STATE EMERGENCY SERVICE

TASMANIAN STRATEGIC FLOOD MAP SWAN-APSLEY STUDY AREA DESIGN FLOOD MODELLING

ADDENDUM TO CALIBRATION REPORT

MARCH 2023

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Project Tasmanian Strategic Flood Map Swan-Apsley Study Area Design Flood Modelling	**Project Number** **120038**
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Project Manager Fiona Ling	

Revision History

Revision	Description	Distribution	Authors	Reviewed by	Verified by	Date
0	Design flood report	Chris Irvine, SES	Sarah Blundy, Holly Taylor, Evmen Wong	Daniel Wood	Fiona Ling	JULY 22
1	Design Report	Chris Irvine, SES	Sarah Blundy, Evmen Wong	Daniel Wood	Fiona Ling	AUGUST 22
2	Report with minor revisions	Chris Irvine, SES	Sarah Blundy, Evmen Wong	Daniel Wood	Fiona Ling	MARCH 23

TASMANIAN STRATEGIC FLOOD MAP
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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 (formerly DPIPWE)
DPIPWE	Department of Primary Industries, Water and Environment
DRM	Direct Rainfall Method
DTM	Digital Terrain Model
FFA	Flood Frequency Analysis
FLIKE	Software for flood frequency analysis
FSL	Full Supply Level
GIS	Geographic Information System
GEV	Generalised Extreme Value distribution
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)
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 Swan-Apsley 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 Swan-Apsley 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 annual maximum series (AMS) from flow gauges within the catchment. The gauges used for FFA are shown in Table 1. The other gauges in the study area were not included in the FFA due to unreliable rating curves or short record lengths or very small catchment areas. More detail on the quality of the gauge data is provided in the calibration report (WMAwater, 2023).

Revised ratings were developed for both Swan River at the Grange and Apsley River U/S Coles Bay Rd (WMAwater, 2021c).

At Swan River at the Grange gauge, as the historic ratings and gaugings show significant variations, it was not appropriate to apply the revised rating curve across the entire record. The revised rating was therefore applied to AMS events since 1996 (the last major rating shift) when stage heights were above 3.75 m (as the DNRE gauging derived rating is preferred for low flows). This application of the rating had relatively minor impacts on AMS peaks as the revised rating is very similar to the DNRE rating during this period.

At Apsley River at Coles Bay Rd gauge, the revised rating was applied to all events above ~4 m, which is where the rating begins to significantly diverge from the DNRE rating. This approach is consistent with the approach used in calibration. There is some uncertainty as to whether the four events in the 1970s and 1980s should also have the revised rating applied as they fell on a significantly different initial rating curve. The rating for these events is pinned on one gauging in 1983 at 200 m^3/s. This rating gave a peak flow for the 1974 event of 900 m^3/s. As a result, the 1974 event at this location sat a long way above all other flood peaks, which is inconsistent with observations at nearby gauges for this event. This anomaly was considered to be rating curve related and, as such, the revised rating was applied to this event. This gives a 1974 flood peak of approximately 600 m^3/s which is more in line with the other rating curves at the site. The DNRE rating was retained for lower AMS events where there are more gaugings available to give higher confidence in this rating.

Table 1: Flow gauges used for FFA

Gauge number	Gauge name	River	Period of record	Number of points in AMS
2200-1	Swan River at the Grange	Swan	26/05/1964 - current	52
2204-1	Apsley River U/S Coles Bay Rd	Apsley	30/05/1968 - current	42

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

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 undertaken. 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

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. Using RCP8.5 results for the year 2090, gives a rainfall scaling factor of 16.3% 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 Glamorgan-Spring Bay 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 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 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.
  - Map the design event envelope and filtered direct rainfall results.

4. CALIBRATION OF DESIGN LOSSES

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

There was a great deal of uncertainty about the flood peak for the largest event on record at Swan River at the Grange (May 1969 event), as shown in the calibration report (WMAwater, 2023). Therefore, this was included in the FFA as a censored peak above a threshold of 900 m^3/s. This maintained its rank as the largest event on record. The resulting FFA fits almost exactly through the original DNRE AMS flood peak of 1,160 m^3/s, however there is a very large confidence interval (Figure 1). To give some confidence in the FFA, the Swan and Apsley FFAs were compared using Equation 1. This showed very good consistency across the gauges with 2% to 0.5% FFA flows within 5% of each other.

Equation 1

$$QScale_{Apsley\ x\%\ AEP} = Q_{Apsley\ x\%\ AEP}\left(\frac{Area\ Swan}{Area\ Apsley}\right)^{0.8} \times \frac{Average\ Swan\ 1\%\ IFD}{Average\ Apsley\ 1\%\ IFD}$$

Table 2: Fitting method and distribution used for FFA

Gauge number	Gauge name	Fitting method	Distribution
2200-1	Swan River at the Grange	Bayesian	GEV
2204-1	Apsley River upstream Coles Bay Road	Bayesian	Log Pearson III

The calibrated external hydrologic model was run through the solver and the initial and continuing losses that best matched the curve 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 curve. The catchment-average continuing loss was distributed across the study area using the hydrological soil group final infiltration rates. As with the calibration report, different CLs were applied over the Apsley catchment to the remainder of the study area.

As the calibration report showed some mismatch between peak flows estimated using the external hydrology model and those estimated using ICM, the external hydrology model was calibrated to give flows lower than the fitted FFA at the Swan River gauge (Figure 1). This meant that the final ICM flows showed a good match to observed data (Section 5.2.1).

The FFA at the Apsley River gauge could not be reached with modelled flows, even with a continuing loss of 0mm (Figure 2). This could potentially relate to the uncertainty in the FFA flows due to uncertainty in the gauge rating curve discussed in Section 2.2. However, it could also relate to the design rainfall. As discussed in the calibration report, this is an area with significant orographic effects on rainfall totals, with gradients in the order 300 mm difference in rainfall across 7 km found for the March 2011 event. The current IFDs are generated as approximately 2 by 3 km grid cells, which may not capture the full variability of rainfall totals in areas of such extreme rainfall gradients.

The percentage differences between the FFA and the modelled peak flow for the 2% and 1% AEP events are shown in Table 3.

Table 3: FFA and modelled peak flows

Gauge name	FFA 2% AEP peak flow (m^3/s)	Modelled 2% AEP peak flow (m^3/s)	2% AEP percent difference	FFA 1% AEP peak flow (m^3/s)	Modelled 1% AEP peak flow (m^3/s)	1% AEP percent difference
Swan River at the Grange	1038	871	-16%	1180	1013	-14%
Apsley River u/s Coles Bay Road	548	501	-9%	613	565	-8%

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

Table 4: Adopted losses

Catchment	Initial Loss (mm)	Continuing Loss (mm/h)			
		Soil Type A	Soil Type B	Soil Type C	Soil Type D
Apsley	8	0	0	0	0
Swan/Meredith	8	3.5	1.8	0.8	0.4

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 3 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%	360	10	24
2%	540	75	49
2%	720	250	11
1%	360	10	23
1%	540	75	46
1%	720	250	15
0.5%	360	10	28
0.5%	540	75	45
0.5%	720	250	11

Diagram 1 shows the ARF-duration-TP set used to give representative flows for each sub-catchment for the 1% AEP event. There are 84 sub-catchments where this is applied (as headwater and coastal catchments are not included). Headwater and coastal 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 80% 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.

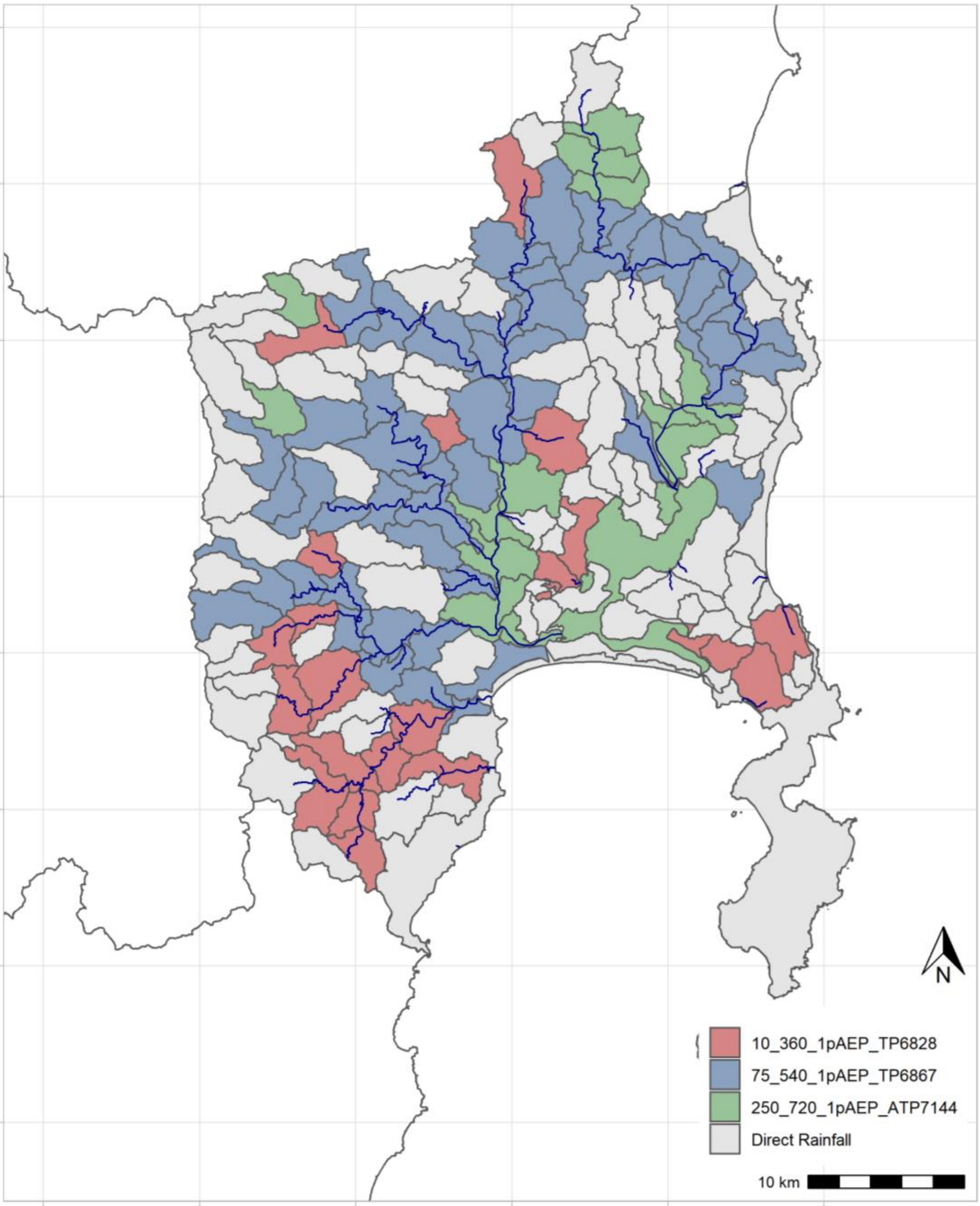

Diagram 1: ARF set relevant for each sub-catchment for the 1% AEP event

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 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%	3.0	5.4	15.5
1%	3.0	5.6	13.0
0.5%	3.0	5.4	10.4

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 km² grid cells, and the mean value of these grid cells within the study area was used.

Table 7 below summarises the downstream boundary levels and dam initial conditions for each design event.

Table 7. Downstream boundary levels and dam initial conditions for each AEP

AEP	Downstream boundary	Downstream boundary (Schouten Island)	Coles Bay Dam	Northern Tin Mine Dam
2%	HAT (0.74 mAHD)	HAT (0.70 mAHD)	FSL (80.35 mAHD)	FSL (125.00 mAHD)
1%				
0.5%				
1% CC	HAT + sea level rise (1.66 mAHD)	HAT + sea level rise (1.62 mAHD)		

5.2. Design Event Results

The results of the design event modelling are shown in Figure 4 to Figure 19 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 20. There are some areas which show different critical events between the hydrodynamic runs and external hydrology runs (i.e. between Diagram 1 and Figure 20). These areas have been inspected and show very similar event peaks across the patterns which have been swapped so differences in flood extent and depth are expected to be very minimal.

As noted in Section 5.1 of the calibration report, bathymetry of the Moulting Lagoon area was not available in the supplied DEM (which adopts a value of -10 mAHD through this area). It is recommended that the design mapping in this area is disregarded, until such time that updated topographic data is available and further modelling is undertaken. This is inclusive of Swanwick.

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. 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 Swan River at the Grange

A review of the design flows produced from the hydrodynamic model at Swan River at the Grange 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 Swan River at the Grange

Parameter	2% AEP	1% AEP	1% AEP CC	0.5% AEP
Modelled peak flow (m3/s)	1050	1192	1426	1385
FFA peak flow (m3/s)	1038	1180	n/a	1322
Peak flow difference (%)	+1%	+1%	n/a	+5%

5.2.2. Review of Results at Apsley River u/s Coles Bay Road

A review of the design flows produced from the hydrodynamic model at Apsley River u/s Coles Bay Road was undertaken, by comparing to the flows derived from the FFA. The modelled peak flows are underestimated compared to the FFA peak flows at this location as discussed in Section 4 (Table 9). The final errors are higher than those presented in the FFA calibration section (Table 3). This is partially due to the introduction of errors by binning ARFs and selecting 3 patterns to run through the hydrodynamic model, however the higher errors are largely due to the difference in routing between the external hydrological model and the hydrodynamic model. This difference is in line with that found in calibration. The differences between the model results and the FFA in the Apsley catchment are in the opposite direction to the Swan catchment, and varying channel routing parameters were applied across the study area in calibration (and therefore in design). If this study area is revisited in future, further refinement of these parameters could reduce the discrepancy between the external hydrology and the hydrodynamic model. These discrepancies between the external hydrology model results and the hydrodynamic model were allowed for in selection of model parameters for the Swan River, resulting in a good fit of hydrodynamic model results to the FFA. Design parameters have been selected to increase flows at Apsley, within reasonable values. Given this, refinement of channel routing parameters in the external hydrology model would not have any substantive impact on design results.

Table 9: Design flows at Apsley River u/s Coles Bay Road

Parameter	2% AEP	1% AEP	1% AEP CC	0.5% AEP
Modelled peak flow (m3/s)	464	522	616	604
FFA peak flow (m3/s)	548	613	n/a	670
Peak flow difference (%)	-15%	-15%	n/a	-10%

6. LIMITATIONS

A detailed uncertainty assessment of the data, hydrological calibration and hydrodynamic model is contained in the Swan Apsley 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 found at the calibration stage, there is considerable uncertainty in the high flow ratings for both the gauges used in this design flood modelling. There is also uncertainty in the design rainfall values, given the high rainfall gradients over the study area for large events.

As noted in Section 5.2, it is recommended that the design mapping in the Moulting Lagoon and Swanwick area is disregarded until such time that updated topographic data is available and further modelling is undertaken. It was also noted that 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.

7. REFERENCES

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Figures

FIGURE 1

Swan River at the Grange

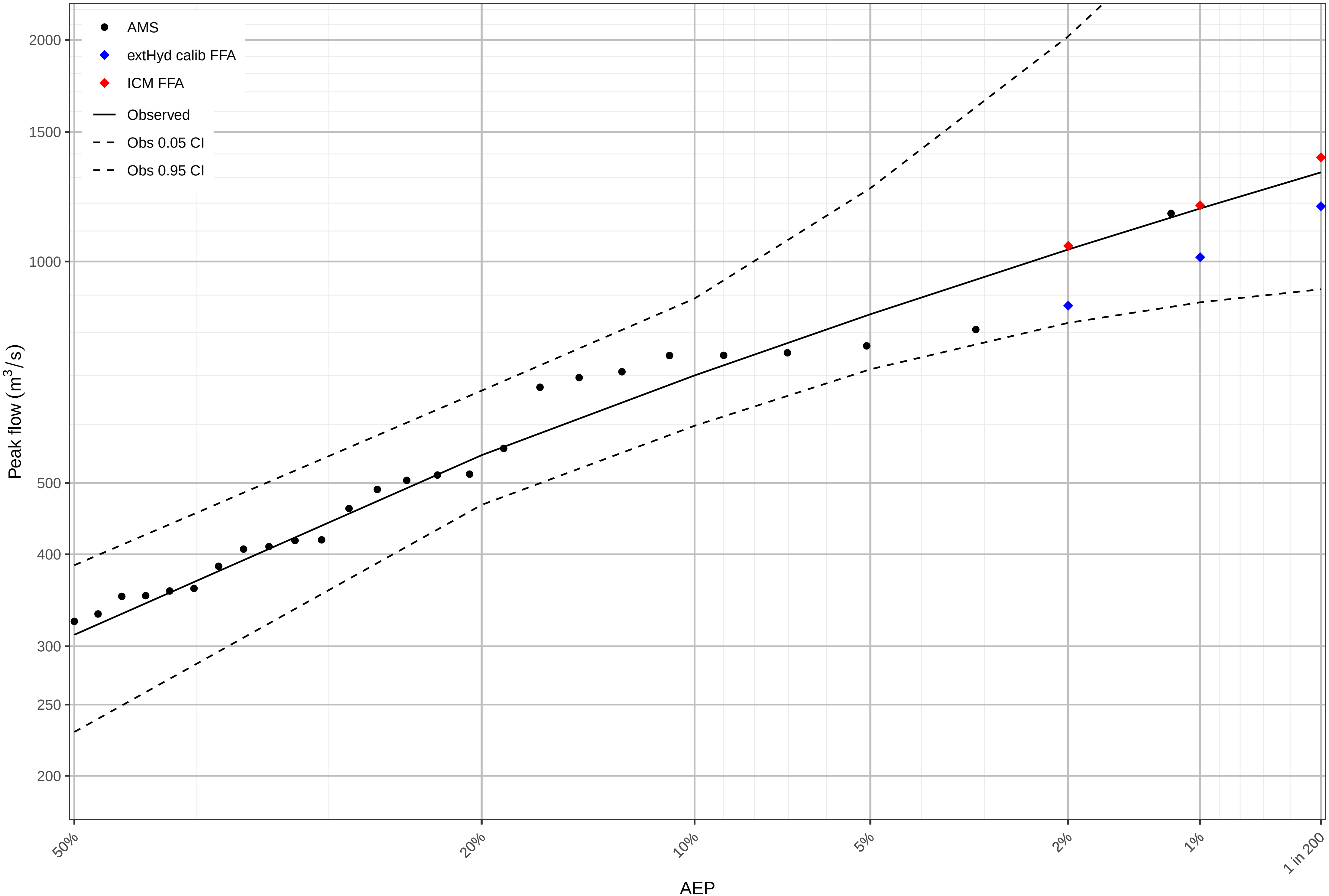

FIGURE 2

Apsley River U/S Coles Bay Rd

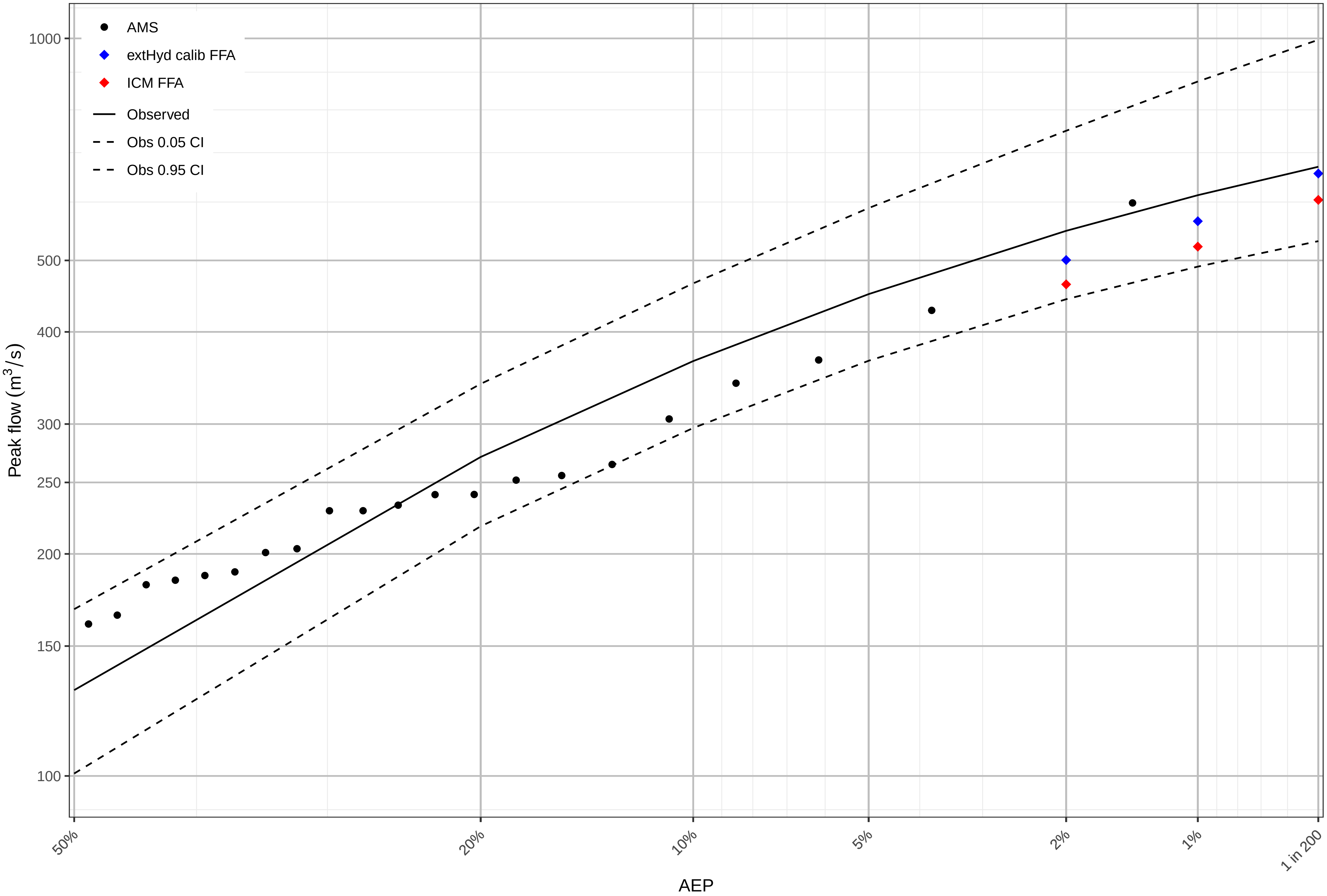

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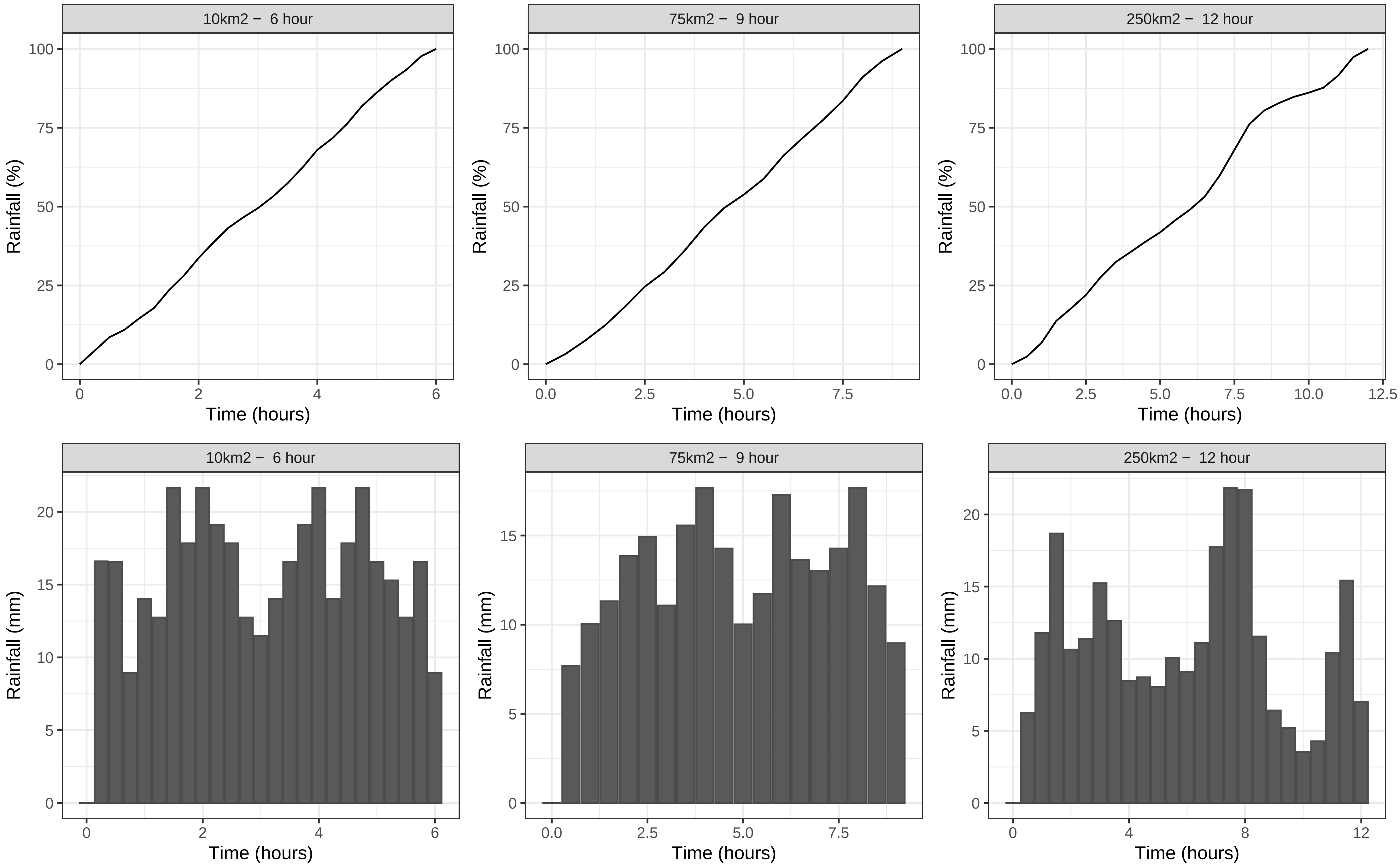
FIGURE 3

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



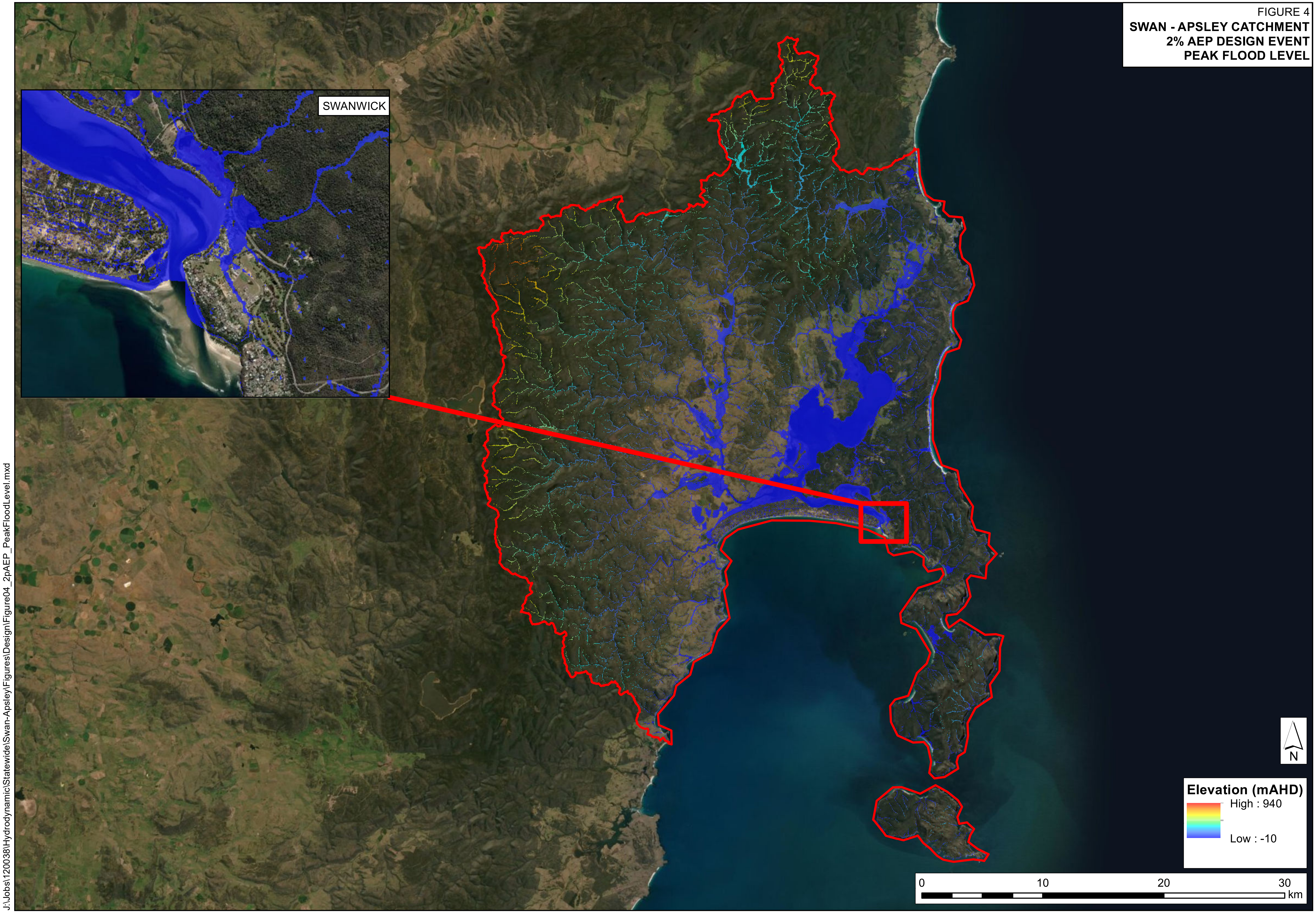


FIGURE 4
SWAN - APSLEY CATCHMENT
2% AEP DESIGN EVENT
PEAK FLOOD LEVEL
SWANWICK
Elevation (mAHD)
High : 940
Low : -10
N
0
10
20
30
km
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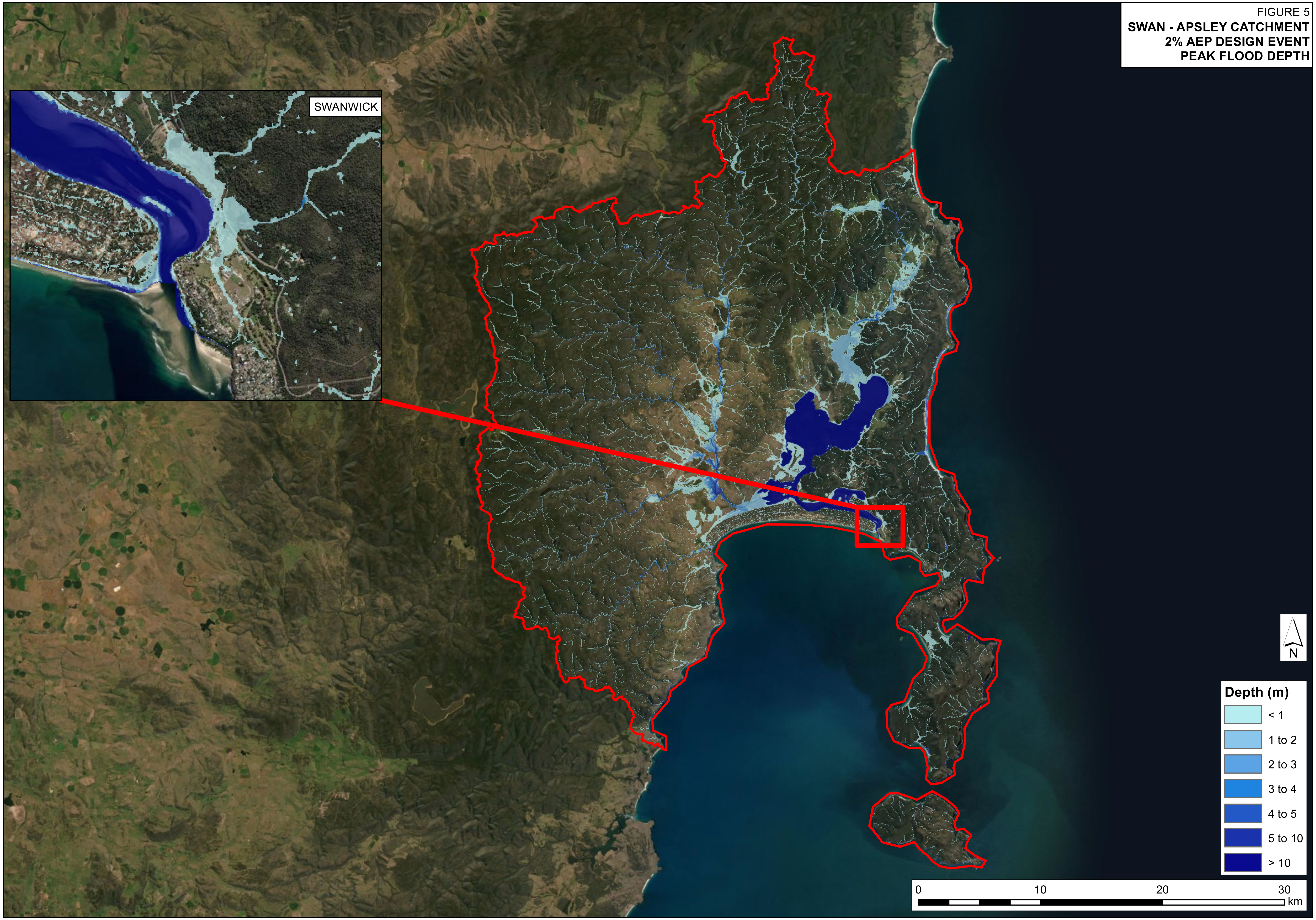
FIGURE 5
SWAN - APSLEY CATCHMENT
2% AEP DESIGN EVENT
PEAK FLOOD DEPTH
SWANWICK
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
N
0
10
20
30
km
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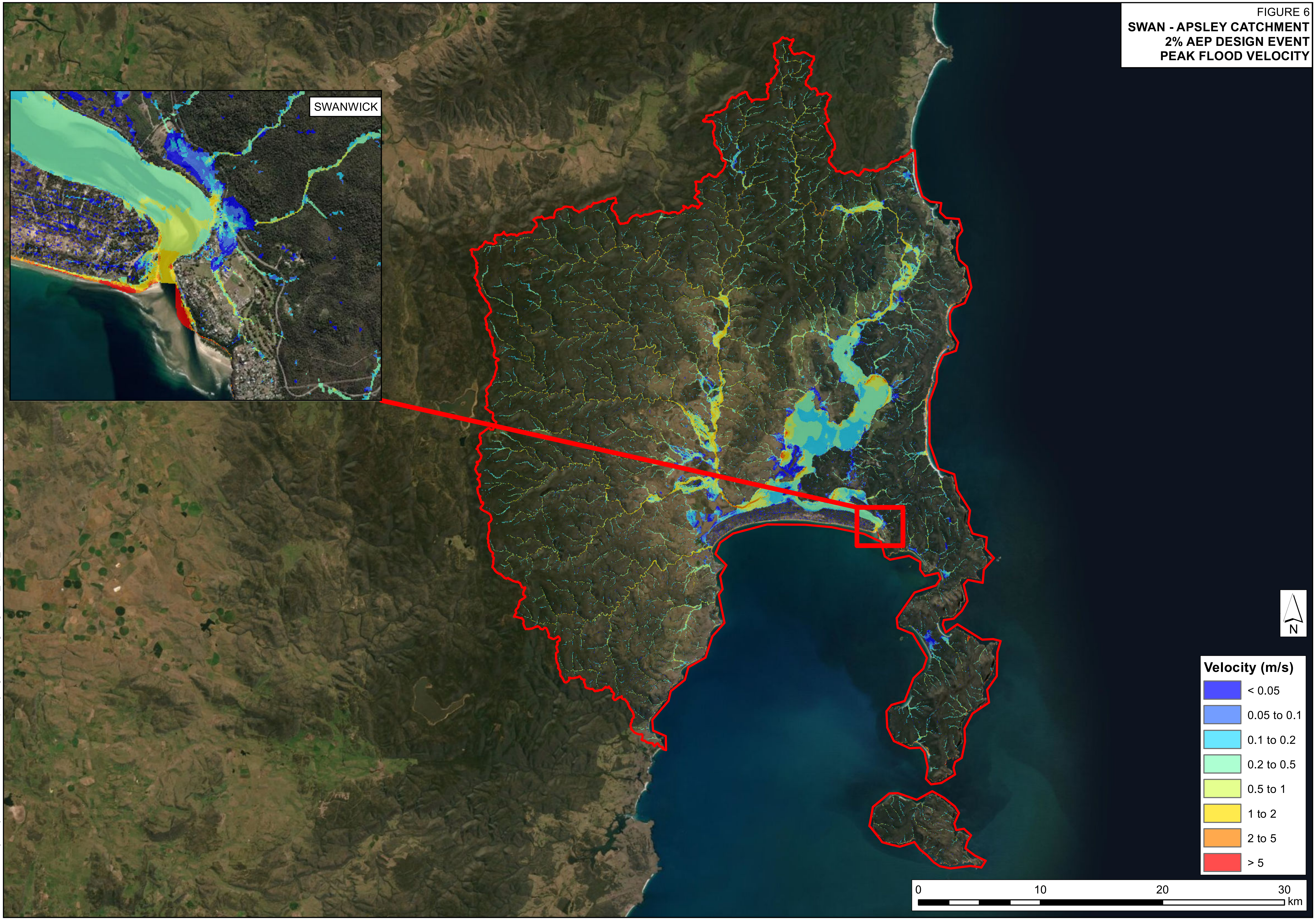

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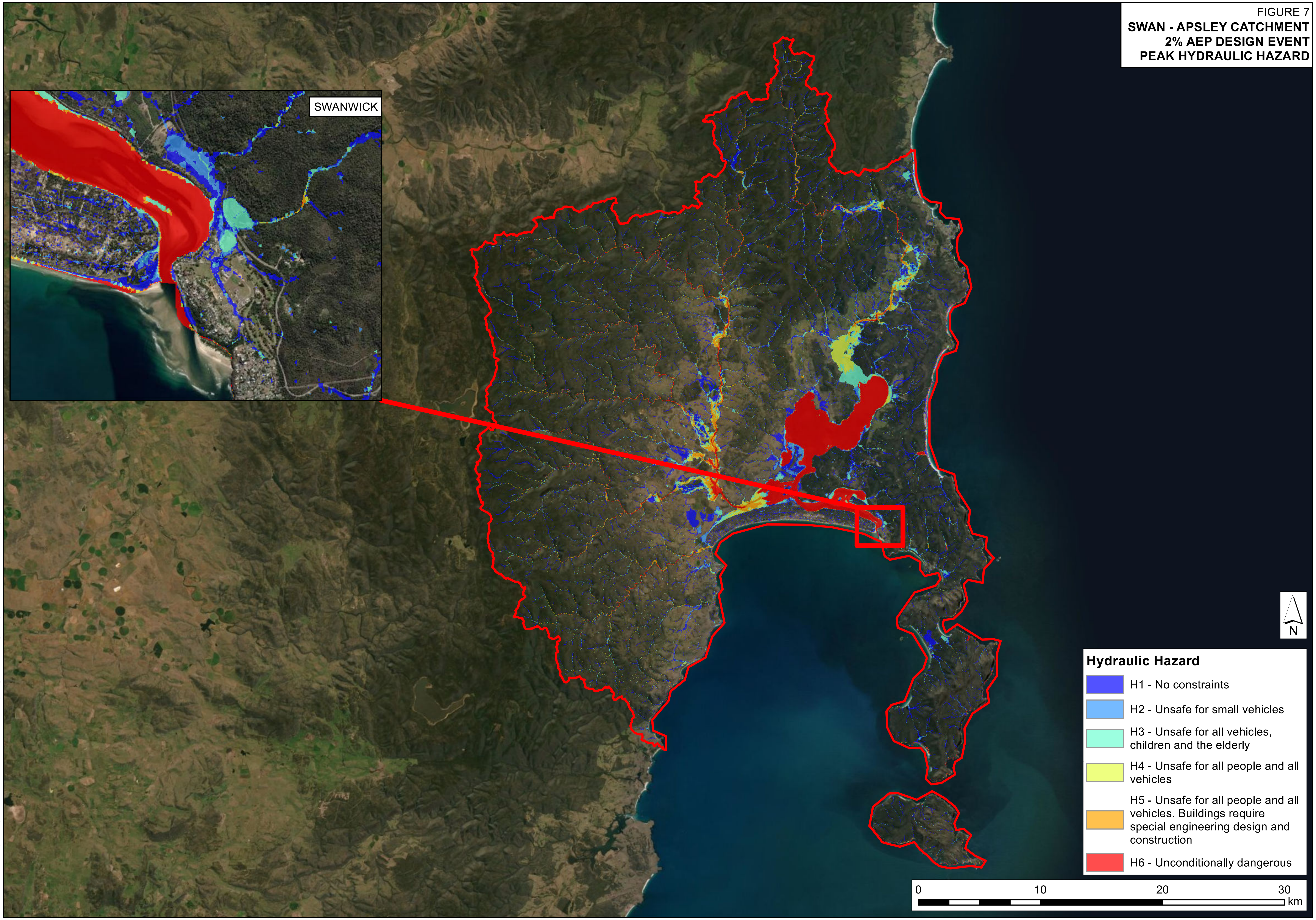

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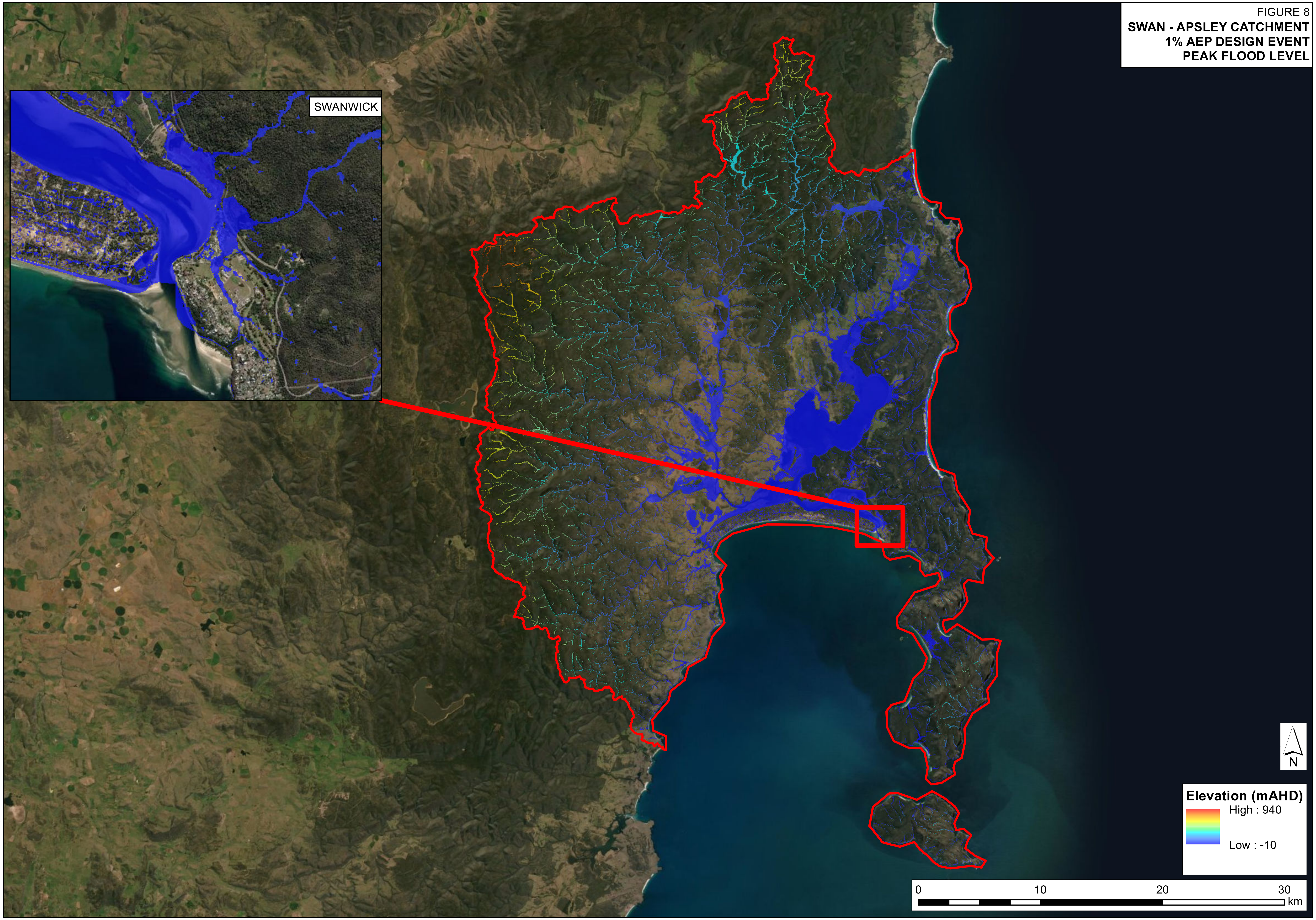


FIGURE 8
SWAN - APSLEY CATCHMENT
1% AEP DESIGN EVENT
PEAK FLOOD LEVEL
SWANWICK
Elevation (mAHD)
High : 940
Low : -10
N
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure08_1pAEP_PeakFloodLevel.mxd

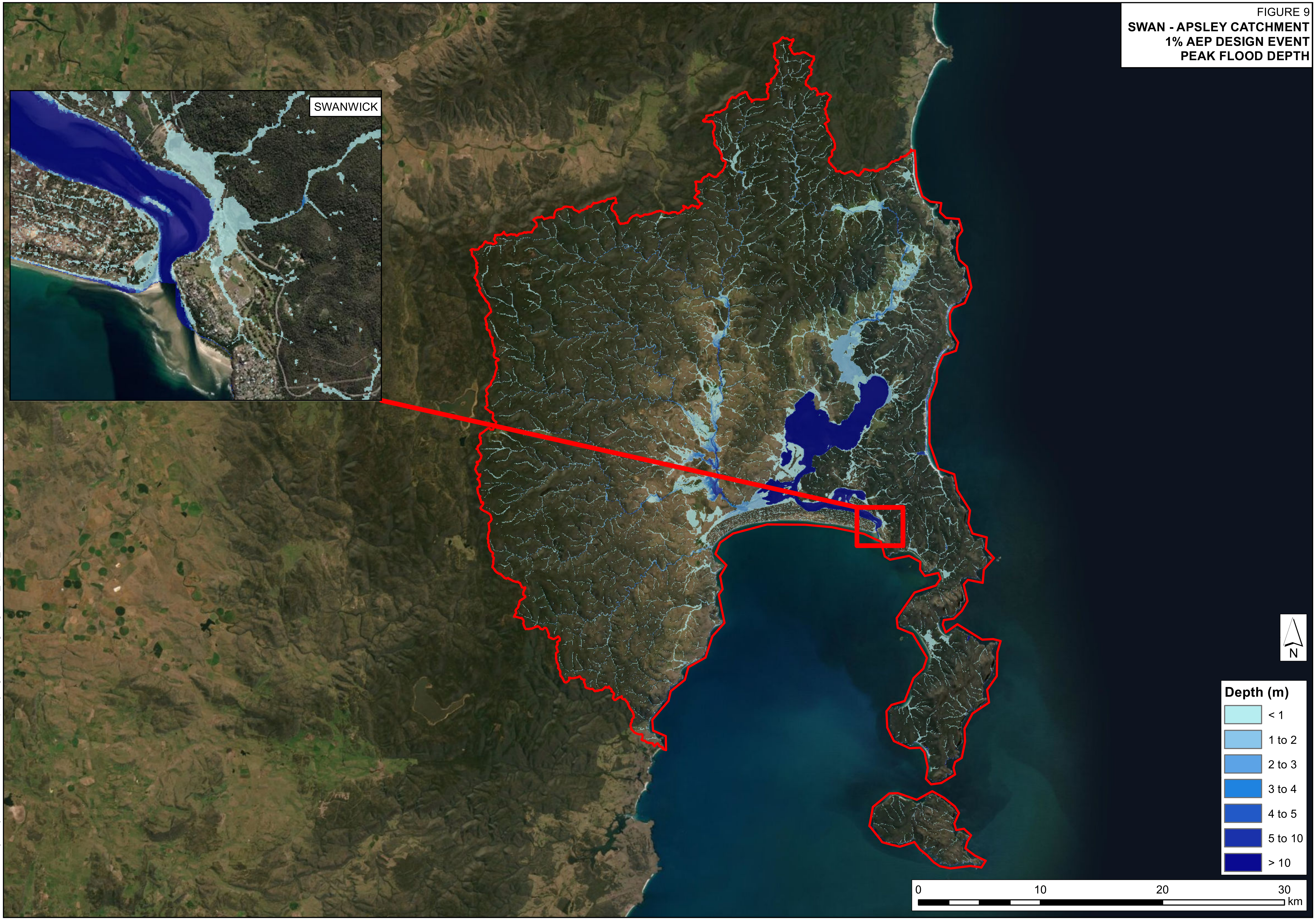
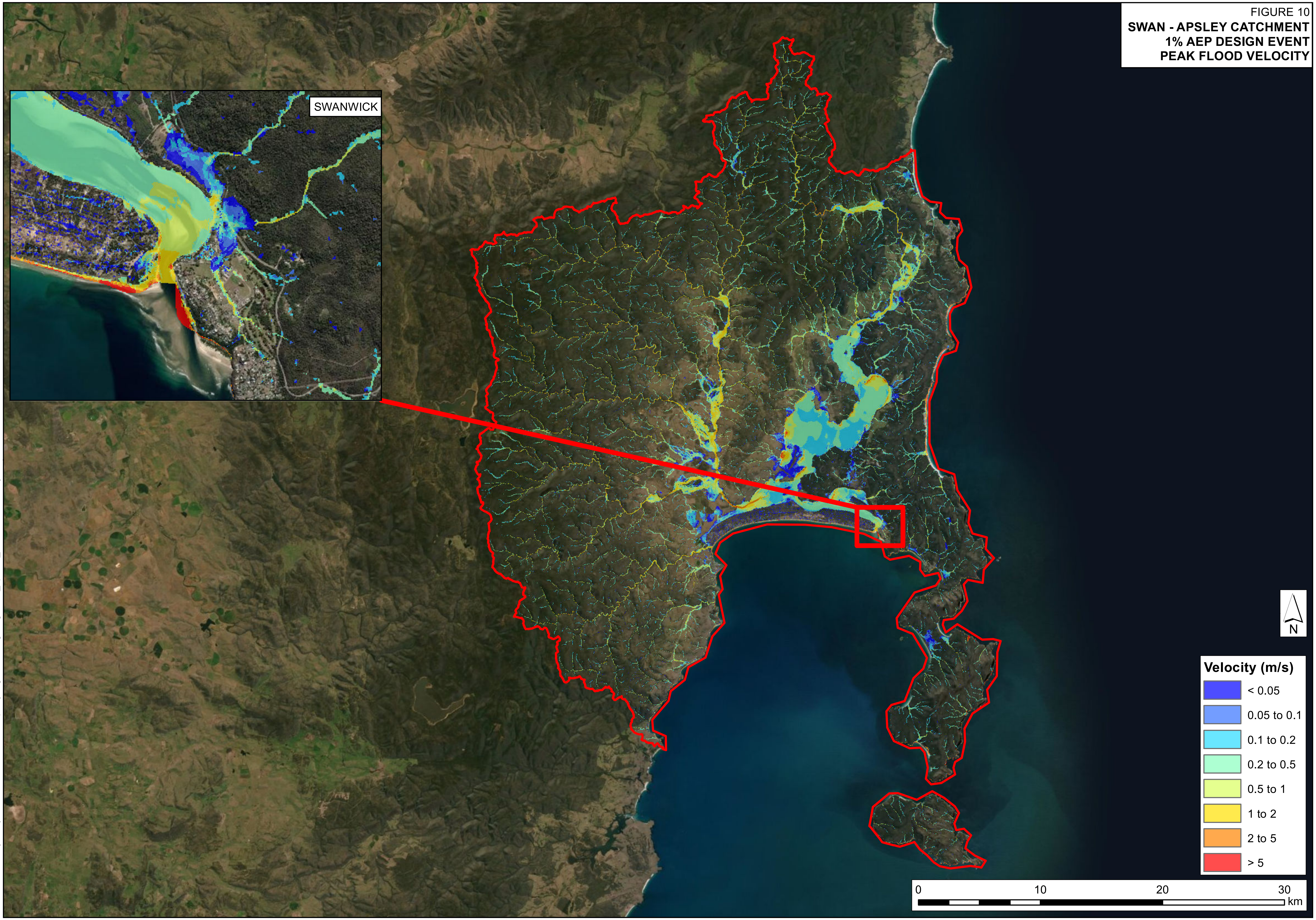
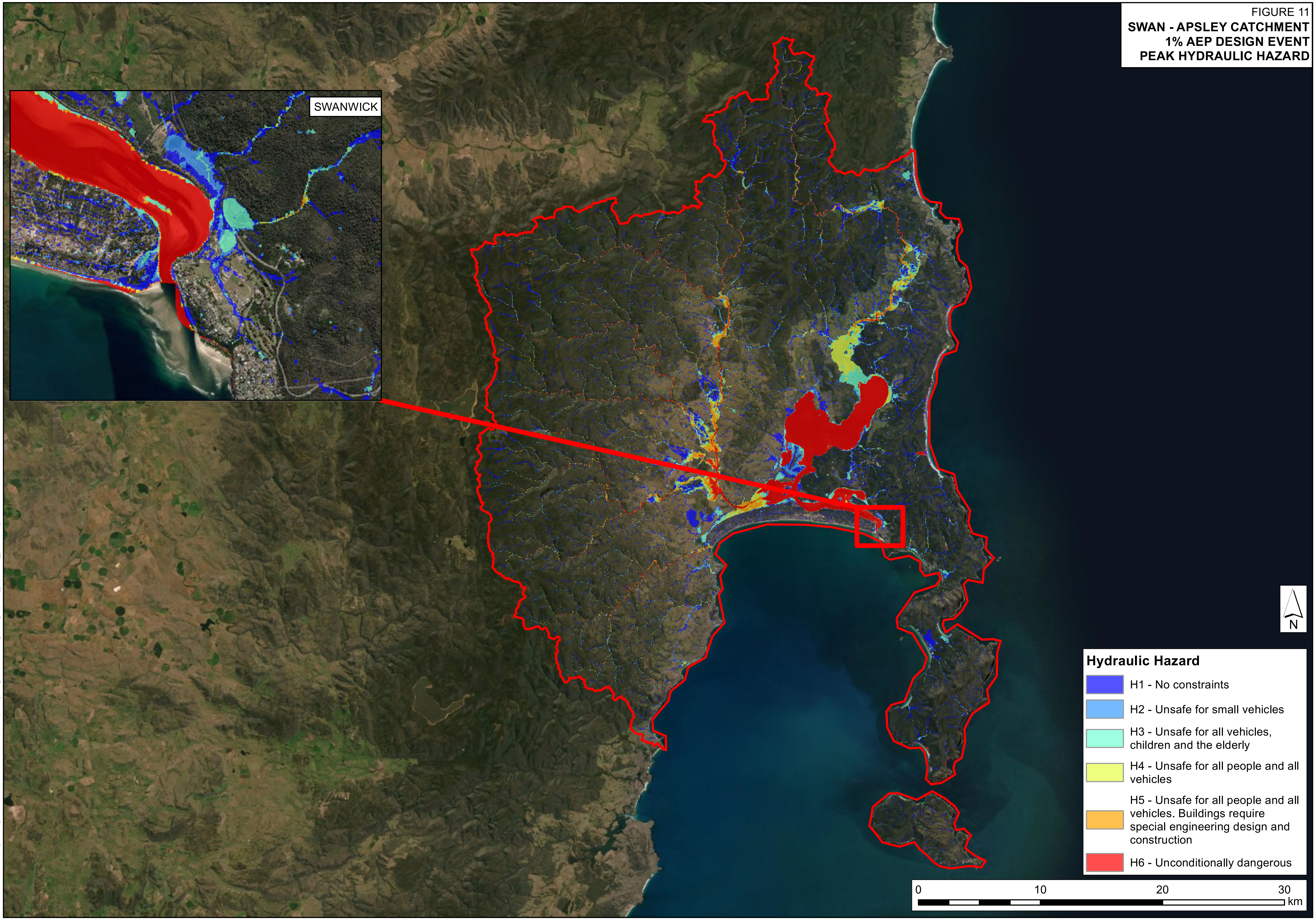


FIGURE 9
SWAN - APSLEY CATCHMENT
1% AEP DESIGN EVENT
PEAK FLOOD DEPTH
SWANWICK
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
N
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure09_1pAEP_PeakFloodDepth.mxd



J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure10_1pAEP_PeakFloodVelocity.mxd



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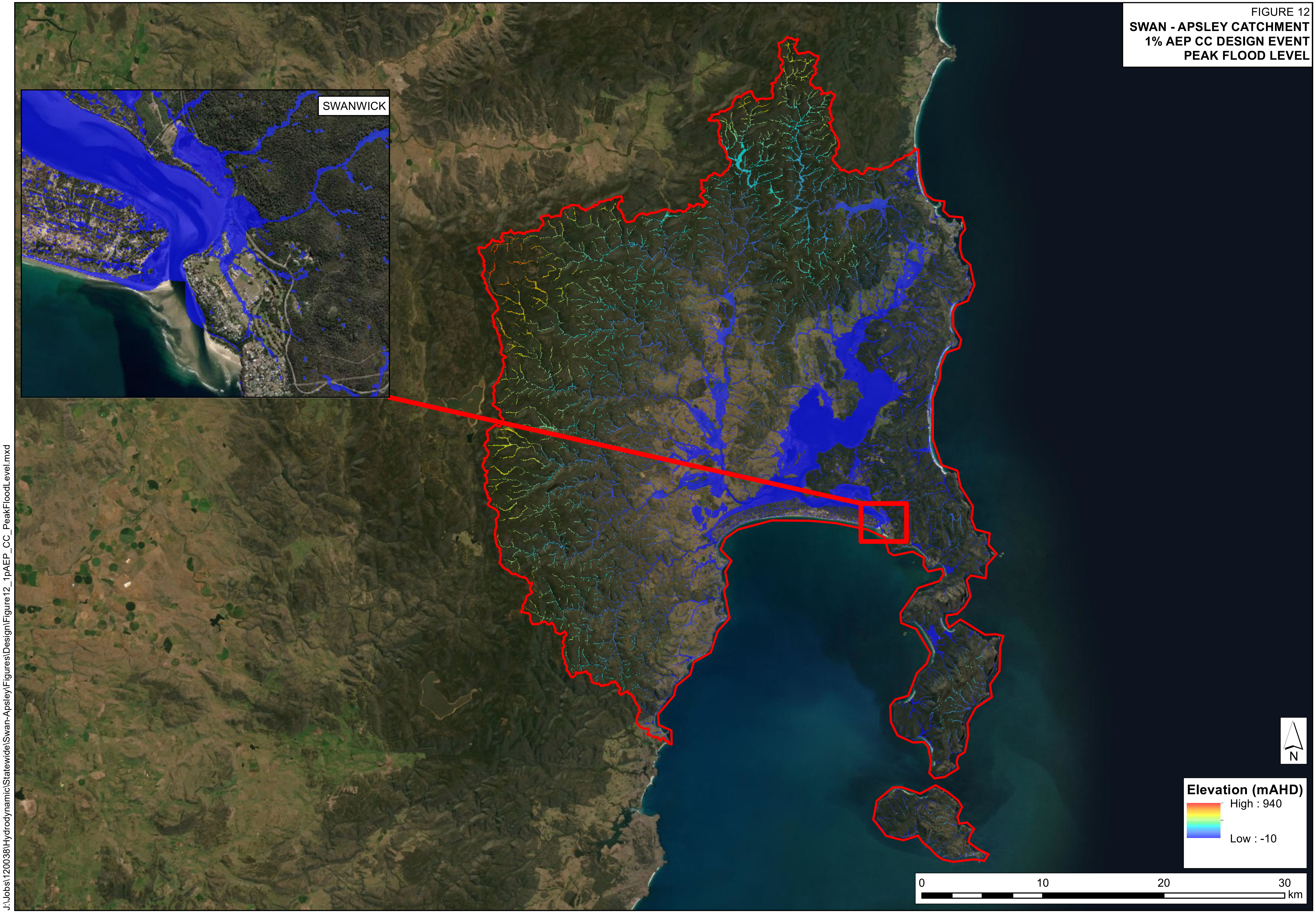


FIGURE 12
SWAN - APSLEY CATCHMENT
1% AEP CC DESIGN EVENT
PEAK FLOOD LEVEL
SWANWICK
N
Elevation (mAHD)
High : 940
Low : -10
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure12_1pAEP_CC_PeakFloodLevel.mxd

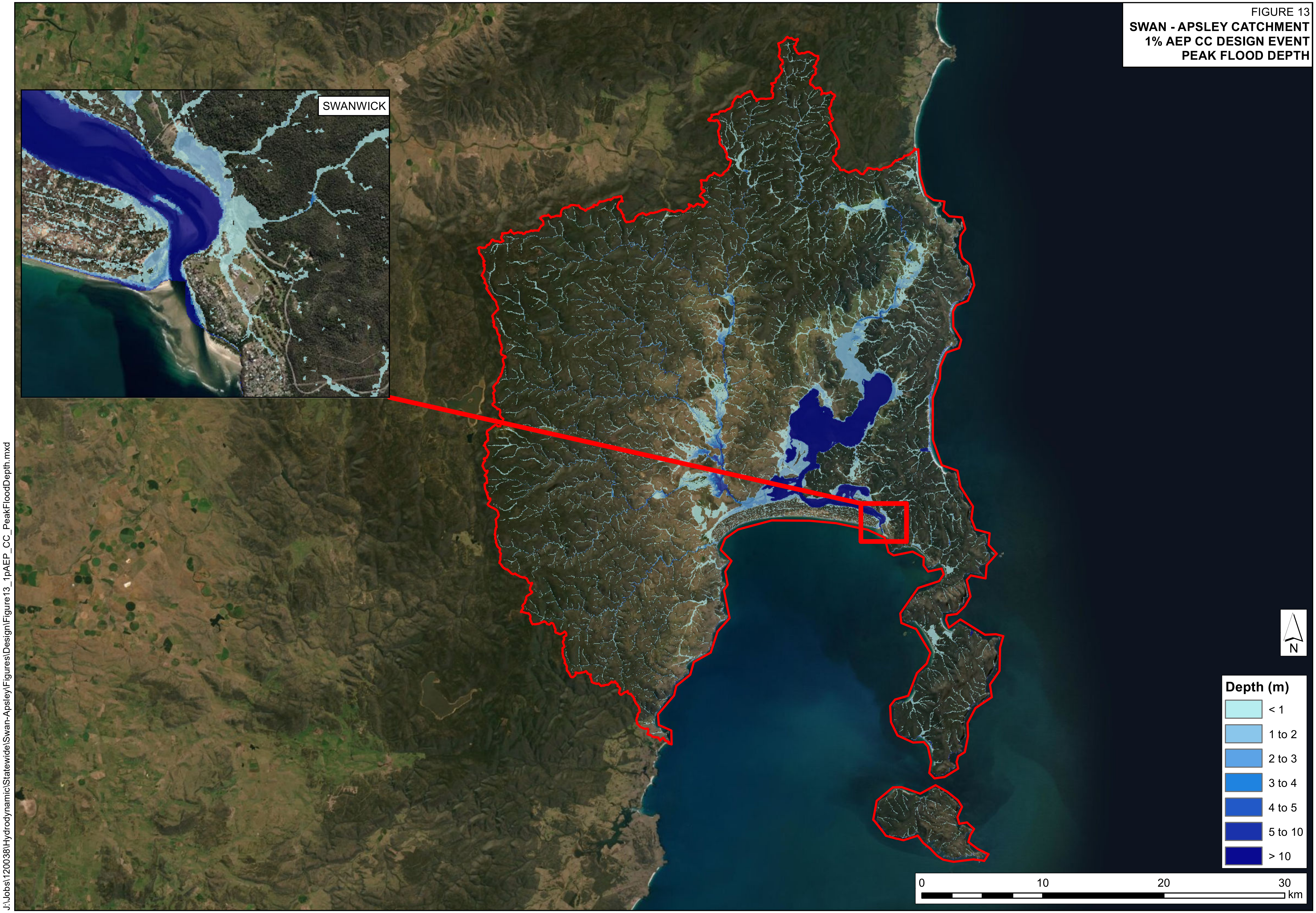


FIGURE 13
SWAN - APSLEY CATCHMENT
1% AEP CC DESIGN EVENT
PEAK FLOOD DEPTH
SWANWICK
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
N
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure13_1pAEP_CC_PeakFloodDepth.mxd

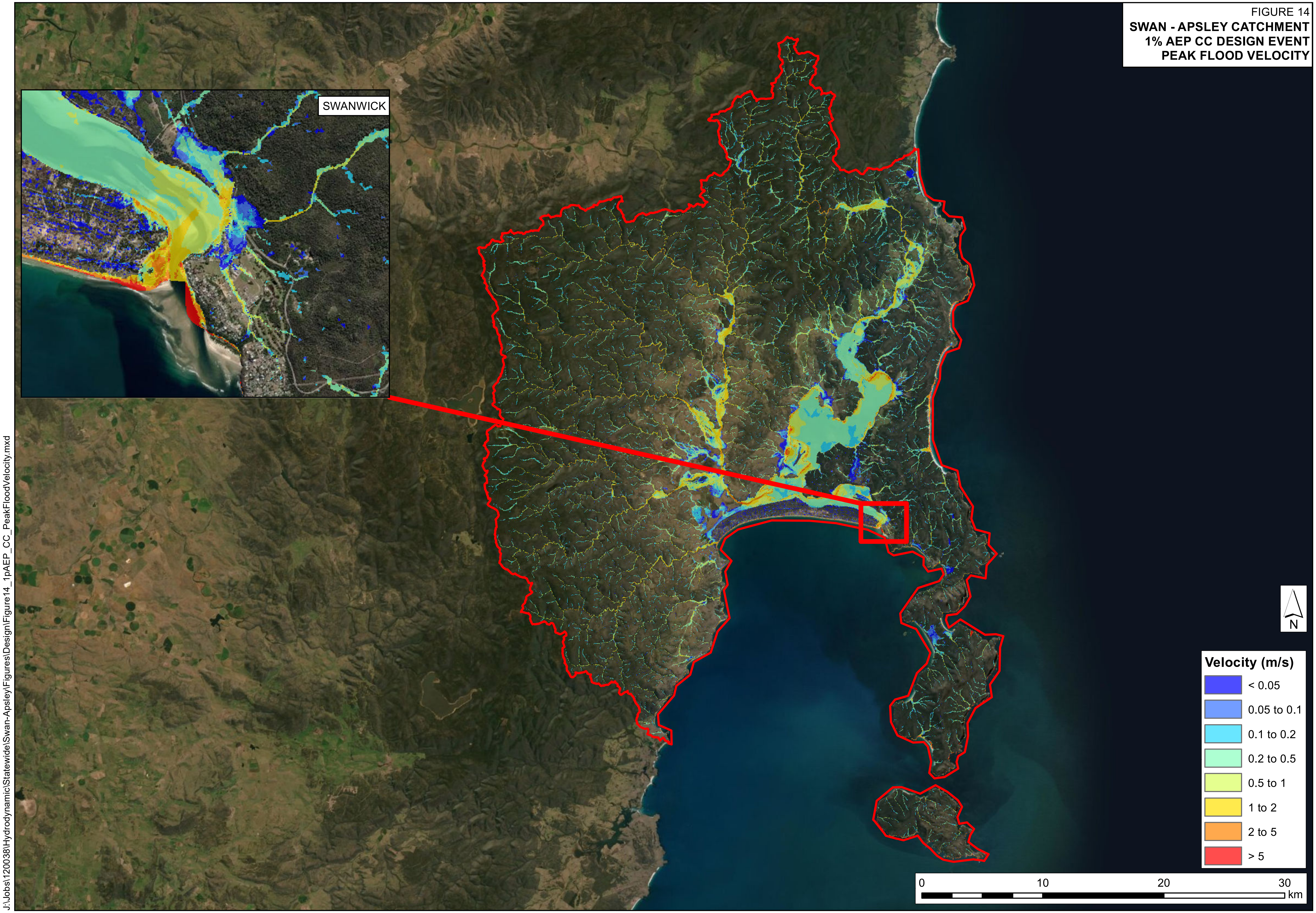


FIGURE 14
SWAN - APSLEY CATCHMENT
1% AEP CC DESIGN EVENT
PEAK FLOOD VELOCITY
SWANWICK
Velocity (m/s)
< 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.5
0.5 to 1
1 to 2
2 to 5
> 5
N
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure14_1pAEP_CC_PeakFloodVelocity.mxd

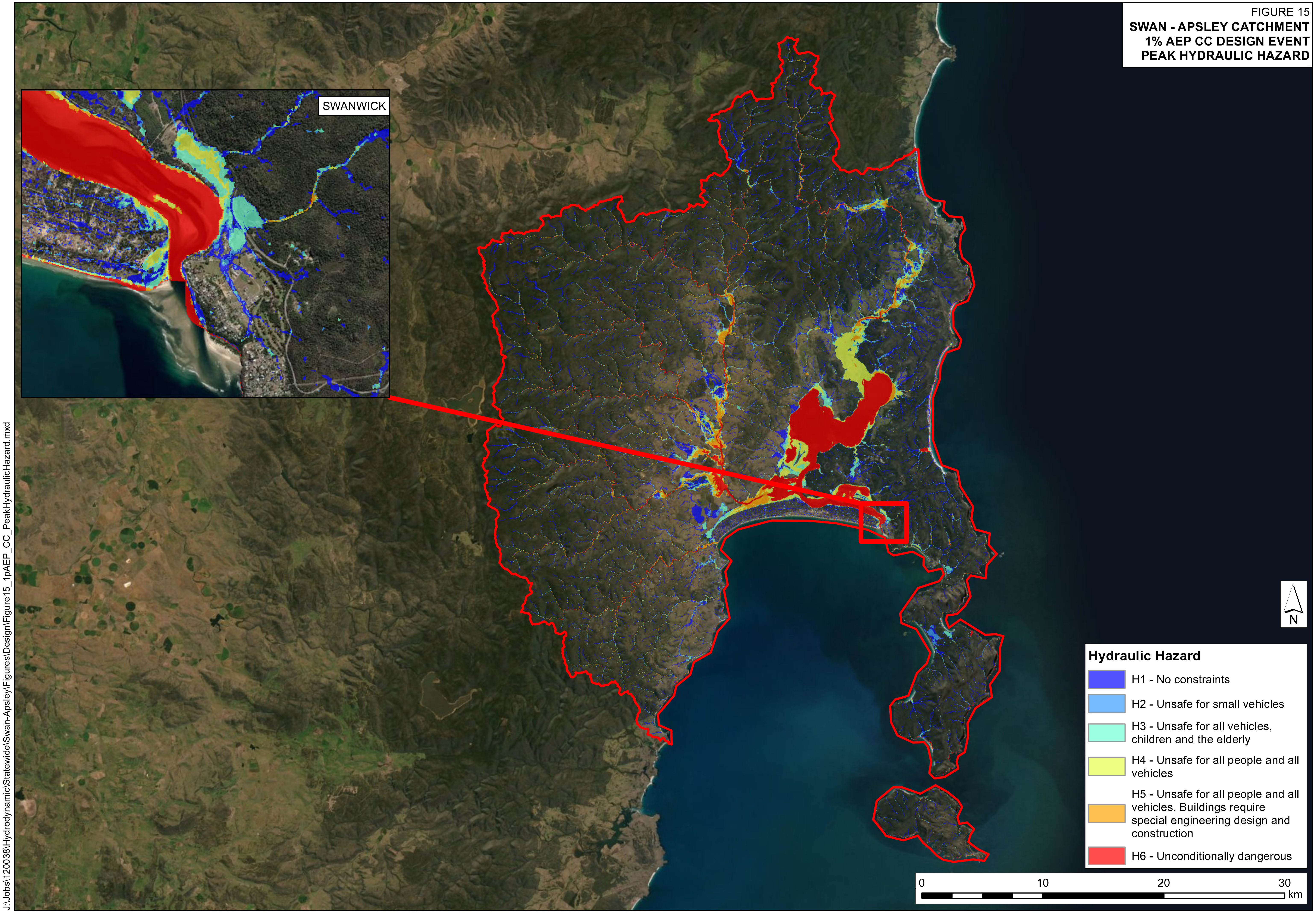


FIGURE 15
SWAN - APSLEY CATCHMENT
1% AEP CC DESIGN EVENT
PEAK HYDRAULIC HAZARD
SWANWICK
N
Hydraulic Hazard
H1 - No constraints
H2 - Unsafe for small vehicles
H3 - Unsafe for all vehicles, children and the elderly
H4 - Unsafe for all people and all vehicles
H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction
H6 - Unconditionally dangerous
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure15_1pAEP_CC_PeakHydraulicHazard.mxd

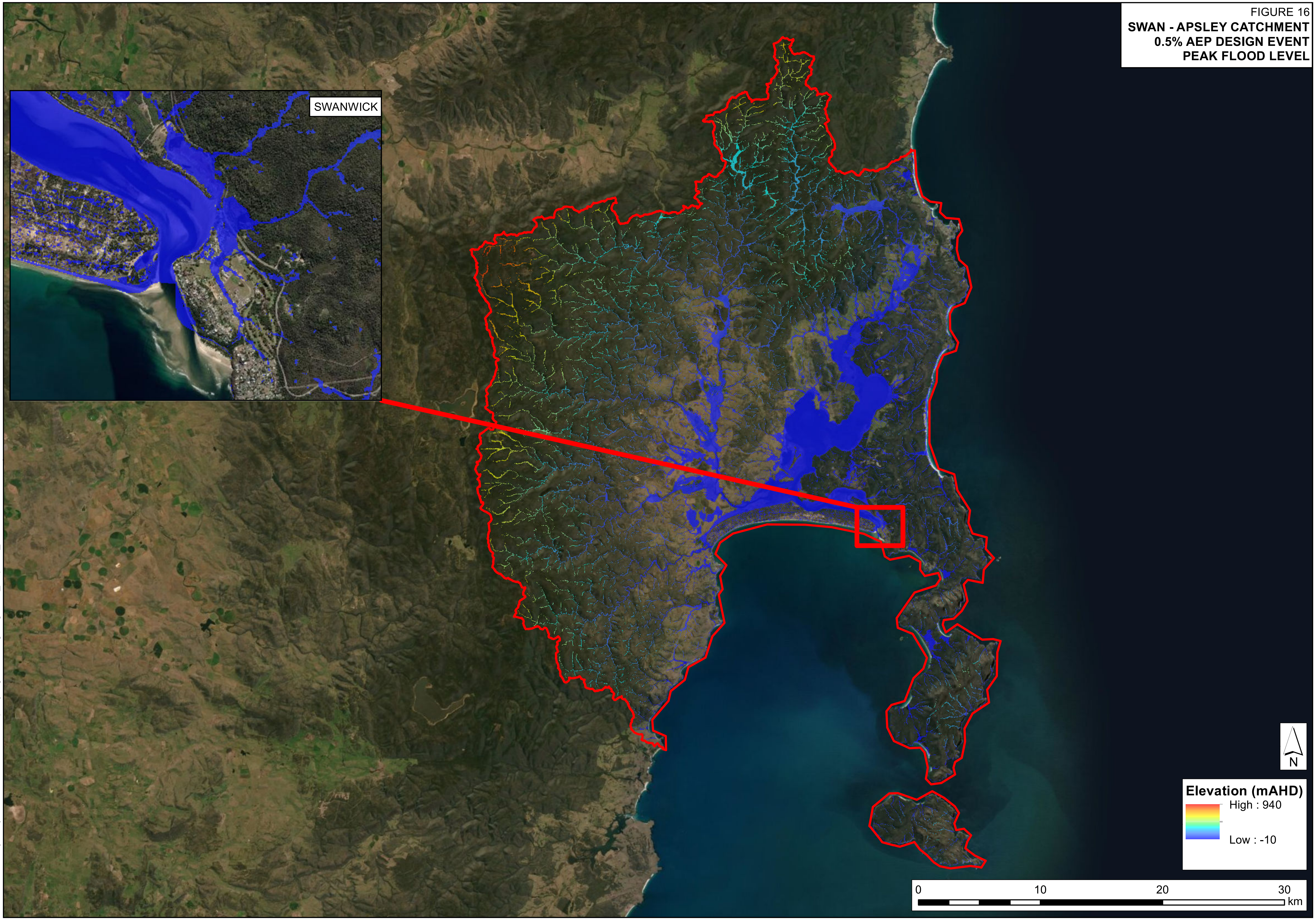
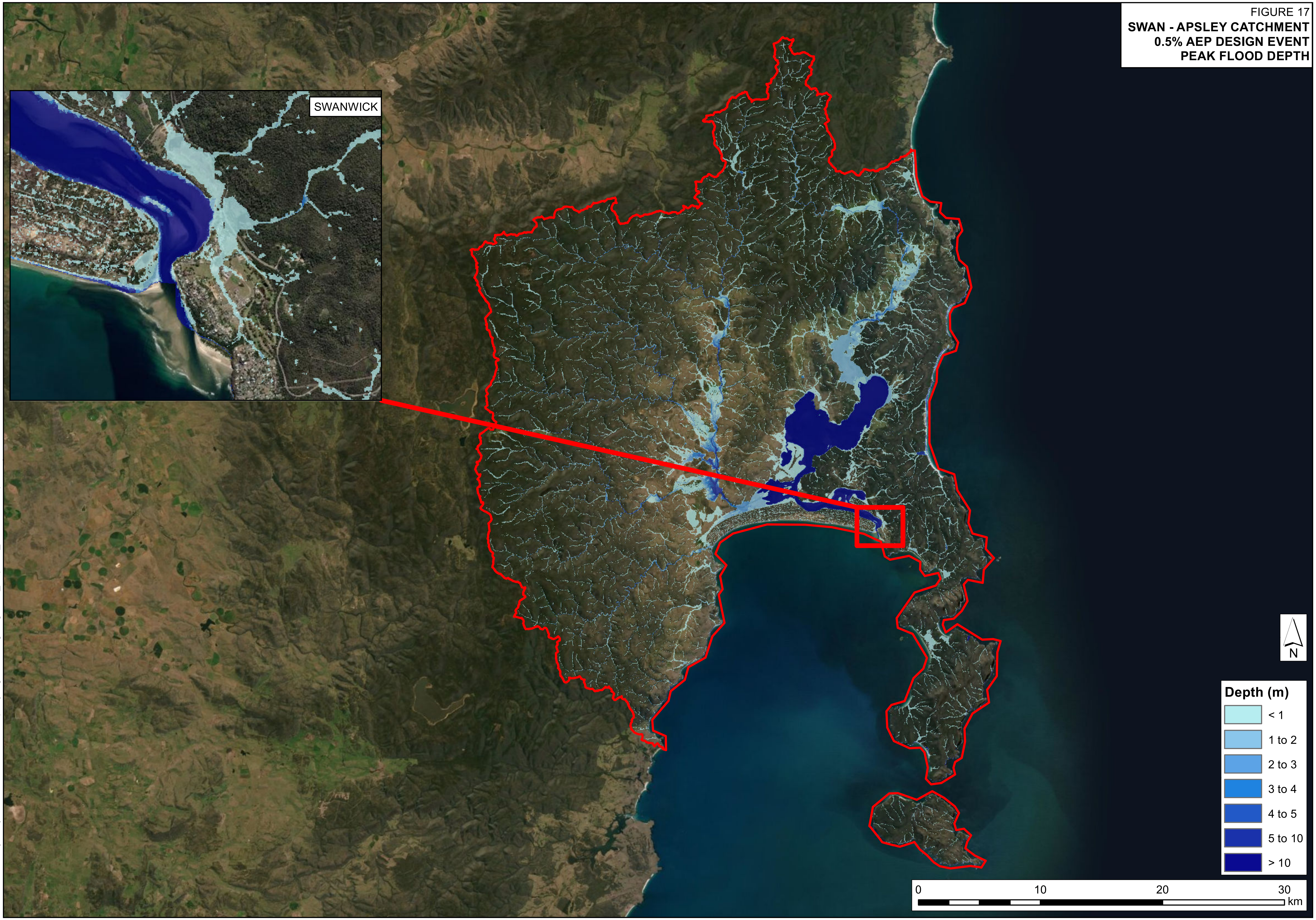


FIGURE 16
SWAN - APSLEY CATCHMENT
0.5% AEP DESIGN EVENT
PEAK FLOOD LEVEL
SWANWICK
Elevation (mAHD)
High : 940
Low : -10
N
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure16_0.5pAEP_PeakFloodLevel.mxd

FIGURE 17
SWAN - APSLEY CATCHMENT
0.5% AEP DESIGN EVENT
PEAK FLOOD DEPTH



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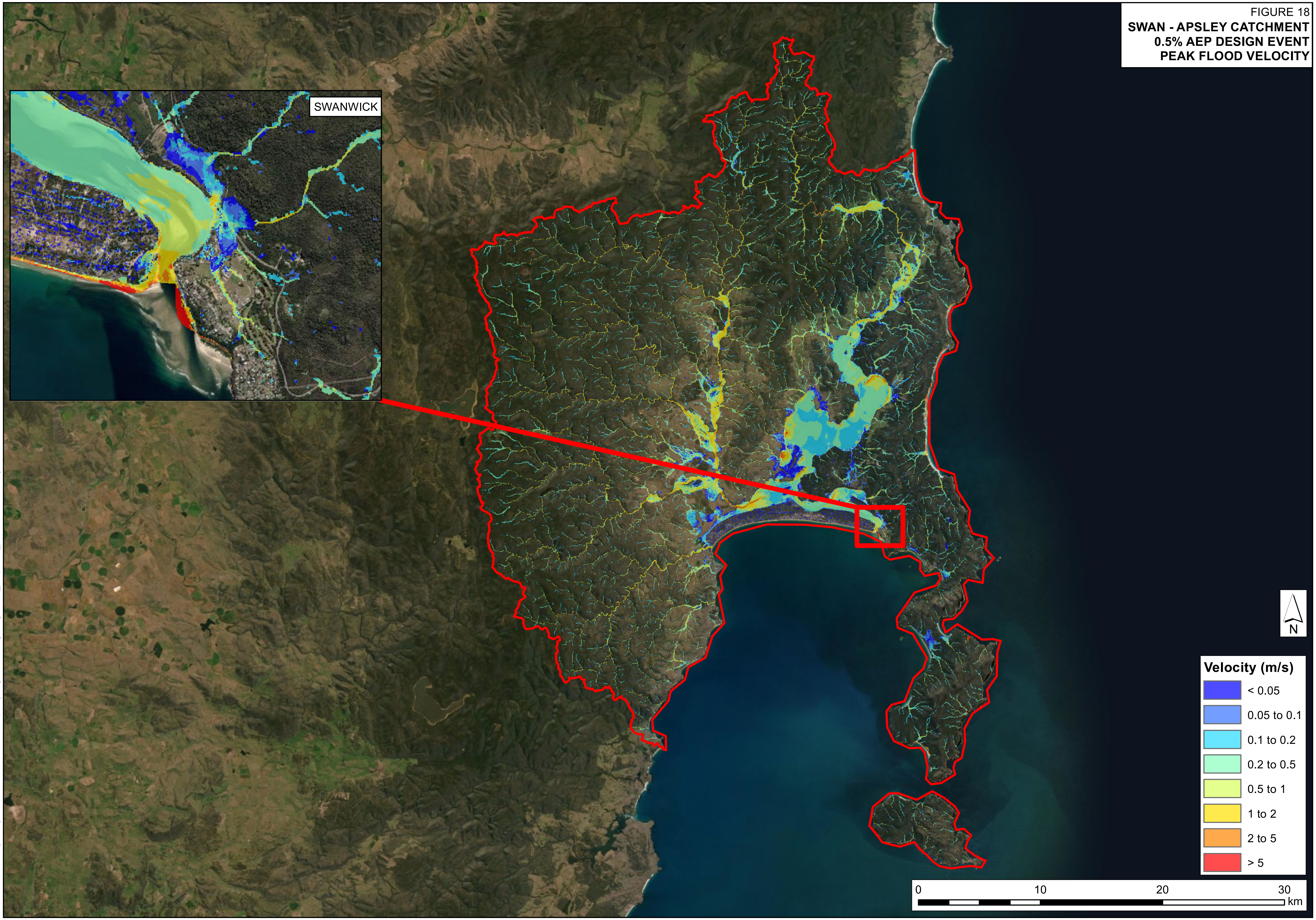


J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure18_0.5pAEP_PeakFloodVelocity.mxd

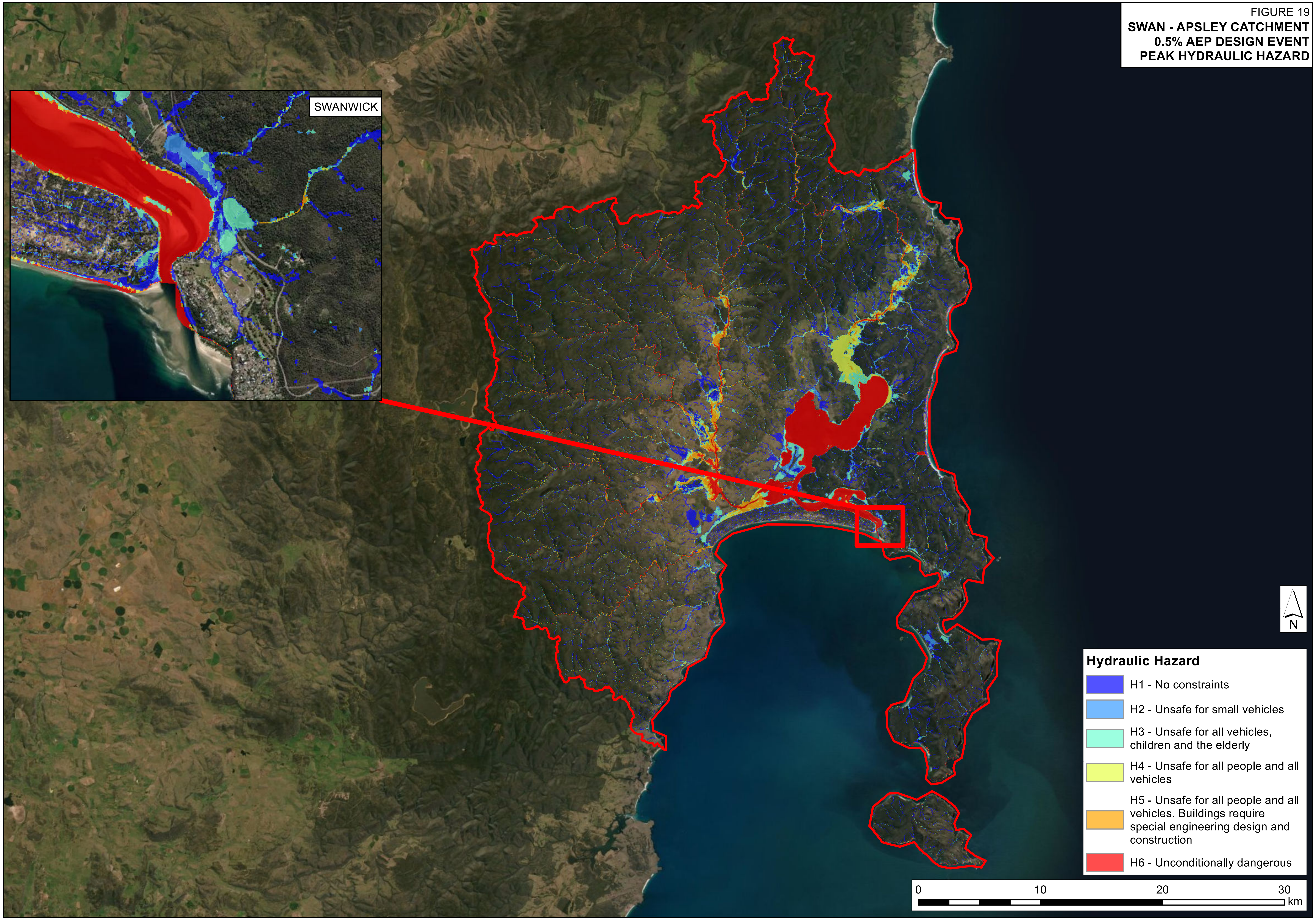
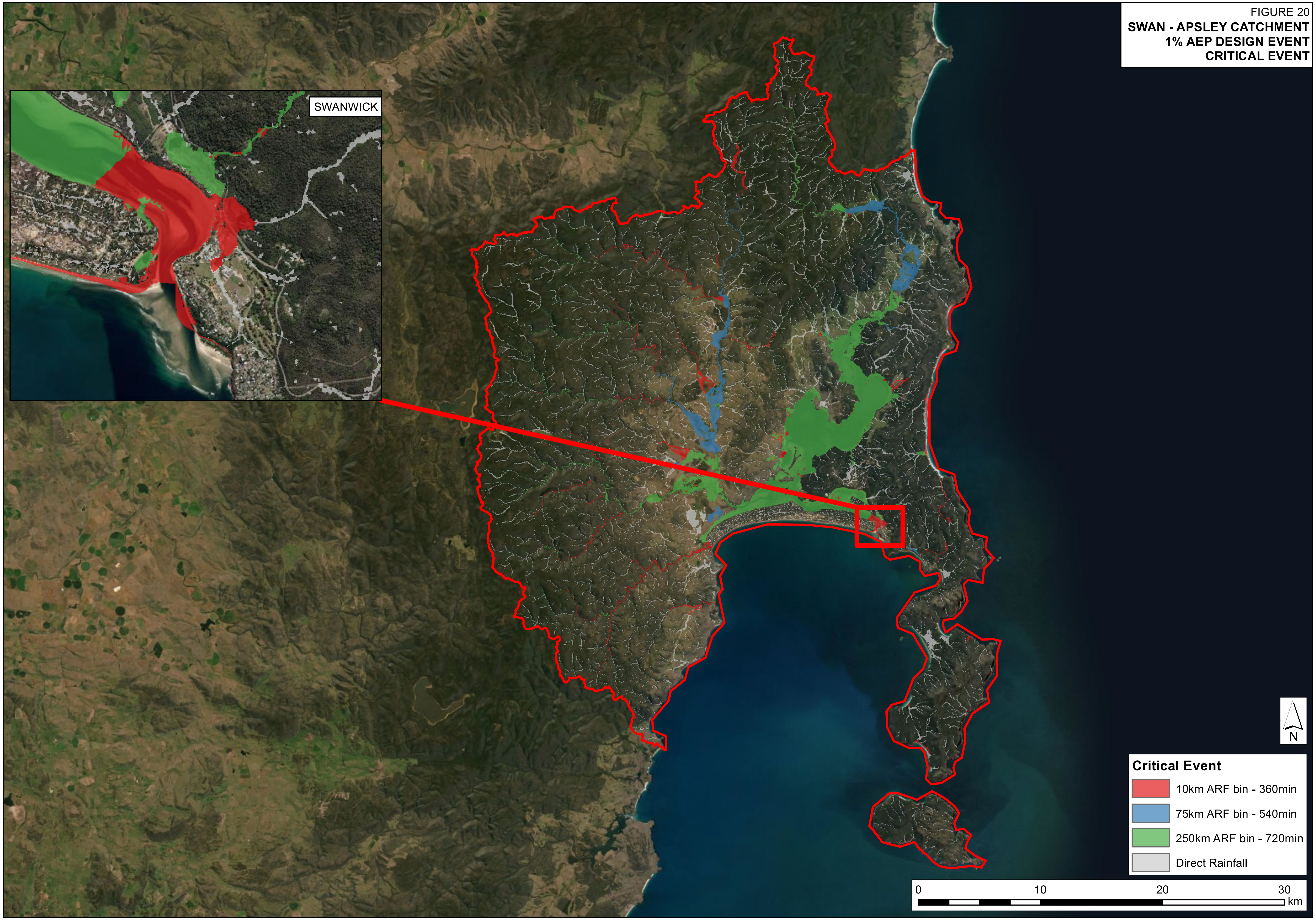


FIGURE 19
SWAN - APSLEY CATCHMENT
0.5% AEP DESIGN EVENT
PEAK HYDRAULIC HAZARD
SWANWICK
Hydraulic Hazard
H1 - No constraints
H2 - Unsafe for small vehicles
H3 - Unsafe for all vehicles, children and the elderly
H4 - Unsafe for all people and all vehicles
H5 - Unsafe for all people and all vehicles. Buildings require special engineering design and construction
H6 - Unconditionally dangerous
N
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure19_0.5pAEP_PeakHydraulicHazard.mxd

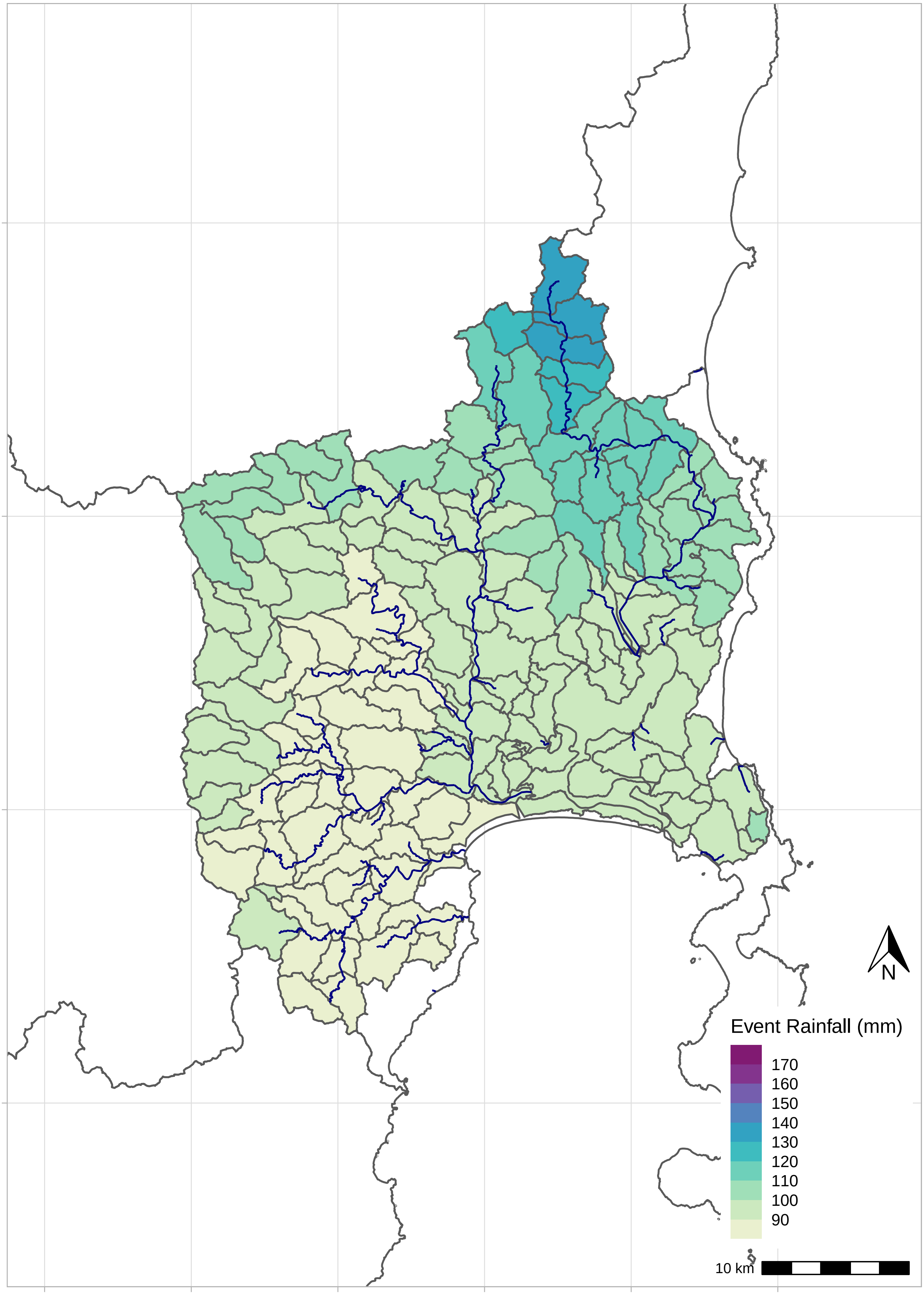


J:\Jobs\120038\Hydrodynamic\Statewide\Swan-Apsley\Figures\Design\Figure20_1pAEP_CriticalEvent.mxd

Appendix A

APPENDIX A. DESIGN EVENT DATA

FIGURE A1
DESIGN RAINFALL DEPTHS
540MIN 2%AEP



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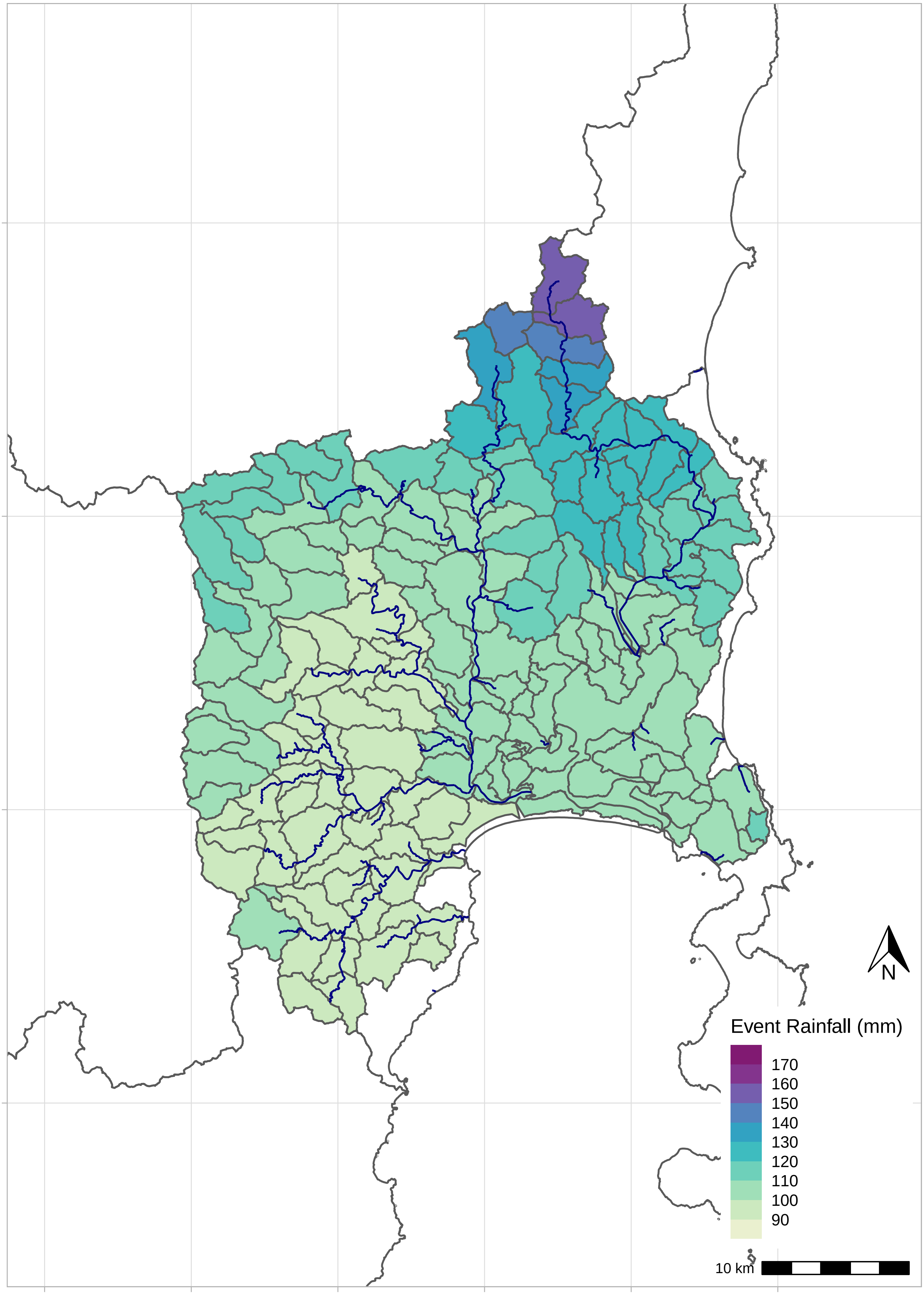
J:/Jobs/120038/Hydrology/Statewide/Design_Events/Swan-Apsley/Swan-Apsleyv1/Report_Figures/FigureA1_5402pAEP_same_scale.pdf

FIGURE A2

DESIGN RAINFALL DEPTHS

540MIN 1%AEP



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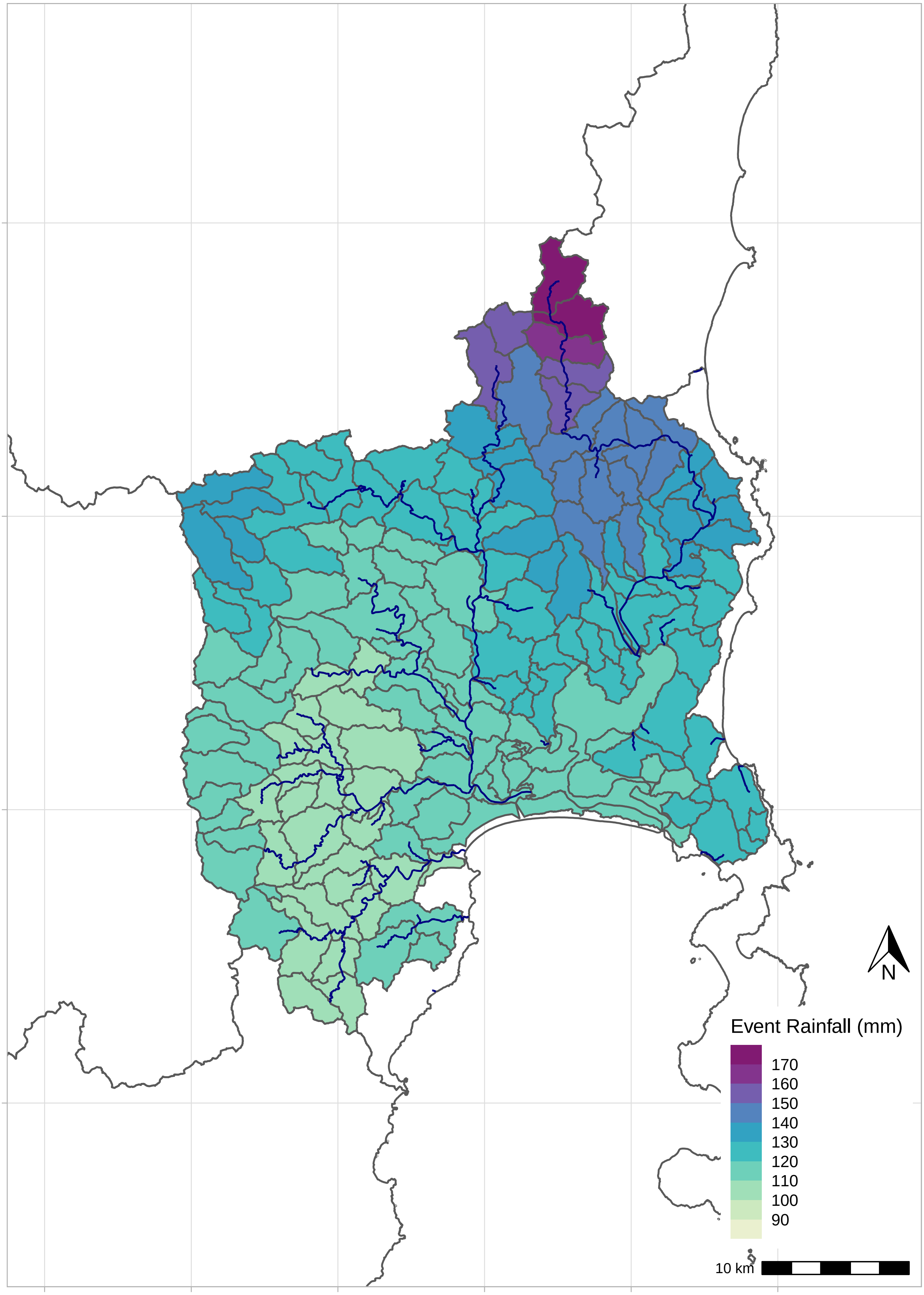
J:/Jobs/120038/Hydrology/Statewide/Design_Events/Swan-Apsley/Swan-Apsleyv1/Report_Figures/FigureA2_5401pAEP_same_scale.pdf

FIGURE A3

DESIGN RAINFALL DEPTHS

540MIN 1IN200AEP



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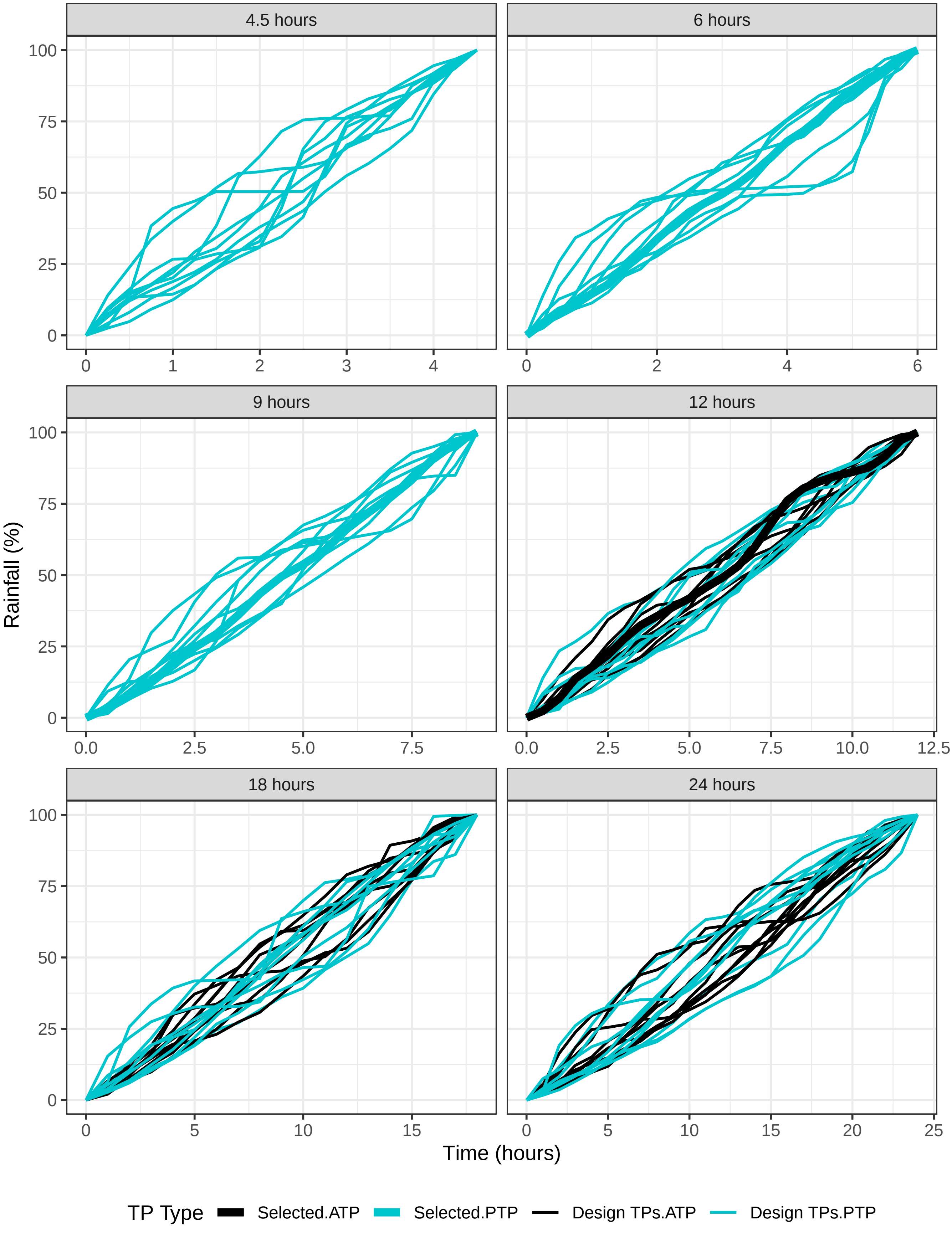
J:/Jobs/120038/Hydrology/Statewide/Design_Events/Swan-Apsley/Swan-Apsleyv1/Report_Figures/FigureA3_5401in200AEP_same_scale.pdf

FIGURE A4

DESIGN TEMPORAL PATTERNS

DURATIONS FROM 4.5 TO 24 HOURS



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Appendix B

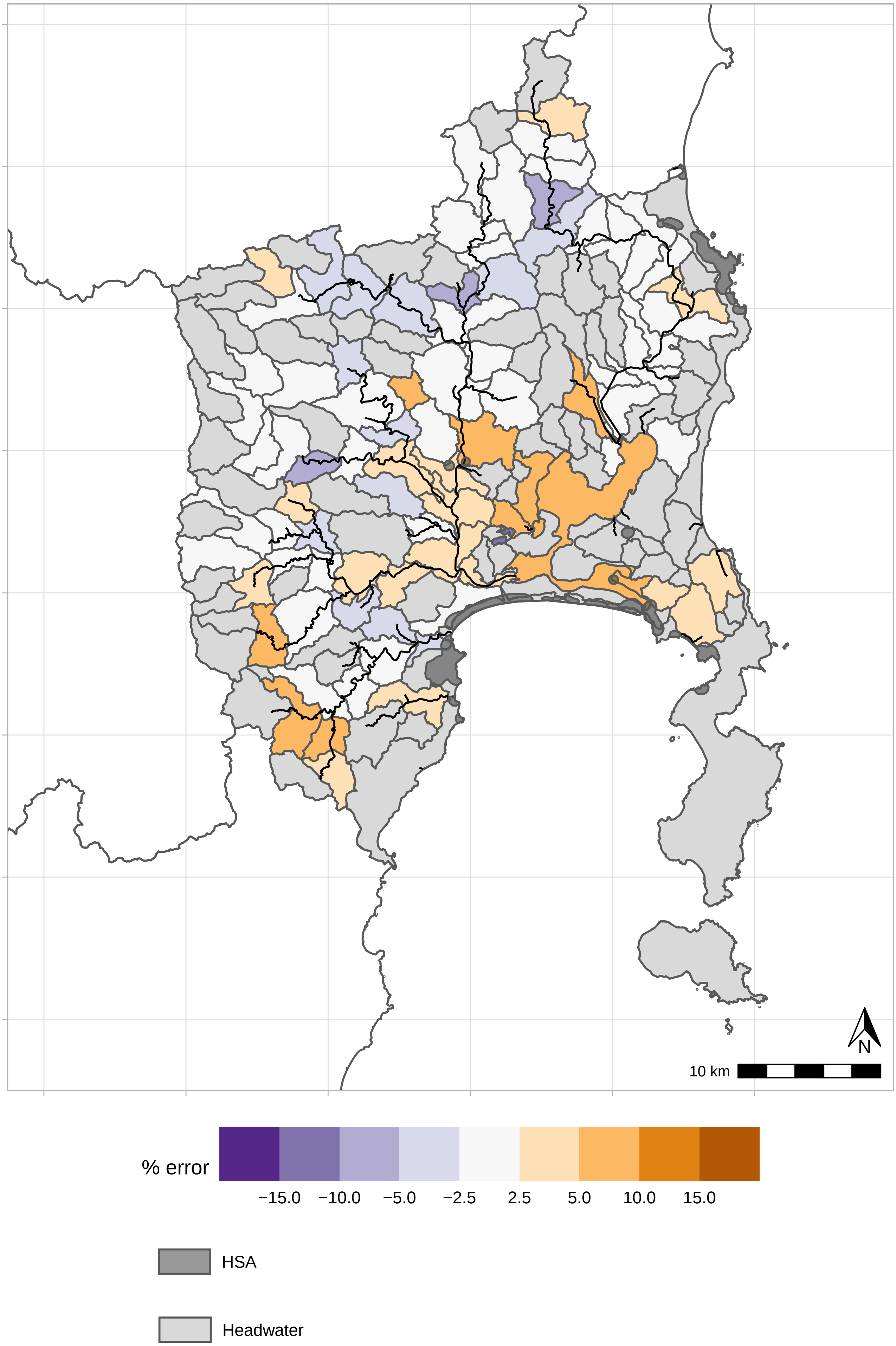
APPENDIX B. DESIGN PEAK ERRORS

Figure B1

Swan−Apsley Catchment

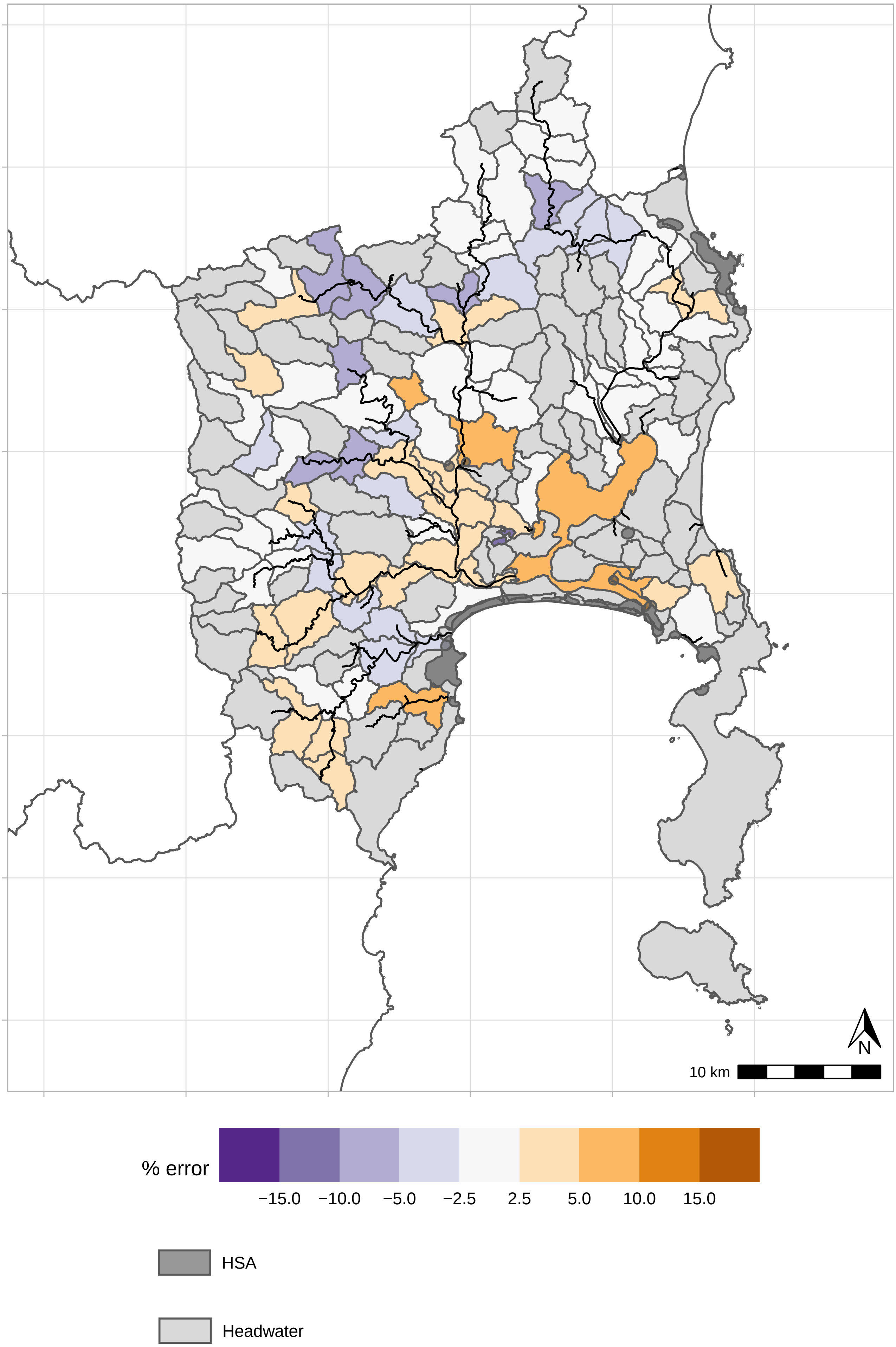
Percentage error in peak flows using selected runs

2% AEP



created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Swan−Apsley/7_Swan−Apsley_Design_Report_Plots.R

Figure B2
Swan−Apsley Catchment
Percentage error in peak flows using selected runs
1% AEP



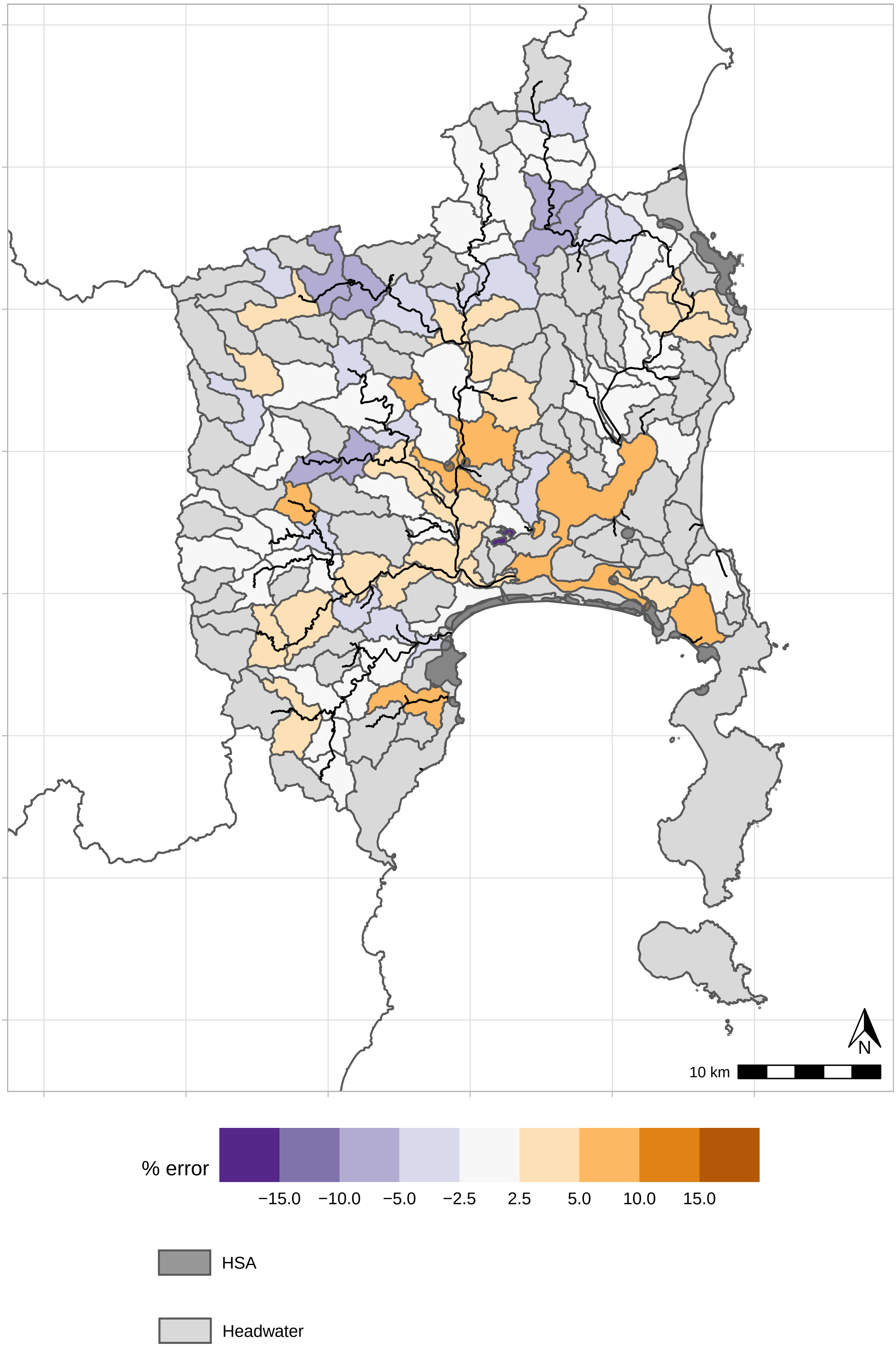
created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Swan−Apsley/7_Swan−Apsley_Design_Report_Plots.R

Figure B3

Swan−Apsley Catchment

Percentage error in peak flows using selected runs

1in200AEP



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