STATE EMERGENCY SERVICE

TASMANIAN STRATEGIC FLOOD MAP KING ISLAND STUDY AREA DESIGN FLOOD MODELLING

ADDENDUM TO CALIBRATION REPORT

MARCH 2023

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Project Tasmanian Strategic Flood Map King Island Study Area Design Flood Modelling	**Project Number** **120038**
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Revision History

Revision	Description	Distribution	Authors	Reviewed by	Verified by	Date
0	Report	Chris Irvine, SES	Sarah Blundy, Holly Taylor, Evmen Wong	Daniel Wood	Fiona Ling	JUL 22
1	Report with minor revisions	Chris Irvine, SES	Sarah Blundy, Holly Taylor, Evmen Wong	Daniel Wood	Fiona Ling	MAR 23

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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
DPIPWE	Department of Primary Industries, Water and Environment
DNRE	Department of Natural Resources and Environment Tasmania (formerly DPIPWE)
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
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 simulation software (hydrodynamic model)
TP	Rainfall Temporal Patterns

1. INTRODUCTION

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

Due to the poor quality DTM available across this study area it was determined at the calibration stage that acceptable flood mapping could not be produced for this area using the regional flood methodology agreed for this project. Therefore, this report outlines the data, methodology and the results of running the external hydrological modelling for the design flood events for the King Island Study Area. If a better quality DTM becomes available, the inputs described in this report can be used for future modelling. No hydrodynamic design models have been run for this 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

The only flow gauge on the island is Ettrick River U/S Southroad. This was not used for calibration as the record was not coincident with any sub-daily rainfall data on the island. Flow data was downloaded from the NRE Tasmanian Water Information Web Portal (DNRE, 2022). Only 13 years of data were available at this gauge, however as no other data is available Flood Frequency Analysis (FFA) was performed on annual maximum series (AMS) at this site (Table 1). There is no information available about the quality of the rating at this site, with the rating but not gaugings available on Water Data Online (BOM, 2022).

Table 1: Flow gauges used for FFA

Gauge number	Gauge name	River	Period of record	Number of points in AMS
13200.1	Ettrick River U/S Southroad	Ettrick River	1981 - 1994	13

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 greater than 75 km^2. Therefore, for 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^2 or used 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 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

As this gauge was not used for calibration the baseflow prior to the top 5 AMS events was reviewed on Water Data Online (BoM, 2022), from which the baseflow was found to be less than 5% of these 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 Methods Report (WMAwater, 2021b).

2.3.7. Climate Change 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. Using RCP8.5 results for the year 2090, gives a rainfall scaling factor of 16.3% to the IFDs.

3. OVERVIEW OF METHODOLOGY

The hydrological and hydrodynamic design modelling 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.

Due to the poor quality DTM available across this study area it was determined at the calibration modelling stage, that acceptable flood mapping could not be produced for this area using the regional flood methodology agreed for this project. Therefore, this report outlines the data, methodology and the results of running the external hydrological modelling for the design flood events for the King Island Study Area. If a better quality DTM becomes available all the inputs can be used for further modelling. No hydrodynamic design models have been run for this study area.

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
    - Not undertaken
- Mapping
    - Not undertaken

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 is shown in Table 2.

Table 2: Fitting method and distribution used for FFA

Gauge number	Gauge name	Fitting method	Distribution
13200.1	Ettrick River U/S Southroad	Bayesian	Log Pearson III

The calibrated external hydrologic model for each study area was run through the solver and the initial and continuing losses that best matched the curve were estimated. As the period of record at the gauge was so short, the uncertainty in the fitted FFA for rare events is high, therefore the FFA calibration was weighted to flows between the 10% and 2% AEP flows. 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 2% AEP and a fair fit for the 1% AEP peak flows. The differences at the 1% AEP are likely partially due to the uncertainty in the estimated FFA flow based on the short record length.

Table 3: FFA and modelled peak flows

	Ettrick River U/S Southroad	
Parameter	**2% AEP**	**1% AEP**
FFA peak flow (m^3/s)	36.4	42.1
Modelled peak flow (m^3/s)	37.7	46.4
Peak flow difference (%)	3%	10%

The adopted loss values are shown in Table 4, and comparisons to site FFAs are shown in Figure 1.

Table 4: Adopted losses

Initial Loss (mm)	Continuing Loss (mm/h)			
	Soil Type A	Soil Type B	Soil Type C	Soil Type D
5	3.85	N/A	0.924	0.462

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 in Figure 2 and Figure A 4.

Storms with smaller ARF bins are not valid for the main river with large accumulated upstream areas, as rainfalls have not been adjusted down by an appropriate ARF. In initial runs, some ARF-duration-TP sets with small (<= 75 km^2) ARFs were being selected along the larger river, in areas with a large upstream catchment area (> 75 km^2). Therefore, for the model runs with an ARF bin of 75 km^2 or less, the main river sub-catchments (upstream areas > 75 km^2) were assigned 0 mm rainfall. This means the smaller ARF sets did not drown out the more appropriate sets along the main river. The resulting selected patterns were reviewed to ensure no pattern with 0 rainfall was selected in sub-catchments where 0 rainfall was applied.

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%	540	45	26
2%	540	120	16
2%	720	25	6
1%	540	45	22
1%	540	120	14
1%	720	25	12
0.5%	540	45	21
0.5%	540	120	15
0.5%	720	25	12

Diagram 1 shows which ARF-duration-TP set gives representative flows for each sub-catchment, and also shows headwater sub-catchments where only direct rainfall would be applied for the 1% AEP event.

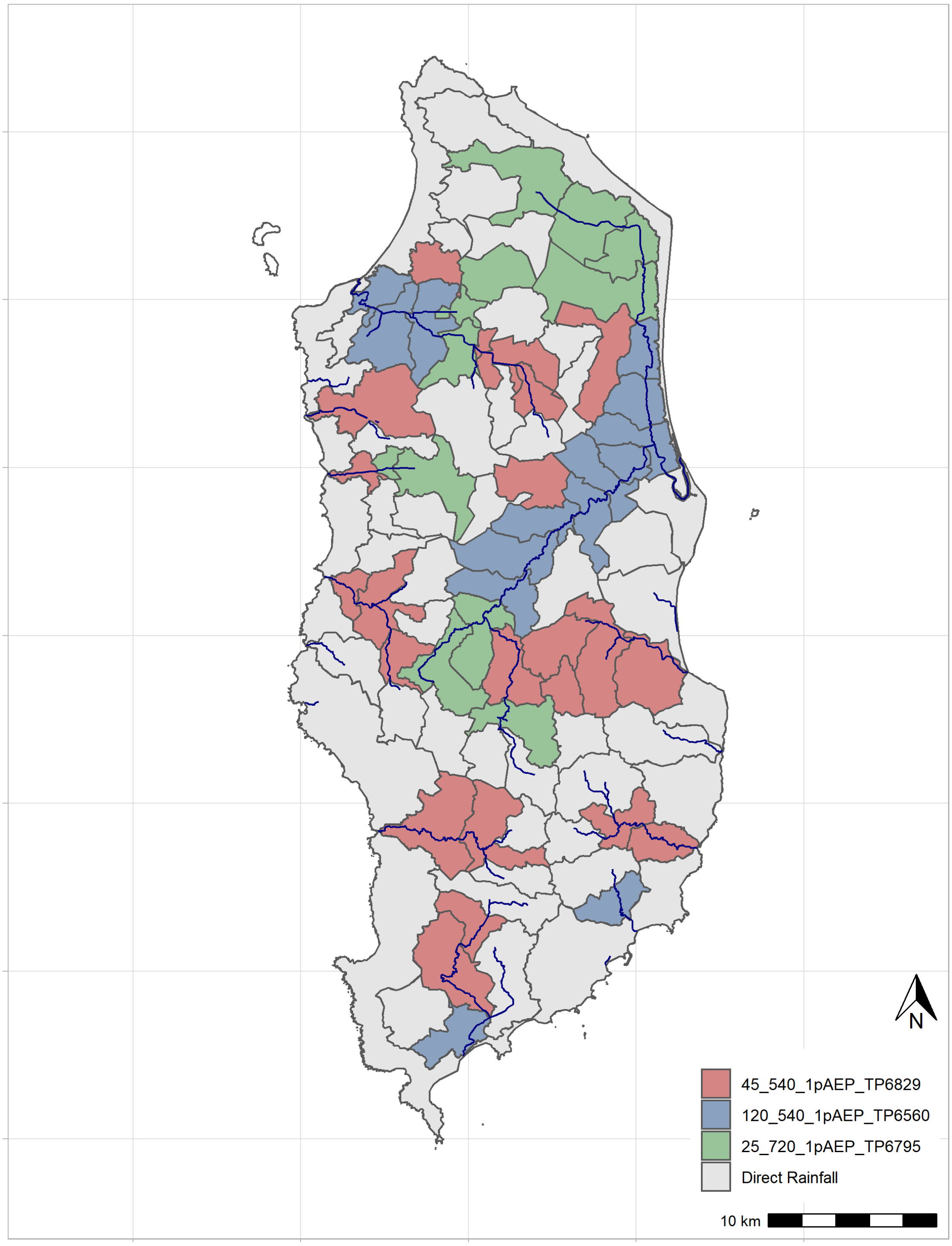

Diagram 1: ARF set relevant for each sub-catchment for the 1% AEP event

The selection of four 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 1

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

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	**90th %ile across sub-catchments**	**Max of all sub-catchments**
2%	4.9%	10.2%	15.7%
1%	4.2%	8.2%	14.0%
0.5%	3.7%	7.4%	13.5%

5.2. Design Event Results

As discussed in the calibration report (WMAwater, 2023) and the methodology (Section 3), the DEM covering this study area is largely limited to the ‘Default DTM’ of the state-wide 10 m DEM. In calibration, this resulted in very poor representation of flooding with flow not following obvious flow paths on aerial imagery. Therefore, flood maps have not been produced for this study area.

6. LIMITATIONS

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

Due to the poor quality of the DEM flood mapping has not been able to be undertaken across this study area.

The flood frequency analysis for this study area relied on a short period of record at the Ettrick River gauge. Therefore, there a very high level of uncertainty in the FFA at this gauge. Unfortunately as there are no flow gauges currently active on King Island it is unlikely that there will be an improvement to the data availability for many years.

7. REFERENCES

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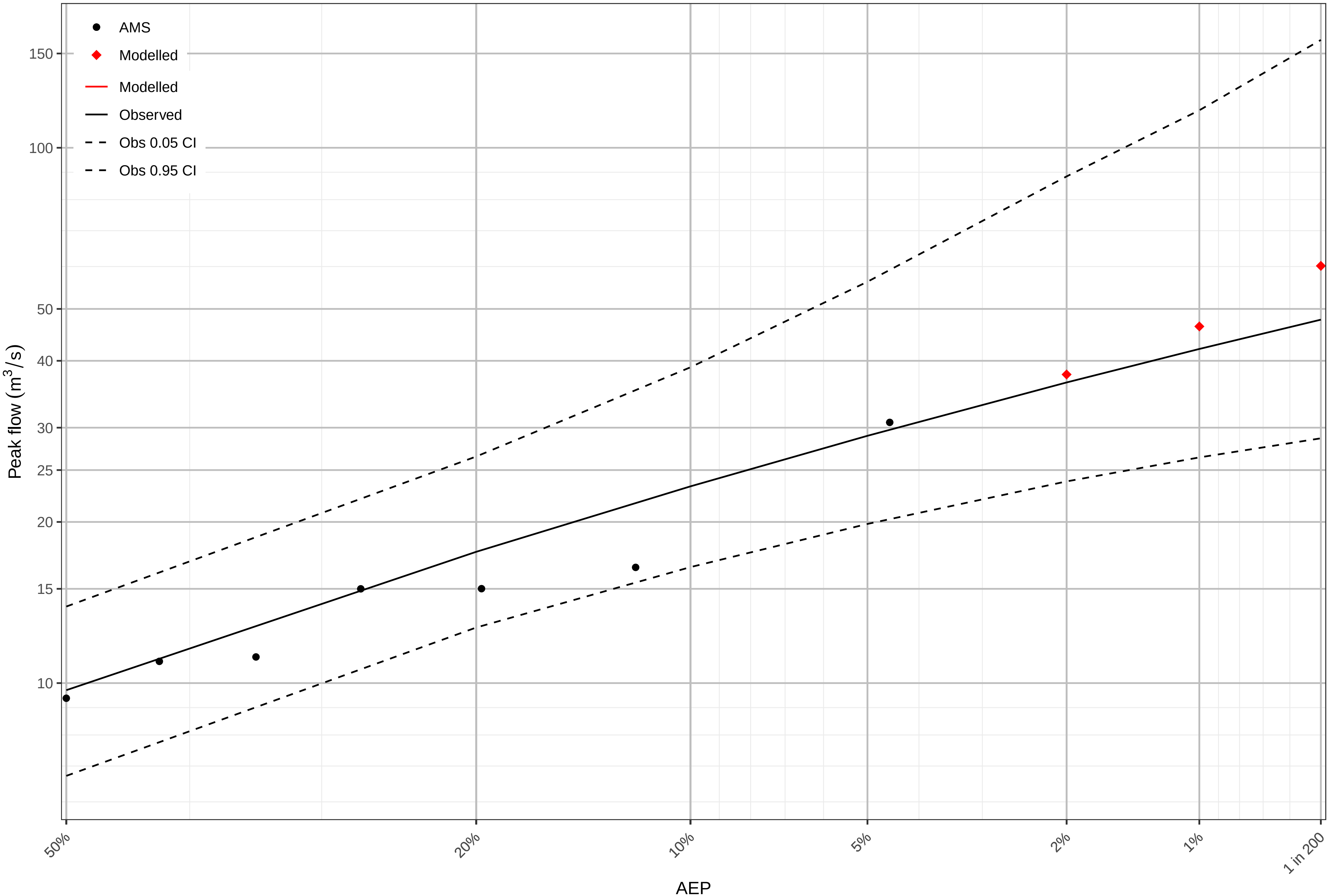
WMAwater (2021a): Tasmanian Strategic Flood Map Hydrology Methods Report, August 2021. Report for State Emergency Service, Tasmania.

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

WMAwater (2023): Tasmanian Strategic Flood Map King Island Catchment Model Calibration Report, March 2023. Report for State Emergency Service, Tasmania.

Figures

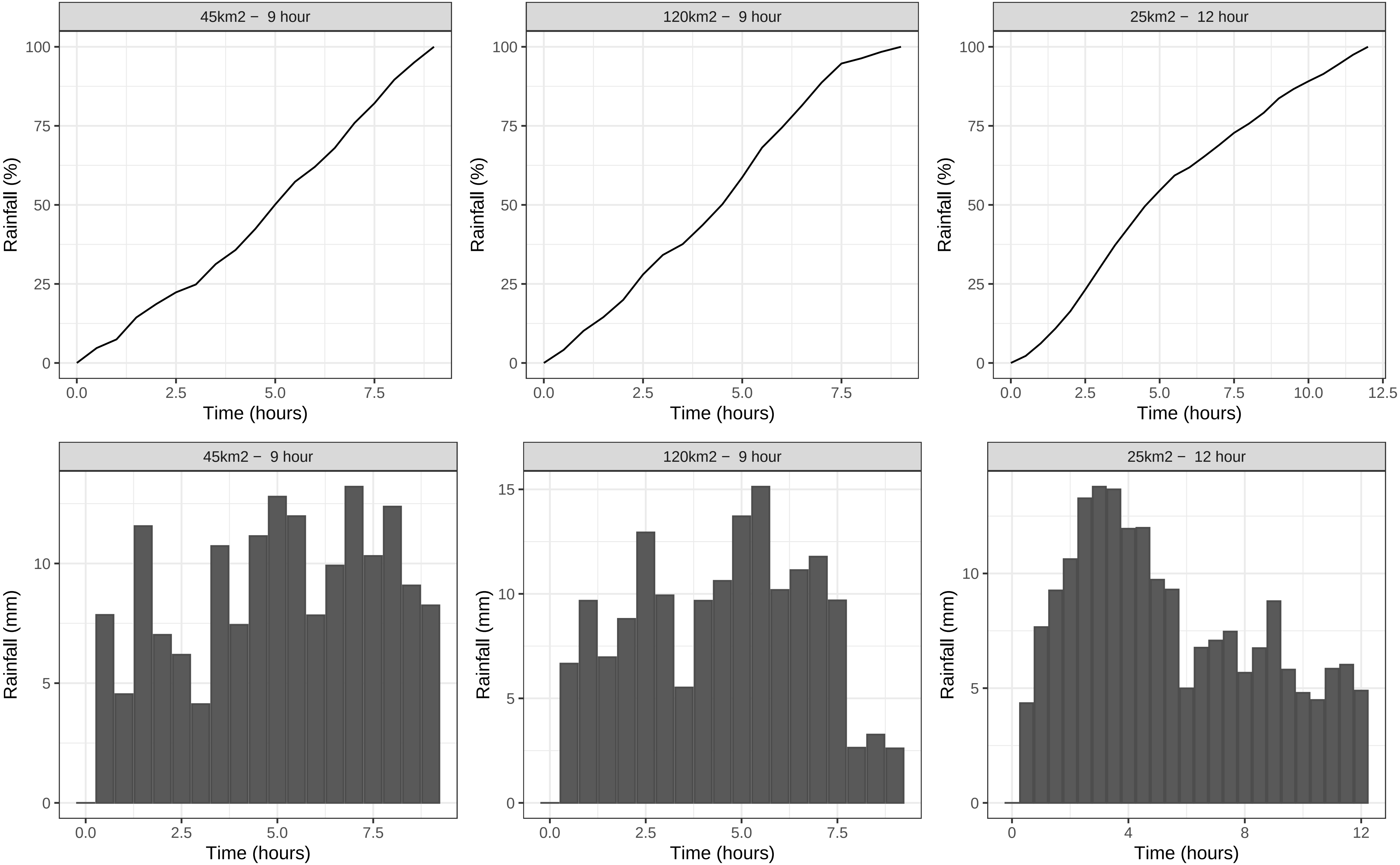
Ettrick River US Southroad



//skyfall.wmawater.com.au/jobs/Jobs/120038/Hydrology/Statewide/FFA_Calibration/King Island/Ettr_Sth/Run_Creation/run_output/20220623_1025-calibv1_PTPv2/outputs/plots/FFA/FFA_KIs35_lognormal_ModAsPts.png

FIGURE 2

SELECTED DESIGN TEMPORAL PATTERNS ALL AEPS BY STORM DURATION AND ARF AREA



Appendix A

APPENDIX A. DESIGN EVENT DATA

FIGURE A1
DESIGN RAINFALL DEPTHS
540MIN 2%AEP

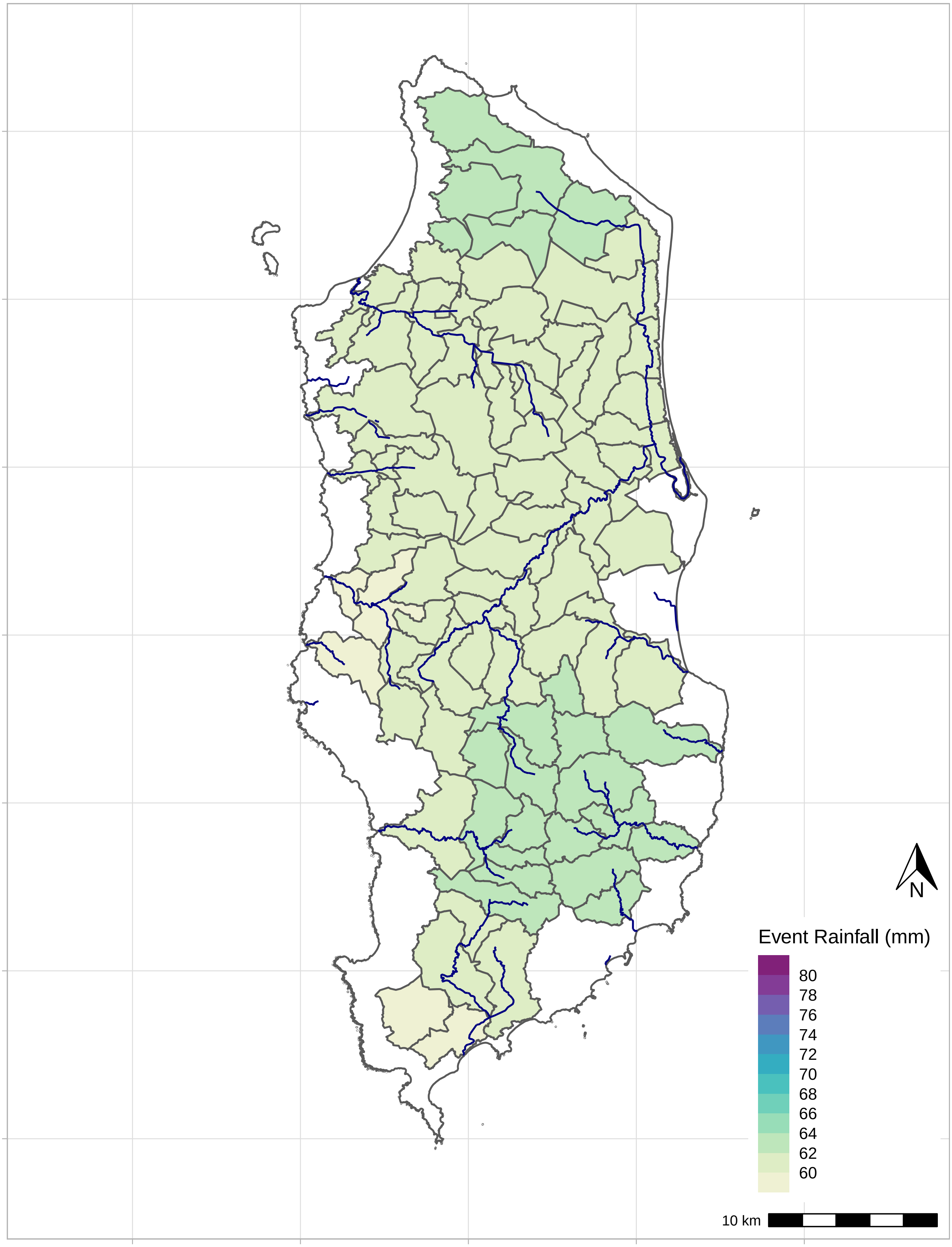


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FIGURE A2

DESIGN RAINFALL DEPTHS

540MIN 1%AEP

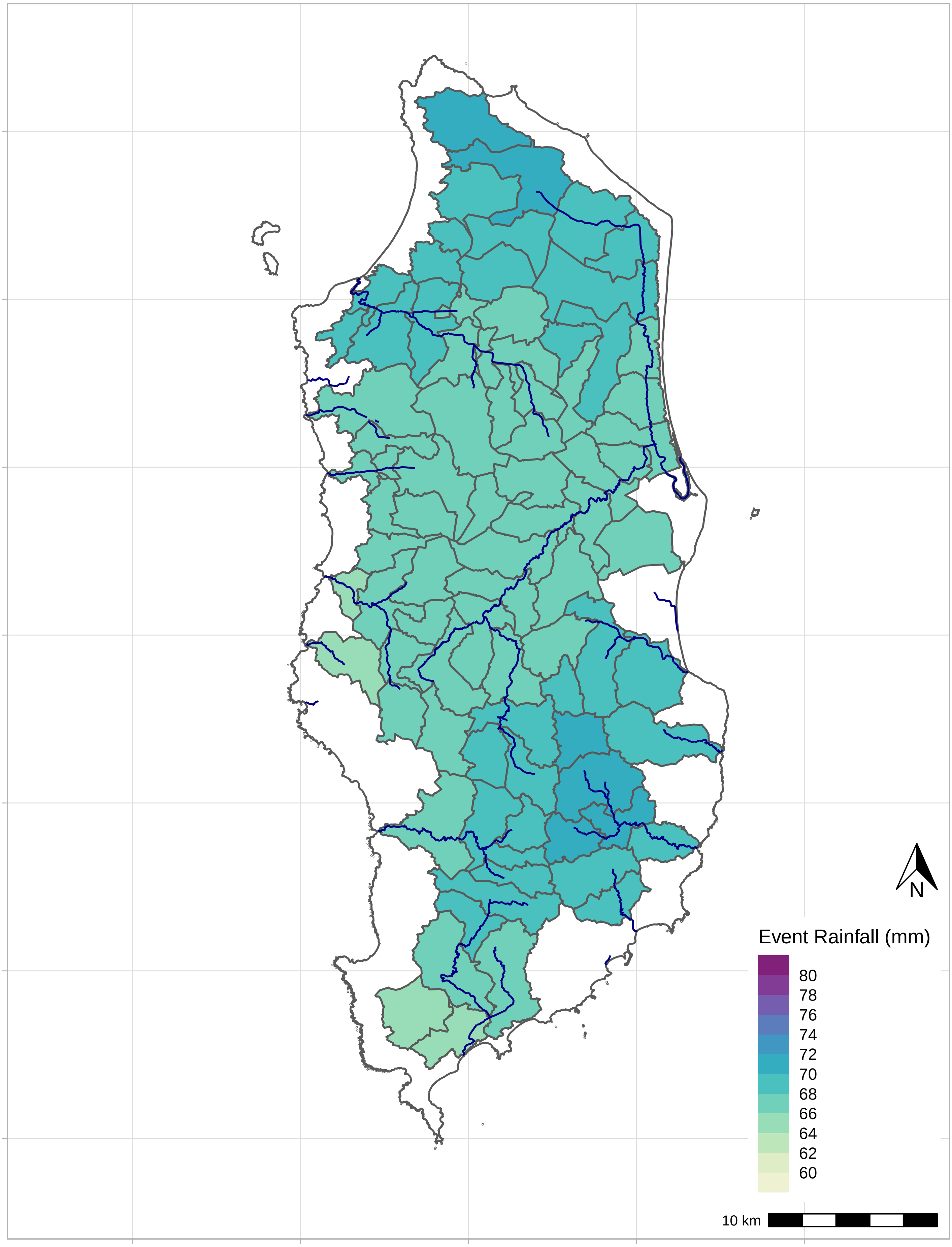

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FIGURE A3

DESIGN RAINFALL DEPTHS

540MIN 0.5%AEP

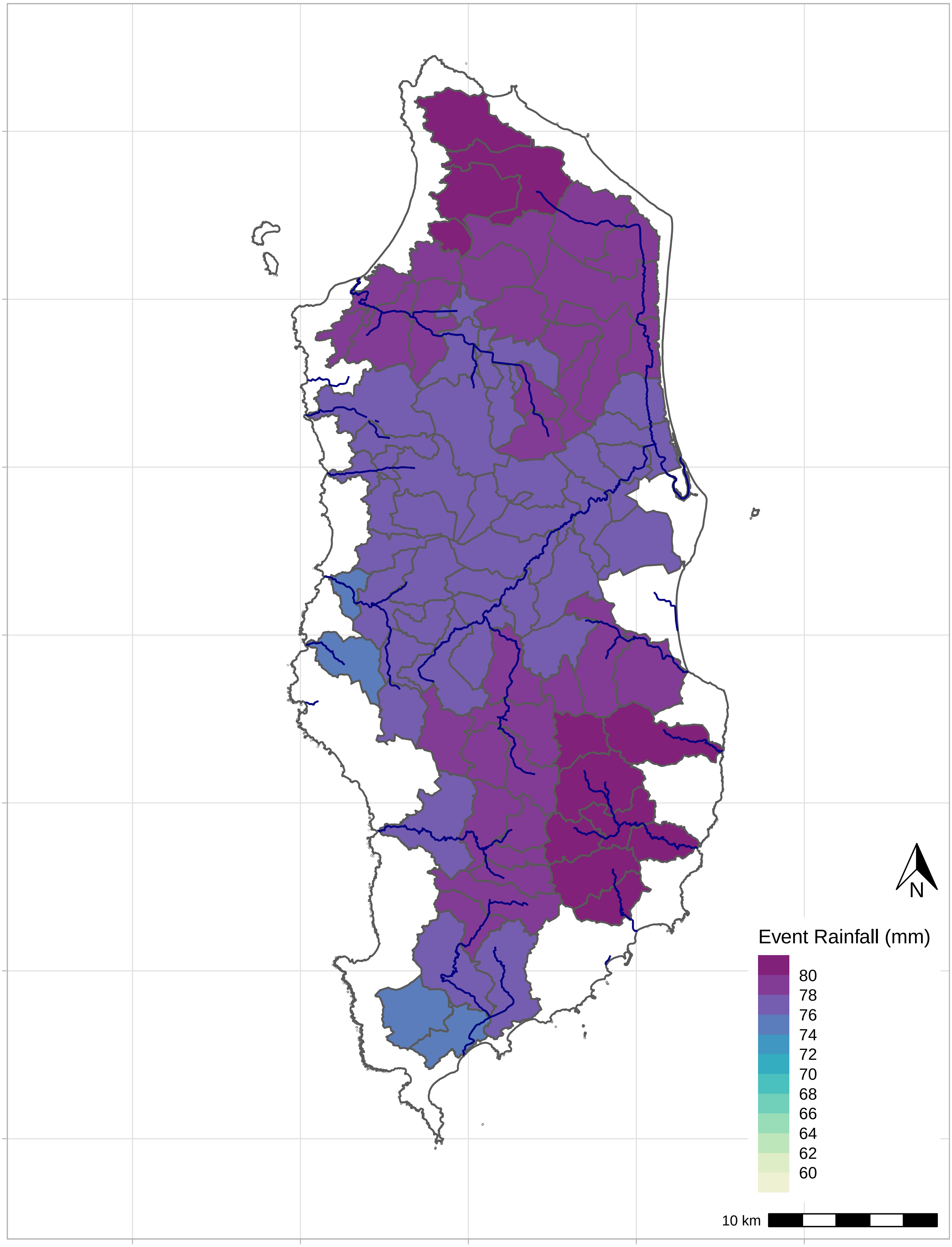

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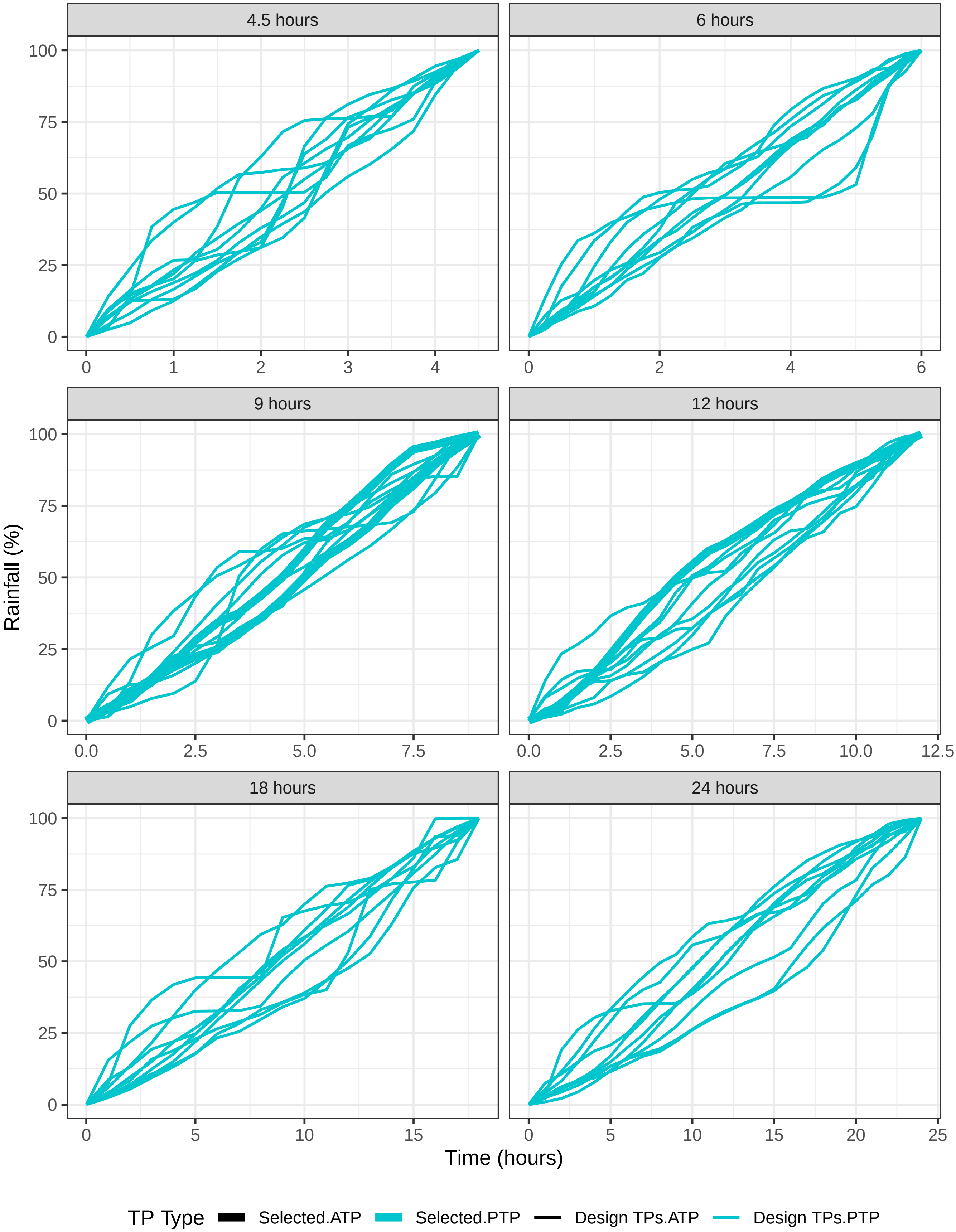
FIGURE A4

DESIGN AREAL TEMPORAL PATTERNS

DURATIONS FROM 4.5 TO 24 HOURS



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Appendix B

APPENDIX B. DESIGN PEAK ERRORS

Figure B1

King Island Catchment

Percentage error in peak flows using selected runs

2pAEP

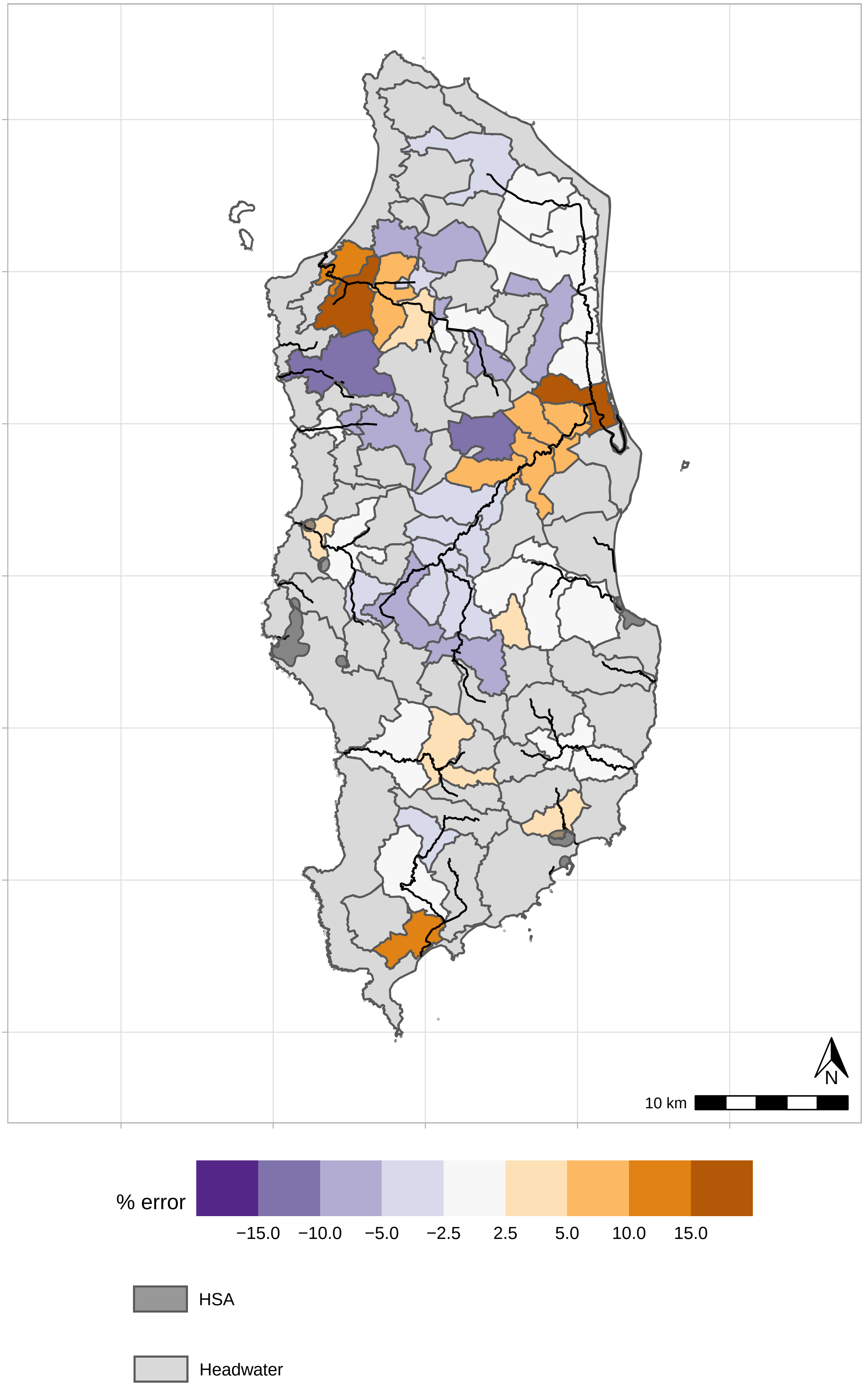

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Figure B2
King Island Catchment
Percentage error in peak flows using selected runs
1pAEP

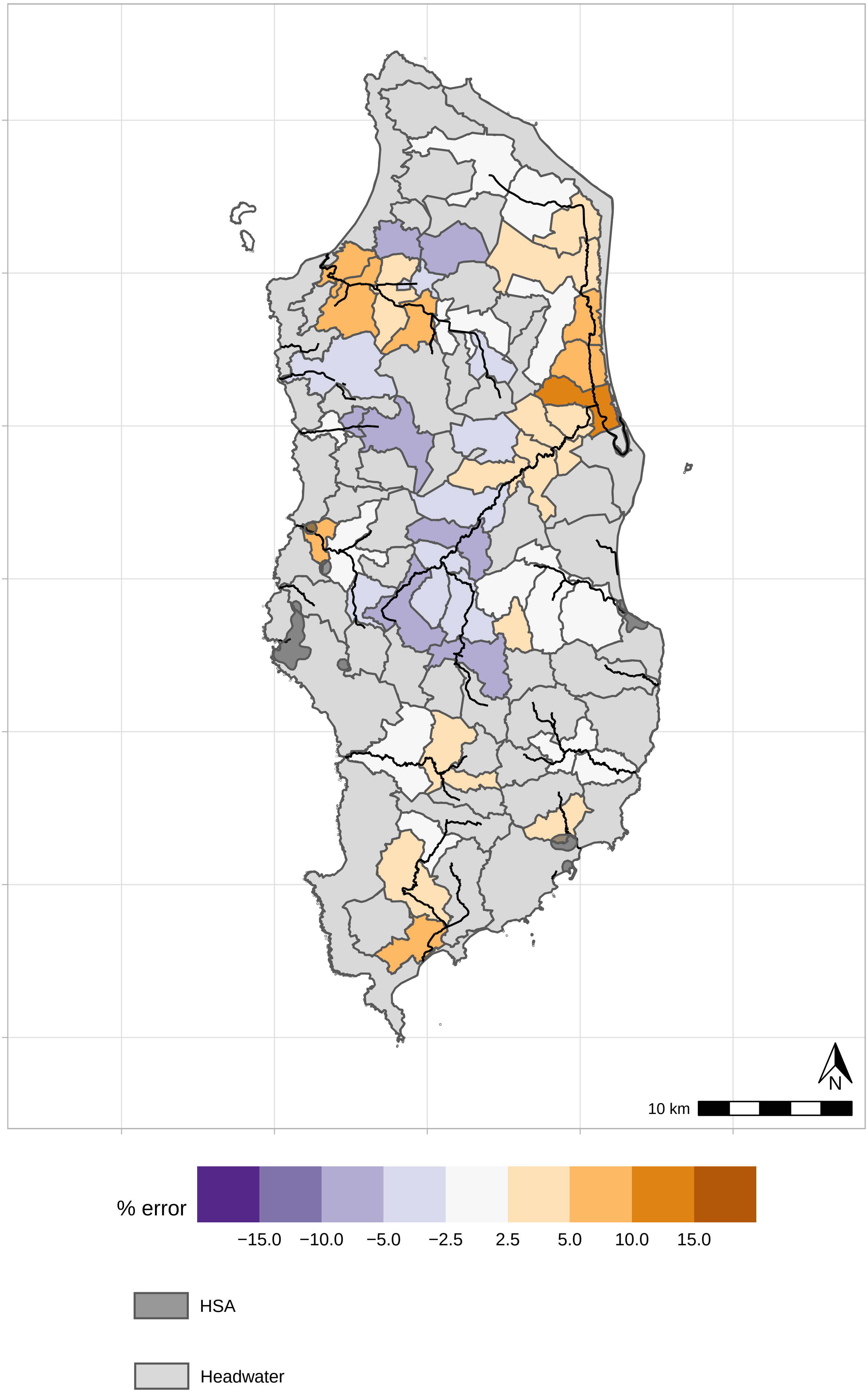

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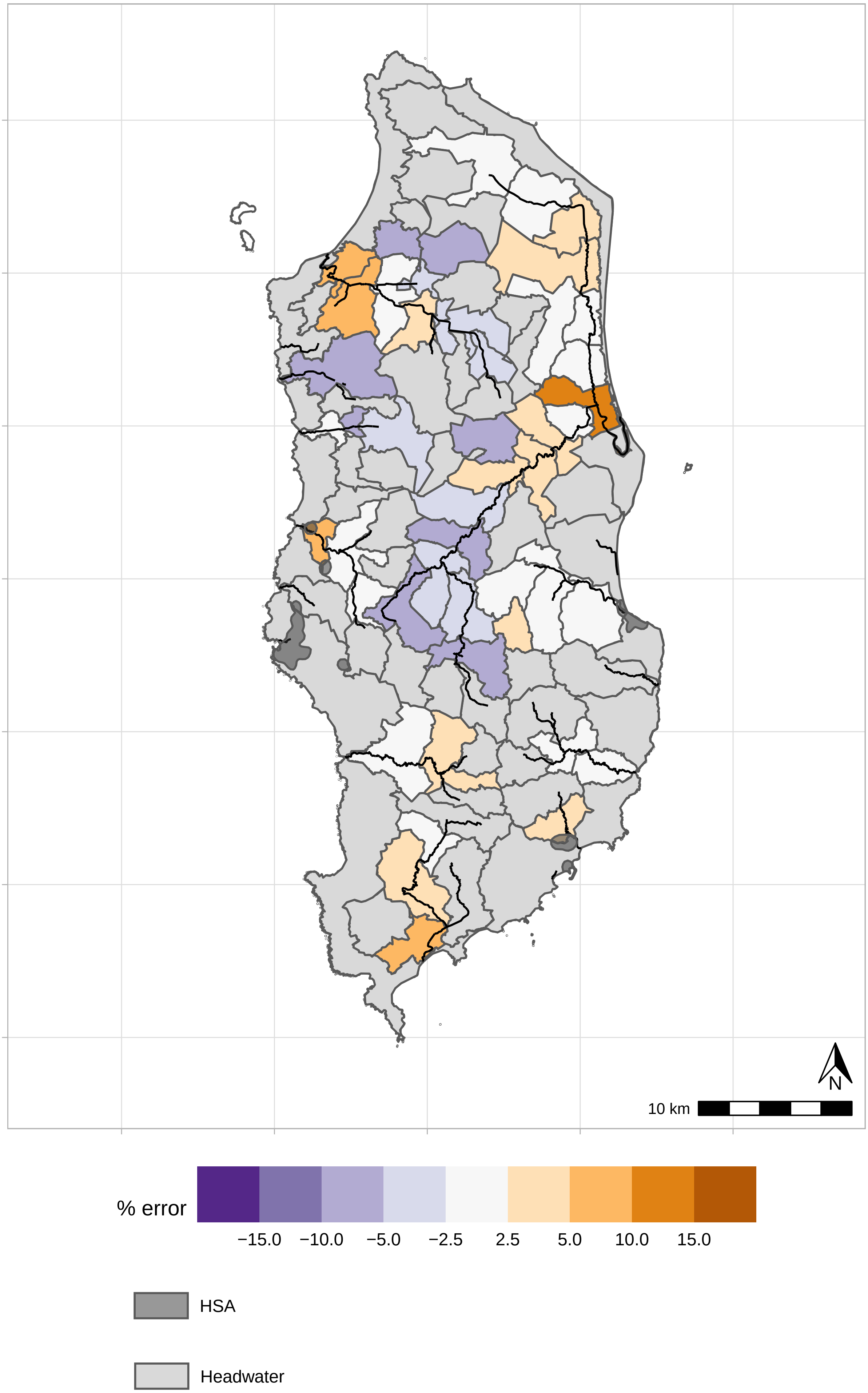
Figure B3
King Island Catchment
Percentage error in peak flows using selected runs
0.5pAEP



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