Fraser Coast Regional Council

Tinnanbar Catchment

Flood Study Report

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Issue Rev 1

SYNERGY

"The interaction of elements that when combined produce a total effect that is greater than the sum of the individual elements"

Document Status

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Project Details

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2 Executive Summary

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

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

2. Design events have been undertaken utilising 2019 Australian Rainfall and Runoff methods. The study has simulated all the events, durations and ensembles in the hydraulic model to ensure the catchment is fully understood and represented.

3. The flood study results were utilised to provide outputs such as level, depth and velocity for all events. In addition, the hazard outputs were used to produce an initial flood risk-based output which can be utilised in the future for risk based land use planning endeavours.

4. The results revealed that the township of Tinnanbar is generally not impacted by flooding up to and including the Probable Maximum Flood

5. The flood study results were utilised to better understand constraints within the road network, particularly for the main entrance and exit routes to the coastal township. The assessment revealed that consideration may be required to be given to upgrading culverts on Tinnanbar Road to provide a higher level of flood immunity for emergency access.

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

3 Background

Synergy Solutions has been engaged by Fraser Coast Regional Council to undertake a package of flood studies within the Great Sandy Strait area. These consist of four regional creek models and five urban drainage models to better understand the flood risk and constraints associated with flooding. This report represents the Tinnanbar catchment and the riverine/creek flooding that impacts the township.

The Tinnanbar catchment is within the Fraser Coast Region and is located adjacent to the Great Sandy Strait and aspects of the catchment include:

- The total modelled catchment area is approximately 10.7 square kilometres in area although this consists of a variety of catchments to cover all gullies around the area.
- The catchment consists of the coastal township of Tinnanbar.
- There is no named creek within the area, though there are a number of major gullies. The catchments discharge to Sandy Strait adjacent Tinnanbar.
- The catchment consists of primarily rural zoning throughout. The township of Tinnanbar has a mix of rural residential and low density residential zonings. Detailed assessment of this has been undertaken in the township urban drainage models.
- There are no bridges within the model and only a few major cross drainage structures.
- Vehicle (and emergency) access to Tinnanbar is restricted with only one road (Tinnanbar Road) which connects the township to Maryborough Cooloola Road.

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 2014 was made available that covered all the catchment (and all the hydraulic area) initially.

Furthermore, the 2022 Lidar was made available in December 2022 and used in the final existing and design modelling runs.

4.3 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 culverts throughout the catchment. Measurements were taken of culvert dimensions where possible and safe/practical 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.
- A detailed review and inspection of major culverts was undertaken to fill missing gaps of Council and DTMR information. Measurements were taken for the number of culverts/pipes and their sizes.

4.4 External Agency Data

DTMR was contacted by Council to source information on cross drainage information. DTMR supplied some information on cross drainage structures for Maryborough Cooloola Road which was incorporated into the modelling. It should be noted that many culverts had to be estimated due to the lack of data made available.

5 Hydrologic Model Development

The following information lists the information, parameters and analysis that was undertaken 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 into sub catchment breakdown, routing parameters and rainfall data. The sub catchment breakdown was also undertaken to ensure major cross drainage culverts were represented and any major trunk drainage systems.

As discussed with Council, the main requirements of this study were to ensure the main Council owned cross drainage structures where possible were modelled.

Sub Catchment Delineation

The sub catchment breakdown was undertaken initially with HEC-HMS and then refined manually to ensure the correct placement of connections to the 2D model and to ensure future development areas could be well represented.

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.

URBS Parameters

URBS parameters were selected based on recommendations in the URBS manual and an understanding of previous projects of a similar nature in Fraser Coast and other Council areas. As no calibration was undertaken/possible, refinement of the URBS parameters was not possible.

6 Hydraulic Model Development

As part of the flood study for the Tinnanbar catchment, a detailed 1D/2D TUFLOW model has been developed. The TUFLOW model was based on TUFLOW software version 2020-10-AE-iSP-w64 and 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 to align with LiDAR information available and to locally focus on the key areas of the Townships and major cross drainage structures. The extents were also determined by Council's brief and the requirement of the majority of the catchment to be modelled hydraulically.

6.2 Boundaries

The upstream and downstream boundaries of the model have been carefully selected to provide the best balance of a highly detailed local assessment, without extending hydraulic representation in the very upper reaches of the catchment.

This enables better capture of the two main tributaries and the focus for the study. 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.
- A downstream boundary that is a sufficient distance from the interest areas, however it is noted that this is restricted due to the close proximity to Sandy Strait. The downstream boundary has been assigned using a HT boundary to simulate existing 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. Sub grid sampling was utilised to enable the use of the underlying 1 metre DEM.

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.

The following is noted with regards to this:

- Combinations of grid sizes of between 5 metres and 20 metres were simulated for a range of combinations of events, durations and ensembles.
- As per guidance provided by Tuflow, it was found that the flows and timing were relatively insensitive to grid size due to the use of Sub Grid Sampling. The table below shows the negligible differences between 5 to 20 metre cell size.

- Due to the complexity of this catchment, it was determined that running ALL of the events, durations and ensembles hydraulically with a slightly coarser grid was the ideal way forward.
- 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.

Table 6-1 Grid Comparison Assessment

Output	5m Grid	10m Grid	15m Grid	20m Grid
Flow (m3/s)	79.383	80.033	80.744	81.455
Time to Maximum (hours)	4.58	4.58	4.58	4.5

As it can be seen from the table, there is negligible difference between scenarios and thus it was determined that a slightly coarser grid size could be used.

6.5 Hydraulic Structures

Major hydraulic cross drainage structures have been represented in the Tinnanbar catchment and modelled within the 1D Estry model of Tuflow. 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 and all the cross-drainage structures were represented. The extent of this representation was defined by the sub catchment breakdown and the desire from Council to have focus on the Council owned roads.

It should be noted that as part of this project, a detailed urban drainage flood study has been undertaken on the townships. These models provide a better understanding of the urban drainage issues of the townships and fully represent the urban drainage network accordingly.

Figure 6-1 Modelled 1D Network

Bridges
On the Tinnanbar system there are no bridges present or modelled.

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, artificial intelligence and field inspections. The Manning's roughness classifications are shown in the tables and figures below.

The process for defining the Mannings roughness values was as follows:

- The background planning scheme zones were used as a first reference.
- GIS process and artificial intelligence (AI) was used to establish a surface mannings roughness. The process uses types of examples manually implied and AI then applies this to the entire catchment. This becomes the initial basis and provides an exceptional level of detail for vegetation.
- Council's road and buildings GIS layers are then utilised to override the raster.

- Other major features (such as major grass, waterways and concrete channels) are manually specified.
- The mannings roughness files are then read in the exact order listed above.

Manning's roughness values were be refined as necessary to provide a locally specific application for the flood model.

Table 6-2 Manning's Roughness Values

Classification	Manning's n
Light Vegetation/floodplain	0.050
Open Ground	0.045
Dense Vegetation	0.085
Bare Earth	0.035
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

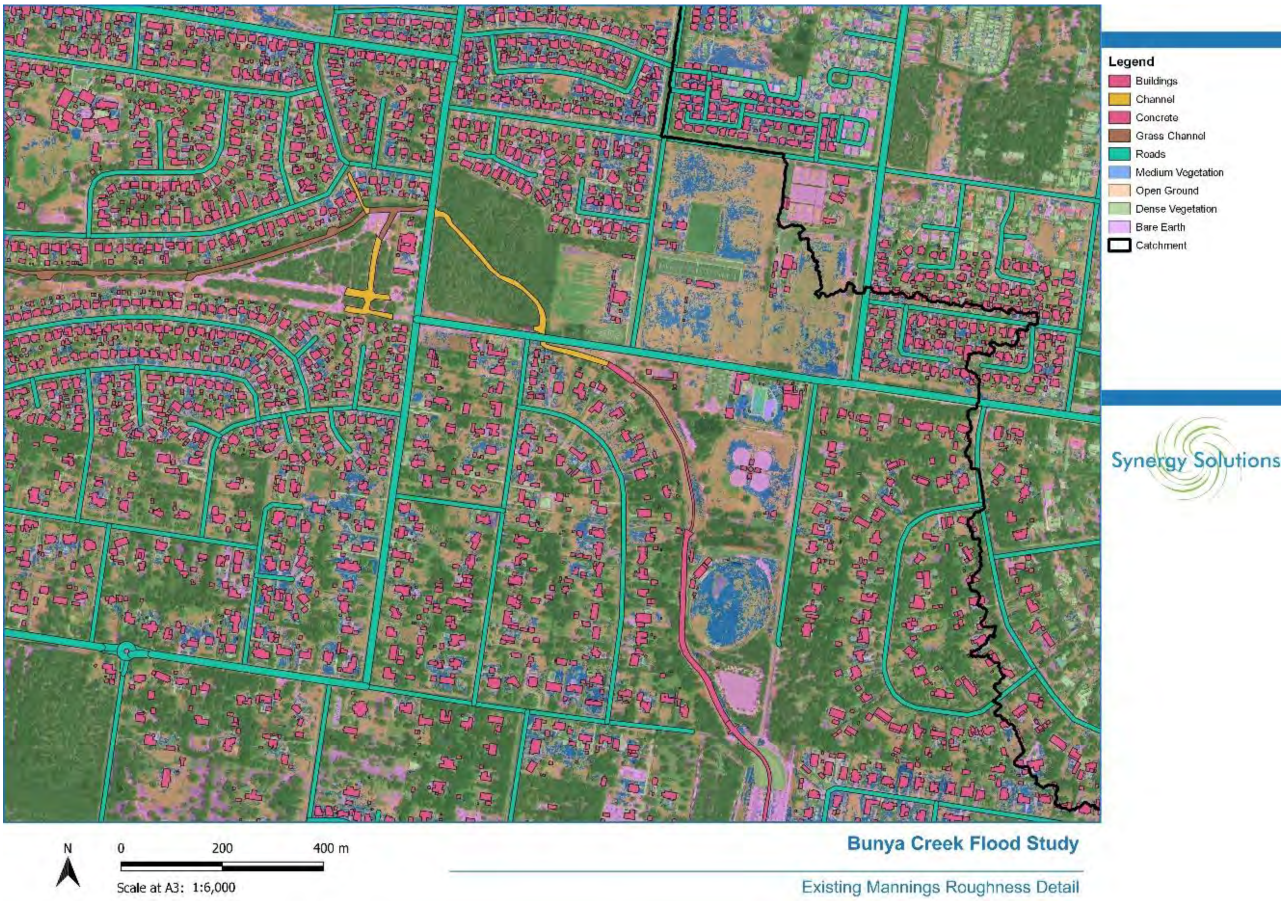


Figure 6-2 Mannings Roughness Example

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. It was not possible to use the URBS model for temporal pattern selection due to the unusually low slopes in the coastal catchments. However, the method adopted was superior regardless and reduced uncertainty.
- Tuflow's median ensemble batching tool was used to find the median temporal pattern for each duration and event. Tuflow's maximum surface tool was then used to provide a maximum surface of all the median durations combined for the entire catchment.
- 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.

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 FCRC Planning Scheme Losses

Zone	Initial Loss	Continuing Loss
Impervious Surface	0	0
Pervious Surfaces (non-sand)	15	2.5
Pervious Surfaces (sand)	35	2.5

The following is noted with regards to losses

- The Datahub initial loss provides an initial loss of 58mm and 7.2mm continuing loss.
- For coastal regions, FCRC's scheme recommends 35mm and 2.5mm.
- Previous works in Bunya Creek with a calibrated model resulted in losses of 25mm and 2.0mm.

A direct rainfall model was undertaken for the region using the ARR datahub losses above. The results indicated that no /minimal flow would be output from the hydrology model until above the 39.2% AEP event (i.e. no flooding would occur in the catchment).

Discussion with Council indicated that this was not representative of the catchment conditions or the region in general. Thus, a decision was made to utilise the FCRC values of 35mm and 2.5mm to ensure a conservative output was gained. Essentially this would also offset some of the issues that are faced with regards to a reduction in rainfall depths with the latest ARR2019 revision.

7.4 Aerial Reduction Factors

Areal Reduction Factors (ARFs) have not been applied as the focus of the study is across the entire catchment. This provides a conservative assessment for multiple points of interest.

8 Climate Change Assessment

The longest 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 Tinnanbar 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 0.98m AHD
- The 800mm increase in sea level rise was added to the MHWS to a value of 1.78m 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 of the Tinnanbar system.

10.1 Median Temporal Pattern Selection

As described previously, all events, durations and ensembles were simulated through the hydraulic model. Tuflow's median ensemble batching tool was used to find the median temporal pattern for each duration and event. An example of this is shown below for the 1% AEP 2 hour duration.

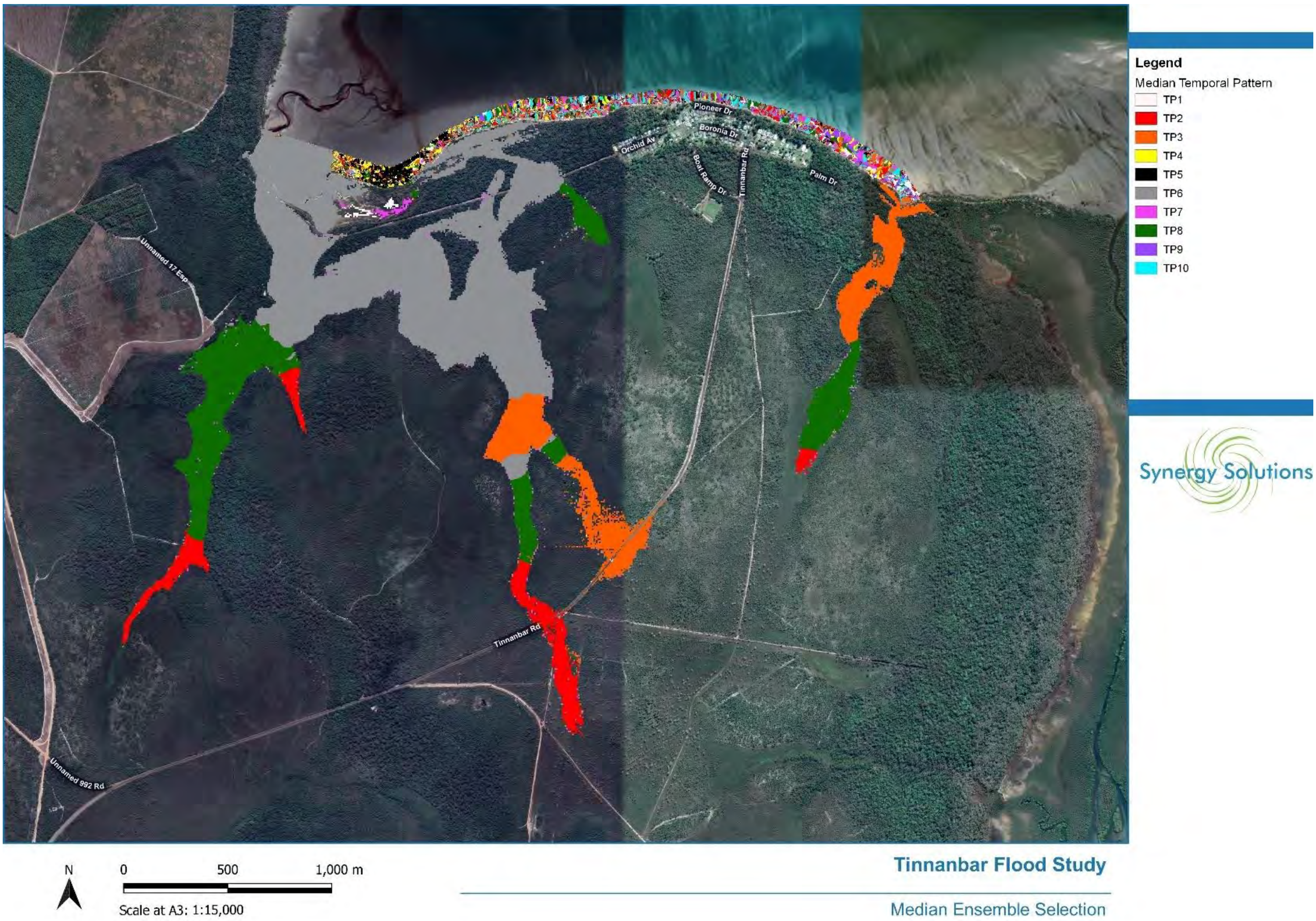


Figure 10-1 Example Median Temporal Patterns

10.2 Critical Durations

Critical durations across the catchment were mapped utilising all durations for all events. An example output for the 1% AEP is shown below.

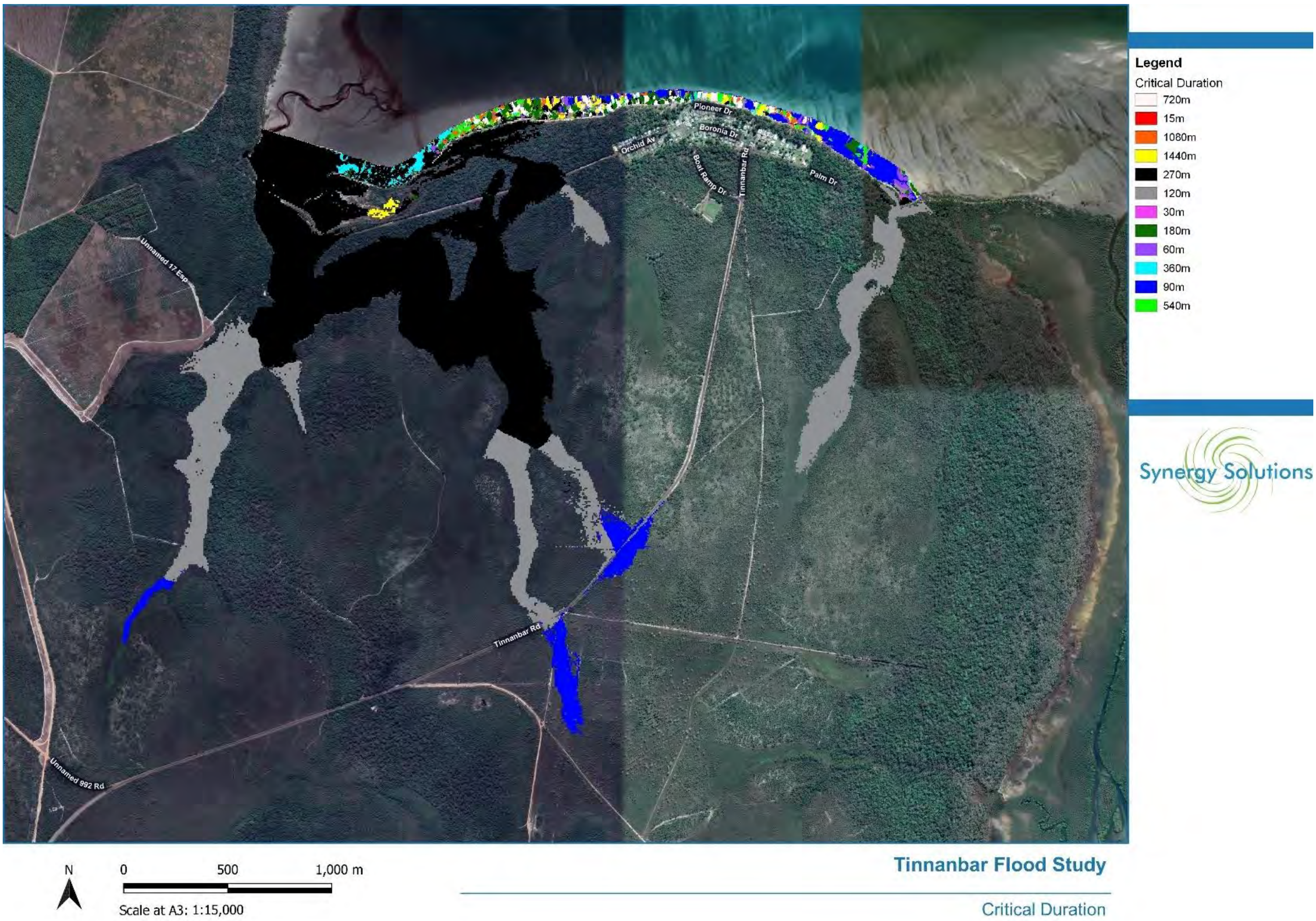


Figure 10-2 Comparison 1% AEP Critical Durations

10.3 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.

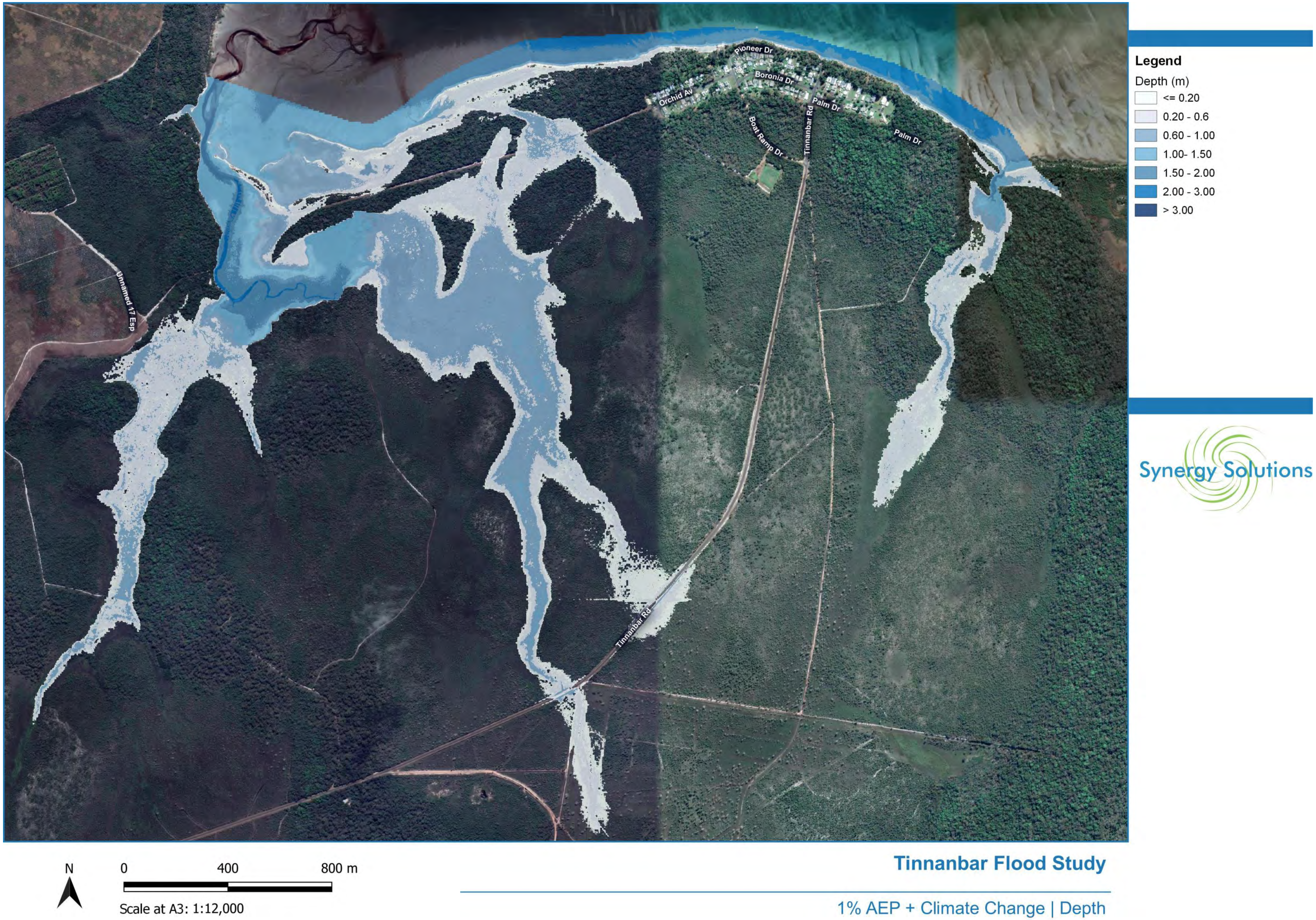


Figure 10-3 1% AEP Plus Climate Change Depth

11 Validation

Validation of flood modelling is an important component of accurate assessment of design flows and thus flood levels. Unfortunately, there are no flood gauges within the catchment and as such only coarse methods can be utilised.

11.1 Regional Flood Frequency Assessment

An assessment below shows the design events verse the RFFE estimates at the discharge location of the catchment and main focus area. The RFFE output makes mention that the catchment is an unusual shape, and the results should not be relied upon. This is evident in the validation whereby the flows only just fit above the RFFE lower estimate.

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	82.856	268	76	937

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

Location	5% Design Event Flow (m3/s)	RFFE Estimate (m3/s)	RFFE Lower Estimate (m3/s)	RFFE Upper Estimate (m3/s)
Bottom Catchment	60.872	133	47.2	366

Each estimate of design flow fits within the lower and upper bounds of the RFFE estimate, however it is noted the flows are on the lower side. Lower design flows are likely associated with reduced rainfall depths with ARR2019 which has been noted across Queensland as an issue to address in the future. In addition, the design flows reported on are also the median pattern which has been recommended by ARR2019. Without a gauge with a long history and a flood frequency assessment, there is no reasonable/legitimate way to adjust/increase flows to match FFA. Furthermore, throughout this flood study, a conservative approach has been taken to Aerial Reduction Factors and rainfall losses.

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

12 Flood Risk Based Outputs

Whilst not strictly required within the current scope of works by Council, additional information was processed and assessed for the project. This included converting the flood model hazard into a risk-based output and also a preliminary assessment of flood risk in the area.

It should be noted that this assessment is not detailed and does not fulfill the requirements of a flood risk assessment.

12.1 Overview

Fraser Coast Regional Council (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.

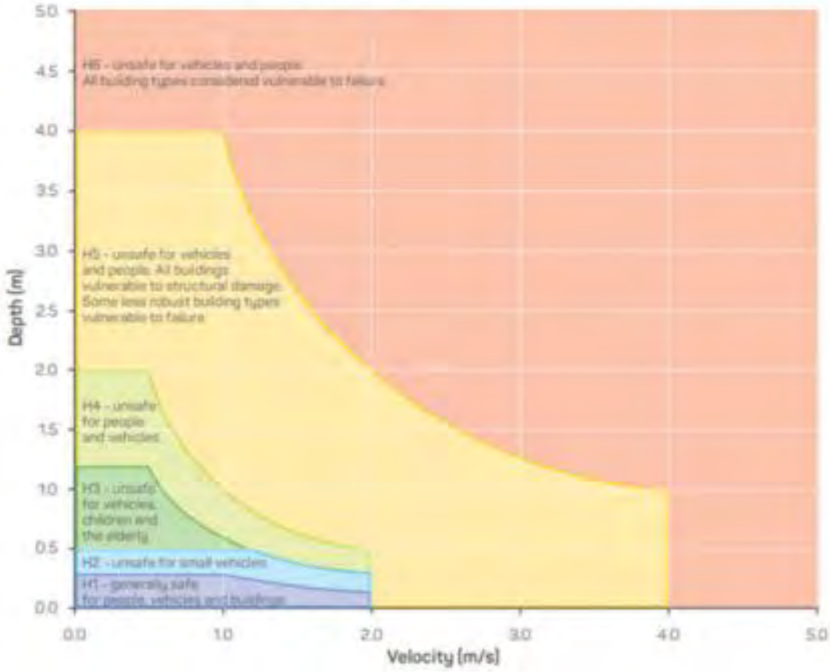


Figure 12-2 AIDR Hazard Curve

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 Curves		
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 H4		High
		D*V = < 1.0	N/A	H5 H6		Extreme

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 Outputs

The 1% AEP + CC hazard outputs and the PMF height extent was processed using Synergy's custom python script which uses the parameters listed above to produce the risk-based map. The mapping is shown below.

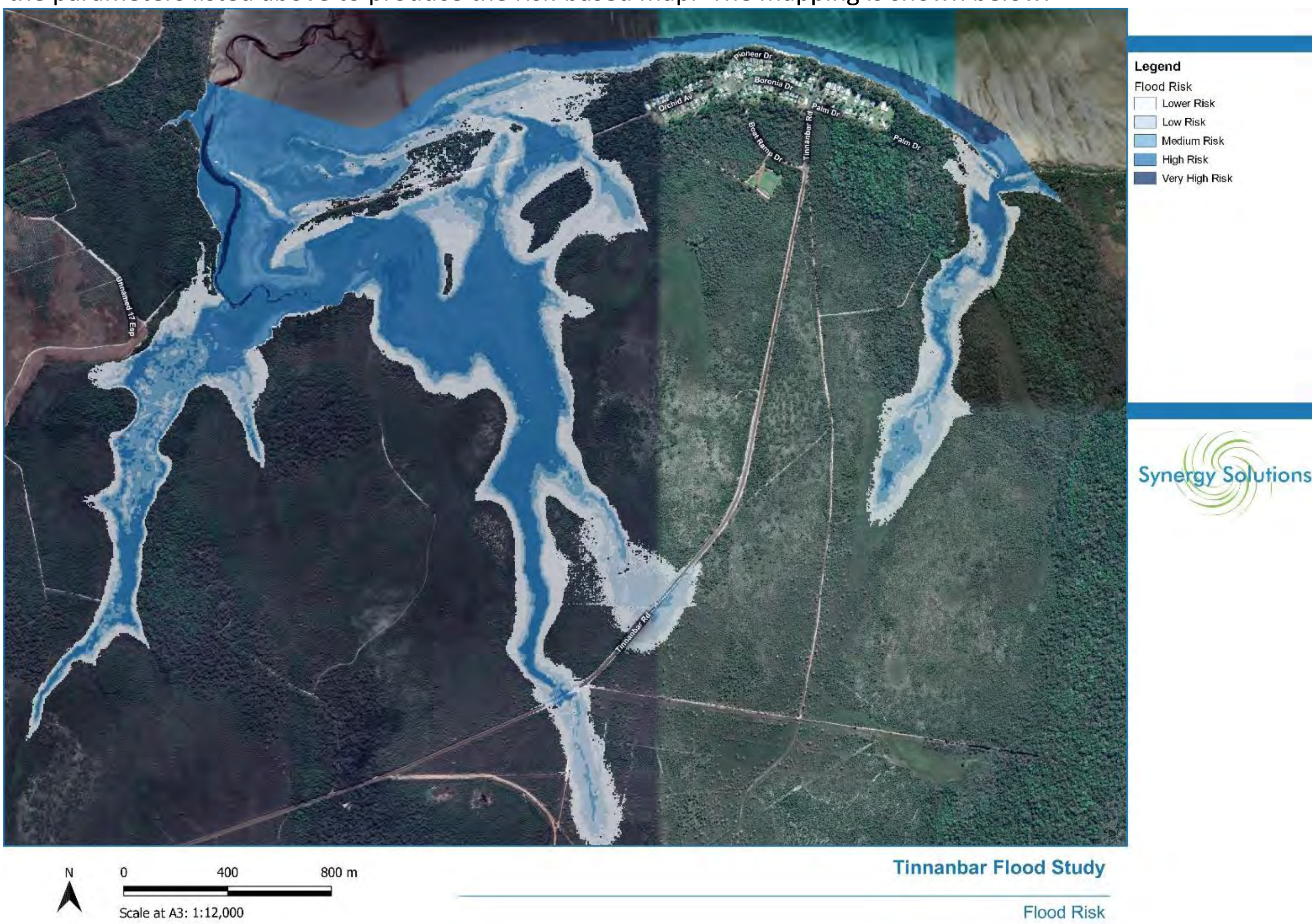


Figure 12-5 Flood Risk Based Mapping

13 Cross Drainage and Route Assessment

One of Council's main drivers of understanding the flooding within the region was to gain an appreciation of the main access roads, their flood immunity, and the potential for access/evacuation to be restricted during flood events. Council specifically excluded assessment of DTMR controlled roads as a study is currently occurring concurrently to investigate flood immunity of their network.

13.1 Culvert and Bridge Flood Immunity

An assessment of major cross drainage infrastructure was undertaken. In addition, the main access road to the township was assessed. The assessment investigated the current flood immunity of the road and the expected immunity from FCRC's planning scheme (also referenced in QUDM). In general, minor roads are required to have a 10% AEP immunity and major roads to have a 2% AEP immunity. Whilst the level of immunity is debatable for rural class roads, flood immunity for roads is not well specified. In addition, because the routes are primary evacuation routes, it is sensible to try to aim for similar levels of immunity as urban roads.

In addition, a high-level duration of closure value has been applied ranging from short (< 1 hour), medium (3 hours) to long (> 6 hours). This will assist in prioritising any future works (i.e. a road that has low immunity on a major road and long duration of inundation would rank the highest).

The table below provides an overview of the assessment:

Table 13-1 Cross Drainage Assessment

Pipe/Bridge Name	Location	Asset Size (mm)	Road Immunity Required (AEP)	Road Immunity Achieved	Meets Standard	Duration of Closure
Tinnanbar001	Tinnanbar Road	450	10%*	63.2% AEP (Q1)	No	Medium

13.2 Township Route Assessment

The Tinnanbar township is accessed off the Maryborough Cooloola Road through Tinnanbar Road. The following is noted regarding this:

- As it can be seen the main culvert on Tinnanbar Road has very low road immunity. The road begins to submerge in a 63.2% AEP event and likely becomes totally impassable by emergency crews during a 10 to 5% AEP event.
- It should be noted that whilst the recommended standard under QUDM for this road is a 10% AEP event, this road functions as the only road in and out of the township and should likely require a higher immunity standard.

Based on this, it is recommended that the culvert at this location is upgraded to a higher standard to provide a higher level of flood immunity for this road.

14 Conclusion

A flood model was built to investigate the drainage aspects surrounding the Tinnanbar catchment. The model constructed investigated both Little and Big Tuan Creeks and the associated tributaries, road networks and the major cross drainage aspects. In addition, a cross drainage assessment was undertaken and an initial flood risk-based output processed and mapped.

The flood modelling investigation showed that:

- Within the Tinnanbar township, there is generally no residential property, structures or houses impacted by flooding up to the Probable Maximum Flood Event. The extent of flooding does not impact on the township.
- Outside of the Tinnanbar township, there are no houses or residential property impacted.
- Tinnanbar Road is impacted by flooding and the road overtops in the 39.3% AEP (Q2) event. During this event there is approximately 80mm of flooding across the road with low hazard. The road likely becomes totally impassable by emergency vehicles during the 10% to 5% AEP event.
- It is recommended that further investigation is carried out into the suitable of the flood immunity of Tinnanbar Road and further detailed flood models used to undertake any further flood modelling.

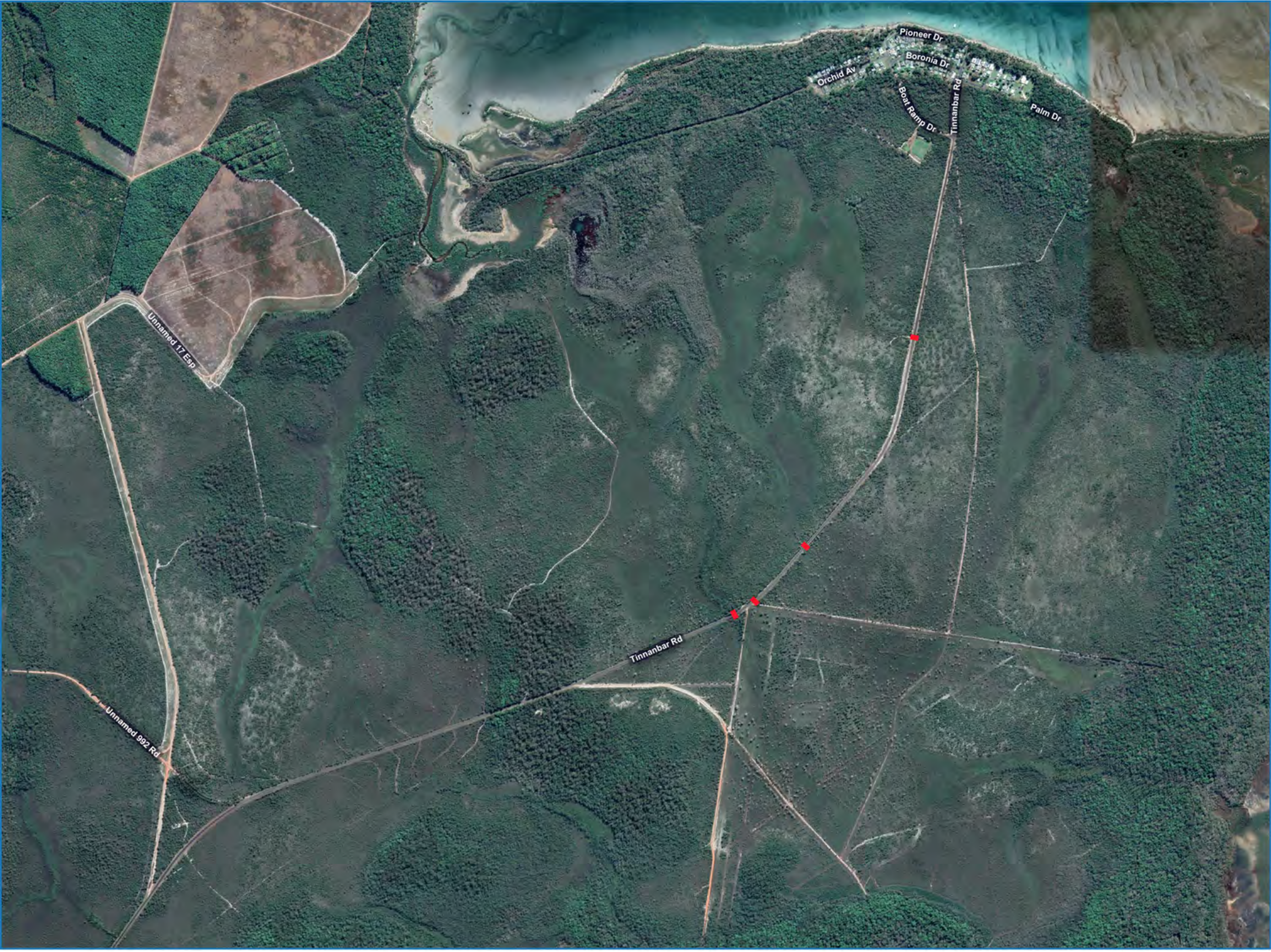
The results of this flood study should be read in conjunction with the Tinnanbar detailed Urban Drainage Flood studies undertaken by Synergy 2023. All studies provide an overview of flood risk to the townships with regards to creek and overland flowpath/drainage related flooding issues.

15 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. Where possible, verification of data has occurred on site, however this is limited in the extent and scope possible.
- 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.
- Council specifically requested only Council controlled roads be investigated for cross drainage immunity. It was noted within the flood study that DTMR roads had flood immunity issues, and this will impact access to the coastal towns.
- The flood modelling undertaken makes use of ARR2019 provisions. It has been noted in the industry and within this report that there are possible issues with the rainfall depths within the new Intensity Frequency Duration outputs. As no flood gauges exist in the catchment, a site-based flood frequency could not be undertaken and thus no investigation of this could be undertaken. It is recommended that further assessment is undertaken by Council with regards to the IFD's and rainfall depths.

16 Appendix A | Model Build Maps



Legend

1D Network

Synergy Solutions

N

0 500 1,000 m

Scale at A3: 1:15,000

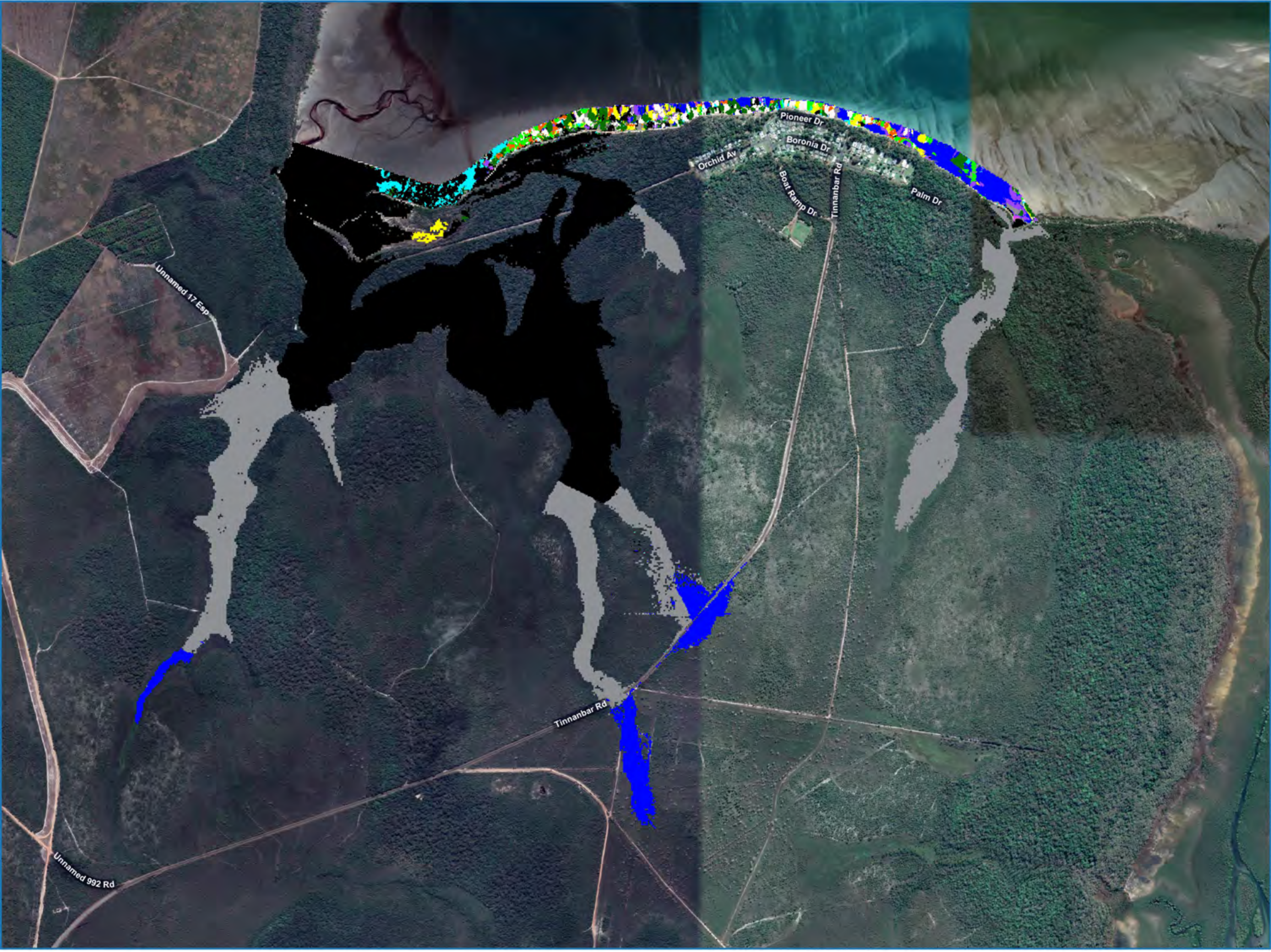
Tinnanbar Flood Study

1D Network

Synergy Solutions

Tinnanbar Flood Study

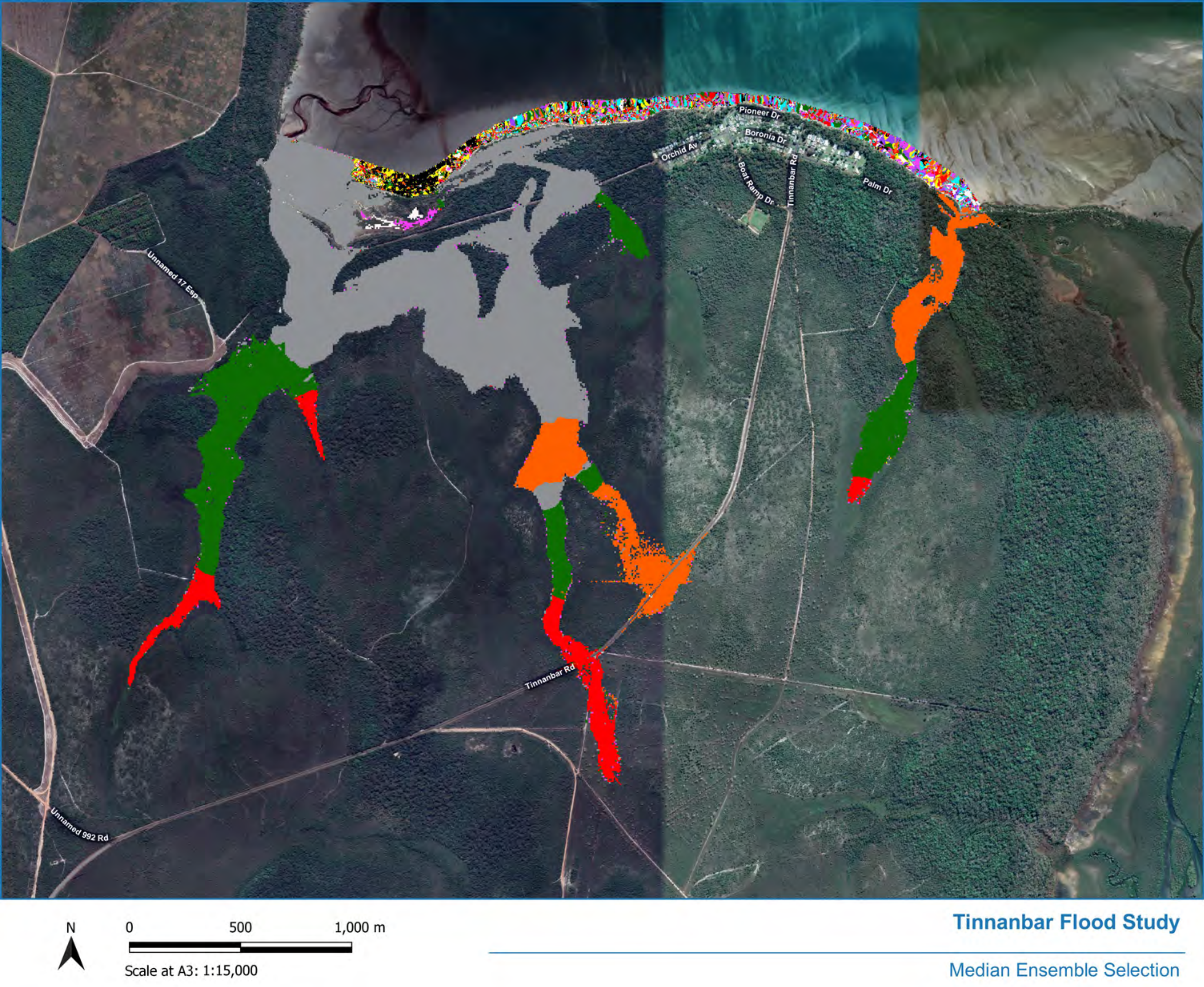
Sub Catchment Delineation



Synergy Solutions

Tinnanbar Flood Study

Critical Duration



Synergy Solutions

Tinnanbar Flood Study

Median Ensemble Selection

17 Appendix B| Existing Flood Maps

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

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

39.3% 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

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

39.3% AEP | Velocity

Legend

VD (m2/s)

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

Synergy Solutions

N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

39.3% AEP | Velocity Depth Product

Legend

Hazard (AIDR)

- H1
- H2
- H3
- H4
- H5
- H6

Synergy Solutions

N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

39.3% 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

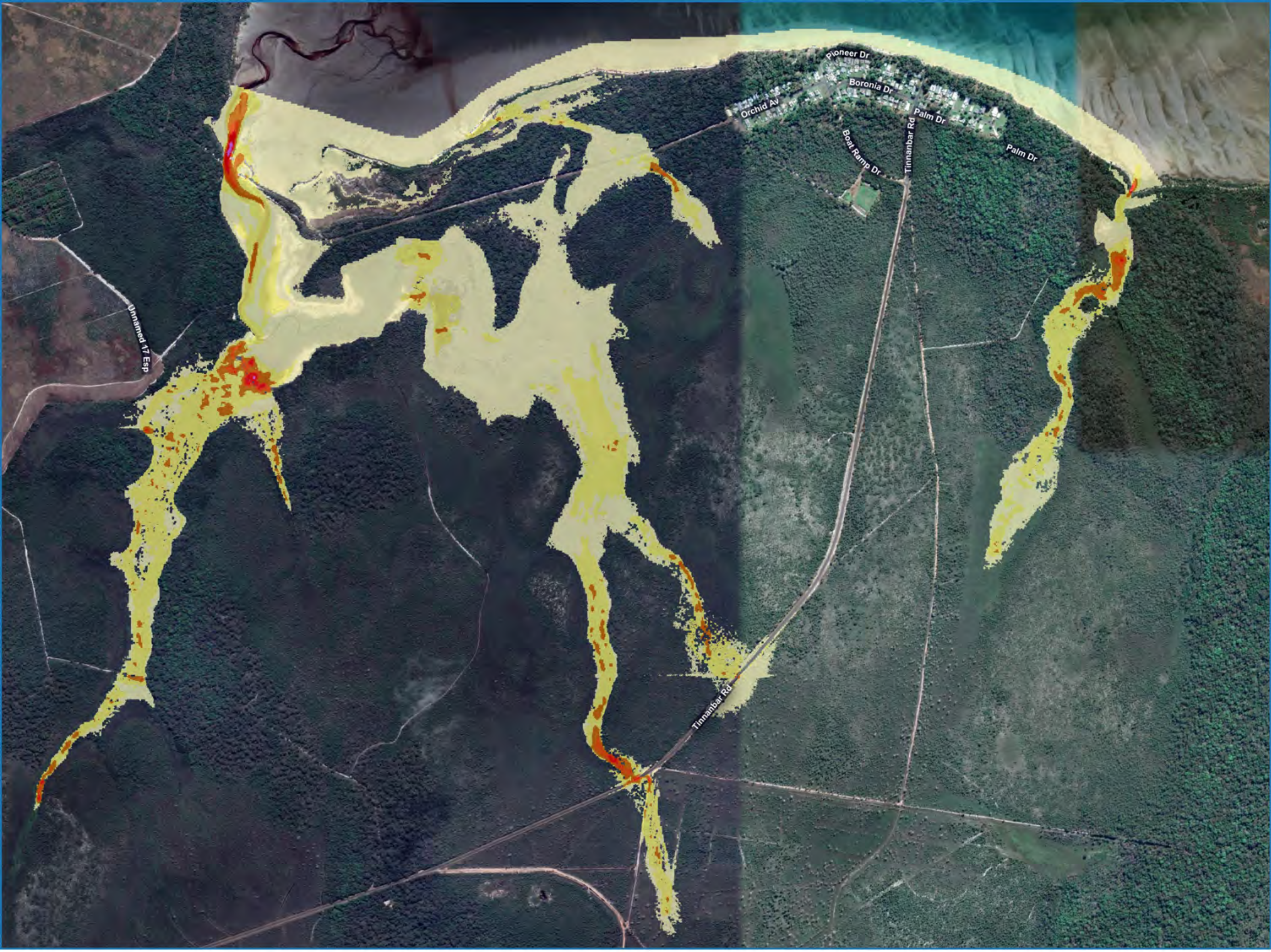
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar 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

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

10% AEP | Velocity

Legend

VD (m2/s)

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

Synergy Solutions

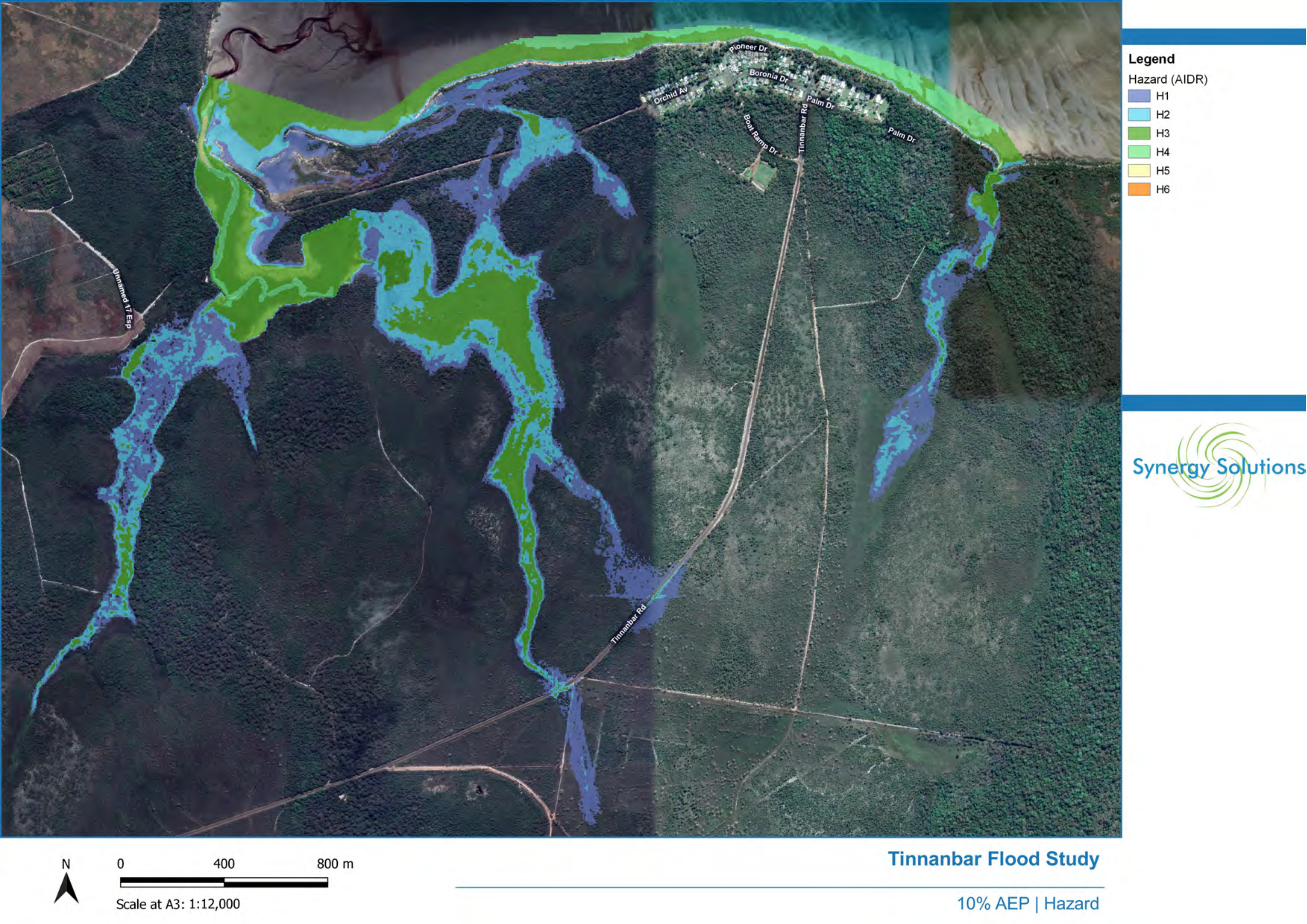
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

10% AEP | Velocity Depth Product



Tinnanbar Flood Study

10% 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

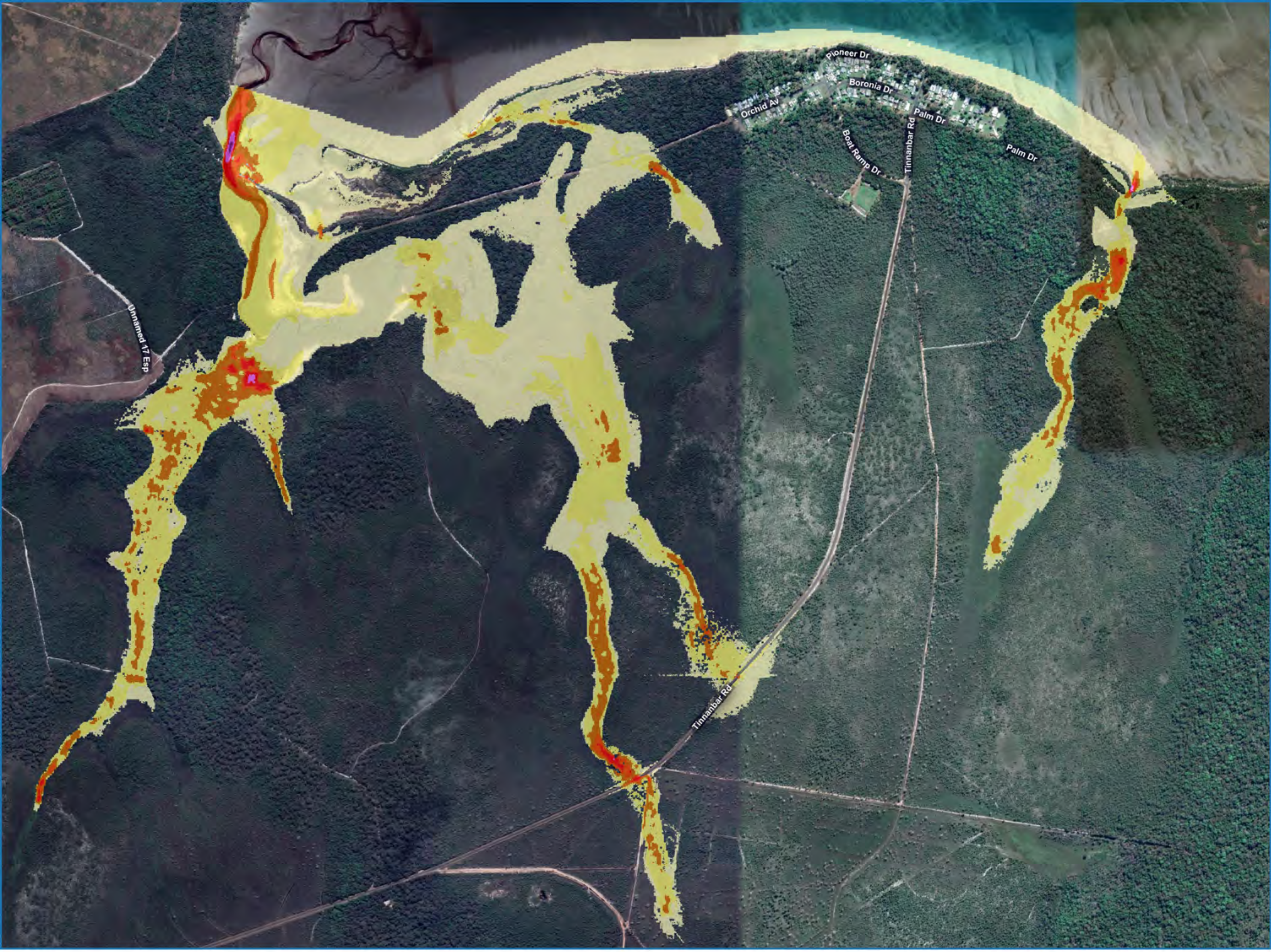
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

1% 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

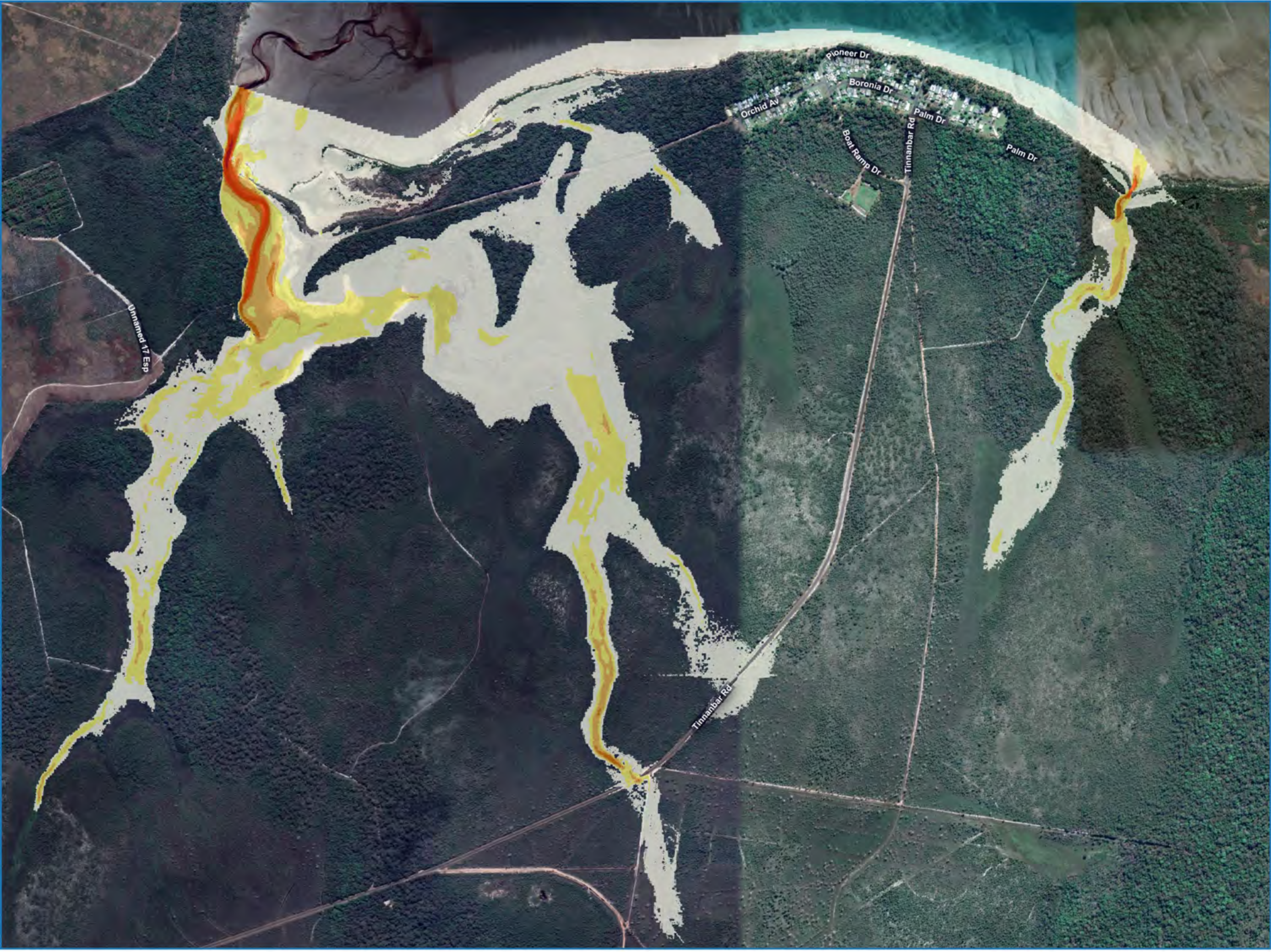
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

1% AEP | Velocity



Legend

VD (m2/s)

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

Synergy Solutions

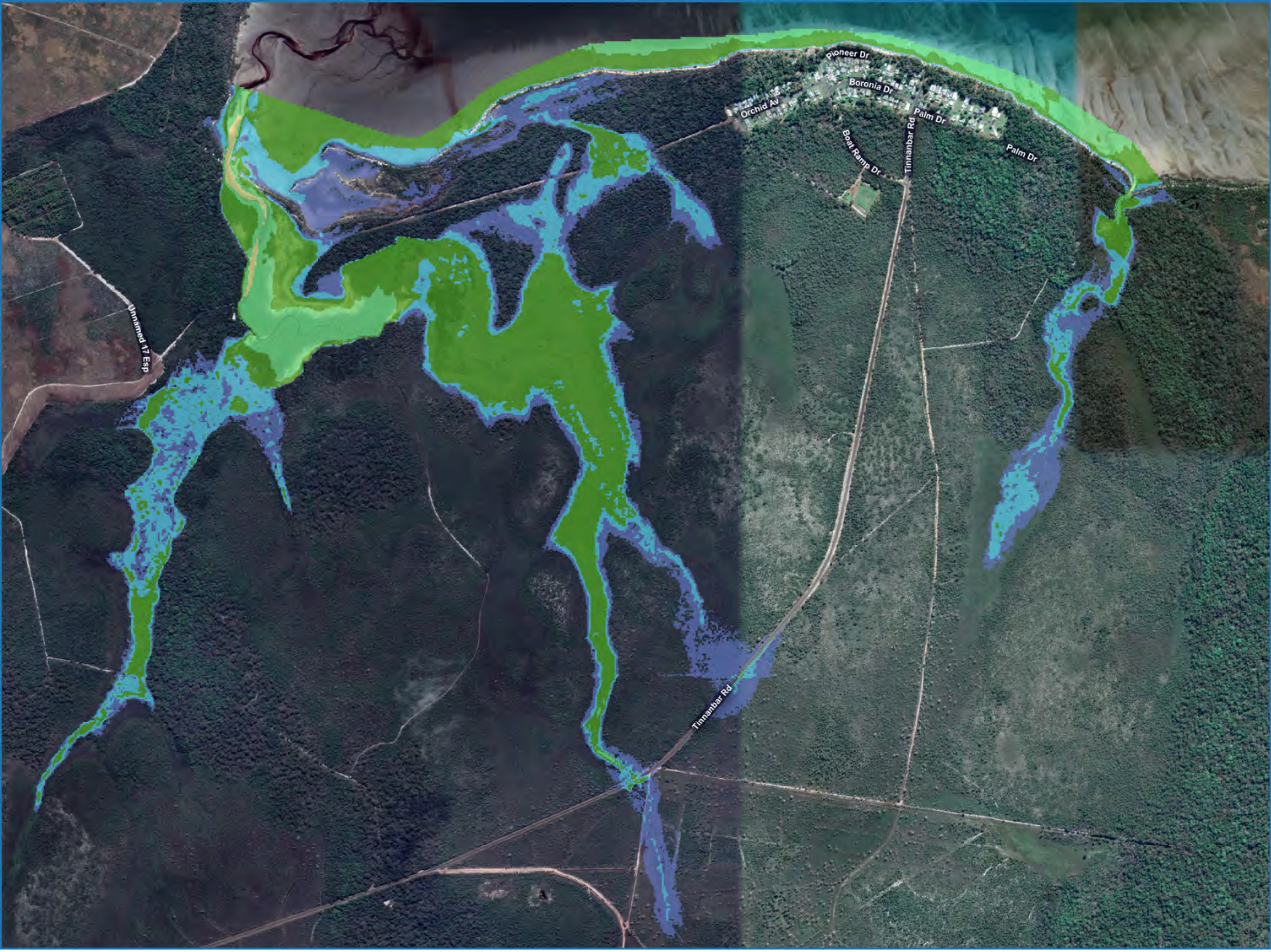
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

1% AEP | Velocity Depth Product



Legend

Hazard (AIDR)

- H1
- H2
- H3
- H4
- H5
- H6

Synergy Solutions

N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar 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

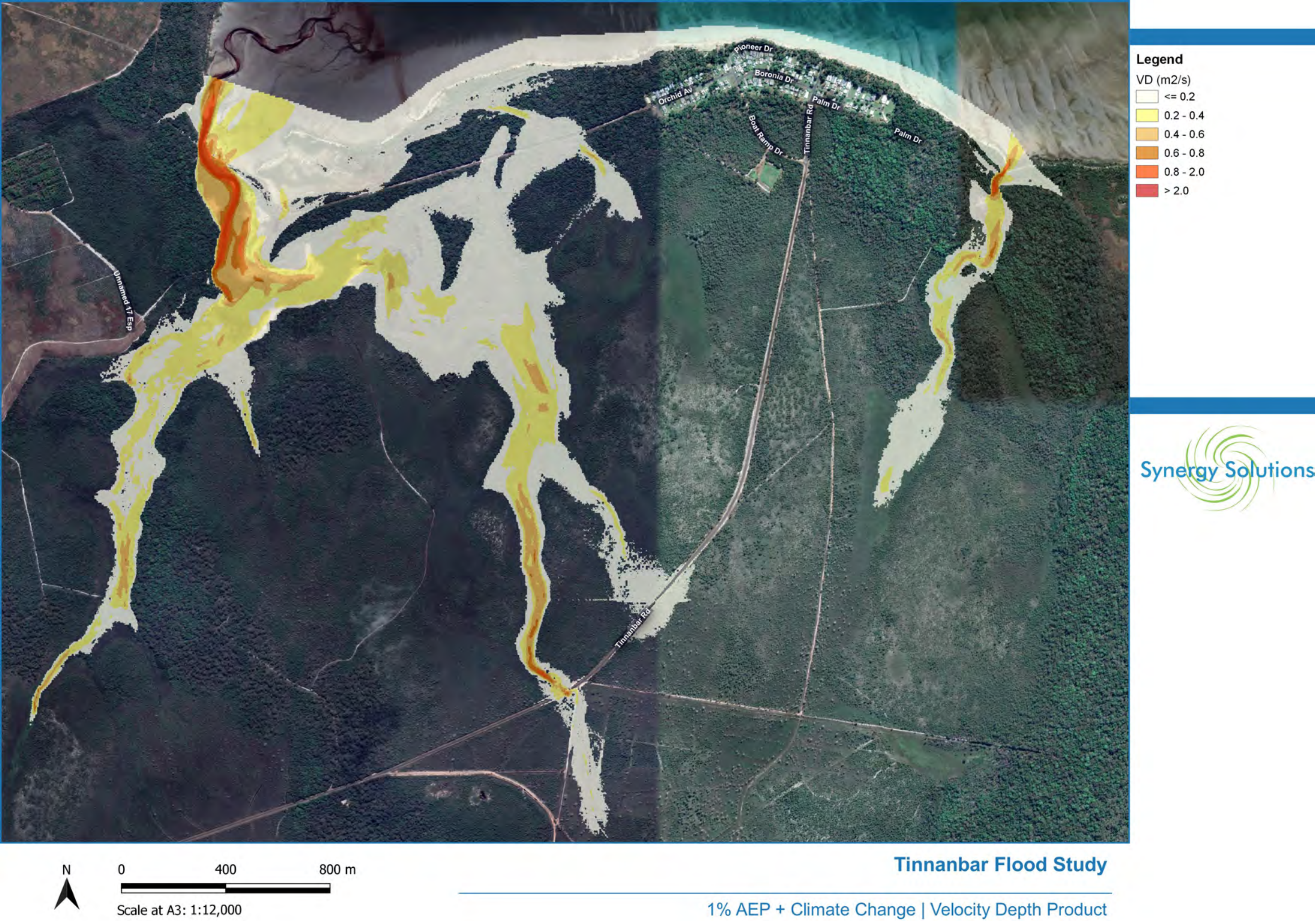
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

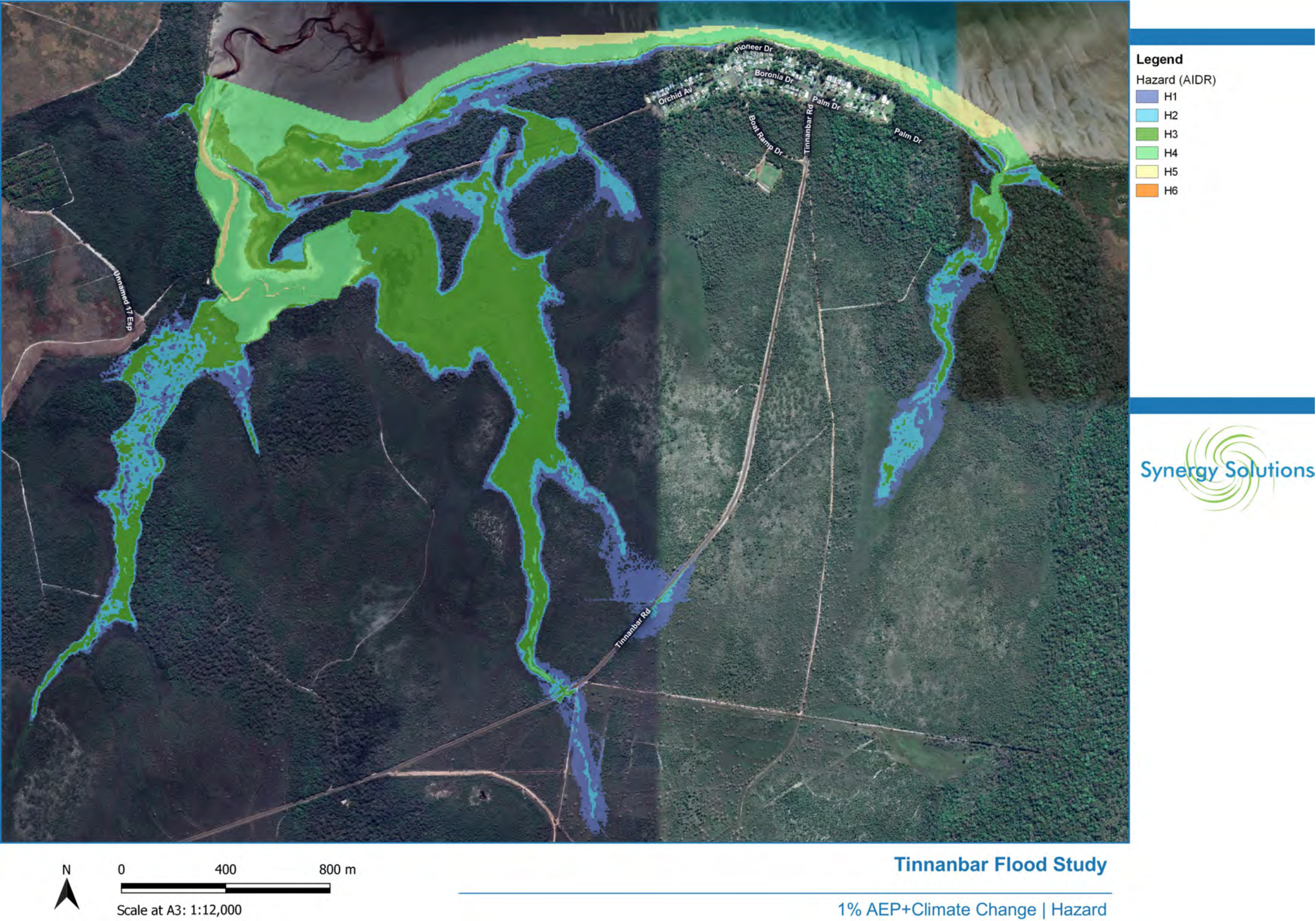
1% AEP + Climate Change | Depth



Synergy Solutions

Tinnanbar Flood Study

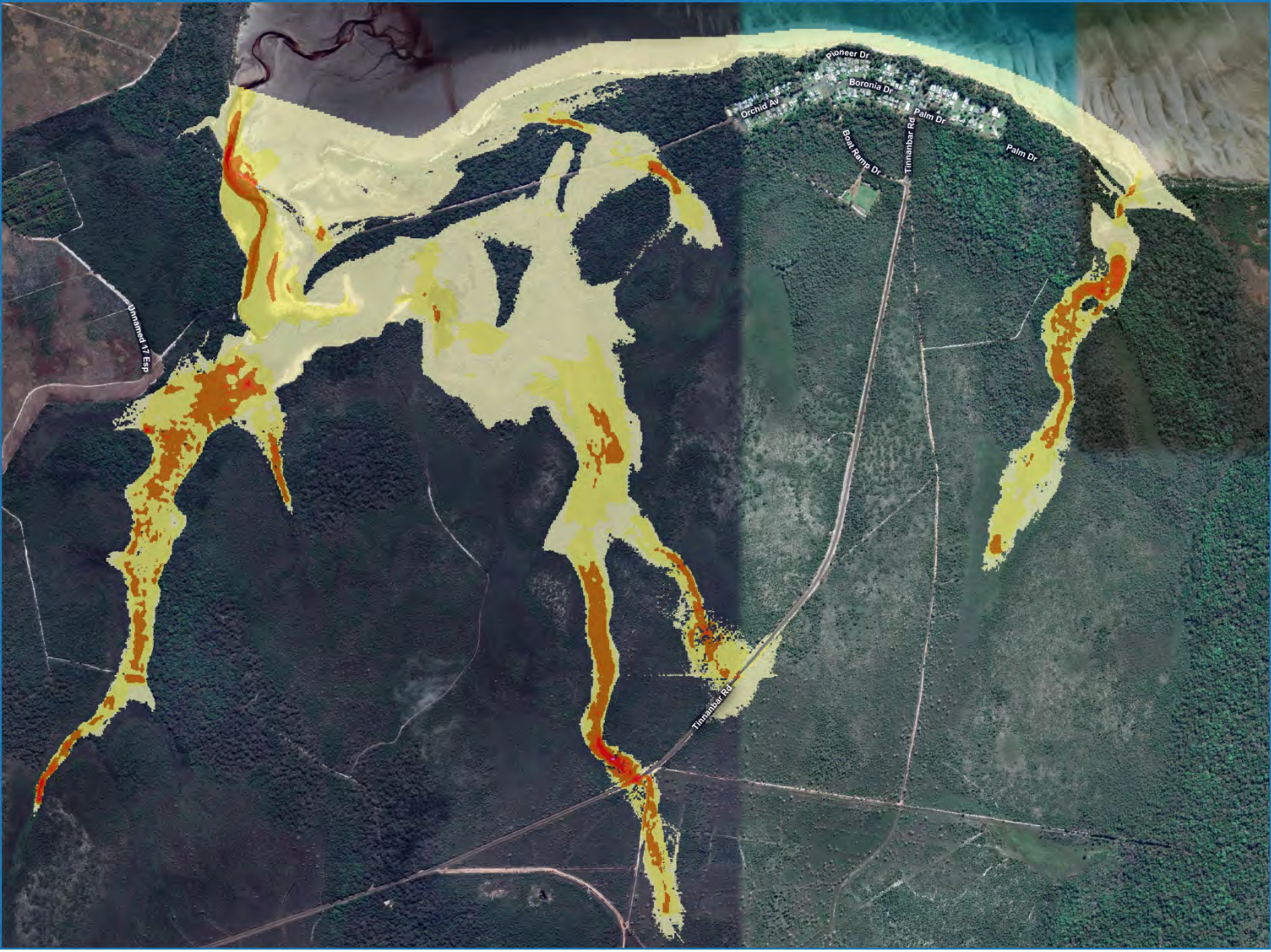
1% AEP + Climate Change | Velocity Depth Product



Synergy Solutions

Tinnanbar Flood Study

1% AEP+Climate Change | Hazard



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

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

1% AEP + Climate Change | Velocity

Legend

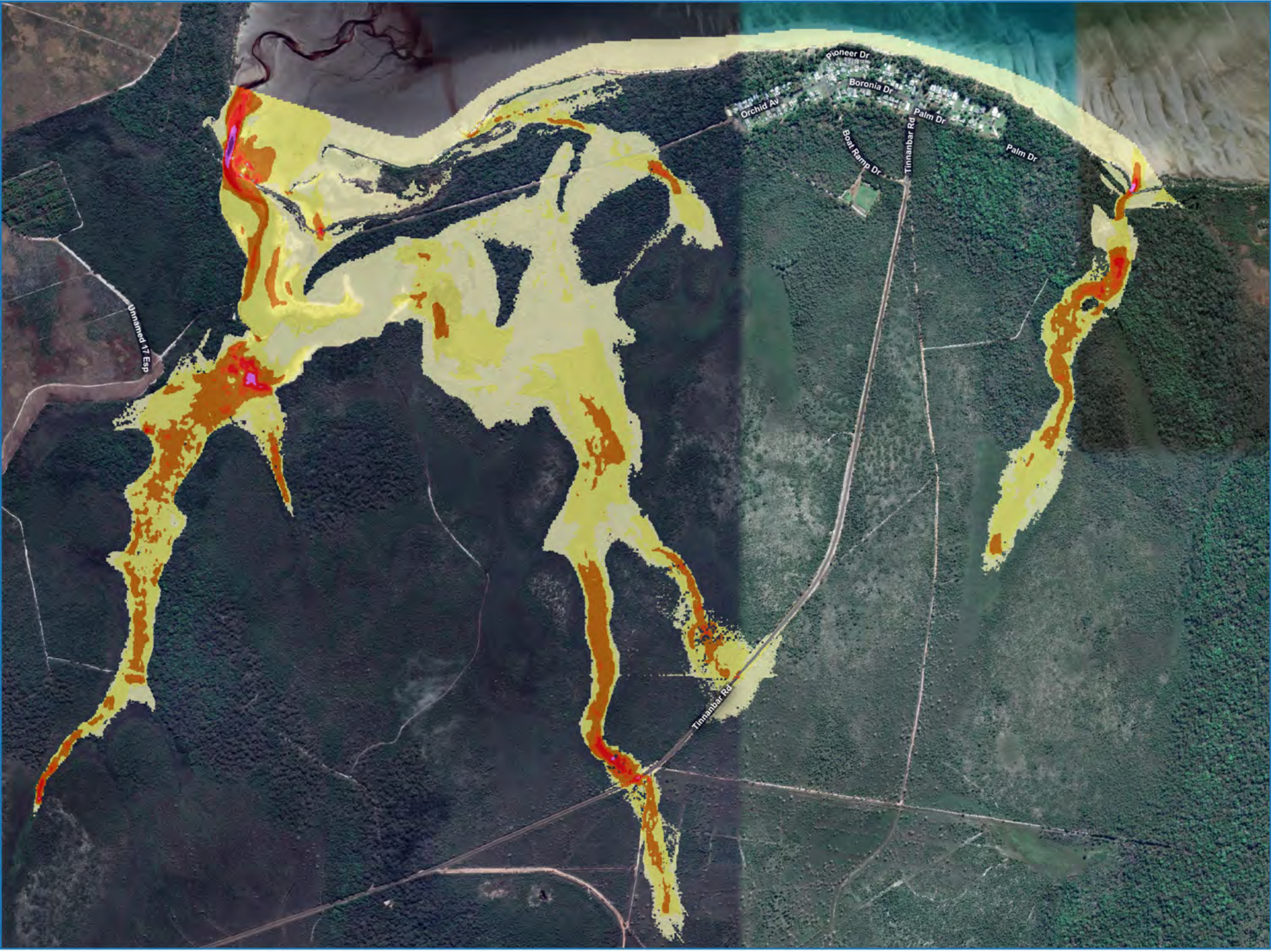
Depth (m)

- <= 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

Tinnanbar Flood Study

0.2% 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

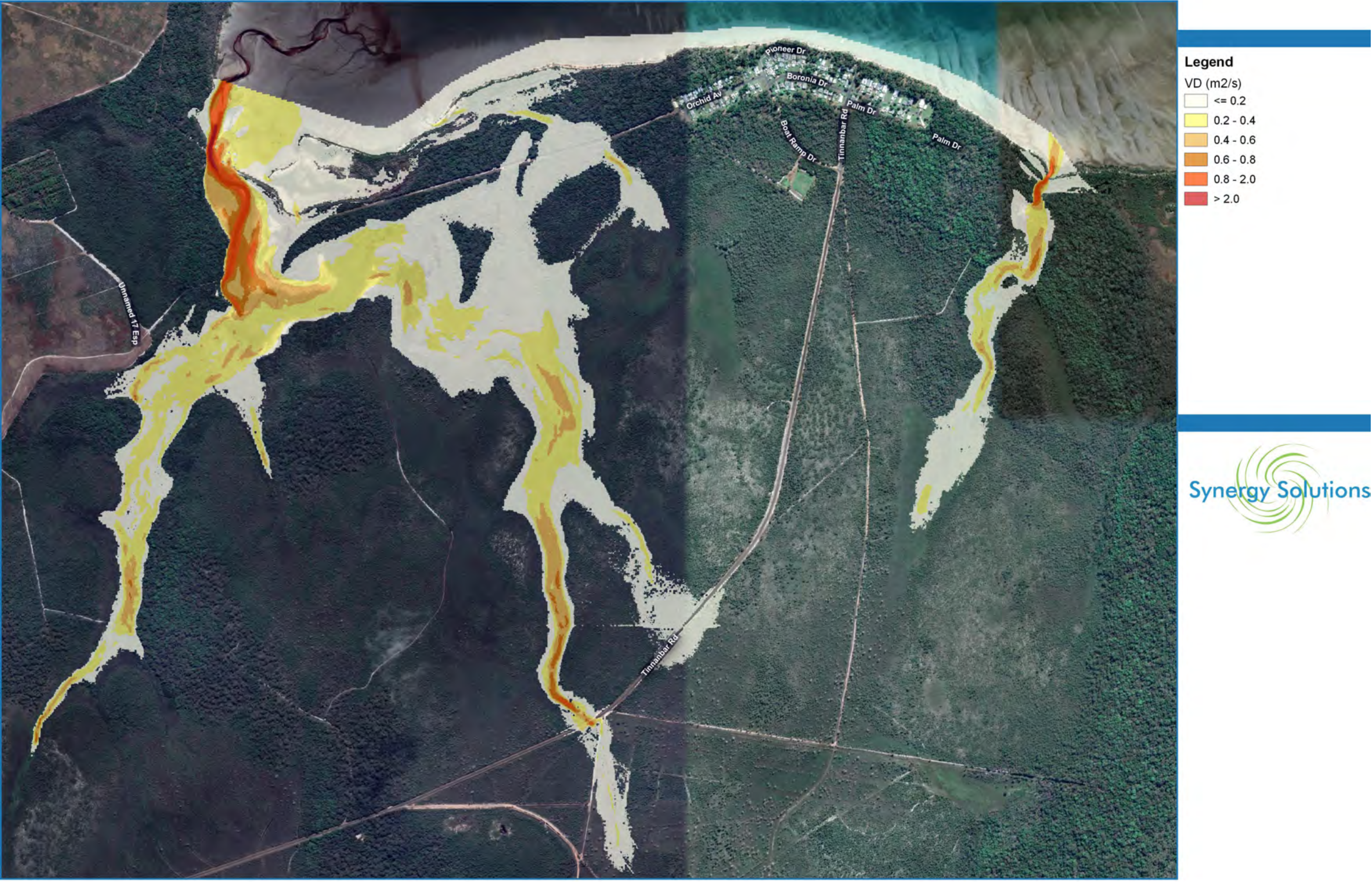
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

0.2% AEP | Velocity



Synergy Solutions

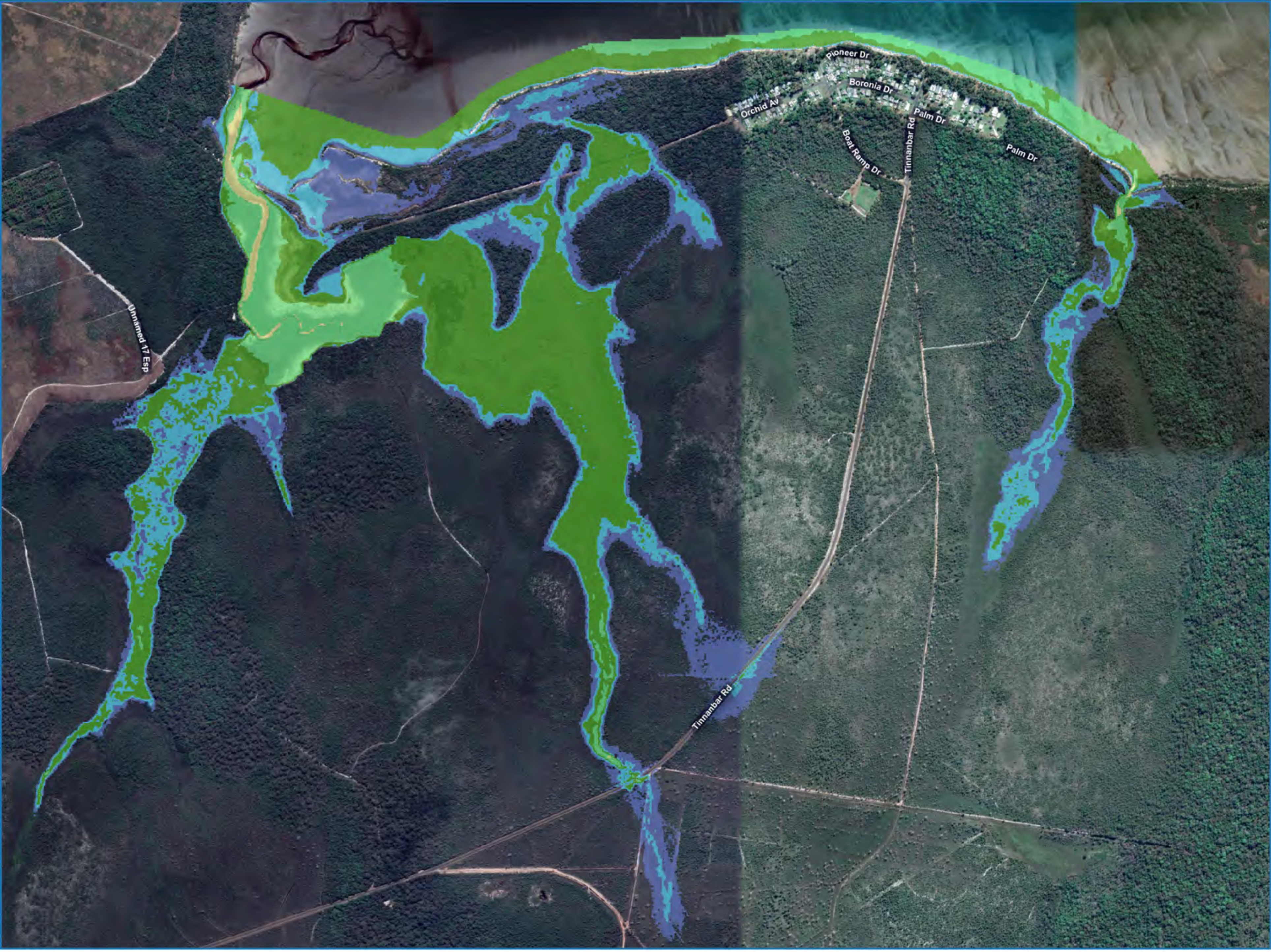
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

0.2% AEP | Velocity Depth Product



Legend

Hazard (AIDR)

- H1
- H2
- H3
- H4
- H5
- H6

Synergy Solutions

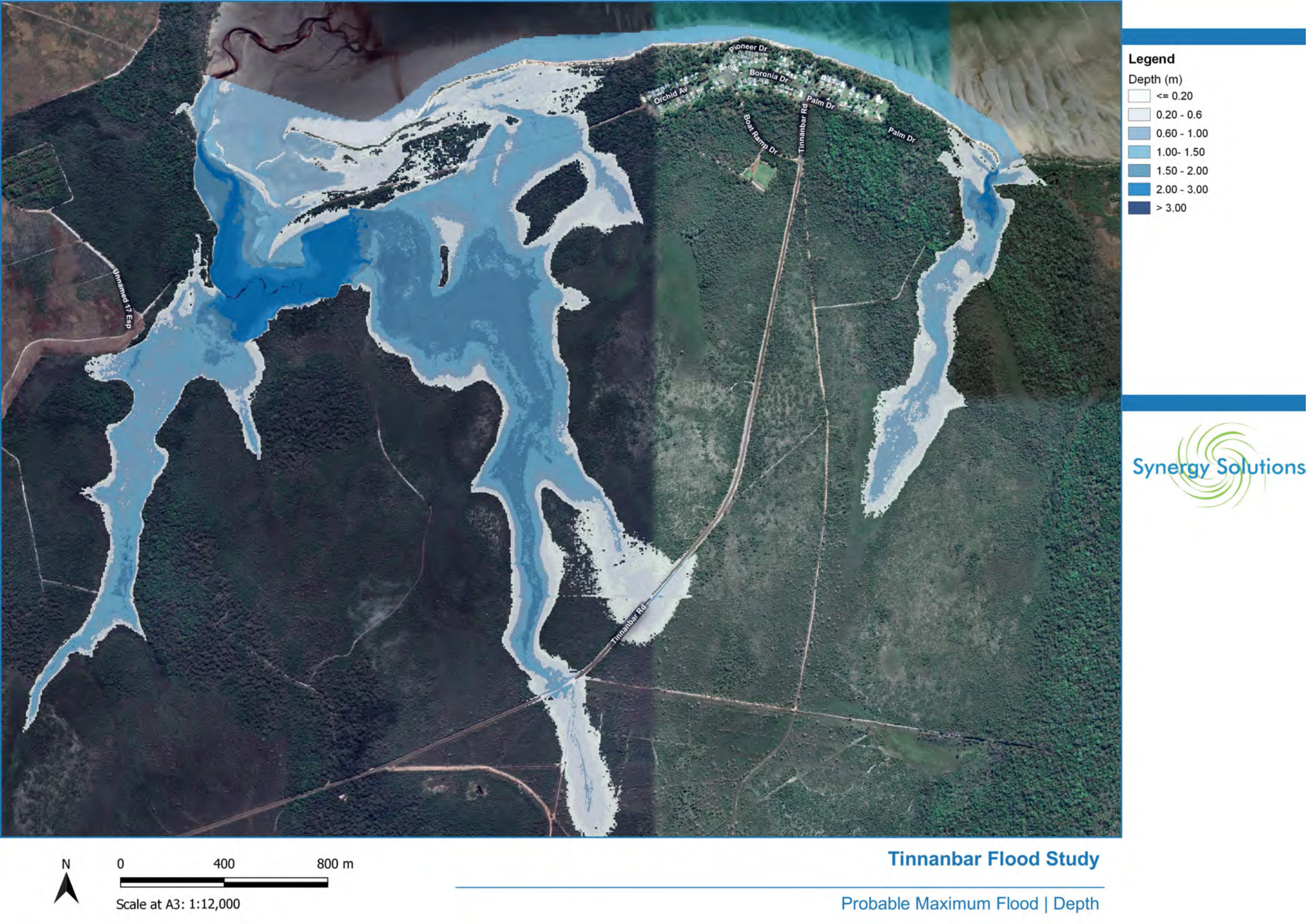
N

0 400 800 m

Scale at A3: 1:12,000

Tinnanbar Flood Study

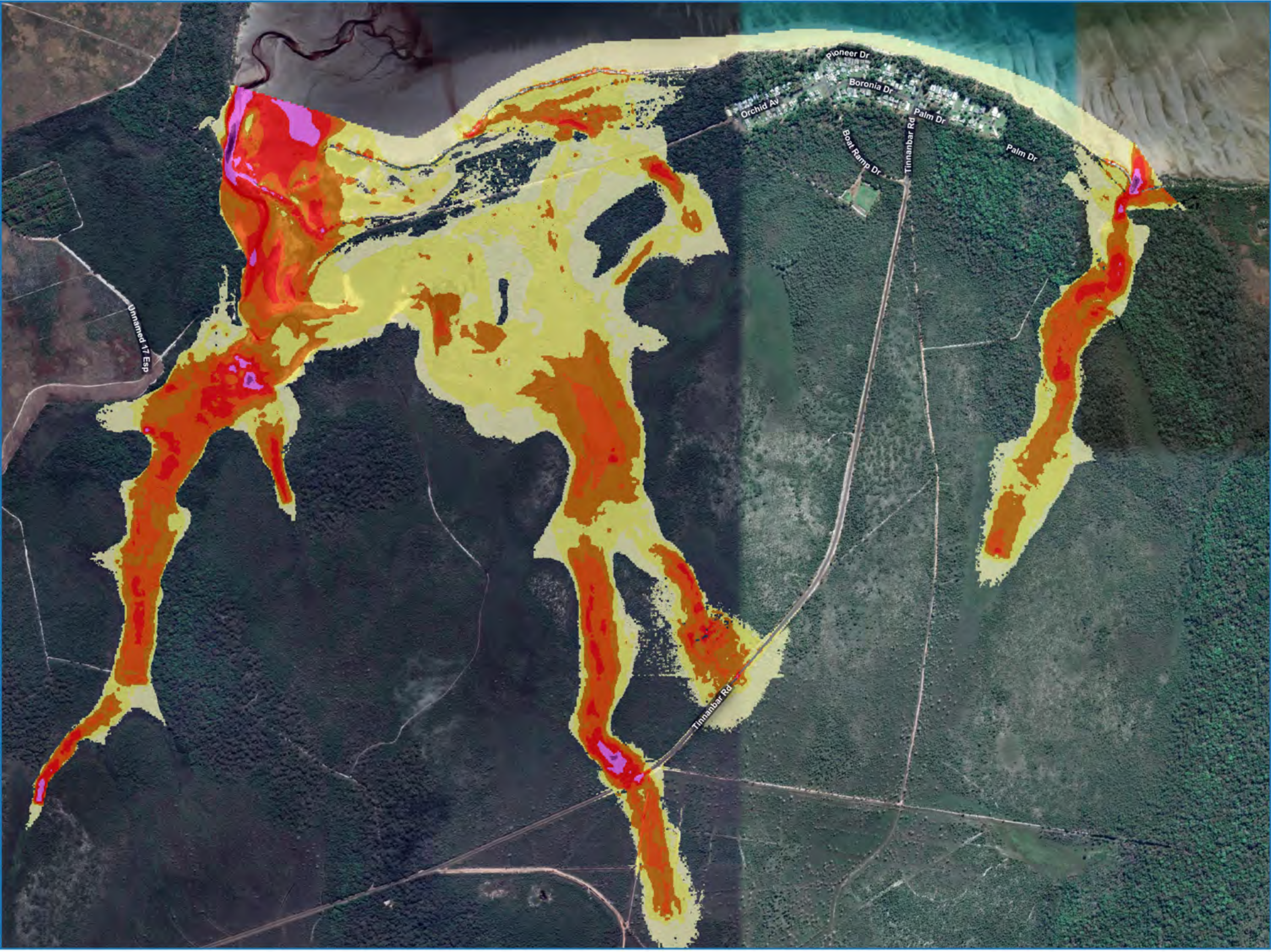
0.2% AEP | Hazard



Scale at A3: 1:12,000

Tinnanbar Flood Study

Probable Maximum Flood | 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

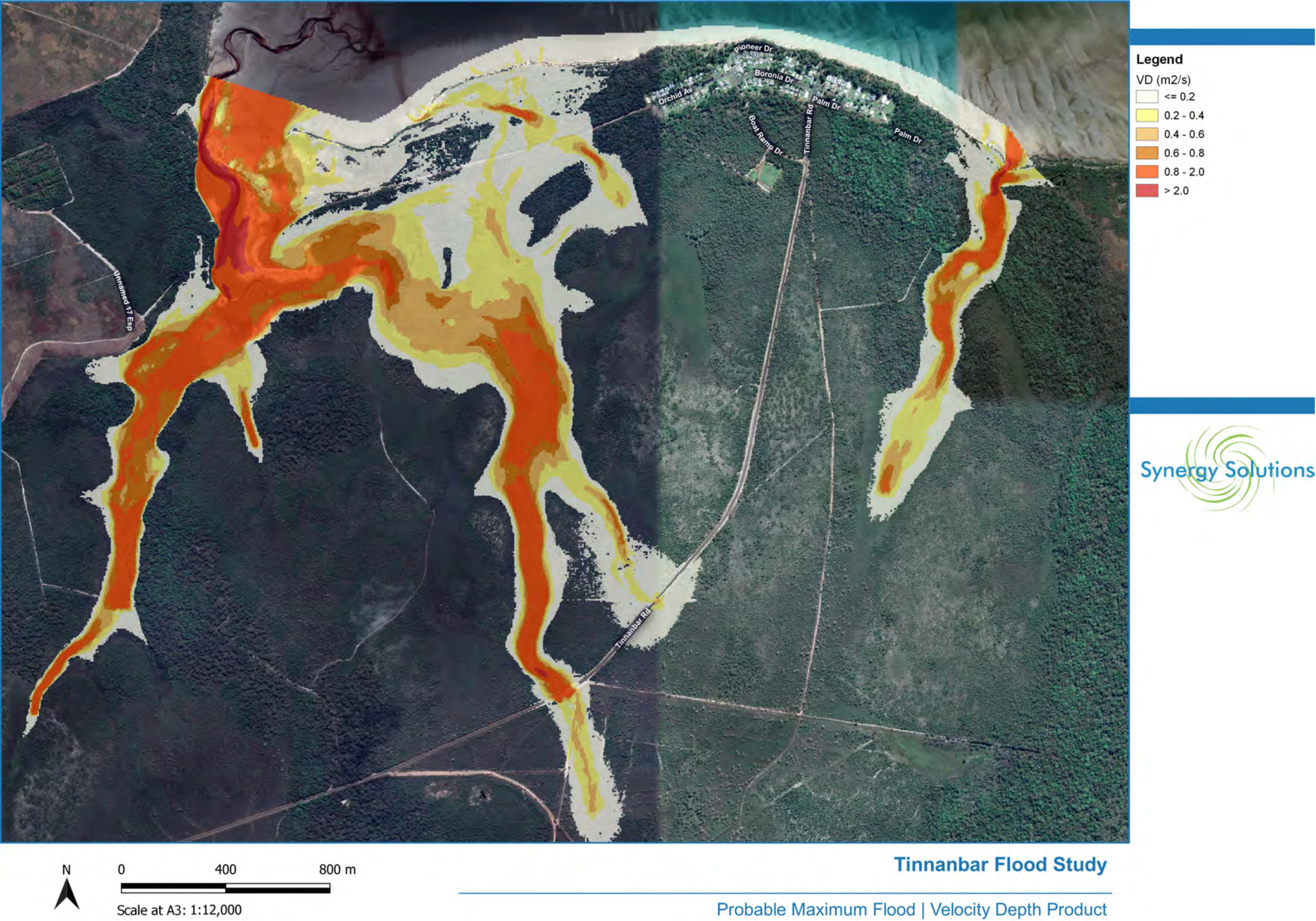
N

0 400 800 m

Scale at A3: 1:12,000

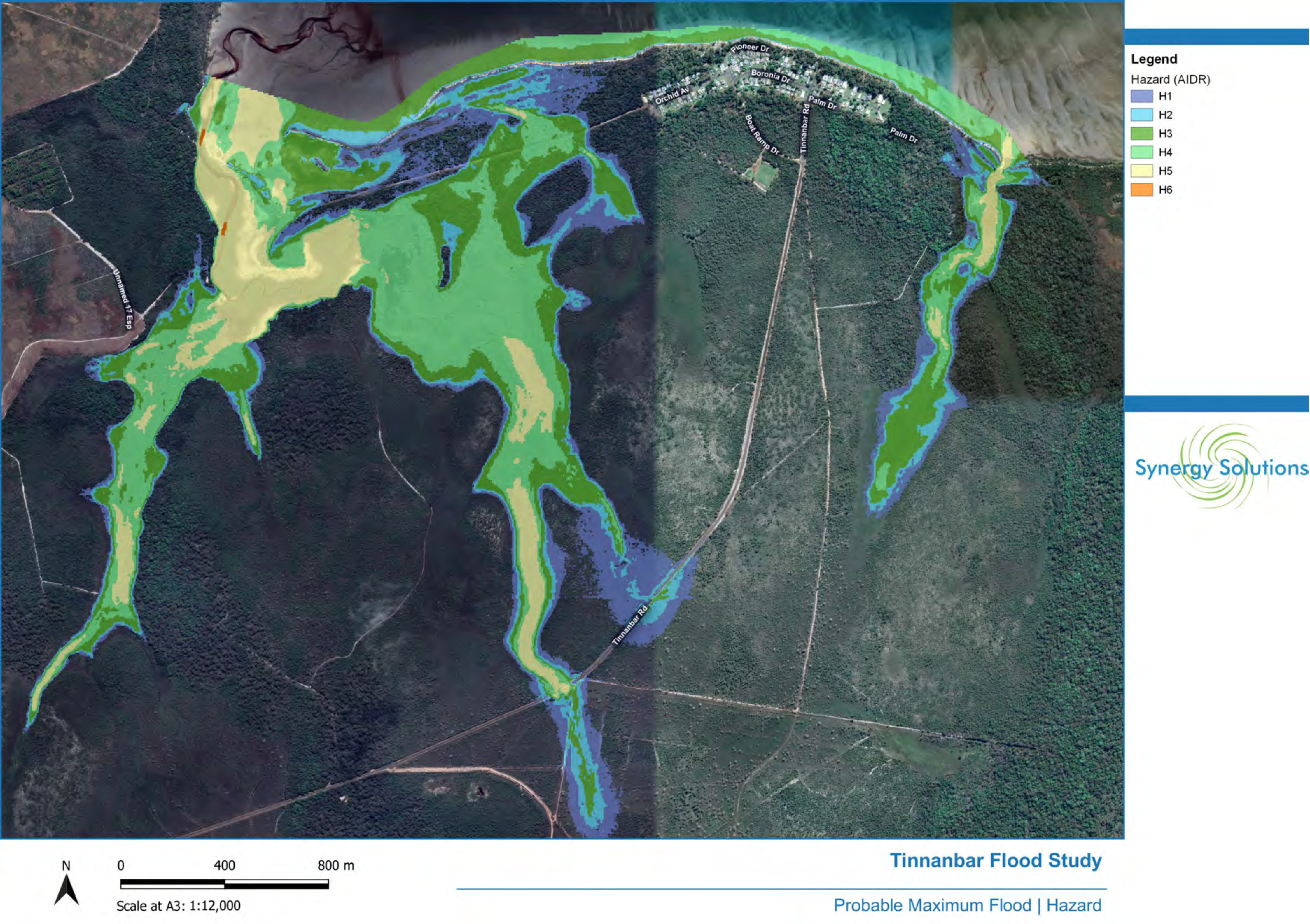
Tinnanbar Flood Study

Probable Maximum Flood | Velocity



Tinnanbar Flood Study

Probable Maximum Flood | Velocity Depth Product

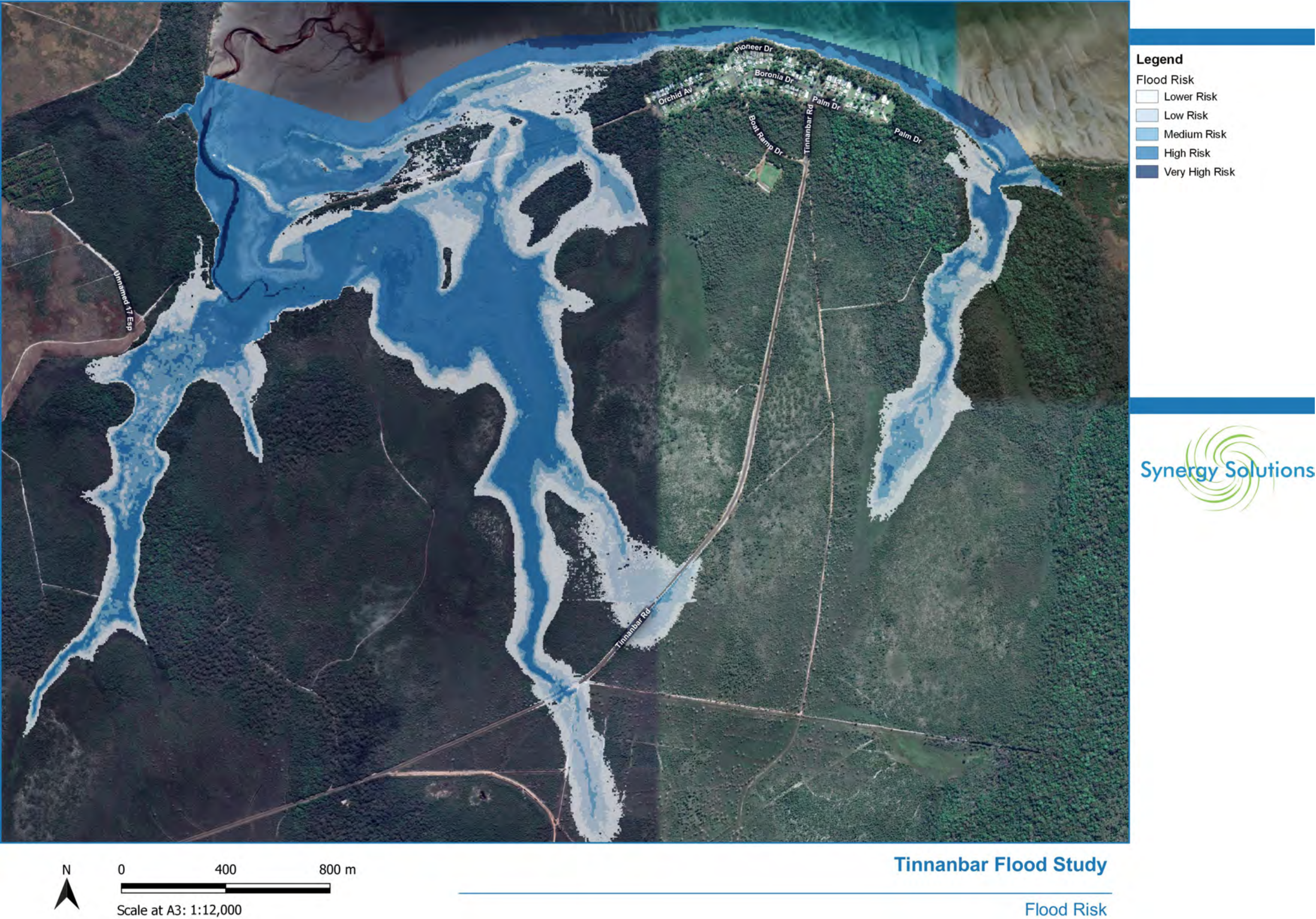


Synergy Solutions

Tinnanbar Flood Study

Probable Maximum Flood | Hazard

18 Appendix C | Flood Risk Map



Synergy Solutions

Tinnanbar Flood Study

Flood Risk