Final Port Stephens Foreshore (Floodplain) Risk Management Study and Plan Review

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Document Control Sheet

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Synopsis: This report documents the Port Stephens Foreshore (Floodplain) Risk Management Study and Plan review including updated existing flood mapping using LiDAR data.

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Executive Summary

Study Background

MidCoast Council (Council) administrates the northern estuary foreshore and catchment areas of Port Stephens, including the coastal settlements of Tahlee, Carrington, North Arm Cove, Bundabah, Pindimar and adjoining areas. The coastal settlements are affected by flooding from the estuary.

The *Port Stephens Foreshore Floodplain Management Study and Plan (FMSP)* was prepared by WMAwater for Council in 2002, based on prior flood hazard and management studies which identified ocean water levels and wave runup levels associated with a range of storm events. Further impacts associated with climate change were then assessed in a subsequent study (WMAwater, 2010).

Detailed topographic data was not available for the Port Stephens foreshore at the time of the prior studies, and as such flooding hazard mapping had not been prepared. Council has initiated the current study to update the Floodplain Risk Management Study (FRMS) with mapping that incorporates the detailed topographic data that has since become available, based on flood levels presented in the *Port Stephens Design Flood Levels – Climate Change Review* (WMAwater, 2010).

The key outcome of this study is to revise Council's floodplain mapping and recommend how the outcomes can be incorporated into planning controls for future development to prepare an updated Floodplain Risk Management Study and Plan (FRMSP).

Flood Risk Mapping Approach

Mapping of estimated still water and wave runup foreshore flooding is required by Council for the 5% and 1% annual exceedance probability (AEP) and extreme flood conditions. Mapping is required for the existing climate and future climate scenarios representing sea level rise (SLR) of 0.5 m by 2050 and 0.91 m by 2100, in line with Council's policy.

Still water flood conditions have been mapped for this study using the design still water flood levels presented in WMAwater (2010) for the existing climate conditions. Sea level rise impacts have been assessed by increasing the still water level by the relevant sea level rise increment. Still water level results for the various scenarios were then intersected with the topographic survey (digital elevation model) to determine flood depths and extents.

Wave runup flood conditions have been mapped for this study using the design wave runup levels presented in WMAwater (2010) and subsequently applying the sea level rise increments. Wave runup levels have been modelled using discrete wave level data across the study foreshore using a GIS tool, and application to a zone extending from the coast to 100 m inland, beyond which wave influence is expected to be negligible.

Flood hazard mapping has also been produced from the modelled flood depths. The flood hazard is a six-tiered classification that relates to the risk to people, vehicles and property. A high flood depth will cause a hazardous situation while a low depth may only cause an inconvenience. High flood velocities are dangerous and may cause structural damage while low velocities generally have no major threat.

Property Inundation and Flood Damages

A flood damages assessment has been undertaken to identify properties affected by flooding. Some of the key property inundation statistics include:

- 18 properties with floor levels below the 1% AEP still water level, increasing to 123 and 182 properties for the 2050 and 2100 sea level rise scenarios; and
- 47 properties with floor levels below the 1% AEP wave runup level, increasing to 151 and 198 properties for the 2050 and 2100 sea level rise scenarios.

The flood damages assessment aims to put a monetary cost on the expected damage due to flooding in the study area. The estimated flood damages when averaged out as a cost per year is **$212,800** (current climate), increasing to **$1,612,200** by 2050 and **$3,394,600** by 2100.

Review of Existing Planning Provisions

An LGA-wide planning review completed by GLN Planning as part of the *Manning River Floodplain Risk Management Study and Plan* (BMT, 2020) is relevant to the current study. The recommendations of the GLN report include:

- Guidance for how to consider floodplain risk management matters when undertaking strategic planning including determining the suitability of different land uses in different areas of the floodplain.
- A detailed review of the existing Local Environmental Plan (LEP) and Development Control Plan (DCP). This will provide an approach and base principles that can be applied when preparing an updated and consolidated LEP and DCP, to address residual flood risks where development is permitted in the floodplain.
- Principles to be applied to ensure the appropriate and clear communication of flood risk through planning documents, including S10.7 Planning Certificates.

Consideration of additional development controls to address inundation risk associated with wave runup has also been identified. The mapping of the wave runup zone completed in the current assessment is suggested to be used as a trigger that requires the proponent to undertake the site-based assessment.

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1 Introduction

The *Port Stephens Foreshore Floodplain Management Study and Plan (FMSP)* was prepared by WMAwater for Council in 2002, based on design flood levels reported in the *Port Stephens Flood Study* (MHL, 1992, 1997 and 1998). Flood impacts associated with climate change were subsequently assessed in the *Port Stephens Design Flood Levels – Climate Change Review* (WMAwater, 2010).

LiDAR[1] topographic data was not available for the Port Stephens foreshore at the time of these studies, and as such flooding hazard mapping had not been prepared prior to this study. Council has initiated the current study to update the FRMS with mapping that incorporates LiDAR data that has since become available and based on flood levels documented in the *Port Stephens Design Flood Levels – Climate Change Review* (WMAwater, 2010).

The key outcome of this study is to revise Council's floodplain mapping and planning controls using the updated flooding information. Mapping of estimated still water and wave runup foreshore flooding is required by Council for the 5% and 1% annual exceedance probability (AEP) and extreme flood conditions (where an extreme flood is an approximation of a flood considered to be the maximum which is likely to occur). Mapping is also required for the existing climate and future climate scenarios representing sea level rise (SLR) of 0.55 m by 2050 and 0.91 m by 2100, in line with Council's policy.

This project has been conducted under the State Assisted Floodplain Management Program and has received State financial support.

1.1 Study Location

Port Stephens is a large tidal estuary on the NSW coast approximately 50 km north of Newcastle and 150 km north of Sydney. The total waterway covers an area of approximately 140 km^2 with the total catchment area draining to Port Stephens being around 2,900 km^2 (WMA Water, 2010).

The estuary flows from west to east, and can be divided into two embayments separated by Soldiers Point (refer to Figure 1-1). Much of the catchment draining to the estuary is undeveloped, comprising a mix of agriculture, state forest and national park. The catchment extends northward towards the Chichester State Forest encompassing the Upper Karuah River, and stretching north-east along the coastline to encompass the Myall River and lake system. MidCoast Council administrates the northern estuary foreshore and catchment areas whilst the southern areas are administered by Port Stephens Council.

The project study area extends along the northern foreshore of Port Stephens, eastward of the Karuah River towards the Myall River, as shown in Figure 1-1. The northern foreshore includes the coastal settlements of Tahlee, Carrington, North Arm Cove, Bundabah, Pindimar and coastal areas to the estuary mouth. The study area does not include the foreshore areas covered by other studies at Myall Lakes (BMT WBM, 2015), Jimmys Beach (SMEC, 2013) and the Karuah River study which is currently in progress. That is, the study area extends west to the downstream fringes of the Karuah

[1] LiDAR (Light Detection and Ranging) – Optical remote sensing technology that can measure distance using laser light and analysing the backscatter. When measured from a place the distance measurements are used to estimate ground level elevation.

River (excluding the Karuah township) and extends north to the downstream limits of the Myall River (not including Tea Gardens and Hawkes Nest).

Ocean waves that penetrate through the 1,300 m wide ocean entrance between Yacaaba and Tomaree Heads impact the eastern embayment only.

LEGEND

Study Area

Title:

Study Area Locality

Figure: **1-1**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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1.2 Foreshore Flooding Behaviour

The Port Stephens estuary is a large coastal waterway that experiences elevated water levels due to several processes, which can interact. The dominant processes are:

- Ocean driven influences, including tides and storm surges;
- Wind and wave activity within the estuary, leading to wave action and increased water levels; and
- Catchment flooding from local rainfall, within the Karuah and Myall River catchments.

With regards to estuary water levels, Port Stephens is subject to storm surge conditions and wave action, which can cause temporary inundation of low-lying foreshore areas. Wave action can propagate into the eastern embayment though the Yacaaba and Tomaree Heads. In addition, the estuary has large fetch distances across both embayment sections and with moderate estuary bed depths (less than 10 m) common. As such, wind waves can be generated locally across the estuary. Estuary water levels can also become elevated from catchment flooding associated with the Karuah and Myall Rivers. In the future, climate change will cause sea level rise resulting in an increase in design foreshore inundation depths across low-lying areas.

1.3 The Need for Floodplain Management in Port Stephens

Future sea level rise will alter foreshore flooding of the Port Stephens estuary; therefore, it is necessary to understand the current and future flood risk. The dominant processes that influence flooding in the estuary are elevated ocean levels and wave runup. The impact of catchment rainfall is only significant when it is combined with elevated ocean levels. Catchment runoff will not produce significant flooding along the estuary foreshore in the absence of elevated ocean levels (WMAwater, 2010).

With regards to flood risk, foreshore residents are unlikely to be caught unaware or become isolated since water levels will rise slowly and there is safe egress to flood free land from all foreshore areas. Nonetheless, there is a risk of foreshore flooding as stated in WMAwater (2002, 2010) and MHL (1998). This study will explore the existing and future climate flood behaviour to further identify and assess flood risk, including a revised set of flood maps.

1.4 The Floodplain Management Process

The State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the NSW Government's *Floodplain Development Manual* (2005).

Under the Policy the management of flood liable land remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through six sequential stages as listed in Table 1-1.

Table 1-1 Stages of Floodplain Management

	Stage	Description
1	Formation of a Committee	Established by Council and includes community group representatives and State agency specialists.
2	Data Collection	Past data such as flood levels, rainfall records, land use, soil types etc.
3	Flood Study	Determines the nature and extent of the flood problem.
4	Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed developments.
5	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
6	Implementation of the Floodplain Risk Management Plan	Implementation of flood, response and property modification measures recommended in the Plan.

Existing climate flood behaviour has previously been assessed and reported in:

- *Port Stephens Flood Study Stage 1* (MHL, 1992)
- *Port Stephens Flood Study Stage 2* (MHL, 1997),
- *Port Stephens Flood Study Stage 3* (MHL, 1998)
- *Port Stephens Foreshore Management Plan* (WMAwater, 2002)
- *Port Stephens Design Flood Levels Climate Change Review* (WMAwater, 2010)

These studies form the basis for future floodplain management activities. The current study represents a review of the existing flood risk management information with an update of flood mapping incorporating detailed topographical data.

1.5 Structure of Report

This report documents the Study's objectives, findings and recommendations.

Section 1 introduces the study.

Section 2 provides background information including a catchment description, history of flooding and previous investigations.

Section 3 outlines the community consultation program undertaken.

Section 4 describes the flood risk mapping approach.

Section 5 provides a summary of design flood conditions.

Section 6 provides a summary of the flood damages assessment including identification of property potentially affected by flooding.

Section 7 provides a review of relevant existing planning measures and controls.

2 Background Information

2.1 Estuary Description

Port Stephens is a permanently open, tide dominated estuary. It is one of the largest estuarine systems in NSW with an estuary area of 140 km² and drainage catchment area of 2,900 km^2 (WMAwater, 2010). The estuary receives inflows from two major river systems: the Karuah and Myall Rivers (MHL, 1997). River inflows, ocean processes, and local weather patterns influence the magnitude of foreshore flooding in the Port Stephens estuary (MHL, 1997).

The Port Stephens estuary has both economic and ecological significance for the surrounding communities and the State. The estuary supports economic industries such as tourism and oyster farming. The waterway is reserved under the Port Stephens – Great Lakes Marine Park; the largest marine park in NSW (Department of Primary Industries (DPIE), n.d.).

2.2 History of Coastal Flooding

There is little qualitative or quantitative flood history in Port Stephens to date. The *Port Stephens Foreshore Management Plan* (WMAwater, 2002), identified past coastal flooding events via a questionnaire survey, which received anecdotal reports of 10 properties experiencing above floor flooding, of which three were flooded by the estuary. Another 60 residents reported inundation of yards, however only some of these reports were attributed to tidal and wave inundation. WMAwater (2002) noted that potentially some residents did not report flooding as they thought it was unimportant or could negatively impact future development plans they may have had.

2.3 Previous Studies

2.3.1 Port Stephens Flood Study

2.3.1.1 Stage 1: Analysis and Review of Existing Information (MHL, 1992)

The *Port Stephens Flood Study* was prepared by MHL in three stages. Stage 1 of the *Port Stephens Flood Study* involved a review of previous studies and historical data to determine the factors influencing flood levels in the Port Stephens area. The findings of the MHL (1992) flood study determined that flood levels are influenced by a combination of the following:

- Astronomical tide levels;
- Ocean storm surge (resulting from low atmospheric pressure, also referred to as barometric pressure setup);
- Local wind setup;
- Wave setup;
- Runoff from the Karuah River and Myall River catchments; and
- Wave runup.

2.3.1.2 Stage 2: Design Water Levels and Wave Climate (MHL, 1997)

Stage 2 of the *Port Stephens Flood Study* involved assessing design flood levels. The flooding mechanisms considered included rainfall and flooding in tributaries to the estuary, in addition to inundation at foreshore areas around the Port which are dependent upon ocean swell wave height, wind wave height, wind setup, barometric pressure setup and still water levels (including tides). Computer models were used to identify flood extents for the 5%, 2%, 1% annual exceedance probability (AEP) and extreme events. A hydrologic model using the WBNM runoff routing software was used to estimate design flood hydrographs. The MIKE-21 two-dimensional (2D) hydraulic software was then used to analyse the effects of design water levels, local wind effects, and runoff from the Karuah River, Myall River and Tilligerry Creek[2].

MHL (1997) used local wind conditions with a numerical model to estimate the wind wave climate in the Port Stephens estuary. To determine ocean swell wave heights where ocean waves penetrate the estuary entrance, wave data recorded from offshore wave rider buoys was propagated to the Port Stephens shoreline with the use of a wave model and empirical formulas. As an outcome from these analyses, MHL (1997) provided design peak water levels, plus design wind wave and ocean wave conditions for the estuary. The reported flood levels along the foreshore are dependent upon the wave approach to shore combining with a still water level, resulting in wave runup and inundation characterised by local bathymetry and foreshore structures.

The findings of the MHL (1997) study, particularly for wind setup and empirical wave calculations, are of use for comparison with wave modelling conducted as part of this study (refer Section 4.10), to ensure consistency.

2.3.1.3 Stage 3: Foreshore Flooding (MHL, 1998)

The purpose of Stage 3 of the *Port Stephens Flood Study* was to generate the 5% AEP, 1% AEP, and extreme foreshore flood levels at 42 locations within the estuary. This was conducted by combining design event water levels, wind wave climates, and ocean wave climates identified in Stage 2 of the study. An assessment of bathymetry and foreshore structures at each of the 42 locations was also undertaken to estimate wave runup to determine design foreshore flood levels.

The study area included the entire estuary shared by MidCoast Council (formerly Great Lakes Council) and Port Stephens Council local governments. Of the 42 water level sites calculated across the estuary, 18 locations fall within the MidCoast Council local government area (LGA). As a key output, this study documents the following coastal and catchment flood behaviour:

- Design event peak water levels for Port Stephens calculated from storm tide, flood runoff and wind;
- Wave climate in Port Stephens from ocean waves, with wave period ranging from 12 to 15 seconds; and
- Locally generated wind waves in Port Stephens.

[2] Tilligerry Creek enters the estuary from the south, with a small catchment relative to the Karuah and Myall Rivers. Refer to Figure 1-1.

2.3.2 Port Stephens Foreshore Floodplain Management Study and Plan (WMAwater, 2002)

The *Port Stephens Foreshore Floodplain Management Study and Plan (FMSP)* was prepared by WMAwater for Council in 2002. It used the design foreshore flood levels derived during the Flood Study (MHL, 1992, 1997, 1998) and developed actions to manage foreshore floodplain risks.

The FMSP report described the results of a questionnaire survey, which documented historical accounts of wind wave activity, foreshore erosion and inundation of low-lying land during storms, most notably the May 1974 storms. The survey also indicated there to be no historical or accurate record of damage to buildings or structures, except for seawalls and other structures upon the immediate foreshore (WMAwater, 2002).

The Plan identified the following high priority actions for flood modification measures:

- F1 - Evaluate if a future development can form part of a levee system.
- F2 - Conduct a community education / information program to advise residents of the value of vegetation barriers along the foreshore.
- F3 - Promote revegetation of foreshore in most favourable areas.
- F4 - Identify specific areas where local flooding is a problem.
- F5 - Work alongside residents to improve local drainage.
- F6 - Monitor the impact of wind wave runup.
- F7 - Ensure all proposed foreshore developments are assessed in regard to wind wave runup, erosion and other coastal hazards. In the future both Councils (MidCoast and Port Stephens Councils) should prepare a Development Control Plan (DCP) covering all aspects of foreshore development.

2.3.3 Port Stephens Design Flood Levels Climate Change Review (WMAwater, 2010)

The *Port Stephens Design Flood Levels Climate Change Review* (WMAwater, 2010) documents the most current design flood level information and assesses climate change impacts for the estuary. Flood level information for the 5% AEP, 1% AEP and extreme flood design conditions are listed for still water levels, wave runup effects and climate change impacts across 42 locations within the estuary, of which 15 span the Council foreshore (refer to Table 2-1 for current and future climate design flood levels along the northern foreshore and Figure 2-1 for corresponding locations).

In assessing climate change influence on design levels, the study found that future sea level rise projections could be directly applied to both the current climate still water level and wave runup levels. Climate change benchmarks of 0.4 and 0.9 m sea level rise were adopted for the future 2050 and 2100 timeframes (note: these levels differ from Council's current policy of 0.55 and 0.91 m sea level rise for the same future planning horizons).

The following key outputs from this study form the basis for the new mapping and review of the FRMSP presented herein:

- current climate flood, ocean and wave runup levels; and

- increased ocean water levels (sea level rise) will raise the design flood and wave runup levels by the same amount as the assumed sea level rise.

Table 2-1 Design Peak Water Levels from WMAwater (2010) for the Project Study Area

Site	Location	Wave runup			Stillwater - no wave runup but includes elevated ocean levels + catchment runoff + local wind effects		
		5% AEP	1% AEP	Extreme	5% AEP	1% AEP	Extreme
28	Karuah Bridge	1.8	1.9	2	1.8	1.9	2
29	Correebah	2.3	2.4	2.7	1.7	1.8	1.9
30	Carrington	2	2.2	2.3	1.7	1.8	1.9
31	Baromee Point	2.2	2.3	2.4	1.7	1.8	1.8
32	Baromee Hill	2.2	2.3	2.4	1.7	1.8	1.8
33	Bundabah	1.7	1.8	2	1.7	1.8	1.8
34	Fame Point	3.2	3.4	3.9	1.7	1.8	1.8
35	Lower Pindimar	2.3	2.4	2.7	1.6	1.7	1.8
36	Orungall Point	2	2.2	2.4	1.6	1.7	1.7
37	Pindimar	2	2	2.2	1.6	1.7	1.7
38	Limestone	1.6	1.7	1.7	1.6	1.7	1.7
39	Tea Gardens	1.6	1.8	2.3	1.6	1.8	2.3(1)
40	Hawks Nest	1.5	1.7	2	1.5	1.7	2.0(1)
41	Jimmy's Beach West	2.9	3.1	3.4	1.5	1.6	1.6
42	Jimmy's Beach East	2.5	2.6	2.9	1.5	1.6	1.6

NOTES:
1) Affected by Myall River flow, particularly in the extreme event.
2) Highlighted numbers indicate where the wave runup level exceeds 2.5 m AHD.

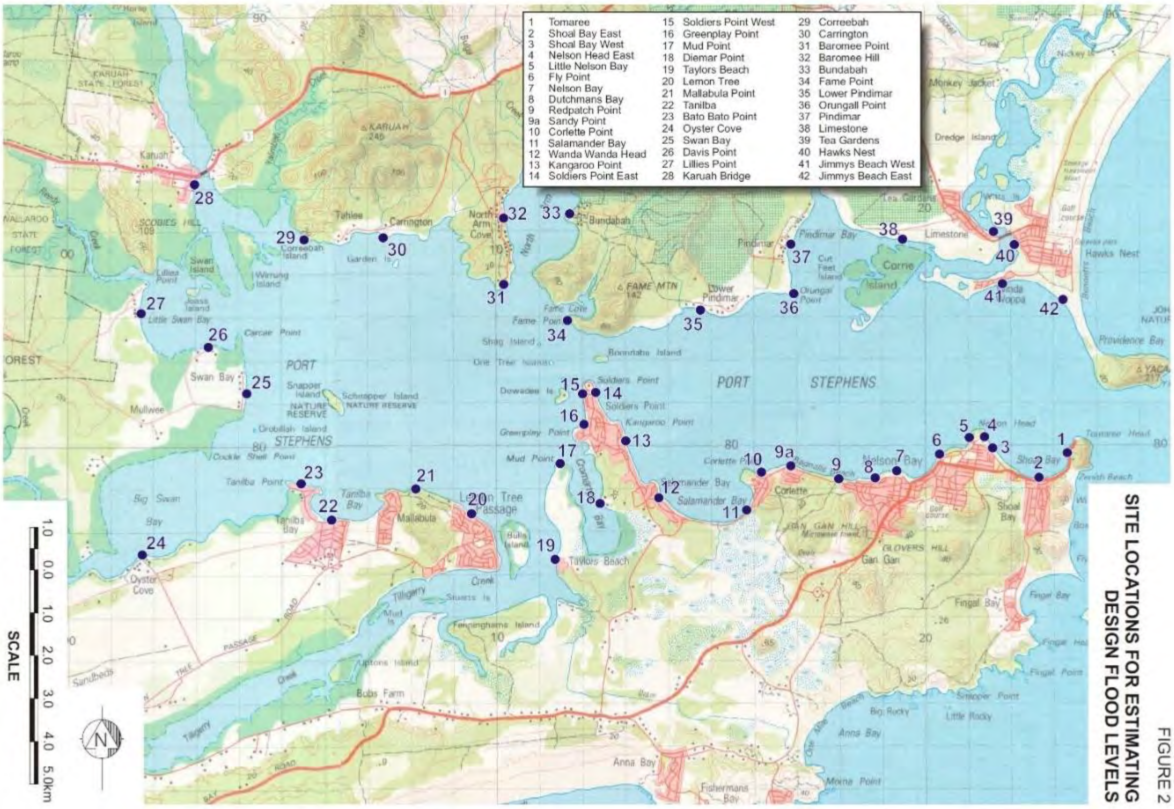


Figure 2-1 Design Flood Level Location, Port Stephens Estuary (source: WMAwater, 2010)

3 Community Consultation

Community consultation is an important component of the floodplain risk management process. The success of a FRMSP hinges on its acceptance by the local community and stakeholders. This can be achieved by involving the community in the decision-making process.

Although existing studies have already provided the community with flood information throughout the study area, the updated mapping process will provide an enhanced visualisation of the flood risk, which may differ from people's current understanding. It is therefore important to engage the community, keeping them informed of the study outcomes.

The key elements of the consultation process for this study includes:

- Consultation with Councils Floodplain Management Committee through meetings and presentations; and
- Public exhibition of the Draft FRMSP.

3.1 The Floodplain Management Committee

The study has been overseen by the MidCoast Council's Floodplain Management Committee (the Committee). The Committee has assisted and advised Council in the development of the FRMSP and is responsible for recommending the outcomes of the study for formal consideration by Council. The Committee includes representatives from the following:

- MidCoast Council - Councillors
- MidCoast Council – technical staff
- Community representatives
- Government bodies:
  - NSW State Emergency Services
  - NSW Department of Planning, Industry and Environment (DPIE) (formerly NSW Office of the Environment and Heritage)
  - Other State Government agencies as required
- Industry and research representatives.

3.2 Public Exhibition

The *Draft Port Stephens Foreshore Floodplain Risk Management Study and Plan* was placed on public exhibition between 2 November 2020 and 9 December 2020. The report was made available on Council's website. Landowners, residents and businesses were invited to participate in the study by providing comment on the Draft Report.

Council also held two drop-in sessions during the exhibition period on 10 November and 30 November 2020 for members of the public to provide feedback to staff who conducted the study.

No formal submissions were received during the exhibition period, although several comments regarding format and presentation of the Draft Report were provided. Whilst the overall findings are unchanged from the exhibition draft, comments received during exhibition have been addressed in this final report.

4 Flood Risk Mapping Approach

4.1 Review of Existing Models and Data

Foreshore flooding within the study area is driven by a combination of catchment and coastal processes, which have been previously assessed in a series of studies summarised in Section 2.3. The catchment modelling completed in Stage 2 of the *Port Stephens Flood Study* (MHL, 1997) used a WBNM hydrological model and MIKE-21 hydraulic model (Section 2.3.1.2). The hydraulic model (MIKE-21) was used to output coastal flooding extents driven by storm surge and wave action. The modelling approaches and outputs in MHL (1997) are considered fit-for-purpose. Therefore, there has been no need to update the modelling for this study.

A review of flooding with respect to climate change was completed by WMAwater (2010) which evaluated future flood levels based on sea level rise affecting still water levels and wave runup levels. WMAwater (2010) adopted sea level rise benchmarks in accordance with the *Practical Consideration of Climate Change* (NSW Department of Environment and Climate Change (DECC), 2007). The approach adopted by WMAwater (2010) to apply to the DECC guideline SLR benchmarks is considered suitable, therefore no review or update has been necessary at this stage.

Detailed topographic and bathymetric survey was not available for the above studies. Therefore, flood hazard and risk mapping has not been produced prior to this study.

4.2 Topographic and Bathymetric Survey

Detailed elevation information has been made available to the current study, as follows:

- LiDAR topographic survey of the onshore areas for the Port Stephens estuary. This data was collected by the NSW Department of Land and Property Information in 2012.
- Bathymetric / hydrographic survey data of the Port Stephens estuary bed and Myall River channel, collected over various survey campaigns including:
  - 2001 - Australian Hydrographic Service bathymetric chart AUS00209 of Port Stephens. The Chart covers the whole region of the Port Stephens estuary;
  - 2007 - Port Stephens Hydrographic Survey (Draft) collected and supplied by DECCW covering the central and eastern basin regions of Port Stephens; and
  - September 2009 - Myall River Entrance Hydrographic Survey, collected and supplied by DECCW, covering the Lower Myall River, Corrie Creek (Northern Channel) and Paddy Marrs Inlet (Eastern Channel).

The above information was combined to produce a Digital Elevation Model (DEM) of the study area, which enabled a set of flood maps to be derived using the approach described below.

4.3 Mapping Approach

Mapping of the estimated still water and wave runup foreshore flooding is required for the 5% AEP, 1% AEP and extreme flood conditions, under the existing climate and future climate scenarios.

As outlined in Section 2.3, design flood conditions for the Port Stephens Estuary were determined by MHL (1997) and reviewed by WMAwater (2010). The established levels for the existing climate were adopted for the purpose of producing flooding maps within this study.

Impacts of climate change and sea level rise were assessed by WMAwater (2010), who found that *"increases in sea level will raise the design flood levels and wave runup levels by the same amount as the assumed ocean level rise".* The future climate change conditions have therefore been modelled herein by adding 0.55 m and 0.91 m to the existing design flood levels to represent 2050 and 2100 future climate scenarios.

Additional numerical modelling has not been required for this study. Rather, the existing flood levels determined across the Port Stephens foreshore were used to map flood behaviour, levels and risk.

Table 4-1 lists the sea level rise conditions mapped for the existing and future climates.

Table 4-1 Adopted Sea Level Rise for Existing and Future Climates

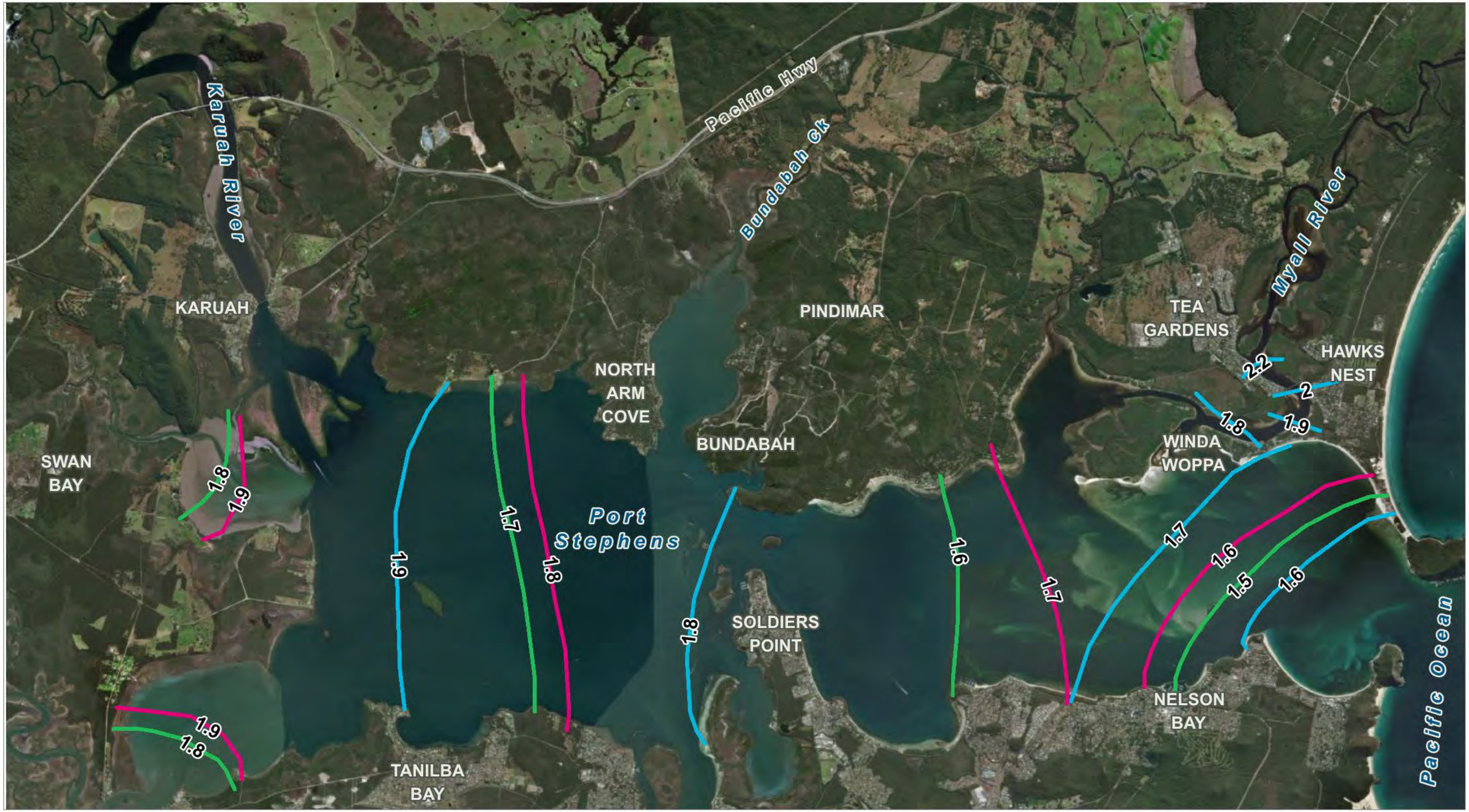
Design Event	Present Day	2050 timeframe	2100 timeframe
5% AEP	+0	+0.55 m	+0.91 m
1% AEP	+0	+0.55 m	+0.91 m
Extreme event	+0	+0.55 m	+0.91 m

4.4 Still Water Level Mapping

Still water flood conditions were mapped for this study using the design still water flood levels presented in WMAwater (2010) for existing climate conditions, and applying the sea level rise listed in Table 4-1 for future climate scenarios. Design still water flooding levels were provided in WMAwater (2010) at point locations across the estuary foreshore, in addition to still water flood gradient maps. The WMAwater (2010) map was georeferenced in GIS and the flood gradient contours were digitised for the current study (see Figure 4-1).

The existing climate still water level contours were interpolated to produce a raster surface for the 5% AEP, 1% AEP and extreme flood design conditions. Sea level rise is accounted for by increasing the still water level raster grids by the respective sea level rise increment. The resultant grids represent the flood levels for the various design events for existing and climate change scenarios.

Flood extents and depths have then been determined by intersecting the flood level grids with the DEM.



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- 5% AEP Flood Contour and Height (mAHD)
- 1% AEP Flood Contour and Height (mAHD)
- Extreme AEP Flood Contour and Height (mAHD)

Title:

Still Water Level Contours Port Stephens

Figure: **4-1**

Rev: **A**

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4.5 Wave Runup Mapping

Wave runup flood conditions were mapped for this study using the design wave runup levels presented in WMAwater (2010) and applying sea level rise for future climate change scenarios (see Table 4-1). As described in Section 2.3, design wave runup levels were modelled for 42 discrete (point) locations across the study foreshore region. These levels were found to vary based on a range of physical factors, including wave exposure and shoreline profile. The current study has mapped the discrete wave level data as a continuous wave level surface using the following approach:

- Distribute discrete wave level data across the study foreshore;
- Model wave runup levels near to the foreshore using a GIS tool that is underpinned by simple assumptions (e.g. influence of wave driven water levels limited to a defined distance from the coastline); and
- Map still water levels across low-lying areas landward of the wave action zone.

Distribution of Design Wave Runup Levels

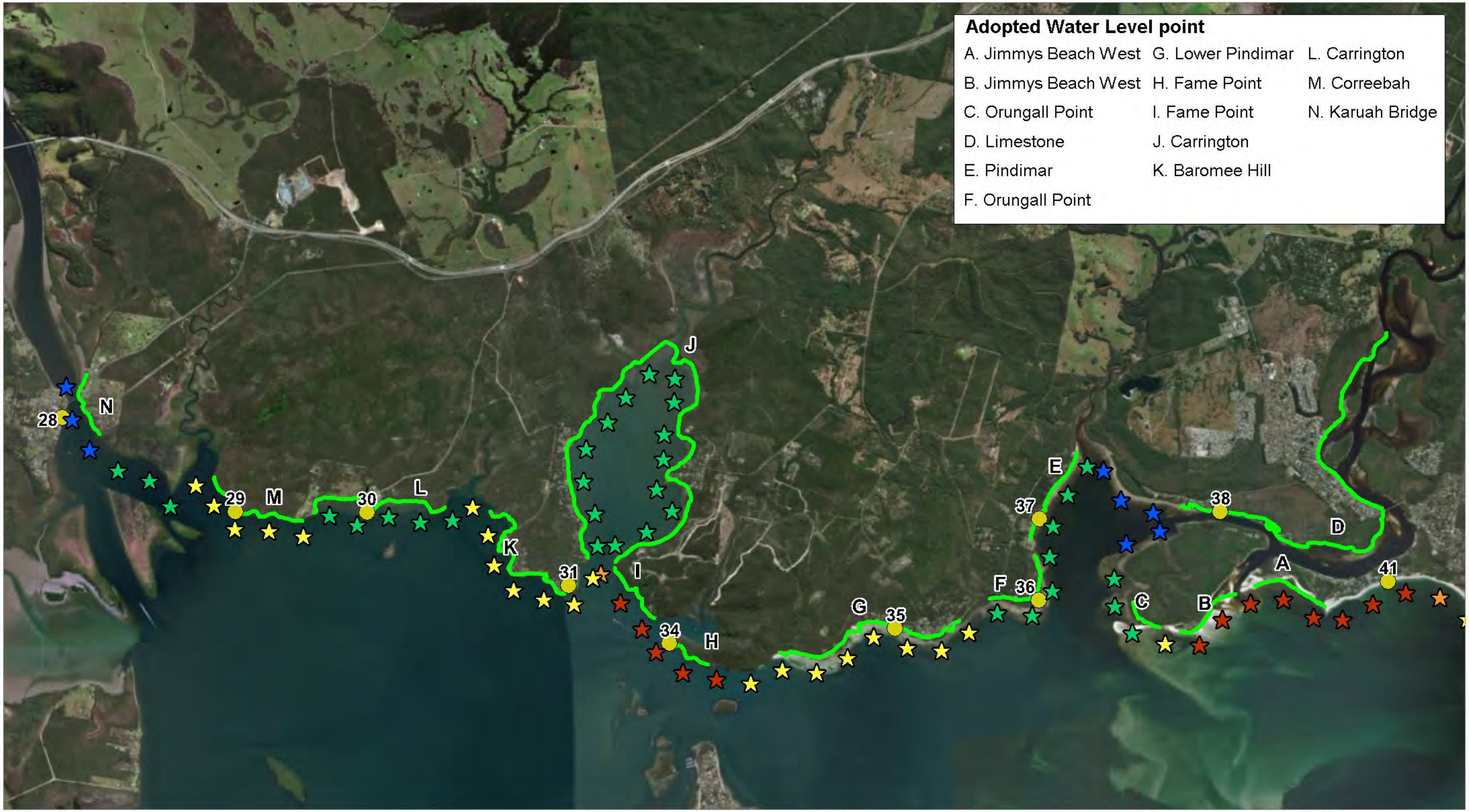
Design water levels from the discrete point locations were applied across the study area by mapping coastline segments that have similar characteristics (coastline orientation and fetch). The corresponding design water levels were then applied to these segments, which are mapped in Figure 4-2. Design water levels were then interpolated between the mapped segments.

Table 4-2 lists the assumptions/reasons for adopted water level points and wave runup levels.

Wave Runup Tool

The study area was mapped with a 100 m buffer landward of the coastline reflecting a potential zone that could be influenced by wave runup. The wave runup levels were adopted within this zone defining the peak inundation depth. The influence of wave setup and runup processes beyond the 100 m landward buffer and within rivers and inlets is assumed to be negligible and therefore the still water level was applied in these areas. This adopted approach produces a minor discontinuity at the 100 m landward buffer location where there is a transition from the higher water level that includes wave influences to the lower water level that considers storm tide only.

The mapping is based on model output at 500 m spacing along the coast. The design water levels have been interpolated onto a 1 m grid and translated over land to determine inundation depths and extents. An example map of the Port Stephens area is provided in Figure 4-3.



LEGEND

Wave Runup Interpolated Segments

A Line ID

Adopted WMA Wave Runup Point

1% AEP & Interpolated Wave Runup Levels [m]

- 3.1 - 3.5
- 2.8 - 3.0
- 2.3 - 2.7
- 2.0 - 2.2
- 1.5 - 1.9

Title:

Wave Runup Interpolation - Port Stephens Estuary

Figure: **4-2**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\DRG_WR_mapping_001.wor"

Table 4-2 Adopted Water Level points and Wave Runup Heights

Shoreline Segment	Adopted WL point	Mapping Qualifier	Wave Runup Heights (m)[1]		
			5% AEP	1% AEP	Extreme
A	41	Comparable shoreline aspect (southwest) and maximum fetch direction (west)	1.4	1.5	1.8
B	41	Comparable shoreline aspect (southeast) and maximum fetch direction (west)	1.4	1.5	1.8
C	36	Comparable shoreline aspect (southwest) and maximum fetch direction (southwest)	0.4	0.5	0.7
D	38	No Fetch	0	0	0
E	37	Comparable shoreline aspect (southeast) and maximum fetch direction (southeast)	0.4	0.3	0.5
F	36	Comparable shoreline aspect (southwest & southeast) and maximum fetch direction (southwest)	0.4	0.5	0.7
G	35	Comparable shoreline aspect (south) and maximum fetch direction (southwest)	0.7	0.7	0.9
H	34	Comparable shoreline aspect (southwest) and maximum fetch direction (west)	1.5	1.6	2.1
I	34	Comparable shoreline aspect (southwest) and maximum fetch direction (west)	1.5	1.6	2.1
J [2]	30	Comparable shoreline aspect (south) and maximum fetch direction (south)	0.3	0.4	0.4
K	31	Comparable shoreline aspect (southwest) and maximum fetch direction (south)	0.5	0.5	0.6
L	30	Comparable shoreline aspect (south) and maximum fetch direction (south)	0.3	0.4	0.4
M	29	Comparable shoreline aspect (southwest) and maximum fetch direction (south)	0.6	0.6	0.8
N	28	No Fetch	0	0	0

[1] Wave runup heights (m) show the difference between the wave runup inundation level (m AHD) and still water inundation level (m AHD) reported in WMAwater (2010), unless otherwise stated.

[2] Wave runup heights adopted for locations where available point data was considered inappropriate (see table for details).

Figure 4-3 Adopted Mapping Methodology of 1% AEP Event; including Wave Runup level. Applied within 100 m of the Shoreline (indicated by Red Line).

Effort has been made to only map inundation in areas with a hydraulic connectivity with the estuary. However, inundation may be shown in some locations that are not directly connected but fall below the criteria water level (i.e. natural low points disconnected from the estuary). The mapping also assumes that there is sufficient time and water available from the overtopping of coastal barriers to fill potential holding basins up to the given water level. In this respect, the mapped inundation areas are likely to be conservative. Some of this conservatism could be removed if the mapping considered overland flow for each simulated event. Such an approach would remove the need to develop a simplified parametric model but would be too computationally intensive for a regional scale assessment.

However, the adopted mapping methodology produces less conservative inundation maps than simply applying the storm tide including wave setup and runup levels at all locations along the coastline, which is sometimes referred to as a 'bathtub' method. The adopted methodology is similar to a simple 'bathtub' method, but is less conservative because the wave runup and wave setup components are removed for locations beyond the 100 m landward buffer (and within rivers and inlets).

4.5.1 Limitations

The wave runup estimations are coarse in terms of mapping a continuous inundation profile along the full foreshore environment, being derived from point specific locations. The previous reporting identifies several considerations regarding the analysis and use of the wave runup results:

- The cross sections (describing the foreshore) may change in time.
- One cross section was taken as being representative of the site. This is an approximation and in reality, there may be significant changes in the cross section away from the point location.
- Design levels are only accurate at each of the 42 sites. Outside of these sites, the actual levels may vary.
- If significant development is to be undertaken, site specific analysis should be undertaken.
- Where buildings are located close to the foreshore the impact of wave runup needs to be addressed more closely (openings to the building, structural integrity, etc).
- The actual design flood levels behind foreshore seawalls depend upon the distance from the seawall and the presence of any buildings.

With the above uncertainties in mind, consideration must be given to potential model inaccuracies, surface water variability during an inundation event and any unresolved localised hydraulic effects.

4.6 Depth Mapping

Mapping the design still water level (SWL) depths can be readily undertaken through the creation of a peak SWL (described in Section 4.4) surface and intersecting this with the LiDAR DEM. This approached was applied to the interpolated SWL raster surface for the 5% AEP, 1% AEP and extreme events for existing climate and sea level rise scenarios. Flood depths were calculated by subtracting the DEM elevations from interpolated SWL raster surface.

4.7 Hazard Mapping

The National Flood Risk Advisory Group (AIDF, 2017) considers a holistic approach to consider flood hazards to people, vehicles and structures. It recommends a composite six-tiered hazard classification, reproduced in Figure 4-4 and summarised in Table 4-3.

The flood hazard classification is determined based on the predicted flood depth and velocity. This is undertaken through the analysis of flood model results. A high flood depth will cause a hazardous situation while a low depth may only cause an inconvenience. High flood velocities are dangerous and may cause structural damage while low velocities generally have no major threat.

Hazard mapping of the SWL and wave runup levels in the Port Stephens estuary was completed based on depth, assuming only minor velocities for the tidal inundation.

Table 4-3 Flood Hazard Classifications

Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly.
H4	Unsafe for all people and vehicles.
H5	Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

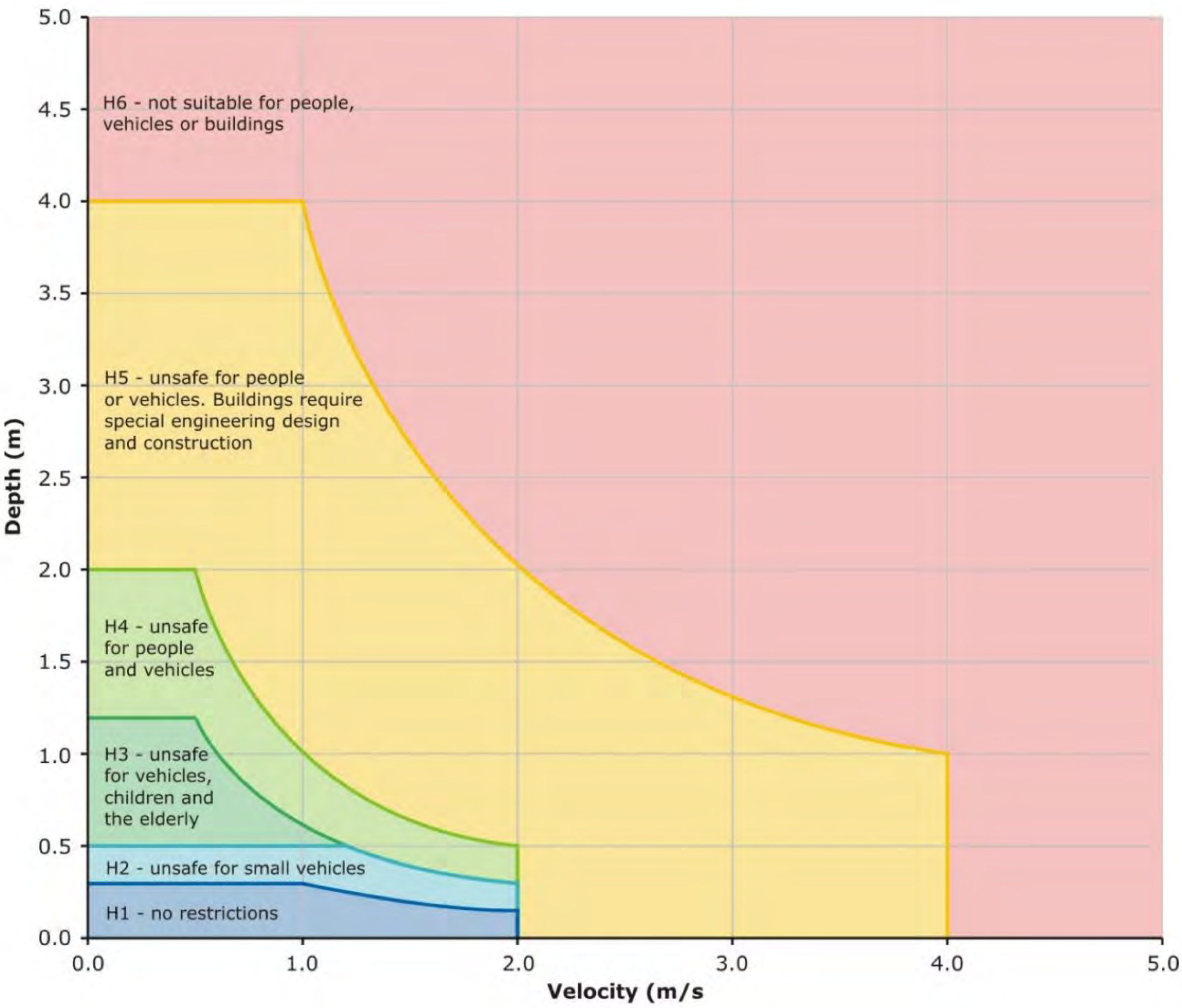


Figure 4-4 Combined Flood Hazard Curves

5 Design Flood Conditions

5.1 Coastal Flood Behaviour

The following sections describe flood behaviour in terms of modelled design still water (SWL) and wave runup (WRU) depths for the 1% AEP and 1% with 2100 SLR (Sections 5.1.1 to 5.1.2). While a range of design scenarios have been modelled, the described scenarios provide a good indication of the changing risk profile through time and have been selected for this reason. Table 5-1 lists the full range of design events and climate scenarios that have been modelled for this study, with the corresponding maps presented in Appendix C.

Table 5-1 Design Event and Climate Scenarios Modelled for this Study

Design Event	Sea level rise (m)		
	Existing Climate	2050 Climate	2100 Climate
5% AEP	0	0.55	0.91
1% AEP	0	0.55	0.91
Extreme event	0	0.55	0.91

5.1.1 Still Water Coastal Flooding

Design still water depth mapping is presented in Appendix C as follows (refer to mapping index in Figure 5-1):

- 'A' series maps: Tahlee to Carrington
  - Maps A-01 to A-03 for the 5% AEP
  - Maps A-07 to A-09 for the 1% AEP
  - Maps A-13 to A-15 for the extreme event
- 'B' series maps: Upper North Arm Cove
  - Maps B-01 to B-03 for the 5% AEP
  - Maps B-07 to B-09 for the 1% AEP
  - Maps B-13 to B-15 for the extreme event
- 'C' series maps: Lower North Arm Cove and Bundabah
  - Maps C-01 to C-03 for the 5% AEP
  - Maps C-07 to C-09 for the 1% AEP
  - Maps C-13 to C-15 for the extreme event
- 'D' series maps: Pindimar South
  - Maps D-01 to D-03 for the 5% AEP
  - Maps D-07 to D-09 for the 1% AEP
  - Maps D-13 to D-15 for the extreme event

- ‘E’ series maps: Pindimar Bay
  - Maps E-01 to E-03 for the 5% AEP
  - Maps E-07 to E-09 for the 1% AEP
  - Maps E-13 to E-15 for the extreme event.

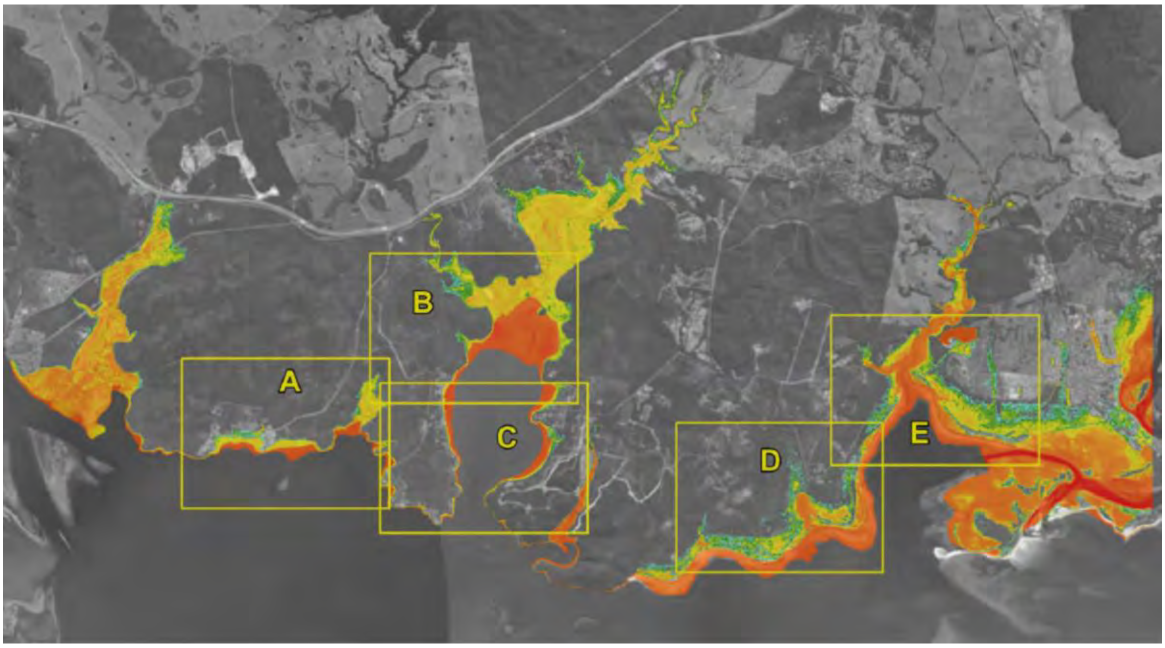


Figure 5-1 Flood Depth Mapping Index

Design still water depth maps show that the following foreshore townships are subject to flood risk:

- Tahlee and Carrington – During the design 1% AEP event, township areas become inundated by depths up to 1.0 m. By 2100, flood extents and depths increase for the same AEP design event to greater than 1.0 m. Church Street is the only exit road for Tahlee residents. Under the existing climate 1% AEP design condition, this exit road becomes flooded with depths less than 1.0 m, which increase to greater than 1.0 m for the 2100 SLR scenario.
- North Arm Cove and Bundabah - During the current and future 2100 1% AEP design conditions, the township areas of North Arm Cove and Bundabah become inundated around the coastal fringe. Flood extents are more contained due to the steep coastal profile. 1% AEP inundation depths less than 1.0 m are shown for existing climate conditions and greater than 1.0 m for the 2100 SLR scenario.
- Pindimar - Pindimar is subject to the largest inundation extents compared to other townships due to the low elevation of the area. Properties and roads become flooded by depths less than 1.0 m under the existing climate 1% AEP conditions, which increase to depths greater than 1.0 m for the 2100 SLR scenario. Pindimar flooding extents increase significantly with future SLR, particularly across residential areas adjoining the western shores of Pindimar Bay. A narrow strip of residential properties situated along the north-eastern foreshore of Pindimar Bay are subject to inundation. These properties are connected to the main township of Tea Gardens via Limekilns Road. The properties and access road become inundated during 1% AEP conditions under

current climate and future SLR scenarios. The roadway east of the residential areas is particularly low-lying and thus subject to flooding.

5.1.2 Wave Runup Flooding

Design wave runup water depth mapping is presented in Appendix C as follows (refer to mapping index in Figure 5-1):

- ‘A’ series maps: Tahlee to Carrington
  - Maps A-04 to A-06 for the 5% AEP
  - Maps A-10 to A-12 for the 1% AEP
  - Maps A-16 to A-18 for the extreme event
- ‘B’ series maps: Upper North Arm Cove
  - Maps B-04 to B-06 for the 5% AEP
  - Maps B-10 to B-12 for the 1% AEP
  - Maps B-16 to B-18 for the extreme event
- ‘C’ series maps: Lower North Arm Cove and Bundabah
  - Maps C-04 to C-06 for the 5% AEP
  - Maps C-10 to C-12 for the 1% AEP
  - Maps C-16 to C-18 for the extreme event
- ‘D’ series maps: Pindimar South
  - Maps D-04 to D-06 for the 5% AEP
  - Maps D-10 to D-12 for the 1% AEP
  - Maps D-16 to D-18 for the extreme event
- ‘E’ series maps: Pindimar Bay
  - Maps E-04 to E-06 for the 5% AEP
  - Maps E-10 to E-12 for the 1% AEP
  - Maps E-16 to E-18 for the extreme event.

The modelled flood extents for WRU design conditions are comparable to those mapped for the SWL design events (existing and future climates). Greater inundation depths and extents will occur across the foreshore fringing areas, due to increased water levels generated by wave runup processes. The following WRU behaviour is described across the foreshore margin areas that have been modelled as subject to wave driven inundation:

- Tahlee and Carrington – Under the existing climate 1% AEP scenario, township areas become inundated by depths greater than 1.0 m. By 2100, flood extents and depths increase to greater than 1.5 m. Under the existing climate 1% AEP design condition, Church Street becomes flooded with depths of inundation less than 1.0 m, which increase to greater than 1.5 m for the 2100 SLR scenario.

- North Arm Cove and Bundabah - Township areas of North Arm Cove and Bundabah become inundated near to the foreshore, with 1% AEP inundation depths less than 1.0 m during existing climate conditions and greater than 1.5 m for the 2100 SLR scenario.
- Pindimar - Properties and road inundation at Pindimar are subject to 1% AEP flood depths of up to 1.25 m and 2.25 m under the current climate and 2100 SLR scenarios, respectively. Residential properties accessed by Limekilns Road along the north-eastern foreshore of Pindimar Bay are also subject to inundation under these design conditions and SLR scenarios.

5.2 Flood Hazard

Flood hazard has been assessed and mapped using the approach outlined in Section 4.7 of the *Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017), which classifies hazard as per Table 4-3. Foreshore flood hazard for design still water level and wave runup conditions is presented in the following sections. The corresponding flood hazard maps are presented in Appendix D.

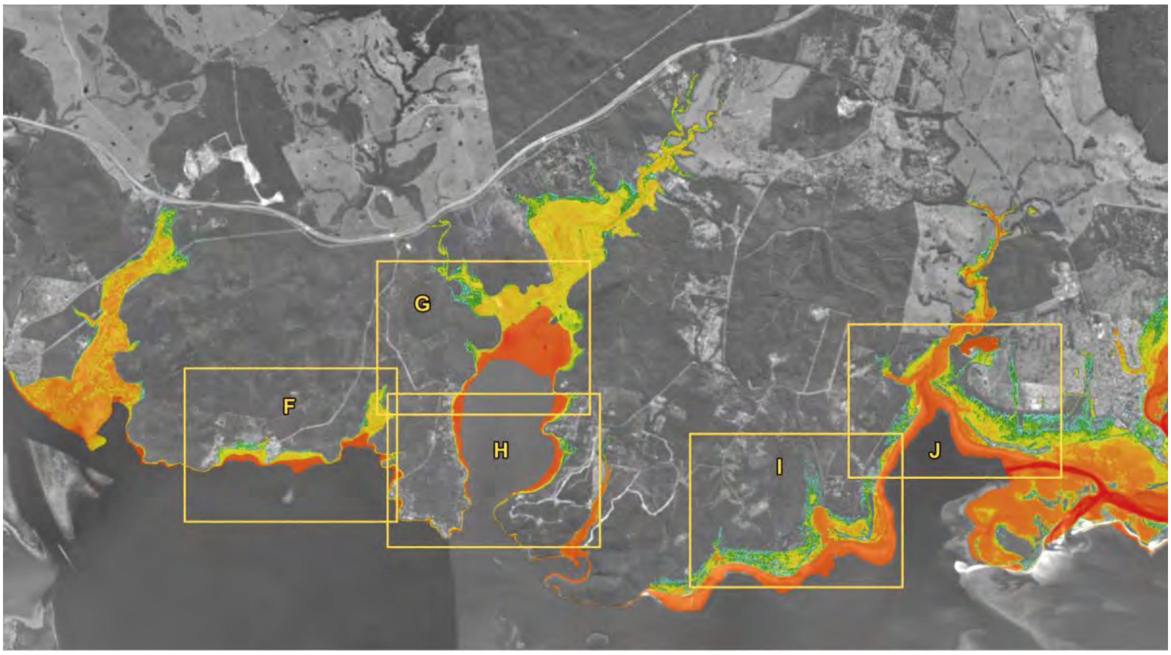


Figure 5-2 Flood Hazard Mapping Index

5.2.1 Still Water Level Hazard

Design still water hazard mapping is presented in Appendix D as follows (refer to mapping index in Figure 5-2):

- ‘F’ series maps: Tahlee to Carrington
  - Maps F-01 to F-03 for the 5% AEP
  - Maps F-07 to F-09 for the 1% AEP

  - Maps F-13 to F-15 for the extreme event
- ‘G’ series maps: Upper North Arm Cove
  - Maps G-01 to G-03 for the 5% AEP
  - Maps G-07 to G-09 for the 1% AEP
  - Maps G-13 to G-15 for the extreme event
- ‘H’ series maps: Lower North Arm Cove and Bundabah
  - Maps H-01 to H-03 for the 5% AEP
  - Maps H-07 to H-09 for the 1% AEP
  - Maps H-13 to H-15 for the extreme event
- ‘I’ series maps: Pindimar South
  - Maps I-01 to I-03 for the 5% AEP
  - Maps I-07 to I-09 for the 1% AEP
  - Maps I-13 to I-15 for the extreme event
- ‘J’ series maps: Pindimar Bay
  - Maps J-01 to J-03 for the 5% AEP
  - Maps J-07 to J-09 for the 1% AEP
  - Maps J-13 to J-15 for the extreme event,

Generally the residential areas exposed to flooding will experience increased hazard with sea level rise as summarised below:

- Tahlee and Carrington – The township areas of Carrington and Tahlee have a H3 hazard classification for the existing climate 1% AEP event. By 2100, flood hazard will increase to a H4 hazard classification for the same event. The Tahlee exit road, Church Street, has a H1 hazard classification during the existing climate 1% AEP event, increasing to H3 for the 2100 SLR scenario.
- North Arm Cove and Bundabah - The foreshore fringes of North Arm Cove and Bundabah have a H3 classification for the existing climate 1% AEP event, and staying at H3 for the 2100 SLR scenario.
- Pindimar - The extensive low-lying township areas across Pindimar have a H3 hazard classification for the existing climate 1% AEP event, increasing to H4 for the 2100 SLR scenario. Some localised areas in Pindimar increase to H5. The narrow strip of residential properties and associated access road situated on north-eastern foreshore of Pindimar Bay have a H1 hazard classification for the existing climate 1% AEP event, increasing to H3 for the 2100 SLR scenario.

5.2.2 Wave Runup Hazard

Design wave runup hazard mapping is presented in Appendix D as follows (refer to mapping index in Figure 5-2):

- ‘F’ series maps: Tahlee to Carrington
  - Maps F-04 to F-06 for the 5% AEP
  - Maps F-10 to F-12 for the 1% AEP
  - Maps F-16 to F-18 for the extreme event
- ‘G’ series maps: Upper North Arm Cove
  - Maps G-04 to G-06 for the 5% AEP
  - Maps G-10 to G-12 for the 1% AEP
  - Maps G-16 to G-18 for the extreme event
- ‘H’ series maps: Lower North Arm Cove and Bundabah
  - Maps H-04 to H-06 for the 5% AEP
  - Maps H-10 to H-12 for the 1% AEP
  - Maps H-16 to H-18 for the extreme event
- ‘I’ series maps: Pindimar South
  - Maps I-04 to I-06 for the 5% AEP
  - Maps I-10 to I-12 for the 1% AEP
  - Maps I-16 to I-18 for the extreme event
- ‘J’ series maps: Pindimar Bay
  - Maps J-04 to J-06 for the 5% AEP
  - Maps J-10 to J-12 for the 1% AEP
  - Maps J-16 to J-18 for the extreme event,

Compared with the SWL, the WRU hazard classifications generally increase near to the foreshore. This reflects the greater depths that are generated by wave runup processes. The greatest increases are noted at Pindimar, particularly for properties on the foreshore side of Cambage Street where wave runup calculations in WMAwater (2010) show that the impacts of waves are greatest.

Flood hazard is summarised below for the different areas:

- Tahlee and Carrington - The township areas of Tahlee and Carrington have a H3 hazard classification for the existing climate 1% AEP event, increasing to a H4 hazard classification during the 2100 SLR scenario for the same event. Existing climate conditions at Church Street have a H3 hazard classification for the 1% AEP event, increasing to H4 for the 2100 SLR scenario.

- North Arm Cove and Bundabah – North Arm Cove and Bundabah have a H3 hazard classification for the existing climate 1% AEP event, increasing to a H4 hazard classification during the 2100 SLR scenario.
- Pindimar - At Pindimar, the hazard classification is H3 for existing climate conditions, and H4 for the 2100 SLR scenario, with some localised areas mapped as H5. Wave runup impacts are insignificant along the north-eastern foreshore of Pindimar Bay and thus the WRU hazard classification profile reflects that mapped for the SWL conditions. Residential properties and the access road are mapped up to hazard classifications of H1 and H3 under current and future sea level rise scenarios, respectively.

Overall, a larger area of the foreshore experiences H3 and H4 hazard from wave runup than experienced during still water conditions.

5.3 Flood Function

Hydraulic categorisation is one of the tools used to identify flood behaviour and risk. Outcomes of the categorisation are primarily used to inform future land use planning. The categorisation is not used to assess individual developments, but rather to give a catchment-scale overview of which areas may be appropriate for different land uses.

There are no prescriptive methods for determining which parts of the floodplain constitute floodways, flood storages and flood fringe. Descriptions of these terms within the *Floodplain Development Manual* are essentially qualitative in nature. A challenge comes from the definition of flood behaviour and associated impacts, which is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment. However, an approach that is becoming increasingly accepted is to define the floodway extent as the area of floodplain conveying around 80% of the total flood flow, as defined by Thomson (2018). This is typically undertaken for the 1% AEP design flood event.

The hydraulic categories as defined in the *Floodplain Development Manual* are:

- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- **Flood Storage** - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or filled, it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked, would cause peak flood levels to increase by 0.1 m and/or would cause the peak discharge to increase by more than 10%.
- **Flood Fringe** - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

The extent of foreshore flooding in the study areas is categorised as Flood Fringe. This is due to the nature of foreshore flooding by SWL and WRU at the coastline rather than catchment driven flood.

The foreshore areas are not significant in either hydraulic conveyance or storage with consideration of tidal inundation as the flooding mechanism.

Given the entire extent inundated by SWL and WRU shown in the hazard and depth maps are classed as Flood Fringe, it was unnecessary to map the hydraulic categories separately for the study area.

6 Property Inundation and Flood Damages Assessment

A flood damage assessment has been undertaken to identify flood affected property, quantify the extent of damages in economic terms for existing and future flood conditions and enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis. The general process for undertaking a flood damages assessment incorporates:

- Identifying properties subject to flooding;
- Determining depth of inundation above floor level for a range of design event magnitudes;
- Defining appropriate stage-damage relationships for various property types/uses;
- Estimating potential flood damage for each property; and
- Calculating the total flood damage for a range of design events.

The current study has updated the previous flood damages assessment (WMA, 2002) within the study area, based on an updated property database and new flood modelling. The current study includes the flood damages assessment for properties in the Tahlee, Carrington, North Arm Cove, Bundabah, Pindimar and adjoining areas which are affected by flooding from the estuary. An outline of the flood damages assessment approach and outcome is presented below.

6.1 Types of Flood Damage

The definitions and methodology used in estimating flood damage are summarised in the *Floodplain Development Manual*. Figure 6-1 summarises the “types” of flood damages as considered in this study. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. The existing WMA (2002) flood damages database calculated direct damages only, therefore this study will adopt the same approach. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters.

The types of damages mentioned in the *Floodplain Development Manual* largely focus on tangible flood damages, particularly property related damages. Economic analysis for infrastructure projects within other Australian industries often includes a wider range of assessment criteria, such as the potential for fatalities, loss of transport connectivity, disruption to essential services (e.g. schools, medical facilities, sanitation) and other environmental values. In certain floodplain areas, incorporation of such additional damage criteria provides for a more robust cost estimation of the consequence of flooding, hence providing a better understanding of the benefit of potential flood mitigation measures through derivation of benefit-cost-ratios (BCR).

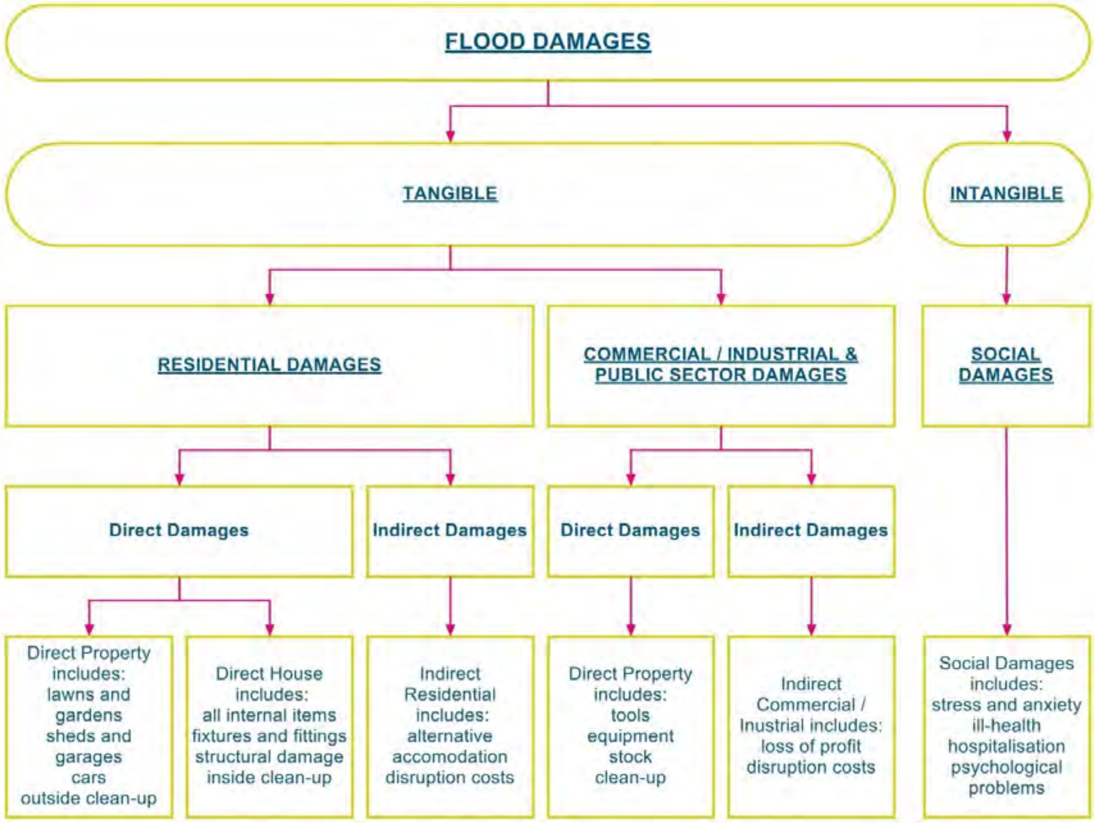


Figure 6-1 Types of Flood Damage

6.2 Basis of Flood Damage Calculations

Flood damages have been calculated using a database of potentially flood affected properties and associated stage-damage curves. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for each property type. Residential damage curves are based on the stage-damage curves for residential property presented in WMA (2002).

For this study, a GIS point dataset was established, representing each building within the extreme flood extents during 2100 climate conditions (0.91 m sea level rise). Existing property floor level survey was provided by MidCoast Council where available. This database included floor levels of 320 properties obtained through planning approvals and 228 floor levels used in the *Port Stephens Foreshore Management Plan* (WMA 2002). Of the properties with floor levels provided by Council, 107 were located within the flood extent. A further 313 properties within the flood extent did not have floor level survey. Missing floor levels for 149 properties were estimated from the LiDAR DEM, assuming a floor level 0.5 m above ground. For the remaining 164 properties located in the Camellia Drive estate, floor level survey was known for only some properties. This data indicated an average floor level of 2.8m AHD. Therefore, a minimum floor level of 2.8m AHD was assumed when floor levels estimated from the LiDAR DEM were less the 2.8m AHD.

For the purposes of the flood damage assessment, only residential properties were identified in the property database provided by Council. Hence, no commercial properties have been assessed for flood damages. Please note all damage values are quoted in 2019 dollars.

6.2.1 Limitations of Assessment

The flood damages assessment is a useful tool to measure potential impacts from foreshore flooding under a variety of design flood conditions, flooding mechanisms and sea level rise scenarios, as opposed to an absolute measure of potential impacts.

The extent of above floor flooding and associated impacts will depend on a range of factors, including:

- **Wave runup:** Wave runup impacts are difficult to quantify based on the available information, noting that wave runup levels have been modelled for a series of discrete foreshore profiles along the estuary. The height of wave runup is dependent on the ocean conditions and foreshore profile, which can vary from property to property (e.g. exposure, presence of ad hoc works). Also, the extent of above floor flooding will depend on whether wave driven elevated water levels propagate into building without interference. Future damage estimates have not taken into account any potential changes in foreshore position due to erosion for example.
- **Future sea level rise:** Future inundation impact estimates due to still water and wave runup flooding are significantly influenced by the extent of future sea level rise. Adopted sea level rise scenarios are consistent with Council policy, which reflect global estimates. However, some uncertainty remains around the rate of sea level rise that will manifest over the medium to long term.
- **Foreshore development profile:** Foreshore development profile has been characterised by a combination of Council property survey data and GIS mapping undertaken in this study to fill in the gaps. The information is considered to provide a good representation of the present-day development profile. However, the available property database has been used as a proxy to assess medium to long term damages, while in reality the future development footprint is unknown.

6.3 Tangible Flood Damages

The maximum depth of flooding expected during still water level and wave runup conditions was determined at each property. The flood modelling results for the 5% AEP, 1% AEP and extreme event inclusive of SLR scenarios were used to generate a continuous flood profile across the foreshore. Simulated flood levels were queried from the GIS output at each property. The resulting output was used to identify the number of properties affected, the frequency of inundation and the depth of inundation.

The associated direct flood damage cost to each property was subsequently estimated from the stage-damage relationships (Appendix A). Flood damage curves include external damages incurred below floor level. A nominal $2,000 value has been adopted for external flood damages for below floor flooding for wave runup scenarios only. Total damages for each flood event were determined by summing the predicted damages for each property.

The Average Annual Damage (AAD) is the average damage in dollars per year that would occur in a designated area from flooding over a long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, infrequently, there will be major flood damage (caused by large, rare flood events). Estimation of the

AAD provides a basis for comparing the effectiveness of different floodplain management measures (i.e. the reduction in the AAD).

6.4 Port Stephens Foreshore Flood Damages

The assessment of the residential flood damages under existing climate conditions are presented in Table 6-1. Assessment of the residential flood damages under future 2050 conditions are presented in Table 6-2. Assessment of the residential flood damages under future 2100 conditions are presented in Table 6-3.

Table 6-1 Summary of Residential Flood Damages associated with Current Sea Levels

Design Event	SWL Direct Damages ($)	WRU Direct Damages ($)	Total Damages ($)
5% AEP	$73,545	$316,000	$390,100
1% AEP	$158,830	$448,000	$607,600
Extreme	$264,970	$644,000	$909,000
AAD	**$41,700**	**$171,100**	**$212,800**

Wave Runup level (WRU) and Still Water level (SWL)

Table 6-2 Summary of Residential Flood Damages associated with 2050 Sea Levels

Design Event	SWL Direct Damages ($)	WRU Direct Damages ($)	Total Damages ($)
5% AEP	$1,642,700	$1,370,400	$3,013,100
1% AEP	$2,173,400	$1,712,200	$3,885,600
Extreme	$2,566,800	$2,230,400	$4,797,200
AAD	**$880,100**	**$732,100**	**$1,612,200**

Wave Runup level (WRU) and Still Water level (SWL)

Table 6-3 Summary of Residential Flood Damages associated with 2100 Sea Levels

Design Event	SWL Direct Damages ($)	WRU Direct Damages ($)	Total Damages ($)
5% AEP	$3,607,300	$2,795,800	$6,403,100
1% AEP	$4,139,200	$3,227,400	$7,366,600
Extreme	$4,569,800	$3,764,600	$8,334,400
AAD	**$1,911,500**	**$1,483,100**	**$3,394,600**

Wave Runup level (WRU) and Still Water level (SWL)

6.5 Property Inundation

A summary of the number of residential properties potentially affected by above floor flooding from still water and wave runup flooding for the 5% AEP, 1% AEP and extreme event, inclusive of SLR scenarios is shown in Table 6-4 and Table 6-5. Note that there are 420 properties in the dataset.

Table 6-4 Properties Flooded Above Floor by Still Water Level

Design Event	Residential
5% AEP	11
1% AEP	18
Extreme	28
5% AEP + 0.55 SLR	106
1% AEP + 0.55 SLR	123
Extreme+ 0.55 SLR	134
5% AEP+ 0.91 SLR	171
1% AEP + 0.91 SLR	182
Extreme + 0.91 SLR	195

Table 6-5 Properties Flooded Above Floor by Wave Runup

Design Event	Residential
5% AEP	31
1% AEP	47
Extreme	66
5% AEP + 0.55 SLR	130
1% AEP + 0.55 SLR	151
Extreme+ 0.55 SLR	170
5% AEP+ 0.91 SLR	188
1% AEP + 0.91 SLR	198
Extreme + 0.91 SLR	210

7 Review of Existing Planning Provisions

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of the local government area (LGA). A review of existing Council planning provisions was undertaken as part of the *Manning River FRMSP* (BMT, 2020).

As part of this review, a Planning Considerations report was prepared by GLN Planning (GLN) (Appendix B) covering land use planning and development controls across the LGA that are applicable to the Port Stephens foreshore area. The recommendations of the GLN report include:

- Guidance for how to consider FRM matters when undertaking strategic planning including determining the suitability of different land uses in different areas of the floodplain.
- A detailed review of the existing Local Environmental Plan (LEP) and Development Control Plan (DCP). This will provide an approach and base principles that can be applied when preparing an updated and consolidated LEP and DCP, to address residual flood risks where development is permitted in the floodplain.
- Principles to be applied to ensure the appropriate communication of flood risk through planning documents, including S10.7 Planning Certificates.

The updated flood mapping represents the best information (including consideration of climate change influence) along the Port Stephens foreshore to inform definition of:

- Flood Planning Areas - either represented in the LEP or DCP;
- Flood Planning Levels - typical application in defining minimum floor levels for future development; and
- Flood Risk Precincts - considering flooding mechanism and hydraulic/hazard category.

The mapping methodology combines the estimated ‘tide plus surge’ and ‘wave runup zone’ water levels. Currently there is no direct planning controls which consider increased inundation risk associated with wave runup along the Port Stephens foreshore. The wave runup contribution to peak inundation levels can vary significantly across the study area and potentially exceed nominal 0.5 m freeboard typically applied in setting minimum floor levels. Omission of wave runup in these instances may not adequately address the potential inundation hazard. Conversely, the estimated wave runup levels can represent an overly conservative condition and impose unnecessary restriction if applied directly in flood planning level estimation.

A potential pathway for integration of wave runup considerations in the planning framework may include:

(1) Adoption of detailed inundation mapping of the still water level (tide + surge) and wave runup zones.

(2) The still water level + freeboard sets the minimum planning level for properties outside of the wave runup zone.

(3) Within the wave runup zone, consideration can be given to:

(a) An additional freeboard allowance to account for the increased risk and uncertainty; or

(b) The proponent undertakes a site-based assessment to investigate wave runup and overtopping potential in detail and potentially reduce the additional freeboard allowance; and/or

(c) Engineering design to mitigate the additional risk associated with wave runup and overtopping.

Based on this approach, the mapping of the wave runup zone completed in this study can be used as a trigger that requires the proponent to undertake the site-based assessment. This would enable local wave runup risk to be considered in the context of a proposed development. A local assessment would overcome some of the uncertainty of the regional wave runup estimates with consideration of local topographic and hydraulic conditions.

8 Conclusion

The principal objective of the study has been to update the flood risk mapping of the Port Stephens foreshore area within the MidCoast LGA. Pre-existing mapping was completed prior to the availability of detailed topographic survey. The availability of LiDAR topographic survey acquired in 2012 provides the opportunity for more refined mapping of foreshore inundation and associated definition of flood risk.

A detailed flood mapping series has been prepared for the 5% AEP, 1% AEP and extreme flood events considering both still water inundation (tide and storm surge) and additional wave runup. Mapping has been prepared for existing climate conditions and future climate change scenarios incorporating potential sea level rise. The mapping series defines:

- Flood inundation extents and depths; and
- Flood hazard.

The updated mapping series will be used by Council to inform flood planning and development assessment such as definition of the Flood Planning Area (defining land subject to flood related development controls) and Flood Planning Levels (such as minimum floor levels for proposed development).

The climate change analysis incorporating sea level rise provisions indicates a substantial increase of properties at risk as sea level rise manifests. This may be typical of an estuarine foreshore environment; however, it does reinforce the need to consider this increase in flood risk in land use planning and development control. The additional inundation risk posed by wave runup along the foreshore environment has also been assessed in the study. The specific mapping of a wave runup zone can be utilised to trigger additional planning and development controls to address this risk.

9 References

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WMAwater (2010), *Port Stephens Design Flood Levels – Climate Change Review*, prepared for the Port Stephens and Great Lakes Councils.

Appendix A Stage-Damage Curves for Flood Damages

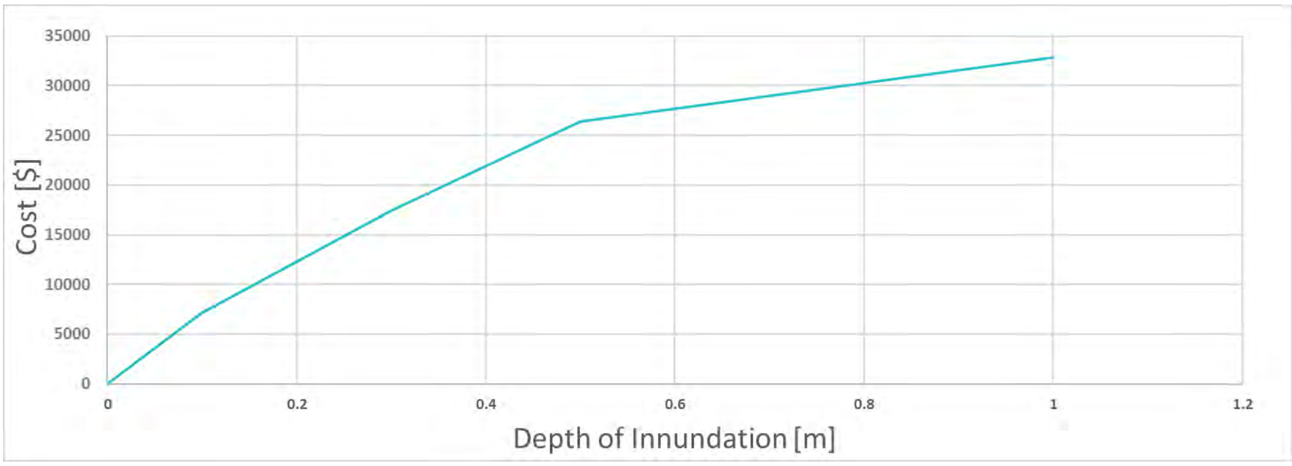

Figure A-1 Still water inundation damage curve

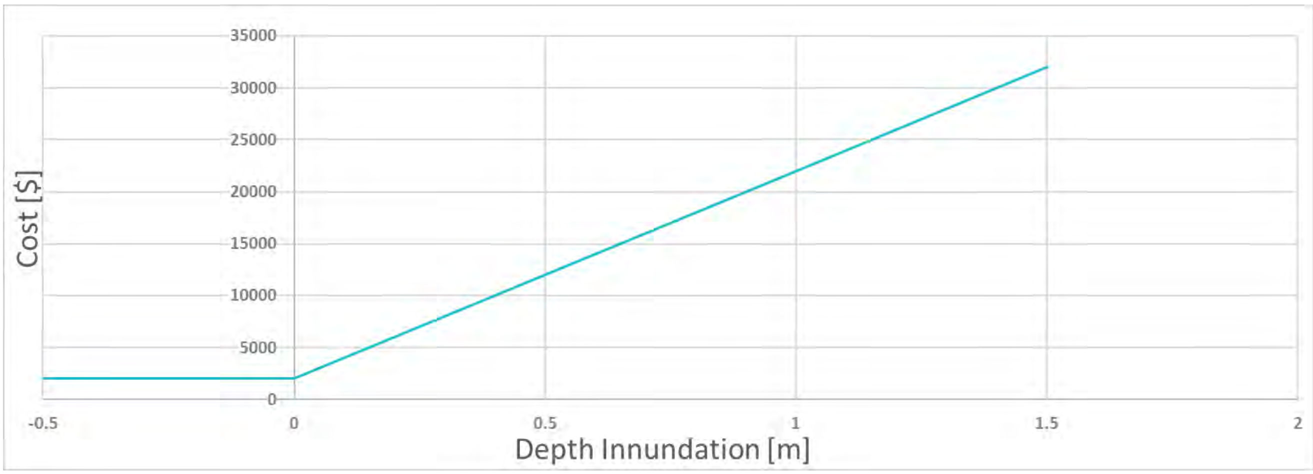

Figure A-2 Wave runup inundation damage curve

Appendix B GLN Report

planning
consulting
strategy

MANNING RIVER

Floodplain Risk Management Study & Plan

Planning Considerations

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Floodplain Risk Management Study & Plan

Manning River, MidCoast Council

Prepared for

BMT on Behalf of MidCoast Council

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Draft	Daniel Williams (BMT)	1-e	08.05.2019	CF/PG	PG
Final	Stephanie Lyons (BMT)	1-e	25.02.2020		PG

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1 Introduction

BMT WBM engaged GLN Planning, to provide town planning input into the preparation of the Manning River Floodplain Risk Management Study (FRMS) and Floodplain Risk Management Plan (FRMP) being prepared on behalf of MidCoast Council (Council).

The brief requires the following land use planning matters to be addressed:

- the consistency of current or proposed future strategic planning directions for the community in relation to addressing floodplain management objectives.
- the adequacy of current land use planning and building controls for specific development areas or developments in relation to addressing floodplain management objectives and managing flood risk to both new development and limiting impacts upon the existing community.
- the suitability of different land uses in different areas of the floodplain considering their use and community response to flooding.
- the suitability of different land uses in different areas of the floodplain, considering the vulnerability of these uses and their users to flooding.
- the residual flood risk, following the instigation of general constraints and in relation to the need for additional constraints, where warranted, in specific areas of the floodplain.
- provide recommendations for changes in land use planning directions or controls to address any identified shortcomings.

In order to address the above matters, we outline the planning context of the study area, focusing on aspects that are specifically relevant to flood risk management (FRM). While the FRMS relates to a part of the local government area (LGA) it will be important for recommendations regarding the preparation of planning controls be structured so that they can also be easily applied to other floodplains in the LGA.

2 Purpose of Report

2.1 The Role of Planning in Flood Risk Management

The key benefits that planning can provide within the suite of strategies delivered by an FRMP are:

- Providing guidance through the strategic planning process where development should occur based on flood risk management (FRM) considerations.
- Provide development controls to minimise the risk to people, private property and public infrastructure where development occurs within the floodplain.
- Ensure that the communication of flood risk, as may be interpreted by the community through planning documents, is not misleading. Planning documents typically deal with where flood related planning controls apply rather than where flood risks exist.

While flood risk management can be relevant to the preparation of a plan for an area or in the assessment of a development application (DA), there will also be other non-FRM considerations that will be relevant.

Flood risk management will ultimately need to be weighed with other relevant planning considerations to achieve balanced outcomes that meet community expectations. Despite this, there are baseline standards or community expectations relating to safety, exposure of property and infrastructure to costly repairs and avoidance of disruption to the occupation of homes and the operation of businesses that should be considered when making planning decisions.

2.2 Objectives of this report

Having regard to the brief, the objectives for this report are to:

- Outline and review the state and local planning policy context (including existing environmental planning polices and instruments and long term planning strategies for the area);
- Identify the planning issues associated with implementing a flood risk management strategy for the study area;
- Discuss options to address these planning issues; and
- Make recommendations for incorporation into the FRMP.

The planning recommendations for the Manning River FRMP will focus on providing advice to Council on changes that can be made to the planning controls to better achieve development that minimises flood risks to as low as reasonably and practically achievable. Advice will also be provided on principles to be applied when considering changes to land use zoning plans in the future and the presentation of planning information, including flood maps prepared for planning purposes. These considerations will take into account the potential impacts of climate change.

2.3 Other Studies

The following FRMPs and related studies provide some background understanding of the planning related FRM context of the study area.

Table 1 Previous Flood Investigations

Study Name	Author	Year
Lansdowne Flood Risk Management Study and Plan	Worley Parsons	2015
Wingham Flood Study - Review and Update	Worley Parsons	2011
Wingham Floodplain Risk Management Study and Plan	Worley Parsons	2011
Manning River Floodplain Management Study	Willing and Partners Consulting Engineers	1996

In addition, Council has produced several strategic planning documents (Table 2) that contribute to an understanding of the existing and future economic, social and environmental characteristics of the study area.

Table 2 Strategic Planning Studies

Study Name	Author	Date
MidCoast Regional Economic Development Strategy (REDS) 2018-2022	Balmoral Group Australia c/- Department of Premier and Cabinet	July 2018
Rural Issues Overview Summary Paper	MidCoast Council	2018
Community Strategic Plan 2018-2030	MidCoast Council	2018

Council is also in the process of reviewing the different local environmental plans (LEPs) applying to its former regions and preparing a single updated consolidated LEP. This process had only recently commenced at the time of preparing this report, and will include the preparation of a Housing Strategy, a Rural Strategy, a CBD Precinct Plan for Taree and an overall review of employment, infrastructure and recreation zoning provisions. The consolidated MidCoast LEP is programmed for completion by December 2021.

This report will have regard to these other studies in order to contribute to establishing a framework for input to strategic planning, planning controls and flood maps for planning purposes that can be applied to other floodplains in the LGA. This includes differentiation in flood risk associated with overland flow flooding as opposed to riverine flooding. The primary focus of this report is to address the planning aspects of the existing, future and continuing flood risks in the study area.

3 Study Area

3.1 Physical Setting

The Manning River is located on the Mid-North Coast of New South Wales (Figure 1). The main mouth of the river system is Harrington with the second opening is located at Old Bar.

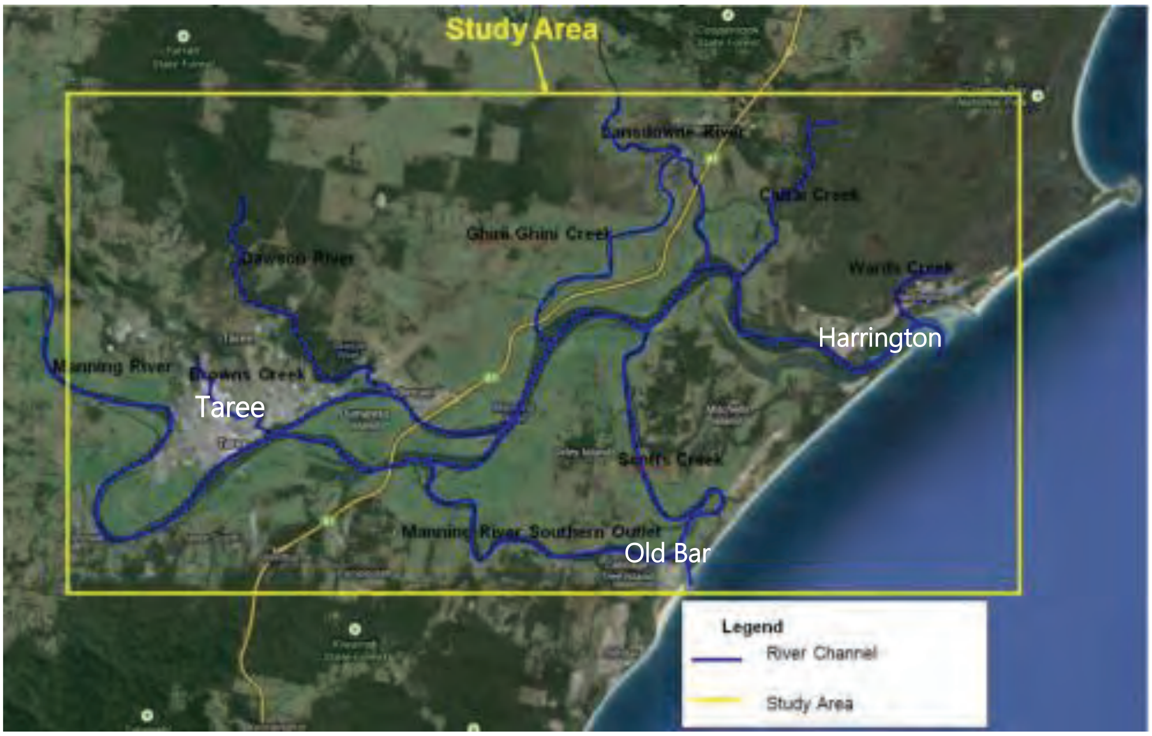


Figure 1: Location (Base Map Source: Study Brief)

The Manning River basin encompasses an area of over 8,100km^2 and drains to the Tasman Sea on the Mid-North Coast. The Manning River catchment also comprises the Gloucester River, Barnard River and Nowendoc River. The lower Manning River floodplain is approximately 2,060km^2 and includes the catchments of Dingo Creek and the Lansdowne River.

The study area comprises the lower floodplain of Manning River from downstream of Wingham to the coast including the township of Tinonee, Taree, Cundletown, Harrington and the adjacent semi-rural and rural areas.

The catchment includes several villages and towns interspersed with rural and environmental lands, and comprises parts of the localities of Mondrook, Tinonee, Taree, Glenthorne, Pampoolah, Dumaresq Island, Oxley Island, Old Bar, Cabbage Tree Island, Mitchells Island, Harrington, Mambo Island, Croki, Ghinni Ghinni, Coopernook and Kundle Kundle.

3.2 Population Characteristics

Characteristics of the permanent population of the area, that could be relevant to assessing flood risk, can be drawn from various sources, mainly the 2016 Census. These include:

- The population of the whole of MidCoast Council LGA was 90,303, based on place of usual residence. The permanent resident population of the study area would be in the order of 30,000 persons.
- Most of the population in the Study Area is contained in the following suburbs/localities:
  - Taree – 16,197
  - Old Bar - 3,795
  - Harrington - 2,896
  - Cundletown - 2,054
  - Tinonee - 757
  - Mitchells Island - 468
  - Pampoolah - 393
  - Coopernook - 341
  - Taree South – 315
  - Manning Point - 239
  - Croki - 43
- The median age in the LGA was 52, being substantially higher than the Australian median age of 38. The median age varies across the study area from 45 in Taree and Tinonee to 61 in Harrington. Just over 38% of the LGA population is aged 60 or over. There is a large shift of people aged 45+ to the Region from other parts of NSW.
- In the LGA 24% of household are renting, 23% have a mortgage and 46% of dwellings were owned outright.
- 84.9% of dwellings in the LGA had one or more motor vehicle (compared to 87.1% for NSW). The remainder had no motor vehicles, or the number was unstated.
- The percentage of persons in the LGA who required assistance with core activities, excluding unstated responses, was 8.7%. This varied across the study area from 5.5% in Tinonee to 10.1% and 10.4% in Harrington and Taree respectively. This reflects the variation in median age across the study area.
- The percentage of persons in the LGA reported as speaking English "not well or not at all" was 8.9% of the population.

The Manning River and its tributaries is an area that attracts a substantial transient population, being marketed as the 'Manning Valley'.

Visitation to the Manning Valley has been increasing since June 2012 and at 2014 averaged approximately 700,000 visitors per year, staying an average of three nights. 56% of visitors travelled from regional NSW, 32% from Sydney and the remainder visit from interstate. Couples are the most common type of travel group, followed by couples with children at 29% and 22% travelling alone. (Manning River Destination Management Plan 2014)

The catchment area of the Manning River is quite large and has a larger percentage of persons in older age groups that could require assistance if required to evacuate, or have no access to a motor vehicle. Most of the population that resides in the Manning River catchment are competent English speakers. A substantial proportion of the persons within the area at any one time will be tourists, who are less likely to be flood aware.

Council's Rural Strategy discussion paper identifies emerging planning issues including an increasing demand for rural housing and rural based tourism.

This data is important in understanding potential emergency management issues and flood awareness education.

3.3 Economic Base

The North Coast Rail Line connects Gloucester, Wingham and Taree to both Sydney and Brisbane. The Pacific Highway is a national connector route running through the LGA.

Taree is a key regional centre that includes a large regional public hospital, other health facilities in addition to the direct rail access and a local airport.

The largest industries in the area are tourism, agriculture, forestry and fishing. Visitors to the LGA spent an estimated $505 million in 2016 making 'tourism' the largest export industry in the MidCoast region. Tourism can be significantly disrupted during and when recovering from floods.

The highest industry sector of employment is health care and social assistance.

The unemployment rate is 9% compared to 6.3% over New South Wales. Approximately 91% of the population is employed, and of those 38,038 persons, 52% work full time and 46% part time.

Approximately 75% of employed people travelled to work by car, truck or motor bike only as a driver or passenger. About 6% worked from home and 4% walked (only) to work. The remainder of employed people cycled or used public transport and taxis only or in combination with other modes.

3.4 Natural Environment

The study area comprises the lower floodplain of Manning River from downstream of Wingham to the coast including the township of Tinonee, Taree, Cundletown, Harrington and the adjacent semi-rural and rural areas. Taree is one of the major towns in the lower floodplain of Manning River and is located 16 km from the coast adjacent the River. The Manning River has two branches downstream of Taree and has two entrances to the ocean; one at Farquhar/Old bar and the other at Harrington.

The natural environment is recognised in Council's strategic plans as an important asset that underpins a broad range of economic activities particularly its tourism industry. Council's Rural Strategy discussion paper identifies emerging planning issues, including the need to manage marine activities and rural waterways to minimise the impact of growth.

4 General Planning Policy Framework

4.1 Overview

The formulation and implementation of FRMPs is the cornerstone of the NSW Government's Flood Prone Land Policy. As with other local planning processes, the preparation of FRMPs is a Council responsibility. The planning recommendations ultimately incorporated within a FRMP and adopted by Council will subsequently require implementation through the separate planning processes, principally governed by the Environmental Planning and Assessment Act 1979 (EPA Act).

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses in areas of high flood risk to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding should relate to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations (i.e. the application of the merits based approach required by the FDM). In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the flood risk management (FRM) planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

4.2 The FRMP Relationship with EP&A Legislation

In 1984 the NSW State Flood Policy was first introduced disbanding the mandatory application of a singular 100 year flood standard and required local Councils to prepare individual floodplain management plans based on a 'merit based approach'. The first Floodplain Development Manual (FDM) was published in 1986 to assist Councils in this task.

While the policy has evolved over time it has remained fundamentally the same, with a new Manual being published but not gazetted in 2001 and the current policy and Manual published and gazetted in 2005. The current FDM is under review but this process is unlikely to be completed within the timeframe of this study.

The changes in the Manual and policy over time are not considered to be fundamentally significant, and have principally retained the following key principles:

a. Local Government is responsible for FRM in NSW with financial and technical support being provided by the State Government. The actions, decisions and information provided by Council and exercised in this duty are indemnified through the provisions of Section 733 of the *Local Government Act, 2003*. Indemnity is provided where Council acts in good faith, which is deemed to be in accordance with the principles of the FDM unless proven otherwise.

b. A merit approach is to be adopted for the purposes of formulating a FRMP that provides a basis for decision making in the floodplain. This is in recognition that flood prone land is a valuable resource which should not be unnecessarily sterilised by the rigid application of prescriptive criteria, and to avoid the approval of inappropriate proposals. The merit approach is defined as follows:

c. "The merit approach weighs socio-economic, ecological and cultural impacts of land use options for different flood prone land areas together with flood damage, hazard and behaviour implications, and environmental protection and wellbeing of the State's rivers and floodplains."[1]

The level of flood risk acceptable to the community is to be determined through a process typically overseen by a committee comprised of local elected representatives, community members and State and Local Government officials (including the SES). This process is shown in Figure 2.

The ultimate intent is to prepare FRMPs for individual floodplains that are adopted by Councils. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.

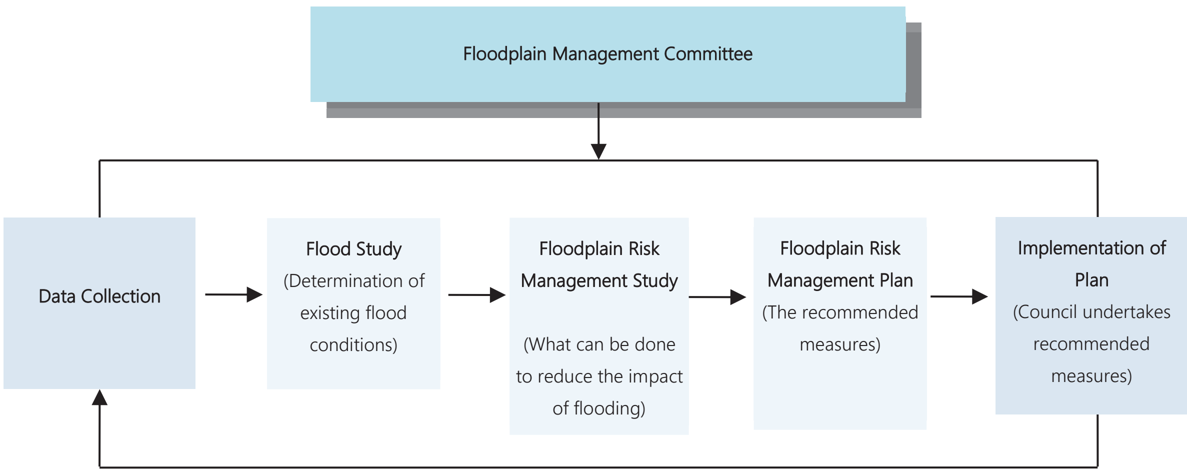


Figure 2: NSW FRM Process (Adapted from FDM 2005, pg.6)

The FDM and planning controls under the EPA Act should not be considered as providing alternate approaches.

The Flood Prone Lands Policy and Manual are separate to the principal planning legislation in NSW, being that contained within the EP&A Act and associated Regulations. Ultimately, the planning recommendations of a FRMP may be reflected in planning instruments and policies brought into force in accordance with the EP&A Act. While the EP&A Act and Regulation refers to flooding as an issue requiring consideration in some circumstances[2] this legislation does not refer to the Flood

[1] 2005 Manual, NSW Government, 2005, page 23.

[2] For example in the determination of what is designated development for the purposes of the Act and therefore requiring the preparation of an Environmental Impact Statement.

Prone Lands Policy or the FPDM. The plans prepared under the EPA Act provide the relevant considerations for the assessment of development applications.

The FRMP can provide appropriate input to the EPA Act planning processes in 3 ways:

- Providing direction at a local and state strategic planning level in addressing FRM (e.g. where new urban areas should be located and the distribution of land uses therein);
- Recommendation of development controls to be incorporated in appropriate planning instruments (e.g. LEPs and DCPs) to mitigate the risk to development where permitted in the floodplain; and
- Ensuring that the planning controls and associated documents (e.g. S10.7 Planning Certificates) contribute to ensuring the community is appropriately informed about the flood risk.

To understand how these outcomes may be best achieved, it is important to consider the existing EPA Act framework and guidelines that relate to FRM.

4.3 2007 Flood Planning Guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the EPA Act and Regulation was issued by the (then) Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the FDM. The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 100 year flood as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development different to the 100 year flood may be imposed subject to an "exceptional circumstances" justification being agreed to by the Department of Planning (now the Department of Planning, Industry and Environment- DPIE) and the Department of Natural Resources (subsequently the Office of Environment and Heritage – OEH and now subsumed into the DPIE agency cluster) prior to the exhibition of a Draft LEP or Draft DCP.

The reference to the FPL in the Guideline is a reference to the 100 year flood plus freeboard (typically 0.5 metres).

The DPIE is currently reviewing the Guideline. The review is expected to be completed during 2020.

4.4 Section 9.1 Directions (Formerly Section 117)

Ministerial directions pursuant to Section 9.1(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood [liable] prone land. The Direction applies to all councils that contain flood prone land when an LEP proposes to "create, remove or alter a zone or provision that affects flood prone land." In such cases, the Direction requires draft LEPs to ensure the following:

- Consistency with the principles of the FDM (including the Planning 2007 Flood Guideline).
- Do not rezone flood prone land zoned special use areas, recreation, rural or environmental protection to a residential, business, industrial or special use area zone;
- Do not permit development in floodways that would result in significant flood impacts on others, permit a significant increase in development on the floodplain, require substantial government spending on flood mitigation, or allow development without consent except for agriculture or flood mitigation works.
- That flood related development controls are not imposed on residential development above the “residential flood planning level” unless adequate justification to the satisfaction of DPIE is provided.
- Flood planning levels must be consistent with the FDM and 2007 Flood Planning Guideline.

Clause (6) of the Direction specifies that a variation to the Direction may be permitted where it is minor or accords with an FRMP.

While Section 9.1 Directions are not relevant to DCPs, the Flood Planning Guideline does indicate the approval of DPIE is required prior to the exhibition of a draft DCP that varies from the Guideline.

4.5 Climate Change Considerations

The FDM highlights the need for climate change to be considered in an FRMS to understand both the potential effects on flood behaviour and as a factor when evaluating management strategies.

The (then) NSW Department of Environment & Climate Change issued an FRM Guideline entitled "Practical Consideration of Climate Change" (25.10.2007). The Guideline addresses the consequences of potential changes in sea levels and rainfall intensities associated with climate change predictions. Due to some level of uncertainty with the timing and magnitude of climate change effects, this Guideline recommends undertaking sensitivity analysis to understand the potential implications of climate change when modelling flood behaviour and frequency and to test the robustness of management strategies.

As part of the management strategies for future development, the 2007 Guideline recommends that where climate change ramifications are considered minor that either existing FPLs be adopted and the potential for risk to increase over time be documented and the community informed, or higher FPLs that include a climate change factor be used. The decision for which option to adopt is a matter for the FRMS process. In a practical sense, the adoption of the higher FPL could be appropriate for new areas or major developments where additional filling or higher floor levels can be readily achieved with marginal additional cost and minimal impacts on surrounding development. Conversely it could be difficult to implement materially higher FPLs for minor development within established areas where there could be amenity, streetscape or drainage impacts.

Where climate change ramifications are likely to be significant, the 2007 Guideline recommends additional measures, including considering:

- Alternate locations for new residential development

- Applying a combination of higher fill and floor levels to maximise the height of habitable floors with minimal environmental impacts
- Consideration of uses more compatible with the long term risk (eg recreation areas, agriculture or environmental purposes)
- Promoting types of development that have a limited life span or are more capable of relocation (eg tourist or short term caravan parks, and tourist or commercial development where investment decisions are based upon known conditions of abandonment and removal)
- Designing developments with more vulnerable components in less exposed parts of the site
- Building-in the potential for retrofit solutions in the future.

The above measures will vary depending on whether considered as part of strategic planning exercise or for incorporation into an LEP or DCP. The measures need to be assessed against a number of evaluation criteria set out in the 2007 Guideline, such as impacts on existing and future flood behaviour, cost/benefit, additional emergency management requirements, aesthetic and environmental issues, and the potential to adapt with changed climate change information.

The impact of climate change on individual sites and development scenarios needs to also be considered for the broader planning area. If roads and services could become inundated in the future this could significantly constrain the viability of development in the long term.

4.6 Regional Planning Strategies

The former DPE published the *Hunter Regional Plan 2036* in 2016. The priorities set for the MidCoast area (pgs 73-74) are to

- grow the economy - enhance tourism infrastructure and connectivity and to provide a broader economic base (see also Action 6.3)
- Protect agricultural land and industries
- Manage development within sensitive water catchments and protect environments that sustain the oyster industry
- Assist long term employment though education/training and by capitalising intra- and inter-regional connections
- Provide housing, services and facilities, as well as accessible public spaces for an ageing population

The Hunter Regional Plan identifies Taree as a strategic centre, which is the largest populated town within the Manning River catchment area. Harrington and Old Bar are identified as areas of "Residential and Employment Land." No part of the study area is identified as a "growth area."

Direction 16 of the Regional Plan seeks to "increase resilience to hazards and climate change". The following actions specified under Direction 16 (pg. 14) are particularly relevant:

> *16.1 Manage the risks of climate change and improve the region's resilience to flooding, sea level rise, bushfire, mine subsidence and land contamination*
>
> *16.2 Review and consistently update flood risk and coastal zone management plans, particularly where urban growth is being investigated.*
>
> *16.3 Incorporate new knowledge on regional climate projections and related cumulative impacts in local plans for new urban development.*

The Plan states that climate change is likely to result in varying rainfall, higher temperatures and prolonged dry periods or drought with Coastal communities likely to be more vulnerable to the threat of coastal recession and, over the longer term, sea level rise.

Managing flooding is an important priority for the NSW Government and councils. Most councils currently include, or refer to, flood planning area mapping in local plans and hydraulic and hazard category mapping of flood prone land, which provides government, developers and landowners with a level of certainty about the risk for particular sites.

4.7 State Environmental Planning Policies (SEPPs)

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EP&A Act by DPIE and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State.

Regional Environmental Plans (REPs) were previously a type of environmental planning instrument prepared under the Act (since repealed) and existing REPs are now deemed SEPPs. No SEPP has been prepared dealing specifically with the issue of flooding, but some regulate development in response to potential flood risks.

Those SEPPs of potential relevance are discussed below.

Seniors Living SEPP

SEPP (Housing for Seniors or People with a Disability) 2004 (Seniors Living SEPP) applies to urban land or land adjoining urban land where dwellings, hospitals and similar uses are permissible.

The Seniors Living SEPP would apply to parts of the study area, and would effectively override Council's planning controls to permit residential development for older and disabled persons to a scale permitted by the SEPP. Notwithstanding, Clause 6(2)(a) of the SEPP restricts its application if land is identified as "floodways" or "high flooding hazard" in Council's LEP.

Codes SEPP

The specification of exempt and complying development is primarily governed by *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* (the Codes SEPP).

The Codes SEPP is divided into a number of "Codes" that deal with exempt development and different types of complying development. Those Codes of specific relevance to the study area or LGA are the Exempt Development Codes (Part 2), the General Housing Code (Part 3), the Rural Housing Code (Part 3a) and the Commercial and Industrial (New Buildings and Additions) Code (Part 5a). The relevant clauses of the Codes SEPP apply to "flood control lots" defined as:

flood control lot *means a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing).*

Note. *This information is a prescribed matter for the purpose of a certificate under section 149 (2) of the Act.*

The Exempt Development Code in the Codes SEPP provides a number of exclusions to what can be considered exempt development on a flood control lot. The General Housing, Rural Housing and Commercial and Industrial (New Buildings and Additions) Codes also provide a number of exclusions as to what can be complying development on a flood control lot (i.e. must not be on any part of a flood control lot which is a storage area, a floodway area, a flow path, a high hazard area or a high risk area). Where otherwise permitted on a flood control lot, specified flood related development controls must, in most circumstances, be imposed on a Complying Development Certificate (CDC).

The manner in which these exemption criteria and development controls apply are summarised by Figure 3.

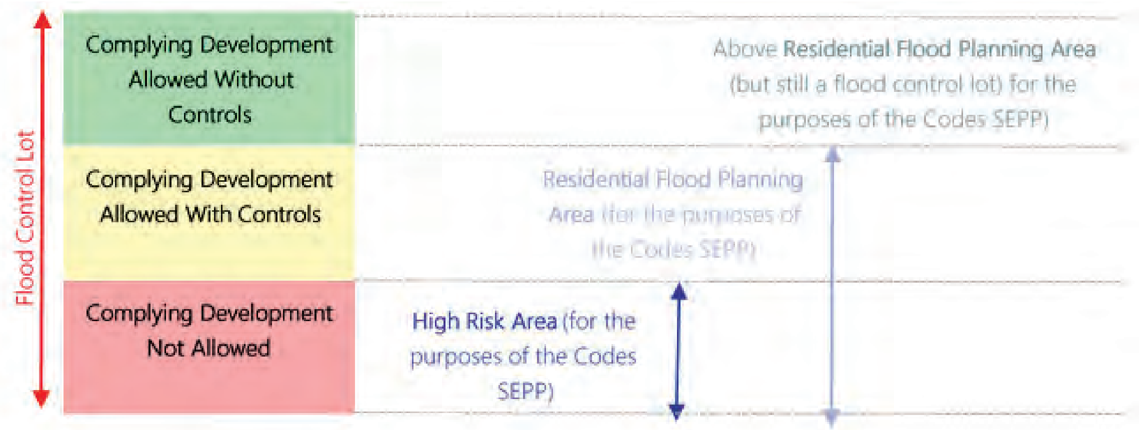


Figure 3: Application of the Codes SEPP to Flood Liable Land

Important considerations for the FRMP, in regard to establishing rules for development that could be approved as complying development, is the defining of high risk areas (where complying development is excluded) and setting of minimum floor levels. The objective should be to ensure that such future development does not lead to increased flood risk to property and persons as a consequence of the application of the CDC process in comparison to outcomes otherwise likely to be achieved through the full DA process. At the same time, the outcome of the FRMP should not create unnecessary administrative burdens on the public and council by requiring a DA where this would be of no likely benefit to reducing flood risk.

Council could proactively provide advice to the public as to where the Codes SEPP applies. The flood maps produced for planning purposes could achieve this by aligning areas identified as high risk areas with those areas within which complying development is excluded under the Codes SEPP.

Rural Lands SEPP

State Environmental Planning Policy (Rural Lands) 2008 (Rural Lands SEPP) is relevant to the rural zones within the study area. The SEPP is principally aimed at maintaining the agricultural potential of rural zoned land. Consequently, the Rural Lands SEPP could have the effect of restricting more intensive non-agricultural activity in locations identified as "significant agricultural land" that can in many situations coincide with the floodplain.

4.8 Local Planning Strategies

MidCoast Council is presently undertaking, or recently completed, several strategic planning projects including the review of existing planning instruments and formulation of plans to guide growth in different parts of the LGA. Those of relevance to the study area are:

- The most significant growth in the LGA is set to occur in Brimbin. Brimbin is located 8km north-east of Taree and extends from the Lansdowne River to the east through to the Dawson River in the west, straddles Lansdowne Road and covers an area of around 3,700ha. The first stage of zone changes has been implemented which will lead to the development of a new town for approximately 22,000 people and 8,000 dwellings, a mixed-use centre, 3 neighbourhood centres, 4 schools, 112 hectares of employment and industrial, and environmental and open space lands. This growth area is subject to minimal flooding issues, and is well suited for growth in regard to FRM criteria.

- The "Figtrees" development on the Manning River is located on the northern bank of the Manning River, approximately 2km east of the Taree town centre. The site is around 20ha in size and includes a disused dairy factory. The site is intended to support about 500 residential units and a range of commercial buildings for cafes, restaurants and other businesses. A voluntary planning agreement outlines public outcomes the landowners are required to provide.

- Three major precincts have been rezoned that provides for the growth of Old Bar. Precinct. 1 is located immediately north of Old Bar and was rezoned to allow tourist facilities. Precinct 2B is located immediately west of the existing Old Bar township on both sides of Old Bar Road providing about 1,400 potential residential lots. Precinct 3 is located directly south of Precinct 2B, providing for an additional 525 residential lots and a 9 hole golf course.

- Coopernook is a village on the banks of the Lansdowne River, to the north of the study area. Approximately 18ha of land bounded by Macquarie and West Streets in Coopernook was rezoned on 31 March 2017 predominantly from rural (RU1) to village (RU5) to provide for rural residential lots to cater for the growth of the village of Coopernook.

These areas have been rezoned and the FRM planning implications are discussed below as part of the review of the current LEPs.

4.9 Local Environmental Plans

The EPA Act facilitates the reproduction of planning instruments into a standardised format known as the 'standard instrument'. Section 3.20 of the EPA Act deals with the prescribing of the standard instrument for LEPs. The standard instrument contains no compulsory clauses or map requirements specifically relevant to addressing flood hazards. However, DPIE have adopted a model local clause in regard to flooding. A model local clause is one which has been settled by Parliamentary Counsel as acceptable and the DPI encourage that it is used as is. A model clause may be varied with justification to suit local circumstances.

The Manning River catchment area falls under the MidCoast Council LGA. The MidCoast Council was formed on 12 May 2016 after the Gloucester Shire, Great Lakes and City of Taree councils were merged. Land Use planning within the Manning River catchment area is regulated by way of the following LEPs:

- Greater Taree Local Environmental Plan 2010
- Great Lakes Local Environmental Plan 2014
- Gloucester Local Environmental Plan 2010

The LEPs above are based on the Standard Instrument. Figure 4 shows the general land use zoning pattern across the Manning River catchment area.

As previously noted, Council is working towards merging the 3 LEPs into one LEP. Irrespective of this outcome, it would be preferable to establish a single comprehensive framework for FRM planning controls for the LGA. Table 1 provides a review of the relevant current LEP provisions before making recommendations as to how they might be rationalised to improve FRM outcomes.

Table 1: LEP FRM Planning Provisions

<table>
<tr><th>LEP Clauses</th><th>Gloucester LEP 2010</th><th>Great Lakes LEP 2014</th><th>Greater Taree LEP 2010</th></tr>
<tr><td rowspan="2">1.2 (2) Aims of Plan</td><td>(d) to embrace and promote the principles of ecologically sustainable development, conservation of biological diversity and sustainable water management, and to recognise the cumulative impacts of climate change,</td><td>NA</td><td>(f) to minimise the exposure of development to natural hazards and natural risks,</td></tr>
<tr><td colspan="3">For FRM purposes we recommend including objective (f) of the Greater Taree LEP within in a future consolidated LEP. Objective (d) of the Gloucester LEP would be appropriate but not essential.</td></tr>
<tr><td>6.1(1)/7.3(1)/7.2(1) Flood Planning - Objectives</td><td colspan="3">All 3 LEPs have the same objectives for this clause. The objectives are consistent with the model clause and appropriate and sufficiently comprehensive.</td></tr>
<tr><td>6.1(2)/7.3(2)/7.2(2) Flood Planning - Application</td><td>The clause can apply to either land shown as "flood planning area" on the flood planning map or land below the FPL as defined below.</td><td>The clause can apply only to land below the FPL as defined below.

The LEP does not incorporate flood planning maps.</td><td>The clause can apply to either land shown as "flood planning area" on the flood planning map or land below the FPL as defined below.</td></tr>
</table>

LEP Clauses	Gloucester LEP 2010	Great Lakes LEP 2014	Greater Taree LEP 2010
	The LEP provides flood planning maps but these appear to have limited coverage.		The LEP provides flood planning maps which appear to have extensive coverage.
6.1(3)/7.3(3)/7.2(3) Flood Planning - Considerations	All 3 LEPs have the same considerations for a development, subject to the clause. The considerations are consistent with the model clause and appropriate and sufficiently comprehensive.		
6.1(5)/7.3(5)/7.2(5) Flood Planning - FPL Definition	*flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.*	*flood planning level means:* *(a) in areas where flooding is affected by ocean water levels—the level of a 1% AEP (annual exceedance probability) flood event estimated using an ocean water level 0.9 metres above the 1990 mean sea level, plus a 0.5 metre freeboard, or* *(b) in all other areas—the level of a 1% AEP (annual exceedance probability) flood event plus a 0.5 metre freeboard.*	*flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.*
	This definition adopts the 2007 Flood Planning guideline default FPL for standard residential development.	This definition is similar to that adopted by the other 2 LEPs except it factors in the climate change related sea level rise benchmark that was mandated by the state government from 2010 to 2012 and remains a generally accepted benchmark.	This definition adopts the 2007 Flood Planning guideline default FPL for standard residential development.
6.3 Development Control Plan (DCP) - Requires the preparation of a DCP for an urban release area before consent can be issued.	NA	One matter required to be addressed by the DCP is: *(f) amelioration of natural and environmental hazards, including bushfire, flooding and site contamination and, in relation to natural hazards, the safe occupation of, and the evacuation from, any land so affected,*	One matter required to be addressed by the DCP is: *(f) amelioration of natural and environmental hazards, including bushfire, flooding and site contamination and, in relation to natural hazards, the safe occupation of, and the evacuation from, any land so affected,*

LEP Clauses	Gloucester LEP 2010	Great Lakes LEP 2014	Greater Taree LEP 2010
		This covers both general flood impact and emergency management (evacuation) considerations.	This covers both general flood impact and emergency management (evacuation) considerations.
7.10 Limited development on foreshore area	NA	NA	This clause applies to - " *foreshore area means the land identified as "Foreshore Area" on the Foreshore Building Line Map.* The clause triggers proposed building within foreshore areas and requires consideration of various matters including: *(3)(h) sea level rise or change of flooding patterns as a result of climate change has been considered.*
Schedule 1 Additional permitted uses	NA	NA	This relates to specific sites where development in addition to that otherwise allowed in the zoning of the land is permitted with consent. Item 1 applies to land at Forster, Forster South, Smiths Lake and Tea Gardens and requires consideration of the "adverse impact on flooding upstream of the land" amongst other matters.

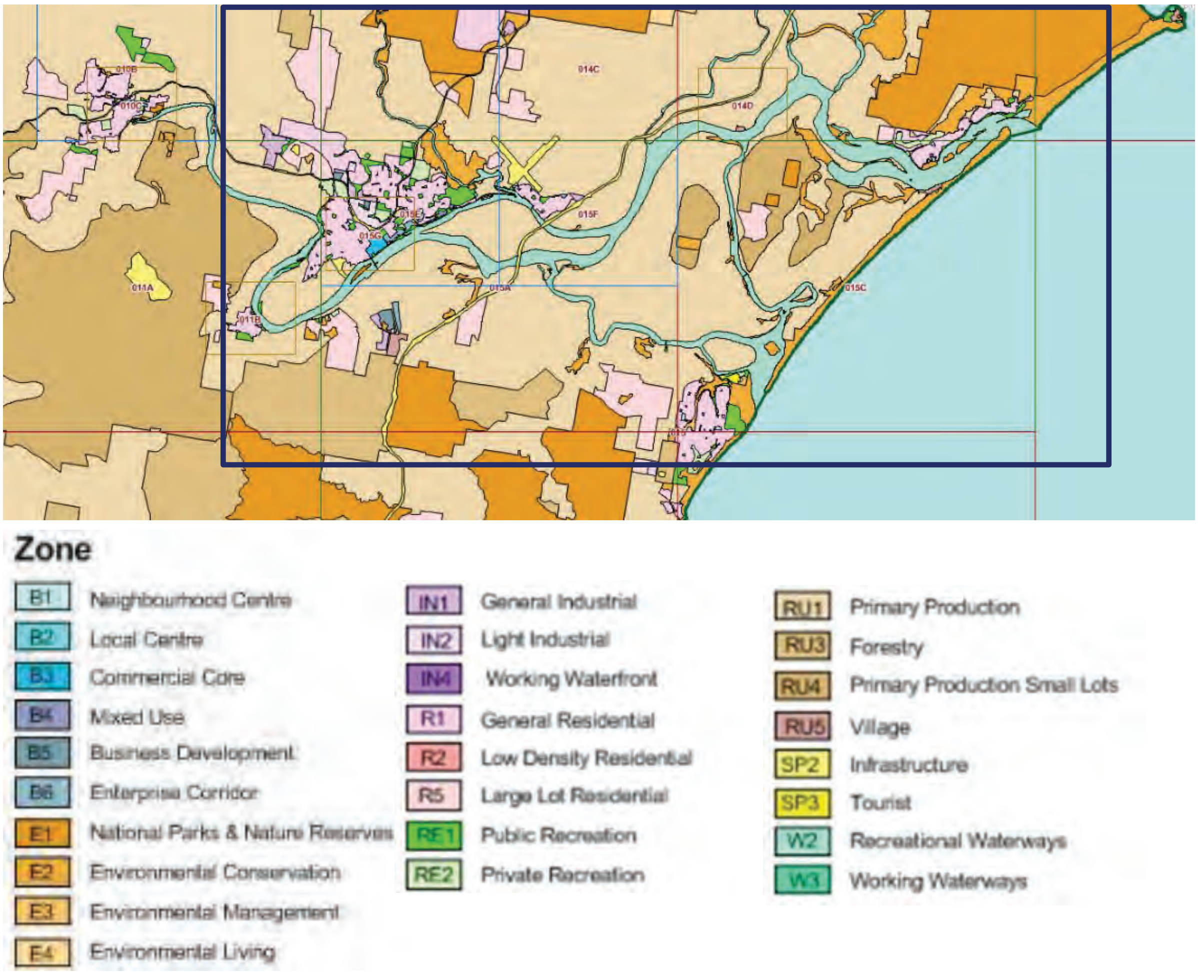


Figure 4: General Land Use Zones Across the Catchment (Source Council on-line mapping)

The issues with the flood planning clause 7.2 to be addressed by the recommendations of this plan include the need to have a consistent and comprehensive basis to trigger the application of the clause. This could involve a combination of maps and a defined extent as occurs with 2 of the three LEPs at present. There also needs to be consideration as to whether the extent of the application of the clause should be limited to the default FPL for standard residential development (ie the 100 year flood plus freeboard). The latter consideration mainly relates to whether the LEP should trigger consideration of flood risks (in particular evacuation) beyond the currently adopted FPL.

A series of maps were prepared by BMT, showing flood planning constraint extents overlain on the LEP land use zone maps (Appendix A). These maps were prepared to facilitate a high level review of whether existing land use zones were appropriately aligned with the extent of flood constraints and to identify areas where potential development permitted within the zones could be incompatible with flood hazards.

A series of 6 planning overlay maps were prepared. Each map overlays a different flood planning constraint based on increasing levels of hazard. The methodology for the preparation of these flood planning constraint maps, and the implications for development in each constraint category, is discussed at section 4.7 of the FRMS prepared by BMT. The categories are based on Guideline 7-5 of the *Australian Disaster Relief Resilience Handbook* (AIDF, 2017), which recommends adoption of four flood planning constraint categories (FPCC), as reproduced in Table 3 below:

Table 2: Flood Planning Constraint Categories (FPCC) (AIDF, 2017)

FPCC	Constraint Subcategory
1	a) Floodway or flood storage area in the DFE*, b) Flood hazard H6 in the DFE.
2	a) Floodway in events larger than the DFE, b) Flood hazard H5 in the DFE, c) Emergency response (isolated and submerged areas), d) Emergency response (isolated but elevated areas), e) Flood hazard H6 in floods large than the DFE.
3	Remaining area below the DFE plus freeboard.
4	Remaining area below the PMF or Extreme Flood.

* DFE = defined flood event more commonly referred to as the flood planning level in NSW. For the Manning River, this is the 2100 1% AEP design event.

Consistent with best practice (as set out in the planning and FRM policies outlined above) development should be avoided in the FPCC 1 areas and in the FPCC 3 areas where mitigation works such as filling work could not be acceptably implemented with no material external impacts on others in the floodplain. In FPCC areas 1 and 2 it is preferable not to encourage flood sensitive land uses or critical infrastructure and to ensure suitable access for evacuation purposes is available.

A high level review of the planning overlay maps indicates the following matters for review, with regard to the separate towns, villages and localities within the study area.

Taree

Areas of a floodway/flood storage and high hazard in a 100 year flood fringe the Residential R1 zoned lands in the western side of Taree and marginally affect the B4 Mixed Use zoned land at the interface of the CBD with the Manning River and extending Browns Creek into IN2 Light Industrial zoned land. The areas, including the Figtrees development, fringing the western, southern and eastern edges of the zoned urban areas of Taree contain land affected by flooding in events more extreme than the 100 year flood, where it is preferable not to encourage flood sensitive land uses or critical infrastructure and to ensure suitable access for evacuation purposes is available.

No review of zoning is currently warranted but these flood hazards should be taken into consideration if reviewing any Planning Proposal for the intensification of uses.

South Taree

Areas of floodway/flood storage extend up the tributaries of Carter Creek into land zoned R5 Large Lot Residential. There are minimal existing dwellings in this area, but it appears that as this area is subject to a minimum 4,000m^2 lot size standard further subdivision is possible.

Closer interrogation is required to determine if this minimum lot size can be realised while providing suitable building platforms and whether it should be increased. These areas are not potentially isolated but parts are affected by flooding in events greater than the 100 year flood.

Tinonee

Areas of floodway/flood storage, and in part high hazard, extend through the R1 zoned land immediately to the west of Claxton Street. This area is presently undeveloped large holdings but subject to a minimum 450m^2 lot size standard. Further development in this area is likely to have unacceptable flood risk and impacts and the current zoning and/or minimum lots size standards should be reviewed.

Detailed analysis should be undertaken of the extent of floodway that affects R1 zoned land along the eastern fringe of the village and the zoning and/or minimum lot size standard should be reviewed to curtail further development where appropriate. Minimal development has yet occurred within the R5 zoned area to the northwest of Tinonee along Tinonee Road. The eastern part of this area along Peg Leg Creek is floodway/ flood storage and high flood hazard in a 100 year flood. These areas are partly affected by flooding in events greater than the 100 year flood.

Pampoolah

Areas of floodway/flood storage and flood hazard in a 100 year flood along Halls Creek affect the rear of lots at the end of Graceland Place and Jonnel Heights Place. A further area of high flood hazard also extends along the creek line that extends down the rear boundary of lots fronting Malcom Road and Mullalone Place. Building areas appear unaffected by these areas of floodway/flood storage, and in part high hazard and not potentially isolated. This area is zoned R5 and is subject to a 1.5ha minimum lots size standard, and is already substantially developed.

Accordingly further review of the zoning of this area does not appear warranted.

Cundletown

Land along the river edge is residential zoned R1, public and private recreation RE1 and RE2 and rural RU1. This interface comprises long residential lots extending down from River Street to the Manning River, which in some cases have been subdivided to create battle-axe lots which front the river. Minor areas of R1 zoned land near the River are affected by the 100 year flood and a floodway extends within a confined area along the boundary of residential lots and the river. These residential properties are not subject to isolation.

It is unlikely that a review of zoning provisions is warranted but more detailed interrogation of the flood maps could be undertaken to determine whether further battle-axe lot subdivisions where not yet approved can provide suitable building platforms outside of the FPL and floodway, and if not a DCP provision could be applied to restrict such further subdivision.

Croki

This is a small village comprising a few scattered houses and a caravan park adjacent the Manning river, zoned R5. The area is subject to a 1,000m^2 minimum lots size standard. Croki is substantially affected by a floodway/flood storage and high flood hazard in a 100 year flood. Consideration should be given to a more restrictive zone and or minimum lot size standard to prevent the intensification of uses within the village, particularly within the more severely flood affected parts.

Coopernook

This area is located on the northern fringe of the study area, to the north of Coopernook Creek and Lansdowne River. There are no parts affected by floodway/flood storage and high flood hazard in a 100 year flood. The village area is zoned rural RU5 with a minimum lot size standard of 1,000m^2 and public recreation RE1.

Only a small area at the far southern eastern end of the village is below the FPL. Consideration should be given to a larger minimum lot size standard to prevent the intensification of uses within this part of the village.

Harrington

Only small areas along creek lines are affected by a floodway/flood storage in a 100 year flood and a few minor additional areas are below the FPL, but all these areas appear to be zoned for open space purposes or rural RU1. However most of the town of Harrington, zoned residential R1, is located below the PMF.

Accordingly the planning controls should include some consideration of evacuation capability in the assessment. This should also be a primary FRM consideration for any Planning Proposal involving the intensification of development.

Manning Point

This area is zoned rural R5 and subject to a 1,000m^2 minimum lot size standard. The area is substantially developed and mostly comprises urban housing, a caravan park, local shops and bowling club. Parts are below the FPL and the western end is within a floodway/flood storage in a 100 year flood.

Based on the extent of existing development and the existing rural zoning there is no apparent need to review the current zoning. However, any planning proposals should avoid intensification unless FRM issues have been addressed.

Mitchells Island

This area comprises rural R5 zoned land subject to a 1.5ha minimum lot size standard, backing onto Scotts Creek. Parts of the western side of this area are below the FPL, and small areas along the edge of the area near the creek, are within a floodway/flood storage in a 100 year flood.

Given the current zoning and minimum lots size a review of the zoning is not warranted.

Oxley Island

This area is zoned rural RU4 and is subject to a 20ha minimum lot size standard. The northern half of this area is affected by a floodway/flood storage in a 100 year flood. This part of the area comprises scattered houses and agricultural uses. Land holdings are quite large and there appears to be potential to pursue further subdivision.

A review of the lot size standard within the area affected by the floodway should be undertaken in the aim of preventing further intensification of houses within the floodway.

Old Bar

The eastern side of Old Bar is mostly zoned residential R1 with the coastal area and creek corridors zoned E2, E3 and RE1 Public recreation. The R1 zoned part is largely unaffected by flooding, with only small parts along the creek corridors being subject to floods up to the PMF. No parts of this area are affected by a floodway/flood storage function in a 100 year flood. Accordingly no review of the zoning appears warranted.

The western part of Old Bar is zoned R5 with a 1.5ha minimum lots size standard and comprises scattered housing on large lots. A narrow corridor of a floodway/flood storage in a 100 year flood extends north-south through this part of Old Bar along Warwiba Creek. The rear boundary of lots have mostly followed Warwiba Creek allowing for house platforms to avoid the floodway.

While no review of zoning appears warranted, careful consideration is required for any future subdivision and building application in this area to avoid flood risks and impacts, particularly those associated with the floodway.

Conclusion

Some of the issues in these areas could warrant further investigation and review of zone boundaries and the flood planning overlay maps as part of Councils program for the review and consolidation of all existing LEPs. Some issues, if identified, could be resolved with specific DCP controls.

A discussion of alternate approaches for adoption flood planning maps is provided later as part of the review of management options.

4.10 Development Control Plans (DCPs)

Separate DCPs provide more detailed controls for each of the 3 LEPs in the LGA. While the study area is wholly contained within the area subject to the Manning region DCP, the FRM provisions of each are reviewed below.

Gloucester DCP

The Gloucester DCP was adopted by the Gloucester Shire Council in November 2011 and applies to all land subject to Gloucester LEP 2010. Its contains discrete sections for different types of development (residential, industrial, tourist, local centres, subdivision and signage) and issue related matters (building lines, setbacks, carparking, waste, cut and fill, and floodplain management).

Section 4.10 “Floodplain Management Guidelines” contains the most relevant provisions. The following table provides a review of the pertinent provisions.

Table 3: Review of Existing Gloucester DCP Provisions

Clause	Provision	Comment
1.1	The DCP applies only to land zoned R2, R3, R5, B2, B4, E3, SP1, RE1 and RE2 in the Gloucester LEP.	The DCP FRM provisions do not apply to Industrial, Rural and Environmental zones. Ideally DCP FRM provisions should apply to the whole LGA.

Clause	Provision	Comment
5.1	States "1. Development of flood-liable land shall not be encouraged" but may be permitted where no off-site impacts are demonstrated, which may require acceptable ameliorative works.	A broader range of FRM considerations would be relevant including on-site impacts and emergency management capability. Phrasing of the provisions could be more definitive and reflective of Council's obligation to accept and assess development applications.
5.2	States "No development shall be allowed in "High Hazard - Floodway" areas."	While the outcome sought is understood, a DCP has no effect where inconsistent with an LEP, which for example provides that development is permissible with consent (s.3.43(5) of the EP&A Act). Issues could arise where a property is substantially affected by a floodway. Consequently, the review of zone boundary extents as outlined above is important to ensure, zoning (and therefore expectations for development) reflect what could be acceptable having regard to FRM considerations.
5.3	Control 1 states: "Council shall require confirmation that the individual evacuation plans are incorporated into SES planning."	It is understood that the SES practice is not to get involved with individual evacuation plans. However the onus could be put on applicants to ensure that individual plans are consistent with SES flood plans
5.4	Provisions 2 and 3 state: "2. Filling of flood-liable land may be permitted provided that evidence is submitted, in the form of a flood study by a suitably qualified engineer, which will substantiate that the proposed development will not alter flood behaviour to the detriment of any other property. 3. Remedial works shall be provided where the increase in flood level for the Designated Flood event exceeds 0.1 m or as determined by Council."	These provisions imply that an off-site impact involving the raising of flood levels by up to 100mm would be acceptable (ie not detrimental). That might not always be the case and the cumulative impacts of several developments that have such an impact could result in significant impacts. This needs to be reviewed on a floodplain wide basis to determine what level of filling (for different types of uses if relevant) could be acceptable.
	Control 6 requires: Filling for residential buildings shall provide a minimum building platform having a minimum area of 700 m^2 or the whole lot, whichever is the lesser."	This could provide a reasonable benchmark standard that could be applied to elevated house pads in rural areas.
5.5	The provisions regarding levees are: "1. The construction of levees to provide flood protection for proposed development shall not be encouraged. 2. Construction of a flood levee may be approved by Council where it is not feasible to fill the site to Designated Flood Level, subject to conditions.	As above, Provision No.1 reflects a Council policy provision that could conflict with a duty to consider applications. In principle, levees are not considered appropriate to facilitate new development (because of residual risks associated with levee failure and over-topping) but may be an appropriate solution to address existing risks to development. The acceptability of a levee should include an assessment of off-site impacts.

Clause	Provision	Comment
	3. Levees shall not be constructed to protect flood liable land where flood depths exceed 1 metre."	
	Control 2 states "2. The whole extent of the levee structure, including access for maintenance purposes, shall be located within a Drainage Reserve, dedicated to Council. Vehicular access to the full length of the levee is to be provided from a public road."	This may be an issue requiring review by Council at a corporate policy level. Taking on the maintenance responsibility of a levee could represent a significant liability.
5.6	These provisions and controls require minimum floor levels to be 0.5m above the "Designated Flood Level". Exemptions may be considered for additions where the extra floor area will be less than 20% of that existing. Reference is also made to the FPL and a requirement that flood compatible building methods be applied where below the FPL.	Terminology should be made consistent – ie use of FPL rather than designated flood. Refinement of the controls could also involve introducing multiple FPLs for different land uses and different building elements (ie habitable and non-habitable floors and car parking). Provision could also be included for a variable freeboard particularly for part of the LGA where only low level overland flow flooding may apply.
5.7	This part of the DCP outlines where exemptions to the above DCP controls could be exercised – mainly in heritage conservation and commercial areas.	There can be appropriate reasons to relax FRM controls in these areas. Raised floor levels may not be sympathetic to the heritage significance of an area. Raised floor levels of individual shops in a traditional street shopping strip would unlikely be compatible with the streetscape and functionality of the shop (including access for persons with disabilities). Where exemptions are provided these could be offset with other controls to provide alternate ways of reducing flood risks – such as those already incorporated in the DCP requiring raised storage areas, use of flood compatible materials and raised service connections. Consideration could also be given to requiring the preparation of a site flood emergency response plan (FERP) to increase the preparedness of occupants and readiness to evacuate.

In addition to the above, other parts of the DCP provide FRM controls for specific uses. Clause 13.2 restricts caravan parks and camping grounds on land affected by a 10 year flood and permanent residents in caravan parks on land affected by a 100 year flood. No freeboard is mentioned. These reflect reasonable requirements, but considerations could also be given to applying standard residential FRM controls to permanent residents (eg that [habitable] floor levels are to be above the 100 year flood (plus freeboard).

This DCP also provides drainage requirements, inclusive of overland flow paths. However, these controls do not relate specifically to FRM matters.

Great Lakes DCP

The Great Lakes DCP was adopted by the Great Lakes Council on 12 November 2013 and came into operation on 4 April 2014. This DCP applies to all land to which Great Lakes LEP 2014 applies. It contains discrete sections for different types of development (low scale residential, apartments and mixed use developments, industrial and subdivision and issue related matters (character statements, environmental considerations, heritage, carparking, access and transport, water sensitive design, tree preservation, landscaping, waste, signage and site specific controls).

Clause 4.2 of Part 4 (Environmental Considerations) of the DCP provides specific flood related provisions. This Part of the DCP also includes provisions regarding coastal hazard management, and while these are related to coastal flooding issues to some extent, they are beyond the scope of this report and are not reviewed.

The FRM requirements of clause 4.2 are succinctly provided under 7 headings. These are summarised and reviewed below.

Table 4: Review of Existing Great Lakes DCP Provisions

Topic	Requirement	Comment
Objectives	The following 5 objectives are provided: • *The risk of impacts from flooding on people and assets are avoided or otherwise minimised.* • *Development is located in response to the identified flood hazard and designed to accommodate flood conveyance and storage.* • *Environmental impacts of development on flood prone land are avoided or otherwise minimised.* • *Development on flood prone land does not adversely impact neighbouring properties or visual amenity.* • *The potential for financial loss or cost to the community as a result of development on flood prone land is limited.* This section also includes a diagram derived from climate change guidelines prepared by the former DECC.	The objectives could be refined and expanded upon. For example clarity about to what extent or to what end financial loss should be limited (5th objective) would be desirable. The DECC based diagram is out of place given it was prepared to illustrate how to consider potential flood related climate change consequences and confusing as to what policy position it seeks to impose. It is recommended that this diagram not be used in the DCP.
Flood Studies	Provides a basic statement that flood studies may be required and a broad outline of what they are to document.	These requirements could be made clearer.
Subdivision Controls	These provisions provide 6 controls for subdivision of flood prone land referring to FPLs inclusive of climate change forecasts (ie to the year 2100).	The ability to rely on a climate change derived 1% AEP FPL without an exceptional circumstances variation is unclear given the terms of the 2007 Flood Planning Guideline. Clarification from the Department should be sought.

Topic	Requirement	Comment
		The provisions could be expanded and made clearer. For example further clarity could be provided to understand what is an acceptable limit of impact caused by filling (control (5).
Building Controls – General	Any building to be certified as structurally sound in a 21000 1 % AEP flood. Definition of habitable floor area is provided.	This provision is considered appropriate except if the building might be required for sheltering in place, in which case structural soundness up to the PMF should be required and clarification regarding reliance on a 2100 1% flood level for residential development is required. Defining of habitable floor area is desirable but needs to be revised to cover off on all forms of development, not just residential.
Building Controls – New Buildings	1. *New buildings are to be designed and located entirely outside of the 2100 flood planning area wherever possible.* 2. *New buildings are to be designed with habitable floor levels above the 2100 1% AEP flood planning level.* 3. *In circumstances where construction of a new building at the 2100 1% flood planning level is likely to have an adverse impact on the adjoining property or the visual amenity of the location, a variation may be sought. If supported by Council, the new building may be designed with habitable floor levels above the 2060 1% AEP flood planning level.* 4. *Vehicle access to new buildings is to be designed to so that ingress and egress from the site is provided above the 2100 1% AEP flood planning level.*	These provisions are generally appropriate, however the following should be considered: • Differential FPLs based on habitable and non-habitable floor areas and different types of land uses can provide practical outcomes. • The ability to rely on a climate change derived 1% AEP FPL without an exceptional circumstances variation is unclear given the terms of the 2007 Flood Planning Guideline. Clarification from the Department should be sought.
Building Controls – Alterations and Additions	1. *Additions and alterations having a gross floor area of 30sqm or less may be constructed at the existing floor level of the building.* 2. *Additions and alterations having a gross floor area greater than 30sqm are to be designed and located so that any new habitable areas have floor levels located above the 2060 1% AEP flood planning level. Note: Any replacement or refurbishment of existing floor areas where structural changes are proposed will be considered as part of the 30sqm addition or alteration gross floor area calculation.* 3. *In circumstances where construction of new habitable areas at the 2060 1%*	These controls are generally appropriate for residential development but not necessarily non-residential development. As above, the ability to rely on a climate change derived 1% AEP FPL without an exceptional circumstances variation is unclear given the terms of the 2007 Flood Planning Guideline. Clarification from the Department should be sought. The control 3 requirement that allows for a reduced level of flood protection to off-set external impacts should be reviewed. Consideration should be given as to whether the off-site impacts could otherwise be expected to be addressed by skilful design.

Topic	Requirement	Comment
	AEP flood planning level is likely to have an adverse impact on adjoining properties or the visual amenity of the location, a variation may be sought. If supported by Council, the habitable areas may be located 500mm below the 2060 1% AEP flood planning level.	
Fencing	*Fences within a floodway are to be of an open-style design to minimise impacts on flood conveyance.*	This is an appropriate control. Similar requirements can also be appropriate in locations other than floodways (eg overland flow paths).
Additional Resources	Hyperlinks to the FDM and SES Subdivision and Building Guidelines are provided	The NSW Flood Prone Lands Policy and FDM is separate to the principal planning legislation in NSW, being that contained within the EPA Act. Ultimately, the planning recommendations of a FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EPA Act. The FDM provides guidance for the preparation of a FRMP that is expected to include recommendations for planning policies and controls but does not provide planning controls specifically applicable to the assessment and determination of a development application (DA). The FDM (pg. 9, paragraph 2.6) does purport to impose development guidelines to be applied by a consent authority in the assessment of a DA. However while reliance on the Manual might be appropriate in the absence of policy documents prepared under the Act (ie the LEP or DCP) are to be given greater weight than the FDM. As discussed by Pain J [22] in *Neate v Shellharbour City Council [2007] NSWLEC 526*, the FDM and planning controls under the EP&A Act should not be considered as providing alternate approaches. The FDM is in effect intended to inform the preparation of planning controls under the Act. As part of the DCP preparation process it could be appropriate to refer to specific guidelines provided by DPIE that could be relevant to determine an appropriate methodology for flood impact assessment or to adopt definitions in the FDM. It is assumed that the hyperlinks labelled with reference to SES guidelines related to those published by the former Department of Environment and Climate Change in 2007 prepared specifically for the Hawkesbury Nepean Floodplain. The hyperlinks are no longer operative. These guidelines provide a useful source of information but this needs to be distilled into policy relevant to the LGA.

Greater Taree DCP

The Greater Taree DCP was adopted by the Greater Taree City Council in October 2009 and came into operation on 25 June 2010. This DCP applies to all land in the Greater Taree LGA. Its contains discrete sections for different types of development (subdivision, residential, commercial, rural and environmental and industrial, and issue related matters (character statements, heritage, carparking and access, local area plans, waste, landscaping and floodplain management).

Part B provides character statements for some of the localities within the original Taree LGA. These could have peripheral relevance where outlining the desired character of floodplain land (eg the river front areas within Coopernook). It is expected that with any further consolidation of planning controls within the amalgamated MidCoast LGA such character statements could be rolled into the "Local Strategic Planning Statements" (LSPSs) currently being prepared by all Councils. In the preparation of LSPSs, Council should ensure that the intended character of an area is reflective of what could be acceptably achieved having regard to FRM constraints

Part E "Flooding Requirements" contains the most relevant provisions. This part of the DCP applies to all parts of the original Taree City LGA "affected by flooding and affected by or potentially affected by overland flow" (cl.E2.3). This Part of the DCP is structured adopting a performance based approach.

The FRM provisions in Part E of the DCP adopt an approach that is an adaptation of the "planning matrix approach"[3] This approach essentially has 3 elements:

1. Determining what land is flood affected (ie up to a PMF) and mapping the area based on differing levels of hazard or risk). This DCP provides that either the land has been mapped as flood liable or based on high level criteria (distance from and height above watercourses) may be identified as "potentially flood prone land" which requires a flood study. Land could be considered flood affected if not affected by flooding but is isolated during a flood ("flood constrained"). If flood affected, then the flood risk precinct (hazard and hydraulic category) of the site is determined (cl.3.2).

2. Grouping development types/ land uses into categories with similar levels of vulnerability to flood hazards with regard to both property damages and risk to life. The land use categories adopted are: critical use facilities; sensitive sues and facilities; subdivision; residential; commercial or industrial; tourist related development; recreation or non-urban uses; and concessional development. Concessional development is small scale development (alterations and additions and some change of uses) where development controls are proportionally relaxed. Fencing is addressed separately.

3. Development controls are then formulated for different land use categories within different flood risk precincts. The types of controls relate to: hydraulic/hazard category; floor levels; building components and methods; structural soundness; flood effects; car parking and driveway access; evacuation and management and design. The stringency of the controls reflects the vulnerability

[3] Bewsher, D & P Grech, May 1997, A New Approach to the Development of Floodplain Controls for Floodplains, paper presented to the 37th Annual Floodplain Management Conference, Maitland.

of the land use and the severity of the flood hazard (ie what flood risk precinct the site is located within).

The DCP applies a range of FPLS as set out in Table 2 (cl.E2.3.1) as outlined below.

Table 5: FPLs Used in Greater Taree DCP

Reference	Description
FPL1	5% AEP (20 Year ARI) flood level.
1% Flood Level	1% AEP (100 Year ARI) flood level. This level is useful for insurance purposes.
FPL2	2100 1% AEP (100 Year ARI) flood level.
FPL3	2100 1% AEP (100 Year ARI) flood level plus 0.5m Freeboard. FPL4
FPL4	Probable Maximum Flood (PMF) level.

The above FPLs incorporate consideration of climate change by assigning some FPLs based on predicted 2100 conditions.

The following table provides a summary of the pertinent provisions per type of control. Note Critical use facilities are blanketly specified as inappropriate on flood prone land.

Table 6: Review of Existing Greater Taree DCP Provisions

Control	Provision	Comment
Hydraulic/Hazard Category	No development in floodway, flood storage area, or a high hazard area, up to: • FPL4 for sensitive uses and facilities. • FPL3 for residential, commercial/industrial, tourist; • FPL1 for recreation/ non-urban; and • FP2 for concessional development Allowance is provided for alternate solutions where justified by a site specific study.	These seem to be practical requirements based on what a site specific flood assessment is likely to determine but allows the opportunity for applicants to test acceptability with more detailed investigations. Further guidance as to the performance outcome sought to be achieved when preparing a site specific assessment, with or without ameliorative measures, would be desirable. The performance outcome presented in clause E3 of the DCP provide information requirements rather than performance criteria and should be renamed. Note, it is not clear under the 2007 Flood Planning Guideline as to whether a residential FPL can be based on a future climate change based scenario with exceptional circumstances approval. Clarification with the Department should be sought.
Floor Levels	Habitable floor levels to be: • FPL4 for sensitive uses and facilities. • FPL2 for residential, commercial/industrial,	The concept of using multiple floor level FPLs depending on the sensitive of the land use appropriately reflects a risk based approach to managing flood risk.

Control	Provision	Comment
	tourist; recreation/ non-urban; and concessional development The controls typically allow non-habitable floor levels at a lower FPL. Subdivision is restricted on land wholly inundated by flooding up to a FPL2 event.	Could benefit from defining key terms such as habitable and non-habitable floors. This could in part be done by a reference back to the FDM. DCP is not clear as to whether proposed changes to flood levels based on acceptable ameliorative work would be relevant to applying the restriction on subdivision.
Building Components and Method	All structures to have flood compatible building components below the prescribed habitable floor level FPL.	This provision is considered appropriate but further guidance as to what are appropriate flood compatible building components and methods is desirable.
Structural Soundness	Engineers report that shows any structure can withstand the forces of floodwater, debris and buoyancy up to the prescribed habitable floor level FPL.	This provision is considered appropriate except if the building might be required for sheltering in place, in which case structural soundness up to FPL4 (the PMF) should be required.
Flood Effects	Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: • Loss of flood storage. • Changes in flood levels, flows and velocities caused by alterations to the flood conveyance. • The cumulative impact of multiple potential developments in the floodplain	The considerations are considered appropriate but further consideration could be warranted as to whether an engineer's report is required in all cases or whether a qualitative assessment could be made by Council in the case of minor developments.
Car Parking and Driveway Access	Variable levels of protection are required dependent on whether: • On surface (FPL1) • Enclosed (FPL2) • Number of spaces (FPL3 where > 20 spaces) • Depth of flooding on driveway and level relative to road.	These provisions are generally appropriate. Should basement car parking become more typical in the major centres then further requirements regarding establishing warning systems and evacuation paths from within enclosed car parks would be warranted.
Evacuation	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to a refuge area above FPL4 for sensitive uses. A flood emergency response plan (FERP) is required for all other uses.	The adequacy of simply requiring a FERP should be reviewed. The review should have regard to whether the locality of any development site is evacuation constrained or subject to inadequate warning time to allow for out of floodplain self-evacuation (particularly in areas subject to flash flooding) and whether requiring shelter in place could be acceptable.

Control	Provision	Comment
Management and Design	Provide an area to store goods above FPL3 (FPL4 for sensitive uses) and do not store hazardous material below FPL3 (FPL4 for sensitive uses).	These provisions could be expanded based on post flood reviews of actual issues that were experienced. Input from the SES and insurance companies could be of assistance.

All FRM provisions of the 3 DCPs have some attributes that could be transferred to a consolidated DCP applying across the LGA. The Greater Taree DCP provides the format with the greatest flexibility to accommodate a range of flood issues and development contexts. However, the preparation of new FRM DCP provision should ideally commence afresh to provide the optimum structure and policy coverage. Relevant recommendations are provided later in this report.

4.11 Developer Contributions

Section 7.11 (formerly section 94) Contributions Plans under the EPA Act provide a basis for the levying of development contributions to construct drainage and flood mitigation works required as a result of future development. where such works are required to ensure the acceptability of development and where it would be unreasonable to expect it to be provided in association with an individual development. Examples of such works could be the construction of a levee, a regional detention basin or upgrading of evacuation routes or evacuation centres.

Standard Section 7.11 contributions can only be applied to fund works with a direct nexus to the new development and cannot be applied for the purposes of rectifying past inadequacies. Section 7.12 (formerly 94A) Contributions Plans are an alternative where no nexus is required but the quantum of the contribution is basically capped at 1% of development costs, unless otherwise approved by the Minister for Planning.

The study area falls within the former Taree LGA and is subject to the Greater Taree S94 and S94A Contributions Plans (both prepared by GLN and dated 2016). These plans are based on an anticipated growth of about 2,230 dwellings (15,800 persons) between 2016 and 2031. The works program in the S94 and S94A Contributions Plans do not include any FRM related works. However, some of the road works provided for in these plans could indirectly improve evacuation capabilities in some areas.

In principle, Contribution Plans could be established within the study area, where it is necessary or appropriate to fund flood mitigation works through such plans. This would be relevant in new greenfield release areas or substantial urban renewal areas where such works are required to ensure the acceptability of the development (e.g. for the upgrading of evacuation routes or evacuation centres to cater for increased population densities, or regional stormwater detention basins).

Where works are required for both existing and future development the cost could be apportioned between future development (within a Contributions Plan) and existing development (to be funded by Council through general revenue or other sources such as special grants).

Future section 7.11 or section 7.12 schemes will also require consideration of the various Ministerial Directions and advisory documents issued by DPIE. These Directions and advices are ostensibly intended to limit costs to development imposed through development levies.

It is expected that new development will be planned with current knowledge of flood liability and will be exposed to minimal (residual) risks compared to the flood liability of existing development. Accordingly, the potential to use developer contributions to fund FRM mitigations options is likely to be limited.

5 Management Options & Recommendations

5.1 Strategic Planning Input

5.1.1 Context

The planning recommendations for the Manning River FRMP focuses on providing advice on principles to be applied when considering changes to land use zoning plans in the future, the presentation of planning information and changes that can be made to the planning controls to better achieve development that minimises flood risks to as low as reasonably and practically achievable. FRM will ultimately need to be weighed with other relevant planning considerations to achieve balanced outcomes that meet community expectations. While the FRMS relates to a part of the LGA it will be important for recommendations regarding the preparation of planning controls be structured so that they can also be easily applied to other floodplains in the LGA.

The catchment area of the Manning River is quite large and has a larger percentage of persons in older age groups that could require assistance if required to evacuate, or have no access to a motor vehicle. Most of the population that resides in the Manning River catchment are competent English speakers. A substantial proportion of the persons within the area at any one time will be tourists, who are less likely to be flood aware. This is important in understanding potential emergency management issues and flood awareness education.

The largest industries in the area are tourism. This this has been a factor in focussing development in locations that take advantage of the extensive river system within the study area. The natural environment is recognised in Council's strategic plans as an important asset that underpins a broad range of economic activities particularly its tourism industry

The strategic planning process requires the consideration of a wide range of factors to produce or review plans that guide land use management and development in an area. FRM is one of these factors.

The planning recommendations ultimately incorporated within a FRMP and adopted by Council will subsequently require implementation through the separate planning processes, principally governed by the EPA Act. In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

5.1.2 General Principles

The primary objective of the NSW Government's Flood Prone Land Policy is to "reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property" and to "reduce private and public losses resulting from floods".

At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land.

The only way to completely remove flood risks from a development is for it to be located outside the extent of the PMF. This is a very risk-averse approach to floodplain management which is not supported by the FDM. In particular one of the principal tenants of the Flood Prone Lands Policy is that "flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development".

When considering future development, both the Policy and the FDM promote the use of a "merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable. In this way the policy avoids the unnecessary sterilisation of flood prone land. Equally it ensures that flood prone land is not the subject of uncontrolled development inconsistent with its exposure to flooding.

As a general rule, almost any development involves some risks to property or people. For example, construction of a new subdivision introduces traffic risks which may be managed (e.g. through construction of traffic lights, signage, etc) but are not completely eliminated. Rather the risks are reduced to a level which is considered acceptable to the community. Flood risks are managed in a similar fashion. Nevertheless in some situations if the residual risks remain unacceptably high, alternative safer forms of development should be pursued.

Best practice FRM in planning involves applying a risk management approach. This requires an understanding or risk management principles and their application to FRM, as discussed below.

5.1.3 Understanding Flood Risk

Within the context of this report, 'flood risk' is defined as the combination of probabilities and consequences that may occur over the full spectrum of floods that are possible at a particular location.

It is important not to confuse 'flood risk' with 'flood hazard' or 'provisional flood hazard'. The terms 'hazard' and 'provisional hazard' are defined in the FDM and are associated with the magnitude of a specific flood. For example, a site may experience high hazard conditions in a 100 year flood and low hazard conditions in a 5 year flood. On the other hand, the term flood risk used in this report does not relate to a single flood, but rather to all floods. It presents a single measure of a site's exposure to its flood threats.

As flood risk combines all the probabilities and consequences of flooding over the full spectrum of flood frequencies that might occur at a site, it can be expressed in mathematical notation as follows:

$$\text{Flood Risk} = \int_{\text{all floods}} \text{Probability} \times \text{Consequence}$$

where probability is the chance of a flood occurring, and consequence is the property damage and personal danger resulting from the site's flood characteristics.

5.1.4 Flood Mapping

In order to understand the severity of flood risk, it is therefore necessary to consider the potential hazards that can occur to people and property in various flood magnitudes which have different probabilities of occurrence. To assist in this task, analyses typically undertaken as part of the FRMS to better understand these hazards include:

- depth of inundation;

- flood velocities;
- duration of inundation;
- rates of rise of flood waters;
- warning times available;
- evacuation capabilities given potential closure of routes due to flooding or traffic congestion on the available routes; and
- isolation of areas into 'islands' as flood waters rise,

This information is mostly reflected in the maps discussed at section 4.9 of this report (and included as Appendix A) and is valuable in understanding FRM issues when undertaking strategic planning exercises. Such maps are different to maps produced for an LEP or DCP – the intention of those maps being to trigger approval pathways and consideration requirements for the assessment of development proposals.

5.1.5 Overview of Methods for Managing Flood Risks

There are three principal options for managing flood risks:

1. avoiding the risk – land use zoning is the key management option by which the flood risk avoided. Inappropriate flood risks can be avoided by ensuring that only development compatible with the flood hazard is located in the floodplain;
2. reducing the likelihood – construction of detention basins, levies and other structural measures can reduce the probability of flooding; and
3. reducing the consequences –

In reducing the consequences of flood risks, a range of measures are available including:

- setting floor levels and other development controls;
- using flood compatible building materials and methods;
- ensuring buildings are structurally sound if exposed to flooding;
- raising flood awareness amongst communities;
- improved emergency management;
- improved flood warning;
- transferring some of the consequences to others through insurance; and
- provision of disaster relief.

In every situation, avoiding the risk through effective land use planning is the preferred option, if possible. Nevertheless pressures for land development, the lack of suitable land outside the floodplain, and a range of other non-flood related issues mean that use of some floodplain land may still be the best option for the community. The FDM guides Councils and consent authorities to use the 'merit approach' in making these land use decisions, balancing flood risk with other social, environmental and economic considerations.

As flood risk comprises risk to property and risk to life, the management of flood risk considers options for managing both the risk to property and risks to personal safety.

5.1.6 Risks to Property

The most common method of reducing the consequences to property is by controlling the height of floor levels relative to a given probability flood. A range of flood planning levels (FPLs) are usually established by councils for this purpose that relate to different land uses and different building components (eg habitable floors, non-habitable floors and car parking). Research associated with numerous other FRMSs we have been involved with has identified that a community would typically accept higher levels of property damage for rural and recreational buildings as opposed to community uses such as hospitals and schools.

Traditionally the 100 year flood (plus freeboard) FPL has been considered to be an acceptable level of risk for most residential, commercial and industrial properties in NSW. It is the default FPL mandated for standard residential development in NSW under the Flood Planning Guideline, without an exceptional circumstances variation.

In addition other complementary controls are used to manage property risks including the use of flood compatible building materials and methods as well as ensuring buildings are strong enough to withstand the forces of flood waters without collapse. These types of controls are discussed as part of the DCP recommendations.

5.1.7 Risks to People

Risk to life should be seen as a key flood constraint when undertaking strategic planning for potential new development. Planning can assist in managing risks to people with a range of measures including recognising evacuation and emergency management constraints, and increasing the community's awareness and preparedness for flooding.

Consideration of flood risks to life are is a requirement of the standard LEP flood clause, incorporated into each of the 3 LEPs applying in the LGA. More detailed considerations are discussed as part of the DCP recommendations. The following provides general principles for consideration for planning purposes.

Emergency management is a principal mechanism that requires consideration within the planning process as it can influence the:

- location of new development – in areas free of flood risk or where evacuation away from the flood risk is possible;
- type of development – for example developments such as seniors housing and child care centres can have limited capacity for self-evacuation and may induce risky action with guardians seeking to travel into flood affected areas to retrieve seniors or children.
- form of development – so that it is designed to allow for pedestrian and/or vehicular evacuation, and buildings that are structurally resilient to the forces of floodwaters if unavoidably required to provide a refuge; and
- connections between developments and safe refuges or support facilities – to ensure that pedestrian paths and road systems are designed to facilitate evacuation and access to safe refuges, support facilities and/or evacuation centres.

The evacuation risks are determined by considering the flood characteristics of the site together with its topography, its proposed uses and demographics of its occupants, and the capacity of evacuation routes.

In most situations it is preferable for residents subject to potential inundation, to evacuate to areas beyond the floodplain prior to the onset of flooding. When for whatever reason this is not possible, and floodwaters overwhelm an inhabited area, the provision of an elevated refuge can provide a safe haven that reduces risk to life. It may also provide an area above the reach of flood waters where valuable goods and personal memorabilia can be stored.

There is some debate in the flood risk management profession as to whether the provision of an on-site refuge is appropriate as it may provide a disincentive for communities to flee the floodplain and may be subject to other risks when sheltering on site. Nevertheless the compelling evidence from numerous recent flood evacuations is that even when adequate time for evacuation exists, residents may not heed the evacuation advice given to them. In some cases, such as for flash flood situations, warning time may not be sufficient to allow for a safe evacuation. Consequently in some situations a requirement for elevated on-site refuges for sheltering in place may be warranted.

A critical issue encountered by people who take refuge in such facilities is the potential isolation. Isolation can be accompanied by additional safety risks to the occupants including the inability to reach medical assistance, lack of food, sanitation, potential for additional fire risks, trauma induced isolation, exposure to extremes of temperature, etc.

To some extent these isolation risks can be mitigated by the provision of adequate support facilities within the refuge. In some instances these support facilities might be comparable to those available at an evacuation centre. The scope of facilities that could potentially be provided is dependent on the scale of development involved. Such facilities need to ensure the health and safety of occupants for the likely duration of flood emergencies and must recognise the age, health, mobility, medical needs and the level of resilience of the occupants. Such support facilities could be made a requirement in a DCP, where on-site refuges are deemed an acceptable option.

5.2 Review of Planning Controls

As noted above flooding is one consideration relevant to the formulation of planning policies and controls.

5.2.1 Flood Planning Maps

The purpose of maps prepared for a planning instrument (LEP) or supporting code (DCP) is to trigger approval pathways and consideration requirements for the assessment of development proposals. The approval pathways could vary from being permitted without consent, exempt development, complying development or a full DA. In some cases an environmental impact statement could be triggered as required for a DA (where as discussed above certain proposals are deemed "designated development" when located on flood prone land).

In order to manage the 2 sets of flood planning area mapping from two of the existing LEPs and the absence of such mapping from the third LEP, the mapping could be omitted from the LEP, but included in an external form referred to in the LEP. Ideally the external form would be adoption as part of the DCP which provides a structured opportunity for community consultation. The adoption of flood maps external to the LEP provides greater ease for on-going updating as more flood studies are prepared and mapping is refined, including overland flow flooding. It also allows for greater flexibility in the format of mapping to for example include multiple flood risk precincts (as discussed in regard to DCP recommendations).

Council could proactively provide advice to the public as to where the Codes SEPP applies. The flood maps produced for planning purposes could achieve this by adopting a flood risk precinct approach and aligning areas identified as high risk areas with those areas within which complying development is excluded under the Codes SEPP.

5.2.2 LEP provisions

The three LEPs that were prepared prior to Council amalgamations remain applicable to the LGA. Council is working towards merging the 3 LEPs into one LEP. Irrespective of this outcome, it would be preferable to establish a single comprehensive framework for FRM planning controls for the LGA. A review of the 3 LEPs was undertaken, as documented above, from which the following four key recommendations are derived:

1. Ideally the flood planning LEP clause should apply to the whole of the floodplain (ie up to the PMF) by changing the definition of the flood planning area. This would allow for the full range of flood risks across the full range of development possibilities to be considered as required. This would require obtaining an exceptional circumstances variation from DPIE, to the extent it imposed a flood related planning control on standard residential development. The broader application of the clause only extends where the broad FRM considerations in the clause apply, and would not impact on the permissibility of development or detailed considerations such as floor levels which is set by the DCP. If required, the LEP flood clause could be adapted so that only evacuation considerations applied above the 100 year flood level (plus freeboard) and there are examples of LEPs that have adopted a second flood LEP clause aimed at achieving a similar outcome. It is recognised that obtaining exceptional circumstances approval will involve a separate exercise of preparing a justification and applying, and if not pursued, would not be critical to the implementation of the FRMP planning recommendations.

2. As discussed above, the mapping could be omitted from the LEP, and included in an external form referred to in the LEP, ideally the DCP.

3. Zone boundaries within flood affected areas were subject to a high level review of alignment with the extent of flood constraints. This will require a more detailed investigation, to determine whether adjustments are required to LEP zone boundaries and/or DCP controls, within the following areas:

    - South Taree
    - Tinonee
    - Cundletown
    - Croki
    - Coopernook
    - Harrington
    - Oxley Island

Additionally, it is expected that with any further consolidation of planning controls within the amalgamated MidCoast LGA relating to character statements such as those currently in DCPs would be rolled into the "Local Strategic Planning Statements" (LSPSs) or possible a future consolidated DCP. LSPSs are currently being prepared by all Councils in NSW in accordance with guidelines issued by the DPE (now DPIE) and will provide a key guide for the formulation of future LEPs. In the preparation of LSPSs, Council should ensure that the intended character of an area is reflective of what could be acceptably achieved having regard to FRM constraints.

5.2.3 DCP Provisions

It is assumed that in conjunction with working towards a consolidated LEP, Council will ultimately prepare a consolidated DCP for the current LGA. This will provide an opportunity to prepare a single and set of comprehensive DCP FRM provisions.

This report has provided a detailed review of existing FRM provisions within the 3 DCPs (see Tables 3, 4 and 6). The comments provided in this review should be taken into consideration to ensure they are addressed within any future DCP.

All FRM provisions of the 3 DCPs have some attributes that could be transferred to a consolidated DCP applying across the LGA. The Greater Taree DCP, provides the approach with the greatest flexibility to accommodate a range of flood issues and development contexts. However, the preparation of new FRM DCP provisions should ideally commence afresh to provide the optimum structure and policy coverage. The following outlines the recommended principles to be applied when preparing the new FRM DCP provisions.

Overview to Preparation of DCP Controls

The Greater Taree DCP is consistent with the planning the "planning matrix approach." The key component of this approach is the preparation of a planning matrix, which provides a matrix of controls that change to reflect the vulnerability of different land uses to flooding and the risk associated with the location of a development within different parts of the floodplain.

The planning matrix approach is well documented and has been applied by over 30 Councils in NSW. The approach is diagrammatically shown in the figure below.

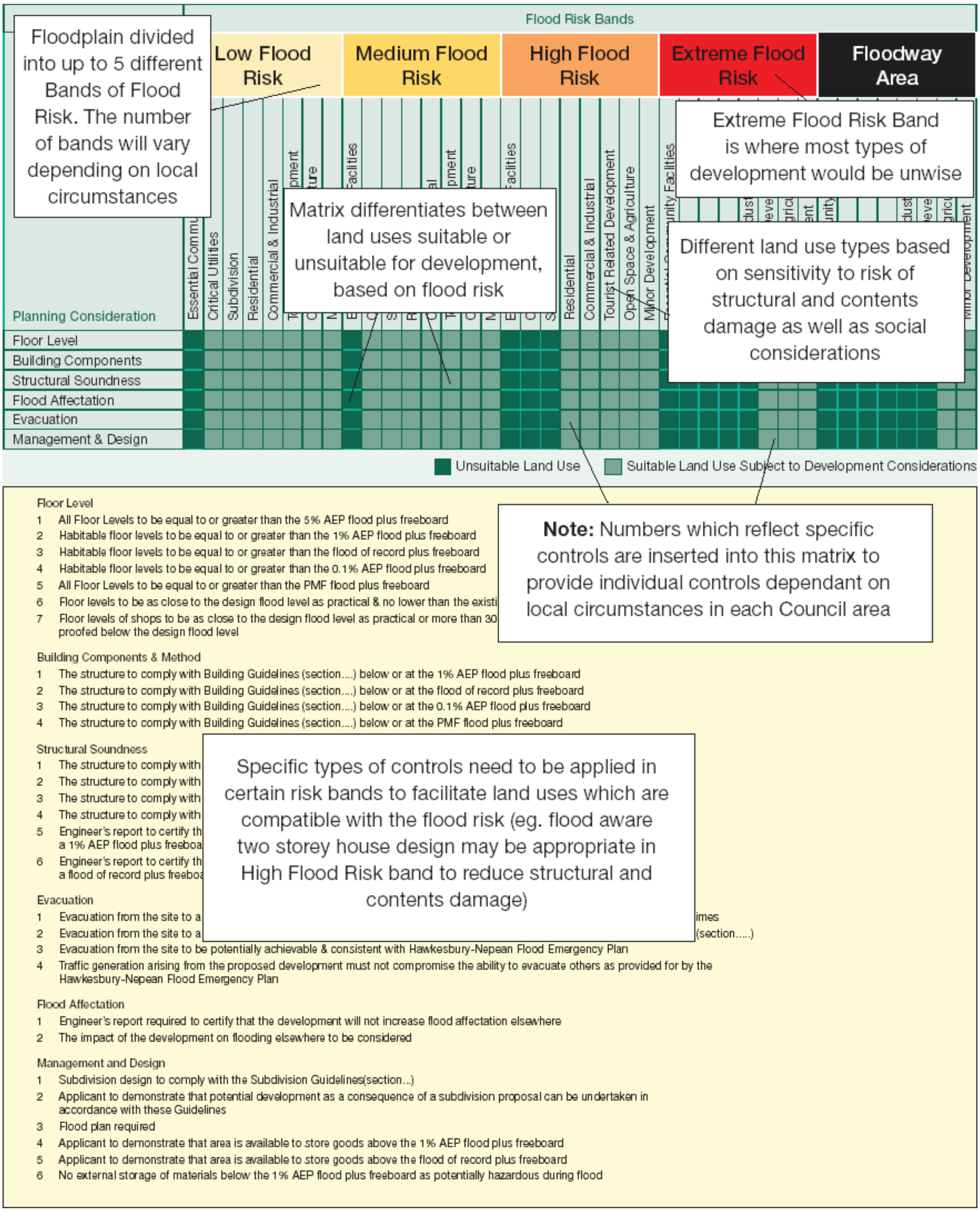


Figure 5: Sample Flood Planning Matrix (Land Use Guidelines, HNFMSC, 2006a, p.114)

While this approach has typically involved presentation in matrix table, it can be written "long hand" as in the case of the Greater Taree DCP.

The intent should be to develop a matrix of controls that would be relevant to the whole LGA. Where different floodplains within the same LGA have materially different flood characteristics or different FRM strategies as a consequence of the recommendations of separate FRMPs, multiple matrices could be prepared. As this report is associated with a FRMP for only part of the LGA, the following is therefore only a summary of the process for applying this approach in preparing FRM DCP controls.

Mapping of flood risk precincts

This involves dividing the floodplain (i.e. all land affected up to the PMF) into areas with similar levels of risk. The number of precincts may vary between different floodplains. A three tier category of low, medium and high is typically adopted for riverine flooding. A further category for "overland flow" can be added for parts of catchments affected by stormwater flooding.

The primary purpose for these maps is to identify the planning controls and information requirements that would apply to individual development proposals. The maps could also have secondary purposes, including to:

1. Identify where the flood LEP clause applies if the LEP maps were not to include a flood overlay series. This is a recommended option (see above).

2. Provide a consolidated source of information to determine whether a development may be excluded from being considered complying development under the Codes SEPP. For example, the DCP maps could ensure that areas mapped "high risk" and possibly also "overland flow" could collectively represent all the categories in the Codes SEPP excluded from the application of the complying development codes.

3. Provide a source of information about flood risk, commonly accessed by the community, that provides a message about flood risk that is consistent with that which may be provided through flood awareness programs by Council or the SES, and what might ultimately be experienced. The use of descriptive terms such as high, medium and low, together with other carefully scripted non-DCP messaging can be important in ensuring the community is properly and fully informed about flood risks without being unnecessarily alarmed.

While the criteria for the formulation of flood risk precincts can vary the following represent those that can serve the above purposes and are often used to produce such maps.

Flood Risk Precinct	Typical Primary Mapping Criteria	Planning Control Outcome
Low	All other and within the floodplain (i.e. within the extent of the probable maximum flood) not identified as being within a high, medium or overland flow precinct.	• Risk of damages are low and modifications to most building structures are unlikely to be cost effective. • Potential for impact on others in the floodplain is low. • No controls are imposed on most development other than emergency management considerations. • Controls on building structures for sensitive uses and facilities critical in a flood emergency should be imposed.
Overland Flow	Depth of inundation of between 50mm to 250mm arising from overland flow in a 100 year flood. Note where the depth of inundation is less than 50mm it is not mapped and would generally	• Risk of damages varies and the potential to impact on others due to the blocking of flood flows could be high.

	be dealt with as part of normal BCA construction requirements.	• Controls to be imposed on most development. • Unlikely to be suitable for complying development.
Medium	Land below the 100 year flood level but excluding that land identified as being within a high or overland flow precinct.	• High risk of flood damages without substantial modifications to building structures & other planning controls. • Impact on others should be manageable • Controls to be imposed on most development.
High	The area of land below the 100 year flood that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.	• Significant risk of building collapse, evacuation constraints, unmanageable impact on others &/or unsustainable risk to communities • Zoning should preclude most development but where permitted significant ameliorative measures would be required that are unlikely to be acceptable due to amenity or environmental impacts. Controls should recognise these difficulties and discourage development on lands mapped as high risk. • Unlikely to be suitable for complying development approval pathways.

Figure 6: Potential Flood Risk Precincts

It is important to note that these criteria are used because they can be readily applied to produce maps with minimal subjective input. However, this does not mean that the other extensive information prepared as part of the FRMS should not be considered. For example an analysis of high hazard extents in floods marginally rarer than the 1% AEP might identify an additional flood runner that should be mapped as medium or high flood risk. The most important consideration is to satisfy the primary intent of the mapping for flood purposes to ensure all appropriate considerations are covered in the development assessment process.

The separation of overland flow areas from the other flood risk precincts allows for the introduction of controls that do not impose excessive requirements on development compared to controls designed for more mainstream flooding. For example, an FPL for floor levels could be based on a lower freeboard in recognition of the lower depth associated with overland flow flooding.

Categorising Land Uses

This involves identifying discreet categories of land uses with similar levels of vulnerability to the flood hazard. The land use categories used in the Greater Taree DCP are appropriate but should be reviewed to ensure they capture all development types defined by the LEP and any other applicable SEPP.

Identifying controls to modify building form and response to flooding

Where the planning process determines land uses are appropriate, but still subject to flood risk. Different planning controls can be imposed to minimise potential damages and to maximise the ability of the community to respond (i.e. preparedness and capacity to evacuate) during a flood. The potential damages that can arise from development relates to both upon the proposed development and on other property as a consequence of external flood effects.

Consistent with the Greater Taree DCP, controls applied to development within a floodplain would typically relate to the following seven considerations:

- Floor level
- Building components and method
- Structural soundness
- External flood effects
- Car parking and driveway access
- Evacuation; and
- Management and design.

Floor level FPLs for residential development is a key control in reducing flood damages and to maximise potential for buildings to survive after flood inundation. The latter consideration is important to the economic and social impact on individuals and consequently the community. These FRM controls need not be complex and can be based on the following basic types of FRM development controls:

- Multiple FPLs can be applied to reflect the vulnerability of different land uses to flood risk (eg a school could be subject to a higher level than a house) different parts of development (eg habitable or non-habitable floor space) could also be subject to different levels.
- The default standard residential habitable floor level (as directed by the Flood Planning Guideline) being the 100 year flood level plus 0.5m freeboard would be expected to be suitable throughout the LGA for most types of development except sensitive uses and critical facilities.
- Despite the above, where a building is intended to provide for shelter in place during a flood, a suitably sized and equipped part of the building should have a floor level at or above the probable maximum flood (PMF).

- Lower FPLs could be applied in situations such as non-habitable floors, open car parking, and low value and robust non-urban and recreational buildings.

There may be parts of the LGA where minimum site levels (as opposed to floor levels) to provide flood protection for external uses or components of uses is important. On larger rural properties where an alternate suitable flood free location cannot be obtained, fill pads constructed to meet the minimum FPL for the proposed use could be an option, subject to satisfying the remaining FRM considerations.

Typically, all structures below the habitable floor level should comprise flood compatible materials and methods of construction.

Appropriate levels of assessment should be applied to ensure a structure can withstand the forces of floodwater, debris and buoyancy up to and including the design floor level. Where a building is intended to provide for shelter in place during a flood, the building should be structurally sound for floods up to and including a PMF.

In regard to external flood effects, appropriate levels of assessment should be applied to ensure development will not materially increase flood affects elsewhere in the floodplain.

For emergency management reasons, reliable access for pedestrians or vehicles should be required from the building, commencing at a minimum level equal to the lowest habitable floor level to a refuge area above the PMF. While evacuation to an area outside of the floodplain is preferable, there can be situations where provision for sheltering in place could be acceptable (for example where warning times are insufficient and an evacuation routes cannot be practically secured).

Environmental management measure will vary dependent on the proposed land use. For example, there may be a need to manage the storage of hazardous materials to avoid pollution spills during floods and secure material that could become uncontrolled floating debris. Additionally, where development is proximate to a waterway, it can be important to addressing the environmental impacts (ecological and scenic) on the riverine corridor.

<u>Summary</u>

It is expected that Council will ultimately prepare a single new DCP for the LGA. This might provide a revised DCP structure and an opportunity to incorporate comprehensive flood related planning controls that can provide basic direction and assistance to both applicants and Council assessment officers. This will also ensure that Council has exercised its duty to consider FRM issues as required by the FRM LEP clause and could contribute to demonstrating that Council has acted in accordance with the principles of the FDM if ever needing to defend any actions, advice or decisions of council, under section 733 of the *Local Government Act , 1993*.

A starting point for managing risk through land use planning is to classify risks throughout the floodplain. The imposition of planning controls is aimed at managing flood risks of development that is permissible by current zoning controls, including redevelopment of existing flood affected property. The above outlines a methodology for mapping risk precincts and preparing controls based on the likelihood and consequences of flooding – ie applying a risk management approach.

5.2.4 Climate Change

The consideration of climate change effects requires determining what would be reasonable standards to apply today to ensure that a development has an acceptable level of flood immunity in the future based on projected climate change flood effects. The aim is to take a precautionary approach to contain flood risks at those levels otherwise considered acceptable today where this can be practically achieved. The time period for consideration of the future is typically year 2100, as already adopted by Council, based on 100 year international forecasts for sea level rise provided from a year 2000 base.

The 2010 NSW Sea Level Rise Policy recommends that strategic and statutory planning documents could respond to the coastal flood risk area affected by projected 2050 and 2100 levels by restricting the intensification of development in areas subject to predicted climate change flood risk or applying planning controls to manage the additional risk. The mechanisms that might be applied include:

- adopting climate change design flood design levels where assessing the suitability of rural land for future urban purposes at the strategic planning stage;

- increasing the design flood levels that would otherwise apply to buildings and land required of development to take into account predicted climate change effects. This would typically be practical in greenfield developments but often impractical for developments within established areas; and

- imposing time-limited consents to provide the potential to remove, replace or adapt development in the future.

The first mechanism relates to strategic planning outcomes, as discussed above.

Regarding the second mechanism multiple FPLs can be used that take into consideration the vulnerability of different land uses, the expected life of development and the practicality of developing at higher levels. This can be integrated into the planning matrix approach.

In a practical sense, the adoption of the higher FPL could be appropriate for new areas or major developments where additional filling or higher floor levels can be readily achieved with marginal additional cost and minimal impacts on surrounding development. Conversely it could be difficult to implement higher FPLs for minor development within established areas where there could be amenity, streetscape or drainage impacts.

The Court has been reluctant to accept time related consents (see for eg *Newton and anor v Great Lakes Council [2013] NSWLEC 1248*). However, if to be considered for inclusion in a future DCP, it should be accompanied with clear objectives and criteria for how it would be applied, what happens at the expiration of the consent period, and opportunities to extend the consent period if circumstances change. The expiration date should also be event trigged (eg the reaching of a certain mean sea level) as opposed to calendar date triggered.

The ability to rely on a climate change derived 1% AEP FPL when apply controls on residential development, without an exceptional circumstances variation is unclear given the terms of the 2007 Flood Planning Guideline. Clarification form the Department should be sought.

5.3 Notifications (communication)

While planning documents are not the principal means to advise people of flood risks for the purposes of creating a flood aware and prepared community, they nonetheless form a component of information sources. To ensure that council exercises an appropriate duty of care of responsibly informing the public of flood risks and to avoid undermining floor awareness education campaigns, it is important to ensure a consistent message is provided by:

- The FRMS and FRMP
- General planning studies and strategies
- Definitions, mapping and controls within planning policies (i.e. LEP and DCP); and
- S10.7 (formerly) S149 Planning Certificates

Adopting the planning matrix approach discussed above, including flood risk mapping, provides a sound basis to ensure the appropriate communication of flood risk within the planning system.

A Section 10.7 Planning Certificate is basically a zoning certificate issued under the provisions of the EPA Act that is generally available to any person on request and must be attached to a contract prepared for the sale of property. The matters to be contained within the Section 10.7(2) Certificate are prescribed within Schedule 4 of the Environmental Planning and Assessment Regulation, 2000 and generally relate to whether planning controls [and not necessarily flood related risks] apply to a property.

A Section 10.7(5) Certificate, being a more complete but more expensive certificate, requires councils to advise of "other relevant matters affecting the land of which it may be aware". These more complete certificates are not mandatory for inclusion with property sale contracts – a Section 10.7(2) Certificate being the minimum required. Where a Section 10.7(5) Certificate is obtained, this could require a council to notify of all flood risks of which it is aware.

It is recognised that S10.7 certificates should not be solely relied upon as community education tools as they have only limited circulation. The majority of flood-affected properties would not be reached in a given year. However, information on a S10.7 Certificate can reflect information that may be provided to people making general enquiries, and together are important sources of information for the community that influence what is the understood (or perceived) flood risk of property that a person owns and/or occupies or operates a business from. With the existing system of notifications on S10.7(2) certificates, if no notification appears, then it is often misunderstood to mean that property is "flood free" rather than there are no flood related development controls. For the purposes of FRM, S10.7 certificates should not confuse or mislead those people who have access to them, with regard to understanding whether there are any risks of floods affecting a particular property.

Schedule 4 of the Regulation was amended, commencing on February 16, 2007, to specify flood related information that can be shown on Section 10.7(2) Certificates. The amendment provisions require the following

7A Flood related development controls information

(1) Whether or not development on that land or part of the land for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including

development for the purposes of group homes or seniors housing) is subject to flood related development controls.

(2) Whether or not development on that land or part of the land for any other purpose is subject to flood related development controls.

(3) Words and expressions in this clause have the same meanings as in the instrument set out in the Schedule to the Standard Instrument (Local Environmental Plans) Order 2006.

As stated in the 2007 Flood Planning Guideline, the new Clause 7(A)(1) of Schedule 4 of the Regulation means that Council should not include a notation for residential development on Section 10.7(2) Certificates in "low risk areas" if no flood related development controls apply to the land. Under Clause 7(A)(2) Council can include a notation for critical infrastructure or more flood sensitive development on Section 10.7(2) Certificates in low flood risk areas if flood related development controls apply. "Low flood risk" areas are undefined, but in the context of the Flood Planning Guideline it is assumed to be a reference to that part of the floodplain between the 100 year flood (plus freeboard) and the PMF.

These provisions require council to distinguish between the situation where there are flood related development controls on nominated types of "residential development" and all other development. More sensitive land uses such as group homes or seniors living is excluded from the limitation of notations for residential development. Importantly, a S10.7(2) Certificate must identify where any flood related development controls apply to any form of development, including residential development on land between the 100 year FPL and PMF if existing prior to the 2007 Flood Planning Guideline or if exceptional circumstances dispensation has been granted.

The relevant notifications placed on S10.7(2) certificates are required to advise on whether "flood related planning controls" apply to the land for which the certificate applies. "Flood related planning controls" is an undefined term. However the relevant form and content recommended for Council's forthcoming LEP and new DCP provisions would provide a consistent basis for providing S10.7(2) notifications, as follows:

- All properties known to be in the PMF would be notified that flood related planning controls apply. This would reduce to the area within the 100 year flood extent (plus freeboard) for standard residential properties if an exceptional circumstances variation is not obtained.

- All properties noted as being subject to flood controls would also be noted as "flood control lots" for the purposes of the Codes SEPP.

- Where flood risk precinct (FRP) mapping has been undertaken the applicable FRP could be noted, with an explanation as to its meaning and application under the DCP provisions. This would exclude standard residential properties being advised of the low flood risk precinct if an exceptional circumstances variation is not obtained.

- Where Council is unsure of whether a property contains flood liable land (due to the lack of flood investigations and mapping in particular areas) a general notation to this effect can be placed with an explanation that a flood study could identify that the land is subject to flooding, in which case flood related controls would apply. This would be relevant where the definition of the flood planning area in the LEP or DCP is based on an FPL and does not refer to a map, in which case the application of the LEP or DCP cannot be certain without further investigation.

Appropriate wording for the notifications should be determined based on legal advice. This should occur concurrently with the adoption of the new LEP and FRM DCP provisions.

6 Conclusion

This report has been prepared to review the planning considerations relevant to the FRMS and FRMP prepared for the Manning River catchment. To provide a meaningful review it was important to review the planning controls as they apply to the whole LGA as now represented by the amalgamated MidCoast Council.

The review outlined within this report has provided recommendations regarding:

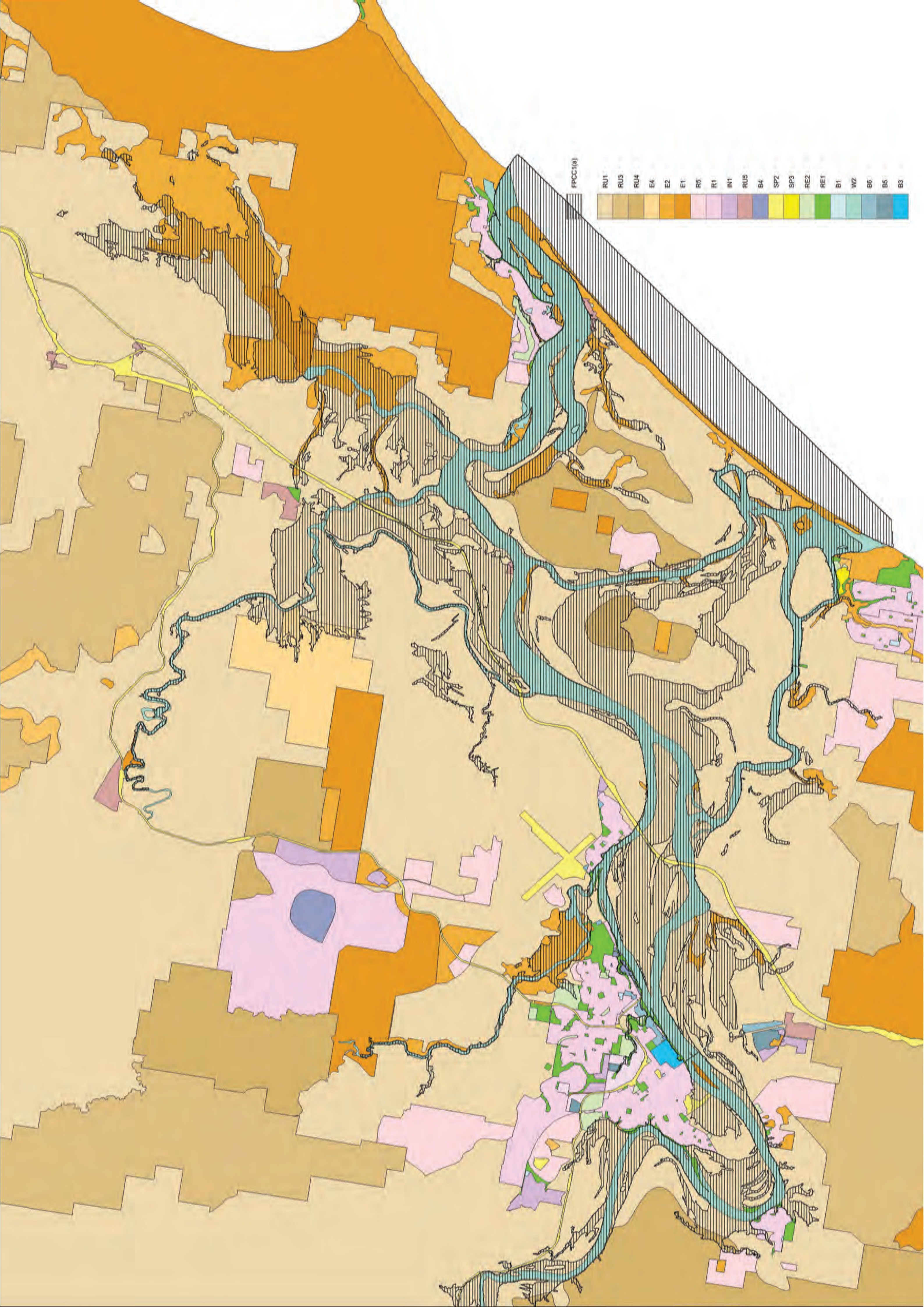
- Guidance for how to consider FRM matters when undertaking strategic planning including determining the suitability of different land uses in different areas of the floodplain.
- A detailed review of existing LEP and DCP development controls and an approach and base principles that can be applied when preparing an updated and consolidated LEP and DCP, to address residual flood risks where development is permitted in the floodplain.
- Principles to be applied to ensure the appropriate communication of flood risk through planning documents, is not misleading, including S10.7 Planning Certificates.

Importantly, both planning and FRM are dynamic processes and will require on-going monitoring and review as new information and issues emerge.

7 Glossary

Abbreviation	
Council	MidCoast Council
DA	Development Application
DCP	Development Control Plan
DPIE	Department of Planning Industry & Environment (formerly Department of Planning & Environment)
EPA Act	Environmental Planning and Assessment Act 1979
EPA Regulation	Environmental Planning and Assessment Regulation 2000
FDM	Floodplain Development Manual
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GLN	GLN Planning
LEP	Local Environmental Plan
LGA	Local Government Area
OEH	NSW Office of Environment and Heritage (Formerly Department of Environment and Climate Change) which ceased as a separate agency in July 2019 to become part of DPIE.
SEPP	State Environmental Planning Policy

APPENDIX A: FLOOD CONSTRAINTS OVERLAY – LAND USE ZONE MAPS



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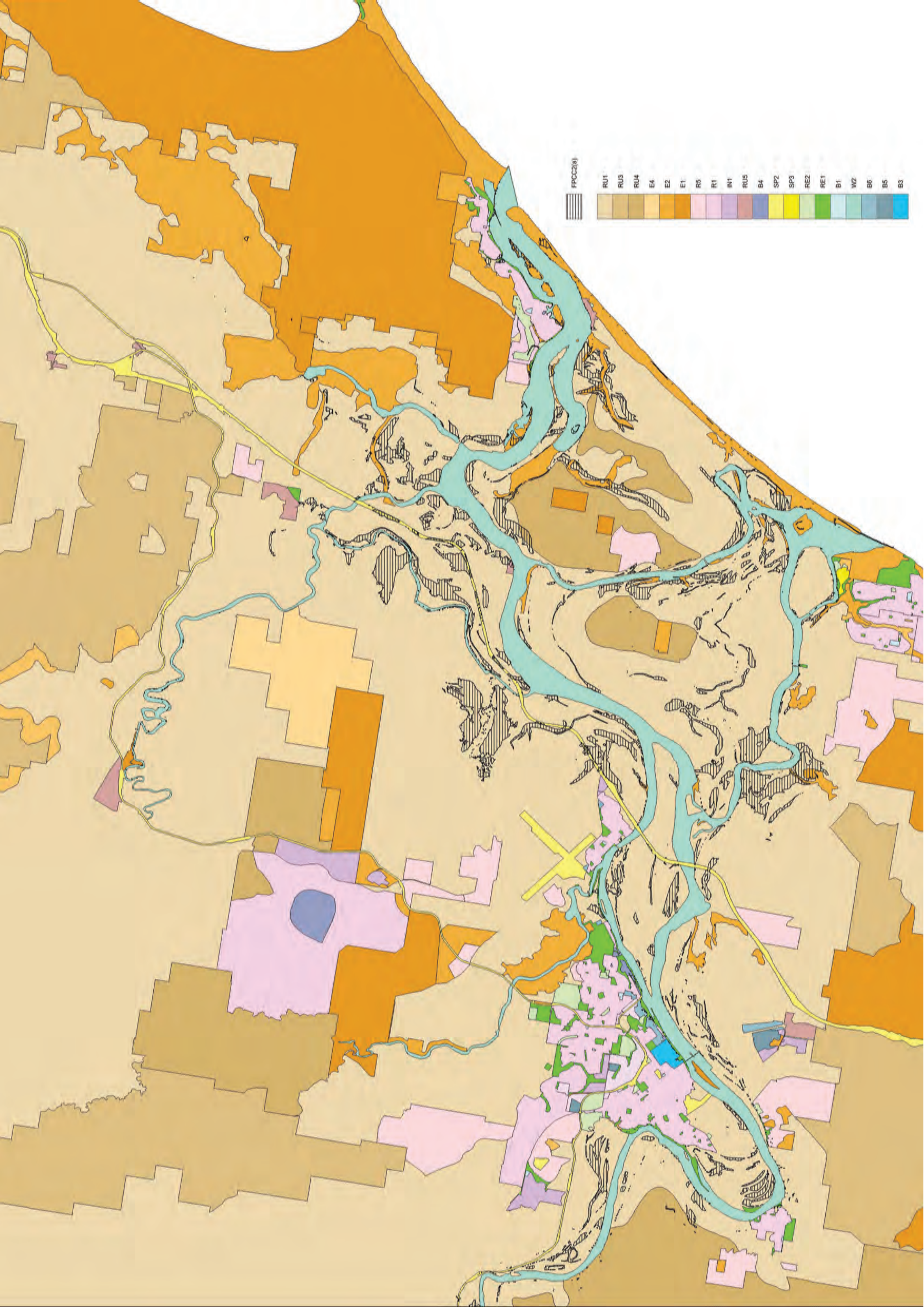
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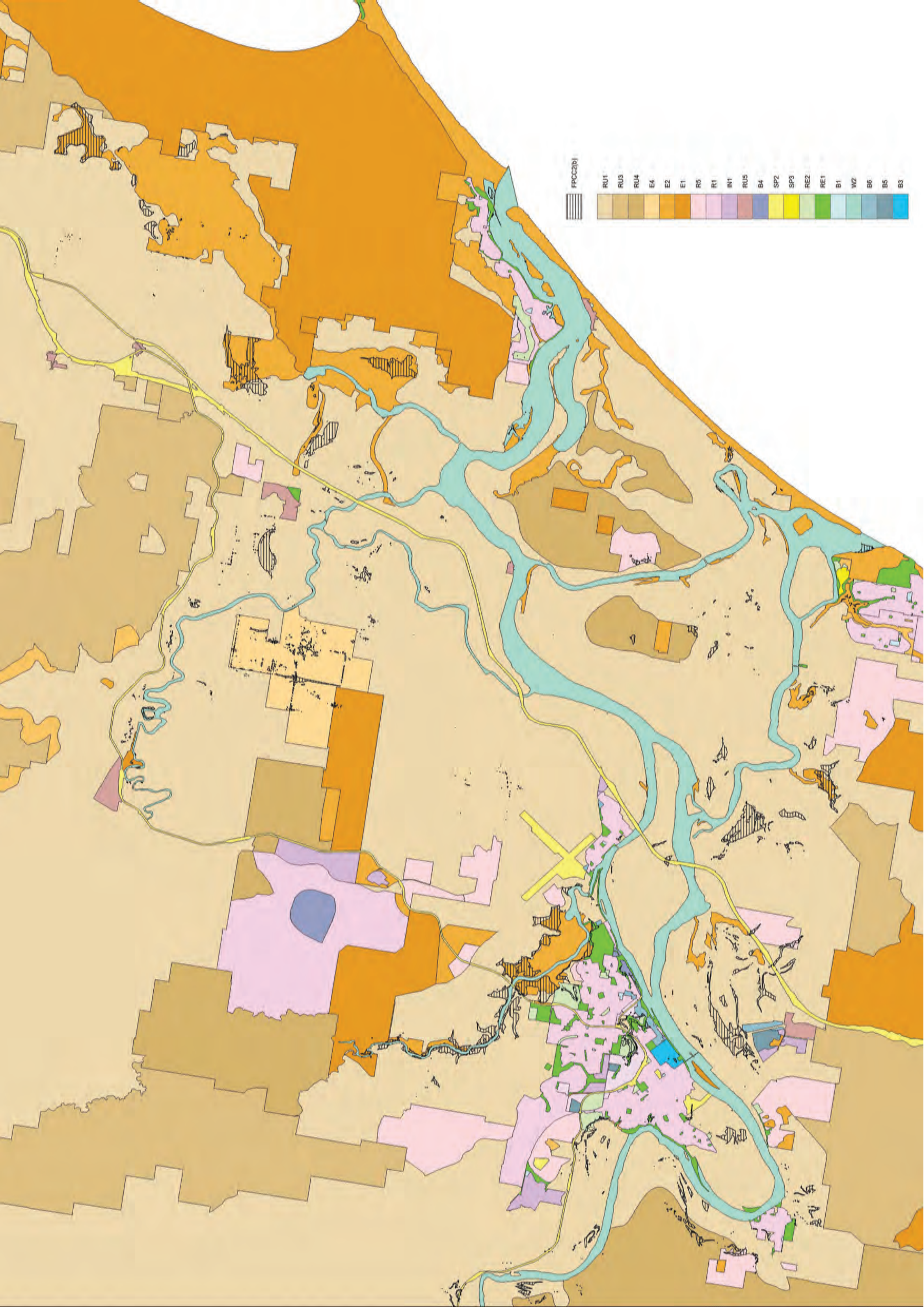
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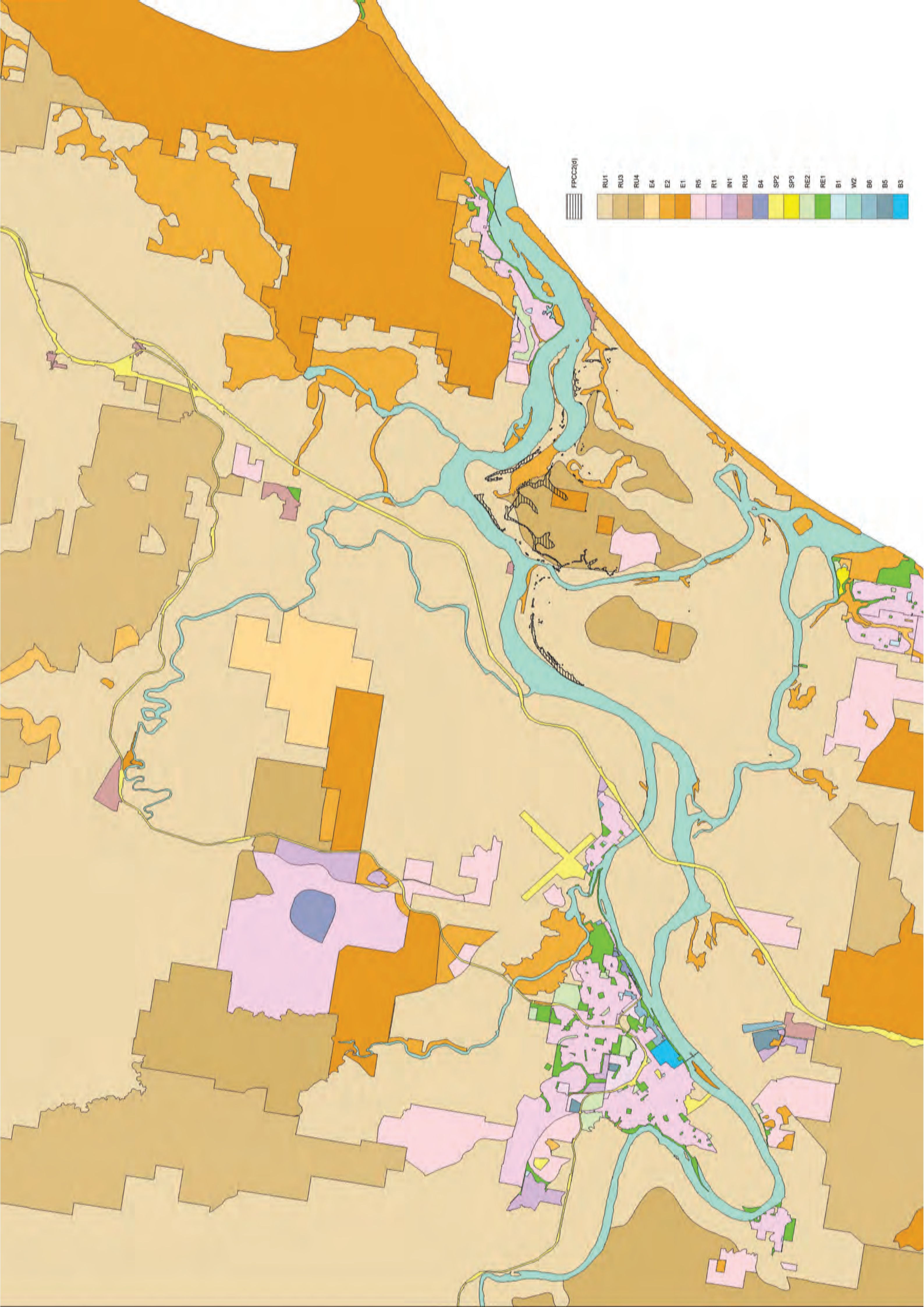
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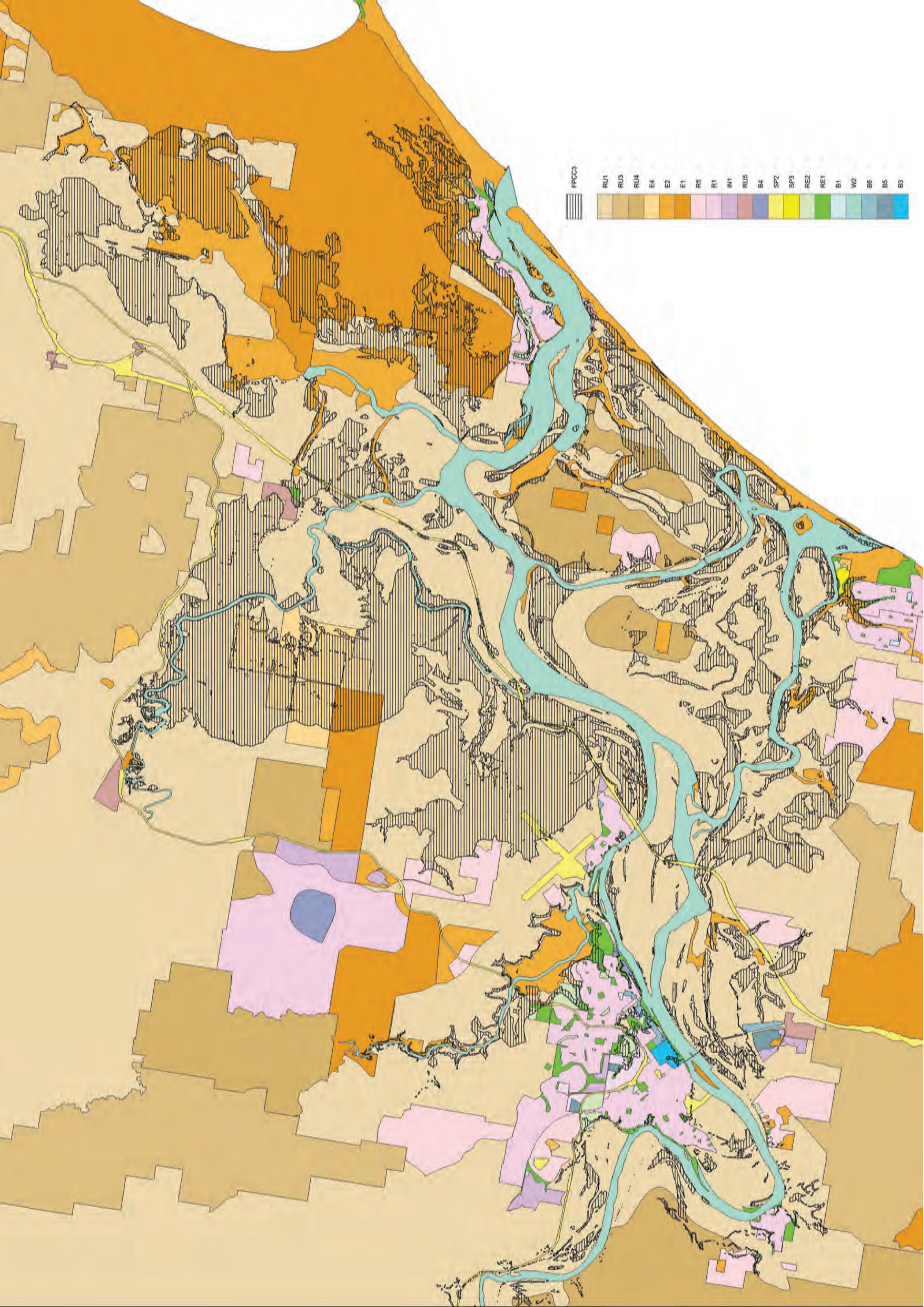
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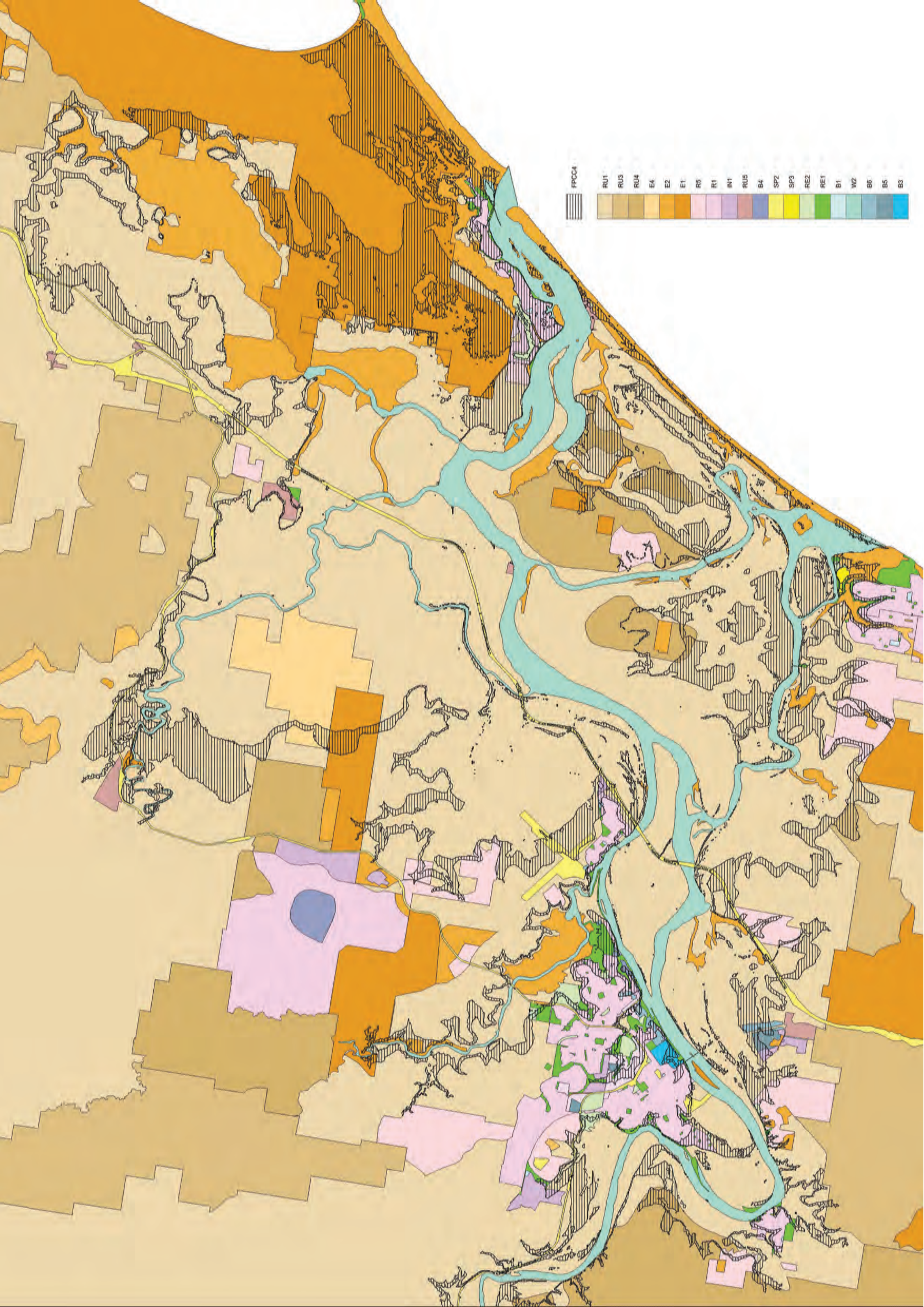
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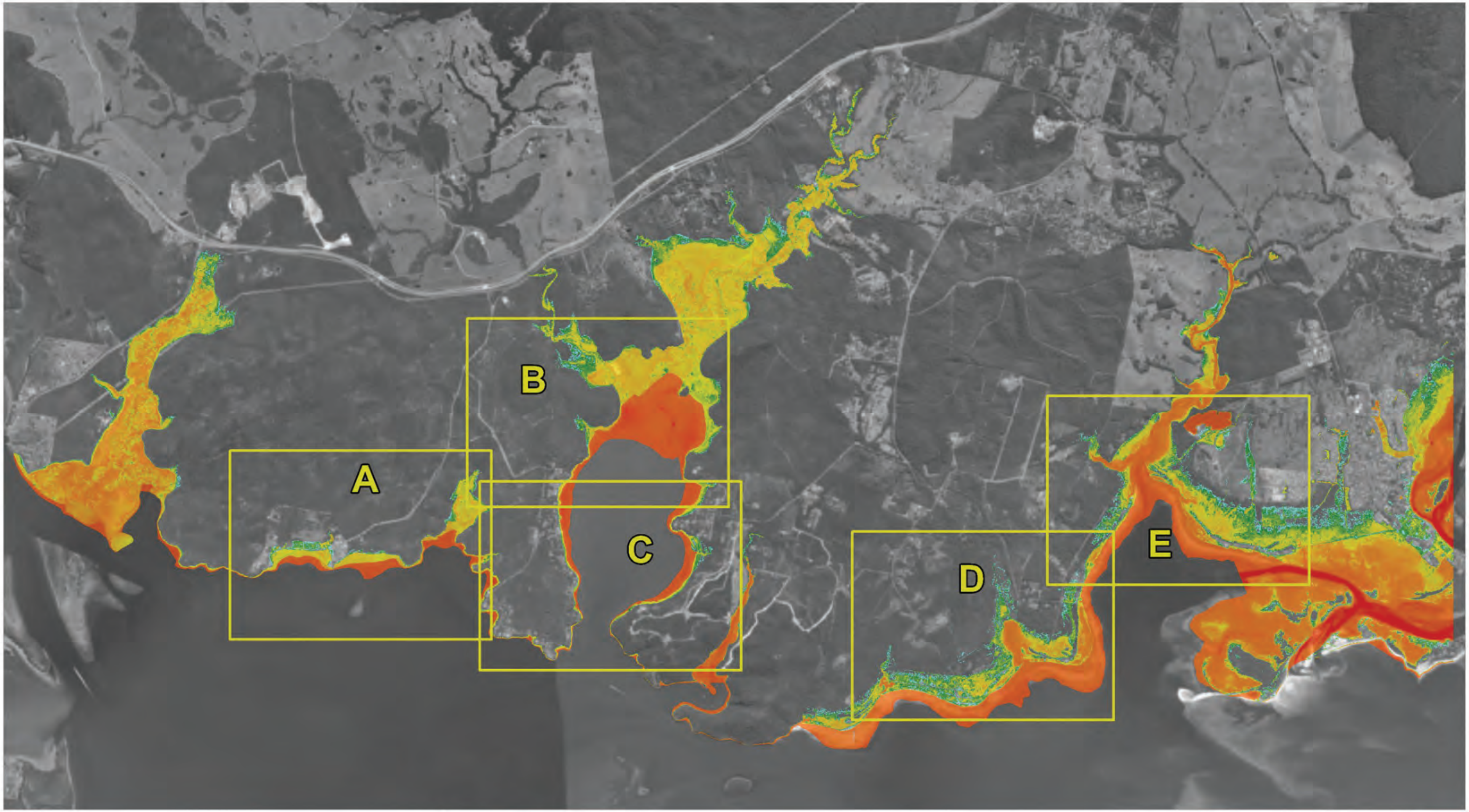
Appendix C Depth Mapping



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Port Stephens FRMS Mapping Index

Figure: **INDEX**

Rev: **A**

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Approx. Scale

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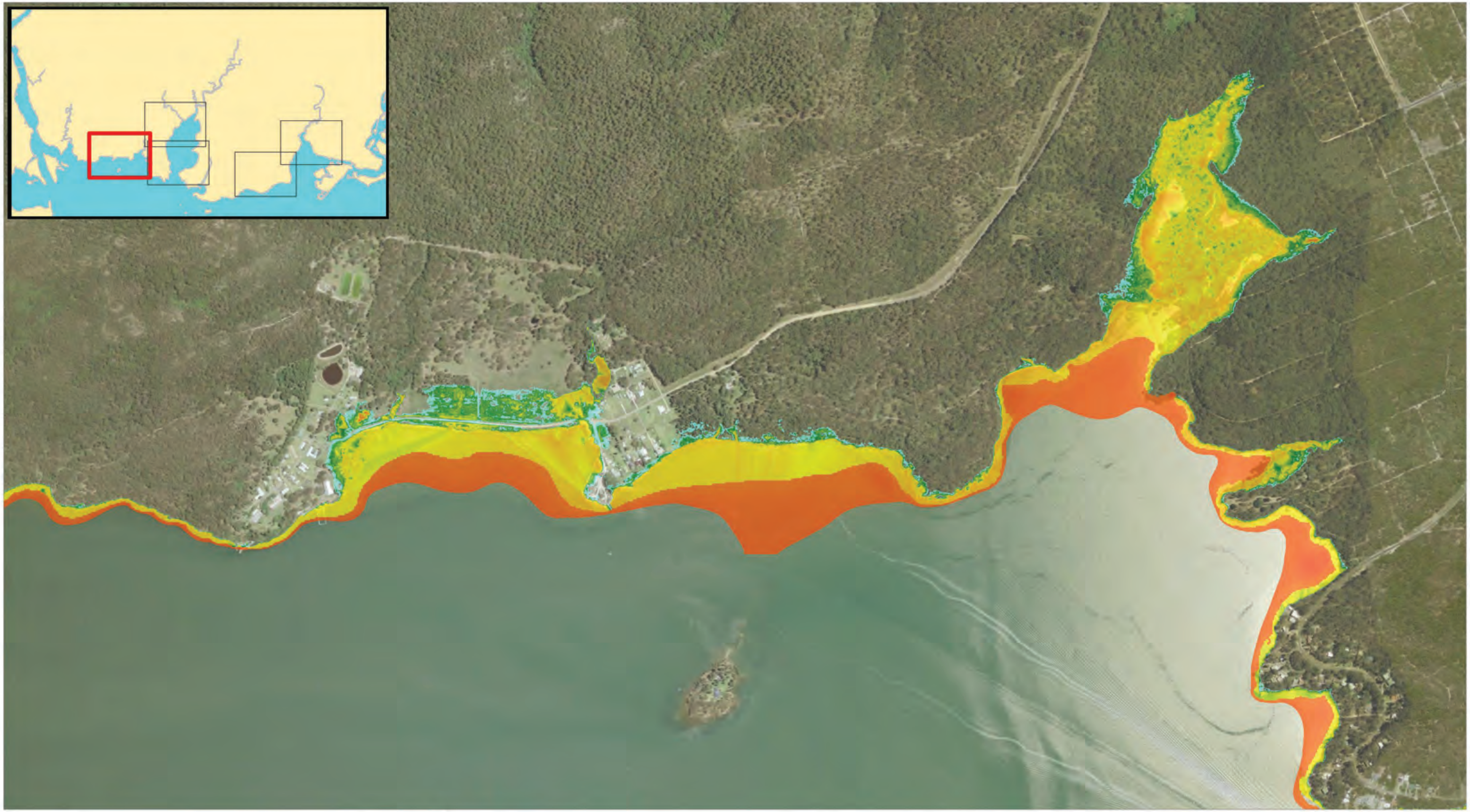

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- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **A-01**

Rev: **A**

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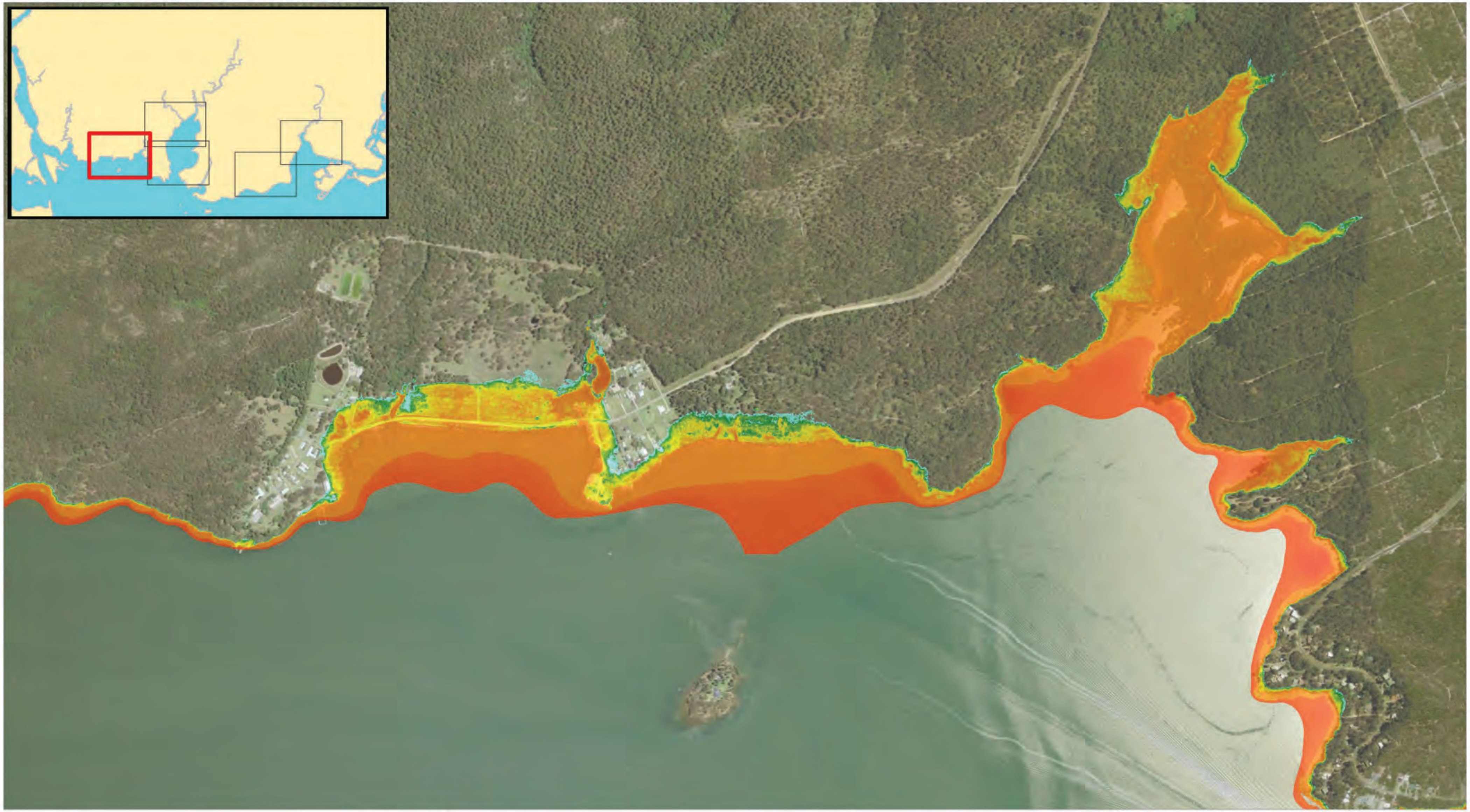

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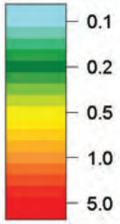

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Figure: **A-02**

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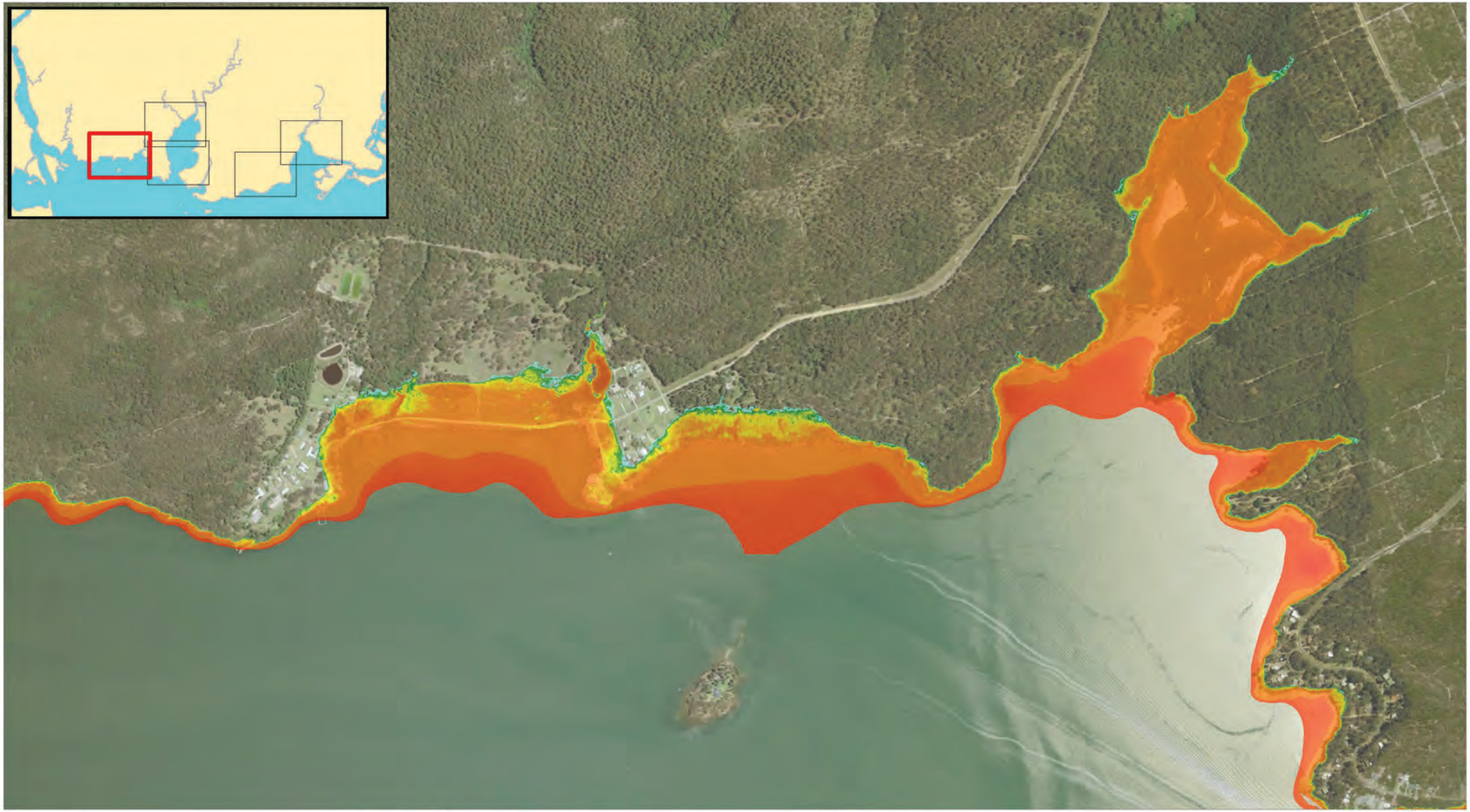

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **A-03**

Rev: **A**

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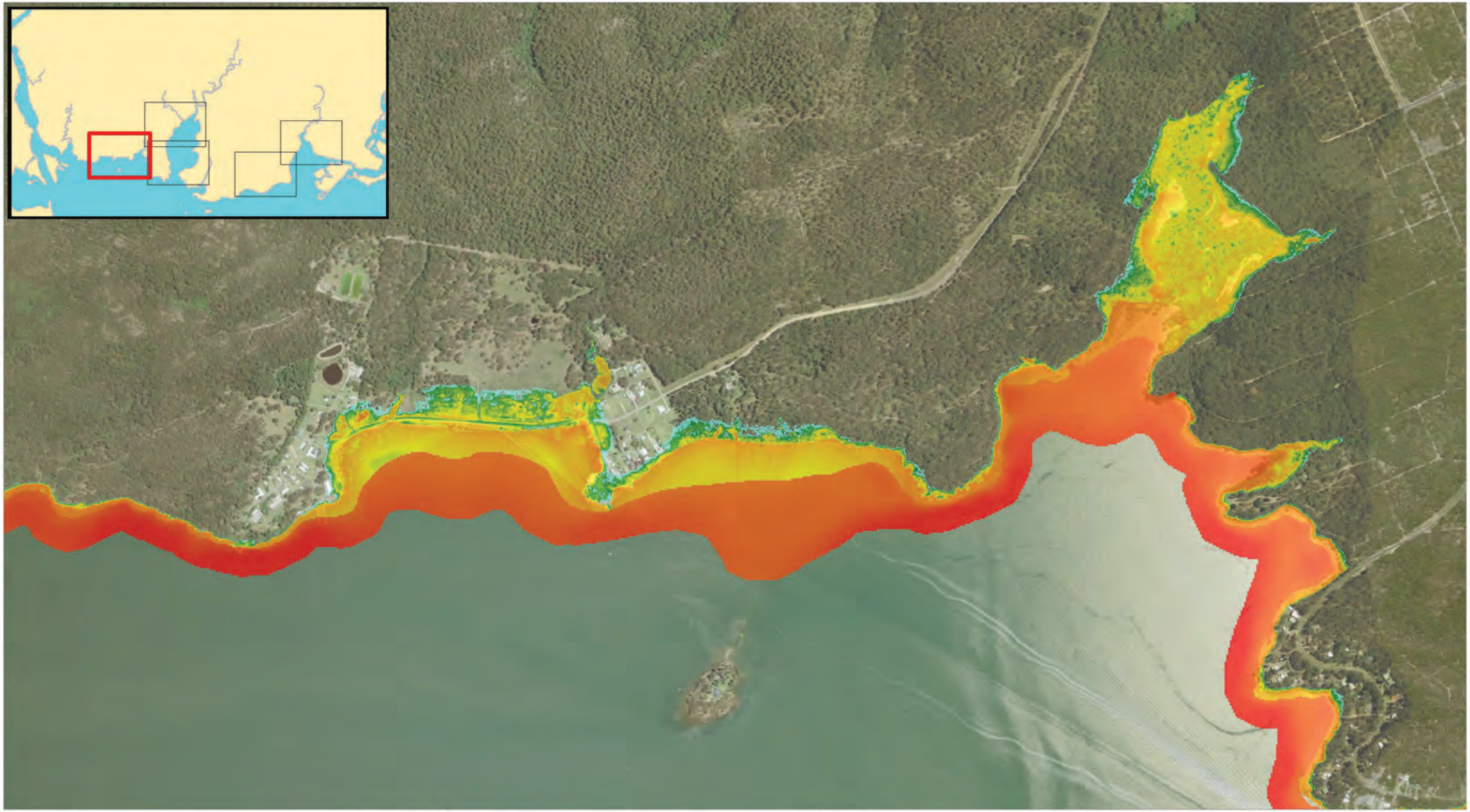

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **A-04**

Rev: **A**

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www.bmt.org

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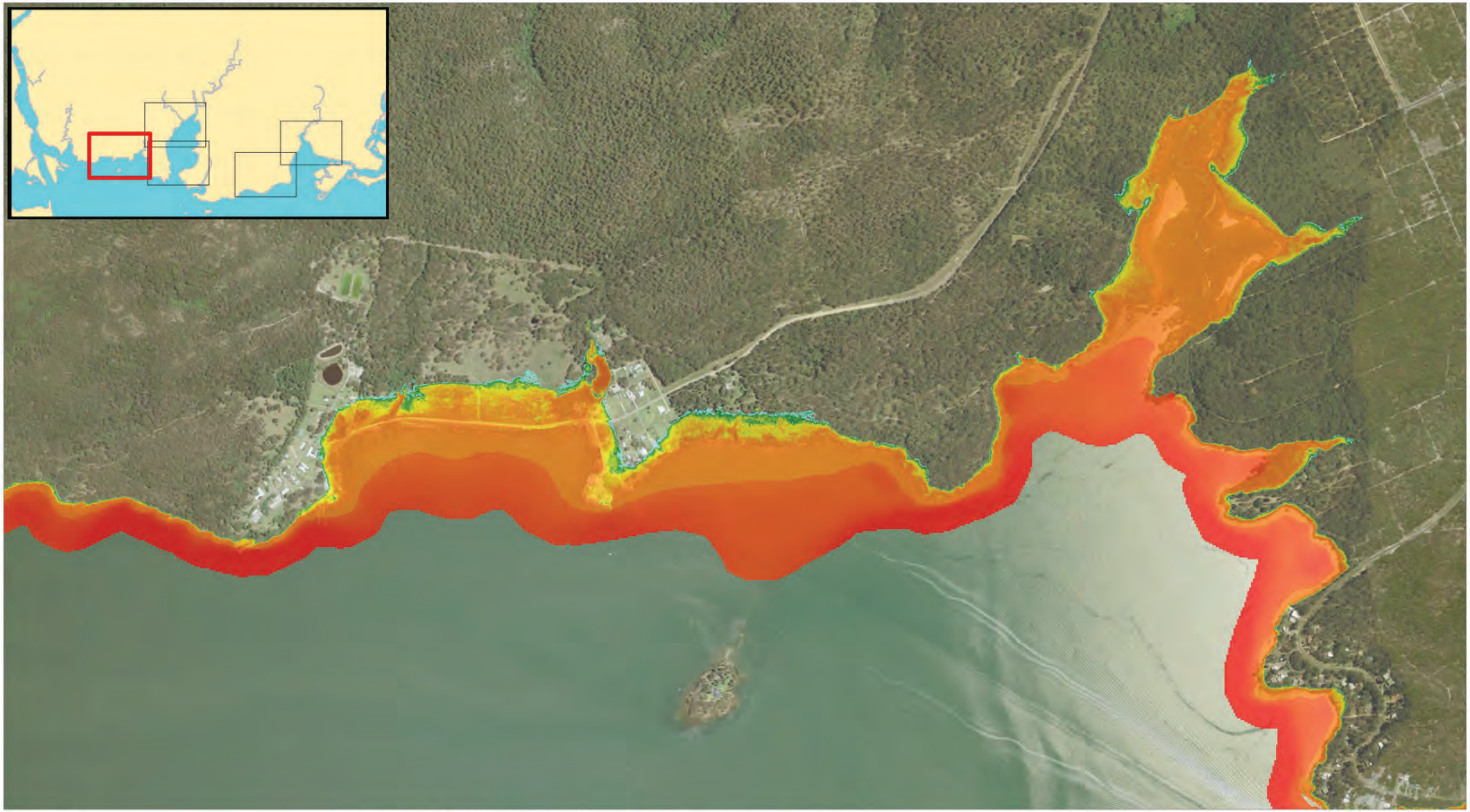

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **A-05**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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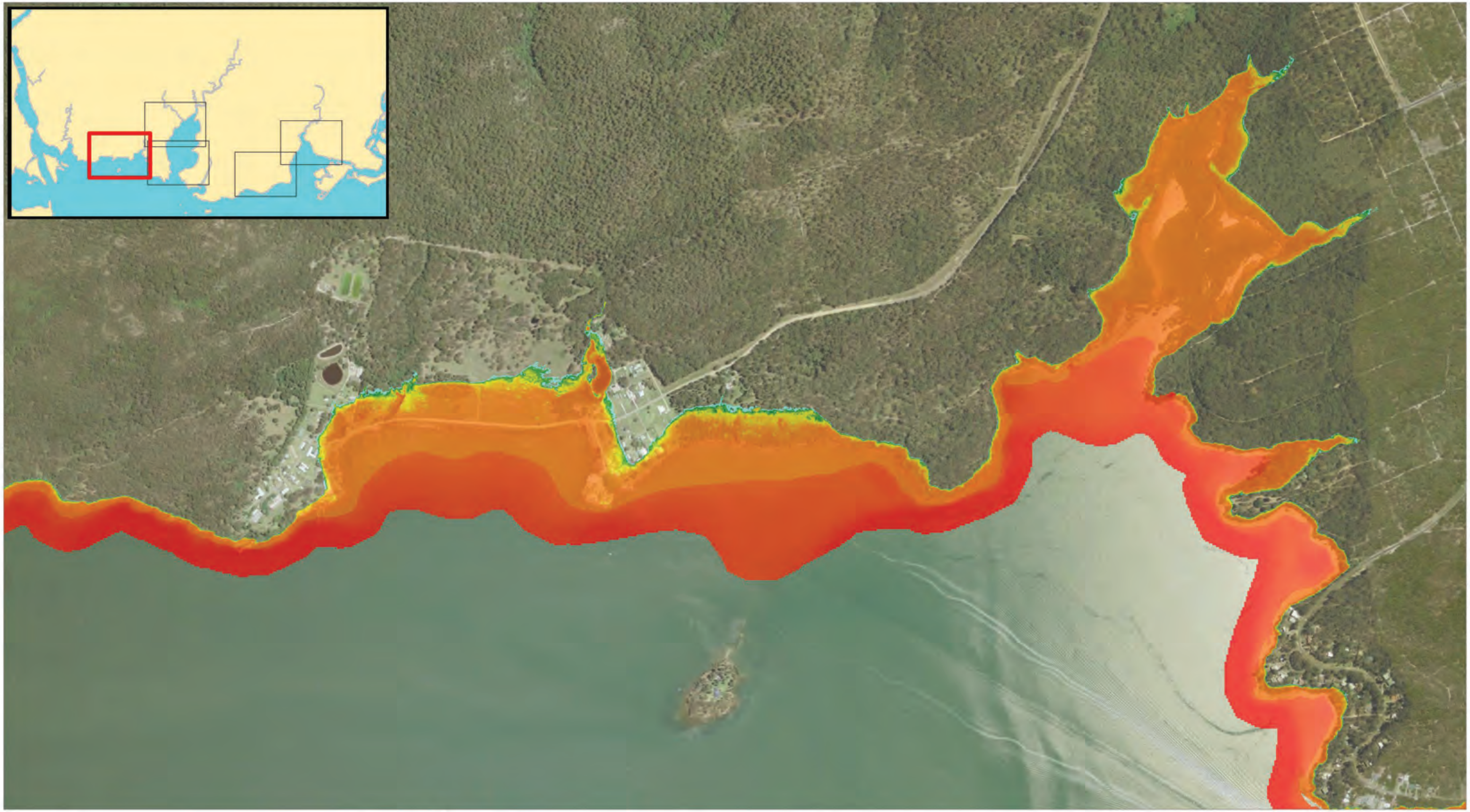
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A05_depth_class_20yWRH_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **A-06**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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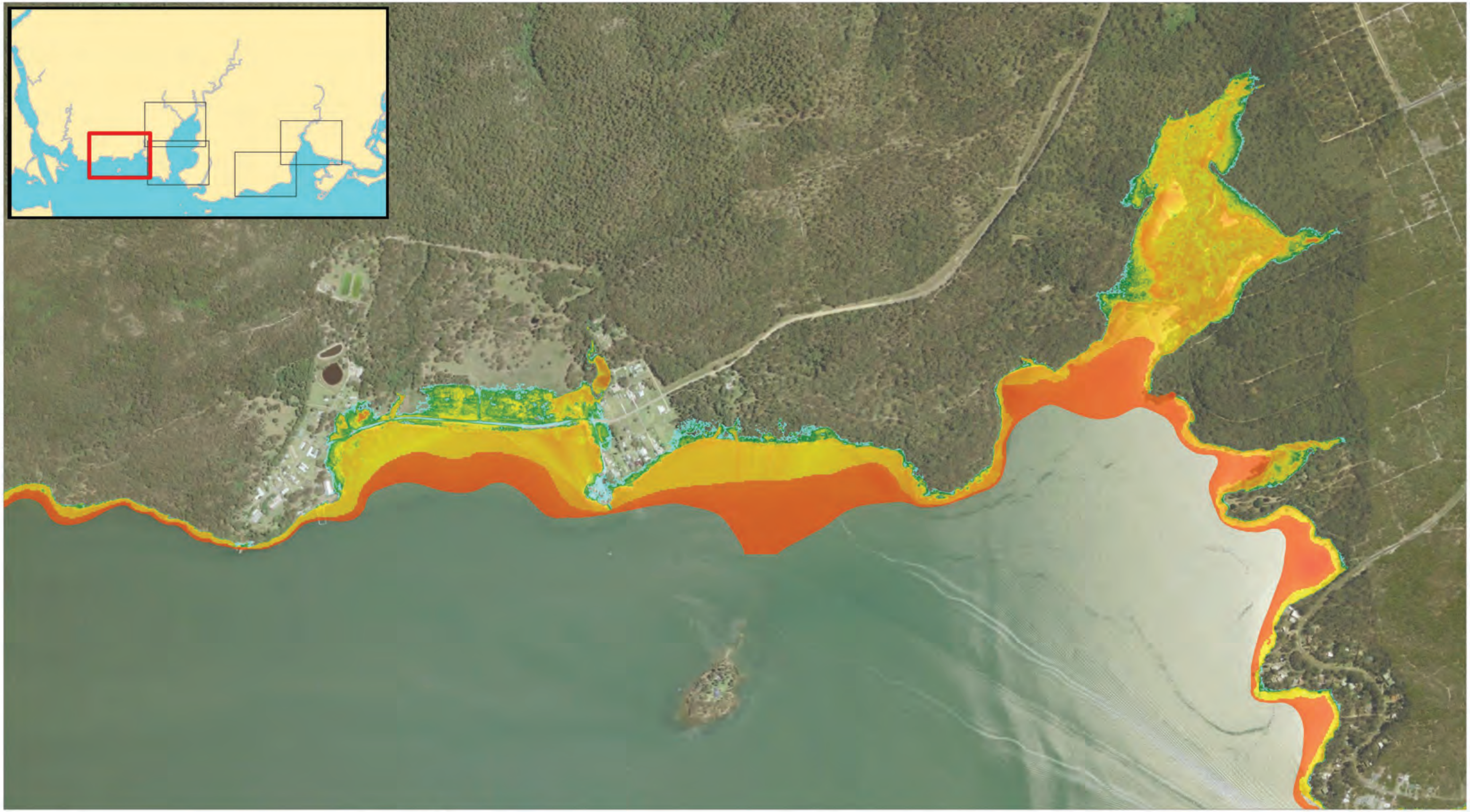
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A06_depth_class_20yWRH_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **A-07**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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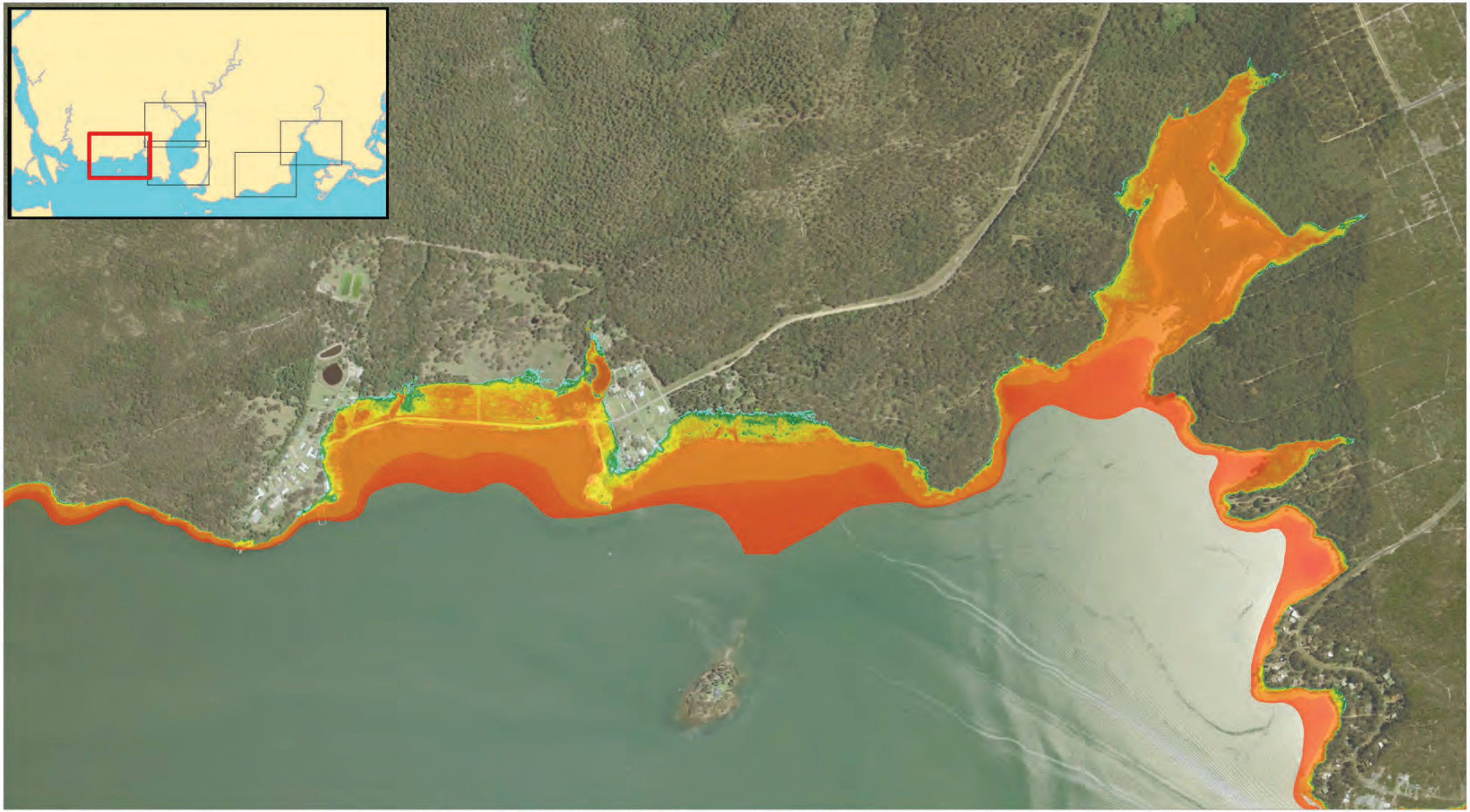
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A07_depth_class_100ySWL_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **A-08**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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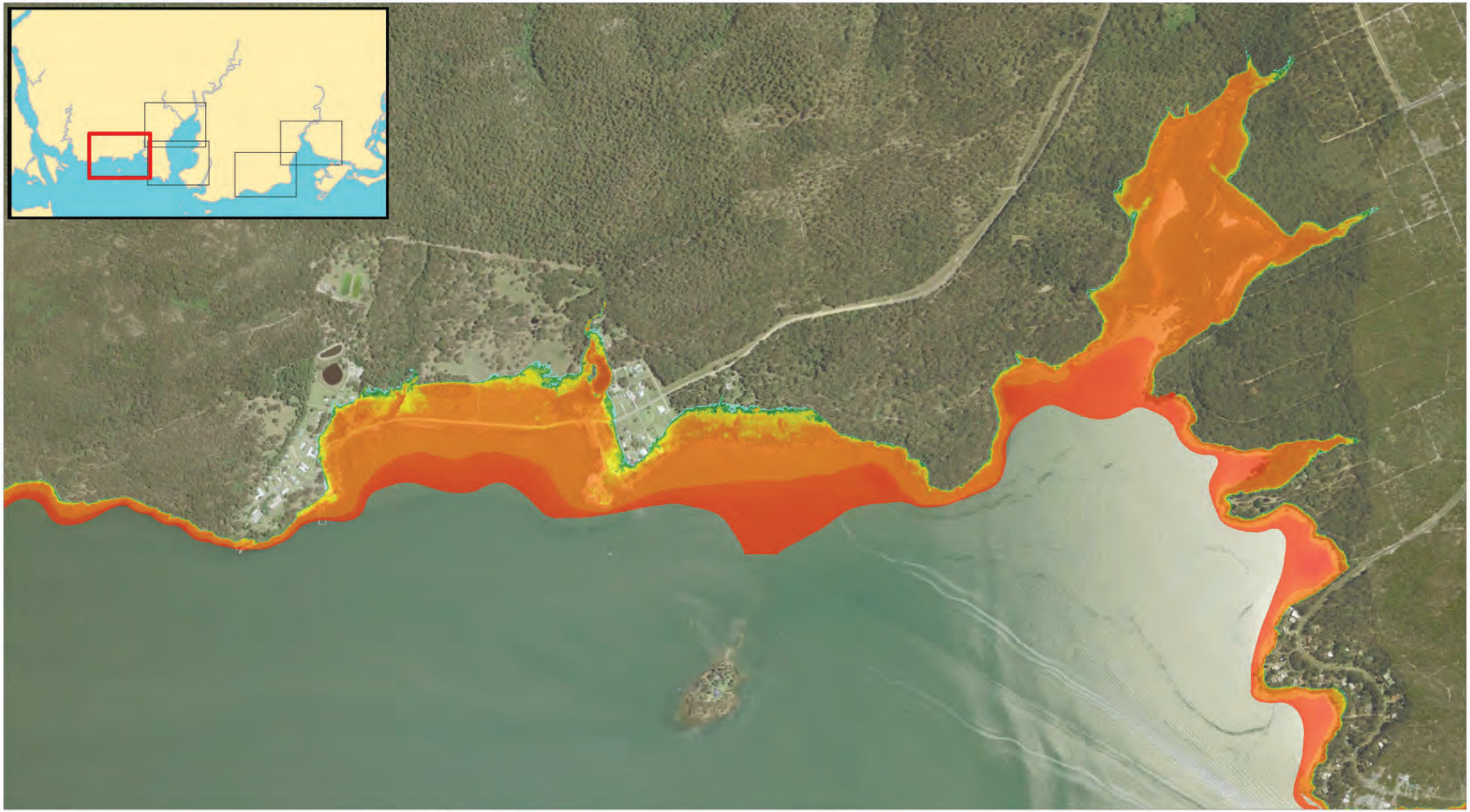
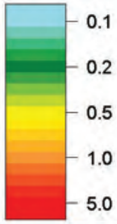
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A08_depth_class_100ySWL_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)



Title:

1% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **A-09**

Rev: **A**

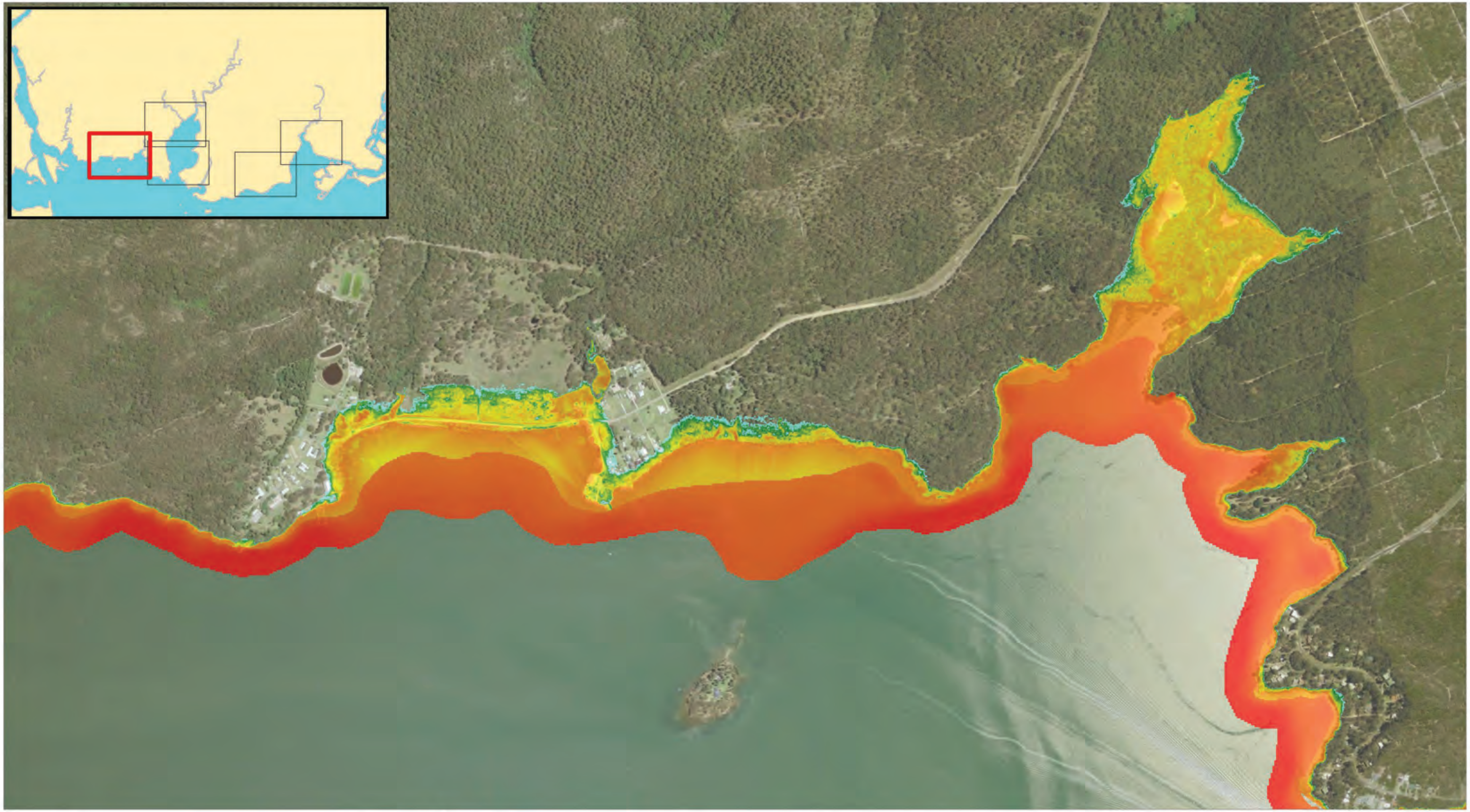
N

0 250 500m

Approx. Scale

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A09_depth_class_100ySWL_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **A-10**

Rev: **A**

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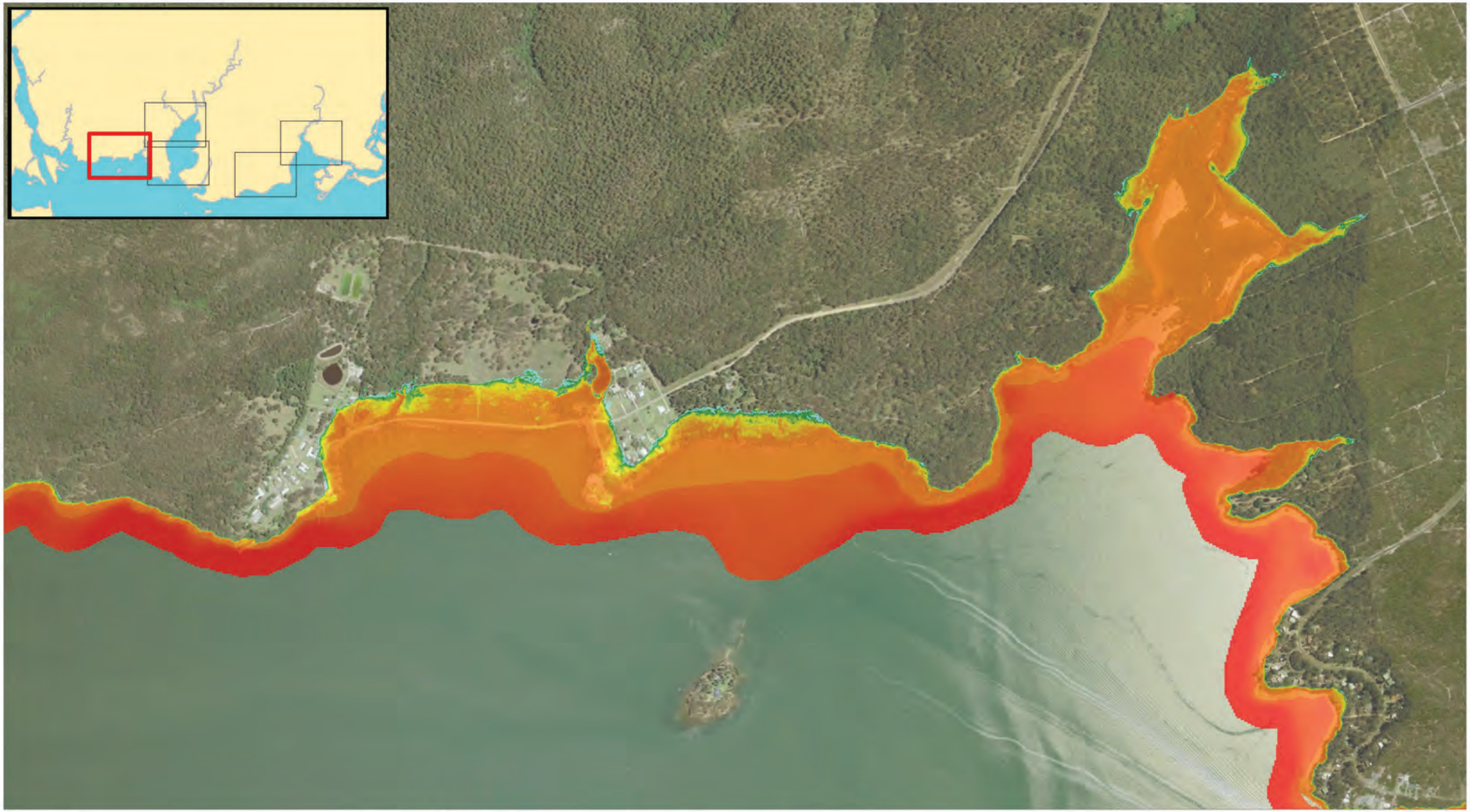
N

0 250 500m

Approx. Scale

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A10_depth_class_100yWRH_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **A-11**

Rev: **A**

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N

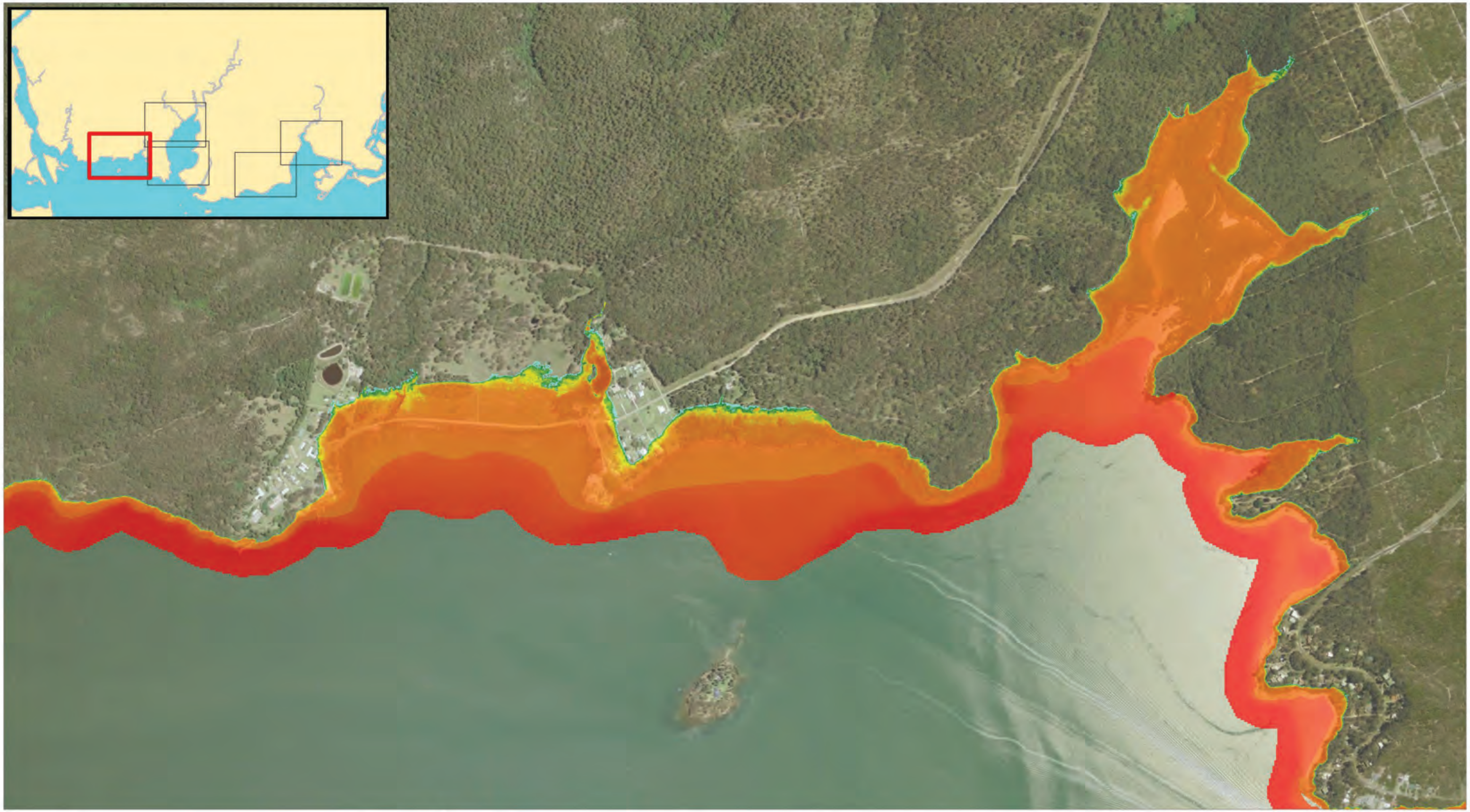
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A11_depth_class_100yWRH_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **A-12**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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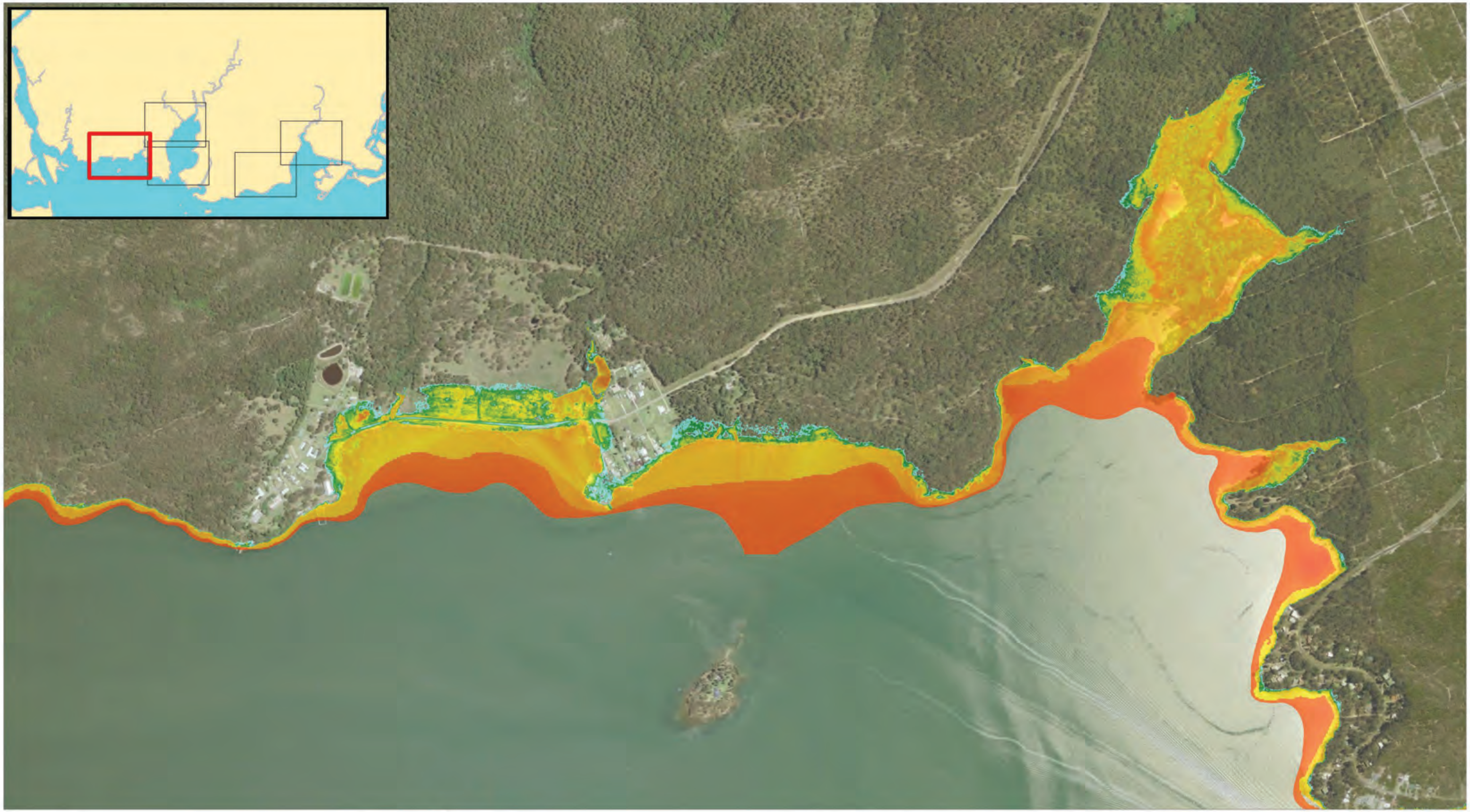
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A12_depth_class_100yWRH_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **A-13**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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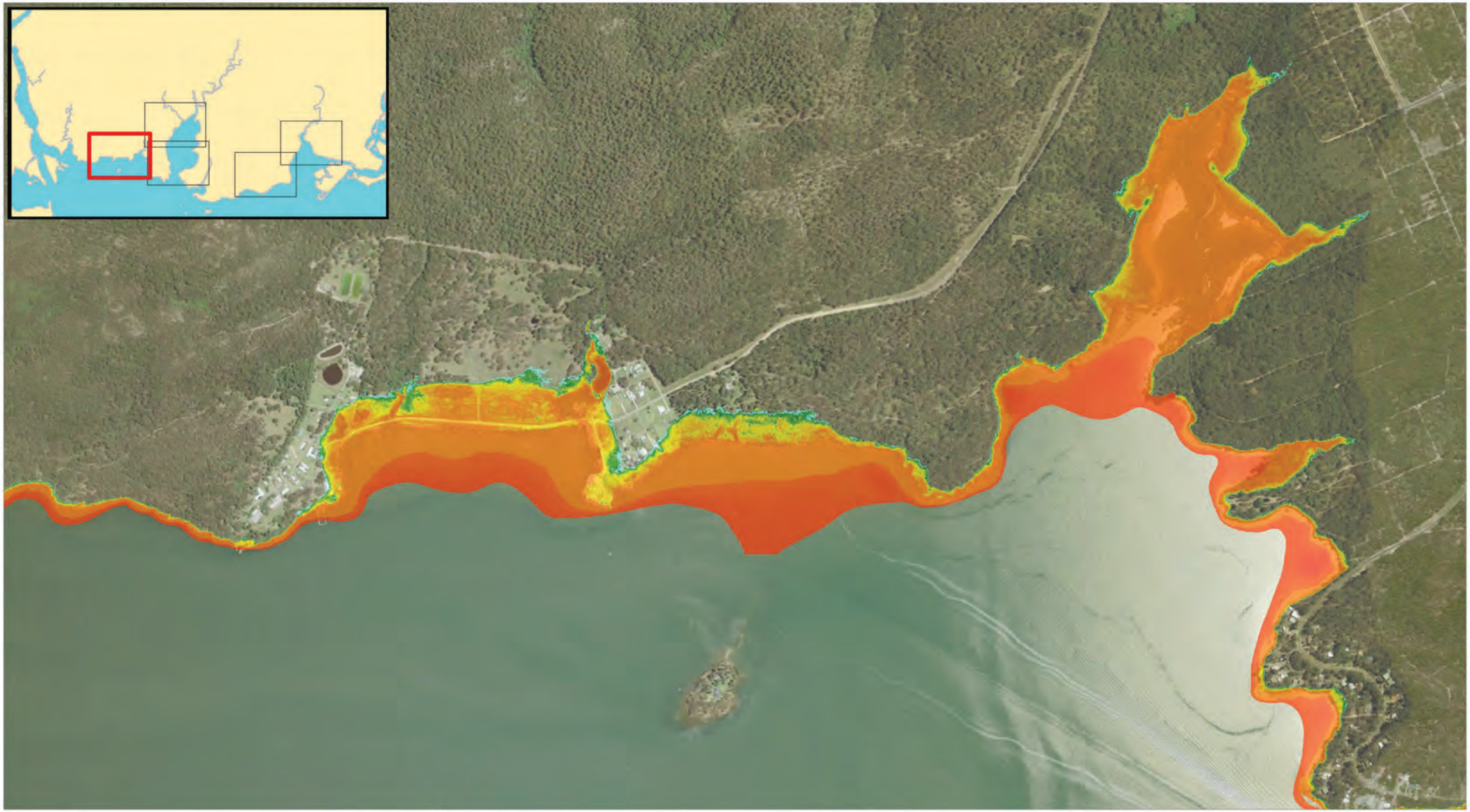
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A13_depth_class_extSWL_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **A-14**

Rev: **A**

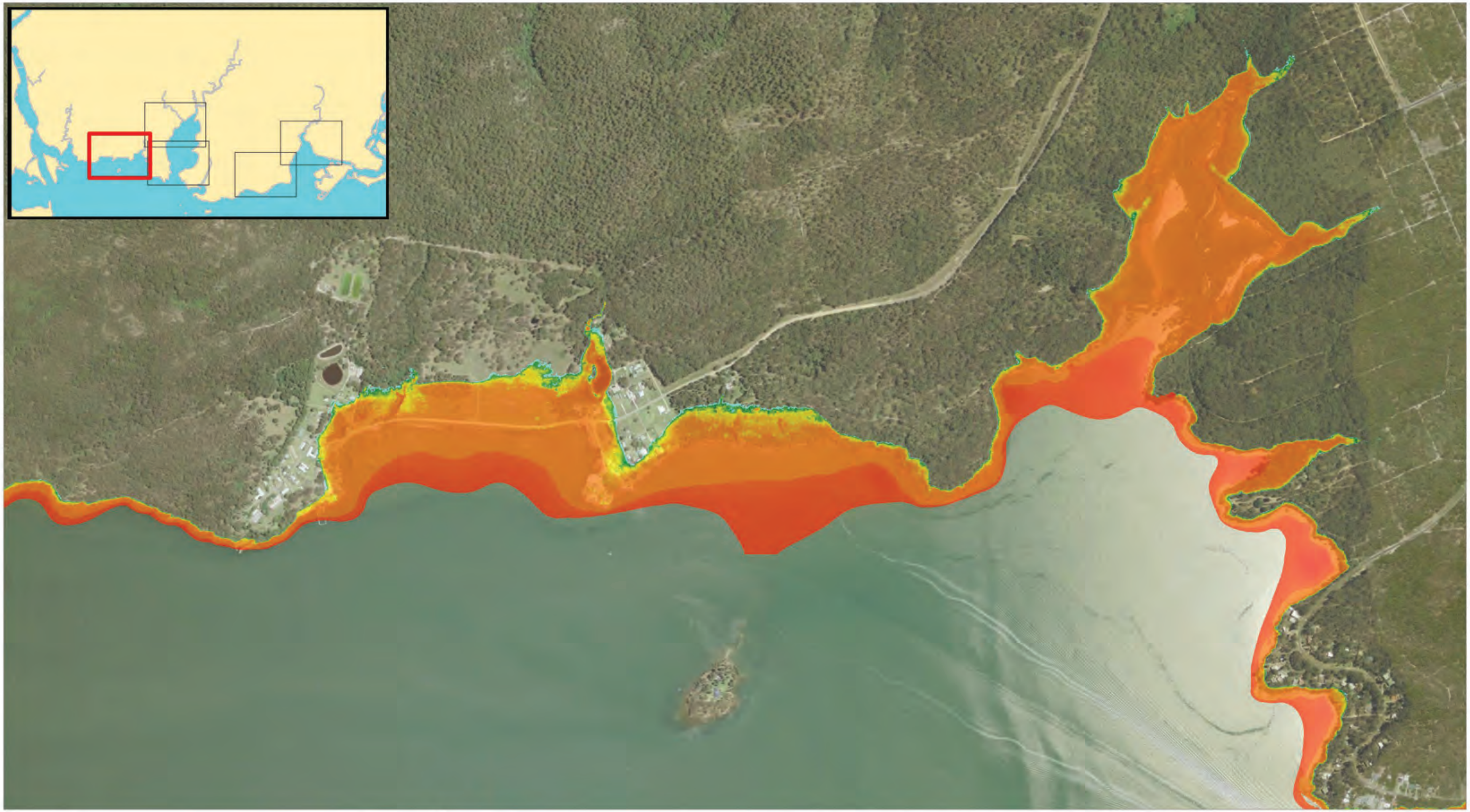
N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A14_depth_class_extSWL_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 — lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 — higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **A-15**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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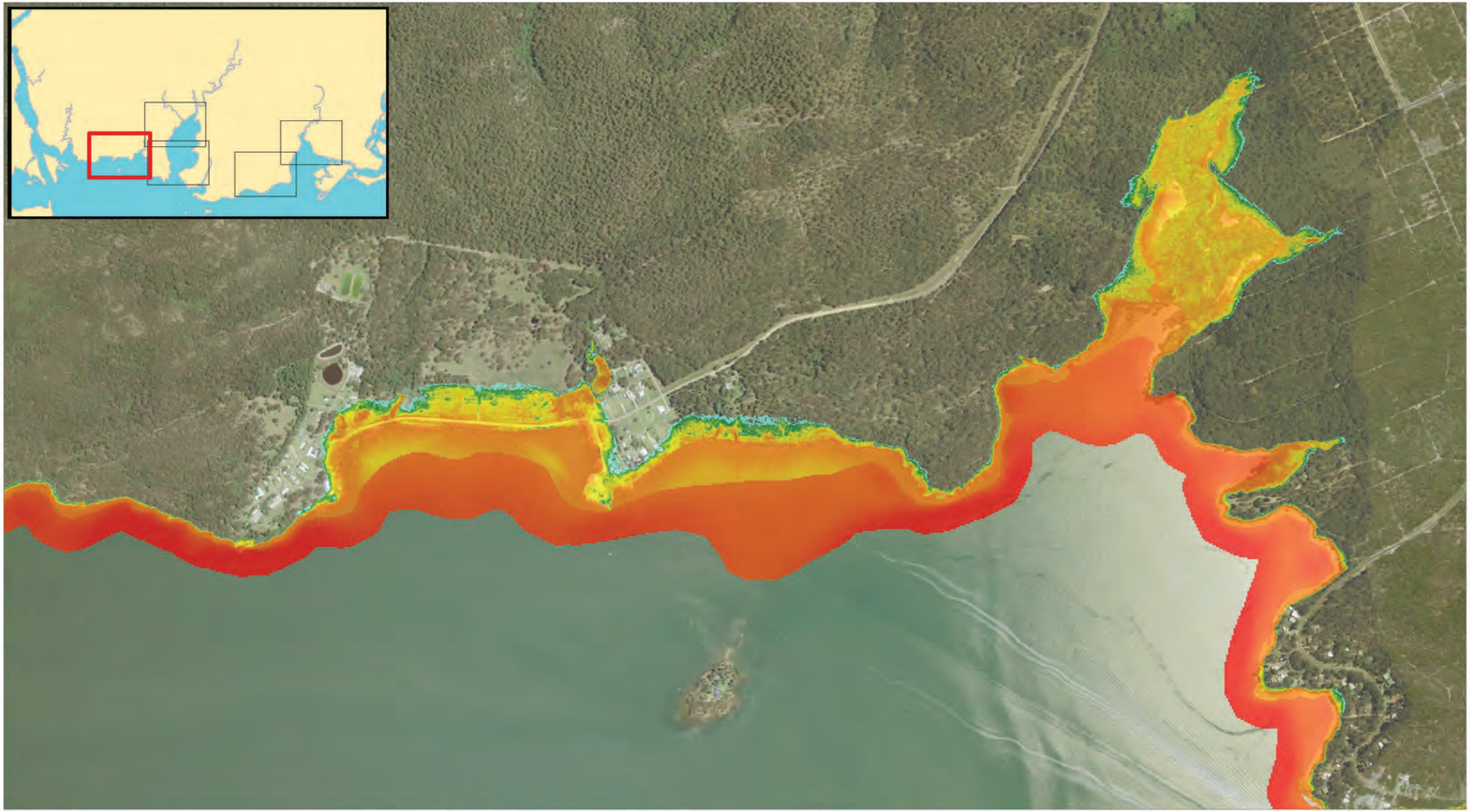
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A15_depth_class_extSWL_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **A-16**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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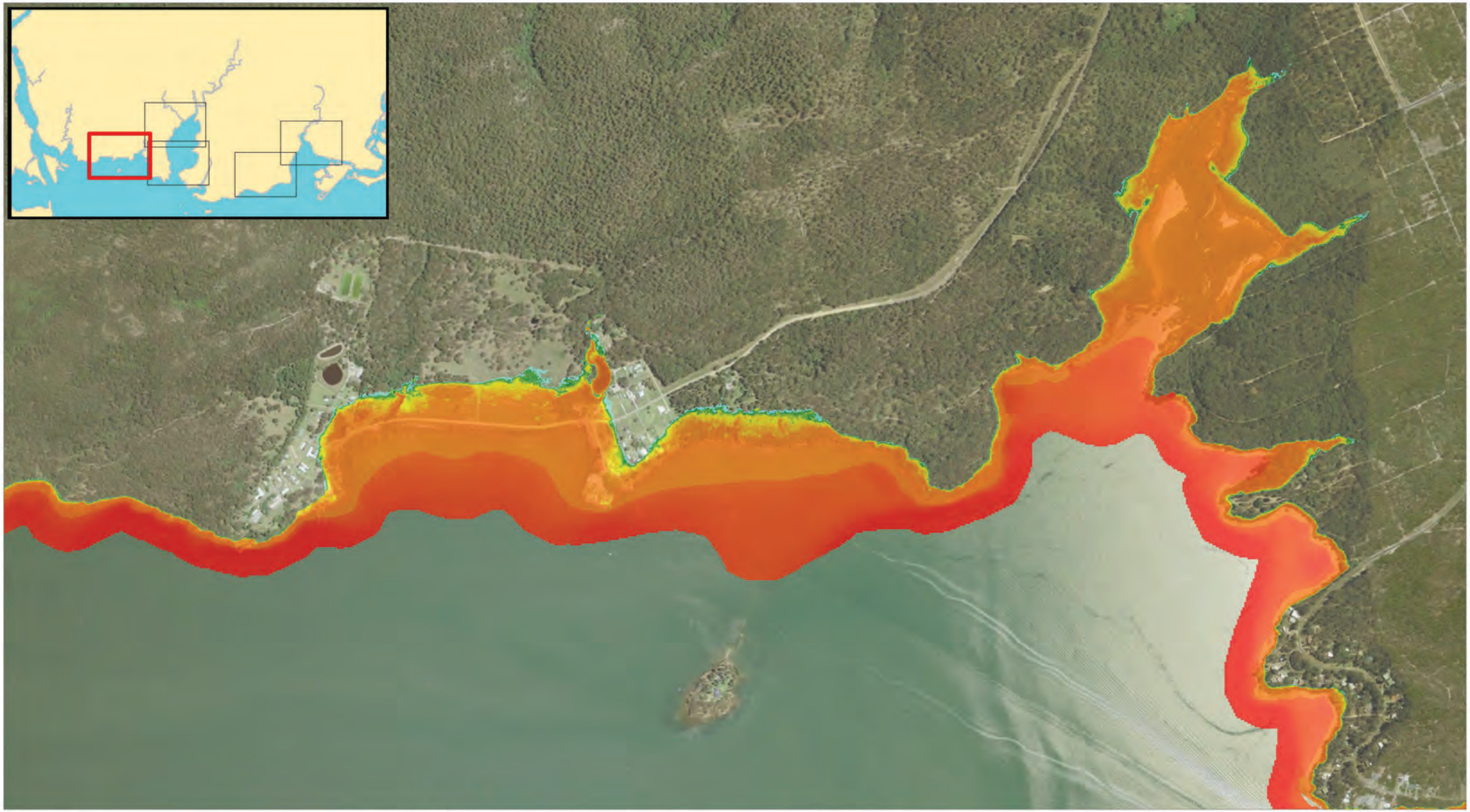
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A16_depth_class_extWRH_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **A-17**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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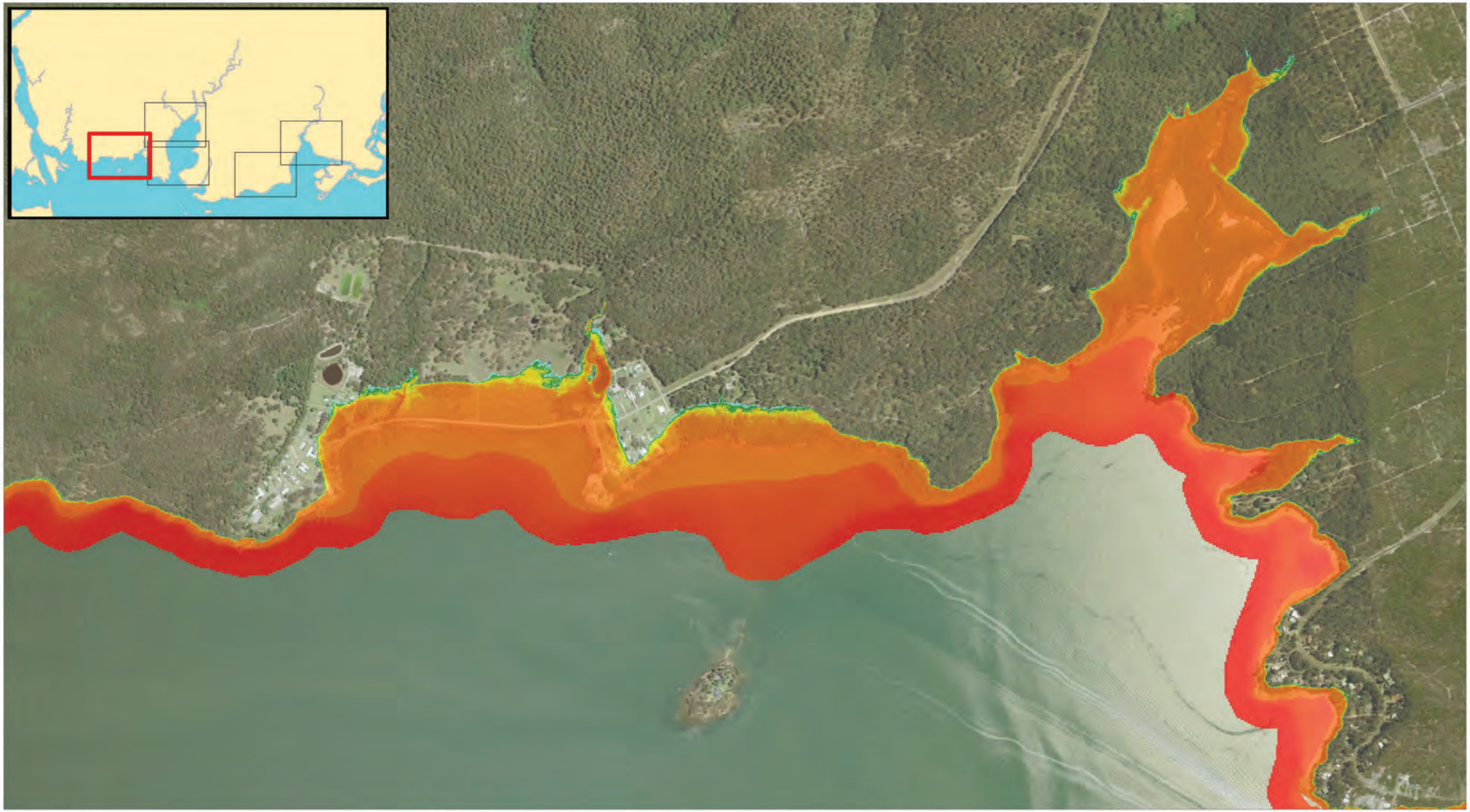
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A17_depth_class_extWRH_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **A-18**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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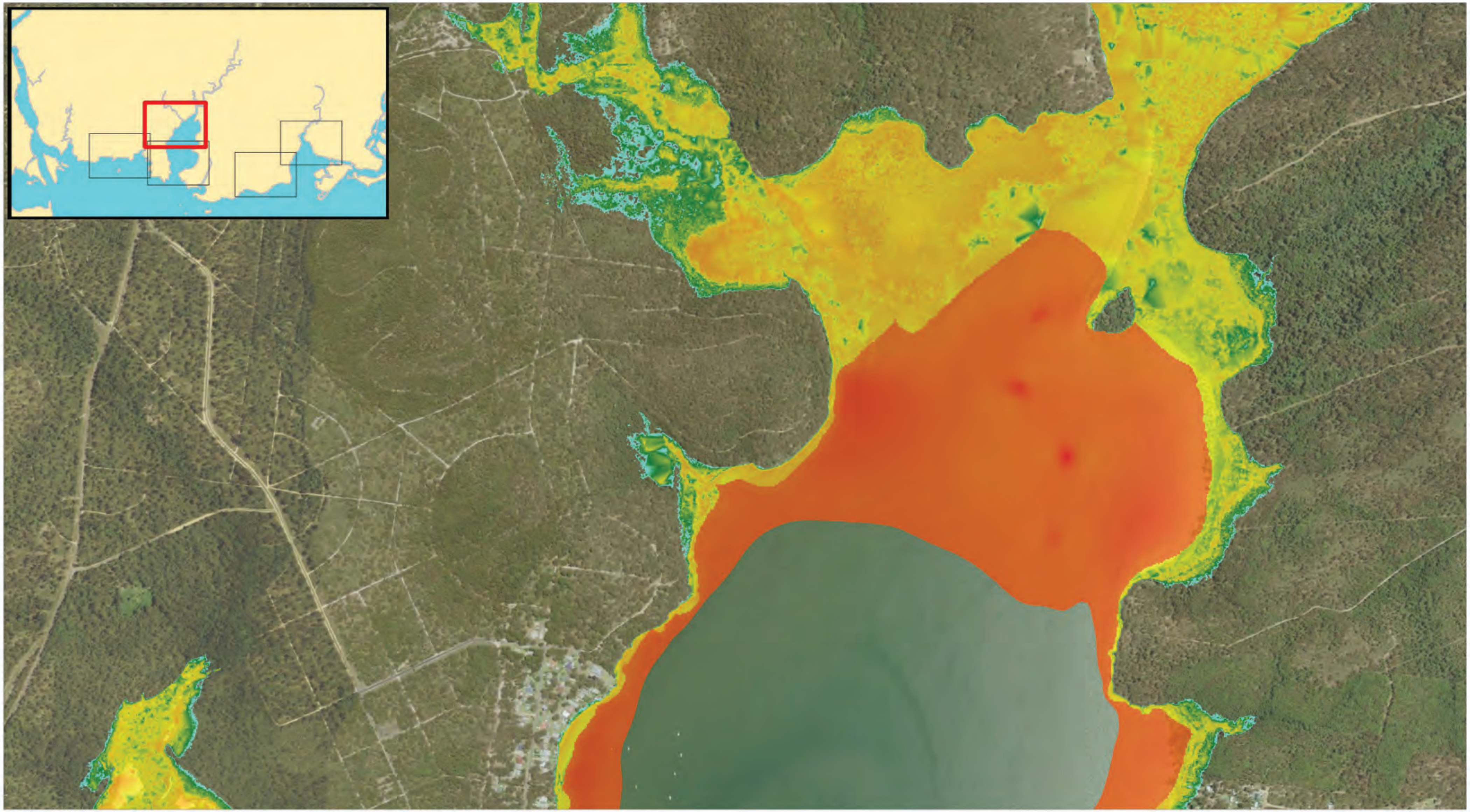
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_A18_depth_class_extWRH_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **B-01**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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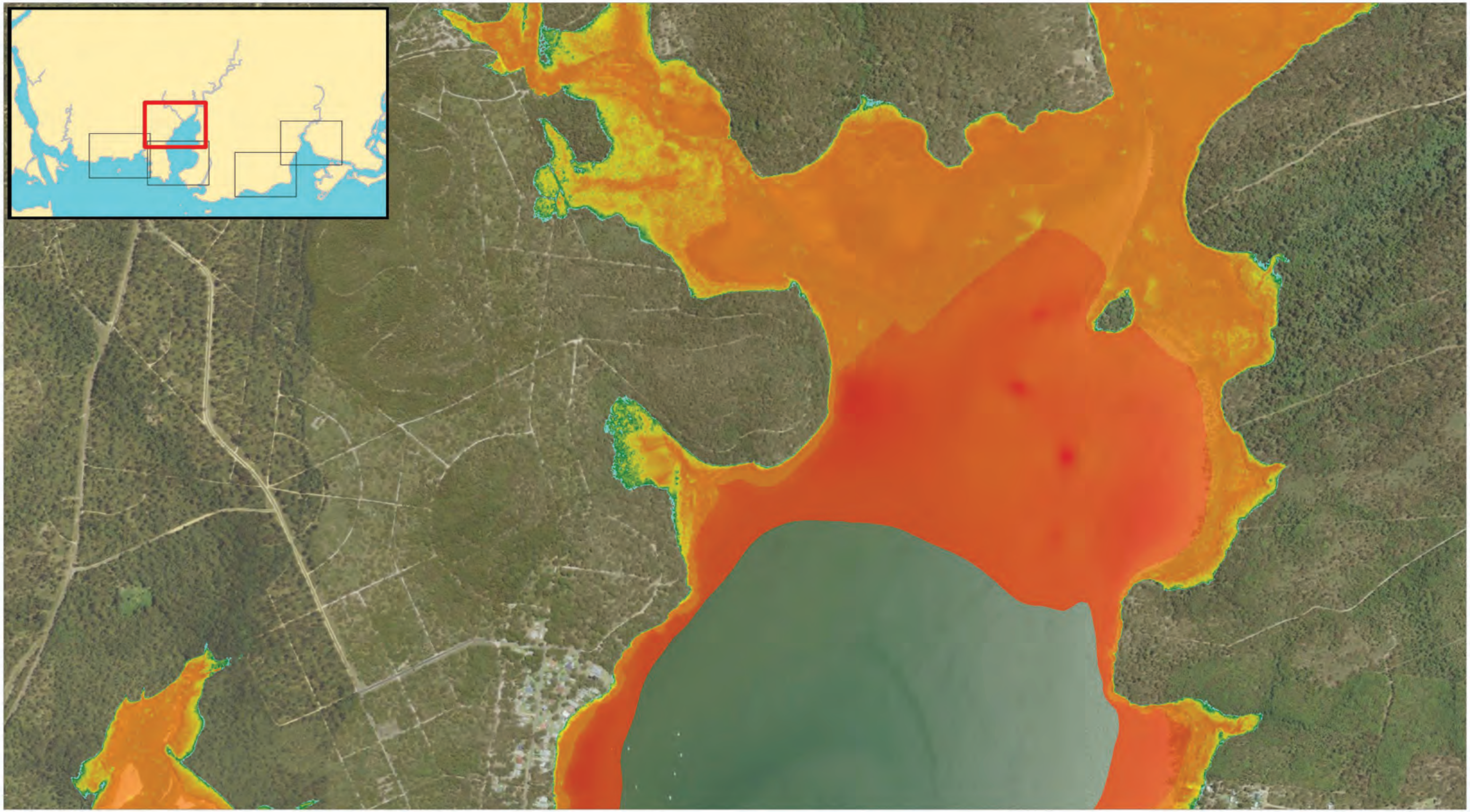
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B01_depth_class_20ySWL_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

0.1	lower depths mapped as same colour
0.2	
0.5	
1.0	
5.0	higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **B-02**

Rev: **A**

N

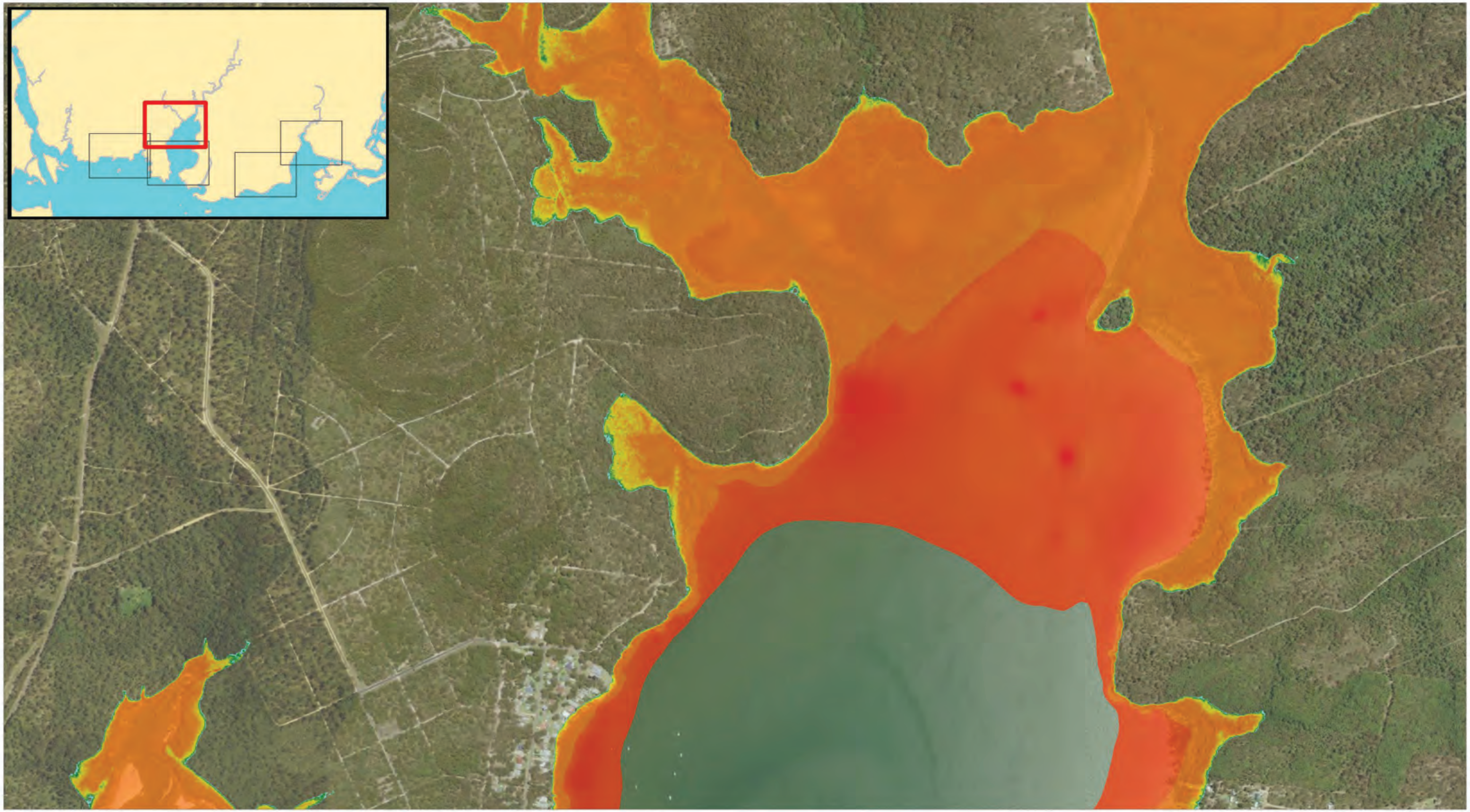
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B02_depth_class_20ySWL_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **B-03**

Rev: **A**

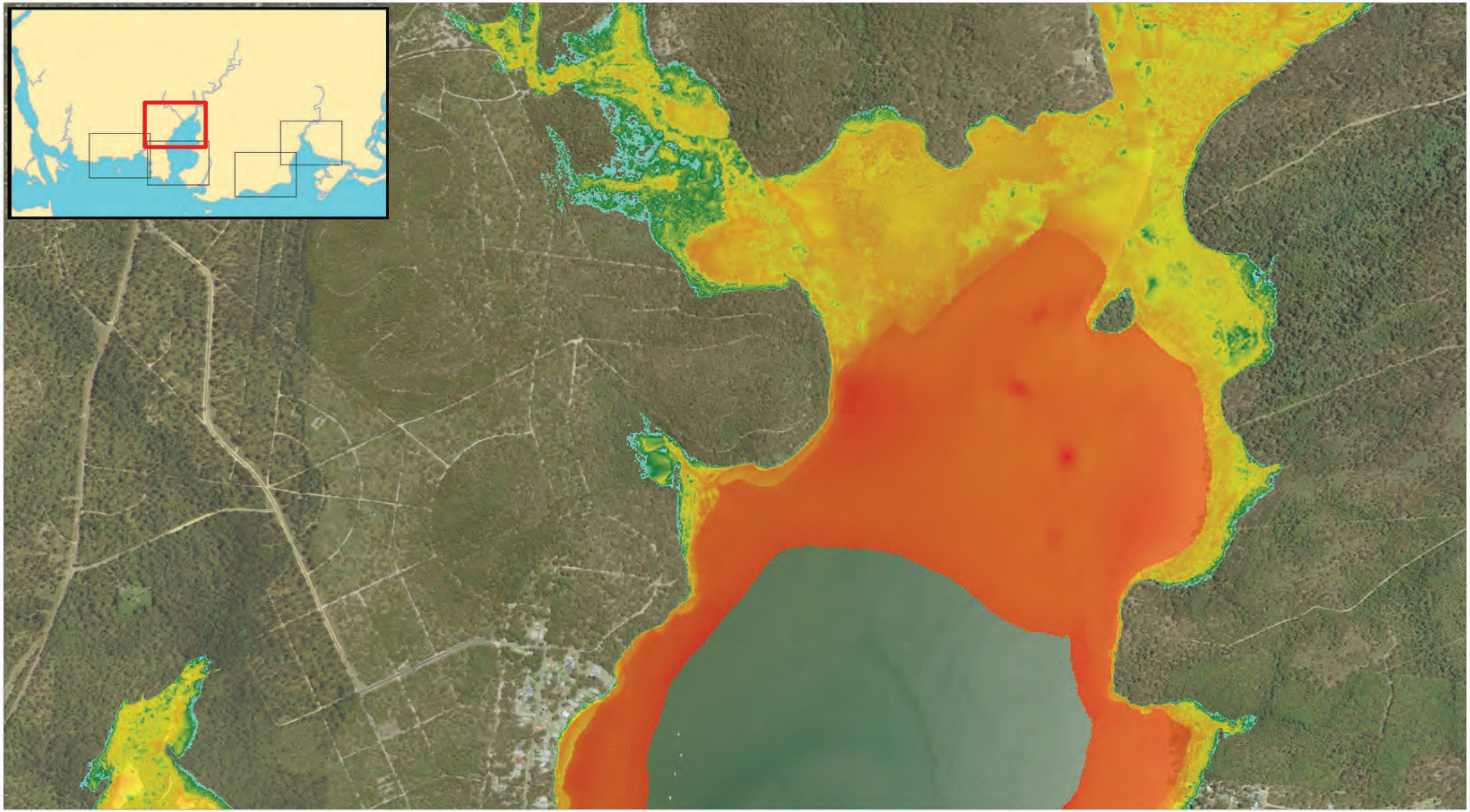
N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B03_depth_class_20ySWL_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **B-04**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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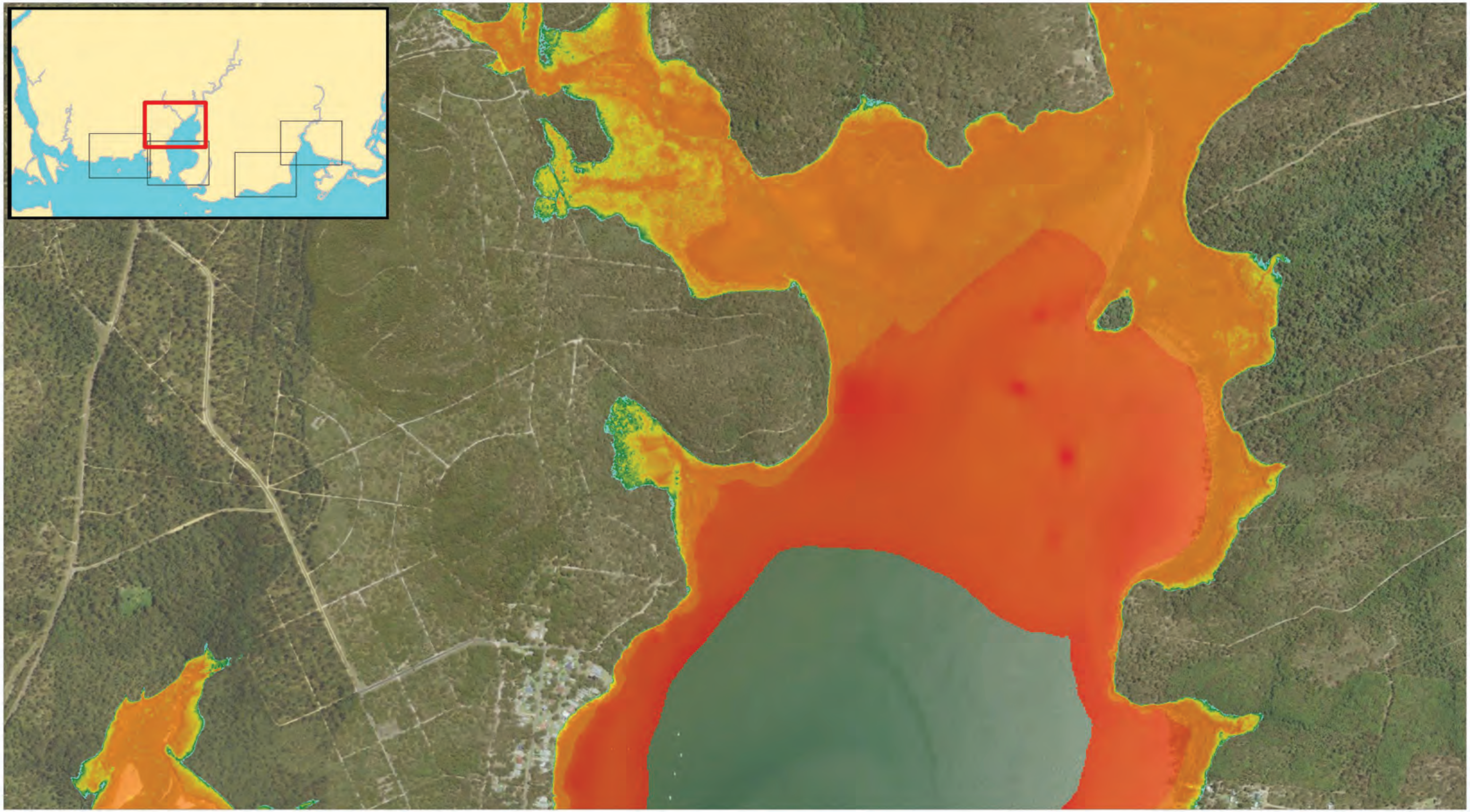
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B04_depth_class_20yWRH_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: B-05

Rev: A

N

0 250 500m

Approx. Scale

BMT

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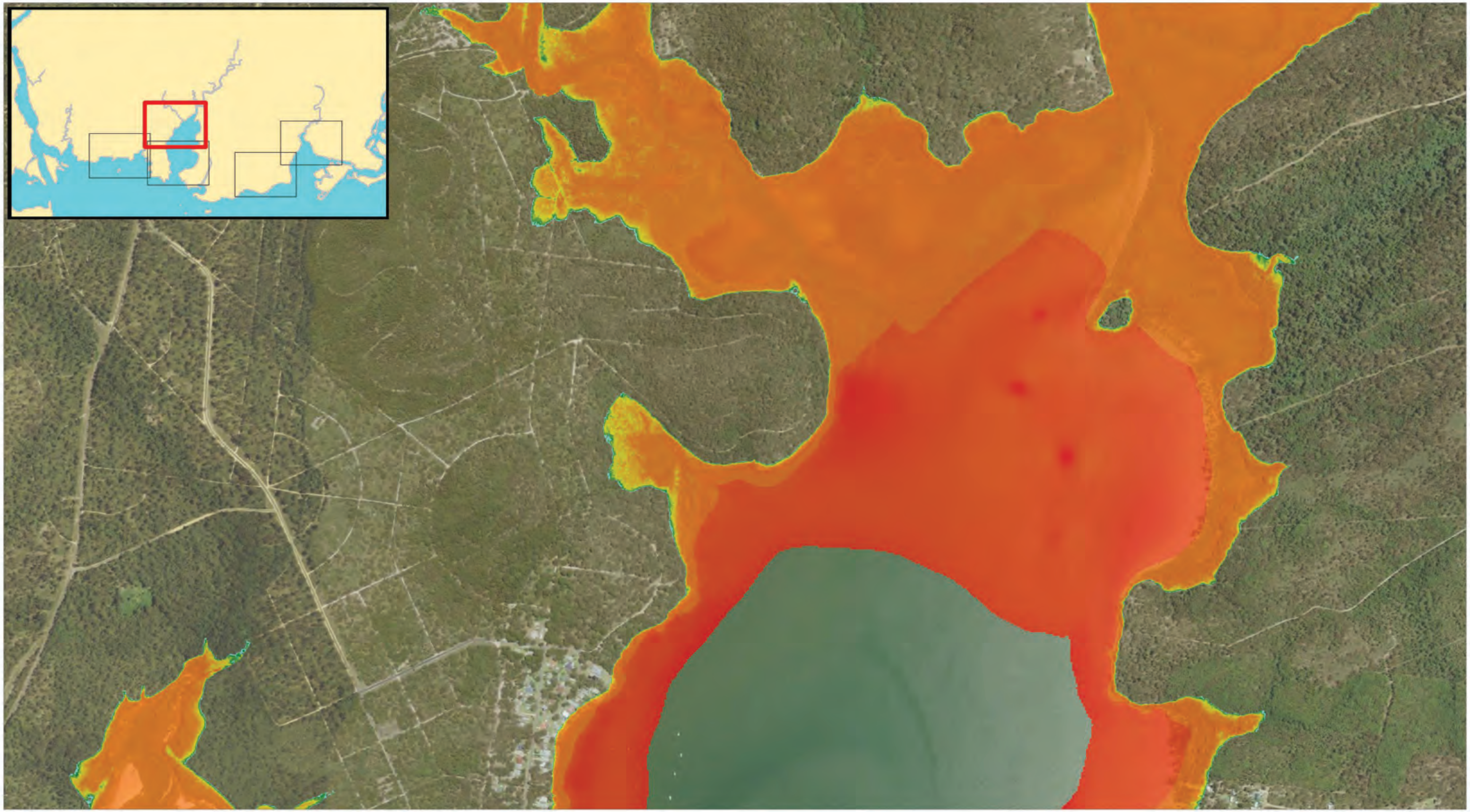
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B05_depth_class_20yWRH_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **B-06**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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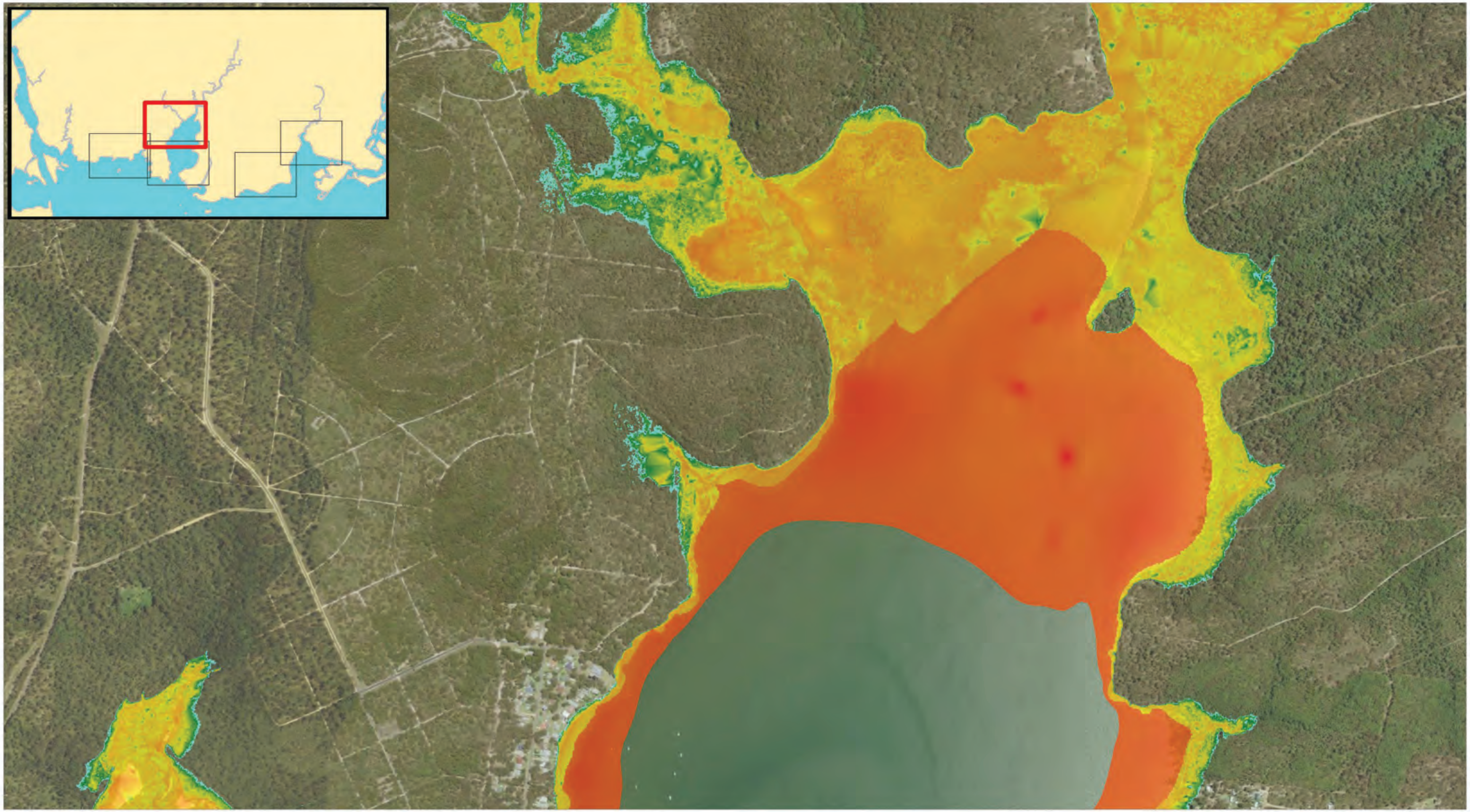
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B06_depth_class_20yWRH_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Upper North Arm Cove

Figure: B-07

Rev: A

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N

0 250 500m

Approx. Scale

BMT

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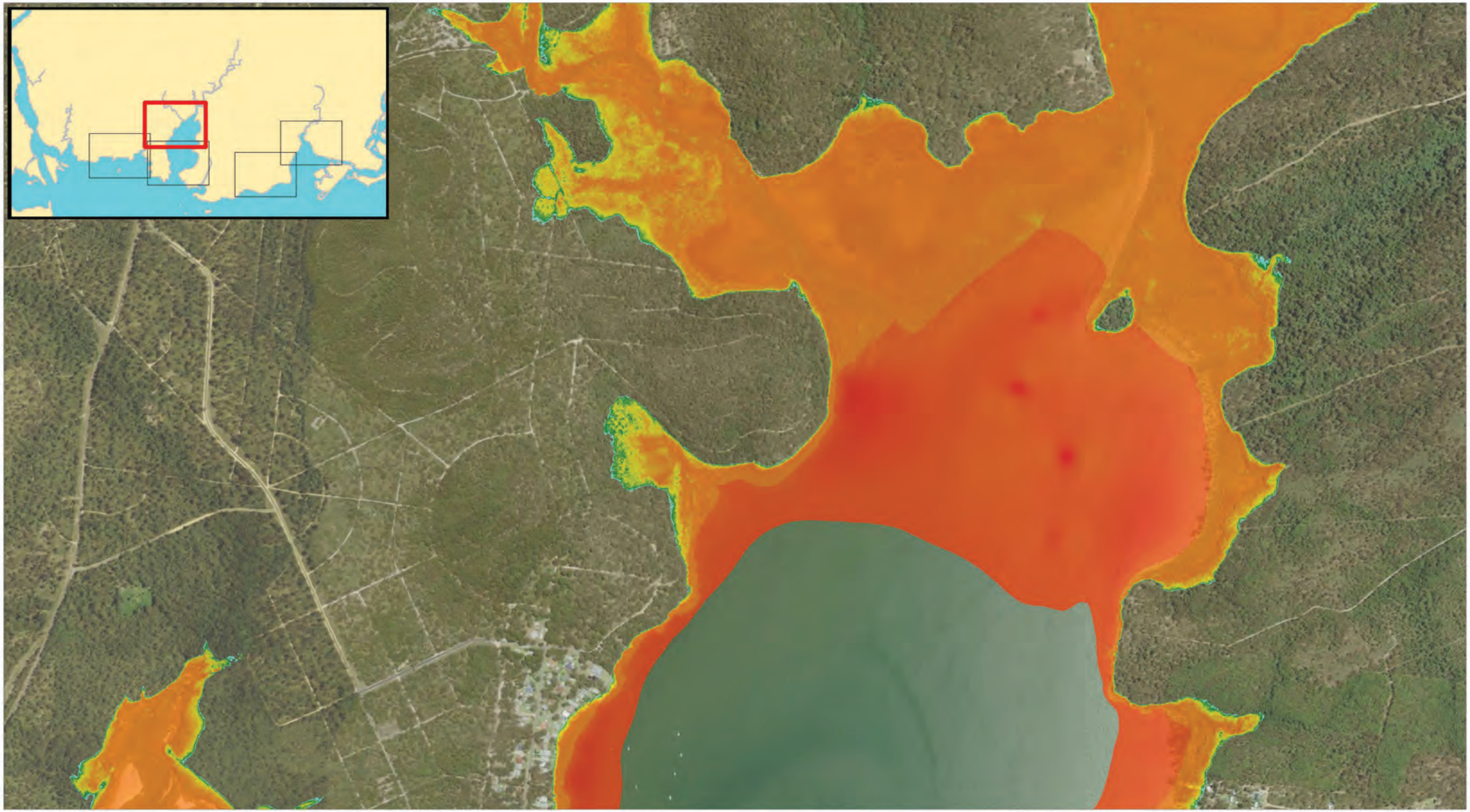
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B07_depth_class_100ySWL_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **B-08**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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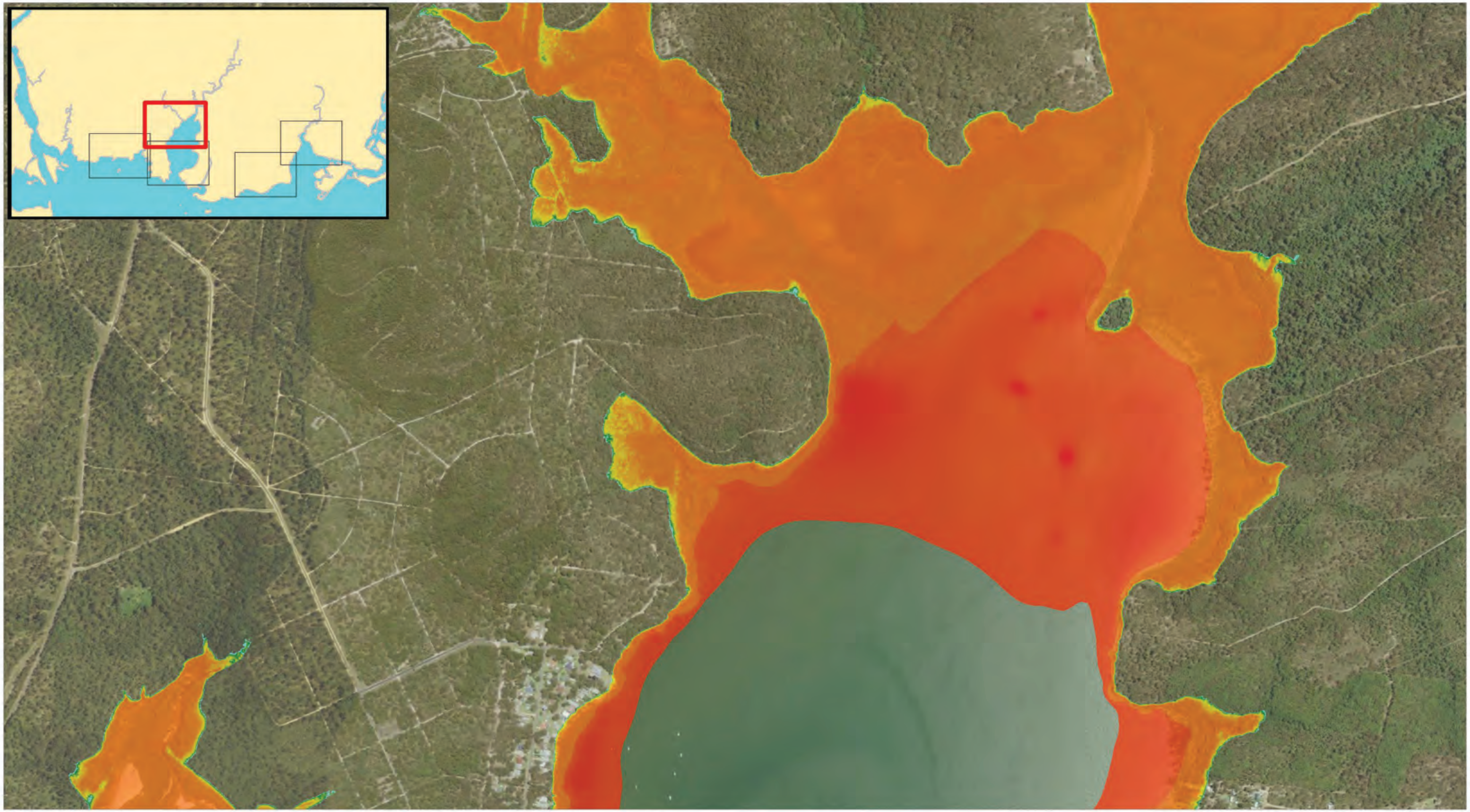
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B08_depth_class_100ySWL_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **B-09**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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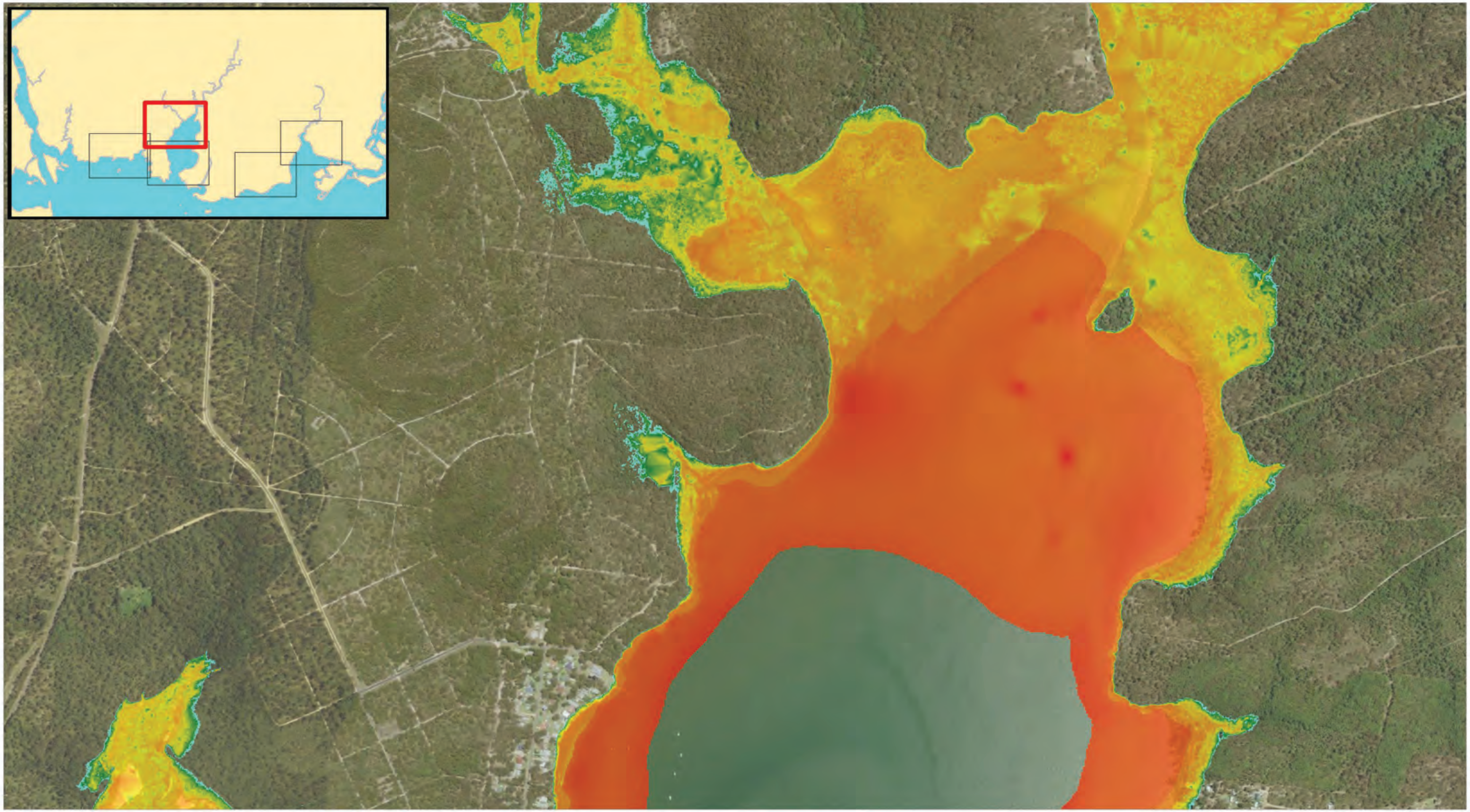
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B09_depth_class_100ySWL_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **B-10**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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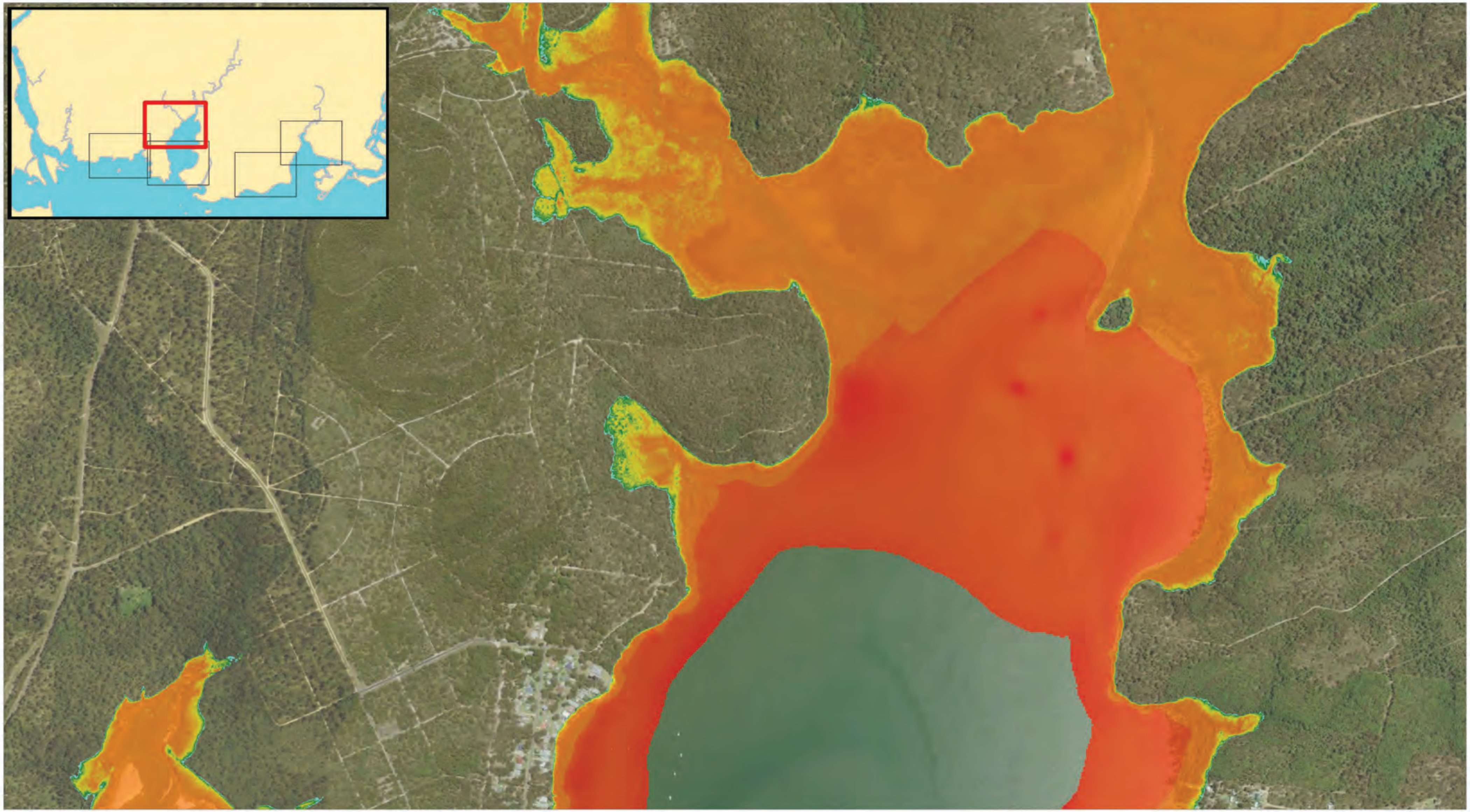
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B10_depth_class_100yWRH_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **B-11**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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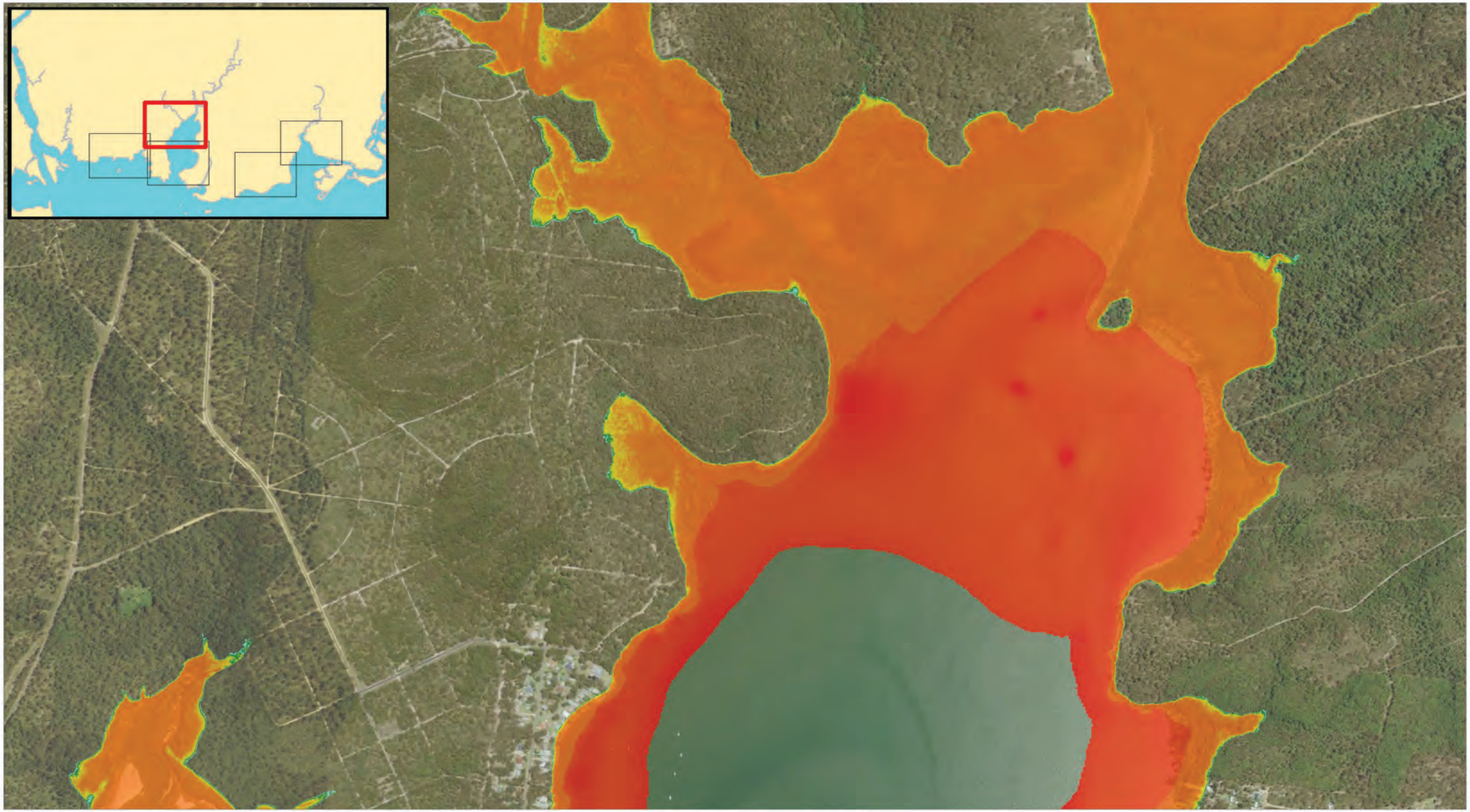
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B11_depth_class_100yWRH_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **B-12**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

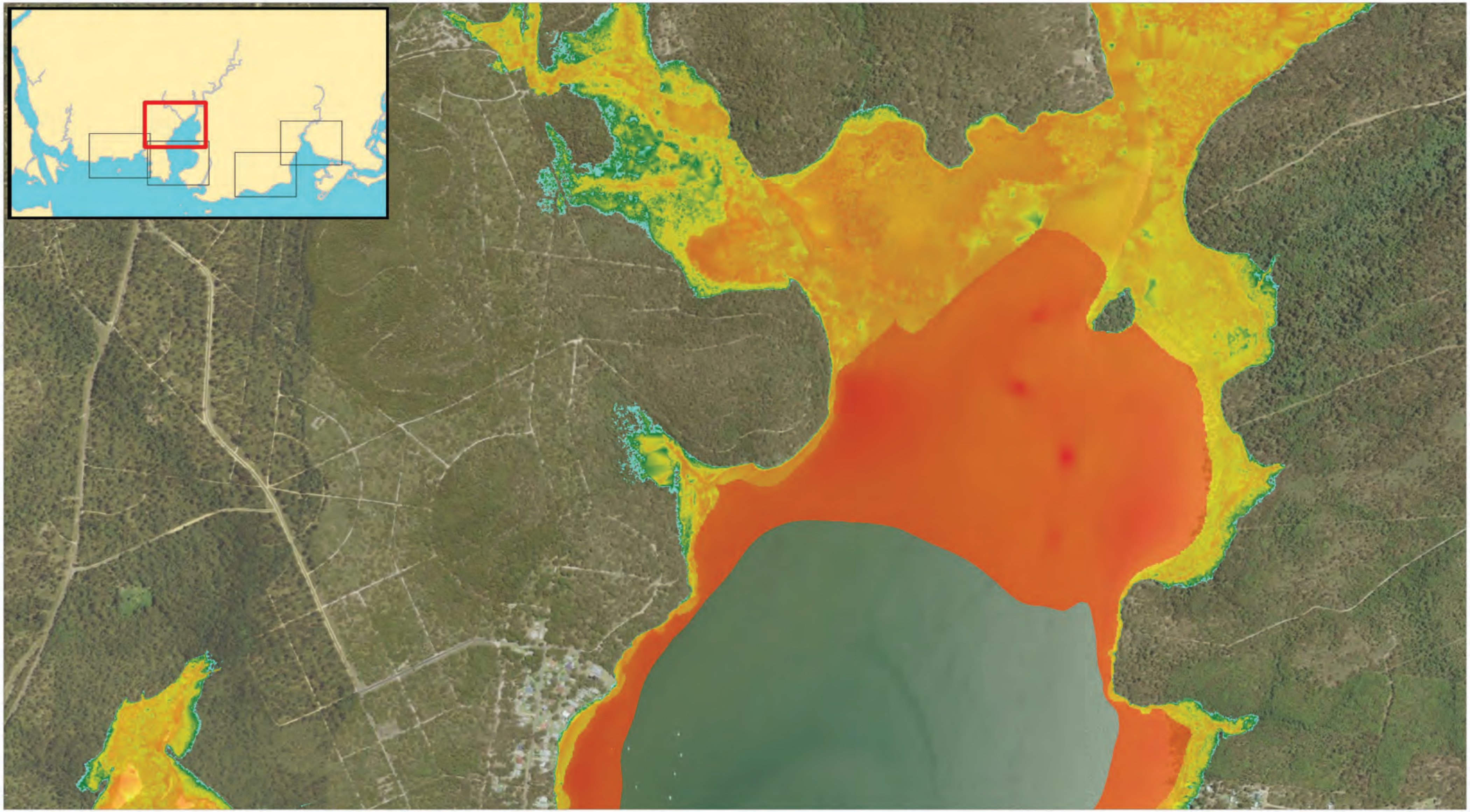
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B12_depth_class_100yWRH_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0 m Sea Level Rise - Upper North Arm Cove

Figure: B-13

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

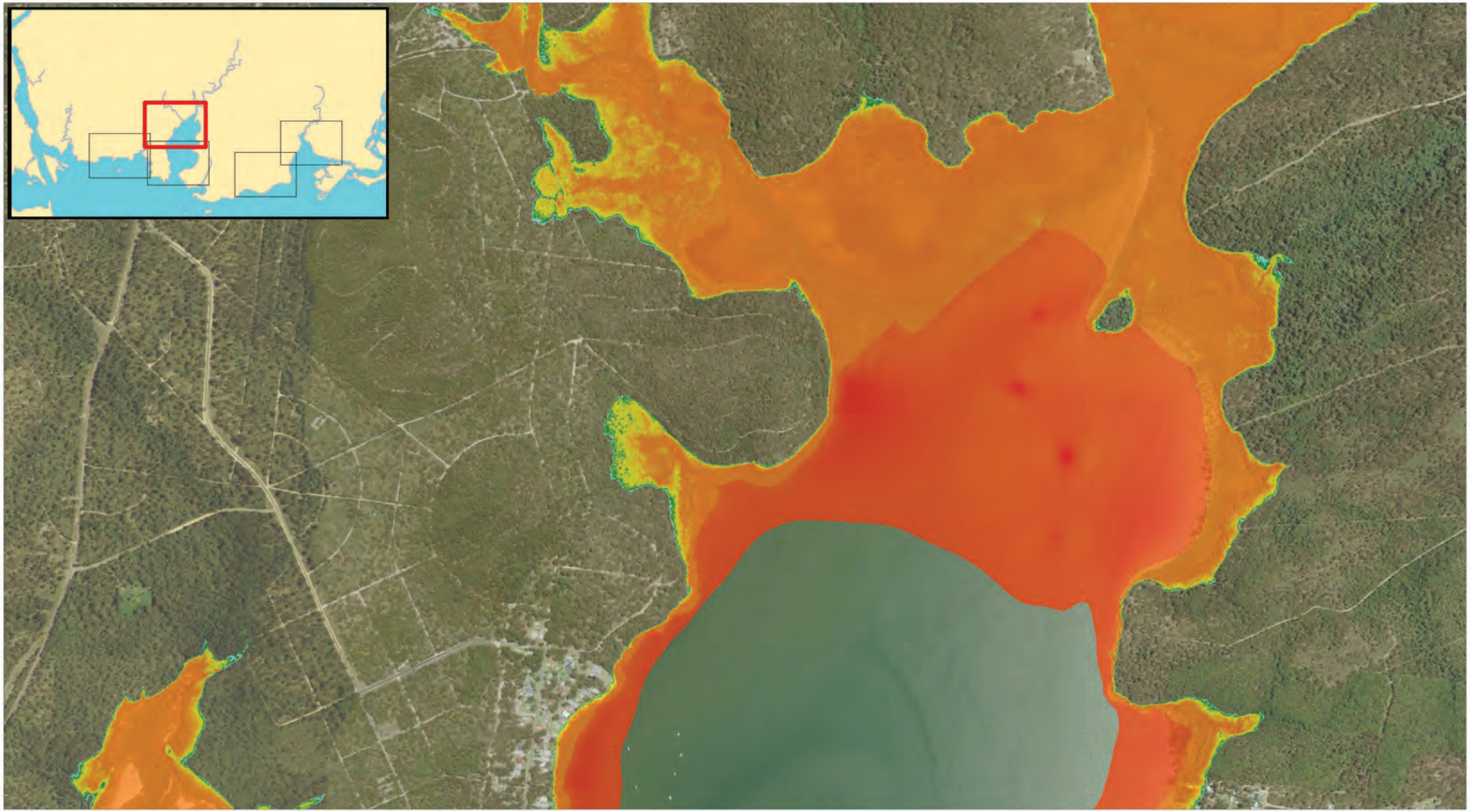
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B13_depth_class_extSWL_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **B-14**

Rev: **A**

N

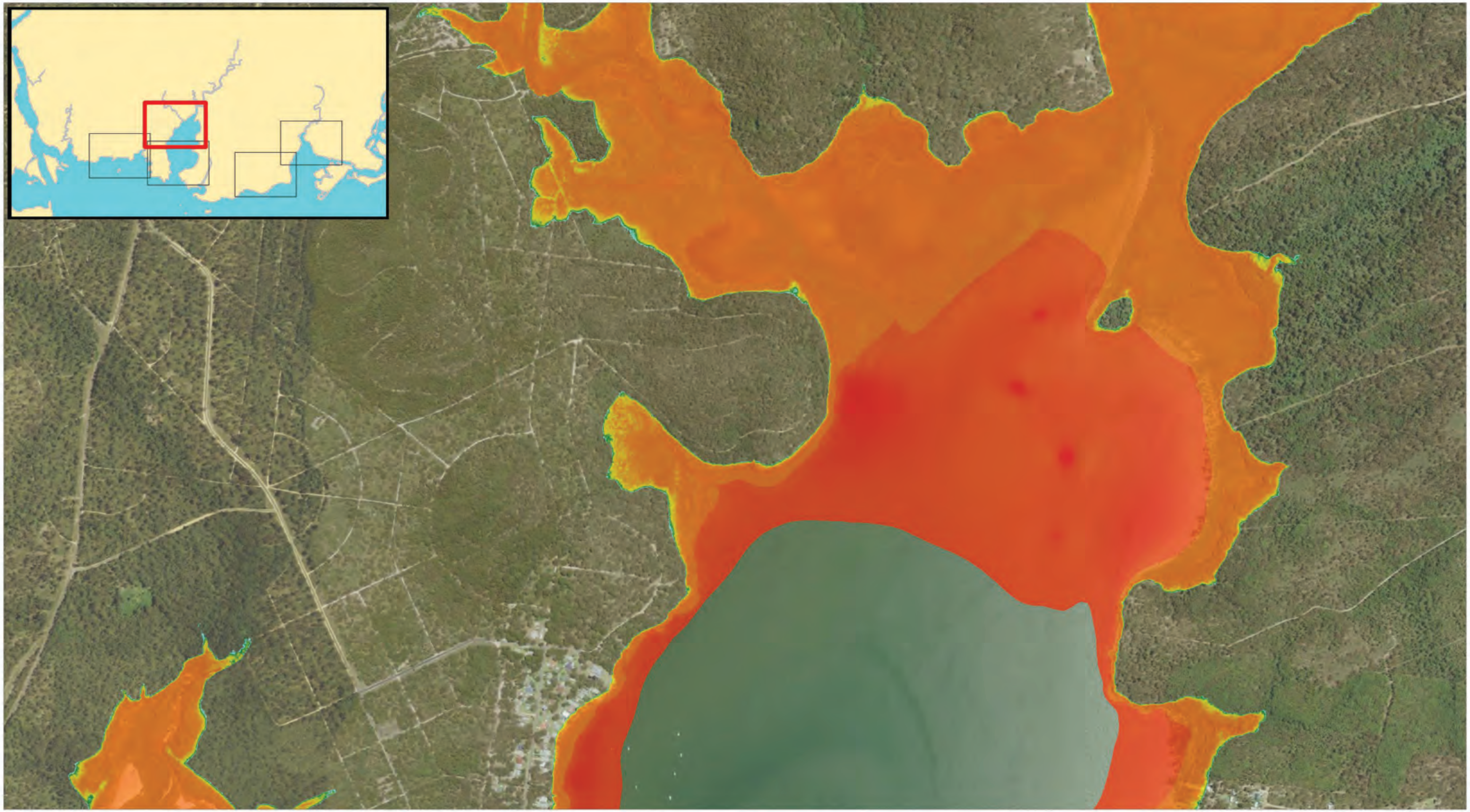
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B14_depth_class_extSWL_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **B-15**

Rev: **A**

N

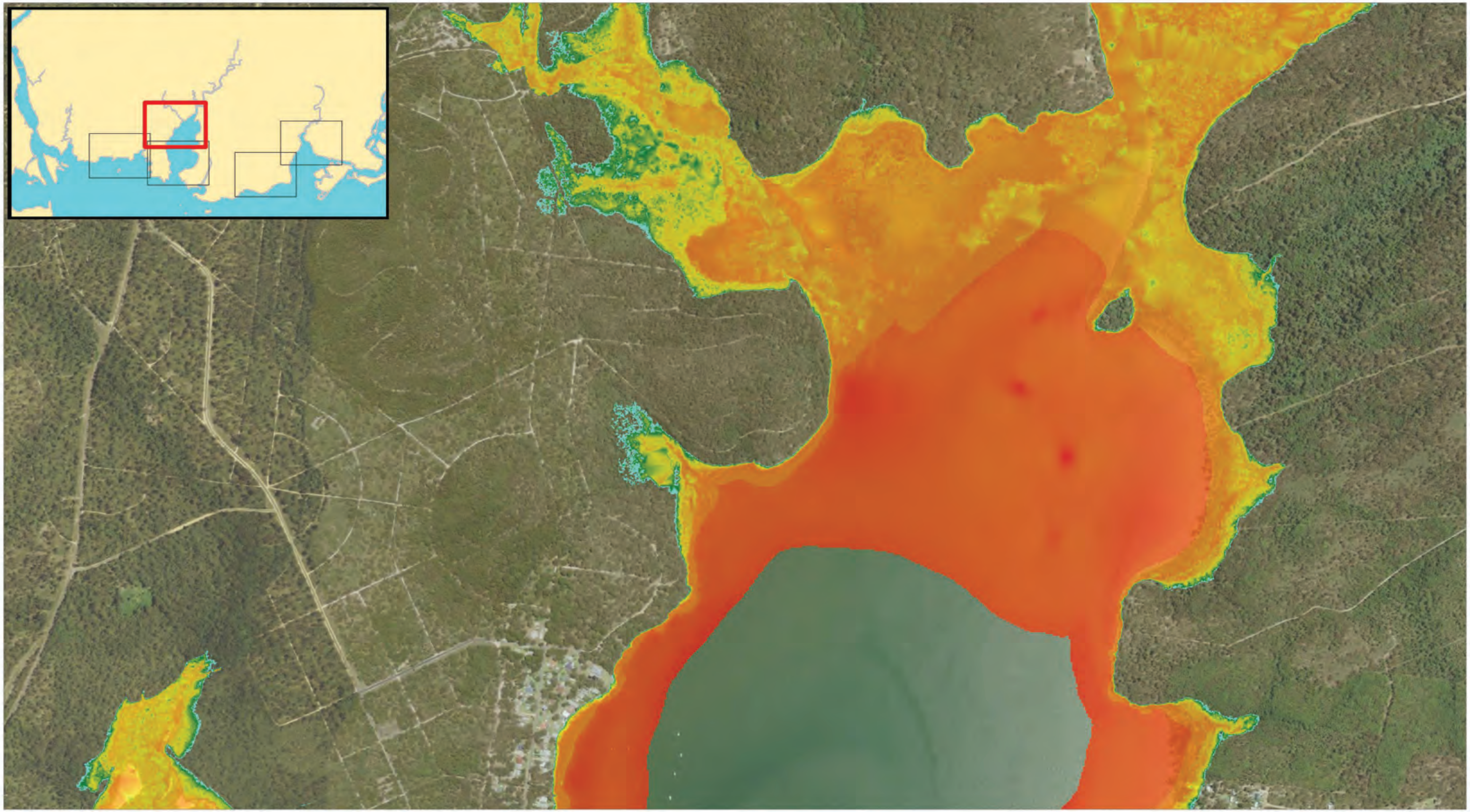
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B15_depth_class_extSWL_0p91SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **B-16**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

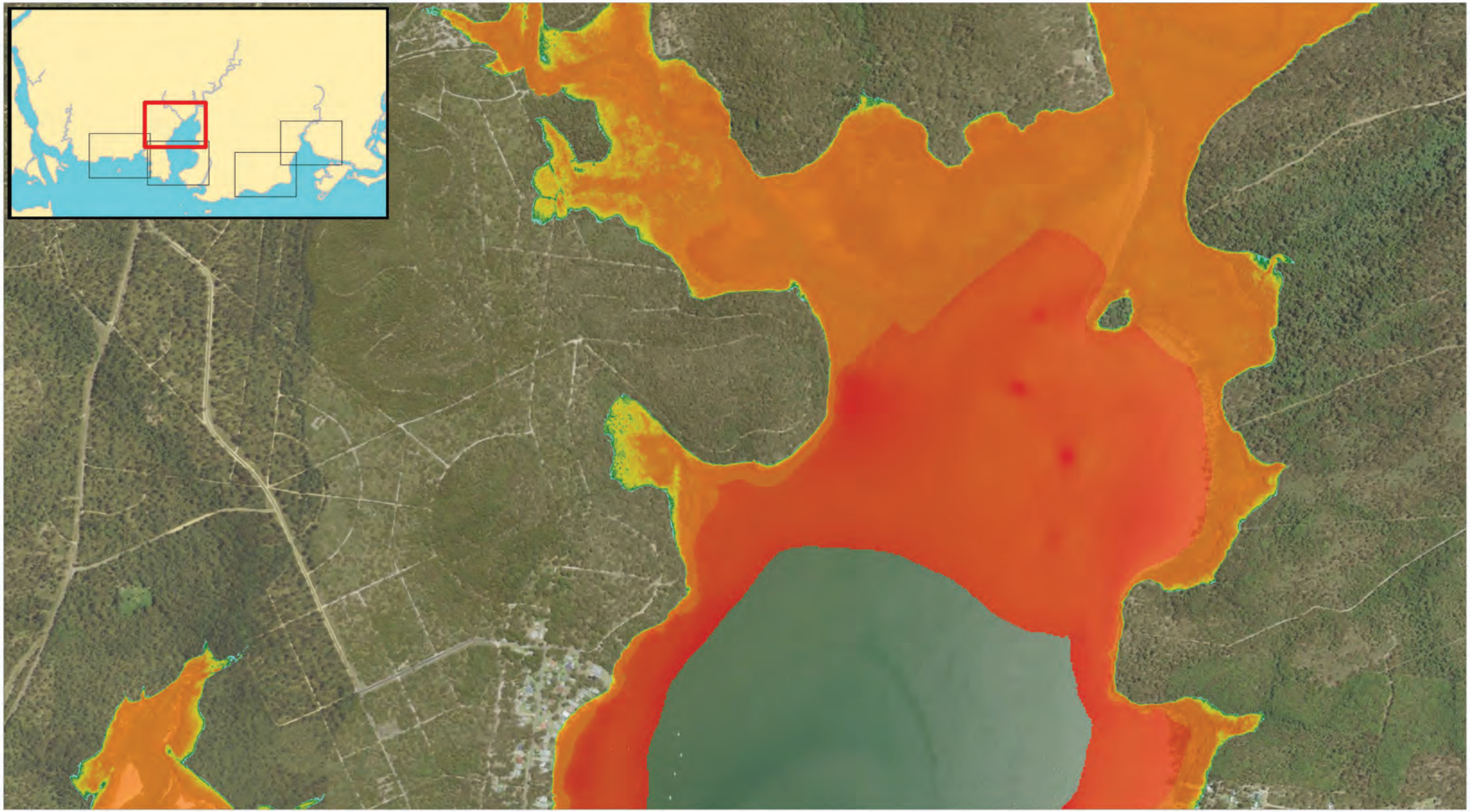
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B16_depth_class_extWRH_0p0SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: B-17

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

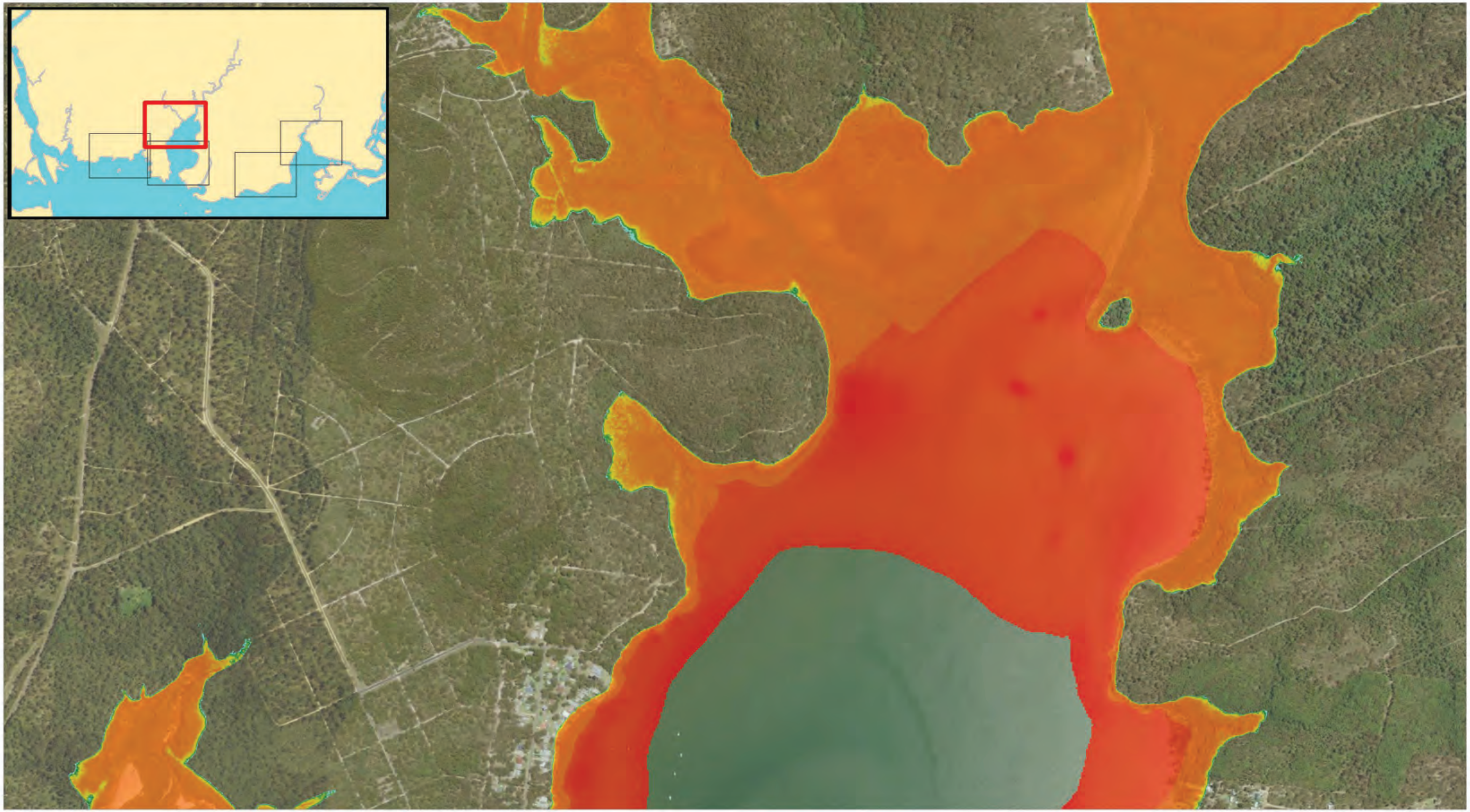
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B17_depth_class_extWRH_0p55SLR_001.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **B-18**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_B18_depth_class_extWRH_0p91SLR_001.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Lower North Arm Cove

Figure: **C-01**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C01_depth_class_20ySWL_0p0SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Lower North Arm Cove

Figure: **C-02**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C02_depth_class_20ySWL_0p55SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Lower North Arm Cove

Figure: C-03

Rev: A

N

0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C03_depth_class_20ySWL_0p91SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Lower North Arm Cove

Figure: **C-04**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C04_depth_class_20yWRH_0p0SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Lower North Arm Cove

Figure: **C-05**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C05_depth_class_20yWRH_0p55SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Lower North Arm Cove

Figure: C-06

Rev: A

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N

0 250 500m

Approx. Scale

BMT

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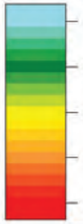
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C06_depth_class_20yWRH_0p91SLR.wor"



Title:

1% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Lower North Arm Cove

Figure: C-07

Rev: A

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C07_depth_class_100ySWL_0p0SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Lower North Arm Cove

Figure: **C-08**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C08_depth_class_100ySWL_0p55SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Lower North Arm Cove

Figure: **C-09**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C09_depth_class_100ySWL_0p91SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Lower North Arm Cove

Figure: **C-10**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C10_depth_class_100yWRH_0p0SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Lower North Arm Cove

Figure: **C-11**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT
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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C11_depth_class_100yWRH_0p55SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Lower North Arm Cove

Figure: **C-12**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C12_depth_class_100yWRH_0p91SLR.wor"

LEGEND

Peak Flood Depth (m)

0.1 lower depths mapped as same colour
0.2
0.5
1.0
5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0 m Sea Level Rise - Lower North Arm Cove

Figure: **C-13**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C13_depth_class_extSWL_0p0SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Lower North Arm Cove

Figure: **C-14**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

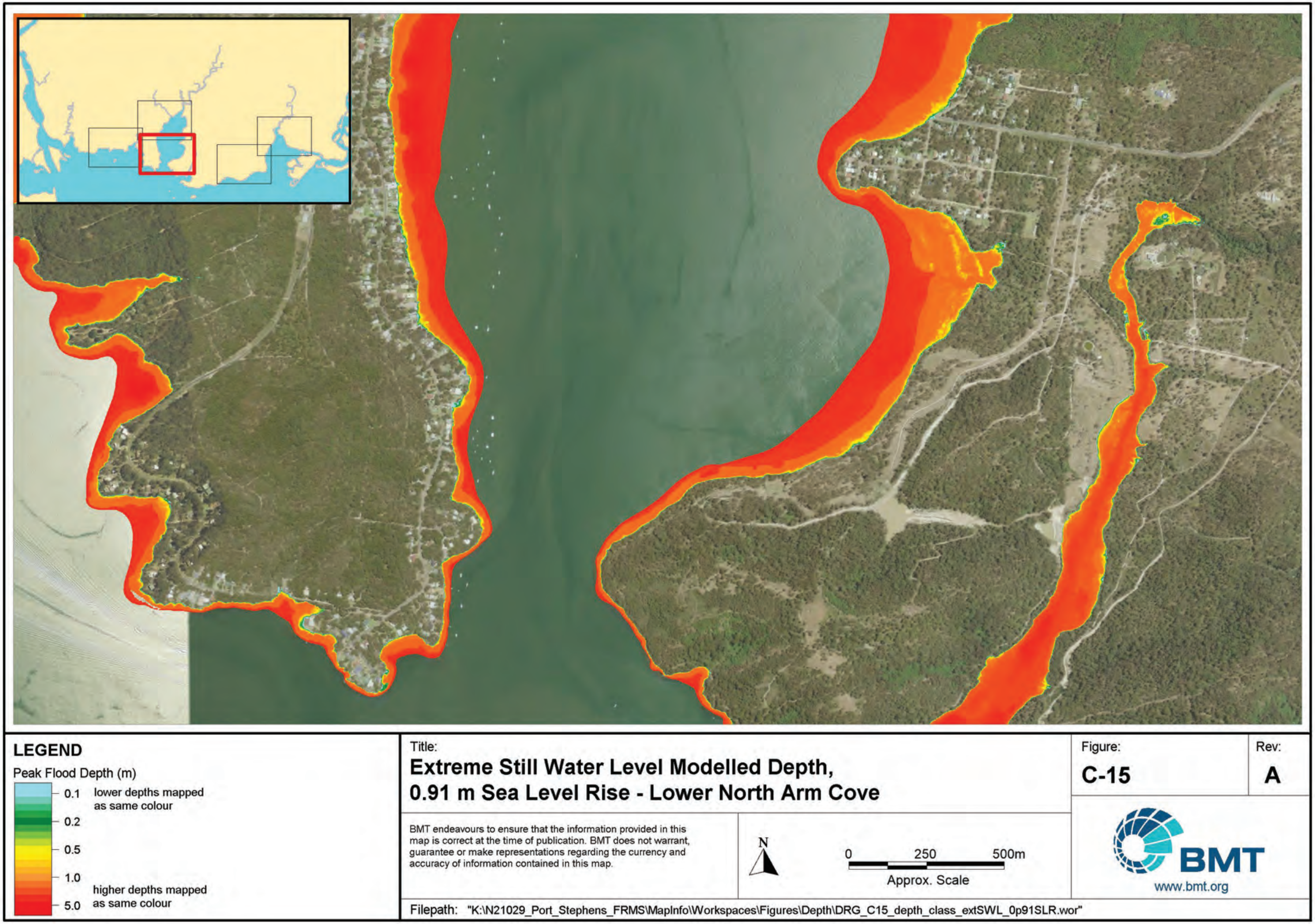
N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C14_depth_class_extSWL_0p55SLR.wor"


LEGEND
Peak Flood Depth (m)
0.1 lower depths mapped as same colour
0.2
0.5
1.0
5.0 higher depths mapped as same colour
Title:
Extreme Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Lower North Arm Cove
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
N
0 250 500m
Approx. Scale
Figure:
C-15
Rev:
A
BMT
www.bmt.org
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C15_depth_class_extSWL_0p91SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Lower North Arm Cove

Figure: C-16

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C16_depth_class_extWRH_0p0SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Lower North Arm Cove

Figure: C-17

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C17_depth_class_extWRH_0p55SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Lower North Arm Cove

Figure: **C-18**

Rev: **A**

N

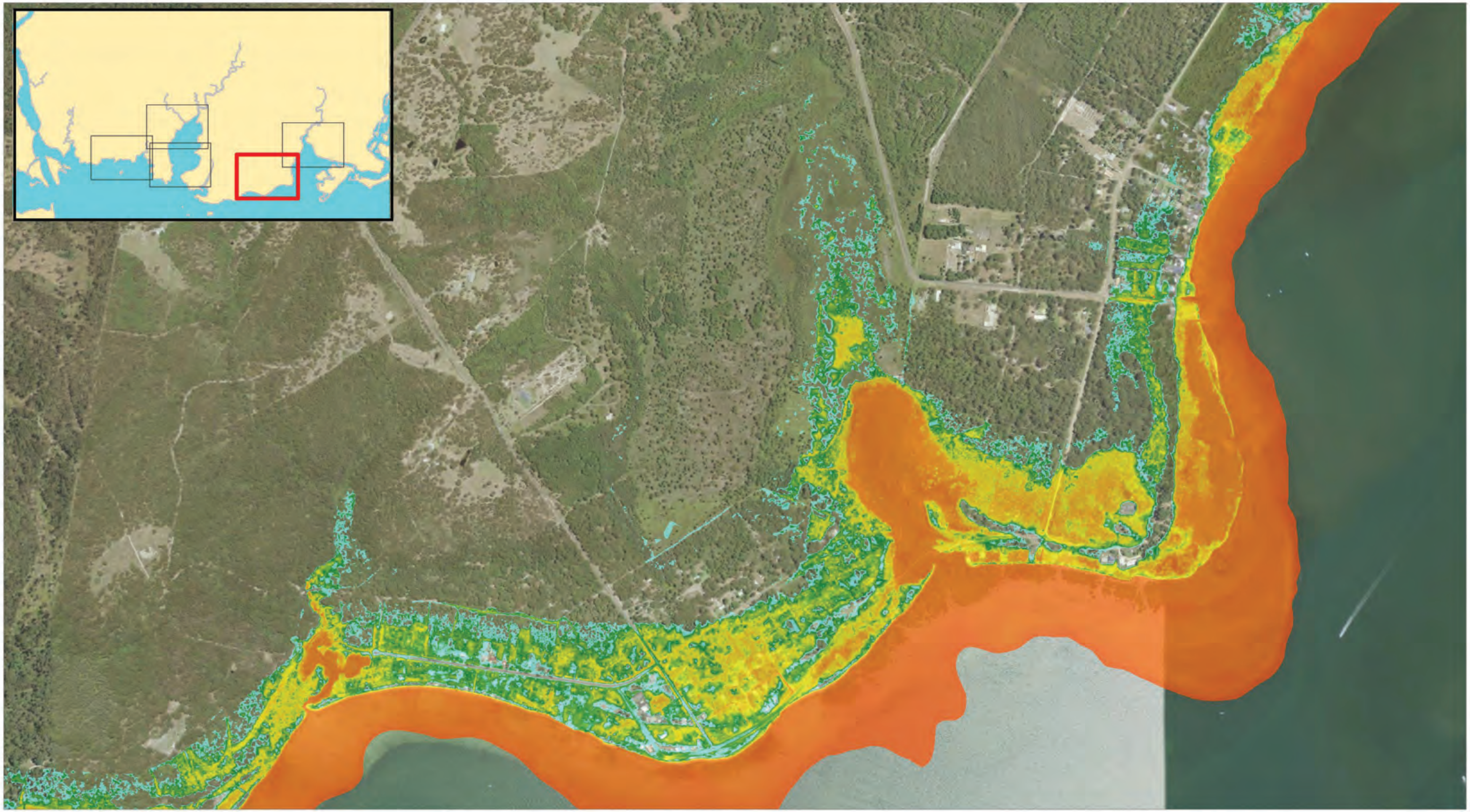
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_C18_depth_class_extWRH_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise Pindimar South

Figure: **D-01**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

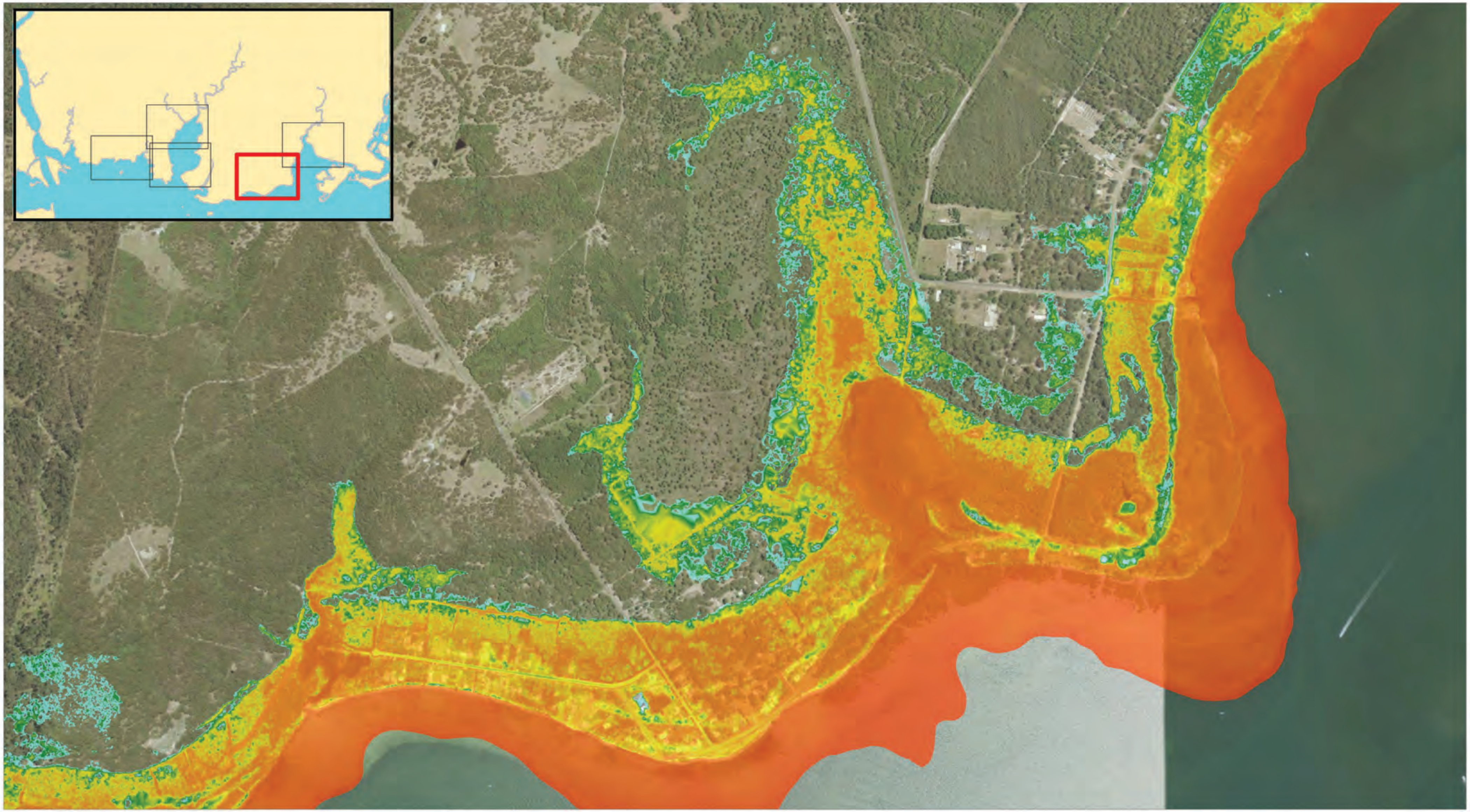
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D01_depth_class_20ySWL_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

Title:

5% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise Pindimar South

Figure: **D-02**

Rev: **A**

N

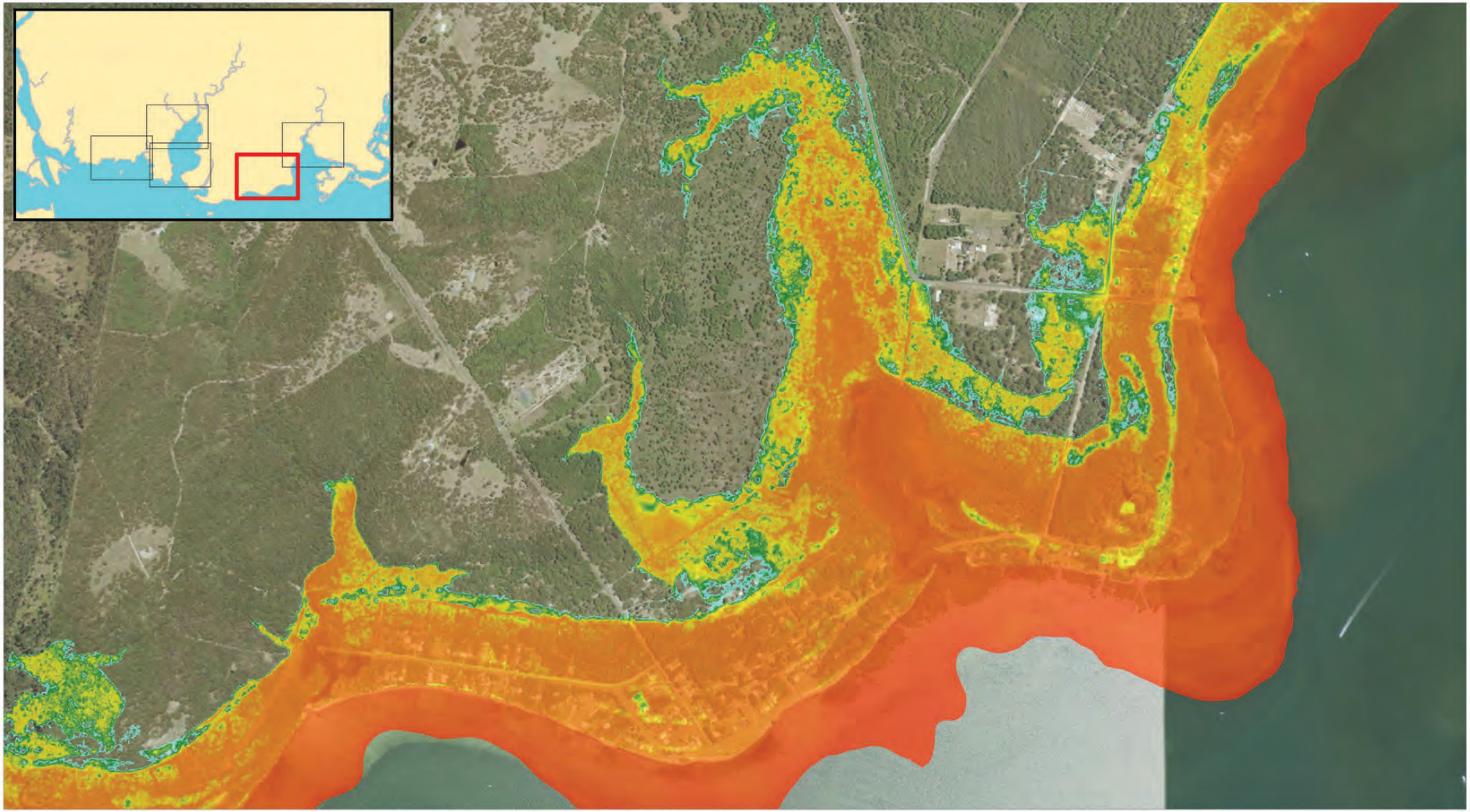
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D02_depth_class_20ySWL_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise Pindimar South

Figure: **D-03**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D03_depth_class_20ySWL_0p91SLR.wor"

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise Pindimar South

Figure: **D-04**

Rev: **A**

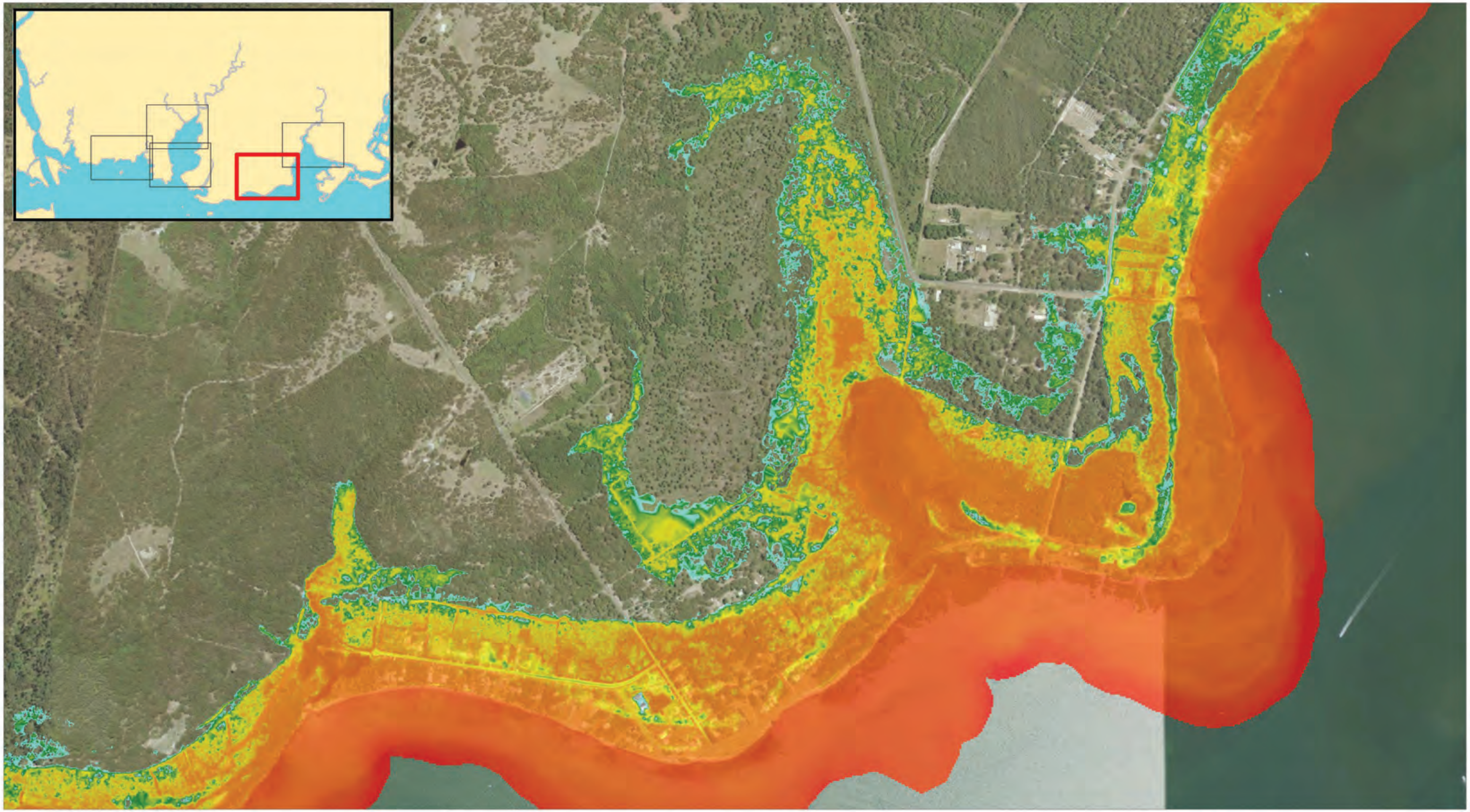
N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D04_depth_class_20yWRH_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise Pindimar South

Figure: D-05

Rev: A

N

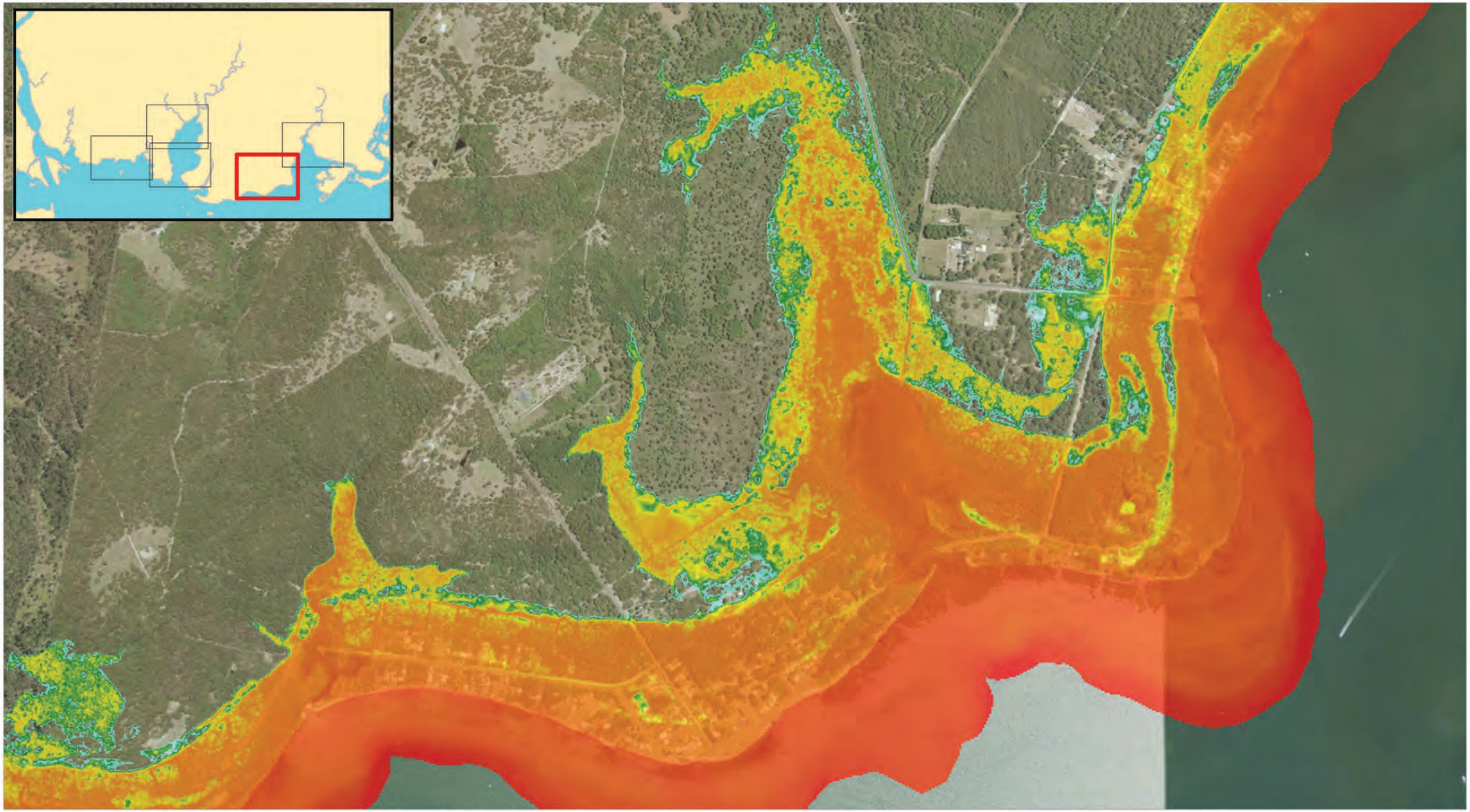
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D05_depth_class_20yWRH_0p955SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0 higher depths mapped
- 5.0 as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise Pindimar South

Figure: D-06

Rev: A

N

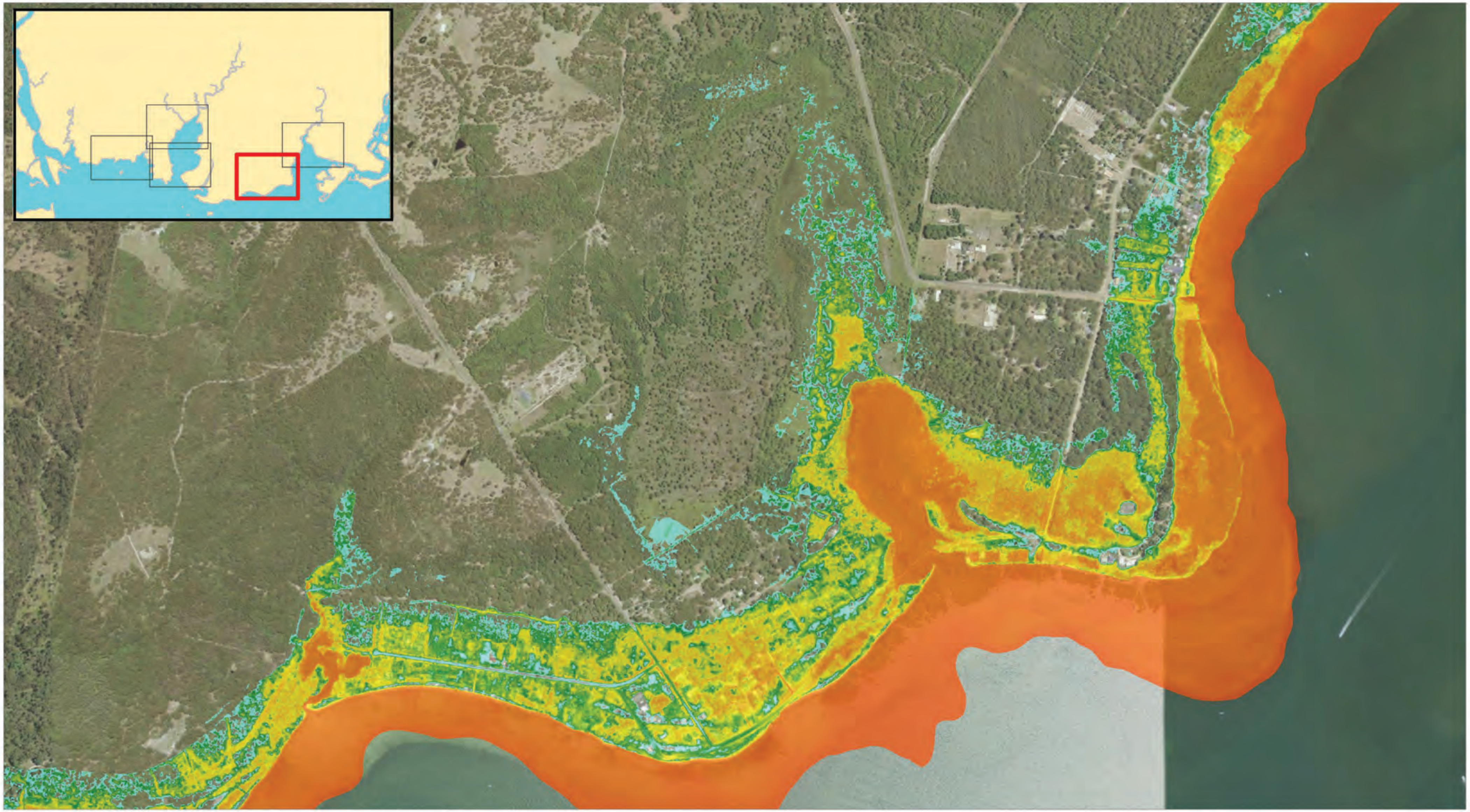
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D06_depth_class_20yWRH_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise Pindimar South

Figure: **D-07**

Rev: **A**

N

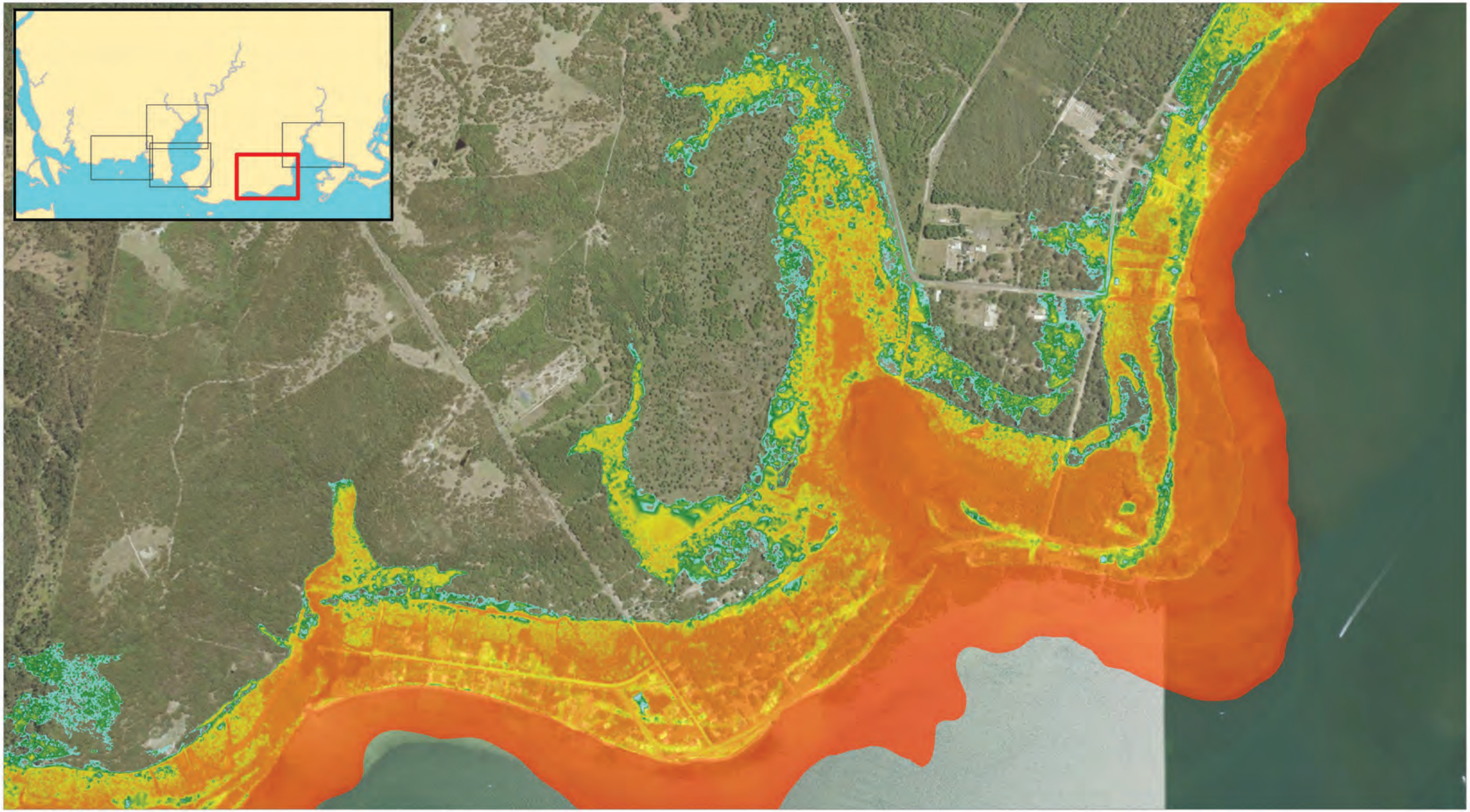
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D07_depth_class_100ySWL_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

0.1	lower depths mapped as same colour
0.2	
0.5	
1.0	
5.0	higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise Pindimar South

Figure: **D-08**

Rev: **A**

N

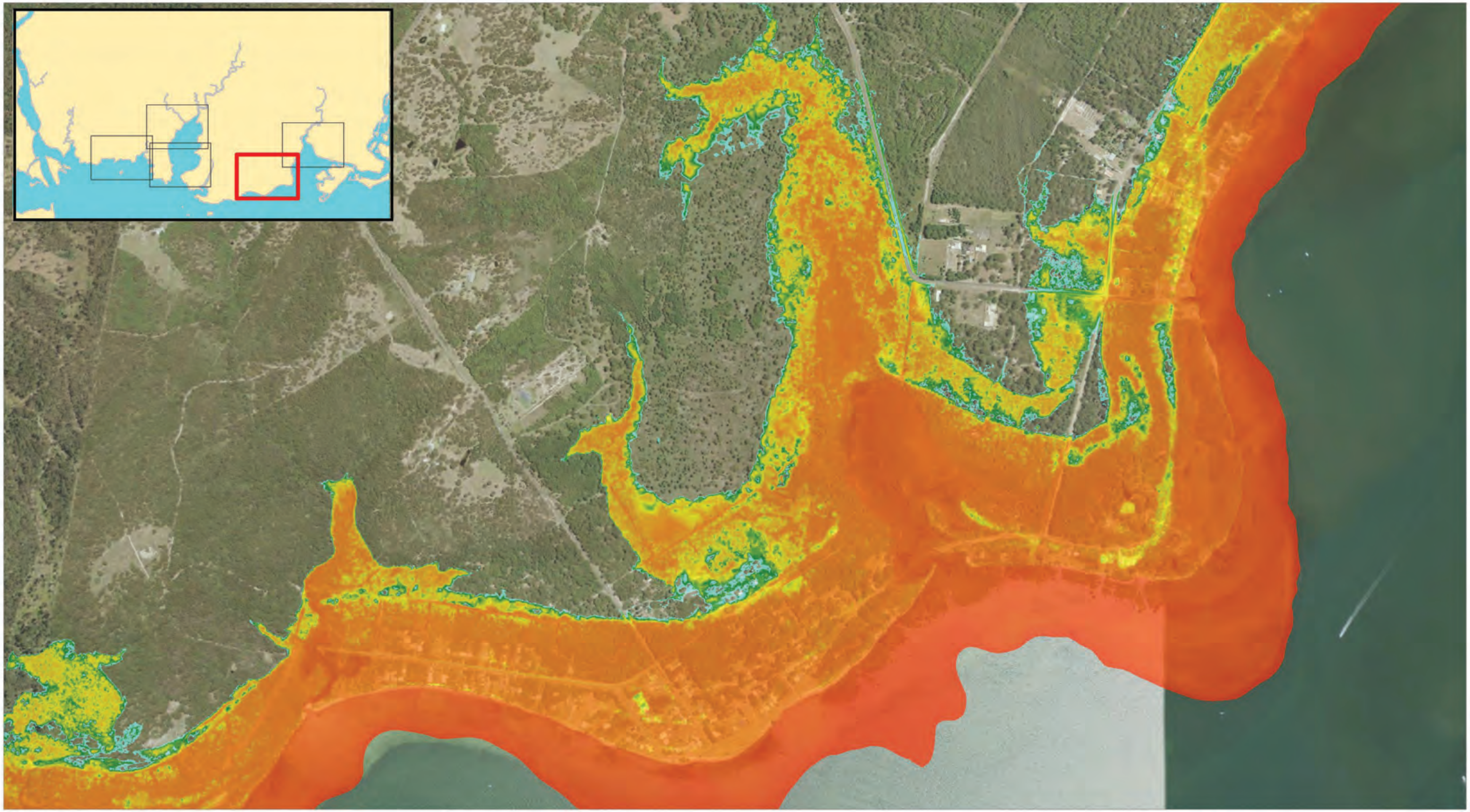
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D08_depth_class_100ySWL_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise Pindimar South

Figure: **D-09**

Rev: **A**

N

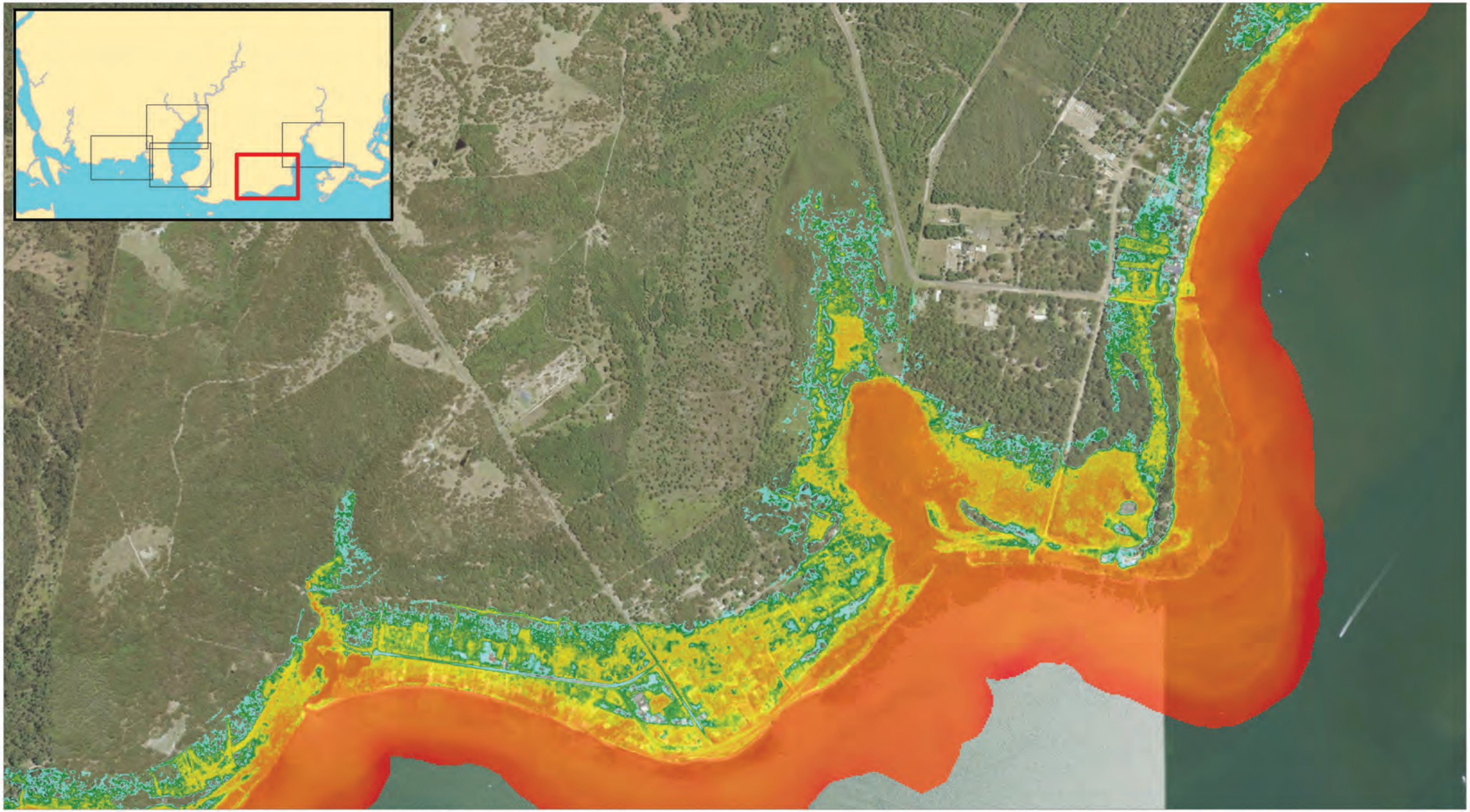
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D09_depth_class_100ySWL_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise Pindimar South

Figure: **D-10**

Rev: **A**

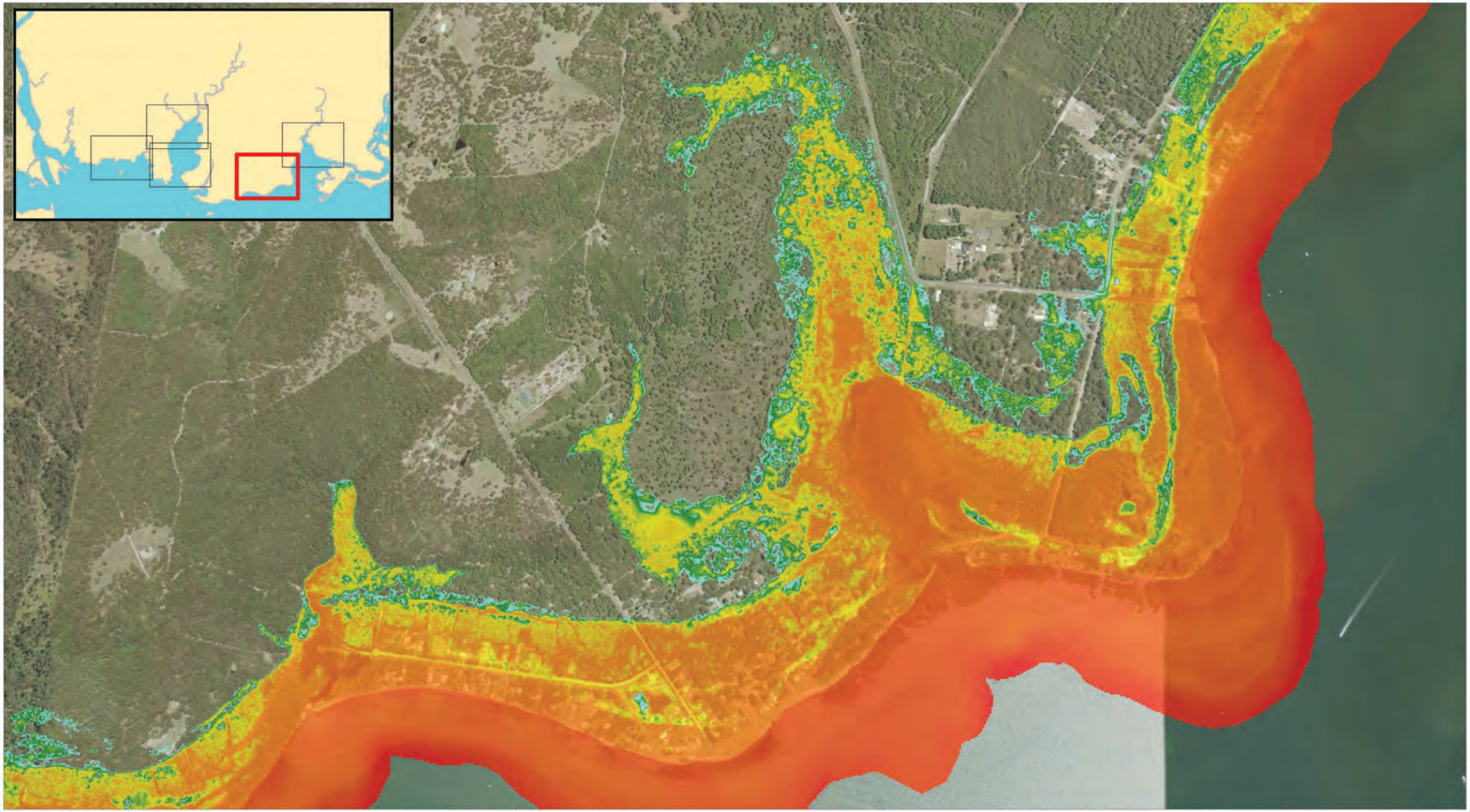
N

0 250 500m

Approx. Scale

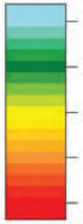
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D10_depth_class_100yWRH_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)



Title:

1% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise Pindimar South

Figure: **D-11**

Rev: **A**

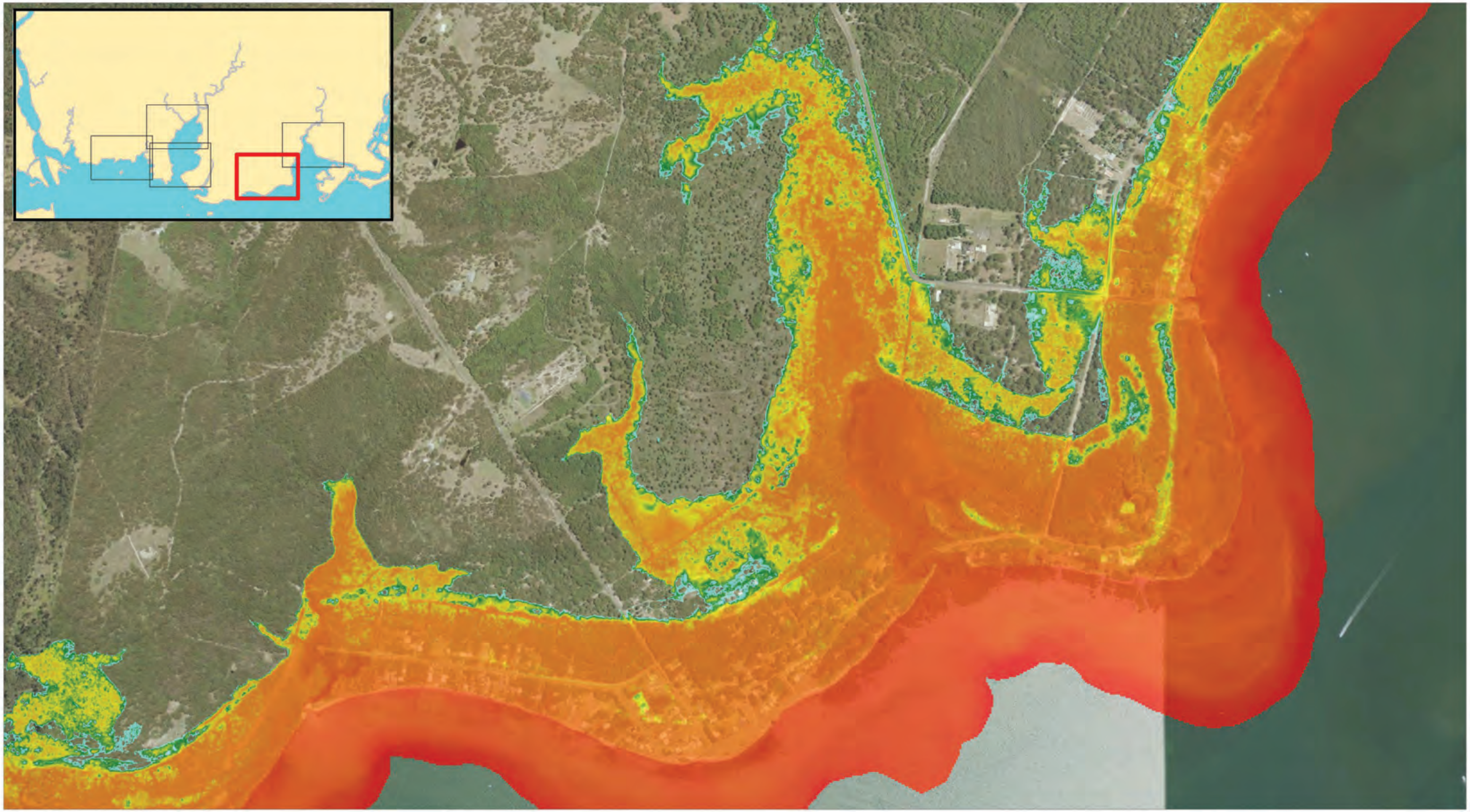
N

0 250 500m

Approx. Scale

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D11_depth_class_100yWRH_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise Pindimar South

Figure: **D-12**

Rev: **A**

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N

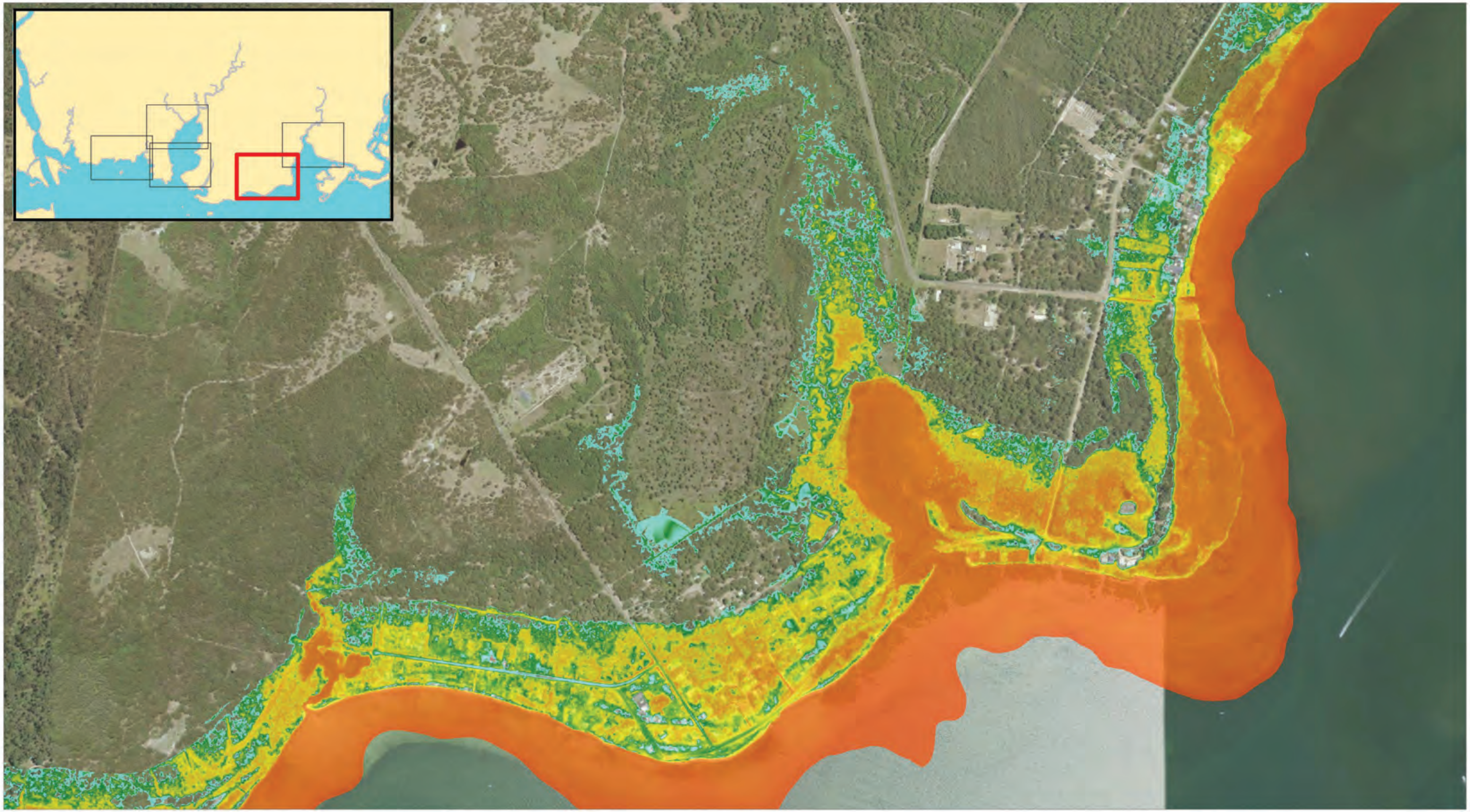
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D12_depth_class_100yWRH_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0 m Sea Level Rise Pindimar South

Figure: **D-13**

Rev: **A**

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N

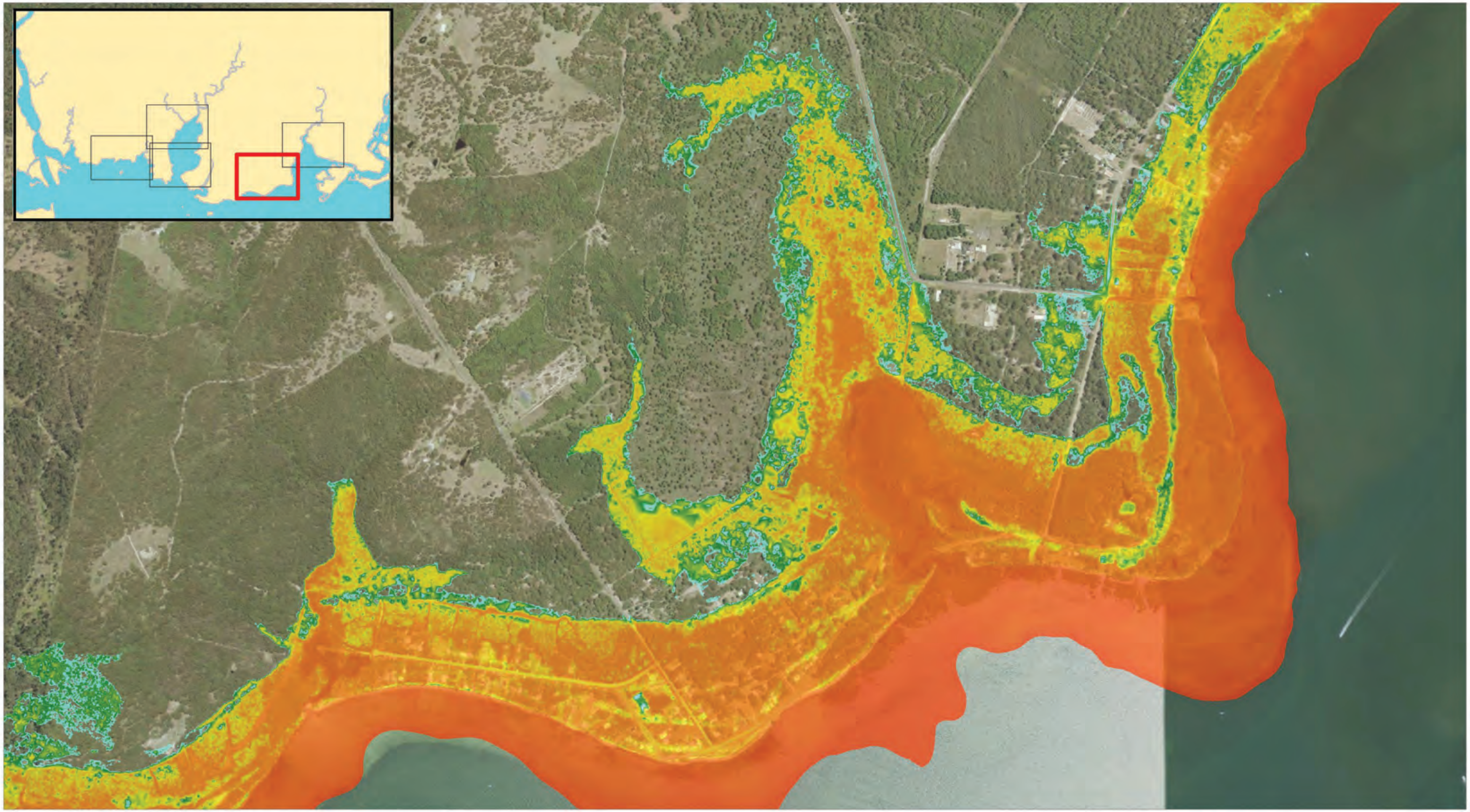
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D13_depth_class_extSWL_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

0.1	lower depths mapped as same colour
0.2	
0.5	
1.0	
5.0	higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.55 m Sea Level Rise Pindimar South

Figure: **D-14**

Rev: **A**

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N

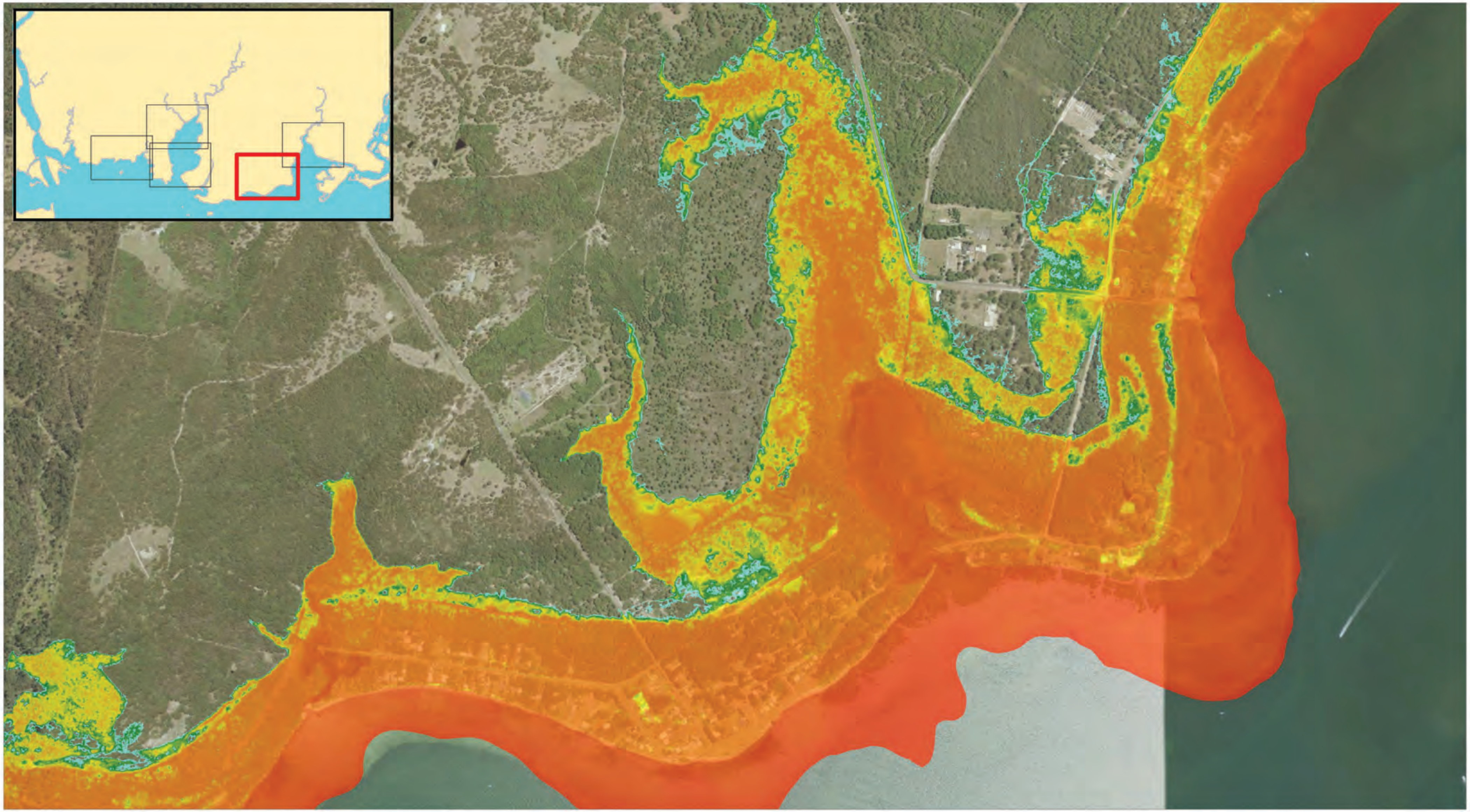
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D14_depth_class_extSWL_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Extreme Still Water Level Modelled Depth, 0.91 m Sea Level Rise Pindimar South

Figure: **D-15**

Rev: **A**

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N

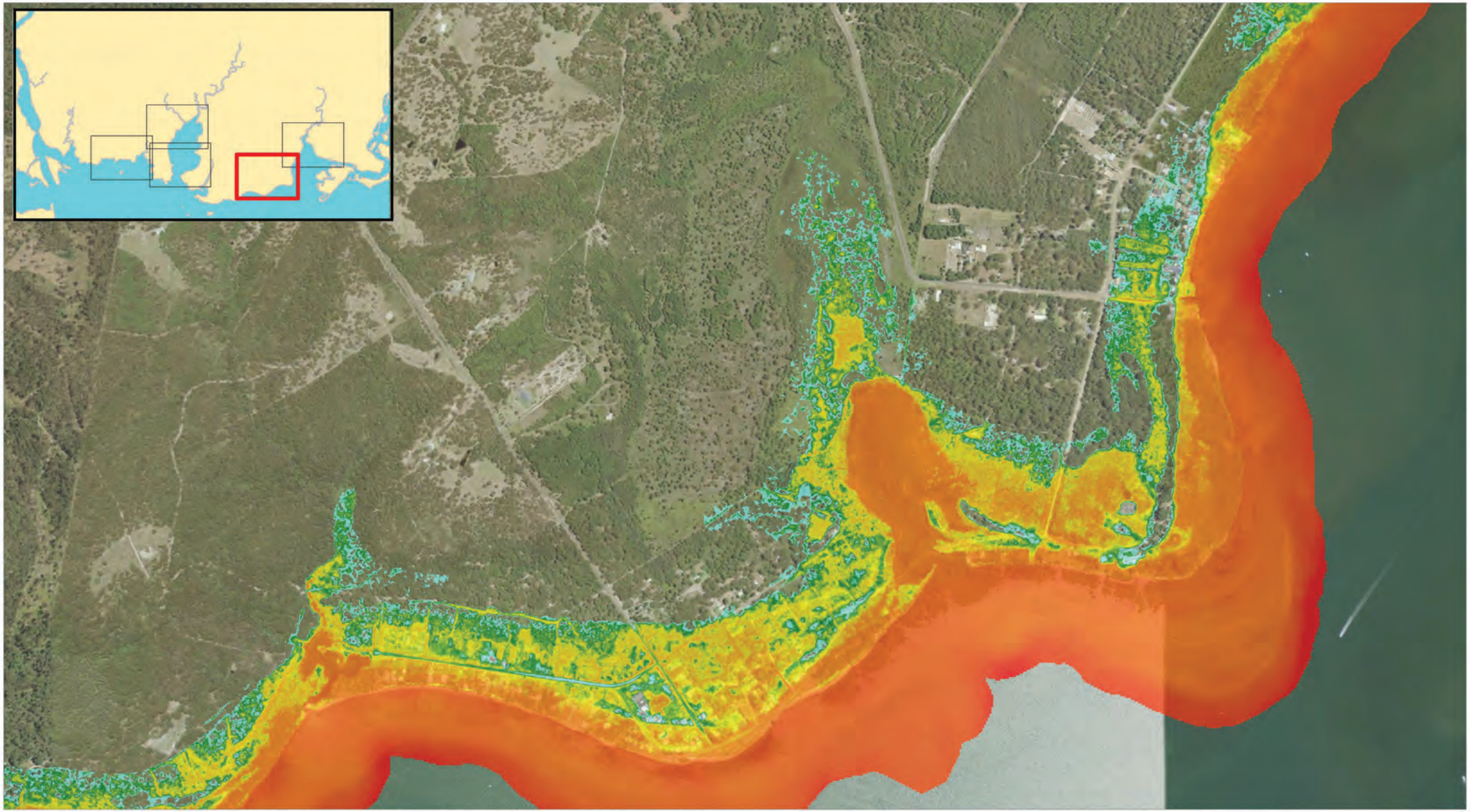
0 250 500m

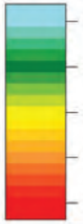
Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D15_depth_class_extSWL_0p91SLR.wor"





LEGEND

Peak Flood Depth (m)

Title:

Extreme Wave Runup Level Modelled Depth, 0 m Sea Level Rise Pindimar South

Figure: **D16**

Rev: **A**

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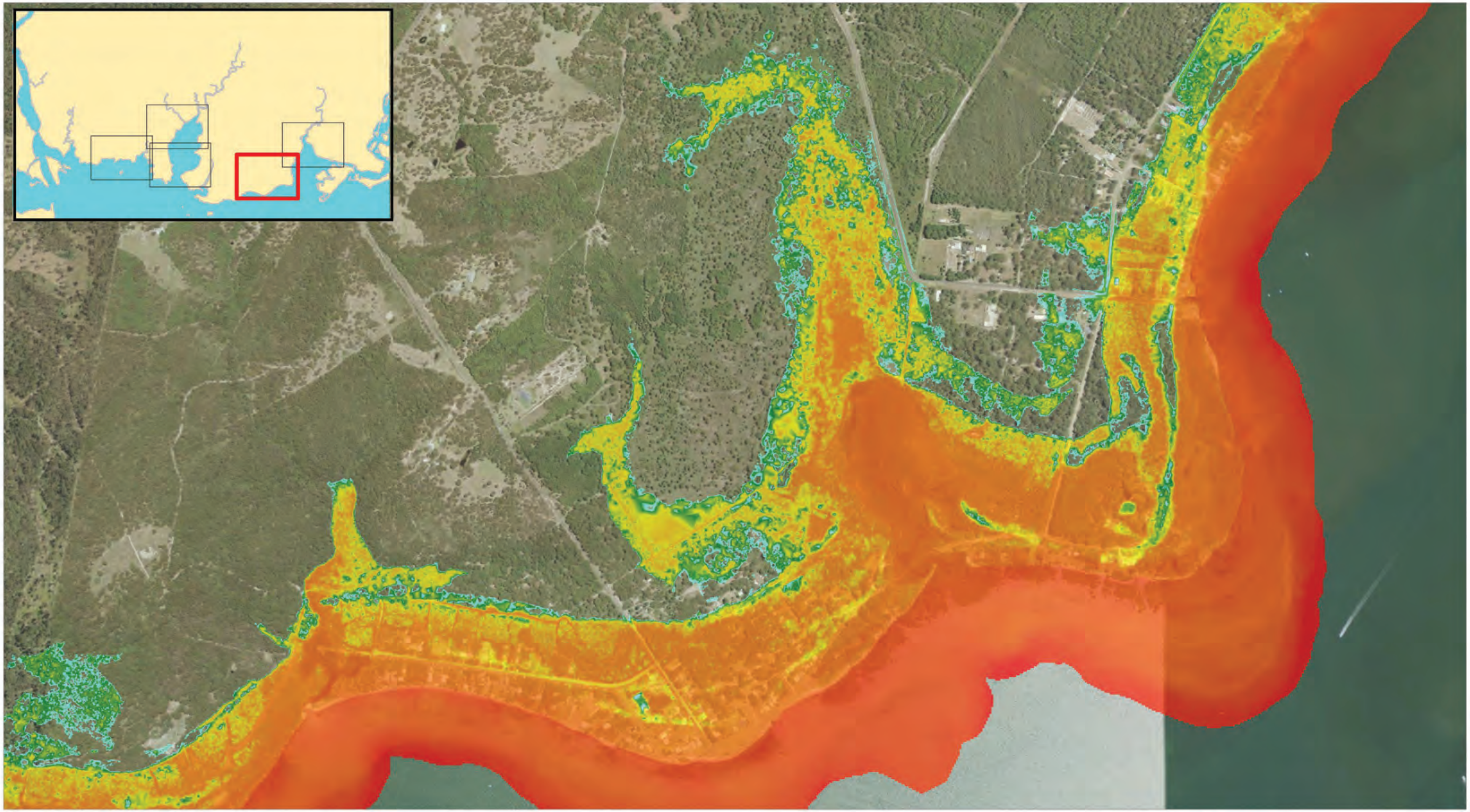
N

0 250 500m

Approx. Scale

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D16_depth_class_extWRH_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0 higher depths mapped as same colour
- 5.0

Title:

Extreme Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise Pindimar South

Figure: D-17

Rev: A

N

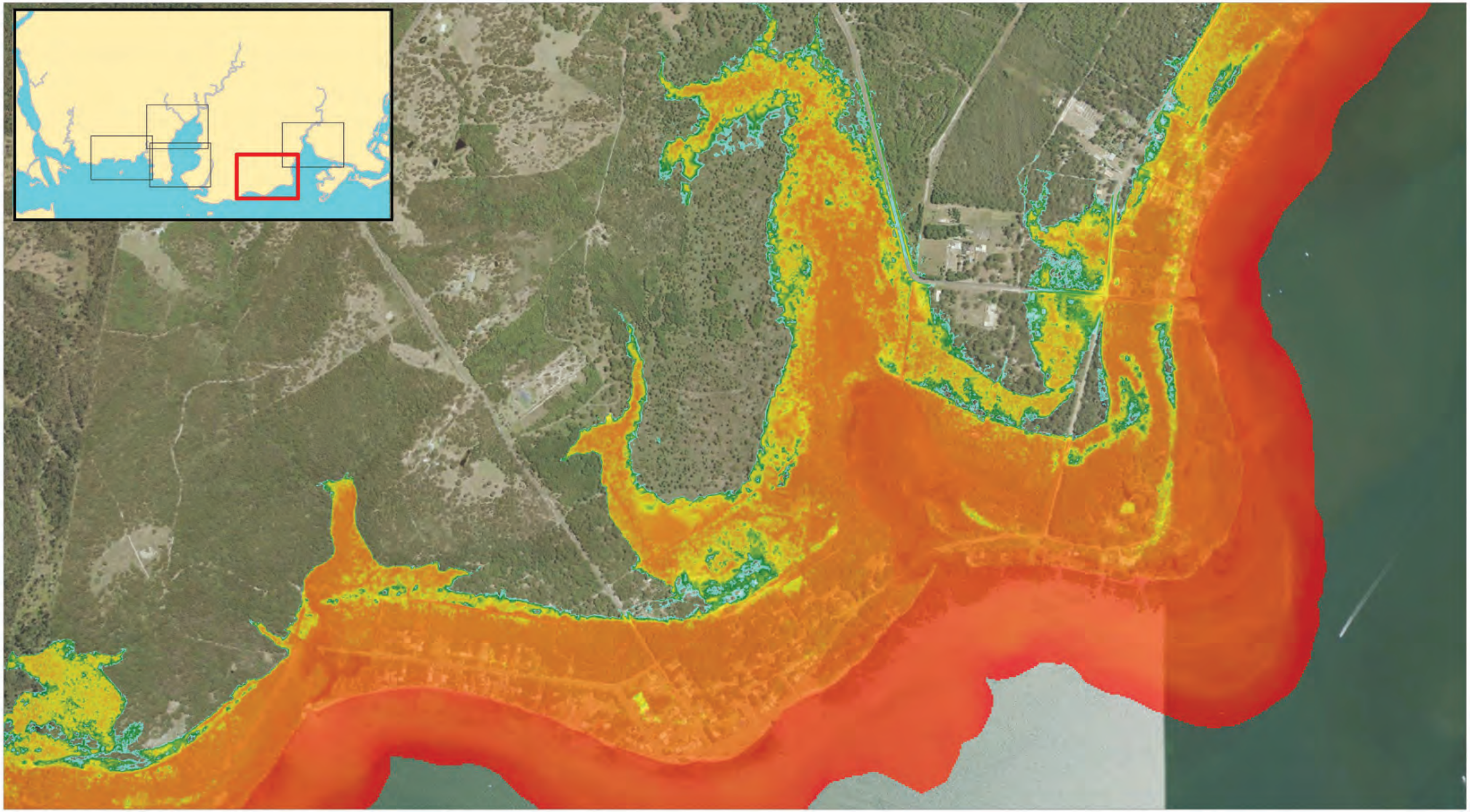
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D17_depth_class_extWRH_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

Depth (m)	
0.1	lower depths mapped as same colour
0.2	
0.5	
1.0	
5.0	higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise Pindimar South

Figure: **D-18**

Rev: **A**

N

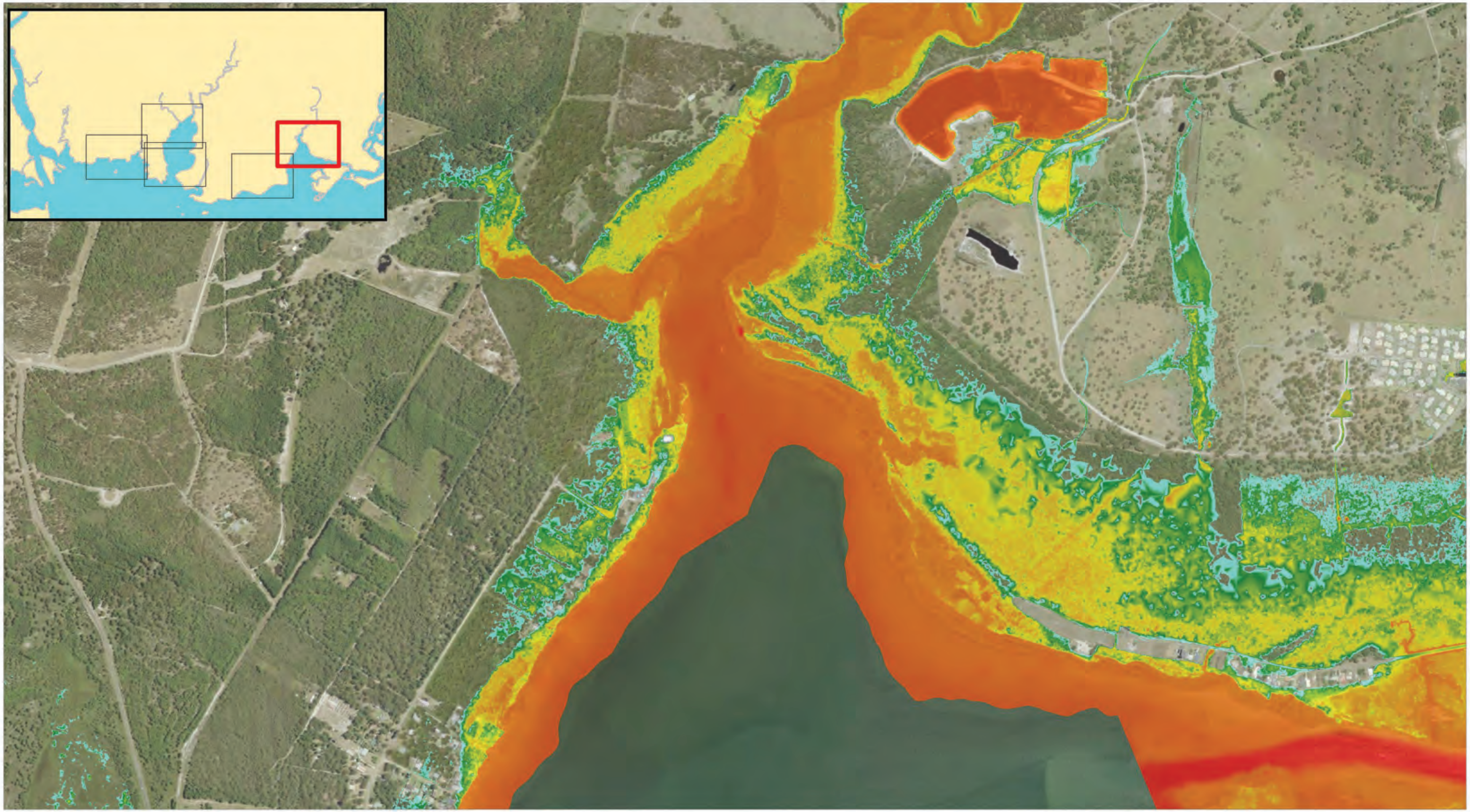
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_D18_depth_class_extWRH_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Pindimar Bay

Figure: **E-01**

Rev: **A**

N

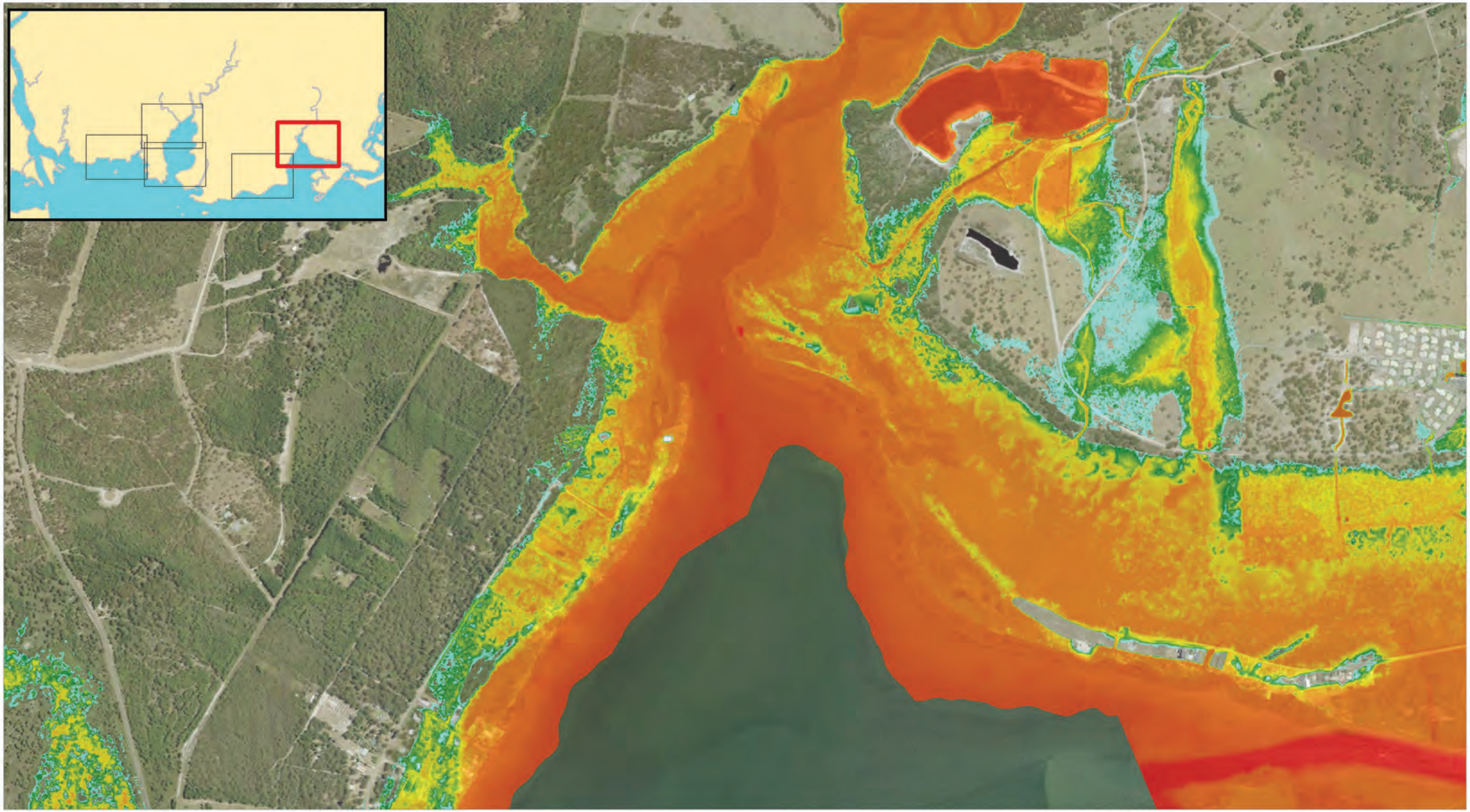
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E01_depth_class_20ySWL_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

0.1	lower depths mapped as same colour
0.2	
0.5	
1.0	
2.0	higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Pindimar Bay

Figure: E-02

Rev: A

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N

0 250 500m

Approx. Scale

BMT

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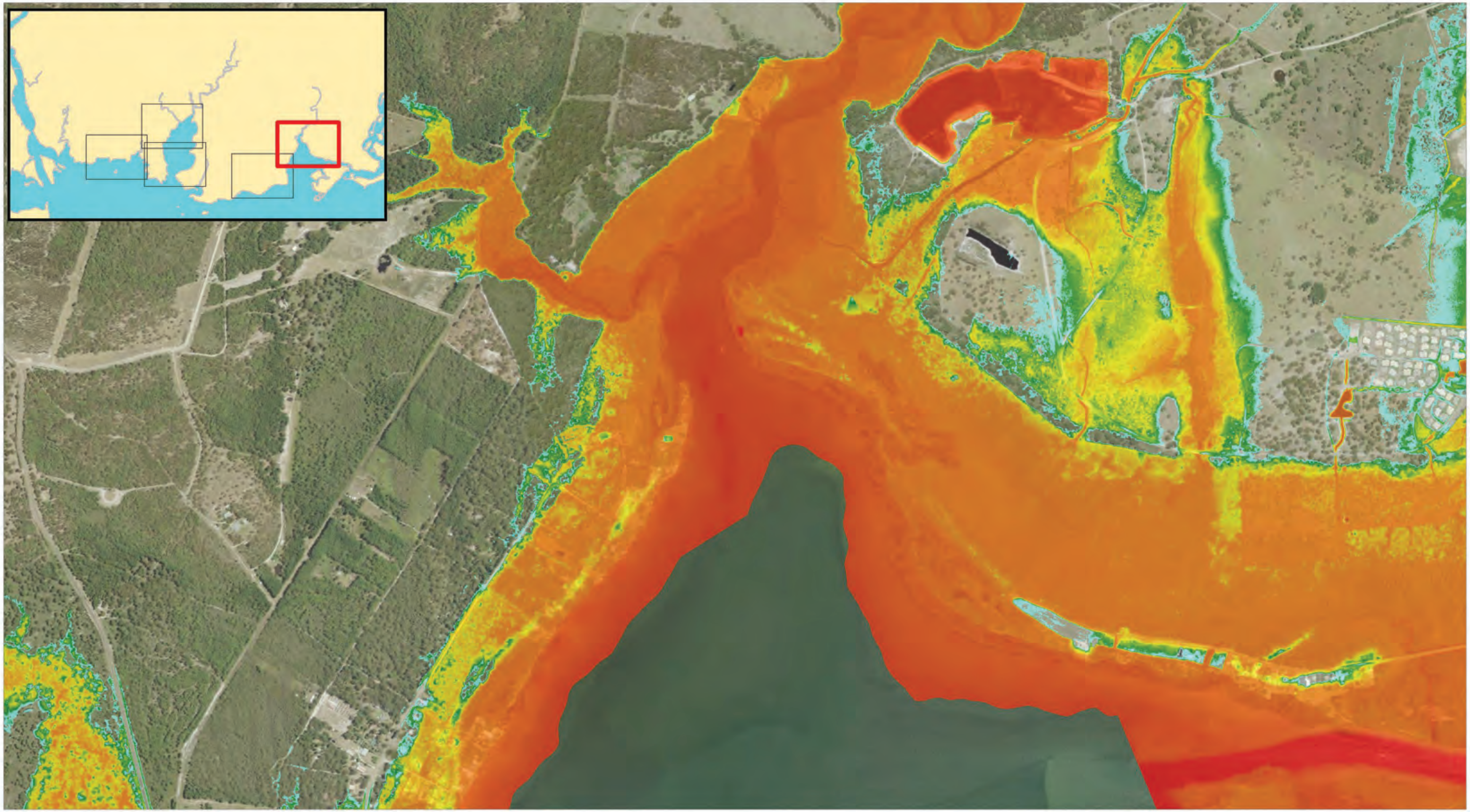
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E02_depth_class_20ySWL_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

5% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **E-03**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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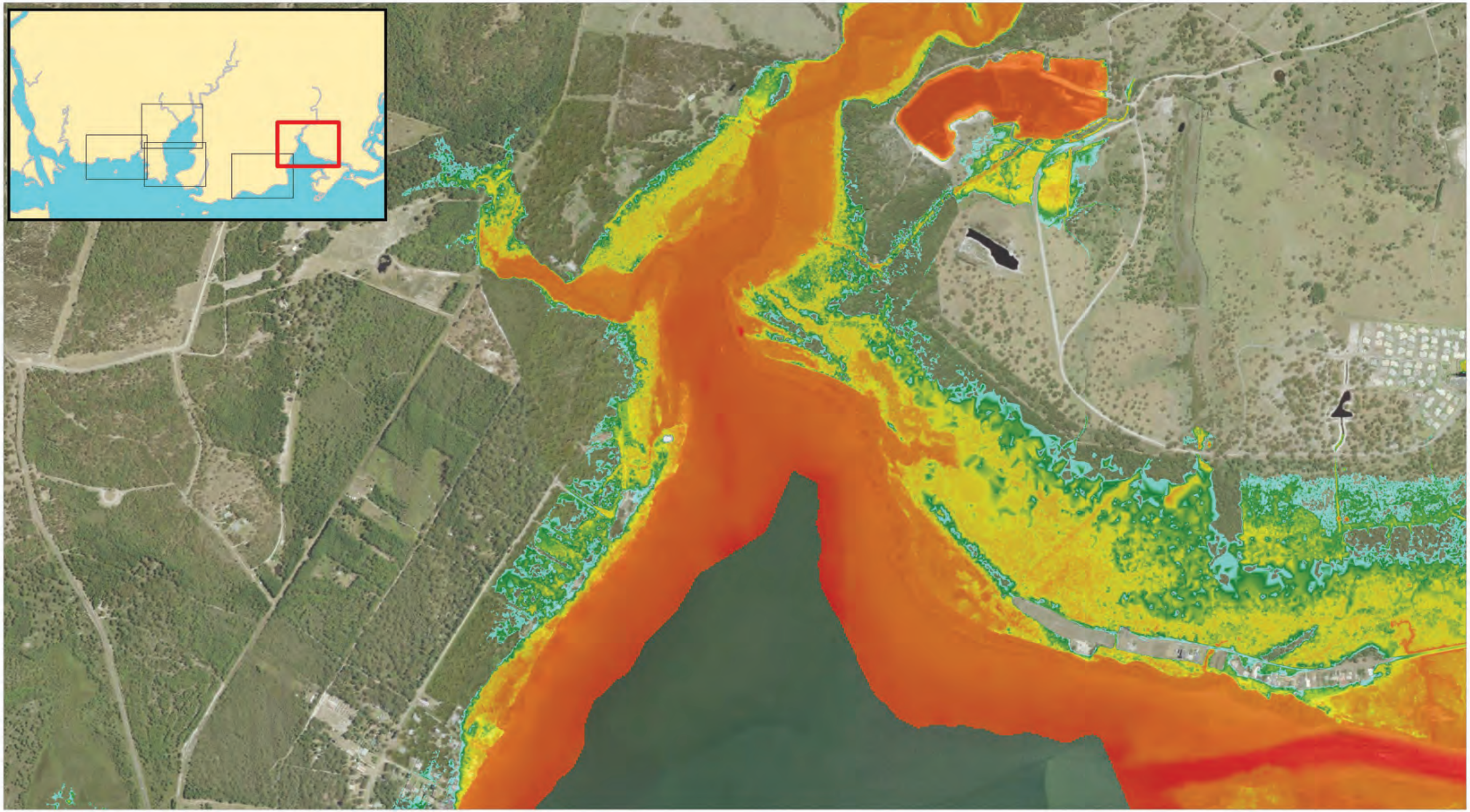
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E03_depth_class_20ySWL_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Pindimar Bay

Figure: **E-04**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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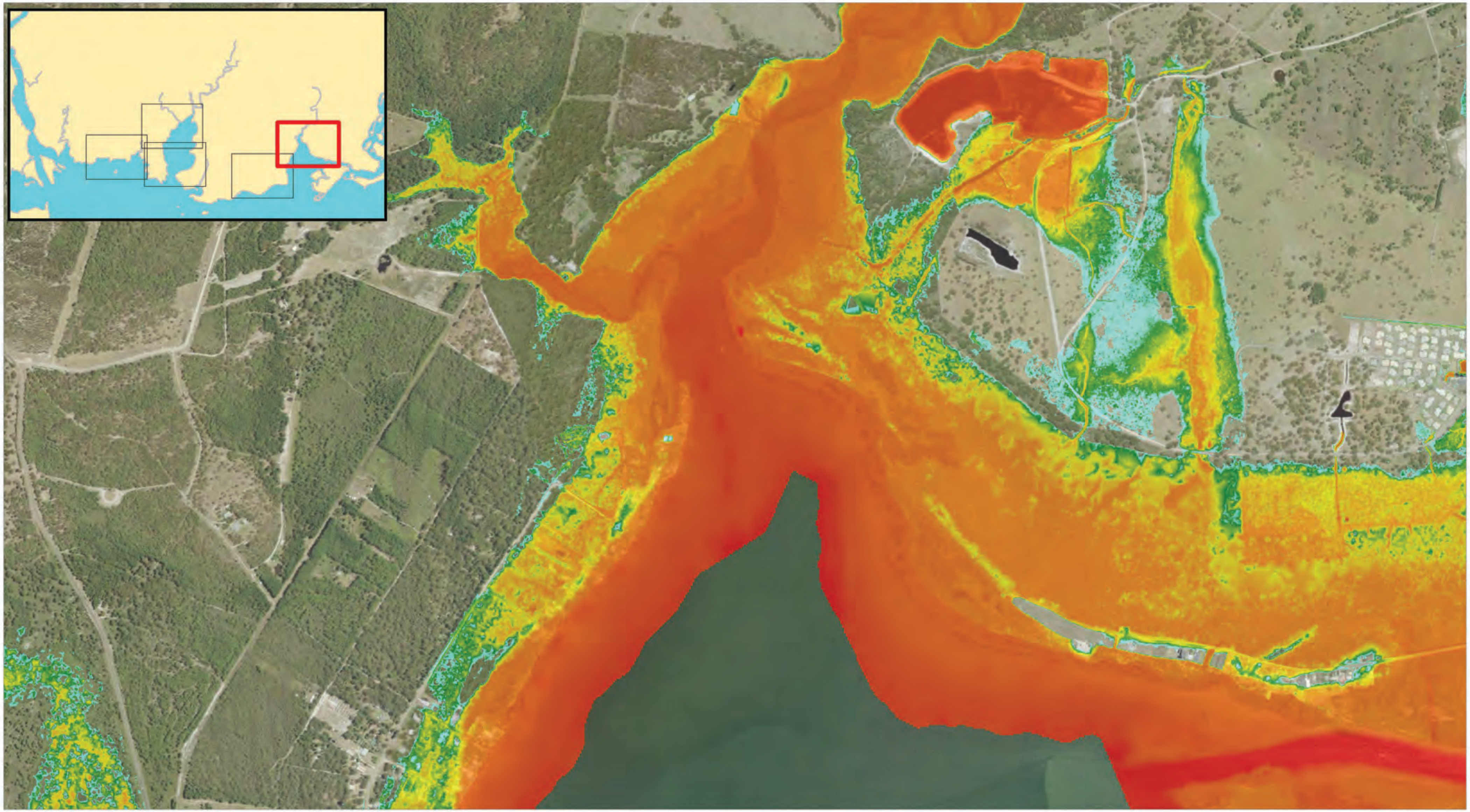
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E04_depth_class_20yWRH_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Pindimar Bay

Figure: E-05

Rev: A

N

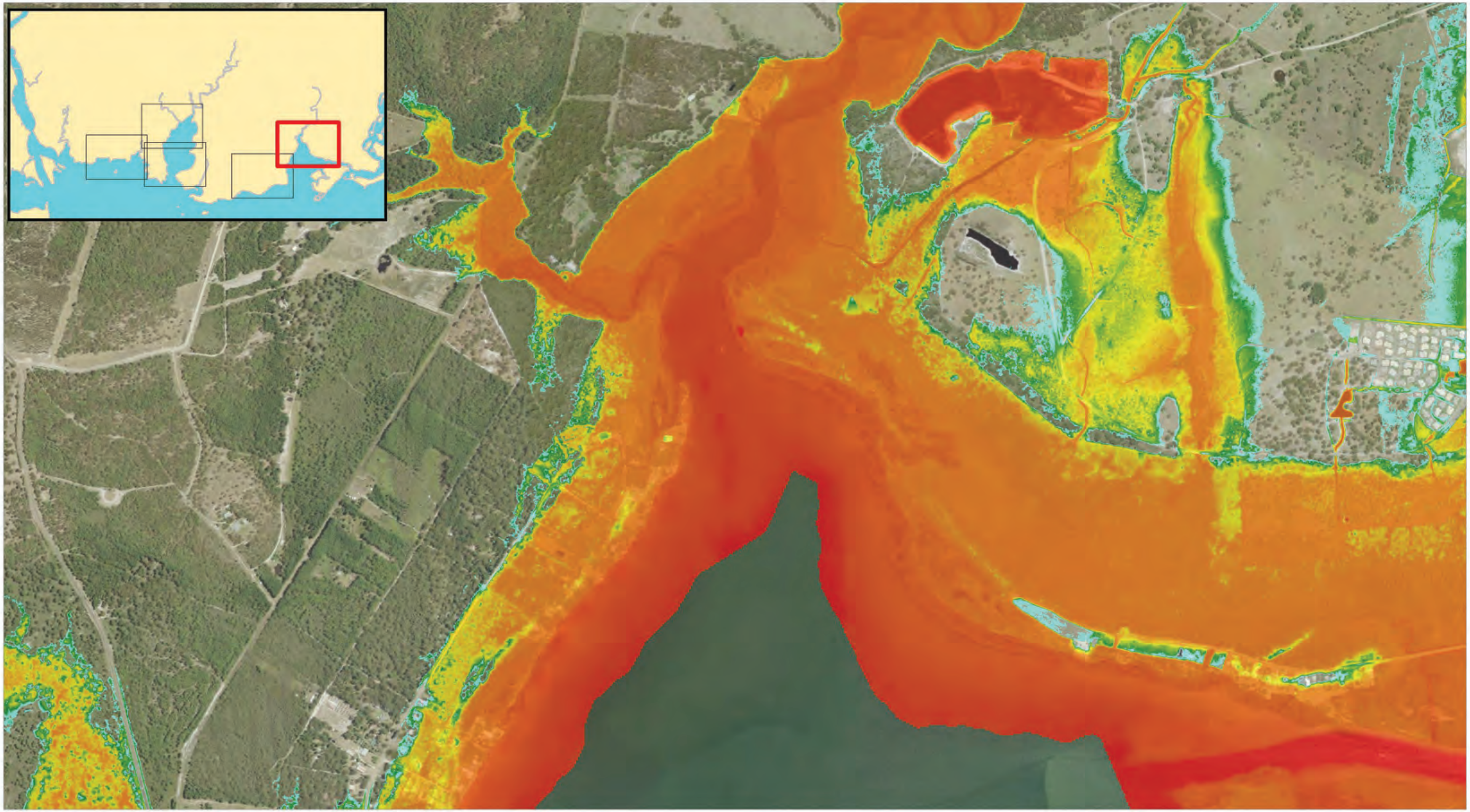
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E-05_depth_class_20yWRH_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

5% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Pindimar Bay

Figure: E-06

Rev: A

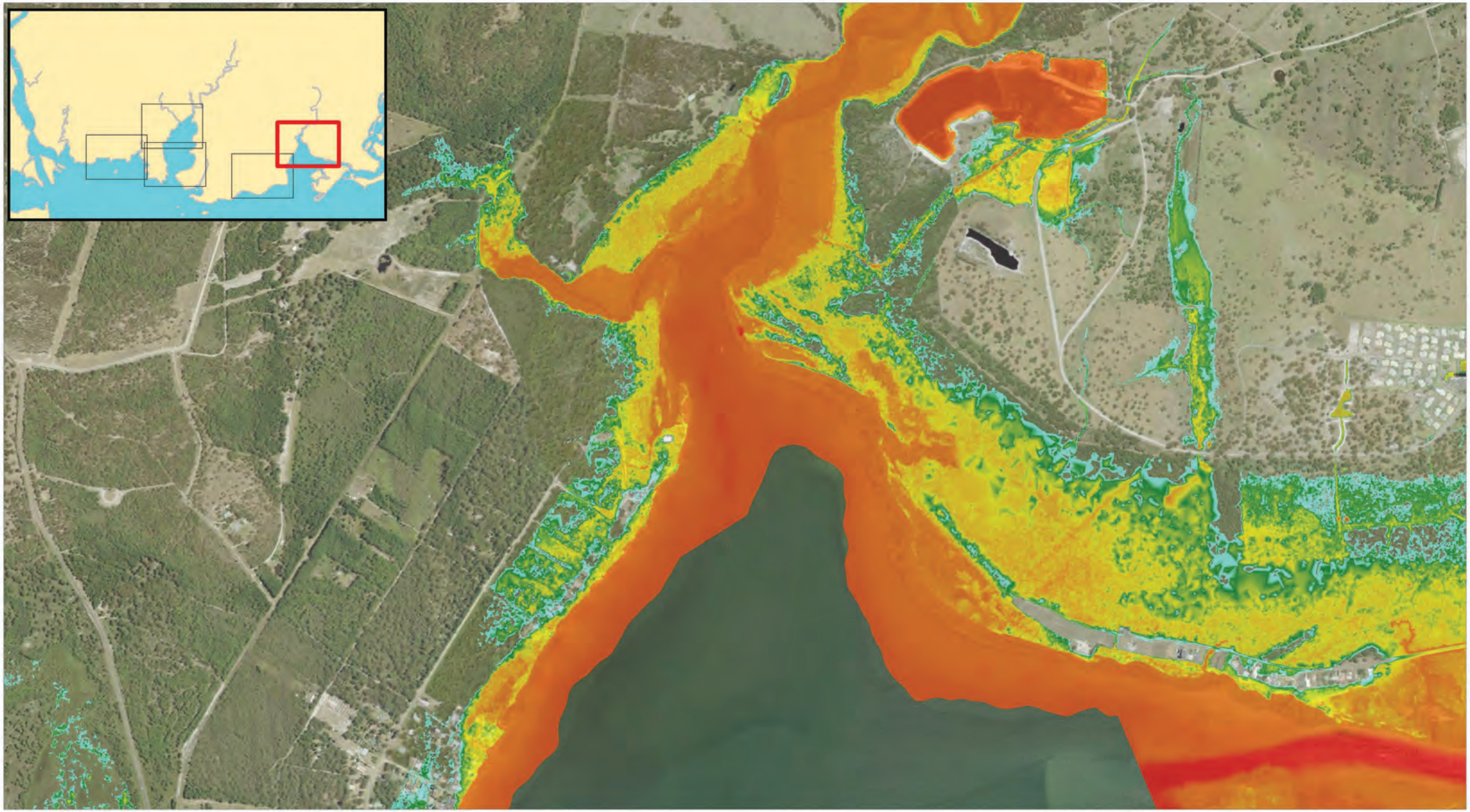
N

0 250 500m

Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E06_depth_class_20yWRH_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 — lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 — higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0 m Sea Level Rise - Pindimar Bay

Figure: **E-07**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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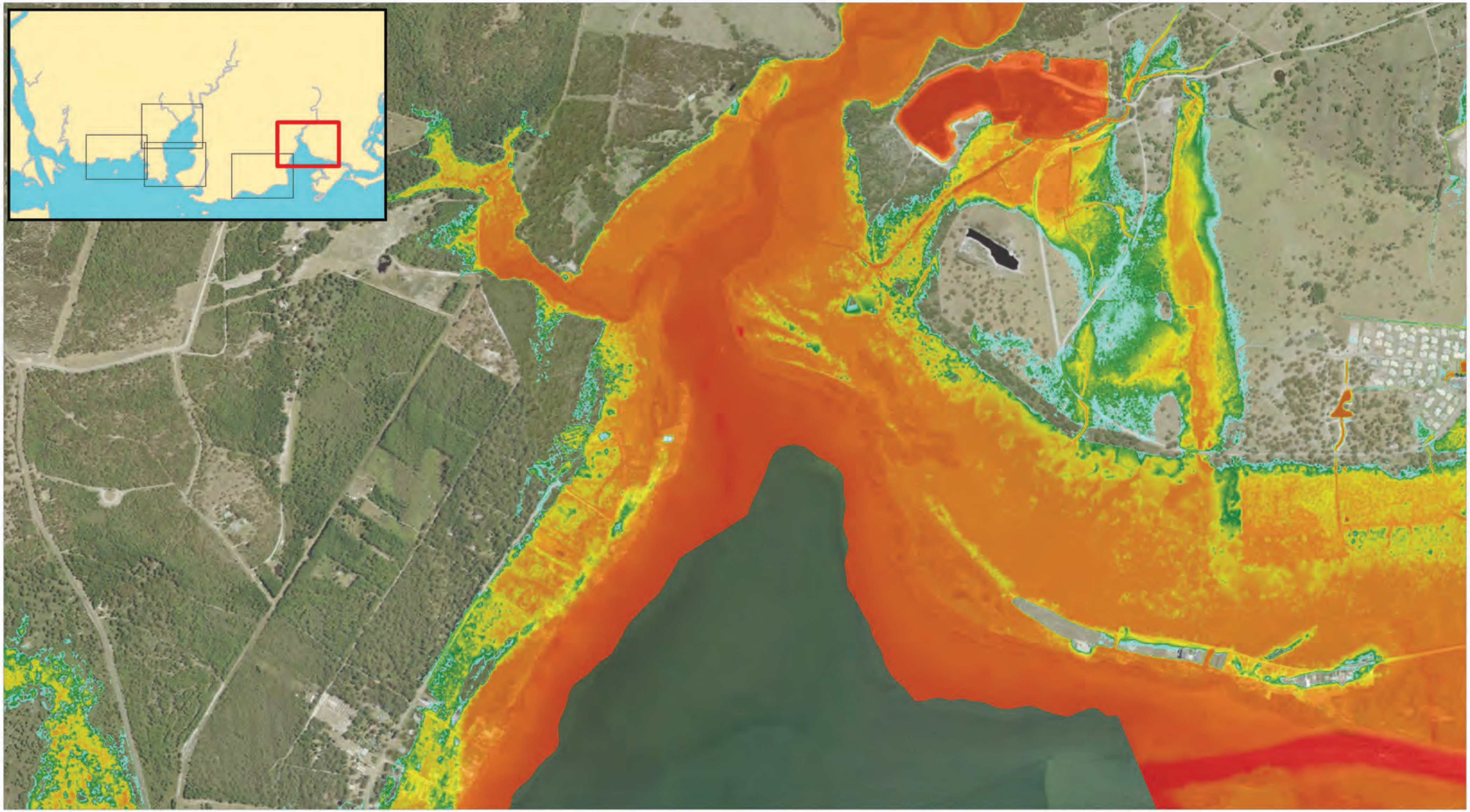
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E07_depth_class_100ySWL_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Pindimar Bay

Figure: **E-08**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT
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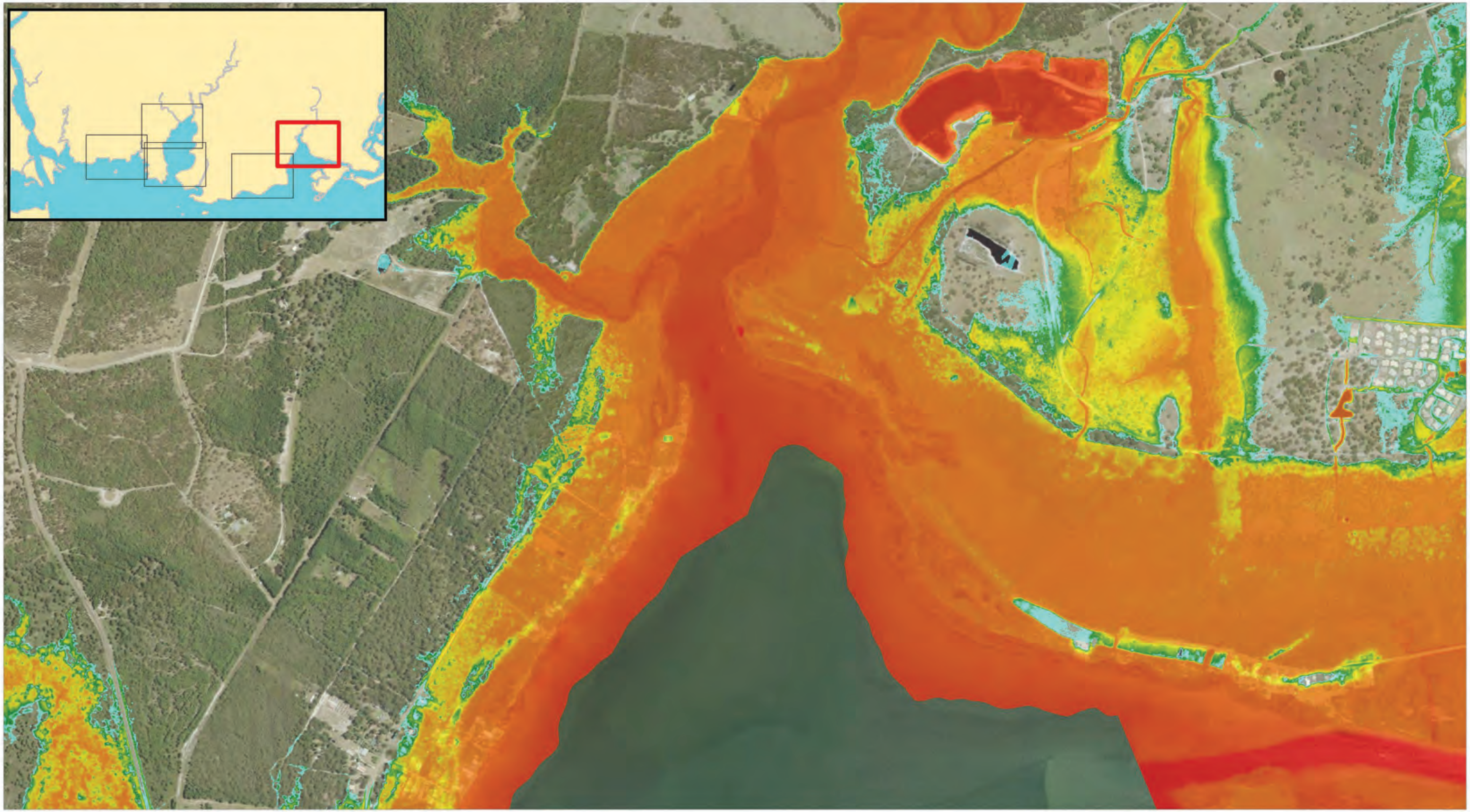
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E08_depth_class_100ySWL_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

1% AEP Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **E-09**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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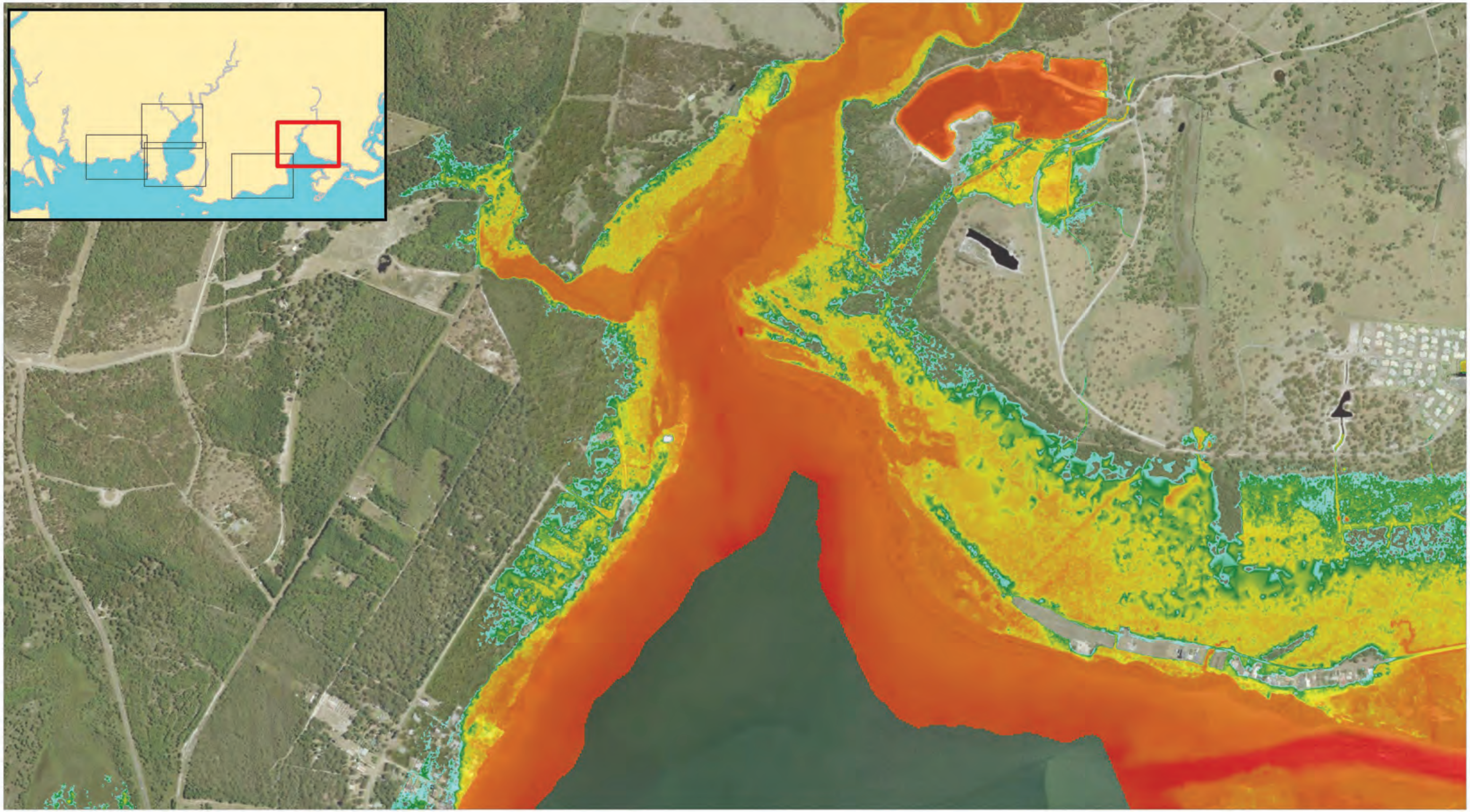
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E09_depth_class_100ySWL_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Pindimar Bay

Figure: **E-10**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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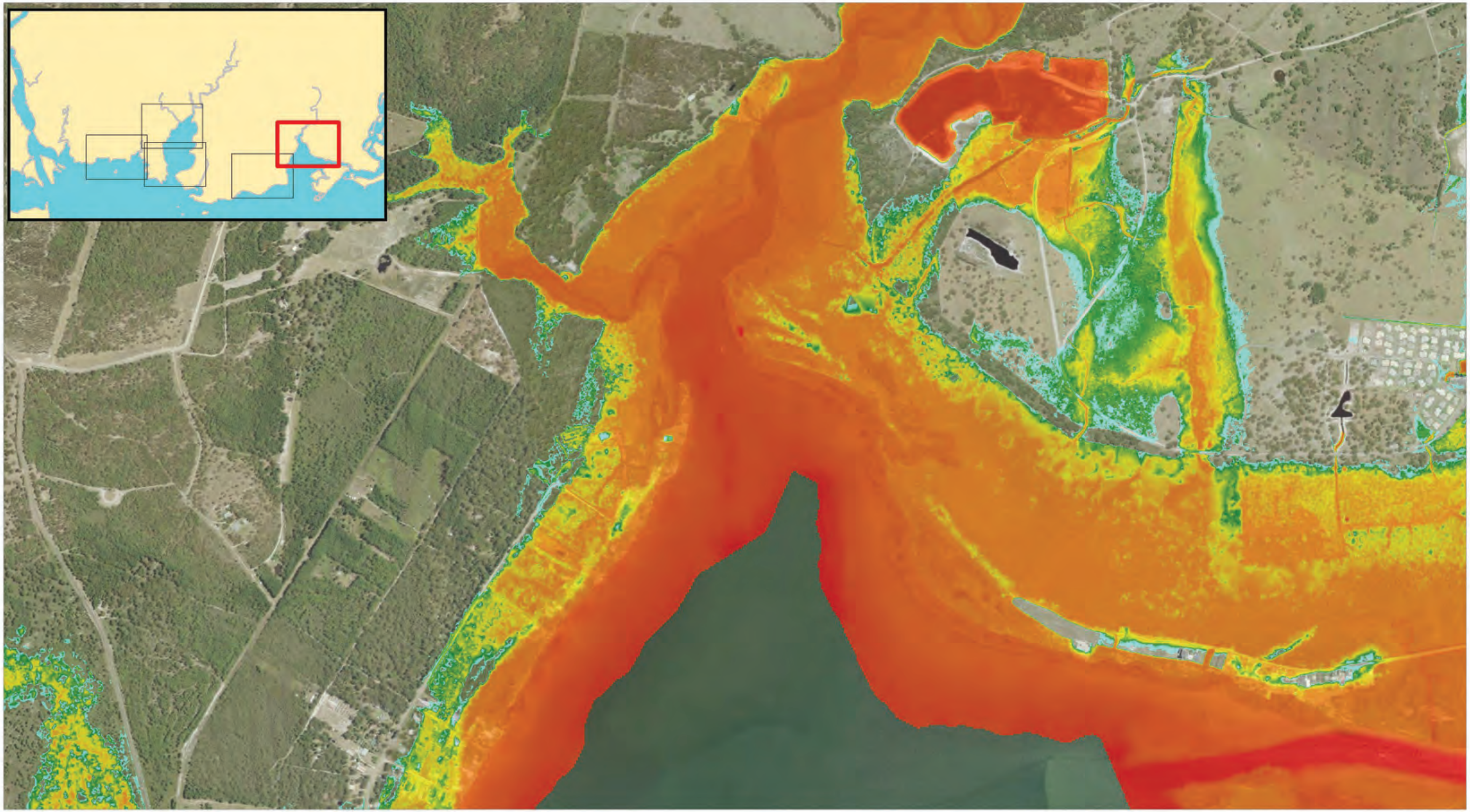
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E10_depth_class_100yWRH_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Pindimar Bay

Figure: **E-11**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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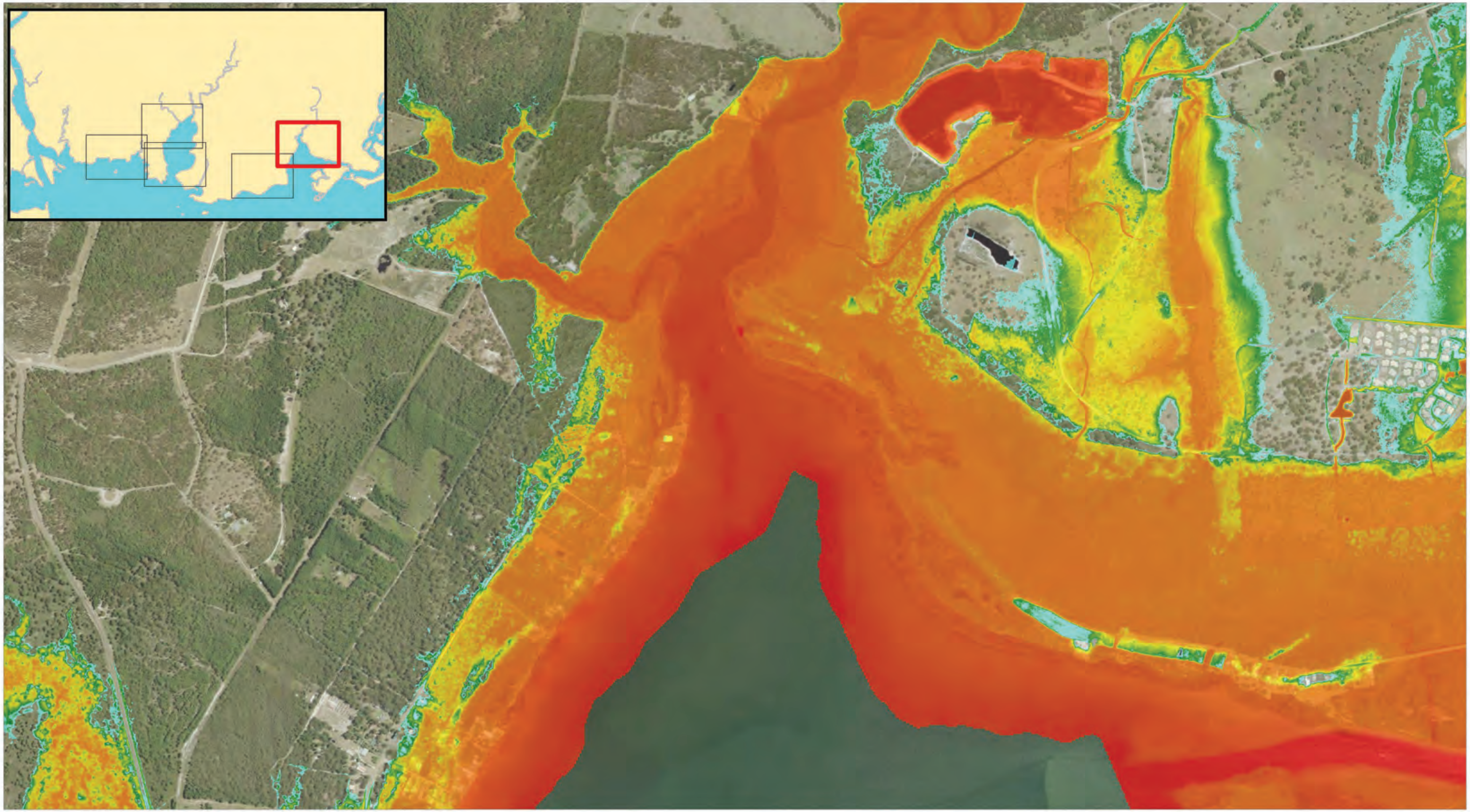
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E11_depth_class_100yWRH_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

1% AEP Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **E-12**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT
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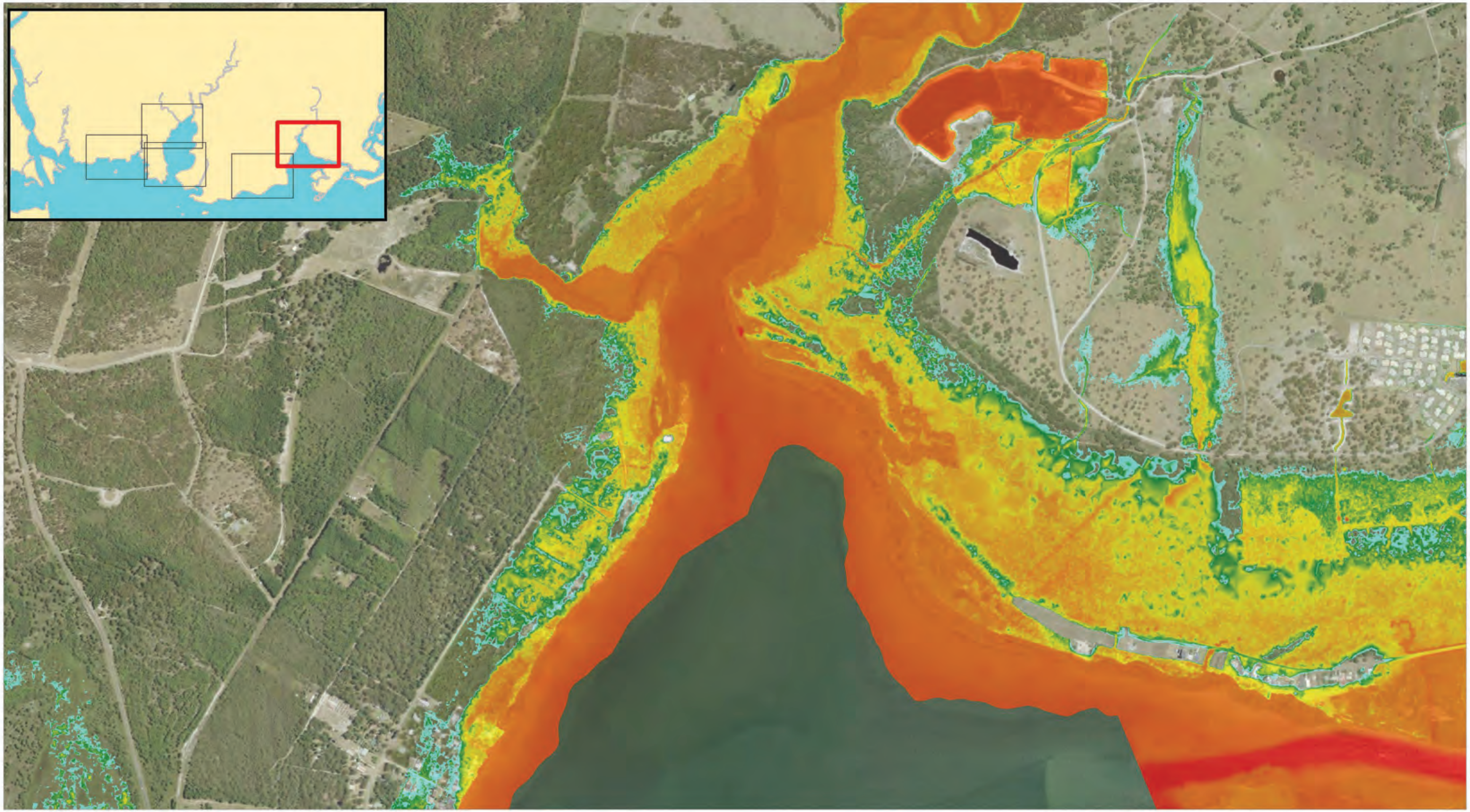
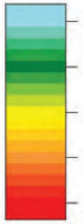
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E12_depth_class_100yWRH_0p91SLR.wor"



LEGEND

Peak Flood Depth (m)



Title:

Extreme Still Water Level Modelled Depth, 0 m Sea Level Rise - Pindimar Bay

Figure: **E-13**

Rev: **A**

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N

0 250 500m

Approx. Scale

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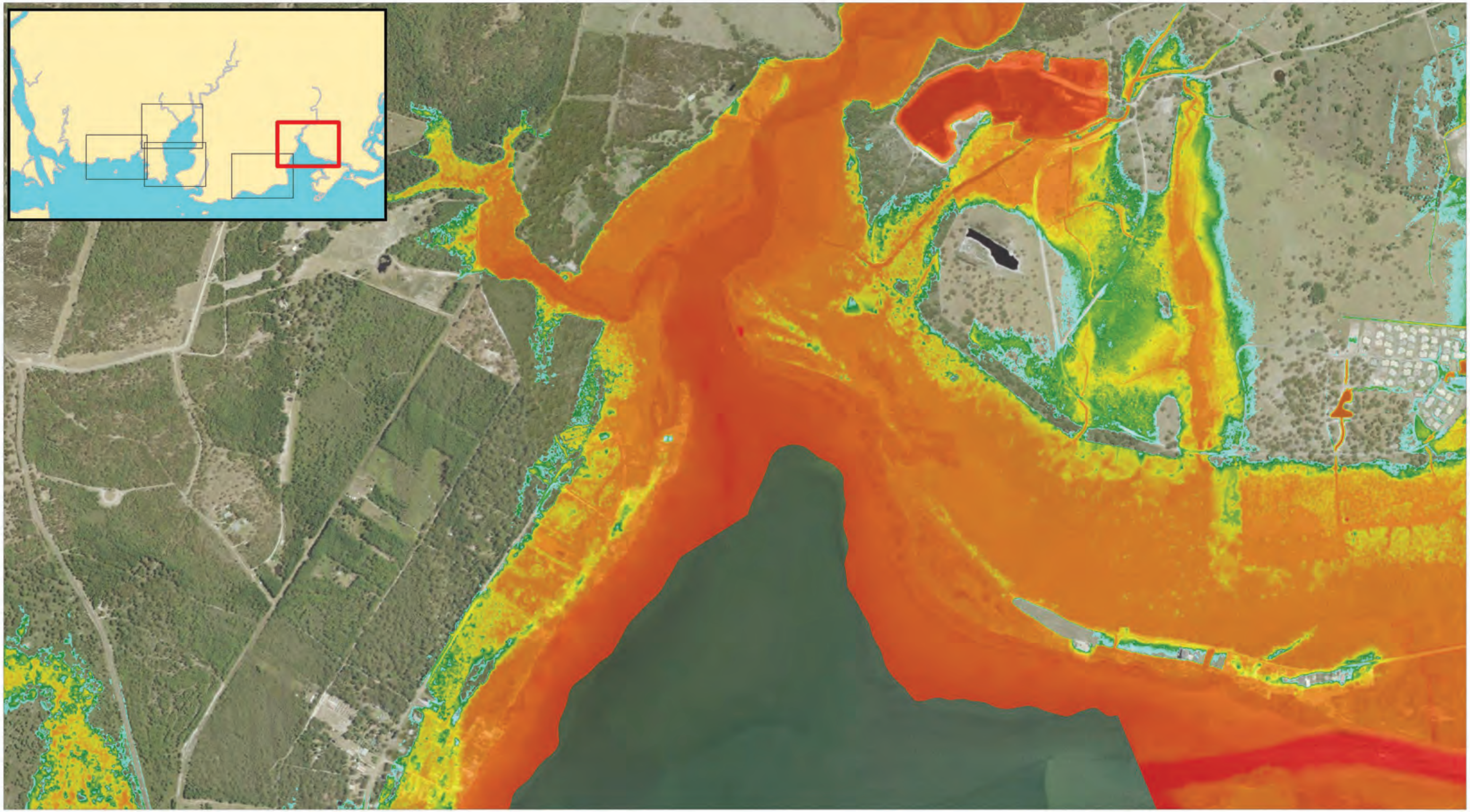
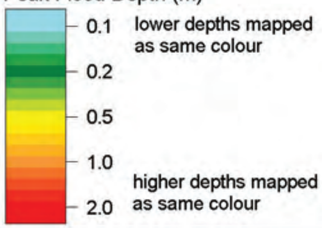
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E13_depth_class_extSWL_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)



Title:

Extreme Still Water Level Modelled Depth, 0.55 m Sea Level Rise - Pindimar Bay

Figure: **E-14**

Rev: **A**

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N

0 250 500m

Approx. Scale

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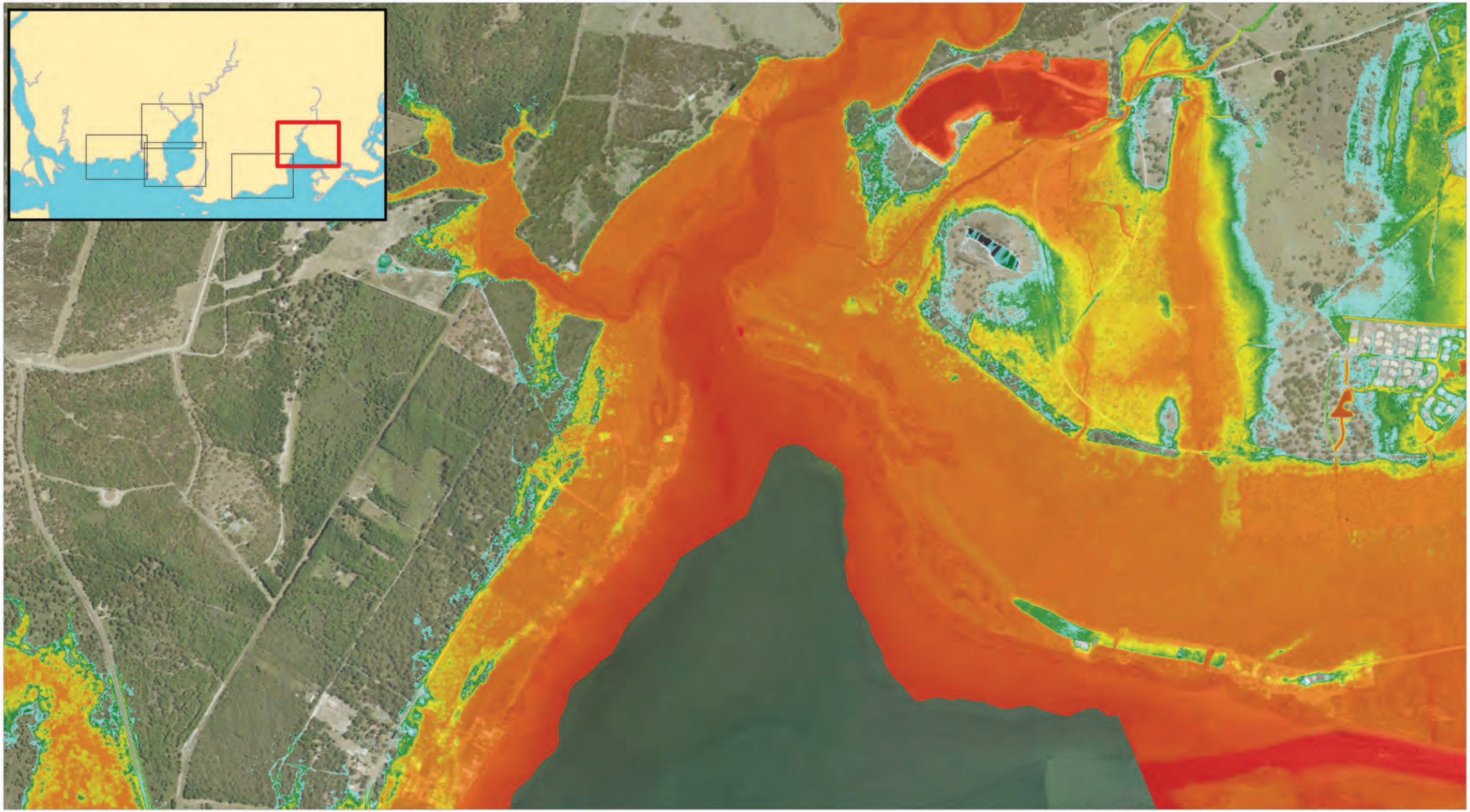
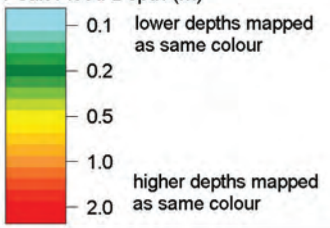
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E14_depth_class_extSWL_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)



Title:

Extreme Still Water Level Modelled Depth, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **E-15**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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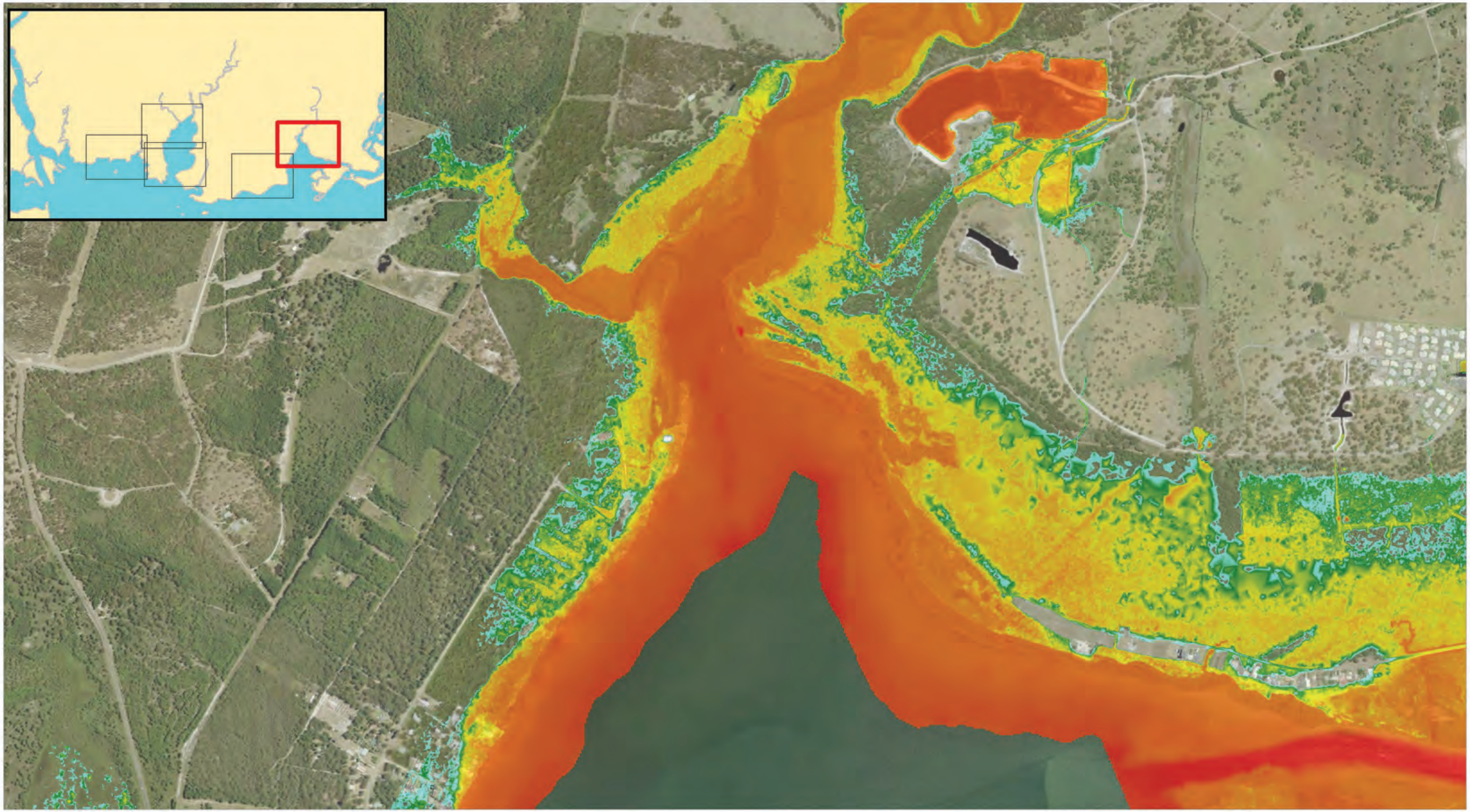

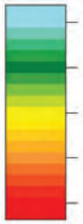

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0 m Sea Level Rise - Pindimar Bay

Figure: **E-16**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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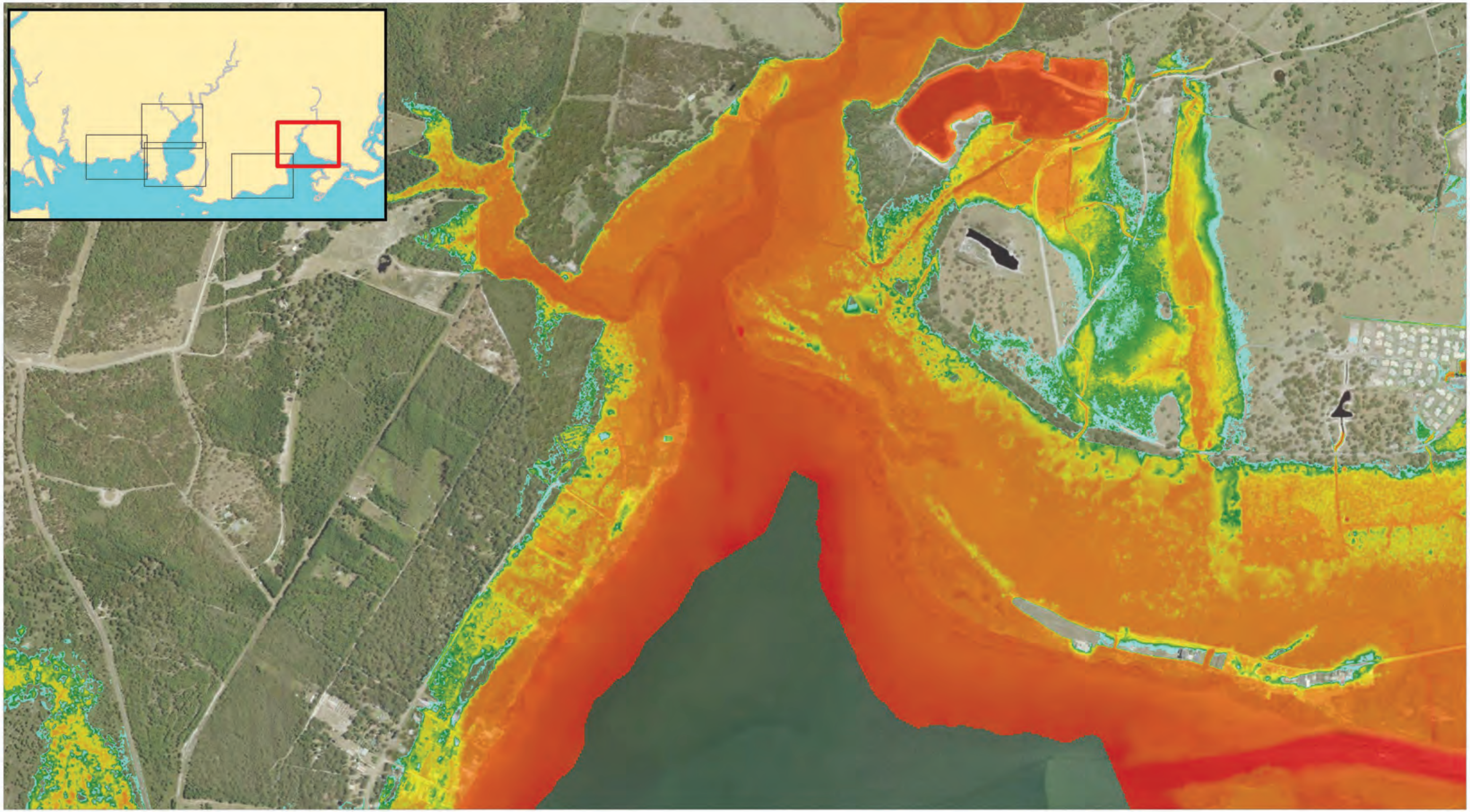
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E16_depth_class_extWRH_0p0SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.55 m Sea Level Rise - Pindimar Bay

Figure: **E-17**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT
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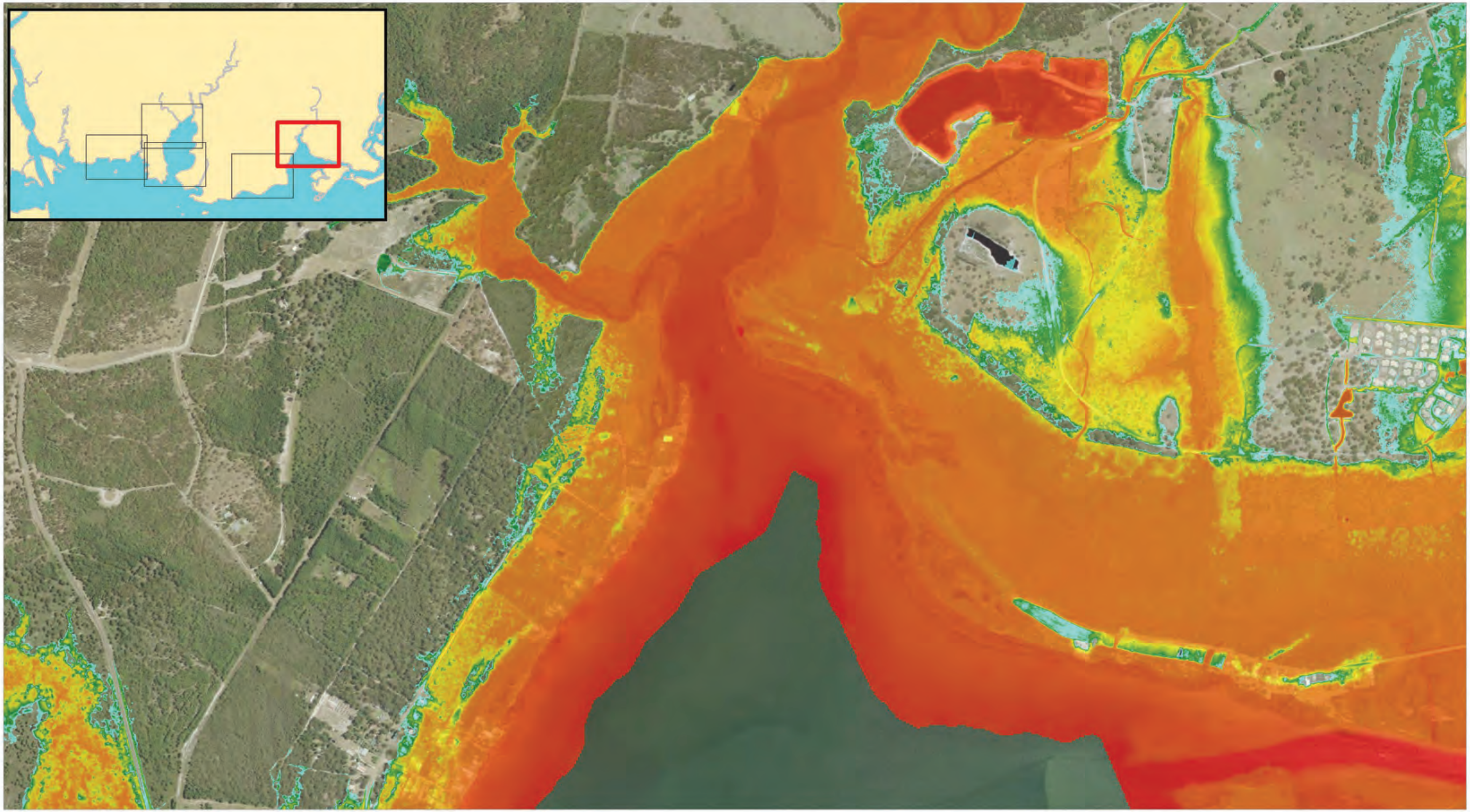
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E17_depth_class_extWRH_0p55SLR.wor"



LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 2.0 higher depths mapped as same colour

Title:

Extreme Wave Runup Level Modelled Depth, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **E-18**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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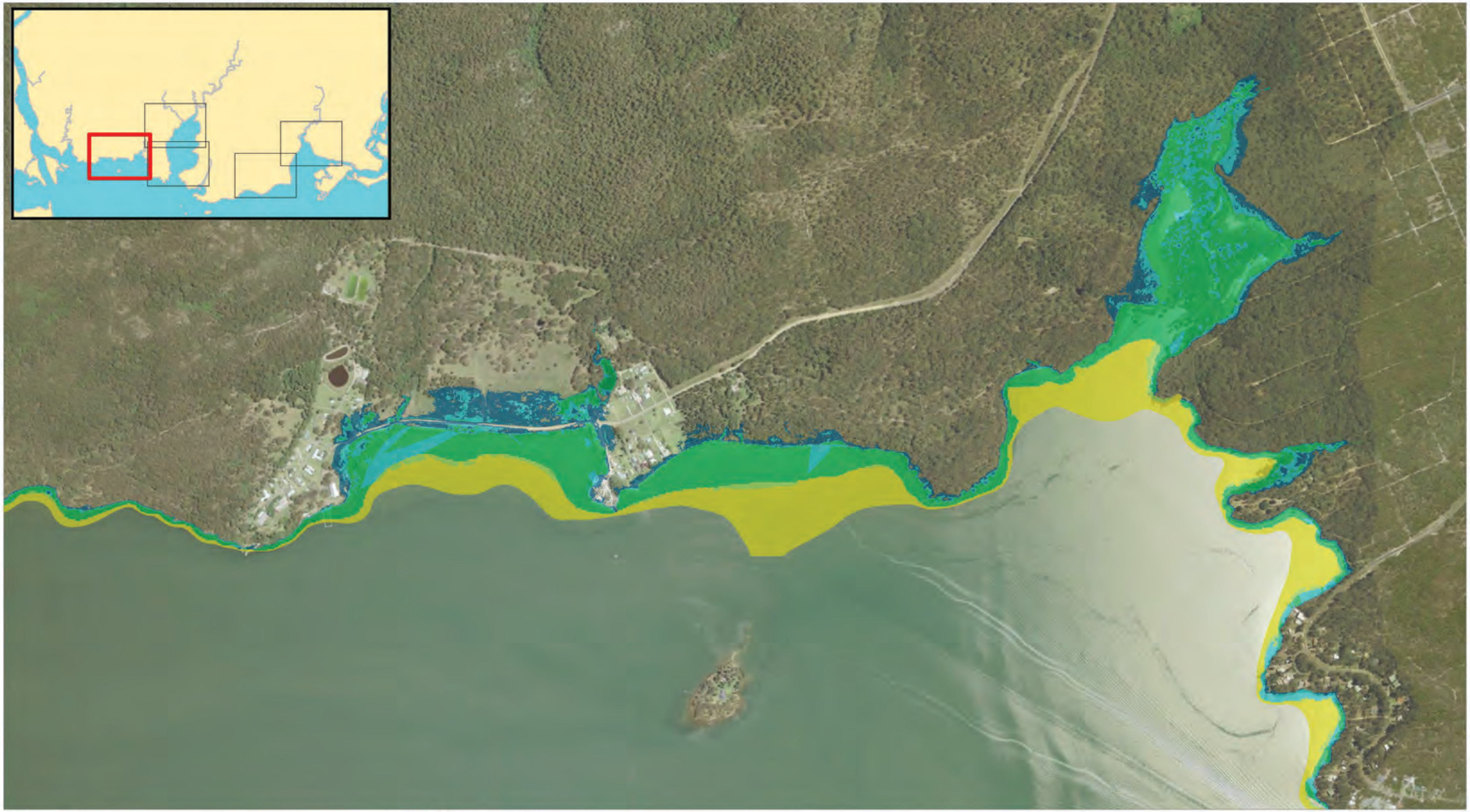
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Depth\DRG_E18_depth_class_extWRH_0p91SLR.wor"

Appendix D Hazard Mapping



LEGEND
Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **F-01**

Rev: **A**

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N

0 250 500m
Approx. Scale

BMT
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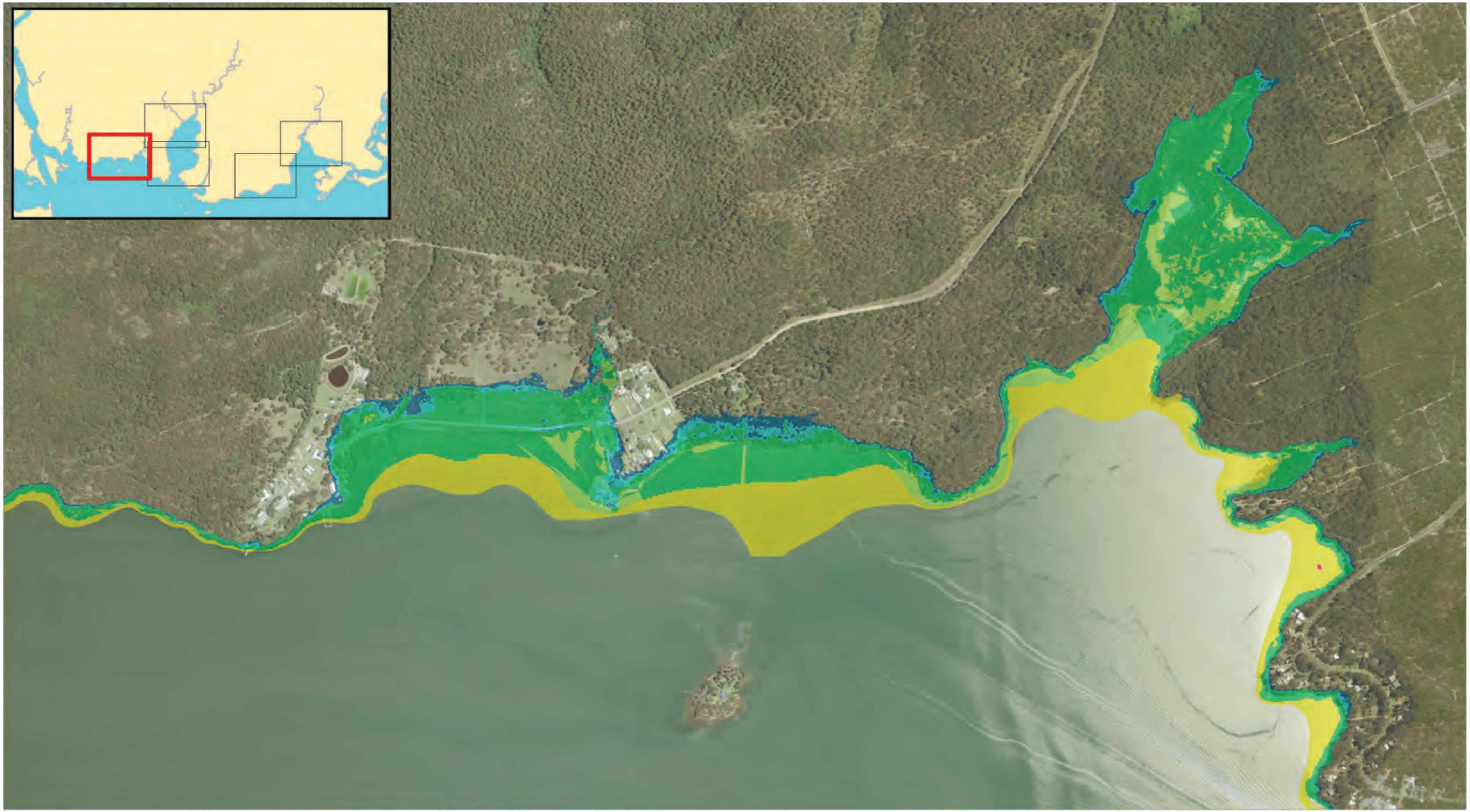
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F01_hazard_class_20ySWL_0p0SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **F-02**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

BMT

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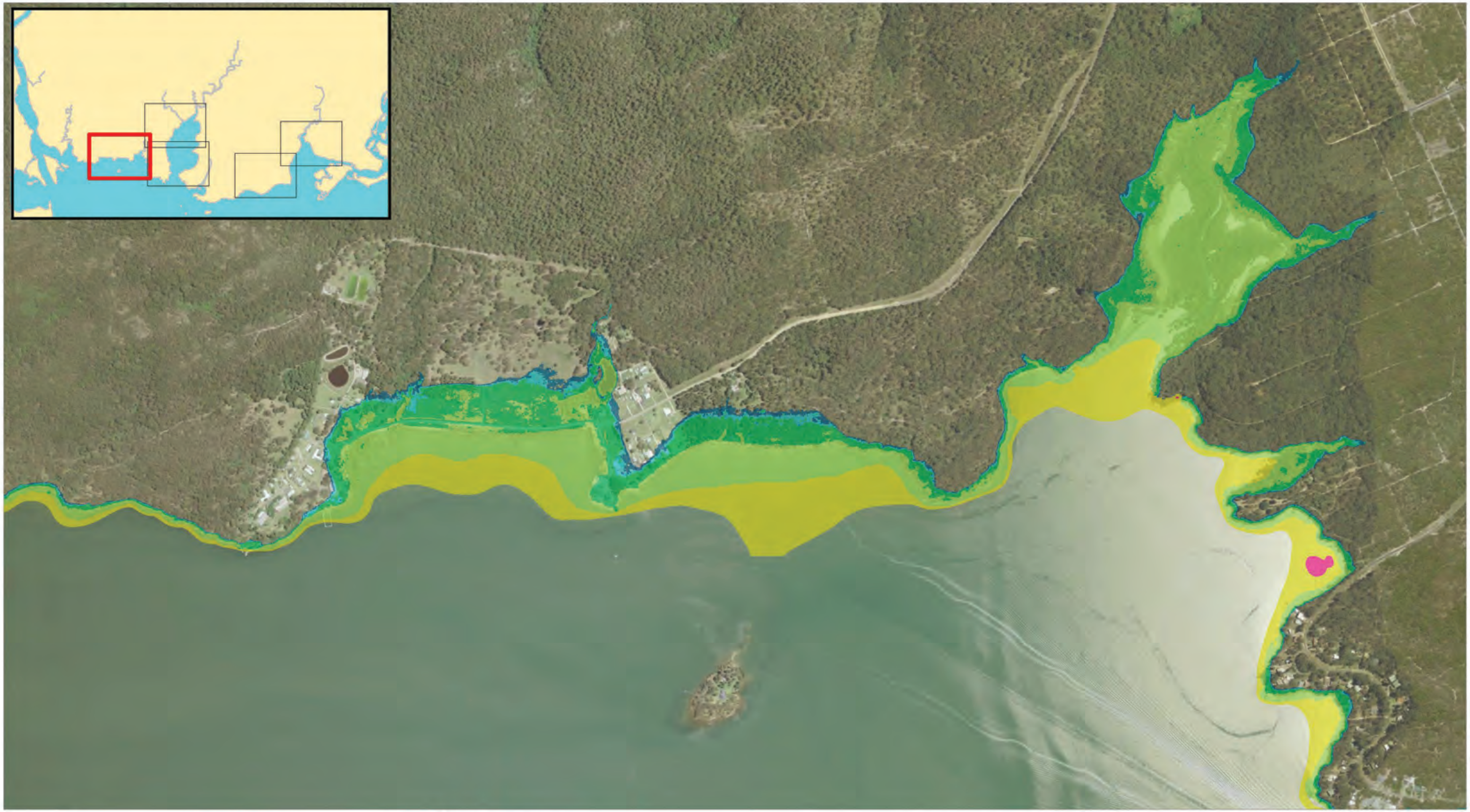

LEGEND

Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **F-03**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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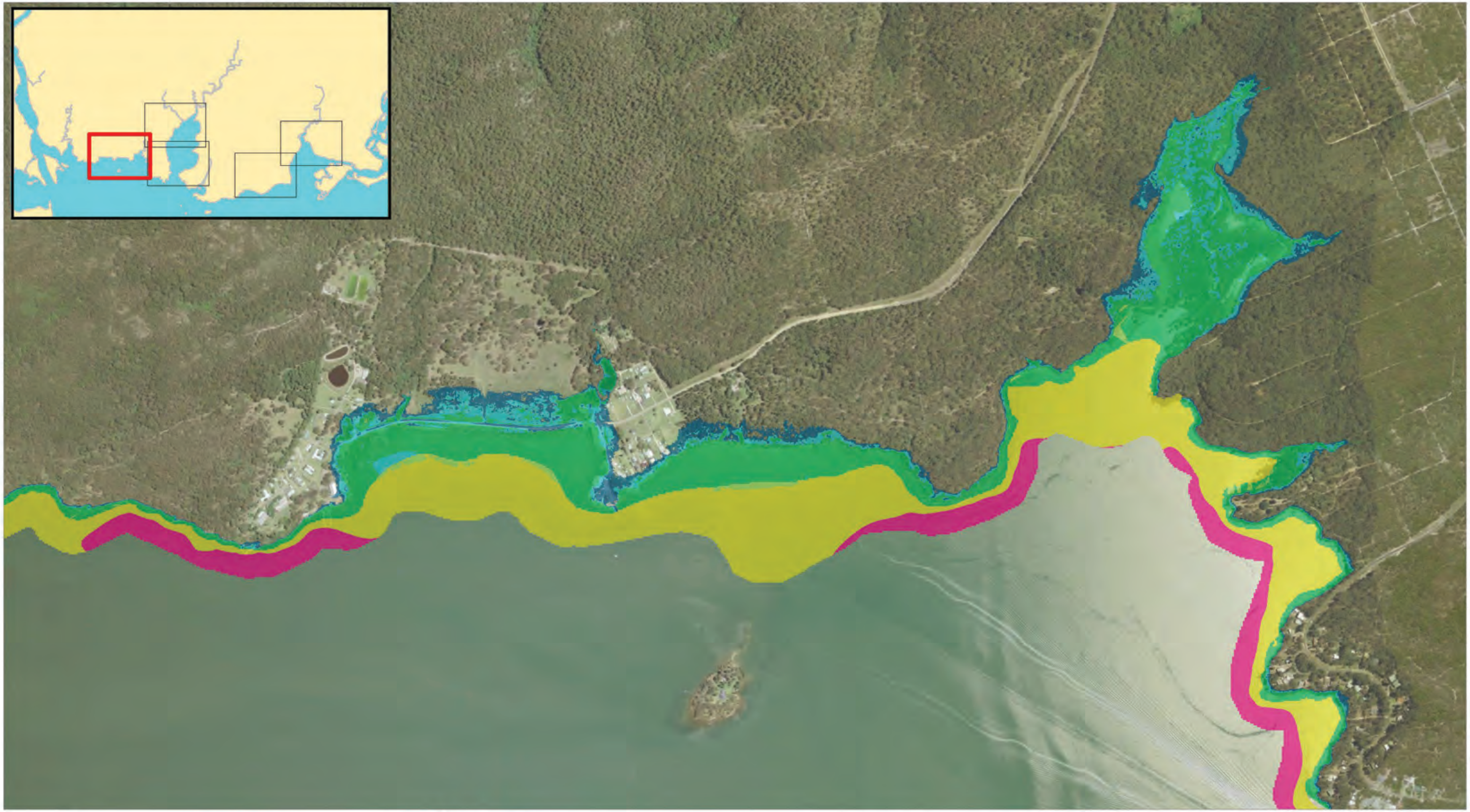
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F03_hazard_class_20ySWL_0p91SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

5% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Tahlee to Carrington

Figure: F-04

Rev: A

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N

0 250 500m

Approx. Scale

BMT

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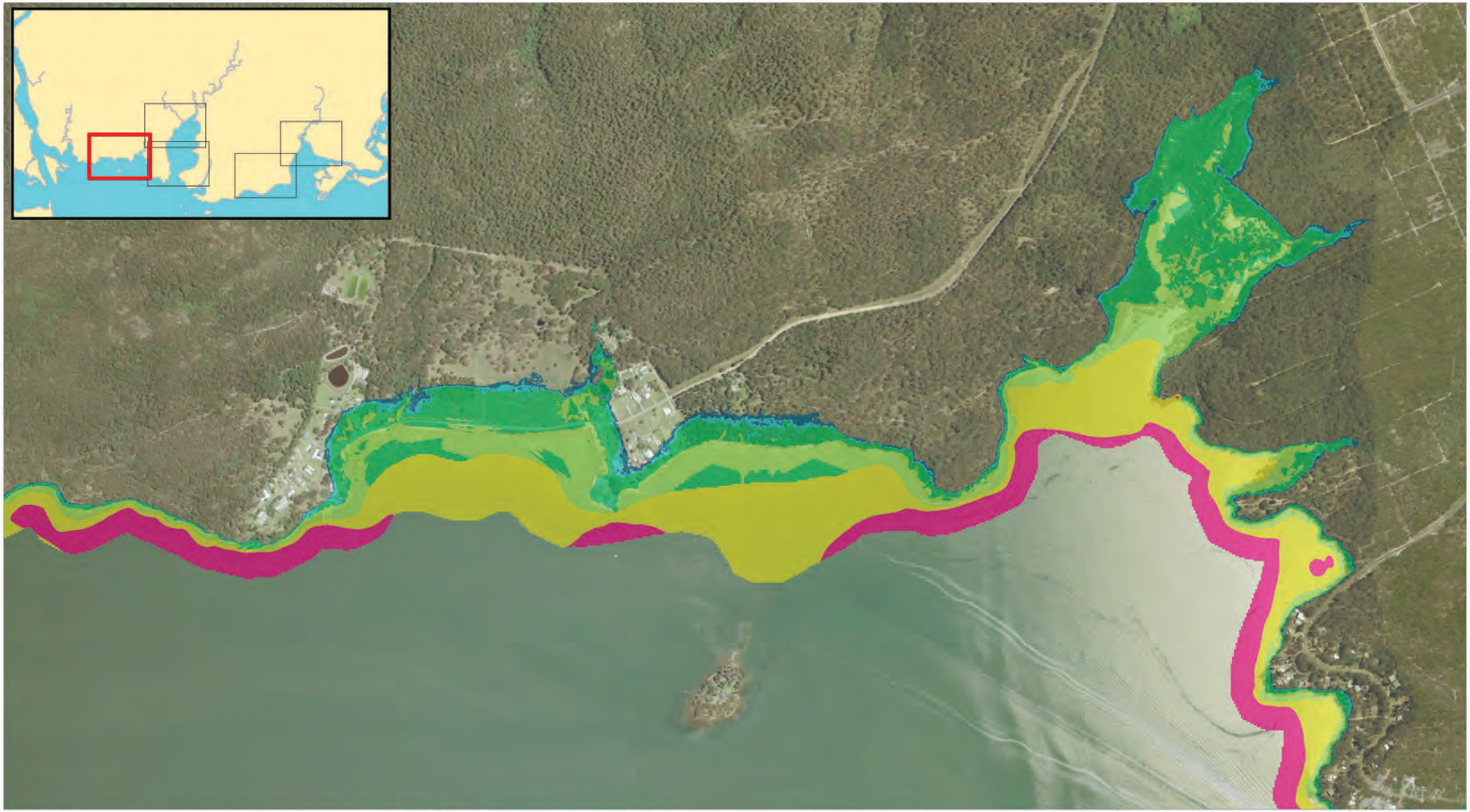
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F04_hazard_class_20yWRH_0p0SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
5% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **F-05**

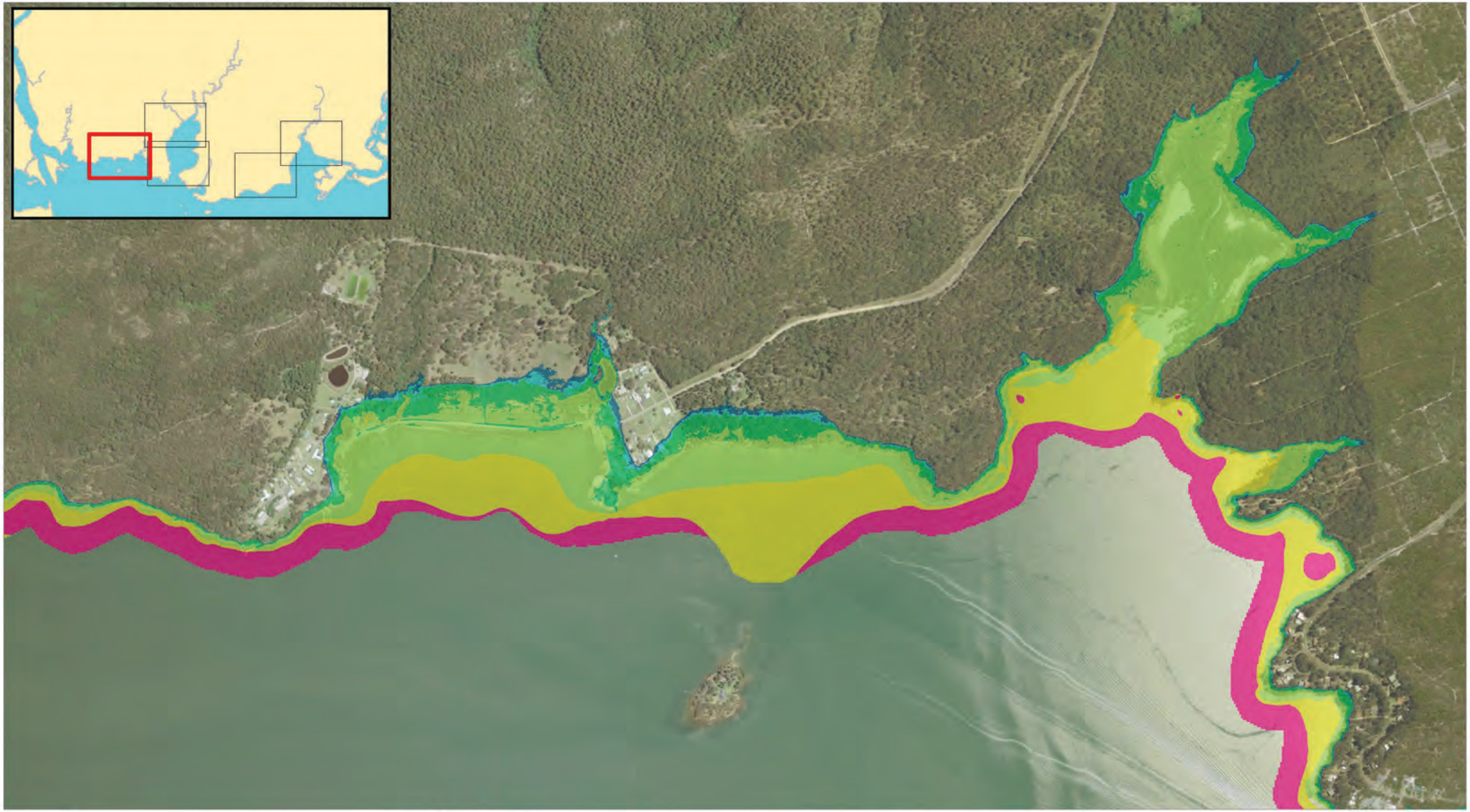
Rev: **A**

N

0 250 500m
Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F05_hazard_class_20yWRH_0p55SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

5% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **F-06**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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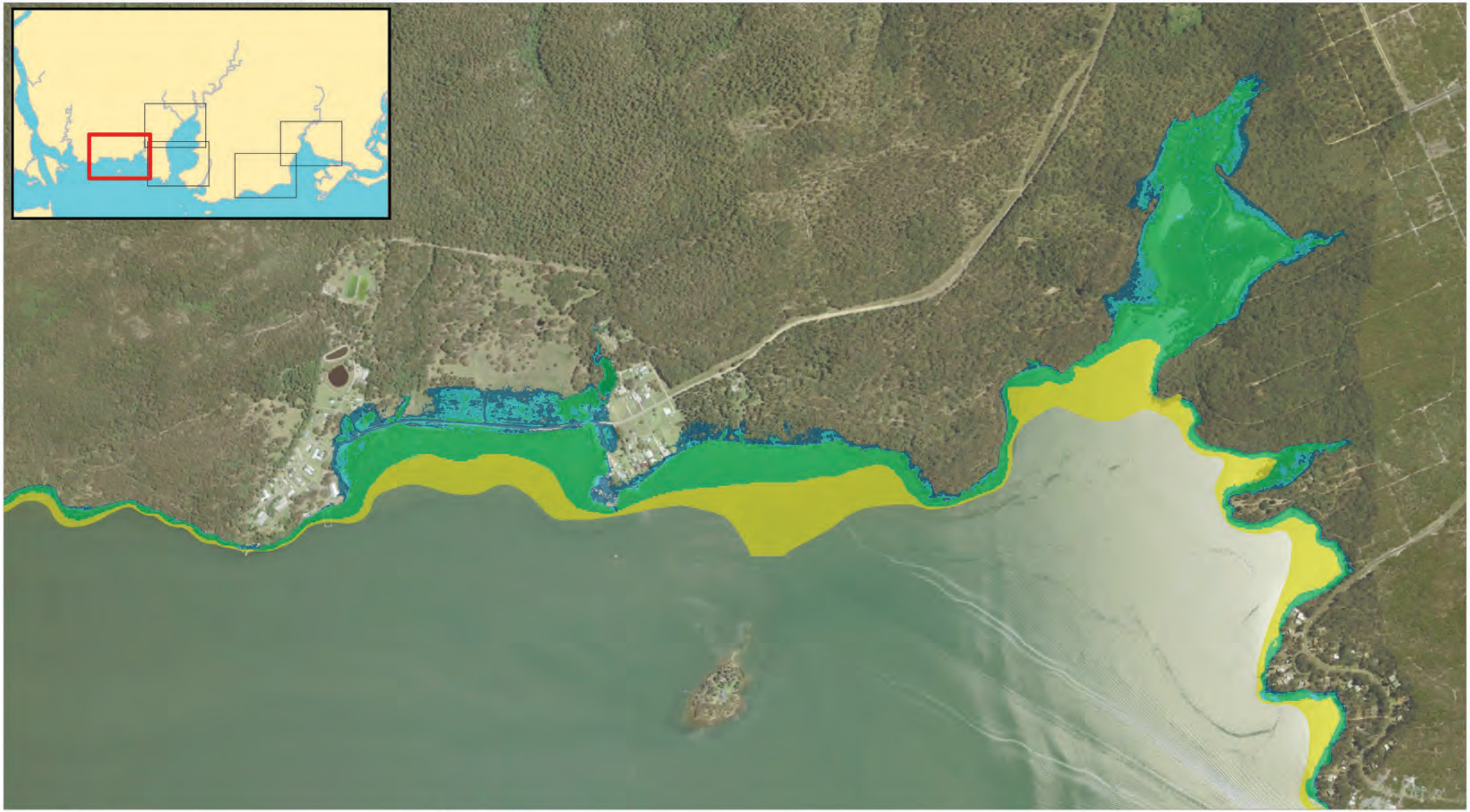
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F06_hazard_class_20yWRH_0p91SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

1% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **F-07**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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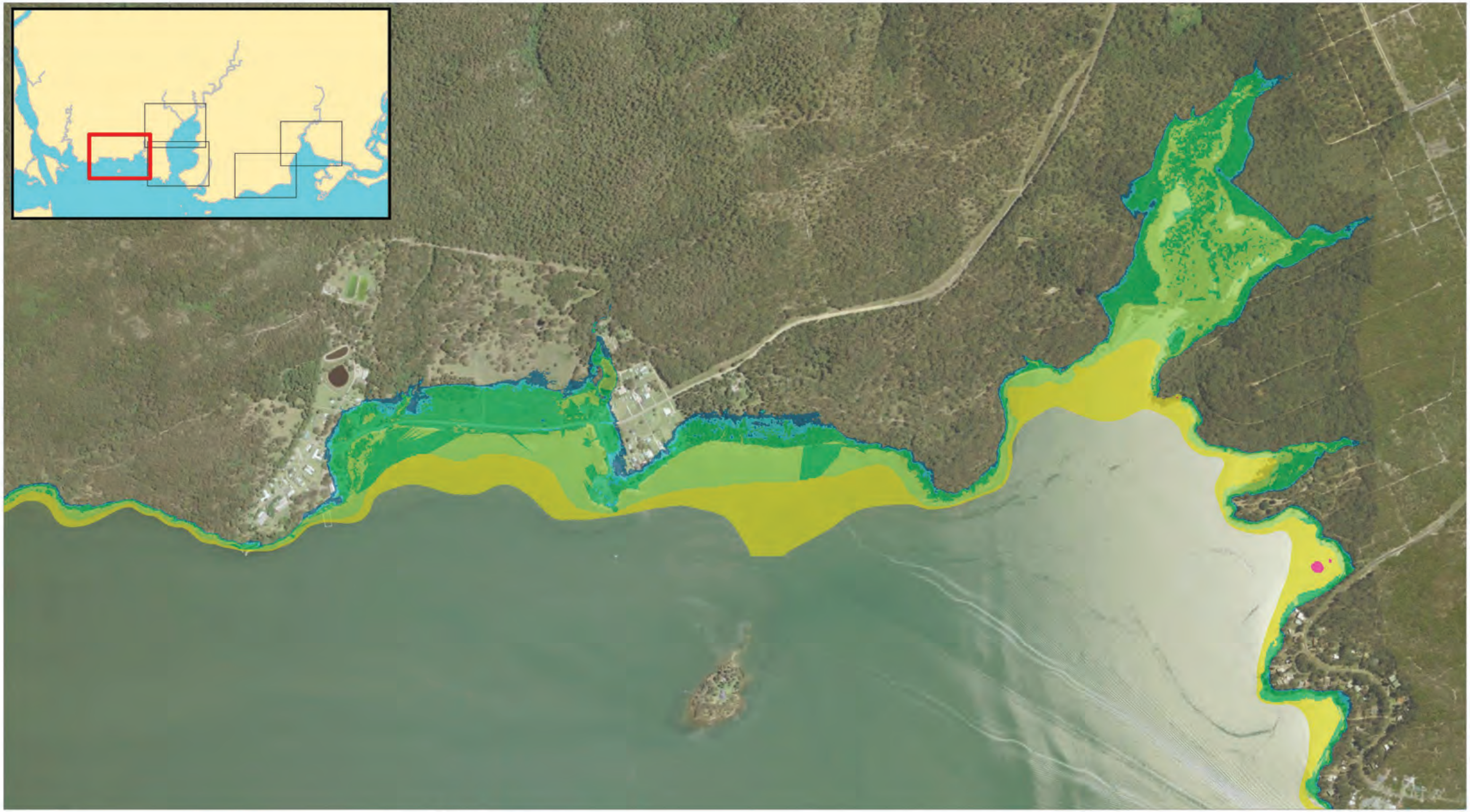

LEGEND
Hydraulic Classification

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

Title:

1% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **F-08**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT
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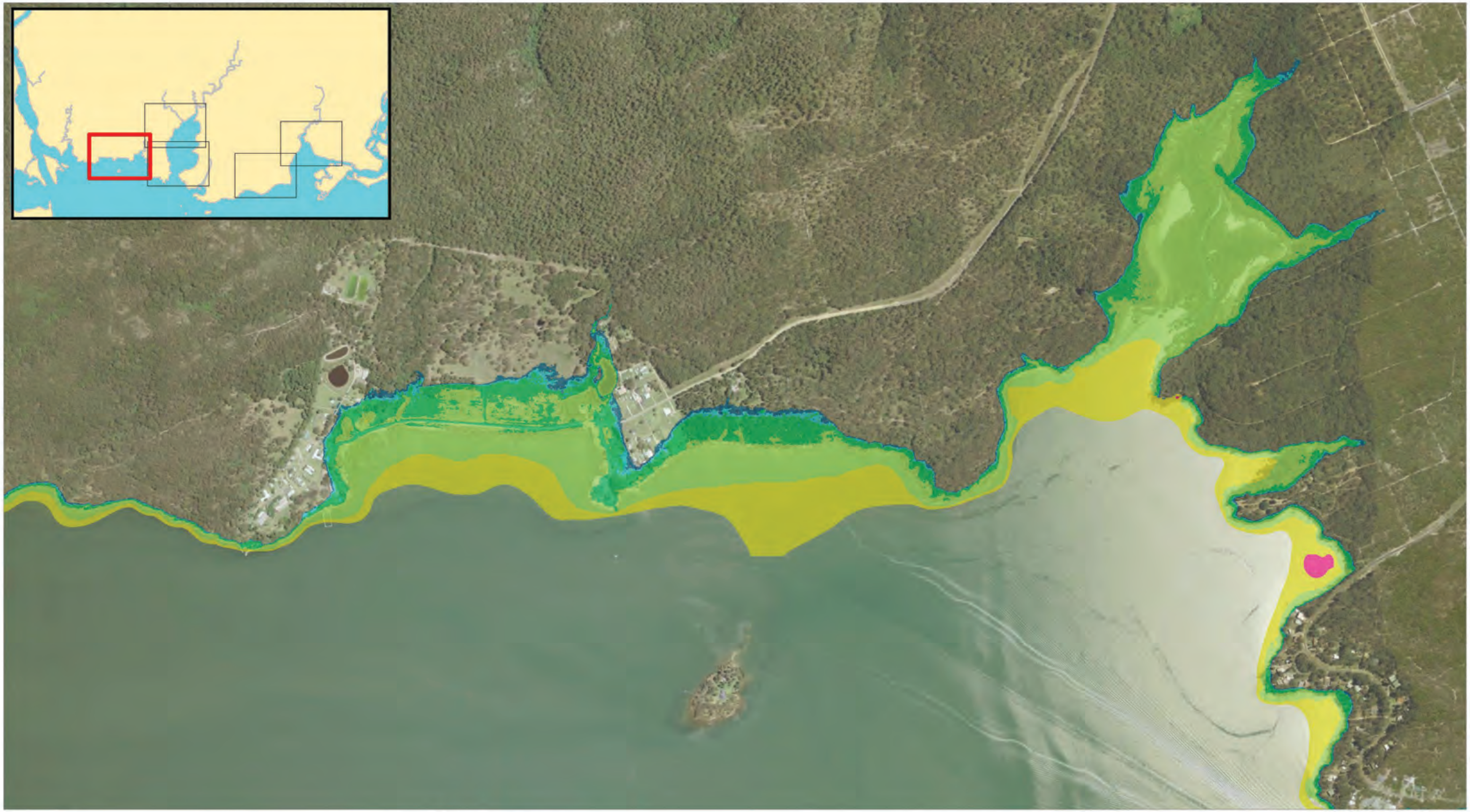
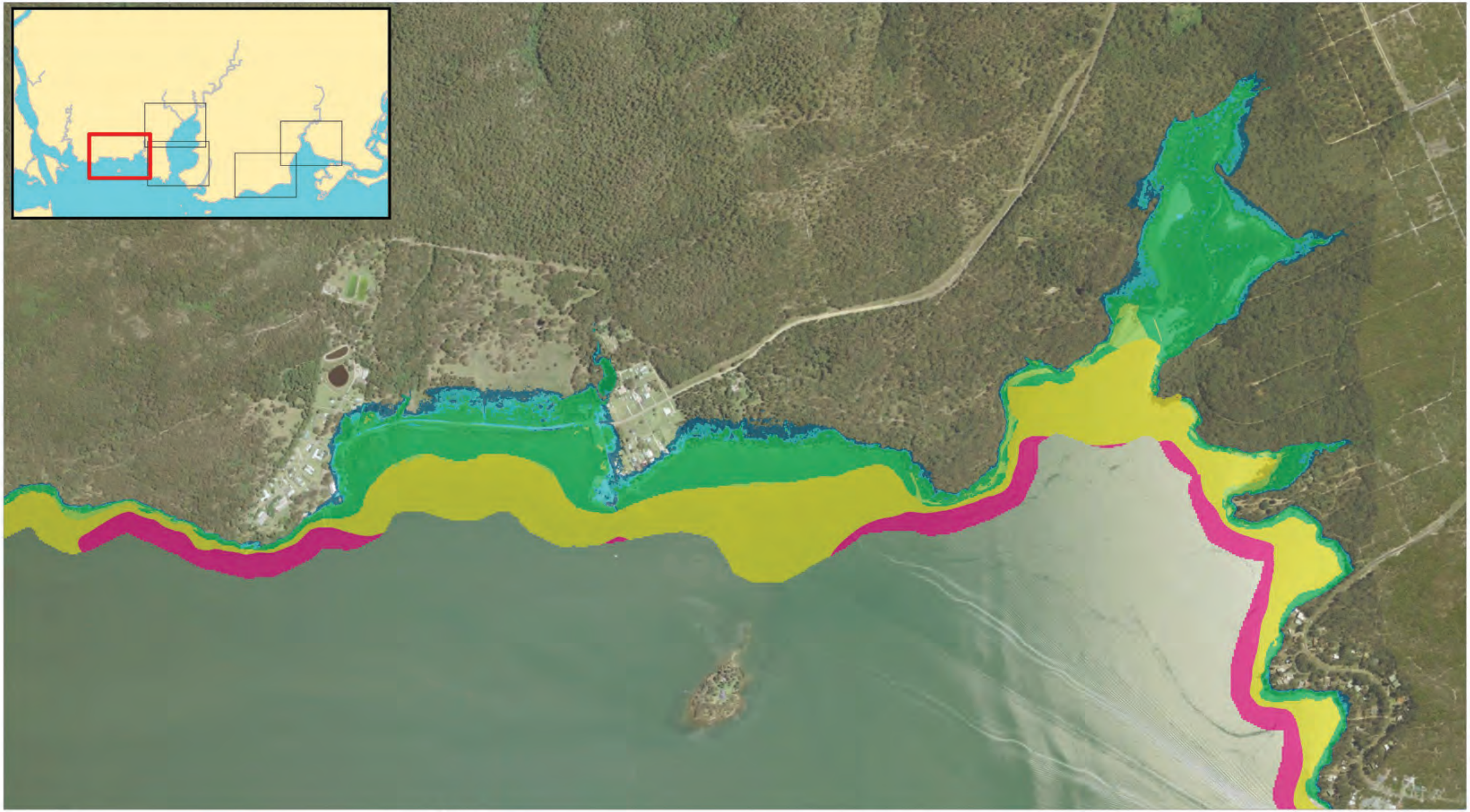
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F08_hazard_class_100ySWL_0p55SLR_001.wor"





LEGEND
Hydraulic Classification

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

Title:
1% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Tahlee to Carrington

Figure: **F-10**

Rev: **A**

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N

0 250 500m
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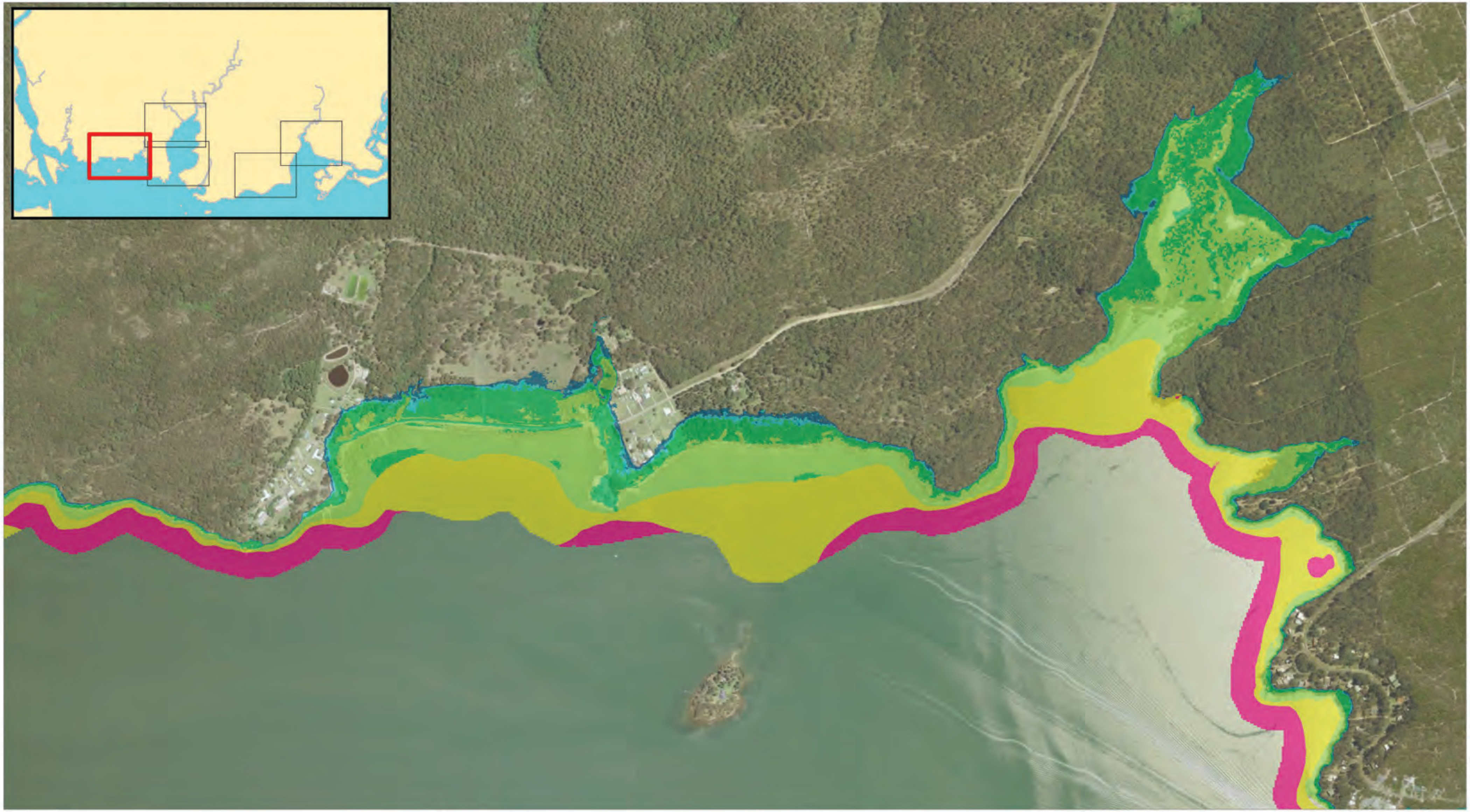

LEGEND
Hydraulic Classification

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

Title:
1% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **F-11**

Rev: **A**

N

0 250 500m
Approx. Scale

BMT
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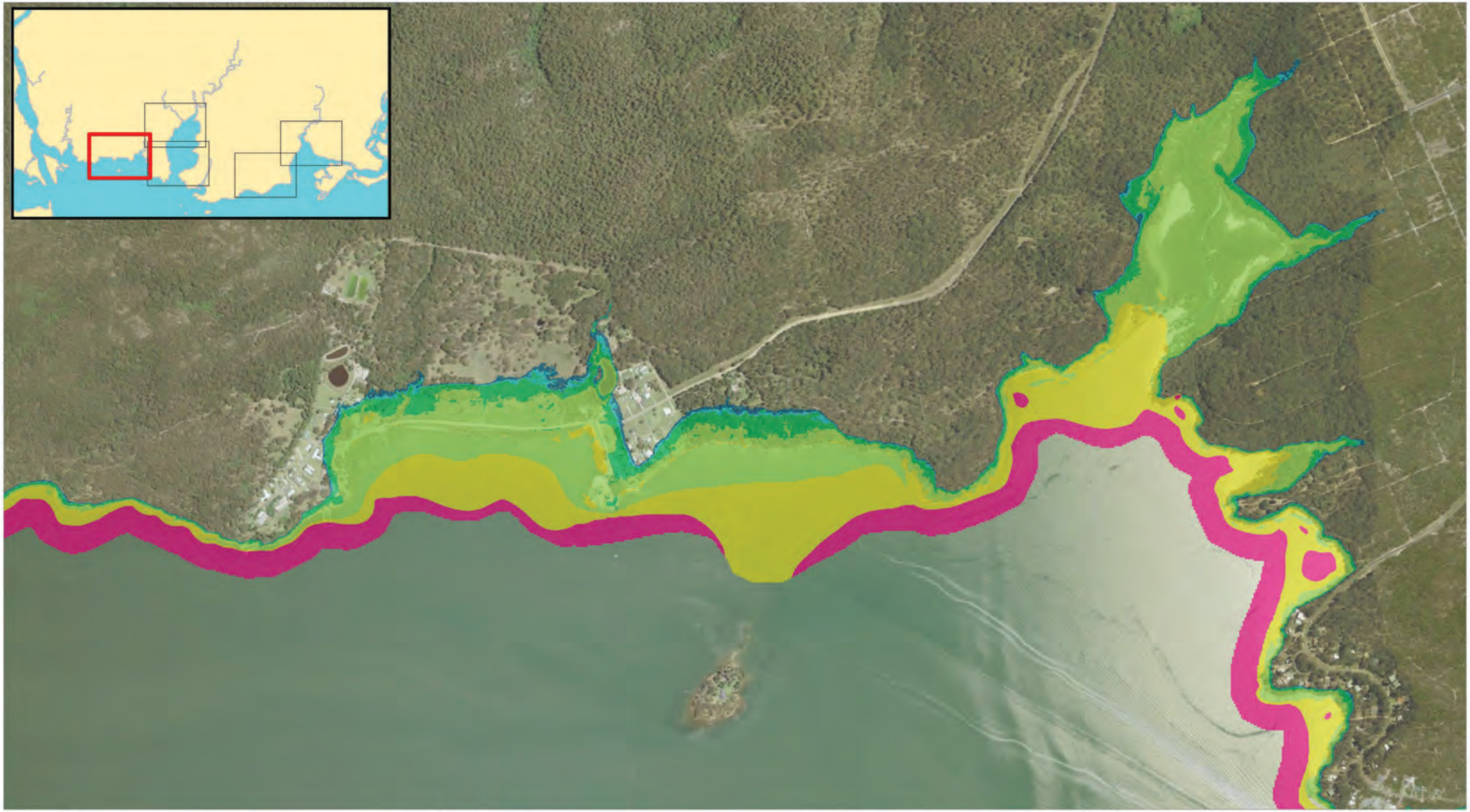
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F11_hazard_class_100yWRH_0p55SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **F-12**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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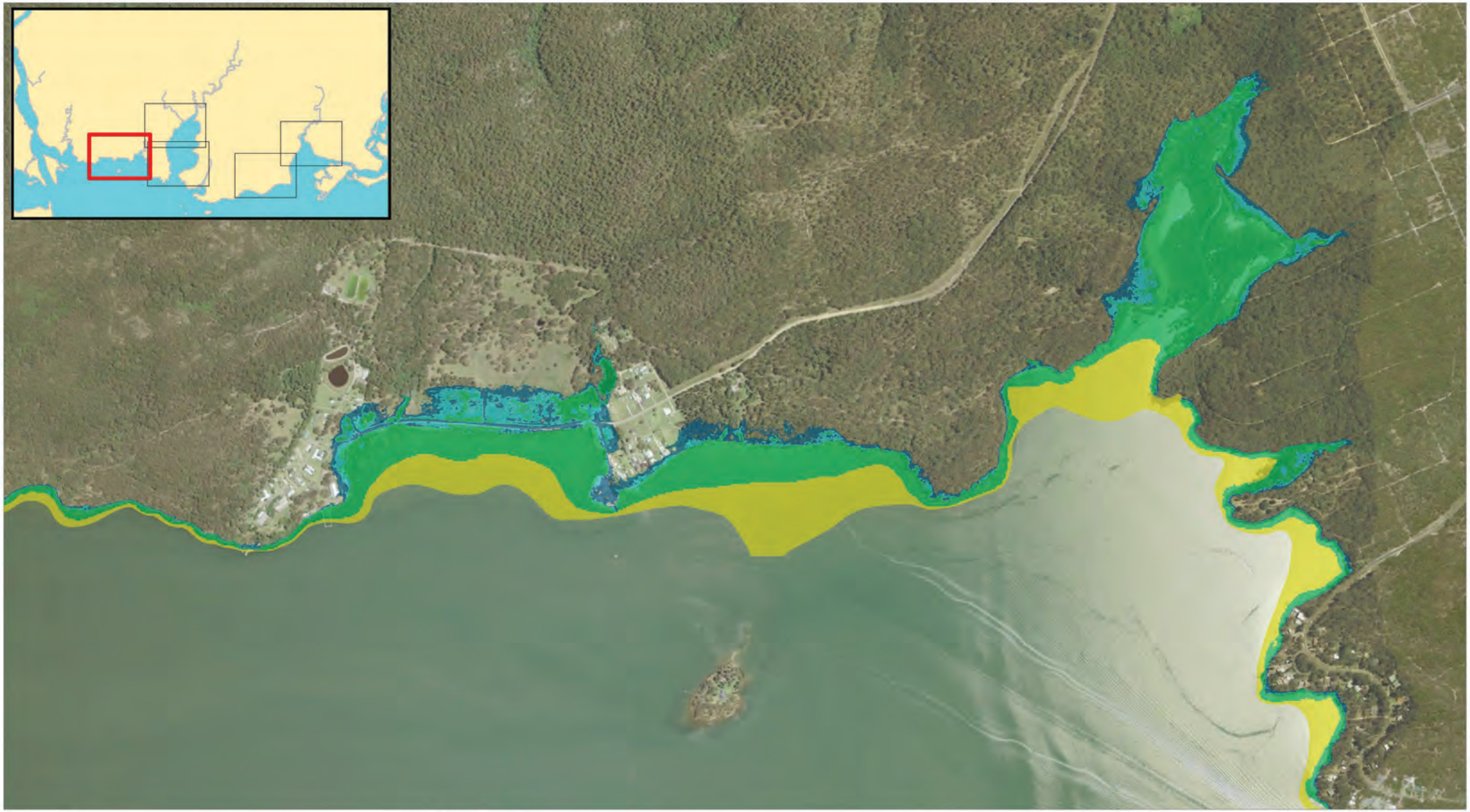

LEGEND
Hydraulic Classification

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

Title:
Extreme Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Tahlee to Carrington

Figure: F-13

Rev: A

N

0 250 500m
Approx. Scale

BMT
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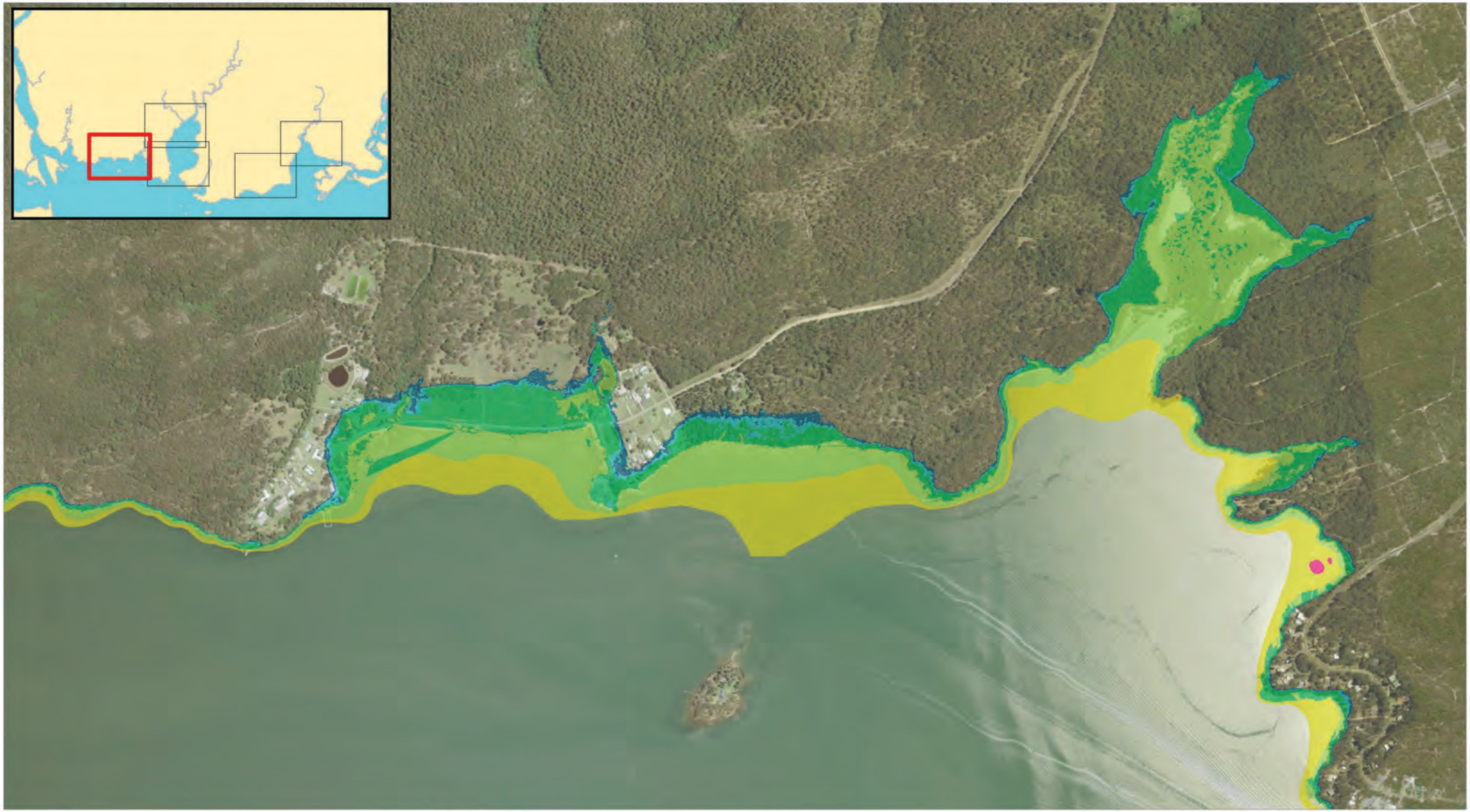
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F13_hazard_class_extSWL_0p0SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
Extreme Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **F-14**

Rev: **A**

N

0 250 500m
Approx. Scale

BMT
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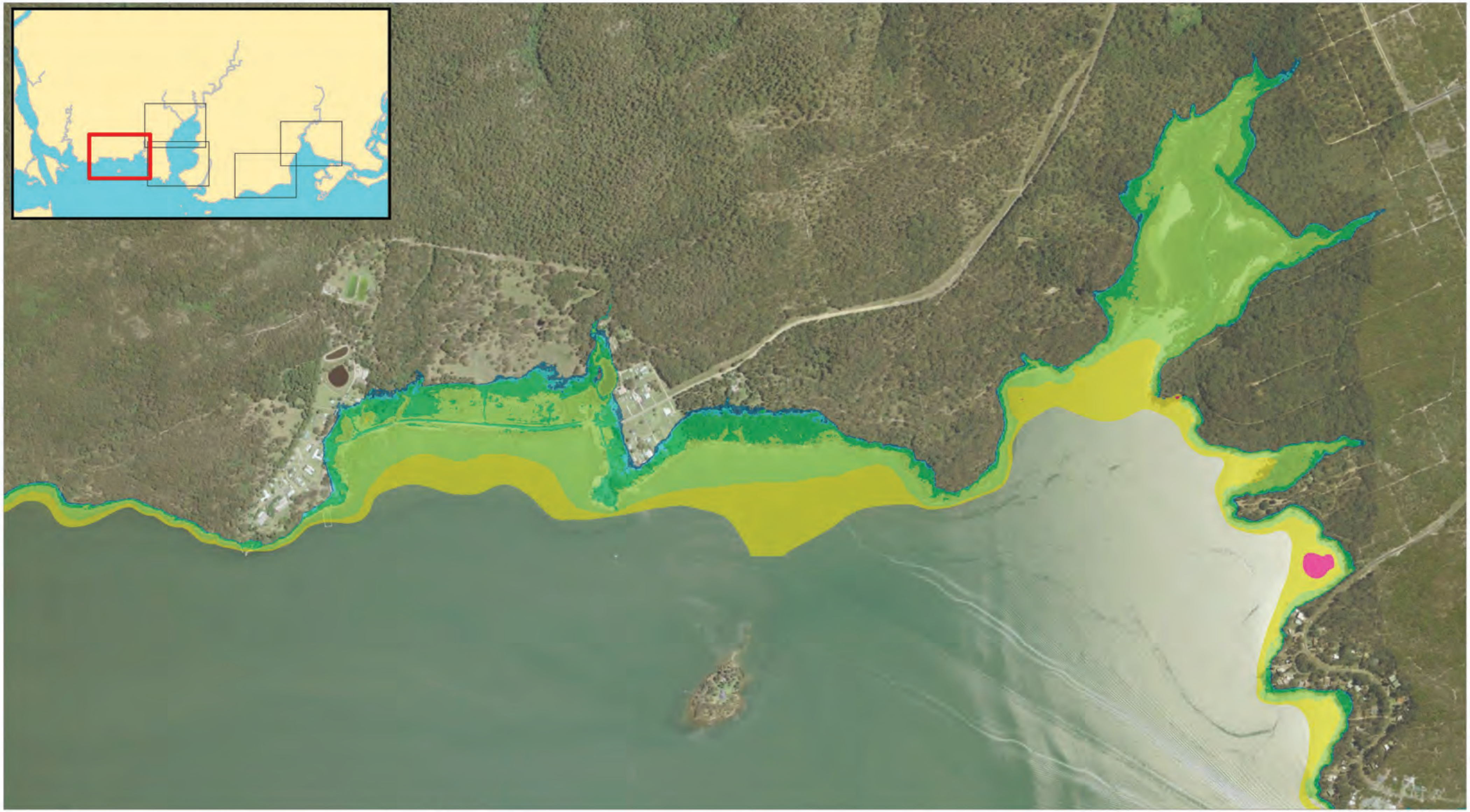
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F14_hazard_class_extSWL_0p55SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **F-15**

Rev: **A**

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N

0 250 500m
Approx. Scale

BMT
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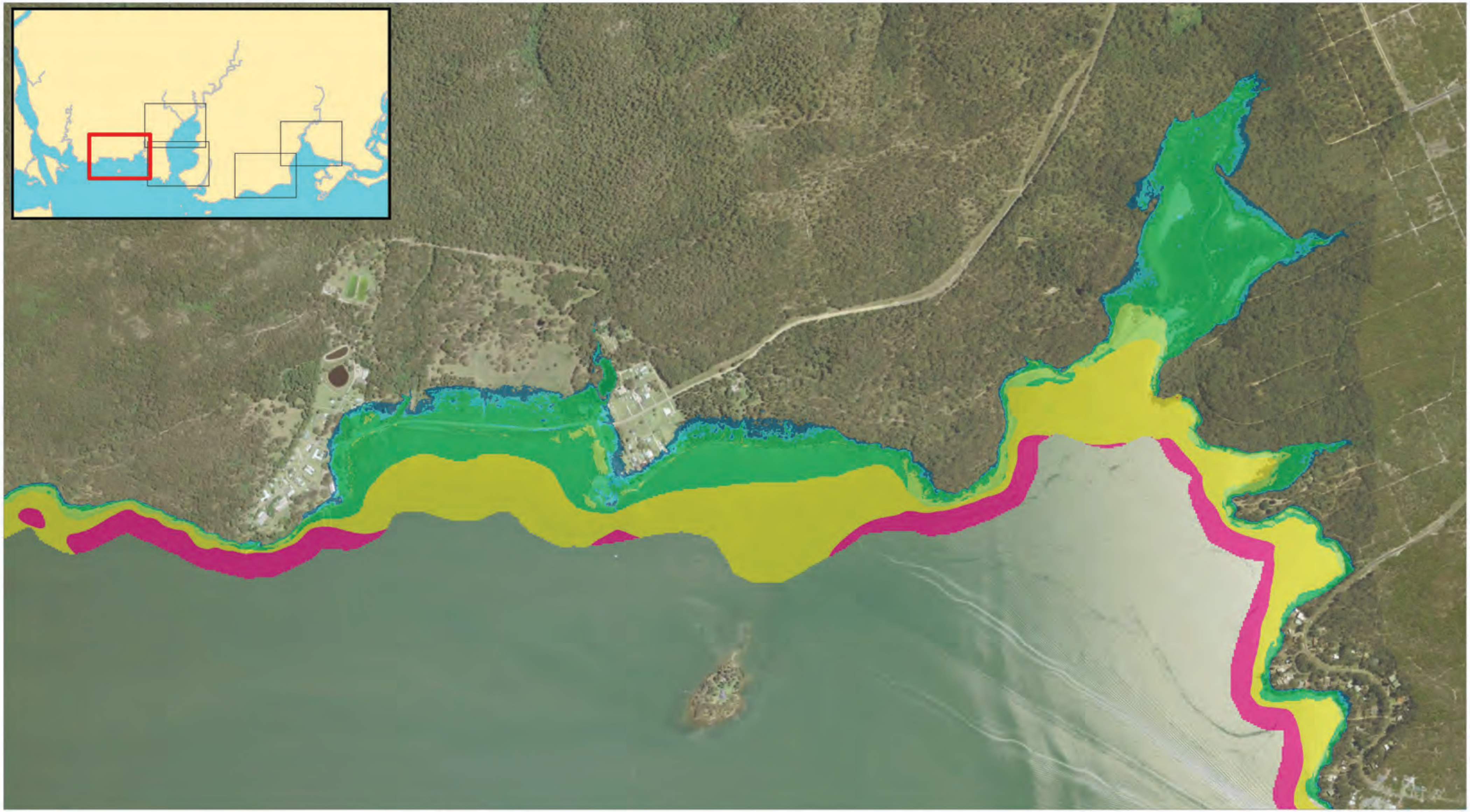
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F15_hazard_class_extSWL_0p91SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
Extreme Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Tahlee to Carrington

Figure: F-16

Rev: A

N

0 250 500m
Approx. Scale

BMT
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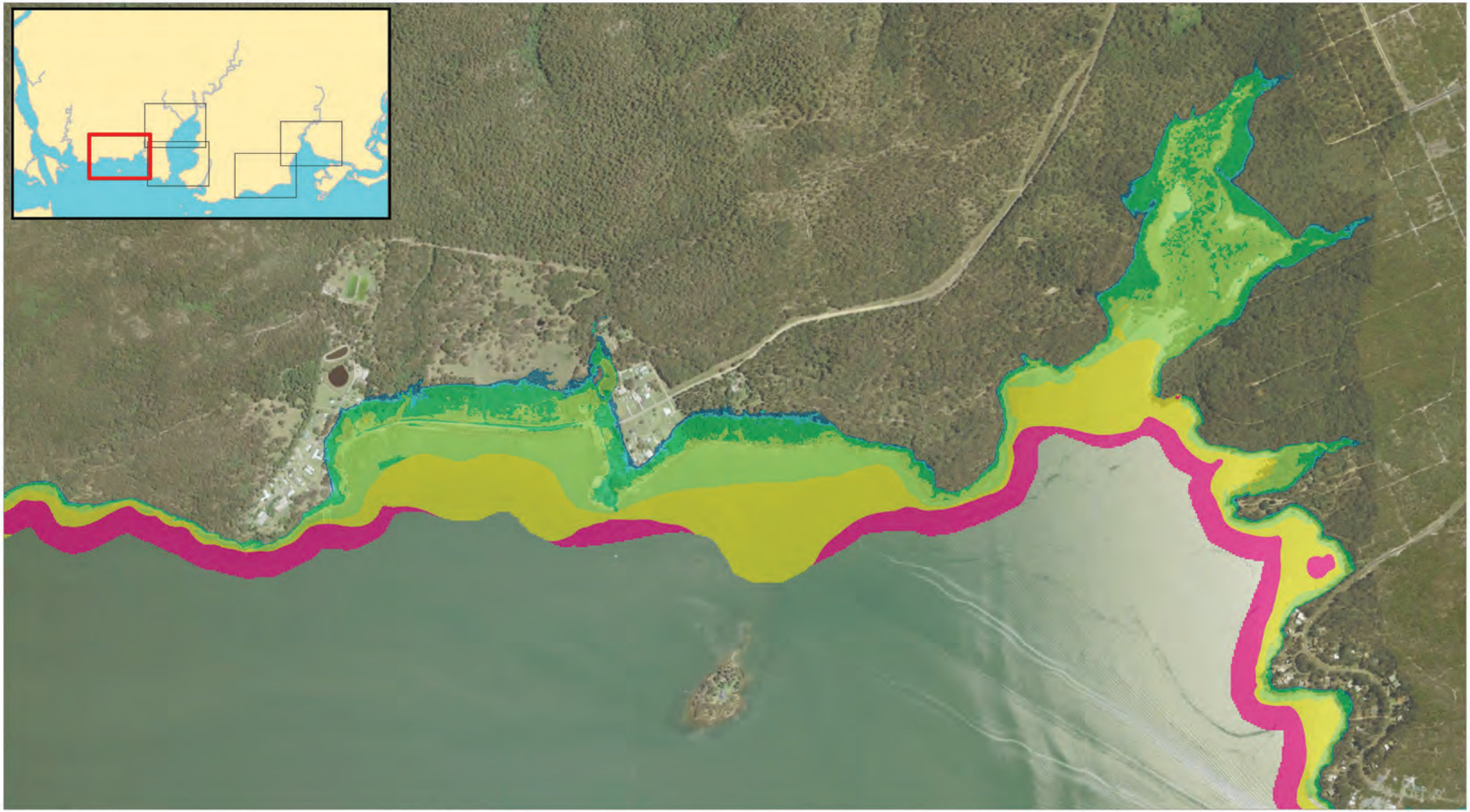
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F16_hazard_class_extWRH_0p0SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Tahlee to Carrington

Figure: **F-17**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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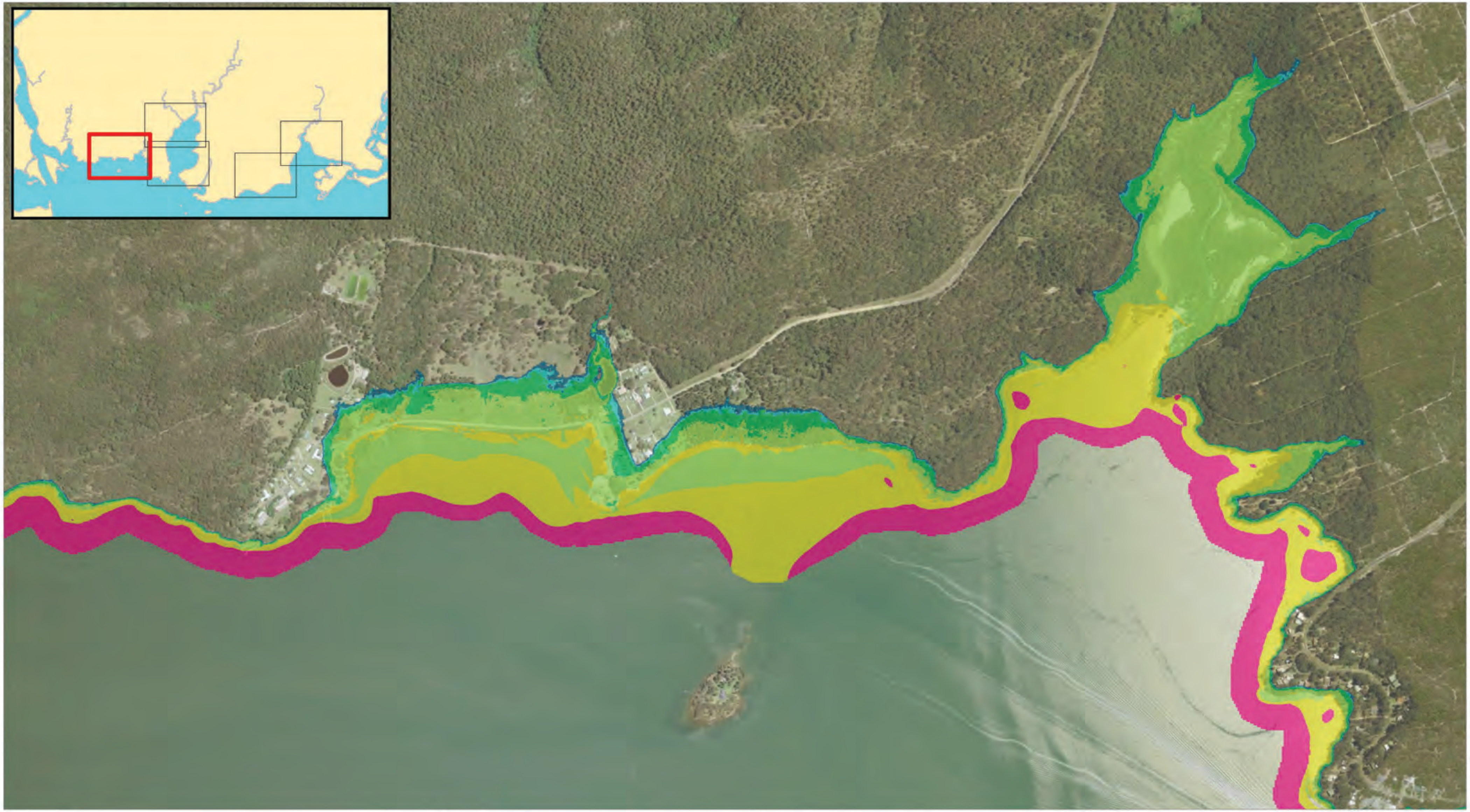
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_F17_hazard_class_extWRH_0p55SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Tahlee to Carrington

Figure: **F-18**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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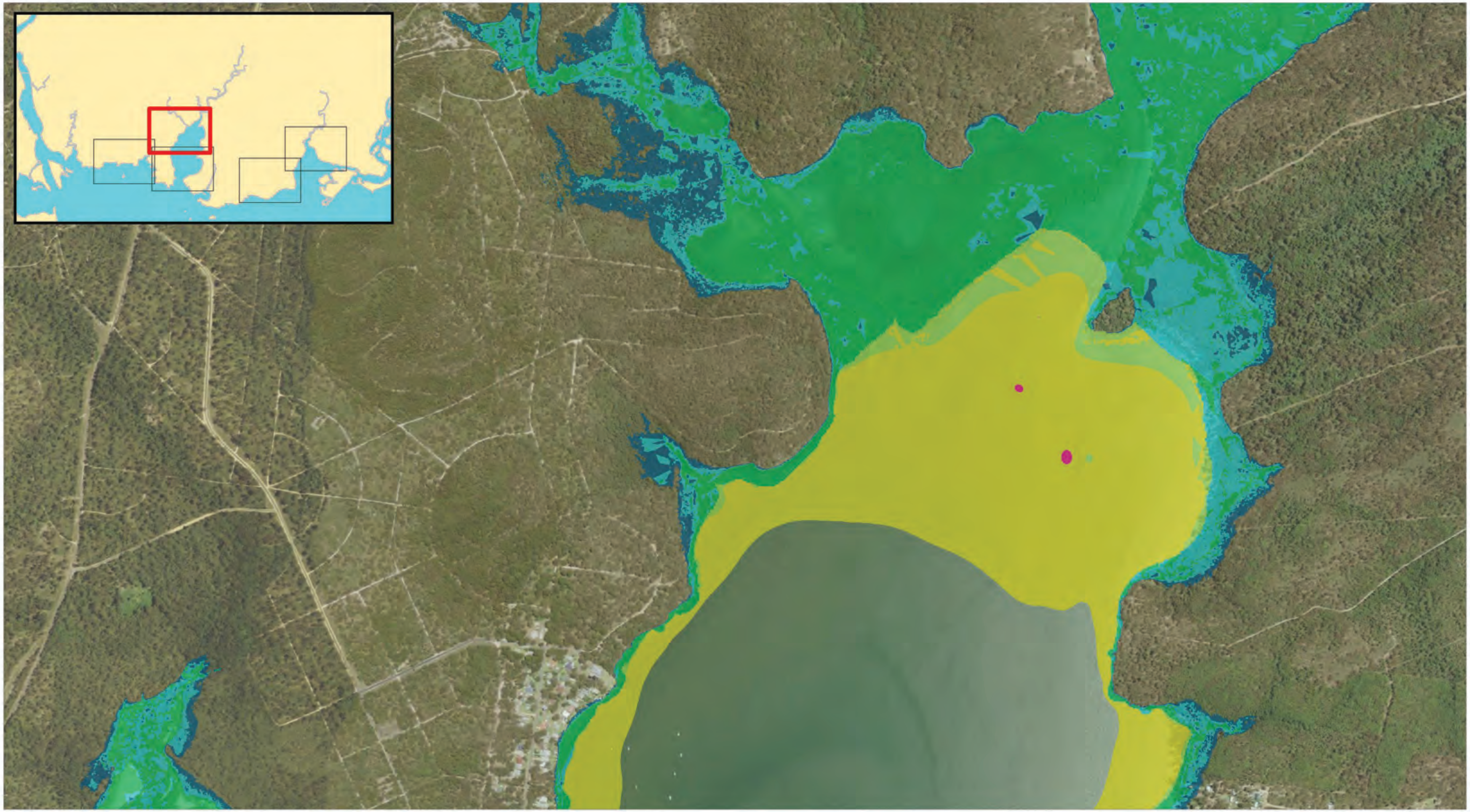


LEGEND
Hydraulic Classification

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

Title:
5% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Upper North Arm Cove

Figure: G-01

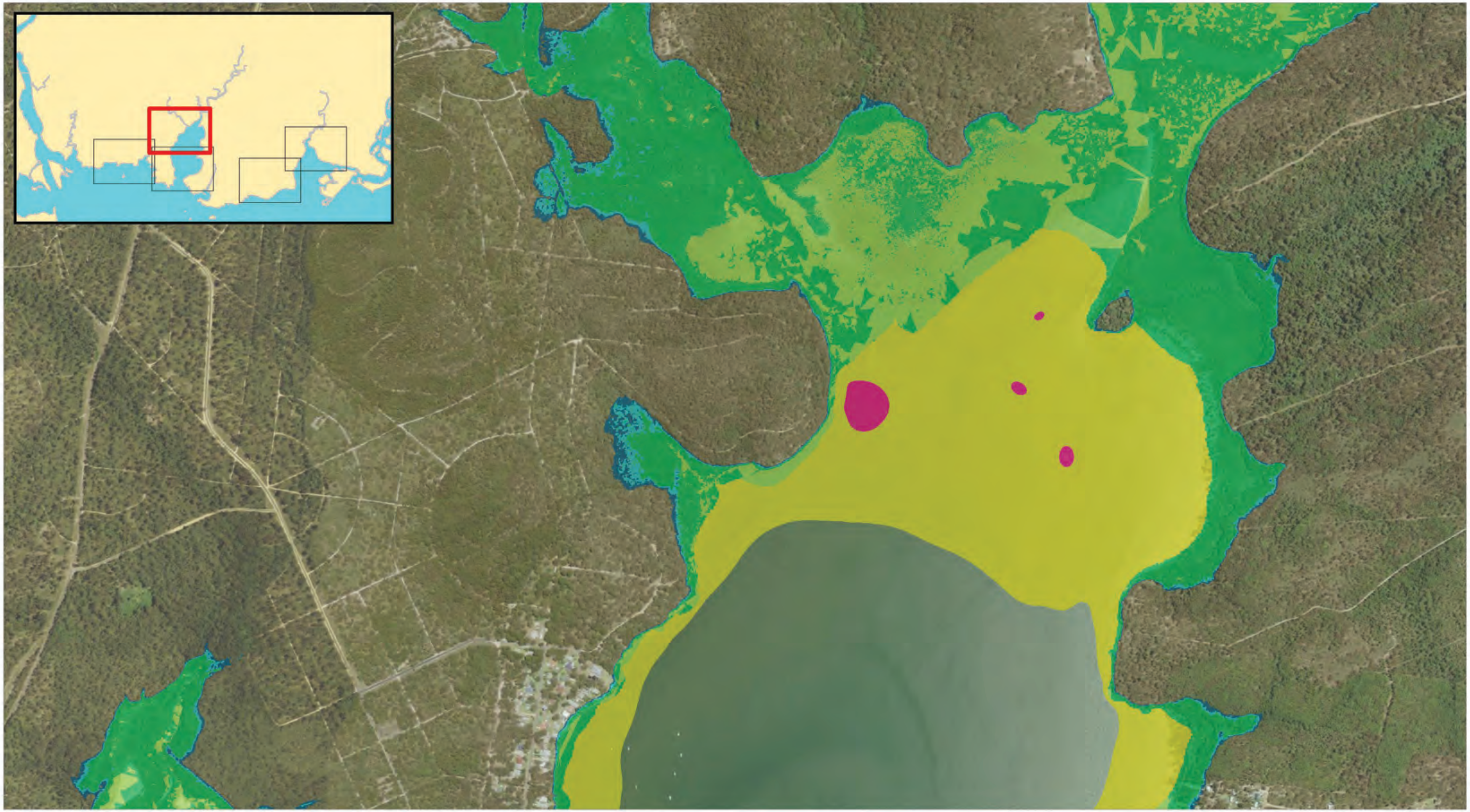
Rev: A

N

0 250 500m
Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_G01_hazard_class_20ySWL_0p0SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **G-02**

Rev: **A**

N

0 250 500m
Approx. Scale

BMT
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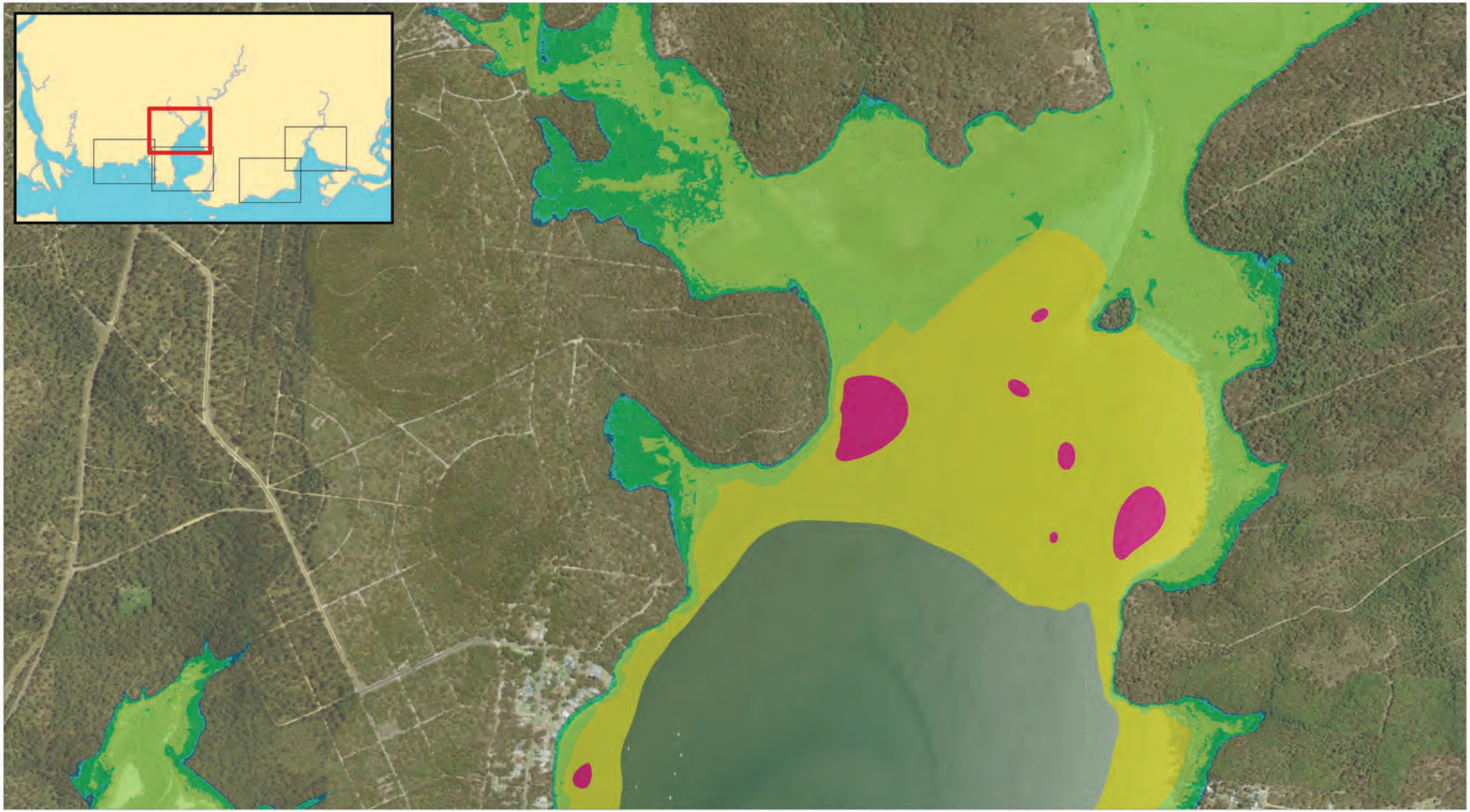
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_G02_hazard_class_20ySWL_0p55SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: G-03

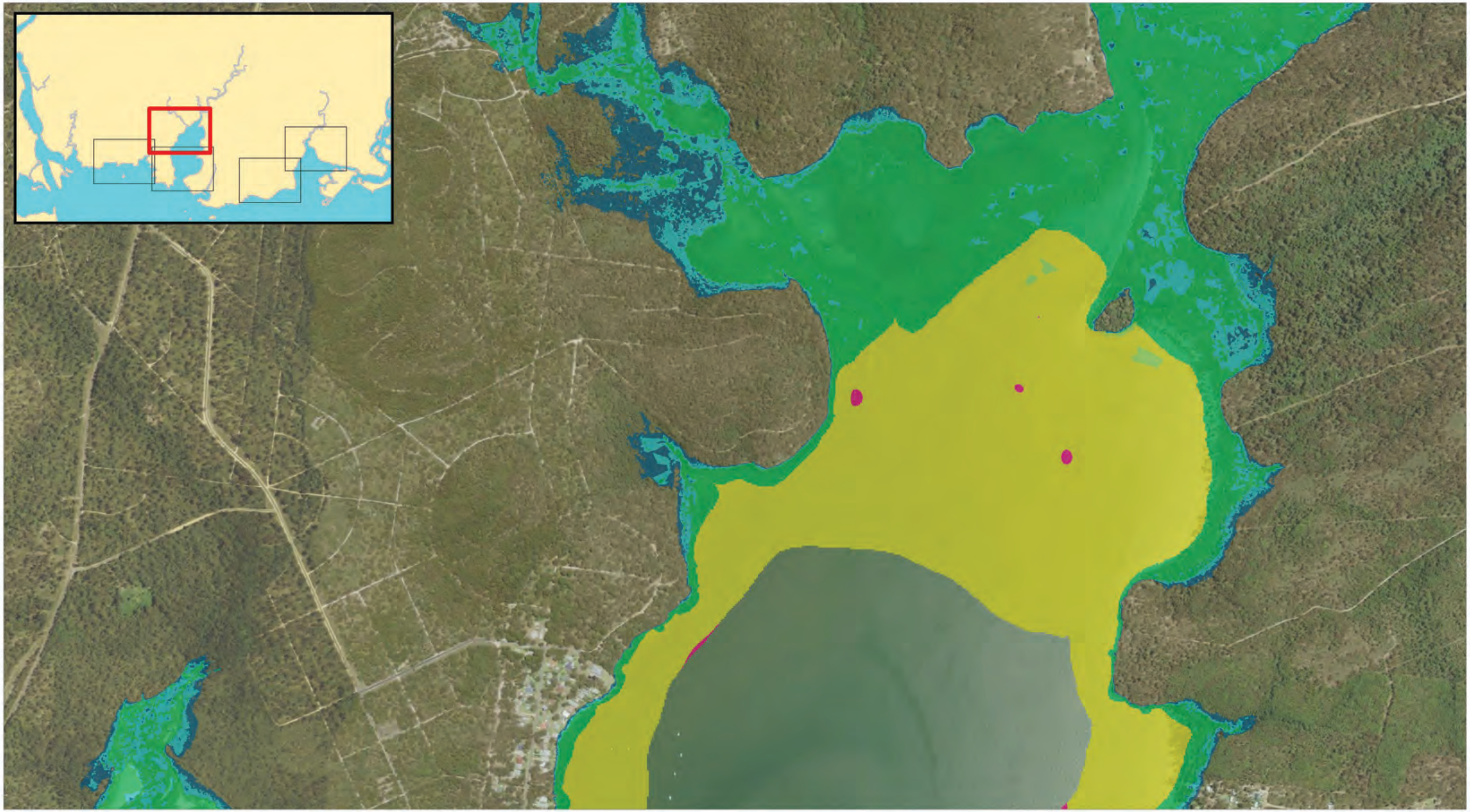
Rev: A

N

0 250 500m
Approx. Scale

BMT
www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_G03_hazard_class_20ySWL_0p91SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

5% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Upper North Arm Cove

Figure: G-04

Rev: A

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N

0 250 500m

Approx. Scale

BMT

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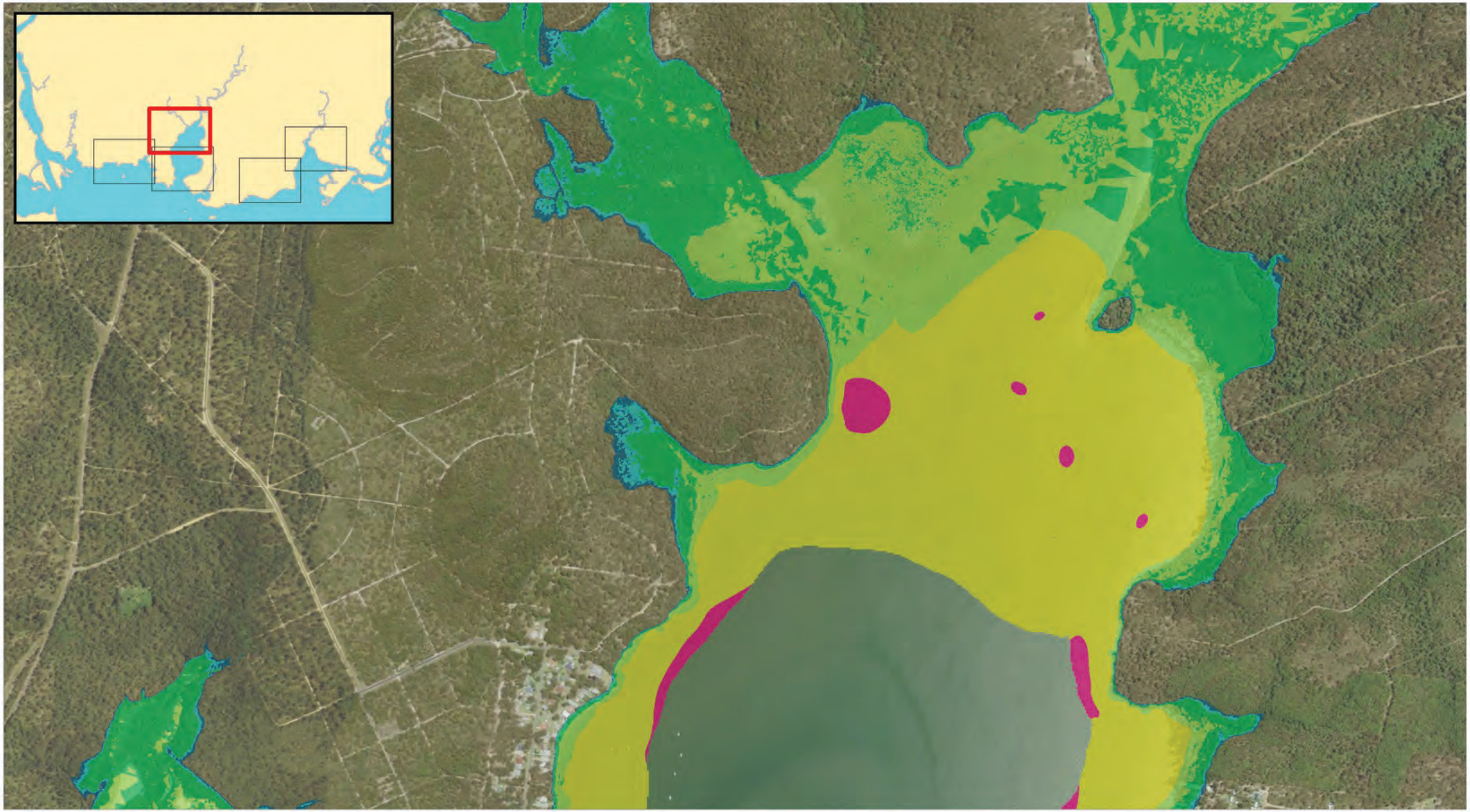
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_G04_hazard_class_20yWRH_0p0SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

5% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: G-05

Rev: A

N

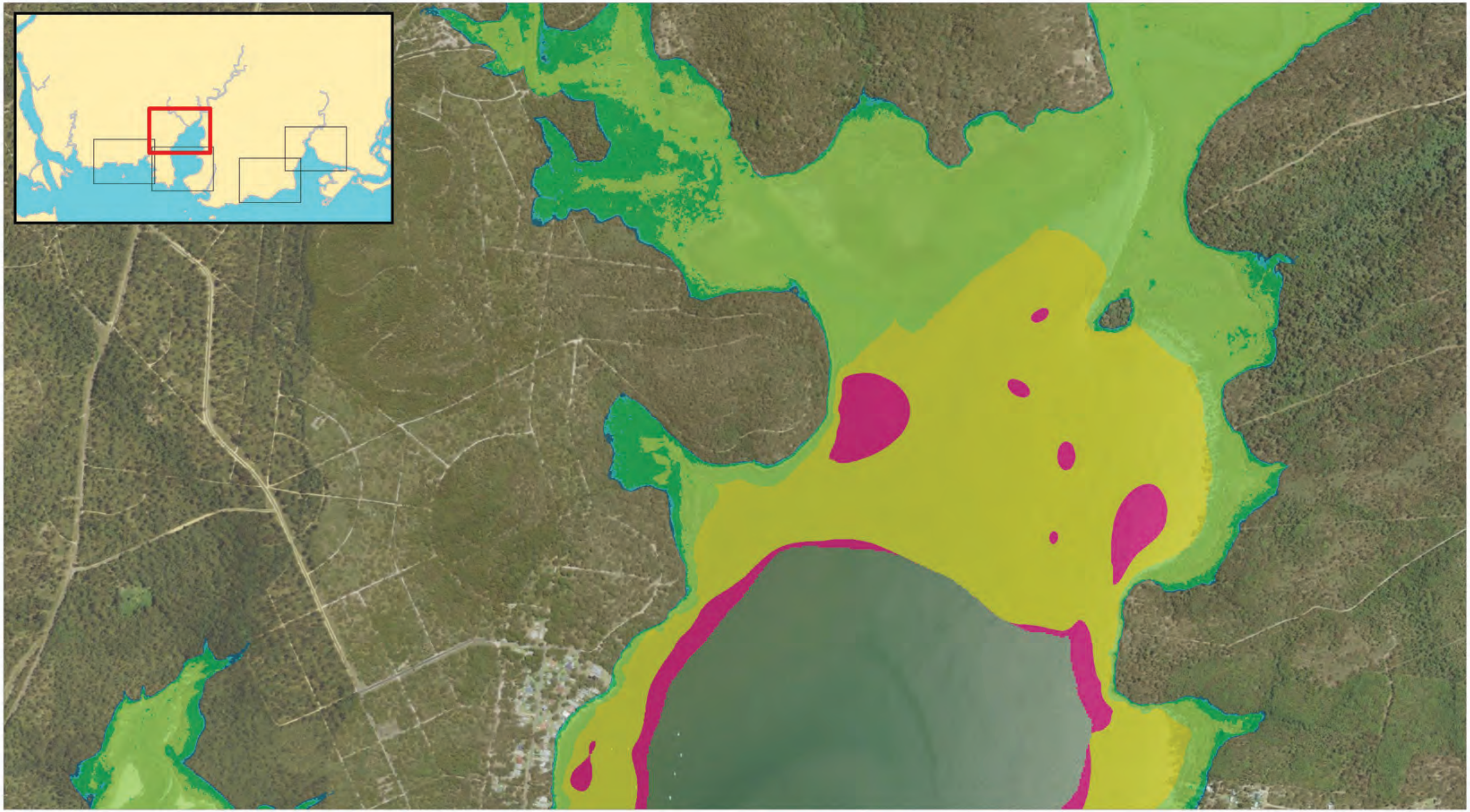
0 250 500m

Approx. Scale

BMT

www.bmt.org

Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_G05_hazard_class_20yWRH_0p55SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
5% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **G-06**

Rev: **A**

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N

0 250 500m
Approx. Scale

BMT
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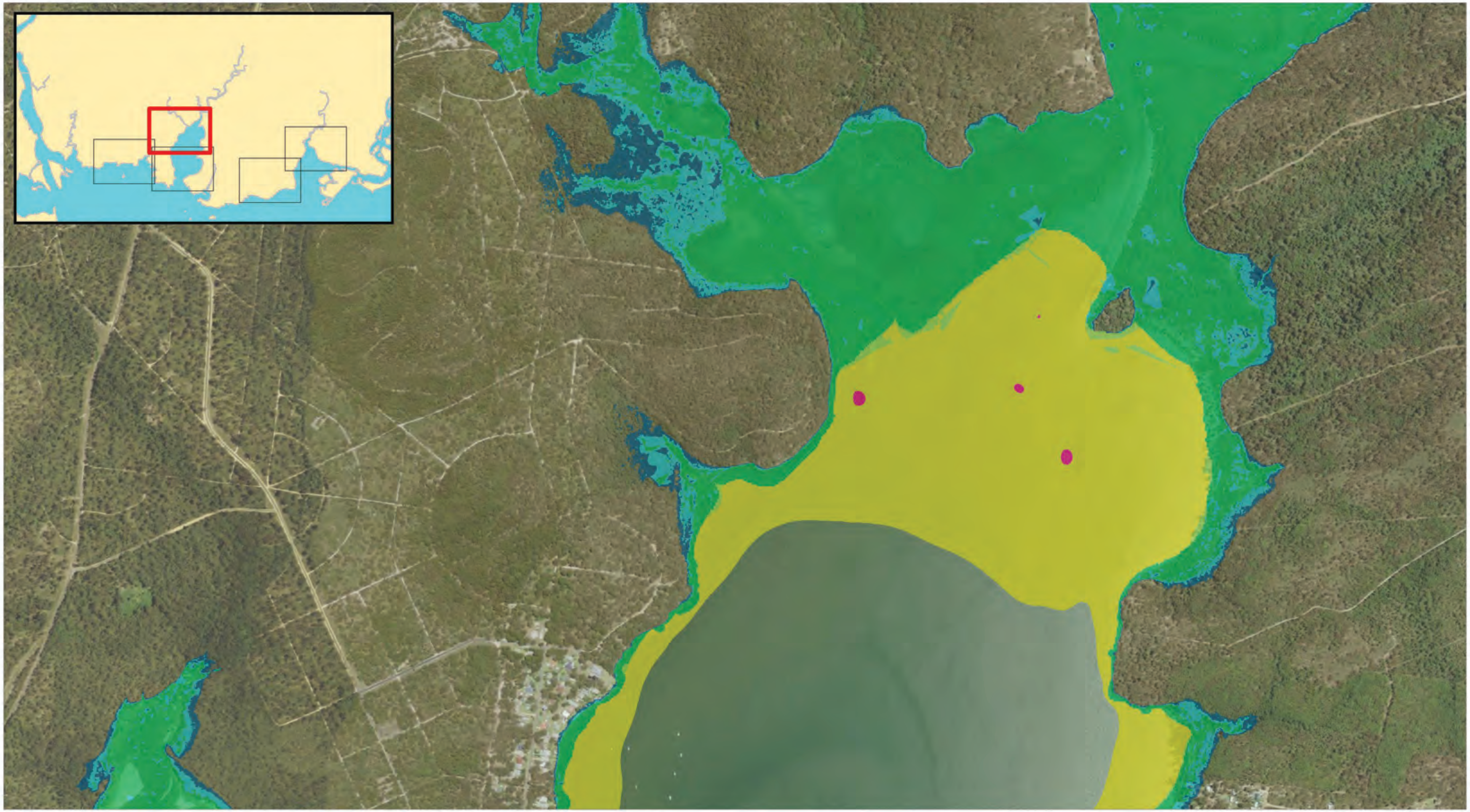
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_G06_hazard_class_20yWRH_0p91SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
1% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **G-07**

Rev: **A**

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0 250 500m
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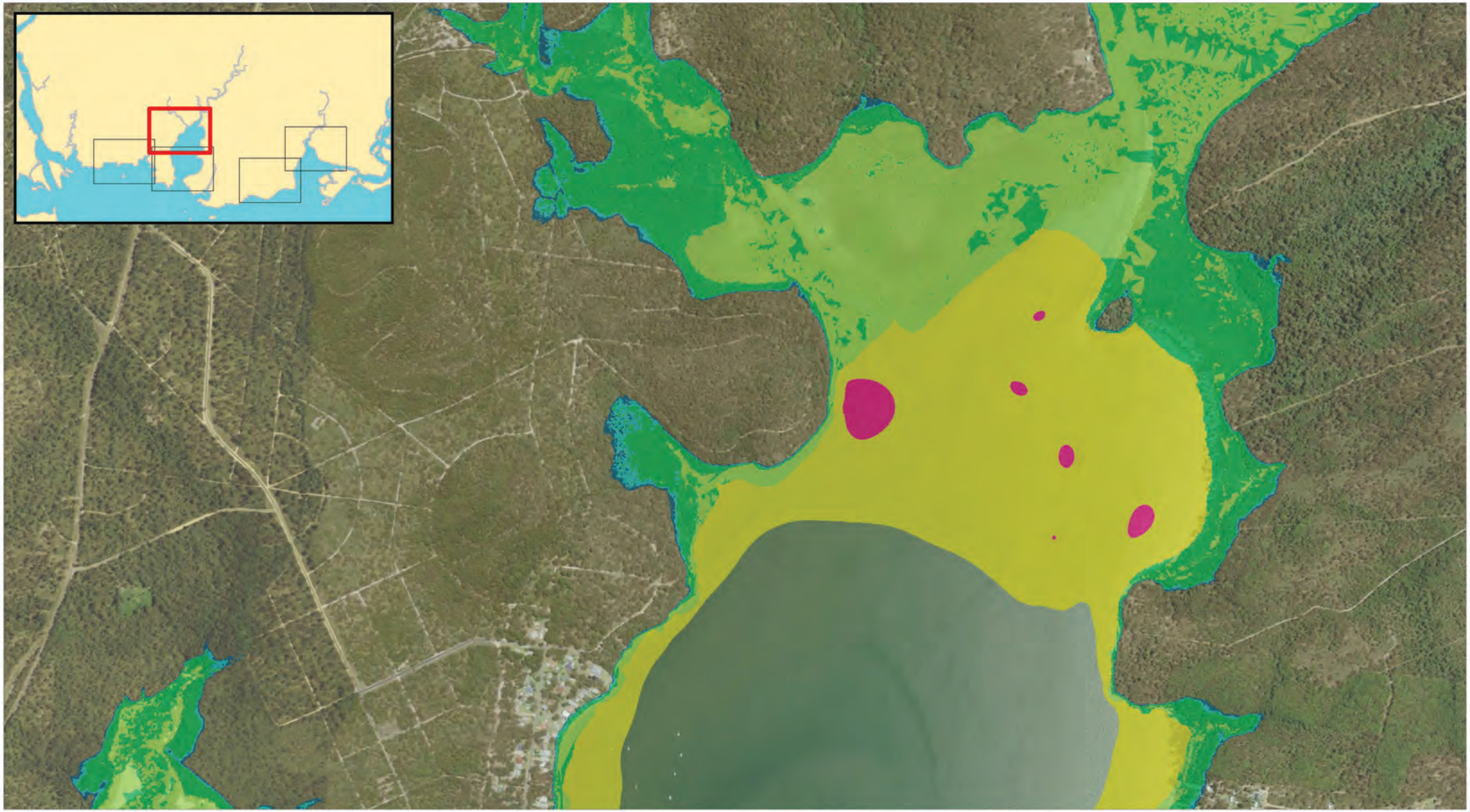

LEGEND
Hydraulic Classification

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

Title:

1% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **G-08**

Rev: **A**

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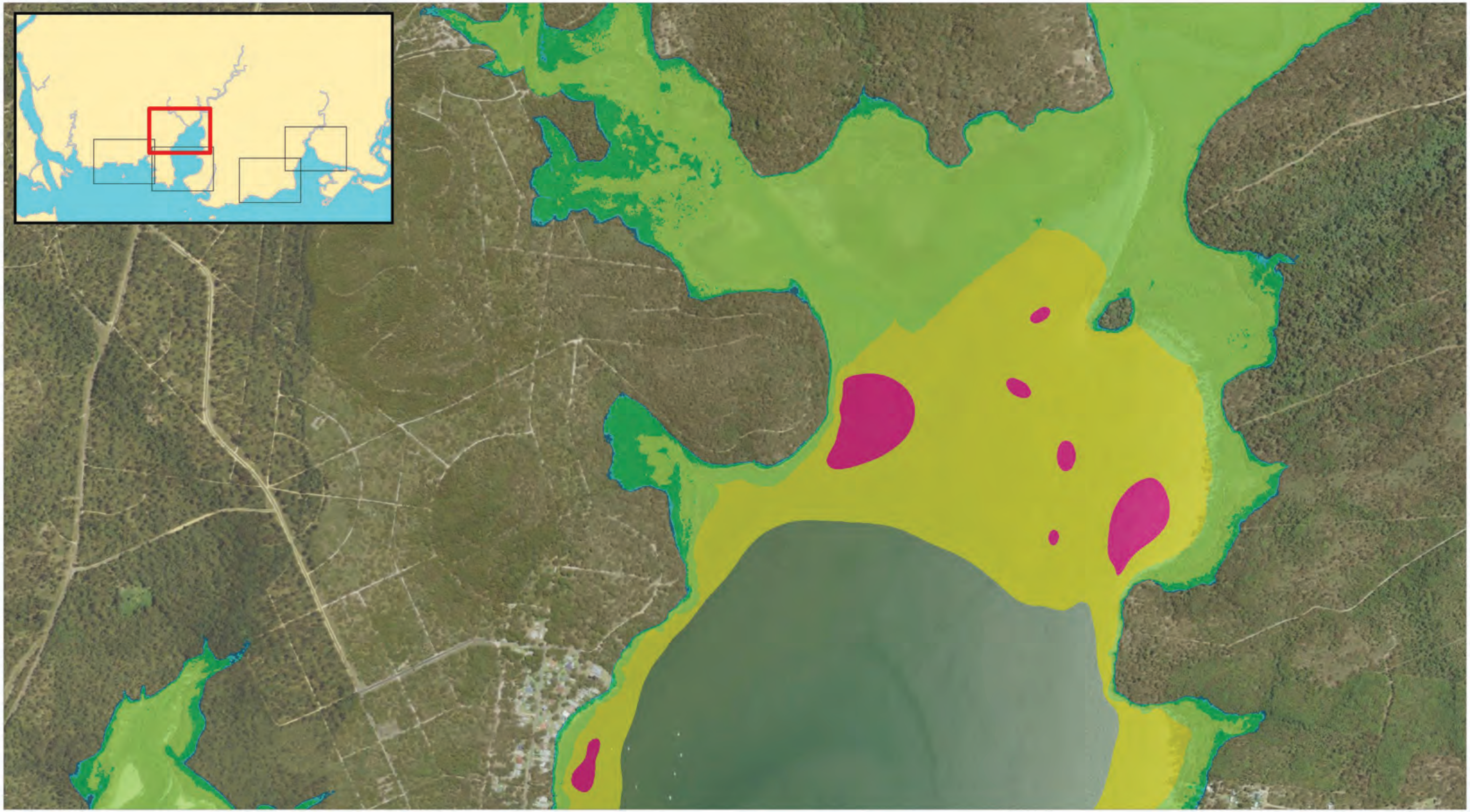

LEGEND
Hydraulic Classification

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

Title:
1% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **G-09**

Rev: **A**

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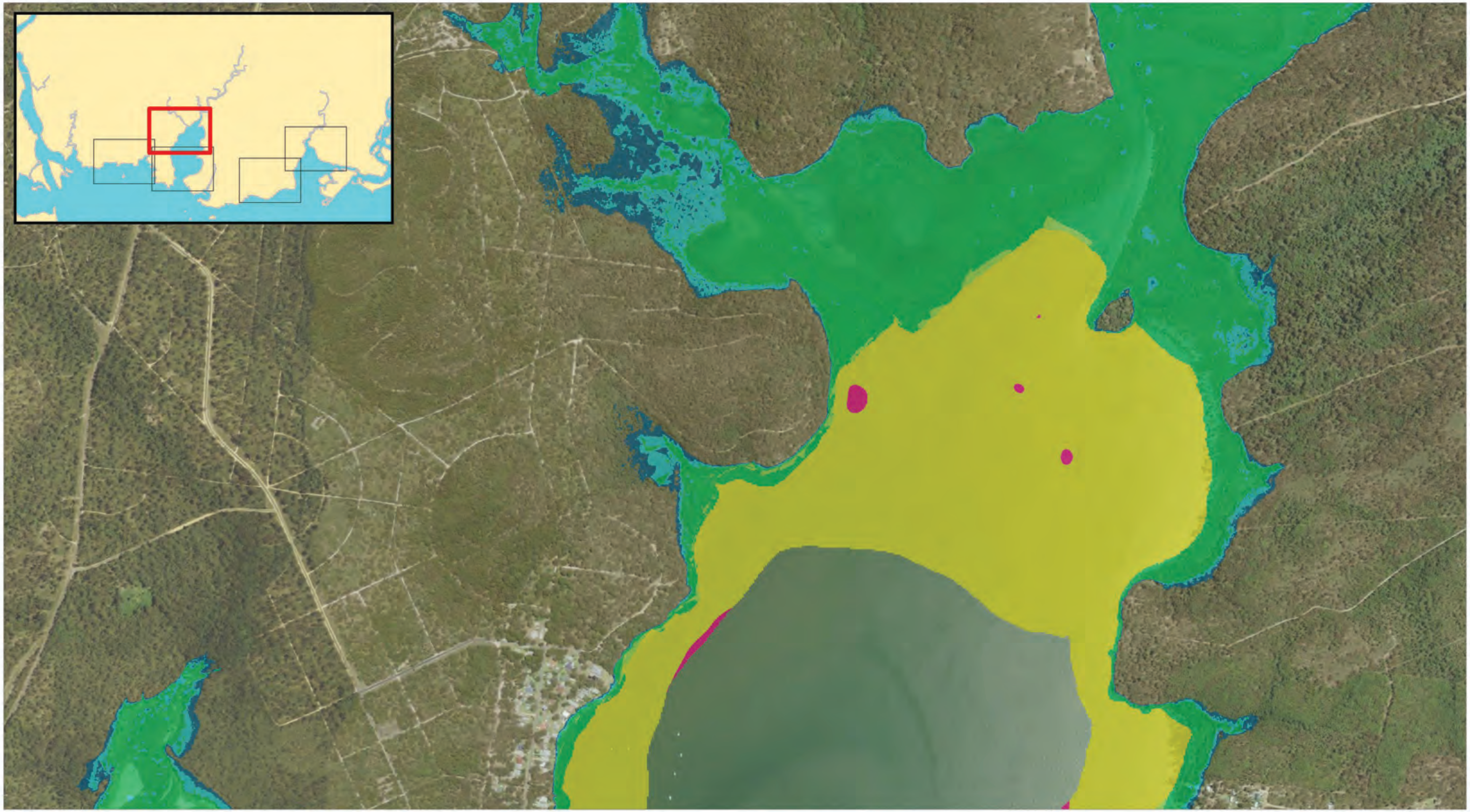

LEGEND
Hydraulic Classification

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

Title:
1% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Upper North Arm Cove

Figure: G-10

Rev: A

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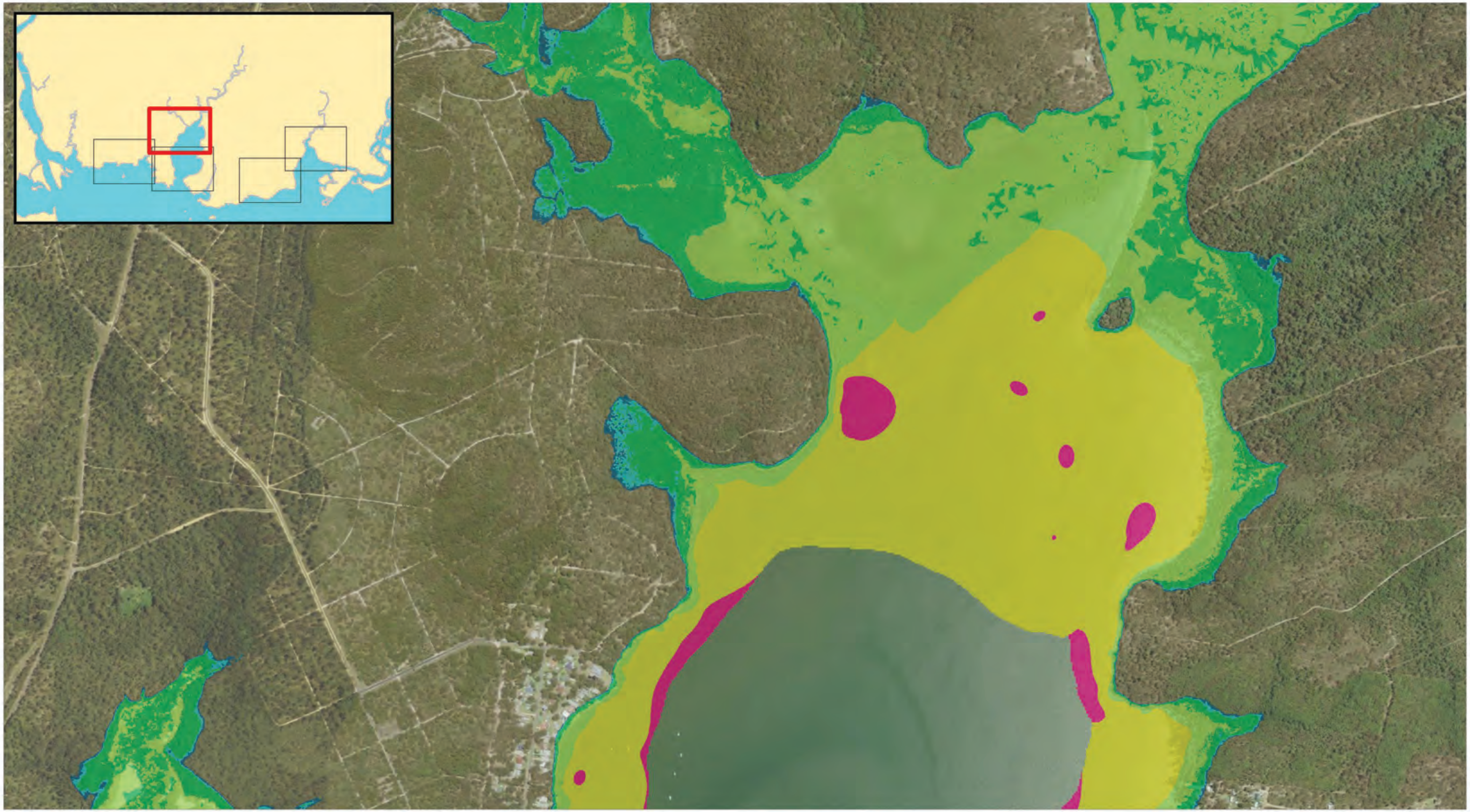

LEGEND
Hydraulic Classification

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

Title:
1% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: G-11

Rev: A

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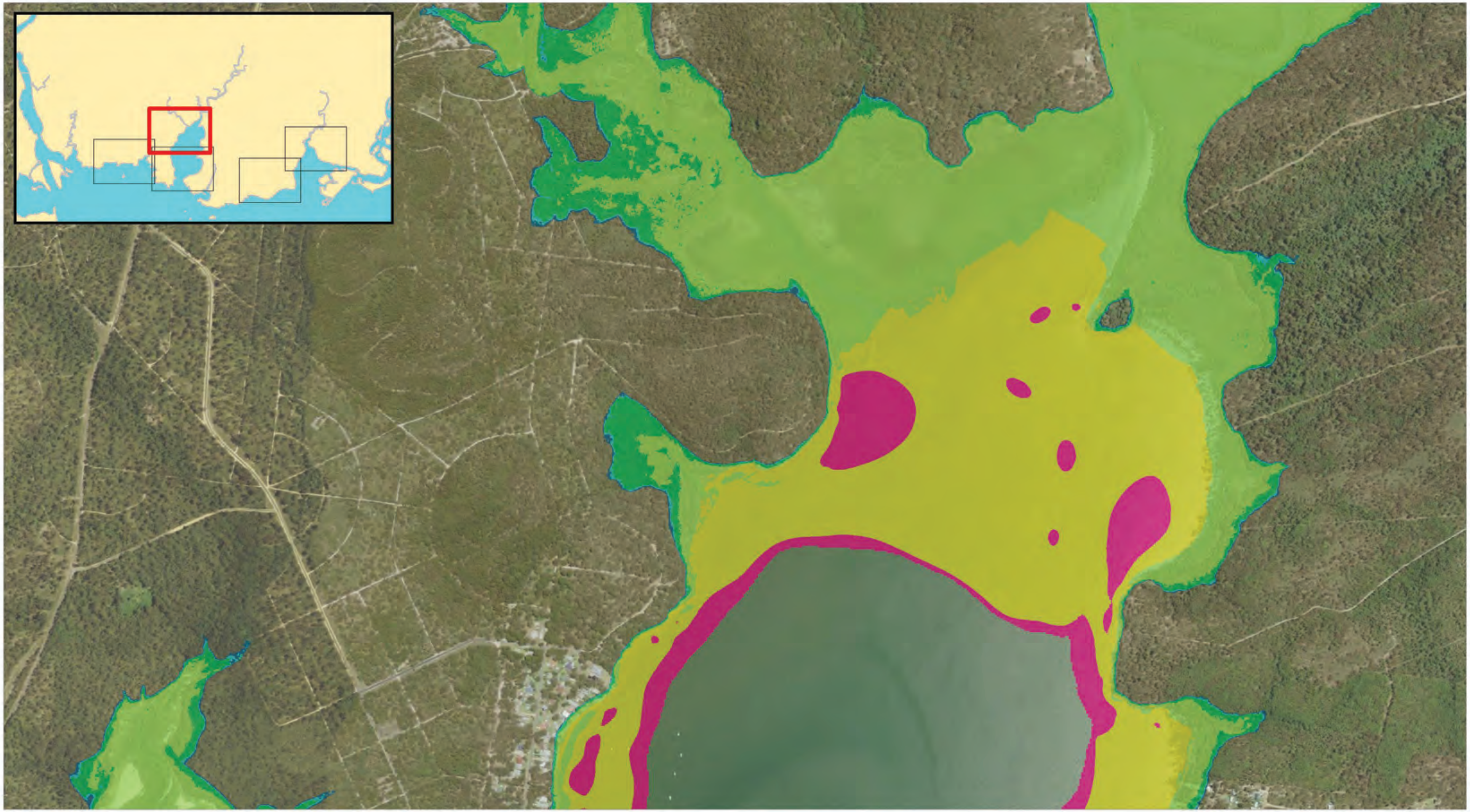

LEGEND

Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: G-12

Rev: A

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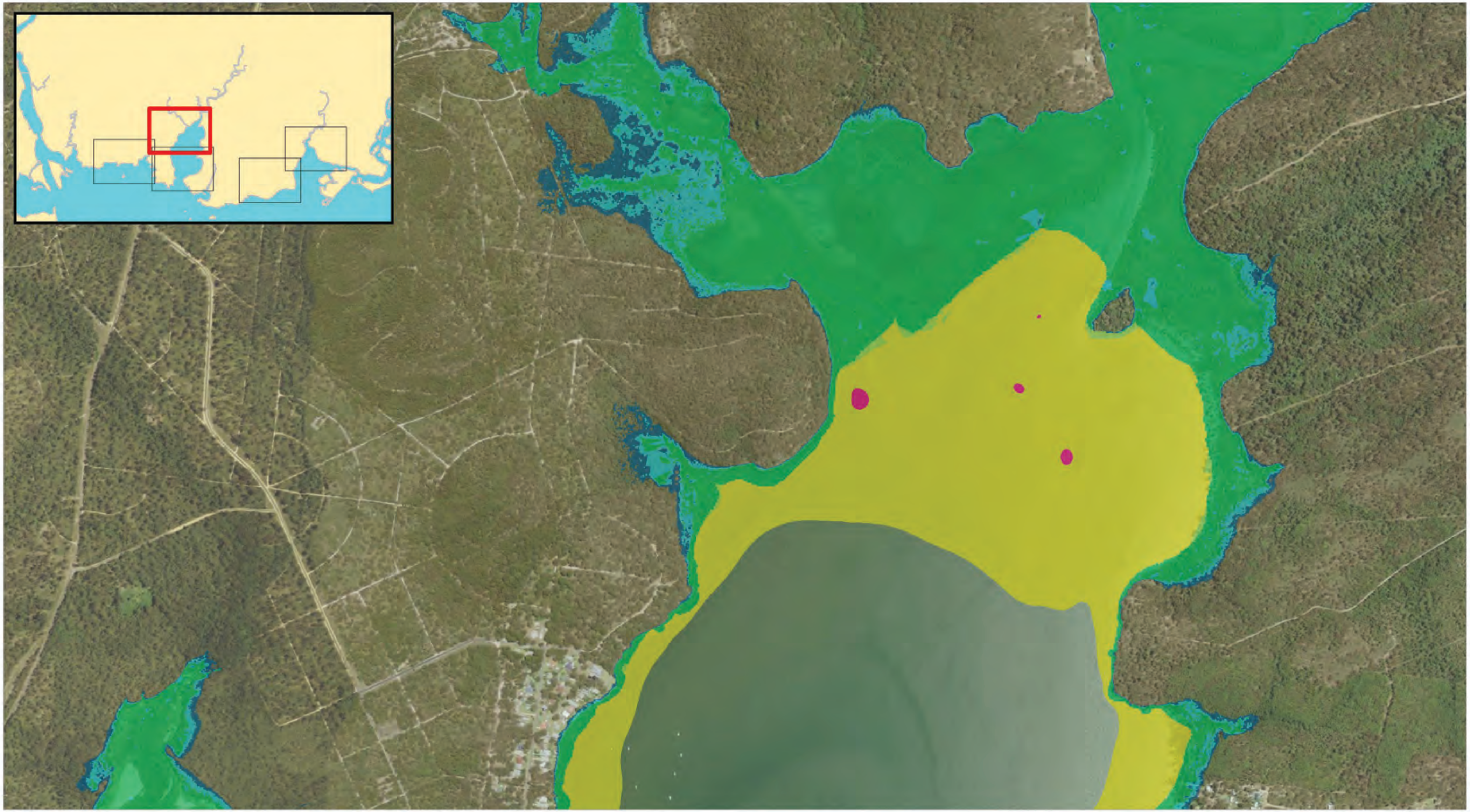

LEGEND
Hydraulic Classification

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

Title:
Extreme Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **G-13**

Rev: **A**

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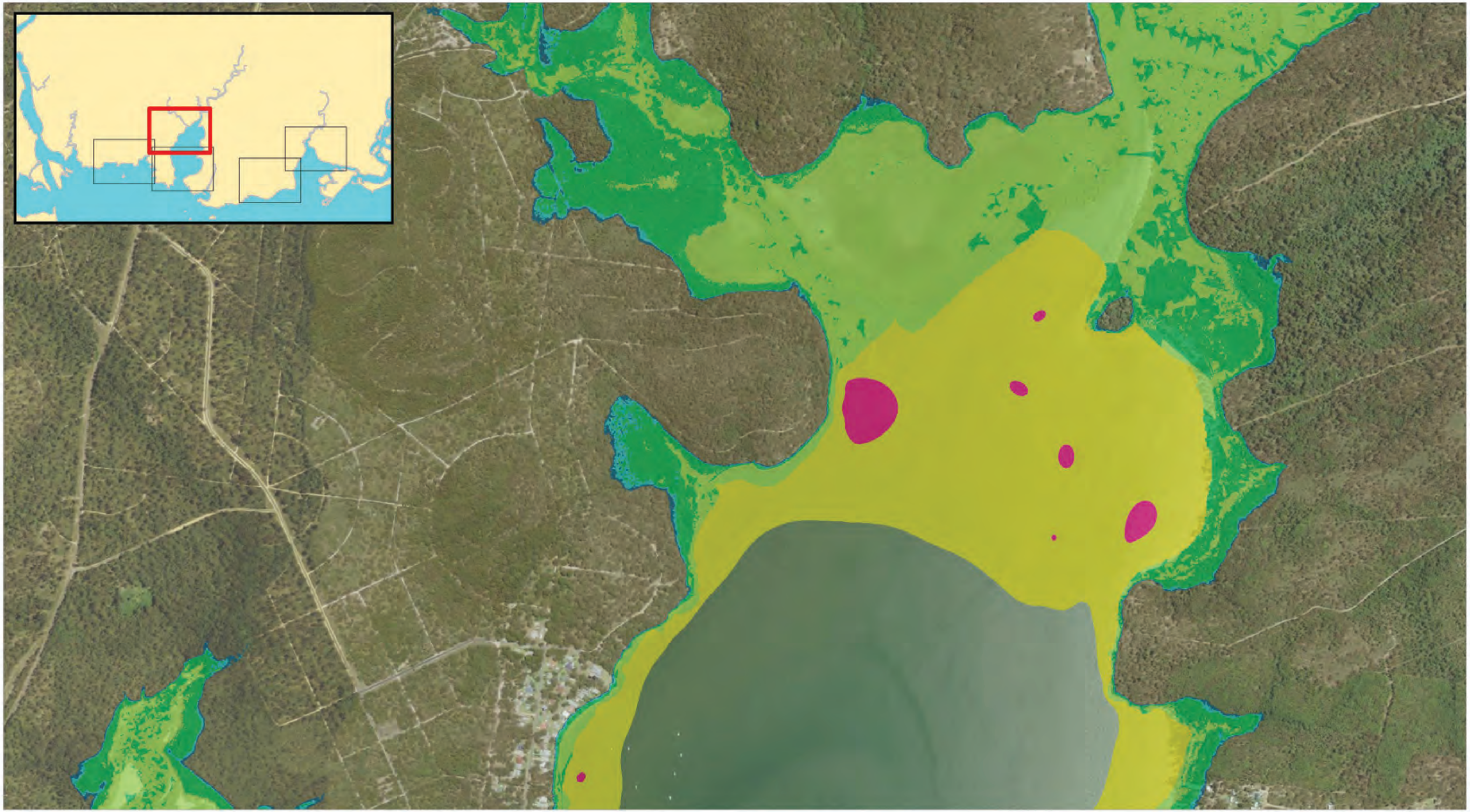

LEGEND
Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: G-14

Rev: A

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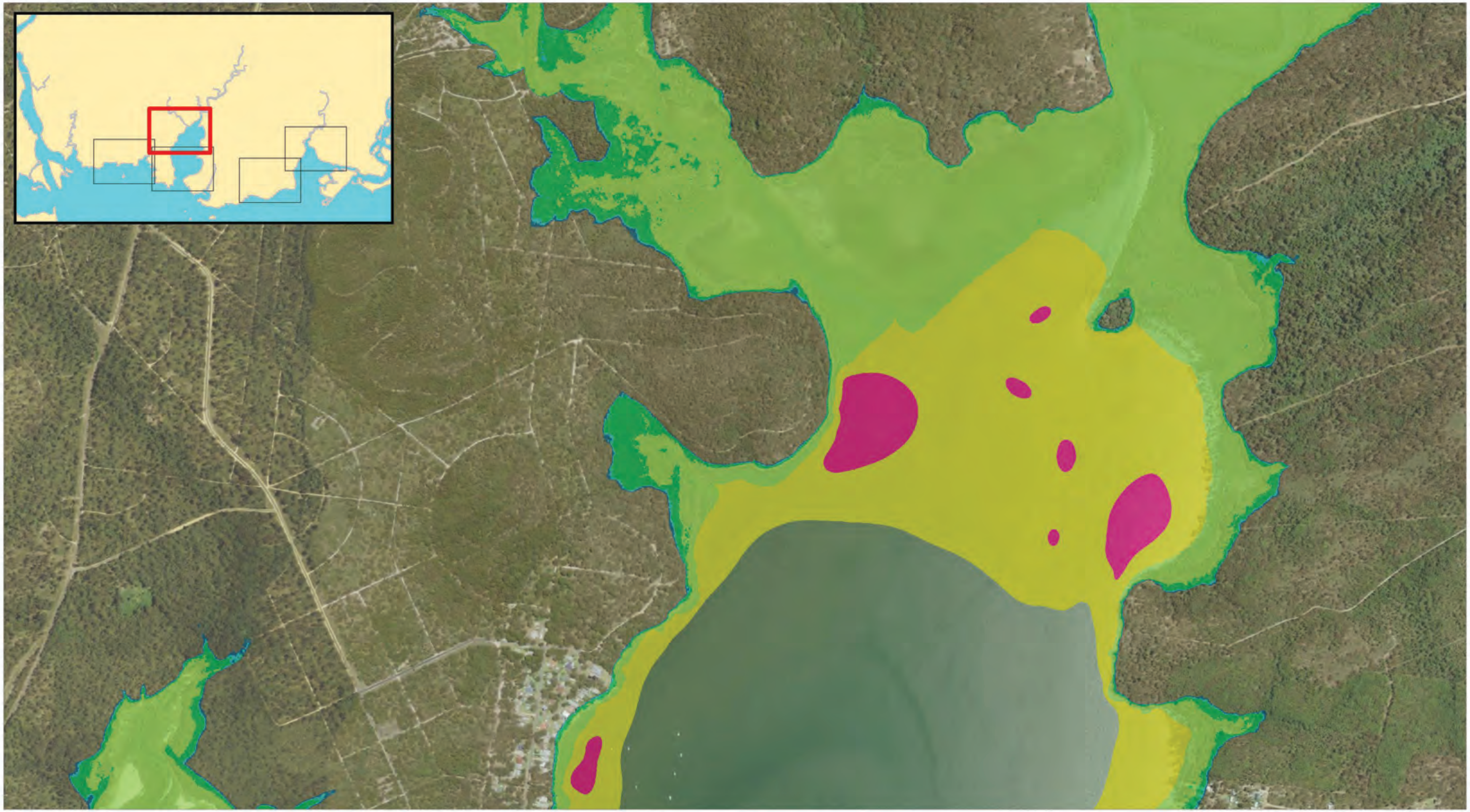

LEGEND
Hydraulic Classification

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

Title:
Extreme Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **G-15**

Rev: **A**

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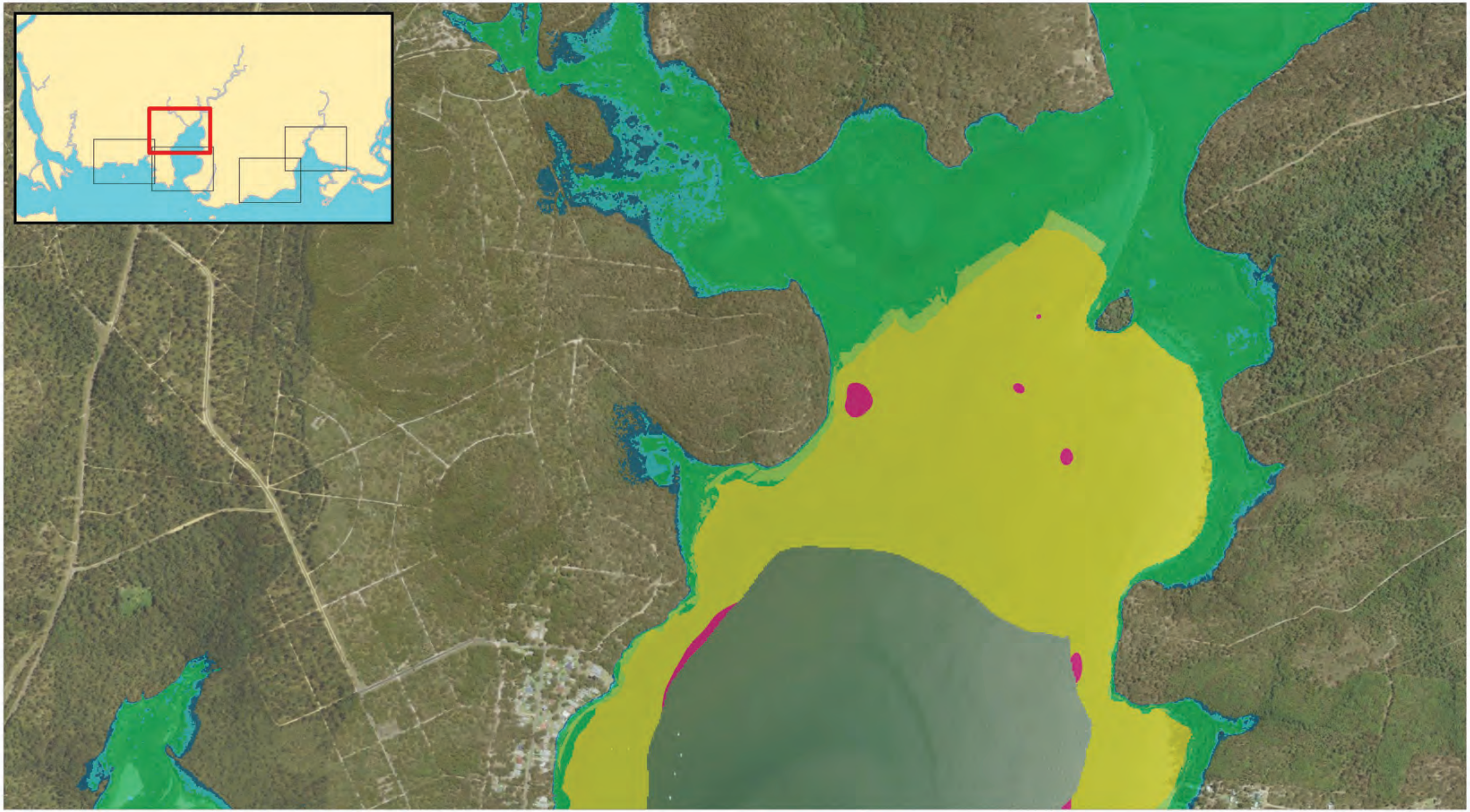

LEGEND

Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Upper North Arm Cove

Figure: **G-16**

Rev: **A**

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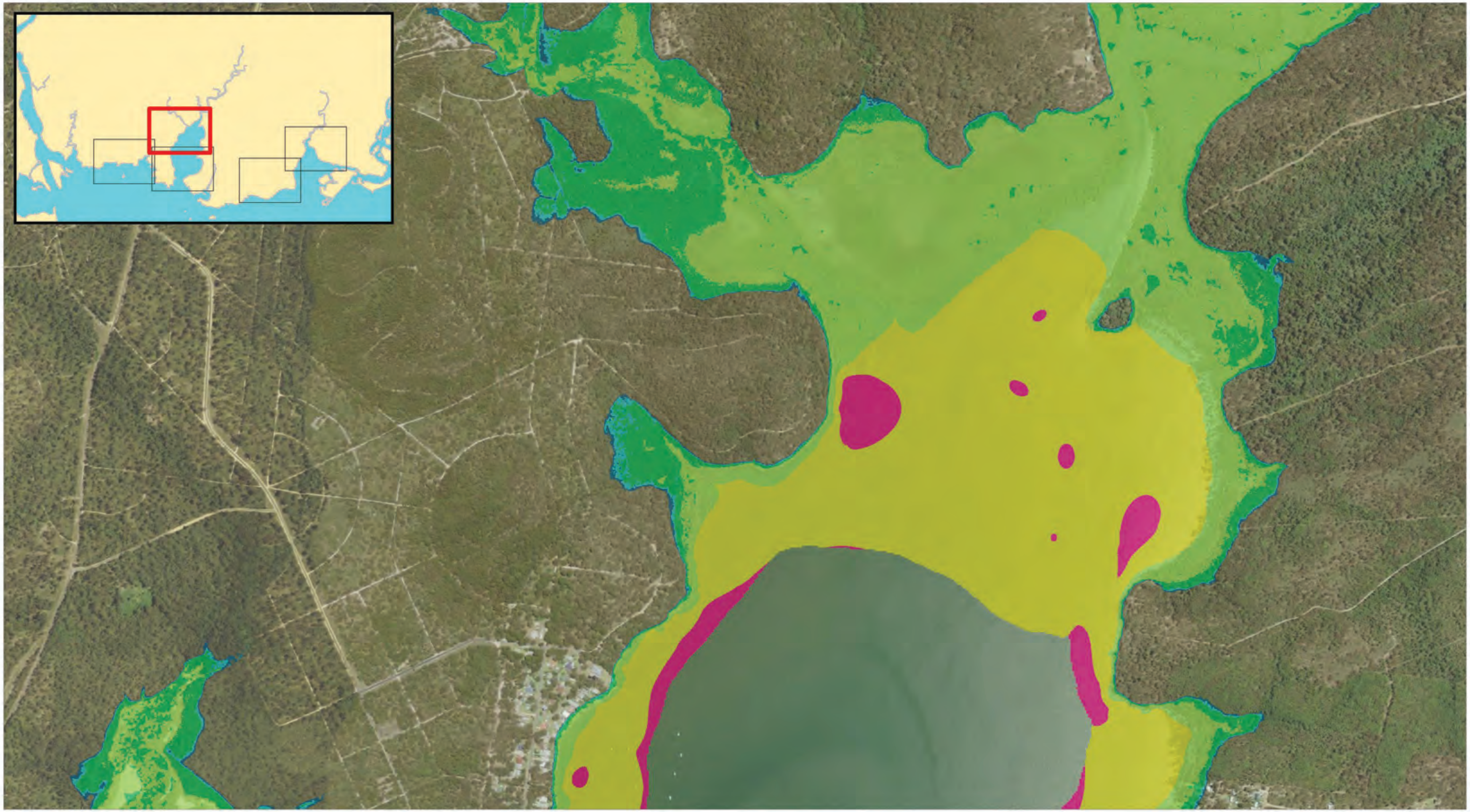

LEGEND
Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Upper North Arm Cove

Figure: **G-17**

Rev: **A**

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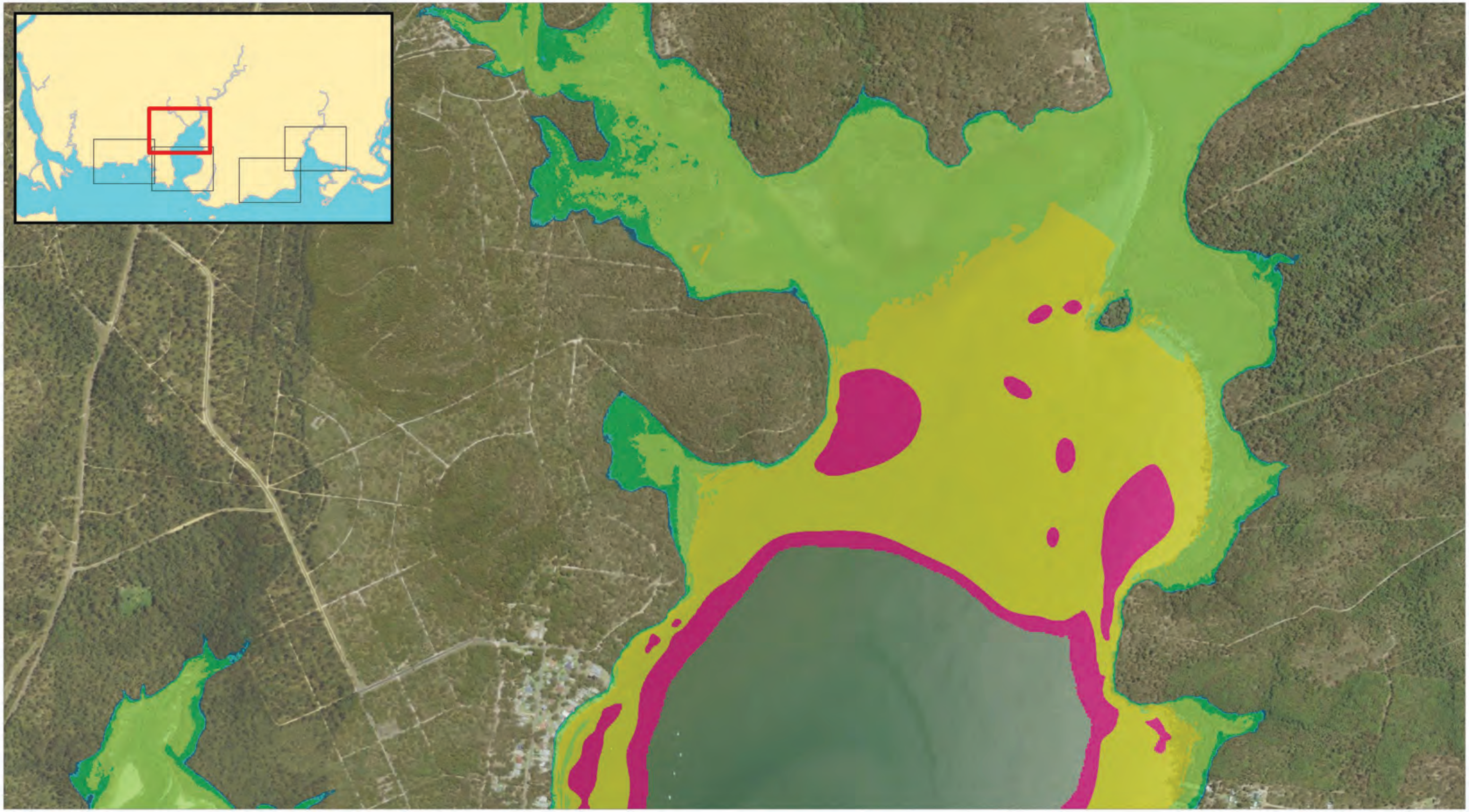

LEGEND
Hydraulic Classification

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

Title:
Extreme Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Upper North Arm Cove

Figure: **G-18**

Rev: **A**

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LEGEND
Hydraulic Classification

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

Title:
5% Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-01**

Rev: **A**

N

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Approx. Scale

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LEGEND
Hydraulic Classification

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

Title:

5% Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-02**

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LEGEND
Hydraulic Classification

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

Title:
5% Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-03**

Rev: **A**

N

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Approx. Scale

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LEGEND

Hydraulic Classification

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

Title:

5% Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-04**

Rev: **A**

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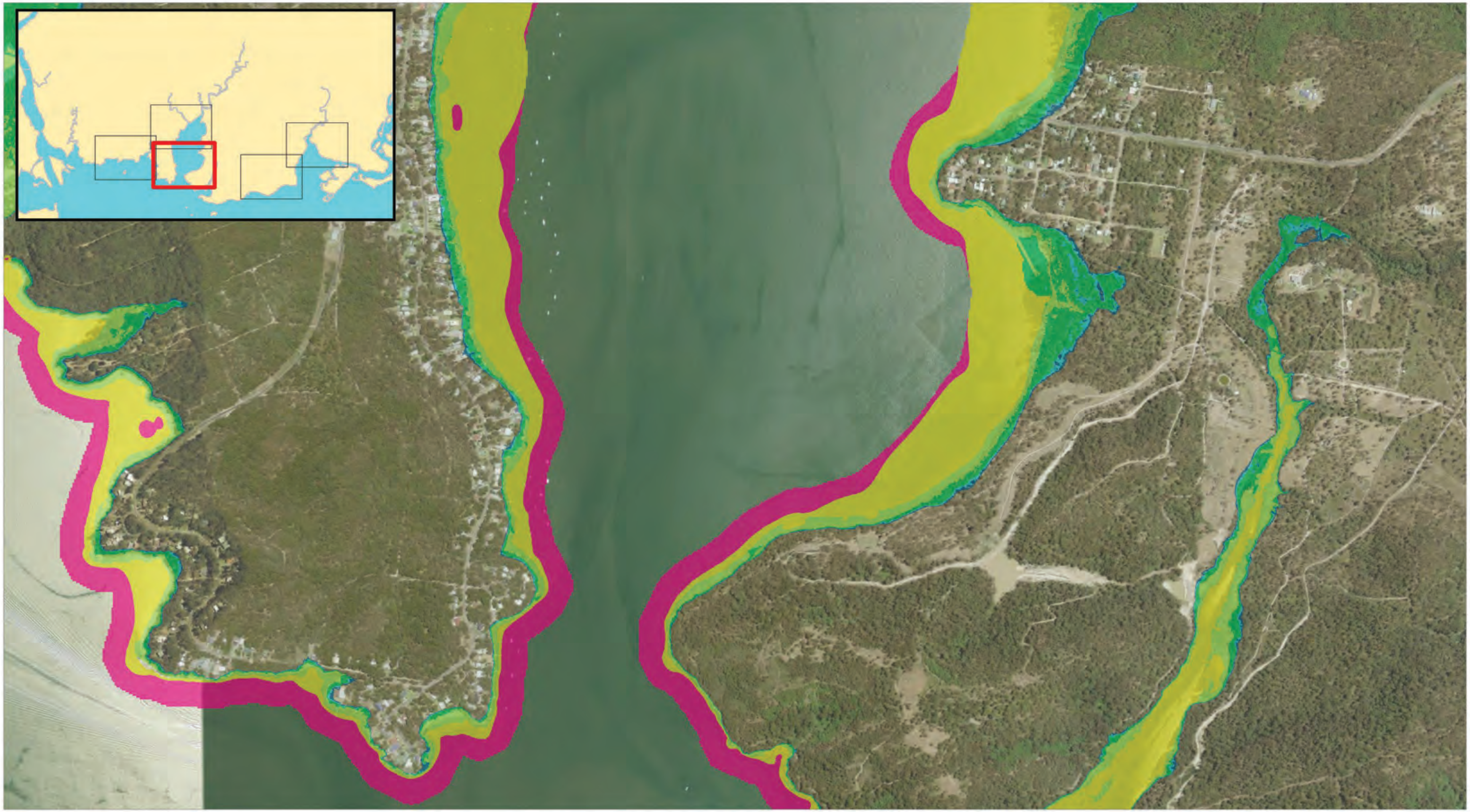

LEGEND
Hydraulic Classification

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

Title:

5% Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-05**

Rev: **A**

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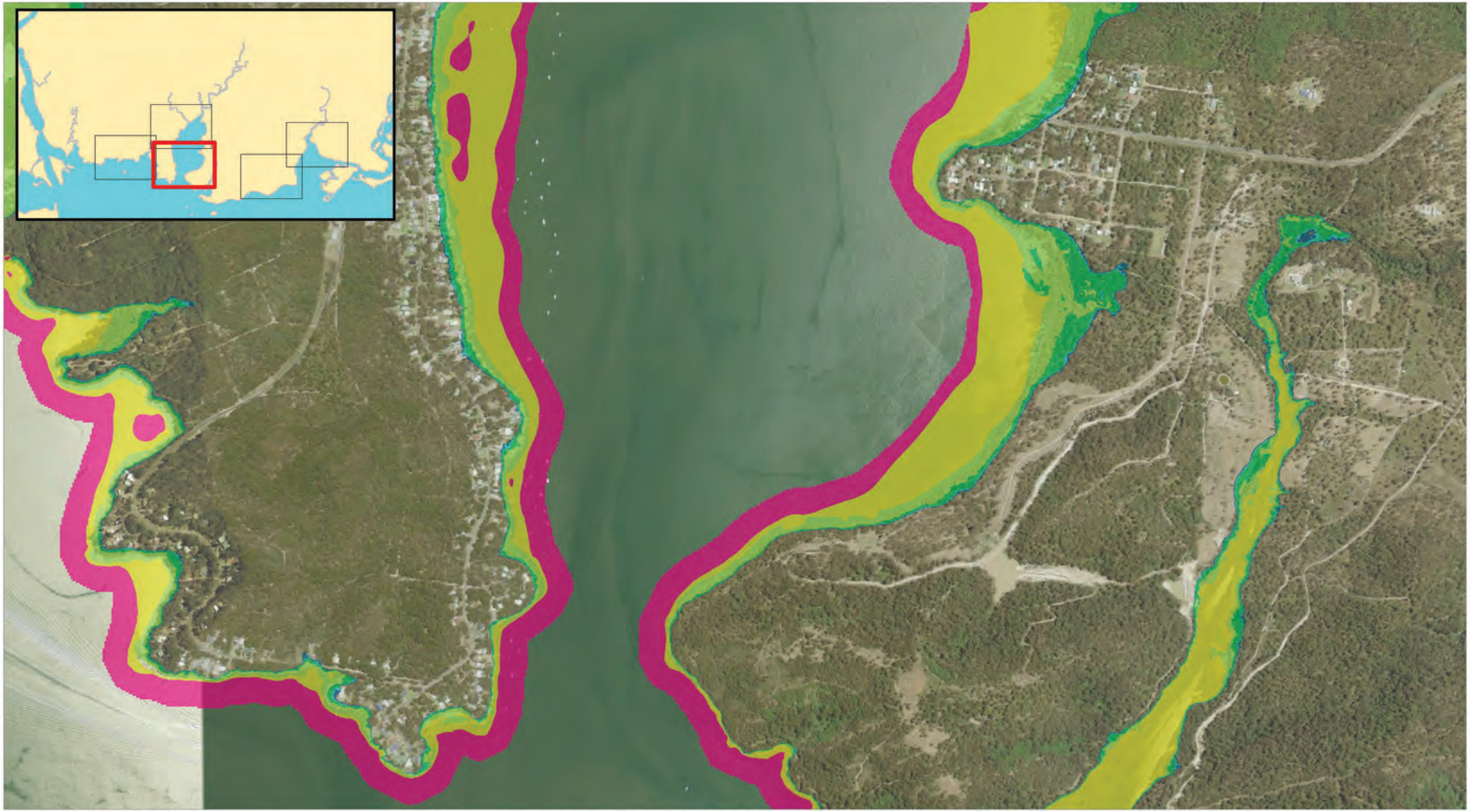
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H05_hazard_class_20yWRH_0p55SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
5% Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-06**

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LEGEND
Hydraulic Classification

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

Title:
1% Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-07**

Rev: **A**

N

0 250 500m
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LEGEND
Hydraulic Classification

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

Title:

1% Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-08**

Rev: **A**

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H08_hazard_class_100ySWL_0p55SLR_001.wor"

LEGEND

Hydraulic Classification

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

Title:

1% Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-09**

Rev: **A**

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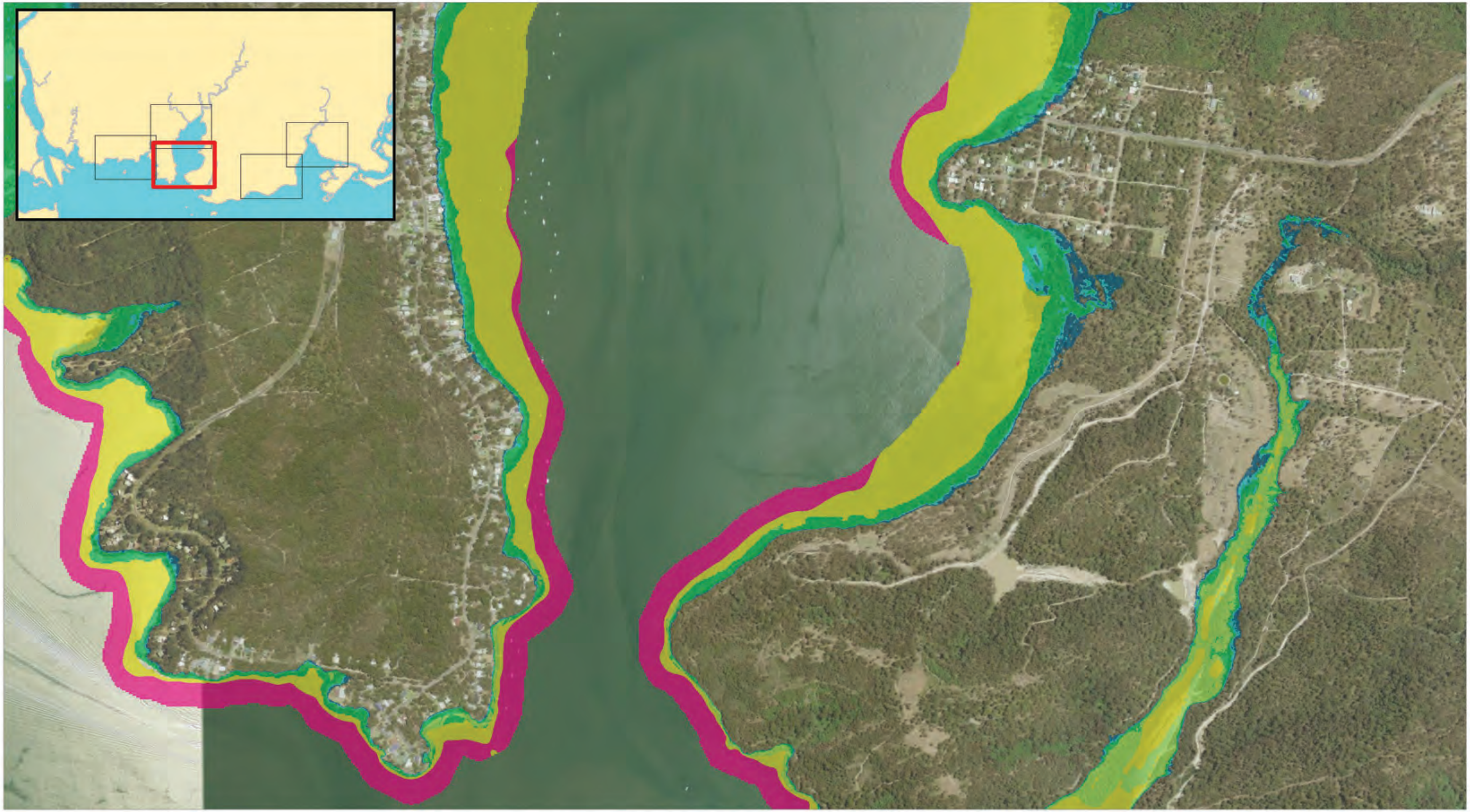

LEGEND
Hydraulic Classification

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

Title:

1% Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-10**

Rev: **A**

N

0 250 500m
Approx. Scale

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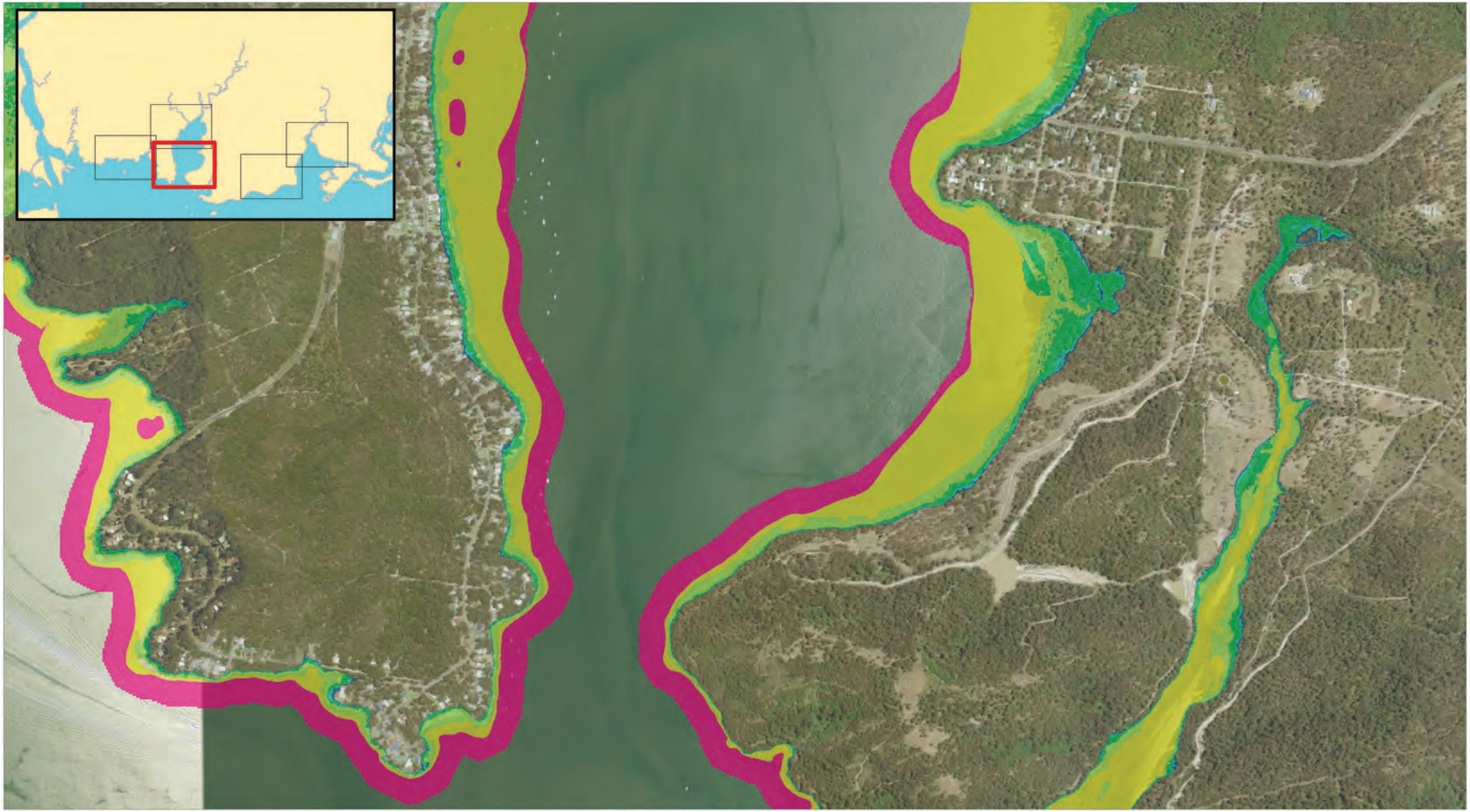

LEGEND
Hydraulic Classification

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

Title:
1% Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-11**

Rev: **A**

N

0 250 500m
Approx. Scale

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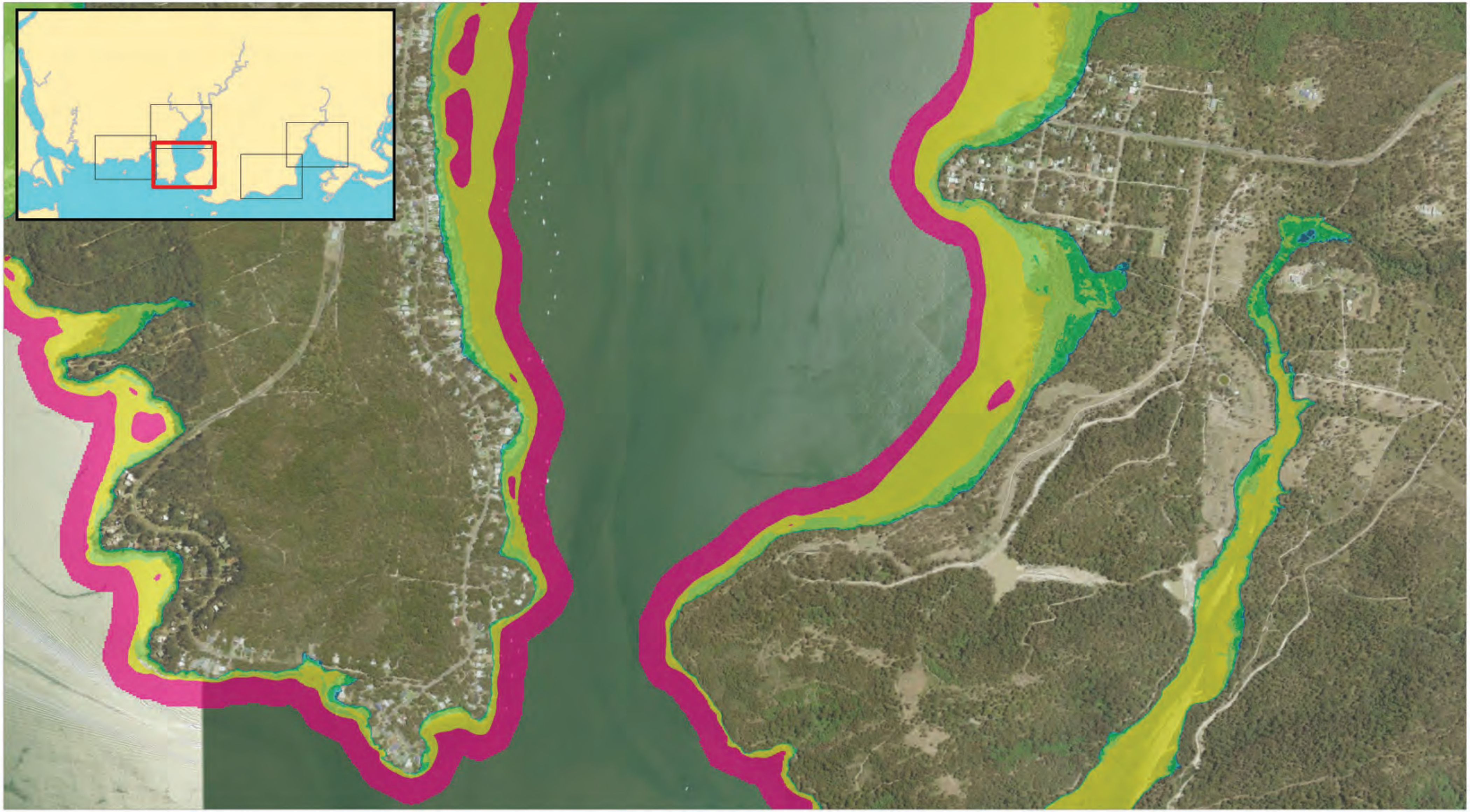
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H11_hazard_class_100yWRH_0p55SLR_001.wor"



LEGEND

Hydraulic Classification

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

Title:

1% Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-12**

Rev: **A**

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H12_hazard_class_100yWRH_0p91SLR_001.wor"

LEGEND
Hydraulic Classification

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

Title:
Extreme Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-13**

Rev: **A**

N

0 250 500m
Approx. Scale

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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H13_hazard_class_extSWL_0p0SLR_001.wor"

LEGEND
Hydraulic Classification

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

Title:
Extreme Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-14**

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LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-15**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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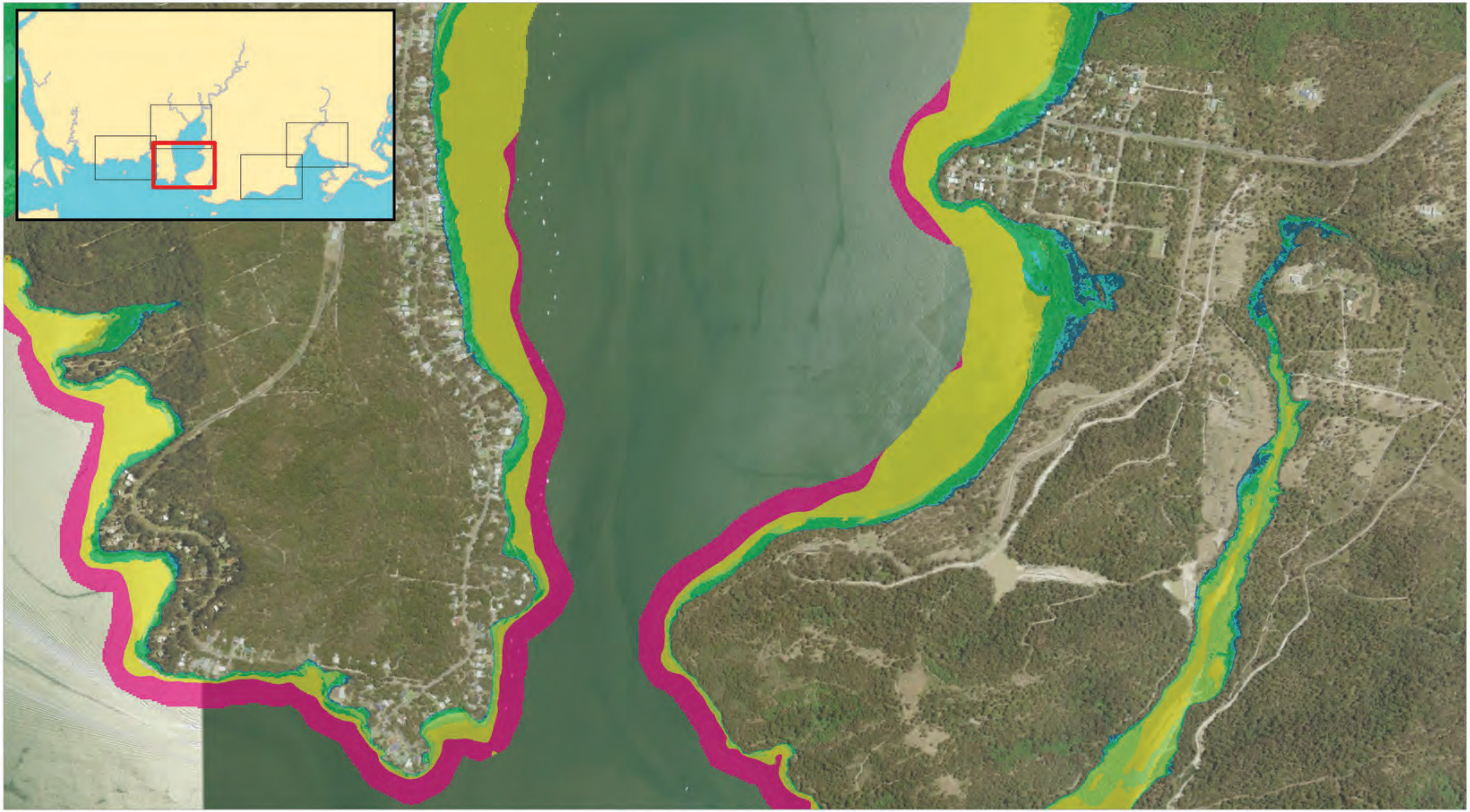
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H15_hazard_class_extSWL_0p91SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
Extreme Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-16**

Rev: **A**

N

0 250 500m
Approx. Scale

BMT
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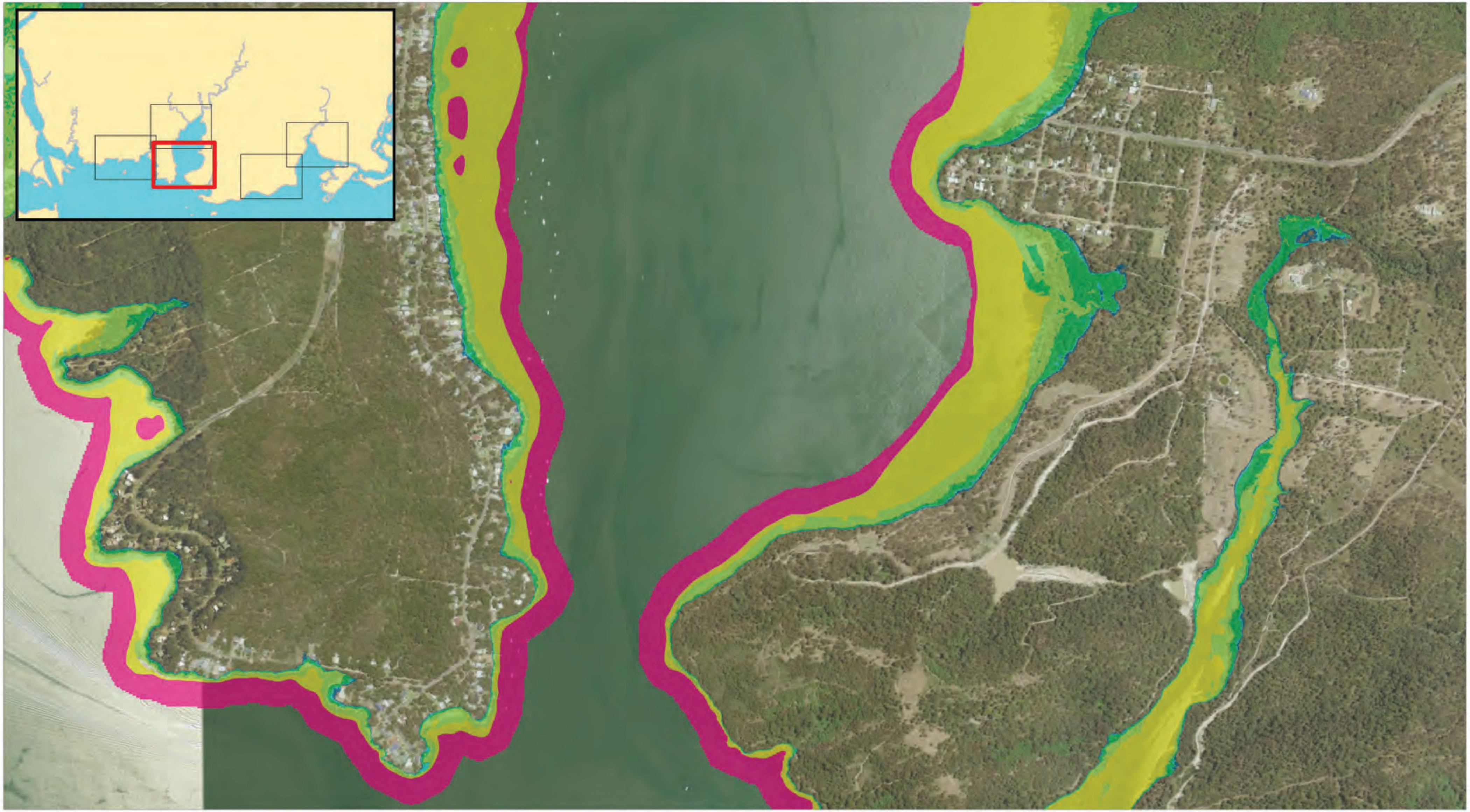
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H16_hazard_class_extWRH_0p0SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
Extreme Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-17**

Rev: **A**

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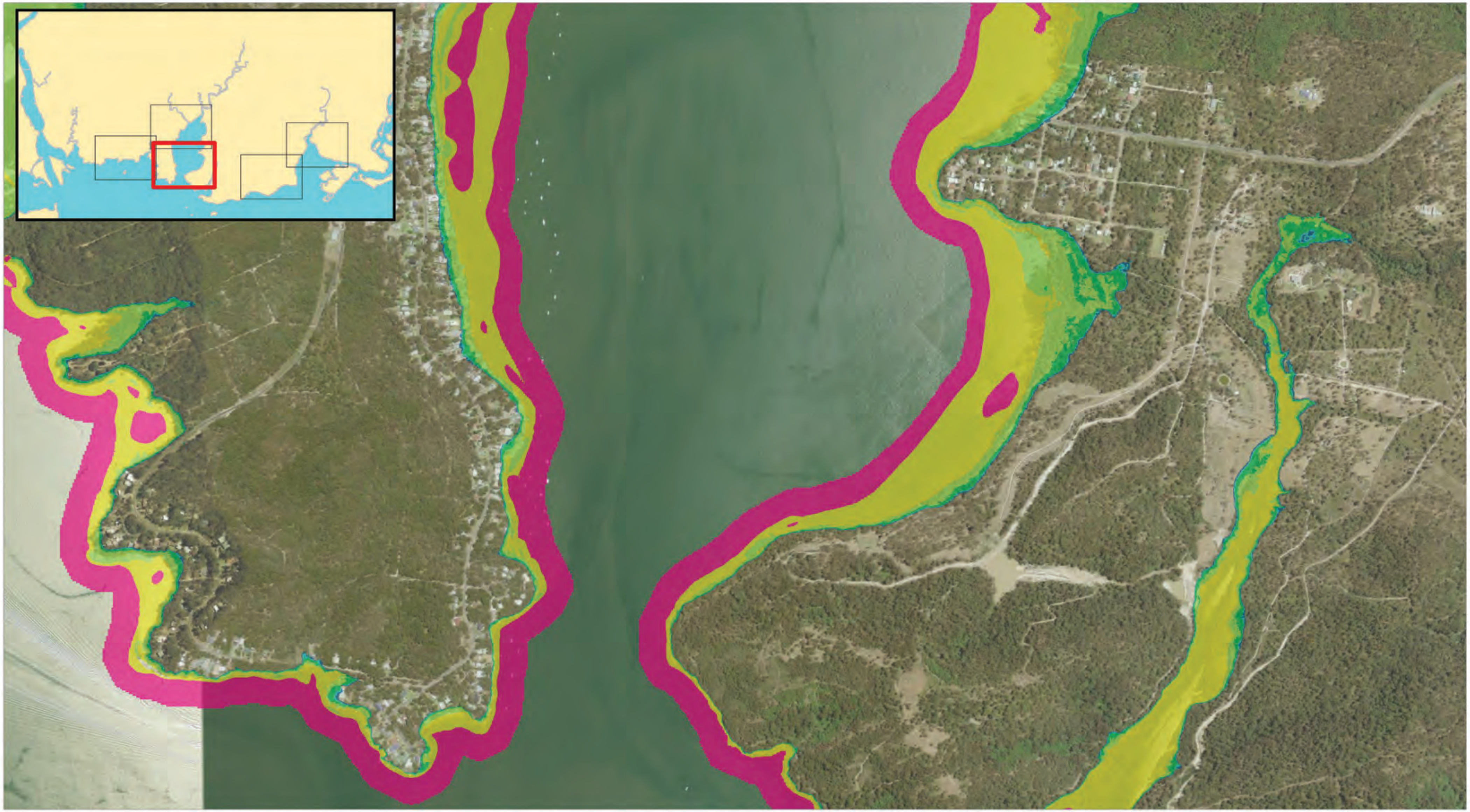

LEGEND
Hydraulic Classification

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

Title:
Extreme Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Lower North Arm Cove and Bundabah

Figure: **H-18**

Rev: **A**

N

0 250 500m
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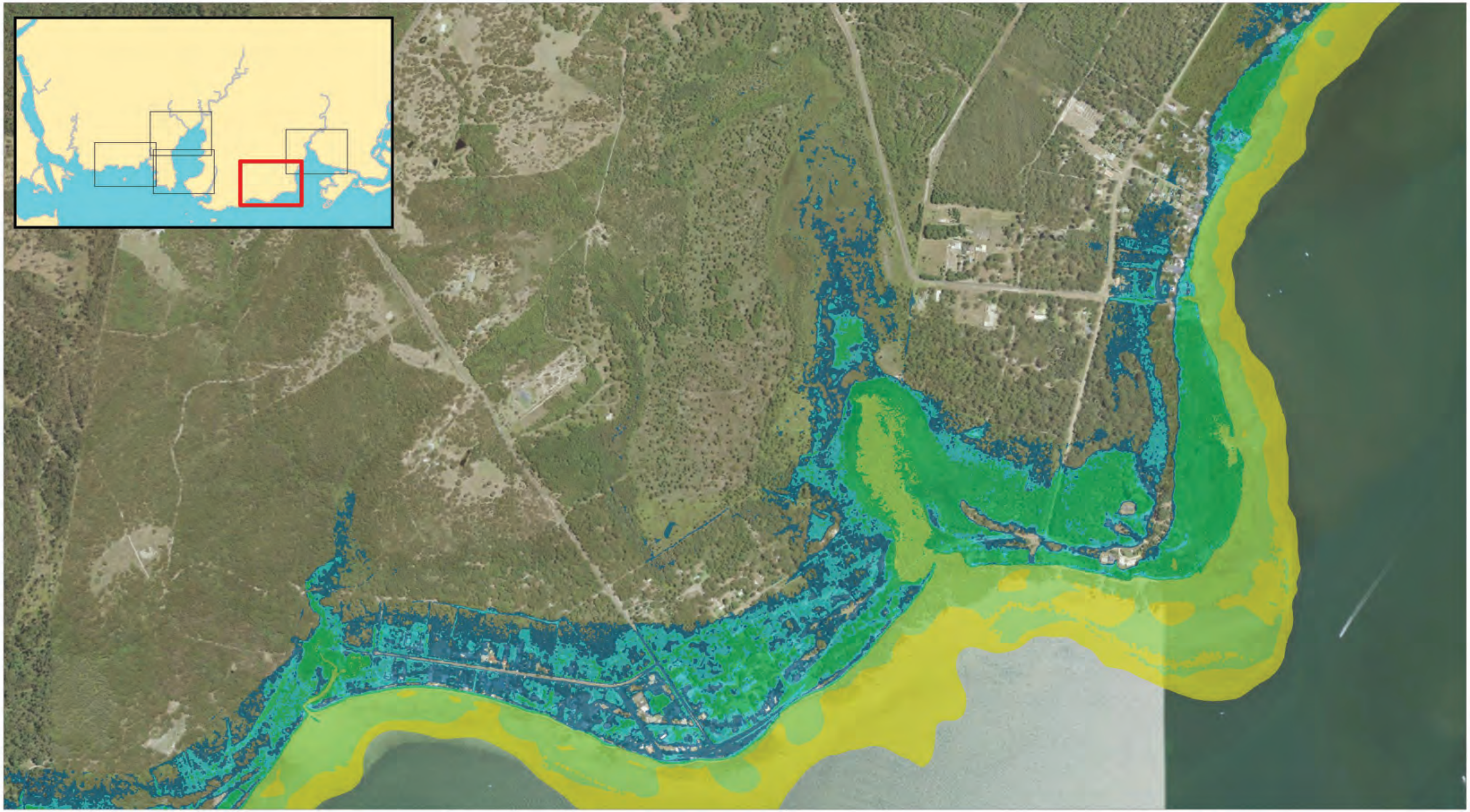
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_H18_hazard_class_extWRH_0p91SLR_001.wor"



LEGEND
Hydraulic Classification

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

Title:
5% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar South

Figure: **I-01**

Rev: **A**

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N

0 250 500m
Approx. Scale

BMT
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Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_I01_hazard_class_20ySWL_0p0SLR.wor"

LEGEND
Hydraulic Classification

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

Title:
5% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise South Pindimar

Figure: **I-02**

Rev: **A**

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0 250 500m
Approx. Scale

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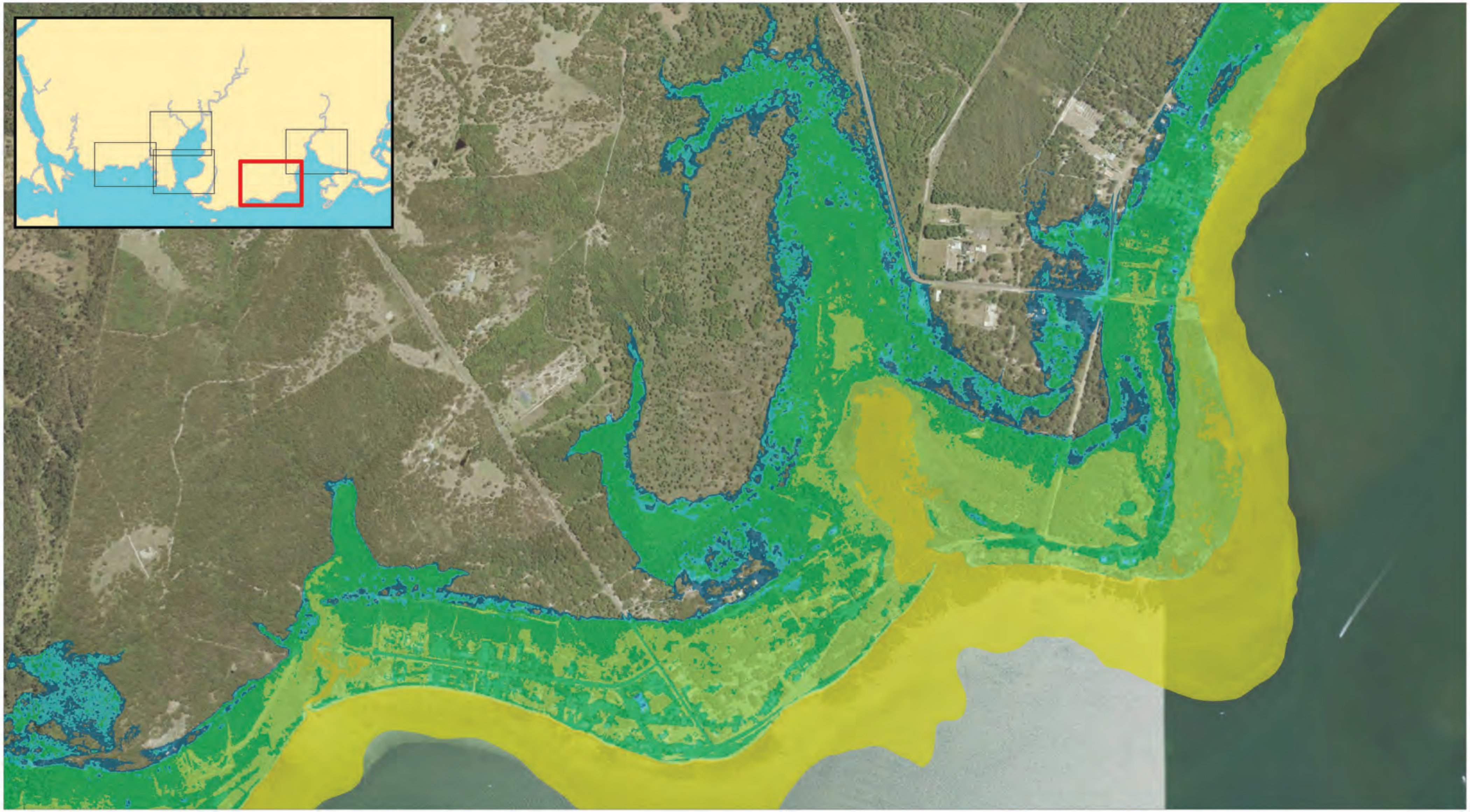

LEGEND
Hydraulic Classification

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

Title:
5% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise South Pindimar

Figure: I-03

Rev: A

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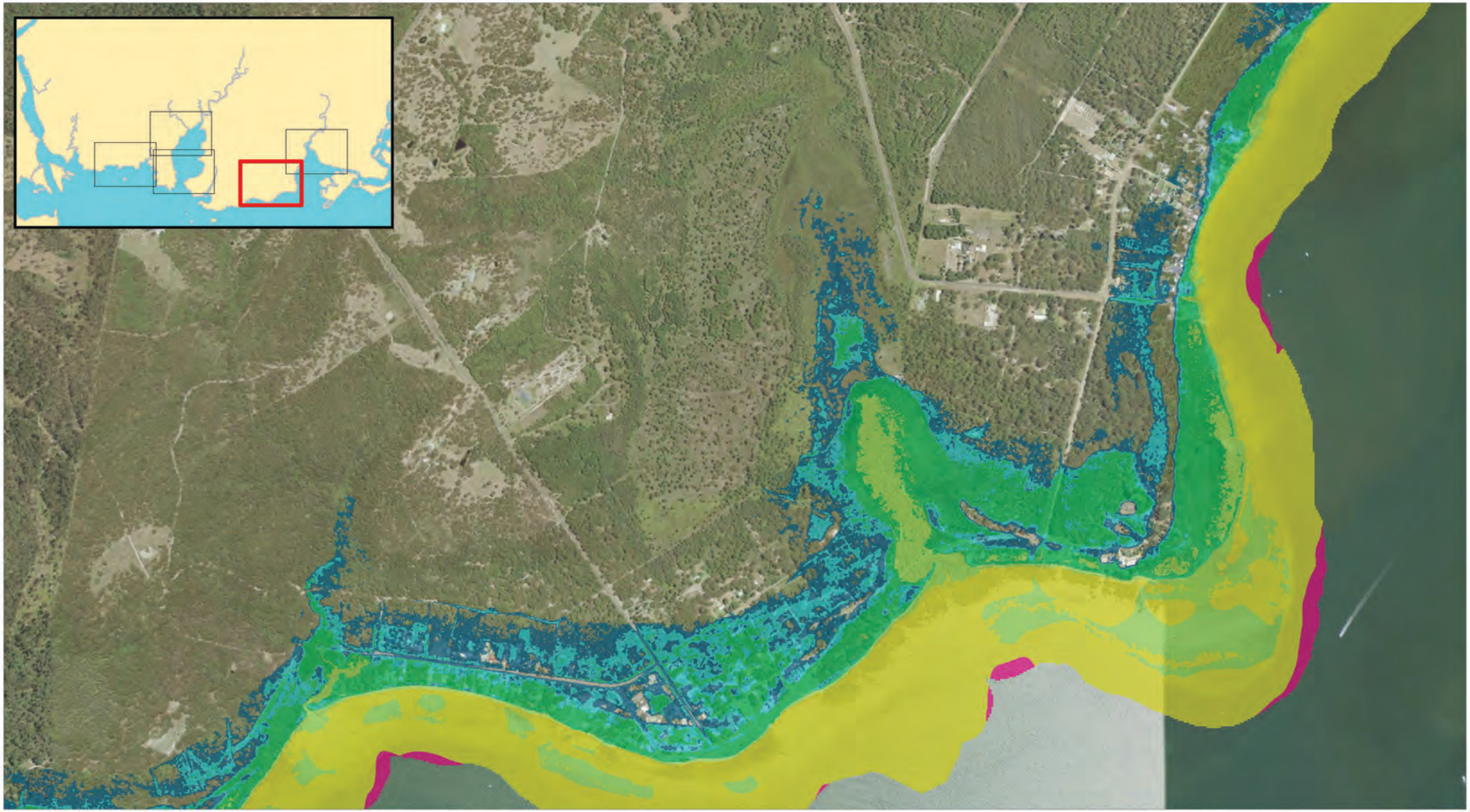

LEGEND
Hydraulic Classification

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

Title:
5% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar South

Figure: **I-04**

Rev: **A**

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Approx. Scale

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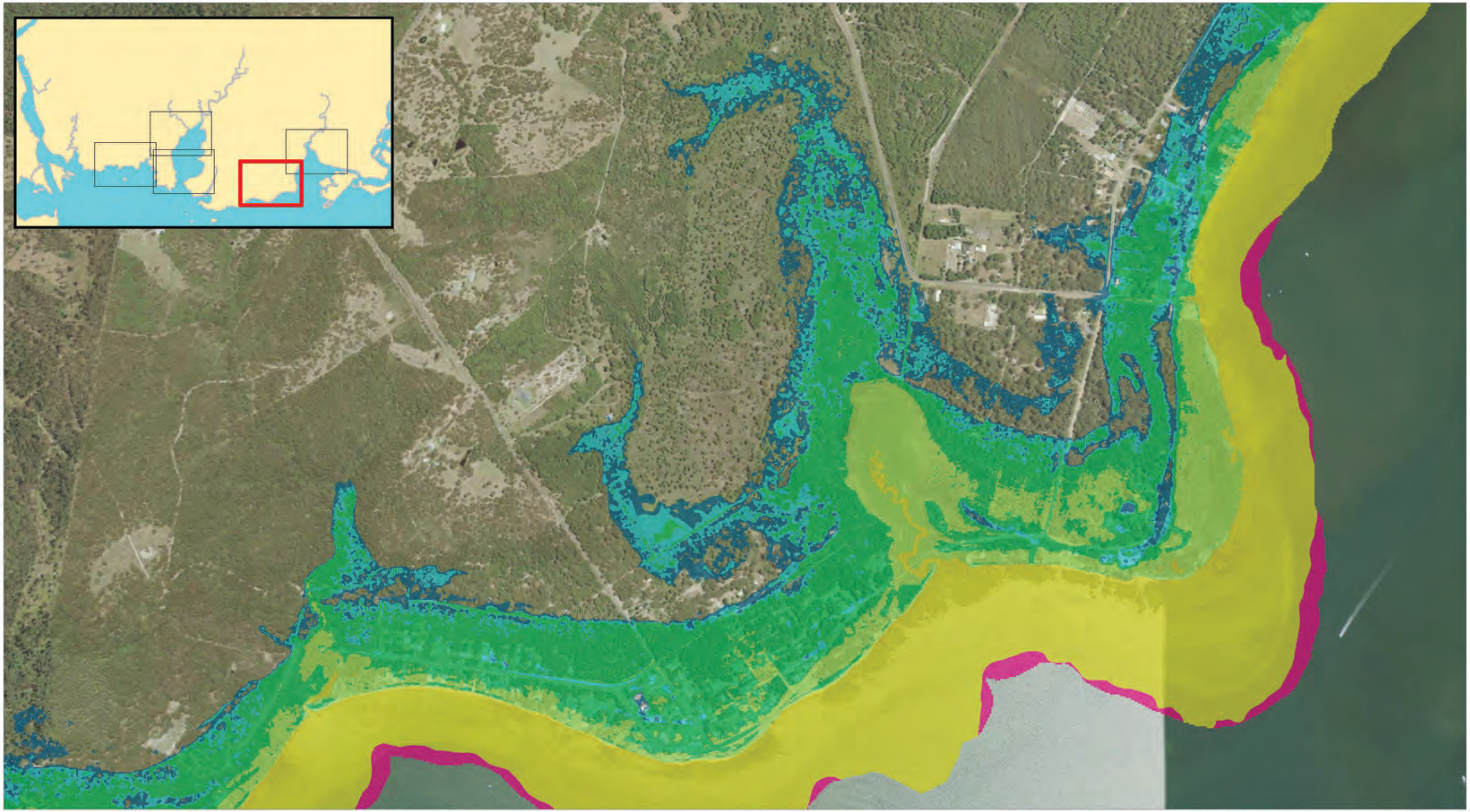

LEGEND
Hydraulic Classification

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

Title:
5% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar South

Figure: **I-05**

Rev: **A**

N

0 250 500m
Approx. Scale

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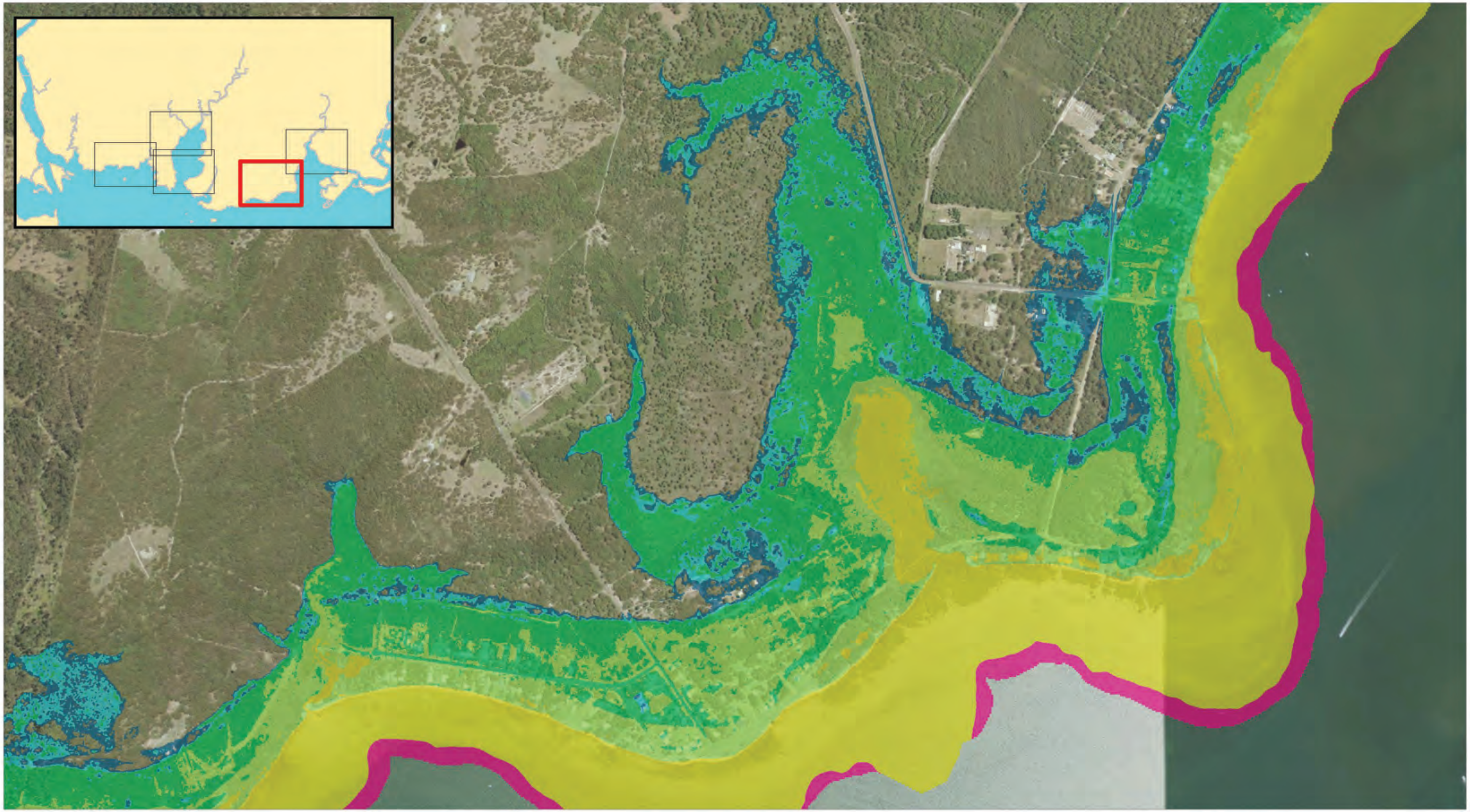

LEGEND
Hydraulic Classification

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

Title:

5% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar South

Figure: I-06

Rev: A

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Approx. Scale

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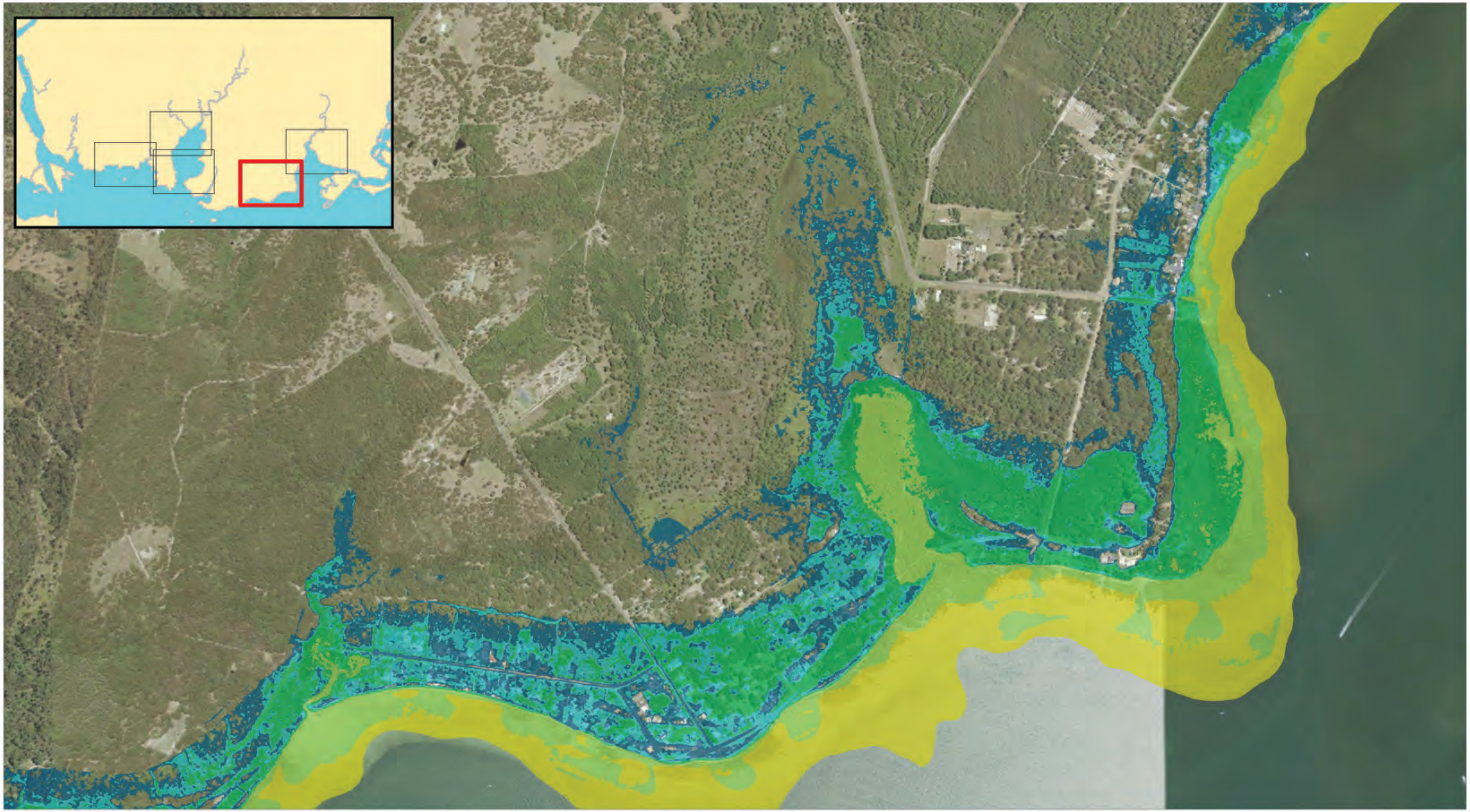

LEGEND
Hydraulic Classification

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

Title:
1% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar South

Figure: **I-07**

Rev: **A**

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0 250 500m
Approx. Scale

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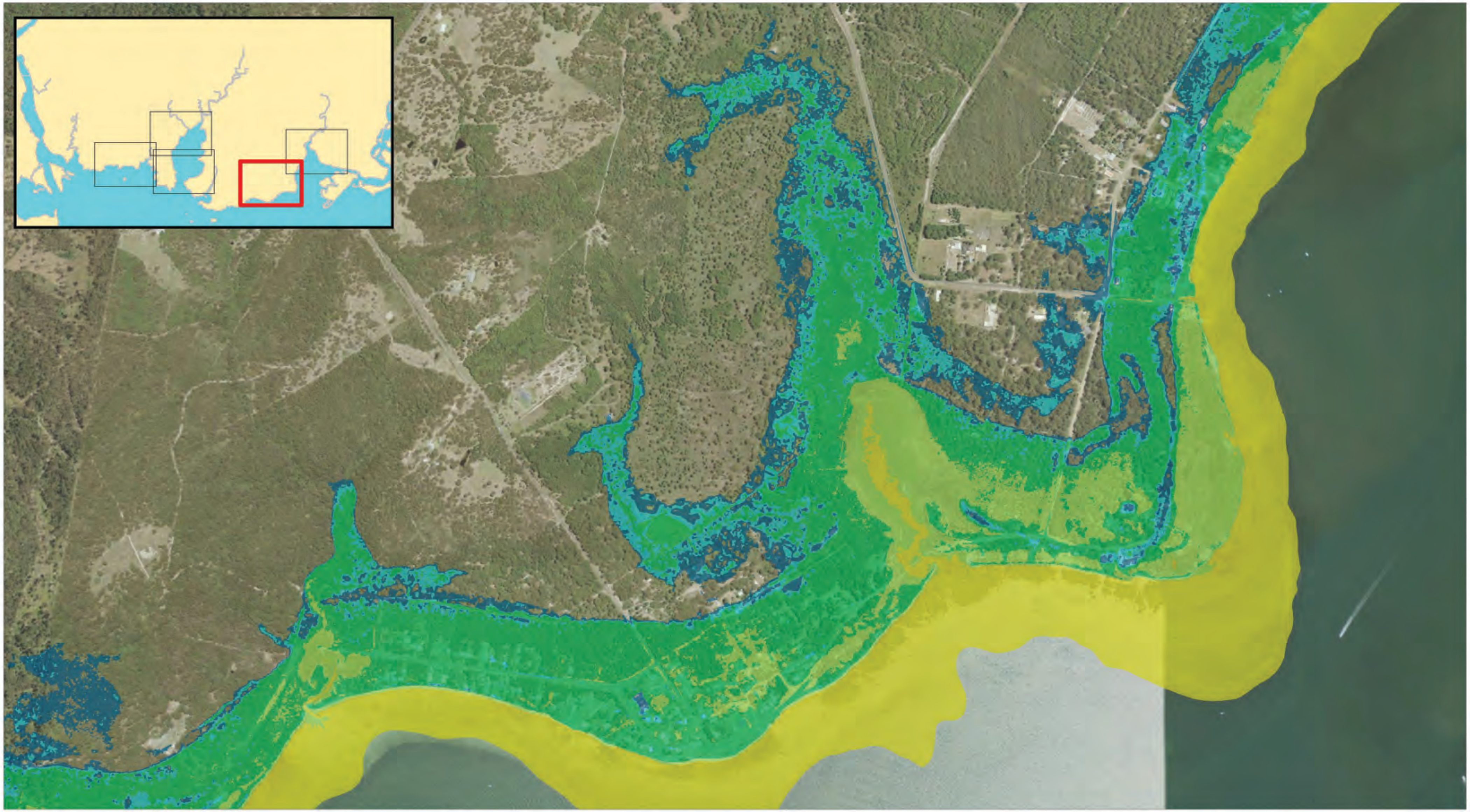

LEGEND
Hydraulic Classification

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

Title:

1% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise Pindimar South

Figure: **I-08**

Rev: **A**

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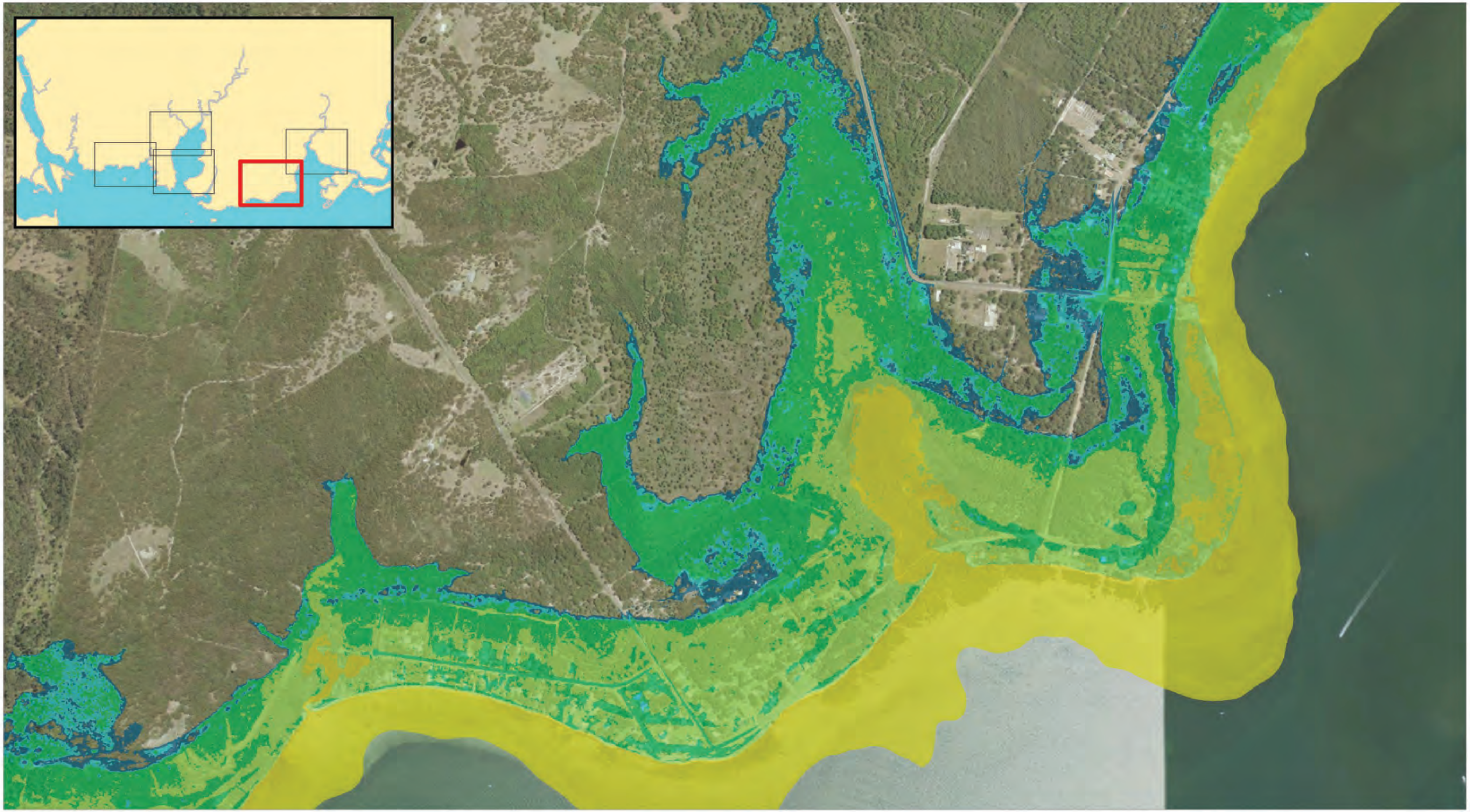

LEGEND
Hydraulic Classification

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

Title:
1% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise Pindimar South

Figure: I-09

Rev: A

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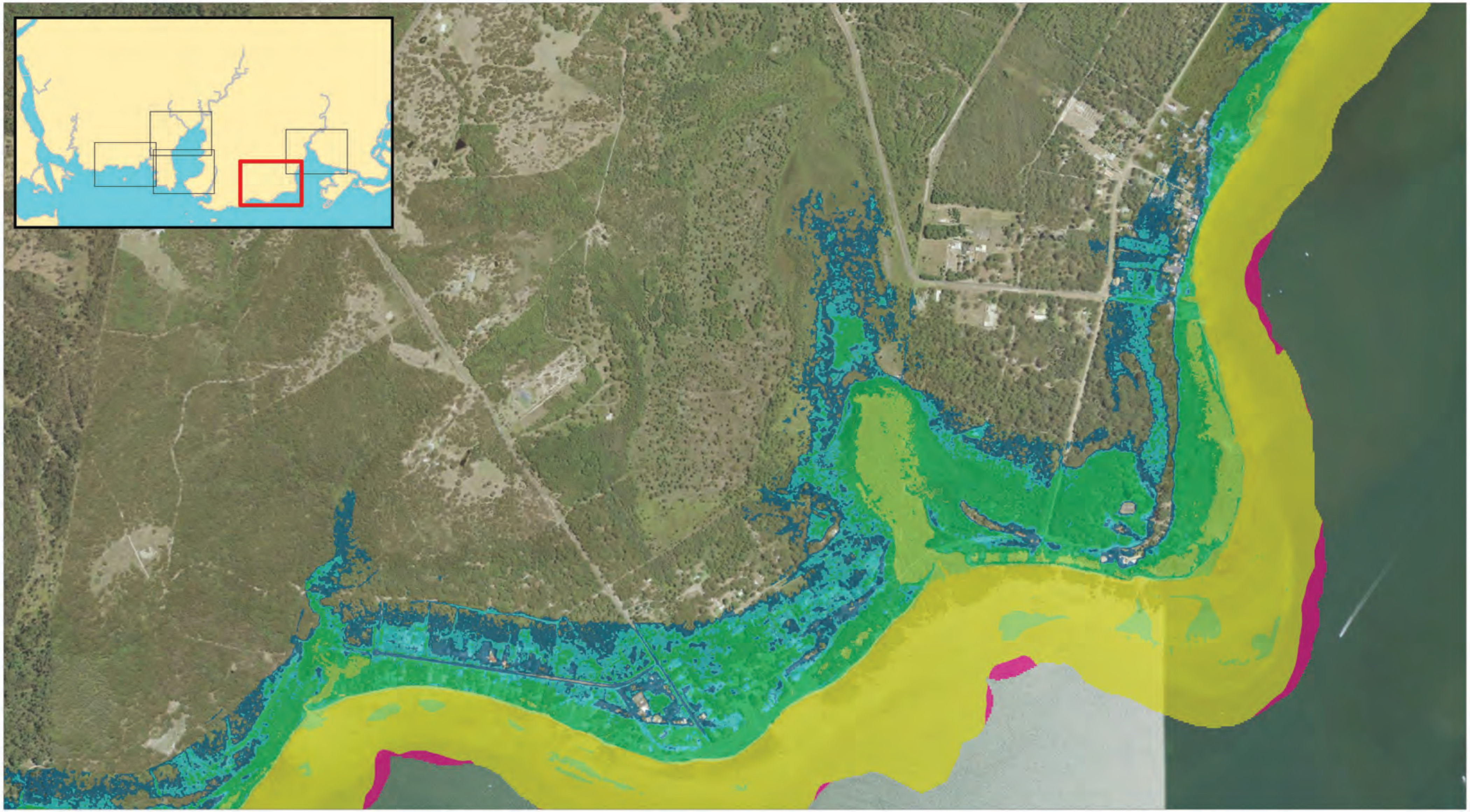

LEGEND

Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar South

Figure: **I-10**

Rev: **A**

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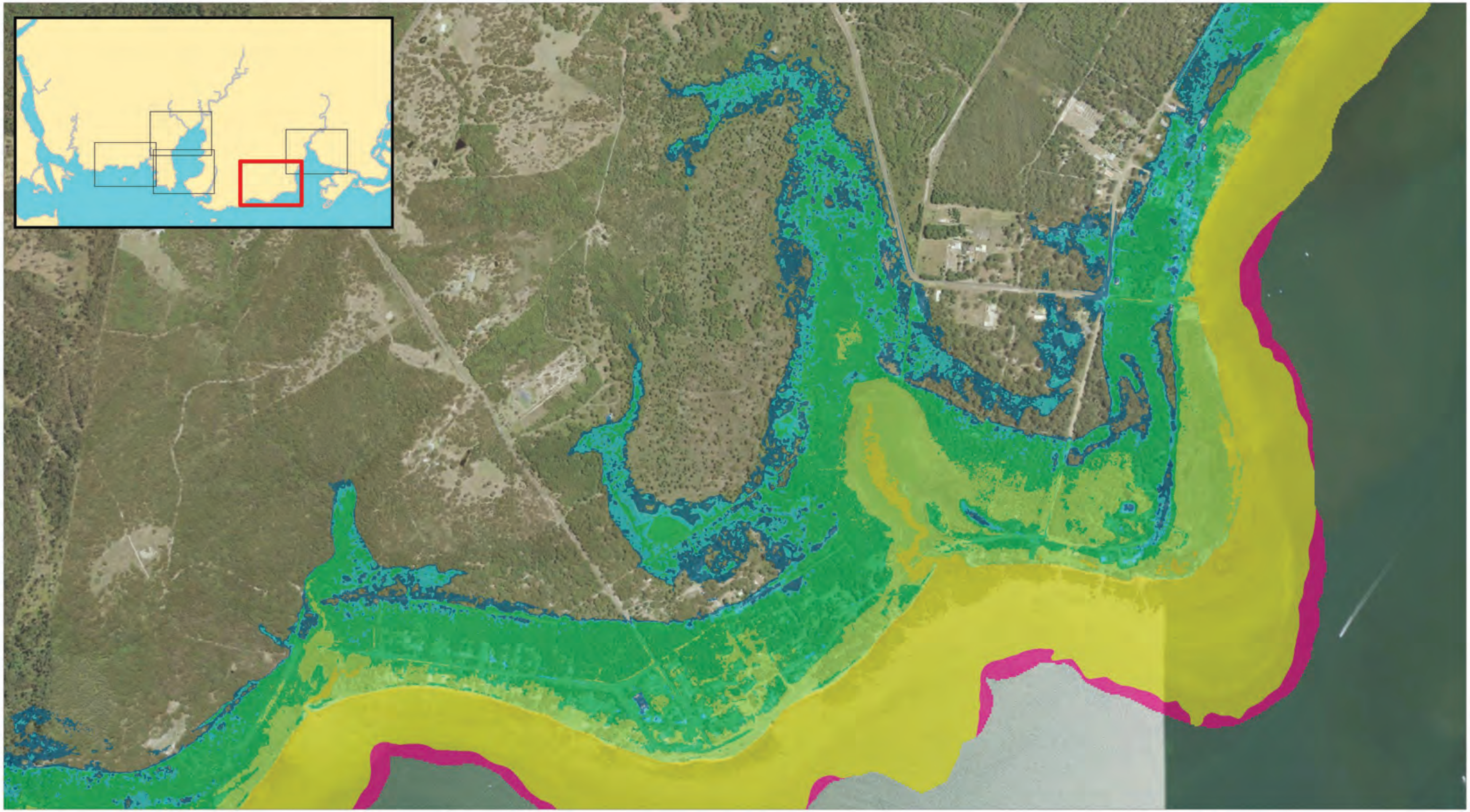

LEGEND

Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar South

Figure: **I-11**

Rev: **A**

N

0 250 500m

Approx. Scale

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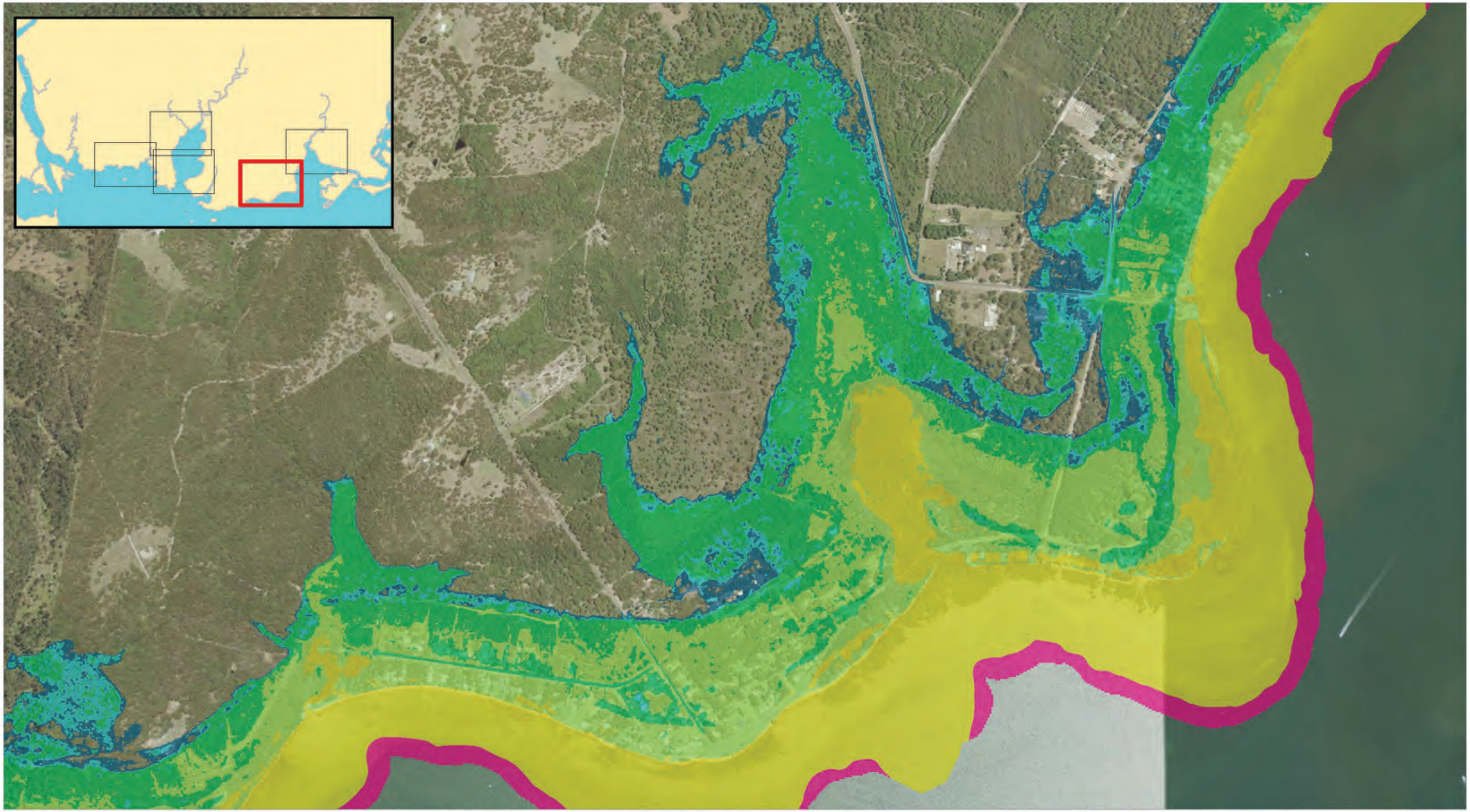

LEGEND
Hydraulic Classification

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

Title:
1% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar South

Figure: I-12

Rev: A

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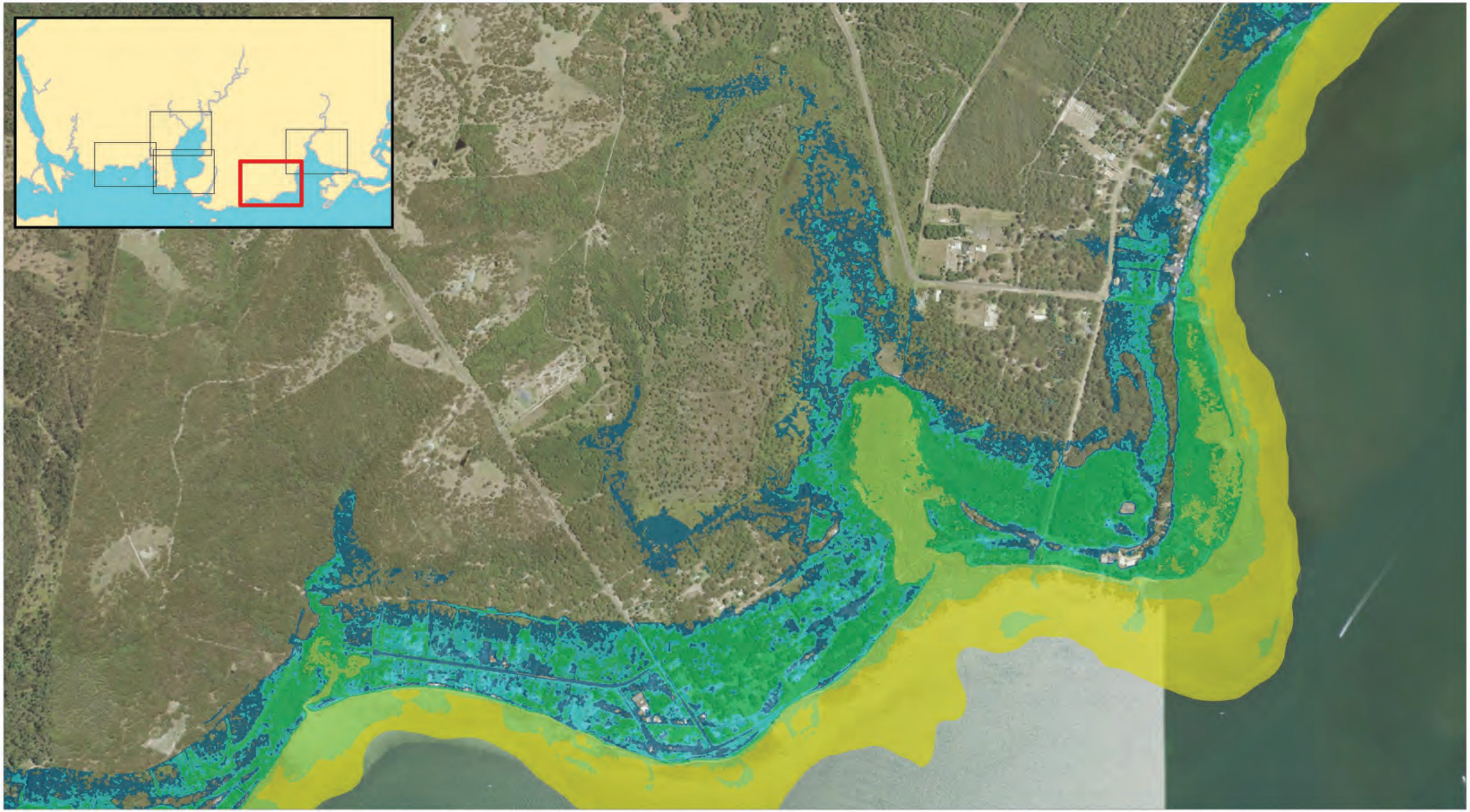

LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar South

Figure: I-13

Rev: A

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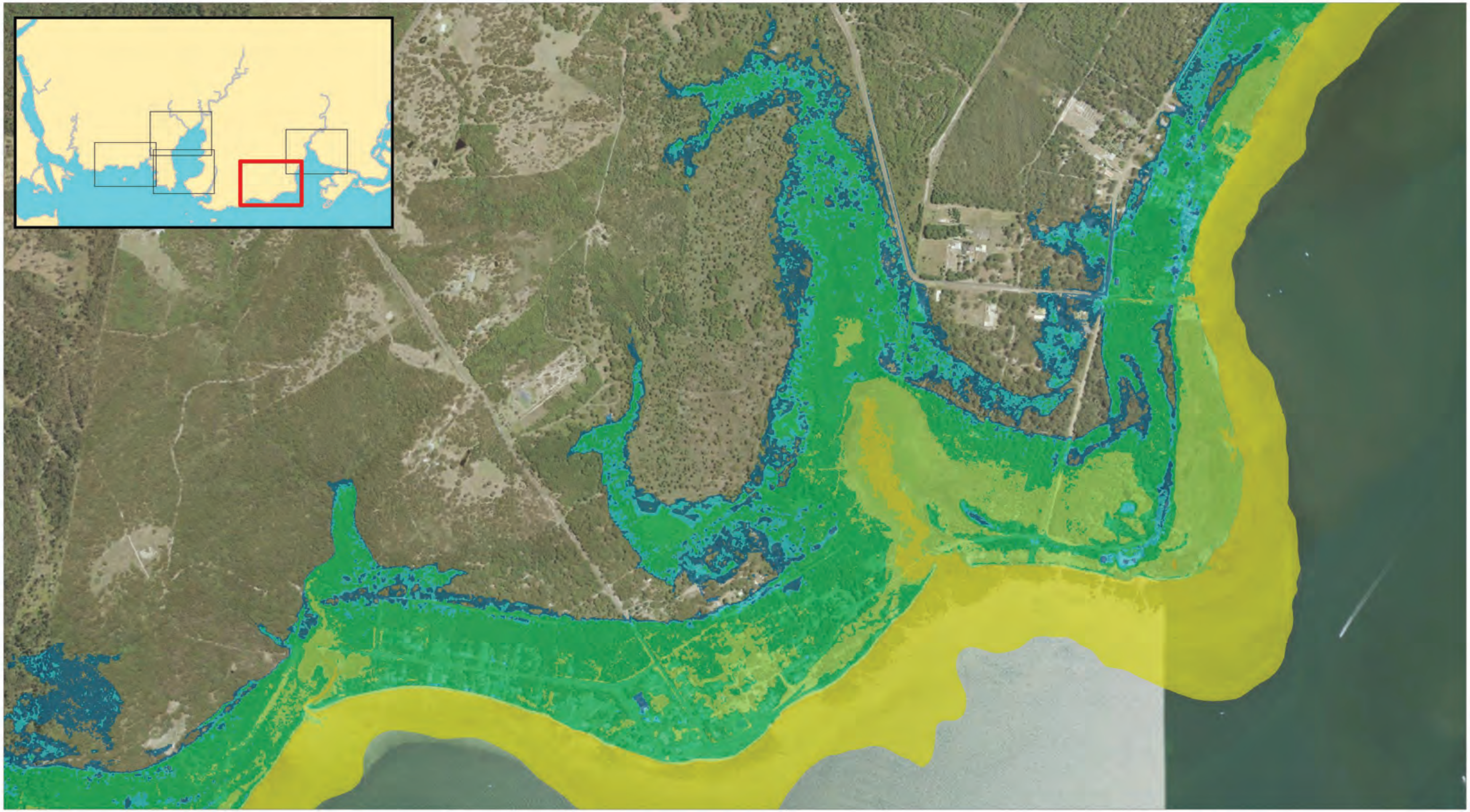

LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise Pindimar South

Figure: **I-14**

Rev: **A**

N

0 250 500m

Approx. Scale

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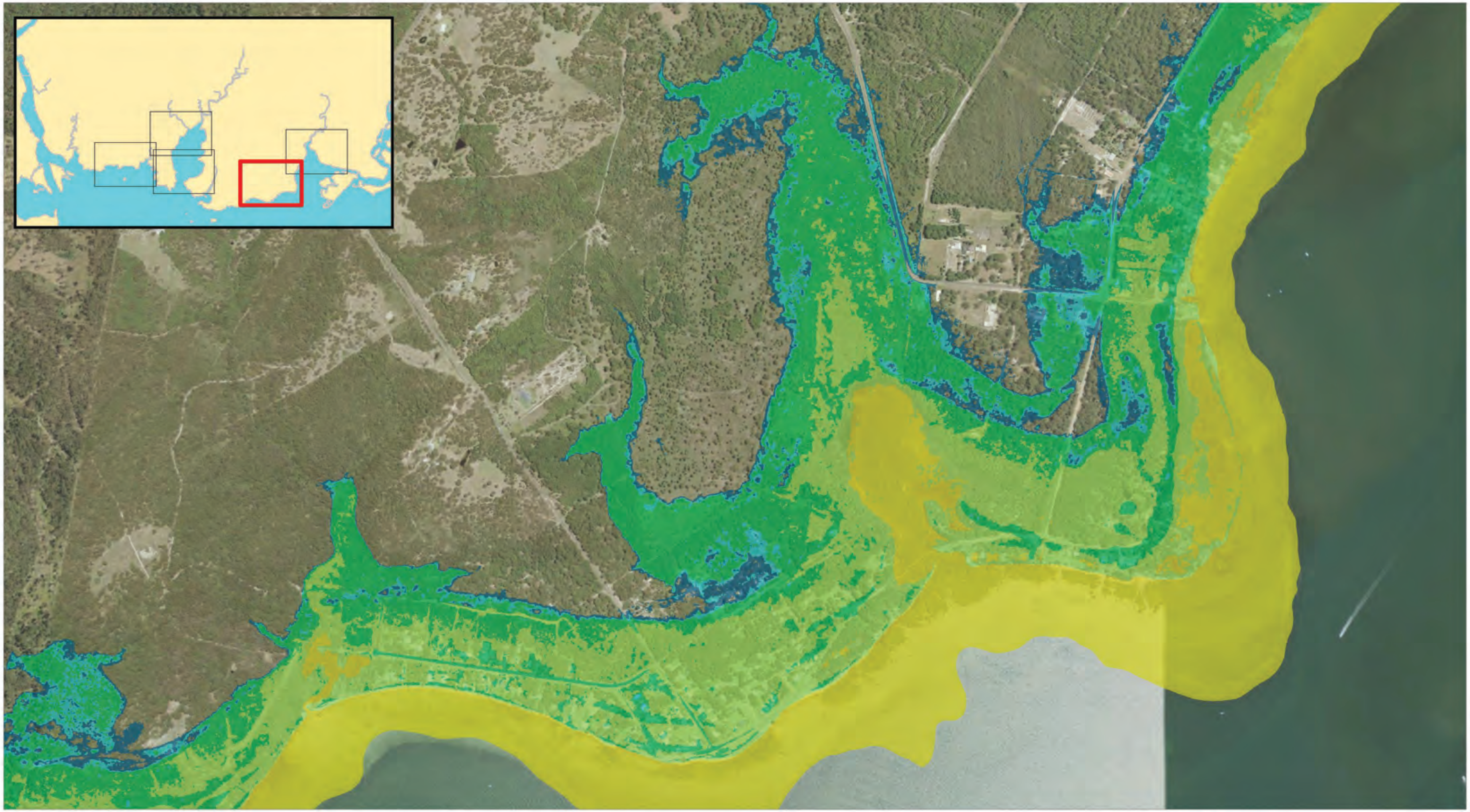
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_I14_hazard_class_extSWL_0p55SLR.wor"



LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise Pindimar South

Figure: **I-15**

Rev: **A**

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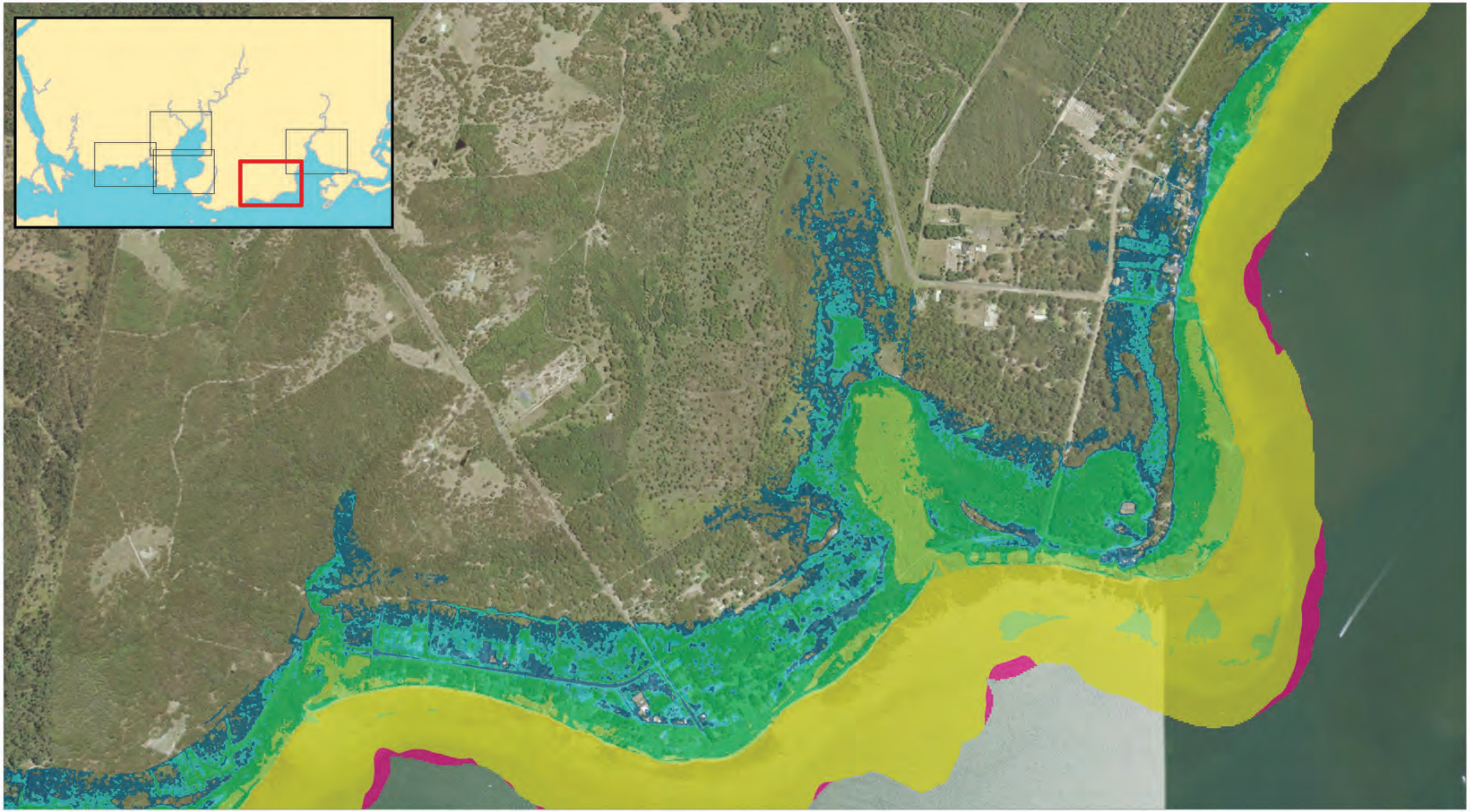

LEGEND
Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar South

Figure: **I-16**

Rev: **A**

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N

0 250 500m

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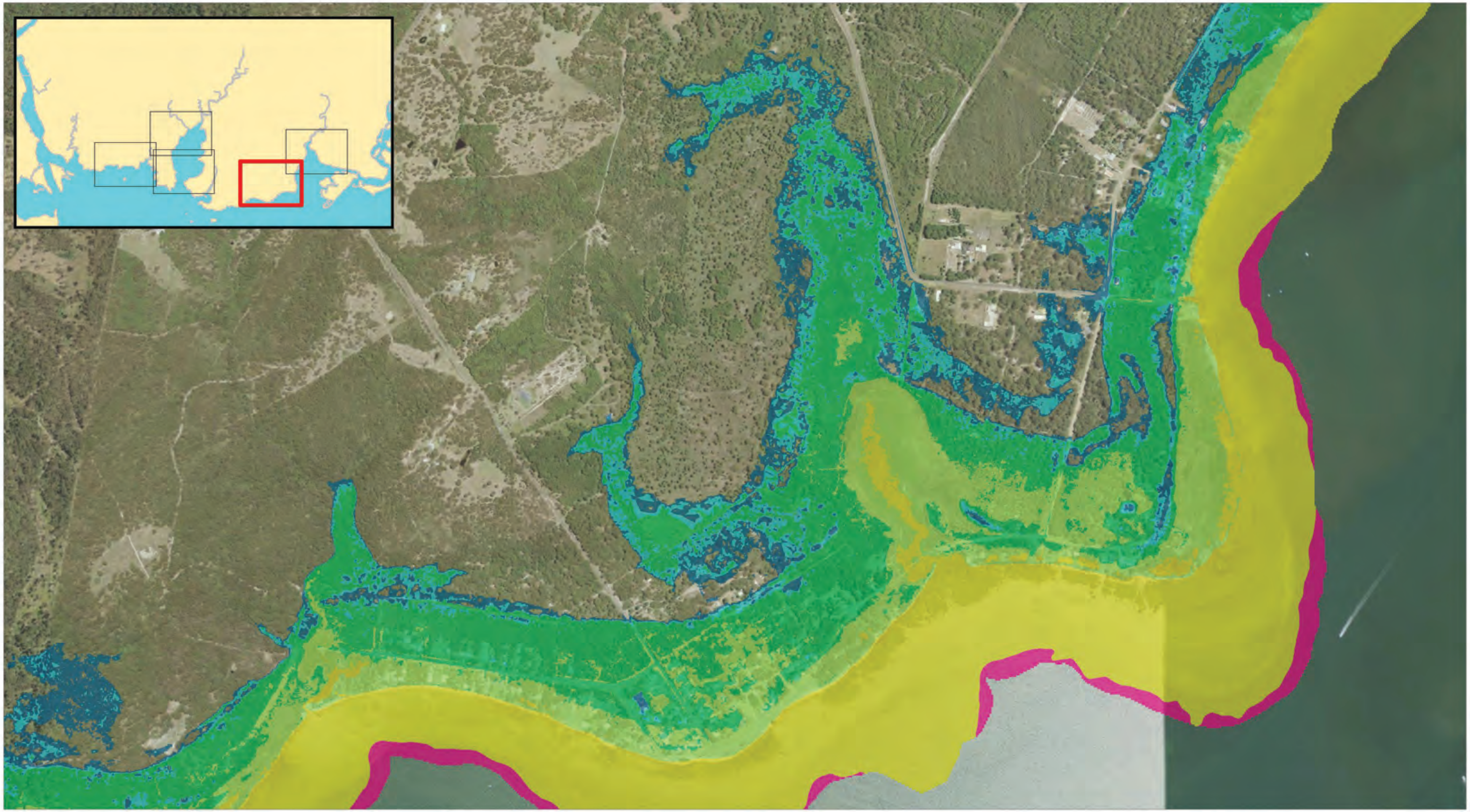

LEGEND
Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar South

Figure: I-17

Rev: A

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N

0 250 500m

Approx. Scale

BMT

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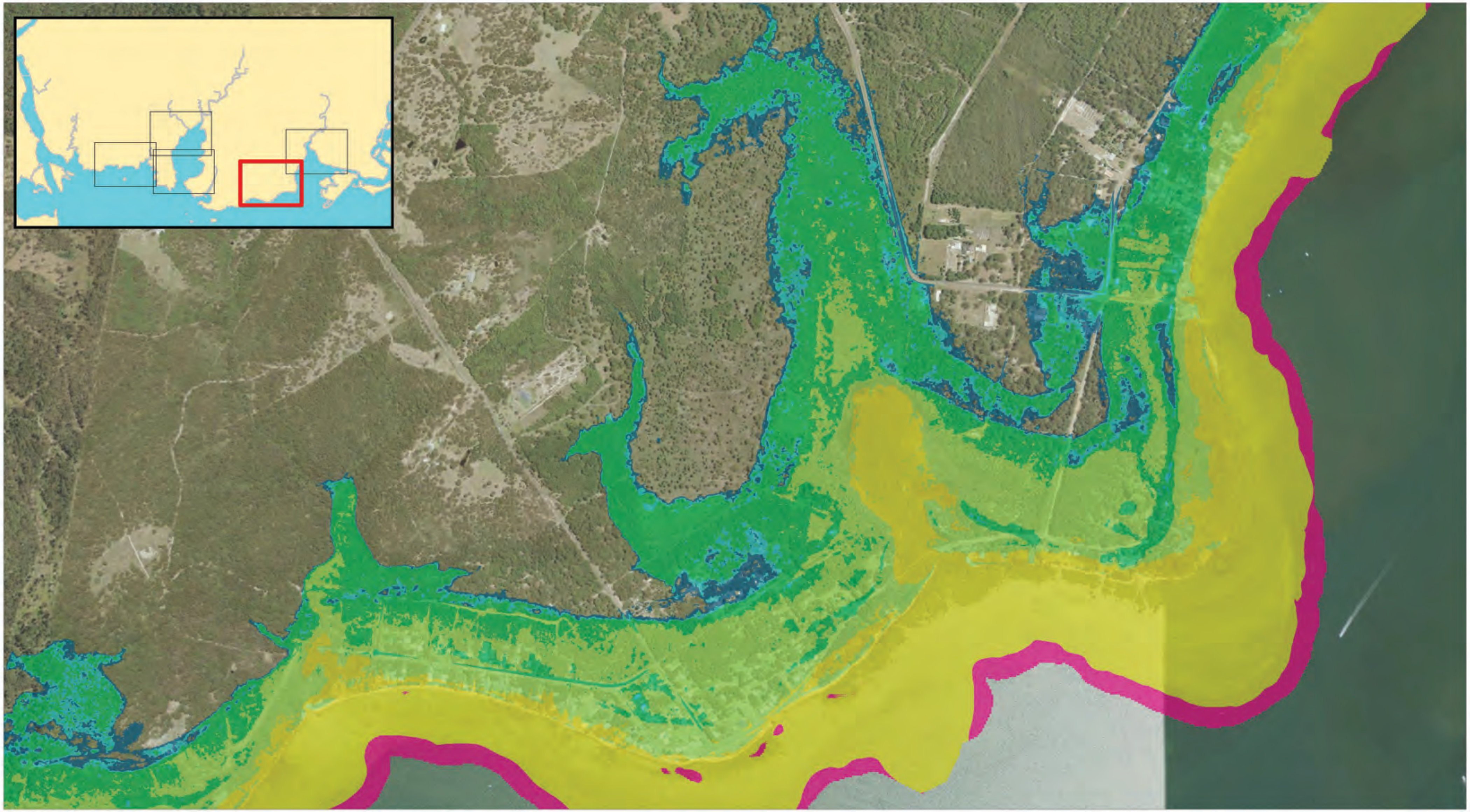

LEGEND

Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar South

Figure: **I-18**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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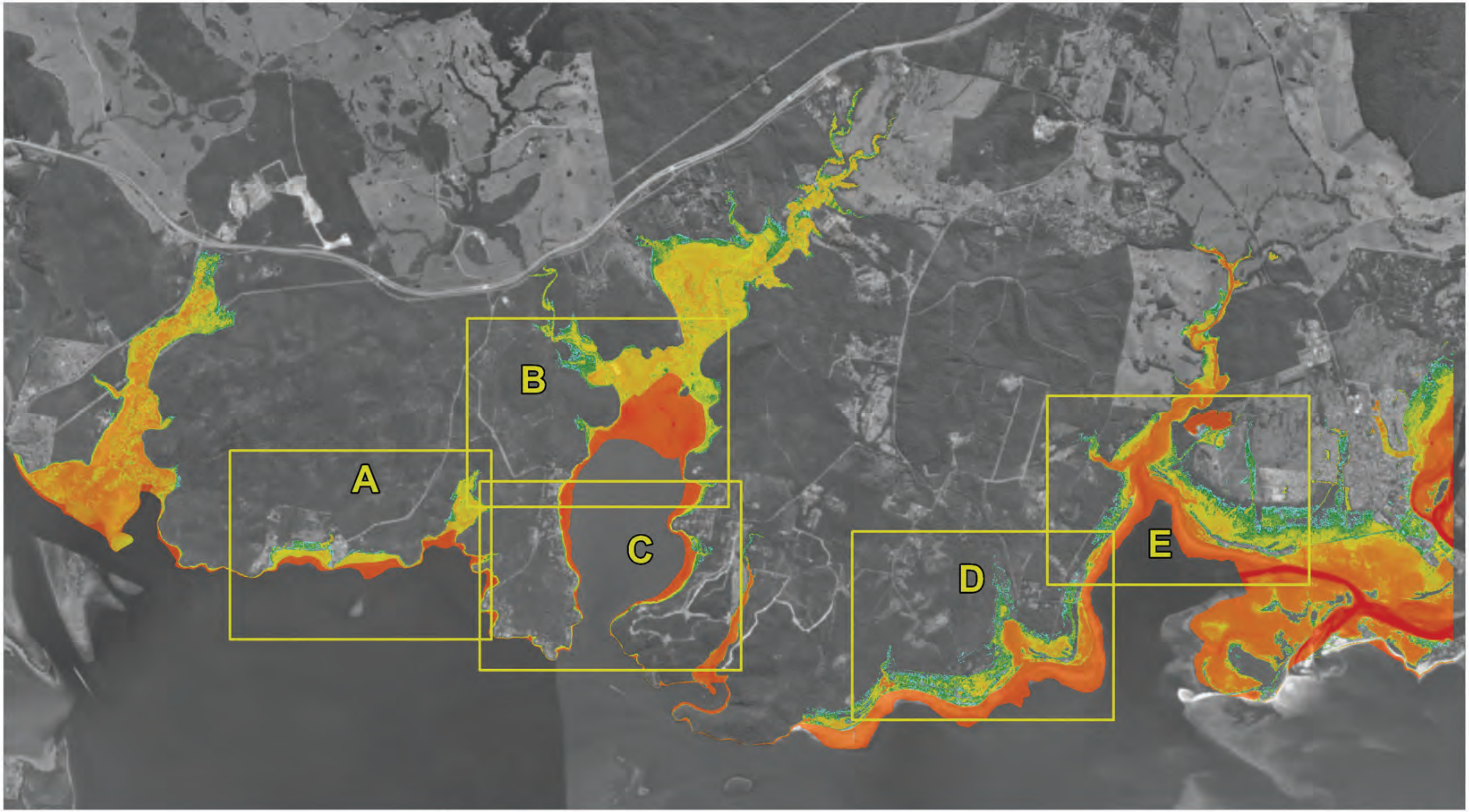

LEGEND

Peak Flood Depth (m)

- 0.1 lower depths mapped as same colour
- 0.2
- 0.5
- 1.0
- 5.0 higher depths mapped as same colour

Title:

Port Stephens FRMS Mapping Index

Figure: **INDEX**

Rev: **A**

N

0 1.25 2.5km

Approx. Scale

BMT

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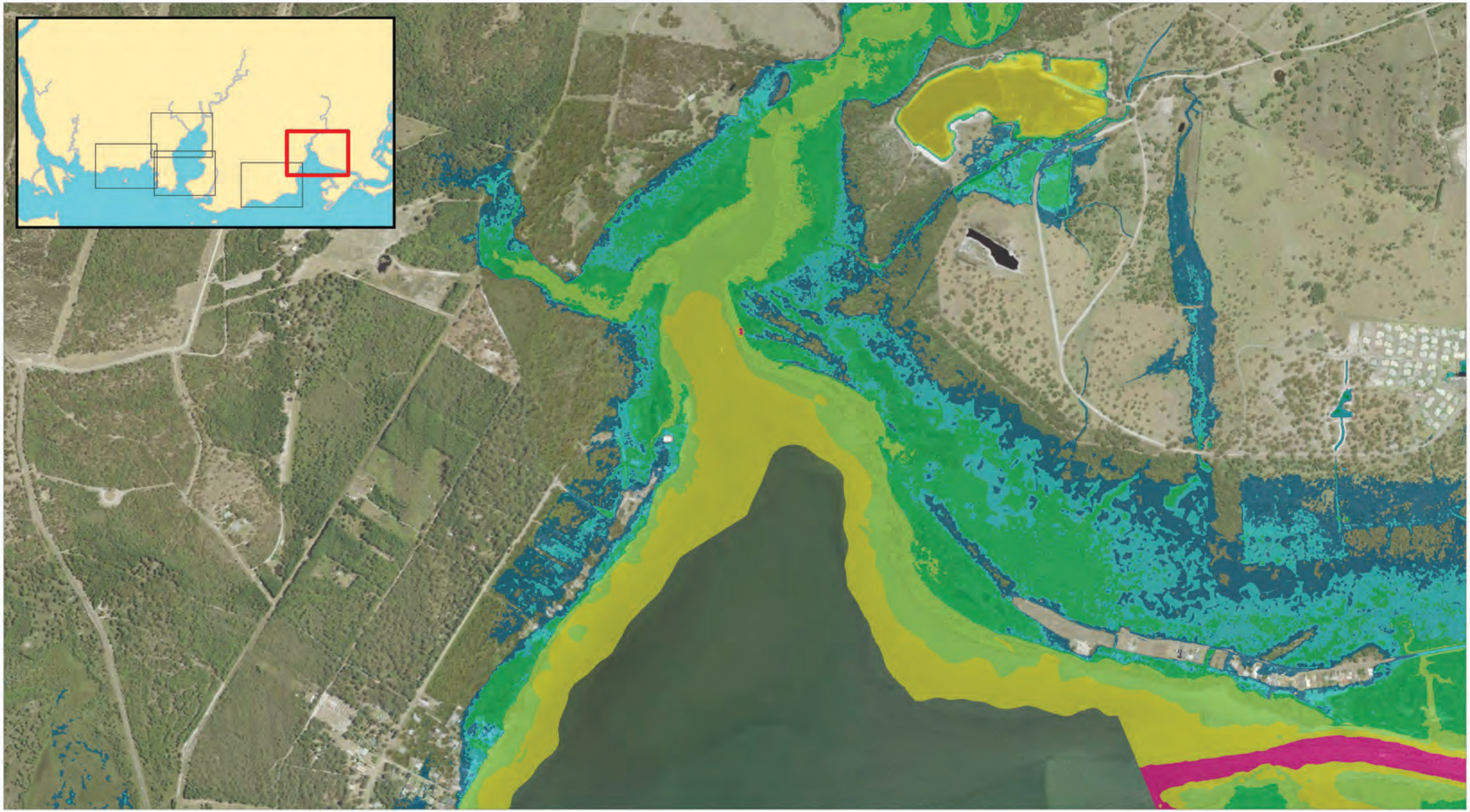

LEGEND

Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar Bay

Figure: **J-01**

Rev: **A**

N

0 250 500m

Approx. Scale

BMT

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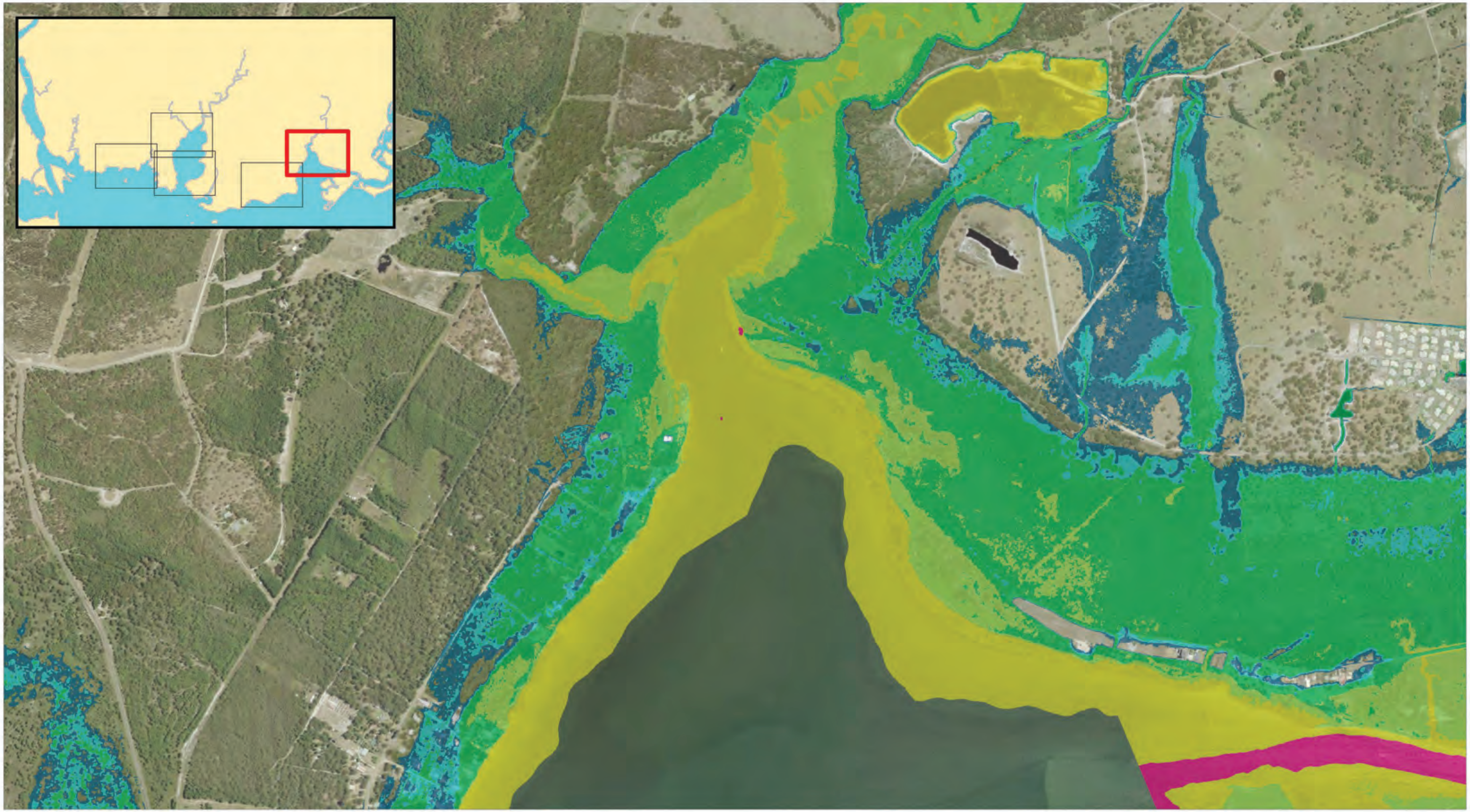

LEGEND
Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar Bay

Figure: J-02

Rev: A

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N

0 250 500m

Approx. Scale

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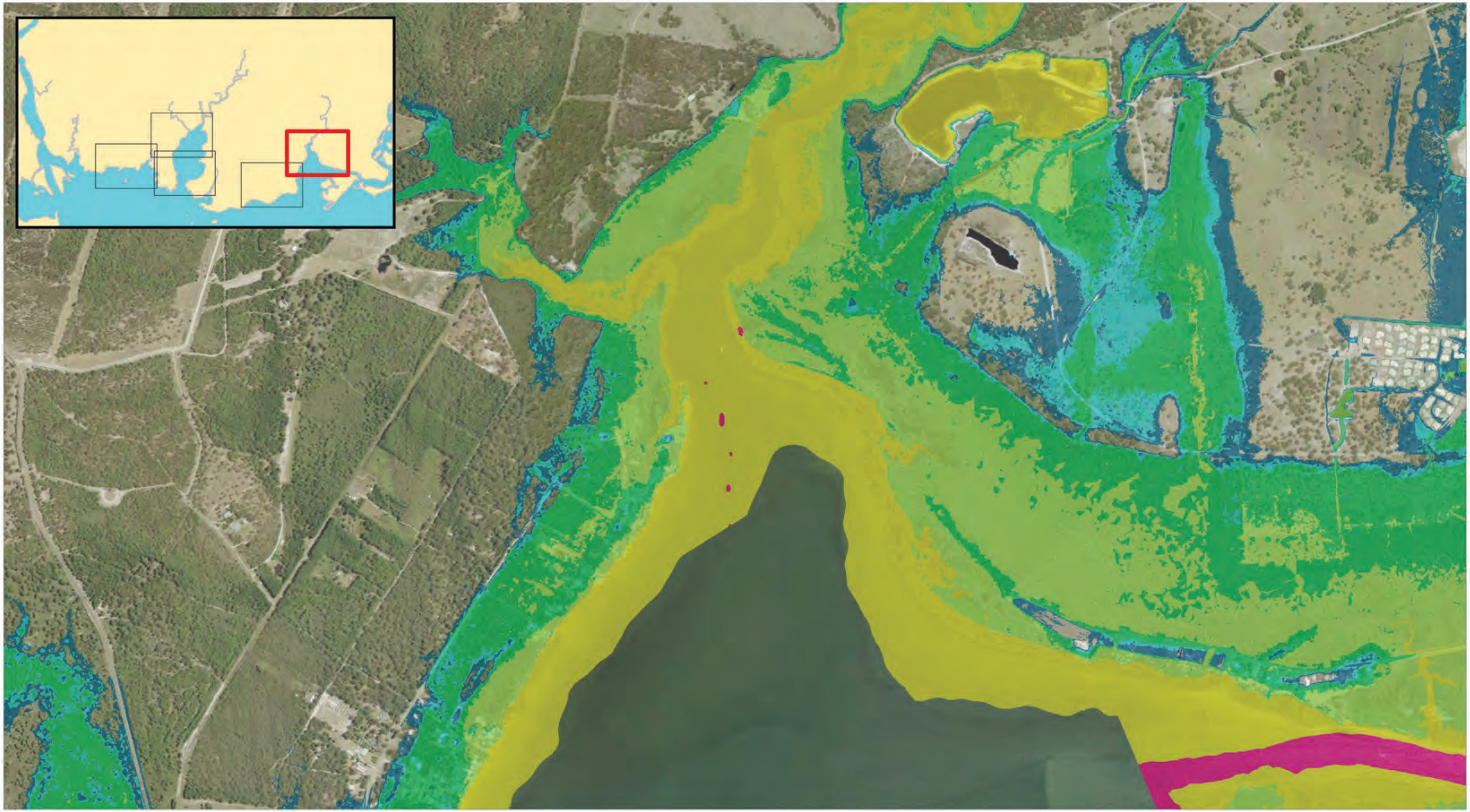

LEGEND

Hydraulic Classification

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

Title:

5% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **J-03**

Rev: **A**

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N

0 250 500m

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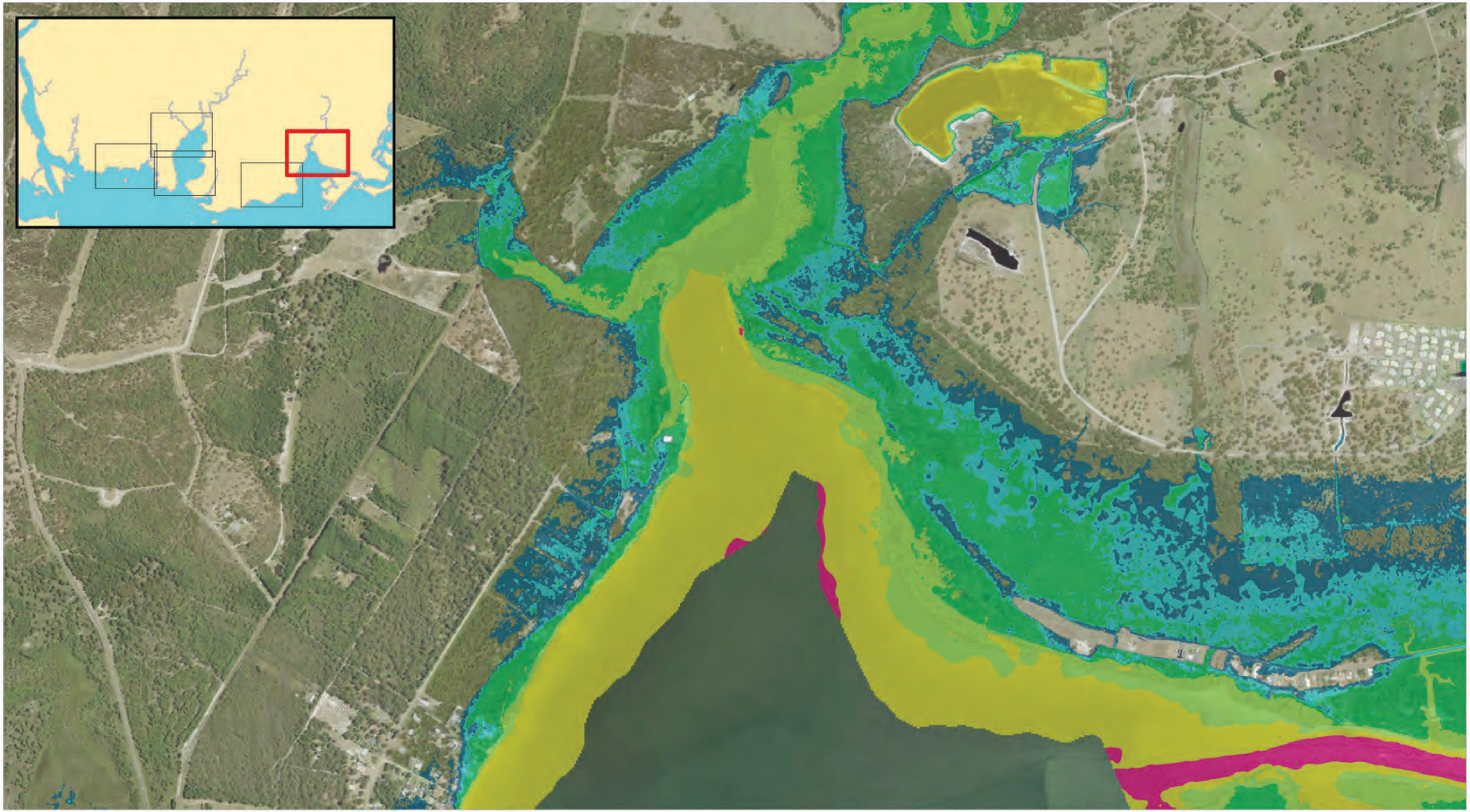

LEGEND
Hydraulic Classification

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

Title:
5% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar Bay

Figure: **J-04**

Rev: **A**

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N

0 250 500m
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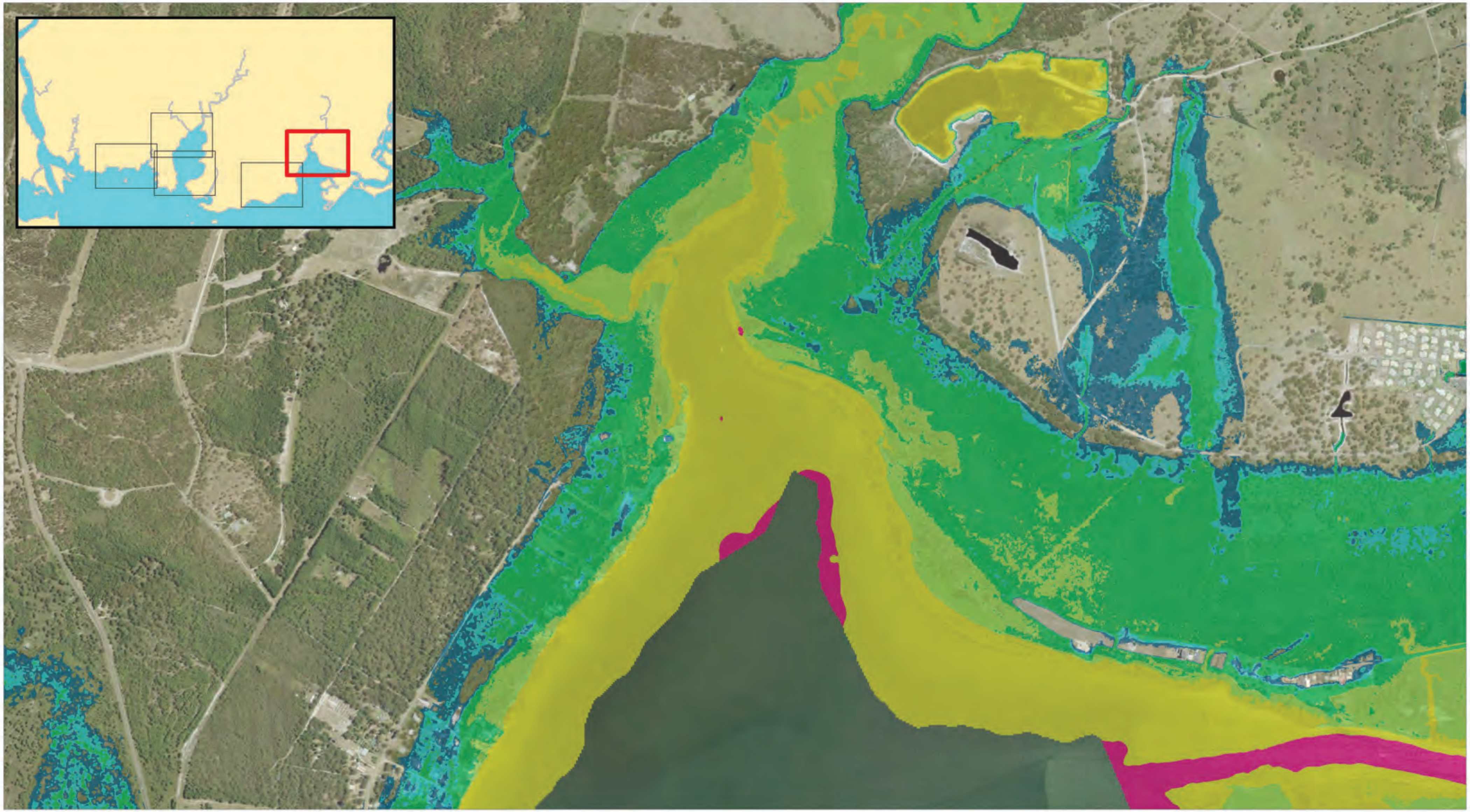

LEGEND
Hydraulic Classification

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

Title:

5% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar Bay

Figure: J-05

Rev: A

N

0 250 500m

Approx. Scale

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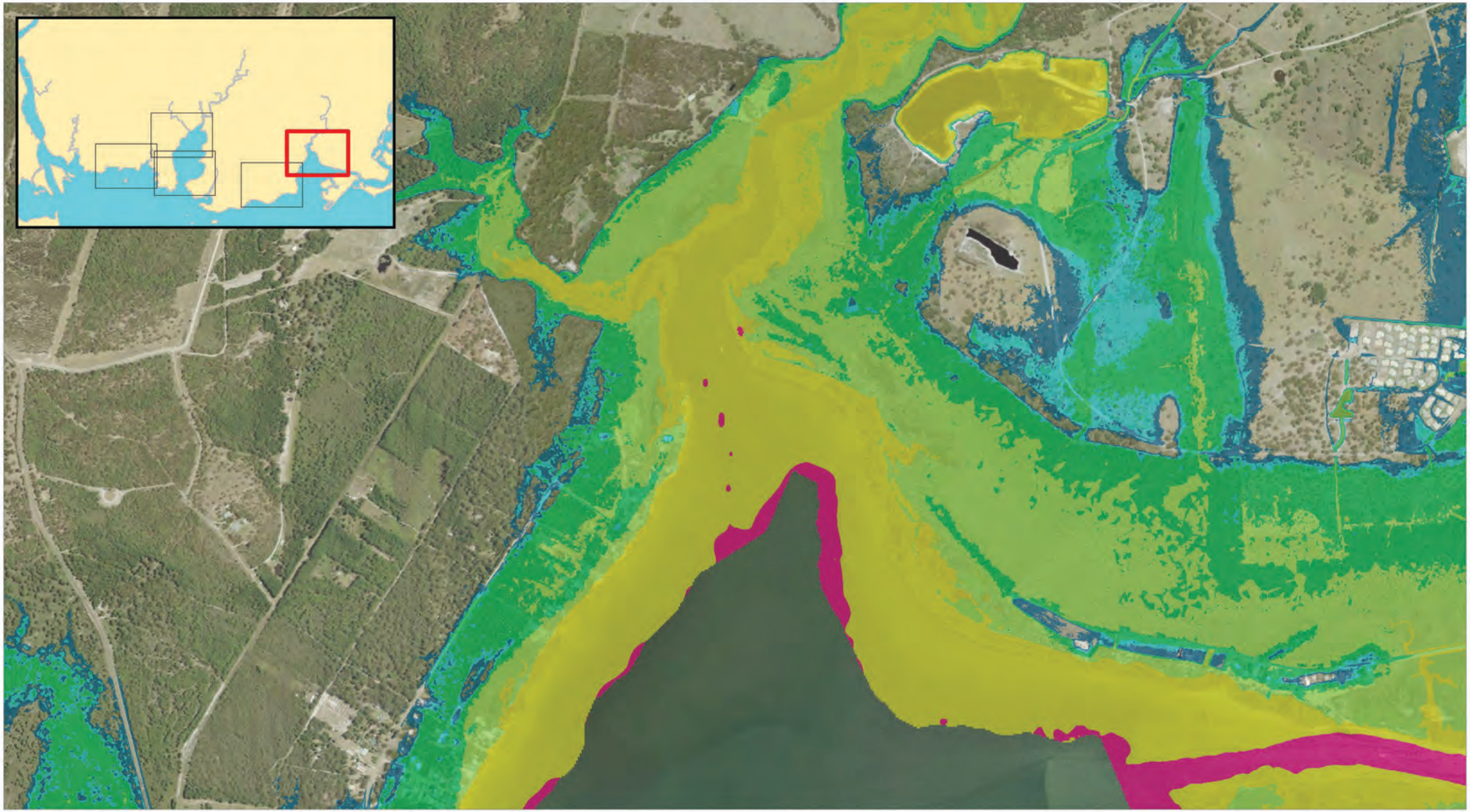

LEGEND
Hydraulic Classification

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

Title:
5% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **J-06**

Rev: **A**

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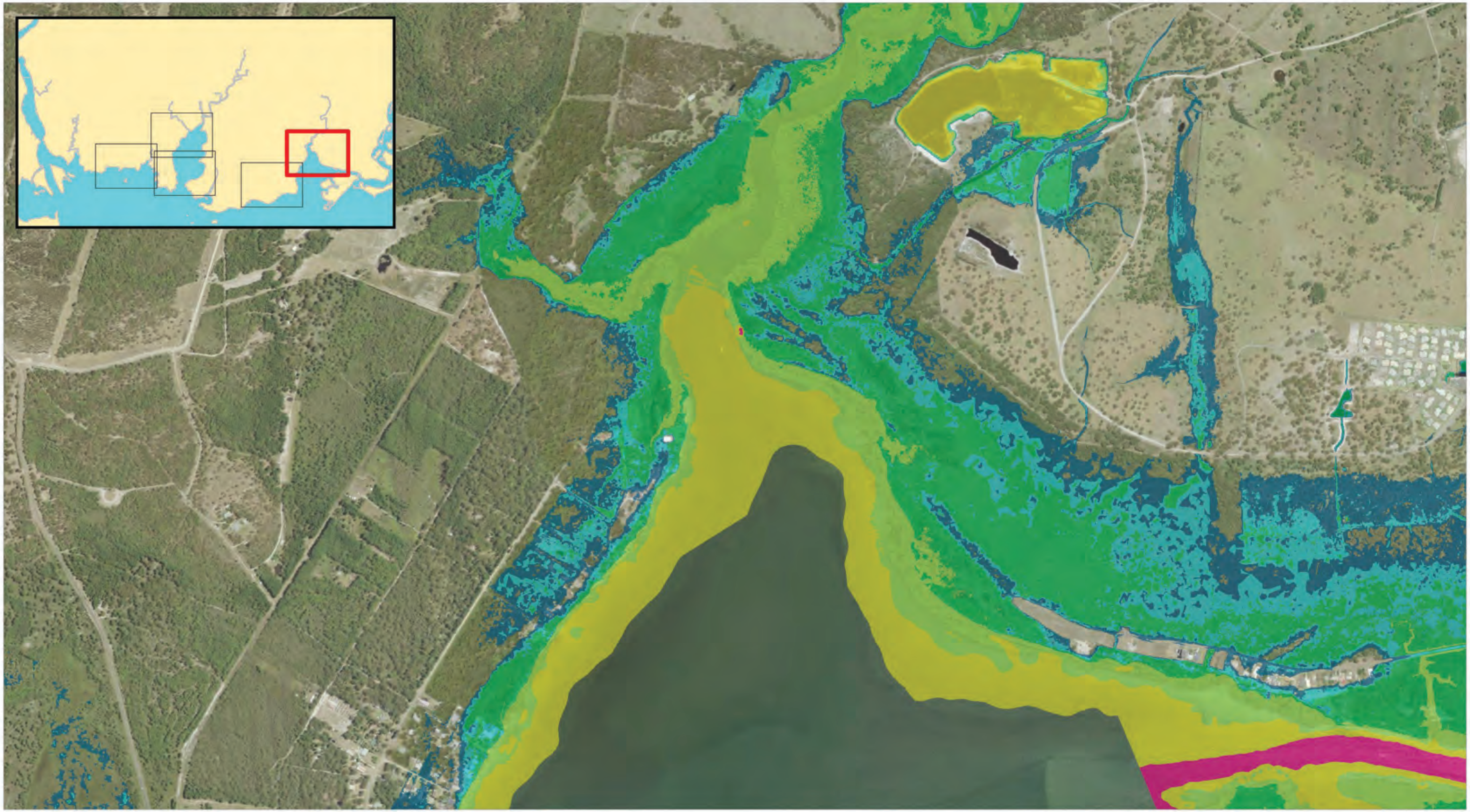

LEGEND

Hydraulic Classification

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

Title:

1% AEP Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar Bay

Figure: J-07

Rev: A

N

0 250 500m

Approx. Scale

BMT

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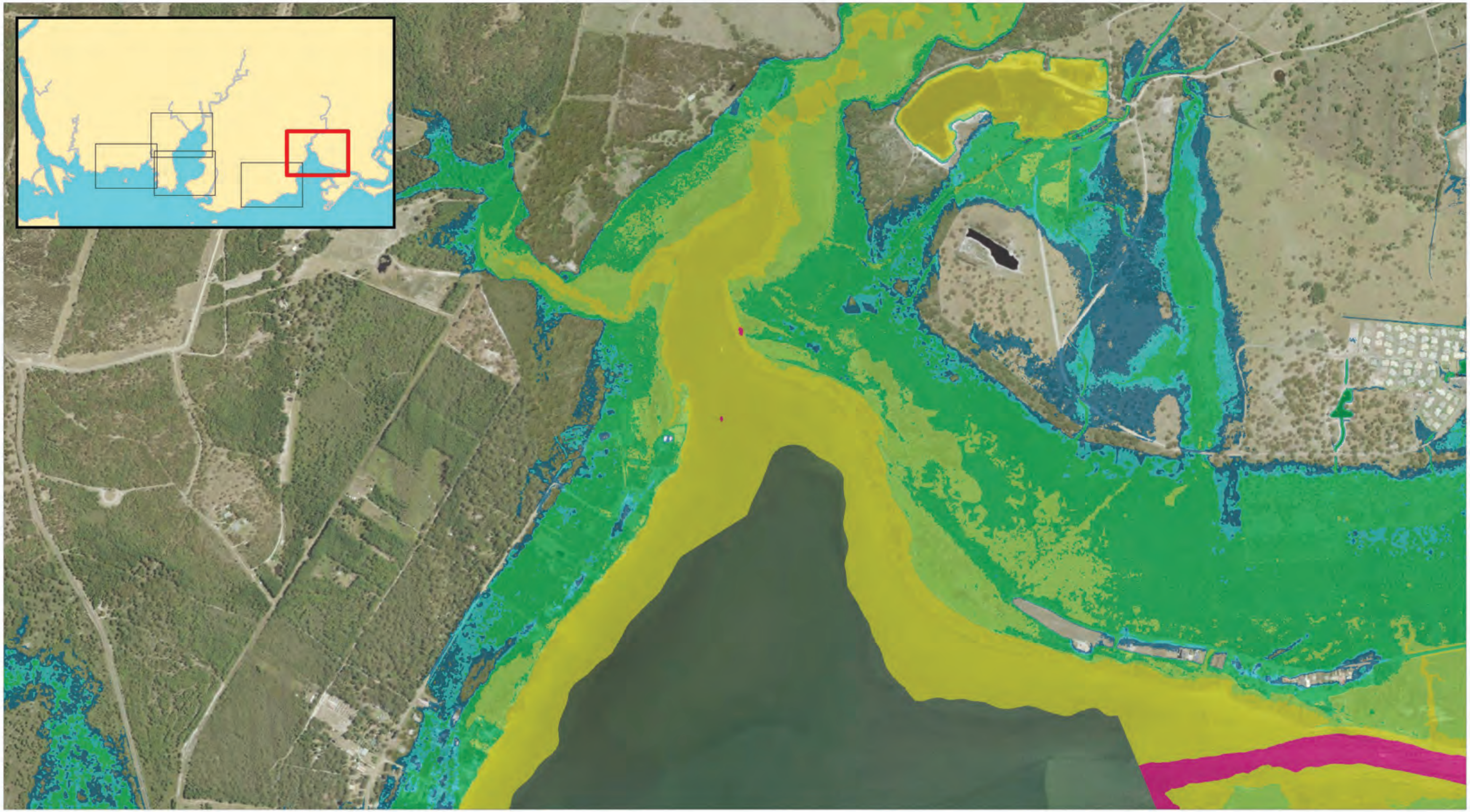

LEGEND
Hydraulic Classification

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

Title:
1% AEP Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise Pindimar Bay

Figure: J-08

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N

0 250 500m
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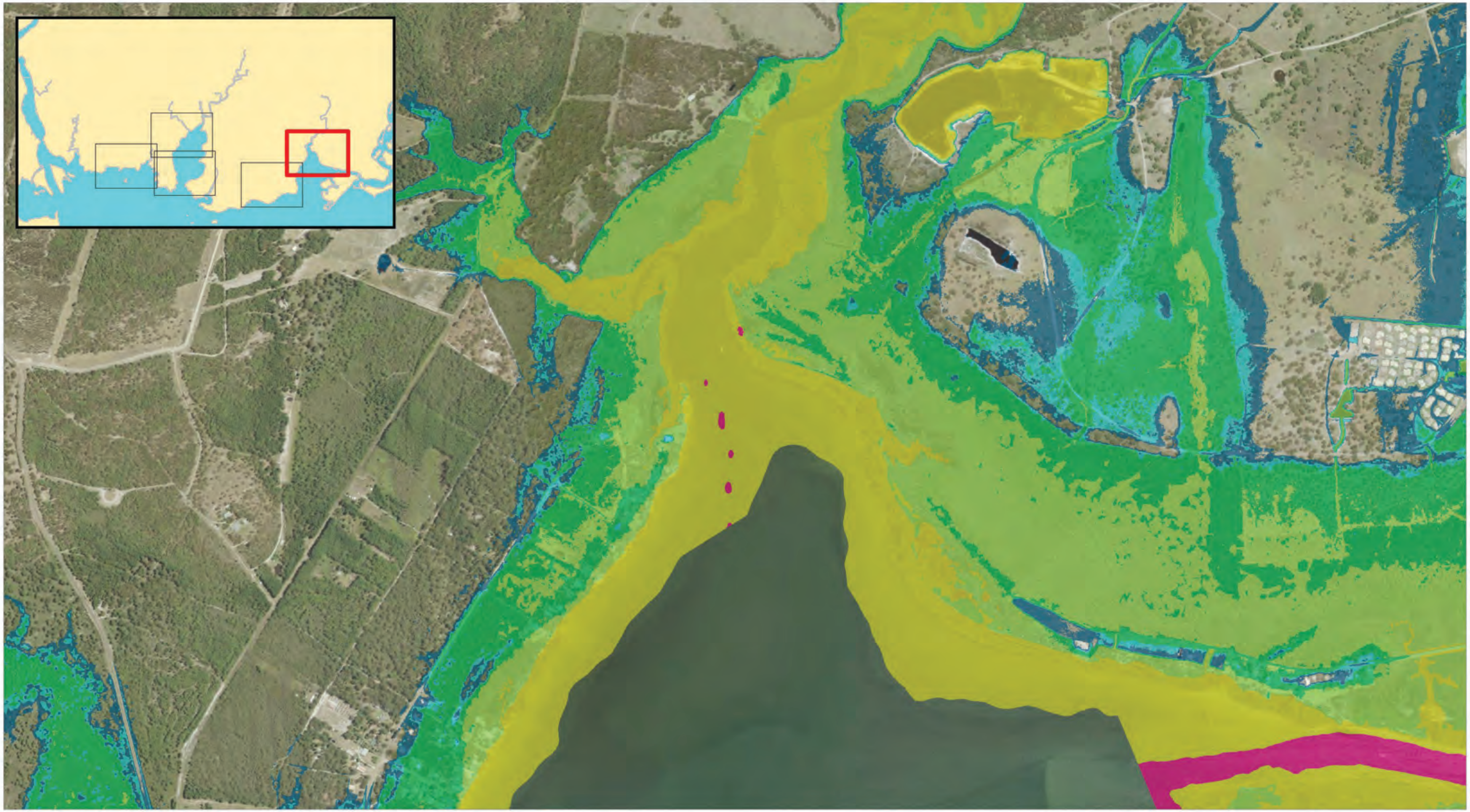

LEGEND
Hydraulic Classification

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

Title:

1% AEP Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise Pindimar Bay

Figure: **J-09**

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N

0 250 500m

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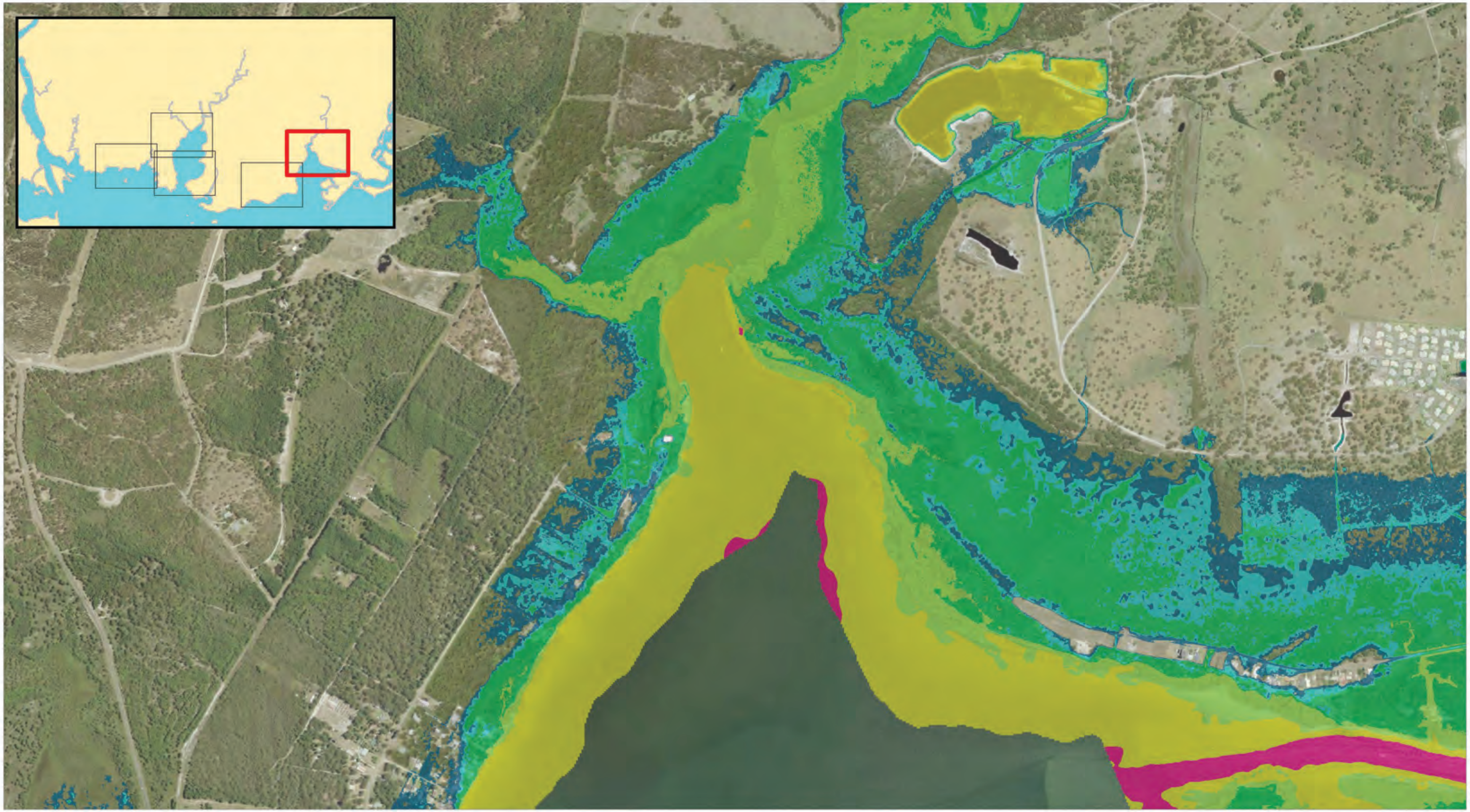

LEGEND
Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar Bay

Figure: **J-10**

Rev: **A**

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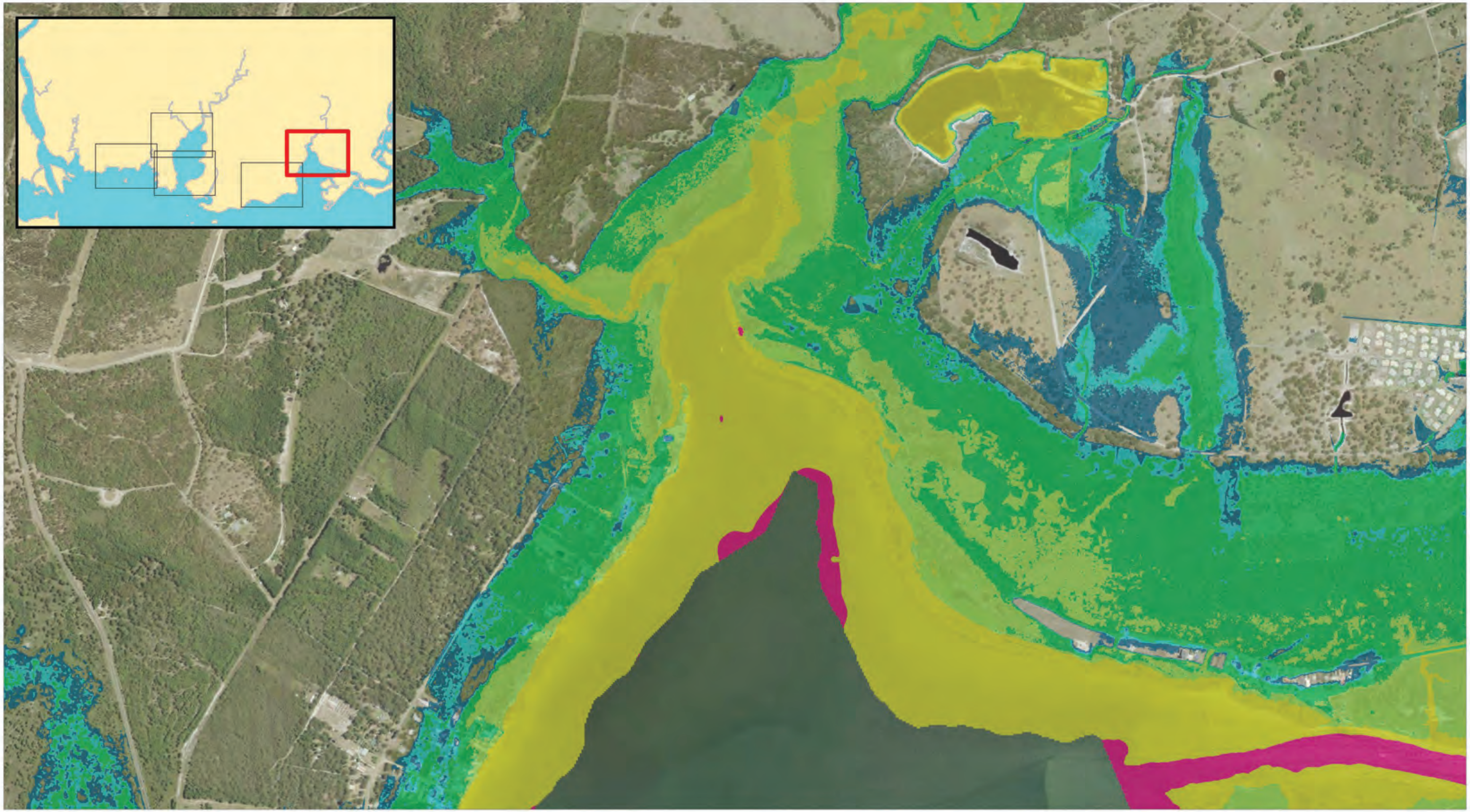

LEGEND

Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar Bay

Figure: **J-11**

Rev: **A**

N

0 250 500m

Approx. Scale

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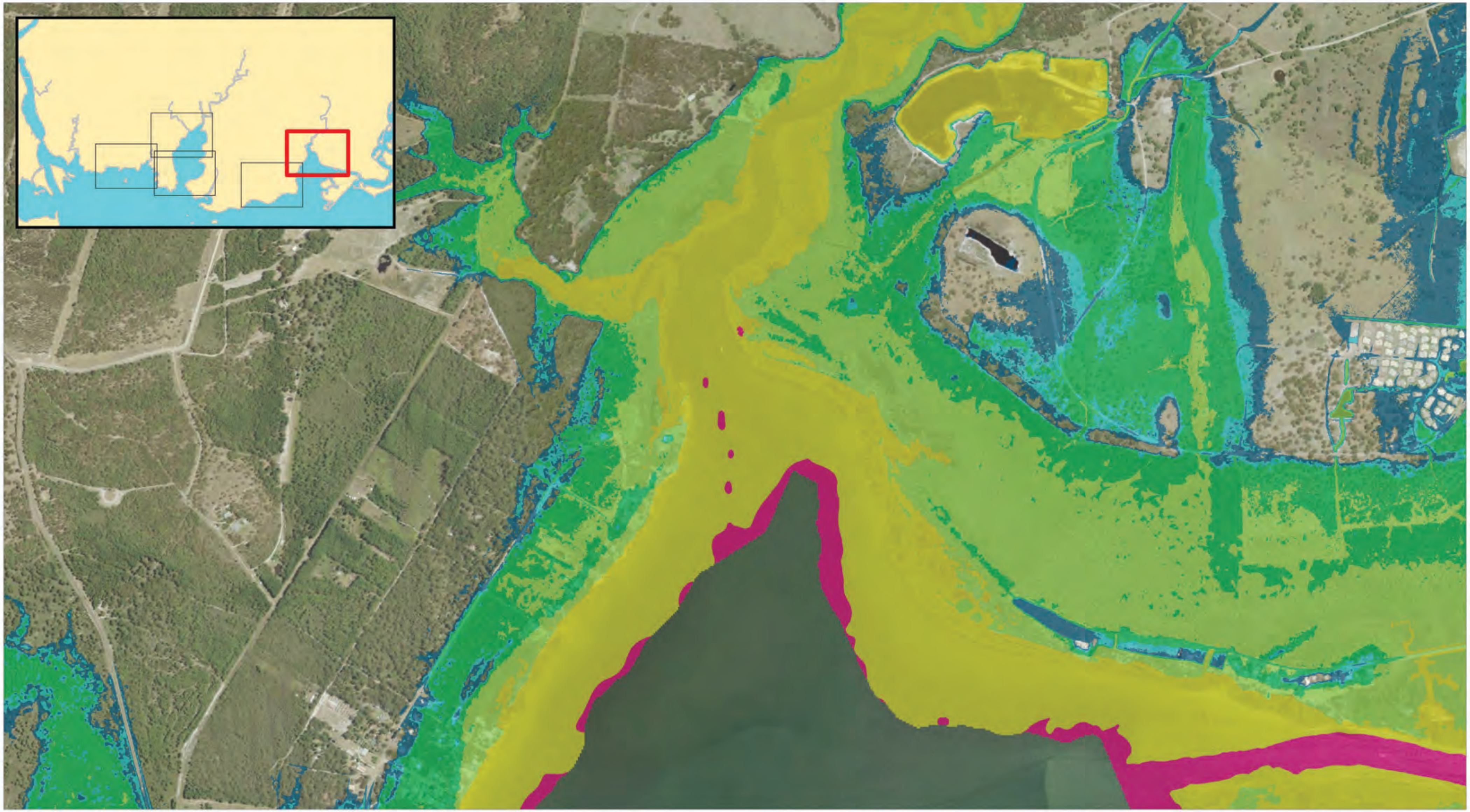
Filepath: "K:\N21029_Port_Stephens_FRMS\MapInfo\Workspaces\Figures\Hazard\DRG_J11_hazard_class_100yWRH_0p55SLR.wor"



LEGEND

Hydraulic Classification

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

Title:

1% AEP Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar Bay

Figure: **J-12**

Rev: **A**

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N

0 250 500m

Approx. Scale

BMT

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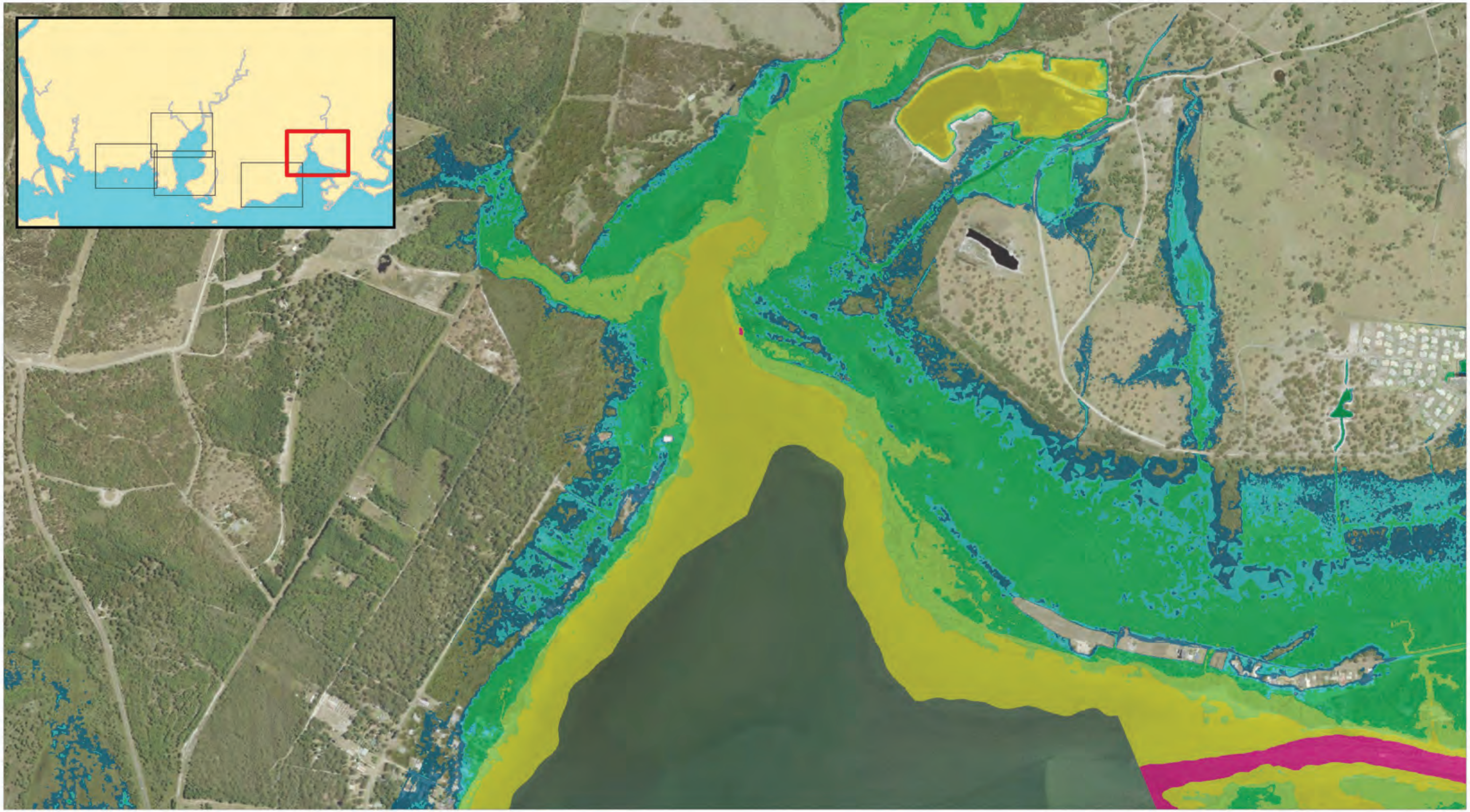

LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar Bay

Figure: **J-13**

Rev: **A**

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N

0 250 500m

Approx. Scale

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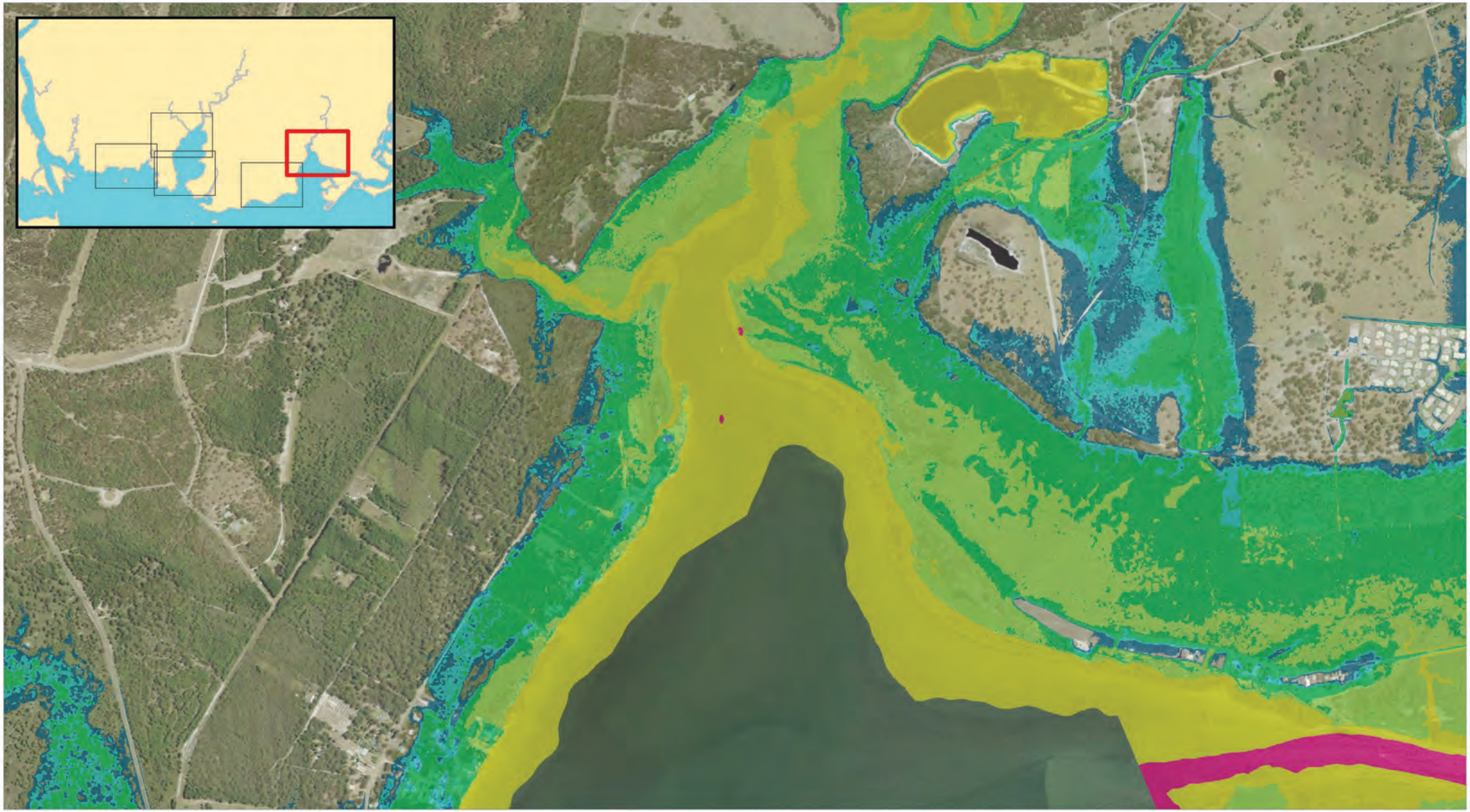

LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.55 m Sea Level Rise Pindimar Bay

Figure: **J-14**

Rev: **A**

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N

0 250 500m

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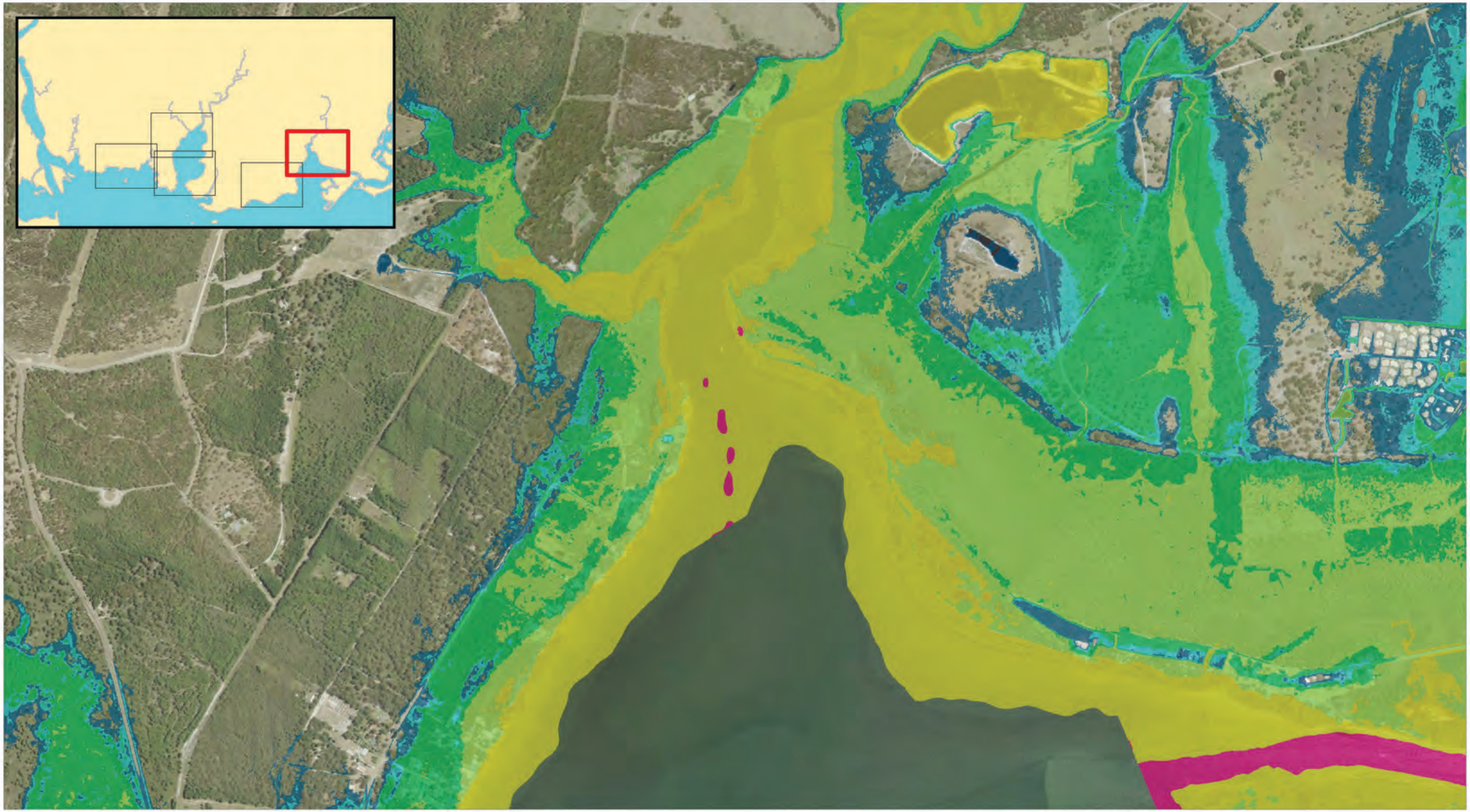

LEGEND

Hydraulic Classification

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

Title:

Extreme Still Water Level Modelled Hazard Category, 0.91 m Sea Level Rise Pindimar Bay

Figure: **J-15**

Rev: **A**

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N

0 250 500m

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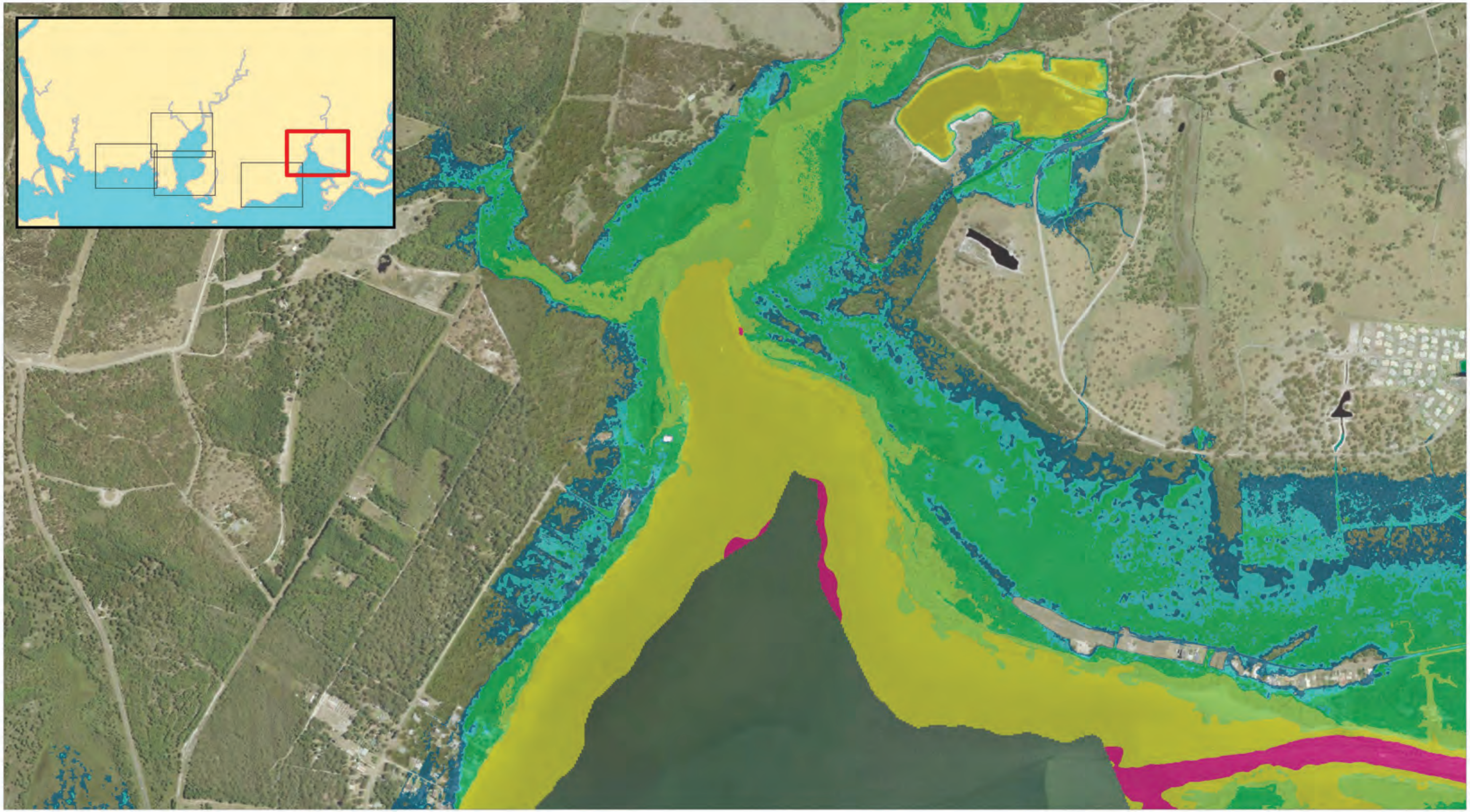

LEGEND
Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0 m Sea Level Rise - Pindimar Bay

Figure: **J-16**

Rev: **A**

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N

0 250 500m

Approx. Scale

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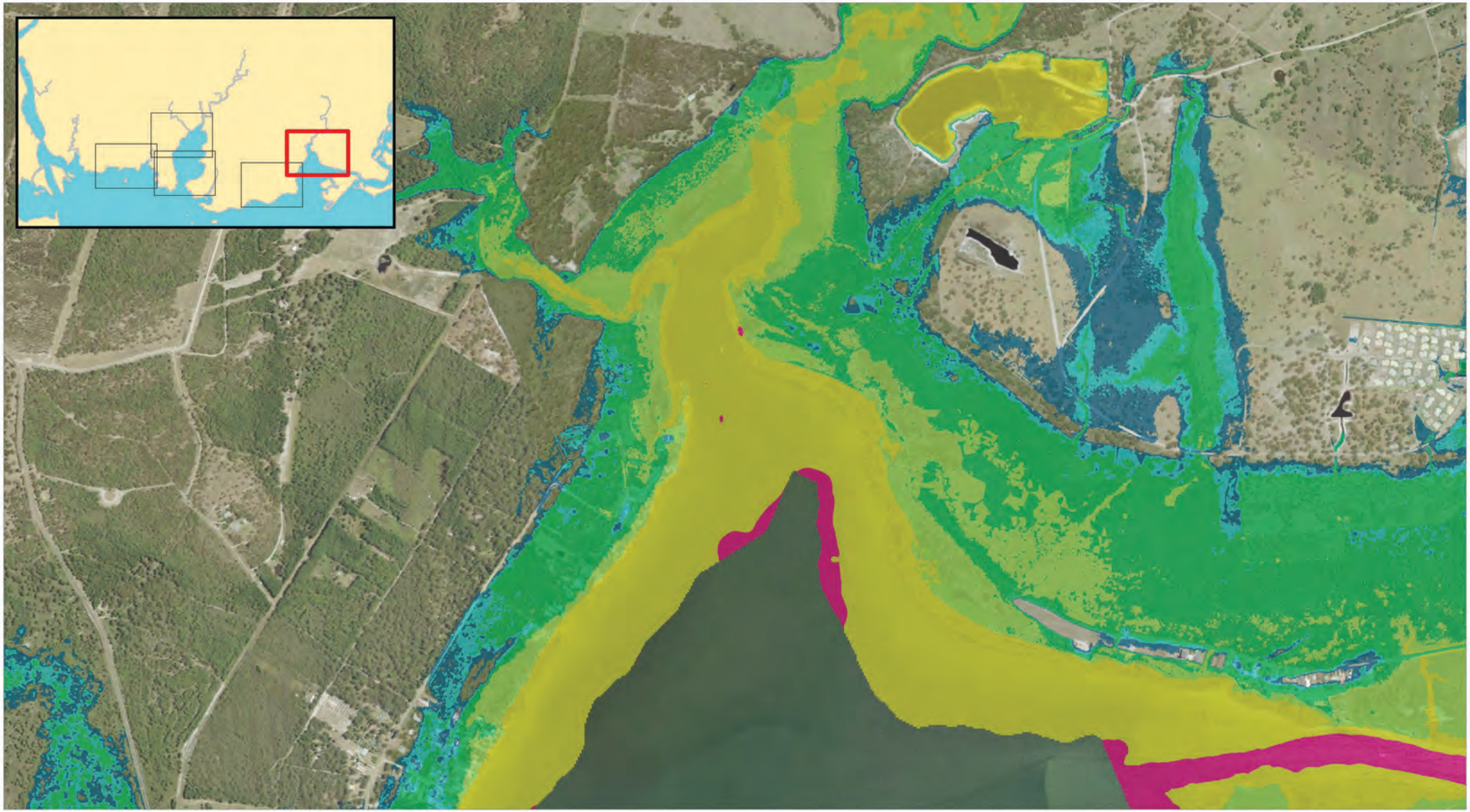

LEGEND
Hydraulic Classification

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

Title:
Extreme Wave Runup Level Modelled Hazard Category, 0.55 m Sea Level Rise - Pindimar Bay

Figure: **J-17**

Rev: **A**

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N

0 250 500m
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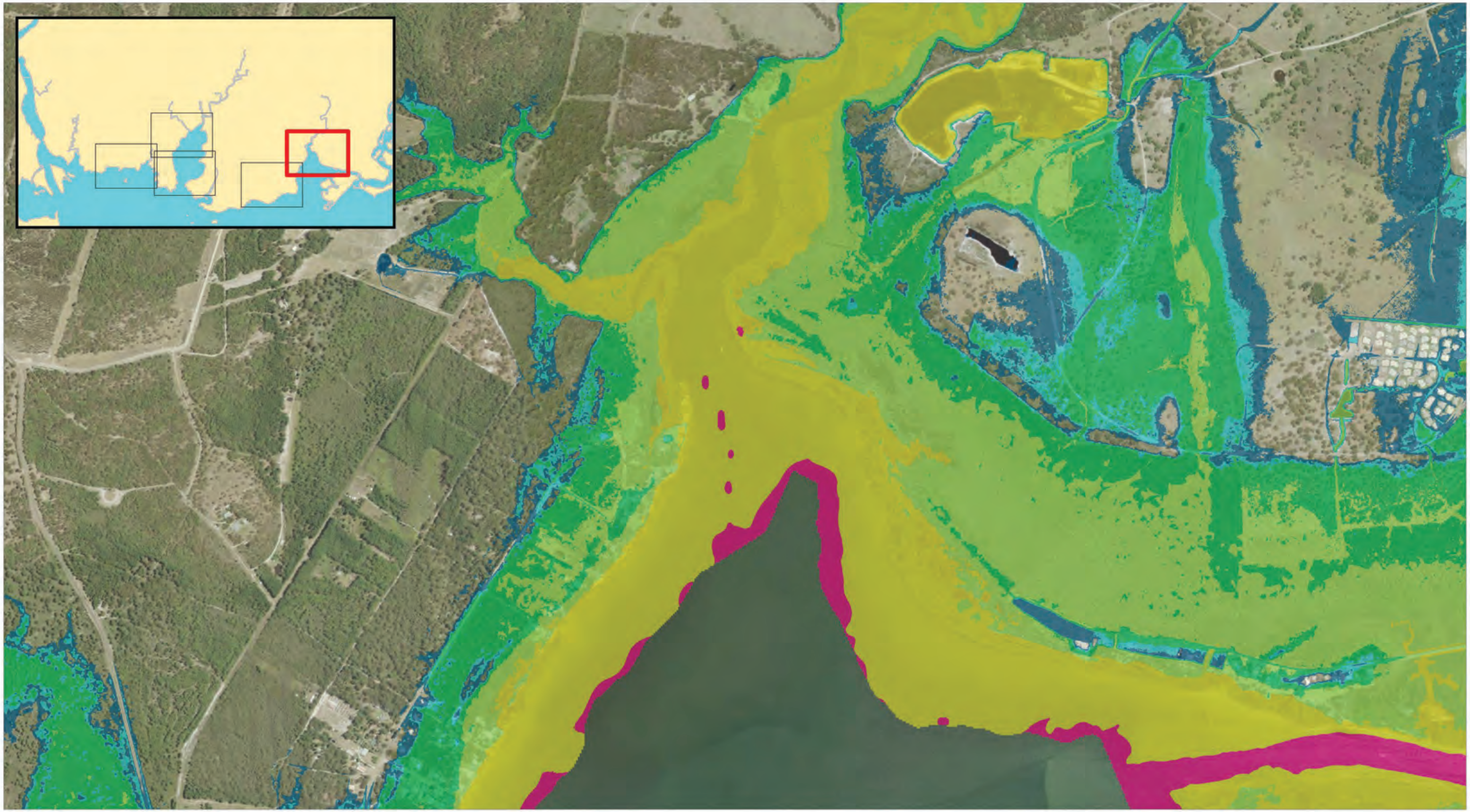

LEGEND

Hydraulic Classification

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

Title:

Extreme Wave Runup Level Modelled Hazard Category, 0.91 m Sea Level Rise - Pindimar Bay

Figure: J-18

Rev: A

N

0 250 500m

Approx. Scale

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