Fraser Coast Regional Council

Eli Creek

Flood Study Report

June 2023

Final Issue Rev 2

Document Status

Revision	Date	Author	Approval
01	15/05/2023	TA | AB	AB
02	07/06/2023	AB	AB

Project Details

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2 Executive Summary

An investigation and assessment utilising a 1D/2D model has been undertaken of the Eli Creek system and the following outcomes were noted in the flood study:

1. A detailed 1D/2D model was constructed incorporating a 5 metre grid with major hydraulic structures such as bridges and culverts included.

2. Design events have been undertaken utilising 2019 Australian Rainfall and Runoff (ARR) methods. The study has simulated all of the events, durations and ensembles in the hydraulic model to ensure the catchment is fully understood and represented. This has resulted in different flows and water levels across the catchment compared to historical studies, however it is noted that this study provides more advanced and up to date methods and as such is considered technically accurate with the available data.

   The results of the flood study are similar in nature, however overall, in the majority of cases, flood levels are slightly less due to the technically superior approach and use of up to date software as well as the use of ARR 2019 rainfall depths (which are generally less). In addition, the flood extents have been more refined due to a focus on only major tributaries and gullies rather than road and drainage characteristics.

3. The existing flood model provides an up to date and accurate account of existing flooding conditions and also a good basis for utilising this model for further works (development scenario assessment, infrastructure design etc)

Overall, this assessment has been a robust undertaking utilising all of the latest and relevant approaches to flood modelling in accordance with ARR19. The flood model provides valuable information and data to assess flood risk in detail for Council and also provides the ability to update land use planning policies and flood hazard overlays if desired.

3 Background

The Eli Creek catchment is approximately 36.0 square kilometres in area and the longest travel path is approximately 9.6 kilometres.

The area and catchment have a wide variety of land uses including the following:

- The very downstream sections are dominated by extensive floodplains and mangrove systems.
- Through the central area to the east is extensive urban development featuring a network of lake systems
- Towards the west are more rural residential dominated landscapes and the upper southern catchment consists of primarily rural and farming lands. Within these areas are also notable future emerging community areas.

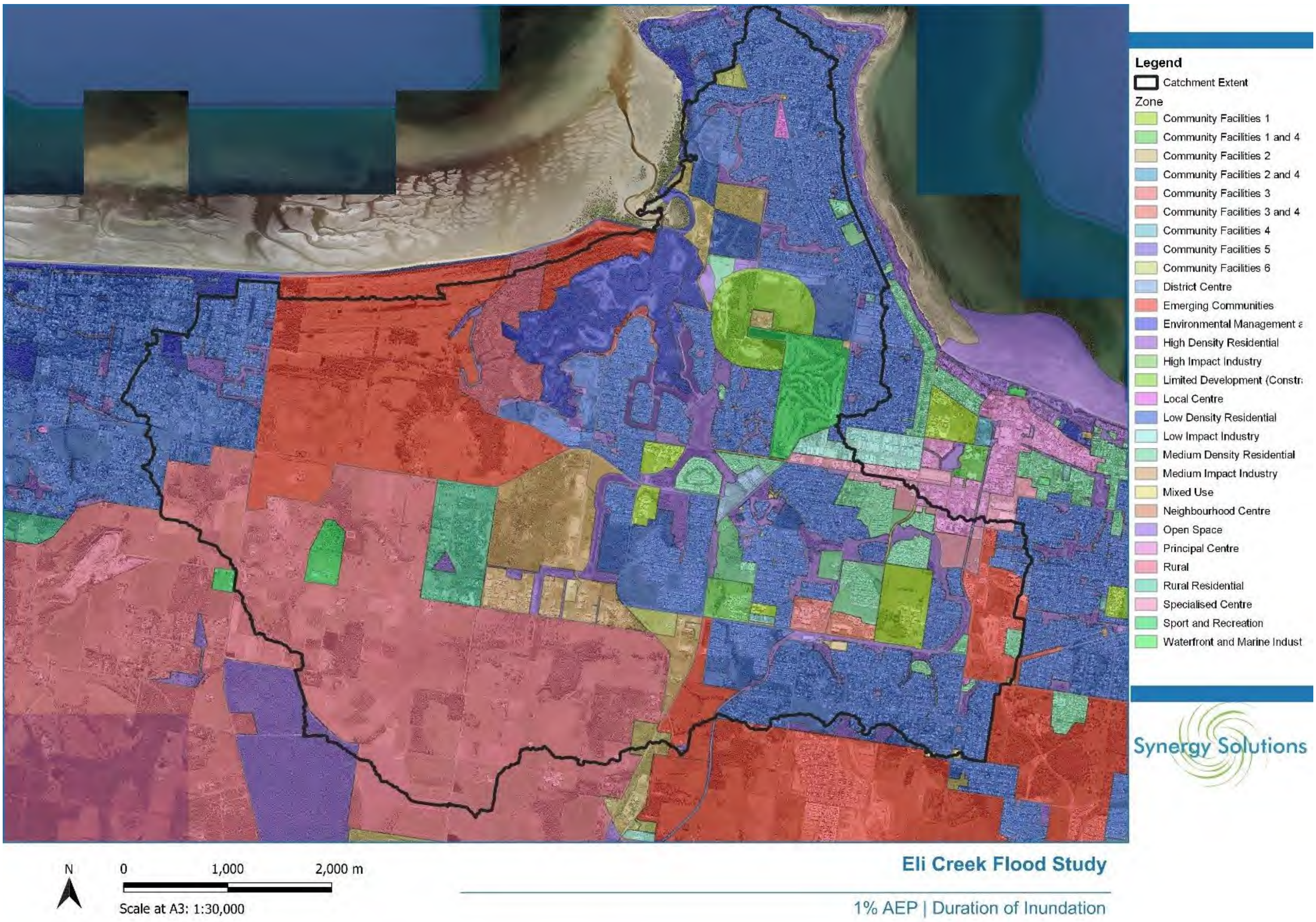


Figure 3-1 Land Use Overview

Previously, a flood study was undertaken by consultants Cardno in 2018 and the following is noted with regards to this study:

- The previous flood study utilised a direct rainfall approach whereas this study uses a traditional coupled hydrology and hydraulic model approach. This changes the detail and appearance of the results.

- The flood modelling was undertaken with 1987 Australian Rainfall and Runoff (ARR) parameters whereas this study utilises 2019 ARR parameters.
- The previous study only provides select storm events, whereas this study provides a full suite of events in accordance with the latest requirements of Fraser Coast Regional Council (FCRC).

This flood study is being conducted to provide a robust fundamental understanding of the existing flood risk in the area and provide the necessary modelling basis for further assessment of development impact.

4 Available Data

A variety of existing data sets were either provided or sourced from a range of agencies for this study. The data sets included a range of digital and hardcopy data provided by Council, Department of Transport and Main Roads (DTMR) and Bureau of Meteorology (BoM). A summary of the various data sets is outlined separately below.

4.1 GIS Datasets

A range of GIS datasets were sourced and provided to Synergy to inform the flood modelling and study. The information below represents a summary of the data made available.

4.2 Lidar

A digital elevation Model (DEM) was sourced through Council and other sources to represent the catchment. A one metre resolution LiDAR data set captured in 2022 was made available that covered all of the catchment (and all the hydraulic area). Table 4-1 below shows a comparison of 2022 LiDAR levels verse on ground survey conducted by Council.

Table 4-1 Bridge Details

Point Number and Description	LiDAR Level (mAHD)	Survey Level (mAHD)	Difference (m)	Comment
Point 1 (Road Crown)	3.110	3.304	+0.194	Typical variation with Lidar resolution of 1m grids
Point 2 (Gully)	3.640	3.481	-0.159	Under Vegetation Cover
Point 3 (Road Crown)	11.590	11.663	+0.073	Typical variation with Lidar resolution of 1m grids

As it can be seen the LiDAR information generally provides a good correlation to survey levels considering the data accuracy differences between the two methods and particular reasons for these differences.

4.3 Survey

The area of modelling had limitations with regards to the invert levels, diameters and missing pipe information. As such, Council organised internal surveyors to undertake survey of key locations within the catchment. In addition, Synergy undertook a site inspection to collect further data of less critical information to balance costs for Council. It should be noted that the survey did not include a full survey of the stormwater network and only focussed on specific areas critical to the model and flooding characteristics (i.e. large cross drainage structures and missing DTMR information).

The survey information was used to update the stormwater information within the Tuflow model.

Figure 4-1 Survey Locations

4.4 Site Inspections

Site inspections were undertaken by Synergy Solutions to inform the flood study. The site inspections were undertaken at key points throughout the area and targeted the following aspects:

- Utilising a rapid direct rainfall model to identify initial flows paths and areas of interest.
- Inspection of bridges through the catchment. The inspection assisted with understanding bridge blockages and filling missing data not available from drawings. Measurements were taken of bridge dimensions where possible and safe to do so.
- Inspection of major developments, road corridors and major cross drainage structures.
- Inspection of vegetation particularly on the creek corridor to inform Manning's roughness values.
- Measurements were also undertaken of missing pipe and culvert information.

Figure 4-2 Site Inspection Photo

4.5 External Agency Data

External agencies were utilised to source, collect, and collate data for a variety of needs in the flood study. The information below presents a description and summary of their use.

Department Transport and Main Roads
DTMR was contacted by Synergy and Council to source information on DTMR owned road and stormwater assets. This information was used to update the flood model.

5 Hydrologic Model Development

The following information lists the information, parameters and analysis that was undertaken in order to produce and refine a detailed URBS hydrological model.

5.1 URBS Model Layout

In developing the URBS model, a high level of detail was incorporated in sub catchment breakdown, routing parameters and rainfall data. This was undertaken to ensure a balance between accuracy and not "crowding" model results so as to adequately provide information for land use planning. The sub catchment breakdown was also undertaken to ensure major cross drainage culverts were represented.

As discussed with Council, the main requirements of this study were to ensure the main creek and major tributaries were represented and not the urban environment in detail to ensure results were reasonable to use within a land use planning context.

Sub Catchment Delineation

A previous direct rainfall model was initially used to ensure the flowpaths and catchment areas were well understood. The sub catchment breakdown was undertaken manually to ensure the correct placement of connections to the 2D model and to ensure future development areas could be well represented. The sub catchment breakdown is shown in Figure 5-1 and also in Appendix A – Sub Catchments.

Figure 5-1 Sub Catchments

Link Routing Process
Zonal statistics were also utilised to accurately assign flowpath lengths, slopes etc into each sub catchment. In this regard, channel routing has been developed based on the lengths and slopes derived from the DEM.

Impervious Fractions and Factors
Impervious areas were developed using a scripted process through QGIS which utilises Manning's roughness grids to accurately account for impervious areas. Zonal statistics were utilised to extract information and assign it to relevant sub catchments. In addition, urbanisation and forest factors were applied to each land use within the model.

This process provides a fundamentally improved estimation of impervious areas rather than estimating percentages through inspection of aerials. The adopted mannings roughness values are shown in Table 6-2.

URBS Parameters

The URBS parameters were defined from previous works undertaken in the adjacent Bunya Creek catchment where calibration had been undertaken.

6 Hydraulic Model Development

As part of the flood study for the Eli Creek catchment, a detailed 1D/2D TUFLOW model has been developed. The TUFLOW model was based on TUFLOW software version 2023-03-AA-iSP-w64 and also makes use of the Highly Parallelised Compute (HPC) solution scheme. The information below represents the individual build elements of the TUFLOW model.

6.1 Model Extents

The model extents have been selected based on the total catchment area and in order to locally focus on the key development areas. The extents were also determined by Council's brief and the discharge point of the catchment. The tailwater conditions were accounted for in the boundary conditions listed below.

6.2 Boundaries

The upstream and downstream boundaries of the model have been selected based on the entire catchment of Eli Creek. The boundaries on the creek are as follows:

- The upstream boundary is defined by the extent of the catchment and the sub catchment inputs. The majority of the catchment has been modelled hydraulically. Sub catchments from the URBS model are connected via 2D SA connections to the Tuflow model.
- The downstream boundary has been assigned using a HT boundary to simulate existing, design and climate change runs. Council's required climate change parameters required Mean High Water Springs (MHWS) plus 800mm for climate change (sea level rise).

6.3 Digital Elevation Model

As described above a one metre resolution LiDAR data set captured in 2022 was used to develop a DEM for the hydraulic model. Due to the use of Sub grid sampling and a fine resolution hydraulic grid of 5.0 metres, all flowpaths were adequately represented.

In addition, the latest features of Tuflow were utilised to undertake an assessment of the terrain and required manual intervention locations. Where the digital elevation model differed significantly (250mm) from the original Lidar surface, break lines were manually specified and burnt into the DEM to ensure the high points of roads and key hydraulic structures were captured.

Figure 6-1 Hydraulic Breaklines

6.4 Cell Size Development

The TUFLOW cell size was chosen via a detailed and iterative process of running many flood models to provide the necessary accuracy for a creek system, simulation times, Australian Rainfall and Runoff (ARR) considerations and to adequately and accurately represent any floodplain storage or characteristics that would affect water levels and/or flows. Combinations and iterations of cell size included:

- Utilisation of TUFLOW Quadtree with a variety of nested cell configurations.
- Combinations of standard and quadtree grid sizes of between 2 metres and 10 metres.
- Use of standard and sub grid sampling (SGS) aspects of TUFLOW available in the latest releases.

The findings of this iterative process concluded that:

- The use of Quadtree was avoided primarily due to the fact an adequate grid size could be utilised across the whole catchment and to reduce the complexity of future users of the model for development assessment purposes.
- In addition, the remap feature of Tuflow was used, whereby the 1m resolution DEM of the model was used to remap the outputs for a finer grid resolution.
- This process takes full advantage of the new Tuflow features whilst allowing simulation of the entire combinations hydraulically. Thus, a more accurate outcome is achieved due to the complexity of the catchment.

With this significant testing, it was deemed appropriate to utilise a TUFLOW model with SGS and a 5m grid size without Quadtree. This provided the most appropriate outcome considering simulation times, ARR19 provisions, accuracy around the future development areas and townships, floodplain representation and simplified models for future use.

6.5 Hydraulic Structures

Hundreds of hydraulic structures are represented in the Eli Creek catchment and were assessed and if necessary, represented in the hydraulic model. The following information details each of these hydraulic structures in detail.

Culverts and Pipes
Council provided a GIS dataset for culverts in the catchment area. Nearly all of the cross-drainage structures were represented and some trunk drainage system lines. The trunk drainage lines represented were those that were either directly connected to major cross drainage structures which would impact on capacity and conveyance or those systems that would cause backwater into road reserves. As Council's focus of this study was not on minor overland flowpaths and urban drainage type flooding, other pipe networks were excluded.

The extent of this representation was defined by the sub catchment breakdown and the desire from Council to have modelling results that were not focussed on drainage level resolution and pit and pipe networks. In addition, the scope and focus of the study is Eli Creek itself, not the urban environment. Thus this focus provides a more refined output for Council.

Figure 6-2 1D Network

Bridges

On the Eli Creek system there is one bridge structure within the hydraulic extents that required representation in the hydraulic model. The bridge structure is an arch culvert and was represented using an irregular culvert shape and 1D section line.

The parameters for the layered shape files are shown below in the table below.

Table 6-1 Bridge Details

Name	Water Level (mAHD)	Blockage (%)	Invert Levels (mAHD)	Width (m)	Height (m)
Endeavour Way Arch Culvert	1.711	10	0.297	12.820	2.859

All the bridges used the terrain surface as the invert of the bridge. The bridge was inspected on site and is shown below in Figure 6-3.

Figure 6-3 Endeavour Road Bridge

6.6 Manning's Roughness

Roughness values have been prepared based on the Manning's roughness "n" value in accordance with ARR19 and based on aerial imagery, GIS process, and field inspections. The Manning's roughness classifications are shown in the tables and figures below.

Manning's roughness values were refined as necessary as part of the hydrologic and hydraulic calibration for the historical flood events.

Table 6-2 Manning's Roughness Values

Classification	Manning's n
Light Vegetation/floodplain	0.050
Dense Vegetation	0.085
Water	0.030
Medium Vegetation	0.070
Road Pavement	0.016
Buildings	0.2
Concrete Channel	0.016
Overgrown Channel	0.030
Grass Channel	0.035
Watercourse with Vegetation	0.050
Rural Residential Zone	0.070
Low Density Residential	0.12
Medium Density Residential	0.15
High Density Residential	0.20

Figure 6-4 Mannings Roughness

7 Design Events

The information below provides an overview of the design events methodology and modelling.

7.1 Summary

The design event modelling and outputs have been undertaken in accordance with the parameters and guidance listed in Australian Rainfall and Runoff 2019. The following is a summary of the work undertaken:

- The URBS and TUFLOW models have been utilised as the basis for providing the design event modelling.
- Parameters and inputs such as pipes, bridges, terrain and Manning's roughness values have remained consistent with other flood models undertaken within the Fraser region (Bunya Creek Flood Model etc).
- The analysis utilised an assessment of multiple storm durations and all ten temporal patterns in accordance with ARR19.
- Due to the success of validating slightly coarser grid cells using Sub Grid Sampling and high-resolution remapping, the entire hydraulic ensemble set was simulated at a coarser resolution of 10 metres.
- Verification has been undertaken using the Regional Flood Frequency Estimation Method (RFFE). At site flood frequency analysis was unable to be undertaken as there are no gauges within the area. The RFFE method provided some validation of design flows.
- Climate change outputs for the 1% AEP have been produced by utilising the RCP 8.5 scenario applied to Mean High Water Springs (MHWS) and based on conversations with Council.

Overall, the framework used, and the modelling and outputs produced are robust with strict adherence to the ARR19 guidance. In addition, steps and methods have been undertaken and processed to ensure the outputs are conservative yet practical.

7.2 Design Rainfall IFD

Design flood estimates have been derived on the design IFD guidance outlined in ARR2019 and includes the updated rainfall IFD prepared by the Bureau of Meteorology (BoM) which superseded the previous ARR1987 IFD information. The updated IFDs are considered to be more appropriate and superior to the former ARR1987 IFDs as they include a greater overall number of rainfall stations as well as more stations with a period of record exceeding 30 years.

Investigation of the IFD's was undertaken for the catchment which showed very little variation in rainfall depths and as such only one IFD pattern was applied to the whole catchment.

7.3 Design Event Losses

Design event losses were considered in combination of assessment of the ARR Datahub losses, consideration of other flood models in the area which had calibration undertaken and Council's planning scheme guidance. As the flood frequency data and assessment was not available, unfortunately this was not able to be utilised to further verify and refine losses across different design events.

Table 7-1 below shows the varying losses for each of the datahub and nearby calibrated flood studies:

Table 7-1 Design Loss Assessment

Data	Initial Loss (mm)	Continuing Loss (mm)
ARR Datahub	26	3.8
Planning Scheme Losses for Coastal Catchments	35	2.5
Selected Design Losses	35	2.5

It was considered that the final design losses best suited the planning scheme losses with a slightly reduced continuing loss. This was also reflective of other studies recently completed in the Sandy Straits area. A higher initial loss also accounts/provides for some loss once pre-burst rainfall is subtracted from the storm losses and the final burst loss is calculated.

7.4 Aerial Reduction Factors

Areal Reduction Factors (ARFs) have not been applied as the focus of the study is across the entire catchment. It was necessary to produce flood extents for very small catchments and thus would not have been conservative to adopt ARF's for these catchments.

7.5 Design Combination Selection

Due to the difficulties in applying ARR2019 fully to flood studies due to the many combinations of events, durations and ensembles, a custom method was derived to find a balance between simulation time and accuracy. If all 1000+ hydraulic simulations were produced, this was estimated to take nearly 1000 hours (42 days) of modelling time which is not practical. At the other end of the scale, it is not appropriate to pick one focal point within the catchment due to the results being used over the entire catchment. A process was developed to select a subset of runs for the fine TUFLOW model to create maximum design flood surfaces valid at all locations. The process was undertaken in the following manner:

1. A coarse TUFLOW model was run for all ARIs, durations and ensembles.
2. Peak flood levels were extracted at 100+ locations across the catchment for all runs.
3. For each location and ARI, the target design flood level was calculated using the mean ensemble, maximum duration approach.
4. Each individual run at each location was given a score based on:
   - How close the run was the to the target design flood level.
   - How close the run's storm duration was the to the design critical duration.
   - Whether or not the run exceeded the target design flood level at the given location or any other location
5. For each location and ARI, the run with the best score was selected. This resulted in 347 unique events that were then simulated in the finer 5.0 metre grid model.

8 Climate Change Assessment

Guidance that is provided in ARR2019 applies for climate change projections out to 2090 and at the direction of Council, for this project design rainfall depths were generated assuming Representative Concentration Pathway (RCP) of 8.5.

ARR2019 did not recommend any changes in temporal patterns, spatial patterns or loss rates associated with climate change projections for design floods, recognising that although there was preliminary research demonstrating that some of these flood causing factors may be sensitive to climate change there was insufficient definitive advice on these factors at the time the ARR chapter was drafted (2015). As such, these parameters have been kept consistent with the current day 1% AEP.

The Eli Creek catchment lies within the East Coast North Natural Resources Management cluster (see Figure 1.6.1 of Bates et al., 2019). Using the guidance in ARR2019, this region is projected to have a 3.7°C increase in temperature to 2090 under RCP 8.5. Applying ARR2019 results in a projected 19.7% increase in design rainfall depths, under this scenario.

A change to the downstream boundary associated with sea level rise was undertaken with the following information:

- The MHWS value of 1.54m AHD was taken from the Point Vernon.
- The 800mm increase in sea level rise was added to the MHWS to a value of 2.34m AHD.
- The sea level scenario was undertaken under the recommendation by Council and in discussion with the project team.

Overall, it is expected that the sea level aspect will impact the bottom portion of the catchment and rainfall intensity increase will have a more profound impact on the upper portions of the study area.

9 Probable Maximum Flood

The Probable Maximum Flood (PMF) was estimated using the Probable Maximum Precipitation Design Flood (PMPDF) estimation technique of ARR2019. The following methodology was undertaken:

- The Annual Exceedance Probability of the PMP was based on the guidelines outlined in ARR2019, which themselves are based on the estimates outlined in ARR1987 and found to be consistent with more recent reviews.
- Temporal patterns were based on the areal temporal patterns developed for the GTSMR PMP methods for durations greater than 24 hours (BoM, 2003), and a combination of both 24-hour GTSMR and longest duration Generalised Short-Duration Method (GSDM) patterns for durations less than 24 hours.
- For the PMF estimation as it is assumed that the pre-burst rainfalls associated with the PMP design burst will either partly or fully satisfy soil moisture deficits.

The results of the PMF assessment are shown within the Appendices.

10 Model Results and Discussion

The following section of the report provides an overview of the results of the design events simulation and also a description of the characteristics of flooding in the Eli Creek catchment.

10.1 Critical Durations

Critical durations across the catchment were informed by the design combination selection process described above. An example of the different pattern sets for the 1% AEP is shown below. A spreadsheet of all of the 347 unique events is contained within the modelling folder for future reference.

Table 10-1 1% AEP Duration and Ensemble Sets

Duration (mins)	Ensemble
30	1,3,5,7,9
60	0,1,2,3,4,5
90	1,2,3,4,8
120	0,2,4,5,7
180	3,4,6,7,8
270	0,1,2,8,9
360	1,2,3,4,5,7,8
720	0

10.2 Post Processing Information

After simulations of all the relevant events, durations and focal points the following post processing was undertaken:

- TUFLOW's asc to asc tool was utilised to collate and provide the maximum surfaces for all durations for all events.
- Each result (level, depth, hazard etc) was maximised based on the collation of the selected temporal pattern and duration and output as a maximum surface combined.
- TUFLOW's remapping tool was then utilised. The remap tool utilises sub grid sampling and the use of the underlying 1 metre digital elevation model to remap the surface to a finder resolution.

Figure 10-1 1% AEP with Climate Change Depth

10.3 Historical Flood Study Comparison

In order to provide a comparison of the new flood study results, the FCRC flood hazard mapping (of which the results were sourced from Council and the Cardno study titled Eli Creek Catchment Analysis – Flood Risk Dated 7th September 2018) and compared in GIS to the new flood study results as shown below.

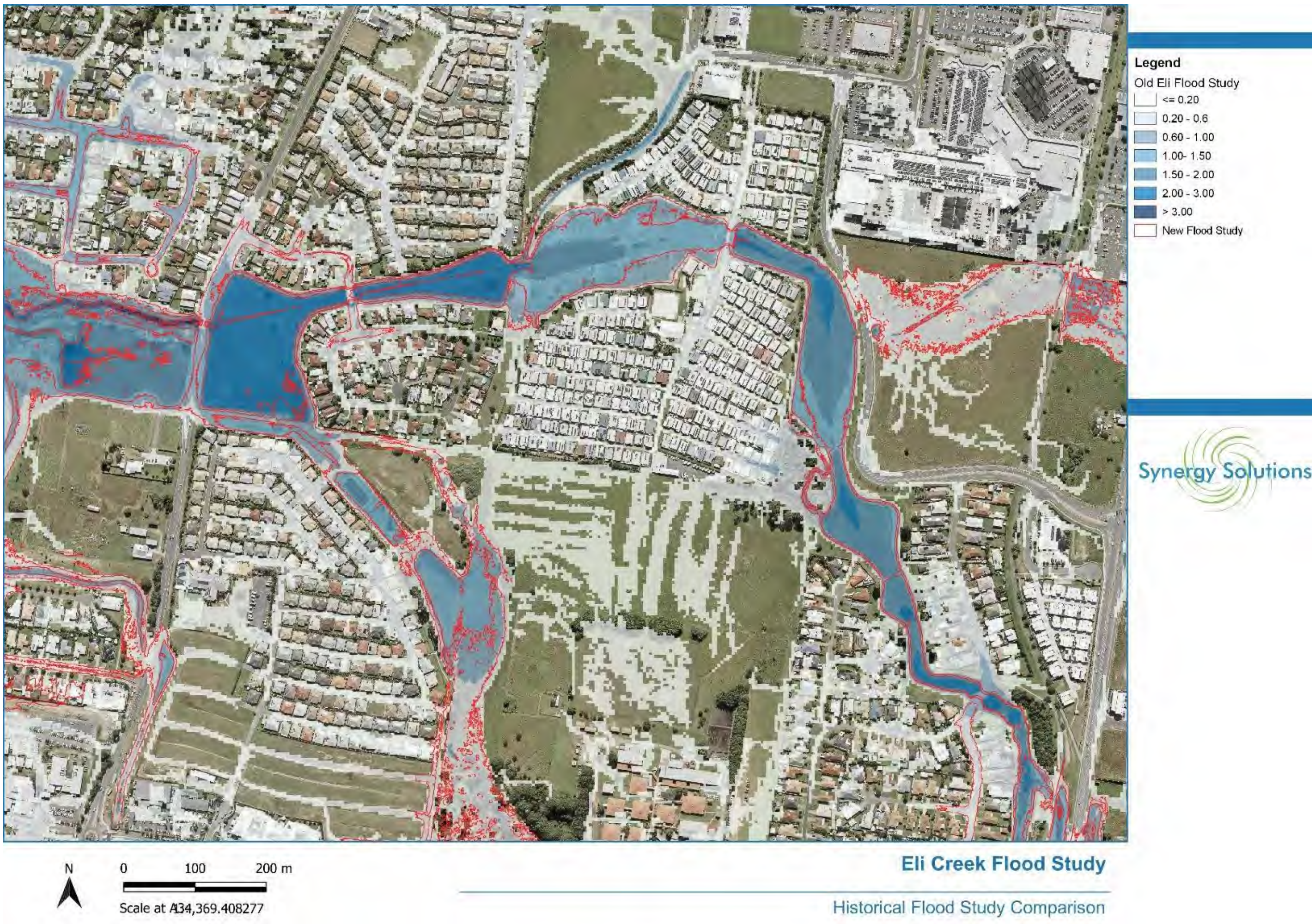


Figure 10-2 Comparison of 1%AEP Climate Change Results Area 1

Across the entire study area and an extract shown in Figure 10-2, the following differences are observed:

- In general, the flood study levels and extents are quite similar. There are however large differences in the extent within the upper catchments (where the URBS model inputs flows into the Tuflow model) and also the original direct rainfall model representing all urban drainage extents. Considering the scope of the project has required a traditional hydrologic/hydraulic model combination and also the removal of urban drainage flooding, this is considered acceptable.
- There are several areas across the catchment where new development has occurred since the historical flood model was undertaken. In addition, the latest 2022 Lidar has been utilised and it is considered the latest model is an excellent representation of present-day conditions.
- In addition, the latest model makes use of advanced features in Tuflow such as sub grid sampling and high-resolution remapping. Consequently, this provides a superior representation of the terrain (particularly steep narrow gullies). This does result in lesser flood extents and a higher flood depth in these channels and this is considered a more accurate representation of flooding.
- Considering the above and the use of lower design rainfall depths (as a result of ARR2019), the similar flood extents to the historical model indicates that a conservative approach has been taken overall.

11 Validation

Validation of flood modelling is an important component of accurate assessment of design flows and thus flood levels.

11.1 Regional Flood Frequency Assessment

An assessment below shows the design events verse the Regional Flood Frequency Estimation (RFFE) method at various locations in the catchment.

Table 11-1 RFFE verse Design Events Comparison 1% AEP

Location	1% Design Event Flow (m3/s)	RFFE Estimate (m3/s)	RFFE Lower Estimate (m3/s)	RFFE Upper Estimate (m3/s)
Bottom Catchment	202.515	509	140	1840

Table 11-2 RFFE verse Design Events Comparison 20% AEP

Location	20% Design Event Flow (m3/s)	RFFE Estimate (m3/s)	RFFE Lower Estimate (m3/s)	RFFE Upper Estimate (m3/s)
Bottom Catchment	64.619	108	44.8	262

Each estimate of design flow fits within the lower and upper bounds of the RFFE estimate, however for the 1% AEP it is noted the flows are quite low. Lower design flows are likely associated with the following components:

- Reduced rainfall depths with ARR2019 which has been noted across Queensland as an issue to address in the future.
- The RFFE website calculator notes this catchment configuration is unusual and outputs should be used with caution.
- The catchment has extensive embedded storage in upper floodplains, the lower marsh environment as well as extensive lake systems. This will impact and significantly lower design flows and result in a greater variation to the RFFE validation methods.

It should also be noted that the RFFE is an estimation method only and can be prone to significant error (and this is a reason for its current revision underway). Furthermore, without a gauge with a long history and a flood frequency assessment, there is no reasonable way to adjust/increase flows to match FFA.

It is considered that the RFFE provides a reasonable validation. The full RFFE extracts are available in the appendices.

12 Initial Flood Risk Outputs

The following information below provides flood risk outputs for further use for Council.

12.1 Overview

Council has initiated projects to develop a new flood risk-based approach that can be incorporated into the revised planning scheme. Currently Council's flood overlays which were developed prior to the introduction of the requirement of flood risk-based planning.

The aim of the flood risk framework is to implement the policy objectives of the State Planning Policy (SPP) state interest policy for Natural Hazards, risk and resilience and to ensure that the Fraser Coast Planning Scheme provides effective planning responses to flood risk. The development of the initial flood risk framework (which is currently being revised) is detailed below.

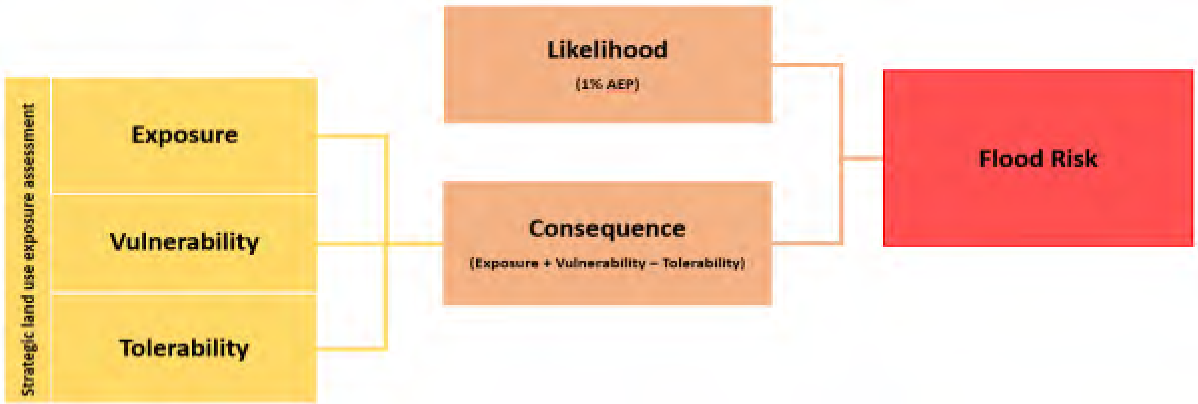


Figure 12-1 Flood Risk Development (Queensland Reconstruction Authority)

The likelihood of flooding measures how frequently a particular area floods and the size of the flood (for examples, smaller floods take place more frequently than larger floods). The SPP principles for preparing flood risk assessments requires Council to consider the widest range of flood events possible across the risk spectrum (i.e. for which data is locally available).

Hazard was determined in accordance with the generic risk approaches listed in ISO 31000. The general flood hazard vulnerability curves diagram is considered best practice and recommended by Engineers Australia and the Australian Institute of Disaster Resilience (AIDR). The hazard results were replicated using individual velocity and depth outputs, as well as the combined velocity depth product outputs from the models for likelihood and applying those outputs to the general flood hazard vulnerability curves model parameters.

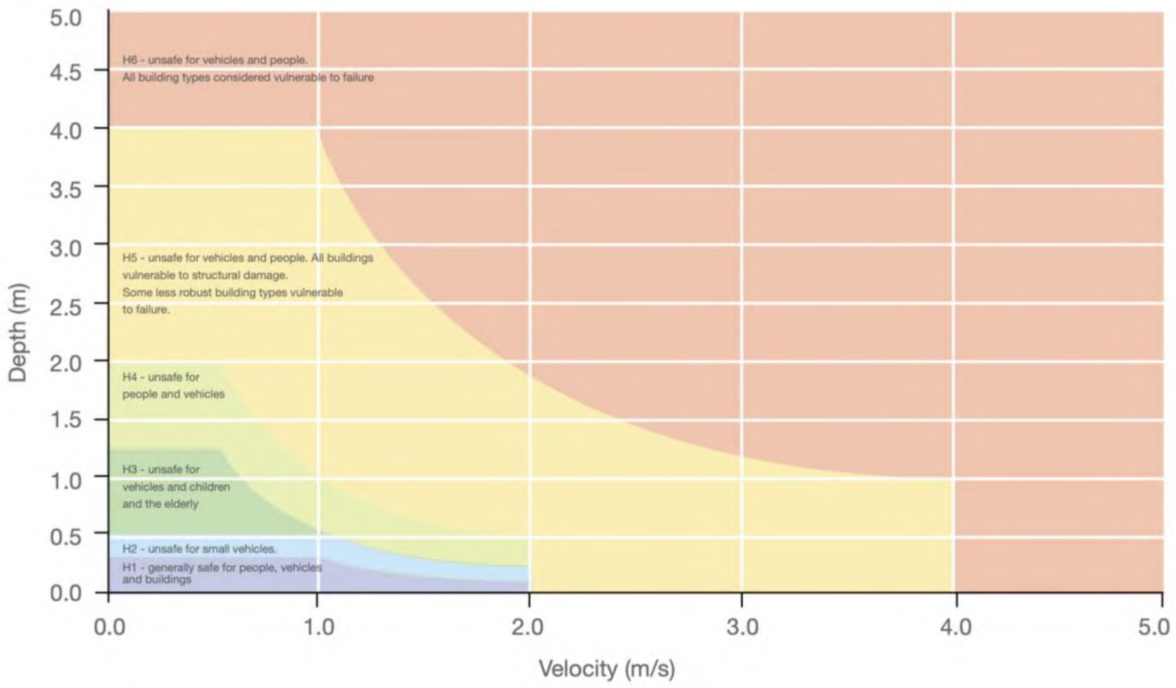


Figure 12-2 AIDR Hazard Curve

H1	Generally safe for people, vehicles and buildings.
H2	Unsafe for small vehicles. Either minimal hazard or hazard to small vehicles but is still below a traditional DFE (1%).
H3	Unsafe for vehicles, children and the elderly. These areas have the capability to cause injuries, fatalities and sweep cars away. Legitimate risk.
H4	Unsafe for people and vehicles. These areas have the capability to cause injuries, fatalities and sweep cars away. Legitimate risk.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure. These areas may cause fatalities and even structural failure of buildings. Generally high conveyance zones and any filling or works within these areas can have significant implications in neighbouring areas.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure. These areas may cause fatalities and even structural failure of buildings. Generally high conveyance zones and any filling or works within these areas can have significant implications in neighbouring areas.

Figure 12-3 AIDR Hazard Definition

The above methodologies for likelihood and hazard are combined to quantify flood risk, which resulted in the following mapped flood risk outputs listed below.

Likelihood		Hazard				Mapped Flood Risk
		Depth Velocity Classification	Limiting Factors*	General Flood Hazard Vulnerability		
1% AEP + CC	x	D*V = ≤ 0.3	2.0m/s velocity 0.3m depth	H1	=	Low
		D*V = ≤ 0.6	2.0m/s velocity 0.5m depth	H2		Medium
		D*V = ≤ 0.6 – ≤ 1.0	2.0m/s velocity 2.0m depth	H3		High
				H4		
		D*V = > 1.0	N/A	H5		Very High
				H6		

Figure 12-4 Flood Risk Output (Synergy 2020)

In addition to the 1% AEP + CC event, the Probable Maximum Flood (PMF) is used to provide an indication of the floodplain extent, and this forms the category "very low risk". Currently Council is revising the flood risk framework to incorporate other flood risk elements such as time to inundation and vulnerability etc to form a wider understanding of flood risk.

12.2 Flood Risk Multipliers

The flood risk framework above represents the initial work conducted to establish the required datasets which includes the use of Time to inundation (TTI) and Duration of Inundation (DOI) information to further establish flood risk overall. In addition, progression with the flood risk implementation framework has established risk multipliers incorporating the use of these datasets. As such an important part of this project was to produce the TTI and DOI datasets in hard copy map form and also as a gridded output that can be used at a later stage to inform the flood risk scoring and multiplying.

12.3 Initial Flood Risk Outputs

The existing outputs were used to produce the flood risk outputs with a python script developed by Synergy. One example of the existing flood risk output is shown below, and all are provided in the Appendices.

Figure 12-5 Flood Risk Map Output

12.4 Time to Inundation and Duration of Inundation Outputs

As described above, the TTI and DOI datasets were produced with the following process:

- The flood models were setup to output a time series XMDF file to enable the use of time based information.
- The model event run times were extended on one longer duration run (12 hours) to ensure the longest durations were captured.
- The 1% AEP and 1% AEP + Climate change were produced.
- The information was then post processed into a suitable WaterRIDE format. For each event, all of the durations and target temporal patterns (30+ variations) were processed and the maximum and minimum results used for DOI and TTI.

- A depth threshold of 50mm was applied to the calculations (i.e. a value is recorded once the depth exceeds 50mm). This will result in a slight difference between mapped outputs on the outer extent of mapping.
- It should be noted for the duration of inundation map, due to the initial water levels within the model, the MHWS boundary and other factors, some areas of the model remain permanently “wet”. As such some of these areas with 150 hours+ of duration are not accurate. Investigation of these areas show they are restricted to areas of no urban population and within lakes systems (i.e. not flooding houses).

The DOI and TTI outputs for the 1% AEP are shown below.

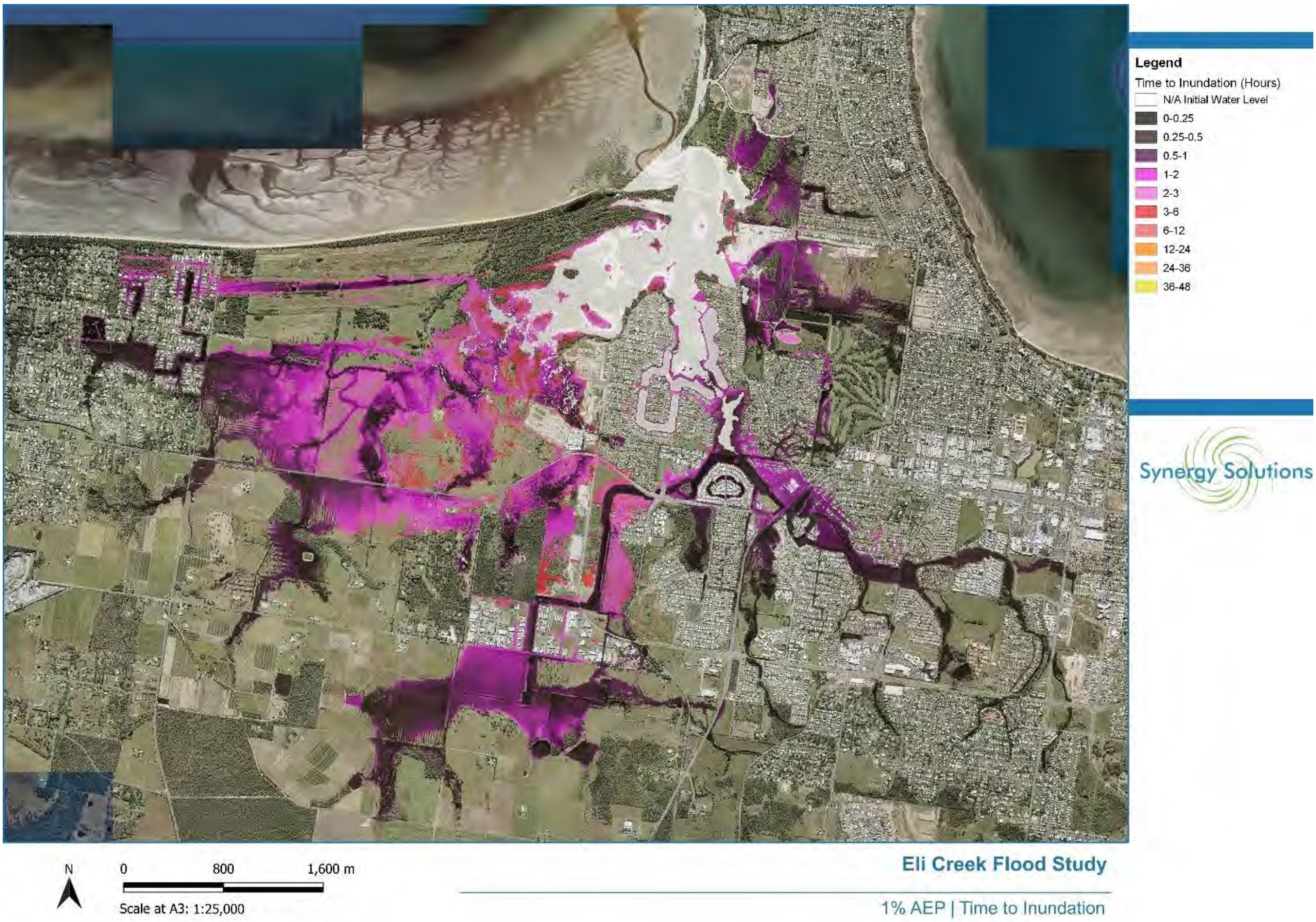


Figure 12-6 1% AEP Time to Inundation

Figure 12-7 1% AEP Duration of Inundation

13 Conclusion

The Eli Creek Flood Study has been undertaken to fulfill the requirement of the scope and to provide Fraser Coast Regional Council a robust flood model for planning purposes. The model may also be utilised in further assessment of development scenarios and impact, culvert upgrades and an initial flood risk-based assessment.

14 Limitations and Assumptions

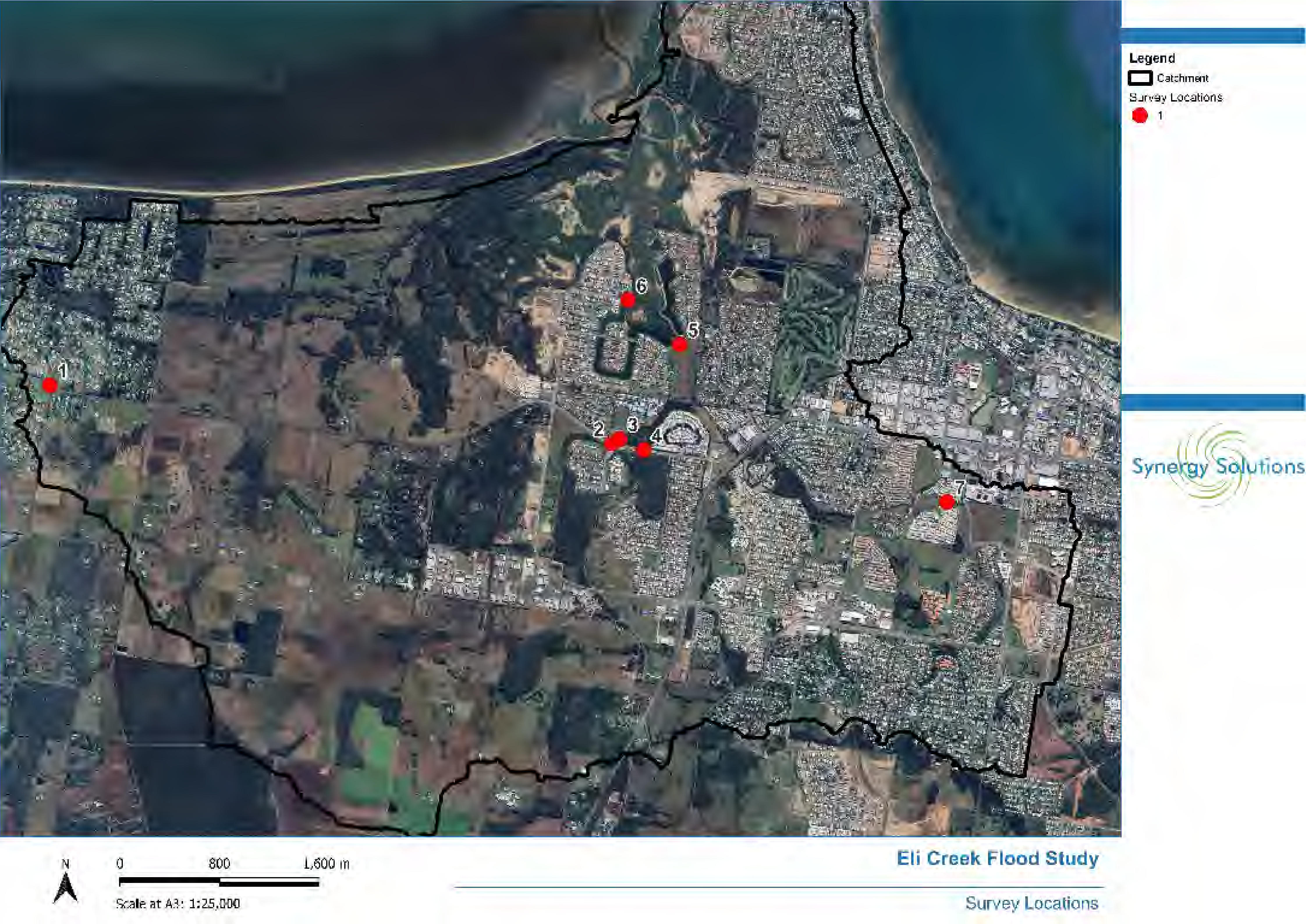
The work undertaken in this report and project, is subject to the following limitations:

- Data provided by external sources and Council is assumed true and correct.
- Aspects of this project have been discussed and agreed with Fraser Coast Regional Council. Limitations are present within these joint project decisions and have been identified.
- Future use of this flood model requires an understanding of the events, durations and temporal patterns utilised. Synergy Solutions have documented and handed over all necessary data to Council for this to occur.

15 Appendix A | Model Build

Eli Creek Flood Study

Sub Catchments



Eli Creek Flood Study

Survey Locations

Synergy Solutions

Eli Creek Flood Study

1D Network

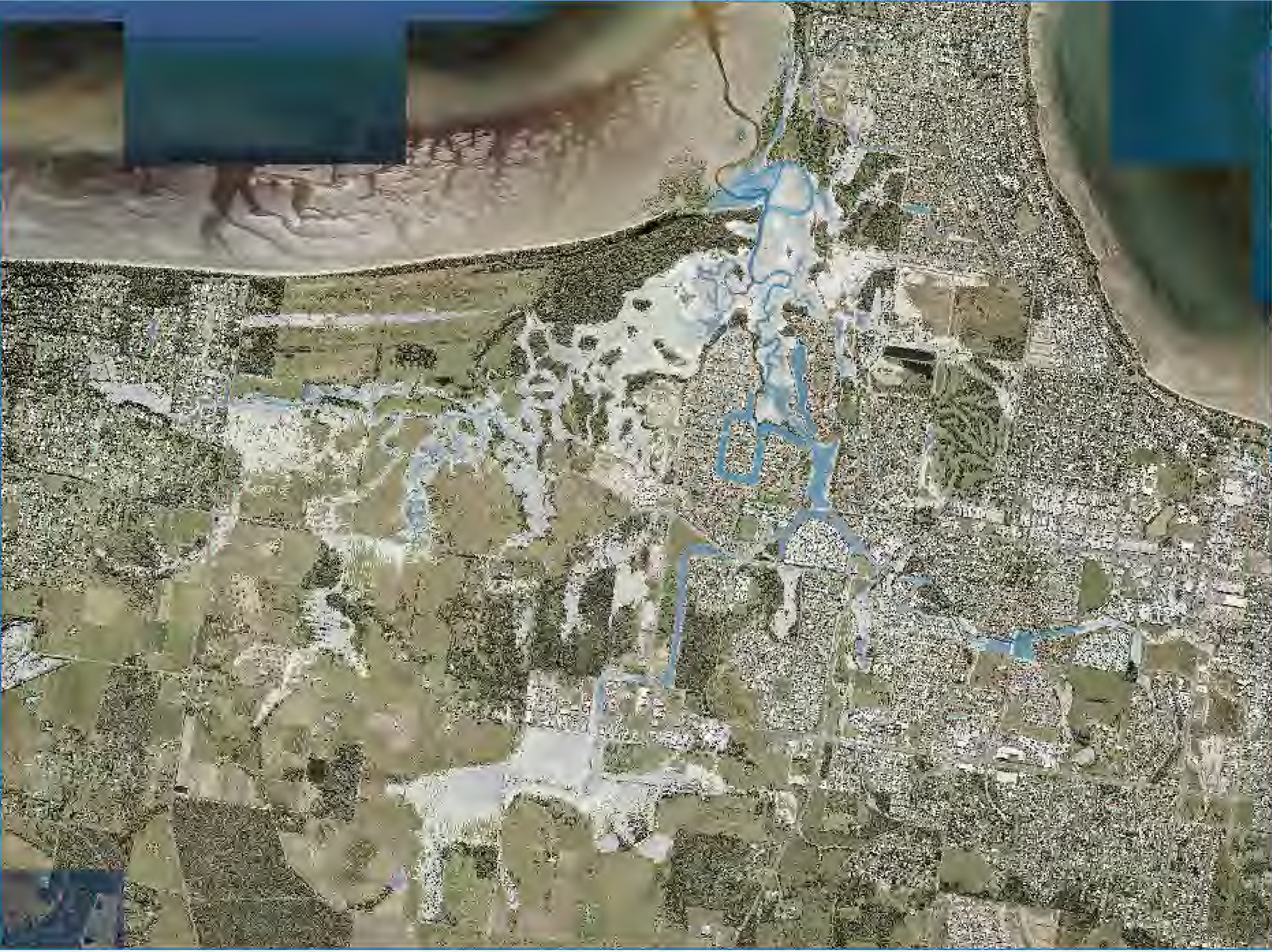
Eli Creek Flood Study

Breakline Locations

Eli Creek Flood Study

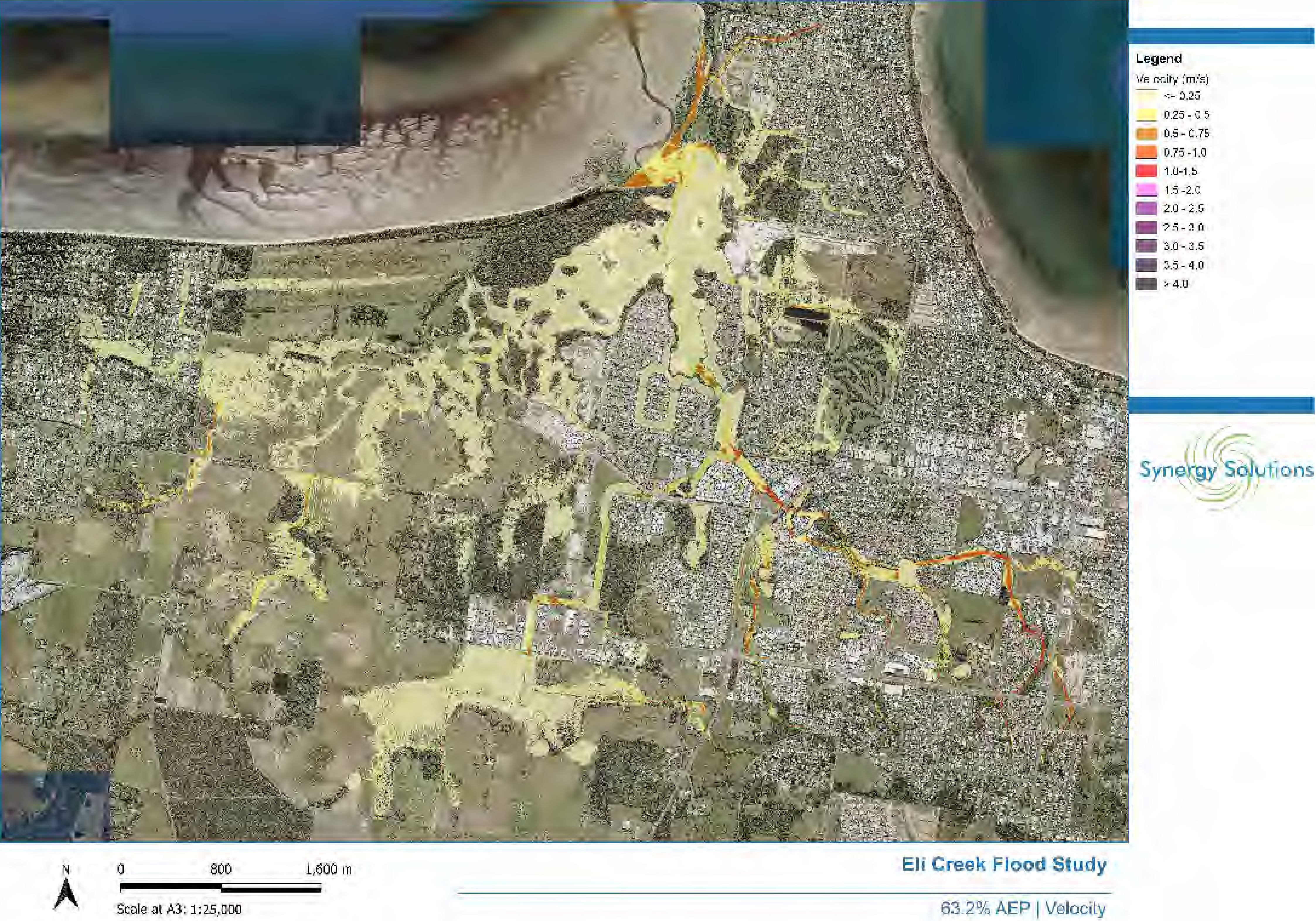
Mannings Roughness

16 Appendix B | Existing Flood Maps



Eli Creek Flood Study

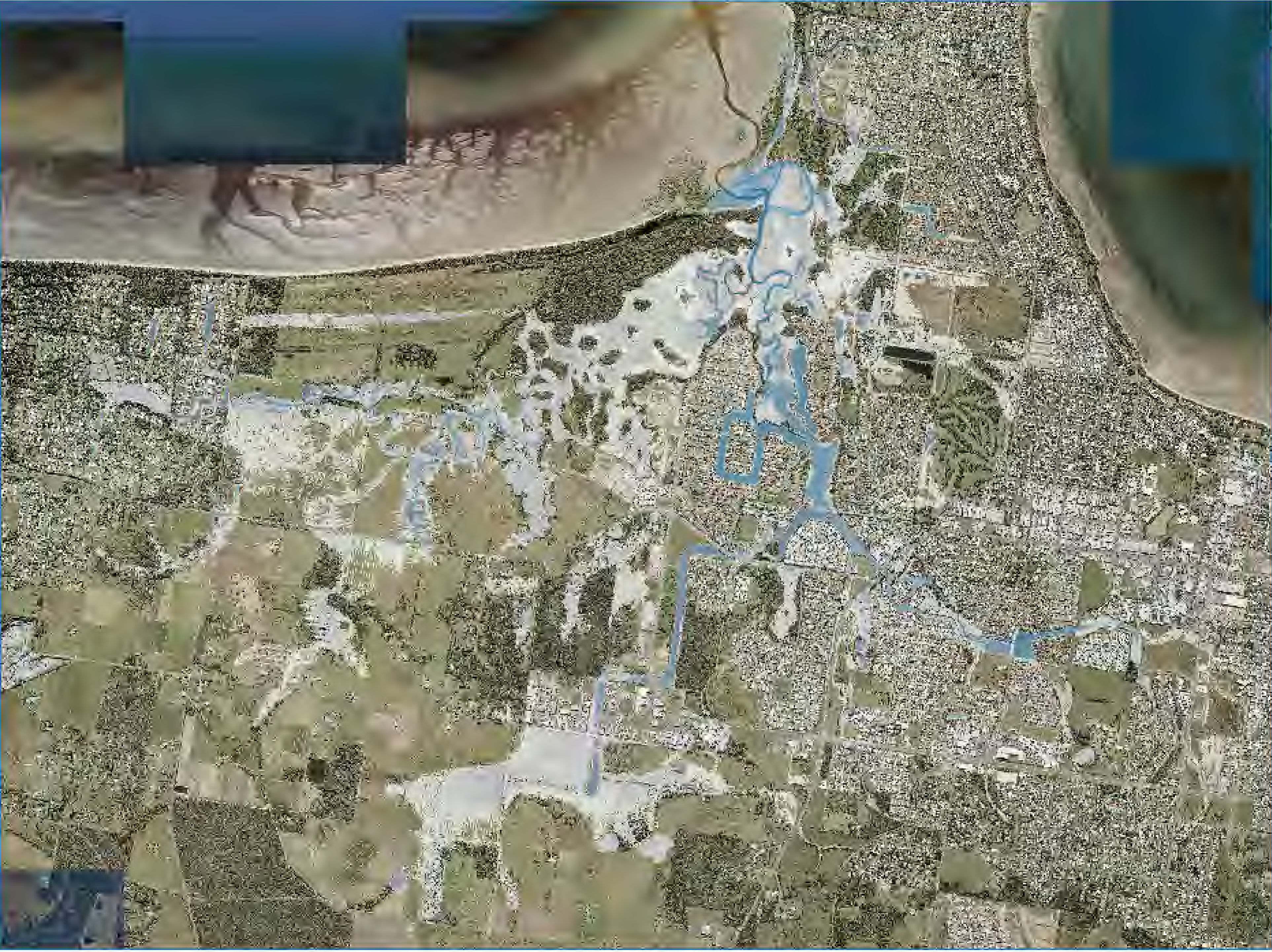
63.2% AEP | Depth



Synergy Solutions

Eli Creek Flood Study

63.2% AEP | Velocity



Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

N

0 800 1,600 m

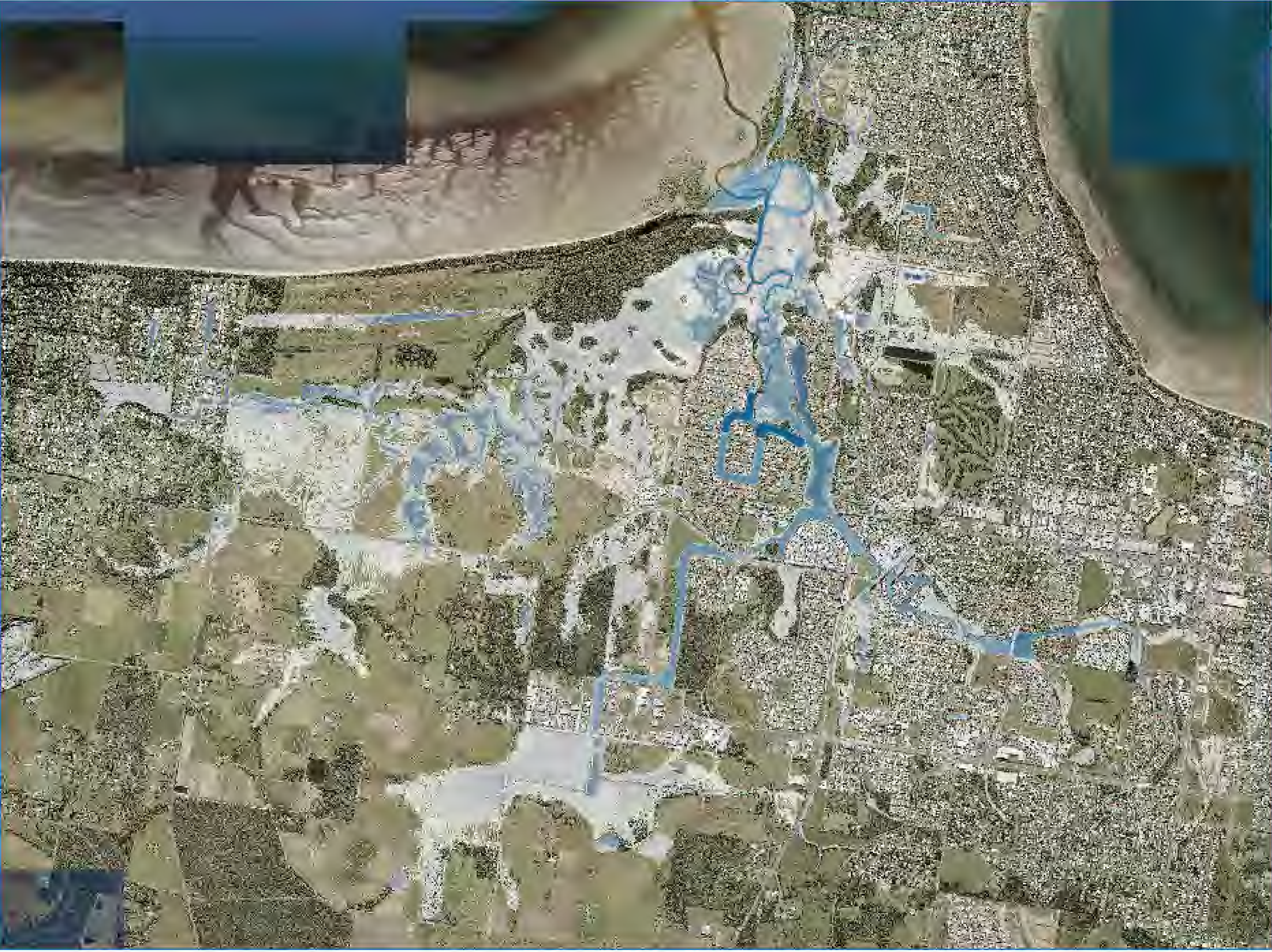
Scale at A3: 1:25,000

Eli Creek Flood Study

39.35% AEP | Depth

Eli Creek Flood Study

39.35% AEP | Velocity



Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

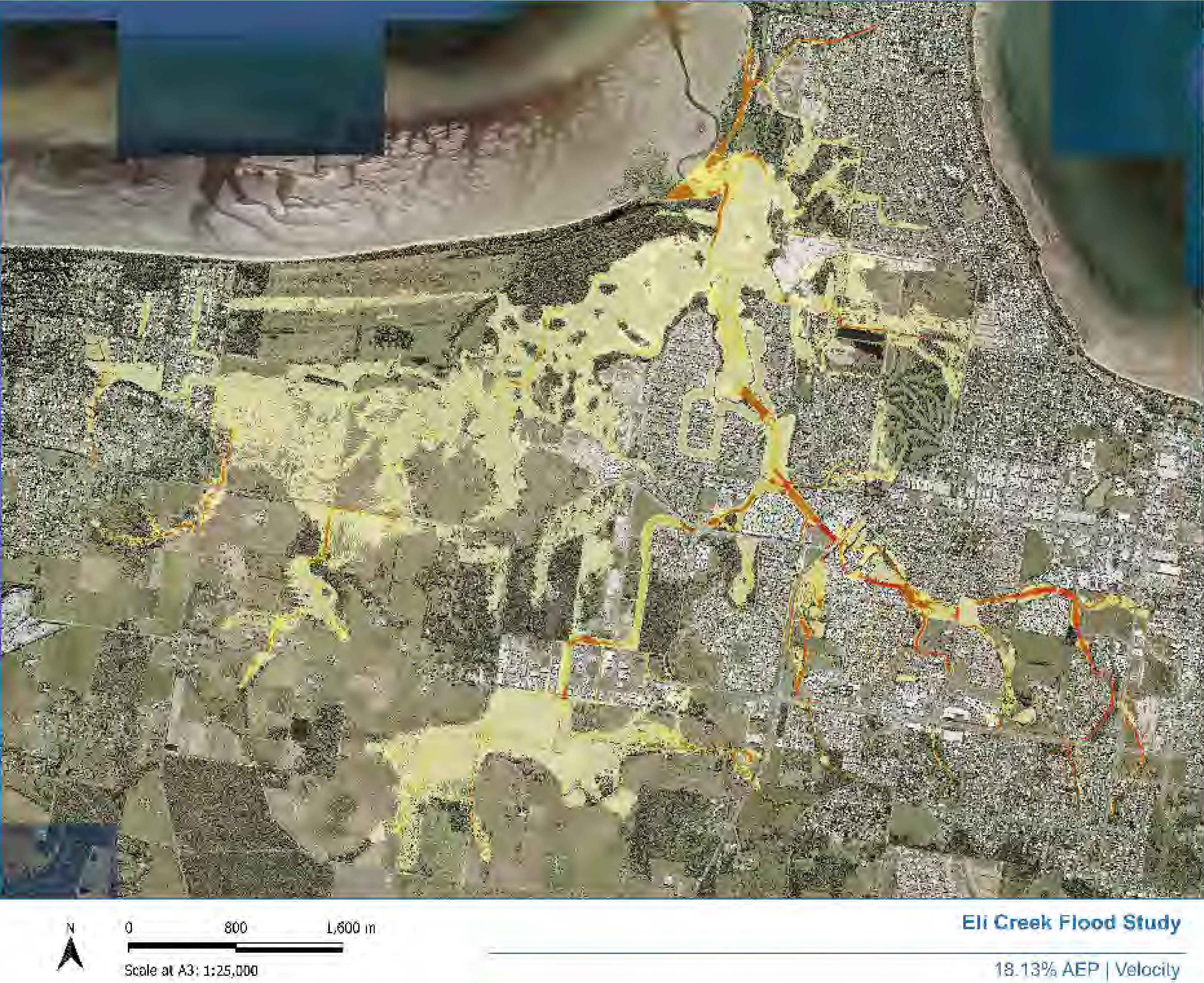
N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

18.13% AEP | Depth



Legend

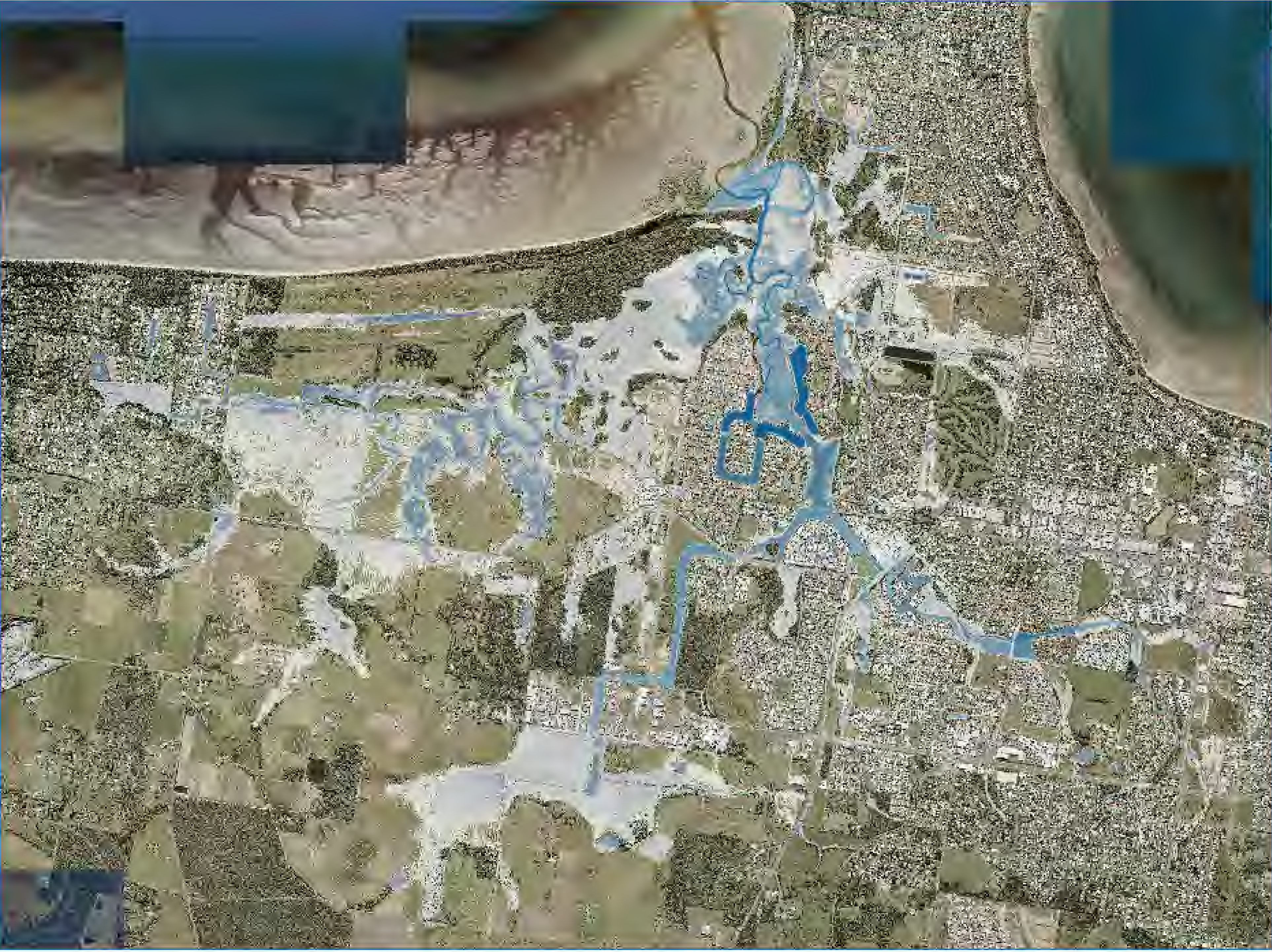
Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0-1.5
- 1.5 -2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- > 4.0

Synergy Solutions

Eli Creek Flood Study

18.13% AEP | Velocity



Legend

Depth (m)

	<= 0.20
	0.20 - 0.60
	0.60 - 1.00
	1.00- 1.50
	1.50 - 2.00
	2.00 - 3.00
	> 3.00

Synergy Solutions

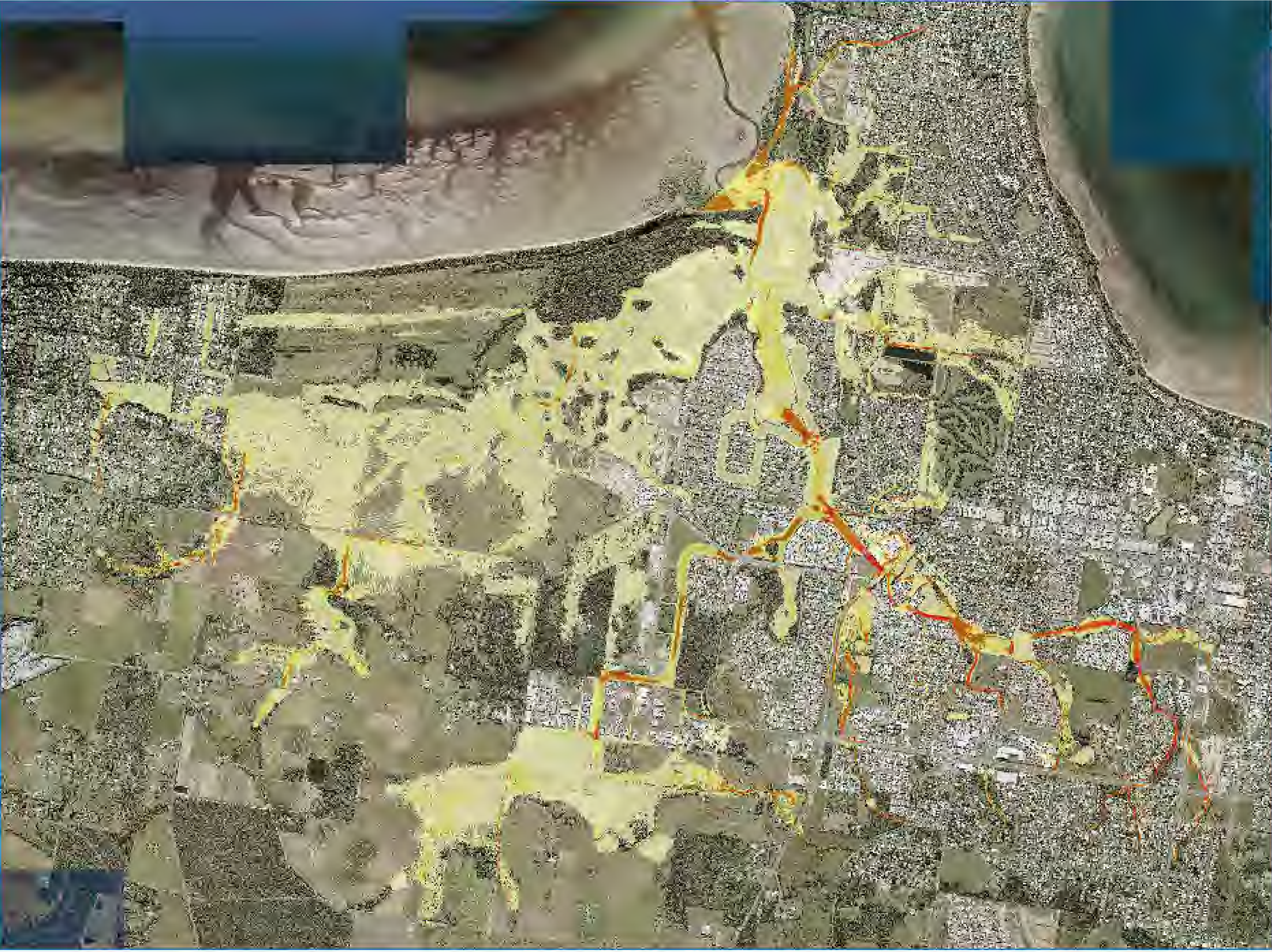
N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

10% AEP | Depth



Legend

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0-1.5
- 1.5 -2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- > 4.0

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

10% AEP | Velocity

Legend

Depth (m)

<= 0.20

0.20 - 0.6

0.60 - 1.00

1.00- 1.50

1.50 - 2.00

2.00 - 3.00

> 3.00

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

5% AEP | Depth

Scale at A3: 1:25,000

Eli Creek Flood Study

5% AEP | Velocity

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

N

0 800 1,600 m

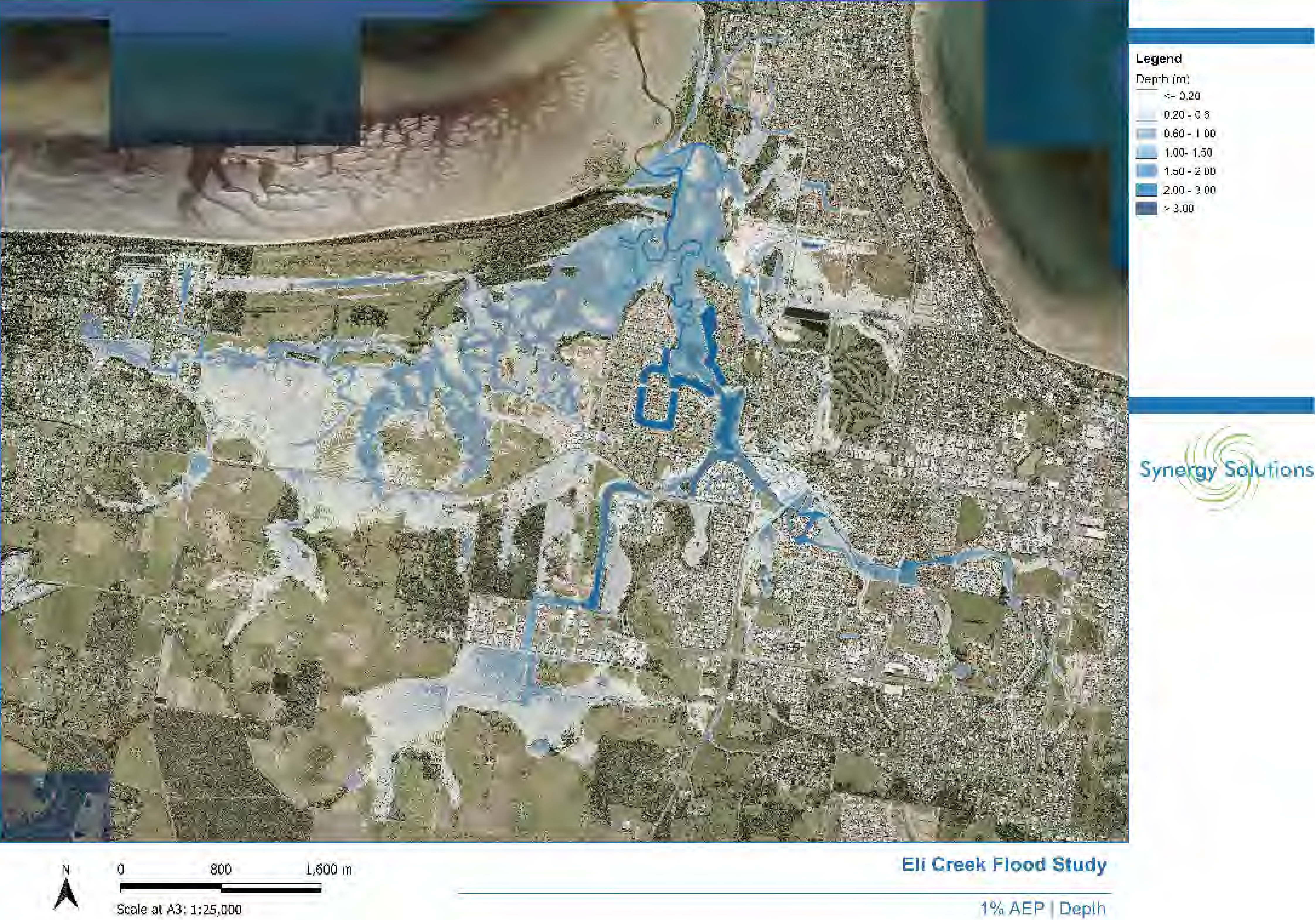
Scale at A3: 1:25,000

Eli Creek Flood Study

2% AEP | Depth

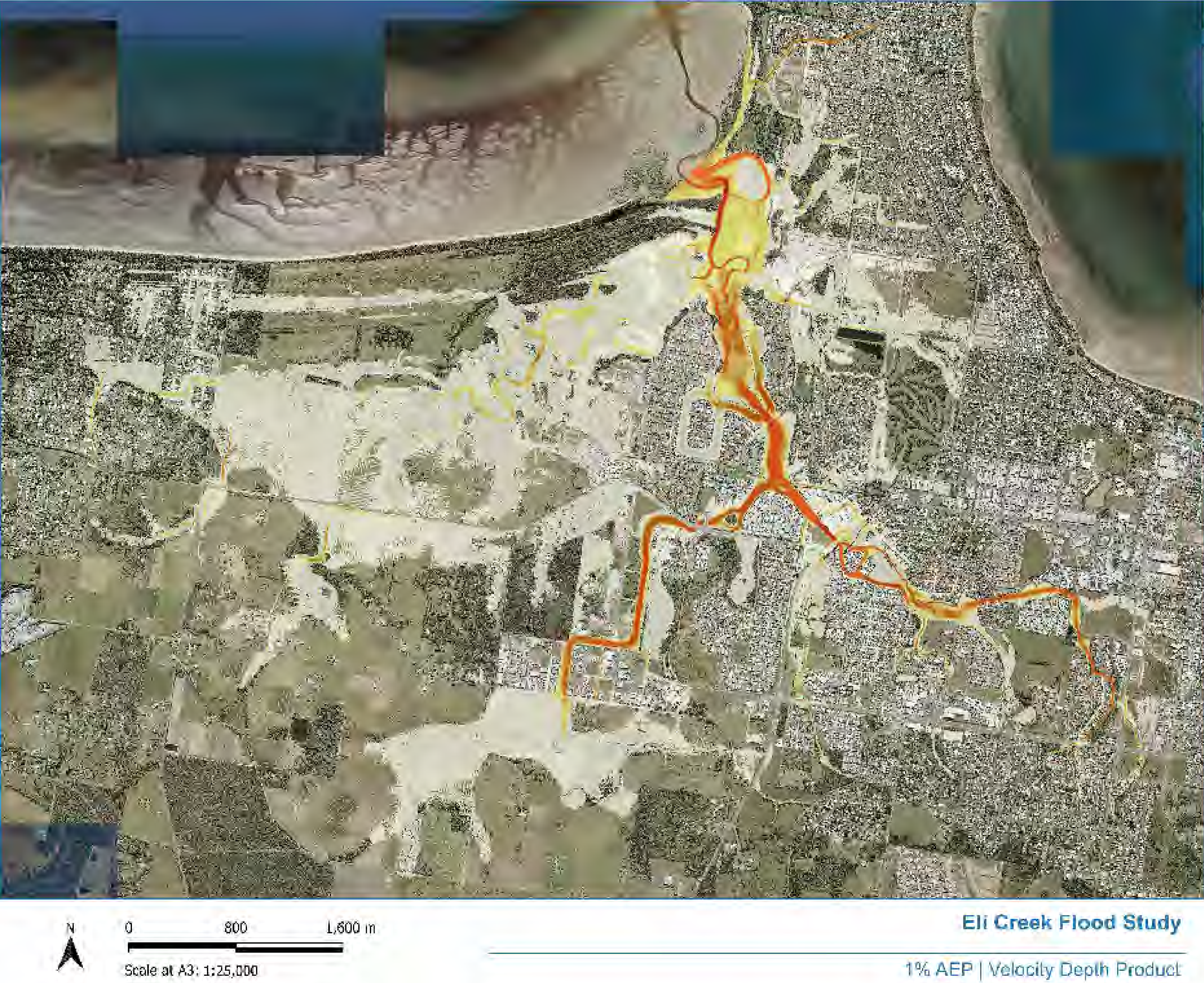
Eli Creek Flood Study

2% AEP | Velocity



Eli Creek Flood Study

1% AEP | Depth



Legend

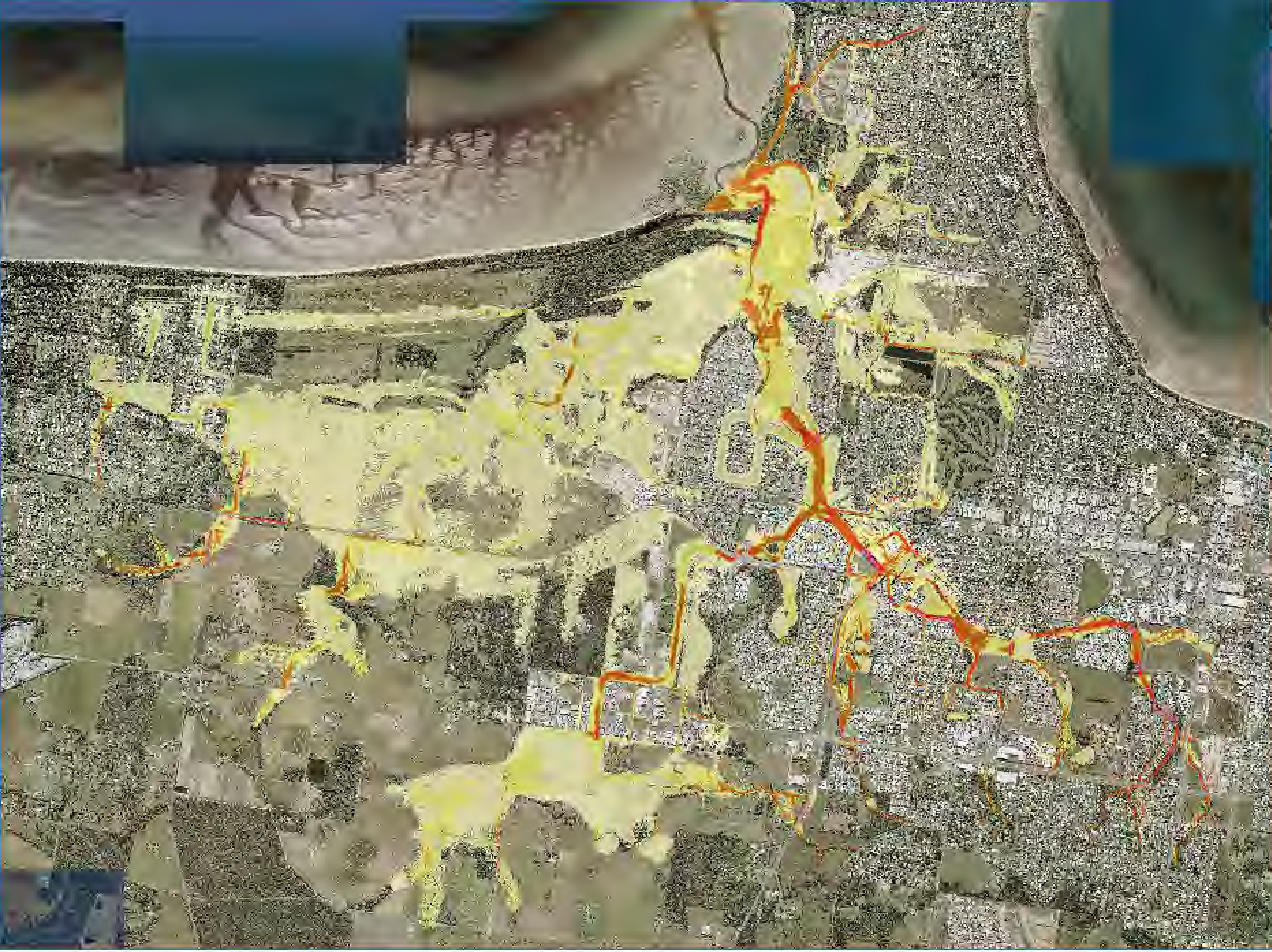
VD Product (m2/s)

- <= 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 2.0
- > 2.0

Synergy Solutions

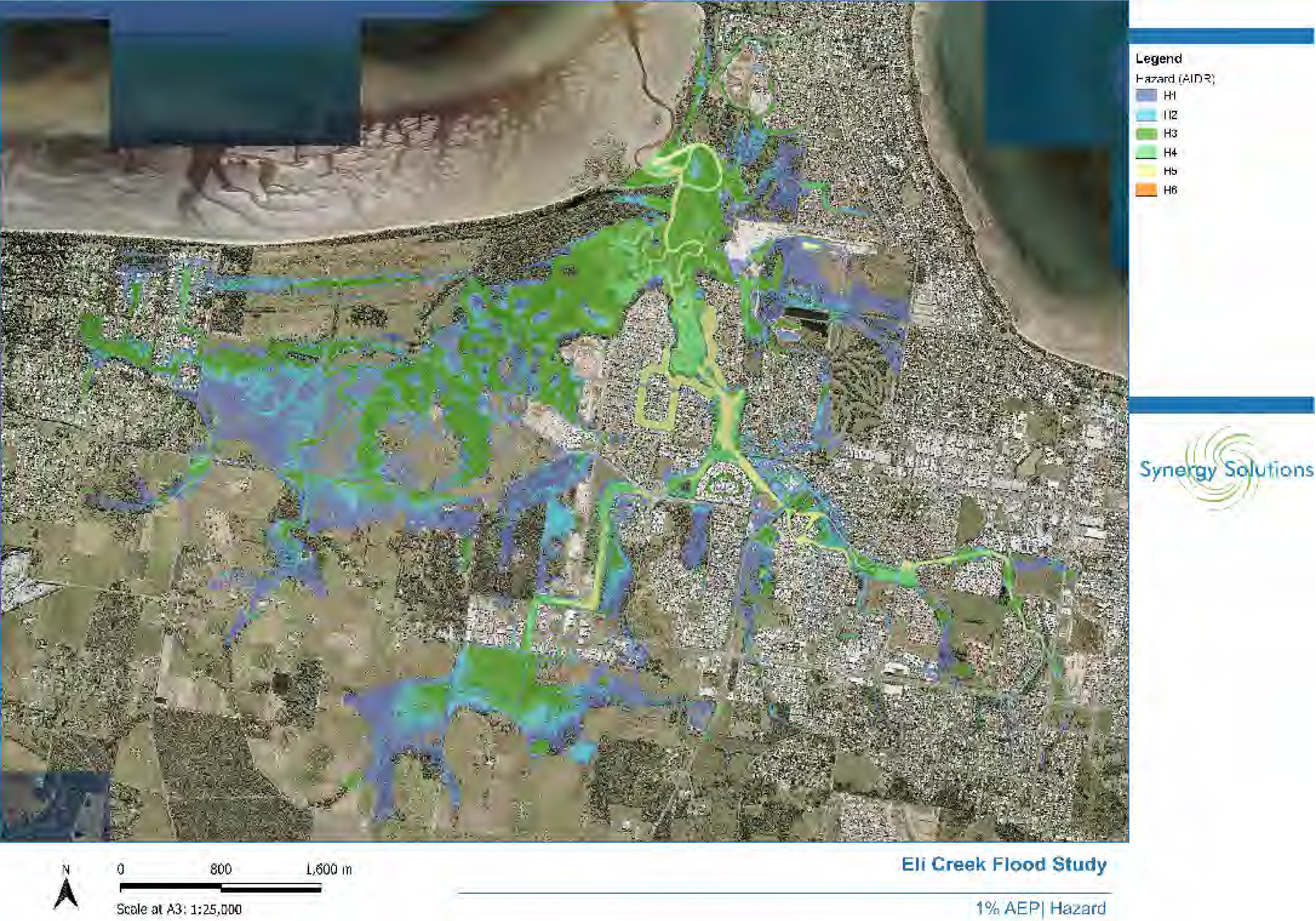
Eli Creek Flood Study

1% AEP | Velocity Depth Product



Eli Creek Flood Study

1% AEP | Velocity



Eli Creek Flood Study

1% AEP| Hazard

Legend

Depth (m)

<= 0.20

0.20 - 0.6

0.60 - 1.00

1.00- 1.50

1.50 - 2.00

2.00 - 3.00

> 3.00

Synergy Solutions

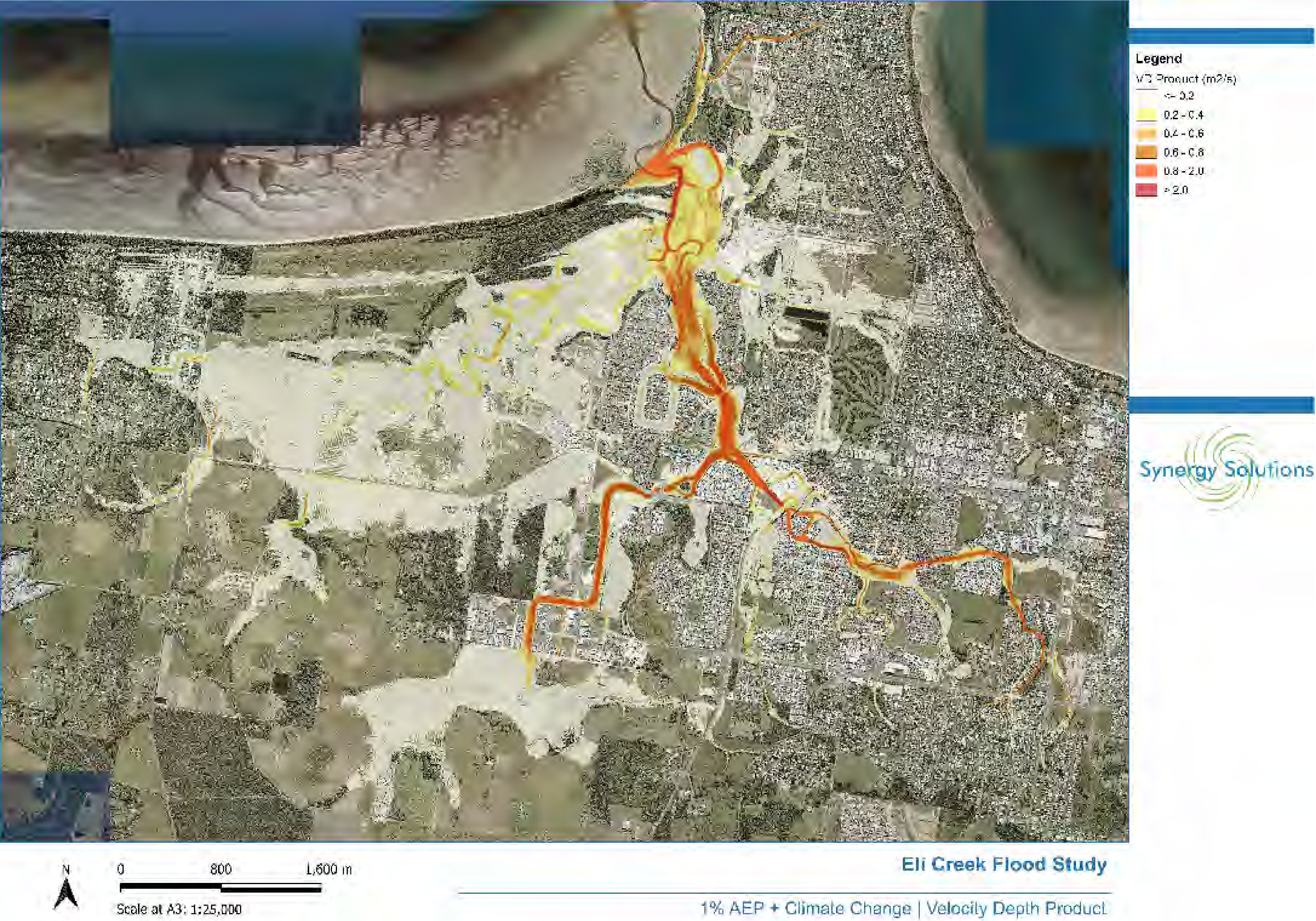
N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

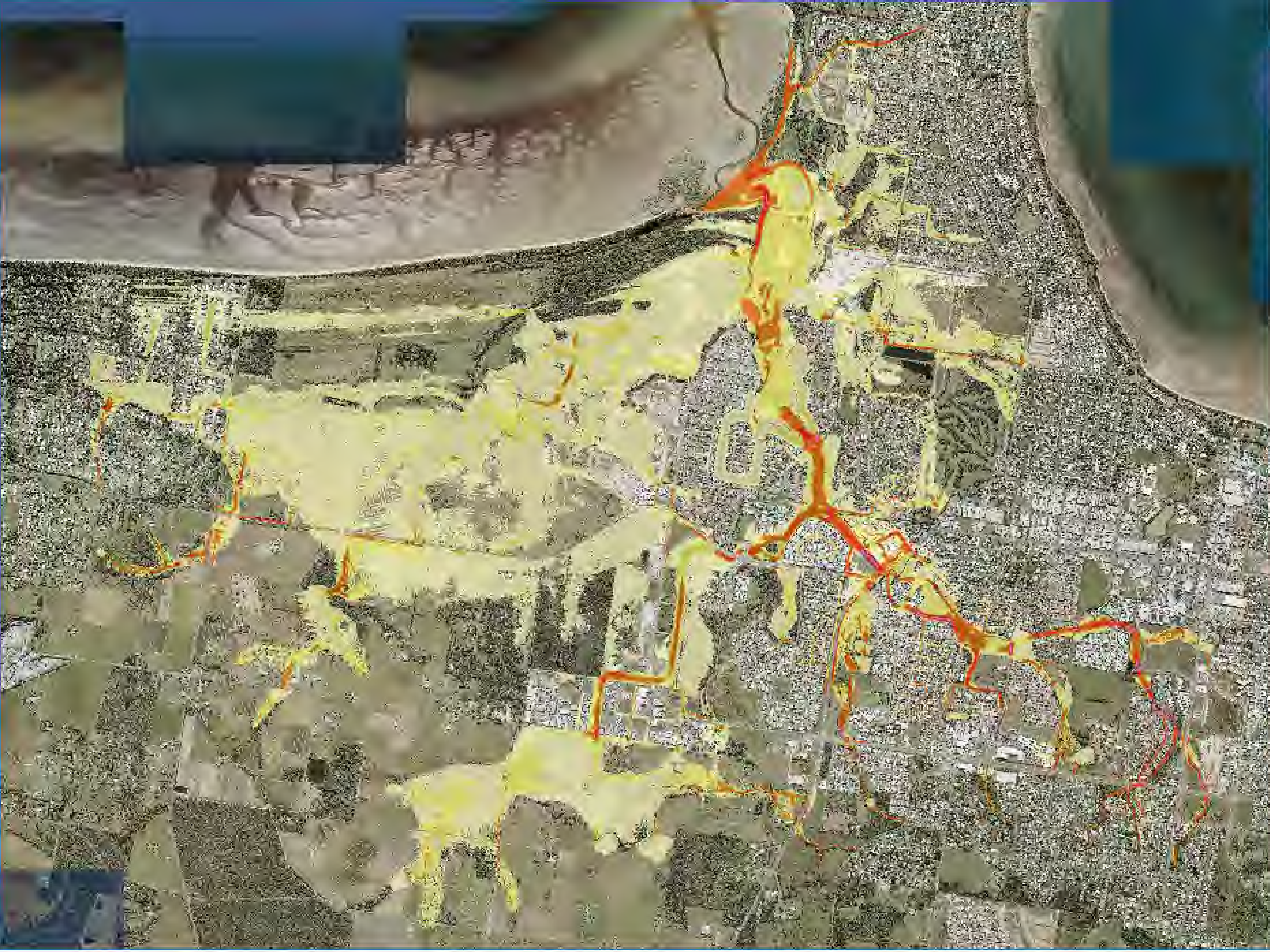
1% AEP + Climate Change | Depth



Synergy Solutions

Eli Creek Flood Study

1% AEP + Climate Change | Velocity Depth Product



Legend

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0-1.5
- 1.5 -2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- > 4.0

Synergy Solutions

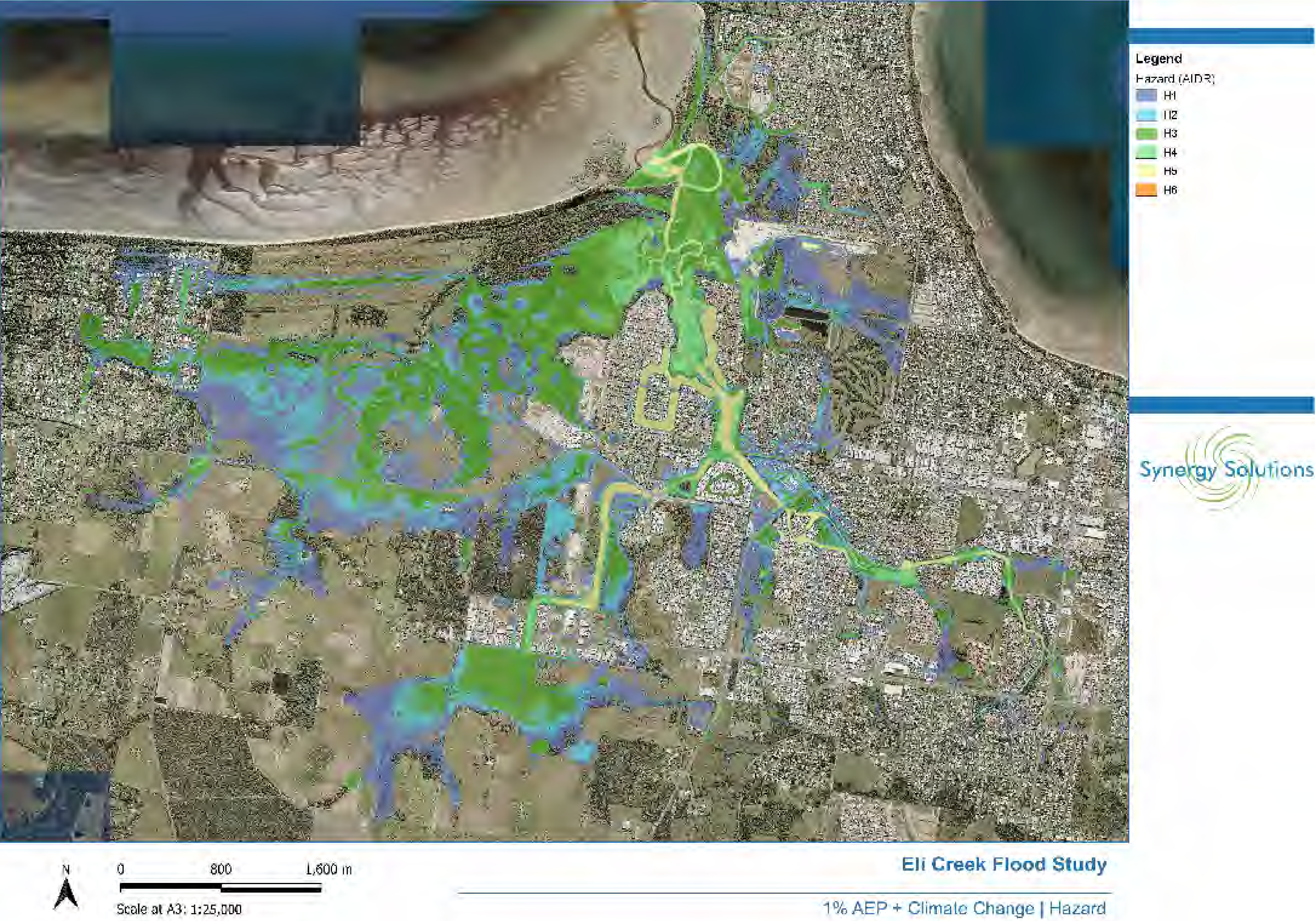
N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

1% AEP + Climate Change | Velocity



Eli Creek Flood Study

1% AEP + Climate Change | Hazard

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

0.2% AEP | Depth

Eli Creek Flood Study

0.2% AEP | Velocity

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

Eli Creek Flood Study

0.05% AEP | Depth

Legend

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0-1.5
- 1.5 -2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- > 4.0

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

0.05% AEP | Velocity

Legend

Depth (m)

<= 0.20

0.20 - 0.6

0.60 - 1.00

1.00- 1.50

1.50 - 2.00

2.00 - 3.00

> 3.00

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

Probable Maximum Flood | Depth

Eli Creek Flood Study

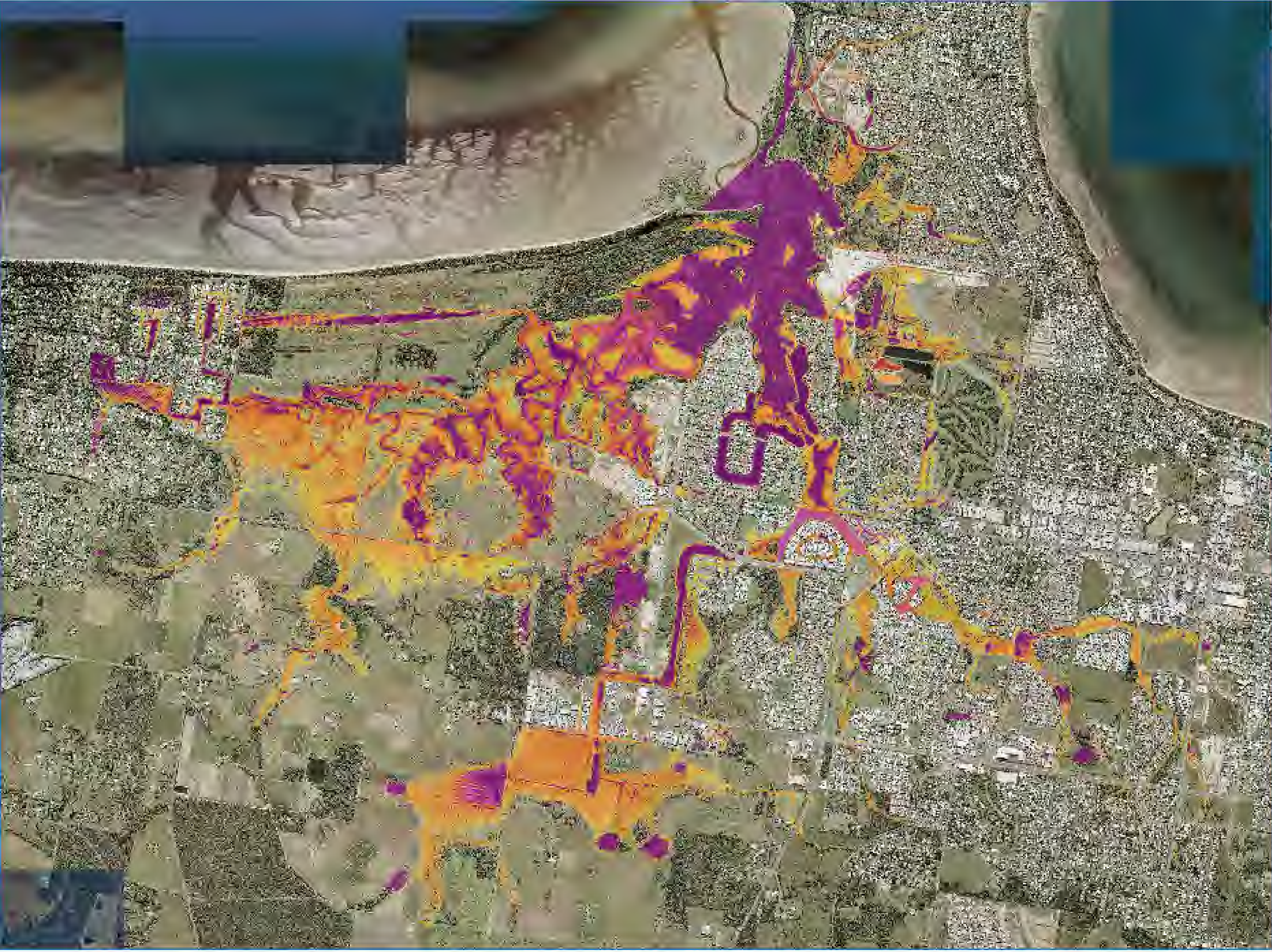
Probable Maximum Flood | Velocity

17 Appendix C | Existing Flood Risk Maps

Synergy Solutions

Eli Creek Flood Study

1% AEP | Time to Inundation



Legend

Duration of Inundation (Hours)

- 0-1
- 1-2
- 2-3
- 3-6
- 6-12
- 12-24
- 24-36
- 36-48
- 48-72
- 72-120
- >120

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

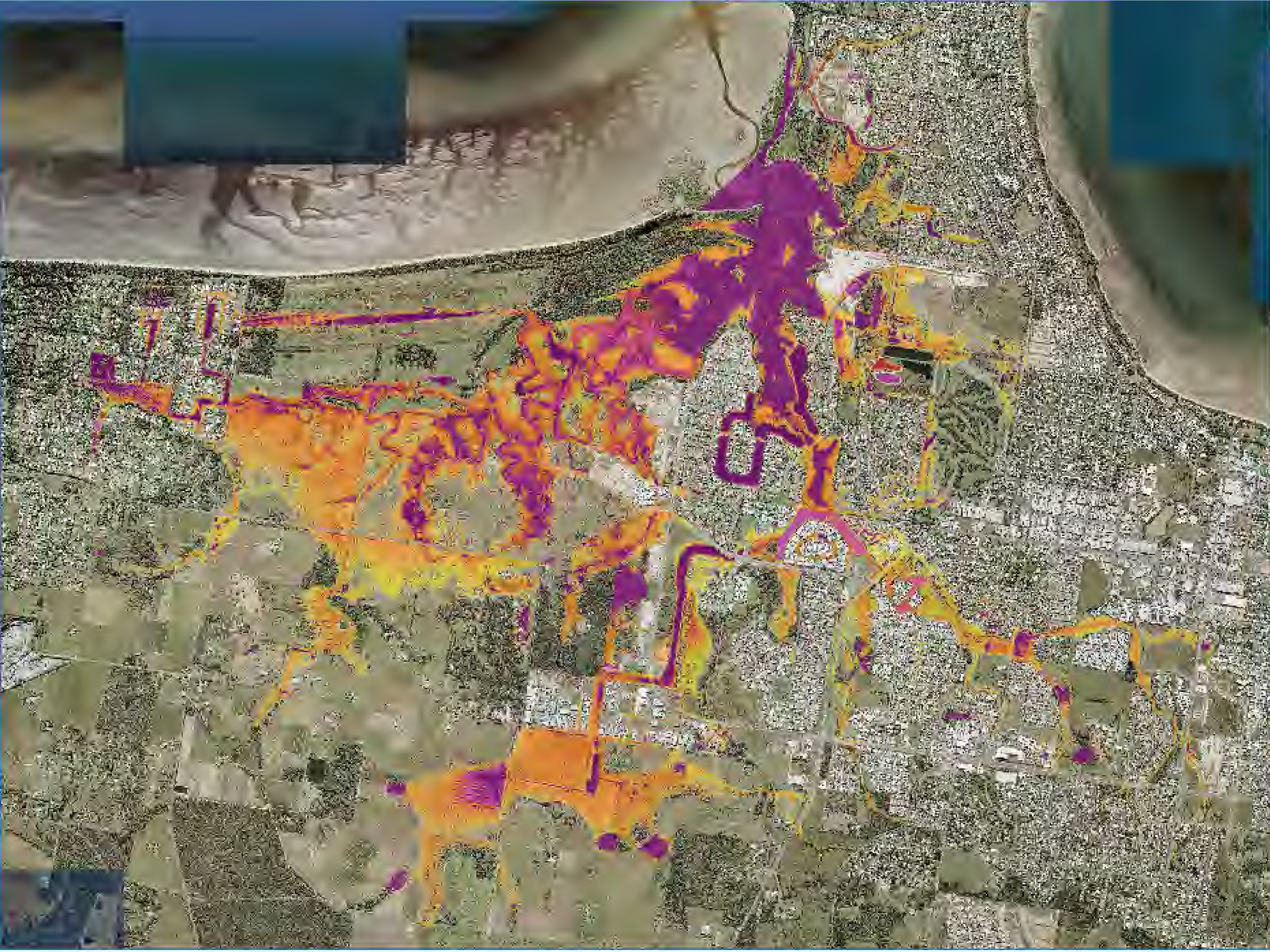
Eli Creek Flood Study

1% AEP | Duration of Inundation

Synergy Solutions

Eli Creek Flood Study

1% AEP Plus Climate Change | Time to Inundation



Eli Creek Flood Study

1% AEP Plus Climate Change | Duration of Inundation

Legend

Flood Risk

- Floodplain Extent
- Low Risk
- Medium Risk
- High Risk
- Very High Risk

Synergy Solutions

N

0 800 1,600 m

Scale at A3: 1:25,000

Eli Creek Flood Study

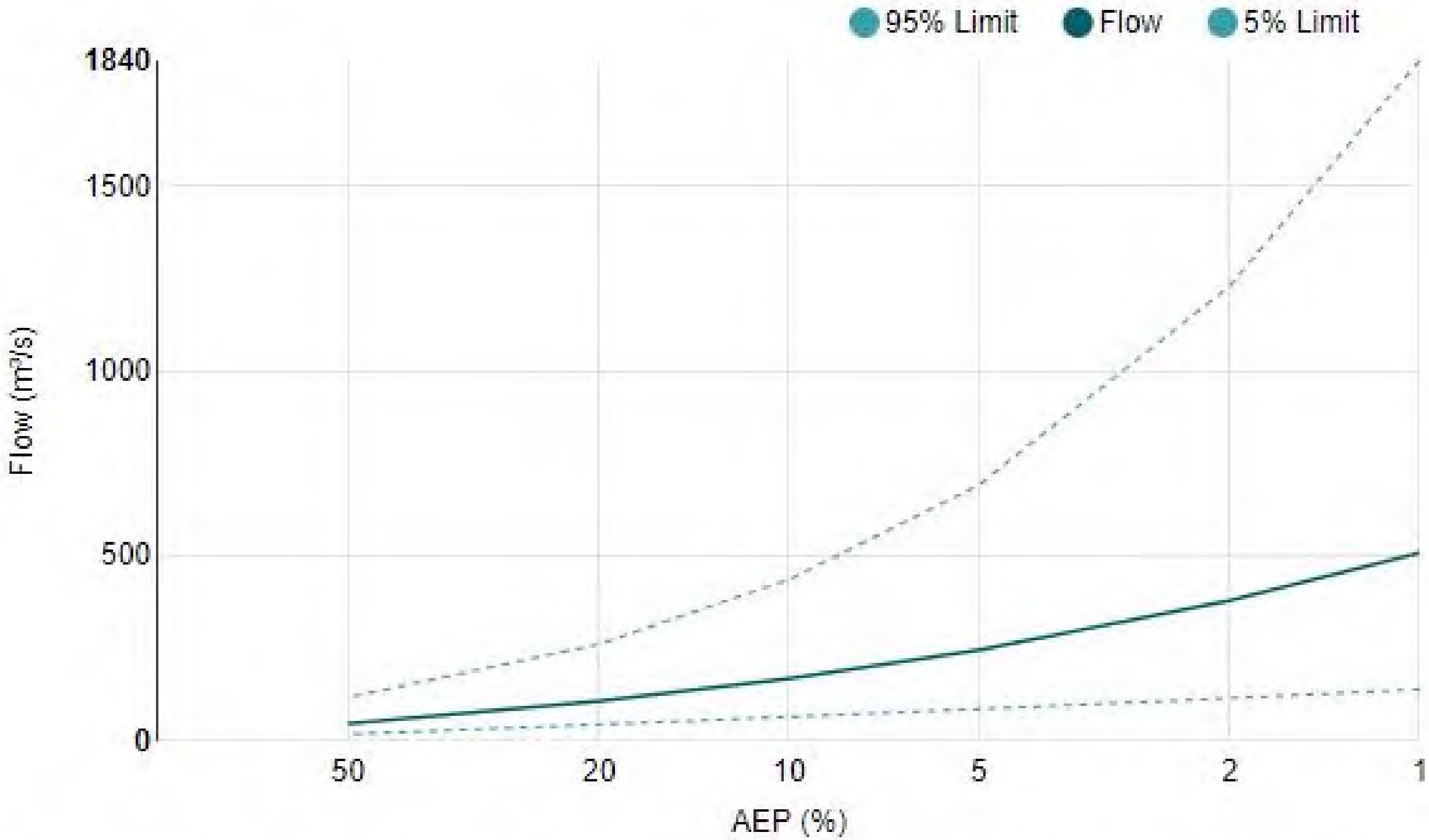
Existing Flood Risk | (PMF and 1% AEP)

Synergy Solutions

Eli Creek Flood Study

Existing Flood Risk | (PMF and 1% AEP Plus Climate Change)

18 Appendix D | RFFE Results



*The catchment has unusual shape. Results have lower accuracy and may not be directly applicable in practice.

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	47.1	18.7	118
20	108	44.8	262
10	169	65.5	437
5	246	86.5	692
2	380	116	1230
1	509	140	1840