STATE EMERGENCY SERVICE

TASMANIAN STRATEGIC FLOOD MAP GREAT FORESTER - BRID CATCHMENT 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

TASMANIAN STRATEGIC FLOOD MAP GREAT FORESTER - BRID CATCHMENT MODEL CALIBRATION

REPORT

MARCH 2023

Project Tasmanian Strategic Flood Map Great Forester - Brid Catchment 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	Luke Roberts, SES	Sarah Blundy, Evmen Wong	Daniel Wood, Fiona Ling	Mark Babister	SEPT 21
1	Report with minor revisions	Chris Irvine, SES	Sarah Blundy, Evmen Wong	Daniel Wood, Fiona Ling	Mark Babister	MAR 23

Cover image: Great Forester River at Barnbougle Golf Course, 'Beyond the Icons' in North East Tasmania by Dorset Council North East Tasmania - https://www.pinterest.com.au/pin/356206651750668110/

TASMANIAN STRATEGIC FLOOD MAP GREAT FORESTER - BRID CATCHMENT MODEL CALIBRATION

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

APPENDICES:

LIST OF DIAGRAMS

LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ALS	Airborne Laser Scanning
AMS	Annual Maximum Series
ARF	Areal Reduction Factor
ARR	Australian Rainfall and Runoff
AWAP	Australian Water Availability Project
AWS	Automatic Weather Station
Bureau	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
HAS	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
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 Great Forester and Brid rivers study area.

2. STUDY AREA

The Great Forester – Brid study area is situated in the North-East of Tasmania. The study area includes three larger rivers: Great Forester River, Little Forester River and Brid River. The study area includes several smaller watercourses that discharge directly into Bass Straight. The study area includes forested areas, tree plantations, pasture and irrigated farmland. There are many irrigation offtakes on the rivers, and off-stream storages within the study area. Tasmanian Irrigation operates the Great Forester irrigation scheme, which commenced operation in 2011. Water is supplied to this scheme from Headquarters Road Dam, located on a tributary of the Great Forester River.

Large floods in the Great Forester -Brid study area include the August 2007 and June 2016 flood events. Large flows were also recorded in July 1988 and October 1992 in the Great Forester and Brid rivers.

The Great Forester – Brid study area has an area of 1141 km^2. The main towns within the study area are Scottsdale and Bridport. The Great Forester – Brid study area and the available gauge information are shown in Figure 1, and land use is shown in Figure 2.

3. AVAILABLE DATA

3.1. Historic Flow Data and Level Data

There are five main flow gauges with data available in the Great Forester-Brid study area, as shown in Table 1. These gauges are owned by DPIPWE, who supplied timeseries of flows, ratings and gaugings for each site. Brid River u/s Tidal Limit and Great Forester u/s Forester Rd gauges have more than 40 years of record, while the other three gauges each have around 10 years of record. All gauges are still operational.

Table 1: Flow gauges

Gauge attribute	Brid River u/s Tidal Limit	Great Forester River u/s Forester Rd	Great Forester River @ Prosperity Road	Brid River u/s Sledge Rd bridge	Little Forester d/s Denison River
Gauge number	19200-1	19201-1	19224-1	19203-1	19206-1
Gauge abbreviated name	Brid u/s Tidal Limit	Great Forester u/s Forester Road	Great Forester at Prosperity Road	Brid u/s Sledge Rd Bridge	Little Forester Gauge
Start date	26/06/1965	19/02/1970	18/03/2003	07/05/2008	28/05/2008
End date	current	current	current	current	current
Latitude	-41.020	-41.112	-41.205	-41.184	-41.104
Longitude	147.372	147.612	147.561	147.475	147.331
Rating quality	Good	Very good	Poor	Poor	Poor
Used for calibration	Yes	Yes	No	Yes	Yes
Assumed local datum in AHD	12.1	42.0	119.7	126.8	36.0
Highest Rated Level (m local datum)	1.50	3.53	Unknown	Unknown	Unknown
Highest recorded stage height date	09/10/1992	11/08/2007	10/08/2007	18/08/2013	18/08/2013
Highest recorded stage height (m local) datum	2.05	3.58	3.28	1.96	3.57
Highest recorded flow (m^3/s)	58	105	26	17	69
Highest recorded flow date	09/10/1992	09/10/1992	10/08/2007	14/01/2011	18/08/2013

3.1.1. Calibration Event Data Availability

Significant flows were recorded in the catchment area for 3 of the 13 flood events selected by the Bureau as calibration events for this project (Table 2). The August 2007 and June 2016 events are the second and fourth largest events on record at Great Forester River u/s Forester Rd, with AEPs of around 3% and 10% respectively. At Brid River u/s Tidal Limit gauge, the same events plotted at AEPs of 10% (August 2007) and 20% (June 2016). The January 2011 event at Brid River u/s Sledge Rd Bridge was the only event with available data at this site and one of the largest on record with an AEP of around 5%.

Only the August 2007 and June 2016 events were used for calibration at the majority of gauges, as the January 2011 event was not significant. The 2011 event has been used at gauges where no other information is available to ensure model response and parametrisation is appropriate for these locations.

Table 2: Summary of the largest events in the Great Forester – Brid study area, selected from the 13 calibration events supplied for the project.

Event name	Used in calibration	Event peak flow (m^3/s) (location)
2007_Aug	Yes, at Brid at Tidal limit and Great Forester u/s Forester Road	35 (Brid u/s Tidal Limit) 102 (Great Forester u/s Forester Road)
2011_Jan	Yes, to confirm parameters are appropriate at Brid u/s Sledge Rd and Little Forester d/s Denniston River gauges	17 (Brid u/s Sledge Rd Bridge) 45 (Little Forester Gauge)
2016_Jun	Yes, at Brid at Tidal limit and Great Forester u/s Forester Road	22 (Brid u/s Tidal Limit) 89 (Great Forester u/s Forester Road)

3.1.2. Rating Curve Quality

Brid River u/s Tidal Limit has gaugings that are larger than the peaks of the calibration events and the rating curve fits well through these gaugings. The Great Forester River u/s Forester Rd has gaugings out of channel that are around the peak of the calibration events and the rating fits well through these gaugings. Great Forester River at Prosperity Road only has very low flow gaugings and flows are quality coded by DPIPWE as “unknown” for the selected calibration events. Little Forester d/s Denison River gauge had no data available for selected calibration events. These gauges were therefore assessed however no significant attempt to match flows was undertaken, noting that they are likely erroneous.

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 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 Great Forester - Brid study area (see Data Review Report WMAwater (2020) for details on calibration events).

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 five sub-daily rain gauges within the Great Forester – Brid study area, however not all gauges were available for each event (Table 3). There was one gauge outside the catchment that influenced rainfall in sub-catchments along the boundaries of the catchment in each event. There are eight daily rain gauges within the study area. The gauges in and around the Great Forester – Brid study area, are shown in Figure 1.

Table 3 – Available Rainfall Information

	August 2007	Jan 2011	June 2016
Number of Sub-daily Stations Available within the catchment	1	2	4
Number of daily Stations Available within the catchment	8	6	6
Number of sub-daily surrounding gauges ~15km	2	3	4
Number of daily surrounding gauges ~15km	11	9	9
Rainfall Totals	40-190 mm	90-160	100-280 mm
Approx duration of rainfall event	48 hours	11 hours	48 hours

*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 2007 – 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 5.

3.3. Dam Information

There is one significant dam, Headquarters Road Dam, in the Great Forester – Brid study area. Details are shown in Table 4.

Table 4: Dam information

Name	Storage Volume (ML)	Crest Length (m)	Spillway Width (m)
Headquarters Road Dam	2330	330	40

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 four of the five gauges in the catchment, with the SES state-wide 10 m DEM used at the remaining gauge (Brid River u/s Tidal Limit). 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 1), was then imported into ICM via the grid import interface.

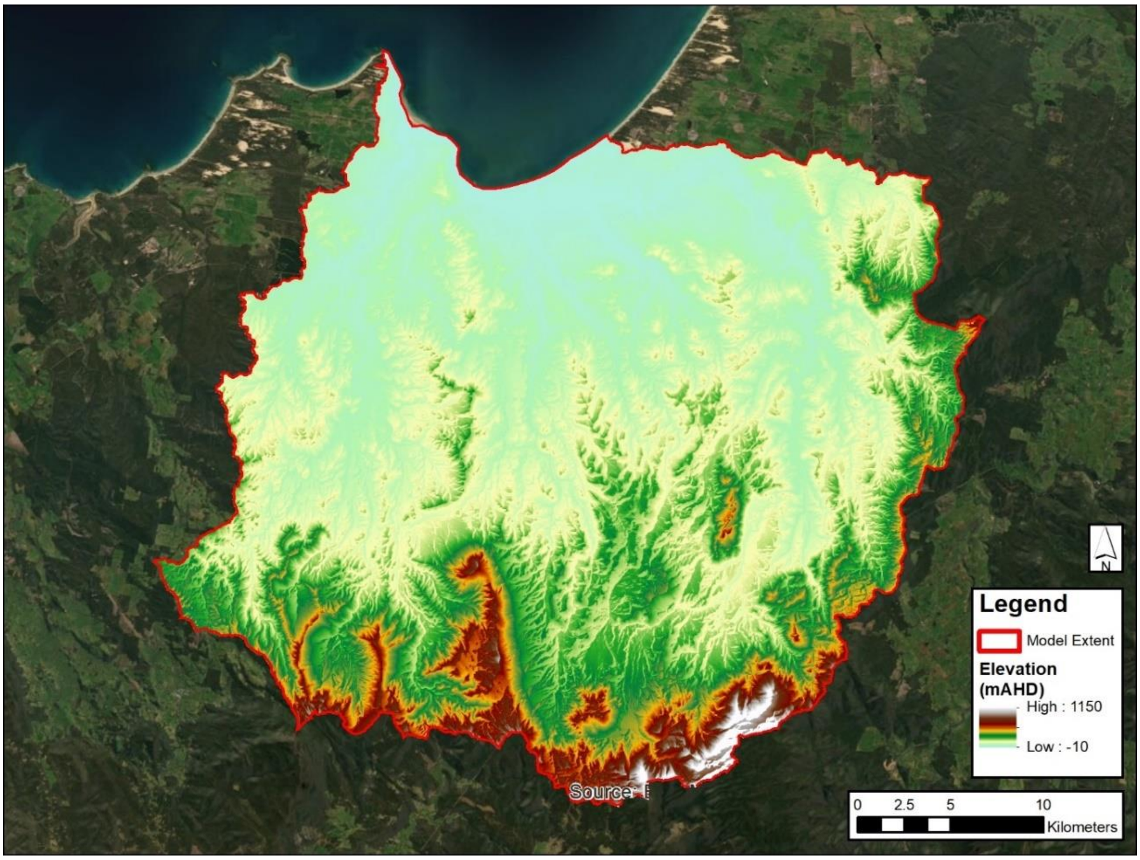


Diagram 1: DEM of the Great Forester-Brid catchment

It is noted that the DEM at the Brid River u/s Tidal Limit gauge is limited to the 'Default DTM' of the state-wide 10 m DEM, which is understood to be comprised primarily of photogrammetric contour data. This is also the case in other areas of the catchment, specifically in the lower reaches of the catchment (Diagram 2). The 'Default DTM' is likely to be a poor representation of the topography of the area.

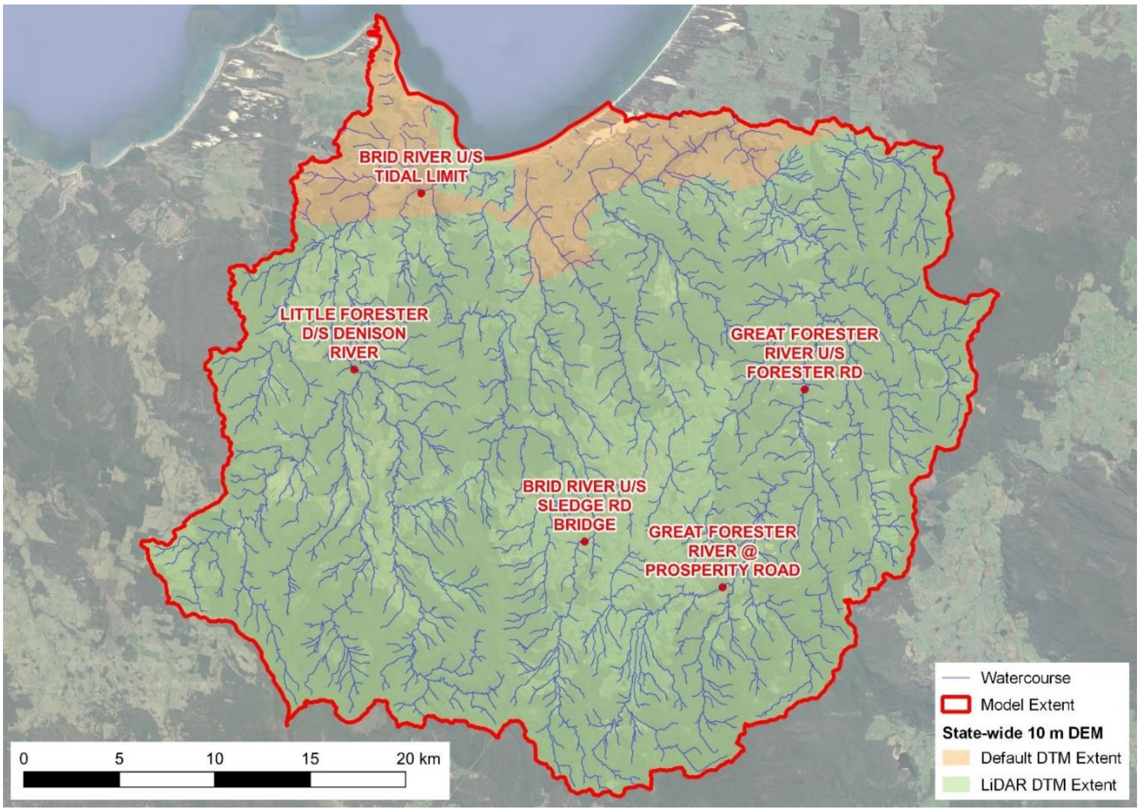


Diagram 2: 'Default DTM' extents for the Great Forester-Brid catchment

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 (Figure 2), 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 0.035 for all upper streams was utilised. 0.035 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.

This change will be revised on a case-by-case basis in future assessments as it is managing a very specific issue. The values derived are shown in the 'Hydrodynamic Modelling Report'. The roughness layer in ICM is shown in Diagram 3.

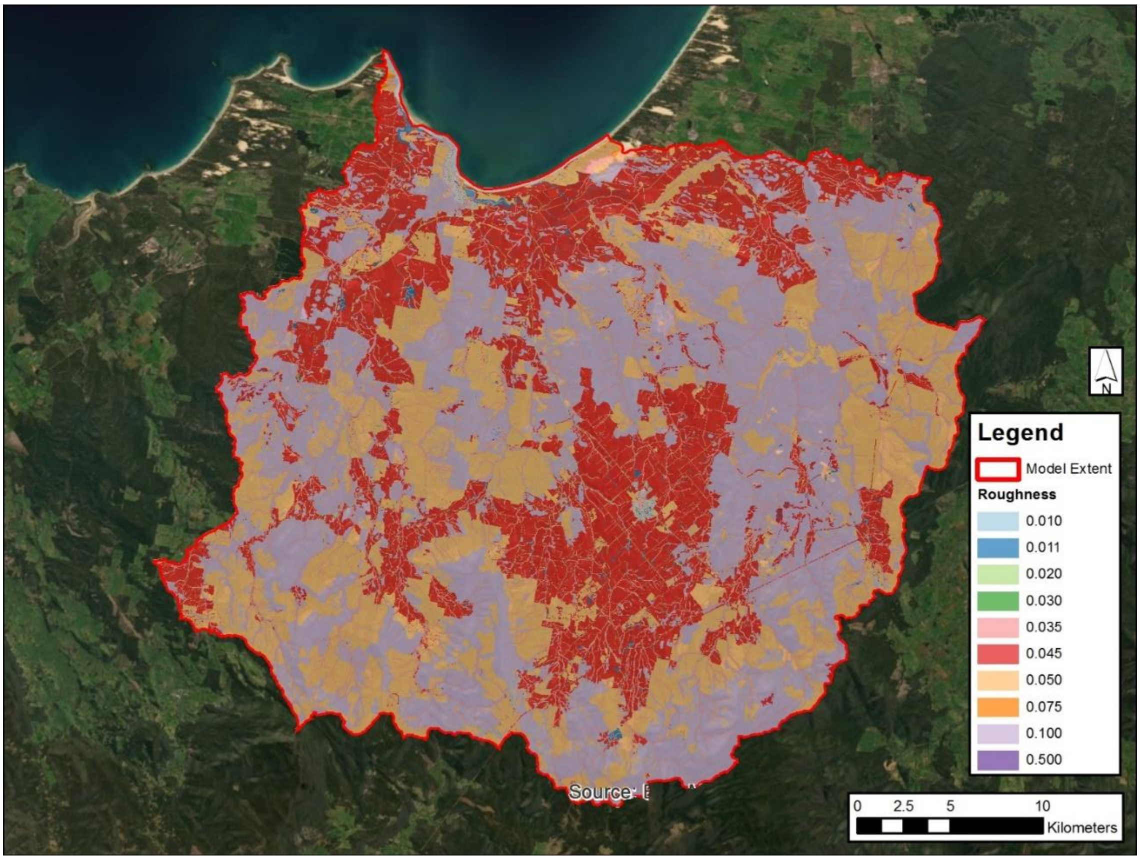


Diagram 3: Roughness layer for the Great Forester-Brid catchment

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 strahlar order 2-5 were buffered by 10 m either side of the centre line with strahlar 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 to ensure that the meshing process did not result in artificial blocking of the flow paths along main stream lines.

The resulting mesh zones for the Great Forester-Brid catchment are shown in Diagram 4.

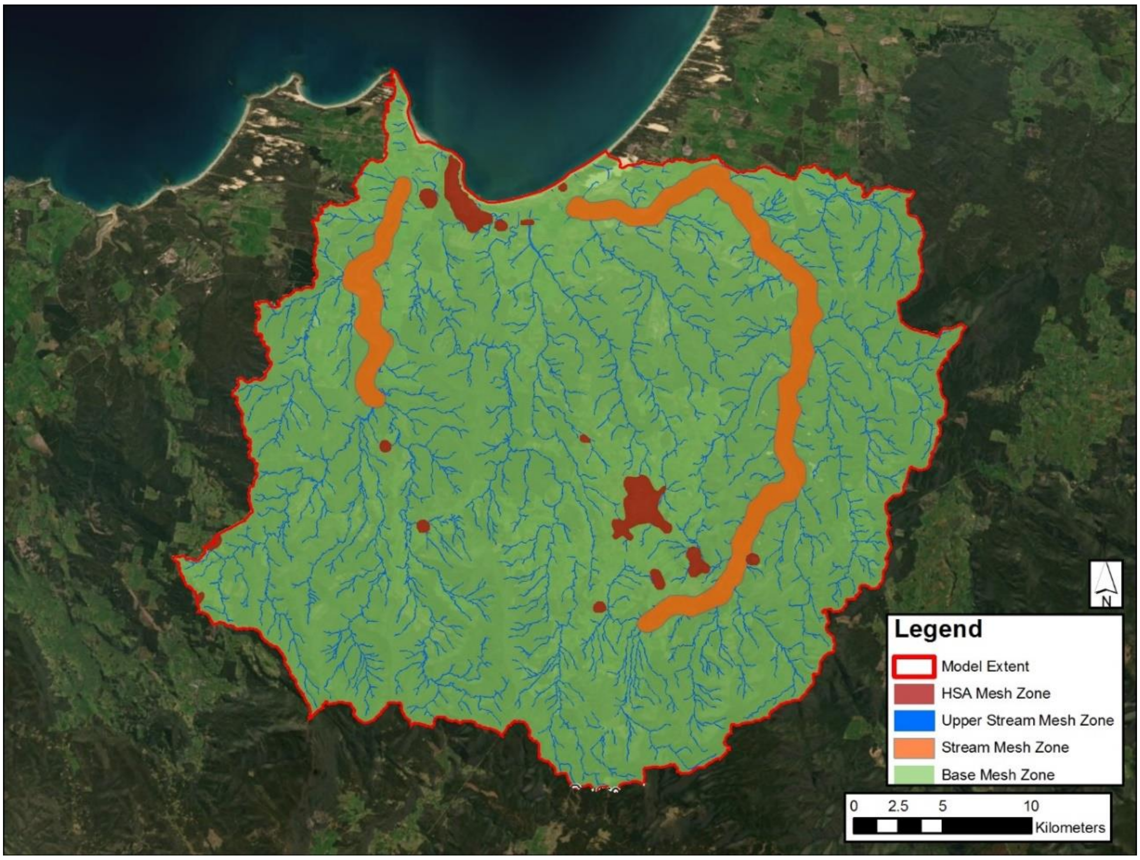


Diagram 4: Mesh zones for the Great Forester-Brid catchment

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 Great Forester-Brid catchment a total of 4 bridges longer than 30 m were identified and imported into the hydrodynamic model.

These include:

- Great Forester River at North East Rail Trail
- Great Forester River at Tasman Highway
- Great Forester River at private access road (downstream of Great Forester River at Waterhouse Road)
- Little Forester River at Bridport Road

Further discussion on this process is provided in the Hydrodynamic Modelling Methods Report.

Headquarters Road Dam was represented within the ICM model using a 2D initial condition and a linear 2D weir structure set to the full supply level of the dam of 284.6 mAHD (inferred from the DEM of the hydrodynamic model).

No major culverts were identified.

5.5. 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) and was used to set a varying tide level for the calibration events. This data was extracted off the coast of Bridport at 10 min time increments and was imported into ICM as a time varying boundary condition. Diagram 5 shows an example of the synthetic tide data that was extracted off the coast of Bridport for the June 2016 event.

Note there is no calibration information to verify the function of the tailwater condition thus no allowance for local storm effects have been undertaken. It is considered that the synthetic tide is a reasonable estimation of tailwater levels for the purposes of calibration assessment.

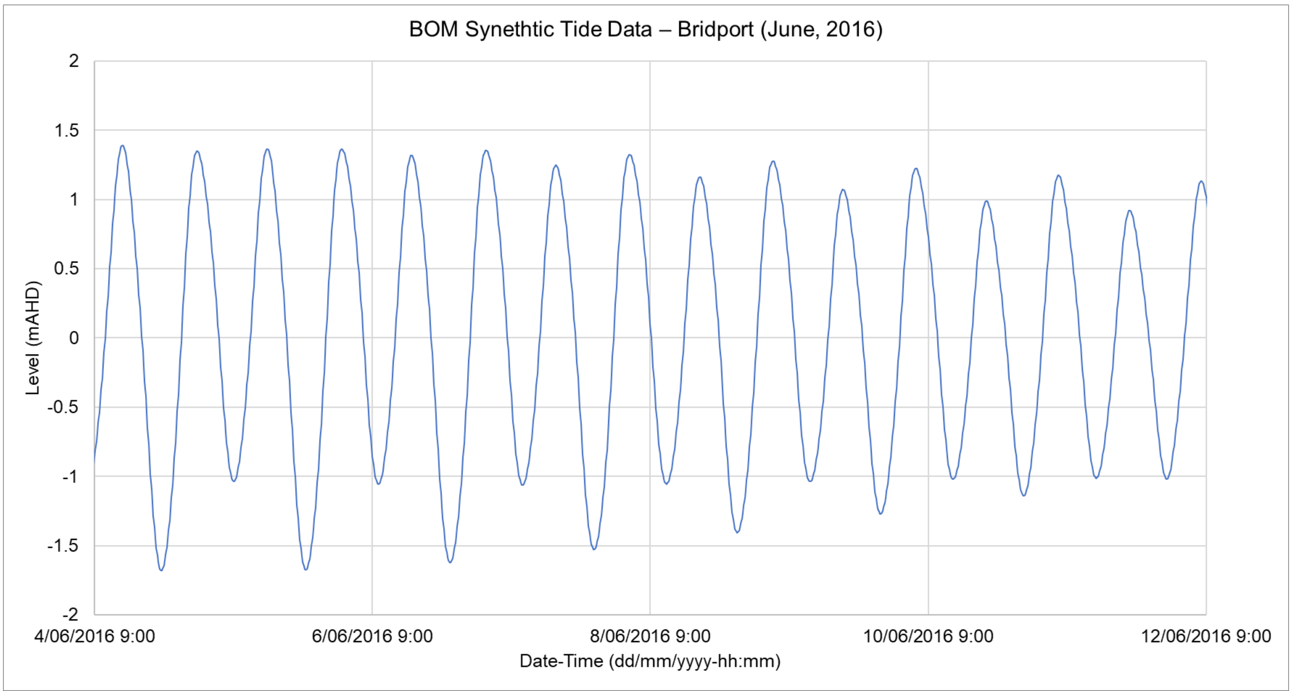


Diagram 5: Synthetic tide data off the coast of Bridport (June, 2016)

5.6. 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.

5.6.1. 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 Great Forester-Brid catchment is shown in Diagram 6. Figure A 1 shows the hydrological soil groups used to distribute the CL and the average PERN used for each sub-catchment.

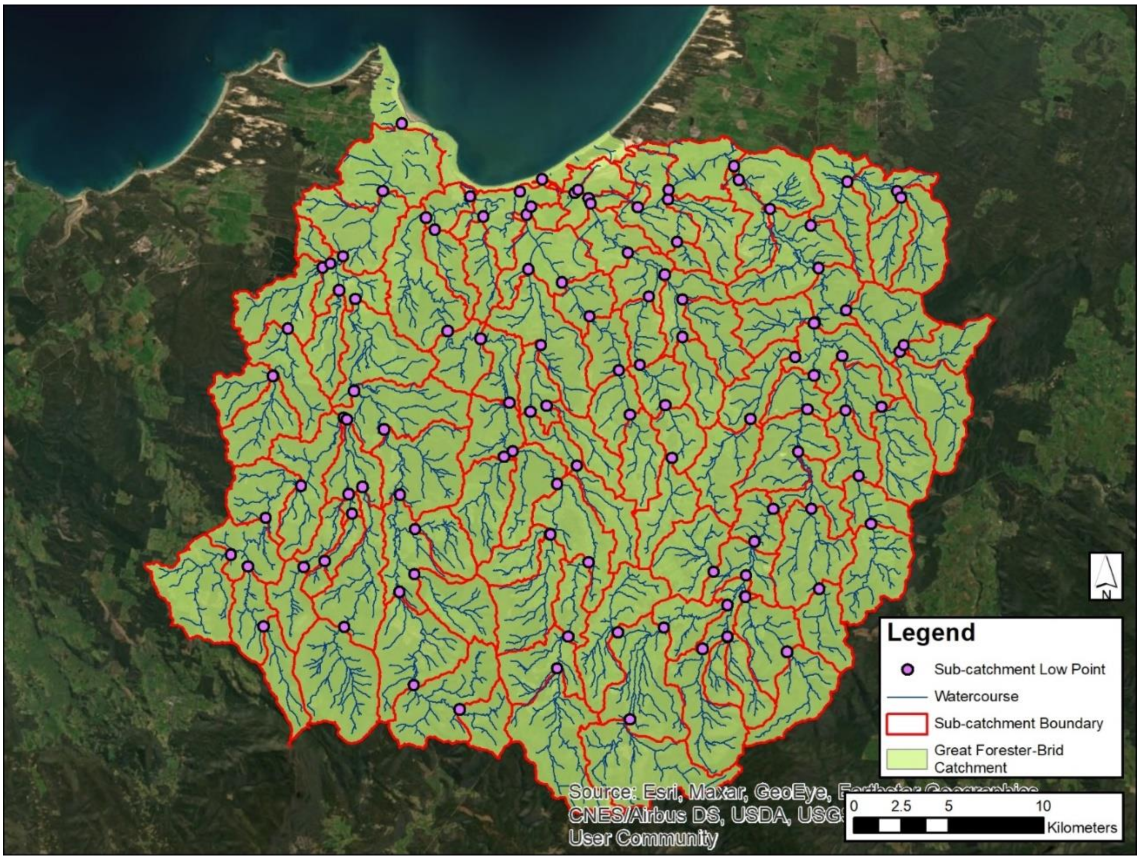


Diagram 6: RAFTS sub-catchment model setup in ICM for the Great Forester-Brid catchment

6. CALIBRATION RESULTS

The ICM model was initially run with the routing and loss parameters derived from the external hydrologic model and the calibration process was undertaken for each calibration event. The model parameters were refined in the ICM model. Prefilling of the model was not undertaken as this was not deemed to be required based on the results of the calibration events.

Within the catchment there are five (5) gauges where historic event information is available. Each gauge has varying quality however and, as such, different outcomes were achieved depending on the limitations at each gauge. The following sections outline the results and limitations of calibration at each gauge.

In general it is considered that a reasonable calibration has been achieved at the majority of sites, however due to data limitations at Brid River u/s Tidal Limit further work will be required in the future should better information become available.

Mapping of the peak flood depths from the calibrated ICM model for each calibration event can be found in Figure 6 to Figure 8.

6.1. Gauge Results

6.1.1. Great Forester River u/s Forester Road

The modelled peak flows for the August 2007 and June 2016 events at the Great Forester River u/s Forester Road gauge show a good match to the recorded peak flow (Table 5). The modelled hydrograph also shows a good match in terms of timing and shape to the recorded hydrograph at the peak of the event, as shown in Diagram 7 and Diagram 8. As this system is peak flow driven, further iterations of the model were not deemed to be required.

Diagram 9 and Diagram 10 show the water level response for the calibration events at the gauge. A gauge zero was not available from the DPIPWE database so an assumed gauge zero of 42 mAHD was used. This gauge zero was inferred from the DEM used for the hydrodynamic model.

The results indicate a generally good match to the recorded levels at the gauge, noting that at low levels the poor definition of local features is unlikely to enable a good match of results to be achieved.

Table 5: Calibrated parameters and discharge at Great Forester River u/s Forester Road

Statistic	2007 August	2016 June
IL (mm)	21	60
Average CL (mm/h)	1.6	2.7
RAF	4.0	4.0
Modelled Peak (m^3/s)	114	96
Observed Peak (m^3/s)	102	89
Peak % difference	+12%	+8%
Modelled Volume (ML)	11,100	10,100
Observed Volume (ML)	11,700	12,200
Volume % difference	-5%	-17%
Modelled peak (mAHD)	45.8	45.5
Observed peak (mAHD)	45.6	45.3
Peak difference (m)	+0.2	+0.2

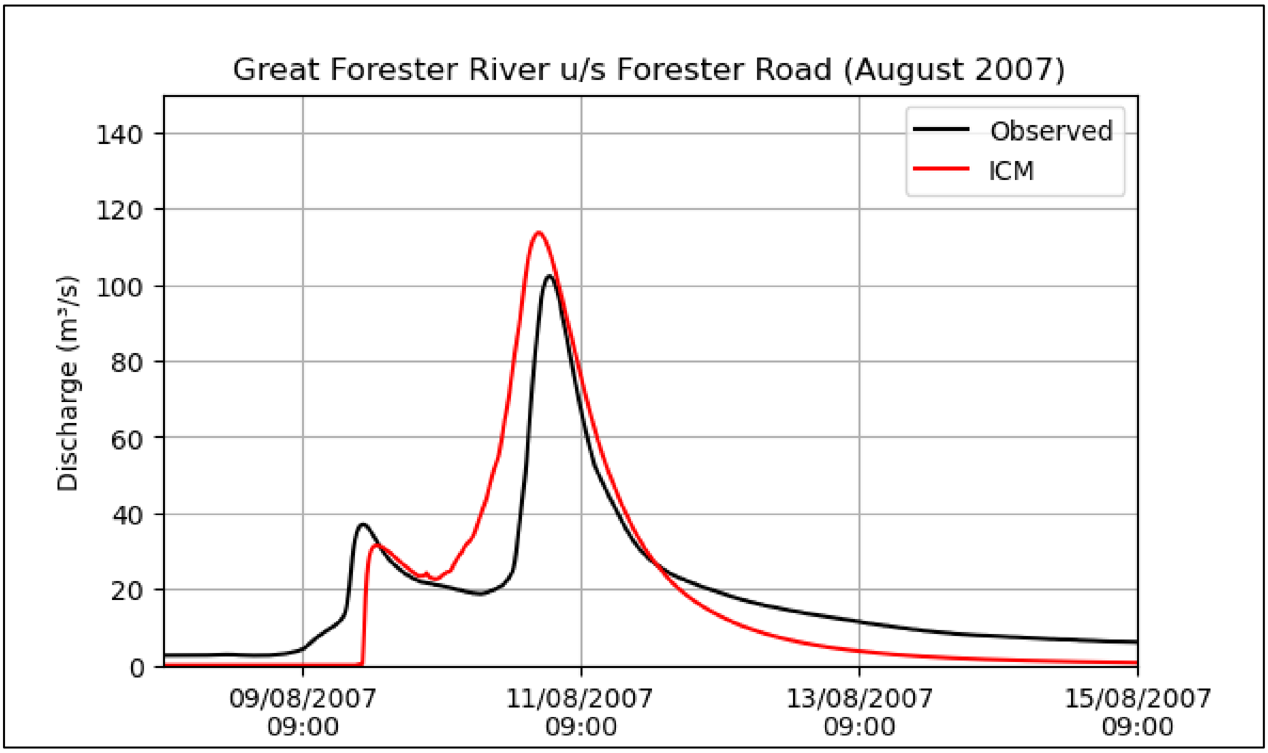


Diagram 7: August 2007 flow comparison at Great Forester River u/s Forester Road

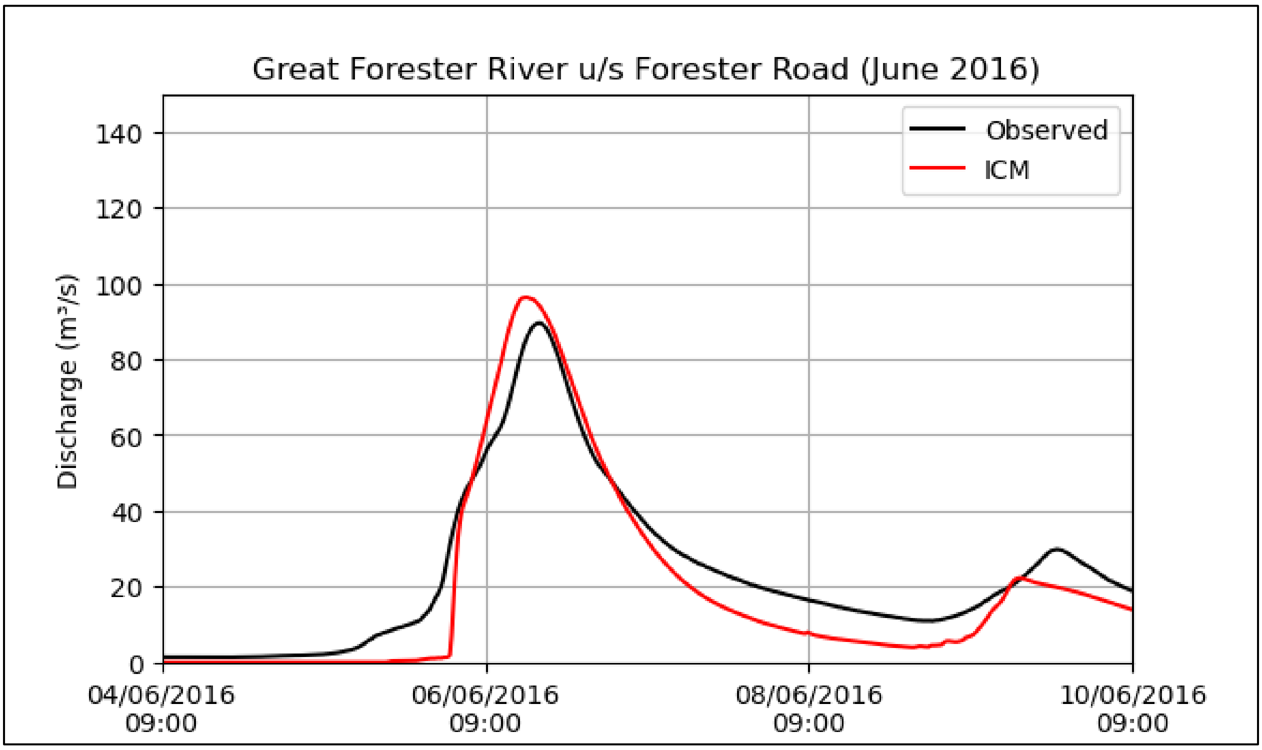


Diagram 8: June 2016 flow comparison at Great Forester River u/s Forester Road

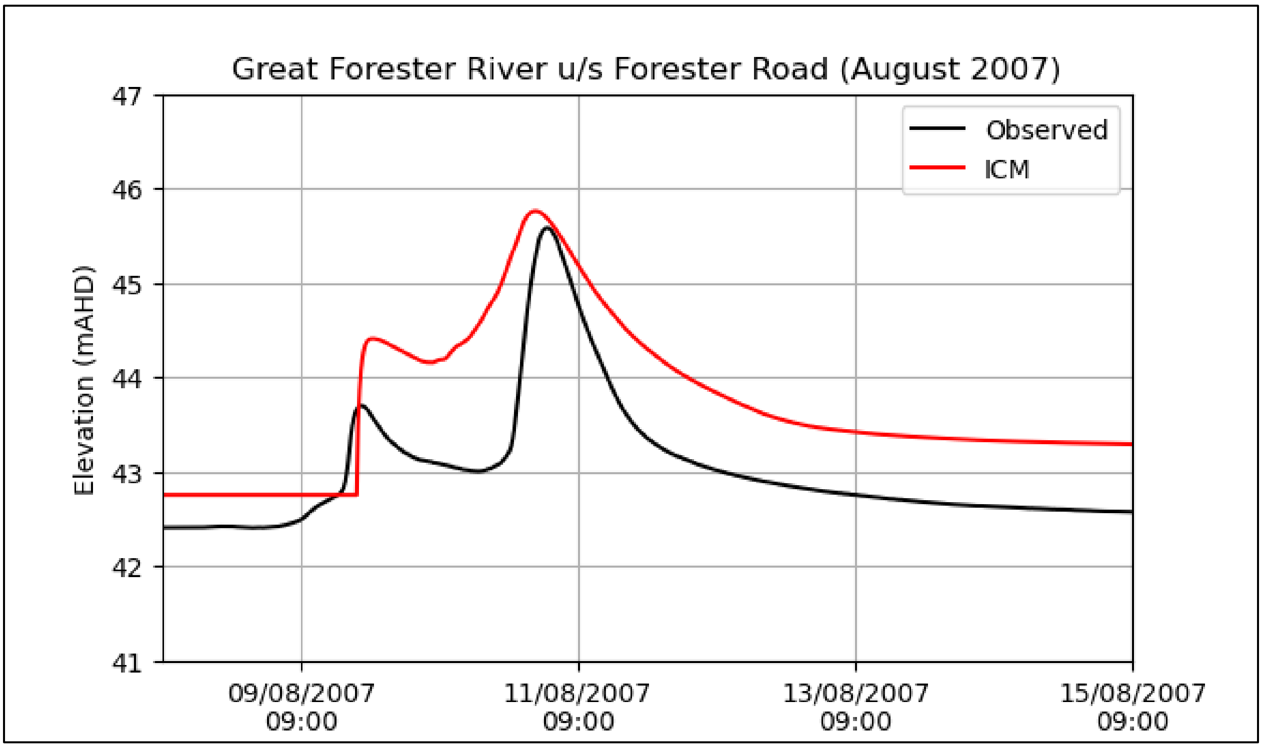


Diagram 9: August 2007 water level comparison at Great Forester River u/s Forester Road

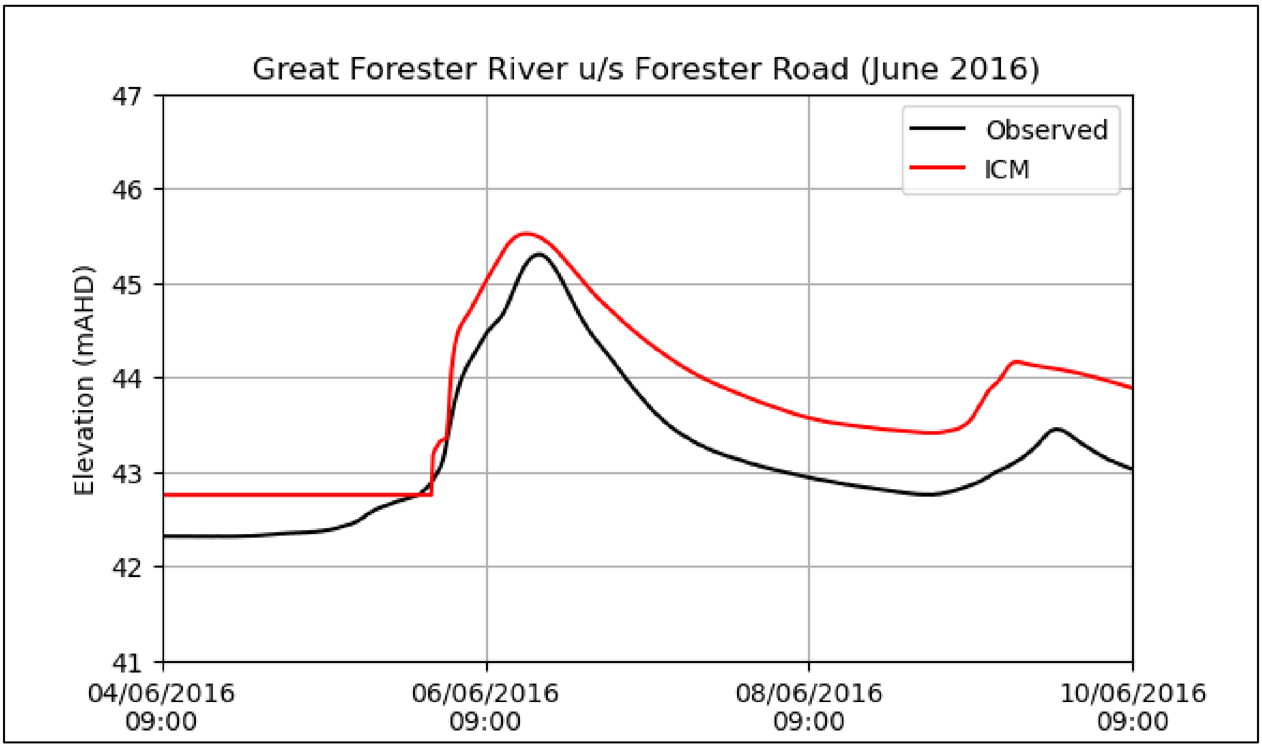


Diagram 10: June 2016 water level comparison at Great Forester River u/s Forester Road

6.1.2. Brid River u/s Tidal Limit

The modelled peak flow for the August 2007 and June 2016 events at the Brid River u/s Tidal Limit shows a poor match to the recorded peak flow (Table 6). The modelled hydrograph also shows fair match in terms of timing and shape compared to the recorded hydrograph at the peak of the event, as shown in Diagram 12 and Diagram 13.

Due to issues present within the DEM (the gauge is limited to the 'Default DTM' of the state-wide 10 m DEM). This results in a significant artificial storage in the hydrodynamic model (Diagram 11). This DEM estimates the ground level at the gauge is in the order of 17 mAHD, compared to a gauge zero of 12.1 mAHD from the DPIPWE database. The discrepancy in the DEM at the location meant that there is low confidence in the output and subsequent calibration outcomes at this gauge.

Future assessments of the zone should be undertaken once further high-resolution topography data is available.

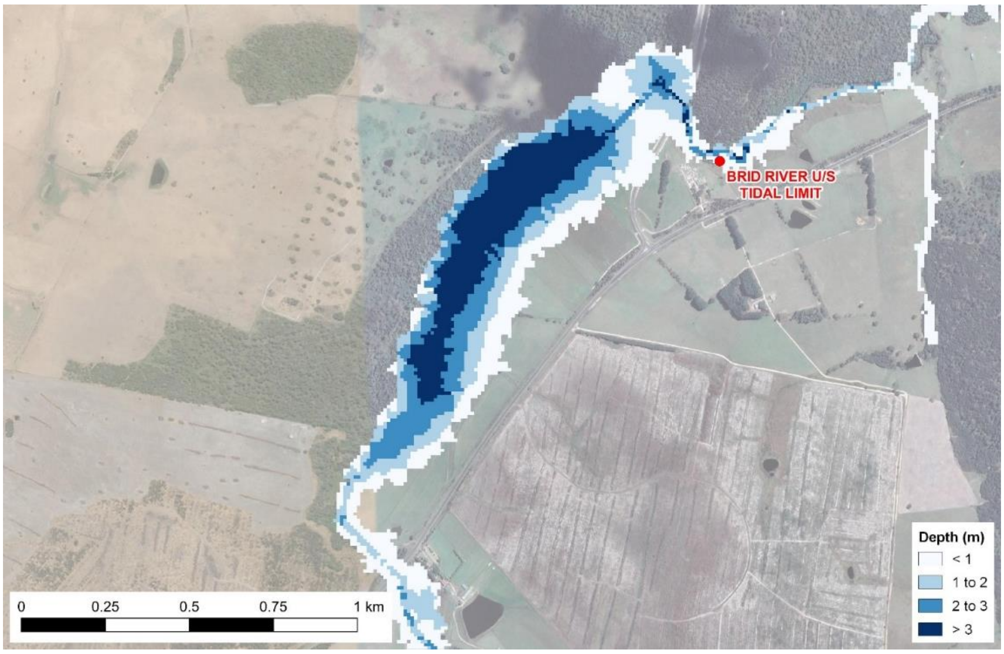


Diagram 11: June 2016 modelled flood depths at Brid River u/s Tidal Limit

For the 2007 event, the results were checked upstream of the large storage to ensure that there was not a gross over estimation of flow. It was identified that the peak flow was similar, however the large volume of flow prior to the peak was present. In the 2016 event, the smaller volume of the event results in a reduction of peak flow modelled at the gauge.

Table 6: Calibrated parameters and discharge at Brid River u/s Tidal Limit

Statistic	2007 August	2016 June
IL (mm)	39	90
Average CL (mm/h)	2.9	2.7
RAF	4.0	4.0
Modelled Peak (m^3/s)	42	17
Observed Peak (m^3/s)	35	22
Peak % difference	+20%	-23%
Modelled Volume (ML)	3,500	2,500
Observed Volume (ML)	4,500	3,800
Volume % difference	-22%	-34%

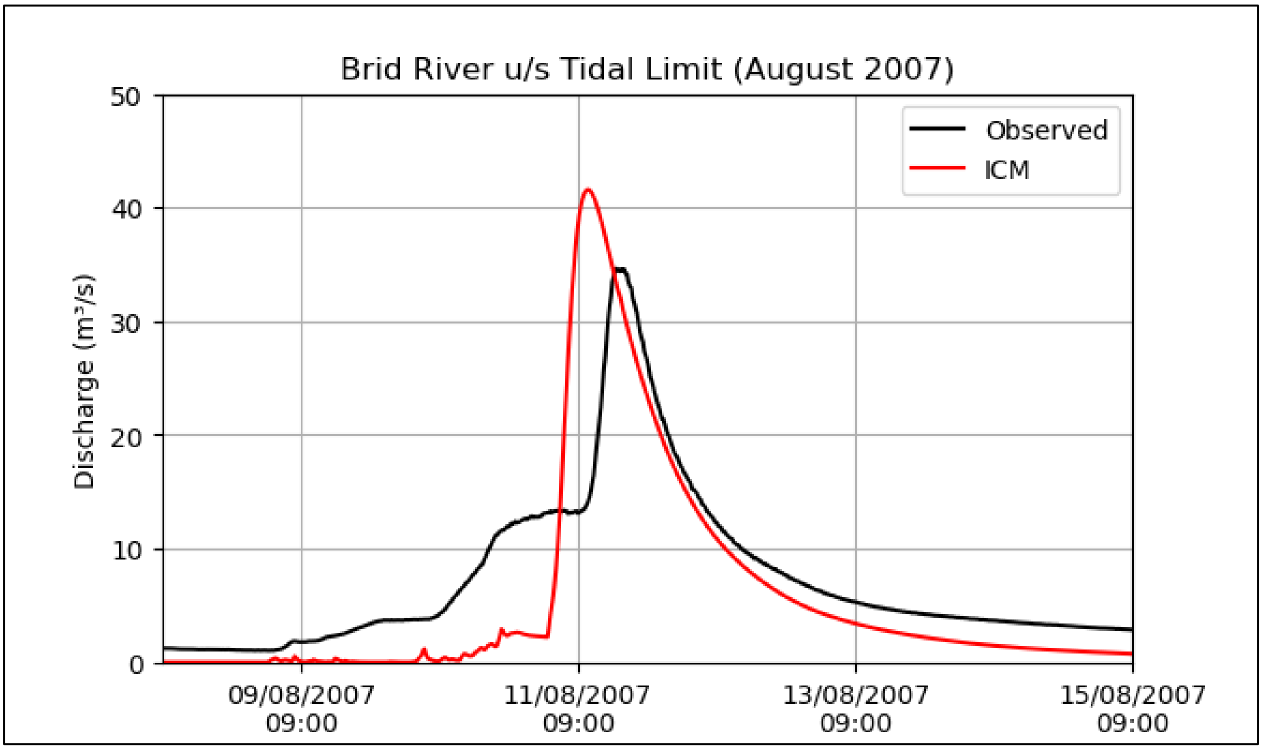


Diagram 12: August 2007 flow comparison at Brid River u/s Tidal Limit

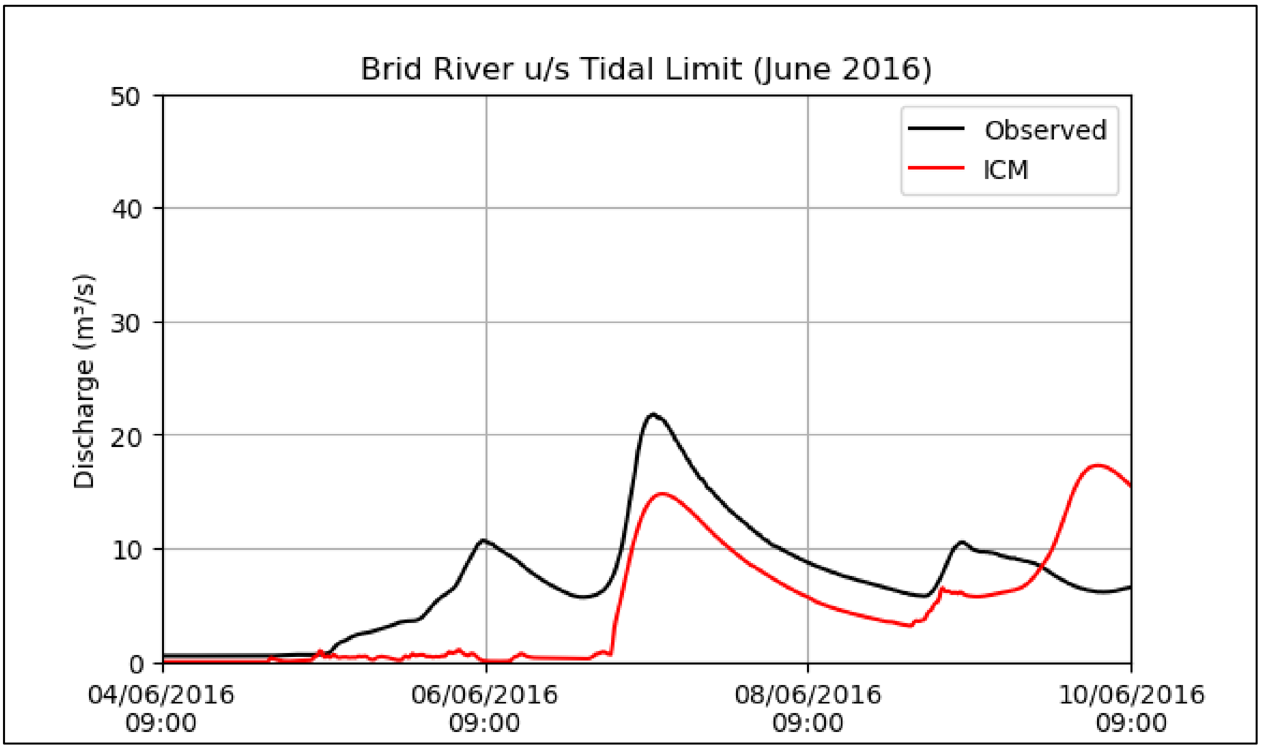


Diagram 13: June 2016 flow comparison at Brid River u/s Tidal Limit

6.1.3. Great Forester River u/s Prosperity Road

A flow and water level comparison was undertaken at the Great Forester River u/s Prosperity Road gauge for the August 2007 and June 2016 events. A gauge zero of 121.0 mAHD was provided for this gauge from the DPIPWE database. This results in level discrepancies however when compared to the model. The gauge zero has been adjusted to 119.7 mAHD to enable a reasonable comparison between the model results and the gauge results.

The results indicate differences between the rating curve utilised at the site and the model response. The modelled flows, although showing a good match to the timing and shape of the recorded flows, overestimates the peak flow of the calibration events (based on the rating curve utilised at the site) (Diagram 14, Diagram 15). The modelled levels, although showing a good match to the timing and shape of the recorded levels, underestimates the peak of the calibration events (Diagram 16, Diagram 17).

Differences between the rating curve utilised at the site and the model response would need to be reconciled before a more meaningful calibration can be undertaken at this location. Given the good match of results at Forester Road further downstream, the outcomes at this location are considered acceptable considering the uncertainties present at the location.

Table 7: Calibrated parameters results comparison at Great Forester River u/s Prosperity Road

Statistic	2007 August	2016 June
IL (mm)	21	60
Average CL (mm/h)	1.6	2.7
RAF	4.0	4.0
Modelled Peak (m^3/s)	45	38
Observed Peak (m^3/s)	26	19
Peak % difference	+75%	+99%
Modelled Volume (ML)	4,527	4,118
Observed Volume (ML)	3,435	3,045
Volume % difference	+32%	+35%
Modelled peak (mAHD)	122.1	122.0
Observed peak (mAHD)	123.0	122.5
Peak difference (m)	-0.9	-0.5

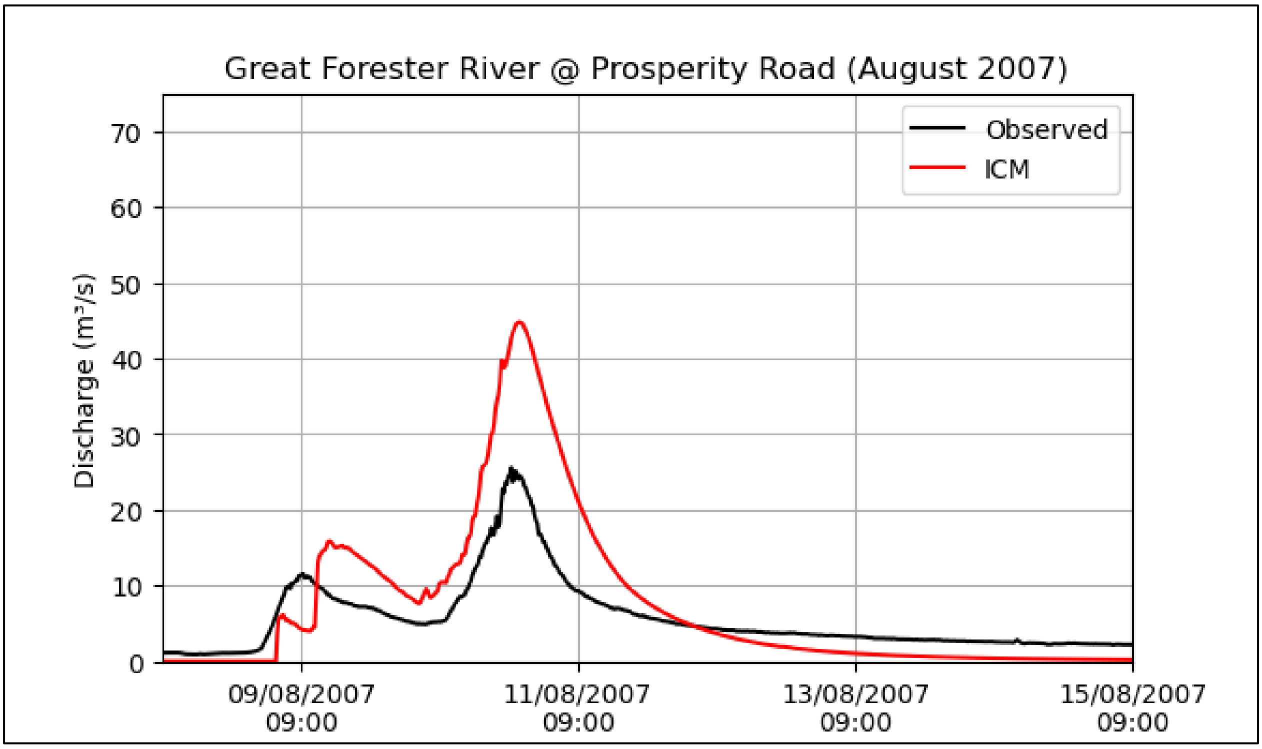


Diagram 14: August 2007 flow comparison at Great Forester River u/s Prosperity Road

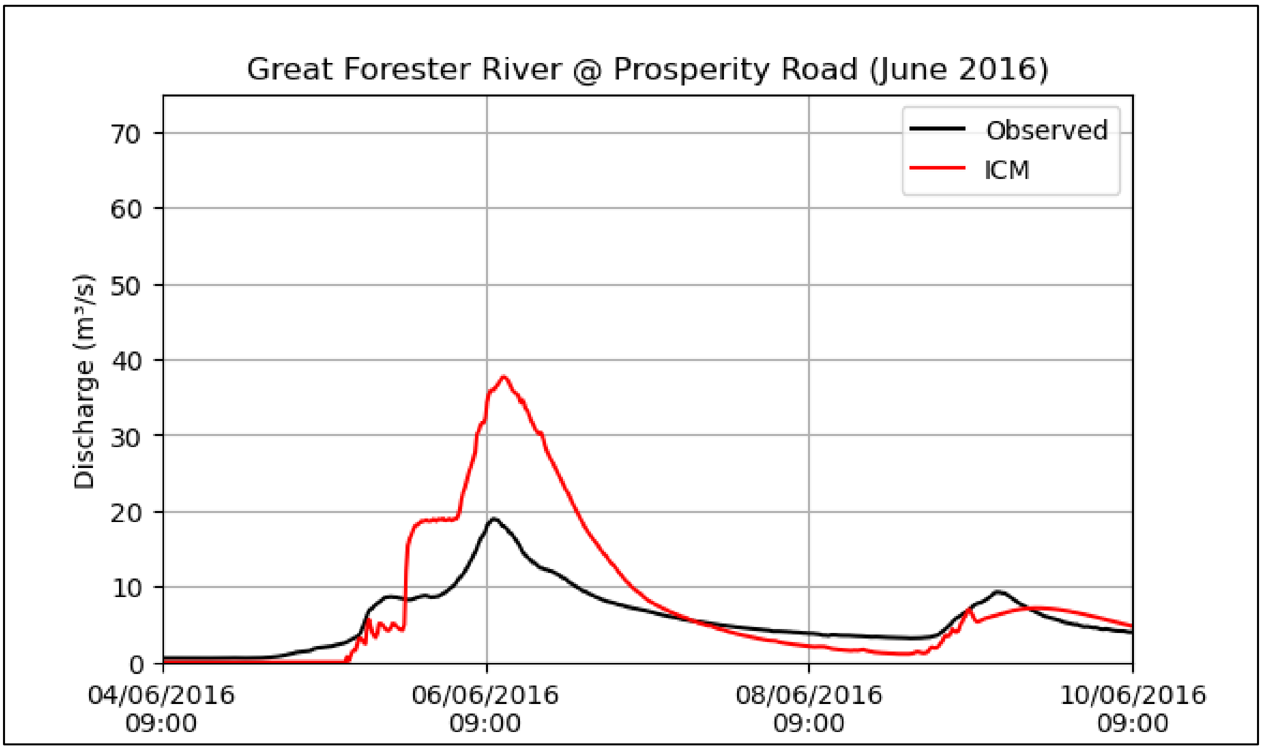


Diagram 15: June 2016 flow comparison at Great Forester River u/s Prosperity Road

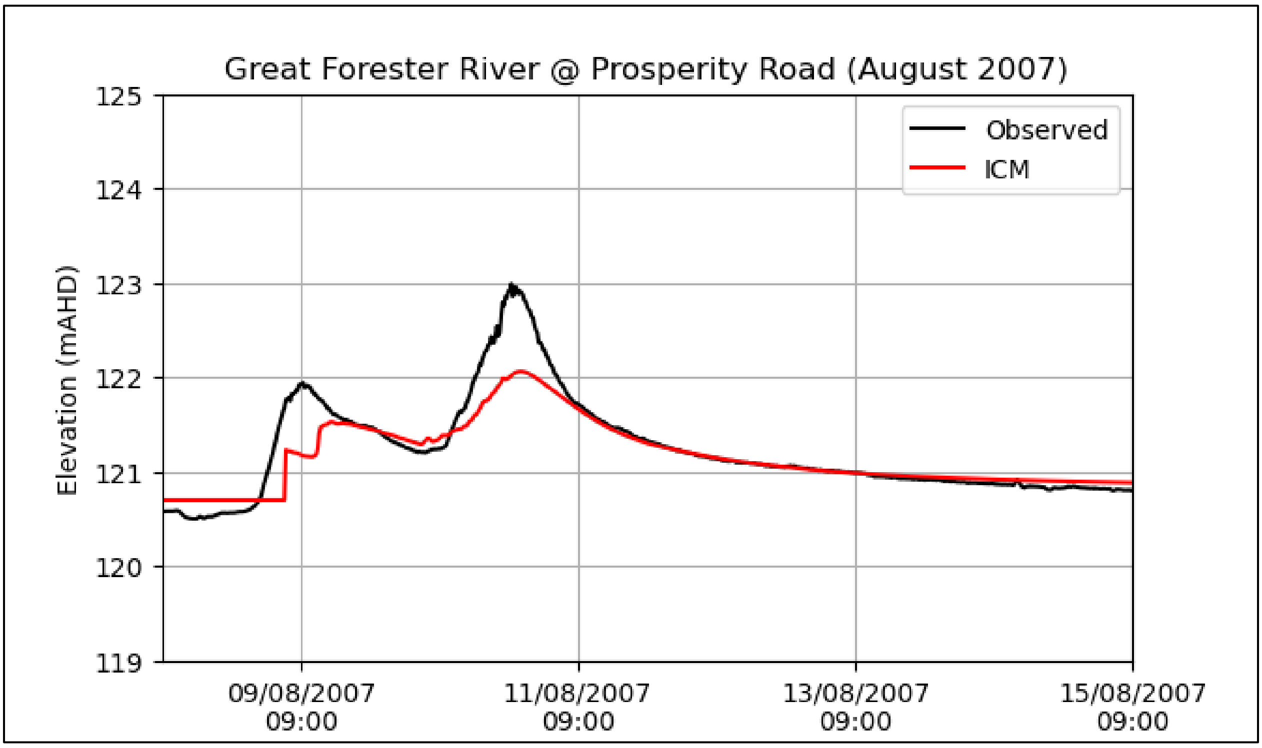


Diagram 16: August 2007 water level comparison at Great Forester River u/s Prosperity Road

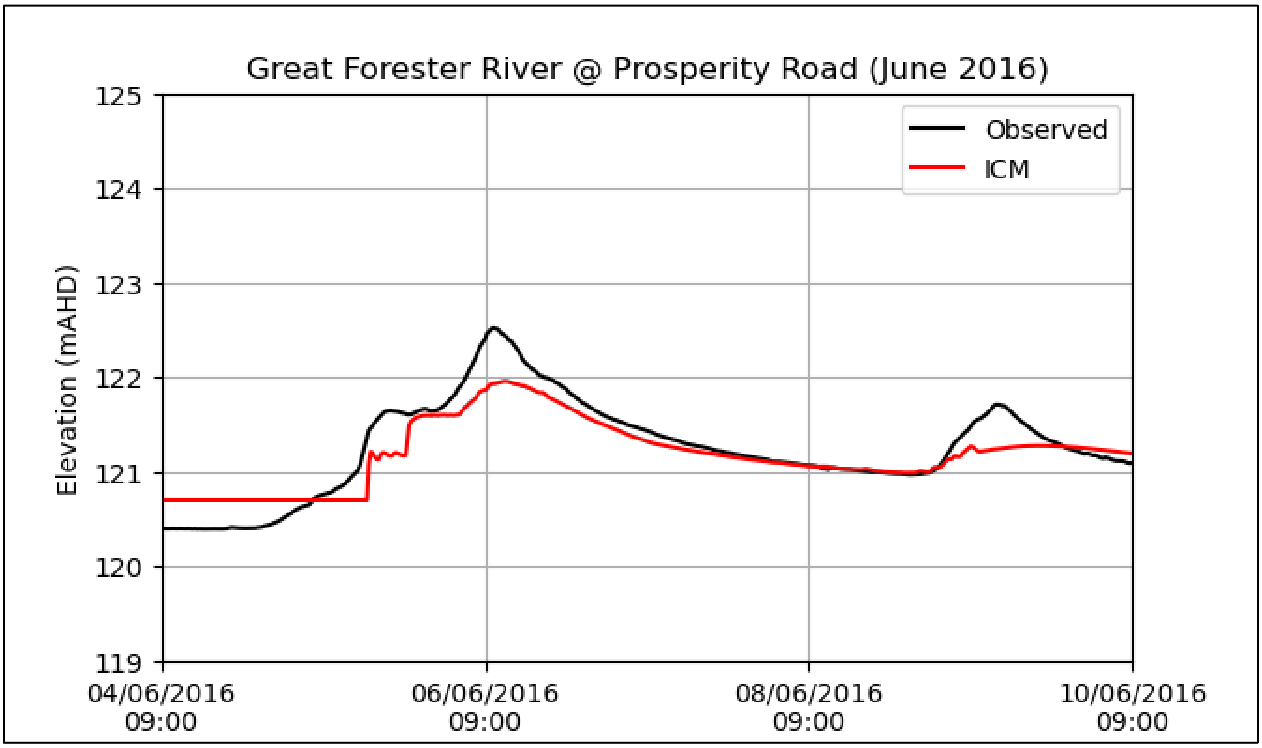


Diagram 17: June 2016 water level comparison at Great Forester River u/s Prosperity Road

6.1.4. Brid River u/s Sledge Road

A flow and water level comparison was undertaken at the Brid River u/s Sledge Road gauge for the January 2011 event, which was estimated to have an AEP of around 5% at the gauge. Stage data was not available for the August 2007 event (gauge commissioned May 2008) and good quality stage data was not available for the June 2016 event (stage quality coded by DPIPWE as “issues”).

A gauge zero of 126.4 mAHD was provided for this gauge from the DPIPWE database, however, the DEM used in the ICM model suggests that the ground level near the gauge is in the order of 126.8 mAHD. A gauge zero of 126.8 mAHD has been used to enable comparison between the modelled and recorded results.

The modelled hydrograph shows a good match in terms of peak flow, timing, and shape to the recorded hydrograph (Diagram 18, Table 8). The results indicate a generally good match to the recorded levels at the gauge (Diagram 19, Table 8). Based on the results it is considered the model parameters utilised are appropriate for this region of the catchment.

Table 8: Calibrated parameters results comparison at Brid River u/s Sledge Road

Statistic	2011 January
IL (mm)	105
Average CL (mm/h)	4.8
RAF	4.0
Modelled Peak (m^3/s)	16
Observed Peak (m^3/s)	17
Peak % difference	-10%
Modelled Volume (ML)	809
Observed Volume (ML)	953
Volume % difference	-15%
Modelled peak (mAHD)	128.7
Observed peak (mAHD)	128.9
Peak difference (m)	-0.2

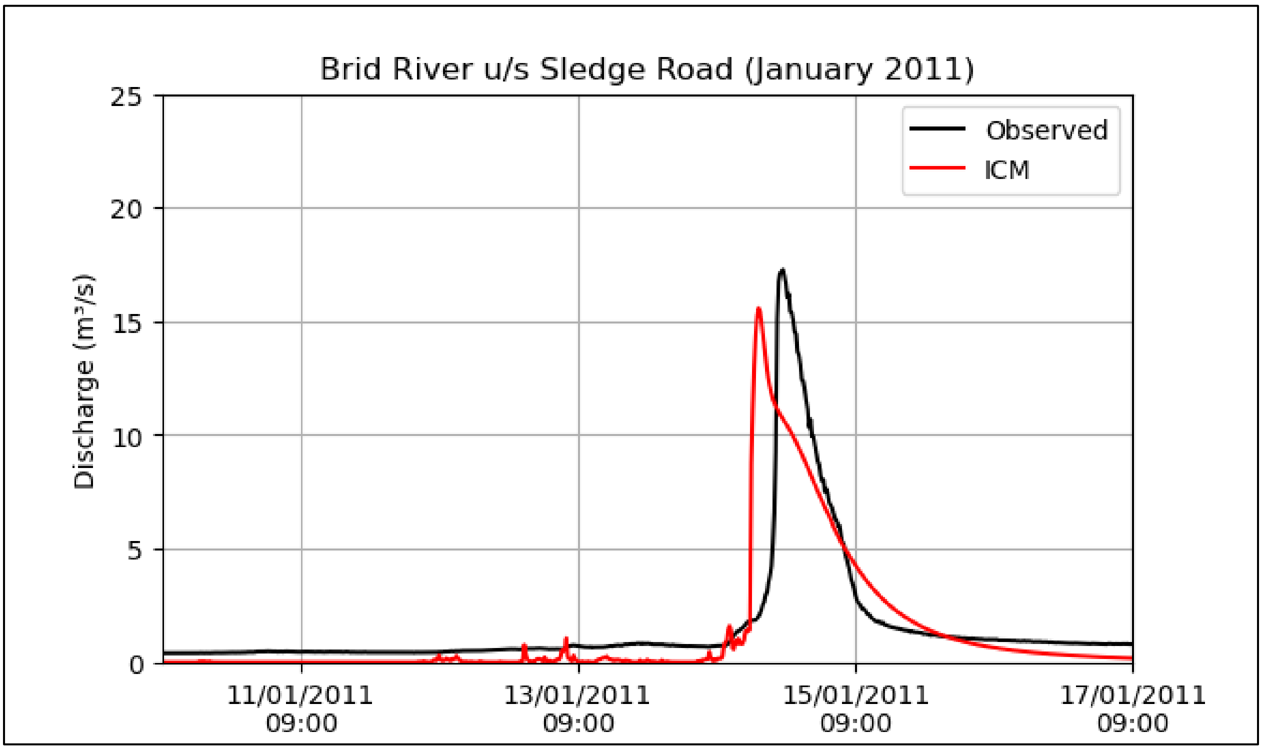


Diagram 18: January 2011 flow comparison at Brid River u/s Sledge Road

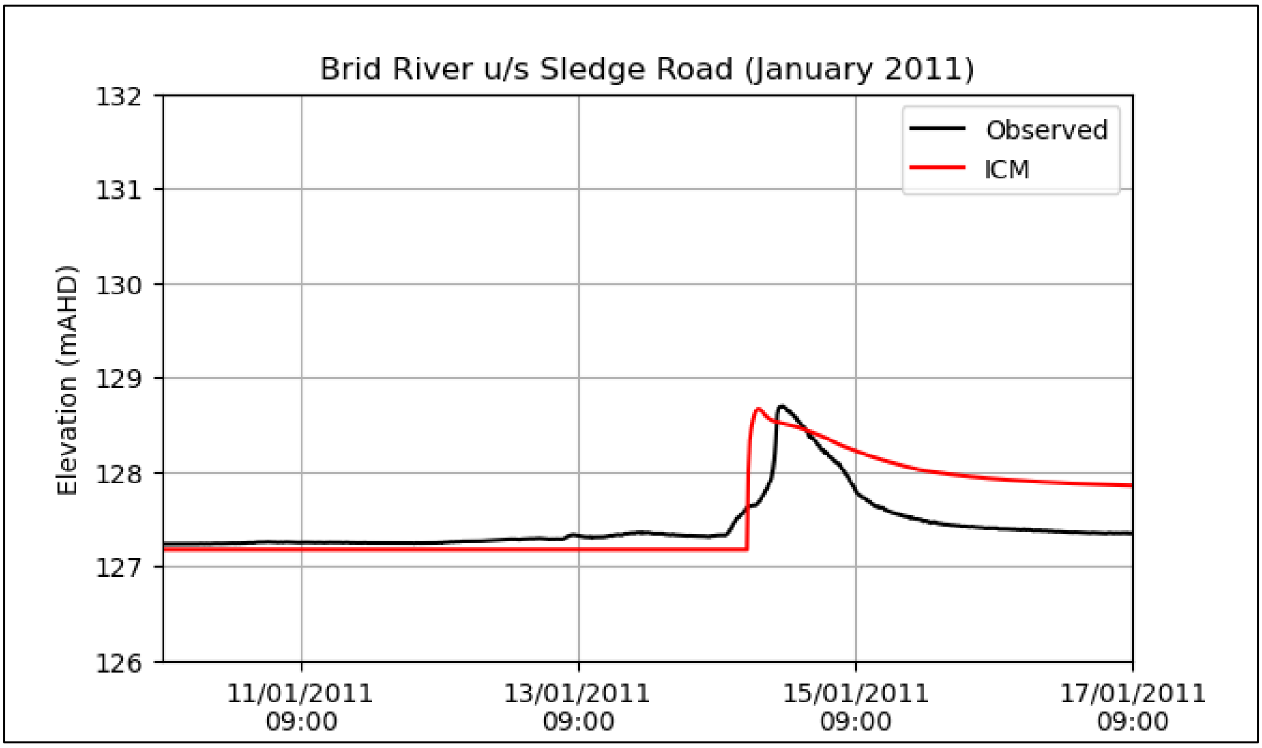


Diagram 19: January 2011 water level comparison at Brid River u/s Sledge Road

6.1.5. Little Forester River d/s Denison River

A flow and water level comparison was undertaken at the Little Forester River d/s Denison River gauge for the January 2011 event. The event was estimated to have an AEP of around 30% at the gauge, making the event minor relative to the scale of this project. The event has been reviewed however to ensure calibration parameters derived from other areas in the catchment are relevant for this area, which has no other available calibration information.

A gauge zero of 31.7 mAHD was provided for this gauge from the DPIPWE database, however the DEM used in the ICM model suggests that the ground level near the gauge is in the order of 36.0 mAHD. A gauge zero of 36.0 mAHD has been used to enable comparison between the modelled and recorded results.

The modelled hydrograph shows a reasonable match in terms of peak flow, timing, and shape compared to the recorded hydrograph (Diagram 20, Table 9). The results indicate a generally good match to the recorded levels at the gauge (Diagram 21, Table 9).

The outcomes support use of the calibrated parameters in this location.

Table 9: Calibrated parameters results comparison at Little Forester River d/s Denison River

Statistic	2011 January
IL (mm)	82
Average CL (mm/h)	4.5
RAF	4.0
Modelled Peak (m^3/s)	55
Observed Peak (m^3/s)	45
Peak % difference	+22%
Modelled Volume (ML)	3905
Observed Volume (ML)	4583
Volume % difference	-15%
Modelled peak (mAHD)	38.7
Observed peak (mAHD)	38.8
Peak difference (m)	-0.1

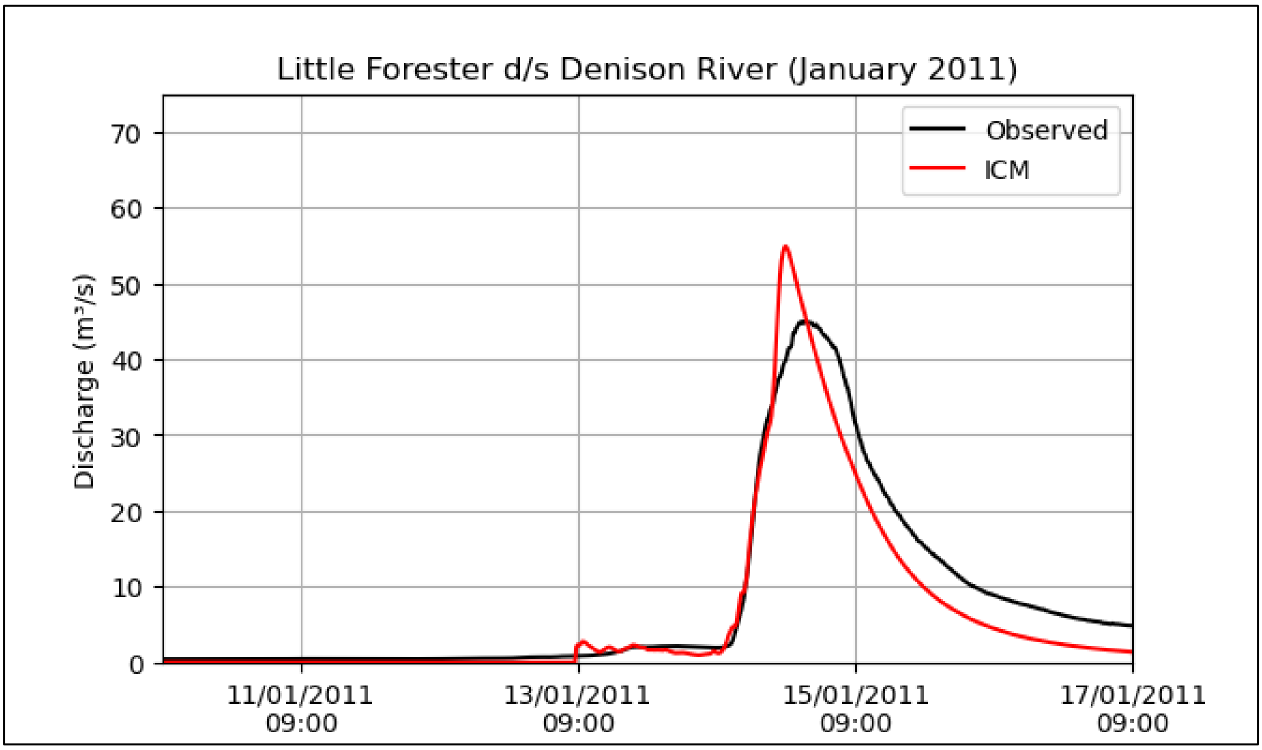


Diagram 20: January 2011 flow comparison at Little Forester River d/s Denison River

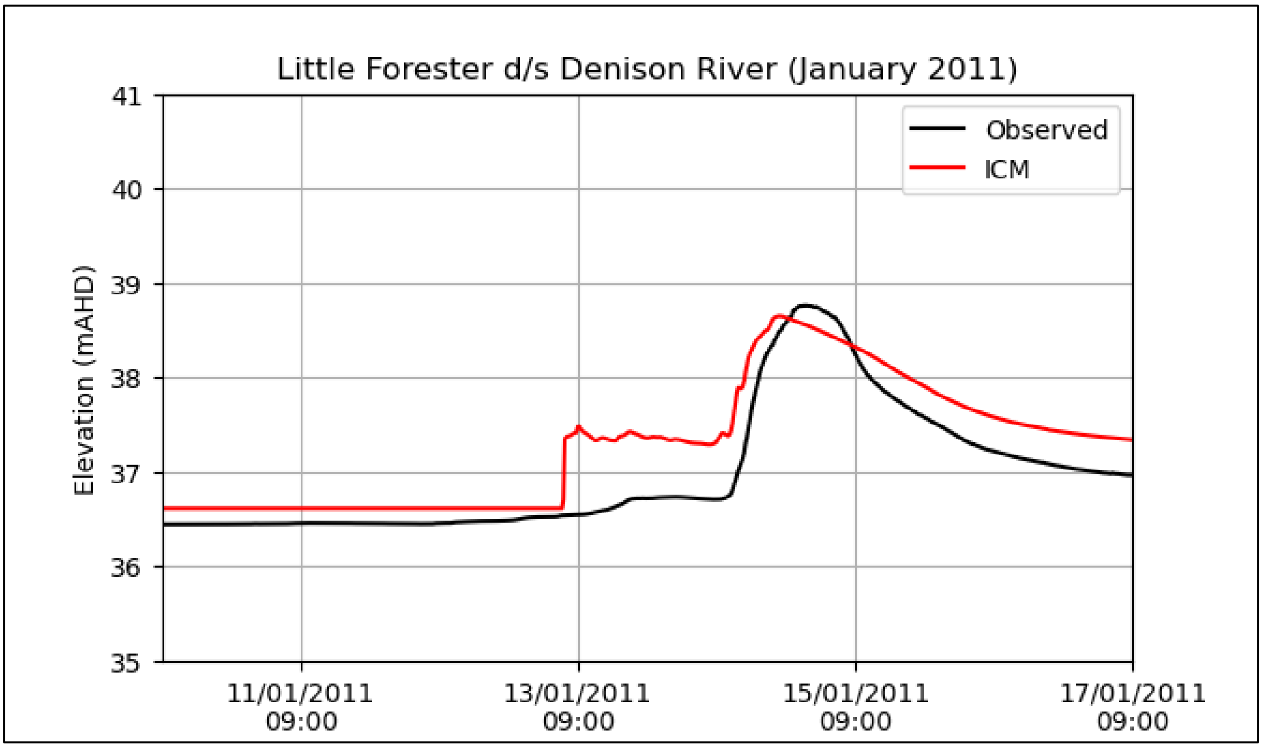


Diagram 21: January 2011 water level comparison at Little Forester River d/s Denison River

6.2. 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. Ideally, this information would have been compared against the modelled flood extents for the June 2016 event, however, the Great Forester-Brid catchment was not included in the June 2016 flood survey.

6.3. Identified Issues

In lieu of the June 2016 flood survey, a high-level review of the modelled flood extents for the June 2016 event was undertaken to identify potential issues that may need to be addressed.

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

- The DEM in some areas of the catchment, specifically in the lower reaches of the catchment, are limited to the 'Default DTM' of the state-wide 10 m DEM. Based on the observations at the Brid River u/s Tidal Limit gauge, it is expected that through these areas there will be a poor representation of flows and levels until such time that improved topographic data is made available.
- Several of the gauges have poor or no quality information. Future works may consider improving gauges in the area to ensure higher quality data is present for future rainfall events.

7. UNCERTAINTY ASESSMENT

Significant flows were recorded at gauges within the Great Forester – Brid study area for three of the study calibration events: August 2007, January 2011, and June 2016. August 2007 and June 2016 events were significant at Great Forester River u/s Forester Road and Brid River u/s Tidal Limit gauges, and reliable flow data was available at these gauges for these events. A short flow record was available at Brid River u/s Sledge Rd Bridge and the January 2011 event was significant at this gauge. The rainfall quality for the 2007 and 2016 events was considered to be good, although only data was only available at one sub-daily gauge for the 2007 event within the catchment. No flood extents or flood levels were available for calibration of the hydrodynamic model.

The uncertainty assessment for the modelling is shown in Table 10. Detail of the uncertainty assessment in provided in Appendix B.

Table 10: Uncertainty assessment for Great Forester - Brid study area model

Category	Quality statement
Hydrology – rainfall input quality	The rainfall quality for the calibration events is generally good, with at least 1 sub-daily rainfall gauge within the study area providing information for each calibration event, and 6 to 8 daily rainfall gauges within the catchment.
Hydrology – observed flows	There are two flow gauges that were operating during August 2007 and June 2016 calibration events within the catchment. These are Great Forester River u/s Forester Road and Brid River u/s Tidal Limit. The ratings at these sites are considered to be excellent, for the events of interest, with gauged levels higher than the peak event levels. Model results were also assessed for the January 2011 event at Brid River u/s Sledge Rd Bridge and Little Forester d/s Denison River.
Hydrology – calibration events	The August 2007 and June 2016 second and fourth largest events on record at Great Forester River u/s Forester Rd, with AEPs of around 3% and 10% respectively. At Brid River u/s Tidal Limit gauge, the same events plotted at AEPs of 10% (August 2007) and 20% (June 2016). The January 2011 event has an AEP of around 5% at Brid River u/s Sledge Rd Bridge.
Hydrology – calibration results	The hydrology calibration was considered to provide a good to excellent match to peak flows, hydrograph volumes and shapes, at Great Forester u/s Forester Road site. The DEM at Brid River u/s Tidal Limit gauge is limited to default DEM and results in an artificial control upstream of the gauge. The calibration results at this gauge are poor to fair.
DTM definition	Base dataset for the digital elevation model (DEM) 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 four of the five gauges in the catchment, with the SES state-wide 10 m DEM used at the remaining gauge (Brid River u/s Tidal Limit).
DTM waterways	No bathymetric data was available and waterway definition was based on the LiDAR to water surface.
Hydrodynamic – observed flood depths	No observed flood depths were available in this area

Category	Quality statement
Hydrodynamic – overall calibration results	Calibration results within the hydrodynamic model generally show a good correlation between recorded and modelled information for the calibration events at gauges where reliable terrain and gauge data is available.
Hydrodynamic – calibration results, peak levels	• Model calibration to peak levels at Great Forester u/s Forester Road gauge was considered to be excellent with modelled peak levels within 0.2 m of observed peak. • No water level comparisons were undertaken at Brid River u/s Tidal Limit gauge due to the uncertainty in the DTM in this area. • Comparison of model results to peak levels at Brid River u/s Sledge Road and Little Forester d/s Denison River gauges were within 0.2 m of observed peak • Comparison of model results to peak levels at Great Forester River u/s Prosperity Road were within 0.9 m of observed peak
Hydrodynamic – calibration results, flood extents	No information on flood extents was available in this area
Hydrodynamic – calibration results, flood depths	No information on flood depths was available in this area

8. REFERENCES

ABC News (2016): Tasmania Floods: Livestock being retured to farmers, but thousands of animals feared dead. https://www.abc.net.au/news/rural/2016-06-12/floods-northern-tasmania-livestock-survival/7503096

Babister, M., Trim, A., Testoni, I. & Retallick, M (2016): The Australian Rainfall & Runoff Datahub 37th Hydrology and Water Resources Symposium Queenstown NZ, 2016 available at http://data.arr-software.org/

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (2019): Editors Australian Rainfall and Runoff: A Guide to Flood Estimation Commonwealth of Australia, Australia, 2019

Bureau of Meteorology (2020). Rainfall Map Information. Bureau of Meteorology, Victoria, Australia URL: http://www.bom.gov.au/climate/austmaps/about-rain-maps.shtml

Bureau of Meteorology (2019). 2016 Rainfall IFD Data System. Bureau of Meteorology, Victoria, Australia URL: http://www.bom.gov.au/water/designRainfalls/revised-ifd/

DPIPWE (2005): Waterways Monitoring Report, Huon River Catchment. https://dpipwe.tas.gov.au/Documents/Huon_Report-.pdf, viewed 06/08/2020.

DPIPWE (2019) Hydrologic Soil Groups of Tasmania (Unpublished). Department of Primary Industries and Water, Hobart, Tasmania. Created March 2019

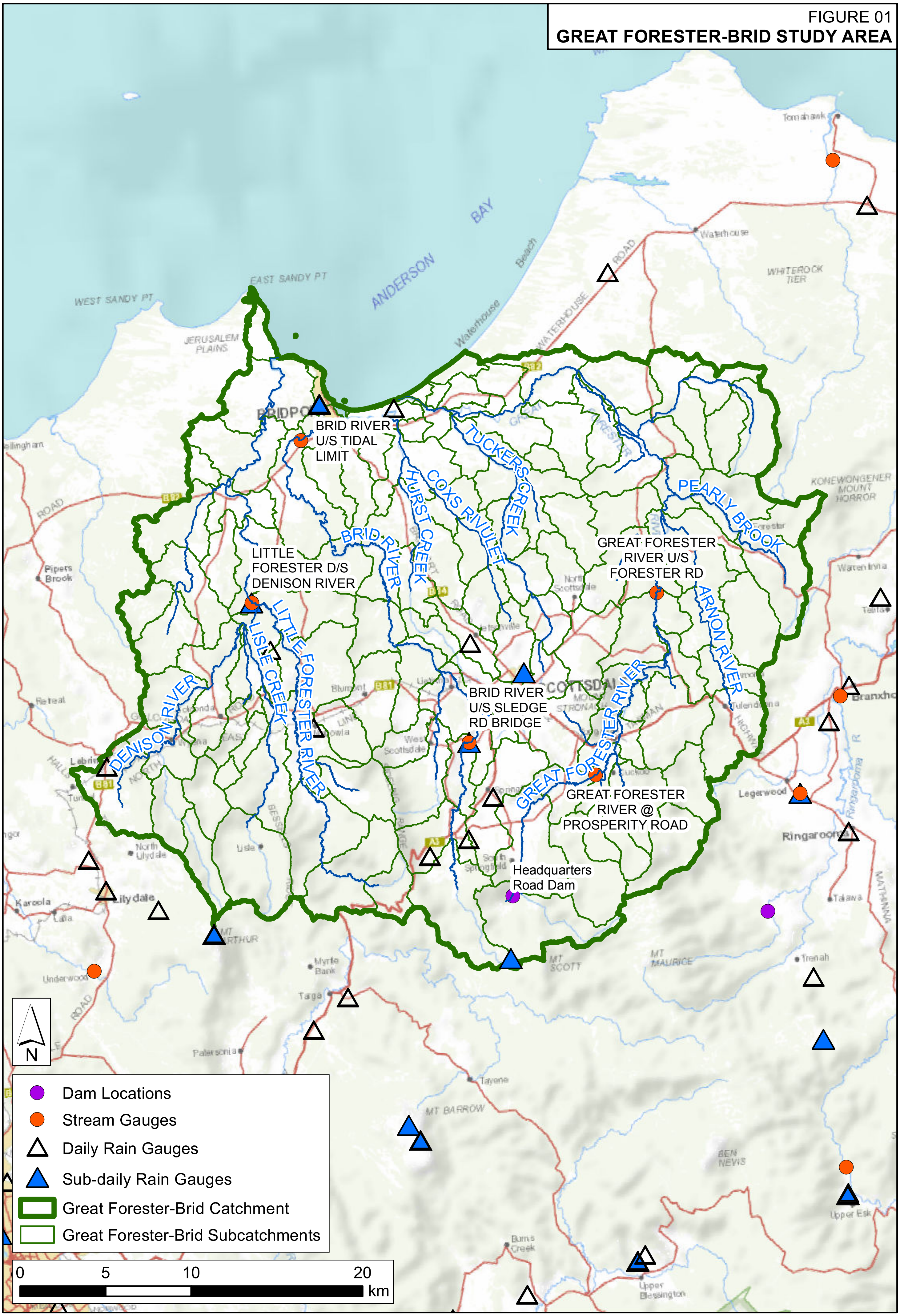
WMAwater (2020): Tasmanian Strategic Flood Map Data Review, September 2020. Report for State Emergency Service, Tasmania.

WMAwater (2021a): Tasmanian Strategic Flood Map Hydrology Methods Report, August 2021. Report for State Emergency Service, Tasmania.

WMAwater (2021b): Tasmanian Strategic Flood Map Hydrodynamic Model Methods Report, August 2021. Report for State Emergency Service, Tasmania.

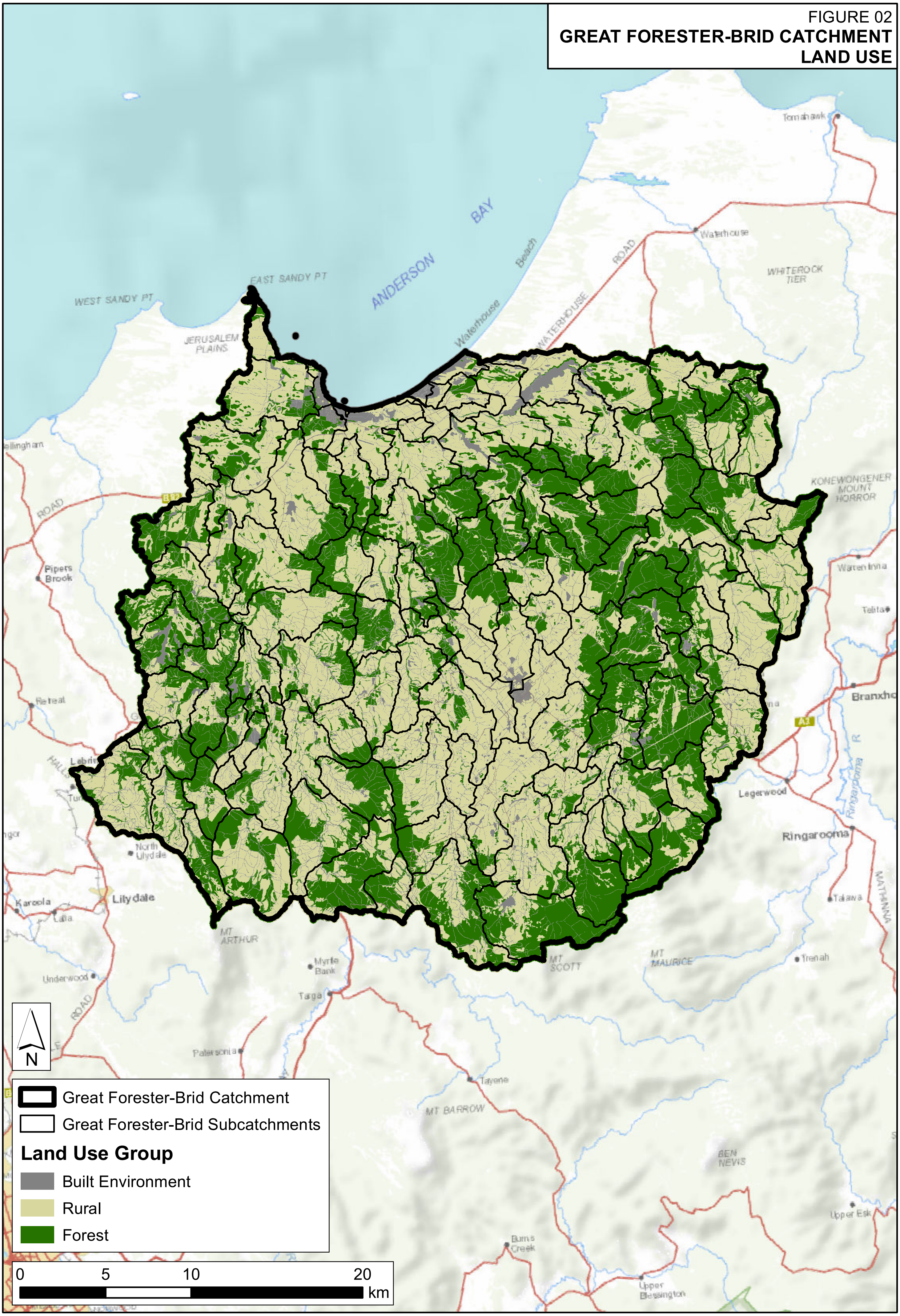
Figures

FIGURE 01
GREAT FORESTER-BRID STUDY AREA



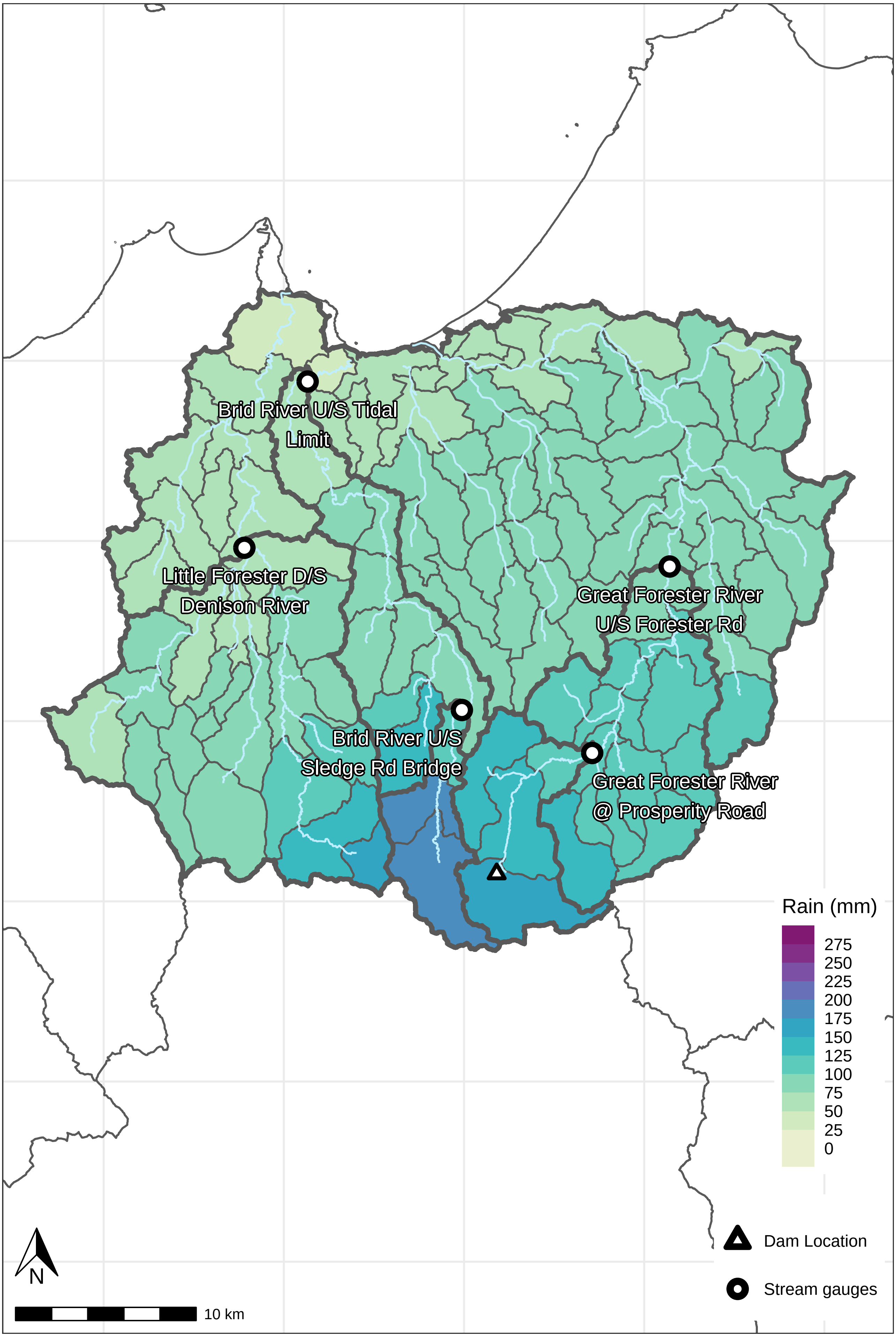
J:\Jobs\120038\GIS\Group_1_Catchment_Figures\Figure01_Great_Forester-Brid_Study_Area.mxd

FIGURE 02
GREAT FORESTER-BRID CATCHMENT LAND USE



J:\Jobs\120038\GIS\Group_1_Catchment_Figures\Figure02_Great_Forester-Brid_Catchment_Land_Use_SubOutline.mxd

FIGURE 3
GREAT FORESTER−BRID
WHOLE_CATCHMENT 2007_AUG

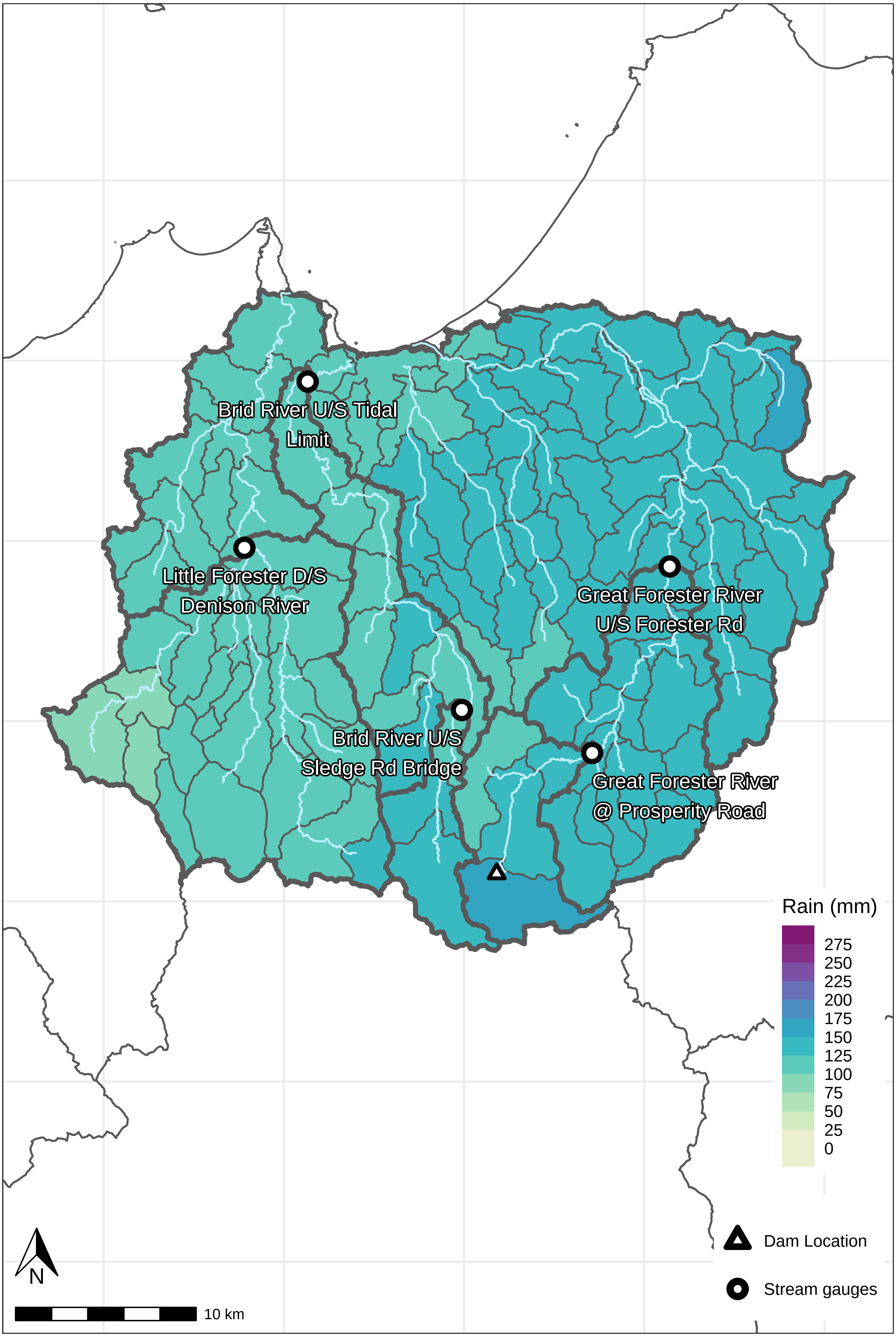


created by J:/Jobs/120038/Hydrology/R_scripts/Generalised_for_statewide/Workflow_Scripts/temp_rerun_Set_calibration_wbn_models_with_rainfall.R
J:/Jobs/120038/Hydrology/Statewide/Calibration/Great Forester−Brid/Subcatchment_rainfalls/Figure3Rain_Whole_catchment 2007_Aug.pdf

FIGURE 4

GREAT FORESTER−BRID

WHOLE_CATCHMENT 2011_JAN

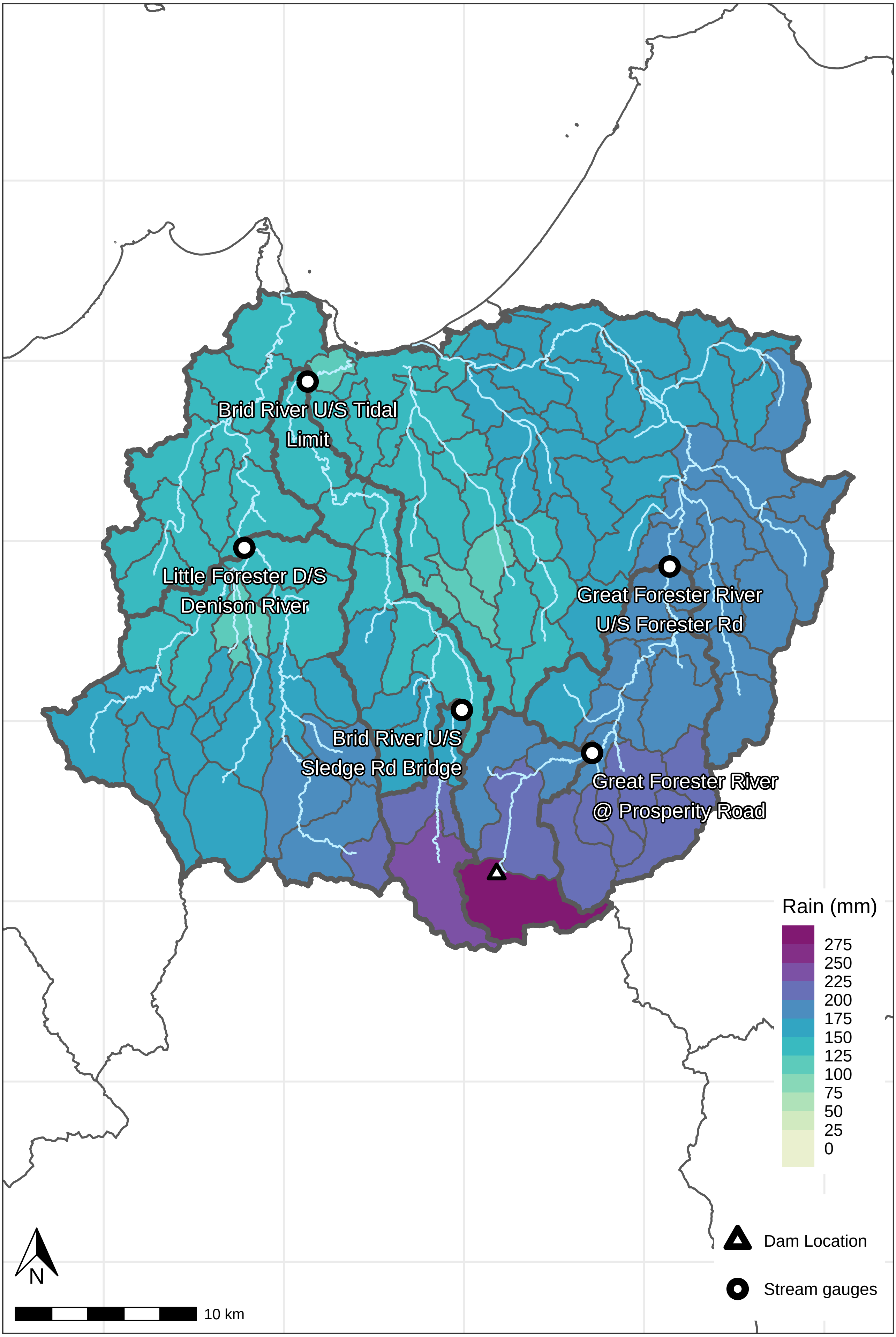


created by J:/Jobs/120038/Hydrology/R_scripts/Generalised_for_statewide/Workflow_Scripts/temp_rerun_Set_calibration_wbn_models_with_rainfall.R
J:/Jobs/120038/Hydrology/Statewide/Calibration/Great Forester−Brid/Subcatchment_rainfalls/Figure4Rain_Whole_catchment 2011_Jan.pdf

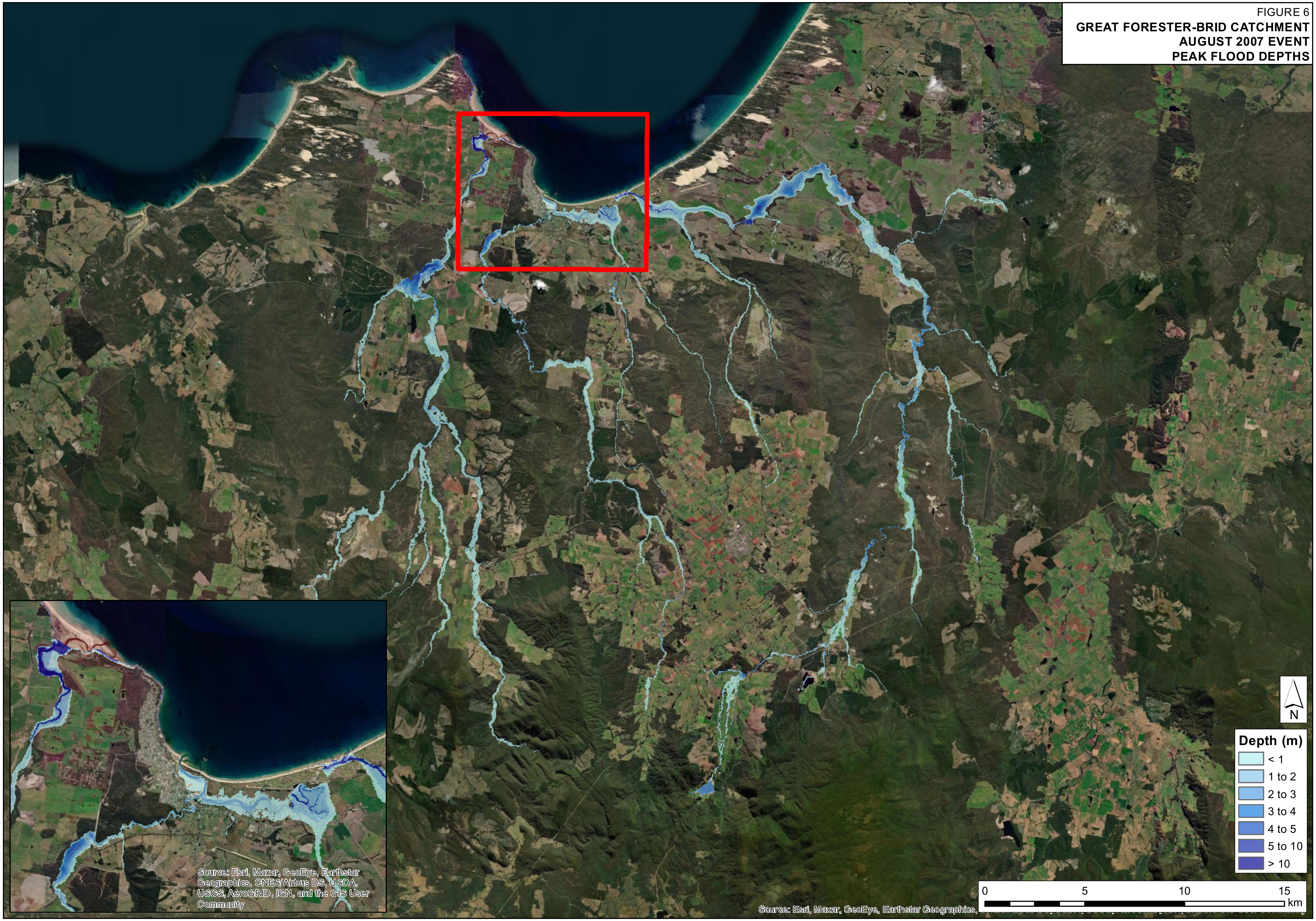
FIGURE 5

GREAT FORESTER−BRID

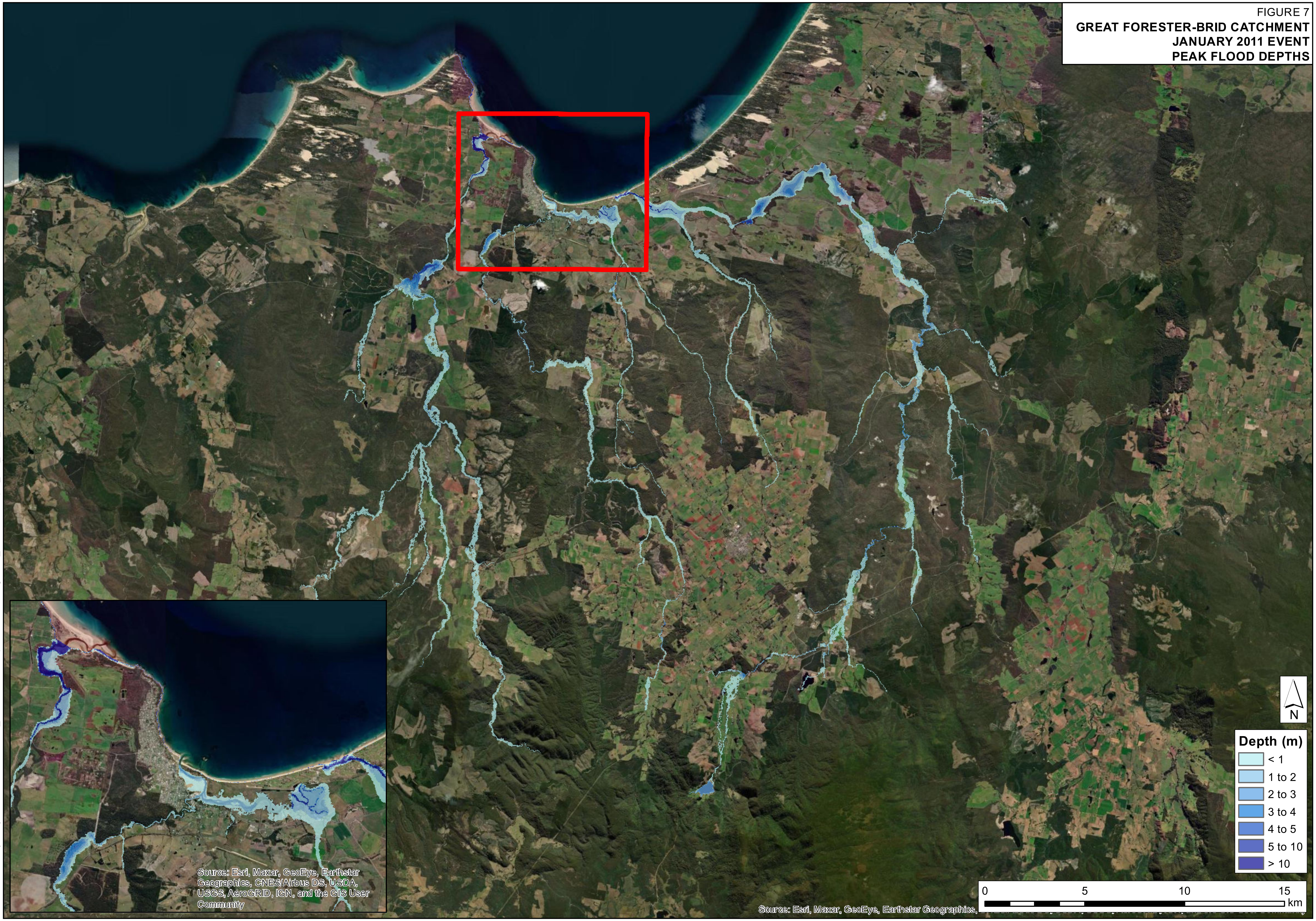
WHOLE_CATCHMENT 2016_JUN



created by J:/Jobs/120038/Hydrology/R_scripts/Generalised_for_statewide/Workflow_Scripts/temp_rerun_Set_calibration_wbn_models_with_rainfall.R
J:/Jobs/120038/Hydrology/Statewide/Calibration/Great Forester−Brid/Subcatchment_rainfalls/Figure5Rain_Whole_catchment 2016_Jun.pdf

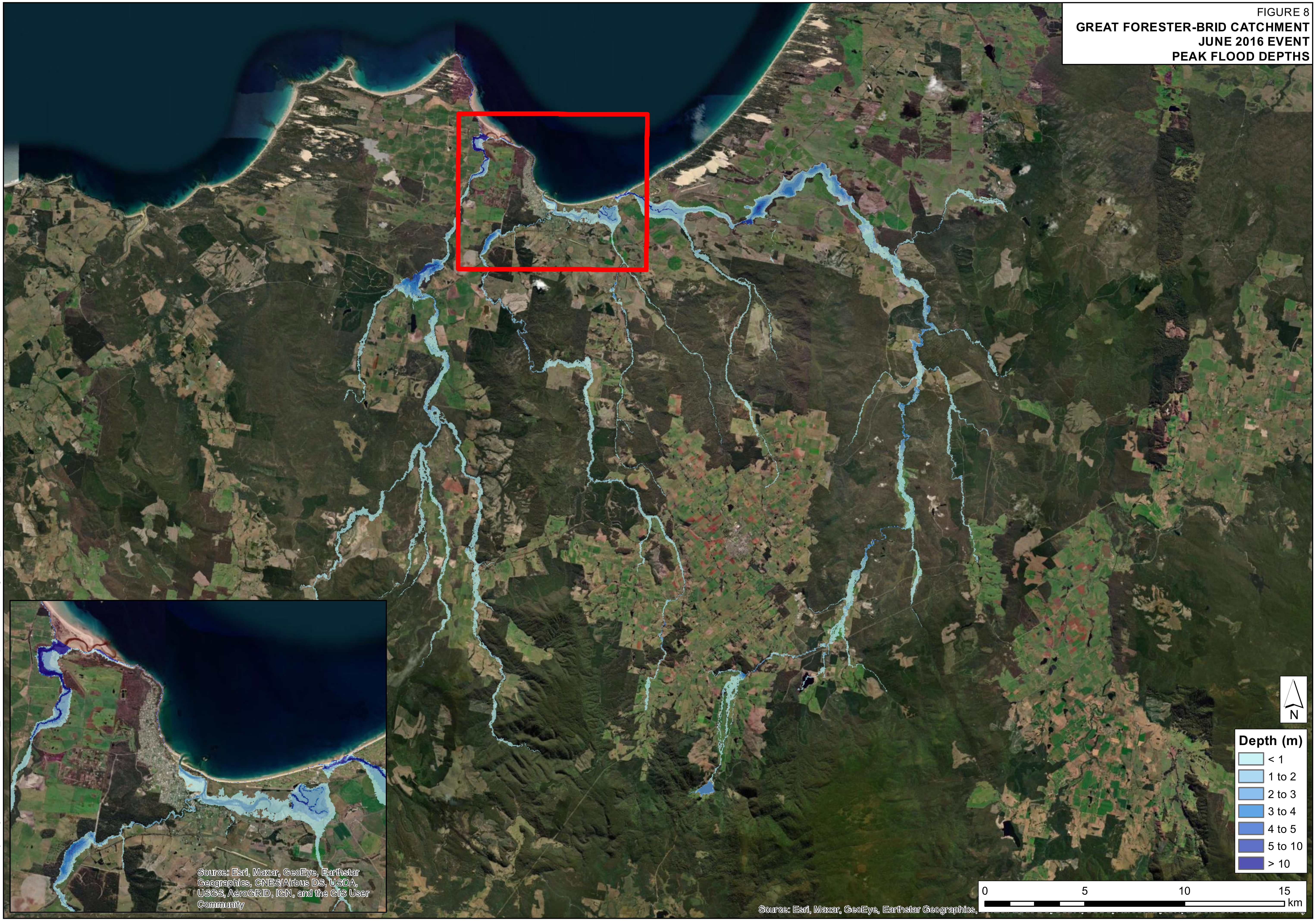


J:\Jobs\120038\Hydrodynamic\Statewide\Great_Forester-Brid\Maps\Calibration\Figure06_PeakFloodDepth_Aug_2007_Event.mxd



J:\Jobs\120038\Hydrodynamic\Statewide\Great_Forester-Brid\Maps\Calibration\Figure07_PeakFloodDepth_Jan_2011_Event.mxd

FIGURE 8
GREAT FORESTER-BRID CATCHMENT
JUNE 2016 EVENT
PEAK FLOOD DEPTHS



J:\Jobs\120038\Hydrodynamic\Statewide\Great_Forester-Brid\Maps\Calibration\Figure08_PeakFloodDepth_June_2016_Event.mxd

Appendix A

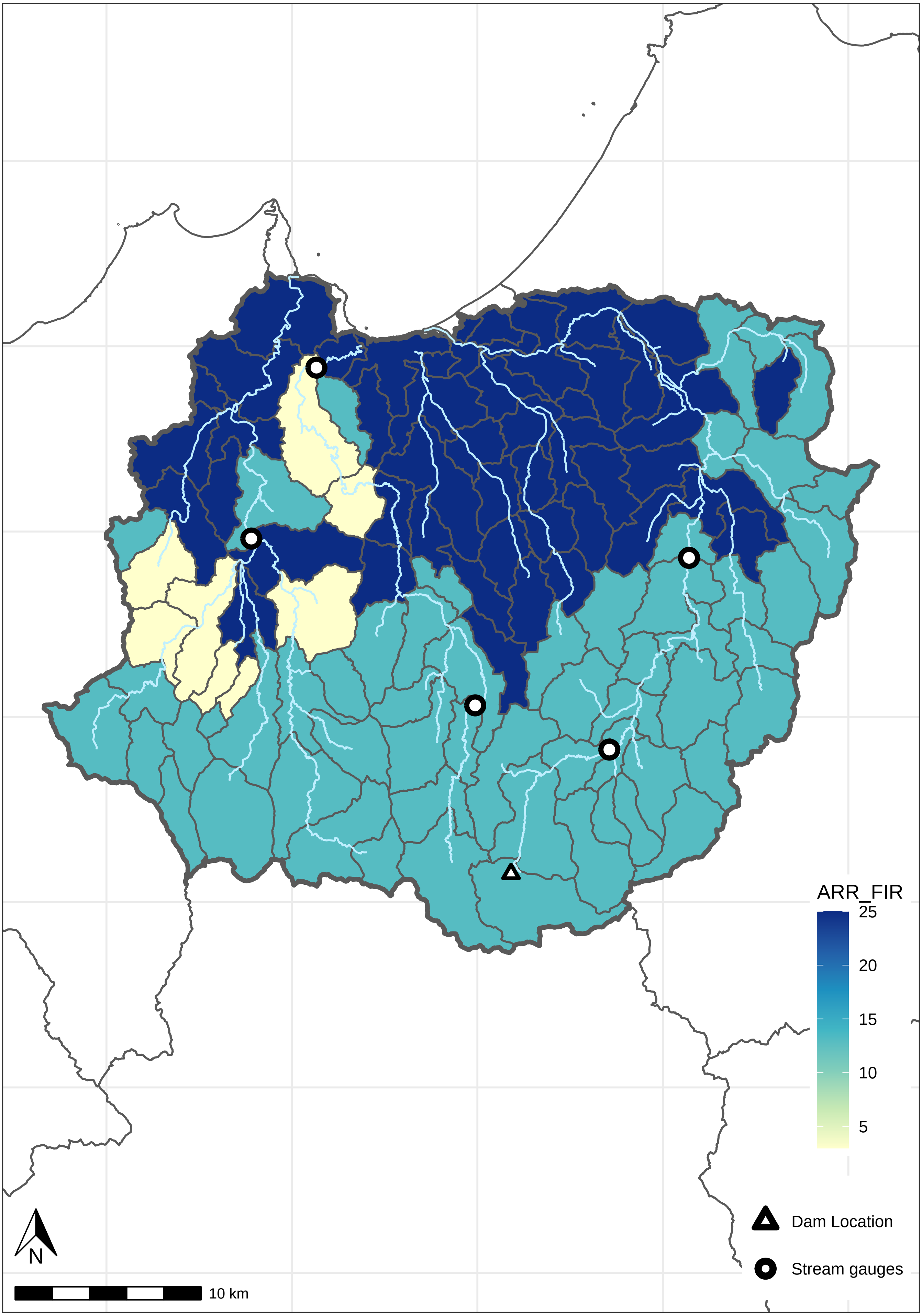
APPENDIX A. AVALIABLE DATA

A.1. Sub catchment Data

FIGURE A1

HYDROLOGICAL SOIL GROUP MAPPING

DOMINANT SUBCATCHMENT SOIL INFILTRATION RATE



created by J:/Jobs/120038/Hydrology/R_scripts/Generalised_for_statewide/Workflow_Scripts/3_Set_calibration_wbn_models_with_rainfall.R
J:/Jobs/120038/Hydrology/Statewide/Calibration/Great Forester−Brid/Subcatchment_rainfalls/Figure_A1_Great Forester−Brid_SoilTypes.pdf

Appendix B

APPENDIX B. UNCERTAINTY ANALYSIS

B.1. Hydrologic Model Uncertainty

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

- For observed flows Great Forester u/s Forester Road and Brid u/s Tidal limit gauges in green shading, gaugings and ratings were not provided for the other gauges, which were not used in calibration.
- For calibration events Great Forester u/s Forester Road is shown with blue shading, Brid u/s Tidal limit with orange shading.

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

Category	Rating				
	Poor	Fair	Good	Very good	Excellent
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:

- Calibration at Great Forester u/s Forester Road is shown with blue shading
- Calibration at Brid u/s Tidal limit with orange shading

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, with orange shading for the area around the Brid u/s Tidal Limit gauge.

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, highlighted in blue for Great Forester u/s Forester Road gauge site and all other gauges in orange for calibration flood levels.

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. Blue shading is used to highlight relevant statements, based on results at Great Forester u/s Forester Road, Little Forester River d/s Denison River, and Brid River u/s Sledge Road gauges. No flood extents or survey points were available for comparison.

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