

**STATE EMERGENCY SERVICE**



# TASMANIAN STRATEGIC FLOOD MAP MUSSELROE-ANSONS STUDY AREA DESIGN FLOOD MODELLING

## ADDENDUM TO CALIBRATION REPORT



**MARCH 2023**



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### ADDENDUM TO CALIBRATION REPORT MARCH 2023

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| <b>Project</b><br>Tasmanian Strategic Flood Map Musselroe-Ansons Study Area Design Flood Modelling | <b>Project Number</b><br>120038                |
| <b>Client</b><br>State Emergency Service   | <b>Client's Representative</b><br>Chris Irvine |
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# TASMANIAN STRATEGIC FLOOD MAP MUSSELROE-ANSONS STUDY AREA DESIGN FLOOD MODELLING

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## LIST OF ACRONYMS

|            |  |
|------------|--|
| AEP        | Annual Exceedance Probability  |
| AMS        | Annual Maximum Series  |
| ARF        | Areal Reduction Factor   |
| ARR        | Australian Rainfall and Runoff   |
| ATP        | Areal Temporal Patterns  |
| Bureau/BoM | Bureau of Meteorology  |
| CC         | Climate Change   |
| CFEV       | Conservation of Freshwater Ecosystem Values (DPIPWE/DNRE)  |
| CL         | Continuing Loss  |
| DEM        | Digital Elevation Model  |
| DNRE       | Department of Natural Resources and Environment Tasmania<br>(formerly DPIPWE)                            |
| DPIPWE     | Department of Primary Industries, Water and Environment  |
| DRM        | Direct Rainfall Method   |
| DTM        | Digital Terrain Model  |
| FFA        | Flood Frequency Analysis   |
| FLIKE      | Software for flood frequency analysis  |
| GIS        | Geographic Information System  |
| GEV        | Generalised Extreme Value distribution   |
| HAT        | Highest Astronomical Tide  |
| HSA        | Human Settlement Area  |
| ICM        | Infoworks ICM software (Innovyze)  |
| IL         | Initial Loss   |
| IFD        | Intensity, Frequency and Duration (Rainfall)   |
| LiDAR      | Light Detection and Ranging  |
| mAHD       | meters above Australian Height Datum   |
| NTC        | National Tide Centre   |
| PERN       | Catchment routing parameter in RAFTS   |
| Pluvi      | Pluviograph – Rain gauge with ability to record rain in real time  |
| PTP        | Point Temporal Patterns  |
| R          | Channel routing param in WMAWater RAFTS WBNM hybrid model  |
| RAF        | RAFTS Adjustment Factor  |
| RAFTS      | hydrologic model   |
| RCP        | Representative Concentration Pathways (RCPs) (CC scenarios)  |
| RORB       | RORB hydrological modelling software   |
| SES        | State Emergency Service  |
| TUFLOW     | one-dimensional (1D) and two-dimensional (2D) flood and tide<br>simulation software (hydrodynamic model) |
| TP         | Rainfall Temporal Patterns   |

## 1. INTRODUCTION

This report is an addendum to the Tasmanian Strategic Flood Map Musselroe-Ansons Study Area Calibration Report (WMAwater, 2023). The study area, available data, model calibration, limitations and uncertainty statements are provided in the calibration report.

This report outlines the data, methodology and the results of modelling the design flood events for the Musselroe-Ansons Study Area.

## 2. DATA

### 2.1. Previous Flood Studies

There were no previous flood studies provided to WMAwater as part of the project data library.

### 2.2. Flow Data

Flood Frequency Analysis (FFA) was performed on the annual maximum series (AMS) for one flow gauge within the catchment. The gauge used for FFA is shown in Table 1. The other gauges in the study area were not included in the FFA due to insufficient record length, inconsistent datasets and/or unreliable rating curves. More detail on the quality of the gauge data is provided in the calibration report (WMAwater, 2023).

A new rating curve was created for Ansons River DS Big Boggy Creek (WMAwater 2021c). The AMS was reviewed using the original DNRE ratings and the revised rating. This showed that there were consistent shifts between the two ratings across the range of flows (Diagram 1). Therefore, the revised rating was applied to all AMS events from where the rating curves diverged (above  $\sim 100\text{m}^3/\text{s}$ ); as DNRE's rating is likely to be more representative of lower flows this was used below this point.

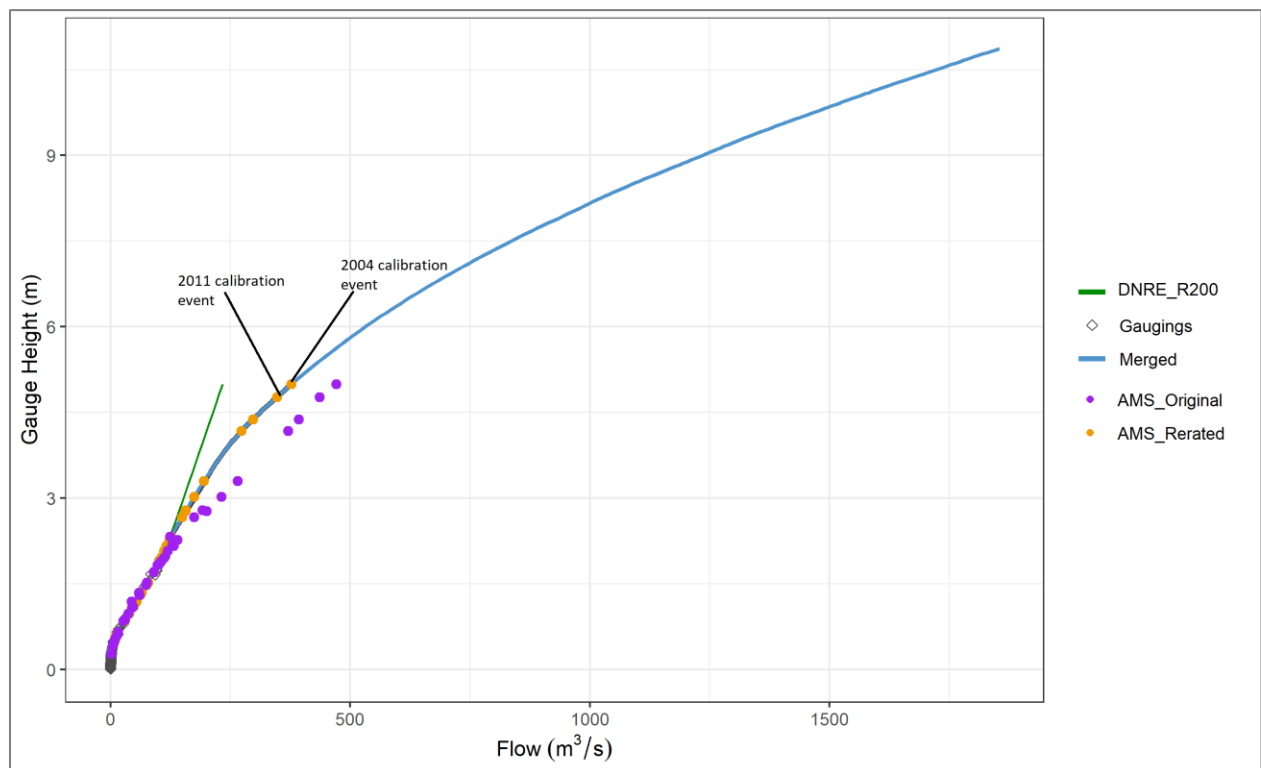


Diagram 1 Ansons River DS Big Boggy Creek AMS events using the original DNRE ratings and the revised hydrodynamic rating with calibration events marked

Table 1: Flow gauge used for FFA

| Gauge number | Gauge name                   | River        | Period of record     | Number of points in AMS |
|--------------|------------------------------|--------------|----------------------|-------------------------|
| 2214-1       | Ansons River DS Big Boggy Ck | Ansons River | 23/05/1979 - present | 36                      |

## 2.3. Design Inputs

The design inputs used in the study (Intensity Frequency Duration (IFD) depths, losses, pre-burst rainfalls, Areal Reduction Factors (ARFs) and temporal patterns) were obtained through the ARR Data Hub (Babister et al, 2016) and the Bureau of Meteorology website (Bureau of Meteorology, 2019).

### 2.3.1. Design Rainfall Depths and Spatial Pattern

Intensity Frequency Duration (IFD) information was sourced from the Bureau of Meteorology website (Bureau of Meteorology, 2019). IFD information was sourced for each individual sub-catchment to give a spatial pattern across the study area. Examples of sub-catchment rainfalls are shown in Figure A 1 to Figure A 3.

### 2.3.2. Temporal Patterns

ARR 2016 Book 2 Chapter 5 (Ball et. al. 2019) recommends the use of areal temporal patterns for catchments with area greater than 75 km<sup>2</sup>. Therefore, for modelling to compare to the flood frequency analysis, the areal temporal patterns relevant to this location were downloaded from the ARR Data Hub. An example of the temporal patterns downloaded from the Data Hub is shown in Figure A 4.

For selection of the final design runs applicable to the entire study area, areal and point temporal patterns were downloaded from the ARR Data Hub. Temporal patterns were filtered for embedded bursts and in some cases patterns with large, embedded bursts causing significant outliers were removed. When assessing the reference critical flow for each sub-catchment as described in the Hydrology Methods Report (WMAwater 2021a), point temporal patterns were used for sub-catchments with an upstream area of less than 75 km<sup>2</sup>, and to assess shorter storms if the critical duration on a larger catchment was identified as 12 hours (the shortest duration available with areal temporal patterns).

### 2.3.3. Pre-burst

Pre-burst rainfall depths were taken from the ARR Data Hub as a ratio of the IFD depths. As Initial Losses (ILs) calibrated to the FFA were greater than 0 there was no need to include sensitivity to adding a pre-burst temporal pattern for this study area, as the pre-burst has effectively been removed from the IL with some IL depth remaining.

### **2.3.4. Losses**

Initial values for sub-catchment initial loss (IL) and continuing loss (CL) were derived from the unpublished Hydrologic Soil Groups of Tasmania data that was provided for use in this project (DPIPWE, 2019).

### **2.3.5. Baseflow**

Baseflow was calculated for each calibration event and was found to be less than 5% of the event peaks. In line with ARR 2016 Book 5 Chapter 4 (Ball et. al., 2019), where baseflows of less than 5% are considered, a small component compared to runoff, a simplified approach to baseflow calculations was used. Hydrodynamic modelling of the calibration events showed that large flood events in this study area were peak rather than volume driven. Baseflows will be a small component of the hydrograph for the AEPs of interest (2%, 1% and 0.5%) and therefore baseflow was not included in the design events.

### **2.3.6. Direct Rainfall**

Two hour direct rainfall storms were created using each sub-catchment's IFD depths using the method described in the Hydrodynamic Method Report (WMAwater, 2021b).

### **2.3.7. Climate Change**

#### **2.3.7.1. Rainfall Factors**

Climate change factors for the study area were downloaded from the ARR Data Hub. ARR recommends the use of the RCP4.5 and RCP8.5 values, however the Tasmanian Interim Planning Scheme recommends the use of RCP8.5 and this has been adopted for this project. RCP8.5 results for the year 2090 give a rainfall scaling factor of 16.3% to be applied to the IFDs.

#### **2.3.7.2. Boundary Conditions**

Sea level rise was included in the climate change scenario and was applied at the downstream boundary of the hydrodynamic model. The rise in water level was taken from the Tasmanian Local Council Sea Level Rise Planning Allowances, which uses sea level rise projections based on RCP 8.5 for 2100. This gave a rise in sea level of 0.92 m for the Break O'Day Council area.

The levels from this document were deemed most appropriate to be consistent with best practise planning around Tasmanian Councils.



### 3. OVERVIEW OF METHODOLOGY

The hydrological and hydrodynamic design modelling methodology was 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 for the design events includes the following steps.

- Data preparation
  - Fitting FFA to suitable flow records
  - Extraction of design data – IFDs, temporal patterns, pre-burst rainfalls from ARR DataHub (automated in the modelling process), derivation of direct rainfall storms
- Hydrologic modelling
  - Identification of flow gauge locations
  - Identification of dam and diversion locations
  - Sub-catchment delineation
  - Include dam storage and spillway ratings where required
  - Event calibration for PERN parameter and event losses, using automated WMAwater RAFTS modelling tool, IDW rainfall surfaces and available flow data.
  - Output event sub-catchment rainfalls, routing parameters and event losses for input to hydraulic model
  - Calibration of design losses to FFA using automated WMAwater RAFTS model
  - Run design events in WMAwater RAFTS modelling tool, with design data, calibrated routing parameters and design losses. Outputs design sub-catchment rainfalls for input to hydrodynamic model.
- Hydrodynamic modelling
  - Run design events and direct rainfall through the calibrated hydrodynamic model with the applicable downstream boundary levels and dam initial conditions.
  - Output design event and direct rainfall results for processing.
- Mapping
  - Convert design event and direct rainfall results to a grid format with a grid resolution of at least 10 m.
  - Envelope design event results to produce the maximum envelope of the inputs.
  - Filter direct rainfall results using a peak flood depth filter of 0.1 m. Clip direct rainfall results to the design event envelope.
  - Output the design event envelope and filtered direct rainfall results for mapping.

## 4. CALIBRATION OF DESIGN LOSSES

FFA was undertaken at the gauge identified in Table 1. The results of the FFA are shown in Figure 1. The fitting method and distribution that provided the best fit to the data at the gauge site is shown in Table 2.

Table 2: Fitting method and distribution used for FFA

| Gauge number | Gauge name                   | Fitting method | Distribution    |
|--------------|------------------------------|----------------|-----------------|
| 2214-1       | Ansons River DS Big Boggy Ck | Bayesian       | Log Pearson III |

The calibrated external hydrologic model for the study area was run through the solver and the initial and continuing losses that best matched the FFA were estimated. As the events of relevance to this study are of 2% AEP or larger, the results were weighted to this end of the FFA. The catchment-average continuing loss was distributed across the study area using the hydrological soil group final infiltration rates.

The percentage differences between the FFA and the modelled peak flow for the 2% and 1% AEP events are shown in Table 3. The modelled data provided a good fit to the FFA 1% and 2% AEP peak flows.

Table 3: FFA and modelled peak flows

|  | Ansons River DS Big Boggy Ck |        |
|--|------------------------------|--------|
| Parameter                              | 2% AEP                       | 1% AEP |
| FFA peak flow (m <sup>3</sup> /s)      | 411                          | 474    |
| Modelled peak flow (m <sup>3</sup> /s) | 393                          | 469    |
| Peak flow difference (%)               | -4.3%                        | -1.1%  |

The adopted loss values are shown in Table 4, and comparisons to site FFAs are shown in Figure 1. The selected CL is much higher than CLs observed in calibration events, however the calibration event rainfalls were much longer events (with 48-72 hours of rainfall) compared with the 12 hour critical duration of the design storm, so the rainfall events are not equivalent. The use of high IL and lower CL was trialled and resulted in a poor fit to the FFA estimation if used in design modelling.

Table 4: Adopted losses

| Initial Loss (mm) | Continuing Loss (mm/h) |             |             |             |
|-------------------|------------------------|-------------|-------------|-------------|
|                   | Soil Type A            | Soil Type B | Soil Type C | Soil Type D |
| 12                | 6.25                   | 3.25        | 1.50        | 0.75        |

## 5. DESIGN EVENT MODELLING

### 5.1. Design Event Selection

Design inputs were run through the hydrological model across the entire study area with a range of ARFs to select representative ARFs, storm durations and temporal patterns to be run through the hydrodynamic model. The selected storms and the number of sub-catchments best represented by each are shown in Table 5. The temporal patterns for each selected run are shown Figure 2 and Figure A 4.

Table 5: Selected storms for each AEP with the number of sub-catchments best represented by each set

| AEP  | Storm duration (min) | ARF bin | # sub-catchments |
|------|----------------------|---------|------------------|
| 2%   | 270                  | 45      | 3                |
| 2%   | 540                  | 75      | 36               |
| 2%   | 540                  | 75      | 5                |
| 1%   | 270                  | 45      | 2                |
| 1%   | 540                  | 75      | 36               |
| 1%   | 540                  | 75      | 6                |
| 0.5% | 270                  | 45      | 2                |
| 0.5% | 540                  | 75      | 38               |
| 0.5% | 540                  | 75      | 4                |

Diagram 2 shows the ARF-duration-TP set used to give representative flows for each sub-catchment for the 1% AEP event. Headwater sub-catchments where only direct rainfall is applied are also shown. In the headwater catchments, direct rainfall was defined as the dominating event, with the rainfall intensities factored to account for losses via a runoff coefficient. For this study area, a runoff coefficient of 50% was adopted. Although direct rainfall is applied to all sub catchments, the mapping process detailed in Section 3 ensures that primary flow paths are not defined by this event.

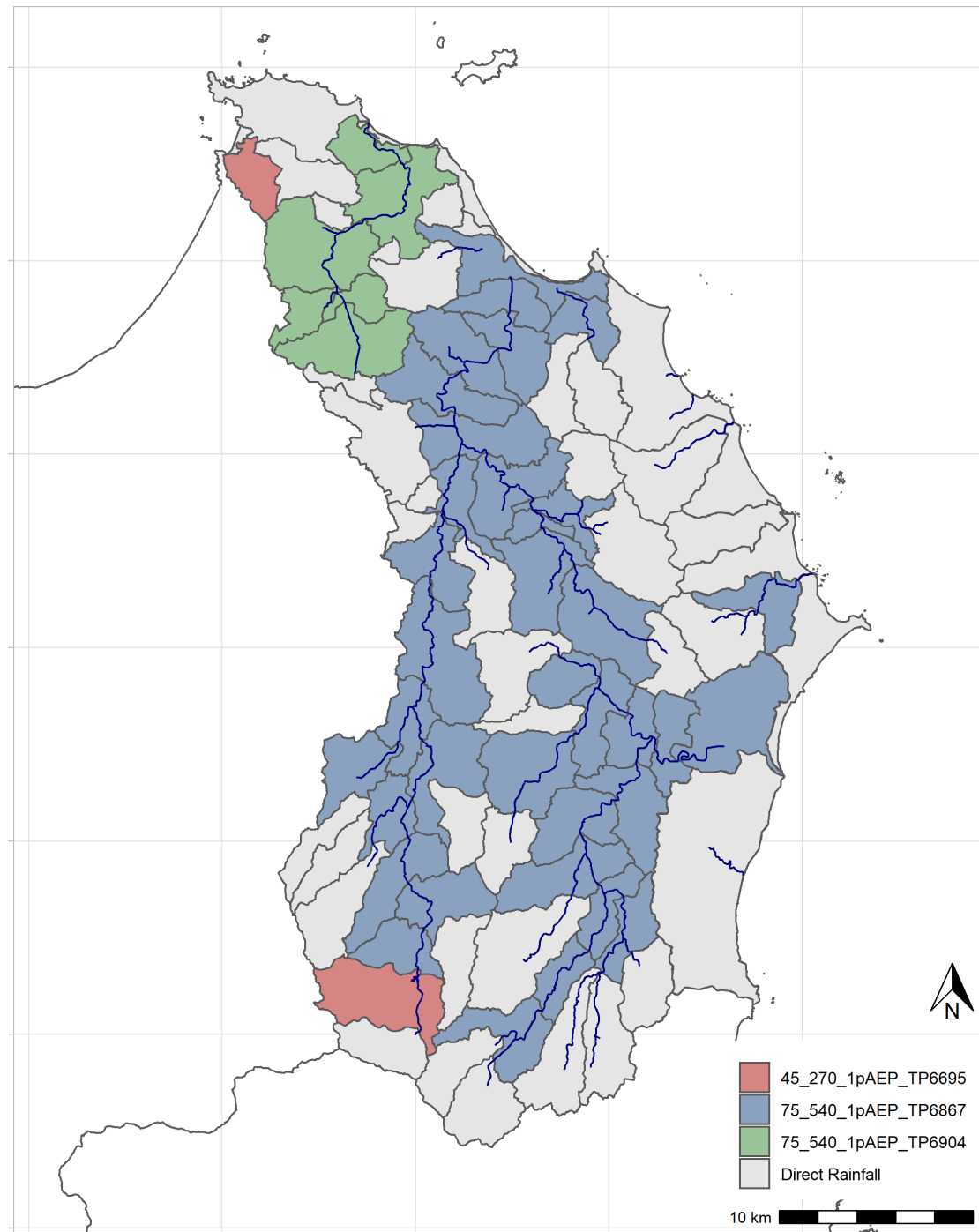


Diagram 2: ARF set relevant for each sub-catchment for the 1% AEP event

The selection of three ARF-duration-TP sets per AEP does introduce errors when compared to running the ideal ARF-duration-TP set through the hydrodynamic model for each sub-catchment, however running thousands of runs of the hydrodynamic model is not computationally feasible. The percentage errors for each sub-catchment are shown in Figure B 1 to Figure B 3 and a summary of the magnitude of the errors is shown in Table 6. Each sub-catchment's absolute percentage error is calculated using the following equation:

$SC\_Q\_Peak_{ref}$  = Sub-catchment peak flow run with ARF from that sub-catchment's ARF bin, with critical duration calculated at this gauge, and TP above the mean selected.

$SC\_Q\_Peak_{sel}$  = Sub-catchment peak flow run with ARF, storm duration and TP from the selected pattern as shown in Diagram 2

$$\text{Absolute subcatchment percentage error} = \left| \frac{(SC\_Q\_Peak_{sel} - SC\_Q\_Peak_{ref})}{SC\_Q\_Peak_{ref}} \right| \times 100$$

Table 6: Sub-catchment errors using the ARF-TP-duration sets shown in Table 5 for each AEP

| AEP  | Absolute sub-catchment error |   |                           |
|------|------------------------------|---|---------------------------|
|      | Mean across sub-catchments   | 90 <sup>th</sup> %ile across sub-catchments | Max of all sub-catchments |
| 2%   | 4.7                          | 8.6   | 14.0                      |
| 1%   | 4.3                          | 7.9   | 15.5                      |
| 0.5% | 4.7                          | 7.1   | 11.2                      |

The selected storms and direct rainfall were then run through the calibrated hydrodynamic model as documented in the calibration report (WMAwater, 2023). For the design event modelling, a static tailwater level set to the highest astronomical tide was adopted for the downstream boundary. This data was provided by the National Tide Centre (NTC) in 5 km<sup>2</sup> grid cells, and the mean value of these grid cells within the study area was used.

Table 7 below summarises the downstream boundary levels for each design event.

Table 7. Downstream boundary levels for each AEP

| AEP   | Downstream boundary              |
|-------|----------------------------------|
| 2%    | HAT<br>(0.90 mAHD)               |
| 1%    |                                  |
| 0.5%  |                                  |
| 1% CC | HAT + sea level rise (1.82 mAHD) |

## 5.2. Design Event Results

The results of the design event modelling are shown in Figure 3 to Figure 18 in terms of peak flood level, depth, velocity, and hydraulic hazard for the 2%, 1%, 1% CC, and 0.5% AEP design events. The results shown are of the design event envelope and filtered direct rainfall results, as detailed in Section 3. A critical event plot for the 1% AEP design event is provided in Figure 19.

For direct rainfall only, in some areas the peak flow for headwater catchments was found to be higher in the hydrodynamic model than in the external hydrologic model. This was most significant in headwater catchments with high slopes. To ensure that the overestimation of these peak flows in the headwater catchments would not impact the design results, the direct rainfall results were clipped to the headwater catchments before the envelope of the design runs and direct rainfall was calculated

The outcomes of the design event modelling have been reviewed against the gauge FFA. There were no existing studies provided to compare design extents and levels to.

### 5.2.1. Review of Results at Ansons River d/s Big Boggy Creek

A review of the design flows produced from the hydrodynamic model at Ansons River d/s Big Boggy Creek was undertaken, by comparing to the flows derived from the FFA. The modelled peak flows show a good match to the FFA peak flows at this location (Table 8).

Table 8: Design flows at Ansons River d/s Big Boggy Creek

| Parameter                 | 2% AEP | 1% AEP | 1% AEP CC | 0.5% AEP |
|---------------------------|--------|--------|-----------|----------|
| Modelled peak flow (m3/s) | 415    | 492    | 622       | 600      |
| FFA peak flow (m3/s)      | 411    | 474    | n/a       | 533      |
| Peak flow difference (%)  | +1%    | +4%    | n/a       | +13%     |



## 6. LIMITATIONS

A detailed uncertainty assessment of the data, hydrological calibration and hydrodynamic model is contained in the Musselroe-Ansons Calibration Report (WMAwater, 2023)

The selection of limited duration-TP-ARF sets introduces some errors across the catchment as described in Section 5.1 This is appropriate for a regional method, however site-specific ARFs, critical durations and TP selection should be used for detailed design modelling at specific locations.

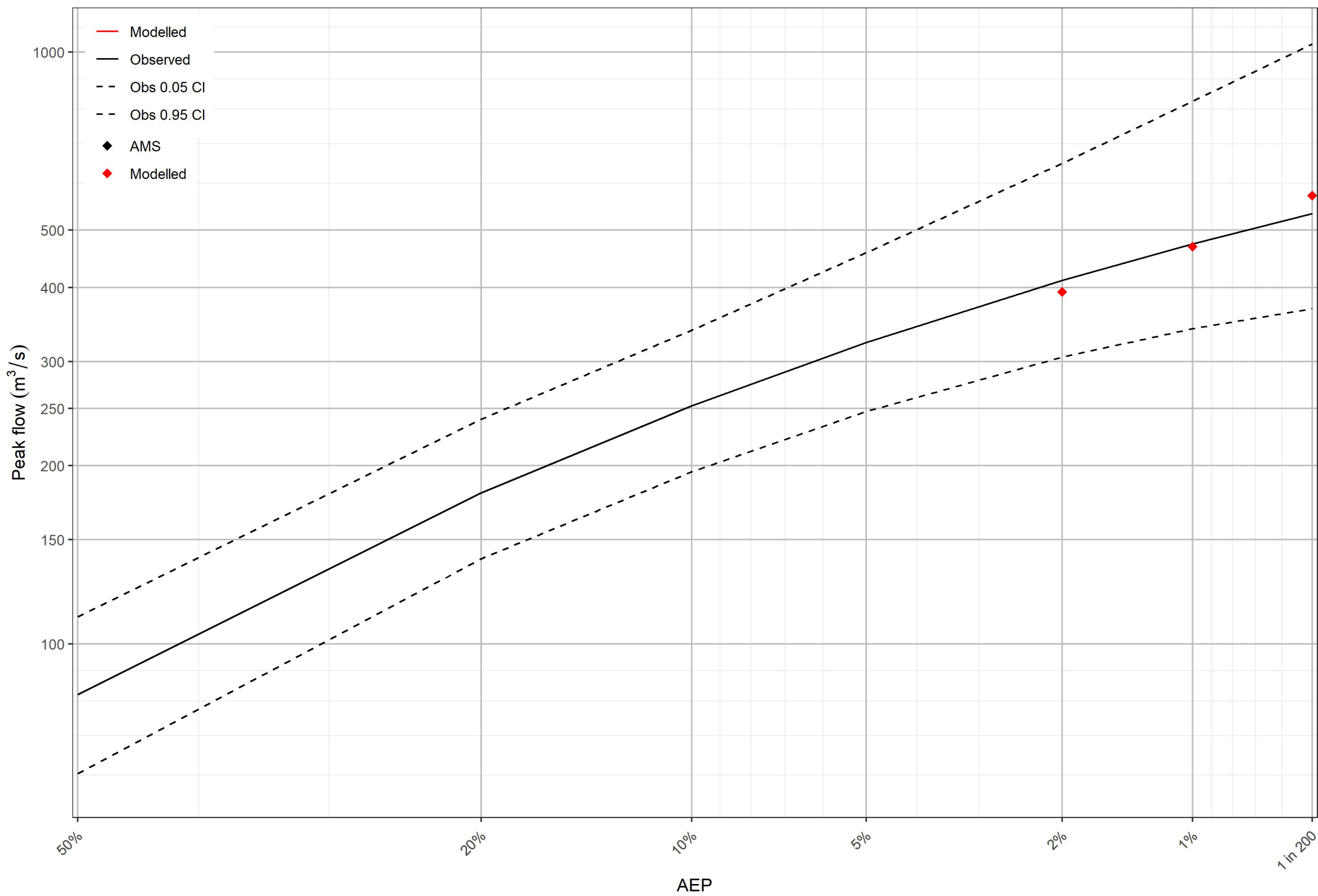
As discussed in Section 5.2 there is some uncertainty introduced by the direct rainfall application on the headwater catchments. While the method used is appropriate for broad scale mapping, a full design event assessment should be undertaken for any future focussed studies in this area.

As noted in the calibration report, 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.

## 7. REFERENCES

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- WMAwater (2021c): Tasmanian Strategic Flood Map, Flow Gauge Rating Revision, Draft, Dec 2021.
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**FIGURE 2**  
**SELECTED DESIGN TEMPORAL PATTERNS ALL AEPS**  
**BY STORM DURATION AND ARF AREA**

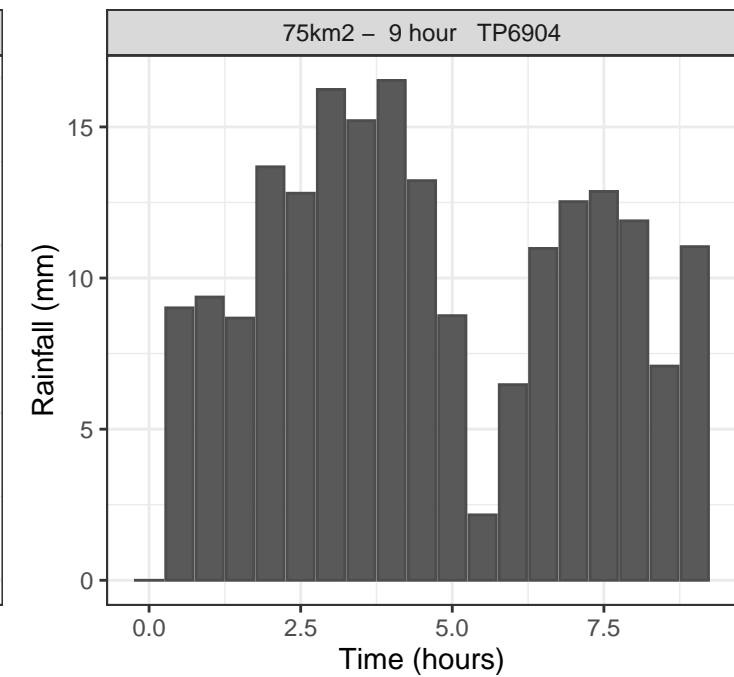
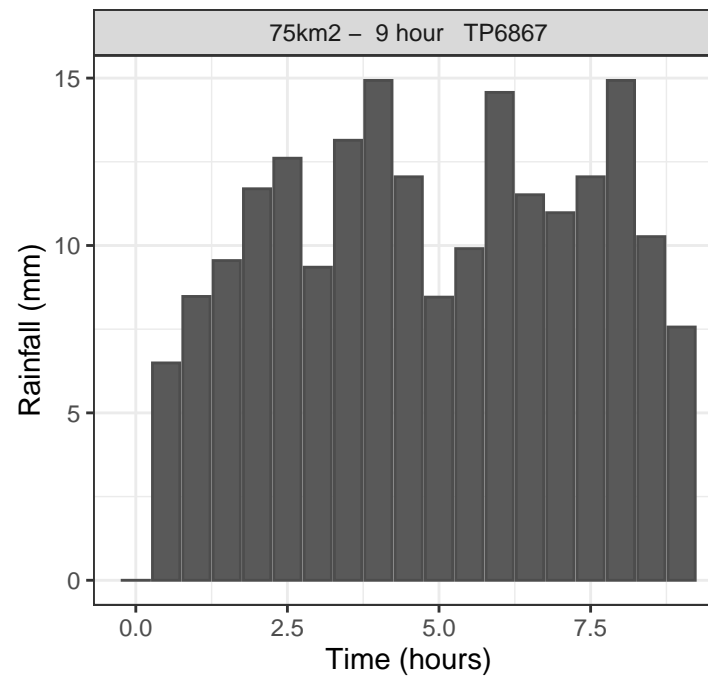
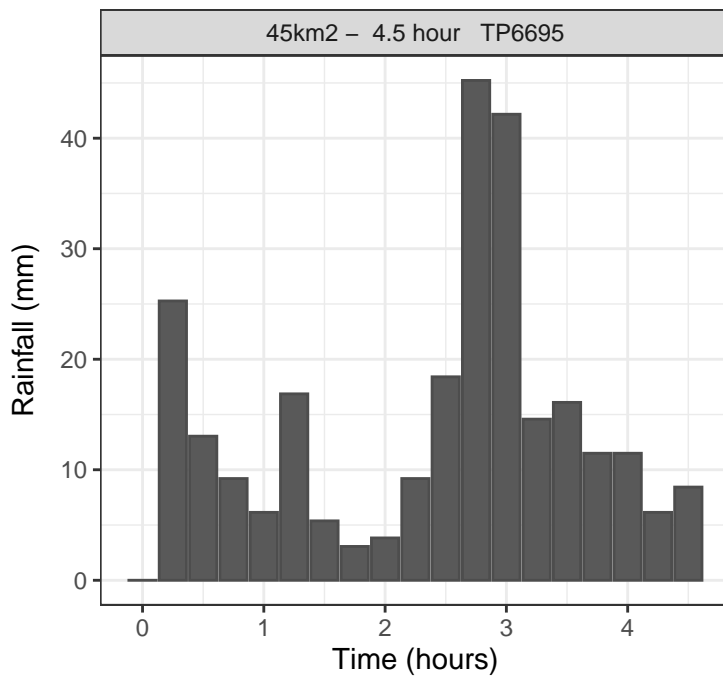
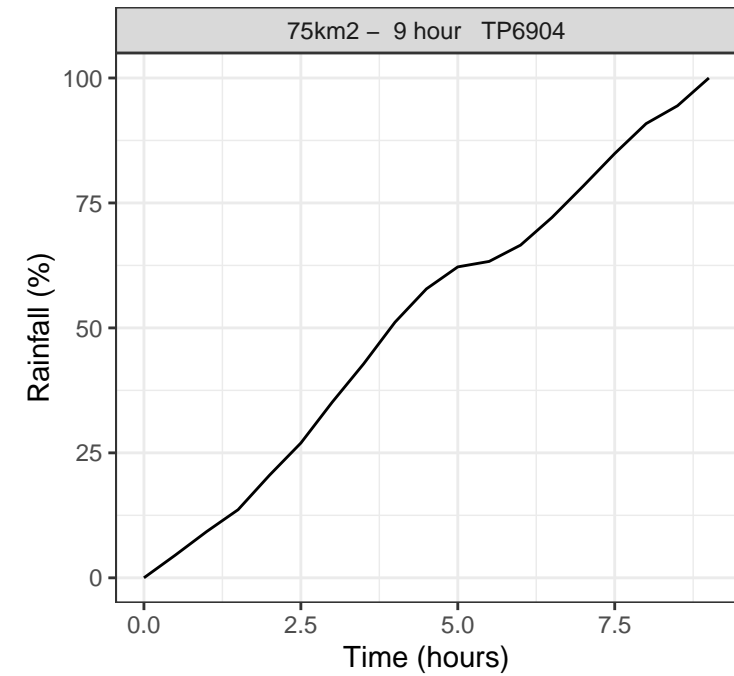
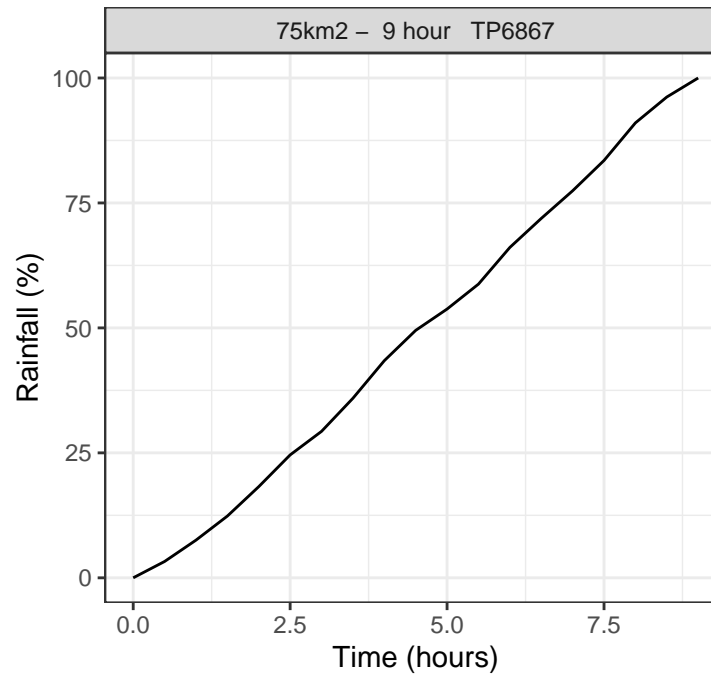
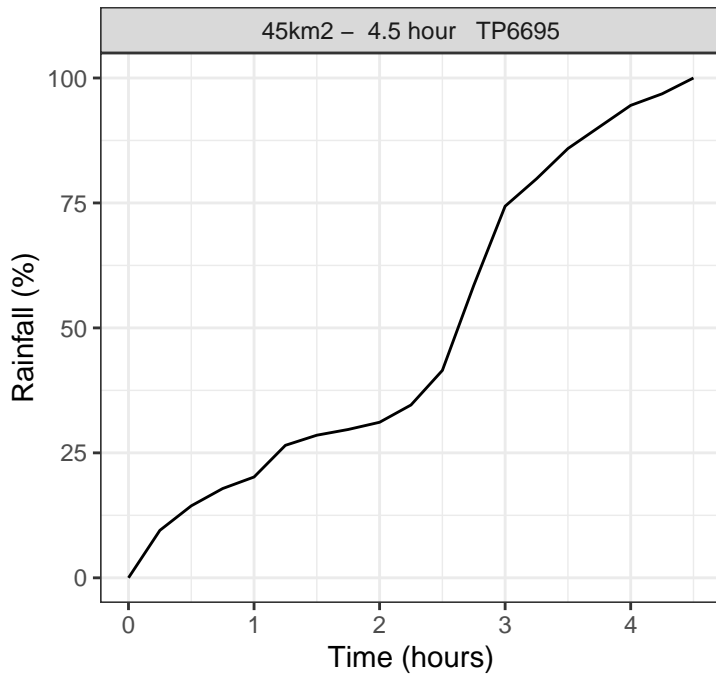




FIGURE 3  
MUSSELROE-ANSONS CATCHMENT  
2% AEP DESIGN EVENT  
PEAK FLOOD LEVEL





FIGURE 4  
MUSSELROE-ANSONS CATCHMENT  
2% AEP DESIGN EVENT  
PEAK FLOOD DEPTH





FIGURE 5  
MUSSELROE-ANSONS CATCHMENT  
2% AEP DESIGN EVENT  
PEAK FLOOD VELOCITY

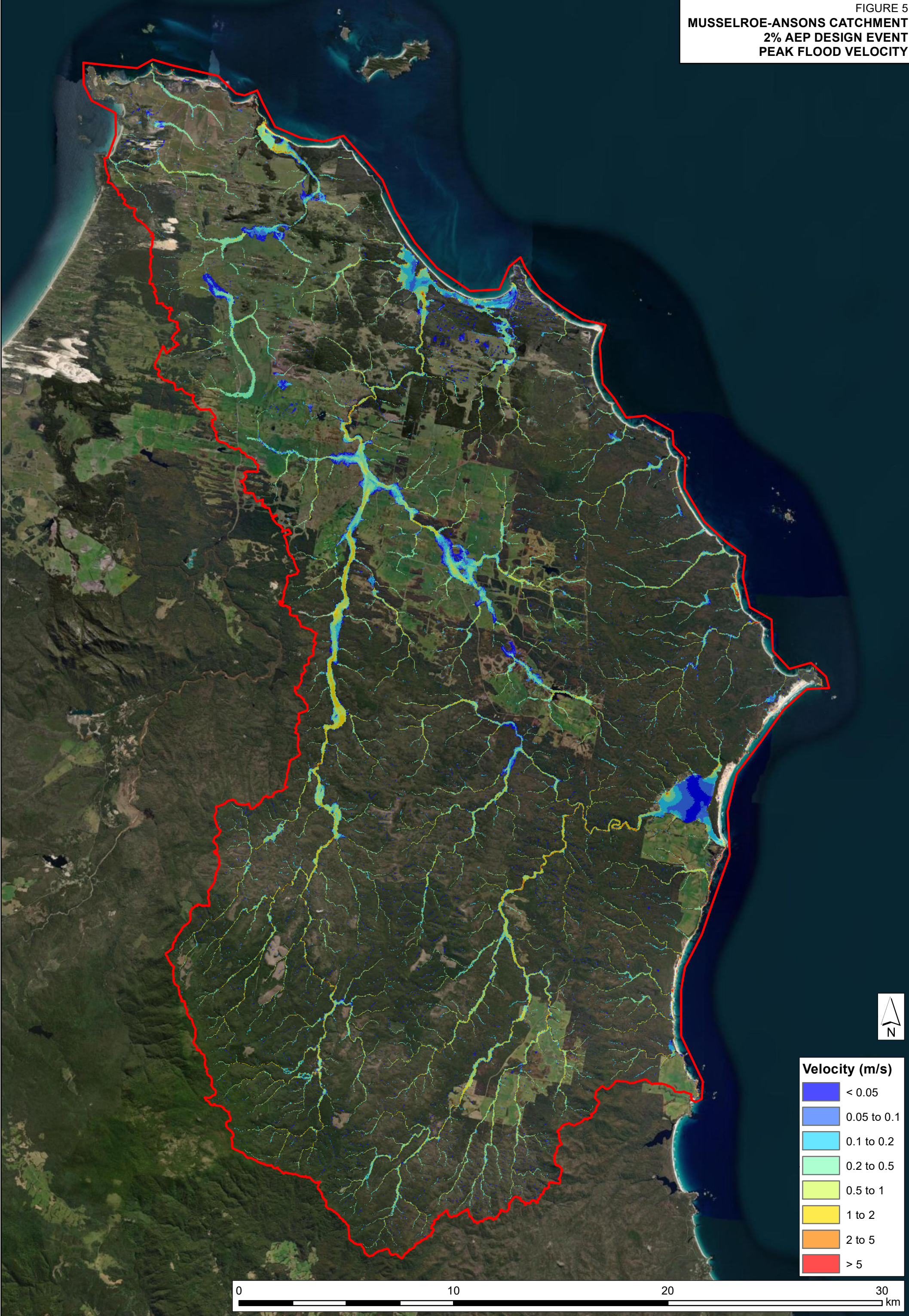




FIGURE 6  
MUSSELROE-ANSONS CATCHMENT  
2% AEP DESIGN EVENT  
PEAK HYDRAULIC HAZARD





FIGURE 8  
MUSSELROE-ANSONS CATCHMENT  
1% AEP DESIGN EVENT  
PEAK FLOOD LEVEL





FIGURE 8  
MUSSELROE-ANSONS CATCHMENT  
1% AEP DESIGN EVENT  
PEAK FLOOD DEPTH





FIGURE 9  
MUSSELROE-ANSONS CATCHMENT  
1% AEP DESIGN EVENT  
PEAK FLOOD VELOCITY

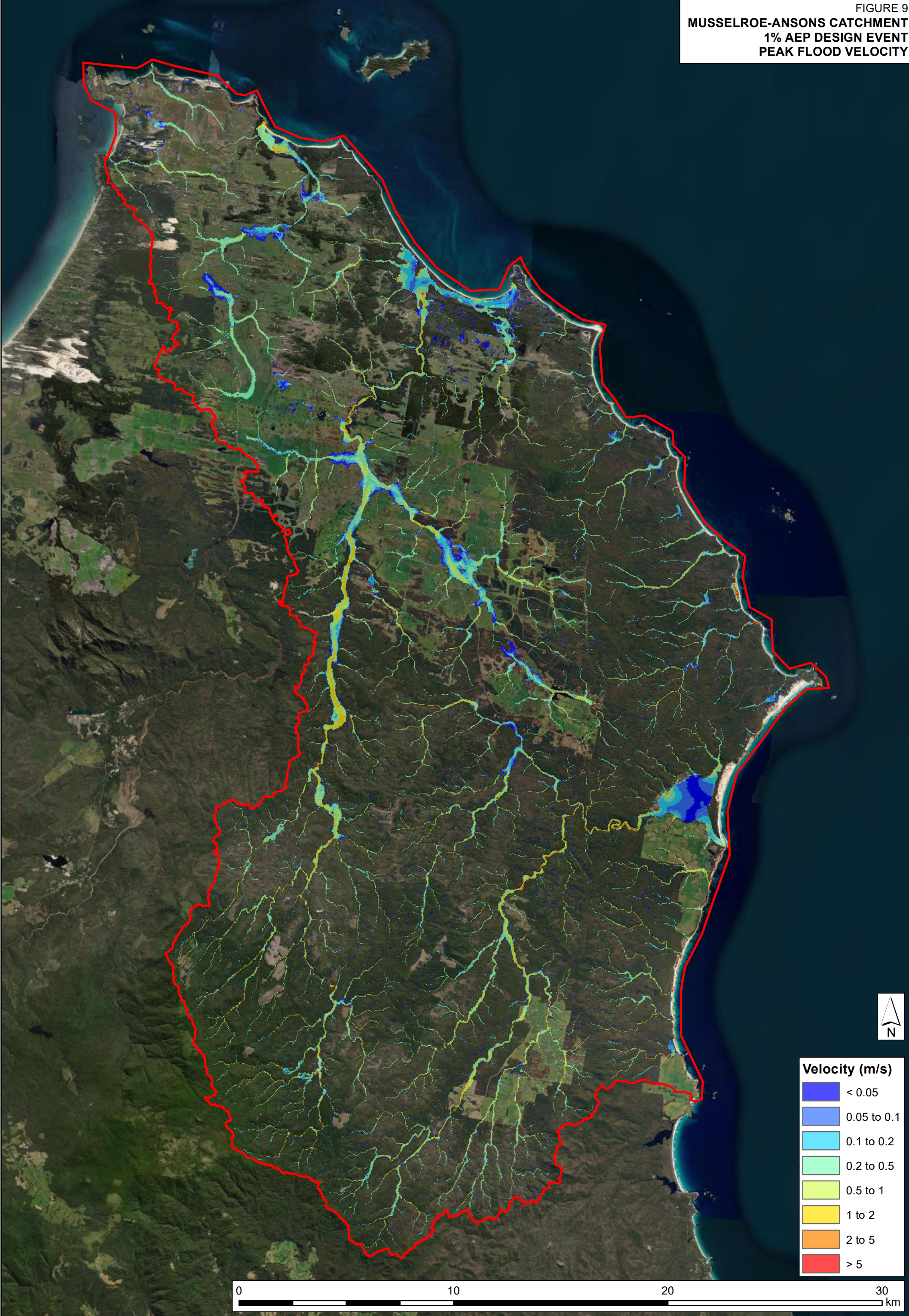




FIGURE 10  
MUSSELROE-ANSONS CATCHMENT  
1% AEP DESIGN EVENT  
PEAK HYDRAULIC HAZARD

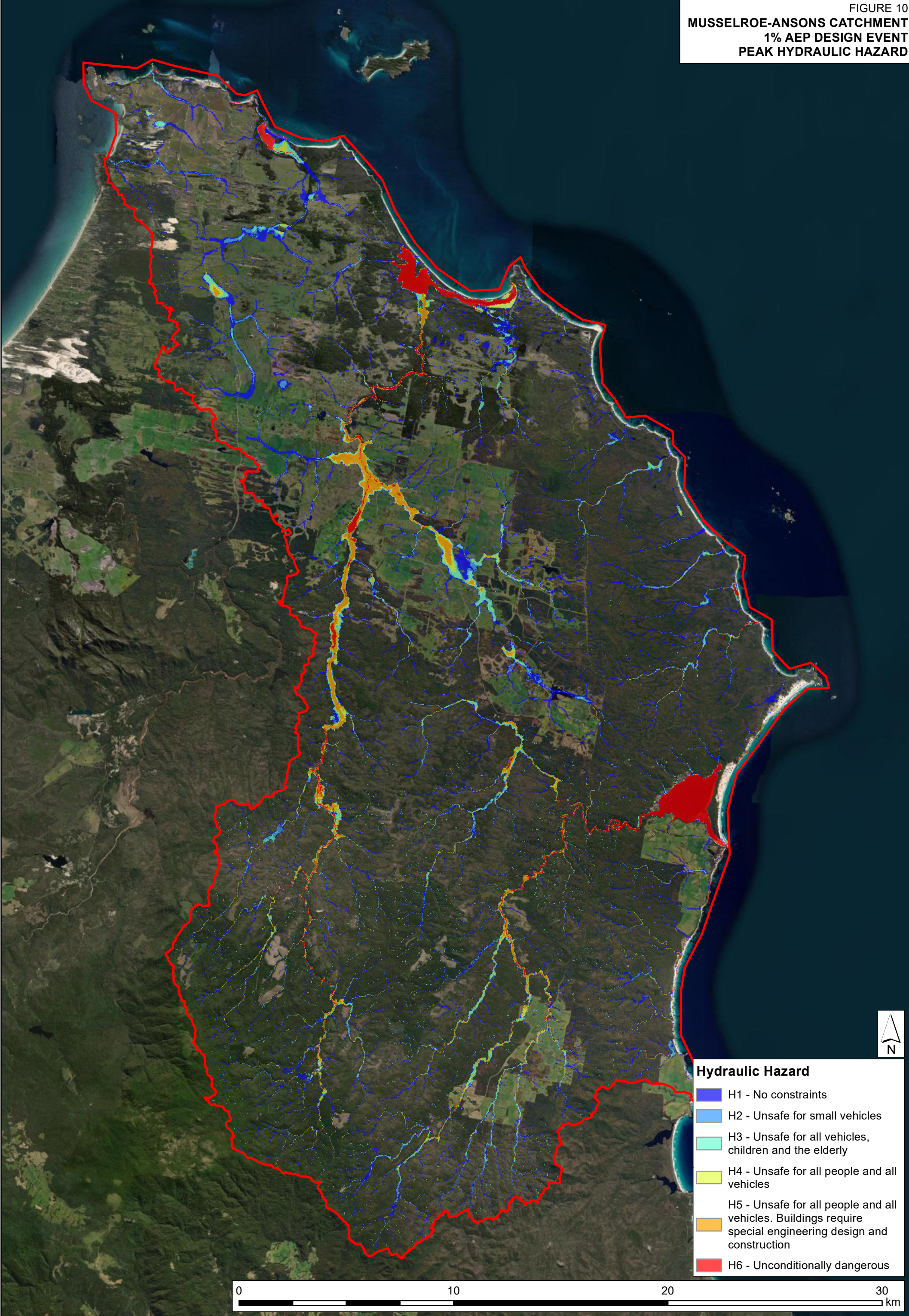




FIGURE 11  
MUSSELROE-ANSONS CATCHMENT  
1% AEP CC DESIGN EVENT  
PEAK FLOOD LEVEL





FIGURE 12  
MUSSELROE-ANSONS CATCHMENT  
1% AEP CC DESIGN EVENT  
PEAK FLOOD DEPTH





FIGURE 13  
MUSSELROE-ANSONS CATCHMENT  
1% AEP CC DESIGN EVENT  
PEAK FLOOD VELOCITY

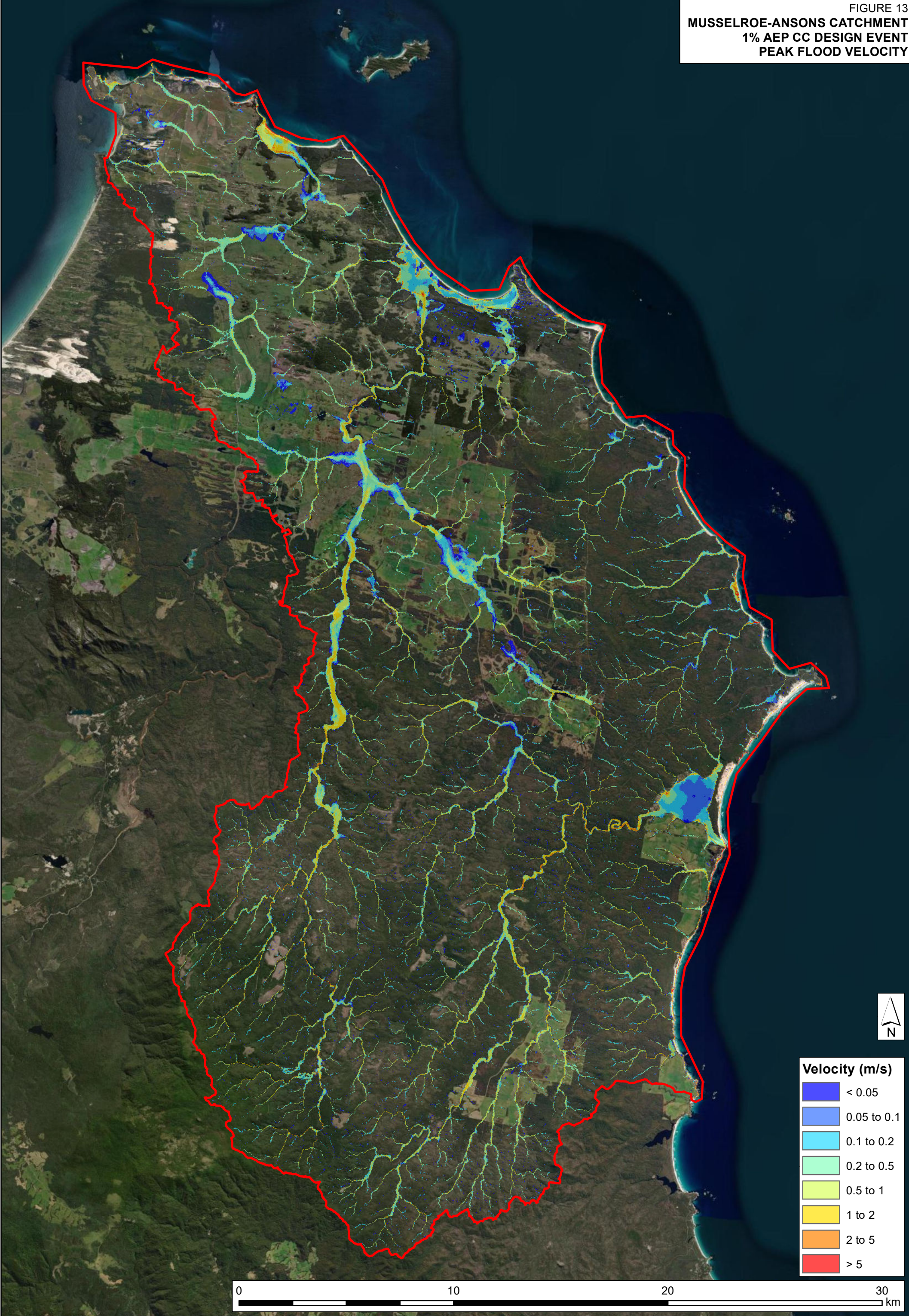




FIGURE 14  
MUSSELROE-ANSONS CATCHMENT  
1% AEP CC DESIGN EVENT  
PEAK HYDRAULIC HAZARD

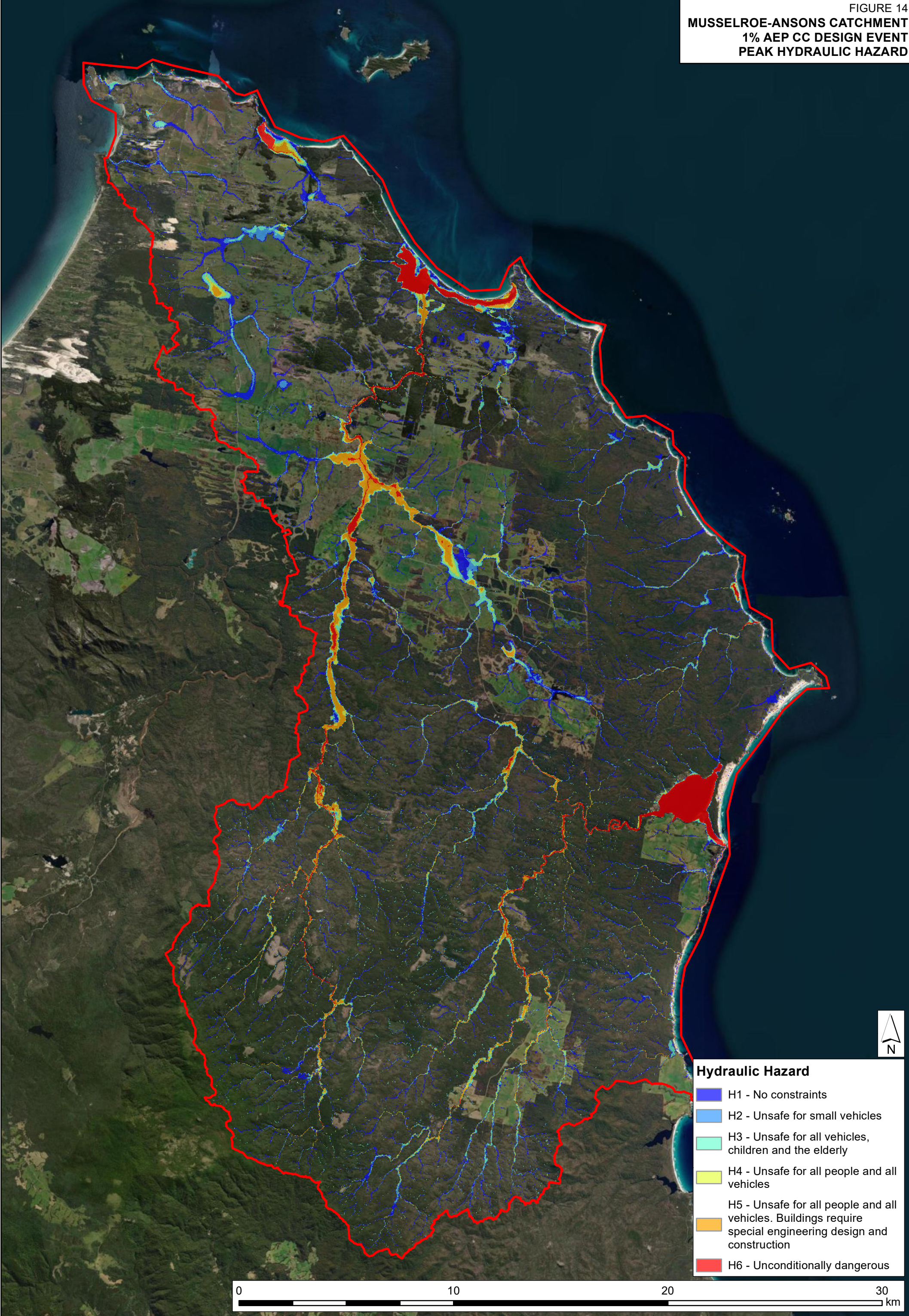




FIGURE 15  
MUSSELROE-ANSONS CATCHMENT  
0.5% AEP DESIGN EVENT  
PEAK FLOOD LEVEL





FIGURE 16  
MUSSELROE-ANSONS CATCHMENT  
0.5% AEP DESIGN EVENT  
PEAK FLOOD DEPTH





FIGURE 17  
MUSSELROE-ANSONS CATCHMENT  
0.5% AEP DESIGN EVENT  
PEAK FLOOD VELOCITY

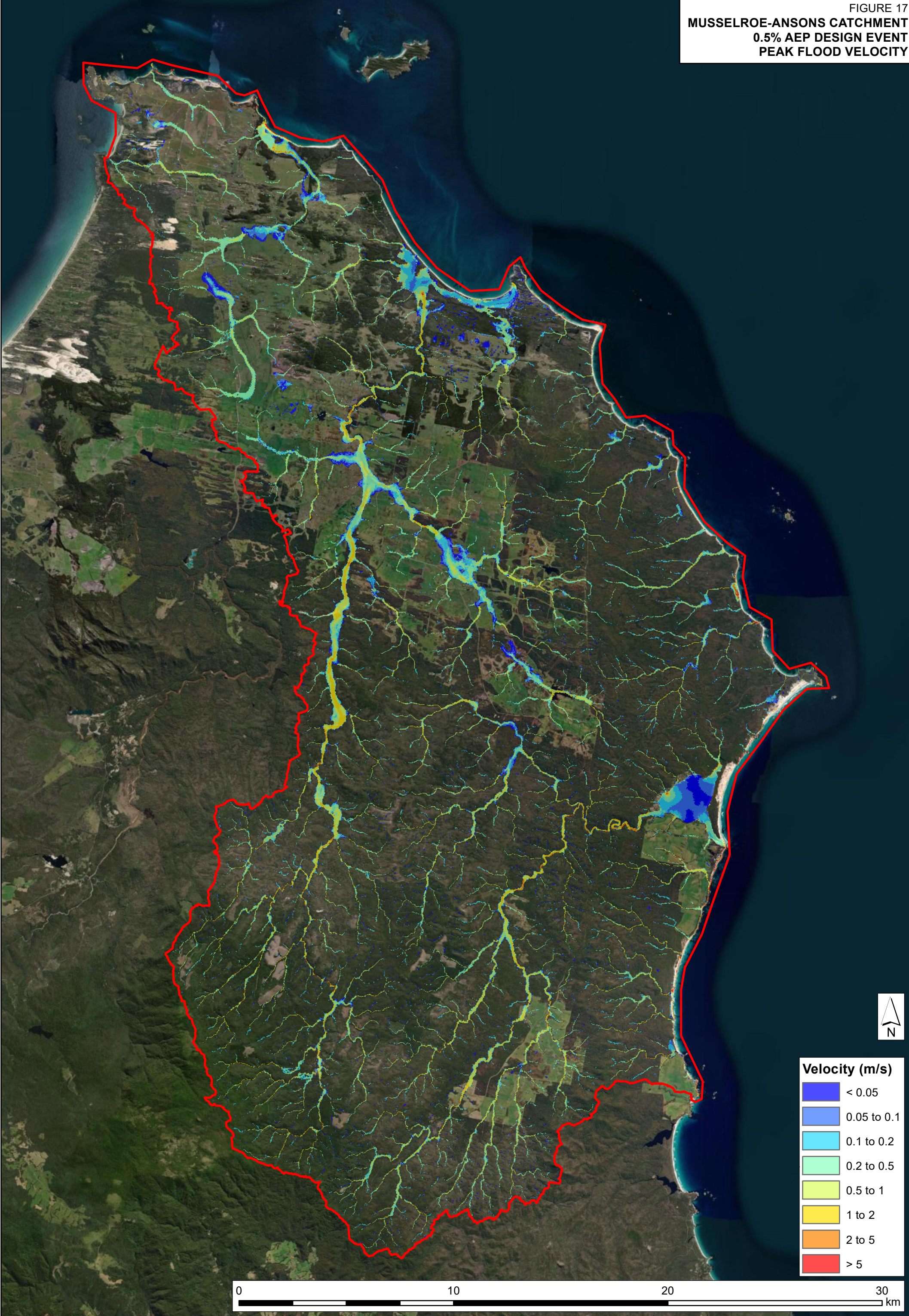




FIGURE 18  
MUSSELROE-ANSONS CATCHMENT  
0.5% AEP DESIGN EVENT  
PEAK HYDRAULIC HAZARD

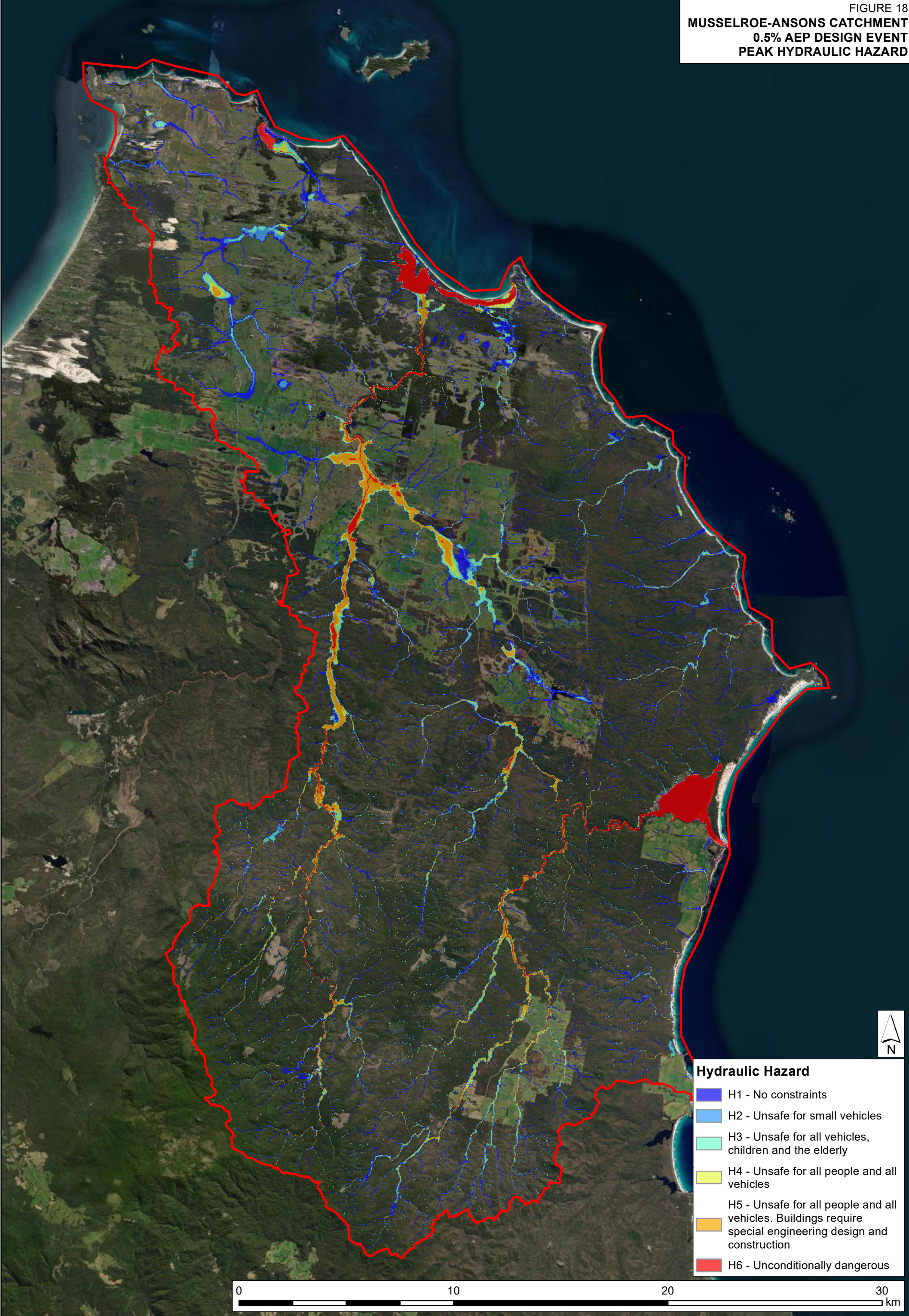




FIGURE 19  
MUSSELROE-ANSONS CATCHMENT  
1% AEP DESIGN EVENT  
CRITICAL EVENT







## **APPENDIX A.      DESIGN EVENT DATA**

FIGURE A1  
DESIGN RAINFALL DEPTHS  
540MIN 2%AEP

created by J:/Jobs/120038/Hydrology/Statewide/Design\_Events/Musselroe-Ansons/7MuA\_Design\_Report\_Plots.R  
J:/Jobs/120038/Hydrology/Statewide/Design\_Events/Musselroe-Ansons/Report\_Figures/FigureA1\_5402pAEP\_same\_scale.pdf

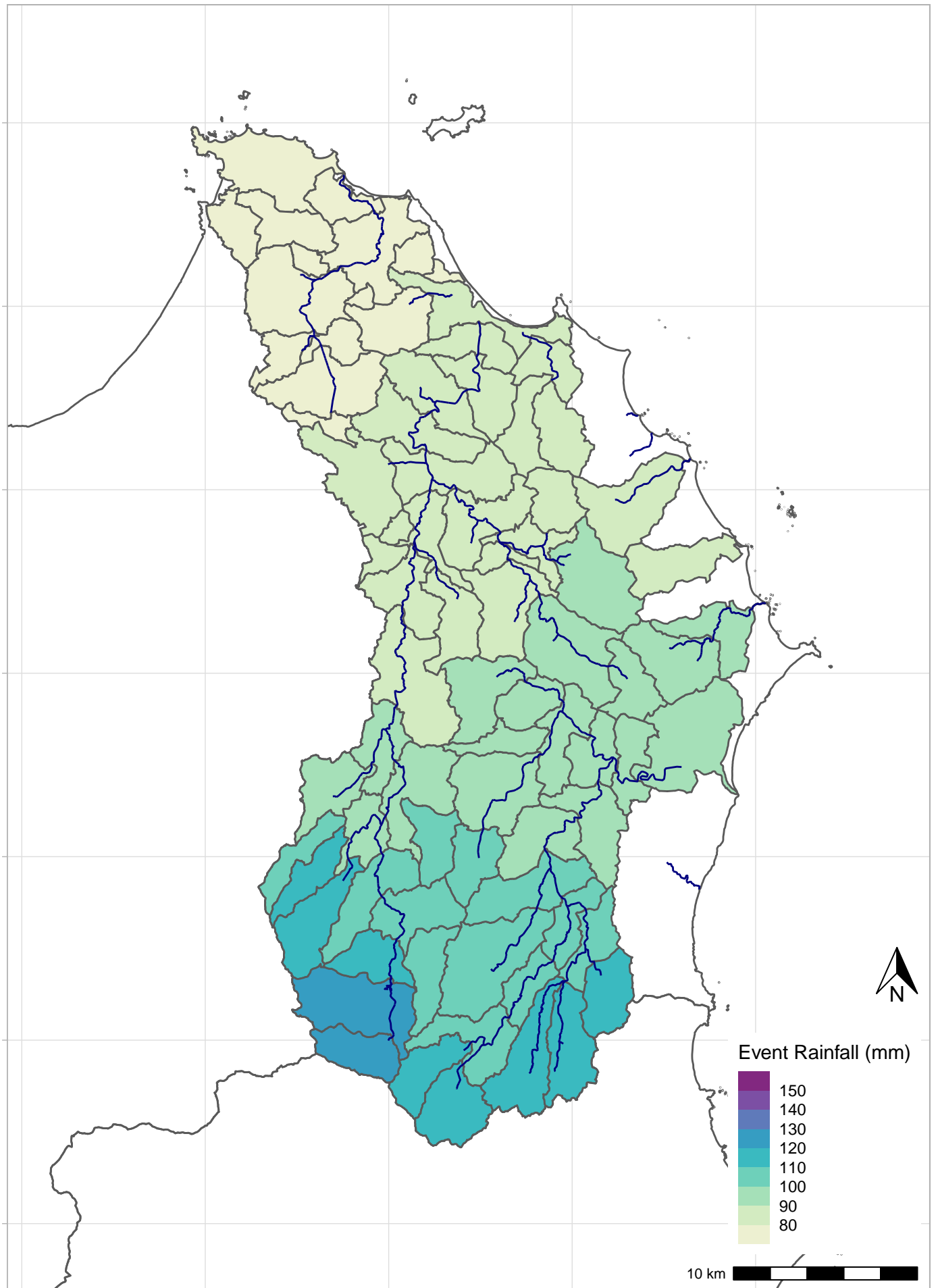


FIGURE A2  
DESIGN RAINFALL DEPTHS  
540MIN 1%AEP

created by J:/Jobs/120038/Hydrology/Statewide/Design\_Events/Musselroe-Ansons/7MuA\_Design\_Report\_Plots.R  
J:/Jobs/120038/Hydrology/Statewide/Design\_Events/Musselroe-Ansons/Report\_Figures/FigureA2\_5401pAEP\_same\_scale.pdf

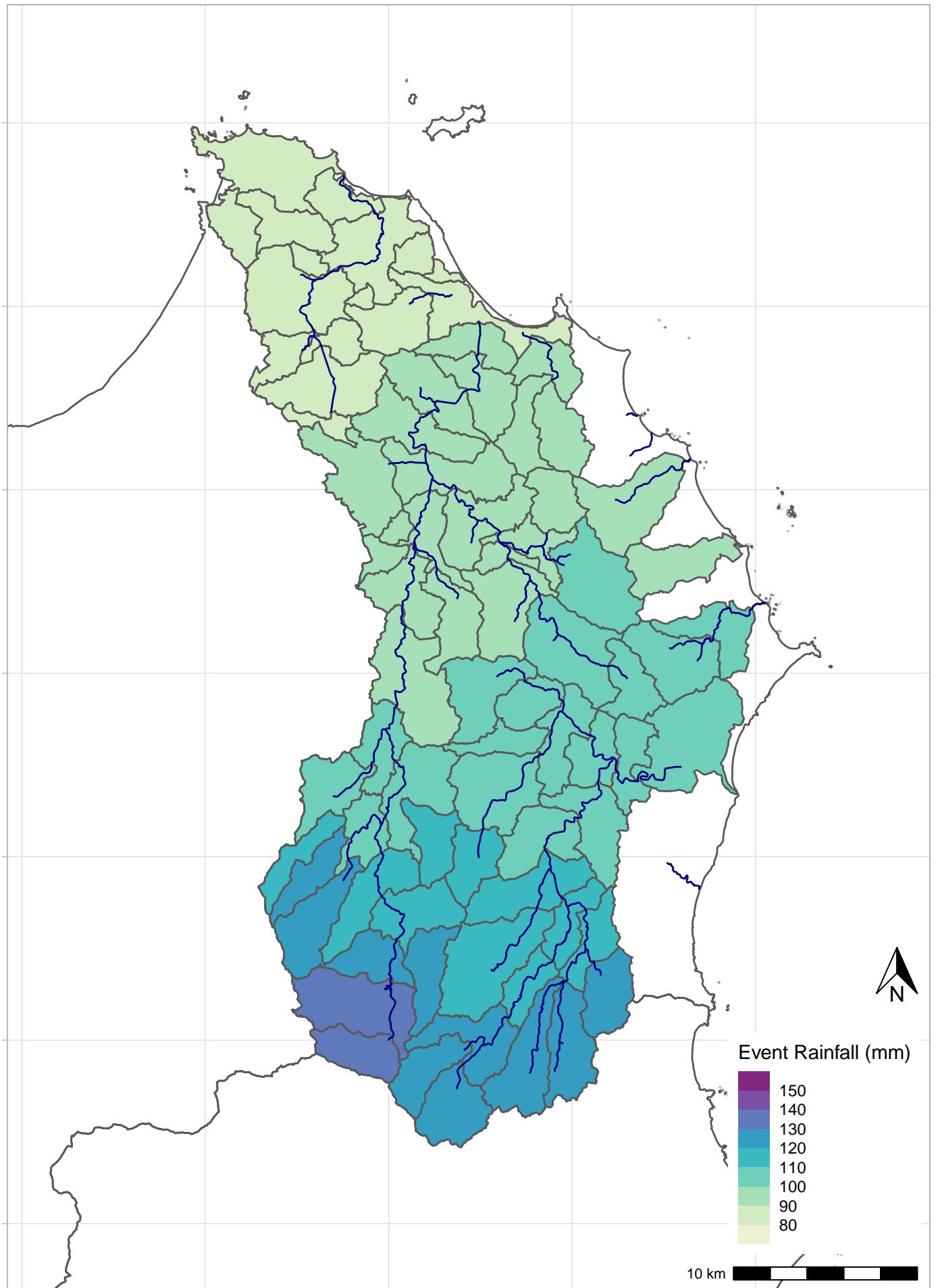


FIGURE A3  
DESIGN RAINFALL DEPTHS  
540MIN 1IN200AEP

created by J:/Jobs/120038/Hydrology/Statewide/Design\_Events/Musselroe-Ansons/7MuA\_Design\_Report\_Plots.R  
J:/Jobs/120038/Hydrology/Statewide/Design\_Events/Musselroe-Ansons/1/Report\_Figures/FigureA3\_5401in200AEP\_same\_scale.pdf

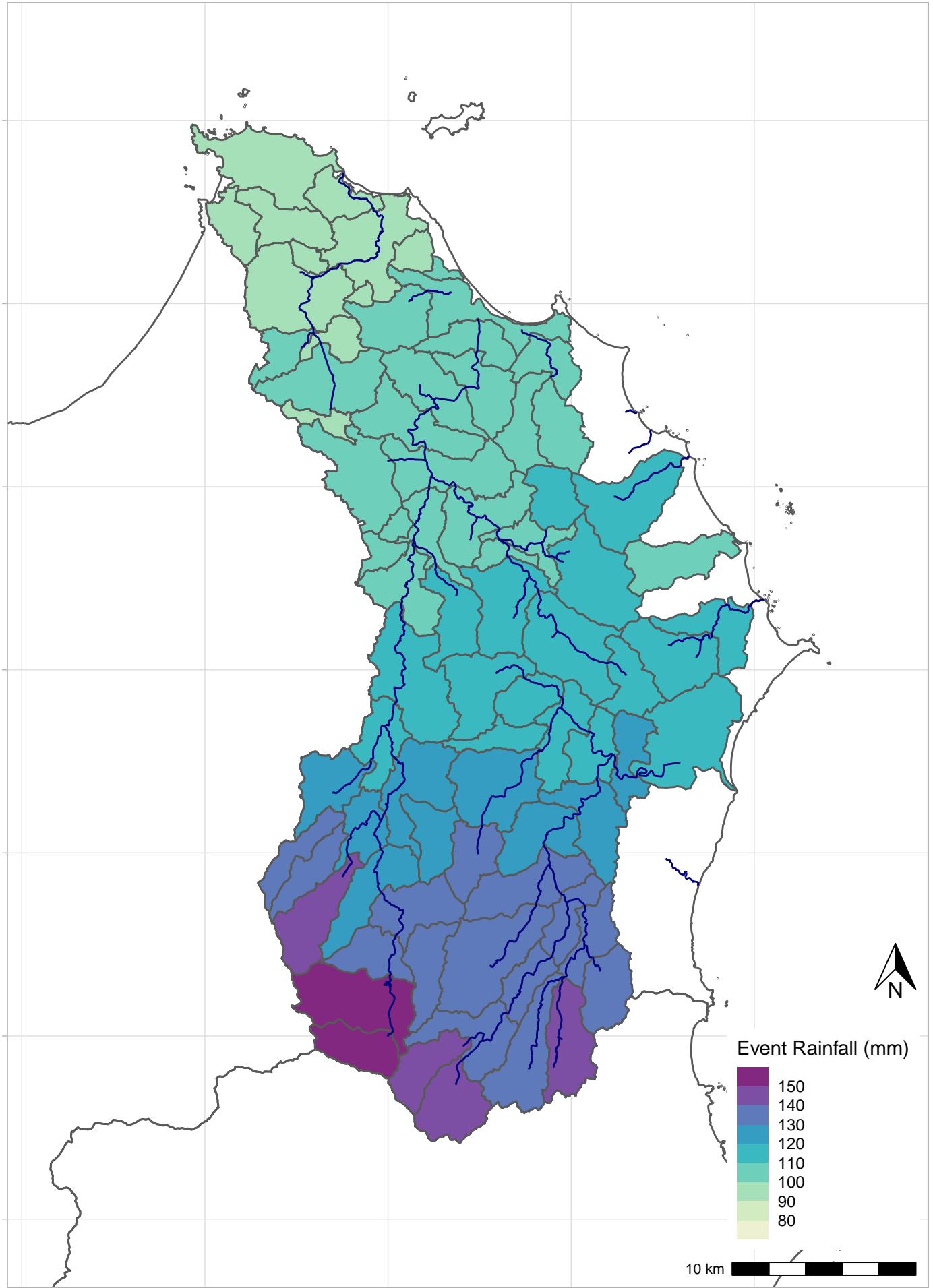
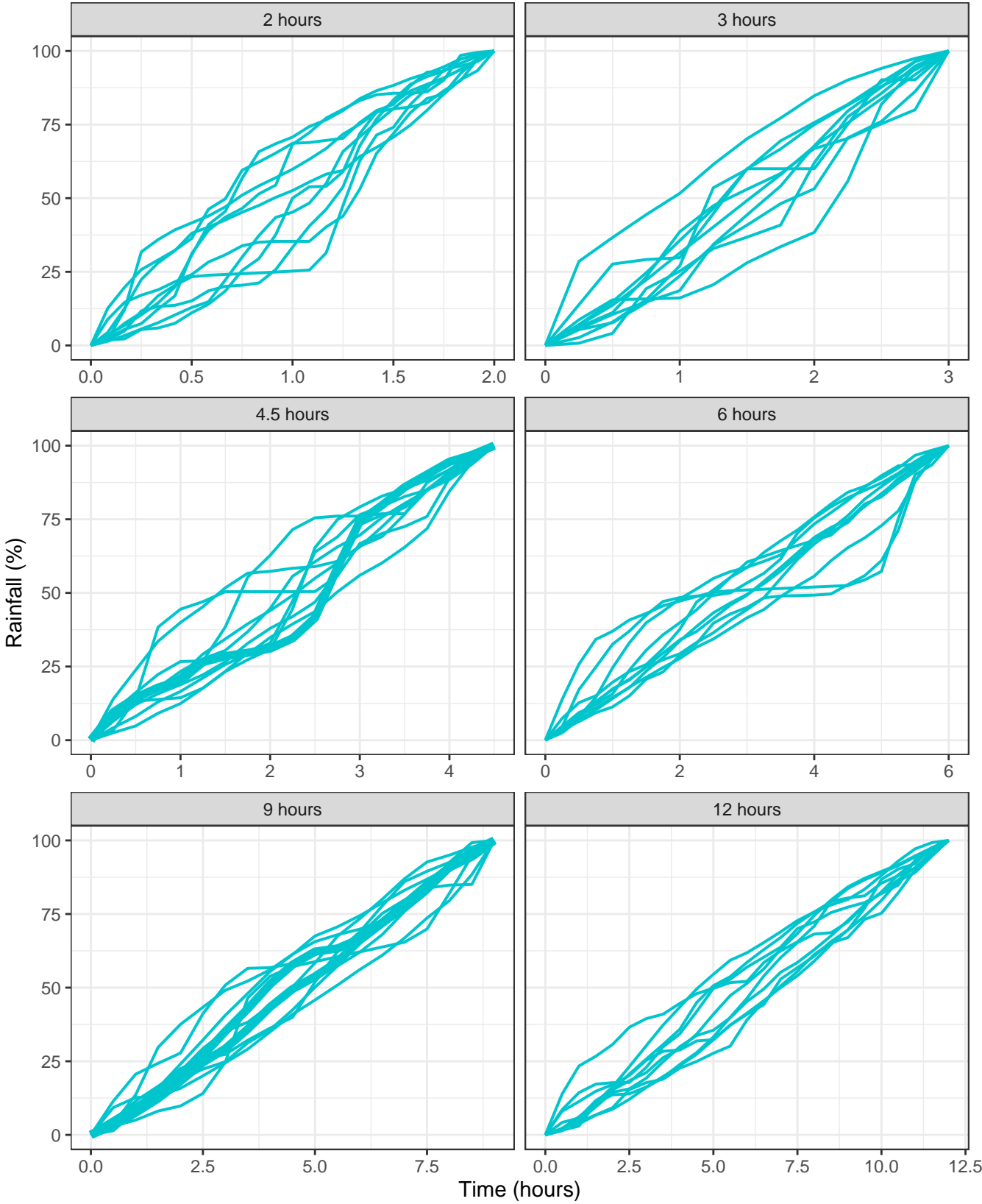


FIGURE A4  
DESIGN AREAL TEMPORAL PATTERNS  
DURATIONS FROM 2 TO 12 HOURS



TP Type   Selected.ATP   Selected.PTP   Design TPs.ATP   Design TPs.PTP

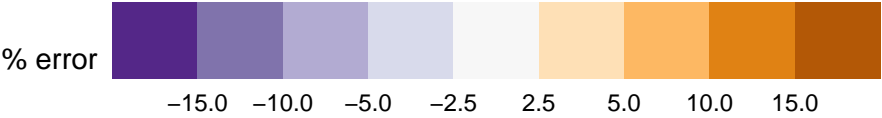
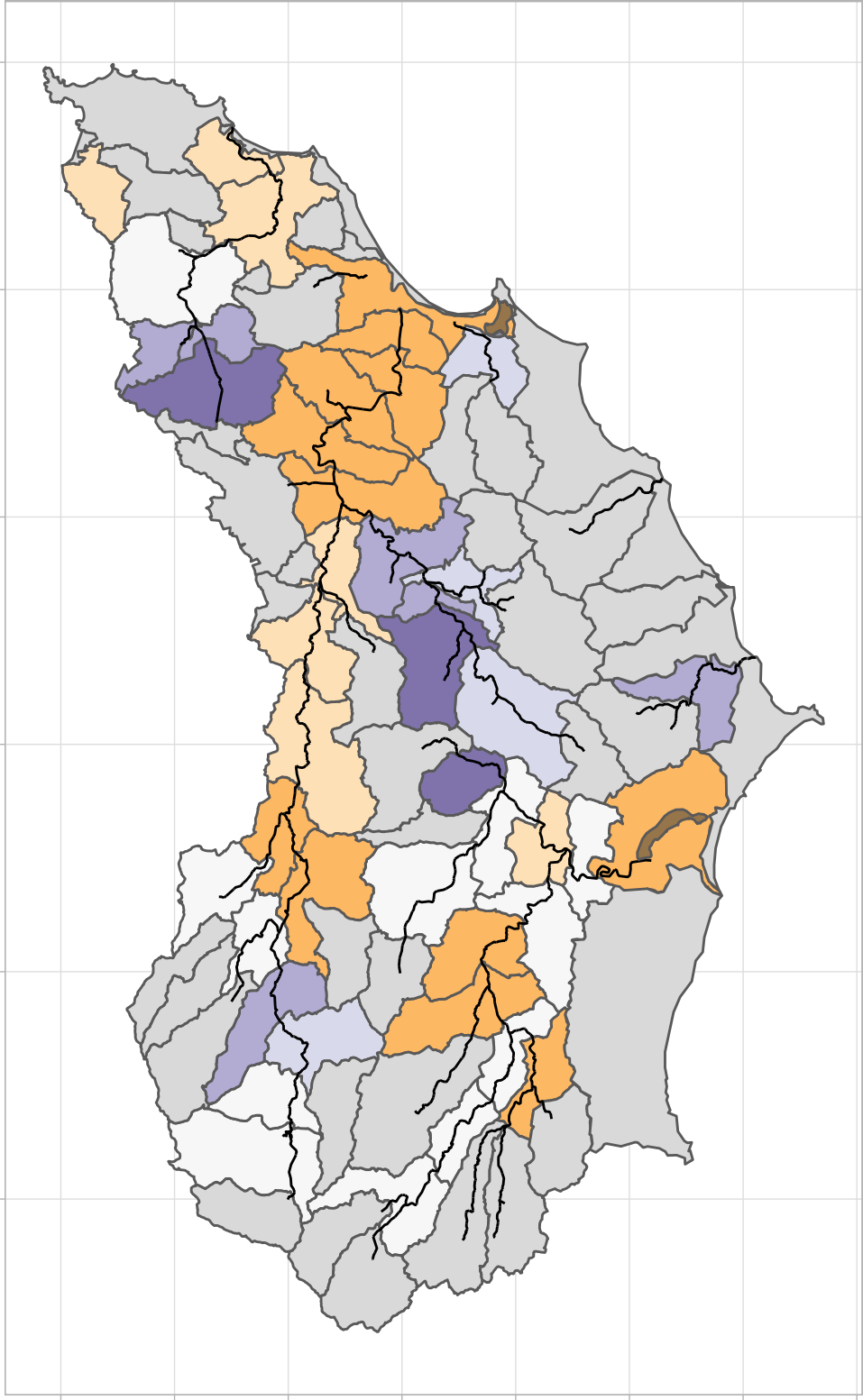




## **APPENDIX B.      DESIGN PEAK ERRORS**

Figure B1

**Musselroe–Ansons Catchment**  
**Percentage error in peak flows using selected runs**  
**2% AEP**



HSA



Headwater

Figure A8  
**Musselroe–Ansons Catchment**  
Percentage error in peak flows using selected runs  
1% AEP

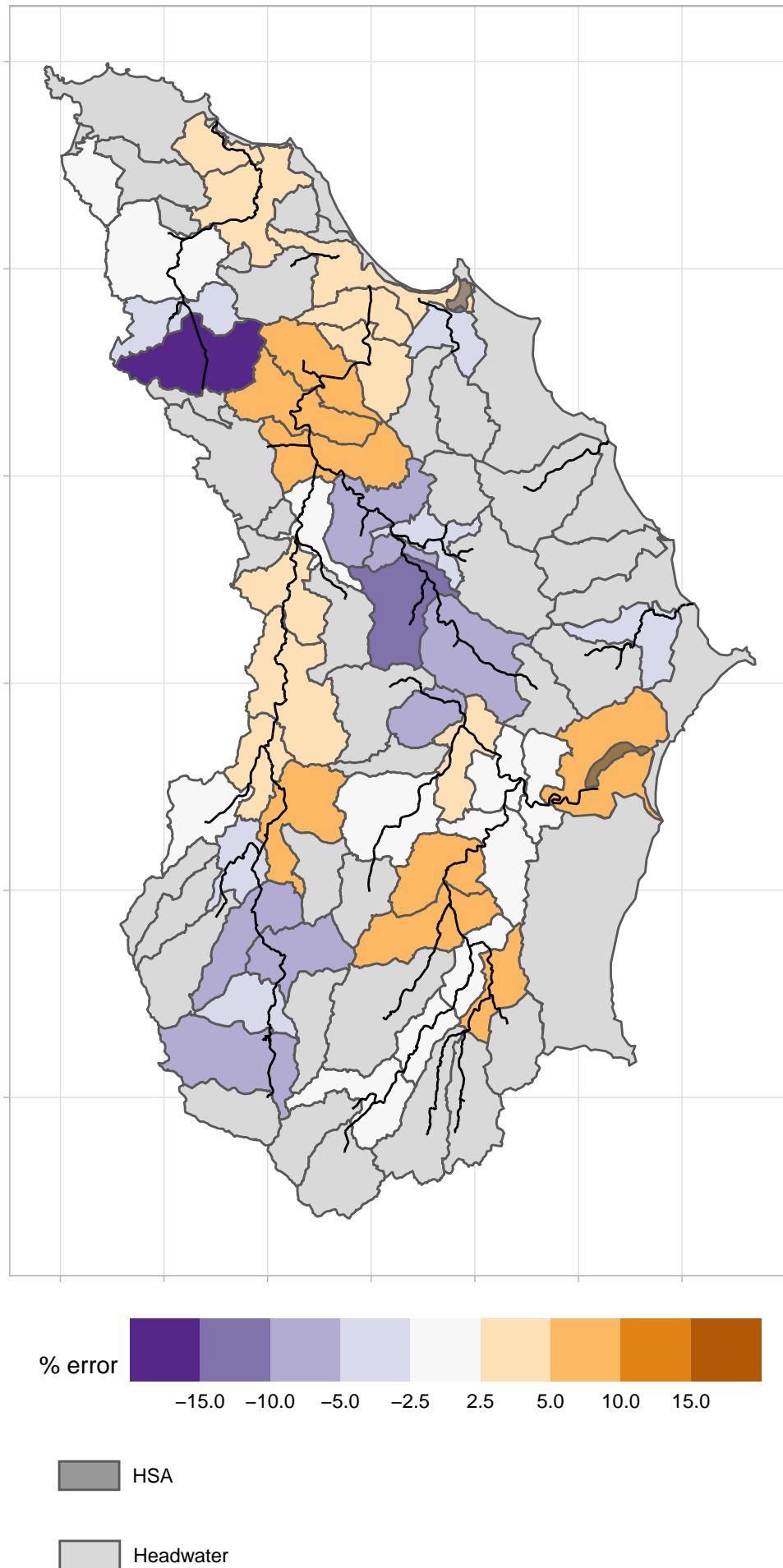


Figure A7  
Musselroe–Ansons Catchment  
Percentage error in peak flows using selected runs  
1in200AEP

