STATE EMERGENCY SERVICE

TASMANIAN STRATEGIC FLOOD MAP SCAMANDER-DOUGLAS STUDY AREA DESIGN FLOOD MODELLING

ADDENDUM TO CALIBRATION REPORT

MARCH 2023

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Project Tasmanian Strategic Flood Map Scamander-Douglas Study Area Design Flood Modelling	**Project Number** **120038**
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Revision History

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

Cover image: https://www.abc.net.au/news/2016-01-29/more-rain-expected-in-tasmanian-flash-flooding-zones/7123014

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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)
ISIS	ISIS 2D modelling software
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 Scamander-Douglas Study Area Calibration Report (WMAwater, 2023a). 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 Scamander-Douglas 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 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, 2023a). George River at St Helens WS and Scamander River U/S Scamander WS both had revised theoretical ratings created (WMAwater, 2021c). These have been applied for all historical events above levels where the ratings diverge from the original DNRE rating. The Douglas River gauge has a number of issues, as identified in the calibration report, with very large inconsistencies between modelled and observed rating curves. However, due to the significantly different losses found between the catchment to this gauge and the remainder of the study area in calibration, along with much very lower losses required for design runs in the Apsley catchment (WMAwater, 2022) which borders the Douglas River, this gauge was also used to inform design losses. More details are provided in Section 4.

Table 1: Flow gauges used for FFA

Gauge number	Gauge name	River	Period of record	Number of points in AMS
2205-1	George River at St. Helens WS	George	10/04/1968 - current	37
2206-1	Scamander River u/s Scamander WS	Scamander	10/04/1968 - current	43
2218-1	Douglas River u/s Tasman Hwy	Douglas	1983-2016	23

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 approximately 5% or less 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 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 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 to Figure 3. The fitting method and distribution that provided the best fit to the data at each site is shown in Table 2.

Table 2: Fitting method and distribution used for FFA

Gauge number	Gauge name	Fitting method	Distribution
2205-1	George River at St. Helens WS	Bayesian	Log Pearson III
2206-1	Scamander River u/s Scamander WS	Bayesian	Log Pearson III
2218-1	Douglas River u/s Tasman Highway	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 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.

The percentage differences between the FFA and the modelled peak flow for the 2% and 1% AEP events are shown in Table 3. As with the calibration, different losses were required to fit across the study area. This gave a good fit to the FFA 1% and 2% AEP peak flows at George River (Figure 1) and to the Scamander River gauge (Figure 2).

The Douglas River has a very high gauged flows, which are likely to be overestimated. The design model cannot produce flows to match this FFA even with no losses (Figure 3). Very significant differences were found between the observed and modelled rating curves at this gauge as discussed in the calibration report (WMAwater, 2023a). The catchment area is almost a quarter the size of that of the Scamander gauge, but the calculated 1% flows are very similar. Therefore, it is unlikely that the observed data is reliable. However, the Douglas River borders the Apsley River (in the Swan-Apsley study area) and is actually much closer to this than to the other gauges within this study area. A CL of 0 mm/hr was adopted in the Apsley River catchment (WMAwater 2023b). Therefore, a CL of 0 mm/hr was also adopted in the Douglas catchment to give conservative flood estimates. This was also applied to the small coastal catchments with the same RAF as Douglas River, for example Wardlaws Creek and Four Mile Creek. Sensitivity tests were conducted with an IL also of 0 mm, and with a median pre-burst rainfall applied with a locally derived pre-burst TP. Application of a pre-burst rainfall made a relatively small difference to results, so the study area-wide IL of 2 mm was used in this area for consistency.

Table 3: FFA and modelled peak flows

Gauge	Parameter	FFA peak flow (m^3/s)	Modelled peak flow (m^3/s)	Peak flow difference (%)
George River at St Helens WS	**2% AEP**	571	546	-4%
	1% AEP	696	668	-4%
	0.5% AEP	834	843	1%
Scamander River u/s Scamander WS	**2% AEP**	582	545	-6%
	1% AEP	655	656	0.2%
	0.5% AEP	721	805	12%
Douglas River u/s Tasman Hwy	**2% AEP**	569	331	-42%
	1% AEP	630	370	-41%
	0.5% AEP	682	426	-38%

The adopted loss values are shown in Table 4, and comparisons to site FFAs are shown in Figure 1 to Figure 3.

Table 4: Adopted losses

Catchment	Initial Loss (mm)	Continuing Loss (mm/h)			
		Soil Type A	Soil Type B	Soil Type C	Soil Type D
George	2	10.0	5.2	2.4	1.2
Scamander	2	8.3	4.3	2.0	1.0
Douglas	2	0.0	0.0	0.0	0.0

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 4 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	25	25
2%	360	45	50
2%	720	450	9
1%	270	25	25
1%	360	45	46
1%	720	450	13
0.5%	270	25	23
0.5%	360	45	48
0.5%	720	450	13

Diagram 1 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 70% 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.

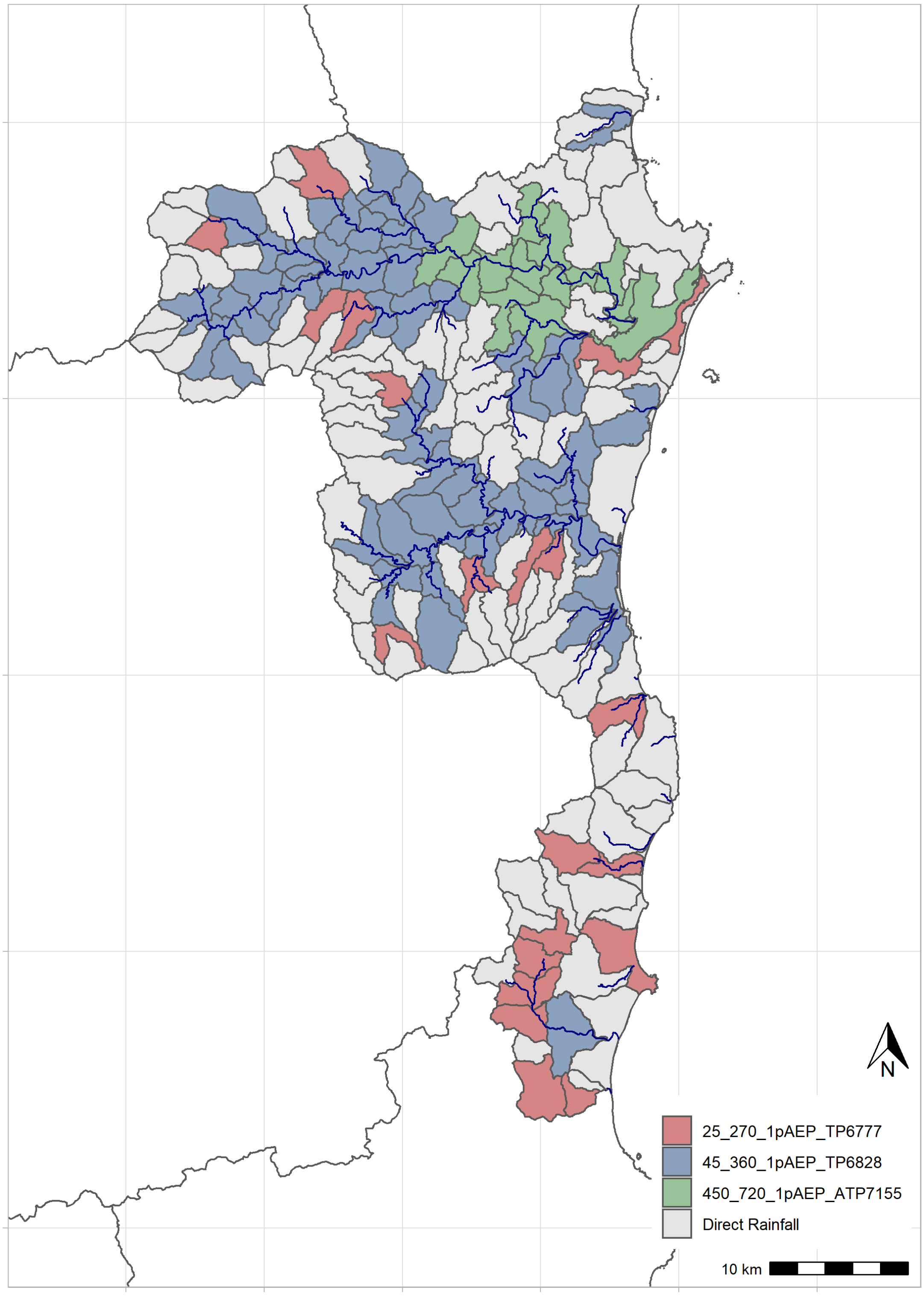

Diagram 1: ARF set relevant for each sub-catchment for the 1% AEP event

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%	4.2%	11.0%	21.2%
1%	4.3%	9.5%	19.9%
0.5%	3.6%	9.0%	15.6%

The selected storms and direct rainfall were then run through the calibrated hydrodynamic model as documented in the calibration report (WMAwater, 2023a). 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 for each design event.

Table 7. Downstream boundary levels for each AEP

AEP	Downstream boundary
2%	HAT (0.78 mAHD)
1%	
0.5%	
1% CC	HAT + sea level rise (1.70 mAHD)

5.2. Design Event Results

The results of the design event modelling are shown in Figure 5 to Figure 20 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 21. Some variability between the critical event in the hydrodynamic model (Figure 21) and external hydrological model (Diagram 1) particularly around the Scamander River estuary, these areas have been reviewed and show only very small differences in flood extent between the two patterns.

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 design event envelope.

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

5.2.1. Review of Results at George River at St Helens WS

A review of the design flows produced from the hydrodynamic model at George River at St Helens WS 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 George River at St Helens WS

Parameter	2% AEP	1% AEP	1% AEP CC	0.5% AEP
Modelled peak flow (m^3/s)	568	693	904	869
FFA peak flow (m^3/s)	571	696	n/a	834
Peak flow difference (%)	-1%	-1%	n/a	+4%

5.2.2. Review of Results at Scamander River u/s Scamander WS

A review of the design flows produced from the hydrodynamic model at Scamander River u/s Scamander WS 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 for the 2% and 1% and a fair match for the 0.5% AEP (Table 9). The fair fit for the 0.5% is likely due to uncertainty in the at site FFA which has a significantly different shape to the shape at George River along with some overestimation specific to this sub-catchment relating to selecting ARF-dur-TP sets across the entire catchment. The modelled flow is still within the confidence intervals at the 0.5% AEP.

Table 9: Design flows at Scamander River u/s Scamander WS

Parameter	2% AEP	1% AEP	1% AEP CC	0.5% AEP
Modelled peak flow (m^3/s)	576	680	875	847
FFA peak flow (m^3/s)	582	655	n/a	721
Peak flow difference (%)	-1%	+4%	n/a	+17%

5.2.3. Review of Results at Douglas River u/s Tasman Highway

A review of the design flows produced from the hydrodynamic model at Douglas River u/s Tasman Highway 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 10).

Table 10: Design flows at Douglas River

Parameter	2% AEP	1% AEP	1% AEP CC	0.5% AEP
Modelled peak flow (m^3/s)	325	364	435	423
FFA peak flow (m^3/s)	569	630	n/a	682
Peak flow difference (%)	-43%	-42%	n/a	-38%

6. LIMITATIONS

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

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.

There is a very high level of uncertainty in the rating curve at the Douglas River gauge which causes uncertainty in design flows in this area. As this gauge is now closed it is unlikely that any improvements will be made to the rating in the future. If additional data was gathered to give more confidence in the Apsley River gauge (high flow gaugings and or local hydraulic models with cross-sectional information) this could be used to give more understanding of the magnitude of errors at the Douglas River, and if they entirely relate to the rating curve, or are partially due to design inputs or modelling.

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Figures

FIGURE 1

George River at St Helens WS

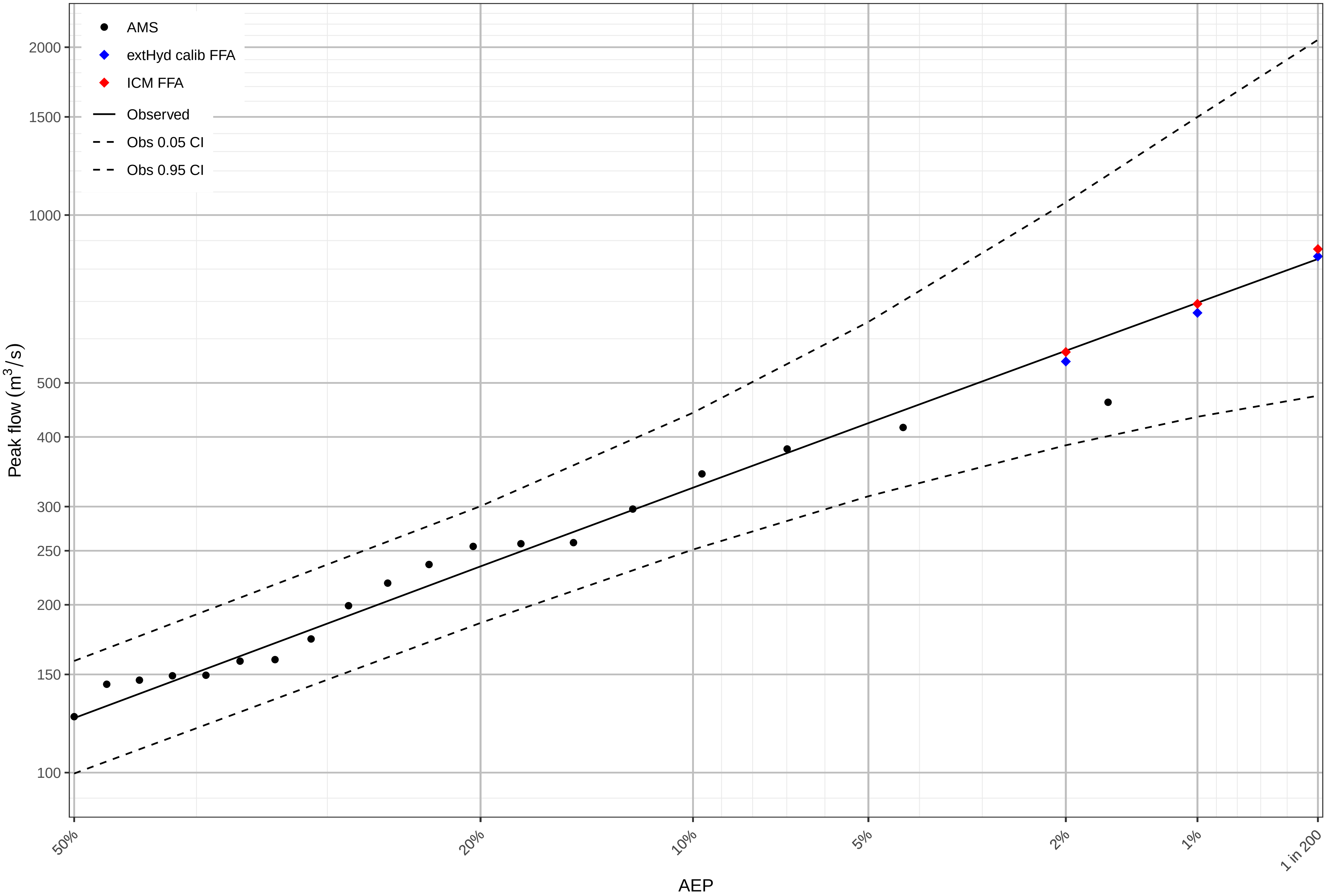

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FIGURE 2

Scamander River U/S Scamander

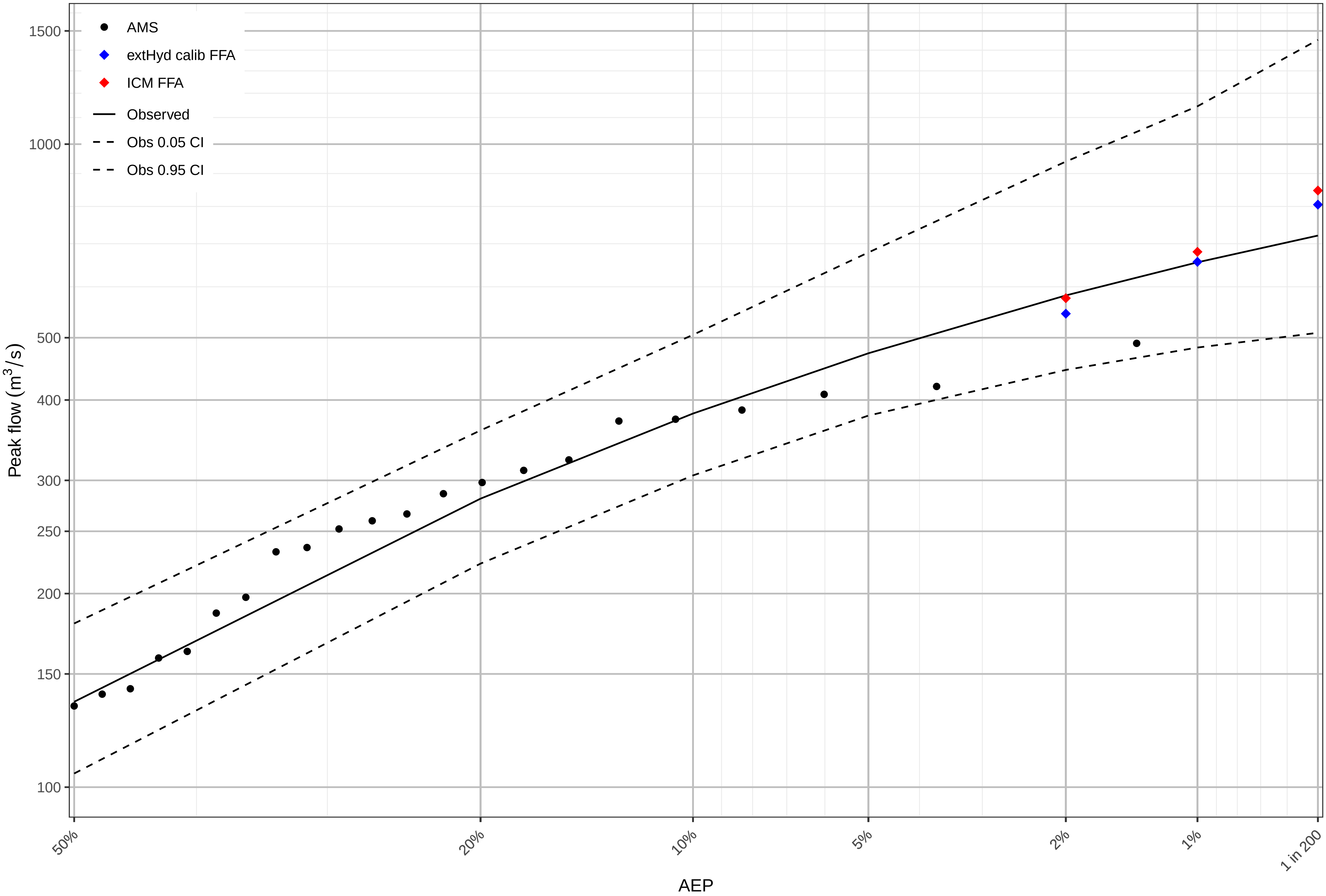

FIGURE 3

Douglas River U/S Tasman Hwy

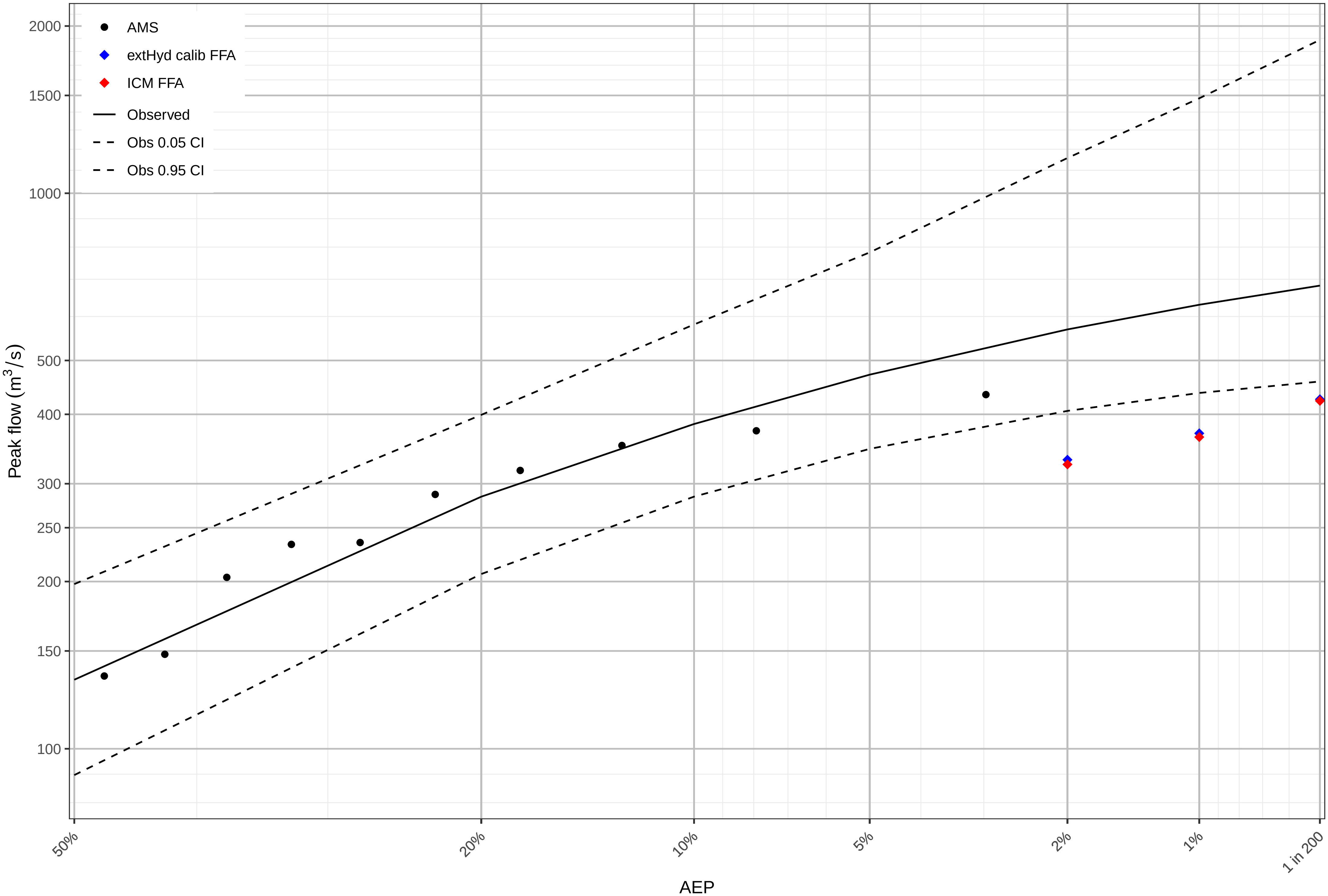

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FIGURE 4

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

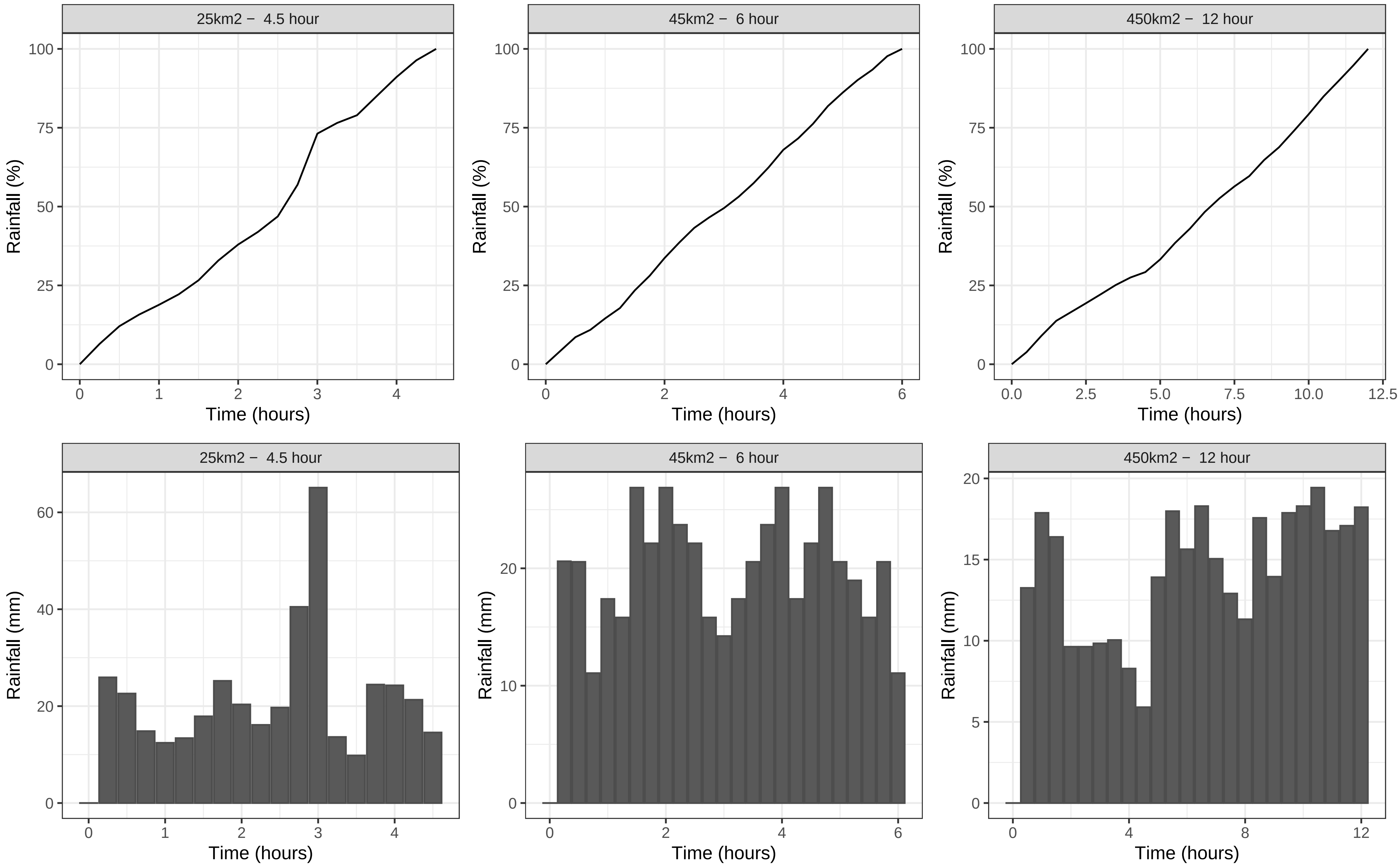
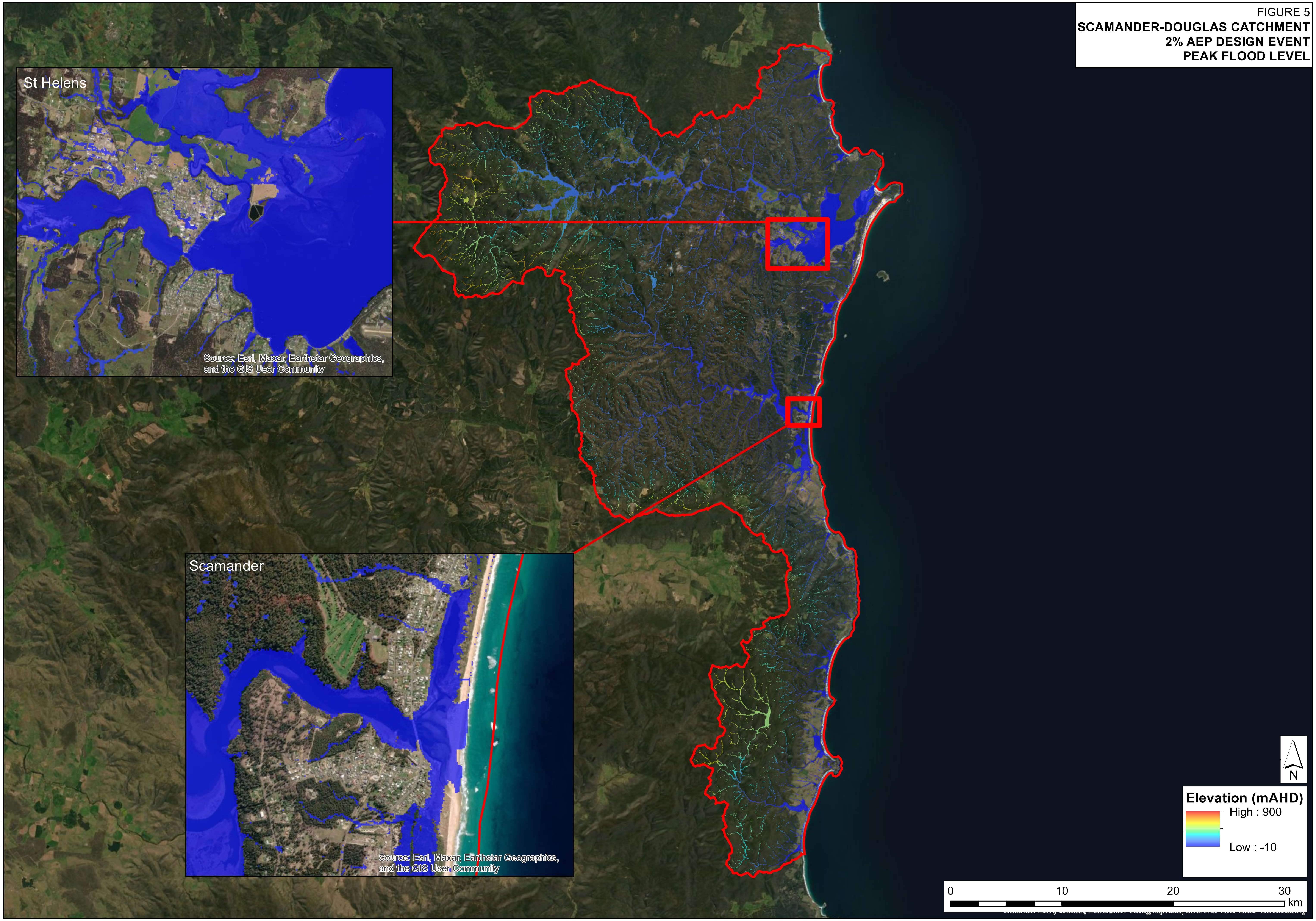


FIGURE 5
SCAMANDER-DOUGLAS CATCHMENT
2% AEP DESIGN EVENT
PEAK FLOOD LEVEL



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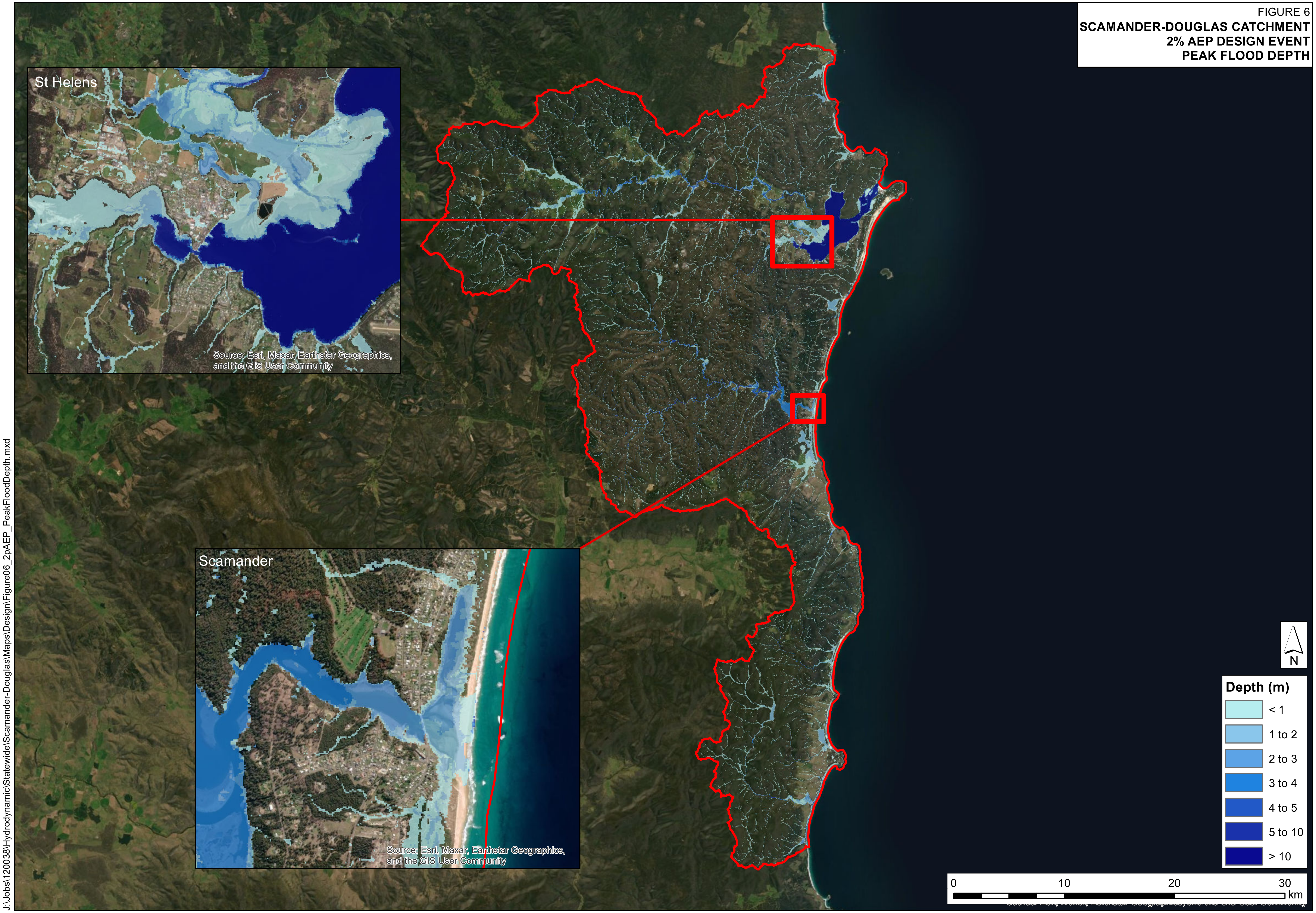

FIGURE 6
SCAMANDER-DOUGLAS CATCHMENT
2% AEP DESIGN EVENT
PEAK FLOOD DEPTH
St Helens
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
0
10
20
30
km
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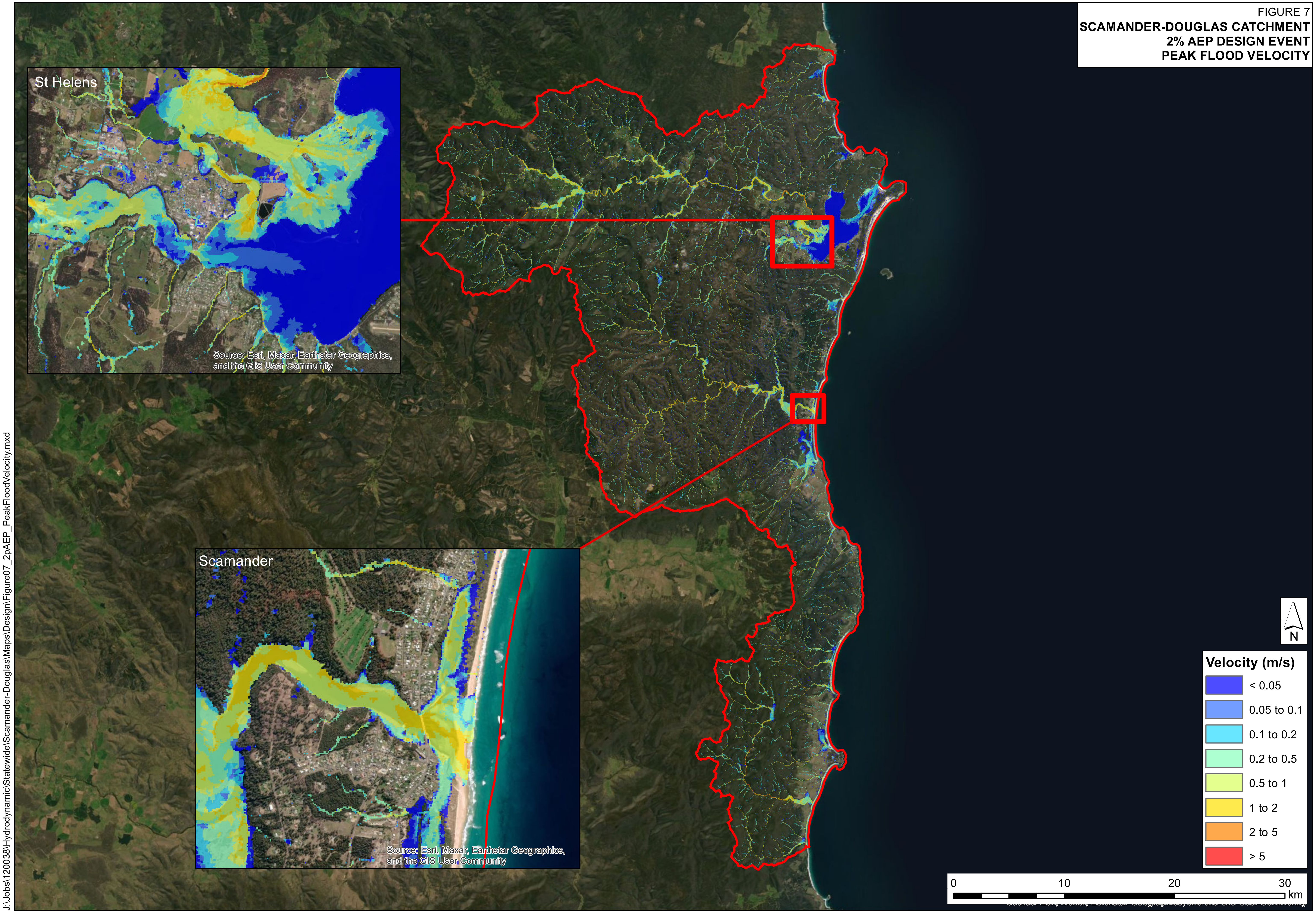
FIGURE 7
SCAMANDER-DOUGLAS CATCHMENT
2% AEP DESIGN EVENT
PEAK FLOOD VELOCITY
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Velocity (m/s)
< 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.5
0.5 to 1
1 to 2
2 to 5
> 5
0
10
20
30
km
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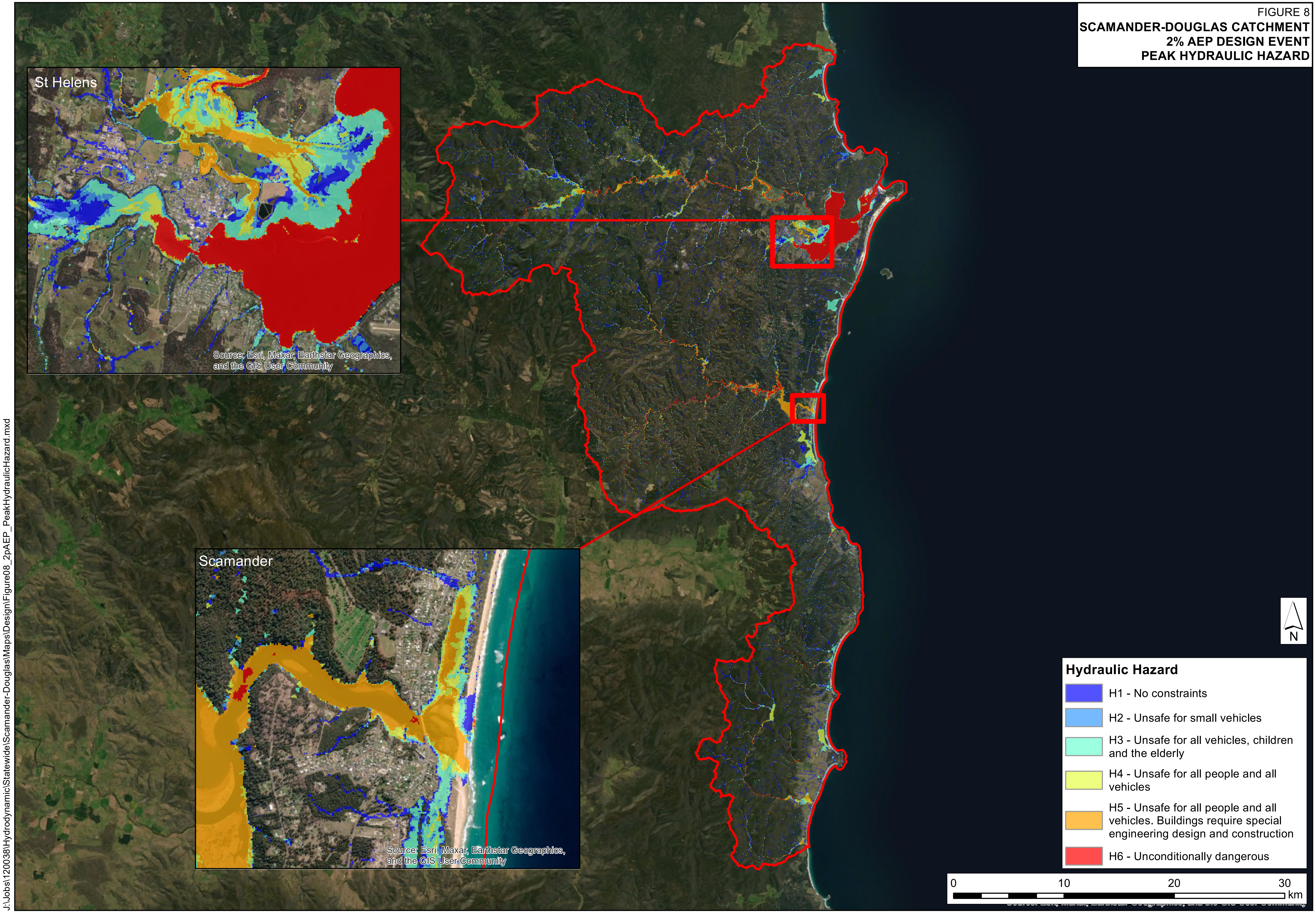


FIGURE 8
SCAMANDER-DOUGLAS CATCHMENT
2% AEP DESIGN EVENT
PEAK HYDRAULIC HAZARD
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Hydraulic Hazard
H1 - No constraints
H2 - Unsafe for small 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\Scamander-Douglas\Maps\Design\Figure08_2pAEP_PeakHydraulicHazard.mxd

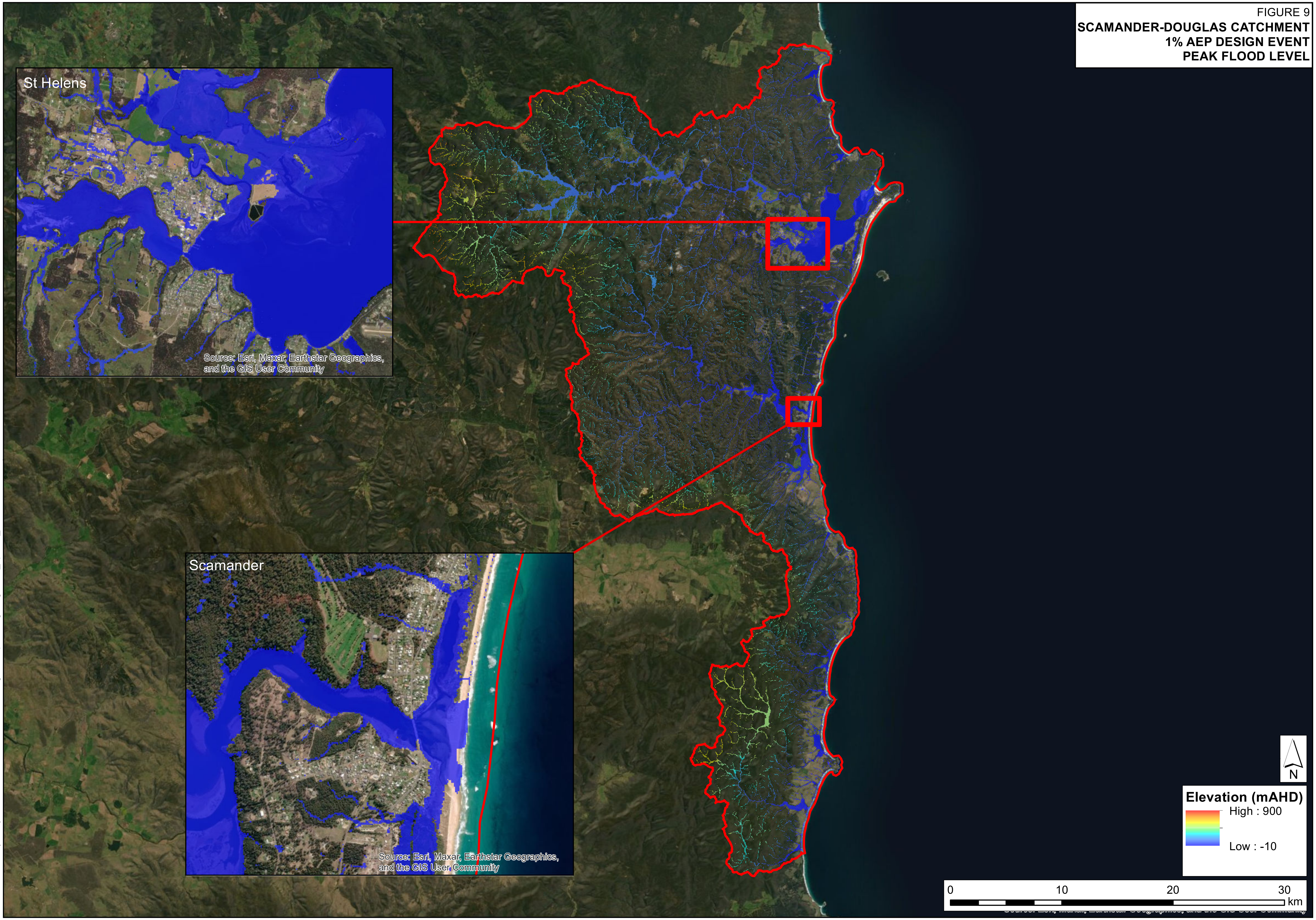


FIGURE 9
SCAMANDER-DOUGLAS CATCHMENT
1% AEP DESIGN EVENT
PEAK FLOOD LEVEL
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Elevation (mAHD)
High : 900
Low : -10
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure09_1pAEP_PeakFloodLevel.mxd

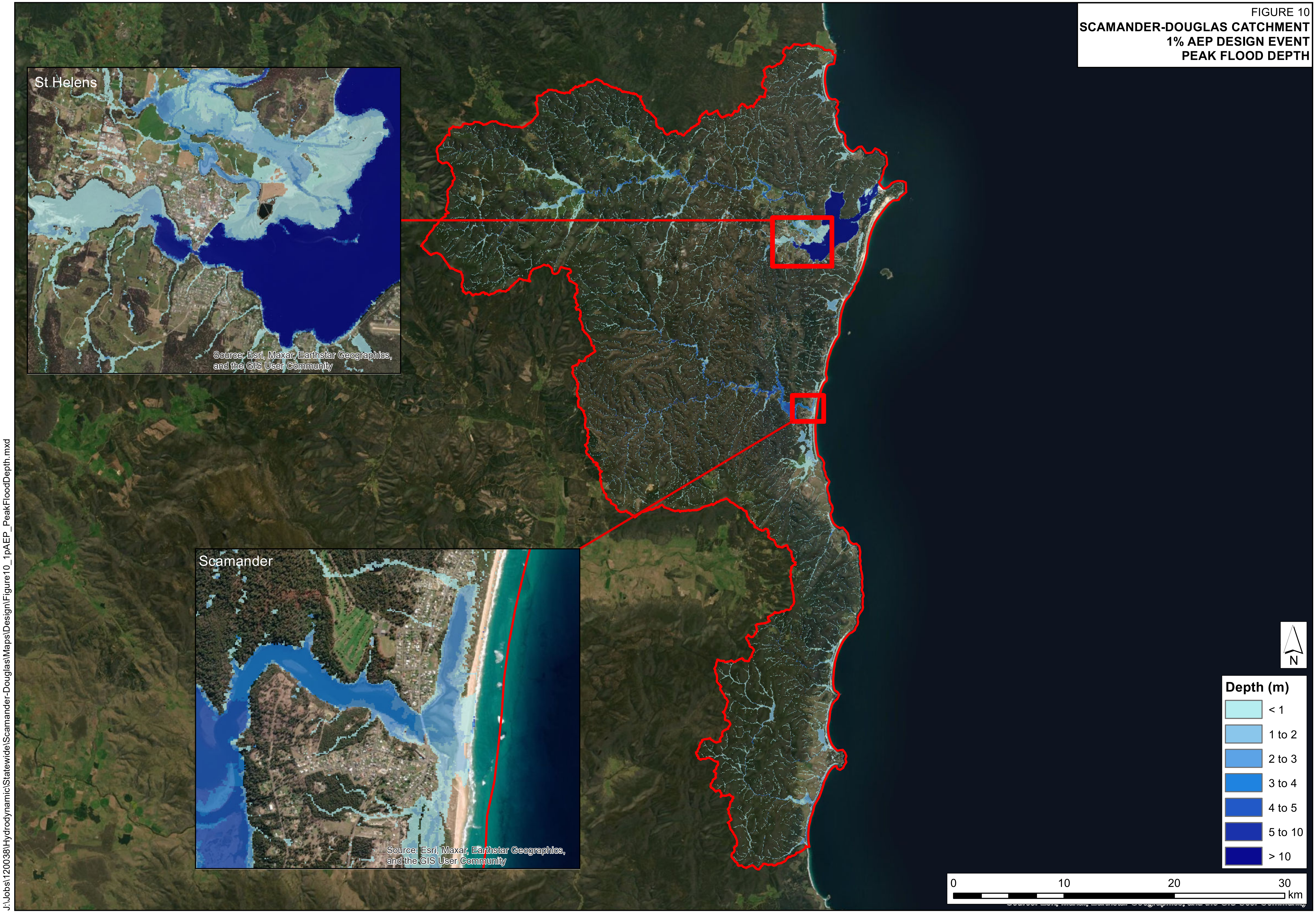


FIGURE 10
SCAMANDER-DOUGLAS CATCHMENT
1% AEP DESIGN EVENT
PEAK FLOOD DEPTH
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure10_1pAEP_PeakFloodDepth.mxd

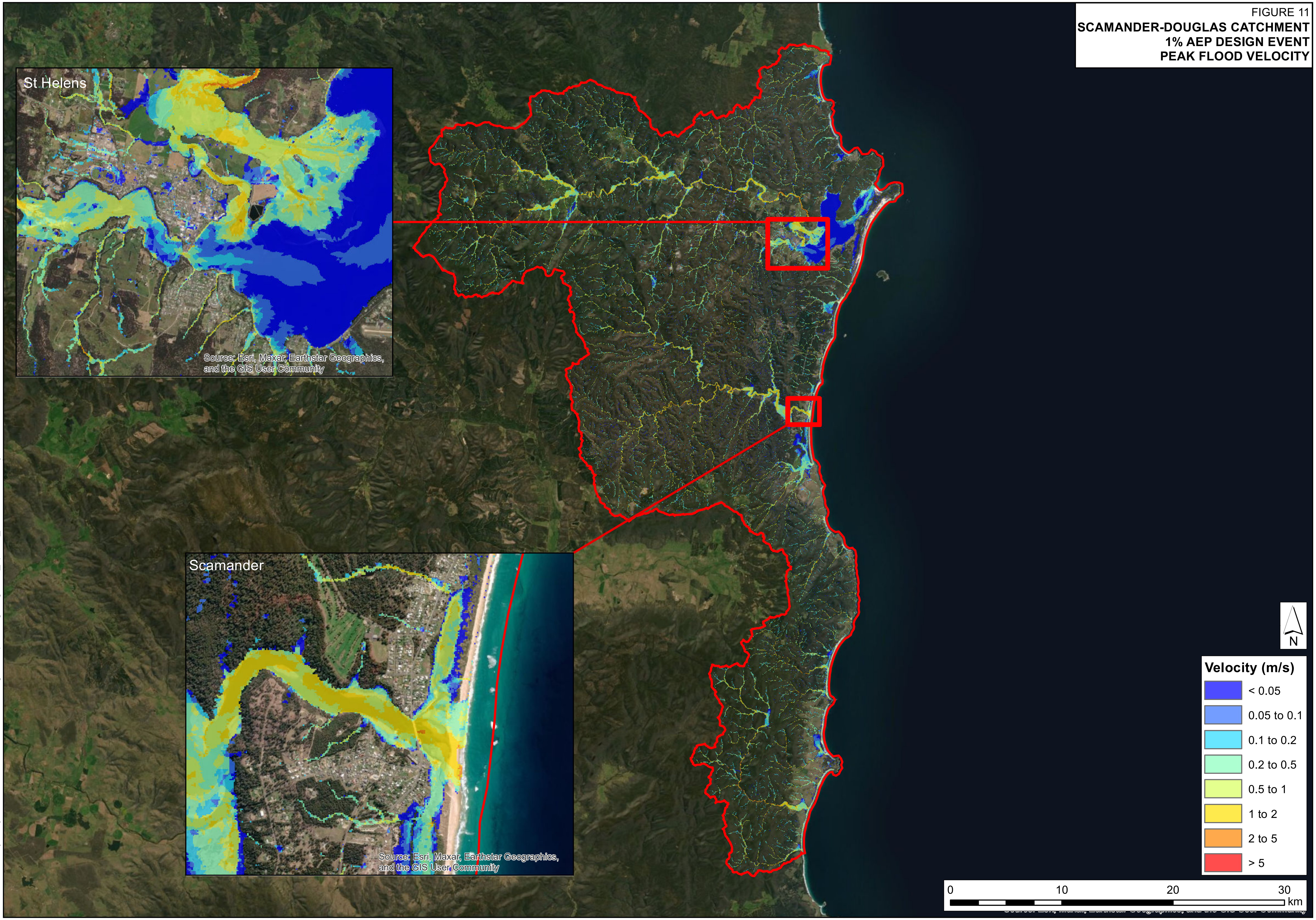
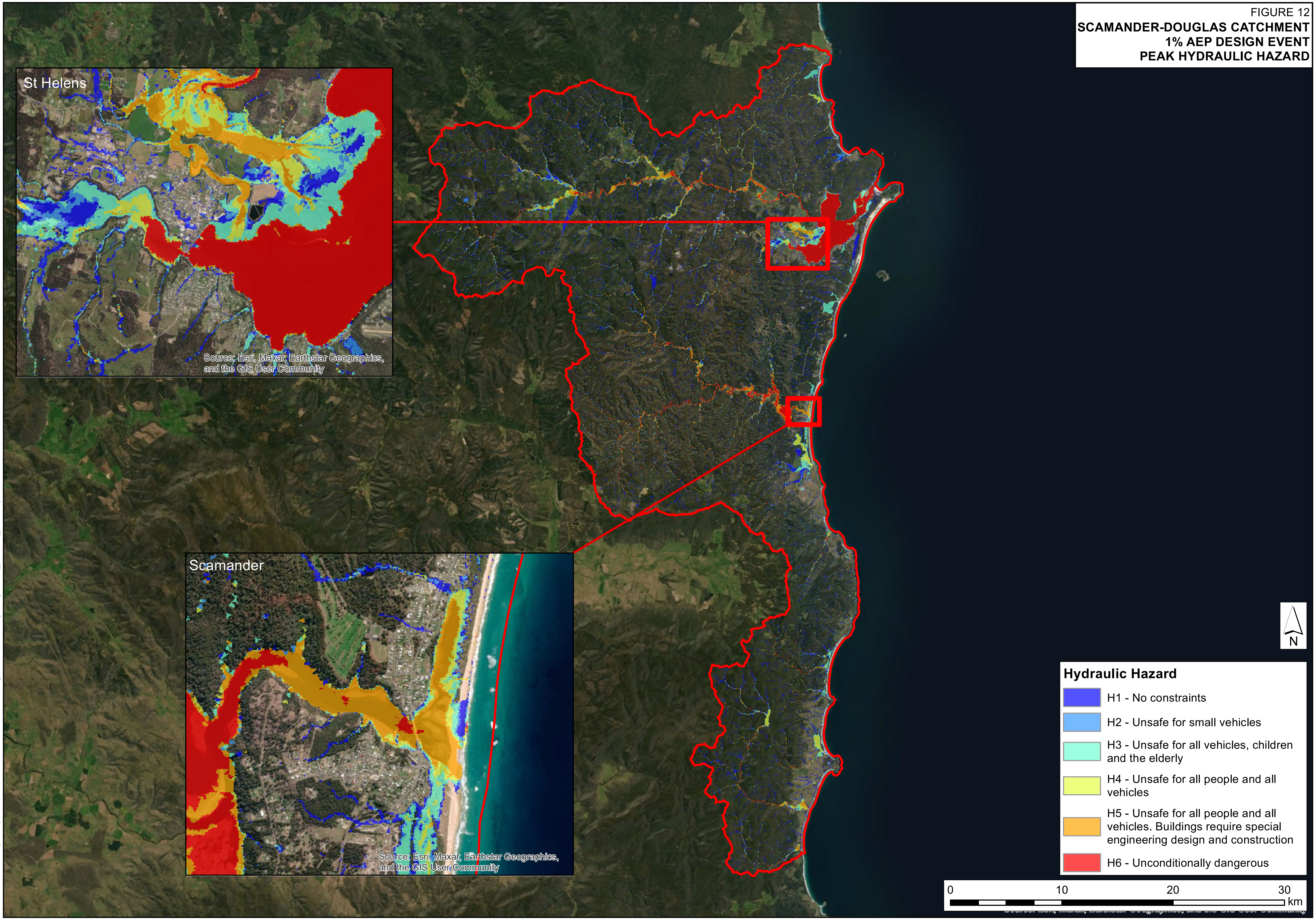


FIGURE 11
SCAMANDER-DOUGLAS CATCHMENT
1% AEP DESIGN EVENT
PEAK FLOOD VELOCITY

J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure11_1pAEP_PeakFloodVelocity.mxd

FIGURE 12
SCAMANDER-DOUGLAS CATCHMENT
1% AEP DESIGN EVENT
PEAK HYDRAULIC HAZARD



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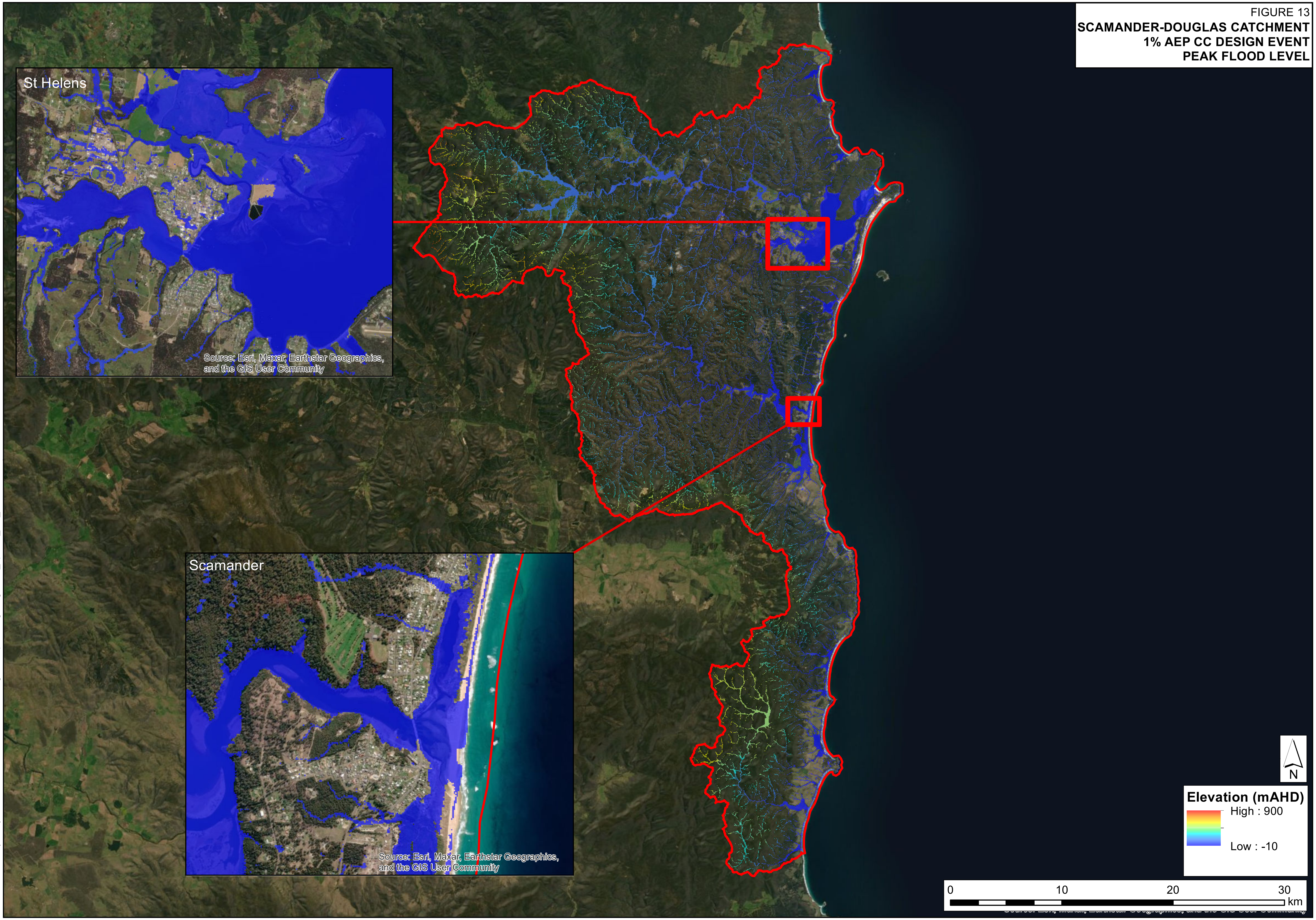


J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure13_1pAEP_CC_PeakFloodLevel.mxd

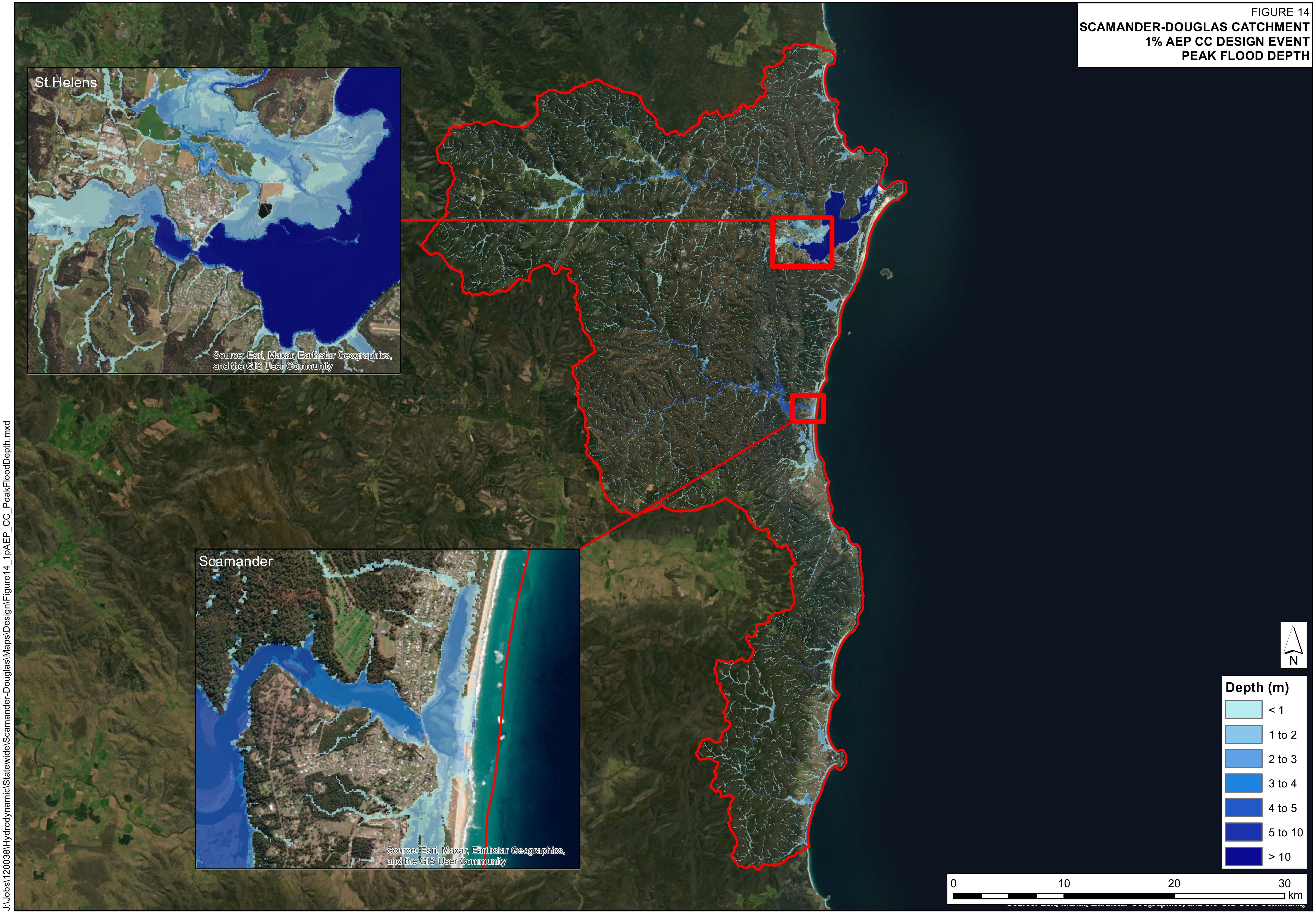


FIGURE 14
SCAMANDER-DOUGLAS CATCHMENT
1% AEP CC DESIGN EVENT
PEAK FLOOD DEPTH
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure14_1pAEP_CC_PeakFloodDepth.mxd

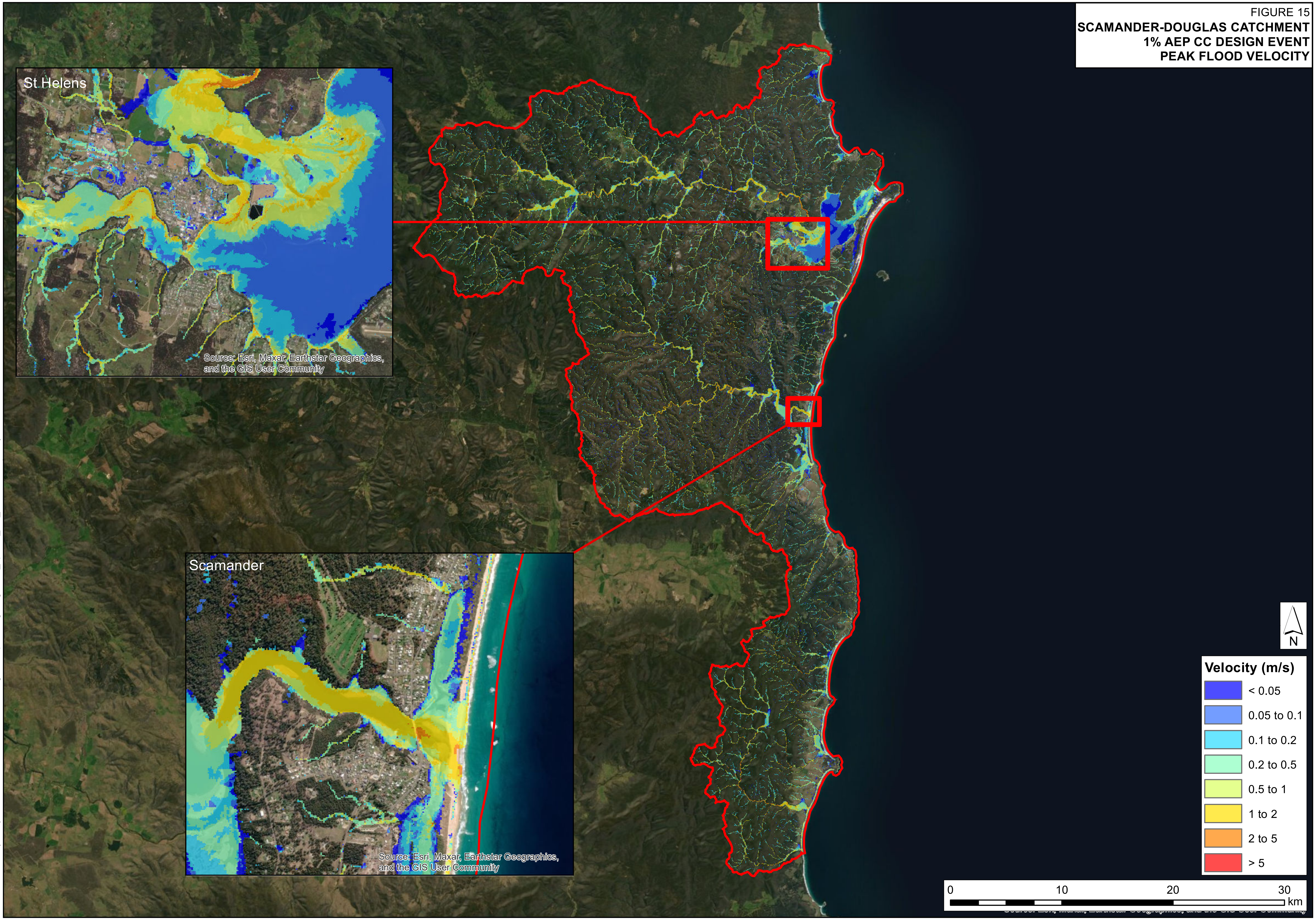
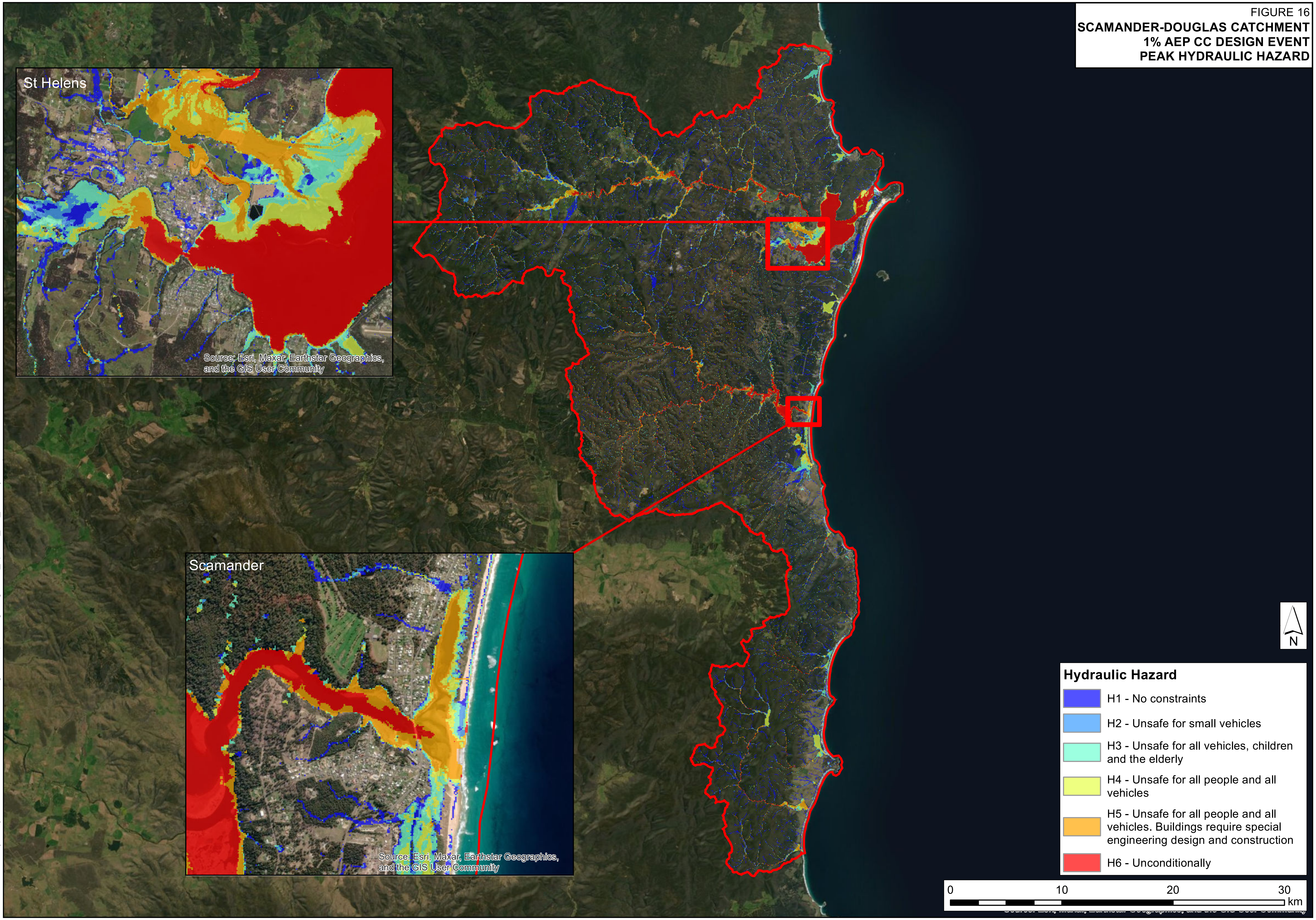


FIGURE 15
SCAMANDER-DOUGLAS CATCHMENT
1% AEP CC DESIGN EVENT
PEAK FLOOD VELOCITY

J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure15_1pAEP_CC_PeakFloodVelocity.mxd



J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure16_1pAEP_CC_PeakHydraulicHazard.mxd

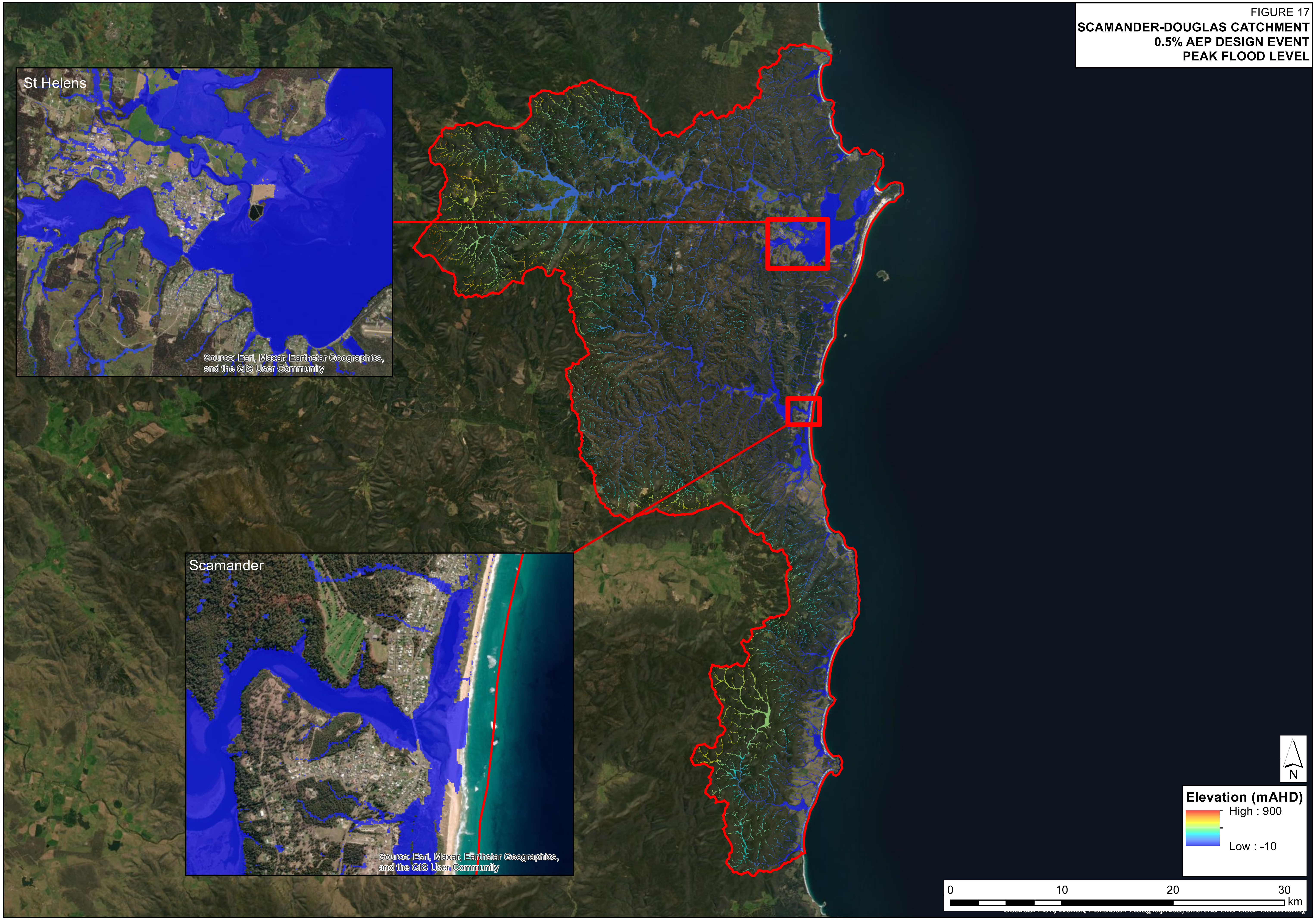


FIGURE 17
SCAMANDER-DOUGLAS CATCHMENT
0.5% AEP DESIGN EVENT
PEAK FLOOD LEVEL

J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure17_0.5pAEP_PeakFloodLevel.mxd

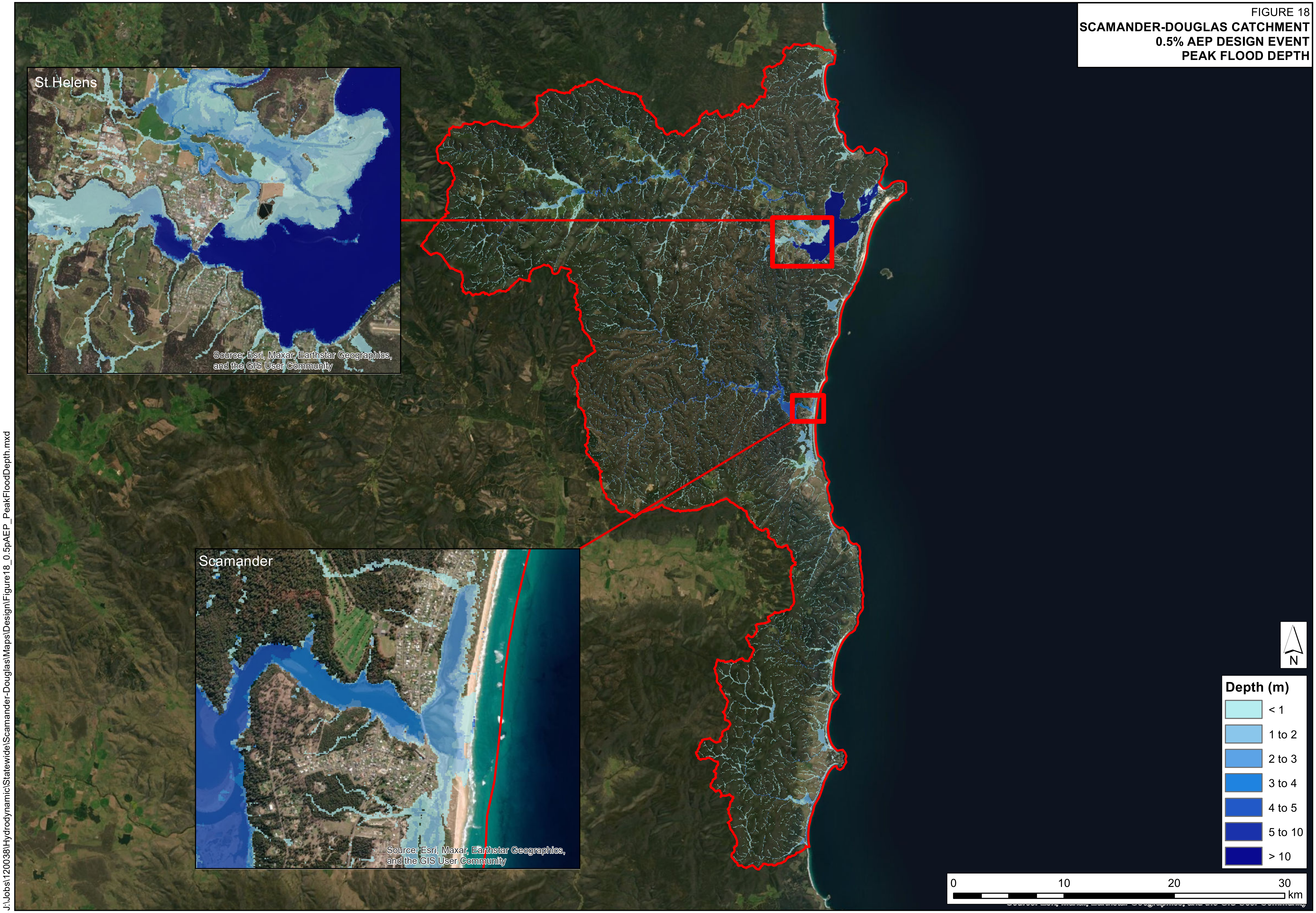


FIGURE 18
SCAMANDER-DOUGLAS CATCHMENT
0.5% AEP DESIGN EVENT
PEAK FLOOD DEPTH
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Depth (m)
< 1
1 to 2
2 to 3
3 to 4
4 to 5
5 to 10
> 10
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure18_0.5pAEP_PeakFloodDepth.mxd

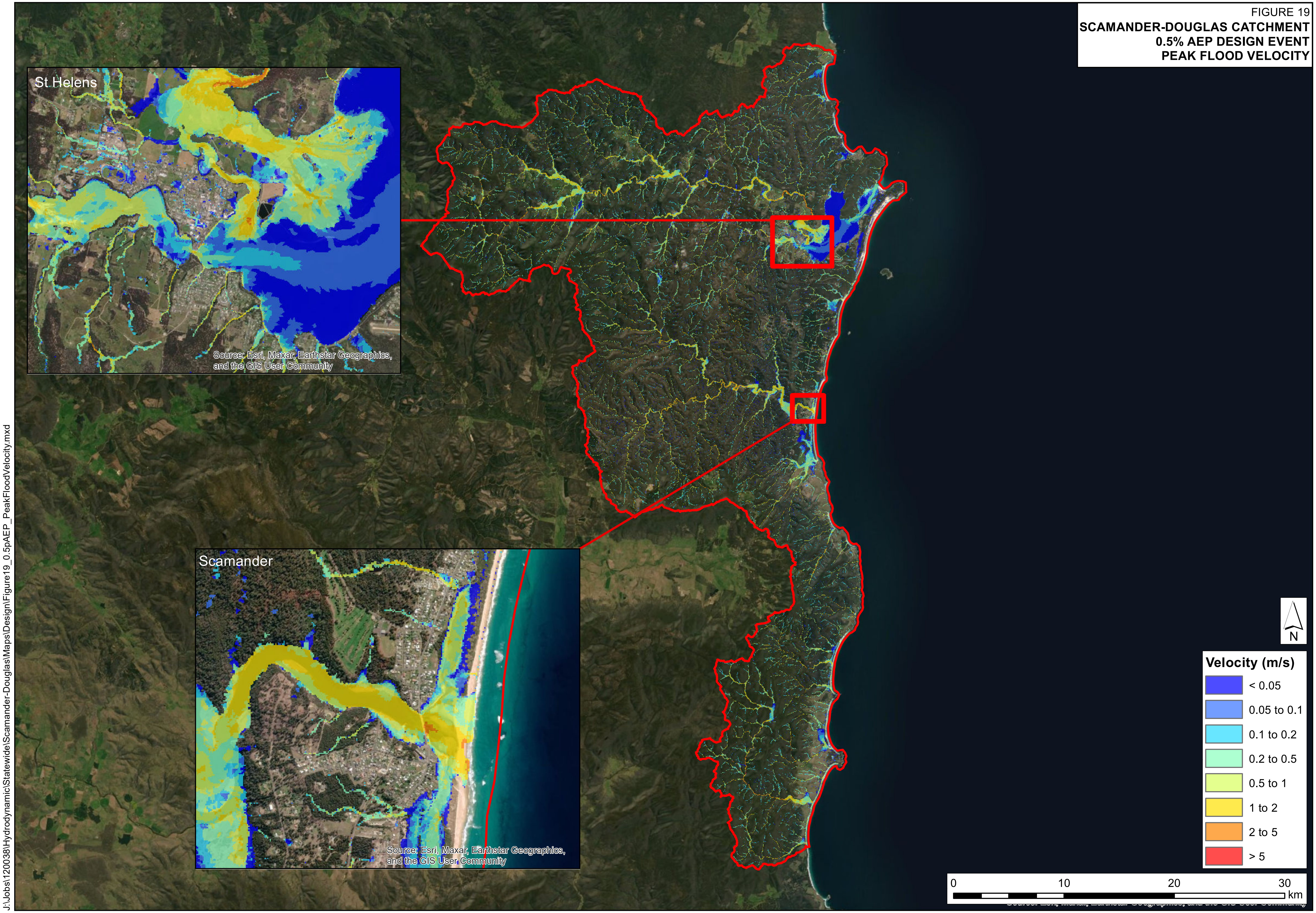
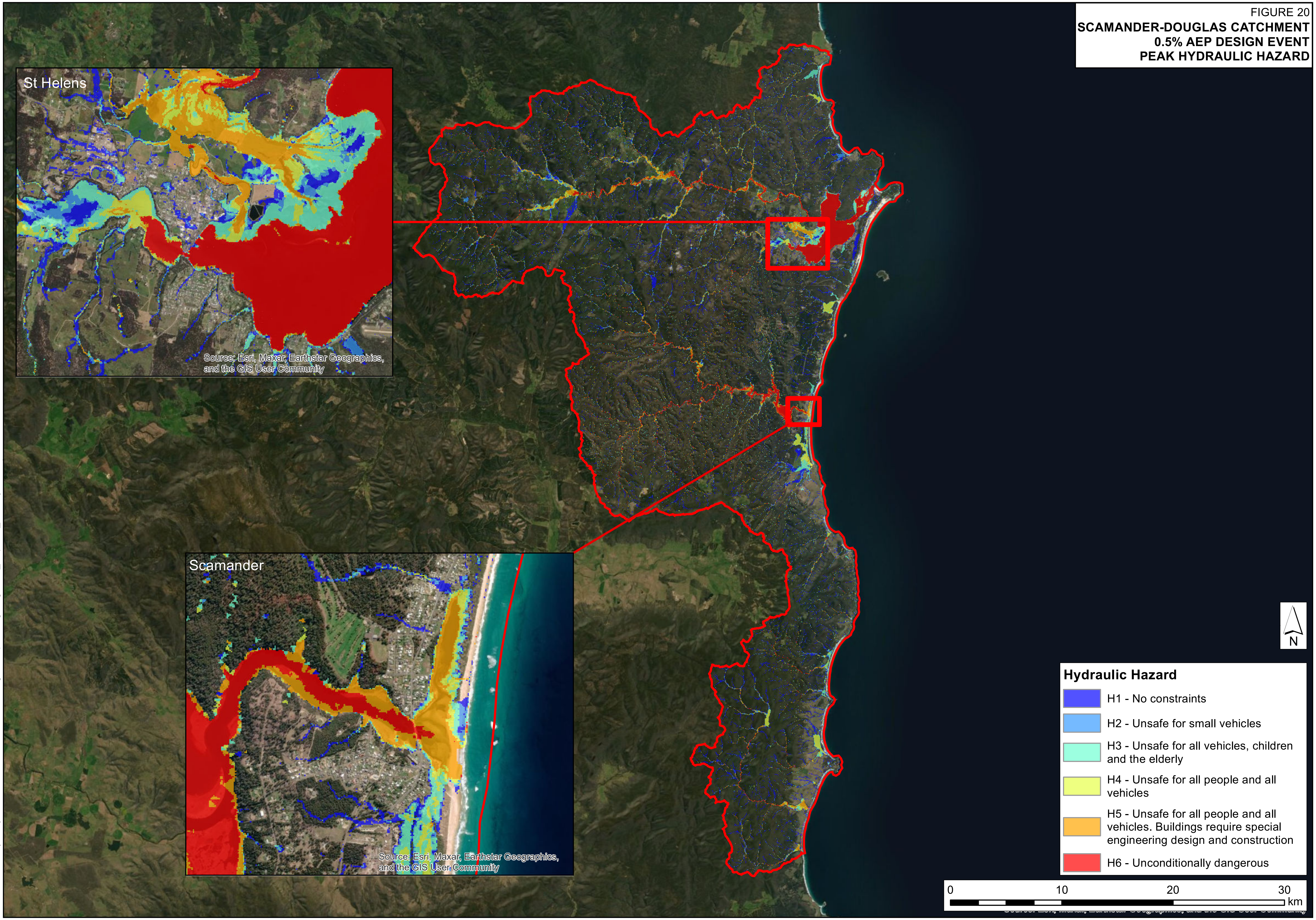


FIGURE 19
SCAMANDER-DOUGLAS CATCHMENT
0.5% AEP DESIGN EVENT
PEAK FLOOD VELOCITY
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Velocity (m/s)
< 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.5
0.5 to 1
1 to 2
2 to 5
> 5
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure19_0.5pAEP_PeakFloodVelocity.mxd



J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure20_0.5pAEP_PeakHydraulicHazard.mxd

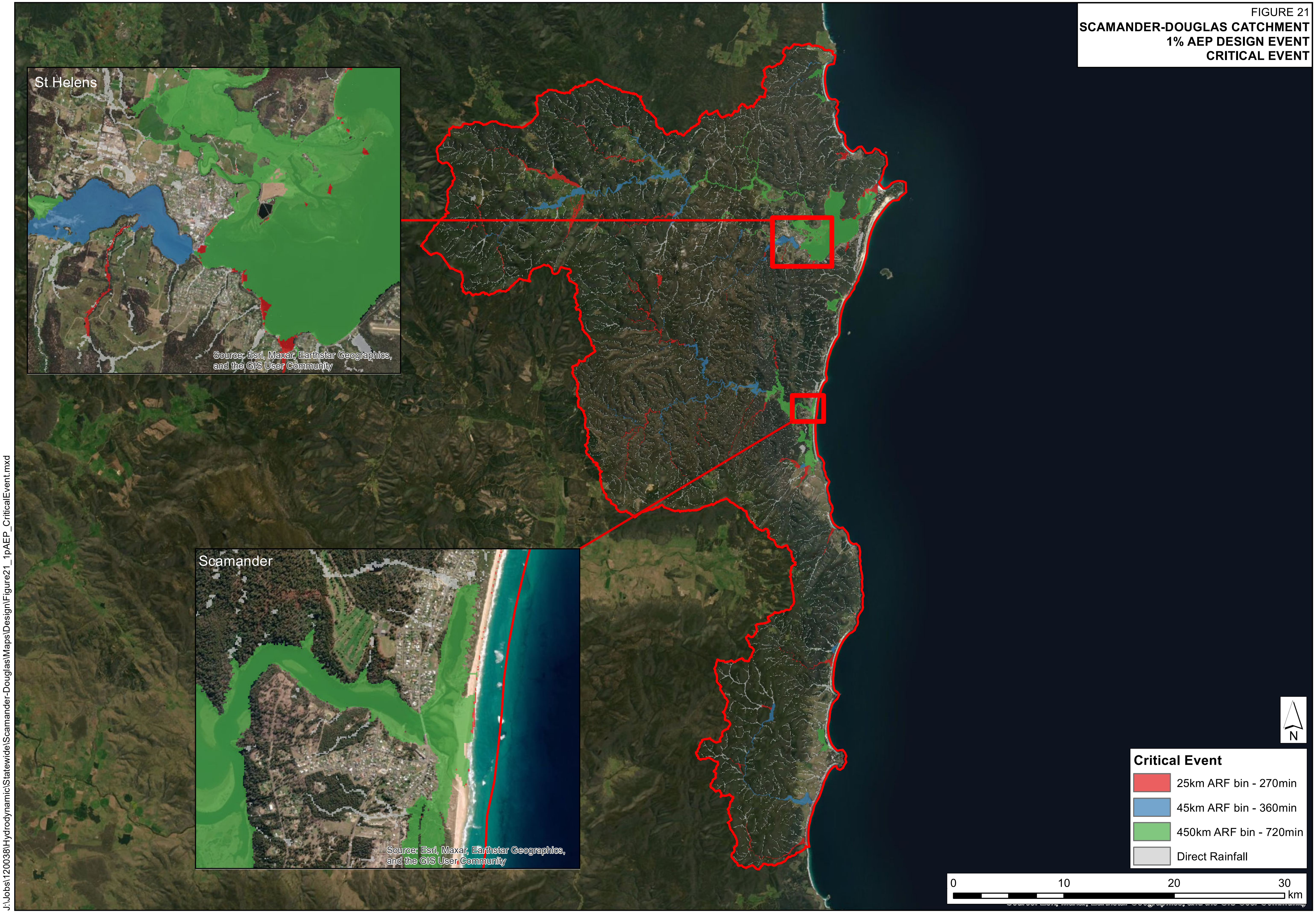


FIGURE 21
SCAMANDER-DOUGLAS CATCHMENT
1% AEP DESIGN EVENT
CRITICAL EVENT
St Helens
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Scamander
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
N
Critical Event
25km ARF bin - 270min
45km ARF bin - 360min
450km ARF bin - 720min
Direct Rainfall
0
10
20
30
km
J:\Jobs\120038\Hydrodynamic\Statewide\Scamander-Douglas\Maps\Design\Figure21_1pAEP_CriticalEvent.mxd

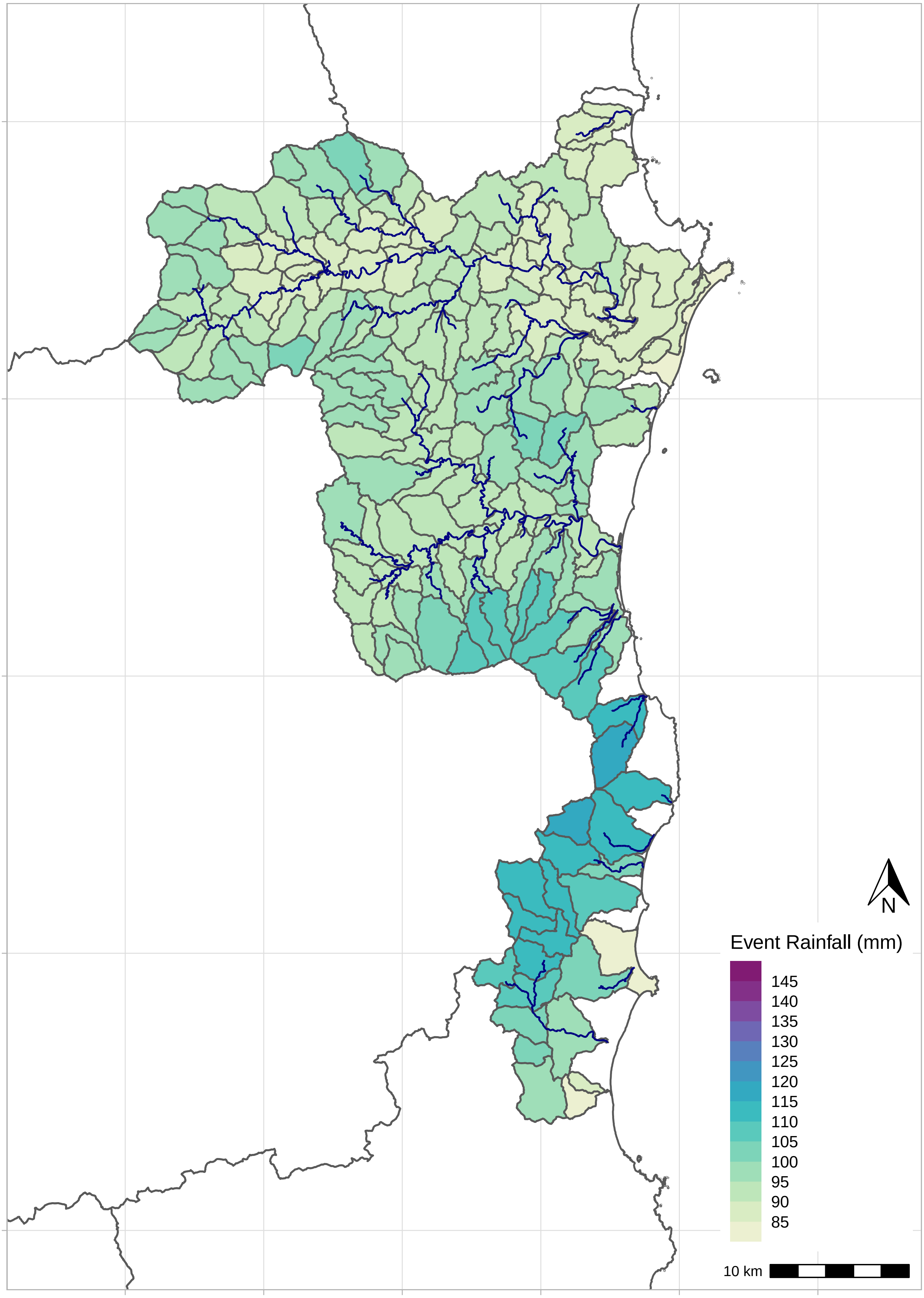
Appendix A

APPENDIX A. DESIGN EVENT DATA

FIGURE A1

DESIGN RAINFALL DEPTHS

360MIN 2%AEP



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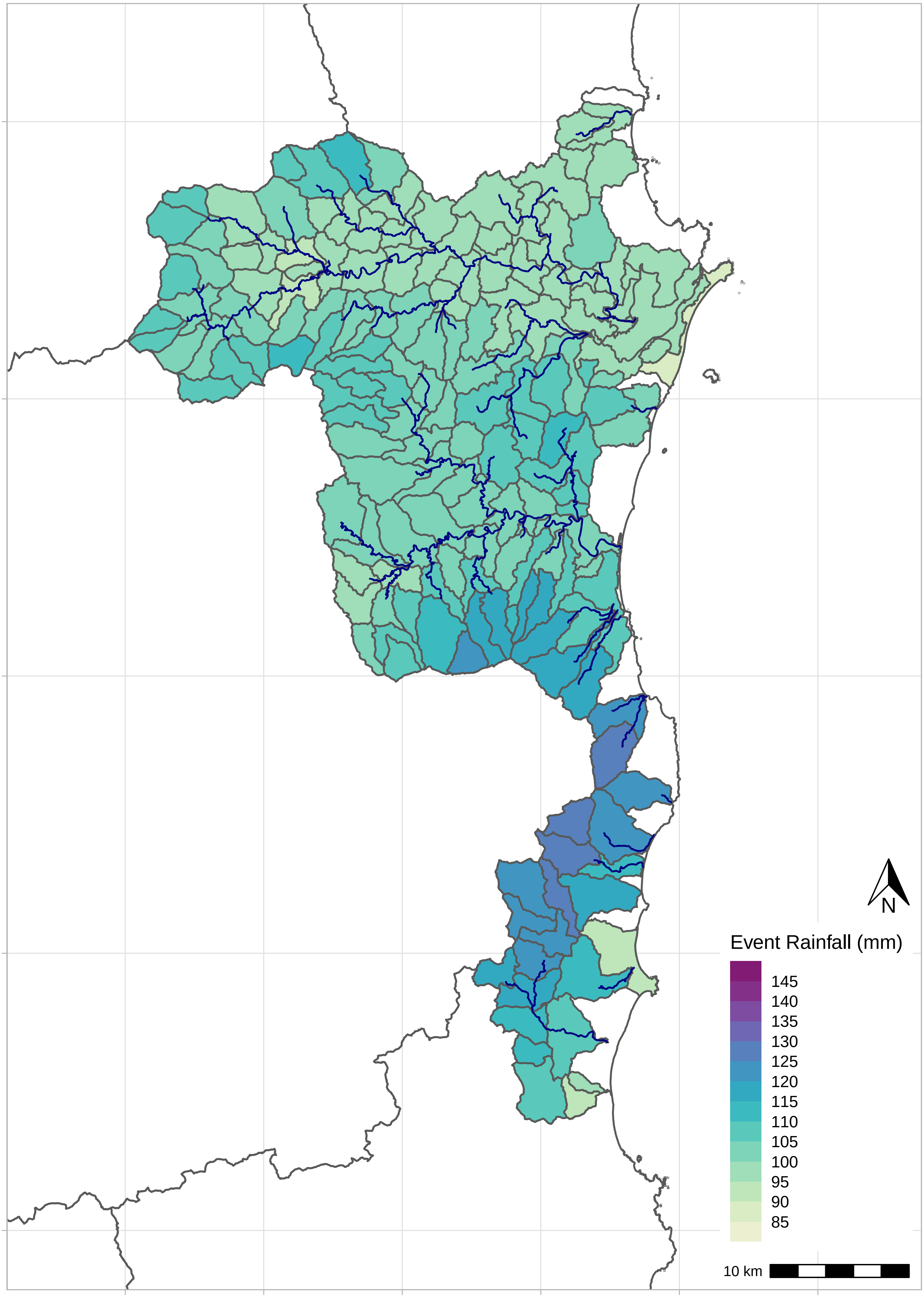
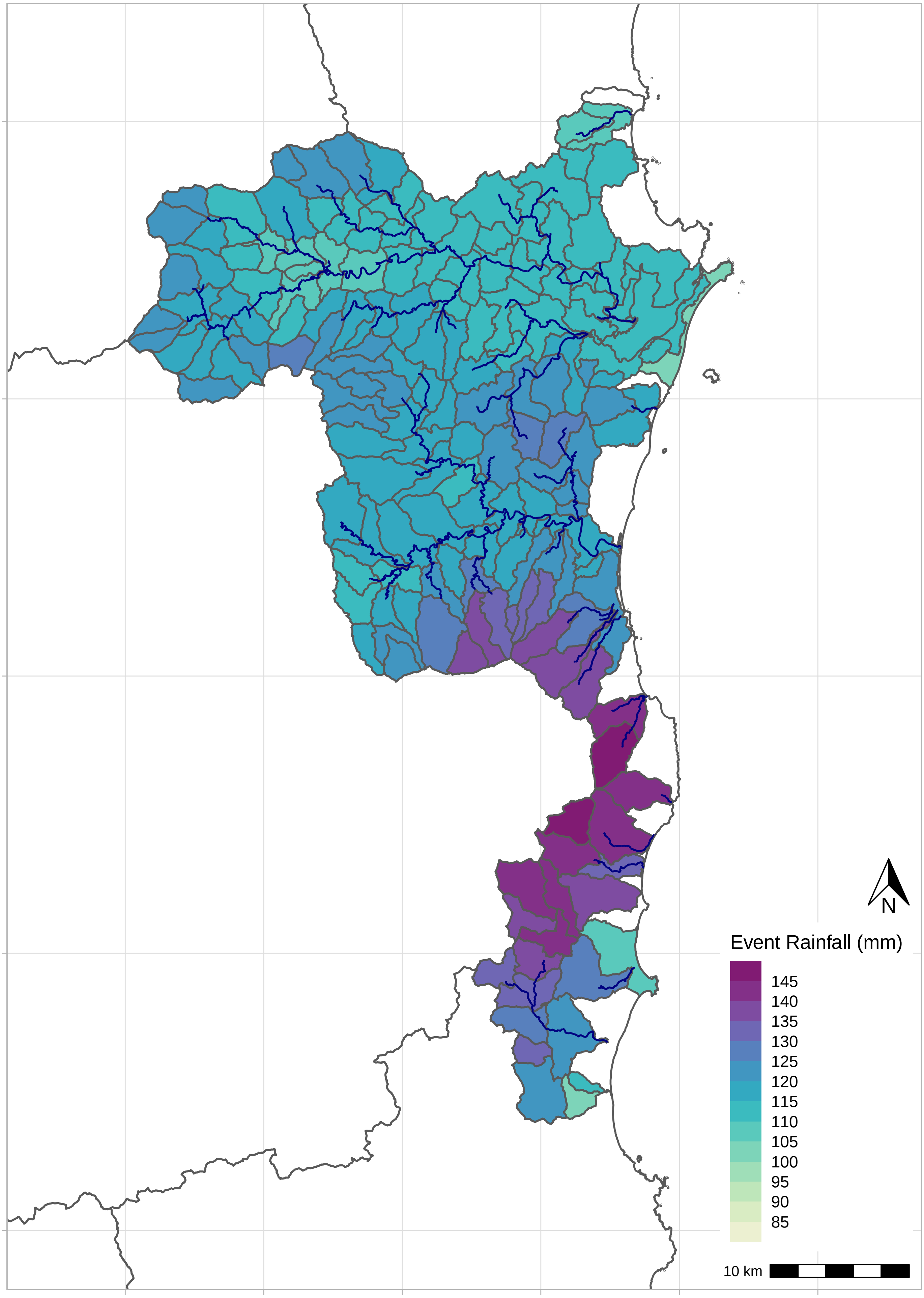
J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/Scamander−Douglasv1/Report_Figures/FigureA1_3602pAEP_same_scale.pdf

FIGURE A2
DESIGN RAINFALL DEPTHS
360MIN 1%AEP



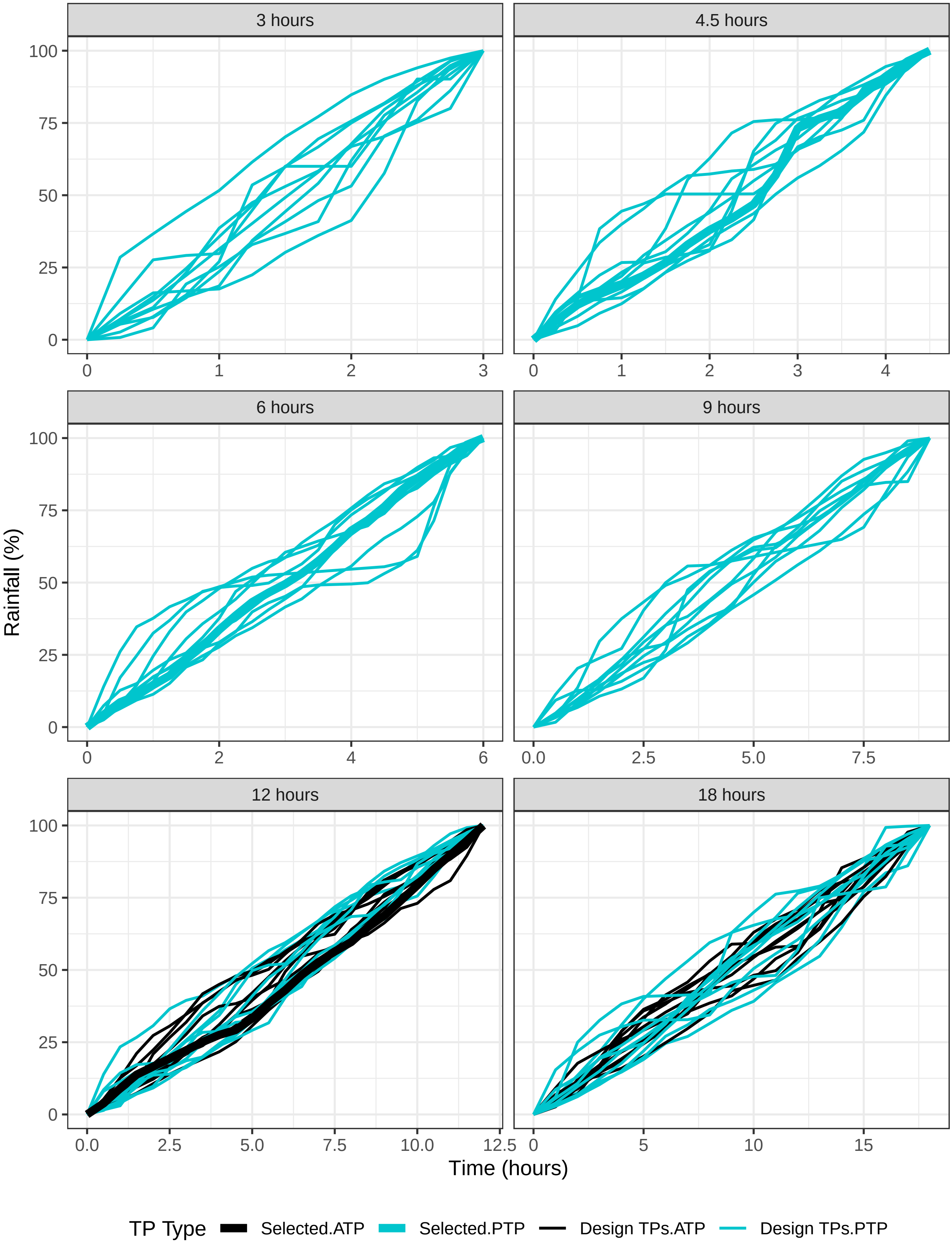
created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/7_ScD_Design_Report_Plots.R
J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/Scamander−Douglasv1/Report_Figures/FigureA2_3601pAEP_same_scale.pdf

FIGURE A3
DESIGN RAINFALL DEPTHS
360MIN 1IN200AEP



created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/7_ScD_Design_Report_Plots.R
J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/Scamander−Douglasv1/Report_Figures/FigureA3_3601in200AEP_same_scale.pdf

FIGURE A4
DESIGN AREAL TEMPORAL PATTERNS
DURATIONS FROM 3 TO 18 HOURS



created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander–Douglas/7_ScD_Design_Report_Plots.R

Appendix B

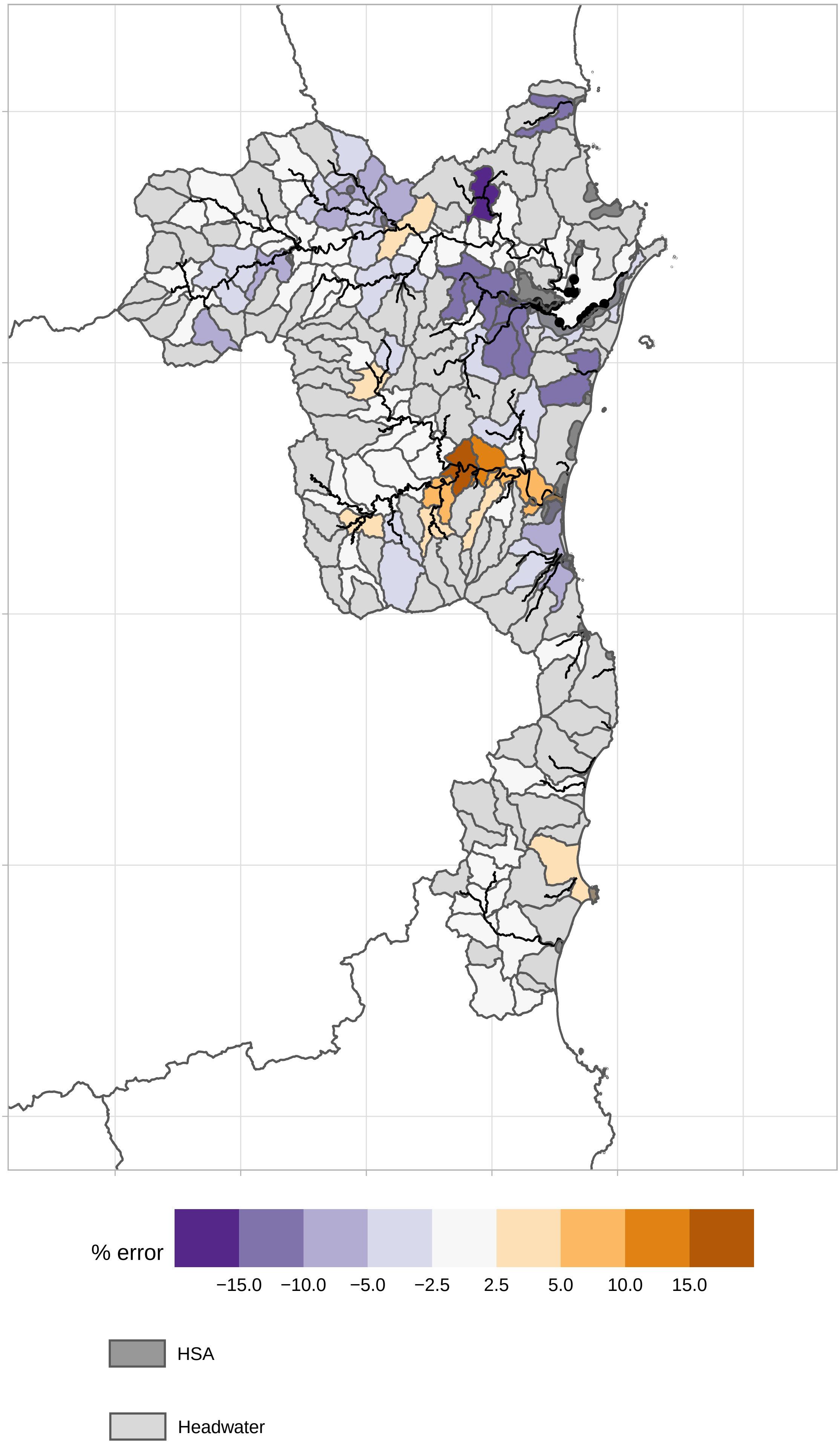
APPENDIX B. DESIGN PEAK ERRORS

Figure B1

Scamander−Douglas Catchment

Percentage error in peak flows using selected runs

2% AEP



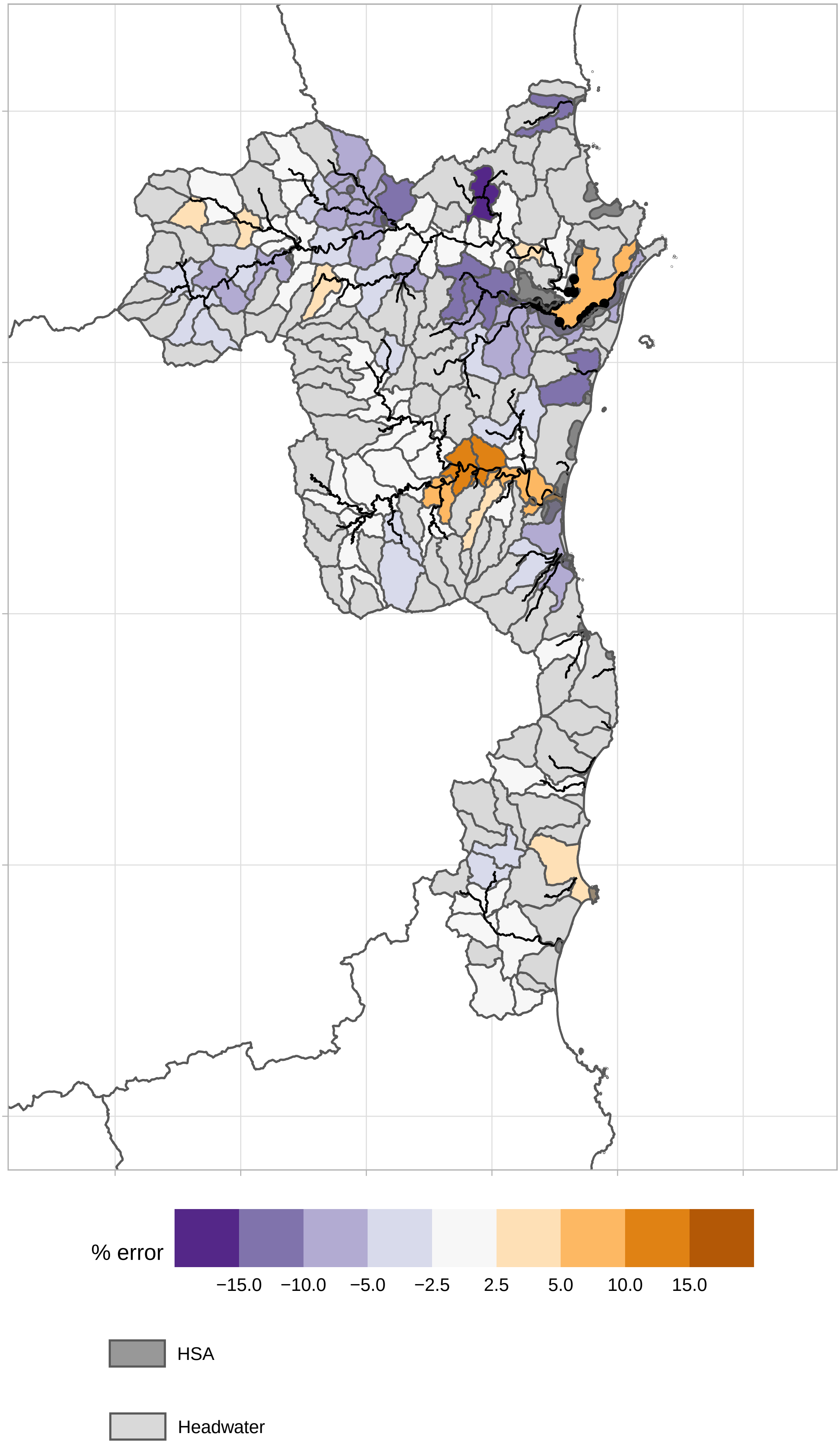
created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/7_ScD_Design_Report_Plots.R

Figure B2

Scamander−Douglas Catchment

Percentage error in peak flows using selected runs

1% AEP



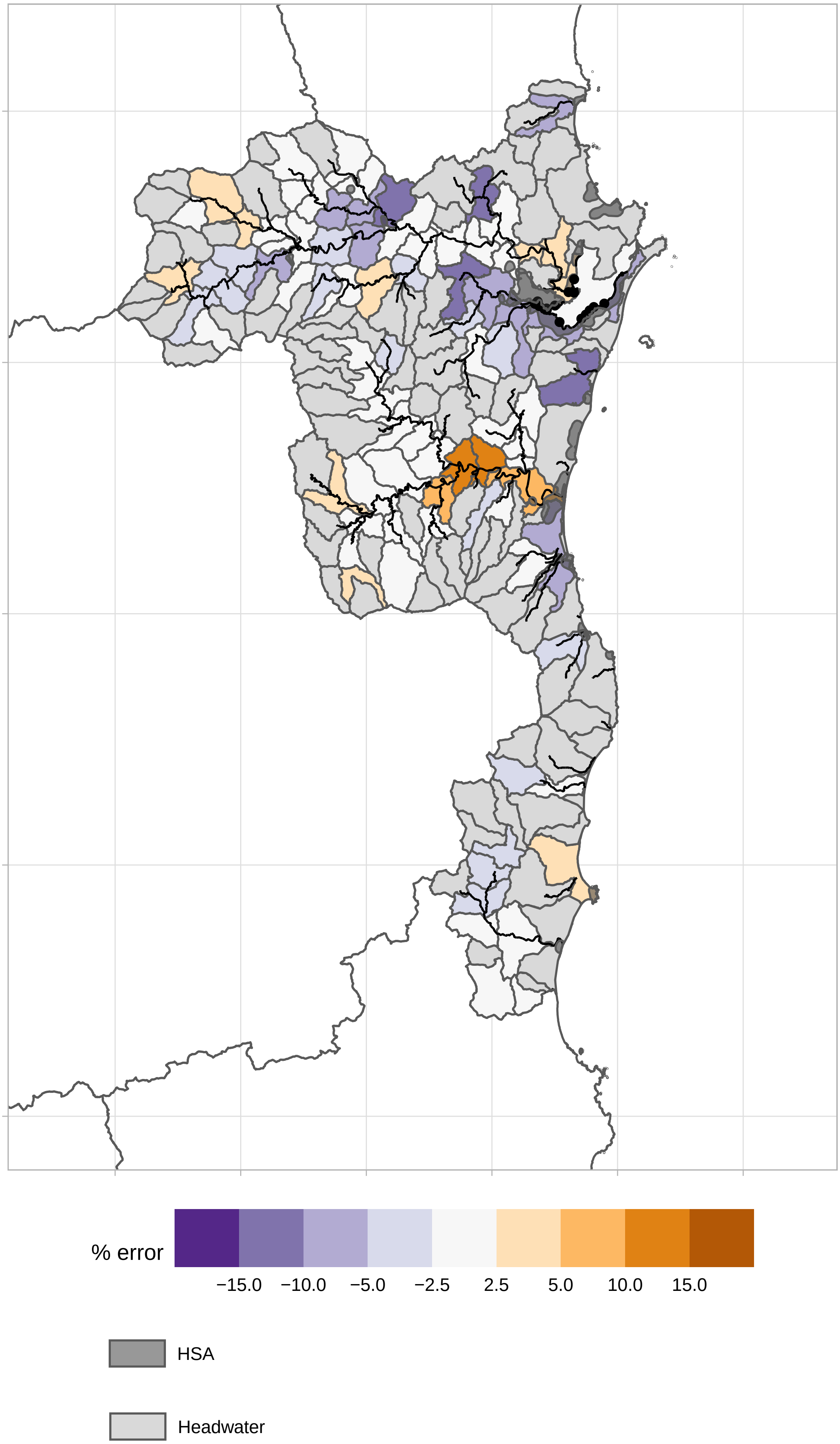
created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/7_ScD_Design_Report_Plots.R

Figure B3

Scamander−Douglas Catchment

Percentage error in peak flows using selected runs

1in200AEP



created by J:/Jobs/120038/Hydrology/Statewide/Design_Events/Scamander−Douglas/7_ScD_Design_Report_Plots.R