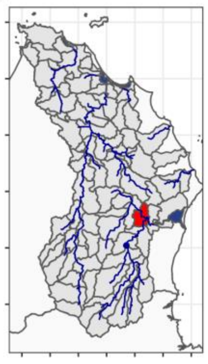
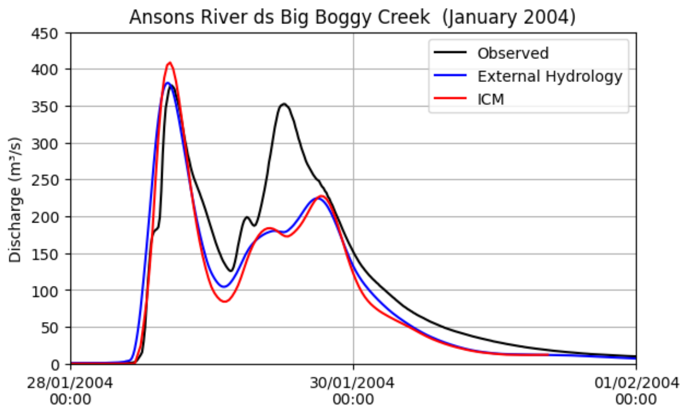
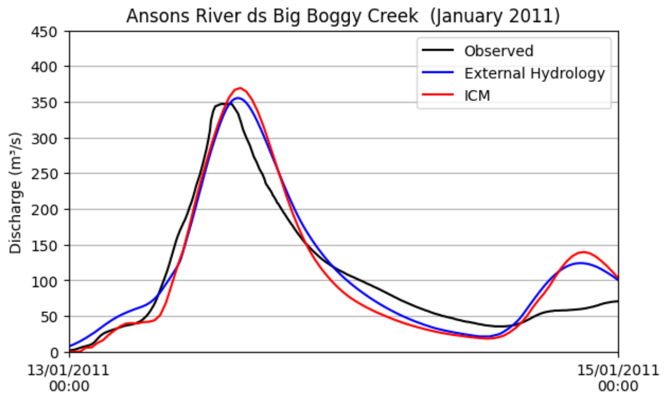
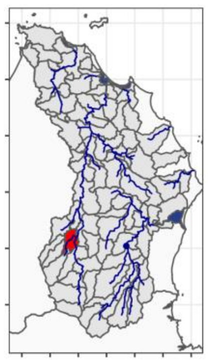
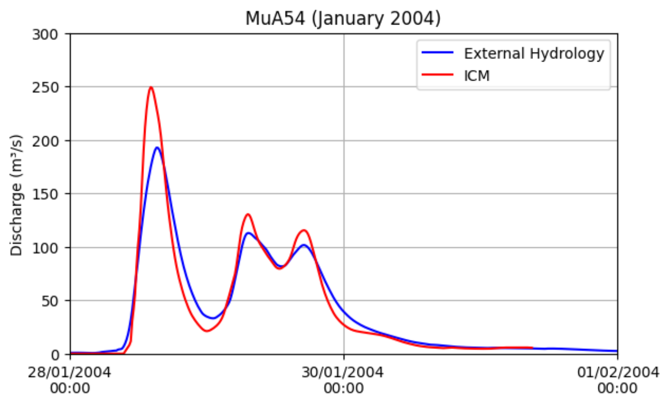
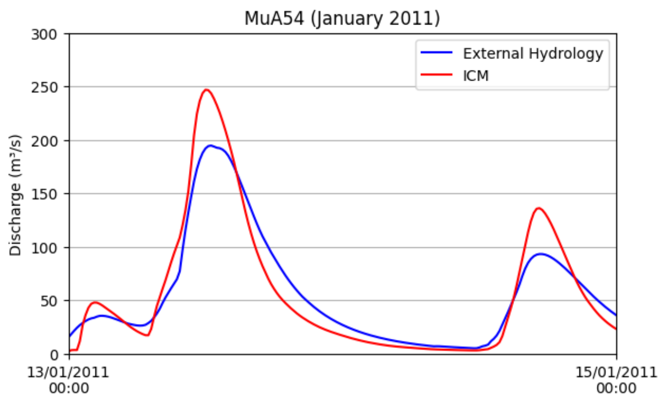
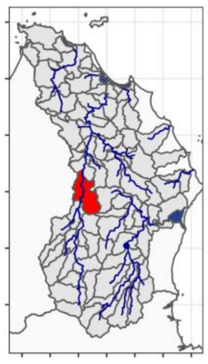
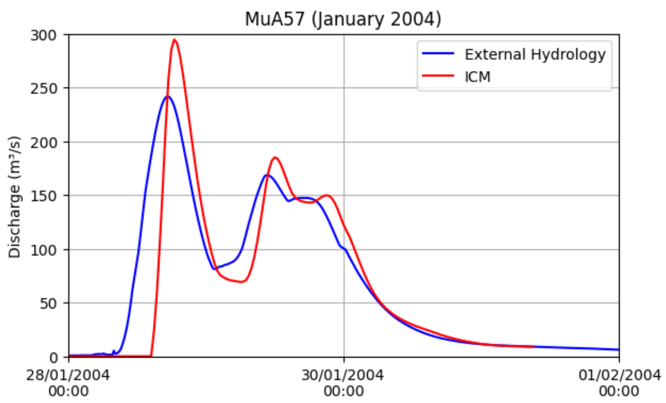
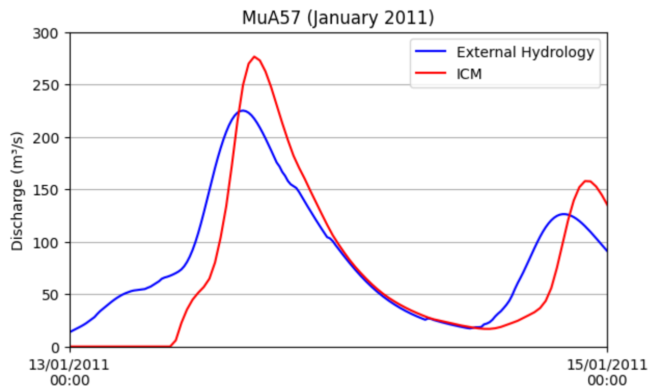
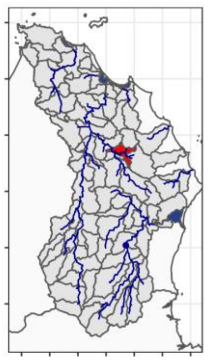
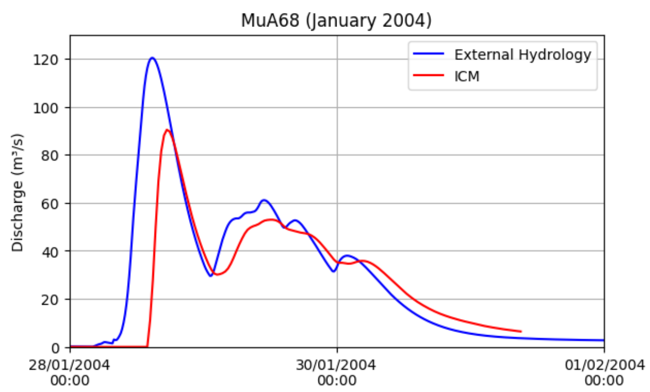
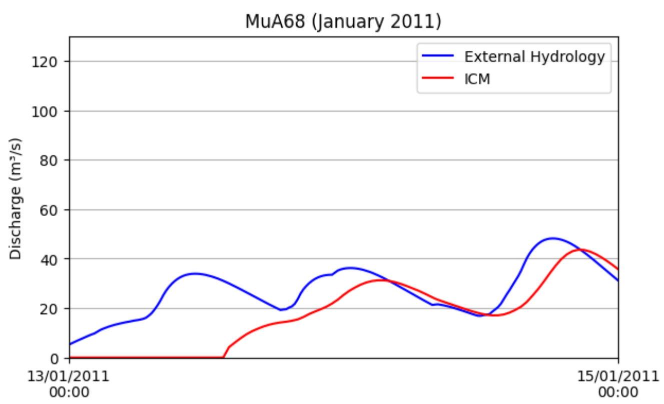
Table B 5: Hydrodynamic calibration quality rating

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 within > +/- 1m of 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 TO ICM HYDRAULIC MODEL COMPARISON CHARTS

Figure C 1 Event hydrographs

Catchment	January 2004 Event	January 2011 Event
mua27 		
mua18 		
Ansn_Bggy 		
mua54 		
mua57 		
mua68 		

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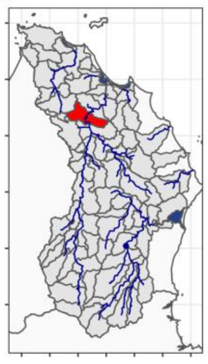

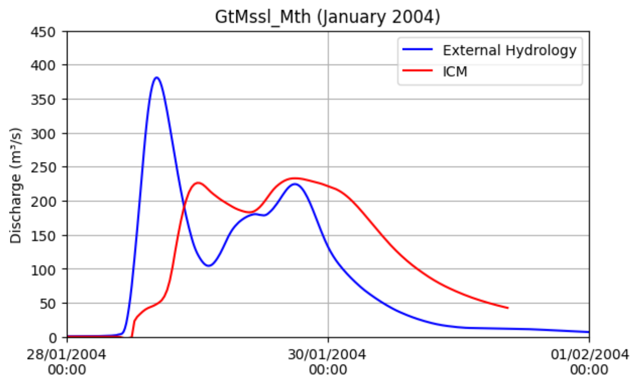

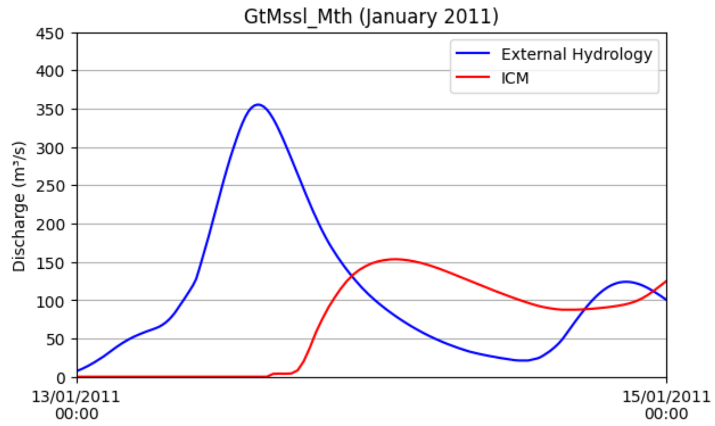

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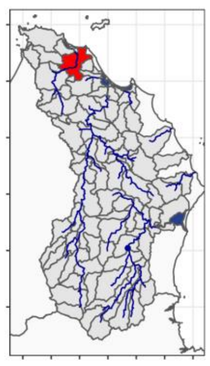

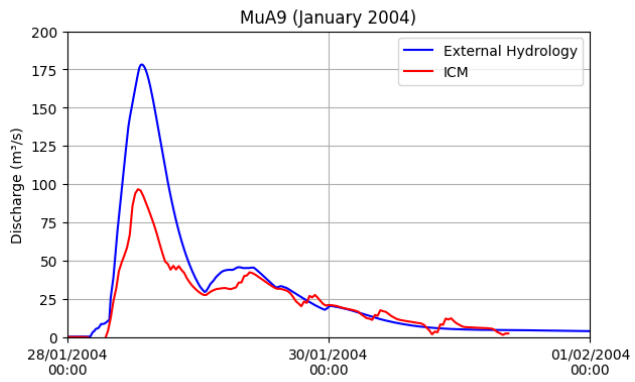

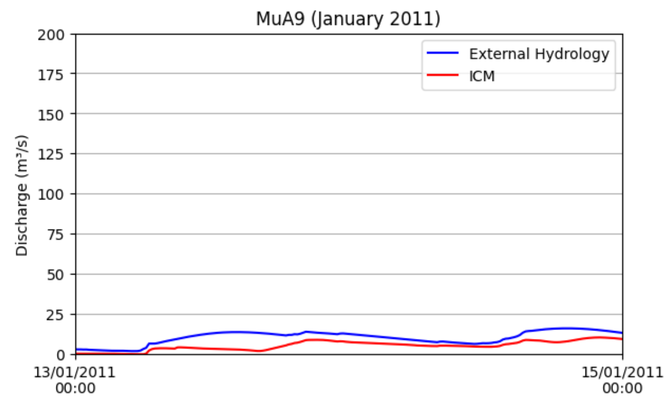

Appendix D

APPENDIX D. REVISED RATING

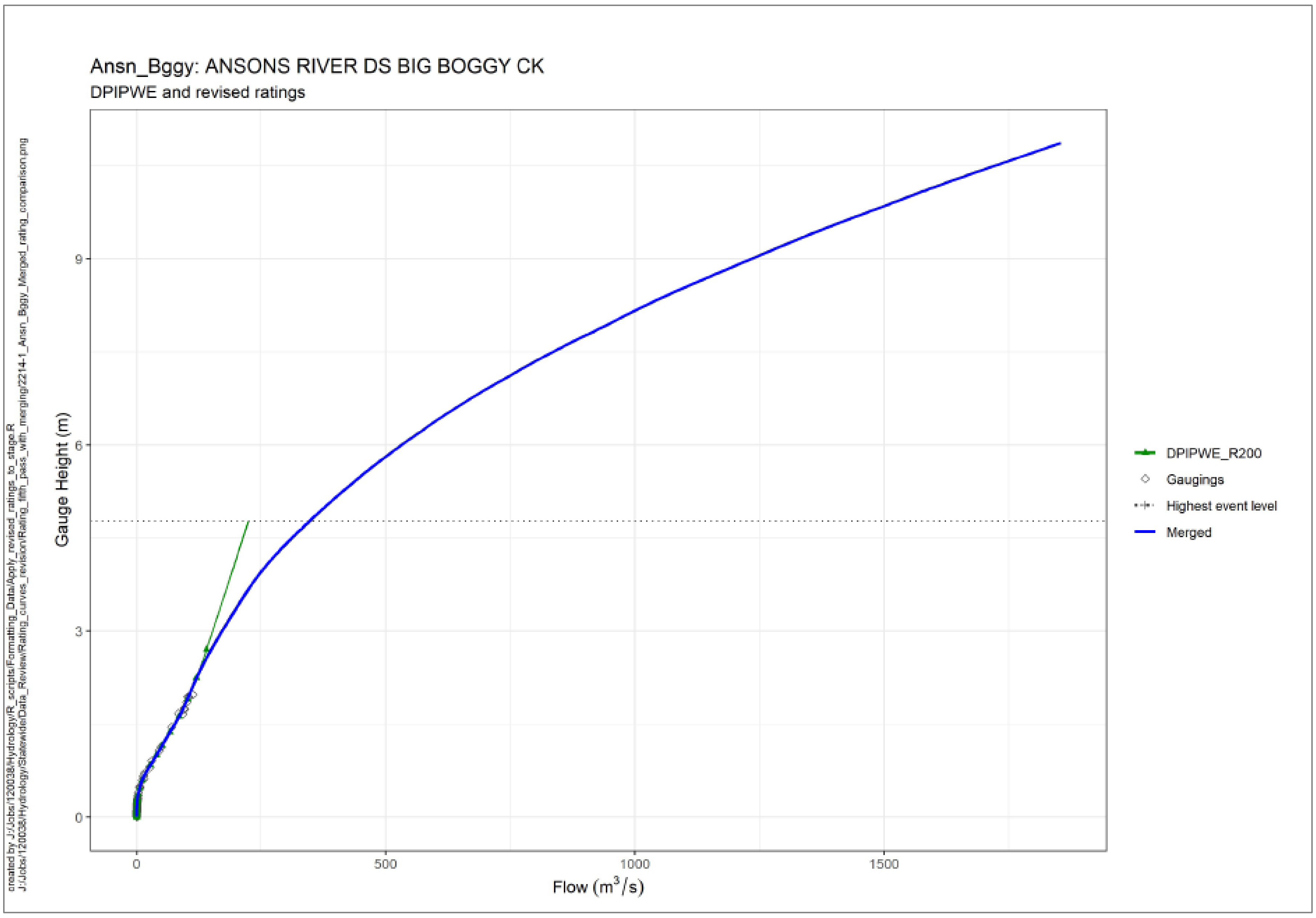

Figure D 1: Revised rating, Ansons River DS Big Boggy Creek (from WMAwater, 2021c)