

REPORT

Lake Conjola Coastal Management Program
Stage 2
Determine Risks, Vulnerabilities and Opportunities

Report B – “Threats and Risk Assessment”

Client: Shoalhaven City Council

Reference: PA2591-SCC-LC-CMP-Stage 2 Report B-0002

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Royal HaskoningDHV
Enhancing Society Together

HASKONING AUSTRALIA PTY LTD.

Level 15
99 Mount Street
North Sydney NSW 2060
Water & Maritime
Trade register number: ACN153656252

+61 2 8854 5000 **T**
project.admin.australia@rhdhv.com **E**
royalhaskoningdhv.com **W**

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Author(s):	Adrian Turnbull
Drafted by:	Adrian Turnbull
Checked by:	Matt Potter
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Approved by:	Greg Britton
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Shoalhaven City Council Acknowledgement of Country x

1 Introduction 16

1.1 Report Structure 16

1.2 Overview of cultural, social, environmental assets and attributes 16

1.3 General NSW Estuary Management 19

1.3.1 Intervention to Open Estuary Entrances 19

1.3.2 Entrance Management Responsibility 19

1.3.3 General Water Quality Considerations 20

1.3.4 Ecological Function Considerations 20

2 Threat Identification 22

3 Inundation 23

3.1 Historical and Recent Inundation at Lake Conjola 23

3.2 Lake Conjola CMP – Application of Sea Level Rise Projections 29

3.3 Tidal Inundation 30

3.3.1 General 30

3.3.2 Current Status and Consideration of Sea Level Rise 30

3.3.3 Hazard Mapping Examples 35

3.3.4 Tidal Inundation Information for Risk Assessment Process 40

3.3.5 Tidal Inundation Outcomes 43

3.4 Catchment Flooding / Inundation 43

3.5 Coastal Inundation 44

3.5.1 General 44

3.5.2 Consideration of Sea Level Rise 44

3.5.3 Hazard Mapping Examples 45

3.6 Coincident Catchment Flooding and Coastal Inundation 48

3.6.1 General 48

3.6.2 Consideration of Sea Level Rise 48

3.6.3 Hazard Mapping Examples 48

3.7 Inundation Results and Conclusions 50

4 Water Quality 52

4.1 General Description of Groundwater and Surface Water 52

4.2 Flushing / Interchange of Water within Lake Conjola 53

4.2.1 Flushing / Interchange of Water after 2 Weeks with a Typical “Choked” Entrance 53

4.2.2 Flushing / Interchange of Water after 2 weeks with a Post-storm Event “Scoured” Entrance 55

4.2.3 Commentary on Flushing / Interchange of Water within Lake Conjola 57

4.3 Groundwater - Water Quality 57

4.3.1 Lake Conjola Waste Transfer Station 57

4.3.1.1 Sample Methodology (Soil, Surface Water and Groundwater) 58

4.3.1.2 Results & Conclusions 59

4.3.2 Conjola Regional Sewerage Scheme (CRSS) 60
4.3.3 Groundwater Monitoring Guidelines / Standards 61
4.3.4 Current Status and Results of CRSS Groundwater Sampling 62
4.4 Surface Water - Water Quality 64
4.4.1 General 64
4.4.2 Ecological Health Assessment 66
4.4.2.1 Ecological Health Guidelines / Standards 66
4.4.2.1 Estuary Ecosystem Health Report Cards 67
4.4.2.2 Estuary Ecosystem Health – Lake Conjola 68
4.4.2.3 Summary of Ecosystem Health Assessment 70
4.4.3 Recreational Water Quality Assessment 70
4.4.3.1 Recreational Health Guidelines / Standards 70
4.4.3.2 Available Lake Conjola Physico-Chemical Water Quality Data 71
4.4.3.3 Data Analysis 75
4.4.3.4 Surface Water Quality Monitoring – Recreational Health – Spatial Distribution of Results 78
4.4.3.5 Surface Water Quality Monitoring – Recreational Health – Sampling Frequency 80
4.4.3.6 Surface Water Quality Monitoring Recreational Health – Spatial Distribution, Rainfall and Entrance Condition 83
4.4.3.7 Summary of Recreational Water Quality Assessment 86

5 Marine Estate / Fisheries 88
5.1 Legal framework - *Marine Estate Management Act 2014* (MEM Act) 88
5.2 NSW Marine Estate – Threat and Risk Assessment (TARA) 88
5.2.1 General 88
5.2.2 Assessment of Shared Risks across Environmental Assets and Social, Cultural and Economic Benefits 89
5.2.3 Ranked Priority Threats to Environmental Assets for the South Region (BMT WBM, 2017) 90
5.2.4 Ranked Priority Threats to Social, Cultural and Economic Benefits for the South Region (BMT WBM, 2017) 91
5.2.5 Shared Priority Threats across Assets and Benefits for the South Region (BMT WBM, 2017) 92
5.2.6 Application of TARA results within the Lake Conjola CMP 92
5.3 Potential Threats to Lake Conjola's Marine Environment 92
5.3.1 Excessive Nutrients 92
5.3.2 Excessive Sediments 93
5.3.3 Study Area Observations 94

6 Influence of Catchment Management on Waterway Health 95
6.1 Application of the Waterway Health Risk-based Framework for the Lake Conjola Catchment 95
6.2 Current Influence on Waterway Health - Risk-based Framework Assessment of Lake Conjola 96
6.3 Waterway Health Risk Assessment for Lake Conjola 102
6.4 Potential Future Influence of Changes in Land Use on Lake Conjola 102

7 Foreshore Erosion, Stabilisation and Structures 105

7.1 General 105

7.2 Ad Hoc Foreshore Stabilisation Works 105

7.3 Lack of Riparian Vegetation 106

7.4 Private Foreshore Structures 107

7.5 Ad Hoc Watercraft Storage 108

7.6 Uncontrolled Stock Access to Foreshore Areas 109

7.7 Uncontrolled Stormwater Runoff 110

7.8 Estuarine Vegetation Migration 112

7.9 Foreshore Management Opportunities 112

8 Current & Future Issues - Significant Climate Change Concerns 117

8.1 Projected Regional Climate Change for Shoalhaven and Illawarra 117

8.2 Regional Vulnerability 118

8.2.1 Vulnerability in the Shoalhaven Illawarra Region 118

8.2.2 Exposure 119

8.2.2.1 Climate Drivers 119

8.2.2.2 Non-climate Drivers 119

8.3 Bushfire 119

8.3.1 Impact of 2019/2020 'Black Summer' Bushfires 119

8.4 Sea Level Rise 125

8.5 Habitat - Impacts of Climate Change on other Estuarine Processes 126

9 Potential Impacts of Threats within the context of Lake Conjola 127

9.1 Risk Assessment Methodology Description 127

9.2 Risk Assessment Matrix – Definitions 127

9.3 Qualitative Threat-Based Risk Assessment 130

9.4 Quantitative Asset-Based Risk Assessment 133

Table of Tables

Table 3-1: Timeline of Significant Events in Lake Conjola's Flood History prior to 2007 (BMT WBM, 2007) 23

Table 3-2: Timeline of Significant Events in Lake Conjola's Flood History from 2012 to 2020 (CCA, 2020) 24

Table 3-3: Timeline of Flooding (>1.0m water level) Events in Lake Conjola's Flood History from 2016 to 2022 MHL water level logger data - Lake Conjola D/S (Station number 216420D) 24

Table 3-4: Lake Conjola water level events 2000-2009 from MHL water level logger data - Lake Conjola D/S (Station number 216420D) 25

Table 3-5: Monthly and Annual total rainfall at Bendalong STP data logger 1991 - 2022 26

Table 3-6: Adopted Design Event Rainfall Totals (BMT WBM, 2013) 27
Table 3-7: Adopted Sea Level Rise Planning Periods 29
Table 3-8: Modelled tidal inundation scenarios 31
Table 3-9: Inundation and Duration - Annualised and Averaged Results Location 4 with 1.2m SLR 39
Table 3-10: Number of properties affected by design flood events (BMT WBM, 2013) 43
Table 3-11: Comparison of Peak Flood Conditions with Climate Change Scenarios (BMT WBM, 2013) 48
Table 4-1: MER Program trigger values for Lake Estuary Class (DPE, 2020, supplied) 67
Table 4-2: Lake Conjola Ecosystem Health Water Quality Ratings 70
Table 4-3: NHMRC “Guidelines for managing risks in recreational waters” assessment categories (2008) 71
Table 4-4: Aquadata water quality parameters assessed for Lake Conjola 73
Table 4-5: Example of Aquadata raw results from single site #E-40 74
Table 4-6: Yearly temporal distribution of enterococci Grade results 76
Table 4-7: Spatial distribution of results, colour-coded by Aquadata sample site location 80
Table 4-8: WQ results in Lake Conjola Village 80
Table 4-9: Sites outside of Lake Conjola Village area recording "poor" water quality results 82
Table 4-10: Relationship between surface water quality, rainfall and entrance condition 84
Table 4-11: Lake Conjola water quality results across all sites and annual rainfall 85
Table 6-1: Lake Conjola catchment - Total Suspended Solids Load pre- and post-development 96
Table 8-1: Climate change projections for the Shoalhaven Illawarra region (OEH, 2014) 117
Table 8-2: 2019/2020 Bushfire – Lake Conjola water quality impact risk - data current as of 02 February 2020 125
Table 9-1: Likelihood Rating Definitions 128
Table 9-2: Consequence Rating Definitions 129
Table 9-3: Risk Rating Definitions 130

Table of Figures

Figure 3-1: Catchment Based Flood Events - March 2022 (source: MHL website, 2022) 28
Figure 3-2: Landward and upward shift in beach profile due to sea level rise (Source: Hanslow et al., 2000) 29
Figure 3-3: Tidal Inundation is projected to become more frequent and over increased tidal ranges with sea level rise (source: riskmanagementmonitor.com) 30
Figure 3-4: Tidal Inundation extent and depth due to 1.2m SLR 33
Figure 3-5: Tidal Inundation duration percentage over 6 weeks due to 1.2m SLR 34
Figure 3-6: Representative Locations (1-27) for assessment of Tidal Inundation 36

Figure 3-7: Location 4 in Lake Conjola Village 37
Figure 3-8: Landing page for Lake Conjola CMP - Tidal Inundation hazard mapping 41
Figure 3-9: Tidal inundation of Lake Conjola Holiday Haven caravan park with SLR of +1.2m, with floor level of structure shown as not inundated 42
Figure 3-10: Processes contributing to total water level changes at the coast 44
Figure 3-11: Coastal Inundation extent and depth due to 1.2m SLR 46
Figure 3-12: Coastal Inundation of Lake Conjola Village with SLR of 0.00m 47
Figure 3-13: Coastal Inundation of Lake Conjola Village with SLR of 0.36m 47
Figure 3-14: Coincident Inundation of Lake Conjola village in Year 2100 with SLR of 0.9m (BMT WBM, 2013) 49
Figure 4-1: Potential sources of surface water and groundwater contamination (source: filterwater.com) 53
Figure 4-2: Lake Conjola - flushing analysis - average tracer concentration after two weeks – typical entrance condition 54
Figure 4-3: Lake Conjola - flushing analysis - average tracer concentration after two weeks – scoured entrance condition 56
Figure 4-4: Lake Conjola Transfer Station Site Location – note upstream of adjoining Pattimores Lagoon (ENRS, 2019) 58
Figure 4-5: Lake Conjola Transfer Station Site - Groundwater Monitoring Well Location Plan (ENRS, 2019) 59
Figure 4-6: Conjola Regional Sewerage Scheme footprint 60
Figure 4-7: The inferred groundwater flow regime as of August 2021 (E2W, 2021) 63
Figure 4-8: The inferred hydrogeological section as of 2021 (E2W, 2021) 64
Figure 4-9: Healthy waterway and impacted eutrophic waterway causes and descriptions 65
Figure 4-10: MER program Grades for ecosystem health condition indicators (chlorophyll a and turbidity) (Northern Beaches Council, 2016) 68
Figure 4-11: MER sampling locations within Lake Conjola (source: DPE MER assessment records, 2021) 69
Figure 4-12: Aquadata water quality sampling sites within Lake Conjola 72
Figure 4-13: Yearly temporal distribution of enterococci Grade results – percentage of grades chart 77
Figure 4-14: Correlation between daily rainfall and Lake Conjola entrance condition (open / closed) 77
Figure 4-15:Spatial Distribution of WQ results, grouped and colour-coded by location 79
Figure 4-16: Timeline and Frequency of water quality sampling in Lake Conjola Village 81
Figure 4-17: Timeline and Frequency of water quality sampling at other “poor performing” sites 82
Figure 4-18: NSW Beachwatch Lake/Lagoon water quality results 2020/2021 86
Figure 5-1: Relationship between Activities, Stressors, Environmental Assets and flow on Social and Economic Benefits - Urban Stormwater Discharges 89

Figure 5-2: Social, cultural and Economic Benefit Dependencies and Threats – Water Pollution 90
Figure 6-1: Land use within the Lake Conjola catchment (2007) (source: DPIE, 2020) 97
Figure 6-2: Lake Conjola Total Nitrogen (kg/yr) by sub-catchment area (source: DPIE, 2020) 98
Figure 6-3: Lake Conjola Total Suspended Solids (kg/yr) by sub-catchment area (source: DPIE, 2020) 98
Figure 6-4: Lake Conjola Total Nitrogen (kg/ha/yr) by location (source: DPIE, 2020) 99
Figure 6-5: Lake Conjola Total Suspended Solids (kg/ha/yr) by sub-catchment (source: DPIE, 2020) 100
Figure 6-6: Lake Conjola Total Phosphorous (kg/ha/yr) by location (source: DPIE, 2020) 101
Figure 6-7: Lake Conjola Total Phosphorous (kg/ha/yr) by sub-catchment (source: DPIE, 2020) 101
Figure 6-8: Lake Conjola Diffuse Source Pollution Risk Assessment overlaid on satellite image (source: DPIE, 2020) 103
Figure 6-9: Updated Lake Conjola land use mapping (2017) (source: SEED, 2020) 104
Figure 7-1: Ad hoc "foreshore stabilisation works" within Lake Conjola Village area 106
Figure 7-2: Foreshore access ramps and waterway structures 107
Figure 7-3: Ad hoc watercraft storage - reduction of public amenity and access 108
Figure 7-4: Uncontrolled riparian access 109
Figure 7-5: Uncontrolled foreshore runoff locations at Lake Conjola Village 110
Figure 7-6: Uncontrolled foreshore runoff locations at Lake Conjola Village 111
Figure 7-7: Uncontrolled foreshore runoff location at Conjola Park 111
Figure 7-8: Unsealed areas adjacent to drainage infrastructure 112
Figure 7-9: Estuarine Vegetation Migration Opportunities 113
Figure 7-10: Foreshore Management Opportunities (FMOs) – Fishermans Paradise 114
Figure 7-11: Foreshore Management Opportunities (FMOs) – Conjola Park 115
Figure 7-12: Foreshore Management Opportunities (FMOs) – Lake Conjola Village & Pattimores Lagoon 116
Figure 8-1: A snapshot of vulnerability in the Shoalhaven Illawarra region (OEH, 2019). 118
Figure 8-2: NSW Fire and the Environment 2019-20: Summary (DPIE, 2020) 120
Figure 8-3: The predicted spread of the “Currowan” bushfire on New Year's Eve 2019 (source: NSW RFS) 121
Figure 8-4: Satellite image of the smoke over the Conjola area on the south-coast of New South Wales at 11:00am, 31 December 2019 (European Union: Copernicus Sentinel data; source: ABC news report 8 June 2020) 122
Figure 8-5: Homes, property and lives were lost in the fires which tore through Lake Conjola on 31 December 2019 (source: Daily Telegraph) 123
Figure 8-6: Google Earth Engine Burnt Area Map (GEEBAM) of the local Lake Conjola region (DPIE, 2020) 124

Figure 8-7: Sediment control works completed after the bushfires to minimise runoff entering the lake (10-2-2020, D.Wiecek, DPE) 124

Figure 8-8: The rate of sea level rise around Australia measured using satellite altimetry, from 1993 to 2019 (source: CSIRO, 2020) 126

Appendices

Acronyms

Glossary

References

Appendix A –Tidal and Coastal Inundation Modelling Report

Appendix B - Tidal Inundation Depth Static Maps - all SLR ranges

Appendix C - Tidal Inundation Duration % Static Maps - all SLR ranges

Appendix D - Tidal Inundation Duration and Frequency Data - by Location

Appendix E - Coastal Inundation Static Maps - all SLR ranges

Appendix F - Shoalhaven Estuary Health Risk Assessment Mapping

Appendix G - Lake Conjola CMP - Threat Based Risk Assessment

Appendix H - Lake Conjola CMP - Asset Based Risk Assessment

Shoalhaven City Council Acknowledgement of Country

We would like to acknowledge the Traditional Custodians of the land in which we gather upon today. We acknowledge their continuing connections to the land, culture and community.

We pay respect to Elders past, present and future.

Executive Summary

Shoalhaven City Council (Council), with support from the NSW Department of Planning and Environment (DPE), have engaged Royal HaskoningDHV (RHDHV) to prepare a Coastal Management Program (CMP) for Lake Conjola. The CMP will consider current and future hazards as well as potential opportunities for adaptation and improvement, seeking to provide a set of prioritised, coordinated and cost-effective actions that, when progressively implemented, will help to ensure that Lake Conjola is ecologically healthy, resilient, attractive and accessible for future generations.

Stage 2 of the Lake Conjola CMP "Determine Risks, Vulnerabilities and Opportunities", addresses concerns raised during development of the Shoalhaven-wide CMP Stage 1 Scoping Study, builds on existing knowledge and lessons learnt from the implementation of management actions from the 1998 Estuary Management Plan and 2015 Estuary Management Plan review, as well as awareness of current and future coastal management issues, constraints and opportunities, to define the scope of subsequent CMP stages.

The results of Stage 2 investigations are reported within three companion documents, separated into key focus areas that reflect the understanding of the key interests of stakeholders.

The companion document, CMP Stage 2 - Report A "*Environmental, Social and Cultural Assets and Attributes*", provides a review of the physical and social attributes and assets within the Lake Conjola catchment, as well as noting the various pieces of legislation that afford protection to these attributes.

This report, **CMP Stage 2 Report B – "*Threats and Risk Assessment*"**, builds upon the knowledge base within CMP Stage 2 - Report A by describing the range of, extent, and potential impact of threats posed by coastal hazards on these attributes, as well as providing an initial consideration of potential mitigation options and actions.

The companion document CMP Stage 2 Report C - "*Entrance Processes and Entrance Management Options*", provides a review of coastal processes and entrance dynamics, past and current entrance management practices, as well as consideration of potential options for management of the entrance into the future.

For Lake Conjola, the following four Coastal Hazards (selected from the seven Coastal Hazards as defined within the CM Act) have been specified by Council for assessment within the CMP:

(c) coastal lake or watercourse entrance instability,
(d) coastal inundation,
(f) tidal inundation,
(g) erosion and inundation of foreshores caused by tidal waters.

The above coastal hazards are in addition to those caused by catchment flooding, and the combination of coincident catchment flooding and coastal inundation (which have already been assessed within the Lake Conjola Floodplain Risk Management Study and Plan (BMT WBM, 2013), and other environmental hazards such as those posed by bushfires, changes in water quality, changes in land use, invasive species and climate change.

As well as existing tidal and coastal inundation hazards connected to current (present day) oceanic water levels, sea level rise projections of 0.1m, 0.23m, 0.36m, 0.6m, 0.9m and 1.2m have been modelled. Sea

level rise projections of 0.23-0.36m for a 20-50 year planning period and 1.2m for a 100 year + planning period have been selected for assessment of future tidal and coastal inundation hazards.

Two divergent but complimentary risk assessment frameworks were utilised to consider the vulnerability of assets, communities and ecosystems within the Lake Conjola area:

- a **qualitative Threat-Based Risk Assessment** that considered high-level issues which may impact many aspects of the study area, and reflect the shared interest / responsibility of many stakeholders (e.g. range of short and long term environmental issues due to inundation of low-lying foreshore lands due to projected sea level rise); and,
- a **quantitative Asset-Based Risk Assessment** that provided detailed information on the frequency, depth and duration of (mainly tidal) inundation for each of 247 Council and Shoalhaven Water owned / managed assets, to aid Asset Managers make appropriate maintenance / renewal decisions.

Many of the key threats and hazards identified for investigation through the Risk Assessment process are well-known to the community and Council. Reflecting the concerns of residents and stakeholders, the primary focus of Stage 2 has been to consider and evaluate:

- the extent and impacts of inundation from tides and ocean based storm events, as well as consideration of prolonged low-lying “nuisance” flooding;
- water quality within Lake Conjola from catchment based inputs into surface water, as well as groundwater inputs from the Conjola Wastewater Treatment Plant; and,
- the influence of alternative options for active management of the entrance to Lake Conjola on the factors above, as well as other factors such as ecosystem health.

The impacts of the four specified Coastal Hazards, as well as other key issues, are considered and assessed as follows:

- *(c) coastal lake or watercourse entrance instability;*

  Management of the entrance, including mechanical intervention to facilitate an opening when the entrance becomes closed, is a key social, environmental and economic consideration for the Lake Conjola community. There are many low-lying properties at risk of inundation when the entrance is closed and water levels increase, as well as concerns within the community of poor water quality and loss of tourism at such times. A range of alternative entrance management strategies have been identified for modelling and assessment in Stage 3 of the CMP process.

- *(d) coastal inundation;*

  Coastal inundation occurs when a combination of meteorological processes raise ocean water levels above normal tidal elevations, and powerful waves can penetrate Lake Conjola (especially if the entrance is open), increasing water levels inside the Lake and causing foreshore inundation and damage. In the longer-term, the extent of coastal inundation will increase due to sea level rise (SLR).

  The number of (primarily residential) properties at risk of over-floor flooding during a 1% Annual Exceedance Probability (AEP) ocean storm event are as follows:

  - Current (0.0m SLR) — 25 of 499 properties inundated (only in Lake Conjola village)
  - 20-50 year (0.36m SLR) — 88 of 499 properties inundated (only in Lake Conjola village)

- 100 year + (1.2m SLR) 287 of 499 properties inundated (primarily in Lake Conjola village, but also in Conjola Park and Fishermans Paradise)

- *(f) tidal inundation;*

  Tidal Inundation is not an immediate hazard (unlike Coastal Inundation); in the short-term to medium-term it would have little to no consequence. However, in the long-term it is projected to cause significant impact to low lying areas. The likelihood of Tidal Inundation progressively increases over time, to a point when low lying areas may be inundated more than once each day, and/or for many consecutive days, presenting a very different hazard to Coastal Inundation.

  While the number of properties affected by over-ground flooding will be much higher, buildings at risk of over-floor flooding due to High High Water Solstice Springs (HHWSS) tidal inundation events ("sunny day" tides, without wind, waves, or other meteorological influences) are:

  - Current (0.0m SLR) 0 of 499 properties inundated
  - 20-50 year (0.36m SLR) 0 of 499 properties inundated
  - 100 year + (1.2m SLR) 16 of 499 properties inundated (only in Lake Conjola village)

  In addition, progressive increases in tide levels due to sea level rise over time will also have an impact on the use of low lying areas that are regularly inundated (including public reserves, carparks and tourist/caravan parks) and the functionality of maritime infrastructure (including boat ramps and jetties).

- *(g) erosion and inundation of foreshores caused by tidal waters;*

  Areas of foreshore erosion, likely linked with tides and waves, already exist within Lake Conjola. Some locations (e.g. on the northern shore of Cunjurong Point / Berringer Lake) are "natural" areas that are subject to erosion due to a combination of moderate public usage and natural processes. A significant proportion of the southern residential foreshore (including Lake Conjola Village and some areas of Conjola Park) is impacted by foreshore erosion, which has been addressed through a range of generally ineffective ad hoc "seawall" structures.

Water quality within Lake Conjola is frequently raised within the community and media outlets as an area of concern, with a range of potential diffuse source and point source contributors. A distinction is made between groundwater (held in aquifers within the soil, not exposed to air) and surface water (waterbodies exposed to air), which can have separate as well as shared sources of potential contaminants.

In operation from 2008, the Conjola Wastewater Treatment Plant (WWTP), owned and operated by Shoalhaven Water, enabled the majority of properties around Lake Conjola to transition away from on-site septic tanks, mitigating significant potential diffuse sources of pollution into the waterbody. Shoalhaven Water assess key parameters annually as part of licence conditions, particularly with respect to the known groundwater plume that extends from the dune exfiltration trench. Concerns have been raised as to the potential for the plume of high nutrient groundwater from the exfiltration system to adversely impact on the water quality within Lake Conjola and Pattimores Lagoon.

To date there is no evidence to suggest that water quality within Lake Conjola and Pattimores Lagoon is being adversely affected by the groundwater inflow. Analysis of the publicly available reports on the comprehensive annual groundwater monitoring program, a requirement of the EPA licence to operate, has shown that the WWTP operates well within discharge limits (with one aberration of elevated ammonia in August 2017), and that the groundwater plume has not yet intersected with the 'surface water' of Lake

Conjola and Pattimores Lagoon. However, ongoing monitoring will be important, particularly adjoining the Holiday Haven Caravan Park and Pattimores Lagoon, where the extent of the groundwater plume is noted to be in close proximity to both waterbodies.

At present there are no definitive negative trends in groundwater nor surface water quality due to human causes. Based on the available data, it is difficult to suggest causality / correlation between water quality and the nutrient plume from the WWTP at this point in time. It is recommended that Council work closely with Shoalhaven Water to ensure continuation of the groundwater monitoring and reporting program, with an increased focus on the assessment of the potential future connection of the nutrient plume into Lake Conjola and Pattimores Lagoon, as there are indications that this may become an issue in the shorter term.

Within the surface water, the estuary / ecosystem / ecological health of Lake Conjola has been monitored for a number of years by Council and DPE. Regular assessment of key water quality parameters, comprising *chlorophyll a* and turbidity, provides an effective measure of the short-term response of estuary health to certain types of pressures. While there has been some variation over time, the overall ecological condition of Lake Conjola has remained high, and with a large proportion of the catchment being National Park, is likely to remain in this condition.

The second surface water matter relates to recreational (human contact) water quality. Council and Shoalhaven Water have a well established and comprehensive physico-chemical water quality sampling program across the LGA. There are approximately 20 water quality monitoring sites within Lake Conjola, with records dating from 1989 until present, publicly available through Council's Aquadata website.

The Aquadata website provides an extensive temporal and spatial data set of numerous parameters of surface water quality for Lake Conjola. However, there are some limitations in the analysis of the data, and hence rigour in the findings, due to annual variations in the number of sites that were sampled, the number of samples taken at each site, the spatial distribution of the sample sites, the parameters assessed at each site, as well as a lack of recorded contextual information such as recent rainfall measurements, Lake water level, and whether the Lake was open or closed. The latter contextual information has been gained from other sources.

Water sampling locations in the upper western portions of Lake Conjola (near Fishermans Paradise) generally recorded good water quality, although poor water quality has been recorded at various times in correlation with rain events, suggesting a catchment based contribution to water quality particularly in the upper reaches. This is supported by modelling of tidal flushing within Lake Conjola, which demonstrates that flushing is limited to the entrance channel even with a fully scoured entrance condition.

Water quality results for enterococci indicate that Lake Conjola is generally suitable for recreation regardless of whether the entrance is open or closed.

In the entrance area, tidal flushing when the entrance is open assists with visual water clarity (aesthetic value), which is widely noted as a preference of residents and visitors to Lake Conjola, and is often cited as an example of desired "high" water quality.

Options for management actions to address the wide range of identified threats and impacts identified through this Stage 2 study will be developed and refined through collaboration and consultation with the community and other stakeholders during the CMP Stage 3 process – *Identify and Evaluate Options*, that will follow completion of Stage 2 of the Lake Conjola CMP.

Appropriate and supported management actions, including consideration of costs, benefits and timing of implementation, will be developed into a structured business plan within Stage 4 of the CMP process.

Once completed, the draft CMP will be publicly exhibited for consideration and comment by community and other stakeholders, before being refined and recommended for adoption by Council, then referral to the Minster for Local Government for Certification.

1 Introduction

1.1 Report Structure

This report, **CMP Stage 2 – Report B – "*Threats and Risk Assessment*"**, is set out in the following manner:

- **Section 1** provides an overview of the project and a brief overview of the Lake Conjola CMP study area, highlighting notable environmental, physical, social and cultural assets and attributes that may be vulnerable (detailed information is provided in ***CMP Stage 2 – Report A***); and,
- **Section 2** provides an outline of the identified coastal hazards and threats to be assessed within the Lake Conjola CMP study area.
- **Section 3** describes the four types of inundation that can impact Lake Conjola:
    - Tidal Inundation;
    - Catchment Flooding / Inundation;
    - Coastal Inundation;
    - Coincident Catchment and Coastal Inundation; as well as,
    - Entrance Management and its relationship to inundation and water quality (brief discussion, detailed information provided in ***CMP Stage 2 – Report C***);
- **Section 4** reviews and describes two aspects of water quality:
    - Groundwater;
    - Surface Water; as well as differing assessments of:
        - Ecological health; and,
        - Recreational safety;
- **Section 5** reviews the wider NSW framework for Marine Estate Management within the context of Lake Conjola, and discusses potential influences and impacts of current and future land use and management of the wider catchment on the Lake Conjola water body;
- **Section 6** reviews impact of current catchment management practices, and considers potential opportunities for improvement;
- **Section 7** considers the pressures of current and future land use practices on foreshore stability, and the associated interaction with waterway health; and,
- **Section 8** reviews and discusses a range of potential issues due to climate change.

With an understanding of the natural and constructed assets and attributes within the Lake Conjola study area, overlaid with the knowledge of current and future hazards from **Sections 3-8**:

- **Section 9** describes the framework and methodology used to consider the likelihood of the various identified hazards occurring against the consequence of the impact within:
    - a qualitative Threat-Based Risk Assessment that considered high-level issues which are a shared interest / responsibility of many stakeholders; and,
    - a quantitative Asset-Based Risk Assessment that considered inundation frequency, depth and duration of Council owned/managed assets to inform maintenance / renewal decisions.

1.2 Overview of cultural, social, environmental assets and attributes

Council recognises and acknowledges that Jerrinja, the coastal Saltwater People of the Shoalhaven and Kiama LGA regional areas, are the original inhabitants and custodians of all land within the Jerrinja Local Aboriginal Land Council (LALC) boundaries.

The land around Lake Conjola has been home for the Jerrinja people for at least 6,000 years. There are many Aboriginal sites in the area, including middens, campsites and rock shelters (NPWS, 2022).

The natural environment of Lake Conjola benefits significantly from the large tracts of Lake Conjola National Park and Narrawallee Nature Reserve within the catchment, with some 85% of land remaining vegetated (not cleared). As a result, there are some 1,600 threatened (and non-threatened) species of flora and fauna, as well as ecological communities, within a 5km radius centred on the study area.

Within a 10 km radius of Lake Conjola, numerous Matters of National Environmental Significance (as defined by the *Environment Protection and Biodiversity Conservation Act 1999*) are recorded, including:

- 8 Listed Threatened / Endangered Ecological Communities;
- 79 Listed Threatened Species and 54 Listed Migratory Species;
- 76 listed marine species, including 12 whales and other cetaceans;
- 5 State and Territory Reserves;
- 1 Regional Forest Agreement; and,
- 38 Invasive Species.

Of specific relevance to management of the entrance to Lake Conjola (which is periodically mechanically opened by Council to reduce catchment-based inundation (flooding due to rainfall)) is the seasonal presence of Little Terns, a protected migratory shorebird which nests on the sand barrier berm during the period from October to March.

South Coast villages such as Lake Conjola have a heavy reliance on tourism for their livelihood. While hosting a relatively small resident population (with respect to catchment size) of some 1200-1400 permanent residents, primarily based in three villages (Lake Conjola, Conjola Park and Fishermans Paradise), the region is an extremely popular tourism destination, hosting approximately 5000 additional people during the peak summer period.

From observation, discussion with residents, tourist accommodation proprietors, Council staff and other stakeholders, it is readily apparent that tourist visitors travel to Lake Conjola for the beaches and waterways in the area, and that a large number of residents and visitors to Lake Conjola are boating enthusiasts.

The economic benefits of tourism activity are difficult to allocate to specific local areas, as there are limited commercial outlets available from within the villages of Lake Conjola, Conjola Park, Fishermans Paradise and Bendalong, and a number of private tourism ventures may be unreported. However, the cumulative benefits of boating pursuits and waterway access to the regional economy is undoubtedly very significant.

The carrying capacity of the receiving environment, as well as local infrastructure, are important considerations for Council when considering strategic regional planning outcomes, as well as asset maintenance and renewal programs.

The majority of residential properties within the Lake Conjola catchment are located within the three main villages of Lake Conjola, Conjola Park and Fishermans Paradise, however there are numerous semi-rural and rural properties around the extended foreshore area. Based on information provided by Council, 499 individual properties have been identified and included within RHDHV's hazard mapping. The location of these residential properties in relation to distance to the foreshore varies, as does the vertical elevation of the properties.

In addition, in order to assist Council's immediate and long term asset management planning, 247 Council owned and/or managed assets within the greater Lake Conjola area have been identified and included within the Asset-Based Risk Assessment process. These include a range of built structures and assets (such as carparks, roads, boat ramps, stormwater and sewer network, caravan park), as well as natural assets (such as Endangered Ecological Communities).

1.3 General NSW Estuary Management

Note:

Detailed discussion and assessment of the management of the entrance to Lake Conjola is provided within the companion document: CMP Stage 2 - Report C - "Entrance Processes and Entrance Management Options".

While the discussion below, largely based on information provided by the NSW Department of Primary Industries[1], reflects management of ICOLLs along the entire NSW coastline, the underlying descriptors and management rationale are relevant to Lake Conjola and Council.

Estuaries provide an interface between freshwater and marine waterbodies, being defined as any part of a river, lake, lagoon, or coastal creek whose level is periodically or intermittently affected by coastal tides, up to the highest astronomical tide (CM Act). Estuaries are located all along the NSW coast, with most occurring south of Sydney where catchments are generally smaller in size and experience lower average rainfall and are either permanently open such as Port Jackson and Lake Illawarra, or intermittently closed such as Lake Conjola.

An intermittently closed estuary is commonly referred to within NSW coastal management frameworks as an "ICOLL", being an "Intermittently Closed and Open Lake/Lagoon". ICOLLs are separated from the ocean by a sand beach barrier or berm, as average wave activity is generally higher than at comparable non-closing estuaries, and can push sand into estuary mouths. This entrance barrier forms and breaks down depending on the movement and redistribution of sand and sediments by waves, tides, flood flows and winds. ICOLLs open and close to the ocean naturally in a constant but irregular cycle.

1.3.1 Intervention to Open Estuary Entrances

Many ICOLLs have been, and continue to be, manually or artificially opened to the ocean by various authorities. Heavy equipment, such as excavators, are used to artificially open ICOLLs by digging a channel through the sand berm between the ICOLL edge and the ocean.

The main reason for artificially opening an ICOLL entrance is to mitigate and reduce the impacts of flooding. When water levels rise in a closed ICOLL following rainfall this can lead to flooding of urban and rural development adjacent to the lake or lagoon foreshore, including private properties, business premises, roads, parklands, sewerage systems and farmland.

Artificial breaching of the entrance barrier is undertaken to 'drain' the ICOLL to the ocean and lower water levels to relieve existing flooding of foreshore development and infrastructure or avoid the likely threat of flooding which would occur before the ICOLL entrance opens naturally. The trigger water level for artificially opening many ICOLLs (rather than let nature take its course) is often a consequence of past developments being allowed to be located in low lying areas too close to the edge of the lake or lagoon.

1.3.2 Entrance Management Responsibility

Responsibility for undertaking artificial openings of ICOLL entrances usually lies with the local council under their duty of care to the local community, guided by adopted estuary management plans and entrance management policies. ICOLL entrances located within National Parks or Nature Reserves are managed by the Department of Planning and Environment (DPE).

[1] *Acknowledgement is made of online information provided by the NSW Department of Primary Industries*

Usually, the ICOLL entrance is Crown Land, so councils are required to obtain the agreement of other State Government agencies (e.g. DPE, Fisheries), and obtain a licence under the *Crown Lands Act 1989* from DPE - Crown Lands to undertake the entrance opening works.

The entrance to Lake Conjola is currently managed in accordance with the Lake Conjola Interim Entrance Management Policy (GHD, 2013), under the guidance of the Southern Coastal Management Program Advisory Committee. Council currently holds Crown Land Licence RN625288 (issued 16 September 2021) that permits artificial opening, subject to a range of terms and conditions including specific requirements relating to, for example, fringing vegetation surveys, protection of migratory shorebirds, protection of any Aboriginal object or place, or other item of archaeological significance.

1.3.3 General Water Quality Considerations

Closed ICOLLs can often cause community concern over issues such as perceived 'poor' water quality, decreased visibility, health of recreational users, unpleasant odour, flooding of low-lying areas of the foreshore and the health of fish stocks. It is often suggested that ICOLL entrances should be opened to flush out the 'dirty' water and replenish it with 'clean' seawater. However, just because an ICOLL is closed does not necessarily mean that it has poor water quality. Many closed ICOLLs maintain good water quality and remain suitable for swimming, water sports and fishing for long periods of time. Furthermore, artificially opening an ICOLL entrance will not always improve the water quality due to the limited tidal movement or 'flushing' in most ICOLLs.

After heavy rainfall the water quality in a closed ICOLL can temporarily worsen as a result of runoff containing sediment, nutrients and pollutants entering the ICOLL from creeks and drains throughout the catchment. In many instances opening the entrance is not the solution and consistent poor water quality is better addressed by improving the management of catchment inputs to ICOLLs; that is, installation of source controls.

1.3.4 Ecological Function Considerations

ICOLLs are very complex environments and the impact of artificially opening entrances on fish species and fish habitats is not well understood. Many species of estuarine fish and prawns that are targeted by recreational and commercial fishers breed in oceanic or coastal waters and enter estuaries and ICOLLs from the ocean as larvae and juveniles. While some fish need to migrate to the sea to complete their breeding cycle, others reproduce in the estuary and do not require an open entrance for spawning.

Long periods (i.e. 3 to 4 years or more) of entrance closure may restrict the recruitment of certain fish species to ICOLLs. However, some fish and fish larvae will enter an ICOLL from the ocean even if it is only open for a short period of time, or during 'wash over' events when seawater flows over the entrance berm during high tides and storm surges. Although enhancing the recruitment of fish and prawns is often cited as justification for artificially opening entrance barriers, fish and prawn recruitment processes are not fully understood and are likely to be very dependent upon climatic factors, as well as a number of other environmental variables.

During long periods of closure, some foreshore vegetation (such as Casuarinas) may die from prolonged waterlogging. However, this is a natural process with riparian vegetation gradually advancing and retreating along the foreshore in response to varying water levels over time. Potential loss of riparian vegetation can be managed in ways other than artificially opening the entrance, including ensuring there are sufficient replacement plants growing on the landward side of the foreshore (i.e. maintaining or establishing riparian buffer areas) and planting or allowing natural rehabilitation of more suitable species that can tolerate wet, salty soils, such as saltmarsh and mangroves.

It should be recognised that flooding and drying are natural components of the hydrological and ecological processes operating within ICOLLs. Coastal lakes and the life they support have evolved in response to these forces, and DPI (amongst others) note that to maintain a ‘healthy’ lake/ICOLL, ideally it should be left to operate as close to its natural state as possible.

2 Threat Identification

For the Lake Conjola CMP, the following Coastal Hazards (as defined within the CM Act) have been identified for assessment:

(c) coastal lake or watercourse entrance instability (refer to **CMP Stage 2 – Report C** for further discussion),
(d) coastal inundation,
(f) tidal inundation,
(g) erosion and inundation of foreshores caused by tidal waters.

As well as these defined coastal hazards, a number of additional threats to the environmental, social and cultural assets and attributes within the Lake Conjola CMP study area have been identified, and are addressed within this report. These include:

- catchment flooding;
- coincident inundation - combination of catchment flooding and coastal inundation;
- poor water quality – groundwater and surface water;
- impacts of catchment management on waterway health;
- foreshore erosion and removal of riparian vegetation;
- inadequate management of foreshore access, private structures, and watercraft storage; and,
- climate change related impacts from increases in sea level, bushfires and rainfall.

Note:

Catchment flooding *and* ***Coincident inundation*** *were identified as matters of concern within the Lake Conjola Floodplain Risk Management Study and Plan (BMT WBM, 2013), and as such, the hazard extent and associated maps were prepared, and mitigation measures were proposed as part of that plan.*

The Lake Conjola CMP modelling and assessment do not revisit these hazards, however, for completeness, a brief summary on ***Catchment flooding*** *and* ***Coincident inundation*** *has been included within this report*.

3 Inundation

3.1 Historical and Recent Inundation at Lake Conjola

The predominant recorded cause of flooding at Lake Conjola is due to catchment-based rainfall. The contribution to inundation based on whether the entrance to Lake Conjola is open or closed is often debated, as it is in many coastal estuarine locations. A review of water level records indicates that elevated water levels in the lake (i.e. above 1m AHD) can occur under both open and closed entrance conditions. A detailed analysis of several selected events involving mechanical openings and natural breakout of the entrance is provided in **CMP Stage 2 – Report C**.

A sequential history of recorded Lake Conjola flood events is provided in **Table 3-1**, **Table 3-2**[2] and **Table 3-3**, with information about the entrance state provided if known. Lake water levels are relative to AHD.

Table 3-1: Timeline of Significant Events in Lake Conjola's Flood History prior to 2007 (BMT WBM, 2007)

Flood Event	Year
Major flood event	1911
Major flood event	1915
Major flood event	1927
Major flood event	1939
Major flood event	1959
Major flood event	1971
Major ocean storm event	1974
Major flood event	1991
Moderate flood event	1992
Minor "sunny day" ocean event	2006

[2] *The flood history data collected by the Conjola Community Association (CCA) is a citizen science project. The information presented has been reviewed and verified as part of the preparation of this report.*

Table 3-2: Timeline of Significant Events in Lake Conjola's Flood History from 2012 to 2020 (CCA, 2020)

Event Month/Year	Lake Water Level	Lake Entrance State	Rainfall (BOM Ulladulla) (time period unspecified)
March 2011	1.32m	Closed	300mm
March 2012	1.27m	Open	101mm
June 2012	1.43m	Closed	54mm
April 2013	1.22m	Closed	226mm
June 2013	1.41m	Closed	186mm
August 2014	1.39m	Closed	178mm
August 2015	2.14m	Closed	309mm
June 2016	1.49m	Closed	235mm
July 2016	1.32m	Open	156mm
Feb 2020	2.03m	Closed	240mm
May 2020	1.28	Open	118mm
July 2020	1.37	Open	362mm

Table 3-3: Timeline of Flooding (>1.0m water level) Events in Lake Conjola's Flood History from 2016 to 2022 MHL water level logger data - Lake Conjola D/S (Station number 216420D)

Event Date	Lake Water Level	Lake Entrance State	Rainfall (MHL Lake Conjola)
27 April 2017	1.11m	Closed	2mm (96 hours)
9 February 2020	1.04m	Closed	221mm (96 hours)
10 February 2020	2.037m		
22 May 2020	1.26m	Open	51mm (96 hours) Ocean storm event (Port Kembla Waverider buoy data) ***Coastal Inundation***
23 May 2020	1.27m		
24 May 2020	1.17m		
25 May 2020	1.09m		
27 July 2020	1.31m	Open	301mm (96 hours)
28 July 2020	1.37m		
9 August 2020	1.19m	Open	187mm (96 hours)
2 March 2022	1.67m	Open	77.5mm (48 hours)
7 March 2022	1.218m	Open	148mm (48 hours)
8 March 2022	1.47m		

There were no significant periods of inundation during the 2000-2009 period when the entrance was open, although the gauging record indicates that water levels slightly exceeded 1m AHD on 9 occasions with 3 events at or above 1.2m AHD (refer **Table 3-4**). It should be recognised that this was also a period of relatively low total annual rainfall of between 740mm and 1,200mm, as shown in **Table 3-5**. It is possible that this combination of events reinforced the actual and perceived efficacy of the entrance clearance works undertaken as recommended by Patterson Britton in 1999.

Table 3-4: Lake Conjola water level events 2000-2009 from MHL water level logger data - Lake Conjola D/S (Station number 216420D)

Event Date	Lake Water Level	Lake Entrance State
6 January 2000	1.04m	Open
1 June 2000	1.11m	Open
2 June 2000	1.14m	
3 June 2000	1.02m	
30 June 2000	1.33m	Open
1 July 2000	1.08m	Open
28 July 2001	1.20m	Open
29 July 2001	1.03m	
23 June 2005	1.12m	Open
10 July 2005	1.09m	Open
11 July 2005	1.03m	
9 April 2006	1.31m	Open
14 June 2007	1.01m	Open
28 June 2007	1.15m	Open
15 December 2008	1.03m	Open
10 June 2009	1.03m	Open

Table 3-5: Monthly and Annual total rainfall at Bendalong STP data logger 1991 - 2022

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1991	47.2	84.4	11.8	44.8	135.6	606.6	165.2	4.6	19.2	23.6	41.6	204.6	**1389.2**
1992	105.6	303.8	72	73	98.8	173	22.4	91.8	55.8	82.8	159.4	120.8	**1359.2**
1993	136.4	71.8	114	36.2	51.4	56.4	72.2	108.4	101.2	102.6	32.8	36.2	**919.6**
1994	16.6	156.4	176.4	182.4	52.8	145.4	29.4	17	36	96	105.4	62.2	**1076**
1995	174.6	30.8	114	15.8	132.2	110.2	30.2	5.6	171.2	102.6	143	78.2	**1108.4**
1996	79.4	35.4	18.6	122.8	101.4	90.2	49.4	54.8	123.4	38.8	101.4	19.8	**835.4**
1997	107.2	98.2	356.4	2	131.8	149.4	62.4	12.2	192.2	49.6	26.6	8.2	**1196.2**
1998	66.8	16	15.8	113.8	173	165	88.8	365	69.6	45.8	93.2	25	**1237.8**
1999	213.4	104.8	133	119	11	75.4	139.8	22.8	92.8	140.2	62.2	104.2	**1218.6**
2000	55.2	46.6	165.2	86.2	22.8	104.6	48.2	18.8	66.4	50	211.2	55	**930.2**
2001	75.4	162.5	71.8	40.4	77.6	29.4	141.2	125.8	106.2	25.6	91	67.8	**1014.7**
2002	130.4	244.6	59.2	105.8	128	49.6	10.2	9		34.4	10.8	73.6	**855.6**
2003	55.2	86.4	79.2	163.2	309	35	77.4	27.4	12	87.4	180.6	41.2	**1154**
2004	94.4	57.4	90.8	82	128.4	3.4	64.8	24.4	148.2	202.4	78.4	99.8	**1074.4**
2005	88.4	87.6	125.4	25.2	169	87	132.2	9.4	64.6	124	93.6	26.4	**1032.8**
2006	78.4	32.8	47.4	11.6	77.6	271.2	167.2	65.4	61	2.8	38.2	95.2	**948.8**
2007	26	213.6	88.6	151.2	12	305.8	66.6	81	30.6	20.2	148	83.6	**1227.2**
2008	77.8	190.2	46.2	71.4	8.2	81.2	53.4	77.4	57.6	103.8	71.2	95.2	**933.6**
2009	29.8	79.4	35	79.6	48.2	58	32.2	13.8	35.4	164.6	36.4	131.4	**743.8**
2010	52.6	196.4	106.6	27.6	196.6	69.2	68	39	74.4	97.8	218.8	134.4	**1281.4**
2011	78.6	87	245.6	155.8	92.8	70.2	170	80.6	39	81	123.2	62.8	**1286.6**
2012	36.8	227	285.4	70.2	26	149.8	30	10.6	24.6	133.4	46.8	19.4	**1060**
2013	184.8	149.8	63.4	344.8	98.8	274	35	11.2	112.4	38	120	73.6	**1505.8**
2014	35.4	51	246.8	84.2	33	110.2	5.2	199.6	40.4	253	30.6	207.2	**1296.6**
2015	169.4	130.4	57.8	207.8	75.6	75.2	86.4	482	84.4	61.2	62.4	45.6	**1538.2**
2016	240	86.2	64.8	51	43.6	318	185.6	75.2	87.8	39.8	37.2	109	**1338.2**
2017	35.2	175.2	434.8	83.4	58.3	84	6.6	51.2	3.4	54.6	89.4	110.8	**1186.9**
2018	93.8	148.4	56.4	57.8	33.6	74.8	4.4	18.8	38.4	112	200	64.6	**903**
2019	62.2	19.8	120.2	179.2	8.8	167	28.4	68.8	86	53	18.6	7.4	**819.4**
2020	34.2	279.2	121.8	70.6	118.2	17.2	362.4	192	18.2	109	128.6	77.8	**1529.2**
2021	126.4	115.4	246.4	5.8	115.2	48.2	22	94.2	33.2	122.6	243.4	316.8	**1489.6**
2022	174	156.2	656	67.5	146.5	9.7	431.3	38.8	169.2	409.9	69.6	39.9	**2368.6**

From 2010 to 2019 the entrance shoaled and closed on a number of occasions, and a number of flood events were experienced during that time. However, it should be noted that annual rainfall increased to

between 1,060mm and 1,540mm over the same period, which may have been a significant contributing factor. The most recent significant flood event in February 2020 occurred while the entrance was closed, and the inundation dropped rapidly once the entrance was open, perhaps reinforcing the perception of direct connectivity between the entrance state and flooding.

A direct measurement of rainfall is not a definitive predictor of the severity of inundation. **Table 3-6** presents the adopted design rainfall totals used to derive the peak flood levels for floods of various magnitudes (BMT WBM, 2013), which indicate that the volumes of rainfall that caused the flood events recorded in March 2011, August 2015 and July 2020 (shown in **Table 3-2** and **Table 3-3**), were all close to 10% AEP events and resulted in variable peak Lake water levels for each event.

Table 3-6: Adopted Design Event Rainfall Totals (BMT WBM, 2013)

Design Event	Rainfall Depth (mm)
20% AEP (5 year ARI)	269
10% AEP (10 year ARI)	309
5% AEP (20 year ARI)	362
2% AEP (50 year ARI)	432
1% AEP (100 year ARI)	487

Following the significant flood event of February 2020, the Lake has remained open, and has experienced periods of moderate as well as significant rainfall, as well as an ocean storm event, with a range of Lake water level responses.

The flood event on 27-28 July 2020 occurred when the entrance was open, rainfall of 301mm was recorded over 96 hours (close to 10% AEP), and Lake Conjola reached a peak water level of 1.37m AHD on 28 July. A similar flood event occurred on 9 August 2020 with an open entrance, recorded rainfall of 187mm, and a peak water level of 1.19m AHD. The water levels decreased rapidly following the peak event, indicating that an open entrance condition may reduce the severity of a minor flood event by enabling the Lake to drain faster.

However, counter to expectations that rainfall volume and flooding have a direct correlation, a recent flood event on 2 March 2022 with an open entrance and rainfall of only 77.5mm resulted in peak water level of 1.67m AHD, whilst a subsequent event on 7-8 March 2022 with an open entrance and rainfall of 148mm reached a peak water level of 1.47m AHD, as shown in **Figure 3-1**. As noted within the Lake Conjola FRMS&P (BMT WBM, 2013), while the entrance state of open or closed is likely to play a role in flooding, especially for smaller events, clearly a range of other factors are also involved, including ocean water levels.

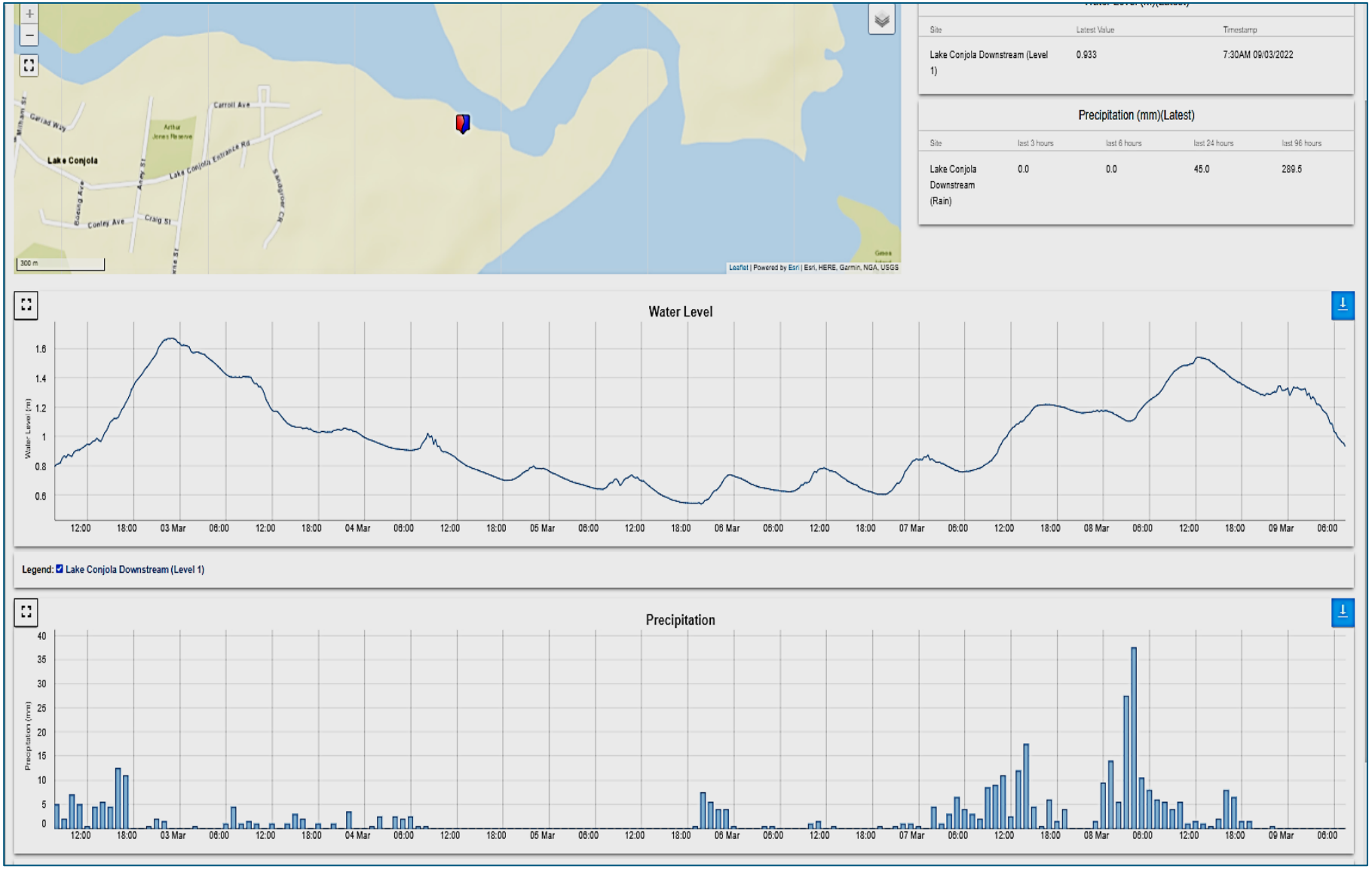

Figure 3-1: Catchment Based Flood Events - March 2022 (source: MHL website, 2022)

3.2 Lake Conjola CMP – Application of Sea Level Rise Projections

The approach adopted by Council for consideration of future planning periods for sea level rise is outlined in **Table 3-7**.

Table 3-7: Adopted Sea Level Rise Planning Periods

Sea Level Rise	Planning Period
0.23m	20-50 years
0.36m	
0.6m	50-100 years
0.9m	
1.2m	100+ years

For the Lake Conjola CMP, a range of sea level rise projections were applied in modelling of tidal inundation and coastal inundation, including 0.1m, 0.23m, 0.36m, 0.6m, 0.9m and 1.2m. The following sea level rise projections were adopted for undertaking risk assessments:

- **0.0m for the current planning period;**
- **0.23m-0.36m for a 20-50 year planning period; and,**
- **1.2m for a 100 year + planning period.**

These sea level rise projections form the basis for consideration of future tidal and coastal inundation hazards within the CMP Stage 2 Risk Assessment process.

An additional factor that requires consideration when assessing coastal hazards is the morphodynamic response of the entrance to Lake Conjola due to sea level rise. Increased sea level will result in a landward and upward shift of the beach profile, including the entrance berms of coastal lagoons, as a result of wave run-up and berm overwash processes, as shown in **Figure 3-2**.

For estuarine entrances at the northern end of a beach, changes to littoral sand transport processes potentially resulting in increased beach accretion adjacent to the entrance may offset or even exceed the progressive shoreline recession associated with sea level rise. For mostly open estuaries, such as Lake Conjola, the increased tendency for accretion within an estuary entrance would make that entrance more susceptible to closure (Haines & Thom, 2007).

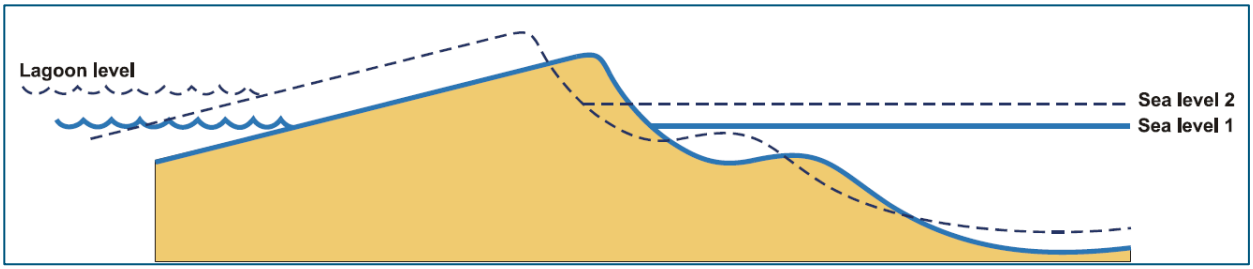

Figure 3-2: Landward and upward shift in beach profile due to sea level rise (Source: Hanslow et al., 2000)

In order to account for potential morphological change of the Lake Conjola estuary entrance, the bathymetry input for tidal and coastal inundation modelling assumed that the area from the ocean

entrance to 'The Steps' had risen at the same rate as sea level rise. Sensitivity testing around this process was also modelled based on the estuary bed not rising with sea level rise.

3.3 Tidal Inundation

3.3.1 General

Tidal inundation (sometimes referred to as 'nuisance flooding') is the inundation of land by tidal action under ordinary meteorological conditions. Tidal inundation may include shorter-term incursion of seawater onto low-lying land during an elevated water level event such as a 'king tide' 'or more permanent inundation due to land subsidence, changes in tidal range or sea level rise. In some scenarios, the risk associated with tidal inundation may be exacerbated when a spring tide coincides with coastal inundation or catchment flooding.

Astronomical tide is a key 'forcing' mechanism for water movement and sediment movement at the entrance to Lake Conjola. The other key forcing mechanism is freshwater discharge from the lake at times of rainfall. During dry periods, freshwater flows are insignificant, while tidal and wave driven processes dominate entrance behaviour.

3.3.2 Current Status and Consideration of Sea Level Rise

The High High Water Springs Solstice (HHWSS) tide level has been utilised to assess the inundation levels of "sunny day" flooding, which can occur simply because of a relatively high tide, without added inputs from rainfall and/or ocean storm events. While not presenting as significant inundation depths as catchment flooding and/or coastal inundation, when subject to sea level rise, tidal inundation is projected to occur on an increasingly frequent basis as shown in **Figure 3-3**, with associated social, environmental, and economic impacts.

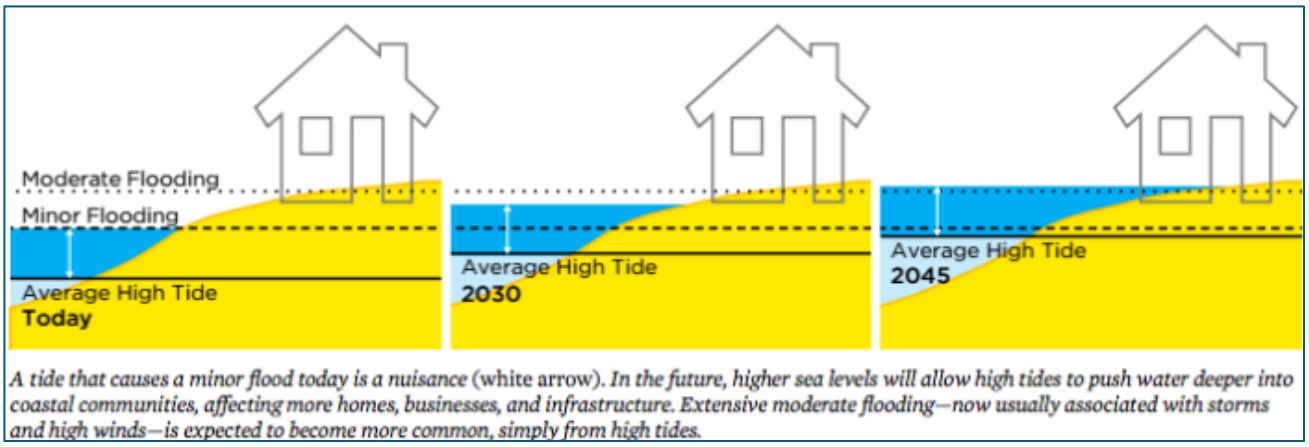

Figure 3-3: Tidal Inundation is projected to become more frequent and over increased tidal ranges with sea level rise (source: riskmanagementmonitor.com)

The impact of future tidal inundation on assets, due to increased inundation depth and extent caused by projected sea level rise, is a key factor for asset owners when considering medium-term and long-term asset management planning. Stage 2 of the CMP involves undertaking detailed studies that help councils to identify, analyse and evaluate risks, vulnerabilities and opportunities within the study area based on assessment of coastal hazards.

To determine the spatial extents within Lake Conjola, and to quantify the potential threats posed by Tidal Inundation, RHDHV developed and calibrated a hydraulic and geomorphological model of Lake Conjola. This model incorporated a post-storm (scoured) entrance bathymetry within the MIKE 21 FM hydrodynamic modelling system. Adoption of a scoured entrance condition allows greater tidal penetration and hence provides conservative (higher) inundation levels due to tide.

A brief description is provided below, while the full report entitled "Stage 2 - Tidal and Coastal Inundation Modelling Report", describing the methodology and findings of the modelling is provided in **Appendix A**.

A range of projected Sea Level Rise (SLR) scenarios were investigated, one for the present-day sea level condition and one for each SLR scenario, as summarised in **Table 3-8**.

Table 3-8: Modelled tidal inundation scenarios

SLR Scenario	Number of Simulations	Description
0m (Present Day)	1	To spatially assess tidal range throughout the estuary
0.10m	1	1 x Entrance bed has risen 0.10m with SLR
0.23m	1	1 x Entrance bed has risen 0.23m with SLR
0.36m	1	1 x Entrance bed has risen 0.36m with SLR
0.6m	1	1 x Entrance bed has risen 0.6m with SLR
0.9m	1	1 x Entrance bed has risen 0.9m with SLR
1.2m	1	1 x Entrance bed has risen 1.2m with SLR
0.1m	1	Entrance bed not raised with SLR
0.23m	1	Entrance bed not raised with SLR
0.36m	1	Entrance bed not raised with SLR
0.6m	1	Entrance bed not raised with SLR
0.9m	1	Entrance bed not raised with SLR
1.2m	1	Entrance bed not raised with SLR

As previously mentioned, the following sea level rise projections were adopted for undertaking risk assessments for the Lake Conjola CMP:

- **0.0m for the current planning period**
- **0.23m-0.36m for a 20-50 year planning period; and,**
- **1.2m for a 100 year + planning period.**

The modelling simulation, extending over six weeks of tides, provided a sufficiently long period to enable the identification of the required tidal constituents and their frequencies and amplitudes.

Utilising results of the six-week modelled period of tidal inundation (rather than a single High High Water Solstice Springs (HHWSS) event), HHWSS was calculated by extracting water level time-series at each of the model grid points within Lake Conjola. Tidal Inundation maps depicting inundation extent, inundation depth and inundation duration (as a percentage of time within the six-week period) were developed for the range of Sea Level Rise (SLR) scenarios described above.

Results of the tidal inundation modelling were presented in the form of “static” maps showing:

- Inundation water depth/extent and water levels; and,
- Inundation duration.

These “static” maps are the standard method used by local governments and other agencies when defining, describing and communicating the hazards / risks / opportunities for a region or location, which are included within printed project reports, and overlaid as shapefiles within Council’s planning and development GIS system.

An example of Tidal Inundation extent and depth due to 1.2m SLR is shown in **Figure 3-4**, with the full set of tidal inundation depth maps provided in **Appendix B**. The corresponding Tidal Inundation duration as a percentage of the 6-week modelled period due to 1.2m SLR is shown in **Figure 3-5**, with the full set of (percentage of time) inundation duration maps provided in **Appendix C**.

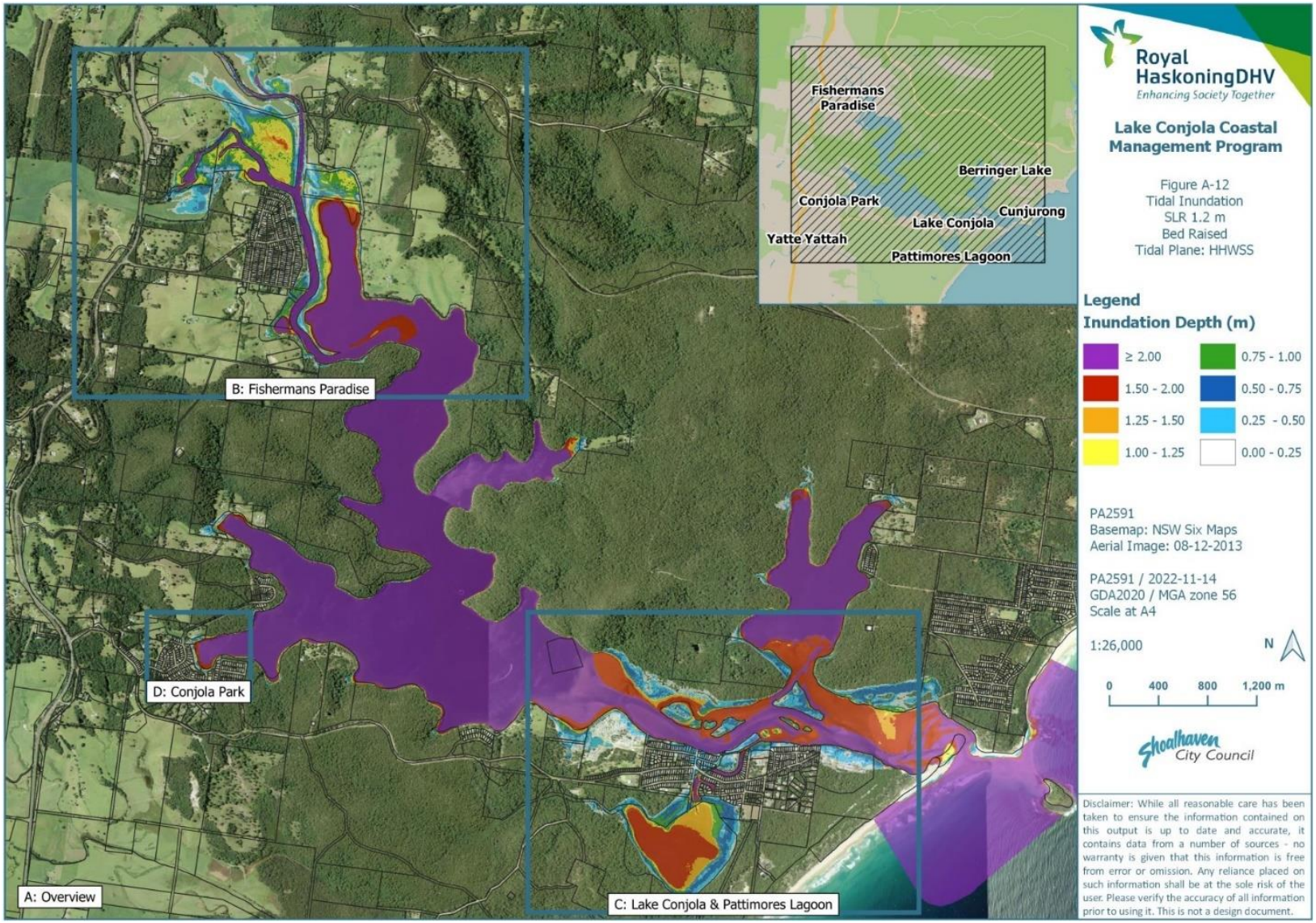

Figure 3-4: Tidal Inundation extent and depth due to 1.2m SLR

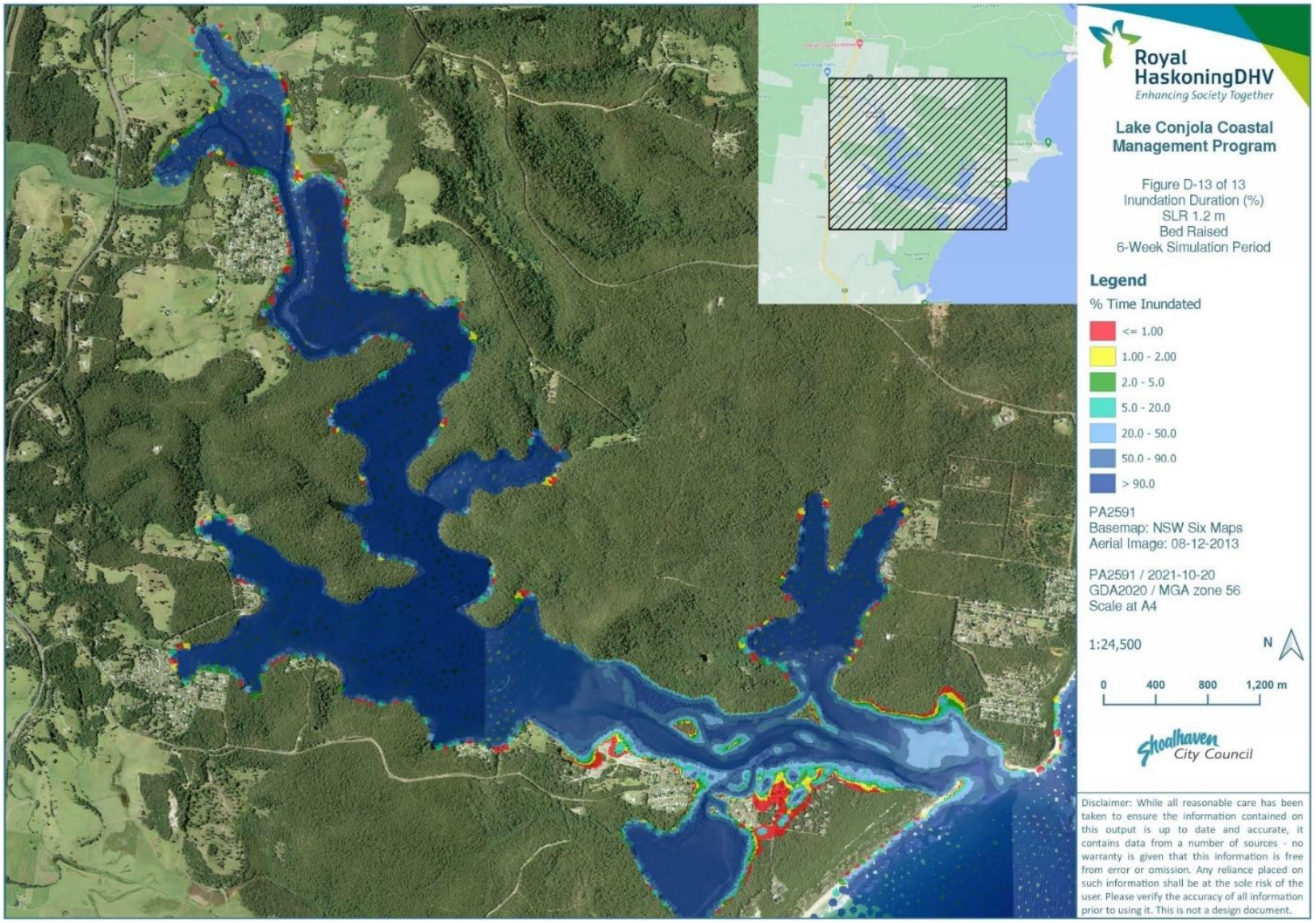

Figure 3-5: Tidal Inundation duration percentage over 6 weeks due to 1.2m SLR

3.3.3 Hazard Mapping Examples

In order to assist Council asset managers when developing medium-term and long-term asset management plans, the duration and frequency of tidal inundation for each of the 247 assets within Council's asset risk register were estimated based on the modelling outputs (described below with key points in **bold**).

A total of 27 representative locations were selected for detailed assessment of Tidal Inundation, as shown in **Figure 3-6**.

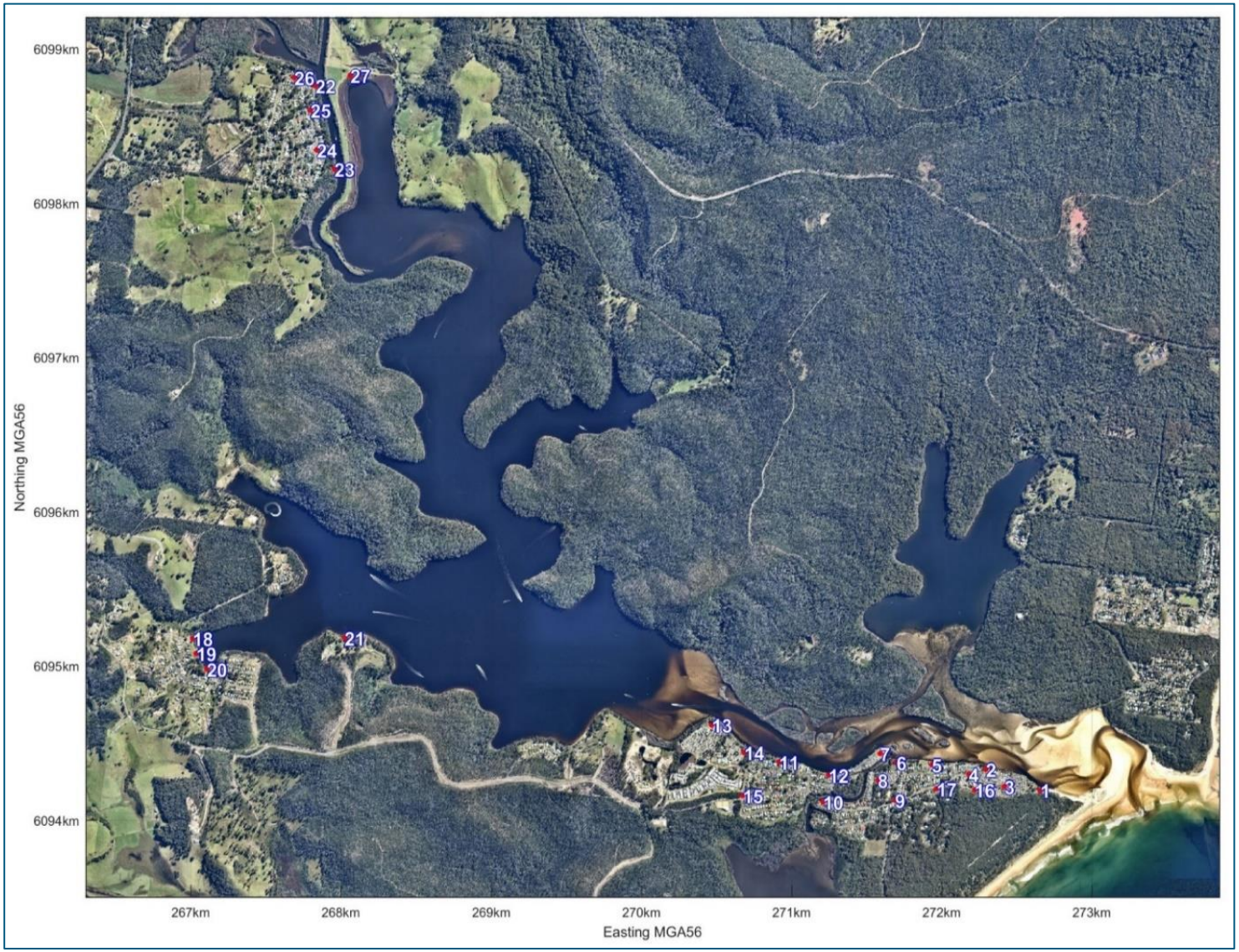

Figure 3-6: Representative Locations (1-27) for assessment of Tidal Inundation

Inundation extents from the modelled 6-week period of tidal variation were generated and overlaid on a Digital Elevation Model (DEM) to provide inundation depths based on the elevation (ground level) of the 27 representative locations around the developed foreshore and low-lying areas of Lake Conjola. For each location, exceedance plots were generated that determined the frequency (number of occurrences) and duration of each time that the variable tidal water level was higher than ground level at that location. A worked example is provided in **Table 3-9**.

Of the 247 Council owned and/or managed assets listed within the Asset-Based Risk Assessment spreadsheet, a large proportion of the assets are located on the southern shoreline, which experiences a greater extent of tidal inundation due to its relatively low elevation, as does the villages of Conjola Park and Fishermans Paradise.

Depth, frequency and duration plots of tidal inundation at each of the 27 representative locations, resulting from the two sea level rise scenarios of +0.36m and +1.2m, were generated, and applied to all 247 assets within the Asset-Based Tidal Inundation risk assessment.

Using Location 4 within Lake Conjola Village as an example site (which is in proximity to the entrance to Holiday Haven Lake Conjola caravan park as shown in **Figure 3-7**), a methodology was developed to convert the detailed 6-week tidal inundation and duration results into a single number for both annualised and averaged results for each location. The full set of results for each of the 27 locations is provided in **Appendix D**.



Figure 3-7: Location 4 in Lake Conjola Village

In order to convert the number of occurrences (frequency) and range of durations of tidal inundation over the modelled 6-week period at each location into an approximate annual number of occurrences and average duration of tidal inundation, the following methodology was applied (noting this gives an indication only and was completed to aid in the risk assessment process):

- The duration of each and every occurrence of inundation (during the modelled 6-week period) was added together to provide the total inundation hours at that location over the 6-week period.
- To calculate the average duration of tidal inundation during the modelled 6-week period, the total inundation hours was divided by the total number of occurrences.

- To conservatively calculate the number of occurrences each year (noting that the 6-week period includes the winter High High Water Solstice Springs), the total number of occurrences over the 6-week period was multiplied by [52 weeks (calendar year) / 6 weeks (modelled period)].
- ***Note: The annual "number of occurrences" may be more than one event per day due to semi-diurnal (twice daily) tidal cycle***
- A worked example for **Location 4** is provided in **Table 3-9**.
  Outcome:
  For this example, the Asset-Based Risk Assessment spreadsheet will record that with 1.2.m SLR, assets within vicinity of Location 4 are projected to be impacted by Tidal Inundation 225 times per calendar year, for an average of 3.1 hours duration each occurrence.
- ***Note: Assets that extend over a large spatial extent and/or have a range of elevations (e.g. Lake Conjola Entrance Road) will have the "worst case" conservative inundation frequency and duration applied as the "Likelihood" of tidal inundation within the Asset-Based Risk Assessment.***

Table 3-9: Inundation and Duration - Annualised and Averaged Results Location 4 with 1.2m SLR

Inundation duration (hrs)	Number of Occurrences	Total inundation duration (duration length x occurrences)
1.0	2	2.0
1.5	5	7.5
2.0	3	6.0
2.5	3	7.5
3.0	4	12.0
3.5	2	7.0
4.0	1	4.0
4.5	1	4.5
5.0	1	5.0
6.0	2	12.0
6.5	1	6.5
7.0	1	7.0
	Total occurrences over 6 week modelled period	**Total inundation hours over 6 week period**
	26	**81**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences		
81 hours / 26 occurrences =	**3.1**	**Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply Total occurrences over 6 week modelled period by 52 weeks (calendar year) / 6 weeks (modelled period)		
26 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**225**	**Occurrences per calendar year NOTE: may be more than one event per day due to semi-diurnal (twice daily) tidal cycle**
Outcome: The Tidal Risk Assessment spreadsheet will record that Assets within vicinity of Location 4 have predicted tidal inundation 225 times per calendar year, for an average of 3.1 hours duration each occurrence.		
Note: Assets that extend over a large spatial extent and/or have a range of elevations (e.g. Lake Conjola Entrance Road) will have the "worst case" conservative inundation frequency and duration applied.		

3.3.4 Tidal Inundation Information for Risk Assessment Process

The landing page for the interactive Lake Conjola CMP - Tidal Inundation hazard mapping, with user options on the left, is shown in **Figure 3-8**.

The example below in **Figure 3-9** shows Tidal Inundation of Lake Conjola Holiday Haven caravan park with SLR of +1.2m. However, the plot provides the highly relevant information that the Holiday Haven reception building has been constructed at a sufficient height so that the floor level of the structure is shown as not being inundated, even though it is surrounded by water.

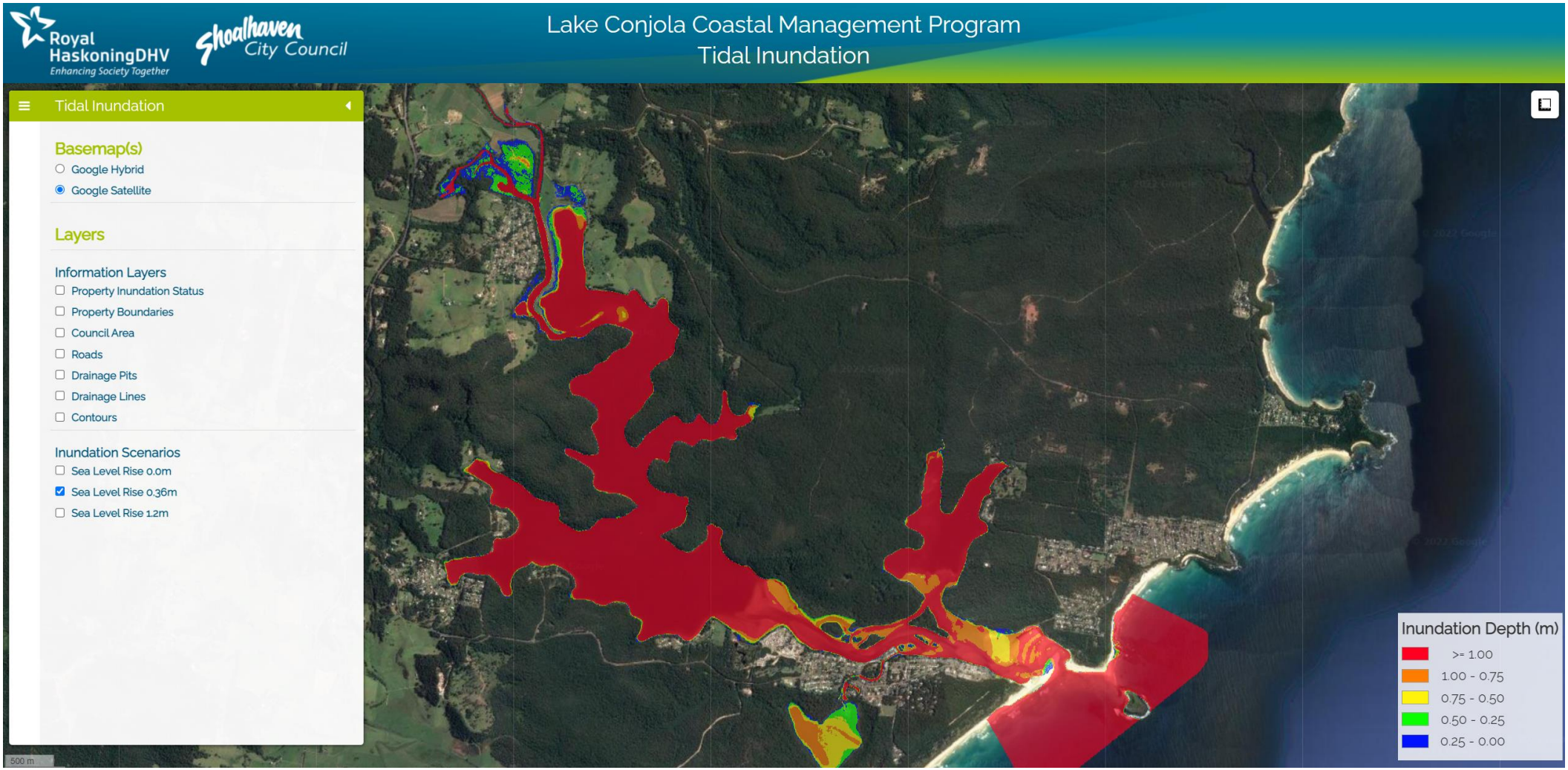

Figure 3-8: Landing page for Lake Conjola CMP - Tidal Inundation hazard mapping

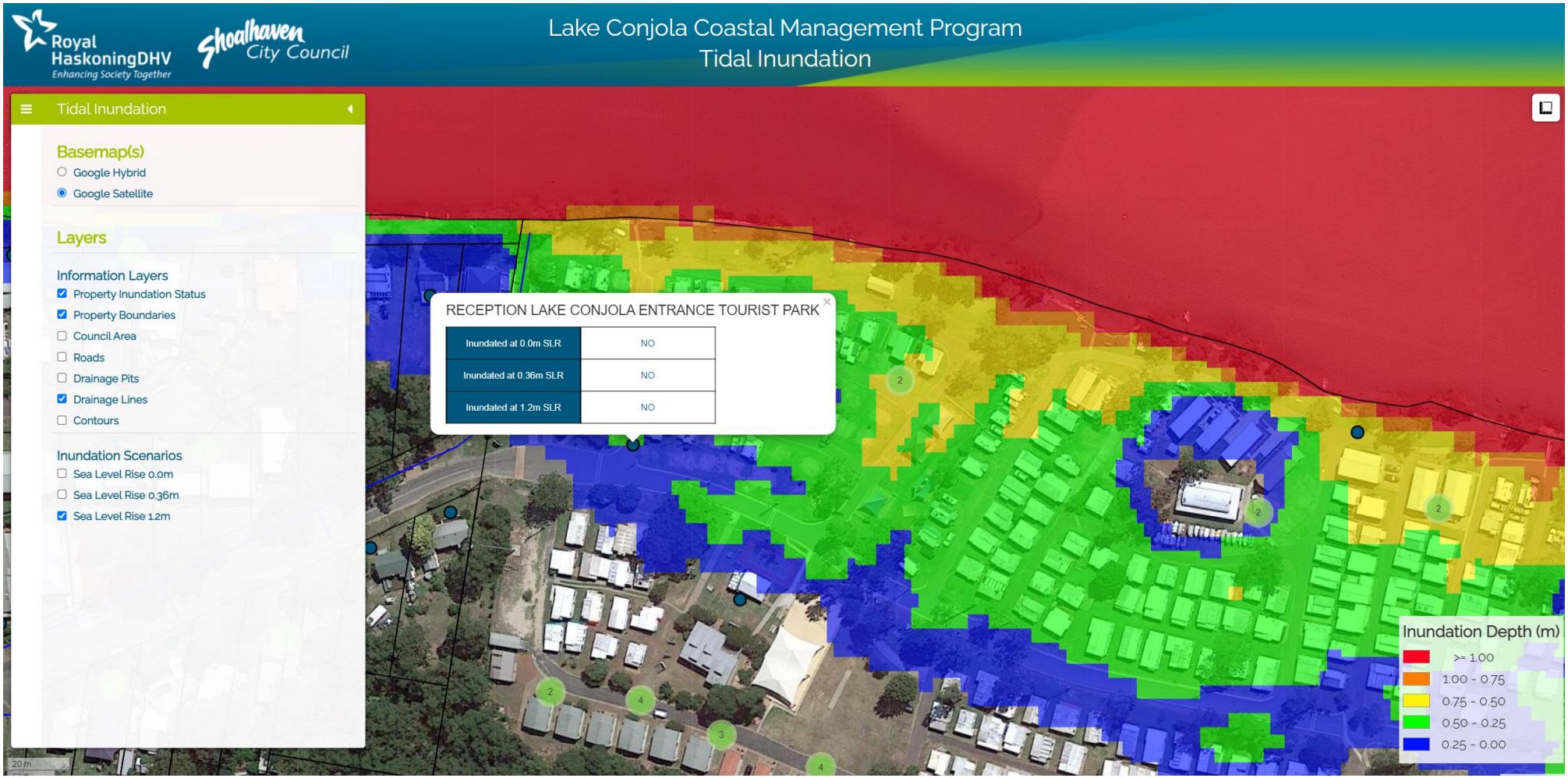

Figure 3-9: Tidal inundation of Lake Conjola Holiday Haven caravan park with SLR of +1.2m, with floor level of structure shown as not inundated

3.3.5 Tidal Inundation Outcomes

A summary of the main outcomes of the Tidal Inundation modelling is as follows:

- Tidal inundation is less “catastrophic” than coastal inundation in the short term, but becomes a significant issue over a 50-100 year planning period, that cannot be resolved by entrance management;
- Tidal Inundation is not a ‘current’ issue during the initial 10 year period for implementation of management actions before the Lake Conjola CMP is reviewed and updated. However, it is a pervasive, incrementally worsening coastal hazard, and requires long term consideration over a 50-100 year planning period (e.g. planning and development controls);
- Cross-references floor levels of buildings (where known) against inundation depth, can identify whether water will enter the structure itself, even if the ground outside is inundated.
- ***Note: As a significant number of residential, community and commercial properties within Lake Conjola village are situated at a low elevation, tidal inundation is projected to progress from occasional low level “nuisance” inundation during highest tides, to potentially become a daily, or twice daily, long duration event.***

3.4 Catchment Flooding / Inundation

Catchment Flooding / Inundation occurs when the amount of water flowing from the catchment due to excessive rainfall exceeds the capacity of the creeks and main waterbody of Lake Conjola and overtops the usual foreshore boundaries and banks. The ability of floodwaters to flow out of Lake Conjola is partly a function of whether the entrance is open or closed, however other factors also have an influence (e.g. tides, ocean levels, storm events).

Low-level Persistent Inundation is used to describe flooding of the lowest parts of the foreshore areas from gradual rises in Lake level during periods of entrance closure or under potentially higher tidal conditions with sea level rise and an open entrance.

A focus on entrance management works to reduce flooding only has some value in association with managing low-level persistent flooding and more frequent flood events. However, for major catchment flood events, the starting condition of the entrance, being in a heavily shoaled state or an open channel, has minimal impact on the peak flood water levels reached in Lake Conjola (BMT WBM, 2013).

A large number of the approximately 499 properties around the foreshore of the Lake are located on the floodplain, and are affected by projected inundation levels, as shown in **Table 3-10**.

Table 3-10: Number of properties affected by design flood events (BMT WBM, 2013)

Flood event	Approximate number of properties affected	Approximate number of properties flooded above floor level
10% Annual Exceedance Probability	291	70
1% Annual Exceedance Probability	352	183
Probable Maximum Flood (PMF)	396	335

The management of catchment flooding is addressed through the floodplain management program in NSW, and is documented in the Lake Conjola Floodplain Risk Management Study and Plan (BMT WBM, 2013). In addition, the Shoalhaven Local Flood Plan outlines preparedness and management operations

to be followed by the SES for all flooding events in the Shoalhaven local government area, including Lake Conjola.

3.5 Coastal Inundation

3.5.1 General

Coastal inundation or ocean storm flooding occurs when a combination of meteorological processes raise ocean water levels above normal tidal elevations and inundates low-lying areas, and/or overtops dunes, structures and barriers. The elevated ocean water levels are due to storm surge (increase in water level due to low barometric pressure plus wind setup), wave setup, wave run-up and over-wash flows.

Storm surge and powerful waves can also penetrate Lake Conjola (particularly if the entrance is open), giving rise to strong currents, as well as elevating the water levels inside the Lake. In the longer-term, the extent of coastal inundation will increase due to sea level rise.

NSW coastal hazard assessment guidelines (OEH, 2010) recommend a 1 in 100 (chance of occurrence each year) ocean storm event for assessing potential risks from coastal inundation.

A visual representation of the combined contribution of various processes to the total water level that may result in coastal inundation is shown in **Figure 3-10**.

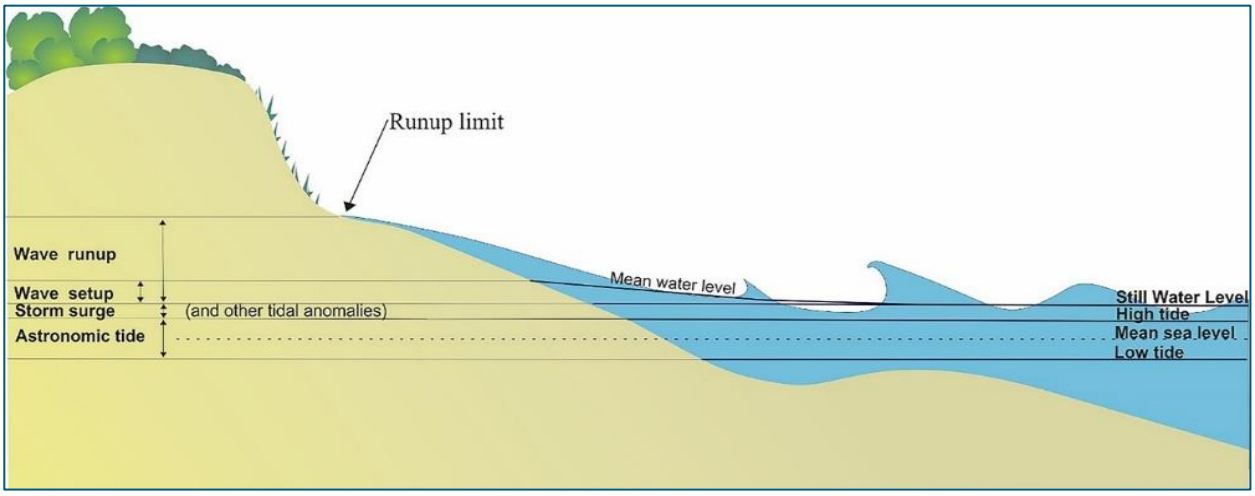

Figure 3-10: Processes contributing to total water level changes at the coast

3.5.2 Consideration of Sea Level Rise

In the same manner as completed for the assessment of Tidal Inundation, to determine the spatial extents within Lake Conjola, and to quantify the potential threats posed by Coastal Inundation, a hydraulic model and geomorphological model of Lake Conjola was developed. As previously noted in **Section 3.3.2**, the full report, entitled “Stage 2 - Tidal and Coastal Inundation Modelling Report”, describing the methodology and findings is provided in **Appendix A**.

The threat posed by ocean flooding to Lake Conjola is as significant as major catchment flooding. Under ocean flooding scenarios an open entrance allows for a greater penetration of ocean water through the inlet into the Lake. As such a wide open entrance condition may in fact exacerbate the ocean flooding risk for some event conditions (BMT WBM, 2013).

Coastal flooding in lowland areas such as Lake Conjola will be of increasing concern as a consequence of sea level rise. This will increase the frequency, duration and height of flooding and consequent emergency evacuations as well as associated property and infrastructure damage (BMT WBM, 2013).

3.5.3 Hazard Mapping Examples

For Coastal Inundation, the hydraulic model was calibrated to “typical” tide conditions (i.e. a period of low wave conditions and minimal rainfall), assumed a typical, non-scoured entrance condition, and applied an ocean boundary condition corresponding to a 1% AEP ocean storm event. Adoption of a non-scoured entrance condition increases the magnitude of the open coast wave setup generated at the entrance and hence provides a conservative (higher) inundation level due to a coastal storm. For sea level rise examples, the model assumed that the bed of the entrance rose at the same rate as SLR.

High level comments regarding the nature of Coastal Inundation are provided below:

- The ‘design’ storm event is a 1-in-100 year (1 % AEP) so a relatively “rare” event;
- ‘Storm surge’ is made up of two components; a rise in mean sea level due to low air pressure (inverted barometric pressure effect), and a rise in water level at the shoreline due to strong onshore winds (wind setup), as shown in **Figure 3-10**;
- Can happen at any time (1% chance each year) though unpredictable;
- May become more frequent due to climate change; and,
- Cross-references to floor levels of buildings (where known) against inundation levels, can identify whether water will enter the structure itself, even if the surrounding ground is inundated.

These issues are discussed further in **Section 9**.

An example of Coastal Inundation extent and depth due to 1.2m SLR is shown in **Figure 3-11**, with the full set of Coastal Inundation maps provided in **Appendix E**.

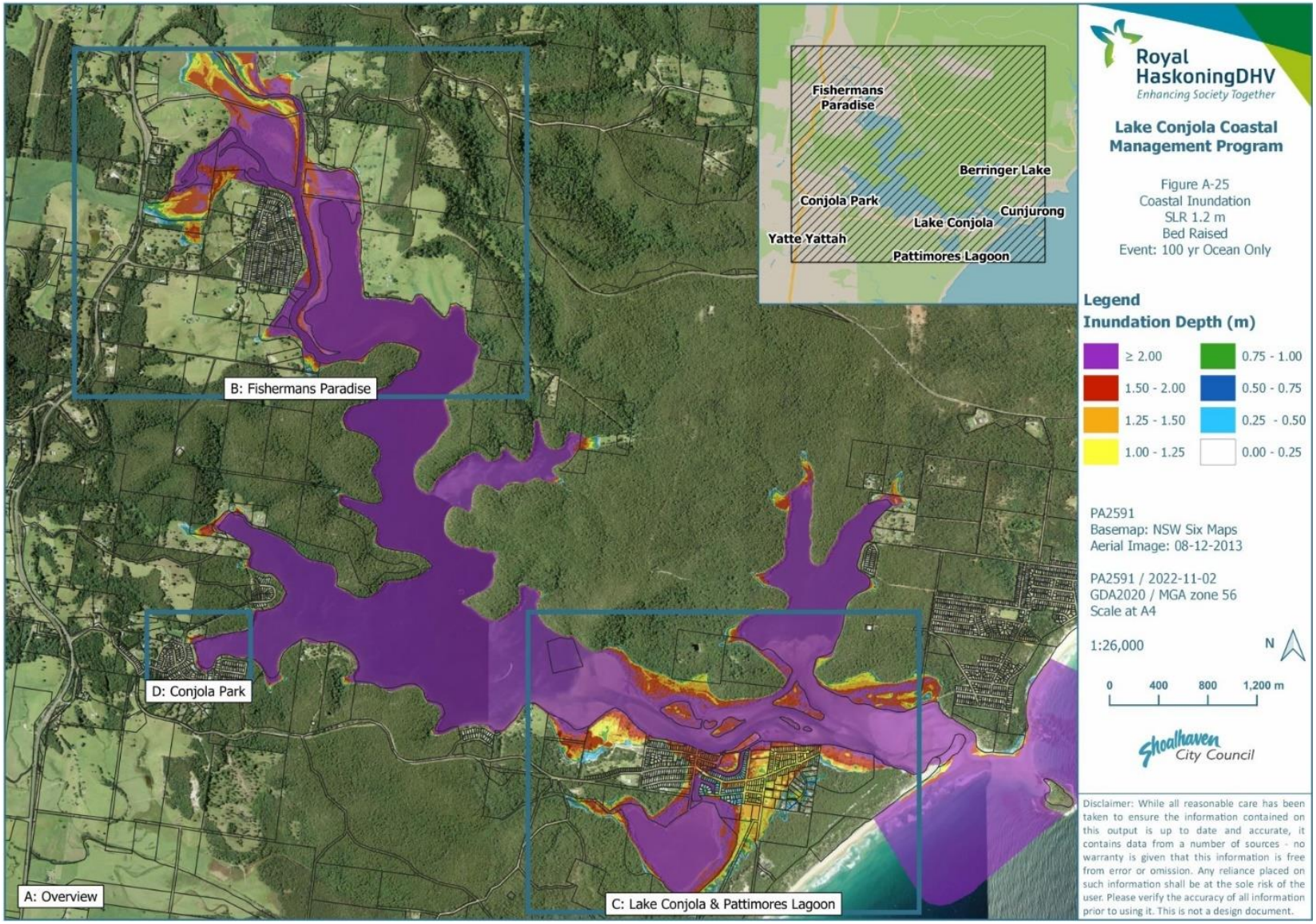

Figure 3-11: Coastal Inundation extent and depth due to 1.2m SLR

The modelling of Coastal Inundation results in significantly increased depth and extent of floodwater compared to Tidal Inundation. **Figure 3-12** provides an image of Coastal Inundation of Lake Conjola Village with SLR of 0.00m, i.e. for the present day 1-in-100-year, or 1% chance of coastal storm event occurring, while **Figure 3-13** provides an image of Coastal Inundation of Lake Conjola Village with SLR of 0.36m, corresponding to a planning period of 20-50 years as per the risk assessment methodology and associated planning periods described in **Section 3.2**.

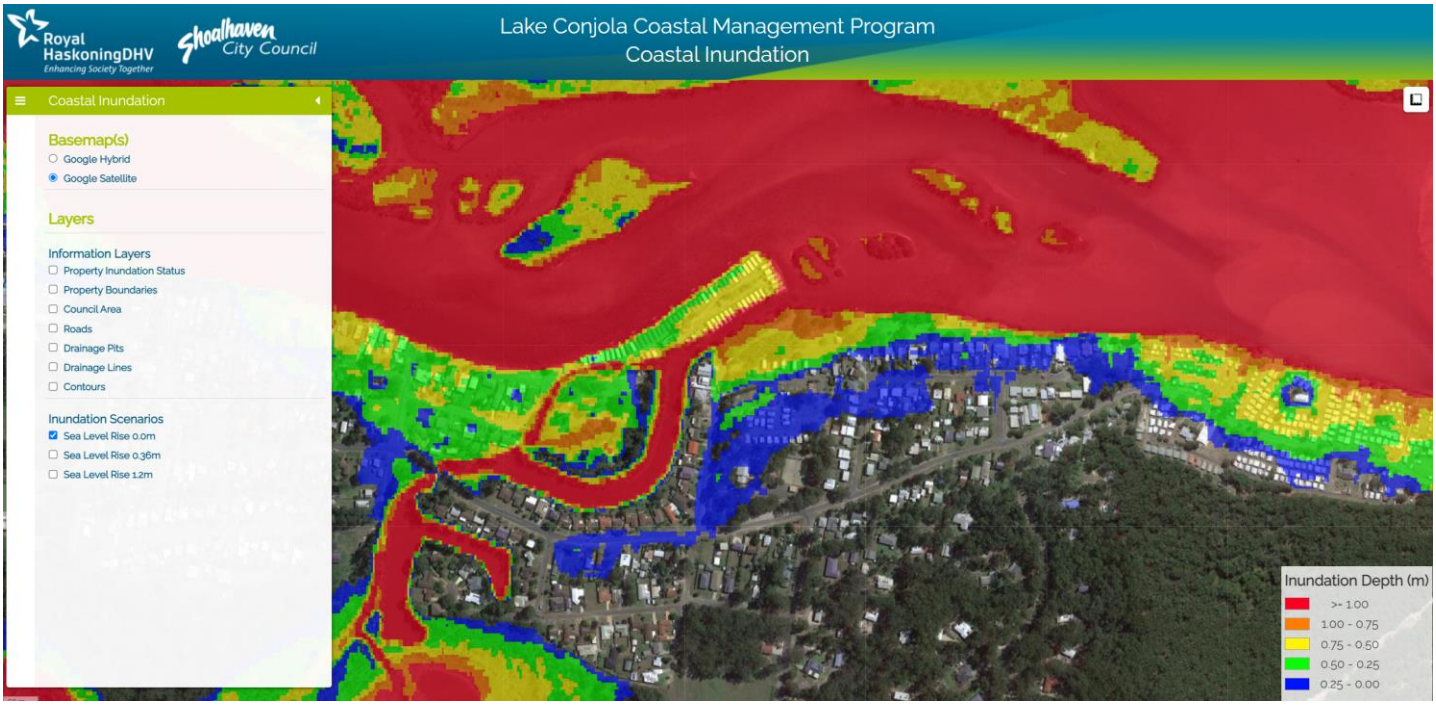

Figure 3-12: Coastal Inundation of Lake Conjola Village with SLR of 0.00m

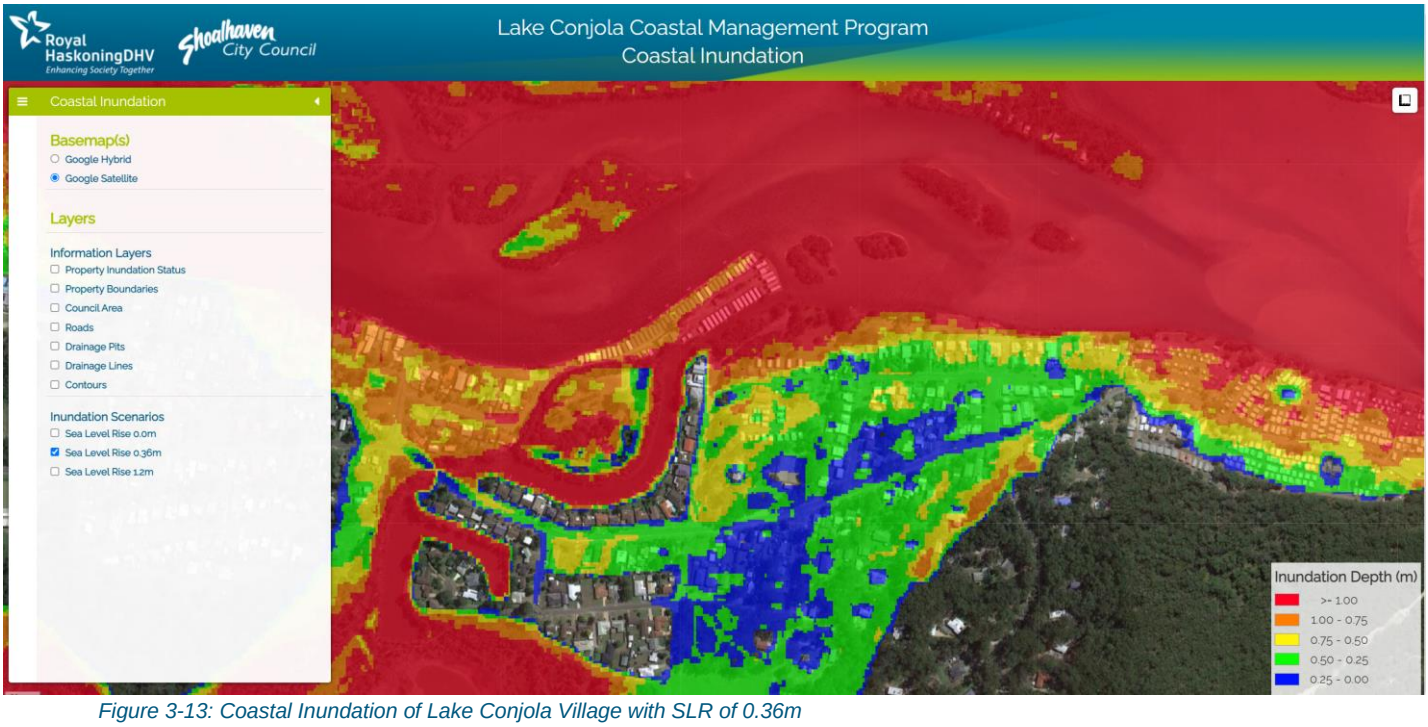

Figure 3-13: Coastal Inundation of Lake Conjola Village with SLR of 0.36m

3.6 Coincident Catchment Flooding and Coastal Inundation

Note: *Acknowledgement is made that the majority of the information on* ***Coincident coastal inundation and catchment flooding*** *provided below has been sourced from the Lake Conjola Floodplain Risk Management Study and Plan (BMT WBM, 2013).*

3.6.1 General

Coincident catchment flooding and coastal inundation can occur due to the same storm cell and therefore design flood levels in a lower coastal waterway will be influenced by a combination of these sources. If oceanic inundation or catchment flooding were examined on their own the flood levels derived are unlikely to be fit for purpose for making informed floodplain risk management decisions in the lower portions of coastal waterways (OEH, 2015).

NSW coastal hazard assessment guidelines (OEH, 2015) recommend a combination of 1 in 100 (chance of occurrence each year) coastal inundation event with 1 in 20 (chance of occurrence each year) catchment flooding event, and vice versa, for assessing potential risks from coincident catchment flooding and coastal inundation.

3.6.2 Consideration of Sea Level Rise

A comparison of peak flood levels under existing conditions and climate change scenarios for both catchment and ocean flooding is provided in **Table 3-11**. The tabulated levels reference levels in Lake Conjola relative to AHD. The direct impact of the sea level rise scenarios on peak flood level conditions is clearly evident. In addition, it is noted that the flood risk from either catchment flooding or ocean derived flooding is relatively similar over longer planning horizons, such that due consideration of both flooding mechanisms is required in assessment of appropriate floodplain risk management options.

Table 3-11: Comparison of Peak Flood Conditions with Climate Change Scenarios (BMT WBM, 2013)

Event Conditions	Planning Horizon		
	Existing	2050 (+0.4m SLR)	2100 (+0.9m SLR)
5% AEP Catchment Event	2.8	3.0	3.2
5% AEP Ocean Event	1.9	2.4	2.9
1% AEP Catchment Event	3.2	3.4	3.5
1% AEP Ocean Event	2.2	2.7	3.3

3.6.3 Hazard Mapping Examples

The design 1% AEP flood inundation extent and depth of flooding in Lake Conjola for the year 2100 design condition (i.e. with 0.9m sea level rise) is shown in **Figure 3-14**.

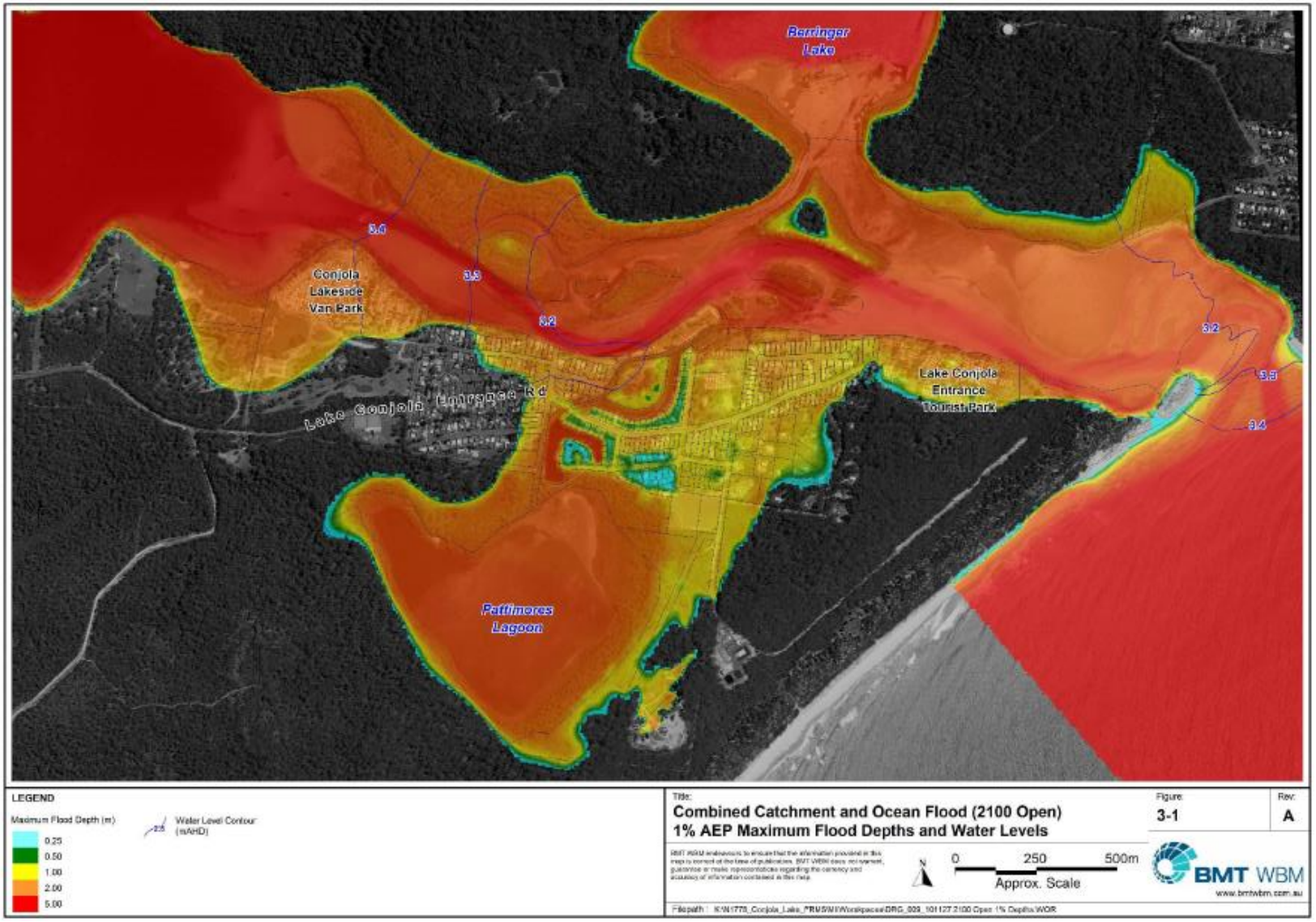

Figure 3-14: Coincident Inundation of Lake Conjola village in Year 2100 with SLR of 0.9m (BMT WBM, 2013)

The peak flood levels and depths of inundation are increased significantly under the climate change scenario. A flood event of this magnitude would result in an extensive inundation of existing property, particularly in Lake Conjola Village. Typical flood depths in the order of 1.5m to 2.0m would result in above-floor flooding to a significant depth for a large number of properties, and extensive property damage. The depth of flooding also heightens the risk to life and existing constraints on evacuating certain parts of the floodplain. Several existing properties in Conjola Park (3) and Fishermans Paradise (3) would also be at threat of above-floor flooding, albeit with minor flood depth (BMT WBM, 2013).

3.7 Inundation Results and Conclusions

At some time in the future with sea level rise, parts of the existing areas of Lake Conjola Village, Conjola Park and Fishermans Paradise will be subject to permanent inundation from normal Lake levels, resulting from an open entrance condition and tidal inflow. Even before permanent inundation, however, increased frequency of flooding and high groundwater levels will become an issue.

It is expected that under sea level rise of approximately 0.36m and / or 0.4m (reflecting both the RHDHV (2021) and BMT WBM (2013) hazard assessments for 50 year planning periods), roads, structures and even ground vegetation would start to become adversely impacted by high groundwater levels, while a sea level rise of 0.9m and / or 1.2m (reflecting both the BMT WBM (2013) and RHDHV (2021) hazard assessments for 100 year planning periods) would result in a significant depth of inundation within many streets and yards on a frequent basis. It is noted that under sea level rise of 0.6-0.9m (50-100 year planning period), there would also be significant inundation of assets.

Under existing conditions, low-level persistent flooding presents problems to the community, noting the current entrance management trigger level of between 1.0m and 1.2m AHD.

It is important to acknowledge that it is impractical to immediately eliminate all flood risks from the existing development adjacent to Lake Conjola. Instead, the aim of future floodplain risk management is to ensure that existing and future development is exposed to an “acceptable" level of risk, consistent with other risks that people live with on a day-to-day basis (BMT WBM, 2013).

The continued occupation of currently affected land in Lake Conjola would require raising of existing ground levels through extensive land filling to combat the risk of rising Lake levels and associated inundation and groundwater problems. If adaptation of existing developed areas cannot be achieved in an economically, socially and environmentally acceptable manner, then planned retreat of current occupied flood prone land may be an appropriate land use strategy (BMT WBM, 2013).

From a community perspective, it is important to understand flooding in Lake Conjola, and be prepared to act appropriately should flooding occur. In essence, the community needs to become “flood ready". This can include preparing a personal emergency plan for a house or business, which should include options for evacuation, emergency contact numbers, and arrangements for post-flood recovery.

Effective management of flooding in Lake Conjola will require significant investment in long term outcomes. It is expected that effective flood management will not be achieved unless there is strong political support for such actions, and this will only occur if the community and elected bodies are active and engaged in the issues.

The nature of flooding in Lake Conjola is such that severe flooding problems can occur with very little warning. In most cases, emergency services such as the SES would not have the time or access from remote stations to help people in need during a major flood. Therefore, the Lake Conjola community

needs to know what to do, and more importantly, what not to do, when faced with a flood situation (BMT WBM, 2013).

The FRMS&P also concluded that while a closed entrance may increase the likelihood of low-level persistent flooding and decreases the likelihood of ocean flooding, it has little impact on major catchment flood events. In these events, flooding is likely to occur whether the entrance is open or closed. A focus on entrance management works to reduce flooding only has some value in association with managing low-level persistent flooding and more frequent flooding events.

Under ocean flooding scenarios an open entrance allows for a greater penetration of ocean water through the inlet into the Lake. As such a wide-open entrance condition may in fact exacerbate the ocean flooding risk for some event conditions (BMT WBM, 2013).

4 Water Quality

4.1 General Description of Groundwater and Surface Water

Groundwater refers to water held underground in the soil or in pores and crevices in rock. The upper surface of the saturated zone is called the water table. Surface water is any body of water above ground, including wetlands, stream systems, rivers and lakes. There may be significant differences in water quality between groundwater and surface water.

It is common for surface water to be contaminated with chemical pollutants that accumulate through surface runoff processes. Surface water can contain contaminants such as nitrogen and phosphorous (from animal manure, chemical fertilisers, wastewater treatment facilities, urban runoff, soil erosion), as well as bacteria such as enterococci (e.g. from animal and human faeces contained within runoff from bushland, farmland, and/or leaky septic tanks). Surface water quality may vary, and at times be unsuitable for human recreation or for the flora and fauna within a waterbody like Lake Conjola.

While groundwater is typically cleaner than surface water, it can still contain various contaminants. These contaminants are picked up from seepage and soil percolation from point and non-point sources. Groundwater pollution mainly occurs when contaminants are leached from, discharged to, or deposited on the land surface that is situated above the groundwater, which at Lake Conjola includes the dunal exfiltration of the sewage effluent from the Conjola Regional Wastewater Treatment Plant.

The sediment layers that are found below the water table can filter the water naturally to remove at least some of the contaminants. While the presence of domestic and industrial pollution sources in the general vicinity of the groundwater will dictate how contaminated the water is, this water can still contain some contaminants even if there are no nearby pollution sources.

A generalised depiction of potential sources of contamination of surface water and groundwater is shown in **Figure 4-1**.



Figure 4-1: Potential sources of surface water and groundwater contamination (source: filterwater.com)

4.2 Flushing / Interchange of Water within Lake Conjola

Of relevance to water quality concerns relating to both groundwater and surface water, is the consideration of residence time of water within Lake Conjola. To assess this factor, numerical modelling of tidal flushing was completed through placement of a 'conservative tracer' equally throughout the waterbody. This modelling assessment was undertaken with two alternative entrance conditions, a typical "choked" entrance condition, and a post-storm event "scoured" entrance condition. The model was run for a two week period for each of the entrance conditions in order to assess the change/turnover in water due to tidal action, as well as determine the spatially dominant influences on water quality.

4.2.1 Flushing / Interchange of Water after 2 Weeks with a Typical "Choked" Entrance

The resulting interchange of water after 2 weeks with a typical "choked" entrance condition are shown in **Figure 4-2**. From 100% tracer concentration, the only section of the waterway that reduced to less than 25% concentration was in the entrance of Lake Conjola, while the channel extending upstream towards Lake Conjola Village reduced to around 50% before losing efficacy further upstream. The remainder of Lake Conjola from 'The Steps' west and northwest, as well as Lake Berringer, lost a maximum of 25% of the tracer with most of the waterbody staying at around 75-80% of the initial tracer concentration. The upper reaches of Conjola Park, Fishermans Paradise, Pattimores Lagoon, and upper Lake Berringer remained at 100% of the initial tracer concentration.

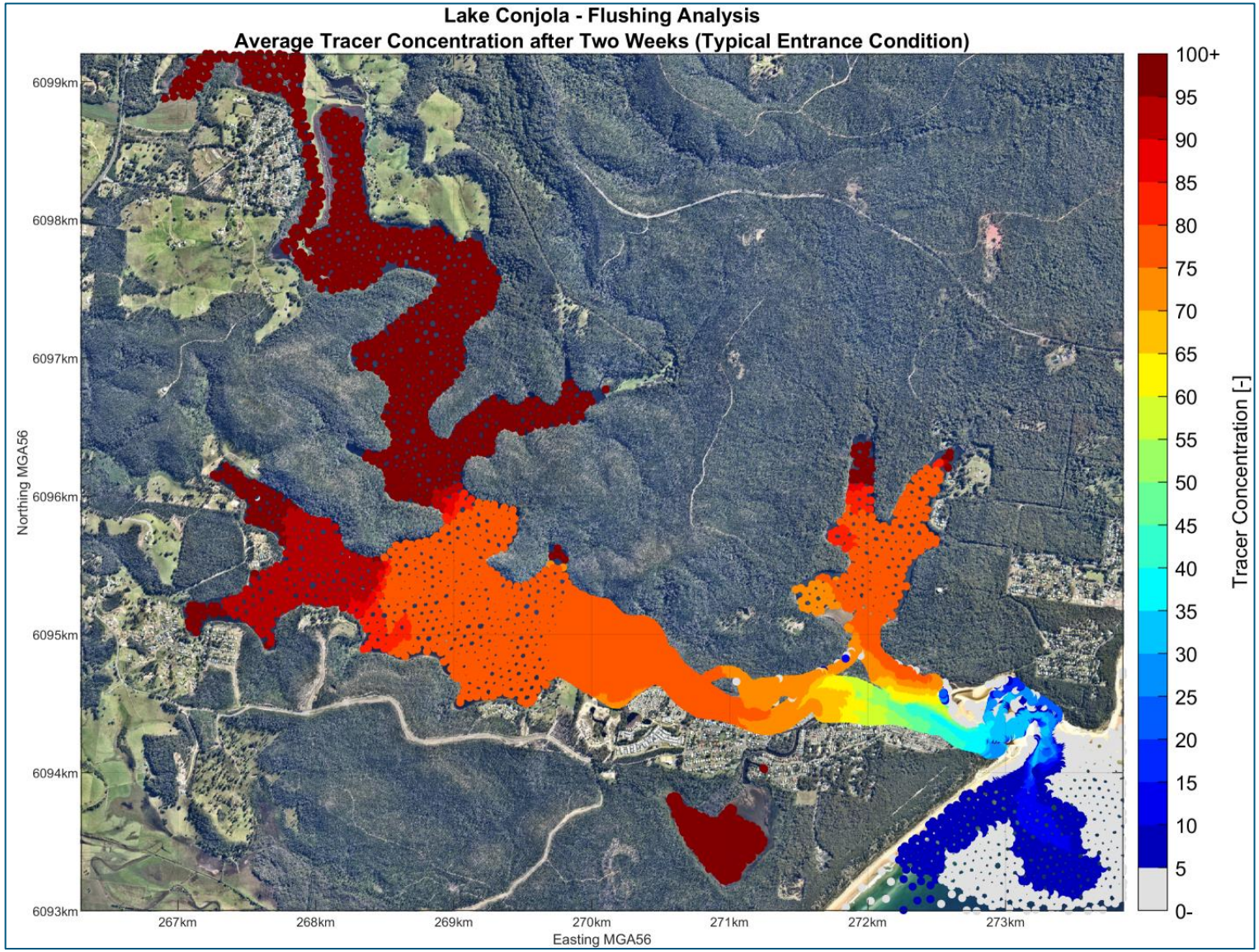

Figure 4-2: Lake Conjola - flushing analysis - average tracer concentration after two weeks – typical entrance condition

4.2.2 Flushing / Interchange of Water after 2 weeks with a Post-storm Event "Scoured" Entrance

To assess the maximum possible water exchange, the tracer model was run to simulate an entrance condition that may exist following a significant flooding event that has scoured the entrance channel. As many residents and stakeholders are aware, a fully scoured entrance to Lake Conjola is not long-lived, and rapidly starts to infill again. The resulting interchange of water after 2 weeks with a post-flood "scoured" entrance condition are shown in **Figure 4-3**.

Using the same initial 100% tracer concentration as in the typical "choked" entrance condition modelling, a fully scoured entrance was shown to generally provide more effective water exchange over two weeks. However, only the entrance and main channel reduced to approximately 20-30% of the initial tracer concentration after 2 weeks, while the main basin beyond 'The Steps' and Lake Berringer lost some 40-60% of the initial tracer concentration. The upper reaches of Conjola Park and particularly Fishermans Paradise remained at around 90-100% of the initial tracer concentration. Tidal flushing, even with a fully scoured entrance, is limited in these areas.

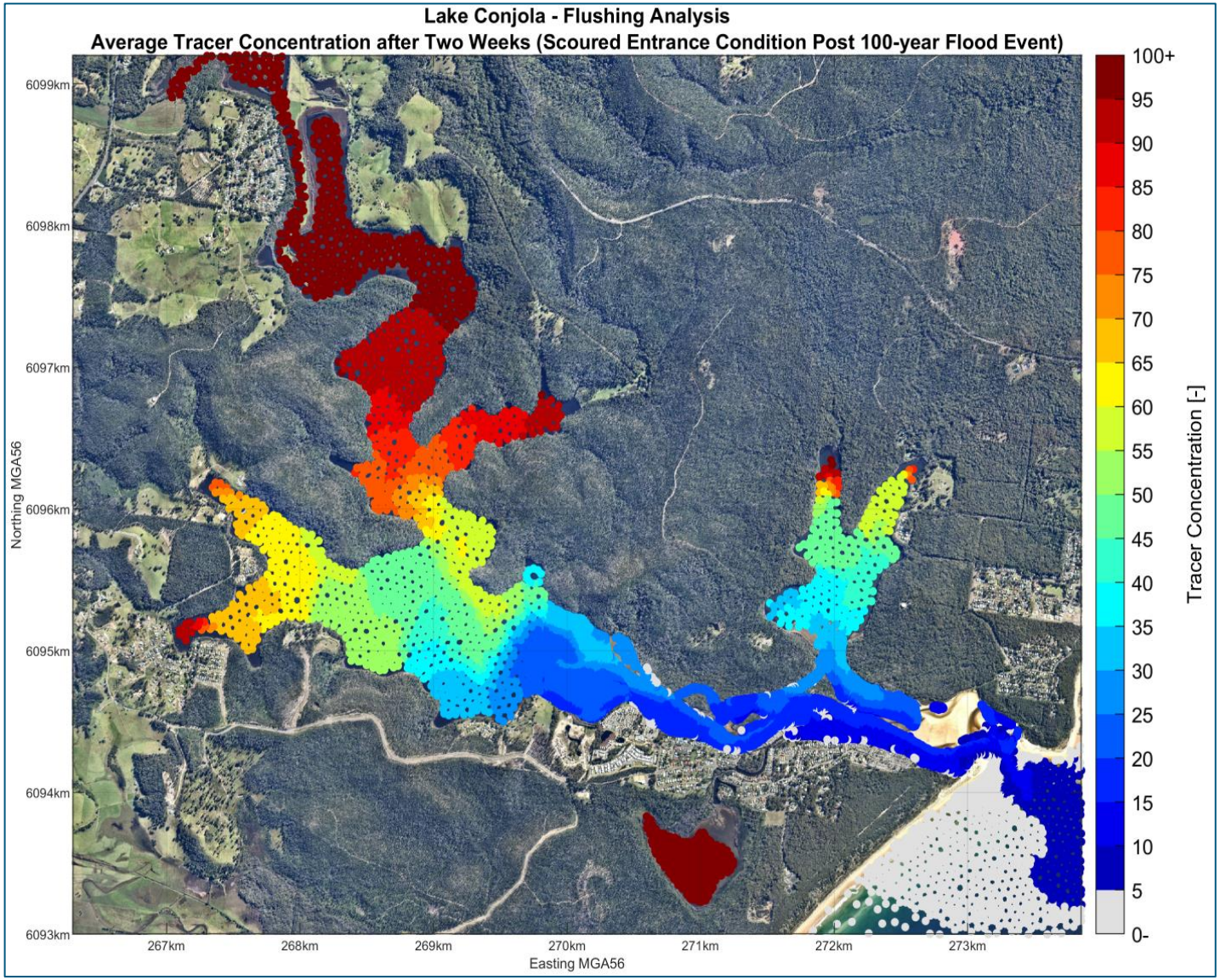

Figure 4-3: Lake Conjola - flushing analysis - average tracer concentration after two weeks – scoured entrance condition

4.2.3 Commentary on Flushing / Interchange of Water within Lake Conjola

The above modelling demonstrates that water quality in the upper reaches of Lake Conjola will primarily be the product of inflows from the catchment, as tidal exchange is very limited in these locations even when the entrance is open and well scoured.

This is an important factor to bear in mind when considering management actions to maintain a healthy waterway, as land use and catchment management practices are likely to have a significant influence on ecological and recreational water quality within Lake Conjola, irrespective of Lake entrance management options and actions.

4.3 Groundwater - Water Quality

Two sites within the Lake Conjola Village area have been identified as potential sources of land and water contamination, being the Lake Conjola Waste Transfer Station and the Conjola Regional Wastewater Treatment Plant.

4.3.1 Lake Conjola Waste Transfer Station

The information provided below is a synopsis of the report prepared by Environment & Natural Resource Solutions Pty Ltd (ENRS) for Council, entitled "*Soil & Groundwater Investigation Lake Conjola Waste Transfer Station*" (dated 30th October 2019, project reference number ENRS1154).

ENRS were commissioned as independent environmental consultants by Council to conduct a soil and groundwater investigation at the Lake Conjola Waste Transfer Station (the Site) to consider the potential for land and water contamination from previous landfill activities at the Site.

The Site is located immediately west of Lake Conjola Village, on the southern side of Lake Conjola Entrance Road near the intersection with Narrawallee Creek Road, as shown in **Figure 4-4**. It is located upstream of the adjoining Pattimores Lagoon, which is within the Narrawallee Creek Nature Reserve.

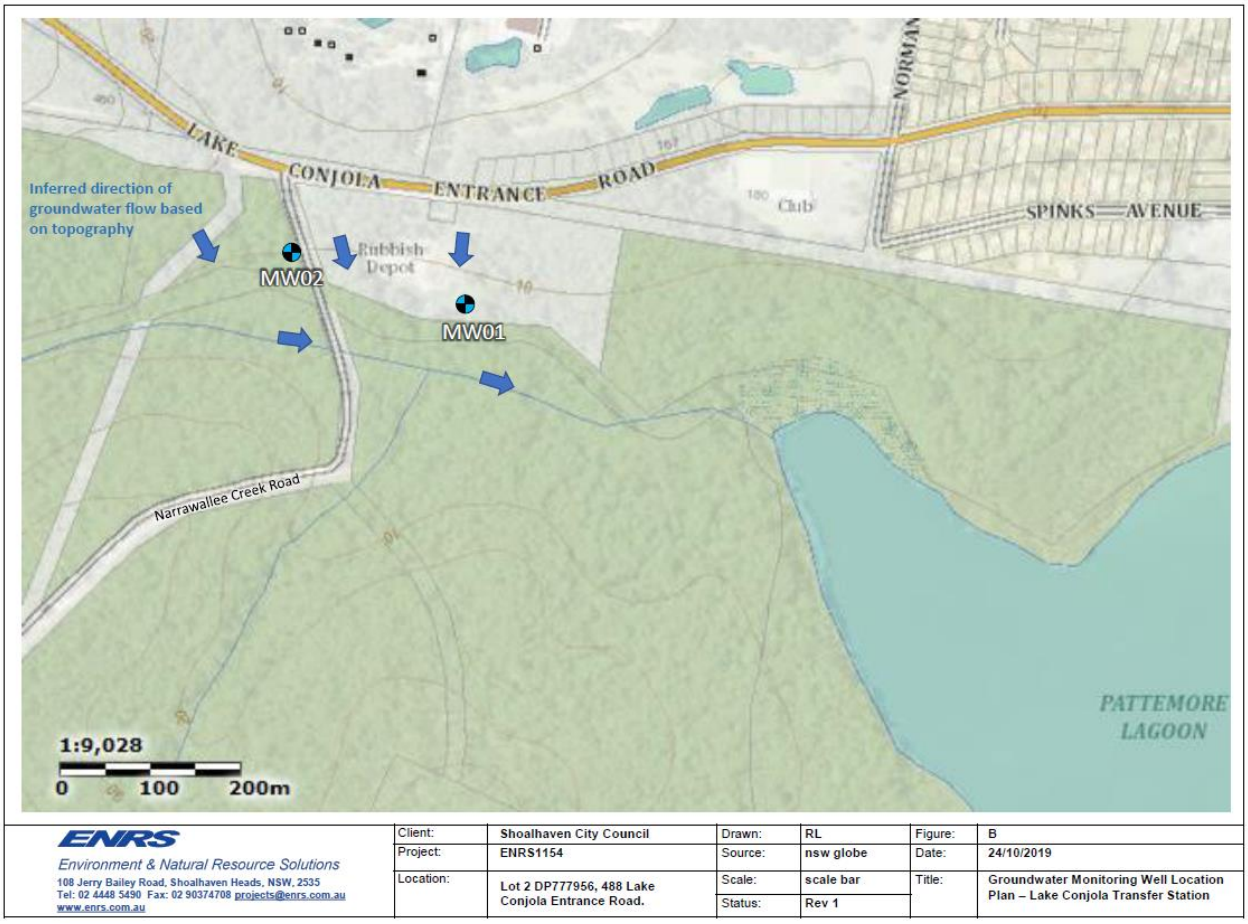

Figure 4-4: Lake Conjola Transfer Station Site Location – note upstream of adjoining Pattimores Lagoon (ENRS, 2019)

4.3.1.1 Sample Methodology (Soil, Surface Water and Groundwater)

ENRS carried out a site inspection and soil sampling on 16 April 2019, with soil samples collected from three (3) locations; upgradient, adjacent and downgradient of the Site as shown in **Figure 4-5** (noted as SS01, SS02 and SS03), reportedly in general accordance with appropriate guidelines.

The Site was inspected after significant rainfall events in April, June and October 2019, however on all occasions no surface water or ponded water was observed to facilitate sampling. As no surface water was observed at the Site the potential for runoff and surface water contamination from the Site is considered low.

ENRS carried out groundwater sampling on 16 October 2019, with samples obtained from two (2) monitoring wells on Site as shown in **Figure 4-5**. MW01 provided an indicator of conditions downgradient of the Site, while MW02 (located on the edge of bushland upgradient of the Site) provided an assessment of naturally occurring background levels (from ENRS, 2019).

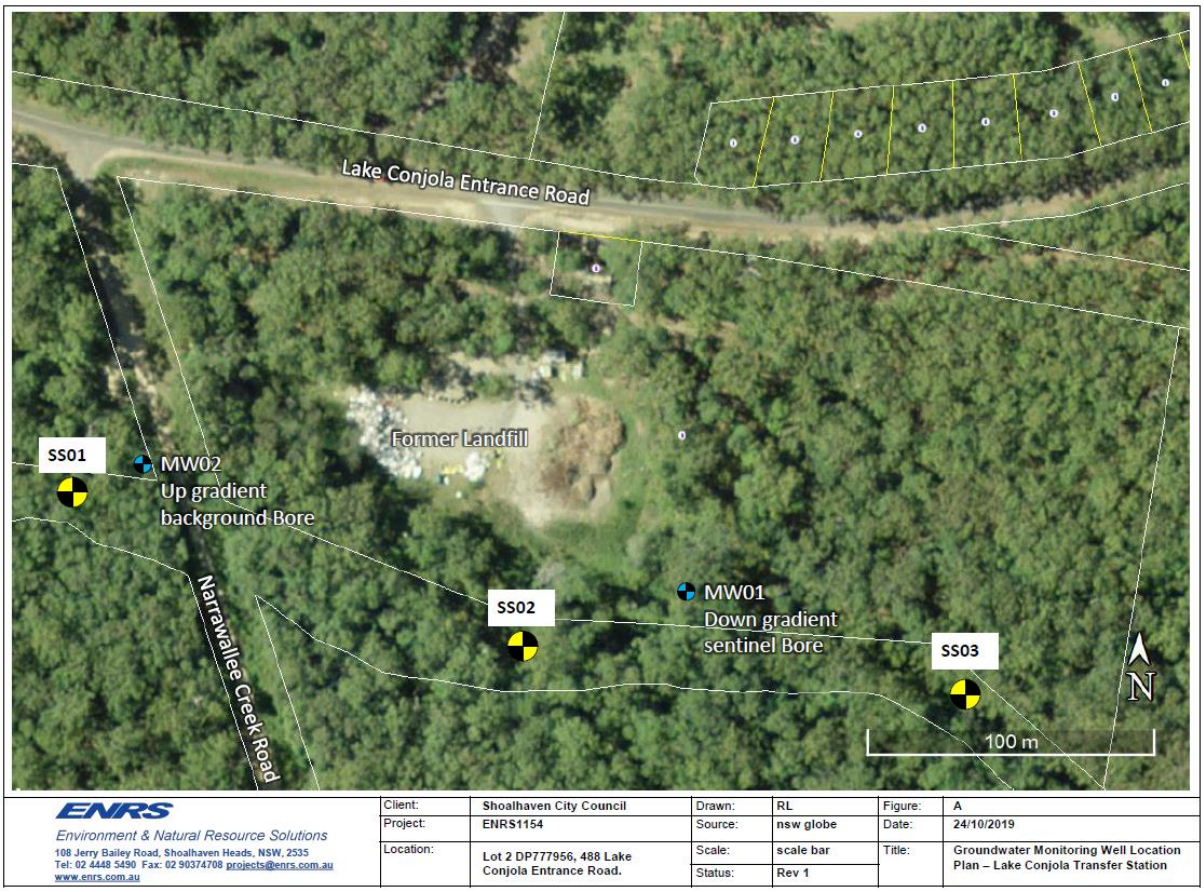

Figure 4-5: Lake Conjola Transfer Station Site - Groundwater Monitoring Well Location Plan (ENRS, 2019)

4.3.1.2 Results & Conclusions

The sample results reported in the NATA accredited Certificate of Analysis (COA) are summarised as:

- Results for soil were below the adopted Site Assessment Criteria for residential land use or the Laboratory Limit of Reporting (LOR), for all tested analytes including; heavy metals, PCBs, OC & OP Pesticides; Monocyclic Aromatic Hydrocarbons; Oxygenated compounds; Halogenated Aliphatic Compounds; Trihalomethanes; Phenolic compounds; Polynuclear Aromatic Hydrocarbons (PAHs); Petroleum Hydrocarbons; and PFAS;
- The results did not report any elevated levels of contaminants in soil to trigger any further investigation;
- Results for groundwater did not show any significant exceedances of the Australian Drinking Water Guidelines (2018) Trigger Values for Health for; heavy metals; Petroleum Hydrocarbons; BTEXN; PAHs; PFAS; Ammonia; Fluoride; Sulphate; Nitrate; Nitrite; and Phosphorus, which is satisfactory;
- The groundwater results indicate the area is characterised by naturally slightly acidic groundwater with elevated salinity and levels of some heavy metals associated with mineral dissolution from the host clay and shale. For example, concentrations of lead were elevated in MW02 in the area upgradient of the Site; and,
- Importantly, the concentrations of heavy metals and Contaminants of Potential Concern in MW01 downgradient of the Site were below the Site Assessment Criteria or within the range of

background levels, which indicates that the groundwater conditions at the Site are satisfactory and unlikely to result in offsite impacts (from ENRS, 2019).

4.3.2 Conjola Regional Sewerage Scheme (CRSS)

The Conjola Regional Sewerage Scheme (CRSS) was commissioned in 2008, with two new Wastewater Treatment Plants at Lake Conjola and Bendalong, connected by an 1800m pipe underbore of Lake Conjola, as shown in **Figure 4-6**.

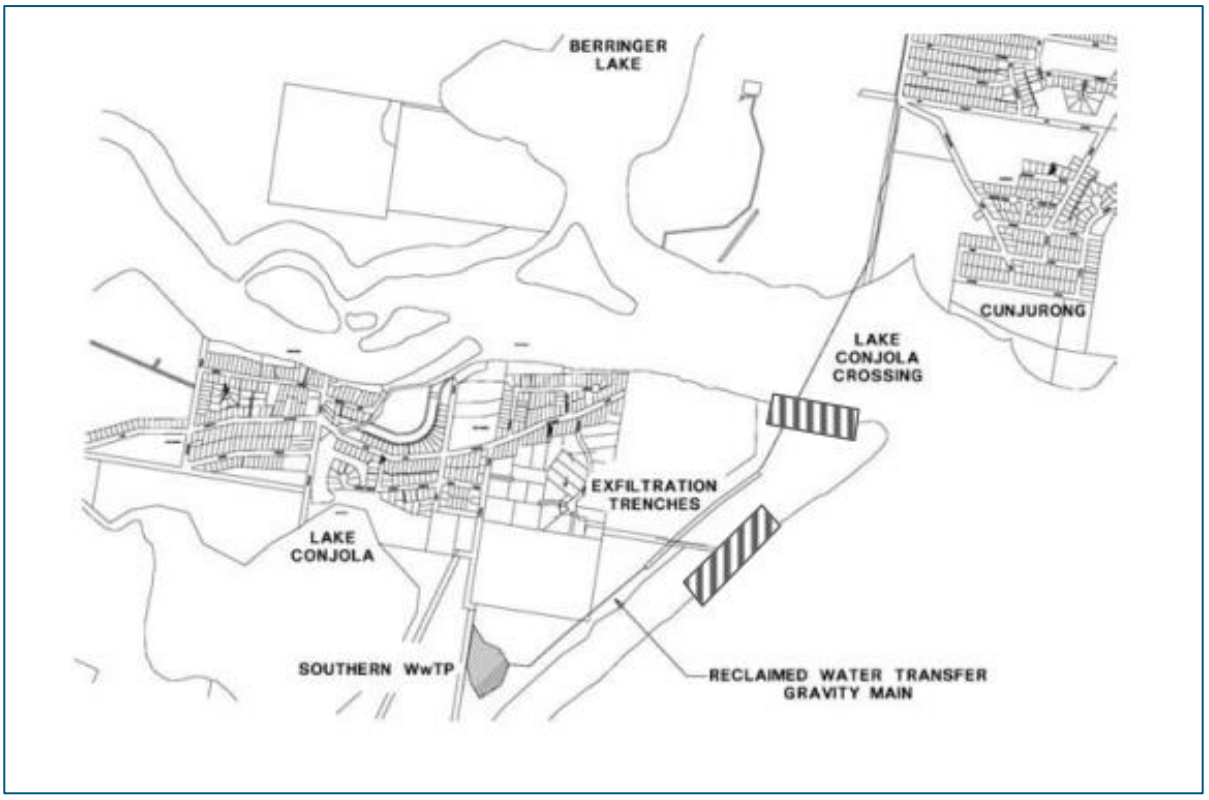

Figure 4-6: Conjola Regional Sewerage Scheme footprint

Prior to construction, CRSS engaged Manly Hydraulics Laboratory (MHL) to design a monitoring program for the Conjola Regional Sewerage Scheme in accordance with scheme approval conditions, published in March 2006 (as draft) as Report No. MHL1473 "*CRSS - Development of Monitoring Program*". This report included a summary of the preferred scheme which comprised northern and southern wastewater treatment plants (WWTP) providing a tertiary level of treatment and reclaimed water transfer pipelines from both WWTP (including a directionally drilled pipeline underneath the bed of Lake Conjola from the northern WWTP) to a dune exfiltration system. The dune exfiltration system is located in the dunes behind Conjola Beach and covers an area approximately 500 m long by 15 m wide. Reclaimed water is delivered into slotted pipes in below-ground trenches and allowed to percolate into the groundwater table.

The CRSS is designed to be low impact without ocean outfalls, utilising natural absorption and breakdown of contaminated material over time. It was expected that operation of the CRSS as designed would result in changes to the hydrology and water quality of groundwater within the area, likely creating a measurable "plume" of affected groundwater.

Monitoring of groundwater is carried out around the dune exfiltration area. The purpose of the monitoring is to ensure that the operation of the CRSS does not unacceptably change the present or potential use of the groundwater resource, the surface water or aquatic ecology, or result in unacceptable noise or odour impacts in the local area. The CRSS is required to comply with the operational discharge requirements of the applicable Environment Protection Licence 12357 for operation of the CRSS, including annual reporting of results.

Previous site investigations and groundwater modelling have indicated minor groundwater mounding below the proposed exfiltration trench. Groundwater flow is expected to occur towards the coast (60%), west to Lake Conjola Village and lake-inlet (35%), and south-west to Pattimores Lagoon (5%). Transport of nutrients and pathogens from the exfiltration site is of potential concern, although groundwater in the village area is known to be impacted by nutrients from septic leakage.

4.3.3 Groundwater Monitoring Guidelines / Standards

Earth2Water (E2W) undertake near-annual monitoring to assess impacts on (and those distributed by) groundwater due to effluent discharged into the dune exfiltration system, completing 6 monitoring reports to date for the periods: 2009-2010, 2010-2011, 2011-2012, 2013-2017, 2017-2019, and the latest (draft) report for 2019 to 2021.

Key findings reported within the E2W monitoring reports include:

- The effluent discharged into the dune exfiltration system generally complies with the EPA limits outlined in the CRSS Environment Protection Licence (12357), with one exception (i.e. high ammonia =23.3 mg/L, August 2019);
- The local groundwater system is highly vulnerable to nutrient pollution from multiple nutrient sources due to the sandy soils, dune sand geology and shallow water table. For example, Groundwater Well MB1S, 31/32, and 294/295 (refer **Figure 4-7** for location at Holiday Haven Caravan Park) are stated as being vulnerable to impact from fertiliser use given the shallow water table and proximity to camper areas (which are fertilised to maintain grass coverage); and,
- The nature and extent of the groundwater nutrient plume is stated as being relatively dynamic, and linked to the Wastewater Treatment Plant (WWTP) outflow volume and quality.

In addition, E2W (2021) notes that:

- rainfall ranges from 910 mm to 1380 mm year, with an average of 1,173 mm/yr;
- the above average rainfall in 2015-2017 (1,375 mm/yr) was associated with the highest effluent volumes discharged (210/218 ML) but a lower relative annual TN load discharged (740 kg/915 kg);
- The annual rainfall at Lake Conjola during the periods 2017 to 2018 (748 mm/yr), and 2018 to 2019 (740.5 mm/yr) were substantially below the previous wet years (Table 33B). The WWTP outflows were lower during 2017-2018 (177.6 ML) and 2018-2019 (189.5 ML) due to the low rainfall; and,
- The WWTP outflows were lower during 2019-2020 (rainfall 877 mm/yr, discharge 102.99 ML) and 2020-2021 (rainfall 1,106 mm/year, discharge 145.19 ML) due to the low to average rainfall, and bushfires *[while not stated, this may be a reference to reduced tourism, affected by COVID also, therefore less material within the system].*

The correlation between high rainfall and increased volume of material requiring processing and disposal, particularly being of a lower TN concentration, may be an indication of (illegal) connection of stormwater pipes into the sewer network. If so, the additional volume of water may be 'artificially' increasing expansion of the groundwater plume. It is recommended that the feasibility of opportunities to investigate potentially illegal stormwater connections and take action as necessary should be considered as a potential management action during Stage 3 of the CMP process.

4.3.4 Current Status and Results of CRSS Groundwater Sampling

The information below is a compilation of the findings and statements within the draft 2019-2021 E2W report:

- The effluent plume has potentially migrated between 200 m to 400 m from the exfiltration trench since commencement in 2008 (refer **Figure 4-7**). The plume is not well delineated, due to data gaps arising from the sand dunes/forest and dry wells (approximately 13);
- The WWTP plume extent in 2019-2021 and 2017-2019 are interpreted by E2W to be similar;
- The precise extent of the WWTP plume to the east, west and south is not readily discernible due to the multiple sources, and several dry wells (data gaps);
- The TP/TN plume north of the exfiltration trench is interpreted to have reached Lake Conjola campgrounds (refer **Figure 4-7**);
- The elevated nutrients (TN, TKN, and particularly ammonia) at the campground wells (MB-1S, MW-3) are noted as likely to reflect impact from fertilisers;
- The WWTP plume outer fringe (low nutrient concentrations) is difficult to differentiate at the downgradient areas due to the multiple nutrient sources (i.e. residences, campgrounds, outdoor showers, fertilised areas with local fauna also generate point and diffused sources of TN, TP and FC), however E2W interpret that the nutrient plume may have stabilised around the fringes given the time series graphs indicate stable TP/TN trends, and the improved water quality of the treated effluent;
- FC levels were within the ANZECC (2000) guidelines for wells within the exfiltration trench plume. Background wells have reported FC levels above guidelines indicating multiple sources, such as former septic tanks and biological sources, at the well locations;
- The groundwater quality away from the exfiltration trench is interpreted to be unaffected by FC, however localised FC could occur immediately around the exfiltration trench due to bio-accumulation;
- Based on the review of surface water quality data (E-39, E-474) from Lake Conjola entrance and Pattimores Lagoon (E-748), E2W consider that it is unlikely that the effluent discharges have adversely impacted the surface water;
- Some risk to the environment (nutrient loads, algal blooms) is indicated by the inferred broad extent of the nutrient plume (TN, nitrate, and some TP) and its proximity to surface water bodies (i.e. Pattimores Lagoon and Lake Conjola, refer **Figure 4-8**); and,
- The capacity of the aquifer and environment (estuary and lagoon) to naturally attenuate the nutrients requires ongoing assessment and monitoring during various conditions.

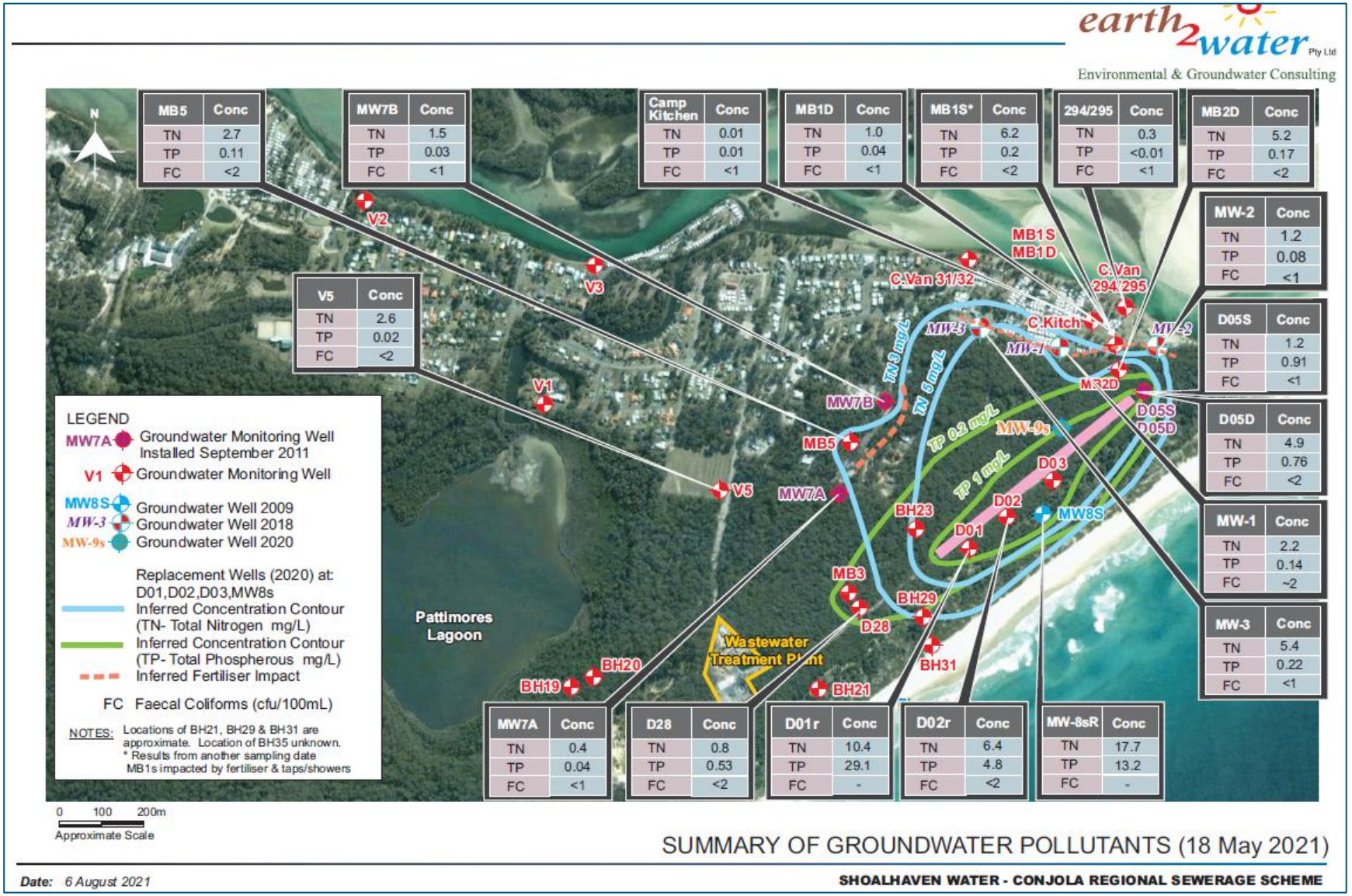

Figure 4-7: The inferred groundwater flow regime as of August 2021 (E2W, 2021)

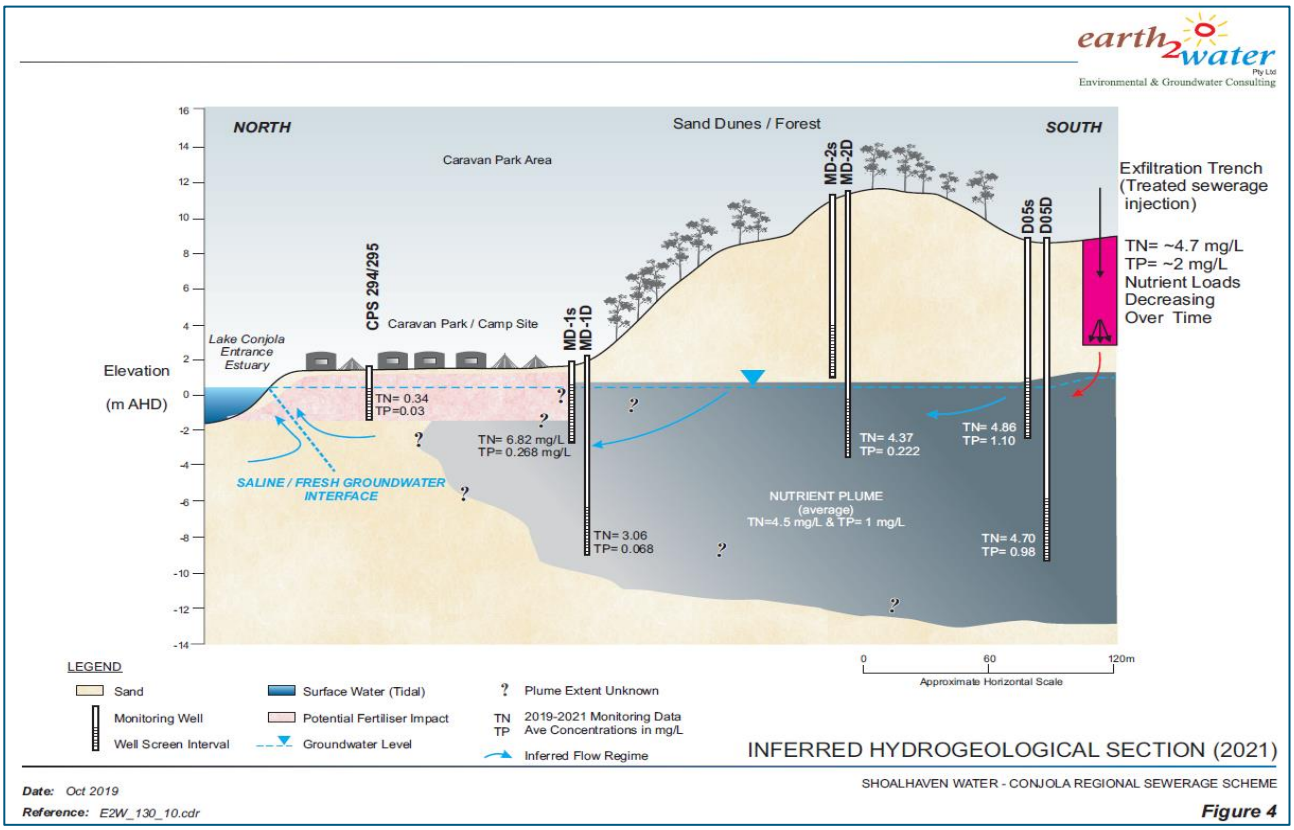

Figure 4-8: The inferred hydrogeological section as of 2021 (E2W, 2021)

4.4 Surface Water - Water Quality

4.4.1 General

Sources of contamination (natural as well as anthropogenic) may have a range of impacts on water quality within Lake Conjola that can affect the natural flora and fauna within and around the waterbody, as well as community / tourist use of the Lake, as shown in **Figure 4-9**.

While both the environment and the community benefit from a healthy waterway, for the purposes of the Lake Conjola CMP there is benefit in separating these two aspects for review and discussion.

> ***Ecosystem health* or the ecological health of a waterway relates to the suitability and resilience of the waterbody for the fauna, flora, and other organisms that rely on it.**
>
> ***Recreational health* refers to the suitability of a place for activities involving direct contact of humans with the waterway, like swimming.**

It is important to note that these two objectives, while seemingly very similar, can be mutually exclusive.

A waterbody (such as an enclosed wetland) may contain a very healthy range of organisms and ecosystem but be unfit for human recreation due to high levels of naturally occurring substances, such as enterococci. Inversely, a highly managed waterbody within a golf course, for example, may be treated to a high standard before aerial irrigation, and is likely to meet human recreational contact requirements, but be unsuitable for aquatic species.

The stated Strategic Directions of the Lake Conjola CMP (refer **CMP Stage 2 – Report A**) seek to ensure that both of these objectives (along with others) are met specifically:

- Maintain ***natural systems and processes*** to improve the ***health and diversity*** of natural systems.
- Support the ***social and economic wellbeing*** of local ***communities*** by ***maintaining safe access*** to beaches and headlands and supporting recreational activities.

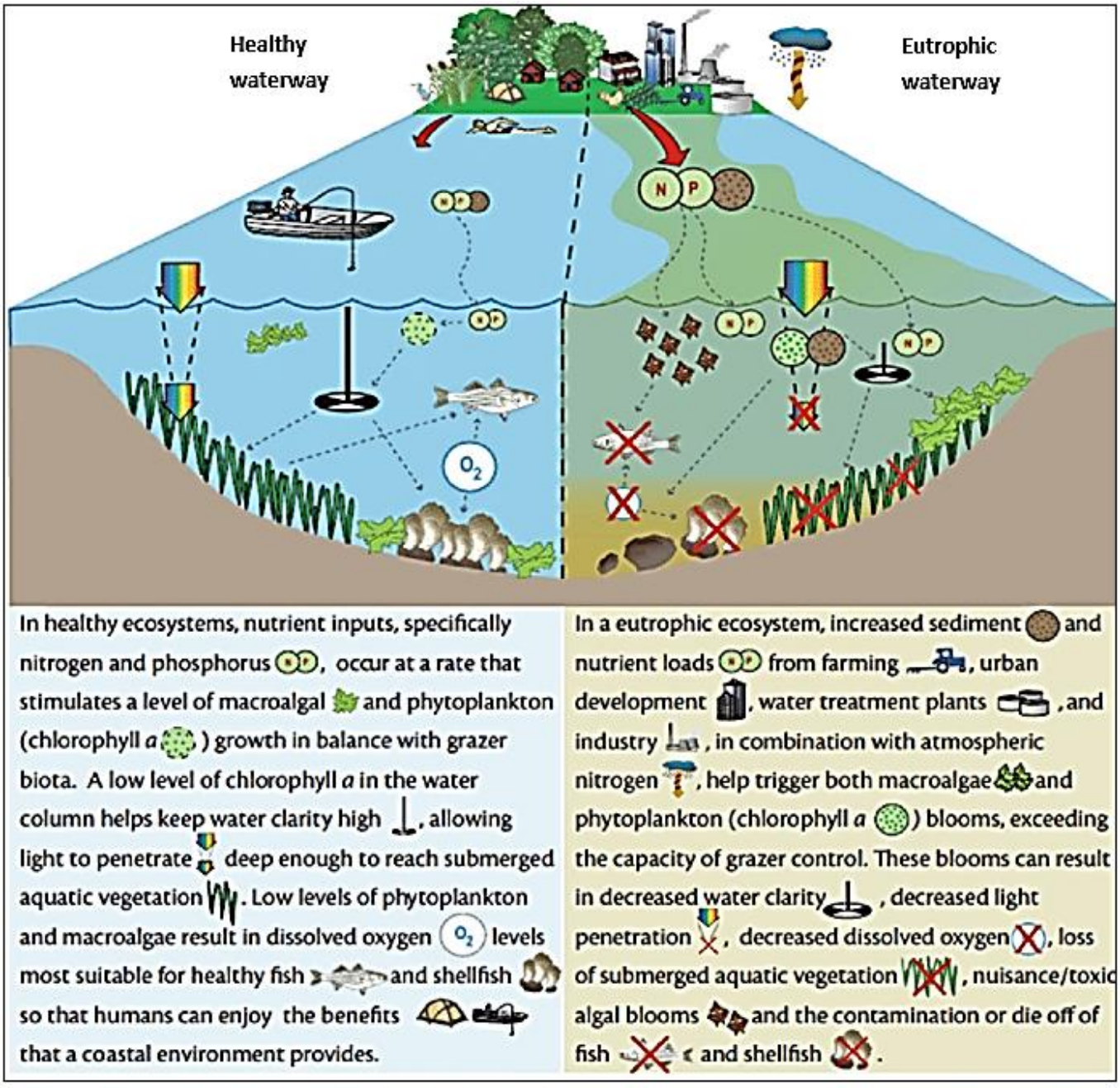

Figure 4-9: Healthy waterway and impacted eutrophic waterway causes and descriptions

4.4.2 Ecological Health Assessment

4.4.2.1 Ecological Health Guidelines / Standards

Assessing estuary ecosystem health (or condition) requires a standardised framework for monitoring, evaluating and reporting on appropriate indicators that measure components of an estuary's ecosystem that contribute to its overall health (OEH, 2016). Research completed in NSW coastal lagoons by Scanes et al. (2007) showed that ecological indicators of *algal abundance* (macro and micro) and *turbidity* were most likely to show interpretable patterns at low to moderate nitrogen loadings (<40 kg Ha^{-1} yr^{-1}).

Whilst monitoring of estuarine macrophytes and fish assemblages provides a longer-term indication of estuary ecosystem health status, measurement of *chlorophyll a* and turbidity provides an effective measure of the short-term response of estuary health to certain types of pressures. These variables form the basis of estuarine trend monitoring in NSW, and led to development of "Monitoring, Evaluation and Reporting Sampling Protocols" (DECCW, 2009).

Chlorophyll a / Algal Abundance

Algae are a diverse group of mostly aquatic plants that include microscopic algae found in waterways. *Chlorophyll a* is a pigment that gives plants their green colour and can be measured to get an indication of how much algae is present in a water sample.

Algae can grow quickly when high levels of nutrients such as nitrogen and phosphorous are present in a waterway, potentially from urban stormwater, agricultural runoff, sewage and sediment runoff from the land. This growth can cause an 'algal bloom' which can reduce the amount of light available to aquatic plants and animals.

Chlorophyll a indicates the amount of microscopic algae (phytoplankton) growing in the water. Excessive input of nutrients from catchment runoff (urban stormwater, agricultural runoff, and sewage overflows) can increase *chlorophyll a* levels and lead to algal blooms and detrimental effects on estuarine plants and animals (OEH, 2016). The algae eventually die and are eaten by bacteria, which removes oxygen from the waterway and potentially harms other species (e.g. fish kills). Low levels of algae usually indicates that low levels of nutrients are entering a waterway. Therefore, a 'good' grade for algae, means that a suitable amount of nutrients are entering and remaining in an estuary (DPE, online 2021).

Turbidity / Water Clarity

Turbidity, or water clarity, is a measure of light scattered by suspended particles such as sediment, algae and dissolved material in the water which affect its colour or murkiness. High levels of turbidity indicate that excessive amounts of sediments are present in an estuary, which equates with poor water quality.

Turbidity can increase from sediments transported in catchment runoff (particularly after heavy rainfall), shoreline erosion and increased microscopic algae. Fine sediment can stay suspended in water until it settles and accumulates in low energy areas of an estuary, like seagrass meadows. Coarser material tends to settle in deeper sections of an estuary (DPE, online 2021).

High turbidity can have negative impacts on aquatic ecosystems, by reducing available light which limits the ability of important underwater plants like seagrass to grow. Alternatively, low levels of

turbidity and good water clarity indicate there is a suitable amount of sediment, organic matter and nutrients entering and remaining in an estuary, which equates with good water quality.

Many NSW local governments, including Council, have been undertaking water quality monitoring and assessment against a range of parameters for a number of years. Implementation of the NSW Natural Resources Monitoring Evaluation and Reporting (MER) Strategy 2010–2015 (*Estuary Theme*) (DECCW, 2010) provided the impetus for many councils to consolidate their previous programmes into the standardised MER format. The MER Program determined trigger values to indicate estuarine conditions which are not desirable for estuarine ecosystem health and should "trigger" investigation.

The current trigger values that are applicable to Lake Conjola (classified as a 'lake') are summarised in **Table 4-1**.

Table 4-1: MER Program trigger values for Lake Estuary Class (DPE, 2020, supplied)

Parameter	MER Trigger Values DPE June 2020
Chlorophyll-a (ug/L)	5.3
Turbidity (NTU)	5.5
Ammonia	14
Phosphate	1
Oxidised Nitrogen	3
Silica	450
Total Dissolved P	9
Total Dissolved N	670
Total Phosphorous	24
Total Nitrogen	750
pH upper	9.1
pH lower	8.1
DO upper %	115
DO lower %	93
DO upper mg/L	8.9
DO lower mg/L	6.7

4.4.2.1 Estuary Ecosystem Health Report Cards

While a range of physico-chemical and biological indicators (such as salinity, oxygen, pH, temperature, suspended sediments, spatial distribution and composition of estuarine macrophytes, and fish species assemblages) can aid in the assessment of the overall condition of an estuary, water quality monitoring of algae (*chlorophyll a*) and water clarity (turbidity) have been determined as providing an effective measure of the short-term response of estuary health to certain types of pressures, and are the key reporting parameters (OEH, 2016). Compliance against the guidelines / trigger values is used to assess the comparable status of indicators and the waterbody, using OEH (2016) gradings as shown in **Figure 4-10**.

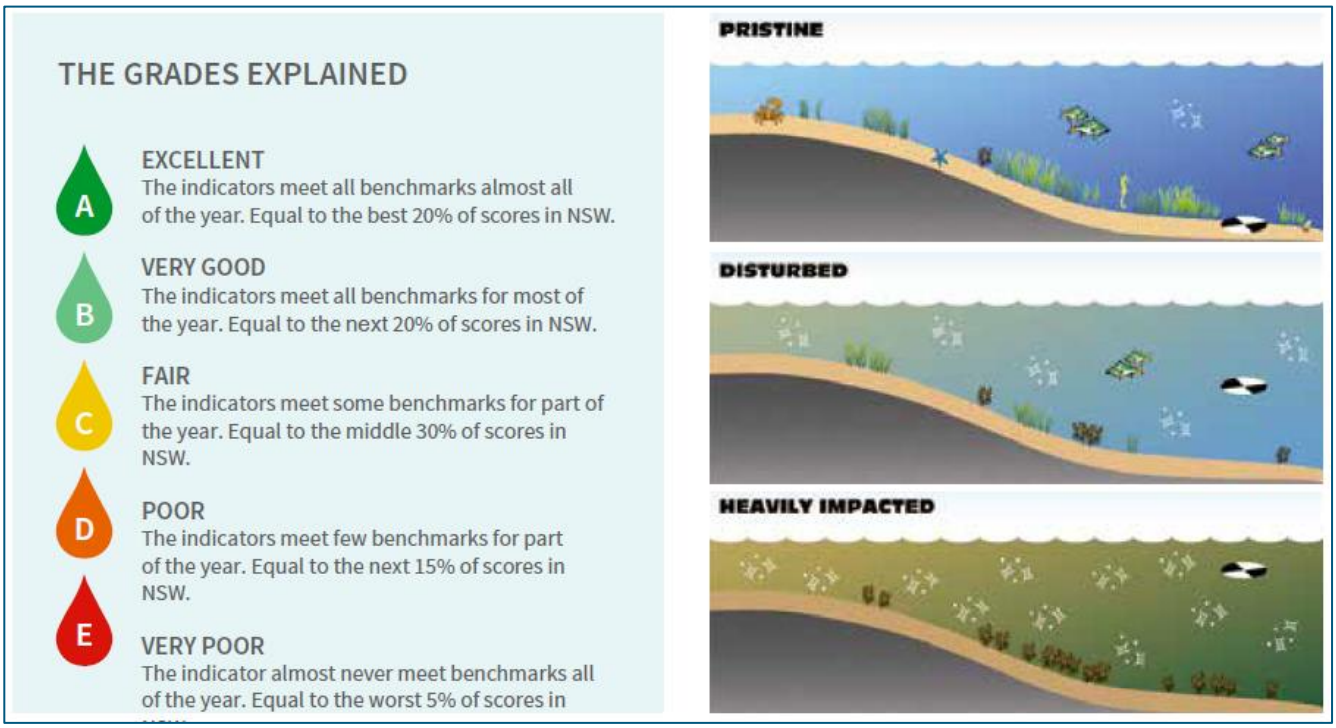

Figure 4-10: MER program Grades for ecosystem health condition indicators (chlorophyll a and turbidity) (Northern Beaches Council, 2016)

4.4.2.2 Estuary Ecosystem Health – Lake Conjola

Following the DPE sampling protocols (OEH, 2016), the spatial scale of interest for the MER Program is whole-of-estuary condition, which for lakes and lagoons such as Lake Conjola is the central basin, and for rivers, the mid to upper sections. To facilitate representative spatial coverage, estuaries are divided into zones. For lakes and lagoons, a zone is an area of approximately 500–700 metres in diameter. The approximate location for each of the three (3) sampling zones within Lake Conjola is shown in **Figure 4-11**.

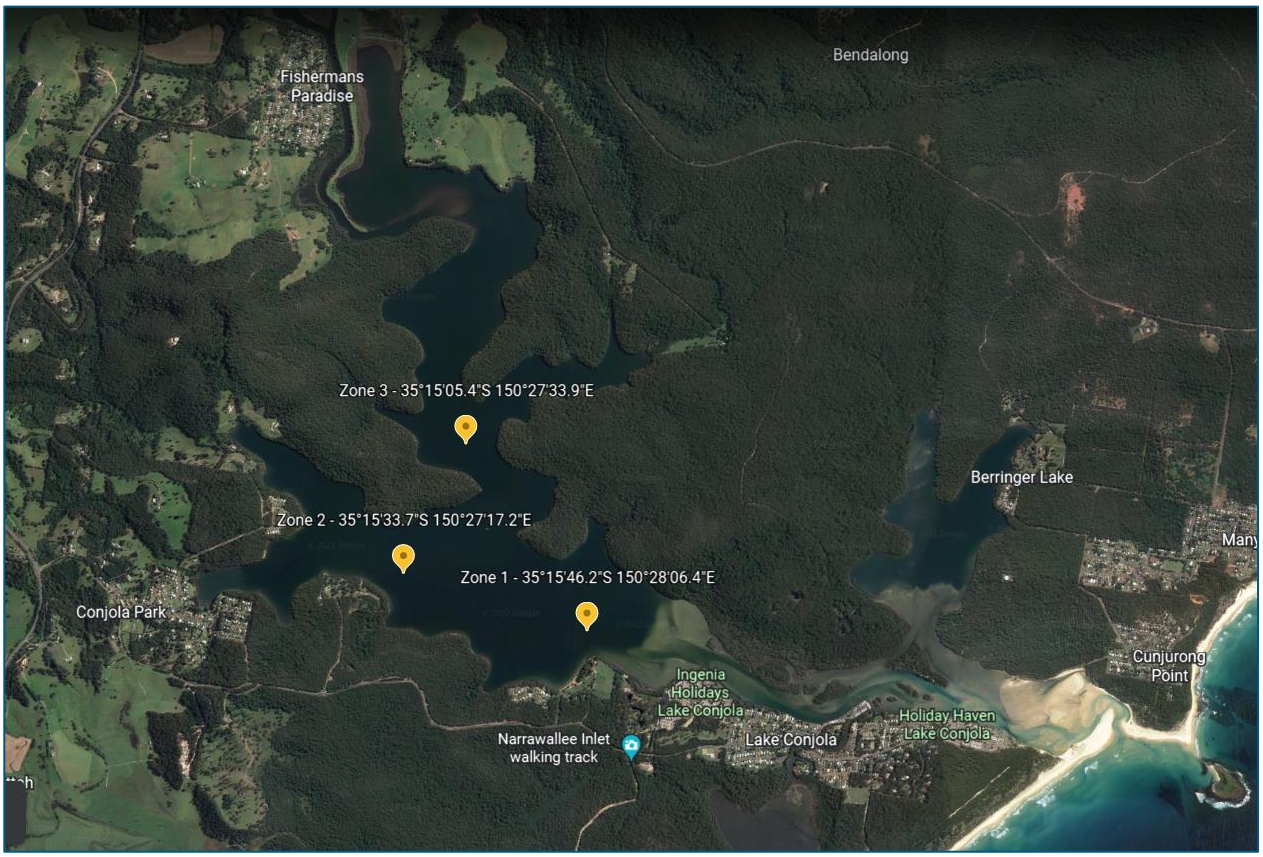

Figure 4-11: MER sampling locations within Lake Conjola (source: DPE MER assessment records, 2021)

While Council has only published one Report Card for Lake Conjola (2010-2011), the ecosystem health of the Lake has been assessed on a number of occasions since 2008-2009 as summarised in **Table 4-2**, with the most recent assessment occurring over the 2019–2020 summer, as part of state-wide impact assessment due to the significant NSW bushfires (discussed further in **Section 8.3.1**).

Table 4-2: Lake Conjola Ecosystem Health Water Quality Ratings

Year	Chlorophyll a / Algal Abundance Grade	Turbidity / Water Clarity Grade	Overall Grade	Data source
2008-2009	A	A	A	DPE *
2010-2011	B	B	B	Council**
2011-2012	A	D	B	Wiecek et al.***
2017-2018	A	A	A	DPE *
2019-2020	A	C	B	DPE****

*DPE online reporting *Health of our estuaries/Conjola Lake*

**Shoalhaven City Council, Lake Conjola Estuary Ecosystem Health Report Card 2010-2011

***Wiecek et al., 2012 "Monitoring the Ecosystem Health of Estuaries on the NSW South Coast", Coastal Conference Paper

****DPE – Water Quality assessment data sheets – supplied 2021 and https://www.environment.nsw.gov.au/topics/water/estuaries/estuaries-of-nsw/conjola-lake

4.4.2.3 Summary of Ecosystem Health Assessment

A summary of the ecosystem health assessment program, results, and recommendations for Lake Conjola is provided below:

- Like many south coast estuaries, Ecosystem Health monitoring of Lake Conjola is not undertaken on an annual basis. Increased frequency of monitoring would create a better dataset for analysis of trends, and consideration of management actions as needed;
- Noting the generally positive results to date, and that the majority of the catchment is undeveloped (and likely to remain so), the projection is that the ecosystem health of Lake Conjola should remain stable; and,
- It is recommended that Council consider increasing the frequency and consistency of community engagement regarding the ecological health of Lake Conjola, using tools such as the Report Card, to address and mitigate community concerns.

4.4.3 Recreational Water Quality Assessment

4.4.3.1 Recreational Health Guidelines / Standards

Unlike assessment of the ecological health of waterways, within which the trigger values can vary drastically even within a relatively small spatial area due to the underlying differences between ecosystems (e.g. freshwater wetland vs estuary/lagoon), the recreational health / suitability of water for human contact is assessed against an international standard.

The World Health Organisation (WHO) developed internationally recognised "Guidelines for safe recreational waters: Volume 1- Coastal and Fresh Water" (WHO, 2005); which were reflected in the Australian National Health and Medical Research Council (NHMRC) prepared "Guidelines for managing risks in recreational waters" (NHMRC, 2008).

Both guidelines (based on significant research) recognise and adopt the presence and concentration of enterococci as the single preferred faecal indicator in marine waters for assessment of recreational water quality, based on the concentrations as shown in **Table 4-3**.

Table 4-3: NHMRC "Guidelines for managing risks in recreational waters" assessment categories (2008)

Category	95th percentile enterococci (colony forming units per 100ml)	Basis of derivation
A	<41	No illness seen in most epidemiological studies
B	41–200	Upper threshold is above the threshold of illness transmission reported in most studies
C	201–500	Represents a substantial elevation in the probability of adverse health outcomes
D	>500	Above this level there may be a significant risk of high levels of illness transmission

Using these parameters, DPE have established "Beachwatch" as a public recreational water quality assessment and reporting program across NSW, including a number of South Coast locations. Adopted Beachwatch protocols used during assessment for a swimming site are that sampling results within Categories A and B (indicating generally low levels of faecal contamination), are reported as a beach suitability grade (or rating) of 'very good' or 'good' respectively.

4.4.3.2 Available Lake Conjola Physico-Chemical Water Quality Data

Council and Shoalhaven Water have implemented a well-established LGA-wide physico-chemical water quality sampling program since 1989, which provides highly detailed data through the publicly accessible 'Aquadata' website.

The data provided through Aquadata is "raw" and neither correlated nor interpreted. The sampling sites within Lake Conjola are shown in **Figure 4-12**, and the wide range of parameters that have been assessed are shown in **Table 4-4**.

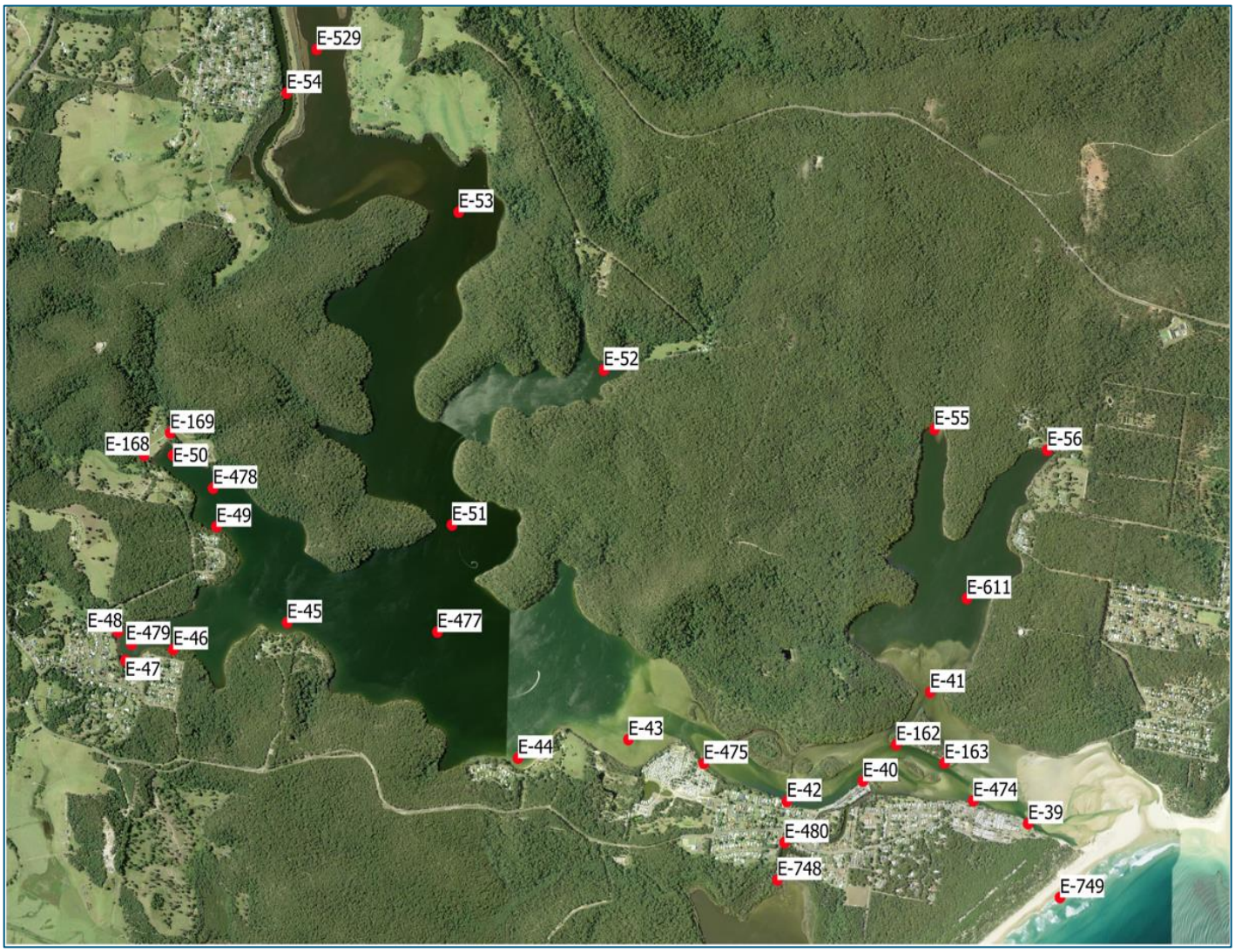

Figure 4-12: Aquadata water quality sampling sites within Lake Conjola

Table 4-4: Aquadata water quality parameters assessed for Lake Conjola

Assessment Parameters	
Temperature (°C)	Nitrite (as N) (mg/L)
Dissolved Oxygen - % (Filtered, % saturation)	TSS (mg/L)
Dissolved Oxygen (Filtered, mg/L)	Redox Potential (mV)
pH (-)	Nitrogen (Total Oxidised) (mg/L)
Salinity (ppt)	Nitrite (as NO2-) (mg/L)
Electrical Conductivity (µS/cm)	Nitrate (as NO3-) (mg/L)
Turbidity (NTU)	Kjeldahl Nitrogen Total (mg/L)
Faecal Coliforms (CFU/100mL)	Ammonia (mg/L)
Enterococci (CFU/100mL)	Arsenic (mg/L)
Nitrogen (mg/L)	Benzene (mg/L)
Chlorophyll a (mg/m3)	Aluminium (mg/L)
Total Phosphorus as P (Organic Phosphate as P) (mg/L)	Cadmium (mg/L)
Location	Chloride (mg/L)
Dissolved Oxygen - % (% saturation)	Copper (mg/L)
pH (Field) (-)	Iron (mg/L)
Depth to Water (m)	Selenium (mg/L)
Electrical Conductivity (Temperature Compensated) (µS/cm)	Sulphate (mg/L)
Dissolved Oxygen (mg/L)	Zinc (mg/L)
Turbidity (Field) (NTU)	E. Coli (CFU/100ml)
Phosphorus (mg/L)	Coliform (CFU/100ml)
BOD (mg/L)	TDS (mg/L)
Nitrite + Nitrate as N (mg/L)	Secchi Disk (m)
Ammonia as N (µg/L)	Chromium (III+VI) (mg/L)
Nitrate (as N) (mg/L)	

The large number of sites, wide spatial distribution, range of sample parameters and long temporal sampling series would suggest that analysis of available data would provide significant insights into water quality trends within Lake Conjola over the past 30+ years. While the data does allow some useful conclusions to be drawn, there are a number of limitations with the data, including that the sampling

methodology has varied significantly over time, with little to no consistency between the frequency of sampling, the number of sites sampled each year, nor the parameters analysed, as shown in **Table 4-5**.

Table 4-5: Example of Aquadata raw results from single site #E-40

Locati	Date: 0	Tempe	Dissolv	pH (-)	Salinity	Electric	Turbidi	Faecal	ococci (cfu	E ratin	Rating	Nitroge	Chloro	Total P	Dissolv	Phosph	Nitroge	Ammo
E-40	23-Jun-08	15.65		7.75	35.23	438200	6.1	23							2.15			
E-40	22/09/2008	17.77		7.76	35.08	45770	1.4	2	5	A	NA	0.39	1.2		8.25	0.007	0	0.3
E-40	8/12/2008	18.77		7.76	35.7	47520	1.7	2	1	A	NA	0.27	1.2		5.6	0	0	0.13
E-40	2/02/2009	26.74		7.33	36.25	56640	6.5	1	2	A	NA	0.32	0		4.62	0.01	0	0.12
E-40	18/05/2009	16.62		8.4	36.58	55200	17.7	1	9	A	NA	0.17	2.7		7.8	0.007	0	0.16
E-40	22-Jun-09	14.98		8.13	35.12	53.25	70.4								7.41			
E-40	28/09/2009	15.23		8.19	35.71	54000	0.5	0	1	A	NA	0.2	0		6.9	0.02	0	0.19
E-40	22/02/2010	27.17		8.11	26.46	41.3	-0.7	10	2	A	NA	0.3	47		505	0.03		0
E-40	13-Jul-10	14.09		8.36	33.27	50700	0	2							7.7			
E-40	13-Sep-10	17.62		8.07	32.67	49900	0	1							7.2			
E-40	13-Dec-10	24.62		7.95	20.18	32400	0	3							6.8			
E-40	14-Mar-11	24.64		7.68	26.76	41700	0	5							5.5			
E-40	21-Jun-11	12.45		8	23.97	37800	0.2	15							8.7			
E-40	14-Nov-11	24.51		7.98	26.51	41400	0	12							5.1			
E-40	14-Feb-12	23.73		7.83	22.05	35100	0.7	26							4.4			
E-40	17-Apr-12	19.4		8.26	27.67	43000	5.8	28							6.3			
E-40	16-Oct-12	19.48		8.01	27.99	43500	48.3	11							6.1			
E-40	5-Mar-13	21.78		8.22	28.32	43900	0.2	9							6.4			
E-40	19-Nov-13	24.72		6.46	31.91	48900	77	1							5.1			
E-40	14-Jan-14	27.76	76	8.34	31.05	47700	36.5											
E-40	15-Jul-14	11.89	108.4	8.25	30.98	47600	0.4											
E-40	7-Aug-14	12.64	99.3	8.29	31.29	48000	0.8	0										
E-40	4-Nov-14	20.14	97.7	8.02	32.91	50300	0	3										
E-40	19-Jan-15	21.87	100.2	8.41	33.77	51400	2.7	12										
E-40	18-Aug-15	13.93	120.4	7.99	29	44900		<1										
E-40	13-Oct-15							<1										
E-40	9-Feb-16	24.11	96.5	8.37	35.08	53190	0.7											
E-40	10-Feb-16							<1										
E-40	3-May-16	18.37	91.3	8.45	35.38	53600	1.3	1										
E-40	26-Jul-16	12.51	68.6	8.59	29.55	45640	2.9	15										
E-40	17-Oct-16	16.31	93.9	3.69	35.52	53780		<1										
E-40	6-Mar-17							76										
E-40	15-May-17	17.15	83.3	8.47	30.97	47590	22.3											
E-40	16/05/2017							3	1	A	NA							
E-40	24-Jul-17	13.19	81.1	7.75	33.25	50710												

Water quality sampling was intensified in 2018/2019 in response to community concerns over lake water quality and the closed entrance at the time. This sampling comprised:

- Sampling commenced at 3 land sites (E-39, E-44 and E-46) in May 2018 (Council policy when entrance is closed);
- Intensification to weekly land sampling at 3-7 sites (E-39, E-474, E-40, E-42, E-475, E-44, and E-46) from November 2018;
- Routine quarterly boat sampling at 15 sites until January 2019;
- Intensification of boat sampling to 11 sites each month and 18 sites each quarter from January 2019; and,
- Intensification to weekly land sampling at 7-9 sites (E-39, E-474, E-40, E-42, E-475, E-44, E-46, E-479, and E-54) from December 2019.

Following the opening of the lake entrance on 10 February 2020, water quality sampling was reduced as follows:

- Continuation of weekly sampling at 8 land sites until end of February 2020;
- Monthly sampling at 8 land sites from March 2020 to May 2020 when all land sampling ceased;
- Routine quarterly boat sampling at 15 sites was resumed from February 2020 to the present time;

- MER boat sampling at 3 sites (refer **Section 4.4.2.2**) every 2 months from February 2020 to the present time (MER/DPE bushfire recovery project sampling); and,
- Monthly boat sampling at 11 sites ceased in April 2020.

As part of the analysis of recreational water quality, other factors that may influence water quality have also been reviewed. This includes rainfall (BOM), water levels (MHL), and entrance open/closed status (Council and CCA), to assess if there are any correlations.

The majority of sites have only been sampled since 2003. As such, the analysis has been focused on the period 2003-2021 as having the most available data, as well as periods of change due to introduction of the CRSS (2008) and Lake entrance closure (from approximately 2011 onwards).

Key parameters focused on were:

- The presence/absence and concentration of enterococci;
- The presence/absence, relative dates, and volume of rainfall; and,
- Whether the entrance to Lake Conjola was open or closed.

The collated, evaluated and contrasted results were then assessed across the:

- Temporal distribution to ascertain whether there were particular periods of time that were impacted by poor water quality; and,
- Spatial distribution across the waterbody of Lake Conjola to determine if there were particular “hot spots” of poor water quality.

4.4.3.3 Data Analysis

An assessment of the temporal distribution of enterococci Grade results between 2003-2021 was undertaken to assess whether there were particular years that were impacted by poor water quality, as shown in **Table 4-6** and **Figure 4-13**. The annual number of water quality samples (all sites) and rainfall (2003-2021) in Lake Conjola is also shown in **Table 4-6**, while the correlation between rainfall and Lake Conjola entrance condition (open / closed) is shown in **Figure 4-14**.

Table 4-6: Yearly temporal distribution of enterococci Grade results

Year	Yearly Analysis (total)				Yearly Analysis (%)				# Samples	Annual Rainfall (mm)
	A	B	C	D	A	B	C	D	2	1154
2003	2	0	0	0	100%	0%	0%	0%	12	1074.4
2004	11	1	0	0	92%	8%	0%	0%	6	1032.8
2005	6	0	0	0	100%	0%	0%	0%	17	948.8
2006	17	0	0	0	100%	0%	0%	0%	87	1227.2
2007	83	4	0	0	95%	5%	0%	0%	46	933.6
2008	44	2	0	0	96%	4%	0%	0%	41	743.8
2009	40	1	0	0	98%	2%	0%	0%	59	1281.4
2010	54	5	0	0	92%	8%	0%	0%	61	1286.6
2011	50	8	2	1	82%	13%	3%	2%	185	1060
2012	155	28	2	0	84%	15%	1%	0%	55	1505.8
2013	38	9	3	5	69%	16%	5%	9%	23	1296.6
2014	18	3	2	0	78%	13%	9%	0%	18	1538.2
2015	17	1	0	0	94%	6%	0%	0%	24	1338.2
2016	23	0	1	0	96%	0%	4%	0%	34	1186.9
2017	30	3	1	0	88%	9%	3%	0%	152	903
2018	128	14	3	7	84%	9%	2%	5%	398	819.4
2019	372	17	5	4	93%	4%	1%	1%	169	1529.2
2020	148	18	0	3	88%	11%	0%	2%	16	1489.6
2021	15	0	1	0	94%	0%	6%	0%	2	1154

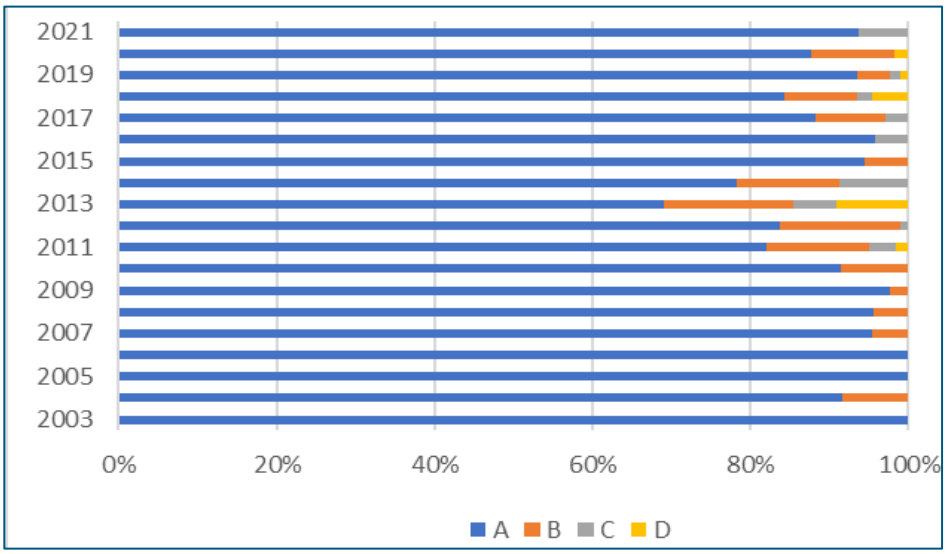

Figure 4-13: Yearly temporal distribution of enterococci Grade results – percentage of grades chart

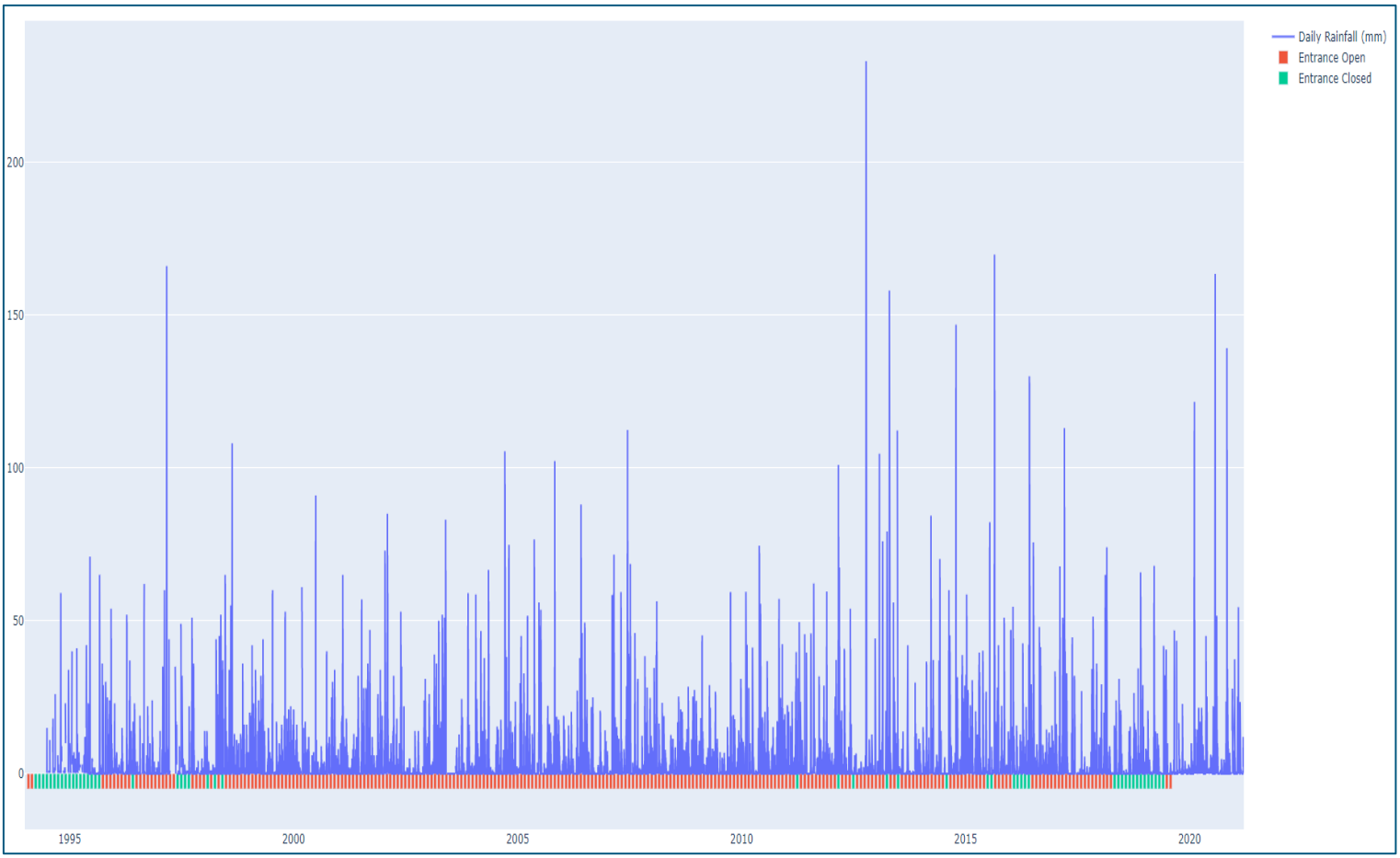

Figure 4-14: Correlation between daily rainfall and Lake Conjola entrance condition (open / closed)

At face value, review of **Table 4-6** and **Figure 4-13** would suggest that water quality has deteriorated since approximately 2011, with a noticeable increase in the number of poor 'C' and 'D' grade results. However, it is important to note the variation in the number of samples that were taken each year, ranging

from 2 to 87 during the period 2003 to 2011, after which the sampling effort significantly increased in particular years (e.g. 185 samples in 2012, 152 in 2018, and 398 in 2019) as did the number of 'C' and 'D' results recorded in those years.

It is noted that 2013, which recorded the highest percentage of 'D' grades, was a particularly "wet" year with significant rainfall (as shown in **Table 4-6**). High rainfall is frequently correlated with poor water quality due to catchment runoff.

These results may not necessarily be indicators of changes in water quality, rather a reflection of the possibility that an increased frequency of sampling may record events that would have been 'missed', and indicative of opportunities that would have benefitted from further investigation.

4.4.3.4 Surface Water Quality Monitoring – Recreational Health – Spatial Distribution of Results

Further investigation into the graded water quality data revealed an interesting spatial distribution of results. These results are shown colour-coded and correlated in **Table 4-7** (with the sites furthest away from the entrance at the top of the table) and mapped in **Figure 4-15**. Observations based on review of the presented data are as follows:

- **Site E-529**, near Fishermans Paradise, recorded **one 'C'** result on 6 March 2017, which occurred while the entrance was open, and following approximately 100mm rain over 2-4 March. It is likely that this event was catchment runoff related and/or a single point source, as the only other locations recording poor results were downstream (E-477, E-39, E-479) and of less impact "B" Grades.
- **Site E-46** in Conjola Park recorded **two 'C'** and **two 'D'** results. However, this site also had the third highest number of total measurements (165) and some of these poor results also coincided with poor water quality measured at other Lake locations.
- The sampling event of 28 November 2018, which experienced 66mm of rain on the day, captured a range of poor "D" results across a number of locations (E-40, E-42, E-46, E-474 and E-475). However, Site E-39 (close to the entrance) recorded a "C" result, and Site E-44 (adjacent to The Leaning Oak Holiday Lifestyle and Roberts Point) recorded only a "B" result. This variation in grades across a broad spatial distribution makes identifying the source challenging without targeted investigations.
- **Site E-44** to the west of Lake Conjola Village, adjacent to The Leaning Oak Holiday Lifestyle and Roberts Point, recorded **six 'C'** and **three 'D'** results, which are some of the highest within the dataset. However, this site also had the second highest number of total measurements (187) and some of these poor results also coincided with poor water quality measured at other Lake locations.
- **Site E-39**, at the eastern end of Lake Conjola Village, recorded **five 'C'** and **four 'D'** results. However, this site also had the highest number of total measurements (213) and some of these poor results also coincided with poor water quality measured at other Lake locations.
- The lowest performing sites are within and adjacent to Pattimores Lagoon, with **Site E-480** recording 100% 'D' grade (although with a sample size of one (1) is difficult to quantify), while **Site E-748** recorded the highest percentage of grades other than 'A', with **28.9% of 'B' grades** (still considered "Good") and **6.7% of 'C' grades**.
- It is noted that water exchange between Pattimores Lagoon and Lake Conjola was physically restricted through construction of a weir in the excavated connecting channel, which sought to

recreate the previously separated wetland area. The weir did however collapse a relatively short time after installation, and no information is available on the current state of the weir or degree of constriction.

- In general, the percentage of poorer water quality grades does not appear to increase with distance away from the entrance. This indicates that the entrance condition may not have a significant influence on recreational water quality. In addition, sites with higher occurrences of 'C' and 'D' grades coincided with the sites that had the highest number of measurements.
- The measurement of poor water quality at some sites may be related to local point sources (e.g. stormwater drain discharge) in some instances, particularly if water quality measured broadly across other lake locations was generally good. The potential influence of preceding rainfall on monitoring results is discussed in **Section 4.4.3.6**.

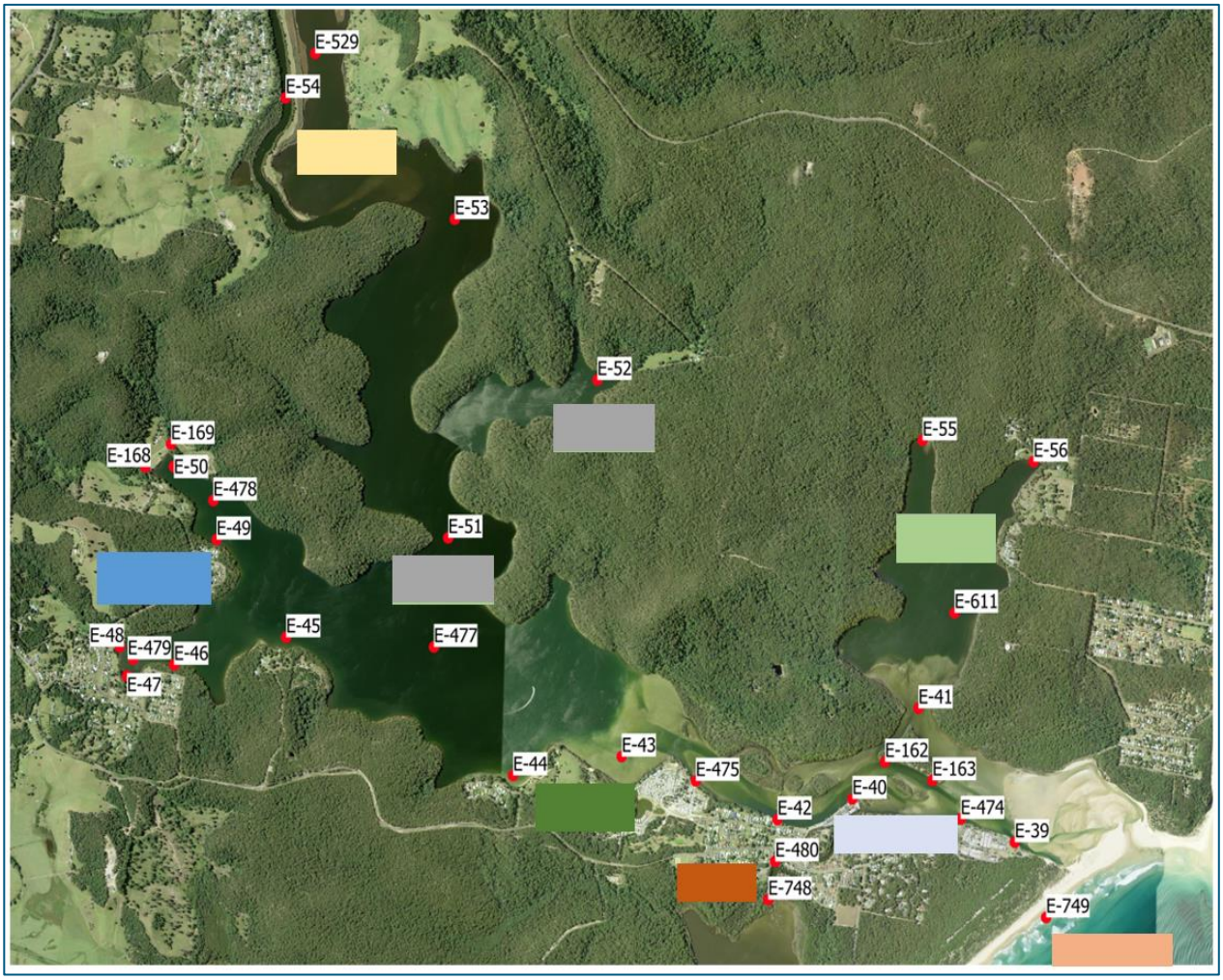

Figure 4-15:Spatial Distribution of WQ results, grouped and colour-coded by location

Table 4-7: Spatial distribution of results, colour-coded by Aquadata sample site location

	Number				Percentage				
Grade	A	B	C	D	A	B	C	D	Location
E-529	34	1	1	0	94.44%	2.78%	2.78%	0.00%	Fishermans Paradise
E-54	35	8	0	0	81.40%	18.60%	0.00%	0.00%	Fishermans Paradise
E-53	64	3	0	0	95.52%	4.48%	0.00%	0.00%	Fishermans Paradise
E-52	29	0	0	0	100.00%	0.00%	0.00%	0.00%	Conjola National Park
E-168	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Conjola Park
E-169	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Conjola Park
E-46	142	19	2	2	86.06%	11.52%	1.21%	1.21%	Conjola Park
E-479	83	3	0	0	96.51%	3.49%	0.00%	0.00%	Conjola Park
E-477	88	3	0	0	96.70%	3.30%	0.00%	0.00%	Main basin
E-611	30	0	0	0	100.00%	0.00%	0.00%	0.00%	Berringer Lake
E-41	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Berringer Lake
E-44	159	19	6	3	85.03%	10.16%	3.21%	1.60%	The Steps
E-43	30	3	0	0	90.91%	9.09%	0.00%	0.00%	The Steps
E-748	29	13	3	0	64.44%	28.89%	6.67%	0.00%	Pattimores Lagoon
E-480	0	0	0	1	0.00%	0.00%	0.00%	100.00%	Pattimores Lagoon
E-475	63	6	1	2	87.50%	8.33%	1.39%	2.78%	Lake Conjola Village
E-40	89	4	0	3	92.71%	4.17%	0.00%	3.13%	Lake Conjola Village
E-42	89	2	1	2	94.68%	2.13%	1.06%	2.13%	Lake Conjola Village
E-162	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Lake Conjola Village
E-163	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Lake Conjola Village
E-474	62	6	1	3	86.11%	8.33%	1.39%	4.17%	Lake Conjola Village
E-39	181	23	5	4	84.98%	10.80%	2.35%	1.88%	Lake Conjola Village
E-749	41	1	0	0	97.62%	2.38%	0.00%	0.00%	Open coast

4.4.3.5 Surface Water Quality Monitoring – Recreational Health – Sampling Frequency

An initial review of the surface water quality results for sites around Lake Conjola Village, as summarised in **Table 4-8**, which record 'C' and 'D' grades at more than one location, suggests that there may be an underlying issue in this area. This could be associated with a point source or range of diffuse sources that may need to be addressed. However, further investigation of the data provides a potential alternative explanation and is discussed below.

Table 4-8: WQ results in Lake Conjola Village

	Number				Percentage				
Grade	A	B	C	D	A	B	C	D	Location
E-475	63	6	1	2	87.50%	8.33%	1.39%	2.78%	Lake Conjola Village
E-40	89	4	0	3	92.71%	4.17%	0.00%	3.13%	Lake Conjola Village
E-42	89	2	1	2	94.68%	2.13%	1.06%	2.13%	Lake Conjola Village
E-162	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Lake Conjola Village
E-163	1	0	0	0	100.00%	0.00%	0.00%	0.00%	Lake Conjola Village
E-474	62	6	1	3	86.11%	8.33%	1.39%	4.17%	Lake Conjola Village
E-39	181	23	5	4	84.98%	10.80%	2.35%	1.88%	Lake Conjola Village

As shown in **Figure 4-16**, there is significant frequency and temporal variability between the sampling undertaken at each site within the Lake Conjola Village area, as well as other locations, which creates significant opportunity for the results to be misinterpreted. For example:

- Site E-40 and E-42 were sampled between 2003-2009, then again from 2018 onwards;
- Sites E-475 and E-474 have only been sampled (though frequently) from 2018 onwards;

- Sites E-162 and E-163 have only been sampled once, with both sites recording an ‘A’ grade; and,
- Site E-39 has been sampled in 2004 and 2006, then very frequently (continuously) from 2007 until present, has recorded the most ‘C’ and ‘D’ results, and is the only site to record poor water quality prior to 2019.

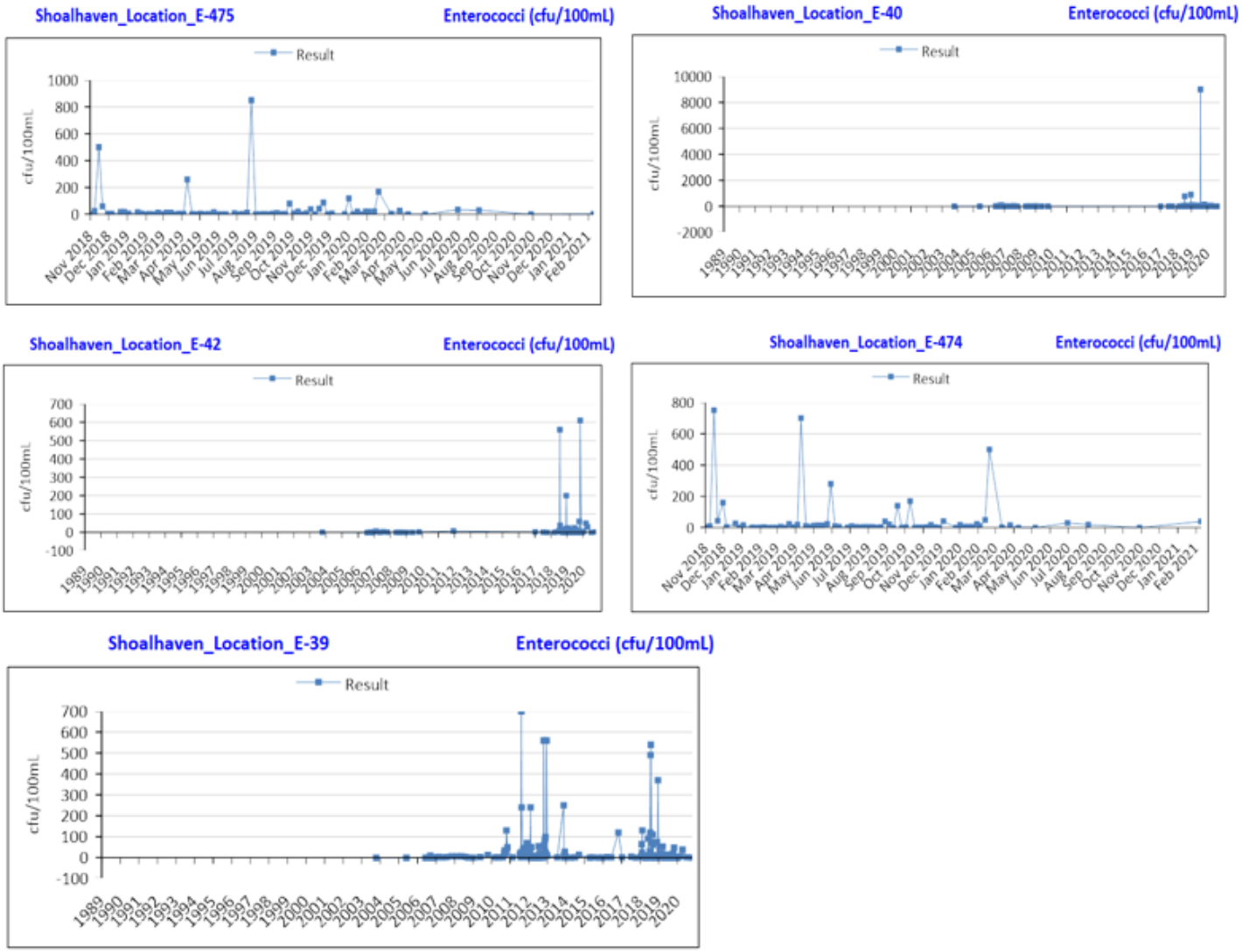

Figure 4-16: Timeline and Frequency of water quality sampling in Lake Conjola Village

As a comparison, the other “poor performing” sites (i.e. Site E-748 in Pattimores Lagoon, Site E-46 in Conjola Park, Site E-44 to the west of Lake Conjola Village, and Site E-529 near Fishermans Paradise) as shown in **Table 4-9**, were sampled sporadically, and often had large temporal gaps in the data record, as shown in **Figure 4-17**.

Table 4-9: Sites outside of Lake Conjola Village area recording "poor" water quality results

Grade	A	B	C	D	Location
E-529	34	1	1	0	Fishermans Paradise
E-54	35	8	0	0	Fishermans Paradise
E-53	64	3	0	0	Fishermans Paradise
E-52	29	0	0	0	Conjola National Park
E-168	1	0	0	0	Conjola Park
E-169	1	0	0	0	Conjola Park
E-46	142	19	2	2	Conjola Park
E-479	83	3	0	0	Conjola Park
E-477	88	3	0	0	Main Basin
E-611	30	0	0	0	Berringer Lake
E-41	1	0	0	0	Berringer Lake
E-44	159	19	6	3	The Steps
E-43	30	3	0	0	The Steps
E-748	29	13	3	0	Pattimores Lagoon
E-480	0	0	0	1	Pattimores Lagoon

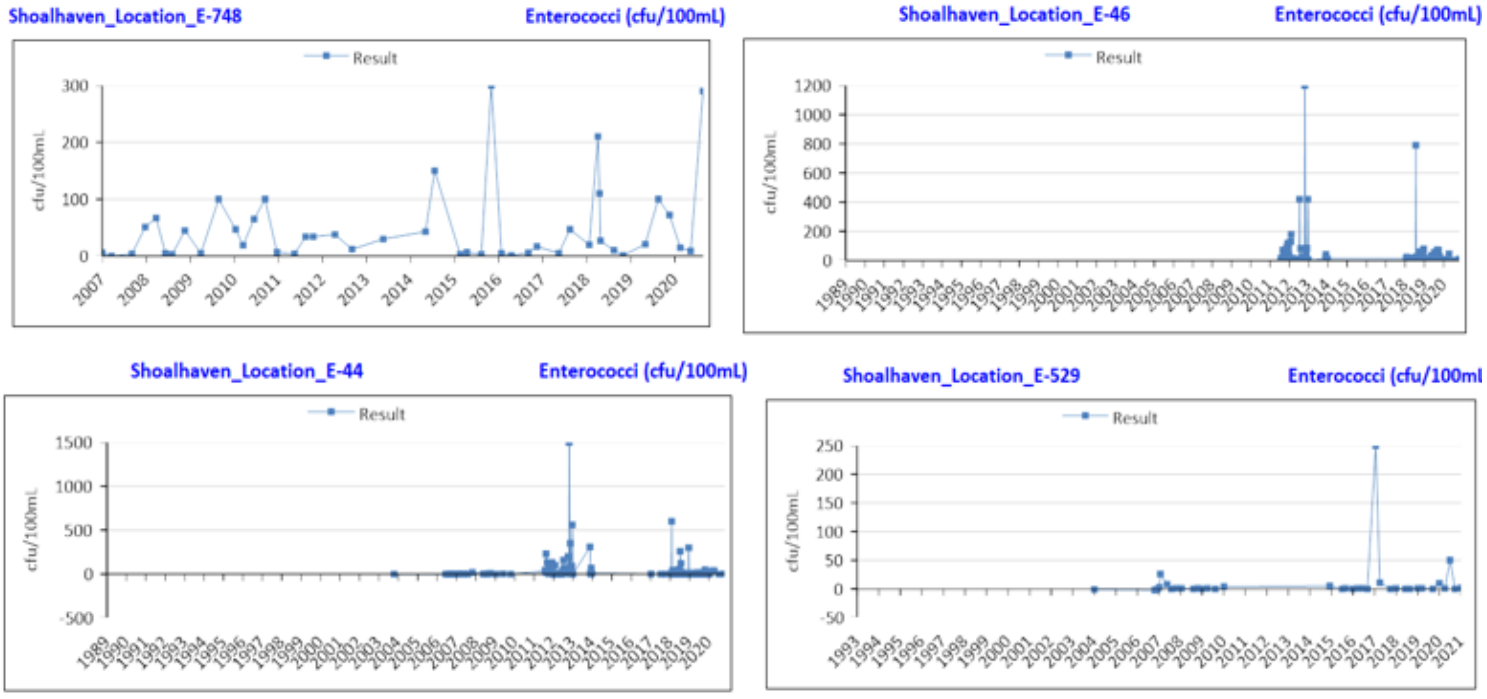

Figure 4-17: Timeline and Frequency of water quality sampling at other "poor performing" sites

As well as the 'poor' results at these locations not being corroborated by adjacent locations, the gaps in the data record create uncertainty as to whether Lake Conjola was widely impacted by poor water quality at a point in time, or whether there has been a series of infrequent, isolated instances that may have been associated with localised sources (e.g. stormwater drain discharge, urban runoff).

4.4.3.6 Surface Water Quality Monitoring Recreational Health – Spatial Distribution, Rainfall and Entrance Condition

Through collation and filtering of Aquadata results to identify occasions when more than one location recorded a ‘C’ or ‘D’ grade, it was possible to generate an overview of the spatial distribution, entrance condition, and recorded rainfall to enable relative comparison between sites over time (refer **Table 4-10**).

The most significant correlation with ‘D’ grade results appears to be rainfall, irrespective of whether the entrance was open or closed, however this relationship was not completely consistent.

The results presented in this manner also highlighted another spatial and temporal gap in the water quality sampling. It appears from the results that 3 sites (i.e. E-39 in Lake Conjola Village, E-44 at ‘The Steps’, and E-46 at Conjola Park) appear to be the only locations affected by poor water quality between November 2012 and March 2017.

However, further examination of the data record reveals these sites were among the very few that were recording water quality data during this time period. If these results were accepted at face value, they would skew the interpretation of collated results by making these locations appear more “polluted” compared to the rest of Lake Conjola. The poor water quality at these sampling times may (or may not) have extended further throughout the Lake, but there is not enough data to be able to determine this.

Table 4-10: Relationship between surface water quality, rainfall and entrance condition

Date	Enterococci (cfu/100mL)	Enterococci rating	Location	Open or Closed	Recent rainfall event	Additional notes	Location
12-Dec-11	700	D	E-39	Open	No	Little bit of constant rain previous week (<10mm)	Lake Conjola Village
19-Dec-11	240	C	E-39	Open	No		Lake Conjola Village
19-Dec-11	230	C	E-44	Open	No		The Steps
12-Jun-12	240	C	E-39	Closed	No	12mm of rain on the day, 54mm 6 days before	Lake Conjola Village
12-Jun-12	180	B	E-46	Closed	No	12mm of rain on the day, 54mm 6 days before	Conjola Park
12-Jun-12	78	B	E-477	Closed	No	12mm of rain on the day, 54mm 6 days before	Main basin
12-Jun-12	84	B	E-479	Closed	No	12mm of rain on the day, 54mm 6 days before	Conjola Park
12-Jun-12	83	B	E-53	Closed	No	12mm of rain on the day, 54mm 6 days before	Fishermans Paradise
19-Nov-12	54	B	E-39	Open	No		Lake Conjola Village
19-Nov-12	63	B	E-44	Open	No		The Steps
19-Nov-12	420	C	E-46	Open	No		Conjola Park
25-Feb-13	560	D	E-39	Open	yes	76.2mm day before	Lake Conjola Village
25-Feb-13	1500	D	E-44	Open	yes	76.2mm day before	The Steps
25-Feb-13	1200	D	E-46	Open	yes	76.2mm day before	Conjola Park
19-Mar-13	85	B	E-39	Closed	No		Lake Conjola Village
19-Mar-13	350	C	E-44	Closed	No		The Steps
19-Mar-13	42	B	E-46	Closed	No		Conjola Park
22-Apr-13	560	D	E-39	Open	Yes	160mm 2 days earlier + 70 mm day before	Lake Conjola Village
22-Apr-13	560	D	E-44	Open	Yes	160mm 2 days earlier + 70 mm day before	The Steps
22-Apr-13	420	C	E-46	Open	Yes	160mm 2 days earlier + 70 mm day before	Conjola Park
24-Mar-14	250	C	E-39	Open	No		Lake Conjola Village
24-Mar-14	310	C	E-44	Open	No		The Steps
6-Mar-17	120	B	E-39	Open	some	average of 20-60mm daily for a week or so before	Lake Conjola Village
6-Mar-17	170	B	E-477	Open	some	average of 20-60mm daily for a week or so before	Main basin
6-Mar-17	76	B	E-479	Open	some	average of 20-60mm daily for a week or so before	Conjola Park
6-Mar-17	250	C	E-529	Open	some	average of 20-60mm daily for a week or so before	Fishermans Paradise
6-Jun-18	64	B	E-39	closed	No	31mm on the day	Lake Conjola Village
6-Jun-18	600	D	E-44	closed	No	31mm on the day	The Steps
28-Nov-18	490	C	E-39	Closed	Yes	65.8mm on the day	Lake Conjola Village
28-Nov-18	770	D	E-40	Closed	Yes	65.8mm on the day	Lake Conjola Village
28-Nov-18	560	D	E-42	Closed	Yes	65.8mm on the day	Lake Conjola Village
28-Nov-18	120	B	E-44	Closed	Yes	65.8mm on the day	The Steps
28-Nov-18	790	D	E-46	Closed	Yes	65.8mm on the day	Conjola Park
28-Nov-18	750	D	E-474	Closed	Yes	65.8mm on the day	Lake Conjola Village
28-Nov-18	500	D	E-475	Closed	Yes	65.8mm on the day	Lake Conjola Village
4-Dec-18	540	D	E-39	closed	No	Closest rain event was 28-Nov	Lake Conjola Village
4-Dec-18	44	B	E-474	closed	No	Closest rain event was 28-Nov	Lake Conjola Village
4-Dec-18	60	B	E-475	closed	No	Closest rain event was 28-Nov	Lake Conjola Village
23-Apr-19	370	C	E-39	Closed	No	9mm on the day	Lake Conjola Village
23-Apr-19	900	D	E-40	Closed	No	9mm on the day	Lake Conjola Village
23-Apr-19	200	C	E-42	Closed	No	9mm on the day	Lake Conjola Village
23-Apr-19	300	C	E-44	Closed	No	9mm on the day	The Steps
23-Apr-19	80	B	E-46	Closed	No	9mm on the day	Conjola Park
23-Apr-19	700	D	E-474	Closed	No	9mm on the day	Lake Conjola Village
23-Apr-19	260	C	E-475	Closed	No	9mm on the day	Lake Conjola Village
4-Mar-20	47	B	E-39	Open	No	14mm on the day	Lake Conjola Village
4-Mar-20	130	B	E-40	Open	No	14mm on the day	Lake Conjola Village
4-Mar-20	610	D	E-42	Open	No	14mm on the day	Lake Conjola Village
4-Mar-20	500	D	E-474	Open	No	14mm on the day	Lake Conjola Village
4-Mar-20	170	B	E-475	Open	No	14mm on the day	Lake Conjola Village
4-Mar-20	730	D	E-480	Open	No	14mm on the day	Pattimores Lagoon

Utilising the widely accepted Beachwatch enterococci ratings system for recreational water quality, a comparison has been undertaken for each year between 2003 and 2021, reflecting on the number of

samples taken as a point of interest, but more interestingly comparison of rainfall to the number of poor water quality results, as shown in **Table 4-11**.

While not statistically validated (as Beachwatch reporting is), the water quality data indicates Lake Conjola is generally suitable for recreation independently of whether the entrance is open or closed. Over the last 19 years, a minimum of 85% of all sample results from all locations (single point sampling of sites across Lake) achieved a Very Good or Good grade.

Table 4-11: Lake Conjola water quality results across all sites and annual rainfall

Year	Yearly analysis (%)				# Samples	Annual Rainfall (mm)
	A	B	C	D		
2003	100%	0%	0%	0%	2	1154
2004	92%	8%	0%	0%	12	1074.4
2005	100%	0%	0%	0%	6	1032.8
2006	100%	0%	0%	0%	17	948.8
2007	95%	5%	0%	0%	87	1227.2
2008	96%	4%	0%	0%	46	933.6
2009	98%	2%	0%	0%	41	743.8
2010	92%	8%	0%	0%	59	1281.4
2011	82%	13%	3%	2%	61	1286.6
2012	84%	15%	1%	0%	185	1060
2013	69%	16%	5%	9%	55	1505.8
2014	78%	13%	9%	0%	23	1296.6
2015	94%	6%	0%	0%	18	1538.2
2016	96%	0%	4%	0%	24	1338.2
2017	88%	9%	3%	0%	34	1186.9
2018	84%	9%	2%	5%	152	903
2019	93%	4%	1%	1%	398	819.4
2020	88%	11%	0%	2%	169	1529.2
2021	94%	0%	6%	0%	16	1489.6
	V. Good	**Good**	**Fair**	**Poor**		

As a comparison, as well as the open coast beaches, Beachwatch also undertake sampling of 17 lake and lagoon swimming sites across NSW (note that this does not include Lake Conjola). In the 2020-2021 sampling period, only four (24%) of the lake and lagoon swimming sites graded by DPE recorded a beach suitability grade of 'Good' (refer **Figure 4-18**). By inference, Lake Conjola would appear to maintain higher recreational water quality than the majority of the monitored Beachwatch locations.

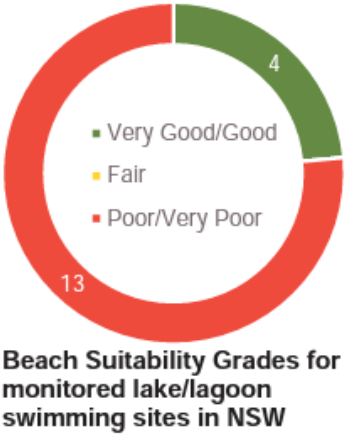

Figure 4-18: NSW Beachwatch Lake/Lagoon water quality results 2020/2021

It is interesting to note that during the 2000's, when the Lake remained open for a long period of time, this coincided with a period of relatively low rainfall, and a drought in most of eastern Australia. Low rainfall can be associated with the occurrence of fewer ocean storms, which are often the drivers of entrance closure due to movement of sand by wave action. During this period water quality was either very good or good.

From 2013 onwards Lake Conjola experienced higher rainfall than during the previous decade, which coincided with a number of entrance closure events. However, Lake Conjola has still recorded good recreational and ecological water quality results.

4.4.3.7 Summary of Recreational Water Quality Assessment

While the Aquadata site provides a significant volume of raw data, inconsistencies within the sampling methodology (temporal and spatial distribution, frequency, range of parameters analysed) lead to difficulties in seeking definitive conclusions. It is recommended that future water quality sampling is undertaken consistently at a selected number of sites that provide spatial coverage across the lake waterbody. A range of ancillary information should also be recorded during each site visit to aid in interpretation of the collected data, including weather conditions, recent rainfall quantity and dates, water levels, tide condition, and open/closed status of the entrance.

However, results of analysis indicate that there is low concern for recreational water quality within Lake Conjola, with poor results generally associated with rainfall (indicating catchment based source(s)) rather than related to entrance condition.

The water quality data indicates that Lake Conjola is generally suitable for recreation independently of whether the entrance is open or closed. Over the last 19 years, a minimum of 85% of all sample results from all locations (single point sampling of sites across the Lake) achieved a Very Good or Good grade.

When poor water quality events do occur, they may not be as widespread throughout Lake Conjola as may have been expected, as poor water quality results appear to be recorded inconsistently at a range of locations. Furthermore, the results do not appear to support the influence of a single large source of pollutants (e.g. groundwater plume, over-fertilisation of rural / farmland, or similar), due to the varied distribution of poor water quality results. It is more likely to be associated with localised point sources such as drains from urban areas.

It is noted that many residents and tourists prefer the look of clear ocean water when the entrance is open, and associate this water clarity with a “healthy” waterway that is suitable for recreation and human contact. Assessment of the recreational health water quality results indicates that Lake Conjola is predominantly a healthy, safe, recreational waterbody, whether the entrance is open or closed.

Often the perceived problems with intermittently closed lakes/lagoons such as Lake Conjola (e.g. poor water quality) can be better managed by increasing public awareness of ICOLL environments, addressing public perception, individual and collective behaviour change (e.g. over-fertilisation of residential and rural properties), and resolving broader issues in the catchment (e.g. reducing polluting inputs, relocating or raising assets and infrastructure), rather than undertaking excessive entrance management actions.

5 Marine Estate / Fisheries

Consistency between the Marine Estate Management Strategy and CMPs is an essential element listed in the Coastal Management Manual (the Manual) (DPIE, 2018). The legal framework for management of the marine estate and the state-wide Threat and Risk Assessment undertaken by the Marine Estate Management Authority (MEMA) are discussed below.

5.1 Legal framework - *Marine Estate Management Act 2014* (MEM Act)

To reduce social conflict and improve effective management of coastal and marine resources beyond existing marine parks, the NSW Government introduced the *Marine Estate Management Act 2014* (MEM Act). The MEM Act provides for strategic and integrated management of the whole marine estate. The marine estate includes all marine waters, estuaries and coastal areas. The NSW Government also established a new advisory Marine Estate Management Authority (MEMA). A statutory object of the CM Act is to support the objects of the MEM Act.

The *marine estate* refers to the coastal waters of the State in accordance with the *Interpretation Act 1987*, which comprise estuaries up to the highest astronomical tide, lakes, lagoons, coastal wetlands, and lands immediately adjacent to, or in the immediate proximity of, coastal waters that are subject to oceanic processes (including beaches, dunes, headlands and rock platforms).

MEMA has undertaken a state-wide Threat and Risk Assessment (TARA) (WBM BMT, 2017) to consider and prioritise the social, economic and environmental threats to community benefits of the marine estate. The Marine Estate Management Strategy (MEMA, 2018) has been prepared to allow a holistic approach to dealing with the cumulative threats to the marine estate.

Although the state-wide MEMA threat and risk assessment was undertaken at a much broader scale than the Shoalhaven region, information from the MEMA background reports will be reflected during development of the actions within the Lake Conjola CMP.

5.2 NSW Marine Estate – Threat and Risk Assessment (TARA)

5.2.1 General

The Marine Estate Threat and Risk Assessment (TARA) process and associated reporting ranked Environmental, as well as Social, Cultural and Economic priority threats across the State, as well as within Northern, Central and Southern NSW regions.

Lake Conjola is included within the South Region assessment, from Shellharbour to the NSW/VIC border, which includes the coastline, estuaries, coastal lakes and lagoons, beaches and ocean waters to the limit of state waters, which is three nautical miles from the coast or relevant island baseline. The landward boundary of the planning area includes coastal and estuarine waters to the limit of tidal influence, but also includes adjoining land uses and activities that could affect the marine estate.

The outputs of the TARA are intended to be used as a key input to inform the development of management responses at a state-wide scale, as well as regional and local scales, with the latter being addressed through new marine park management plans, and coastal management programs. The priority threats for the Environmental TARA and Social, Cultural and Economic TARA, as well as the shared risks (that are priorities across both the Environmental and Social, Cultural and Economic assessments) for the South region, are described below.

5.2.2 Assessment of Shared Risks across Environmental Assets and Social, Cultural and Economic Benefits

Through tabulating the data obtained from the TARA process, the combined list of environmental stressors across the marine estate can be viewed through a social, cultural and economic lens with a view to identifying those stressors that have high and moderate risk to environmental assets, and that pose high and moderate risks to social and economic benefits if realised, with the linkages between activities and stressors documented, along with the prioritisation methods (BMT WBM, 2017).

Figure 5-1 shows graphically how priority stressors (in this case urban stormwater discharges, relevant for Lake Conjola) affect environmental and social, cultural and economic benefits of the marine estate. When considering this figure from right to left, the dependencies between social, cultural and economic benefits derived from the marine estate and environmental assets can be more clearly identified as well as identification of the key stressors that 'flow through' to impact these social and economic benefits indirectly. An example of this flow is shown vertically in **Figure 5-2** for the stressor 'Water Pollution' (BMT WBM, 2017), which is also relevant for Lake Conjola.

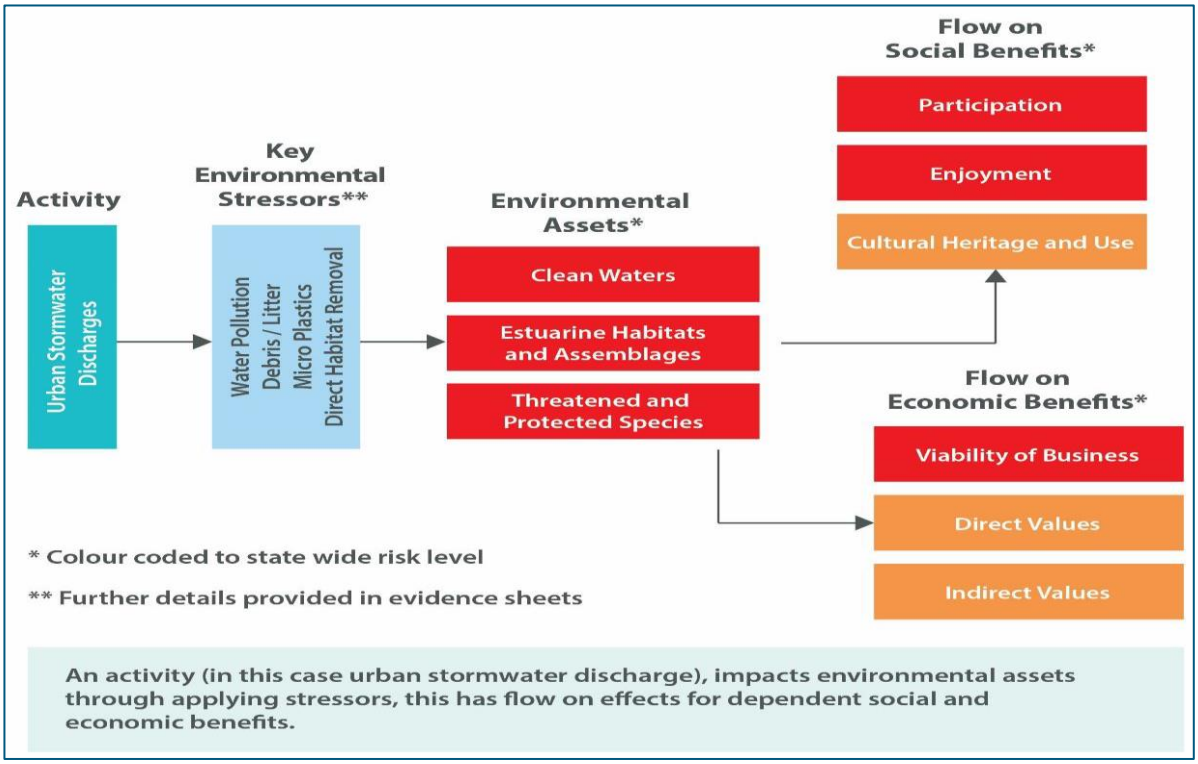

Figure 5-1: Relationship between Activities, Stressors, Environmental Assets and flow on Social and Economic Benefits - Urban Stormwater Discharges

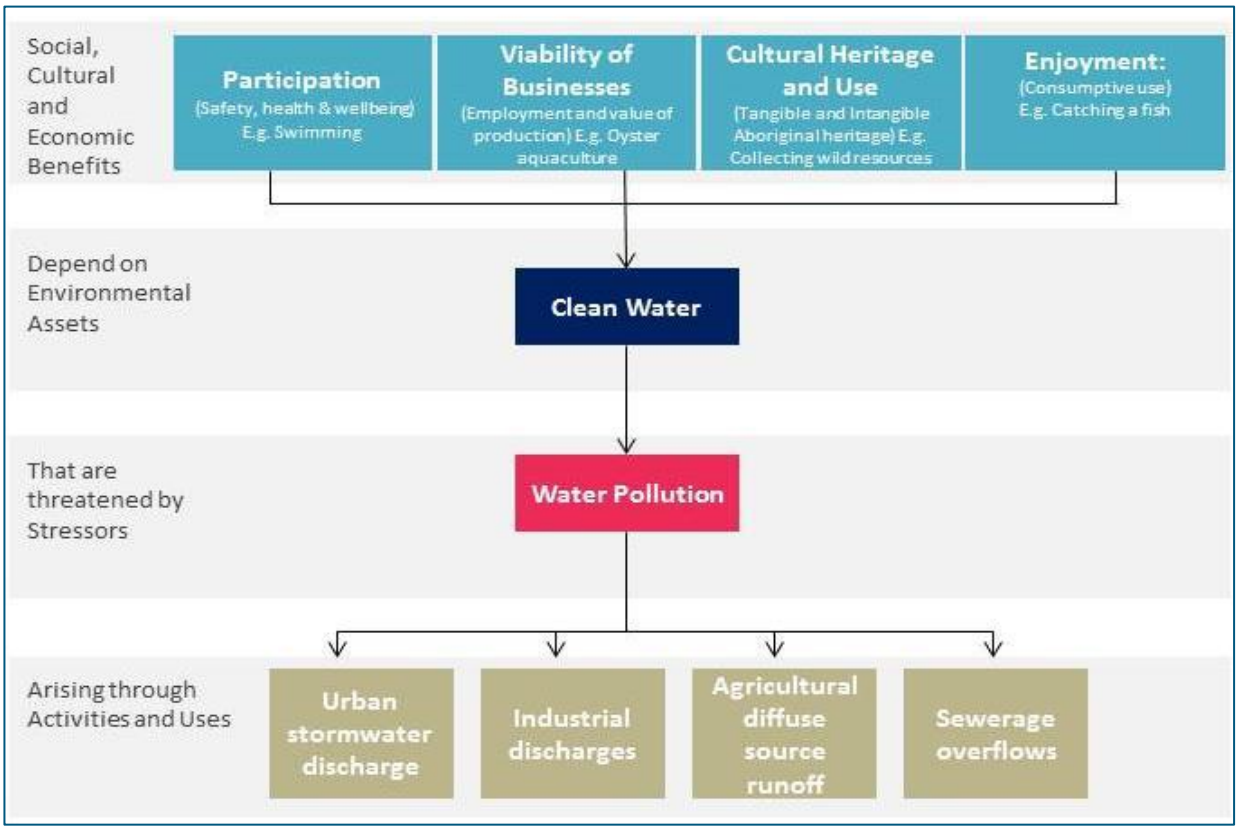

Figure 5-2: Social, cultural and Economic Benefit Dependencies and Threats – Water Pollution

5.2.3 Ranked Priority Threats to Environmental Assets for the South Region (BMT WBM, 2017)

The ranked priority threats to environmental assets for the South Region are listed below (threats not considered to be relevant for Lake Conjola have been ~~struck through~~).

- Agricultural diffuse source runoff (in estuaries)
- Estuary entrance modifications
- Urban stormwater discharge
- Modified Freshwater flows - Modified freshwater flows (in estuaries)
- Clearing riparian and adjacent habitat including wetland drainage (in estuaries)
- Climate Change (20yrs)
- Recreation and tourism - Boating and boating infrastructure (in estuaries)
- Foreshore development
- Navigation & entrance management and modification, harbour maintenance, dredging etc. (in estuaries)
- Stock grazing of riparian and marine vegetation (in estuaries)
- Sewage effluent and septic runoff (in estuaries)
- Recreation and Tourism – four wheel driving (in estuaries)
- Recreational fishing - Boat-based line and trap fishing
- Deliberate introduction of plants and animals (e.g. foxes, bitou bush)
- Passive Recreational Use
- ~~Commercial fishing – Estuary General~~

- Oyster aquaculture (in estuaries)
- ~~Commercial fishing - Ocean Haul~~
- Recreational fishing – Shore-based line and trap fishing
- ~~Beach nourishment and grooming~~
- ~~Charter activities – Whale and dolphin watching~~
- ~~Commercial fishing - Ocean Trap and Line~~
- ~~Commercial fishing – Abalone (in coastal and marine waters)~~
- ~~Commercial fishing – Sea urchin and turban shells (in coastal and marine waters)~~
- Recreational fishing - Hand Gathering (in coastal and marine waters)
- ~~Shipping - Small commercial~~
- ~~Shipping – Large commercial (in estuaries)~~

5.2.4 Ranked Priority Threats to Social, Cultural and Economic Benefits for the South Region (BMT WBM, 2017)

The ranked priority threats to social, cultural, and economic benefits for the South Region are listed below (threats not considered to be relevant for Lake Conjola have been ~~struck through~~).

- Water pollution on environmental values - urban stormwater discharge
- Water pollution on environmental values - Agricultural diffuse source runoff
- Water pollution on environmental values - litter, solid waste, marine debris and microplastics
- Inadequate social and economic information
- Lack of compliance with regulations (by users) or lack of compliance effort (by agencies)
- Reductions in abundances of species and trophic levels
- Limited or lack of access infrastructure to the marine estate
- Climate change stressors 20 years
- Loss of public access (either by private development or Government area closures)
- Anti-social behaviour and unsafe practices
- Inadequate, inefficient regulation, over-regulation (agencies)
- Loss or decline of marine industries
- Pests and diseases
- Conflict over resource access and use
- Habitat (physical) disturbance
- Overcrowding / congestion
- Water pollution on environmental values - septic runoff, point source pollution and sewage overflows (such as outfalls, WWTPs, etc.) and
- Modified hydrology/hydraulics and flood regime
- Wildlife disturbance (shorebirds, turtles, whales) and impacts to ecological health by dog walkers, 4WD, marine vessels, etc.
- Lack of community awareness of the marine estate, associated threats and benefits, regulations and opportunities for participation
- ~~Seafood contamination~~
- ~~Excessive or illegal extraction~~
- Sediment contamination
- Lack of or ineffective community engagement or participation in governance
- Other water pollution/contamination affecting human health and safety

5.2.5 Shared Priority Threats across Assets and Benefits for the South Region (BMT WBM, 2017)

The shared priority threats across assets and benefits for the South Region are listed below.

- Climate change stressors (sea level rise, altered storm/cyclone activity, flooding, climate and sea temperature rise, altered ocean currents and nutrient inputs)
- Agricultural diffuse source runoff (in estuaries)
- Urban stormwater discharge
- Habitat (physical) disturbance

Note: This list includes only those priority threats that are directly comparable between the environmental and social, cultural and economic TARAs. Other threats will overlap between the two TARA priority lists however they are not directly equivalent.

5.2.6 Application of TARA results within the Lake Conjola CMP

There is significant overlap between the issues and threats identified within the TARA and those that have been considered during development of the threat based approach to risk assessment prepared during Stage 2 of the Lake Conjola CMP.

The Environmental, as well as Social, Cultural and Economic priority threats identified for the South Region and listed above, have been considered and included (where relevant) within the Threat-Based Risk Assessment (refer **Section 9.3**) undertaken for the Lake Conjola CMP with Council and a number of State Government Agencies.

5.3 Potential Threats to Lake Conjola's Marine Environment

5.3.1 Excessive Nutrients

Agricultural development and urbanisation in the coastal areas has led to a marked increase in nutrient loads entering estuarine and coastal waters. Nationally, nutrients entering marine waters through river discharge account for about 85% of nutrients in coastal zone waters (Brodie, 1997). Land clearing, grazing and the use of agricultural fertilisers are recognised as being the primary causes of increased catchment nutrients and domestic sewage and other effluents can be significant near urban centres (Brodie, 1997; Koop and Hutchings, 1997b). This has resulted in eutrophic conditions and increased algal blooms in many estuaries and bays around Australia (Brodie, 1997).

Australian marine waters are naturally nutrient poor due to a combination of factors including the poor nutrient status of Australian soils, the small quantity of freshwater runoff, and the absence of major upwelling systems. Nutrient deficiency in turn limits primary production. Eutrophication alters the ecosystem via the following biological progression (GESAMP, 1990):

- Increased primary production;
- Changes in plant species composition;
- Very dense, often toxic, blooms;
- Conditions of hypoxia (low oxygen concentrations) or anoxia (no oxygen);
- Adverse effects on fish and invertebrates; and
- Changes in structure of benthic communities.

Eutrophic waters typically support a high standing stock of attached algae or phytoplankton (Brodie, 1997), the latter also producing an increase in turbidity resulting in decreased light penetration that affects benthic plants.

Adverse effects on marine invertebrates can range from massive kills caused by the low levels of dissolved oxygen or the toxins released from dense blooms of noxious dinoflagellates, to more indirect effects resulting from habitat deterioration or shifts in community structure to favour more pollution tolerant taxa. For instance, the turbidity caused by increased growth of microscopic phytoplankton can have serious consequences for the growth and survival of seagrass beds, which rely on adequate transmitted light and therefore, relatively clear waters (Engel and Thayer, 1998).

Seagrass die-off due to eutrophication, with associated losses of fauna, has been documented in several locations (e.g. Hutchings et al. 1991). Most light reduction is caused by increased water turbidity and an increase in the biomass of epiphytes on the seagrass leaves (Larkum, 1976; Hutchings et al., 1991; State of the Environment Advisory Council, 1996; Butler and Jernakoff, 1999; Longstaff et al.,1999).

Within the context of Lake Conjola, it is important to recognise sub-catchments and / or site-specific locations that are likely to produce the highest concentrations of TN by location and per hectare. This is discussed further in **Section 6**. Consideration of the range of land uses within developed sub-catchments may identify opportunities for point source and / or diffuse intervention measures to reduce TN exports into Lake Conjola. The main sources of nutrient input into Lake Conjola are from uncontrolled runoff from urbanised foreshore areas and from grazing land use.

5.3.2 Excessive Sediments

Increased sediment loads result in less light penetration and siltation. The process originates from human activities in catchments (e.g. vegetation clearance, excavation, construction) that lead to greater volumes of terrigenous material being carried into coastal areas by rivers, or from physical disturbance of marine sediments (e.g. by dredging). For example, dredging increases water turbidity while the dredging is in progress and the effect is prolonged when the dredge material is resuspended by wind and/or wave action (Fitzpatrick and Kirkman, 1995).

Poor management practices in catchments can result in markedly increased sedimentation (Gourlay and Hacker, 1986; Arakel et al.,1989; Frouin, 2000) and may result in the expansion of mudflat and mangrove habitat at the expense of other habitats (Brodie,1997). In addition, when suspended sediments settle, benthic organisms and aquatic vegetation can be smothered and bottom substrates altered (e.g. from sand to mud).

Seagrasses are susceptible to sedimentation due to both light reduction and direct smothering (Robertson, 1991). Depth distributions of seagrasses are linked to light penetration, and they can be impacted by events that reduce the amount of light reaching the seagrasses for long periods. Light deprivation occurs through increased turbidity or increased epiphyte growth on seagrass leaves (often related to increased nutrient levels). Changes to their community structure may have impacts on the seagrass community (Fitzpatrick and Kirkman, 1995).

Within the context of Lake Conjola, the twin processes of erosion and sedimentation describe the progressive movement of material being transported into the lake or away from the foreshores by action of waves, water and wind. Potential sources of sediment include the catchment, lake foreshore and ocean.

The processes of erosion and sedimentation may include aeolian transport of barrier dune sands, fine catchment soil carried via flooding or storms, coarser sediment from bank erosion transported down

tributary streams, estuary bank erosion from wind-waves and boat wake, human intervention (changes in land use, modification to channels/riparian areas), natural channel meandering and marine sand carried into the inlet channel by tidal exchange when the entrance is open.

During preparation of the Lake Conjola Estuary Management Plan (Council, 1998), evidence of significant sedimentation was identified dating back to 1944 in the shoals behind the entrance dune, suggesting that the majority of the deposited sand had originated from the southern entrance dune. It was noted that there were few existing erosion problems in the main water bodies of Lake Conjola, Berringer Lake and Pattimores Lagoon. Minor localised bank erosion had been identified generally along tidal channels connecting to the ocean.

The Lake Conjola Estuary Management Plan (Council, 1998), found that possible causes of sedimentation and erosion included:

1. Sediment generation – road construction and maintenance, agriculture and forestry land use practices, and urban development;
2. Bank Erosion – Natural channel migration, wind waves, freshwater flood flows, vegetation removal and human activities on banks/dunes, trampling by stock and boating activities (wake); and,
3. Aeolian/wind transport of exposed dunes.

5.3.3 Study Area Observations

Inspection of the study area by site walkover of foreshore areas and boating access to remote areas of the lake identified several mechanisms for release of nutrients and/or sediments into the Lake Conjola marine environment. These are discussed in **Section 7** and comprise:

- Ad hoc foreshore stabilisation works (refer **Section 7.2**);
- Lack of riparian vegetation (refer **Section 7.3**);
- Uncontrolled stock access to foreshore areas (refer **Section 7.6**); and,
- Uncontrolled stormwater runoff (refer **Section 7.7**).

6 Influence of Catchment Management on Waterway Health

6.1 Application of the Waterway Health Risk-based Framework for the Lake Conjola Catchment

In 2020, the NSW government undertook a comprehensive desktop analysis of the Shoalhaven LGA catchments and provided two reports to help inform the prioritisation and location of management actions that contribute to achieving outcomes for the health of estuaries, and to support the management objectives of the CM SEPP.

Seeking to assist the delivery of Shoalhaven LGA CMPs, in 2020 DPE proactively undertook development of the first two steps in the Waterway Health Risk-based Framework for the entire Shoalhaven coastal area. DPE have prepared draft diffuse source pollution risk assessment maps, and an associated draft report entitled *"Shoalhaven Local Government Area Estuary Health Diffuse Source Pollution Risk Assessment Mapping"* to help inform the preparation of Coastal Management Programs (CMPs) for Shoalhaven estuaries, including Lake Conjola.

Entitled "NSW Estuary Health Risk Dataset – A first-pass risk assessment to help with the prioritisation of catchment management actions" (DPIE, 2019), and the (draft) "*Shoalhaven Local Government Area Estuary Health Diffuse Source Pollution Risk Assessment Mapping*", the information and dataset has aided a 'first-pass' assessment within the Lake Conjola CMP (DPIE, 2020).

The maps that have been generated through this assessment, when used with other information sources, can assist in identifying potential priority areas for managing sediment and nutrient runoff (e.g. through appropriate land management practices). They can also help to identify high risk areas where land use intensification (e.g. converting bushland to urban or agricultural uses) should be avoided, as changes to these areas are likely to have a greater influence on estuary health than elsewhere in the catchment.

Where land use intensification is to occur, application of stringent pollutant reduction targets may be required for developments in these areas, to ensure a neutral or beneficial effect on estuary water quality.

The NSW Estuary Health Risk Dataset is underpinned by an effects-based assessment (EBA), which consists of a coupled series of catchment, hydraulic or hydrodynamic and ecological response models in order to predict:

i) the quantity and quality of runoff from a catchment;
ii) transport of runoff and pollutants in an estuary; and,
iii) ecological responses to changes in algal biomass, water clarity and seagrass cover in an estuary (DPIE, 2020).

The modelled outputs provide a good representation of spatial trends to identify relative priorities, but do not provide absolute values to allow decisions on the amount of nutrients or sediments that need to be mitigated, or provide predictions on the absolute amount of algal biomass within an estuary.

Catchment runoff models are available for all 184 coastal catchments in NSW, where the catchment is divided into different land-use types, and the area of each land-use type is multiplied by specific local export coefficients (Roper et al., 2011). The export coefficient is the rate at which total nitrogen (TN), total phosphorous (TP), or total suspended solid (TSS) loads from each land-use type is exported to the estuary (DPIE, 2020).

The export coefficients were expressed in kilograms per hectare of the catchment per year, and derived by multiplying modelled surface flows (Littleboy et al., 2009) with measured TN, TP or TSS export concentration data (per land use) from accepted literature (Roper et al., 2011). Surface flows were modelled using 2CSalt (Littleboy et al., 2009), which is part of a suite of Australian catchment modelling tools available in the eWater Toolkit (DPIE, 2020). Using these two inputs, loads under current land use ('Diffuse current') and hypothetical natural land use ('Diffuse pre-clear') were derived along with wastewater treatment plant inputs ('WWTP'), as shown in **Table 6-1** (DPE SEED database – Estuary TSS, 2011).

Table 6-1: Lake Conjola catchment - Total Suspended Solids Load pre- and post-development

Total Suspended Solids Load		
Diffuse pre-clear (t/yr)	Diffuse current (t/yr)	Wastewater Treatment Plant (t/yr)
245	269	0.1

6.2 Current Influence on Waterway Health - Risk-based Framework Assessment of Lake Conjola

As noted above, the estuary health risk assessment is based on a coupled series of catchment runoff and estuary (hydraulic or hydrodynamic and ecological response) models, using standard export rates for TN, TP or TSS export based on land use (along with other parameters including soil type and climate).

The model is a prediction of sediment and nutrient export to the estuary but has only been calibrated based on generalised land use data. Other pollutant types and sources (e.g. stream bank erosion) are not considered. Land use data is based on the 2007 mapping which in some cases may now be outdated. This is acknowledged as a limitation that needs to be considered when interpreting the maps (DPIE, 2020), however in a relatively undeveloped catchment such as Lake Conjola, it is likely that the findings will still be applicable.

The initial assessment of catchments across the Shoalhaven LGA identified and ranked recommended priority areas for detailed investigation of catchment management actions to minimise diffuse source pollution. Three estuaries were ranked as High Priority, with key locations identified as:

1. Shoalhaven River
    - Lower Estuary – Primarily agricultural and urban land
2. **Lake Conjola**
    - **Lower Estuary - Urban foreshore areas including Lake Conjola, Conjola Park and agricultural land**
3. St Georges Basin
    - Lower Estuary – Urban areas including St Georges Basin, Sanctuary Point, Old Erowal Bay, Sussex Inlet and Wandandian

The following maps were developed by DPE for high (and medium) priority estuaries, including Lake Conjola:

- land use;

- modelled export of Total Nitrogen (TN);
- modelled export of Total Suspended Solids (TSS);
- modelled export of Total Phosphorous (TP); and,
- risk to estuary health for each sub-catchment.

Note: the information below is a subset of the data and mapping developed by DPE, and provided in **Appendix F**.

The majority of the Lake Conjola catchment is forested, with some small urban settlements and grazed areas located within the middle and lower catchment. The “urban” settlements of Fisherman’s Paradise, Conjola Park and Lake Conjola Village are located close to the lake foreshore, as shown in **Figure 6-1**.

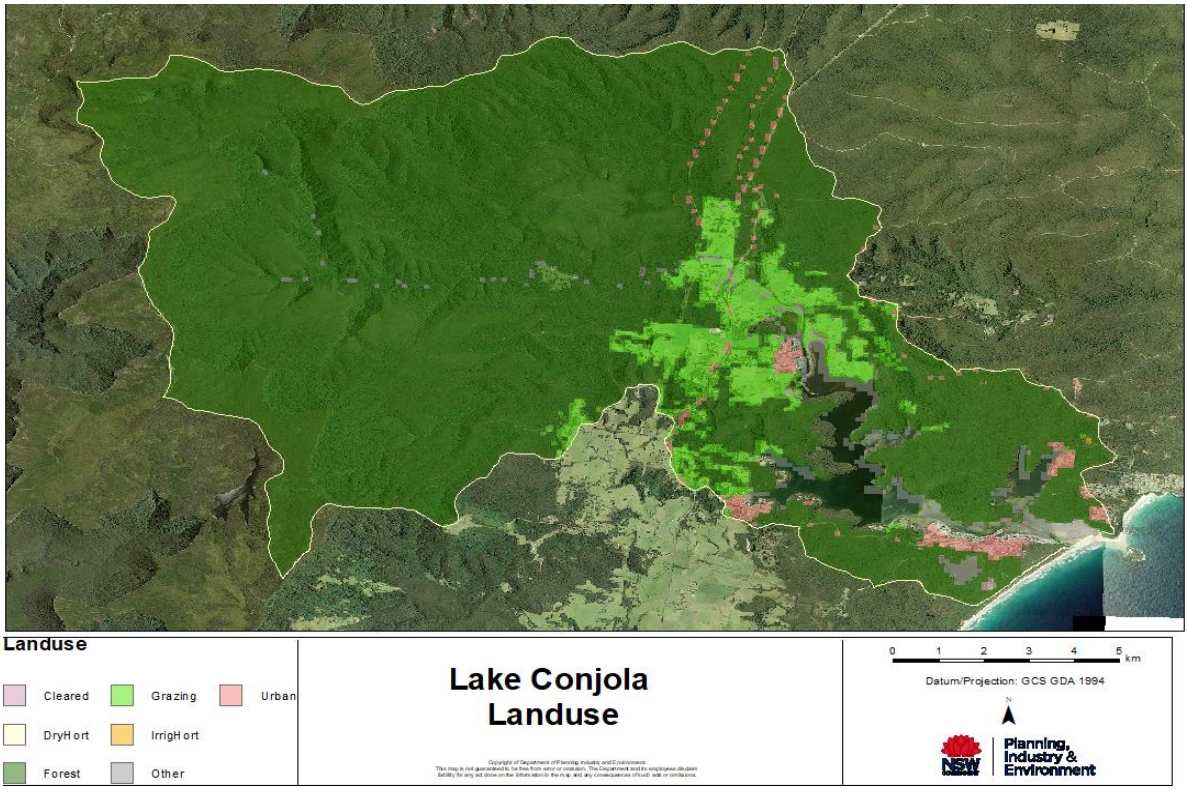

Figure 6-1: Land use within the Lake Conjola catchment (2007) (source: DPIE, 2020)

When assessed by sub-catchment area, Total Nitrogen (TN) and Total Suspended Solids (TSS) export rates were generally highest in the undeveloped upper sub-catchments as shown in **Figure 6-2** and **Figure 6-3**.

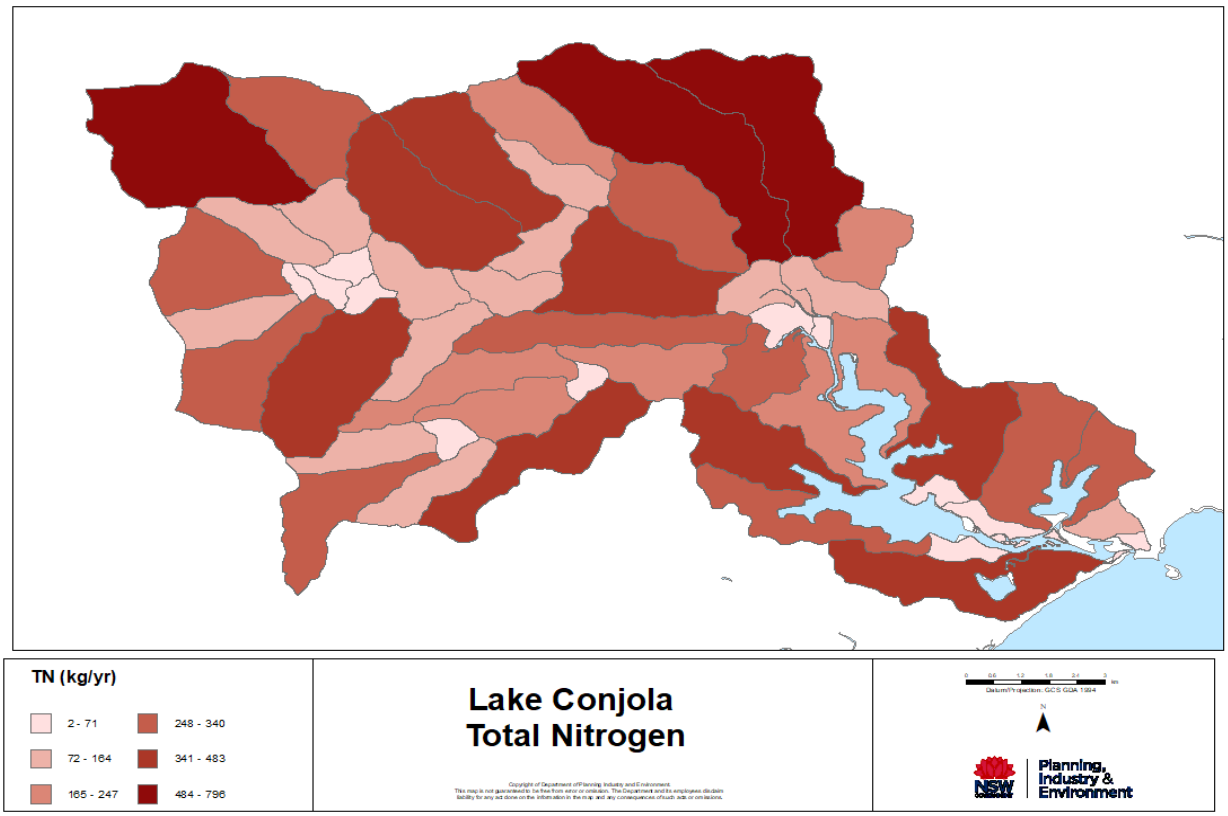

Figure 6-2: Lake Conjola Total Nitrogen (kg/yr) by sub-catchment area (source: DPIE, 2020)

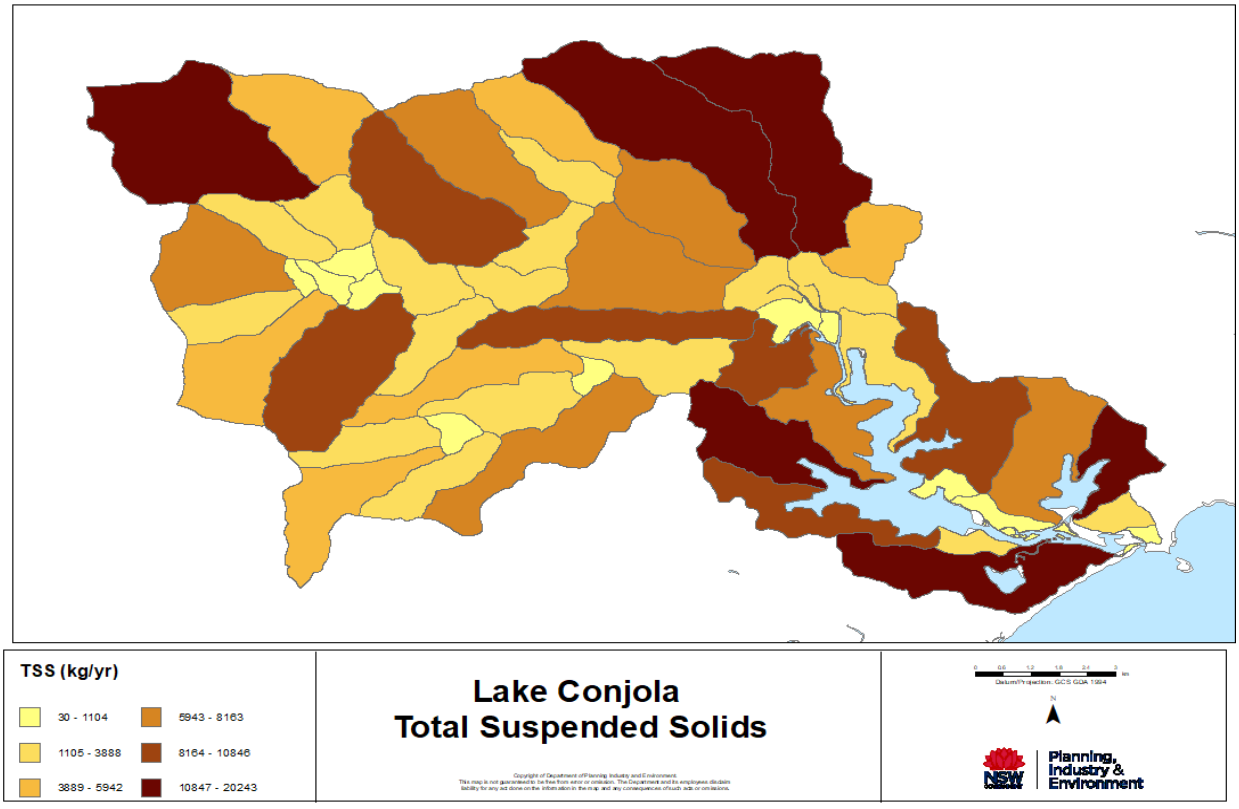

Figure 6-3: Lake Conjola Total Suspended Solids (kg/yr) by sub-catchment area (source: DPIE, 2020)

When assessing the export rates by location and per hectare, TN and TSS export rates are reflective of land use within the catchment, with higher export rates generated from urban and rural development areas as shown in **Figure 6-4** and **Figure 6-5**.

The mapped results for TN and TSS highlight the importance of maintaining the upper sub-catchment areas in an undeveloped, forested state, as developed sub-catchments have higher volumes of TN and TSS per hectare.

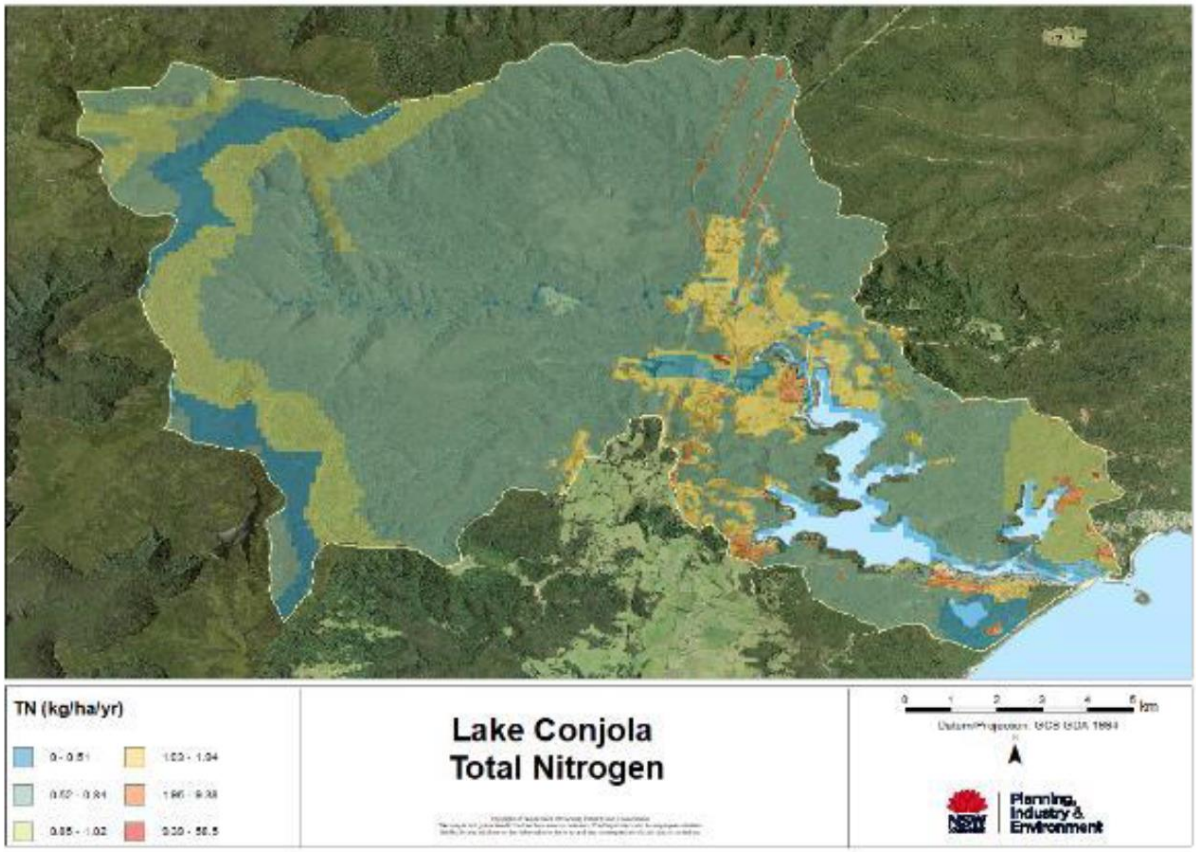

Figure 6-4: Lake Conjola Total Nitrogen (kg/ha/yr) by location (source: DPIE, 2020)

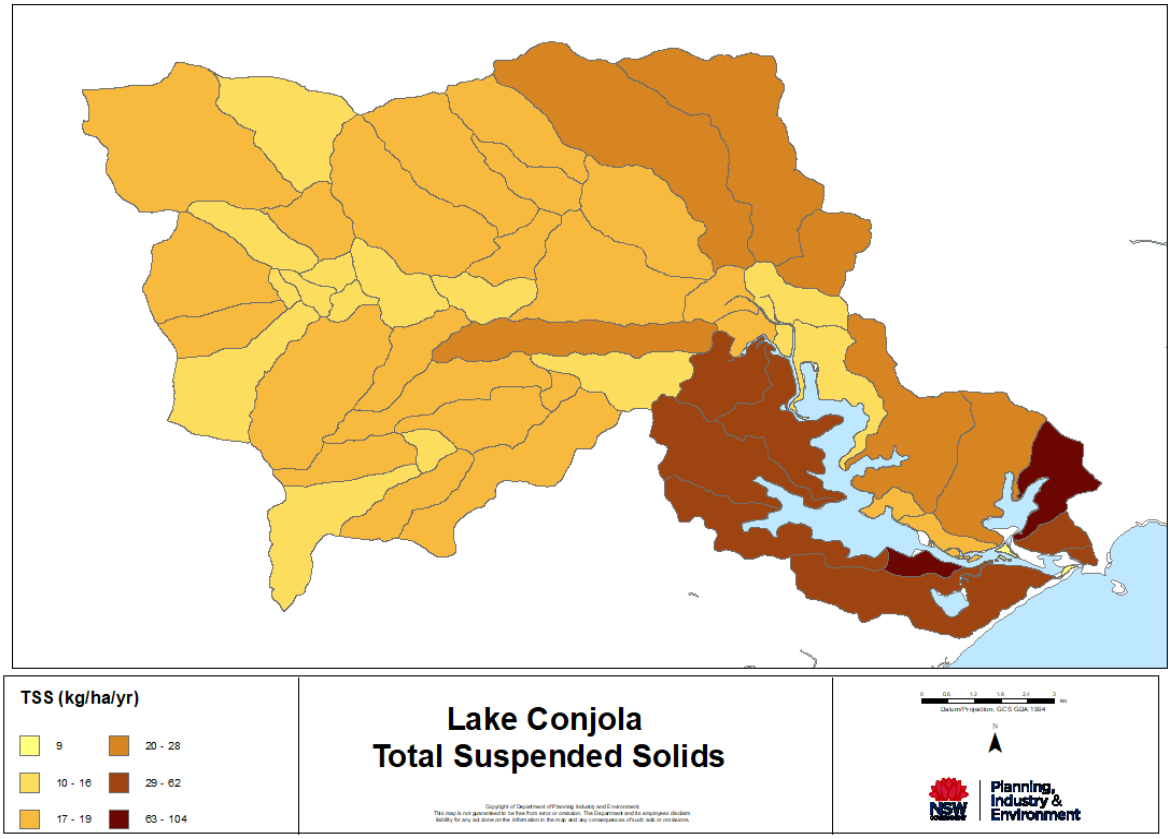

Figure 6-5: Lake Conjola Total Suspended Solids (kg/ha/yr) by sub-catchment (source: DPIE, 2020)

When assessed by location and per hectare, Total Phosphorous (TP) export rates were reflective of land use within the sub-catchment, with higher export rates generated from urban and rural development areas, potentially reflecting use of fertilisers or similar products, as shown in **Figure 6-6** and **Figure 6-7**.

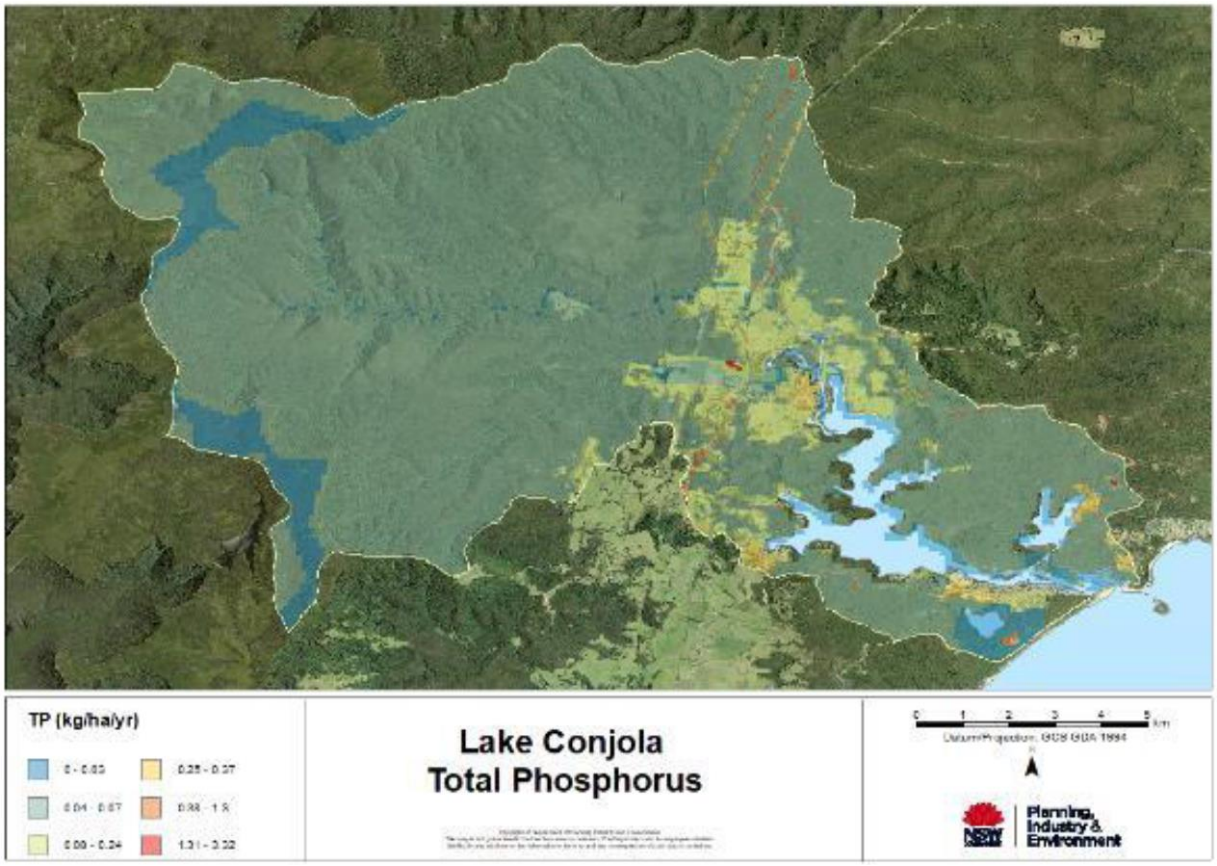

Figure 6-6: Lake Conjola Total Phosphorous (kg/ha/yr) by location (source: DPIE, 2020)

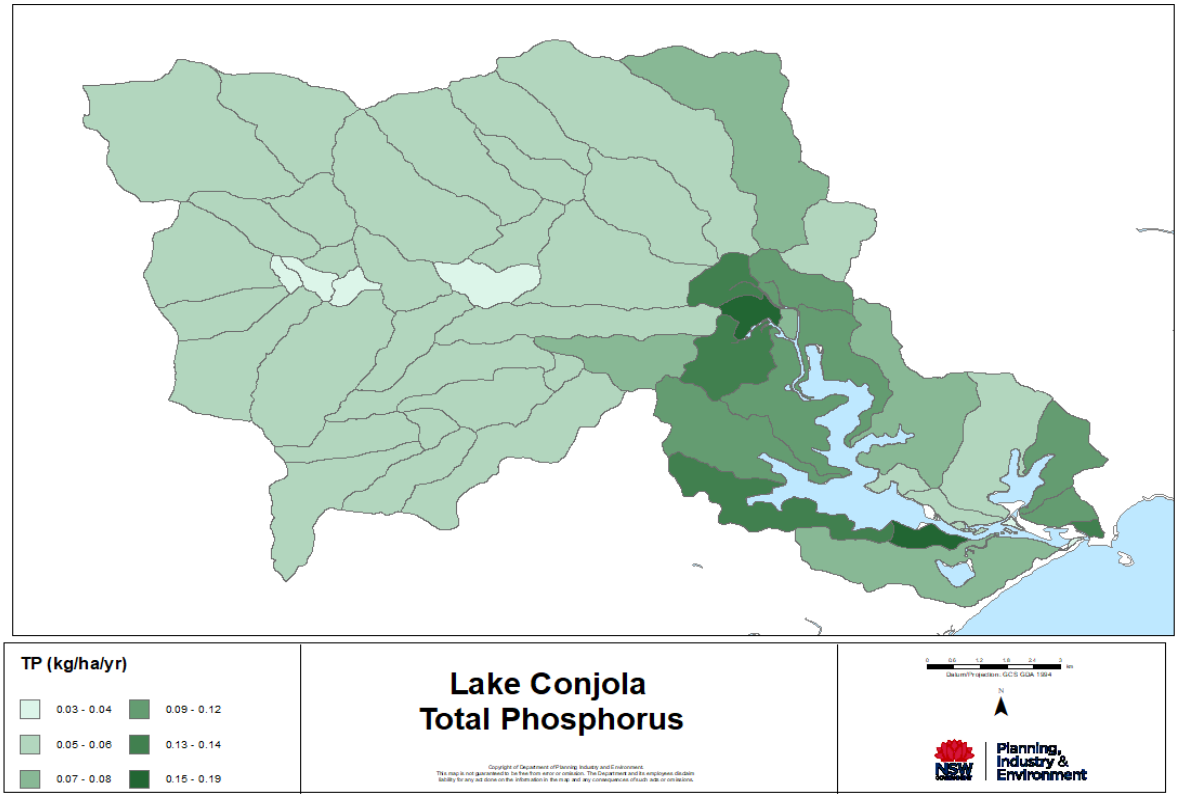

Figure 6-7: Lake Conjola Total Phosphorous (kg/ha/yr) by sub-catchment (source: DPIE, 2020)

The mapped results also suggest that, with the highest concentrations by location and per hectare, the range of land uses within developed sub-catchments may represent opportunities for point source and / or diffuse intervention measures to reduce TN, TSS and TP exports into Lake Conjola.

6.3 Waterway Health Risk Assessment for Lake Conjola

A Risk Assessment based on the combined and collated assessment of land use and modelled inputs was undertaken in DPIE (2020) to generate overall risk scores for diffuse source pollution within each of the sub-catchments of Lake Conjola.

The outcomes of the catchment and estuary models were classified into likelihood or consequence criteria, and integrated via a risk matrix. Likelihood represents the extent and intensity of land use pressure, with criteria including exports of surface flows (SF), TN, TP and TSS loads from the sub-catchment or loads per hectare. Consequence represents the extent of impact on estuary health (DPIE, 2019).

These Likelihood and Consequence scores were combined to determine a risk rating of high, medium or low for each estuary sub-catchment. The risk assessment methodology used was consistent with guidance provided in the NSW Treasury's Risk Management Toolkit and risk management standard (ISO 31000) (DPIE, 2020).

The results of the waterway health Risk Assessment are discussed below.

6.4 Potential Future Influence of Changes in Land Use on Lake Conjola

The highest risk sub-catchments are those in the steeper, undeveloped upper catchment, and areas surrounding the lake foreshore, identified as red polygons, as shown in **Figure 6-8**. These high-risk sub-catchments represent areas where land use intensification should be avoided (DPIE, 2020).

Priority areas for further detailed investigation of potential management actions within the Lake Conjola catchment include the urban areas nearest to the foreshore, as well as the areas with grazing land use.

The mapped results also suggest that, with the highest concentrations by location and per hectare, the range of land uses within developed sub-catchments may represent opportunities for point source and / or diffuse intervention measures to reduce TN, TP and TSS exports into Lake Conjola.

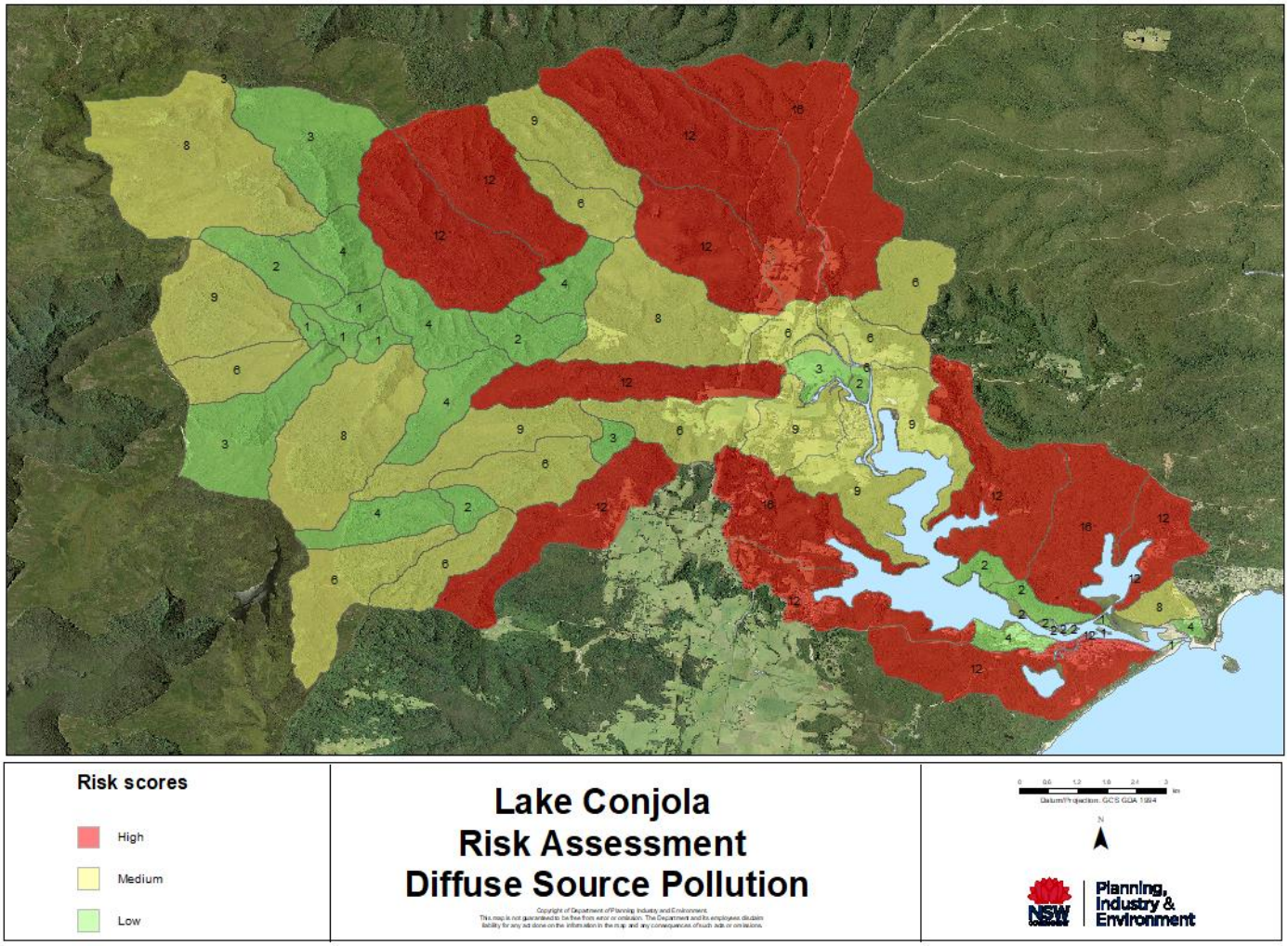

Figure 6-8: Lake Conjola Diffuse Source Pollution Risk Assessment overlaid on satellite image (source: DPIE, 2020)

It should be noted that the land use mapping used in the analysis is fairly coarse and has missed some parts of the urban areas located on the foreshore of Lake Conjola as the base mapping layer is from 2007 (as this was the most up to date available at the time of development of the NSW Estuary Health Risk Dataset). This has potentially led to a lower risk score for parts of the Lake Conjola urban area (DPIE, 2020).

For reference, and comparison with 2007 land use shown in **Figure 6-1**, updated 2017 land use mapping is shown in **Figure 6-9**. It is recommended that all current and future Risk Assessments related to the Lake Conjola CMP consider the updated 2017 land use mapping.

Priority areas for further detailed investigation of potential management actions within the Lake Conjola catchment include the urban areas nearest to the foreshore, as well as the areas with grazing land use as shown in **Figure 6-9**.

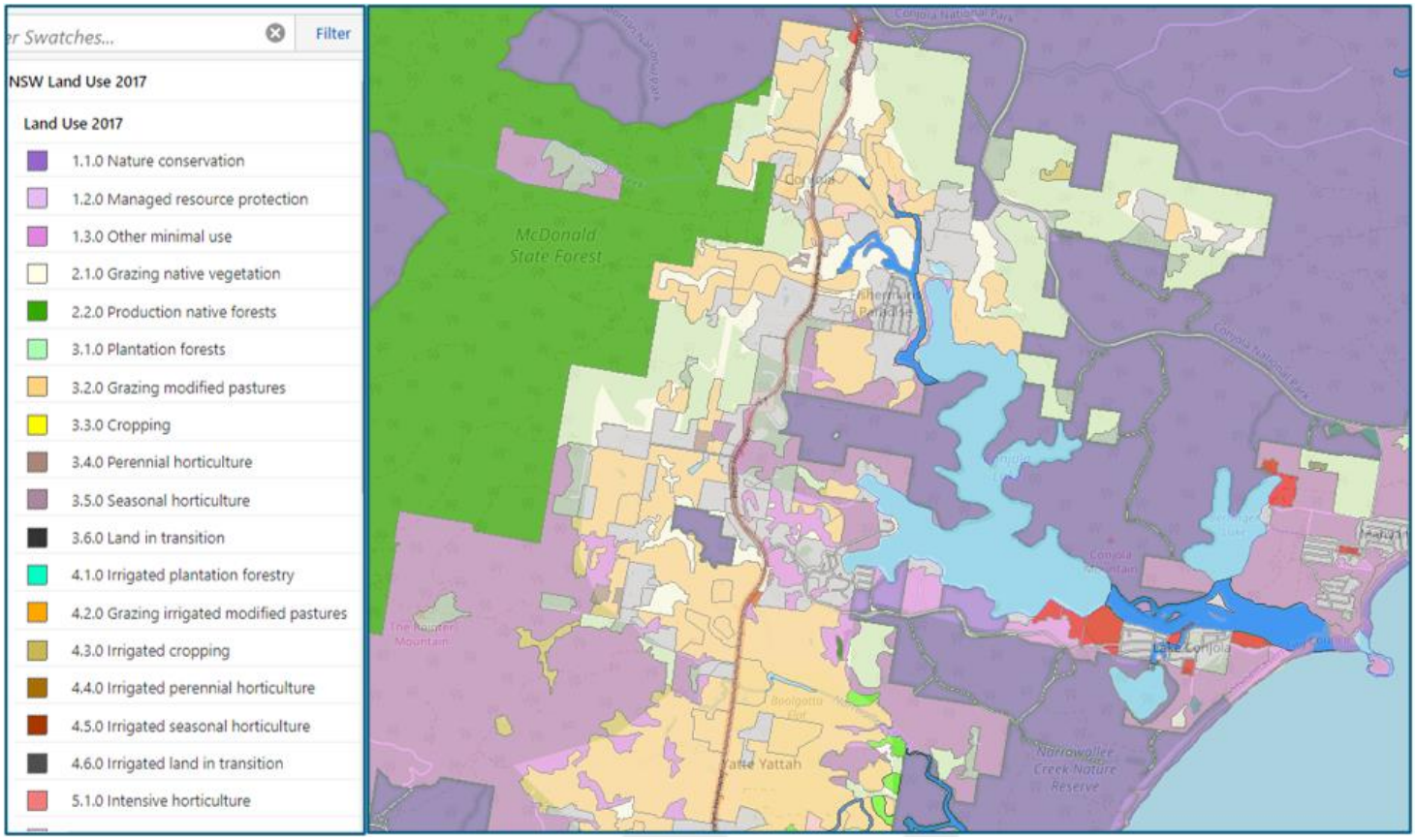

Figure 6-9: Updated Lake Conjola land use mapping (2017) (source: SEED, 2020)

7 Foreshore Erosion, Stabilisation and Structures

7.1 General

While recognising the wide range of significant inundation and water quality matters relevant to the Lake Conjola CMP, consideration must also be given to the identified coastal hazard "*erosion and inundation of foreshores caused by tidal waters*".

The first two objects (section 3) of the CM Act are directly relevant, being:

(a) to protect and enhance natural coastal processes and coastal environmental values including natural character, scenic value, biological diversity and ecosystem integrity and resilience, and
(b) to support the social and cultural values of the coastal zone and maintain public access, amenity, use and safety.

With the majority of development located within three villages (Lake Conjola Village, Conjola Park, and Fishermans Paradise), water quality immediately offshore from these locations has been identified as being a concern within the community, and there are opportunities for localised "point source" treatment options for e.g. uncontrolled stormwater runoff (often containing excess nutrients, sediment, animal/bird faeces etc.) through installation of raingardens or similar.

Appropriate access to, and management of, public and private foreshores of Lake Conjola are recognised as opportunities for short-term and medium-term actions that can be taken to address the (abridged) Coastal Hazard (as defined under the CM Act) of "(g) erosion and inundation of foreshores caused by tidal waters", which has been specifically identified as a relevant Coastal Hazard within the Lake Conjola CMP.

7.2 Ad Hoc Foreshore Stabilisation Works

At a number of foreshore locations within Lake Conjola Village in particular (although there are similar sites elsewhere also) are numerous examples of ad hoc foreshore stabilisation works utilising an array of materials, designs, heights, depths and lengths. The most common feature of these ad hoc works is that they have almost universally failed, resulting in ongoing uncontrolled erosion and sedimentation into the main waterbody, as well as generating a large number of hazardous objects and locations, as shown in **Figure 7-1**.

Rehabilitation of these foreshores, that may involve upgrading of protection structures, would be of benefit to the Lake and is an opportunity to improve safety and amenity, bank stability, reduce erosion and improve foreshore habitat. Any foreshore stabilisation works should be carried out following the principles of the environmentally friendly seawall guidelines.



Figure 7-1: Ad hoc "foreshore stabilisation works" within Lake Conjola Village area

7.3 Lack of Riparian Vegetation

It is noted that another common feature of the locations with ad hoc foreshore stabilisation works is the lack of riparian vegetation up to and including the bank of Lake Conjola. It is recommended that consideration is given to rationalisation and consolidation of the number and spatial extent of foreshore access locations.

There may be a number of benefits realised through this process, including:

- Potential removal of failed foreshore protection works;

- Bank stabilisation through revegetation with appropriate native species;
- Creation of habitat through revegetation with appropriate native species;
- Reduction in long term maintenance costs of constructed works; and,
- Reduction in erosion and loss of public foreshore land.

7.4 Private Foreshore Structures

In conjunction with the above, public access to and along foreshores within the Lake Conjola area is not always possible, due to a range of privately demarcated foreshore access ramps and jetties, as shown in **Figure 7-2**. The Marine Estate Management Strategy has identified that private accessways on foreshores are an issue that requires a strategic approach of identification of appropriate locations for placement, and removal from inappropriate locations, which could be applied within Lake Conjola (subject to recognition of current leases/licences).



Figure 7-2: Foreshore access ramps and waterway structures

7.5 Ad Hoc Watercraft Storage

There are numerous watercraft strewn around the foreshore (refer **Figure 7-3**) that not only restrict access and may cause contamination as they break down, but also impact on sensitive foreshore vegetation including saltmarsh, and significantly reduce the amenity of the Lake Conjola foreshore. Other jurisdictions have implemented removal programs, which have also included construction of designated watercraft storage facilities to mitigate re-occurrence. This would have a number of benefits at Lake Conjola.



Figure 7-3: Ad hoc watercraft storage - reduction of public amenity and access

7.6 Uncontrolled Stock Access to Foreshore Areas

Uncontrolled stock access to foreshore areas is relatively common in the upper reaches of Lake Conjola, and there are a number of public land lots within or adjacent to the main villages, as well as numerous private landholdings around the Lake, where riparian vegetation has been removed to the waterline, destabilising the immediate foreshore as well as removing habitat for a variety of terrestrial, avian and marine species, as shown in **Figure 7-4**.



Figure 7-4: Uncontrolled riparian access

Uncontrolled stock access to foreshore areas increases the sediment and nutrient load into the waterway. Increased sediment load is caused by trampling of bank areas by stock leading to loss of vegetative cover and collapse of banks into the waterway. The occupation of foreshore areas by stock also increases the likelihood of animal faeces being released and/or washed into the waterway, and along with the absence of riparian vegetation to provide runoff filtration can increase the nutrient load. Management actions to mitigate this issue could include:

- working with farmers/landowners to support change in farming practices (e.g. stock access to water)
- reinstatement of a riparian vegetation buffer along foreshore areas; and,
- installation of fencing to prevent foreshore stock access.

7.7 Uncontrolled Stormwater Runoff

Field inspection along the Lake Conjola foreshore identified several locations where surface runoff from developed urban areas was discharged into the lake in an uncontrolled manner (refer **Figure 7-5**, **Figure 7-6** and **Figure 7-7**). Management actions at these locations could include:

- filtering of runoff with provision of a riparian vegetation buffer along the foreshore edge;
- at source interception of runoff with raingardens or similar;
- replacement of hard drainage channels with grassed and vegetated swales; and,
- installation of stormwater quality improvement devices (SQIDs) such as gross pollutant traps.



Figure 7-5: Uncontrolled foreshore runoff locations at Lake Conjola Village



Figure 7-6: Uncontrolled foreshore runoff locations at Lake Conjola Village



Figure 7-7: Uncontrolled foreshore runoff location at Conjola Park

In addition, there was also unsealed areas of loose soil or gravels that were located adjacent to drainage infrastructure (refer **Figure 7-8**). These areas are likely to contribute to the sediment load discharged into the lake via the stormwater drainage system. Management actions at these locations could include:

- vegetation or paving of unsealed areas; and,
- street sweeping to remove loose sediment and gravel from sealed surfaces.



Figure 7-8: Unsealed areas adjacent to drainage infrastructure

7.8 Estuarine Vegetation Migration

Areas of low-lying wetland vegetation along the Lake Conjola foreshore have the potential to migrate landwards under the influence of sea level rise. Some of these foreshore areas are located within National Park and a landward buffer for would be protected by NPWS. Other areas of inundation of significant foreshore areas (e.g. most of the southern foreshore of the entrance channel) have limited opportunity for estuarine vegetation migration due to urban development. However, there are some foreshore areas that could be subject to 'coastal squeeze' where vegetation is adjacent to undeveloped private land may be unable to migrate due to existing or future foreshore protection or land management practices (e.g. clearing/grazing). These areas are shown on **Figure 7-9** based on the predicted extent of tidal inundation from a sea level rise of 1.2m (100+ year planning period). The management actions in these areas would be to work closely with landowners over time to explore setting aside buffers for future estuarine vegetation migration through voluntary mechanisms such as land purchase or other compensatory funding.

7.9 Foreshore Management Opportunities

The range of potential issues and actions that have been identified for further discussion and early implementation have been grouped into an array of Foreshore Management Opportunities (FMOs), as shown in **Figure 7-10**, **Figure 7-11** and **Figure 7-12**.

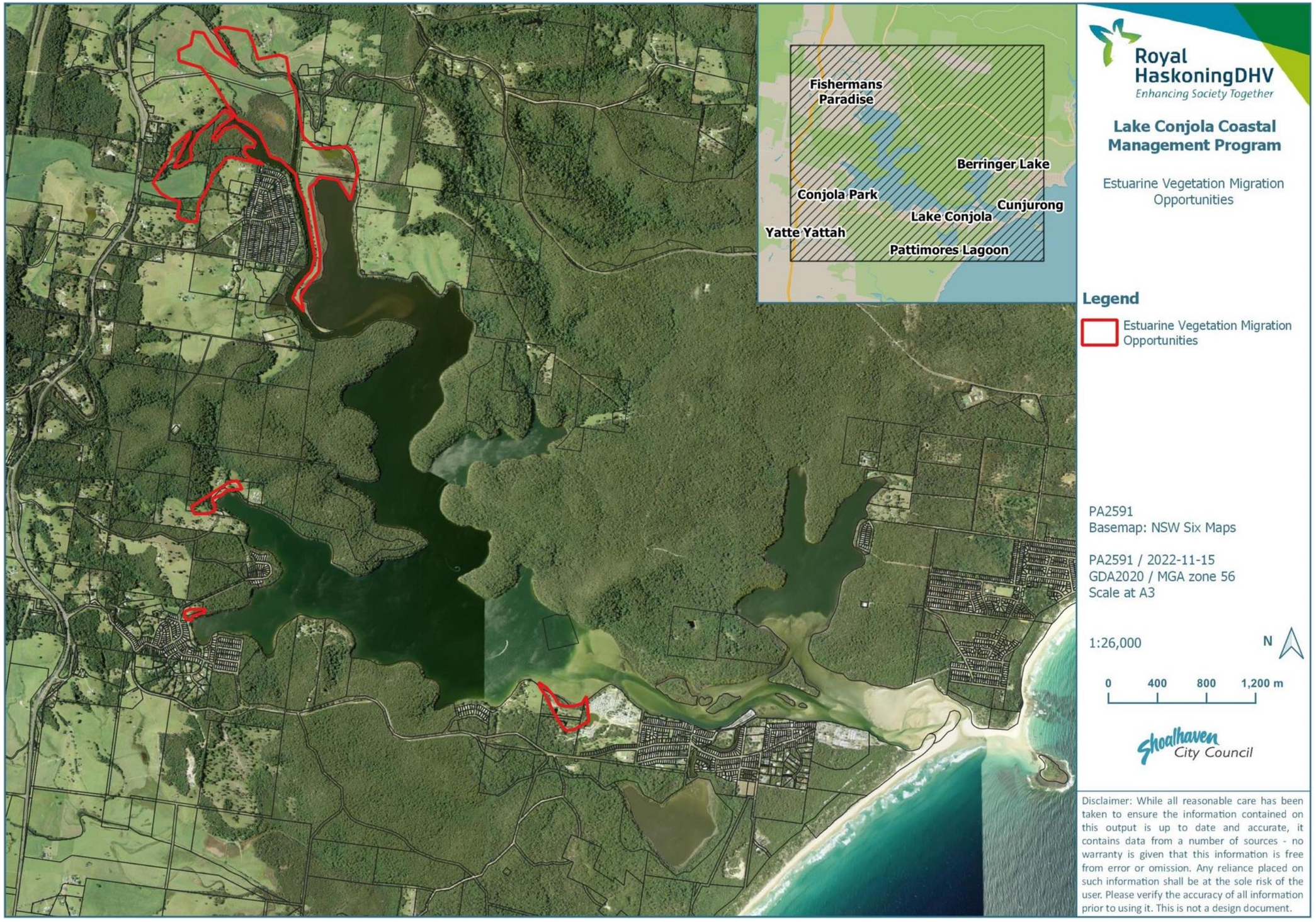

Figure 7-9: Estuarine Vegetation Migration Opportunities



Figure 7-10: Foreshore Management Opportunities (FMOs) – Fishermans Paradise

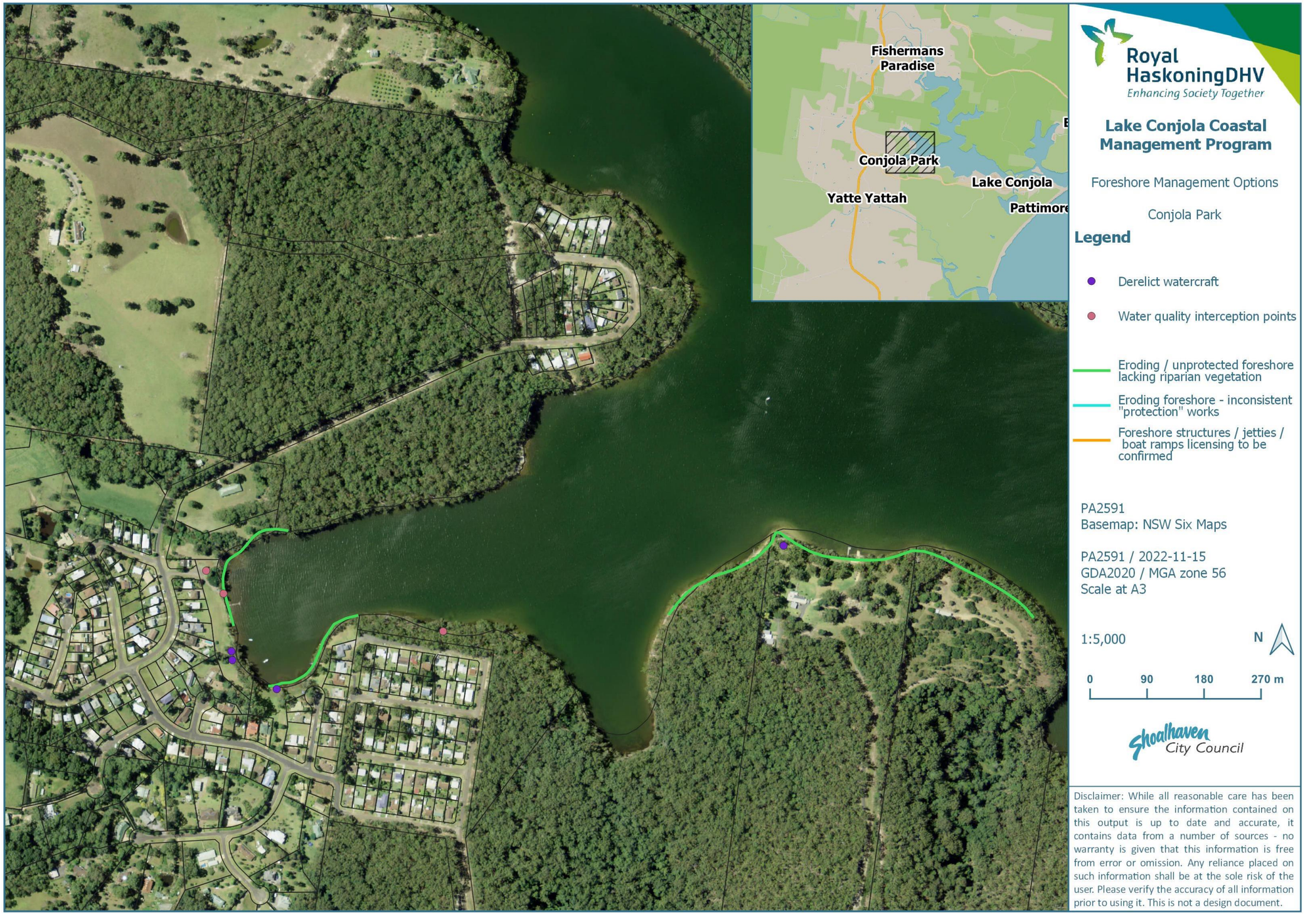

Figure 7-11: Foreshore Management Opportunities (FMOs) – Conjola Park

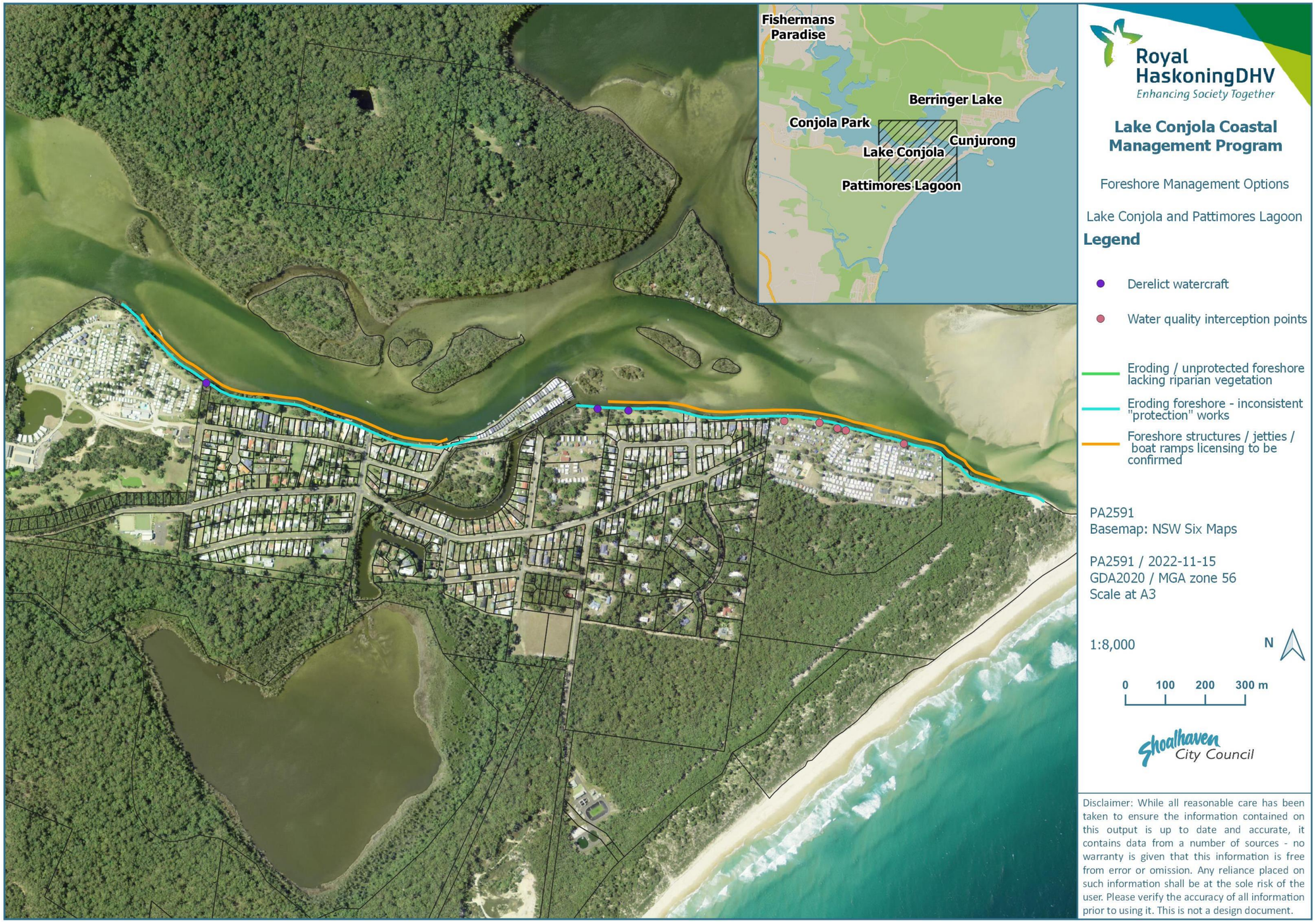

Figure 7-12: Foreshore Management Opportunities (FMOs) – Lake Conjola Village & Pattimores Lagoon

8 Current & Future Issues - Significant Climate Change Concerns

8.1 Projected Regional Climate Change for Shoalhaven and Illawarra

Through AdaptNSW, OEH prepared the regional *Illawarra Climate Change Snapshot report* that provided information on projected climate for the Shoalhaven Illawarra area.

The climate projections for 2020–2039 are described in the report as “near future” (sometimes paraphrased as 2030, as representing the middle of the 20 year period). The climate projections for 2060–2079 are described in the report as “far future” (sometimes paraphrased as 2070, as representing the middle of the 20 year period) (OEH, 2014).

A range of projected changes in climate variables for the Shoalhaven Illawarra region are shown in **Table 8-1**, with key climate change projections noted as:

- The region is expected to experience an increase in all temperature variables (average, maximum and minimum), more hot days, and fewer cold nights for the near and far futures. Heatwaves are also projected to increase, be hotter and last longer;
- Seasonality of rainfall will change. Autumn rainfall will increase in the near future and the far future. The majority of models agree that winter rainfall will decrease in the near future and far future. Spring rainfall is projected to decrease in the near future; however, summer rainfall is projected to increase in the near future; and
- Fire risk will increase, with projected increases in average and severe Forest Fire Danger Index values in the near future and the far future.

Table 8-1: Climate change projections for the Shoalhaven Illawarra region (OEH, 2014)

Climate variables (average across the region)	Trend	Projections	
		Near future (2030)	Far future (2070)
Atmospheric CO_2	Increase	A2 IPCC emissions scenario	
Max temperature	Increase	0.7°C	1.9°C
Min temperature	Increase	0.6°C	2.0°C
Hot days	Increase	0 to +3 days	+2 to 7 days
Cold nights	Decrease	–3 to –6 days	–10 to –13 days
Heatwaves	Increase (frequency) Increase (intensity) Increase (duration)	1 to 1.5 events 1.5 to 7°C 1.5 to 2.5 days	2.5 to 3.5 events 1.5 to 7°C 1.5 to 2.5 days
Rainfall	Wetter and drier	–13% to +12%	–9% to +30%
Change in rainfall by season	Wetter and drier	Summer (–20 to +21%) Autumn (–24 to +33%) Winter (–21 to +14% Spring (–25% to +13%)	Summer (–12% to +40%) Autumn (–13% to +50%) Winter (–39% to +35%) Spring (–18% to +19%)

*Negative values represent drying and positive values represent wetting under projections for annual rainfall and seasonality rainfall. Source: Office of Environment and Heritage (2014)

8.2 Regional Vulnerability

8.2.1 Vulnerability in the Shoalhaven Illawarra Region

Regions across New South Wales vary in their vulnerability to climate change, with a snapshot of vulnerability for the Shoalhaven Illawarra region shown in **Figure 8-1**. The snapshot draws on workshop activities, the adaptation survey, discussions and supporting literature and data to illustrate regional vulnerability as three components:

- Red boxes – defined as the community's exposure to the range of biophysical and socioeconomic drivers that could potentially stress the ability of the region to function.
- Orange boxes – show the sensitivity to the diverse impacts that result from exposure to drivers of change.
- Green box – adaptive capacity represented by a set of attributes that act to determine how the region might respond to reduce future vulnerability. If present, these attributes can enable adaptation. If they are absent or negative, adaptive responses will be constrained (OEH, 2019).

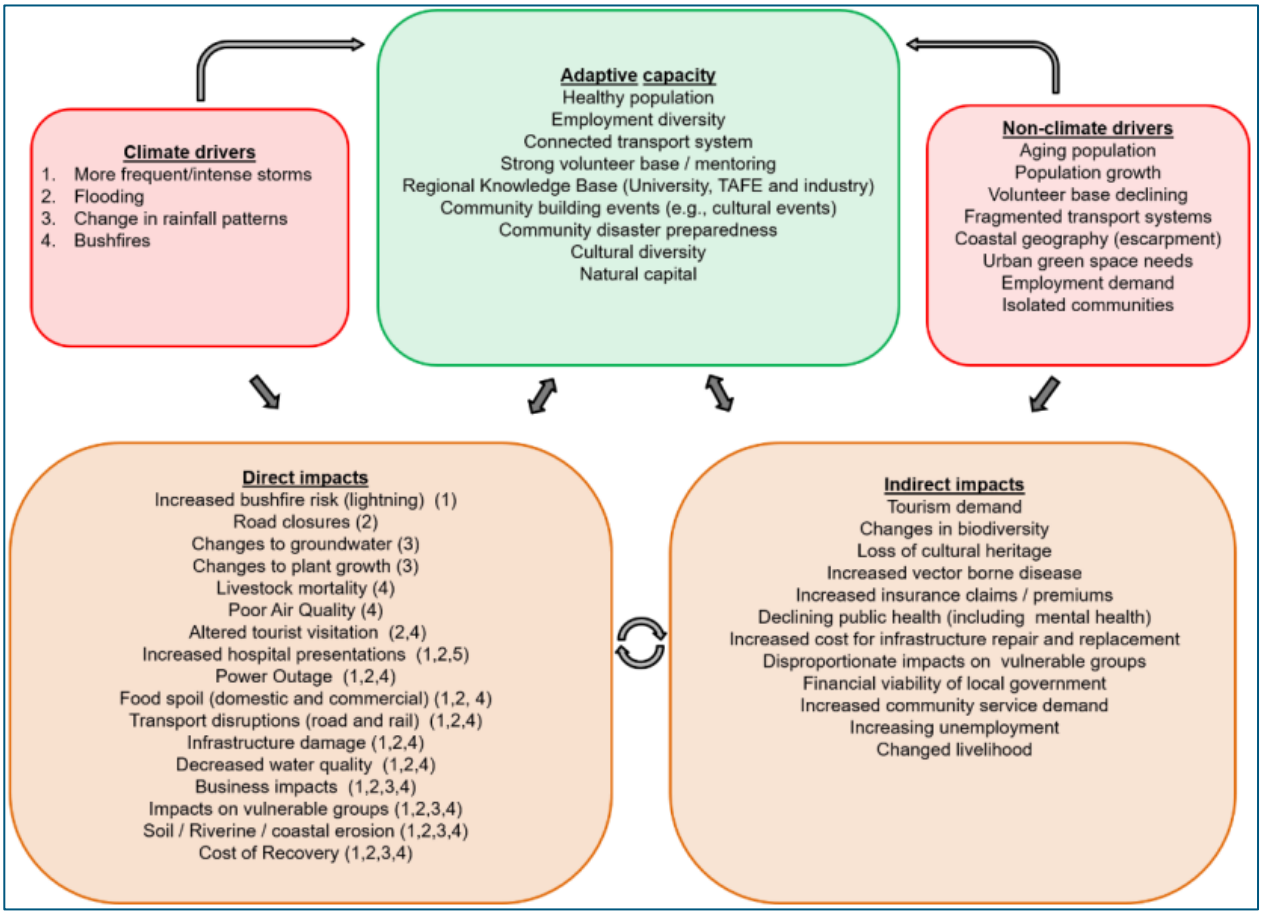

Figure 8-1: A snapshot of vulnerability in the Shoalhaven Illawarra region (OEH, 2019).

8.2.2 Exposure

8.2.2.1 Climate Drivers

The main climate drivers of the Shoalhaven Illawarra region are more frequent and intense storms, flooding, changes in rainfall patterns and increasing frequency of bushfires. Of these drivers, changes in rainfall patterns and average fire weather are projected in the regional climate modelling (OEH, 2019).

8.2.2.2 Non-climate Drivers

Non-climate drivers are drawn from the system transition models representing the range of socioeconomic and biophysical changes currently affecting the Shoalhaven Illawarra region. They operate at a range of scales from national (population growth and ageing) to regional (coastal geography, employment demand) and local (volunteer base declining, isolated communities). While they act independently of climate drivers, they may interact with climate impacts within the region (OEH, 2019).

For example, population growth is in part influenced by capital city house prices, proximity to Sydney for employment, and the natural environment of the region. However, in combination with climate drivers, population growth can, for instance, increase local exposure of the community to impacts of climate change (such as flooding and bushfires) and increase demands on emergency management and other government services (OEH, 2019).

8.3 Bushfire

8.3.1 Impact of 2019/2020 ‘Black Summer’ Bushfires

From September 2019 to March 2020, fires heavily impacted various regions of the state of New South Wales. In eastern and north-eastern Victoria large areas of forest burnt out of control for four weeks before the fires emerged from the forests in late December. Multiple states of emergency were declared across New South Wales, Victoria, and the Australian Capital Territory. Reinforcements from all over Australia were called in to assist fighting the fires and relieve local crews in New South Wales, with key statistics shown in **Figure 8-2**.

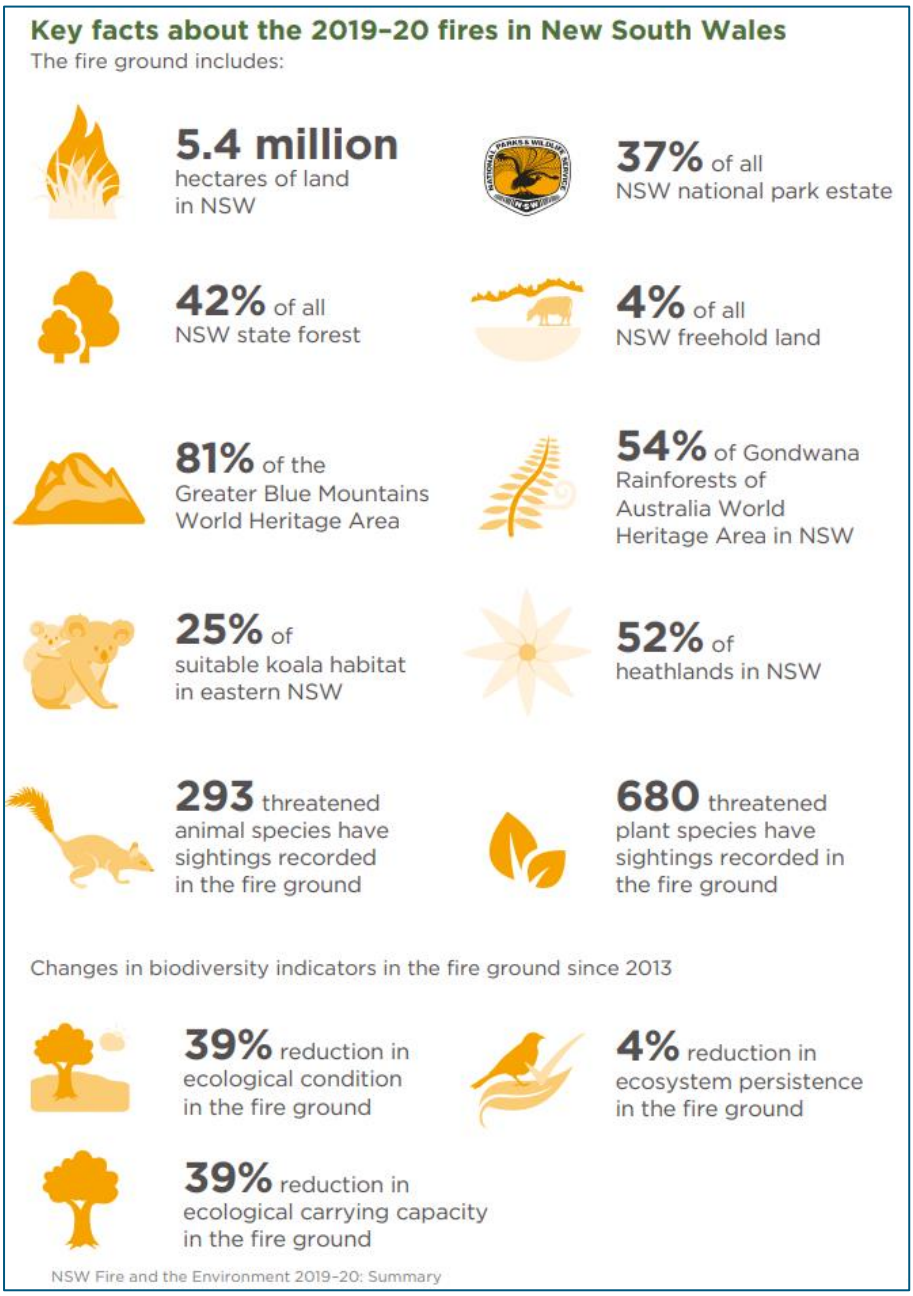

Figure 8-2: NSW Fire and the Environment 2019-20: Summary (DPIE, 2020)

The "Currowan" region of 2019-2020 'Black Summer' Bushfires (as named by the NSW RFS, shown in **Figure 8-3**), burned across the Shoalhaven, Eurobodalla and Bega Valley LGAs affecting more than one million hectares and impacting approximately 47 estuaries and coastal catchments, including the Lake Conjola region in particular.

A diverse range of landscapes and ecosystems were also affected including rainforests, wet sclerophyll forests, heathlands and sensitive waterways and aquatic ecosystems. Many of these areas provide habitat and support for threatened animal species.

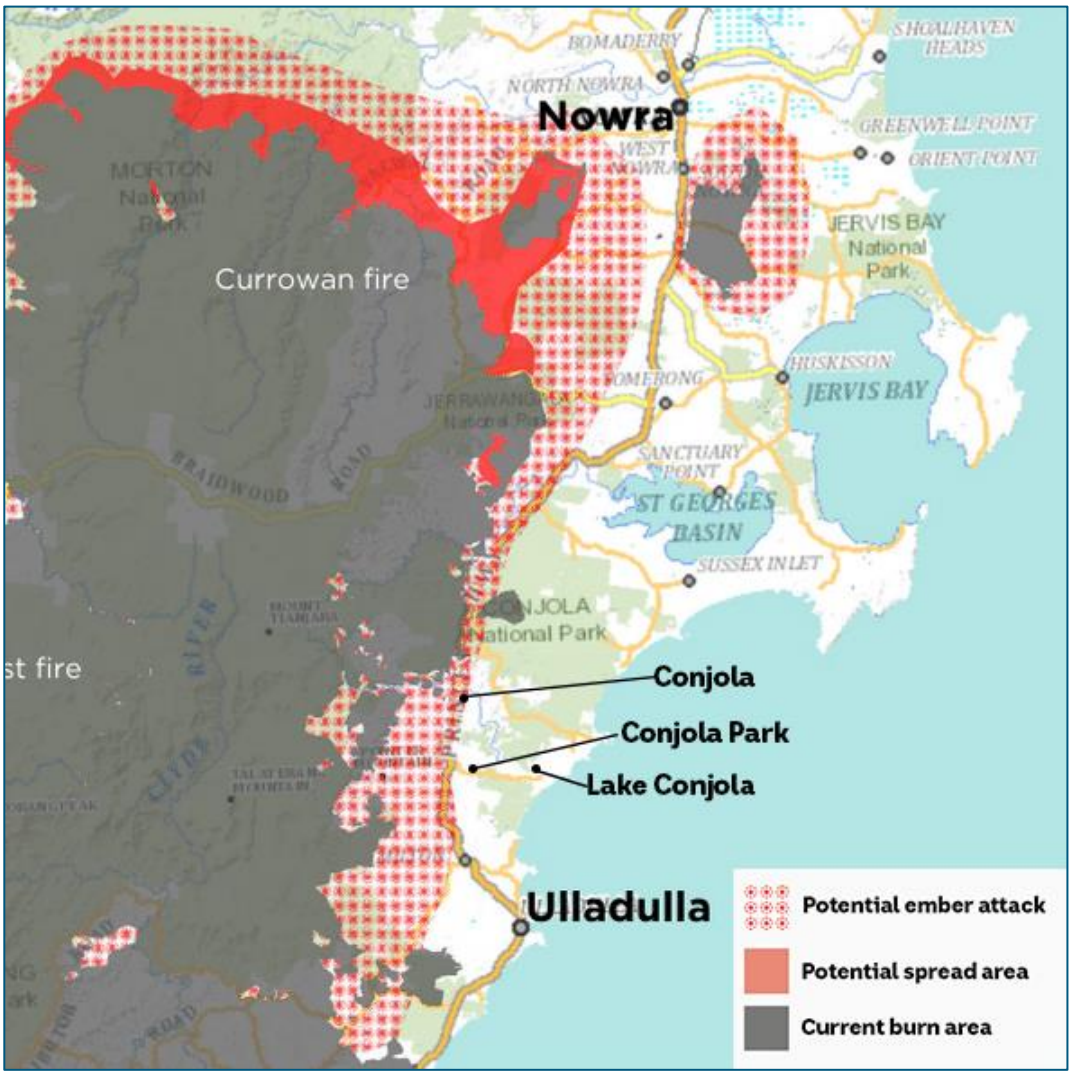

Figure 8-3: The predicted spread of the "Currowan" bushfire on New Year's Eve 2019 (source: NSW RFS)

Despite efforts from multiple agencies, the "Currowan" bushfire circumvented bushfire control measures and burned east towards the coast (including the Lake Conjola area) on New Year's Eve 2019 and during New Year's Day 2020 (refer **Figure 8-4**).

The Lake Conjola community was isolated for eight days at the height of the crisis, with telecommunications towers knocked out and the only connection to the outside world being the ABC emergency broadcasts and local radio station 2ST. As well as local residents, there were around 5,000 tourists and campers in the area, the majority of which were young families (Canberra Times news report, 6 July 2020).

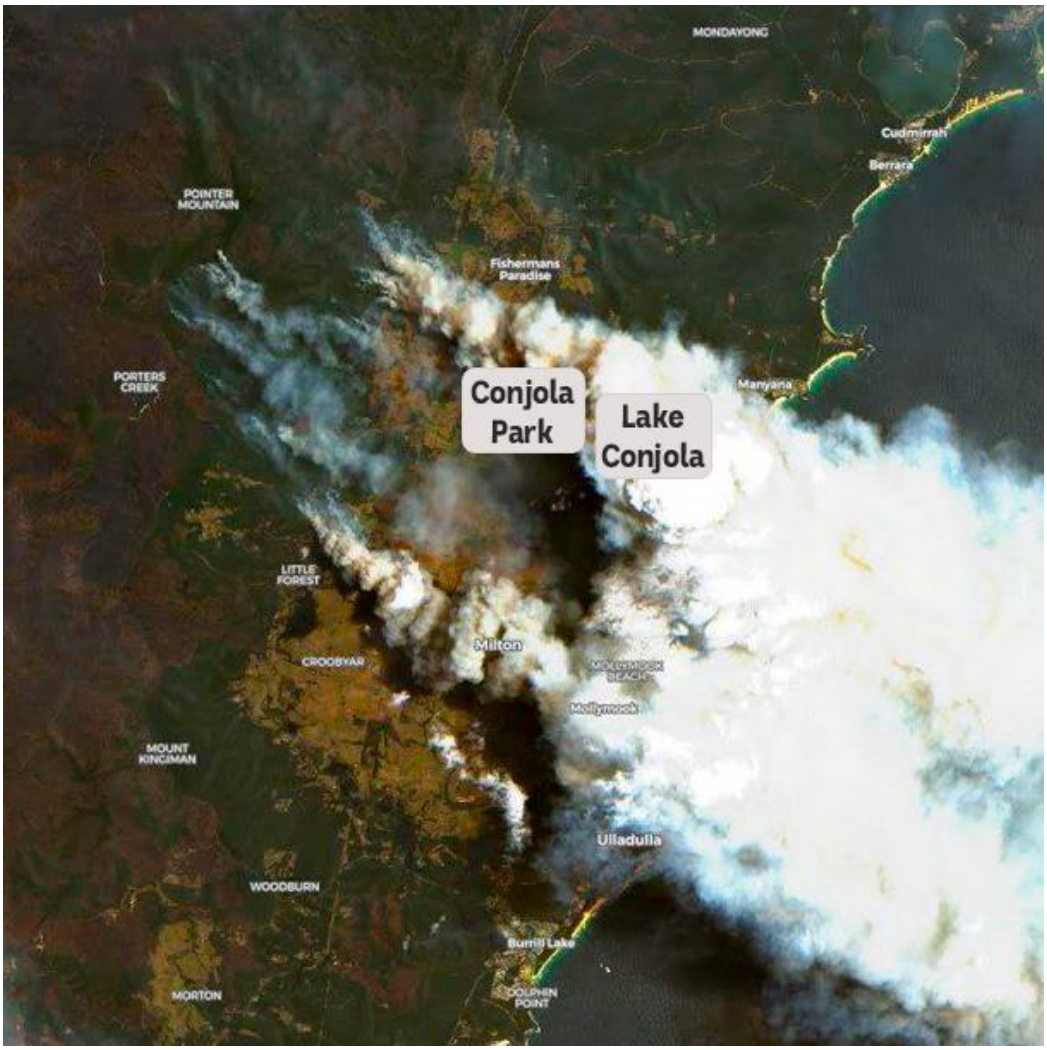

Figure 8-4: Satellite image of the smoke over the Conjola area on the south-coast of New South Wales at 11:00am, 31 December 2019 (European Union: Copernicus Sentinel data; source: ABC news report 8 June 2020)

Three people died and more than 89 homes were destroyed or damaged extensively (refer **Figure 8-5**) when the “Currowan” portion of the bushfires hit the Lake Conjola region on New Years' Eve 2019 (Canberra Times news report, 6 July 2020).



Figure 8-5: Homes, property and lives were lost in the fires which tore through Lake Conjola on 31 December 2019 (source: Daily Telegraph)

To determine how widespread, and how damaging to affected vegetation the wildfires in NSW during late 2019 and January 2020 had been, the Department of Planning and Environment (DPE) instigated the Google Earth Engine Burnt Area Map (GEEBAM) project (published January 2020). As is shown in **Figure 8-6**, significant tracts of land within the Lake Conjola area were impacted by the Currowan bushfire, with the vast majority of bushland within the catchment rated as 'very high' burnt classification, reaching the shores of Lake Conjola from all sides (DPIE, 2020).

After the 2019–20 bushfires had passed, any rainfall in burnt areas had the potential to rapidly degrade waterways by eroding exposed soil and washing in ash and charcoal. This post-bushfire runoff reduces water quality by increasing the levels of nutrients, trace metals, suspended solids and organic matter, which can lead to fish kills or algal blooms, and loss of habitat for platypus, frogs and turtles. Reduced water quality can impact the health of sensitive estuarine ecosystems, which in turn affects local industries such as tourism, fishing and oyster-farming (DPIE, *NSW Wildlife and Conservation Bushfire Recovery: Medium-term response plan*, 2021).

As part of this state-wide bushfire impact assessment, DPE Science Division (Environment Energy and Science Group) undertook a range of additional mapping, monitoring and modelling to understand the impact of bushfires to NSW estuaries and their catchments. Along with providing data and technical support to local governments and other agencies, a number of short reports were developed and released, including a Water modelling and monitoring factsheet (DPIE, 2020).

Sediment runoff control works were completed after the bushfires to help minimise the impact of rain and runoff on bare exposed areas resulting from the complete loss of groundcover. These works focused on drainage lines and included installation of coir logs to trap sediment mobilised after rainfall before it entered the estuary (refer **Figure 8-7**).

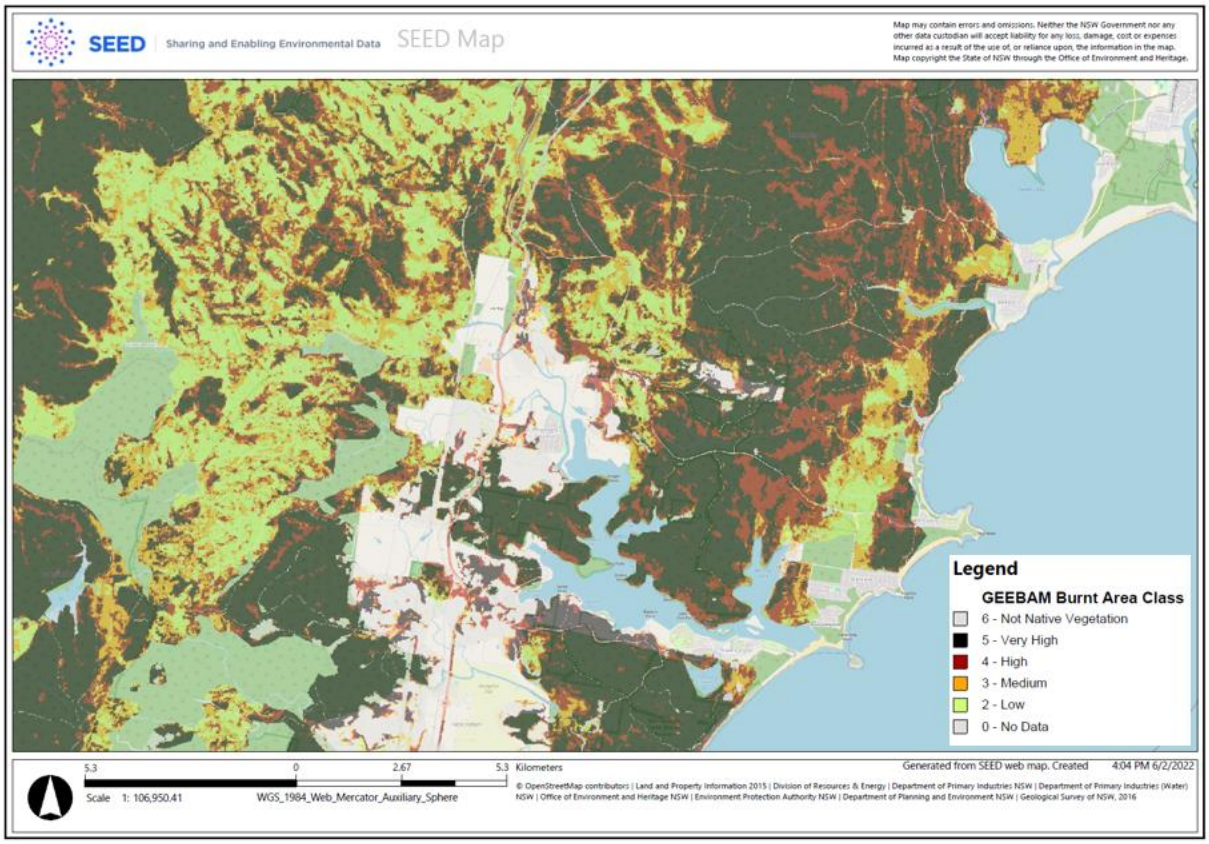

Figure 8-6: Google Earth Engine Burnt Area Map (GEEBAM) of the local Lake Conjola region (DPIE, 2020)



Figure 8-7: Sediment control works completed after the bushfires to minimise runoff entering the lake (10-2-2020, D.Wiecek, DPE)

Utilising a combination of the degree of burning in the catchment and the natural water movement through the estuary, the risk of water quality impact from bushfire runoff on NSW estuaries and streams was assessed. Physical water quality sampling in Lake Conjola was completed over the 2019–20 summer, when 2 sites were sampled on a monthly basis, as part of this state-wide impact assessment.

As of 2 February 2020, Lake Conjola had been assessed as having a very high risk of impact to water quality, as shown in **Table 8-2**.

Table 8-2: 2019/2020 Bushfire – Lake Conjola water quality impact risk - data current as of 02 February 2020

Catchment	% area burnt	Water quality impact risk
Conjola Lake	77%	Very high

Fortunately for the ecosystem health of Lake Conjola (and many other NSW estuaries), the significant rainfall event within two weeks of this risk assessment greatly reduced the projected impact of the bushfires on water quality due to the substantial flushing of affected estuarine water into the much larger ocean waterbody (discussed in **Section 4.4.2.2**).

8.4 Sea Level Rise

Of all the impacts from climate change, the projected rise in mean sea level is one of the most significant concerns for integrated coastal zone management. In addition to higher projected storm surge, increased tidal and oceanic inundation levels, a rise in the mean sea level will also result in landward recession of unconsolidated (sandy) shorelines. Depending on the rate and scale of sea level rise (SLR), the environmental, social and economic consequences, in particular within low-lying intertidal areas, are expected to be significant (DECCW, 2009).

As discussed in **Section 3.2**, Council has an adopted position on SLR projections and planning period (timeframe), and have also provided direction on the SLR projections that were utilised within the hazard mapping and risk assessments completed for the Lake Conjola CMP.

As well as open coast recession and higher inundation levels, saltwater intrusion and landward advance of tidal limits within estuaries will have significant implications for freshwater and saltwater ecosystems and development margins, particularly building structures and foundation systems within close proximity to the shoreline. Existing coastal gravity drainage, stormwater infrastructure and sewerage systems may become compromised over time as sea level rises.

Sea level rise will also influence entrance opening regimes for intermittently closed and open estuaries, such as Lake Conjola. The level of protection provided by existing seawalls and other hard engineering structures will decrease over time due to the increasing threat from larger storm surges and inundation at higher projected water levels (DECCW, 2009).

Australia, like other nations, is already experiencing sea level rise. Sea level varies from year to year and from place to place, partly due to the natural variability of the climate system from the effect of climate drivers such as El Niño and La Niña.

Based on satellite altimetry observations since 1993 (refer **Figure 8-8**), the rates of sea level rise to the north and southeast of Australia have been significantly higher than the global average, whereas rates of sea level rise along the other coasts of the continent have been closer to the global average (CSIRO, 2020).

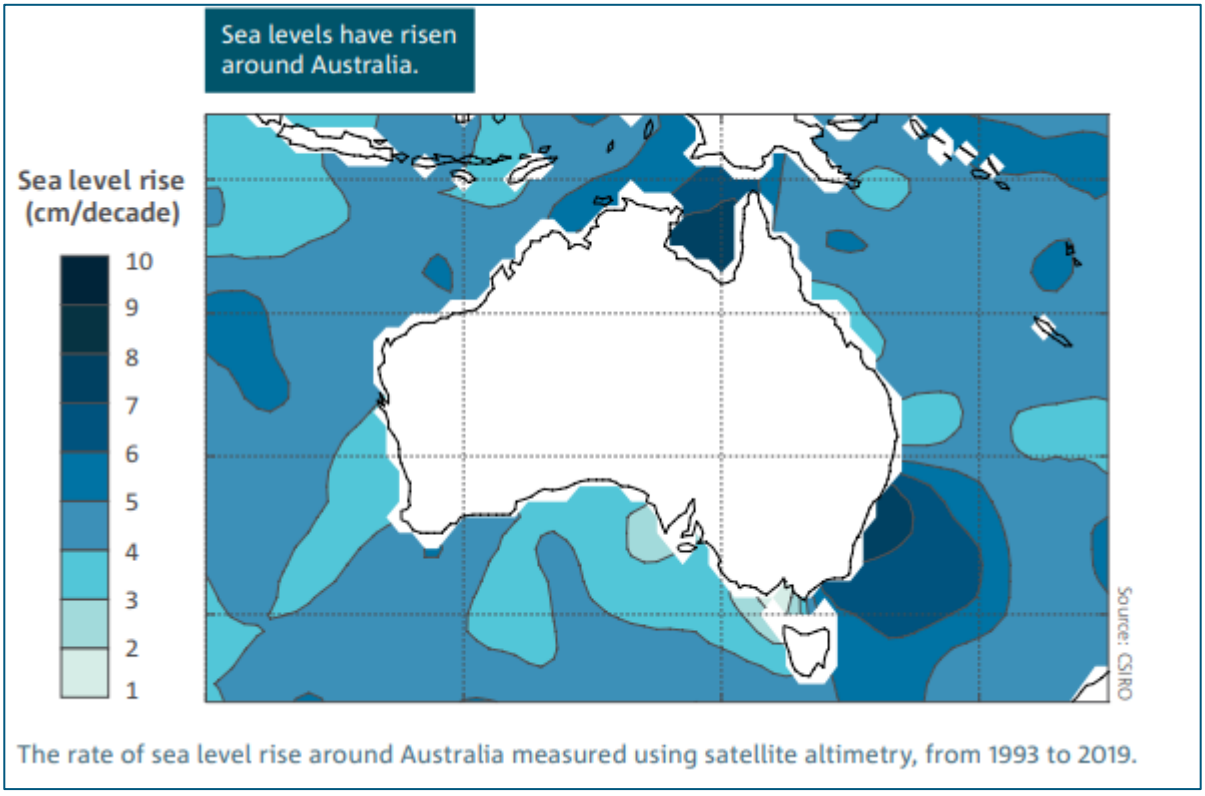

Figure 8-8: The rate of sea level rise around Australia measured using satellite altimetry, from 1993 to 2019 (source: CSIRO, 2020)

8.5 Habitat - Impacts of Climate Change on other Estuarine Processes

The biophysical processes of estuaries are highly inter-related; however, it is the coastal processes and catchment inputs that have the greatest influence on lagoon structure and condition (Haines, 2006). While the impacts of future climate change on physical entrance processes is discussed in **Section 3.2**, it is acknowledged that climate change will also have widespread impacts on other physical, chemical and biological processes of estuaries (Haines & Thom, 2007).

For example, changes to typical water levels within estuaries will impact on fluvial deposition and foreshore erosion processes. Changes to precipitation could alter the delivery of sediments, nutrients and contaminants to estuaries (Boesch, 2002), while changes to entrance processes will modify the potential for tidal flushing and assimilation of these catchment inputs (Haines & Thom, 2007). Furthermore, and highly relevant for Lake Conjola, increasing water levels will result in inundation of fringing wetlands and saltmarshes (Walsh, 2004).

While it can be expected that some estuarine ecological communities (such as mangroves and saltmarshes) may migrate landward in response to increased water levels (to the detriment of existing brackish and terrigenous vegetation communities (Bird, 2002; Boesch, 2002; Hughes, 2003; Gilman, 2004), the rate of climate change may be faster than the rate at which some species can adapt (DEH, 2003; Hartig et al., 2002, Haines & Thom, 2007).

9 Potential Impacts of Threats within the context of Lake Conjola

9.1 Risk Assessment Methodology Description

Following identification and quantification of the range of current and projected future threats to the cultural and environmental assets and attributes that exist within Lake Conjola, it is appropriate to undertake a risk assessment in order to determine the severity of, and potential to mitigate, each of the identified risks. For the Lake Conjola CMP, two alternative though complimentary risk assessment methodologies were undertaken, for consideration and application by distinct stakeholder groups:

- **Qualitative Threat-Based Risk Assessment**
  - An ***outcome*** based approach that reflects the interests of the community and agencies, and enables consideration of catchment wide issues that may impact many assets and attributes.
  - Two examples are:
    a) increased frequency of tidal inundation due to sea level rise will impact residential assets, commercial assets and ecosystems, as well as impacting on the amenity and social fabric of Lake Conjola communities – consideration can be given to addressing the range of impacts of increased inundation rather than treating each asset type separately;
    b) currently there are watercraft stored in an ad hoc manner at a range of foreshore locations around Lake Conjola – consideration can be given to a single action for a Lake-wide approach to removal and rehabilitation of the sites, rather than a separate action for watercraft removal from each reserve/location that may be undertaken in isolation of the collective benefit.
- **Quantitative Asset-Based Risk Assessment**
  - An ***output*** based approach that reflects the interests of Council asset managers, and enables consideration of factors impacting each asset so that accurate forward planning for asset improvement / renewal / removal can be undertaken.
  - Two examples are:
    a) ensuring that renewal of a low lying public facility such as a toilet block utilises materials that can be inundated for periods of time without damage;
    b) considering the projected impact of a range of threats to a specific asset such as a road which is required for evacuation during significant events, whereby asset renewal can take into account opportunity to raise the asset, utilise materials with high resilience to inundation, adaptation of the stormwater connections to improve drainage, etc.

There are different benefits that arise from each Risk Assessment methodology, hence the reason for the range of approaches currently utilised within NSW coastal management frameworks.

The Qualitative Threat-Based Risk Assessment is provided as **Appendix G**, while the Quantitative Asset-Based Risk Assessment is provided as **Appendix H**.

9.2 Risk Assessment Matrix – Definitions

The qualitative threat-based and quantitative asset-based risk assessment methodologies both utilise Council's adopted Risk Assessment Matrix to define and evaluate the relative quantum of each threat. The Risk Assessment Matrix comprises several rating tables defining the 'likelihood', 'consequence' and overall risk rating (based on the combination of likelihood and consequence), which are provided below in **Table 9-1**, **Table 9-2**, and **Table 9-3** respectively.

Table 9-1: Likelihood Rating Definitions

1. Likelihood Rating Table		
Descriptor	**Description**	**Frequency**
Almost Certain (5)	The event is expected to occur in normal circumstances	Several times a year
Likely (4)	This event may occur at some time during the year	Once or twice a year
Possible (3)	The event may occur sometime. Some previous event history.	Once every 2 to 5 years
Unlikely (2)	The event could occur in some circumstances, but would not be expected	Once every 6 to 9 years
Rare (1)	The event may occur but only in exceptional circumstances	Once every 10 or more years

Table 9-2: Consequence Rating Definitions

2. Consequence Rating Table - Amended 25-2-2022					
Category	**Negligible**	**Minor**	**Moderate**	**Major**	**Severe**
	1	**2**	**3**	**4**	**5**
People (staff, contractors, volunteers, and the community)	•Minor injury with no treatment required •Isolated, internal or minimal impact on staff morale or performance •Little or no disruption to community	•Minor injury with first aid treatment required •Contained impact on staff morale or performance of short term significance •Some displacement of people (<24hrs) or some minor disruption to community (<24 hrs)	•Medical attendance, time off work •Significant impact on staff morale or performance of medium term significance •Localised displacement of people; normal community functioning with some medium-term inconvenience; localised damage rectified by routine arrangements	•Serious illness or injury •Major impact on staff morale or performance with long term significance •Large number displaced for >24hrs; external resources required for personal support; significant damage that requires external resources	•Fatality or permanent disability •Extensive impact or organisational morale or performance •General and widespread displacement for extended duration; community unable to function without significant support
Environment	•Contained, localised •Reversible impact.	•Contained, small scale •Reversible impact.	•Contained, widespread •Reversible impact.	•Uncontained, widespread •Reversible impact.	•Uncontained •Irreversible impact.
Financial	•Negligible financial loss (up to 1% of Council's budget) •No impact on program or business operation	•Minor financial loss (up to 3% of Council's budget) •Minimal impact on business operation	•Significant financial loss (up to10% of Council's budget) •Considerable impact on business operation	•Major financial loss (up to 20% of Council's budget) •Severe impact on business operation	•Extensive financial loss (>20% of budget) •Long term consequences for operations.
Governance	•Isolated non-compliance or breach •Negligible financial impact	•Contained non-compliance or breach with short term significance and minor financial impact	•Serious breach involving statutory authority or investigation •Prosecution possible with significant financial impact	•Major breach with fines and litigation •Long term significance and major financial impact	•Extensive fines and litigation with possible class action •Threat to viability of programs or services
Information Technology	•No measurable operational impact to organisation	•Minor downtime or outage in single area of organisation •Address with local management and resources	•Significant downtime or outage in multiple areas of organisation •Substantial management required and local resources	•Loss of critical functions across multiple areas of organisation •Long term outage •Extensive management required and extensive resources	•Extensive and total loss of functions across organisation •Disaster management required
Property & Infrastructure	•Isolated or minimal loss; •short term impact •repairable through normal operations	•Minor loss with limited downtime •Short term impact •Mostly repairable through normal operations	•Significant loss with temporary disruption of services •Medium term impact on organisation	•Critical loss or event requiring replacement of property or infrastructure •Long term impact on organisation	•Disaster with extensive loss and long-term consequences •Threat to viability of service or operation
Reputation	•Public awareness may exist but there is little public concern •Resolved by day to day management process	•Attention from local media, and/or heightened local concern	•Significant and sustained adverse local media attention •Serious concerns expressed and large decrease in support from the public	•Significant adverse national media attention •Significant decrease in public support •Damage to reputation at a national level.	•Subject of sustained adverse publicity in multiple media. •Significant long-term detrimental effect on business areas.

Table 9-3: Risk Rating Definitions

3. Risk Rating Table					
Consequence					
Likelihood	Negligible (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Almost Certain 5	M (5)	M (10)	H (15)	E (20)	E (25)
Likely 4	L (4)	M (8)	H (12)	H (16)	E (20)
Possible 3	L (3)	M (6)	M (9)	H (12)	H (15)
Unlikely 2	L (2)	L (4)	M (6)	M (8)	M (10)
Rare 1	L (1)	L (2)	L (3)	L (4)	M (5)

9.3 Qualitative Threat-Based Risk Assessment

Utilising the adopted Risk Assessment Matrix to define the Likelihood, Consequence and resultant Risk Rating, the Qualitative Threat-Based Risk Assessment:

- Considers a wide range of threats (including coastal/tidal inundation, population growth, stormwater erosion, exotic plant/animal species, entrance dynamics, user conflicts, water quality) and the hazards they present;
- Anticipates the potential impact of these threats on four key interconnected Risk Assessment "themes", being:
  - Public Safety;
  - Infrastructure;
  - Environmental; and,
  - Public amenity.
- Evaluates the change in perceived risk over four planning timeframes (Current, 20 year (0.23m SLR), 50 year (0.36m SLR) and 100 year + (1.2m SLR) Planning Horizons); and,
- Enables consideration of potential mitigation strategies that may be applied within the 10 year CMP timeframe, as well as indicating longer term issues that may require significant strategic planning to deliver improved future outcomes.

A Threat-Based Risk Assessment Workshop was facilitated on 29 November 2021 by Council and RHDHV and attended by representatives of a number of State government agencies and key stakeholder groups (including DPE, Fisheries, DPE - Crown Lands, NPWS, Shoalhaven Water). This workshop utilised an initial RHDHV risk assessment matrix. Following input from stakeholders during and following the workshop, the Qualitative Threat-Based Risk Assessment was completed.

Following the 29 November 2021 workshop, Council developed and provided an internal Council Risk Assessment Matrix (dated 25 February 2022) which, while very similar in framework, varied within the descriptions of both likelihood and consequence. This required amendment of the completed Threat-Based Risk Assessment to reflect the adopted rating system.

An example of the completed Threat-Based Risk Assessment for Public Amenity is shown below. The broad indicative control measures identified against each risk (refer **Appendix G**) will be used as the basis for further prioritisation and refinement of management actions in Stage 3 of the CMP process.

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
4. Public Amenity Risk Assessment															
4.1	Stormwater erosion	- Reduced Lake amenity and access resulting from erosion caused by stormwater discharge or surface runoff	2	2	4	2	2	4	2	3	6	2	3	6	- Re-grading of eroded areas to restore foreshore profile by Council maintenance staff - Consider redirection of surcharge flows - Improve energy dissipation at stormwater outlets, consider creation of raingardens
4.2	Tidal inundation	- Reduced public amenity in low-lying areas	3	1	3	3	1	3	3	1	3	3	5	15	- Consideration of implementing inundation mitigation structures such as earth embankments
4.3	Population growth; coastal development; & human use of the coastal zone	- Increased visitation from residents and visitors resulting in more crowding, less available parking, conflicts between user groups - increased requirement for maintenance of accessways and other assets etc. - Reduced public amenity due to increased/damaging private coastal/foreshore development	1	5	5	2	5	10	3	5	15	3	5	15	- Collaborate with TfNSW appropriate management of users, e.g. number of vessels within Lake Conjola - Investigate/enforce appropriate and permissible use of public foreshores by private interests e.g. retaining walls, jetties, watercraft; in collaboration with TfNSW, Crown Lands, Fisheries - Create/enforce time limits on parking in highly popular locations - Create/enforce Council policies on the use of open spaces and the coastal zone - Review/Amend/Implement development and planning controls within LEP/DCP that are applied to new development - Council support for community based revegetation campaigns and other community "ownership" projects
4.4	User conflict	- Potential conflict due to variety of recreational uses; such as personal watercraft, recreational powered watercraft, passive recreation	2	2	4	2	3	6	2	3	6	2	3	6	- Collaborate with TfNSW to implement appropriate actions within the "Boating Plan of Management - Lake Conjola Estuary" (NSW Maritime Authority, March 2005) - Consider collaboration with TfNSW regarding reviewing and enforcement of current and potential controls on watercraft
4.5	Water quality (surface water)	- Various adverse impacts on public amenity due to poor water quality caused by a variety of surface water inflows (stormwater runoff/agricultural runoff/sewer overflows) and inadequate infrastructure maintenance	3	2	6	3	3	9	3	3	9	3	4	12	- Continue and refine surface water monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Investigate and manage sewage overflows - Support volunteer based foreshore rehabilitation initiatives such as Bushcare - Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) or raingardens in private development activities - Undertake maintenance of existing stormwater improvement devices - Review/Amend/Implement water quality development and planning controls within LEP/DCP that are applied to new development - Consider development and implementation of water quality targets for existing and future land use within the Lake Conjola catchment, utilising the "Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions" (OEH, 2017) - Improve/manage riparian vegetation - Stormwater management system improvements - Improve community education on the factors influencing water quality and on mitigation actions - Work with farmers/landowners to support change in farming practices (e.g. stock access to water) - Collaboration with agencies e.g. LLS to provide support for changing detrimental land use practices
4.6	Water quality (groundwater)	- Various adverse impacts on public amenity resulting from migration of the groundwater plume containing effluent from the Conjola Regional Sewerage Scheme	3	1	3	3	3	9	3	3	9	3	3	9	- Continue groundwater monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Future review of entrance management policy - Consider opportunities for sewage treatment and discharge improvements - Identify and monitor potential source sites that could leach contaminants into the Lake (e.g. landfill)

9.4 Quantitative Asset-Based Risk Assessment

Utilising the adopted Risk Assessment Matrix to define the Likelihood, Consequence and resultant Risk Rating, the **Quantitative Asset-Based Risk Assessment**:

- Considers threats of inundation to 247 Council owned and/or managed assets within Lake Conjola, identified by a range of filters including location, asset type, and description;
- Enables informed asset management practices through consideration of factors impacting each asset, so that accurate forward planning for asset improvement / renewal / removal can be undertaken;
- Evaluates the change in perceived risk over three sea level rise scenarios (0.0m AHD (current), 0.36m AHD (20-50 year) and 1.2m AHD (100 year +)); and,
- Enables consideration of potential mitigation strategies that may be applied within the 10 year CMP timeframe, as well as indicating longer term issues that may require significant strategic planning to deliver improved future outcomes.

An Asset-Based Risk Assessment Workshop was facilitated on 6 December 2021 by Council and RHDHV and attended by a number of internal Council asset managers and key stakeholders (including Holiday Haven Caravan Park management). This workshop utilised an internal Council Risk Assessment Matrix (dated 2 December 2021). With input from stakeholders during and following the workshop, a draft Quantitative Asset-Based Risk Assessment was prepared.

Following the 6 December 2021 workshop, RHDHV completed additional detailed analysis of the frequency and duration of tidal inundation for each of the 247 identified assets, as described in **Section 3.3.4**. This analysis was used in conjunction with an updated internal Risk Assessment Matrix (dated 25 February 2022) to complete the Quantitative Asset-Based Risk Assessment.

An example of the completed Asset-Based Risk Assessment is shown below. A list of management options and controls was developed for each asset type for future consideration by asset managers, and is included in **Appendix H**.

Tidal Inundation Hazard and Risk Assessment

Date:

				Current (SLR 0.0m)						20-50 yr Planning Horizon (SLR 0.36m)						100 yr + Planning Horizon (SLR 1.2m)					
Asset Category	Asset Type	Asset Name / Location	Suburb	Consequence	Likelihood	Closest relevant assessed Location (n/r if not relevant)	Average Annual Tidal Inundation Occurrences	Average Total Inundation Duration per occurrence (hours)	Risk Rating	Consequence	Likelihood	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurrences	Average Total Inundation Duration per occurrence (hours)	Risk Rating	Consequence	Likelihood	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurrences	Average Total Inundation Duration per occurrence (hours)	Risk Rating
				Current	Current				Current	20-50 yr	20-50 yr				20-50 yr	100 yr +	100 yr +				100 yr +
Community Asset	Carpark\Carpark	Berringer Lake boat ramp car park	Berringer Lake	1	1	n/r	0	0	1	1	1	11	0	0	1	2	5	11	260	5.2	10
Community Asset	Carpark\Carpark	Yooralla Bay boat ramp car park	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1
Community Asset	Open Space / Reserves / Parks	Picnic Bay	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1
Community Asset	Open Space / Reserves / Parks	Yooralla Bay Reserve	Conjola Park	1	1	18	0	0	1	1	5	18	Portion always Inundated	Portion always Inundated	5	1	5	18	Portion always Inundated	Portion always Inundated	5
Community Asset	Open Space and Recreation\Park Furniture\Play Equipment	Play Equipment	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1
Community Asset	Community Building	RFS Brigade building	Cunjurong	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1
Community Asset	Natural Area	Cunjurong Point	Cunjurong	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1
Community Asset	Carpark\Carpark	Cunjurong boat ramp car park	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	5	n/r	0	0	5
Community Asset	Carpark\Carpark	Lake Conjola boat ramp car park	Fishermans Paradise	1	1	23	0	0	1	1	5	23	104	3.3	5	3	5	23	Near permanent inundation	Near permanent inundation	15
Community Asset	Community Building	RFS Brigade building	Fishermans Paradise	1	1	22	0	0	1	1	1	22	0	0	1	1	1	22	0	0	1
Community Asset	Open Space / Reserves / Parks	Hazel Robotham Reserve	Fishermans Paradise	1	1	22	0	0	1	1	4	22	0	0	4	1	5	22	61	4.3	5
Community Asset	Carpark\Carpark	Lake Conjola Community Centre	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1
Community Asset	Carpark\Carpark	Holiday Haven boat ramp car park	Lake Conjola	1	5	1	0	0	5	2	5	1	52	2.4	10	3	5	1	485	14.1	15
Community Asset	Community Building	Lake Conjola Community Centre	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1
Community Asset	Community Building	RFS Brigade building	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1
Community Asset	Natural Area	Conjola Beach	Lake Conjola	1	5	n/r	Portion always Inundated	Portion always Inundated	5	1	5	n/r	Portion always Inundated	Portion always Inundated	5	1	5	n/r	Portion always Inundated	Portion always Inundated	5
Community Asset	Natural Area	Narrawallee Creek Nature Reserve	Lake Conjola	1	1	n/r	0	0	1	1	4	n/r	Portion frequently Inundated	Portion frequently Inundated	4		5	n/r	Portion always Inundated	Portion always Inundated	0
Community Asset	Open Space / Reserves / Parks	Edwin Avenue Reserve	Lake Conjola	1	1	11	0	0	1	1	1	11	0	0	1	2	5	11	260	5.2	10
Community Asset	Open Space / Reserves / Parks	Leaning Oak Point	Lake Conjola	1	1	13	0	0	1	1	1	13	0	0	1	2	5	13	138.7	43	10
Community Asset	Open Space / Reserves / Parks	Roberts Point	Lake Conjola	1	1	13	0	0	1	1	1	13	0	0	1	1	1	13	0	0	1
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Bowling Club	Lake Conjola	1	1	15	0	0	1	1	1	15	0	0	1	1	1	15	0	0	1
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Community Centre tennis court	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Sports Field - off Thorne Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1

Acronyms

The following pages provide a list of acronyms that are in common use when describing the NSW coastal management framework, and are often used during development of Coastal Management Programs:

ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
BC Act	*Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
CLM Act	*Crown Land Management Act 2016*
CM Act	*Coastal Management Act 2016*
CM SEPP	State Environmental Planning Policy (Coastal Management) 2018
CMP	Coastal Management Program (prepared under the Coastal Management Act 2016)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Council	Shoalhaven City Council
CZMP	Coastal Zone Management Plan (prepared under the former Coastal Protection Act 1979)
DCP	Development Control Plan
DECC	Department of Environment Climate Change (previously DIPNR, now DPE)
DECCW	Department of Environment, Climate Change and Water (previously DECC, now DPE)
DIPNR	Department of Infrastructure, Planning and Natural Resources
DoI	Department of Industry (now DPE)
DPE	Department of Planning and Environment (previously DIPNR, DECC, DECCW, OEH, DPIE)
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment (now DPE)
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FM Act	*Fisheries Management Act 1994*
FM Regulation	Fisheries Management (General) Regulation 2002
HHWSS	High High Water Springs Solstice
ICOLL	Intermittently Closed and Open Lake/Lagoon
IP&R	Integrated Planning and Reporting (in accordance with the *Local Government Act 1993*)
ISEPP	State Environmental Planning Policy (Infrastructure) 2007
ISO	International Organisation for Standardization
LEP	Local Environment Plan
LGA	Local Government Area
LG Act	*Local Government Act 1993*
LLS Act	*Local Land Services Act 2013*
MEMA	Marine Estate Management Authority
MEM Act	*Marine Estate Management Act 2014*
MHL	Manly Hydraulics Laboratory
MHWS	Mean High Water Springs
MIDO	Maritime Infrastructure Delivery Office
MLWM	Mean Low Water Mark

NES	National Environmental Significance
NOW	NSW Office of Water
NP&W Act	*National Parks and Wildlife Act 1974*
NPWS	National Parks and Wildlife Services
NRM	Natural Resource Management
NSW GIS	New South Wales Geographic Information System
OEH	Office of Environment and Heritage (previously DIPNR, DECC, DECCW, now DPE)
PoEO Act	*Protection of the Environment Operations Act 1997*
REF	Review of Environmental Factors
RH SEPP	*State Environmental Planning Policy (Resilience and Hazards) 2021*
RMS	Roads and Maritime Services
SCC	Shoalhaven City Council
SEPP	State Environmental Planning Policy
SEPP CM	State Environmental Planning Policy (Coastal Management) 2018
SERM Act	*State Emergency and Rescue Management Act 1989*
SIS	Species Impact Statement
TfNSW	Transport for New South Wales
TSC Act	*Threatened Species Conservation Act 1995*

Glossary

This glossary provides definitions of terms that are in common use when describing coastal processes and coastal management. It supplements definitions provided in the *Coastal Management Act 2016* (CM Act) and *State Environment Planning Policy (Resilience and Hazards) 2021* (RH SEPP). It is not a comprehensive dictionary of coastal terminology.

Many definitions are included with acknowledgement of the Coastal Management Glossary developed by State of NSW and Office of Environment and Heritage (2018), while others are sourced from the US Army Corps of Engineers, as well as from glossaries provided in relevant Standards and other coastal management guidelines in current use in Australia.

Accretion – as the build-up of sediments to form land or shoaling in coastal waters or waterways. It may be either natural or artificial. Natural accretion is the build-up of land on the beach, dunes, or in the water by natural processes, such as waves, current and wind. Artificial accretion is a similar build-up of land resulting from built structures such as groynes or breakwaters, or activities such as filling and beach nourishment, or also aggradation. (USACE)

Adaptation – adjustment in natural or human systems in response to actual or expected climate change or its effect, to moderate harm or to take advantage of beneficial opportunities.

Annual Exceedance Probability (AEP) – the probability (expressed as a percentage) of an exceedance (e.g. large wave height or high water level) in a given year.

Asset – something of value and may be environmental, economic, social, recreational or a piece of built infrastructure.

Average Recurrence Interval (ARI) – the average time between which a threshold is reached or exceeded (e.g. large wave height or high water level) of a given value. Also known as Return Period.

Bathymetric data – measurements of the shape of the bed or the depth of a body of water.

Beach – the CM Act defines beach as an area that is generally composed of sand or pebbles or similar sediment that extends landward from the lowest astronomical tide to the line of vegetation or bedrock or structure.

Beach erosion – refers to landward movement of the shoreline and/or a reduction in beach volume, usually associated with storm events or a series of events, which occurs within the beach fluctuation zone. Beach erosion occurs due to one or more process drivers; wind, waves, tides, currents, ocean water level, and downslope movement of material due to gravity.

Beach fluctuation zone – CM Act defines beach fluctuation zone as 'the range of natural locations a beach profile occupies from its fully accreted condition to its fully eroded condition, with

a) a landward limit defined by the escarpment resulting from the erosion associated with a 1% storm event or a more extreme event of record, whichever is the greater landward limit, and

b) a seaward limit that is the 40m depth seaward of the highest astronomical tide for the open coast and 10m depth seaward of the highest astronomical tide for estuaries or tidal coastal lakes.'

Beach material – granular sediments, usually sand or shingle moved by the sea.

Beach nourishment – beach restoration or augmentation using clean dredged or fill sand. Dredged sand is usually hydraulically pumped and placed directly onto an eroded beach or placed in the littoral transport system. When the sand is dredged in combination with constructing, improving, or maintaining a navigation project, beach nourishment is a form of beneficial use of dredged material.

Beach profile – a cross-section taken perpendicular to a given beach contour; the profile may include the face of a dune or seawall, extend over the backshore, across the foreshore, and seaward underwater into the nearshore zone.

Beach system – the CM Act defines as 'the processes that produce the beach fluctuation zone and the incipient foredunes and foredunes landward of the relevant beach'. In general, this means coastal lands, composed of sand, gravel or shell, between a seaward limit of 40 metres depth in the State coastal waters and a landward limit at the lee side of the dunes.

Bedrock – a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.

Benthic – of, pertaining to, or related to, the bottom of a stream or other body of water.

Berm – on a beach, a nearly horizontal plateau on the beach face or backshore, formed by the deposition of beach material by wave action or by means of a mechanical plant as part of a beach renourishment scheme. Some natural beaches have no berm, others have several.

Breakwater – a man-made structure protecting a shore area, harbour, anchorage or basin from waves.

Catchment area – the area which drains naturally to a particular point on a river, thus contributing to its natural discharge.

Catchment flooding - the inundation caused by runoff generated from significant rainfall in the catchment, contributing to flows into Lake Conjola.

Climate – the characteristic weather of a region, particularly regarding temperature and precipitation, averaged over some significant interval of time (years).

Climate change – occurs naturally in response to long-term variables, but often used to describe a change of climate that is directly attributable to human activity that alters the global atmosphere, increasing change beyond natural variability and trends.

Coast – a strip of land of variable width that extends from the shoreline inland to the first significant landform that is not influenced by coastal processes (such as waves, tides and associated currents).

Coastal asset – includes natural features of the coastal zone, including landforms, ecosystems and species; and built assets such as infrastructure, public and private buildings or structures.

Coastal dune – vegetated and unvegetated sand ridges built-up at the back of a beach. They comprise dry beach sand that has been blown landward and trapped by plants or other obstructions. Stable sand dunes act as a buffer against wave damage during storms, protecting the land behind from saltwater intrusion, sea spray and strong winds. Coastal dunes also act as a reservoir of sand to replenish and maintain the beach at times of erosion.

Coastal environment – the landscape, functions and communities in the coastal zone.

Coastal environment area – land identified in the CM Act as land containing coastal features such as coastal waters of the State, estuaries, coastal lakes, coastal lagoons and land adjoining those features, including headlands and rock platforms. The CM SEPP maps the extent of the coastal environment area for planning purposes.

Coastal hazard – defined in the CM Act to mean the following:

- beach erosion
- shoreline recession
- coastal lake or watercourse entrance instability
- coastal inundation
- coastal cliff or slope instability
- tidal inundation
- erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters.

Coastal inundation – coastal inundation occurs when a combination of meteorological processes raise ocean water levels above normal tidal elevations, causing land that is usually 'dry' to become inundated by sea water. Alternatively, the elevated water level may result in wave run-up and overtopping of natural or built shoreline structures (e.g. dunes, seawalls).

Coastal Management Area – any one of four areas that make up the coastal zone as defined in the CM Act. These are the coastal wetlands and littoral rainforests area, coastal vulnerability area, coastal environment area, and the coastal use area.

Coastal management objectives – specific objectives identified in the CM Act for each of the four coastal management areas.

Coastal management program – a long-term strategy for the coordinated management of land within the coastal zone, prepared and adopted under Part 3 of the CM Act.

Coastal processes – marine, physical, meteorological and biological activities that interact with the geology and sediments to produce a particular coastal system.

Coastal threat – a process or activity that is putting pressure on or impacting on the health or function of a coastal ecosystem, or on the amenity and social or cultural value of the coastal landscape. Examples include the discharge of effluent or poor-quality stormwater into coastal lakes and lagoons, discharges from acid sulfate soils, or the spread of invasive species. High recreational demand can also be a threat to coastal ecosystem health.

Coastal use area – land identified by the CM Act and CM SEPP as being land adjacent to coastal waters, estuaries, coastal lakes and lagoons where development is or may be carried out (now or in the future). The CM SEPP maps the extent of the coastal use area for planning purposes.

Coastal vulnerability area – defined in the CM Act as land subject to seven coastal hazards.

Coastal wetland – wetlands are areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water and have soils, plants and animals in them that are adapted to, and depend on, moist conditions for at least part of their lifecycle. Coastal wetlands include marshes, mangroves, swamps, melaleuca forests, casuarina forests, sedgelands, brackish and freshwater swamps and wet meadows.

Coastal zone – as defined in the CM Act and CM SEPP: the area of land comprised of the following coastal management areas: the coastal wetlands and littoral rainforest area, the coastal vulnerability area, the coastal environment area and the coastal use area.

Coastal zone (general) – the transition zone where the land meets water, the region that is directly influenced by marine and lacustrine hydrodynamic processes. Extends offshore to the continental shelf break and onshore to the first major change in topography above the reach of major storm waves. On barrier coasts, includes the bays and lagoons between the barrier and the mainland.

Coastal zone management – the integrated management of issues affecting the coastal zone. Coastal zone management is not restricted to coastal protection works, but includes also development and activities to manage the economical, ecological, cultural and social values of the coast.

Coastal zone management plan – a management plan for the open coast, an estuary or a coastal lake, prepared under the *Coastal Protection Act 1979*.

Coincident inundation - is the combination of both **catchment flooding** and **coastal inundation**, which can occur due to the same storm cell generating both rainfall and elevated ocean water levels. Design flood levels in the lower portion of a coastal waterway will then be influenced by a combination of these sources, resulting in higher predicted levels of inundation (i.e. the worst form of inundation).

Consequence – the outcome or impact of a hazard or threat.

Dredging - An underwater excavation activity intended to remove sediments and debris. Often used to keep navigable pathways within waterways

Dune – subaerial (see coastal dune).

Ecosystem – the living organisms and the non-living environment interacting in an area, encompassing the relationships between biological, geochemical, and geophysical systems; or a community and its environment including living and non-living components.

El Niño southern oscillation (ENSO) – a year to year fluctuation in atmospheric pressure, ocean temperatures and rainfall associated with El Niño (warming of the oceans in the equatorial eastern and central Pacific). El Niño tends to bring below average rainfall.

Endangered Ecological Community - An assemblage of species occupying a particular area, listed as endangered under relevant State and Federal legislation.

Entrance management - Includes artificial opening of entrances, managing the configuration, height or location of the beach to enable entrance opening at a level lower than the natural range.

Environment – surroundings, the physical and biological system supporting life, including humans and their built environment. Includes cultural features of archaeological or historical interest.

Eolian or Aeolian processes – pertaining to the wind, especially used with deposits such as loess and dune sand, and sedimentary structures like wind-formed ripple marks.

Erosion – the wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

Estuary – CM Act defines as any part of a river, lake, lagoon, or coastal creek whose level is periodically or intermittently affected by coastal tides, up to the highest astronomical tide.

Estuary inundation – flooding around the shoreline of an estuary or coastal lake, by a mixture of tidal water and catchment flood water.

Exposure – the potential for assets to be impacted by a hazard based on data or modelling of the hazard.

Evacuation - The temporary movement of people from a dangerous or potentially dangerous place to a safe location, and their eventual return. It is a safety strategy which uses distance to separate people from the danger created by the hazard.

Fit for purpose – right for the job it is intended to do. A fit for purpose assessment considers the level of data detail and the types of consultation required to make a reasonable management decision. In general, the detail and consultation required will increase with risk, complexity and impact.

Flood - Relatively high water level which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences, including Tsunami.

Flood liable land (also referred to as flood prone land) - Land susceptible to flooding by the Probable Maximum Flood (PMF) event. This term also describes the maximum extent of a floodplain which is an area of a river valley, adjacent to the river channel, which is subject to inundation in floods up to this event.

Floodplain - The area of (low-lying) land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.

Floodplain Management Plan - A plan developed in accordance with the principles and guidelines in the New South Wales Floodplain Development Manual. Such a plan usually includes both written and diagrammatic information describing how particular areas of flood prone land can be used and managed to achieve defined objectives.

Floodway - An area where a significant volume of water flows during floods. Such areas are often aligned with obvious naturally-defined channels and are areas that, if partially blocked, would cause a significant redistribution of flood flow which may in turn adversely affect other areas. They are often, but not necessarily, the areas of deeper flow or the areas where higher velocities occur.

Foredune – the larger and more mature dune lying between the incipient dune and the hind-dune area. Foredune vegetation is characterised by grasses and shrubs. Foredunes provide an essential reserve of sand to meet the erosion demand during storm conditions. During storm events, the foredune can be eroded back to produce a pronounced dune scarp.

Foreshore – the part of the shore, lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall; or the beach face, the portion of the shore extending from the low water line up to the limit of wave uprush at high tide. The CM Act defines the foreshore as ‘the area of land between highest astronomical tide and the lowest astronomical tide’.

Groyne – a shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore; or a narrow, roughly shore normal structure built to reduce longshore currents, and/or to trap and retain littoral material. Most groynes are of timber or rock and extend from a seawall, or the backshore, well onto the foreshore and rarely even further offshore.

Hazard – a process, or activity that affects an asset or value. See also 'coastal hazards' which are the specific hazards defined in the CM Act.

Highest Astronomical Tide (HAT) – the highest level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions. In Australia HAT is calculated as the highest level from tide predictions over the tidal datum epoch (TDE), this is currently set to 1992 to 2011.

The **HAT** and the **Lowest Astronomical Tide (LAT)** levels will not be reached every year. LAT and HAT are not the extreme water levels which can be reached, as storm surges may cause considerably higher water levels to occur.

High High Water solstice Springs (HHWSS) – The greatest 'spring tide' effects occur during the summer and winter solstices, when the sun travels across its highest and lowest arcs in the sky (longest and shortest days, respectively), in June and December in the Southern Hemisphere. On average, the HHWSS tidal plane in NSW is approximately 13 centimetres lower than HAT (NSW Estuary Tidal Inundation Exposure Assessment (OEH, 2018)).

Hydrodynamic – relates to the specific scientific principles that deal with the motion of fluids and the forces acting on solid bodies immersed in fluids, and in motion relative to them.

Impacts – include damage, harm or losses to exposed communities, property, services, livelihoods, access, use and amenity, heritage, ecosystems and the environment because of exposure and sensitivity. Impacts may also be positive.

Incipient dune – the most seaward and immature dune of the dune system. Vegetation characterised by grasses such as spinifex. On an accreting coastline, the incipient dune will develop into a foredune.

Indirect Effect - Indirect effects are generally a consequence of infrastructure damage or interruption of services and can affect communities distant from the actual flood footprint i.e. floodplain. Indirect effects can also refer to indirect losses due to disruption of economic activity, both in areas which are inundated or isolated. Indirect effects are one of the three primary sources of risk in the context of flooding (the other two are inundation and isolation).

Intertidal – that land area between mean low water and mean high water that is inundated periodically by tides.

Inundation - See definition for Flood.

La Niña – the opposite state to El Niño, occurring when the SOI is positive. La Niña tends to bring above average rainfall over much of Australia.

Lagoon – a shallow body of open water, partly or completely separated from the sea by a coastal barrier or reef. Sometimes connected to the sea via an inlet.

Likelihood – the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically (such as a probability or a frequency over a given time period).

Littoral – of or pertaining to a shore, especially of the sea. Often used as a general term for the coastal zone influenced by wave action, or, more specifically, the shore zone between the high and low water marks.

Local council – for the purposes of the coastal management manual, a council that is wholly or partly within the coastal zone of NSW.

Lowest Astronomical Tide (LAT) – the lowest level that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions. This level will not be reached every year.

Low-level persistent flooding - (sometimes referred to as 'nuisance flooding') refers to inundation of the lowest parts of the foreshore areas from gradual rises in Lake level during periods of entrance closure and occasional rainfall, or under potentially higher tidal conditions with sea level rise and an open entrance.

Marine sediment – sediment originating from the sea.

Mean High Water Springs (MHWS) – the average throughout the year of two successive high waters during those periods (approximately once a fortnight) when the range of the tide is at its greatest.

Mean High Water Neaps (MHWN) – the average height obtained from the two successive high waters during those periods (approximately once a fortnight) when the range of the tide is least.

Mean Low Water Neaps (MLWN) – the average height obtained from the two successive low waters during those periods (approximately once a fortnight) when the range of the tide is least.

Mean Low Water Springs (MLWS) – the average height obtained by the two successive low waters during those periods (approximately once a fortnight) when the range of the tide is at its greatest.

Mean sea level – the arithmetic mean of hourly heights of the sea at a tidal station, observed over a long period of time.

Midden - Aboriginal place of significance where debris from eating shellfish and other food has accumulated over time. Often found on headlands, beaches and dunes, around estuaries, swamps and along the banks of rivers, creeks and lakes.

Natural coastal processes – the coastal processes over which people have no control, such as wind, waves and tides.

Over-wash – the part of the wave uprush that runs over the crest of a berm or structure and does not flow directly back to the ocean or lake. When waves overtop a coastal protection structure, they often carry sediment landwards which is then lost to the beach system. Also defines a process in which waves penetrate inland of the beach, which is common on low barriers.

Pollution – the condition caused by the presence of substances of such character and in such quantities that the quality of the environment is impaired; or the human-induced alteration of the chemical, physical, biological or radiological integrity of an aquatic ecosystem.

Recession – a continuing landward movement of the shoreline; or a net landward movement of the shoreline over a specified time.

Rehabilitation - The process of returning the environment in a given area to some degree of its natural state, after some process has resulted in its damage.

Riparian vegetation - Vegetation located along the banks of a body of water, usually rivers.

Resilience – the ability of a system (human or natural) to adapt to changing conditions (including hazards or threats, variability and extremes), and rapidly recover from disruption due to emergencies. Resilient systems or communities have the capacity to ‘bounce back’ after a disrupting event such as a major storm or an extended heat wave, to moderate potential damages, take advantage of opportunities, maintain or restore function or to cope with the consequences.

Revetment or seawall – a type of coastal protection works which protects assets from coastal erosion by armouring the shore with erosion–resistant material. Large rocks/boulders, concrete or other hard materials are used, depending on the specific design requirements.

Riparian – pertaining to the banks of a body of water, such as an estuary.

Risk – effect of uncertainty on planning and management objectives, usually characterised by reference to potential hazards, their consequence and their likelihood. Consequence combines the concepts of magnitude, sensitivity and duration.

Risk-based Framework - a protocol that decision-makers, such as councils and environmental regulators, can use to help manage the impact of land-use activities on the health of waterways in New South Wales.

Sea level rise – an increase in the mean level of the oceans. Relative sea level occurs where there is a local increase in the level of the ocean relative to the land, which might be caused by ocean rising, the land subsiding, or both. In areas with rapid land level uplift (e.g. seismically active areas), relative sea level can fall.

Sensitivity – the degree to which a built, natural or human system is directly or indirectly affected by changes in hazards, threats or climate conditions.

Shoreline recession – refers to continuing landward movement of the shoreline, that is, a net landward movement of the shoreline, generally assessed over a period of several years. As shoreline recession occurs the beach fluctuation zone is translated landward.

Stakeholder – a person or organisation with an interest or concern in something.

Storm surge – the increase in coastal water level caused by the effects of storms. Storm surge consists of two components – the increase in water level caused by the reduction in barometric pressure and the increase in water level caused by the action of wind blowing over the sea surface (wind set-up).

Storm tide – an abnormally high water level that occurs when a storm surge combines with a high astronomical tide. The storm tide must be accurately predicted to determine the extent of coastal inundation.

Threats – see Coastal threats. In the coastal management context, a threat is a process or activity which puts pressure on one or more coastal assets or values. Threats may include land uses (e.g. urban, recreation), land management, climate change, industrial discharges, stormwater runoff, overfishing, invasive species as well as the pressures from coastal hazards.

Tidal channel – a major channel followed by tidal currents, extending from offshore into a tidal marsh or a tidal flat; tidal inlet.

Tidal inundation – the inundation of land by tidal action under average meteorological conditions and the incursion of sea water onto low lying land that is not normally inundated, during a high sea level event such as a king tide or due to longer-term sea level rise.

Tide - The periodic rise and fall of the water of oceans, seas, bays, etc., caused mainly by the gravitational interactions between the Earth, Moon and Sun.

Tributary - A stream or river that flows into a larger stream or lake.

Trigger – pre-negotiated decision-making points and commitments, so that action on coastal risks is taken when necessary, and when it is most convenient and affordable for the affected community

Vulnerability – a function of exposure and sensitivity of assets to a hazard, which determines the potential impacts of the hazard. For instance, the vulnerability of coastal assets may be influenced by the extent and impact of environmental, social and economic factors such as saline contamination of soils from flooding, erosion of built-up and natural areas, loss of vegetation, disruption to use, or access, or continuity of service, or loss of amenity, corrosion of built structures, undermining of foundations or damage to contents. Vulnerability also considers the adaptive capacity which is the capacity to adapt or the resilience in the system to manage the impacts and changes.

Wave run-up – the vertical distance above mean water level reached by the uprush of water from waves across a beach or up a structure.

Wave set-up – the rise in the water level above the still water level when a wave reaches the coast. It can be very important during storm events as it results in further increases in water level above the tide and surge levels.

Wind waves – ocean waves resulting from the action of the wind on the surface of the water.

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Appendix A –Tidal and Coastal Inundation Modelling Report

REPORT

Lake Conjola CMP

Stage 2 - Tidal and Coastal Inundation Modelling

Client: Shoalhaven City Council

Reference: PA2591-RHD-ZZ-XX-RP-Z-0002

Status: S0/P01.01

Date: 03 December 2021

Royal HaskoningDHV

Enhancing Society Together

HASKONING AUSTRALIA PTY LTD.

Level 15
99 Mount Street
NSW 2060 North Sydney
Water & Maritime
Trade register number: ACN153656252

+61 2 8854 5000 **T**
project.admin.australia@rhdhv.com **E**
royalhaskoningdhv.com **W**

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Table of Contents

1 Introduction 1
1.1 Background 1
1.2 Project Understanding and Strategic Context 2
1.2.1 Statutory Framework 2

2 Glossary of Terms 4

3 Available Data 8
3.1 Previous Reports and Studies 8
3.2 Lake Conjola Flood Study (BMT WBM, 2007) 9
3.2.1 Introduction 9
3.2.2 Models 9
3.2.2.1 DEM 9
3.2.2.2 Hydraulic Model 10
3.2.2.3 Geomorphologic Model 11
3.2.3 Model Calibration and Verification 12
3.3 Topography and Bathymetry 14
3.4 Physical Process Data 14
3.4.1 Water Level Data 14
3.4.2 Wave Data 17
3.4.3 Sea Level Rise 17

4 Modelling Approach 19
4.1 Introduction 19
4.1.1 Coincident Events 19
4.2 Model Systems 20
4.2.1 MIKE 21 FM 20
4.3 Hydrodynamic Modelling of Tidal Inundation 20
4.3.1 Introduction 20
4.3.2 Model Setup 21
4.3.3 Sensitivity Analyses 23
4.3.4 Model Calibration 24
4.3.5 Model Boundary Conditions 24
4.4 Hydrodynamic Modelling of Coastal Inundation 25
4.4.1 Introduction 25
4.4.2 Model Setup 26
4.4.3 Sensitivity Analyses 27
4.4.4 Model Calibration 28
4.4.5 Model Boundary Conditions 28

5 Tidal Inundation Flooding 30
5.1 Results 30
5.2 Discussion 30
6 Coastal Inundation Flooding 33
6.1 Results 33
7 References 34

Table of Tables

Table 3-1 Summary of previous reports and studies 8
Table 3-2 Summary of topographic and bathymetric data 14
Table 3-3 Summary of water level data 14
Table 3-4 Summary of tidal planes for the Jervis Bay and Ulladulla ocean tide gauges 15
Table 3-5 Summary of offshore wave data 17
Table 4-1 Tidal inundation scenarios 21
Table 4-2 Hydrodynamic model resolution 21
Table 4-3 Coastal inundation scenarios 26

Table of Figures

Figure 1-1 Lake Conjola locality plan (source: Nearmap, April 2021) 1
Figure 3-1 Conjola Lake hydraulic model layout (BMT WBM, 2007) 11
Figure 3-2 Conventional calibration process (from: BMT WBM, 2007) 13
Figure 3-3 Ocean tide gauge locations near Lake Conjola 15
Figure 3-4 Lake Conjola tide gauge locations 16
Figure 3-5 Tidal plane analysis at Lake Conjola (MHL, 2012) 16
Figure 3-6 Lake Conjola M2 tidal constituent time-series (from: https://mhlfit.net/users/ShoalhavenCityCouncil-LakeConjolaM2) 17
Figure 4-1 Lake Conjola tidal inundation model bathymetry (Present Day) 22
Figure 4-2 Catchment Inflows for the 1% AEP Design Event 23
Figure 4-3 Sensitivity analysis of entrance channel scour degree 24
Figure 4-4 Tidal inundation ocean boundary (present day) 25
Figure 4-5 Lake Conjola coastal inundation model bathymetry (Present Day) 27
Figure 4-6 Coastal inundation sensitivity analyses 28
Figure 5-1 Attenuation of the HHWSS tidal plane for the Present Day 31

Figure 5-2 Attenuation of the HHWSS tidal plane for 2120 (bed not raised) 32
Figure 5-3 Attenuation of the HHWSS tidal plane for 2120 (bed raised) 32

Appendices

Appendix A: Tidal Inundation Maps
Appendix B: Coastal Inundation Maps

1 Introduction

1.1 Background

Haskoning Australia Pty Ltd, a company of Royal HaskoningDHV (RHDHV), has been engaged by Shoalhaven City Council (Council) for the carrying out of the Coastal Management Plan (CMP) for Lake Conjola. A locality plan of Lake Conjola is presented in **Figure 1-1**.



Figure 1-1 Lake Conjola locality plan (source: Nearmap, April 2021)

The primary purpose of a CMP is to set out the long-term strategy for co-ordinated management of land within the coastal zone to meet local needs over a defined implementation period. CMPs consider management issues and opportunities that relate to each of the four coastal management areas (where applicable):

- Coastal wetlands and littoral rainforest areas;
- Coastal vulnerability areas;
- Coastal environmental areas; and
- Coastal use areas.

The CMP for Lake Conjola is prepared in accordance with the NSW Government's coastal management framework including the requirements of the Coastal Management Act 2016 (CM Act), the State Environmental Planning Policy (Coastal Management) 2017 (CM SEPP) and the NSW Coastal

Management Manual parts A and B (the Manual) (also refer **Section 1.2**). Preparation of the CMP involves progressing through each of the five stages outlined within Part B of the Manual

This report presents the results of the following assessments undertaken as part of Stage 2 of the CMP:

- **Tidal inundation**
  The inundation of land by tidal action under average meteorological conditions (also referred to as 'nuisance flooding'); and
- **Coastal inundation**
  Occurs when a combination of marine and atmospheric processes raises ocean water levels above normal elevations and inundate low-lying areas or overtop dunes, structures and barriers. It is often associated with storms resulting in elevated still water levels (storm surge), wave setup, wave run-up and over-wash flows.

1.2 Project Understanding and Strategic Context

1.2.1 Statutory Framework

The statutory and policy framework for coastal and marine management was the subject of the New South Wales (NSW) Coastal Reforms over several years. The passage of the Marine Estate Management Act (MEMA) 2014 and the Coastal Management Act 2016 marked the commencement of a new set of arrangements for all coastal areas in NSW.

The Coastal Management Act 2016 (CM Act) was enabling legislation and now has practical effect through the commencement of the State Environmental Planning Policy (SEPP) (Coastal Management) 2018. The Coastal Management SEPP (CM SEPP) includes digitised maps for three of the four management areas comprising the coastal zone, plus land use objectives and development controls associated with those management areas.

The Coastal Reforms also established a basis for cohesive coastal and marine planning in NSW, meaning that the existing legislative framework, including the Environmental Planning and Assessment Act 1979, and the work of the Marine Estate Management Authority (MEMA), are now integrated.

One of the objectives of the CM Act is "to promote integrated and co-ordinated coastal planning, management and reporting". The CM Act also requires that the Coastal Management Manual provides guidance regarding the local council's integration of its Coastal Management Program with its Integrated Planning and Reporting framework obligations under the Local Government Act 1993. Chapter 3 of the NSW Local Government Act 1993 outlines the principles for local government. While all principles are relevant, some specific common areas are:

- Councils should work co-operatively with other councils and the State government to achieve desired outcomes for the local community (consistent with the sediment compartment approach of the Coastal Management Act).
- Councils should consider the long term and cumulative effects of actions on future generations (consistent with planning for sea level rise).
- Councils should identify and prioritise key local community needs and aspirations and consider regional priorities (consistent with CMP engagement processes).
- Councils should identify strategic goals to meet those needs and aspirations (consistent with CMP planning).

- Councils should manage risks to the local community or area or to the council effectively and proactively (CMP risk and threat assessments).
- Councils should make appropriate evidence-based adaptations to meet changing needs and circumstances (consistent with CMP arrangement for management of the Coastal Vulnerability Area).
- Councils should actively engage with their local communities, through the use of the Integrated Planning & Reporting (IP&R) Framework and other measures (consistent with CMP engagement processes).

The IP&R Framework is all about responsible and sustainable decision-making by Councils, and the Coastal Management SEPP has, as a stated core aim, to establish a framework for land use planning to guide decision-making in the coastal zone. The CM Act and the CM SEPP, as well as the Local Government Act, have inbuilt bridges between the statutes, to achieve a consistent and compatible method of identifying current and future risk, prioritising responses and imposing financial rigor and good practice in terms of allocating scarce resources.

In addition, the CM Act was developed to connect and enable delivery of the priorities outlined within the Marine Estate Management Act (2014) and its associated planning requirements. Key issues were identified within the Threat and Risk Assessment for the Marine Estate, and will be used to inform and guide sections of the CMP.

2 Glossary of Terms

Term	Description
Annual Exceedance Probability (AEP)	The probability (expressed as a percentage) of an exceedance (e.g. large wave height or high water level) in a given year.*
Astronomical tides	Tides which are only influenced by the gravitational effect of the moon and the sun. Does not include climate, geography or other factors.
Australian Height Datum (AHD)	A common national plane of level corresponding approximately to mean sea level.
Average Recurrence Interval (ARI)	The average time between which a threshold is reached or exceeded (e.g. large wave height or high water level) of a given value. Also known as Return Period.*
Bathymetry	Depth profile of an area. Usually notated by amount of meters below mean sea level where negative signifies height above.
Bedrock	A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.*
Calibration	The process by which the results of a computer model are brought to agreement with observed data.
Catchment area	The area which drains naturally to a particular point on a river, thus contributing to its natural discharge.*
Catchment flooding	Flooding due to floodwaters that originate from heavy or prolonged rain causing stormwater to travel down-slope towards an estuary.**
Chart Datum (CD)	Chart Datum, common datum for navigation charts. Typically, Lowest Astronomical Tide.
Climate change	Occurs naturally in response to long-term variables, but often used to describe a change of climate that is directly attributable to human activity that alters the global atmosphere, increasing change beyond natural variability and trends.*
Coast	A strip of land of variable width that extends from the shoreline inland to the first significant landform that is not influenced by coastal processes (such as waves, tides and associated currents).*
Coastal inundation	Coastal inundation occurs when a combination of marine and atmospheric processes raises the water level at the coast above normal elevations, causing land that is usually ‘dry’ to become inundated by sea water. Alternatively, the elevated water level may result in wave run-up and overtopping of natural or built shoreline structures (e.g. dunes, seawalls).*
Coastal lake or lagoon	A coastal water body that is generally closed off from the sea by a sandy barrier. Water levels and water quality may be quite different to the nearby ocean.*
Coastal management program	A long-term strategy for the coordinated management of land within the coastal zone, prepared and adopted under Part 3 of the CM Act.*

Coastal processes	Marine, physical, meteorological and biological activities that interact with the geology and sediments to produce a particular coastal system.*
Design storm	A hypothetical extreme storm with waves that coastal protection structures will often be designed to withstand. The severity of the storm (i.e. return period) is chosen in view of the acceptable level of risk of damage or failure. A design storm consists of a design wave condition, a design water level and a duration.*
Design wave	In the design of harbour works, coastal protection works etc., the type or types of waves selected as having the characteristics against which protection is desired.*
Drowned river valley	A type of wave-dominated estuary, usually a deep bedrock embayment, with a wide, deep mouth.
East Coast Low	An intense low-pressure system that occurs off the east coast of Australia, bringing storms, high waves and heavy rain. East coast lows generally occur in autumn and winter off NSW, southern Queensland and eastern Victoria.*
Ebb tide	The outgoing tidal movement of water within an estuary.
Estuary	CM Act defines as any part of a river, lake, lagoon, or coastal creek whose level is periodically or intermittently affected by coastal tides, up to the highest astronomical tide.*
Flood tide	The incoming tidal movement of water within an estuary.
Flushing time	The time required to replace all the water in an estuary, harbour, etc., by action of current and tide.*
Foreshore.	The area of shore between low and high tide marks and land adjacent thereto
High High Water Solstice Springs (HHWSS)	The greatest ‘spring tide’ effects occur during the summer and winter solstices, when the sun travels across its highest and lowest arcs in the sky (longest and shortest days, respectively), in June and December in the Southern Hemisphere. On average, the HHWSS tidal plane in NSW is approximately 13 cm lower than HAT (NSW Estuary Tidal Inundation Exposure Assessment (OEH, 2018)).
Highest astronomical tide (HAT)	The highest level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions. In Australia HAT is calculated as the highest level from tide predictions over the tidal datum epoch (TDE). The HAT and the Lowest Astronomical Tide (LAT) levels will not be reached every year. LAT and HAT are not the extreme water levels which can be reached, as storm surges may cause considerably higher and lower levels to occur.*
Hydrodynamic	Relates to the specific scientific principles that deal with the motion of fluids and the forces acting on solid bodies immersed in fluids, and in motion relative to them.*
Intermittently closed and open lakes and lagoons (ICOLL)	Coastal lakes and lagoons where the entrance may be closed to the sea from time to time and for varying periods, by accretion of a berm. ICOLLs have sensitive water quality because they accumulate loads of sediment and

	nutrients from the catchment and may have poor water circulation and flushing. The most sensitive waterways listed in the CM SEPP are all ICOLLs. The catchments of these lakes and lagoons are included in the coastal environment area.*
Lowest Astronomical Tide (LAT)	See CD.
Mean high water mark	The line of the medium high tide between the highest tide each lunar month (the springs) and the lowest tide each lunar month (the neap) averaged over out over the year. In NSW, the methods for determining the position of the MHWM are outlined in the Crown Directions to Surveyors - No. 6 Water as a Boundary.*
Mean sea level	The arithmetic mean of hourly heights of the sea at a tidal station, observed over a long period of time.*
Neap tides	Tides with the smallest range in a monthly cycle. Neap tides occur when the sun and moon lie at right angles relative to the earth (the gravitational effects of the moon and sun act in opposition on the ocean).
Numerical model	A mathematical representation of a physical, chemical or biological process of interest. Computers are often required to solve the underlying equations.
Sea level rise	An increase in the mean level of the oceans. Relative sea level occurs where there is a local increase in the level of the ocean relative to the land, which might be caused by ocean rising, the land subsiding, or both. In areas with rapid land level uplift (e.g. seismically active areas), relative sea level can fall.*
Sediment transport	The process whereby sediment is moved offshore, onshore or along shore by wave, current or wind action.*
Significant wave height (H_s)	H_s may be defined as the average of the highest 1/3 of wave heights in a wave record ($H_{1/3}$).
Spring tides	Tides with the greatest range in a monthly cycle, which occur when the sun, moon and earth are in alignment (the gravitational effects of the moon and sun act in concert on the ocean)
Storm surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components – the increase in water level caused by the reduction in barometric pressure and the increase in water level caused by the action of wind blowing over the sea surface (wind set-up).*
Storm tide	An abnormally high water level that occurs when a storm surge combines with a high astronomical tide. The storm tide must be accurately predicted to determine the extent of coastal inundation.*
Swell waves	Ocean waves that travel beyond the area where they are generated.*
Tidal flushing	The removal of water and sediment from an estuary, by the ebb and flow of tidal currents that are stronger, more constant, or more prevalent than the incoming river flow.*
Tidal inundation	The inundation of land by tidal action under average meteorological conditions and the incursion of sea water onto low lying land that is not normally

	inundated, during a high sea level event such as a king tide or due to longer-term sea level rise*
Tidal limit	The most upstream location where a tidal rise and fall of water levels is discernible. The location of the tidal limit changes with freshwater inflows and tidal range.
Tidal planes.	A series of water levels that define standard tides, e.g. 'Mean High Water Spring' (MHWS) refers to the average high water level of Spring Tides
Tides	The regular rise and fall in sea level in response to the gravitational attraction of the Sun, Moon and Earth.
Wave run-up	The vertical distance above mean water level reached by the uprush of water from waves across a beach or up a structure*
Wave set-up	The rise in the water level above the still water level when a wave reaches the coast. It can be very important during storm events as it results in further increases in water level above the tide and surge levels*

** source: https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Coasts/coastal-management-glossary-180195.pdf*

3 Available Data

3.1 Previous Reports and Studies

A number of relevant studies have previously been conducted. These studies have been reviewed as part of this study and the relevant information will be incorporated, as required. A summary of the key studies is provided in **Table 3-1** and BMT WBM (2007) is further discussed in the following section.

Table 3-1 Summary of previous reports and studies

Study / Report	Month/Year	Author	Description
Lake Conjola Entrance Study	May 1999	PBP	The Lake Conjola Entrance Study was commissioned to develop an understanding of existing lake processes, determine the effects of (manipulation of) existing entrance conditions on flood behaviour and water quality, and discuss and undertake economic assessments of management options
Lake Conjola Entrance Management Plan	January 2003	MHL	The management plan describes the system for management of the entrance of Lake Conjola on the NSW south coast to ensure a permanently open entrance.
Lake Conjola Flood Study	July 2007	BMT WBM	Report for the Lake Conjola Flood Study covering the development and calibration of computer models, establishment of design flood behaviour and flood mapping.
Lake Conjola Floodplain Risk Management Study and Plan	February 2013	BMT WBM	The Lake Conjola Floodplain Risk Management Study and Plan investigates and presents a flood risk management strategy for the catchment. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Management Plan, which describes how flood liable lands within the Lake Conjola catchment are to be managed in the future.
Lake Conjola Interim Entrance Management Policy	August 2013	GHD	The policy outlines the circumstances under which Shoalhaven City Council (SCC) is to artificially open Lake Conjola entrance and provides a rational decision-making procedure for undertaking the works
Coastal Zone Management Plan for the Shoalhaven Coastline	June 2018	Shoalhaven City Council	The Coastal Zone Management Plan sets out the plan for coastal management within the Shoalhaven City local government area for the next five years and beyond. During the next 5 years Council will develop a new Coastal Management Program in accordance with the

			latest requirements of the NSW Coastal Management Act 2016.
Shoalhaven CMP Scoping Study	August 2020	Advisian	The Scoping Study documents Stage 1 in the development of a Coastal Management Program (CMP) for the Shoalhaven coastline. The Scoping Study sets the scene for Shoalhaven City Council's coastal planning process leading to the development of a Coastal Management Program (CMP), as required by the NSW Coastal Management Act 2016.

3.2 Lake Conjola Flood Study (BMT WBM, 2007)

3.2.1 Introduction

The Lake Conjola Flood Study (BMT WBM, 2007) was undertaken as part of the NSW Floodplain Risk Management Process. Its main objectives were:

- to examine and define the flood behaviour of Conjola Lake in the vicinity of the villages lying on its foreshores; and
- to provide input for the subsequent floodplain management study and plan.

Computer models were developed to predict the flood risks for areas surrounding Conjola Lake. These models have been used to determine hydraulic categories and the provisional flood hazard.

3.2.2 Models

For the purpose of the Flood Study (BMT WBM, 2007), four (4) different computer models were developed:

- Digital Elevation Model (DEM);
- Hydrologic Model (not discussed here);
- Hydraulic Model; and
- Geomorphologic Model.

3.2.2.1 DEM

The Conjola Lake DEM was created from five different survey data sources:

- Bathymetry
  - Bathymetric data from the PBP (1999) RMA model, based on the DPWS's 1993 cross-sectional survey of the lake (likely to have a high level of accuracy);
- Topography
  - Ground survey of residential areas undertaken in 1995 for the Reticulated Sewerage Survey Scheme EIS (Shoalhaven Water, 1995) - the most comprehensive dataset (accuracy of about 0.1m);
  - Land & Information Centre (LIC) 2m contour data (least accurate data source), as shown on orthophoto maps, to define bank levels in the forested national park areas (year unknown?);

- Land & Information Centre (LIC) 10m contour data (least accurate data source), as shown on topographic maps, to define higher ground where data was missing (year unknown?); and
- Ground survey of creeks and structures undertaken in June 2003 as part of the Flood Study (BMT WBM, 2007).

The lake bathymetric survey undertaken in 1993 is likely to have a high level of accuracy. However, currents, floods and sedimentation may have modified the bathymetric geometry since that time. GHD, (1996) reported that the catchment does not produce much sediment, thus changes due to sedimentation would be minor. As a consequence, it is estimated that the bathymetric survey has an accuracy of about 0.1 to 0.4m depending on the location in the lake.

This accuracy does not apply to the entrance channel, however. Separate DEMs were generated for the lake for the purpose of model calibration, based on entrance conditions presented in relevant air photos, as follows:

- March 1967 for the February 1971 flood;
- June 1972 for the March 1975 flood; and
- November 1991 for the February 1992 flood.

The accuracy of the DEM generated at the entrance channel for historical events is expected to be in the order of 0.5 to 1m as ground and bed levels were estimated from aerial photographs without field measurement of ground control points. Further, the time between the date of the photography and the calibration flood event is almost four years in the case of the 1971 flood. Given the dynamic nature of the entrance channel, it is highly likely that the entrance conditions for the 1971 event were somewhat different to those represented in the 1967 air photo.

For the modelling of the design floods, two more DEMs were constructed, with the entrance geometries reflecting the two “managed” options adopted by Council and as described in MHL (2003).

3.2.2.2 Hydraulic Model

The hydraulic model simulated the dynamic flooding behaviour in Conjola Lake, including the interactions between the main part of the lake, the entrance channel and the floodplains. The modelling software, TUFLOW, was used to develop a hydraulic model of the study area which was a mixture of the following domain types (also refer **Figure 3-1**):

- one-dimensional (1D), suited to modelling areas away from the areas of interest where flow is essentially 1D; and
- two-dimensional (2D), covering the key areas of existing and future management interest which produces a significantly higher order of resolution in terms of hydraulic computations.

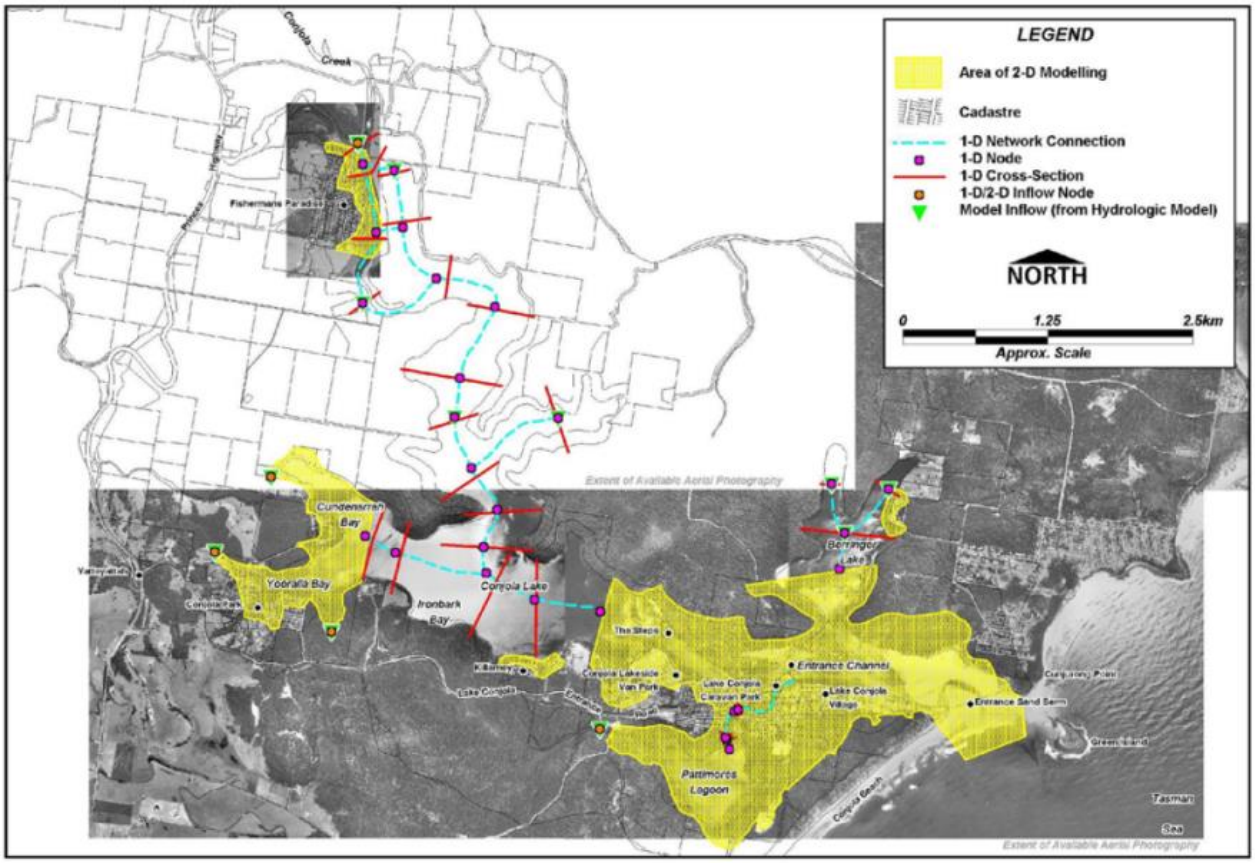

Figure 3-1 Conjola Lake hydraulic model layout (BMT WBM, 2007)

Inputs to the hydraulic model included:

- Topography/bathymetry of the waterway and the floodplain, based on the DEM and creek cross-sections;
- Hydraulic roughness of the channel bed and the floodplain land;
- Hydraulic structures along the canal linking Pattimores Lagoon to Conjola Lake;
- Inflows: the rainfall runoff calculated by the hydrologic model at nodes adjacent to the lake and over the lake body. The runoff hydrographs were introduced into the hydraulic model at 12 different locations around Conjola Lake; and
- Boundary water levels: depending on the entrance channel geometry, the sea levels can influence water levels in the lake. The downstream sea condition takes into account all dominant sea level parameters (astronomical tide, storm surge and wave setup).

3.2.2.3 Geomorphologic Model

Marine sand is deposited in the entrance channel via two main processes:

- lateral transport along Conjola Beach in a northerly direction; and
- onshore transport of incipient nearshore sand bars (particularly following entrance scour events).

The entrance channel is influenced by two primary hydrodynamic processes:

- regular tidal movement of seawater; and

- episodic freshwater runoff from the catchment draining to the sea.

The geomorphologic model (based on the Van Rijn (1990) theory of sediment transport) developed for the Flood Study (BMT WBM, 2007) was combined with the hydraulic model to assess bed and bank scour conditions at the lake entrance. The geomorphologic model used the hydraulic parameters to predict erosion and accretion, and then recalculates the bed levels for the hydraulic model at each time step.

The Van Rijn formulation is generally accepted as being the latest and most accurate method for estimating sand transport and was considered appropriate to combine with the 2D (depth-averaged) TUFLOW hydraulic routines.

Due to computational demands of the geomorphologic module, the extents of the model coverage were kept to a minimum. While some sediment transport can be expected throughout Conjola Lake during flood events, preliminary calculations showed that most transport occurs at the downstream end of the entrance channel in the immediate vicinity of the entrance sand berm.

During the calibration events, the erosion of the sand berm was restricted to a limited area, however, for the design floods, the area of sediment transport was much larger (due to the assumed open entrance conditions). Consequently, the geomorphologic model extent was set wider for the design events in order to conservatively include all potential critical erosion areas throughout the entrance channel.

Inputs to the geomorphologic model included:

- D50: 0.25 mm;
- D90: 0.5 m;
- Fall Velocity: 0.015 m/s;
- Sand Grain Density: 2650 kg/m3;
- Water Density: 1035 kg/m3; and
- Wet/Dry cell boundary slope stability: 5m (horizontal): 1m (vertical).

3.2.3 Model Calibration and Verification

Generally, hydrologic and hydraulic model calibration require boundary conditions as depicted in **Figure 3-2**.

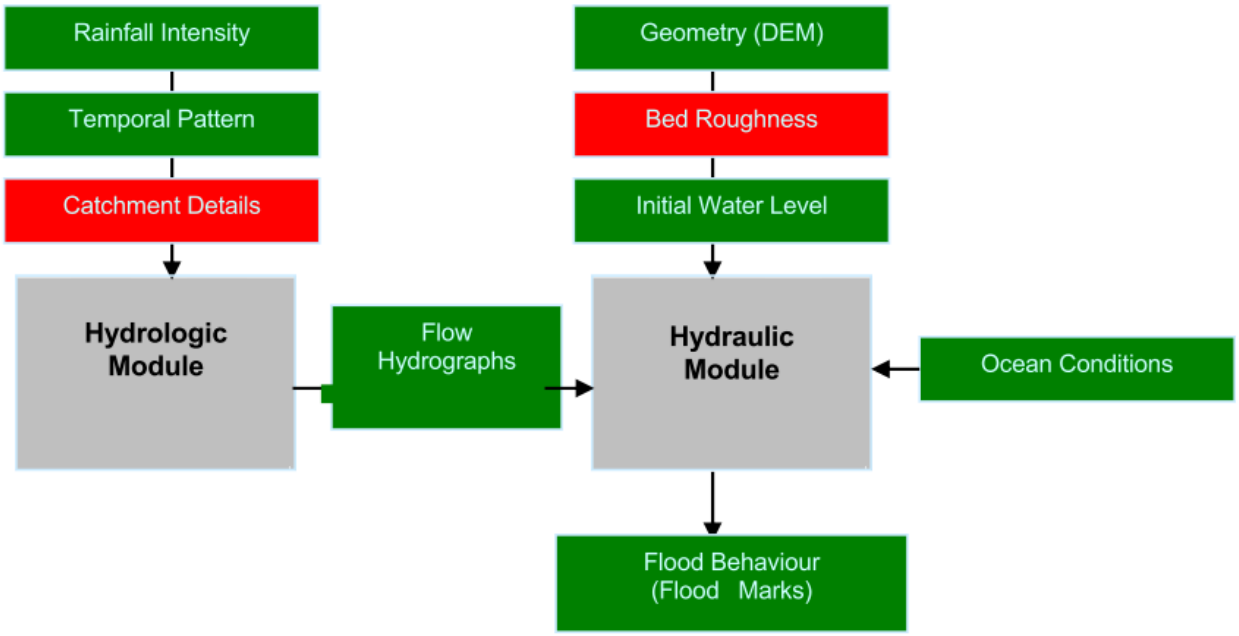

Figure 3-2 Conventional calibration process (from: BMT WBM, 2007)

Conventional calibration of the Conjola Lake models was not possible as more than one input was unknown or lacked effective accuracy to be suitable for calibration. Conventional calibration process variables for hydraulic models include:

- Geometry (DEM);
- Bed roughness (typically the one unknown in hydraulic model calibration);
- Initial water level;
- Flow hydrographs (from hydrologic model); and
- Ocean conditions (Waves, water level).

To fulfil the conventional calibration approach, the additional unknown parameters needed to be fixed, otherwise the models would be unsolvable (i.e. too many unknowns within the equations). In doing so, however, it was recognised that the calibration is based on a series of 'assumed' input parameters, which in essence negated the outcomes of the calibration. However, without any reasonable alternative calibration approach, considerable care was given in assigning model assumptions, ensuring that adopted values were practical and justifiable.

The hydraulic model was calibrated and verified to three historical floods:

- 1971 (calibration)
  - largest flood on record for Conjola Lake
  - sufficient amount of historical information available
- 1975 (verification)
  - important due to its high rainfall
  - quality of the collected data questionable
- 1992 (calibration)
  - not particularly significant in terms of total rainfall
  - resident survey results provided a significant amount of information

However, at the time only limited historical flood information was found in previous studies (GHD, 1996, PBP, 1999). To supplement this information a resident survey of the local communities was carried out and the historical flood information obtained from the interviews and subsequent survey of flood marks compiled directly into the historical flood database.

Comparison of different historical aerial photographs of the catchment showed that the vast majority of the catchment was in a forested condition at the time of these historical flood events, and that this condition largely remained at the time of the flood study (2007).

The only change to the lake that has significant potential to alter flood behaviour was associated with the condition of the entrance channel. The channel is considered to be quite dynamic, responding to major catchment runoff and coastal storm events, particularly in respect to the height of the entrance berm. Aerial photograph interpretation has shown a high degree of variability in entrance channel morphology over the past 30 years (PBP, 1999).

3.3 Topography and Bathymetry

The terrain data summarised in **Table 3-2** was supplied by Council for use in this project.

Table 3-2 Summary of topographic and bathymetric data

Data set	Source
Lake bathymetry	BMT WBM (2013)
Entrance bathymetry	LiDAR survey (OEH, 2018)
Topography	LiDAR survey (OEH, 2011)

3.4 Physical Process Data

3.4.1 Water Level Data

Available water level data is summarised in **Table 3-3**.

Table 3-3 Summary of water level data

Data Set	MHL Station ID	Availability	Years of Available Data
MHL Ulladulla Harbour Gauge	216471	Jan 2008 - Apr 2021	13.2
MHL Jervis Bay Gauge	216470	Sep 1989 - May 2021	31.7
MHL Lake Conjola Gauge	216420	Sep 1992 - Jul 2017	28.2
MHL Lake Conjola Gauge	216420D	Sep 2016 - Present	

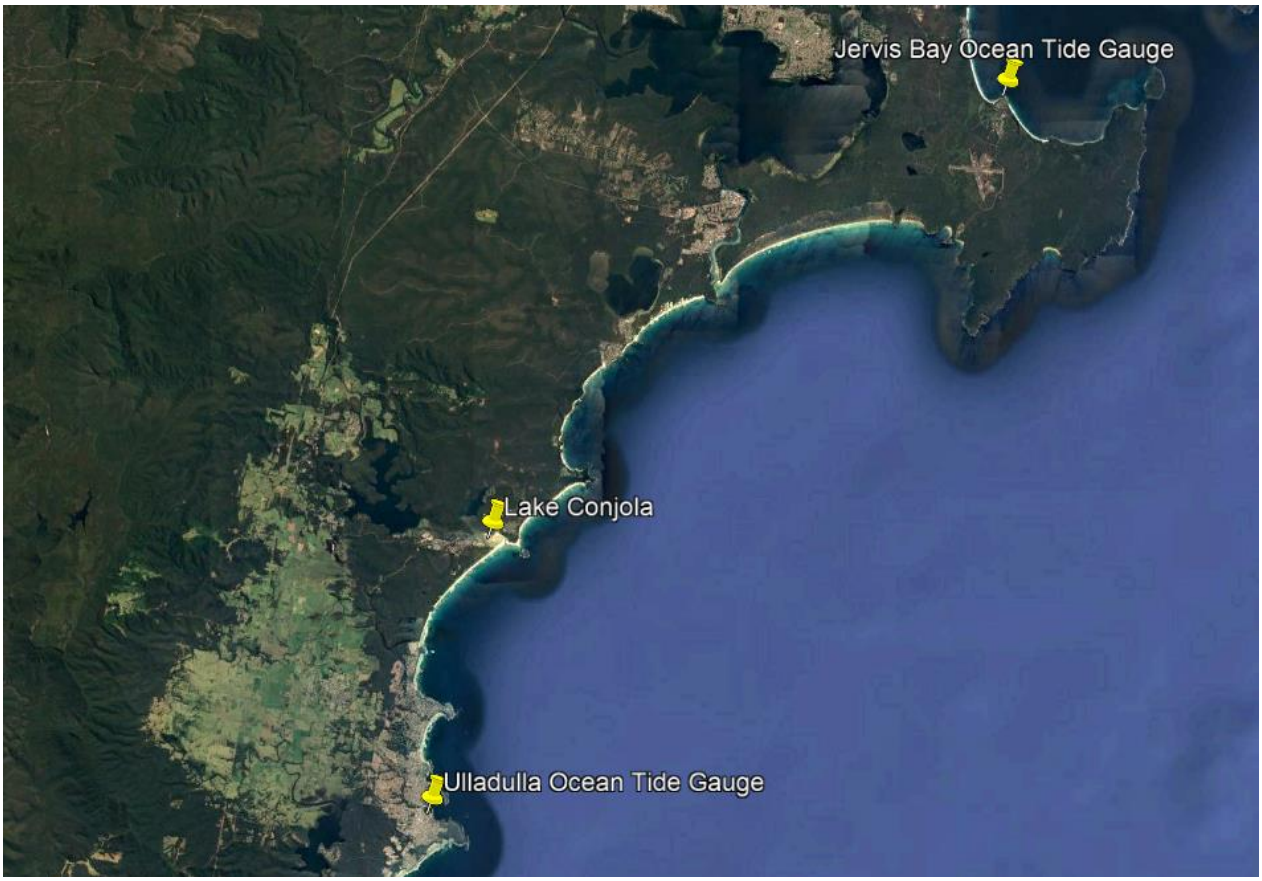

Figure 3-3 Ocean tide gauge locations near Lake Conjola

There are no sea level recorders located at Conjola Lake that measure tide levels in the Tasman Sea. The nearest sea level recorder is located in Ulladulla Harbour, approximately 10 km south of Lake Conjola (refer **Figure 3-3**). A selected number of tidal planes are presented in **Table 3-4** based largely on MHL (2020). The HHWSS tidal planes were calculated by RHDHV.

At the time of the previous flood study (BMT WBM, 2007), the nearest sea level recorder was located in Jervis Bay, which is approximately 20 km north of Conjola Lake (refer **Figure 3-3**) and has been recording hourly tide levels since July 1995. BMT WBM (2007) conducted a statistical analysis between Jervis Bay and Sydney tide records, which showed a good correlation.

Table 3-4 Summary of tidal planes for the Jervis Bay and Ulladulla ocean tide gauges

Tidal Plane	Jervis Bay Ocean Tide	Ulladulla Ocean Tide	Source
HAT	+1.12	+1.20	MHL (2020)
HHWSS	+1.05	+0.97	RHDHV
MSL	+0.02	+0.05	MHL (2020)
AHD	0.00	0.00	MHL (2020)
LAT	-0.97	-0.90	MHL (2020)
Chart Datum	-1.07		MHL (2020)



Figure 3-4 Lake Conjola tide gauge locations

A combined period of over 28 years of Lake Conjola tide gauge data is available from two stations (refer **Figure 3-4**). MHL (2012) presents tidal plane and tidal phase analysis calculated from data collected from the automatic water level monitoring station 216420 (refer **Figure 3-4**) at Lake Conjola (among other locations along the coast of NSW). The tidal planes presented in MHL (2012) represent a specific period of data (20 individual years from 1 July 1990 to 30 June 2010 inclusive - where available, refer **Figure 3-5**), and hence may vary with time as a result of changing hydrodynamic conditions (e.g., entrance conditions and freshwater inflow).

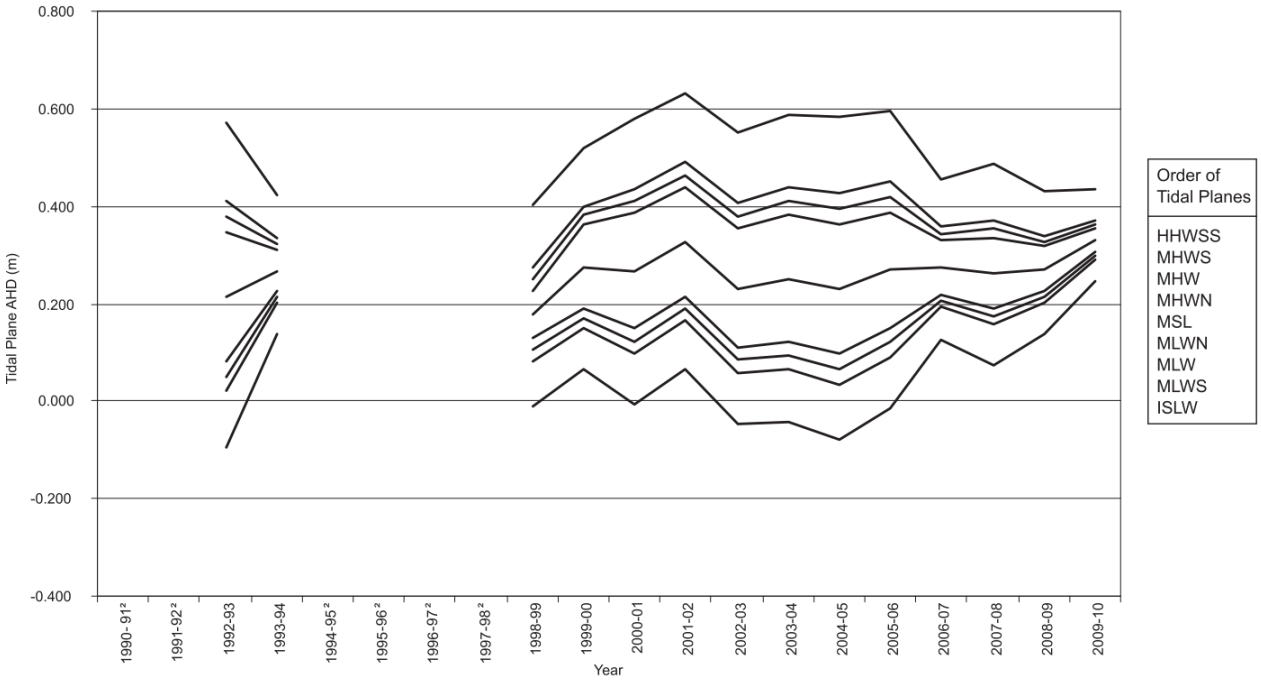

Figure 3-5 Tidal plane analysis at Lake Conjola (MHL, 2012)

Manly Hydraulics Laboratory developed a tool which monitors the M2 tidal component (the tide producing force due to the moon), as a proxy for various stages of entrance closure of Lake Conjola (refer **Figure 3-6**).

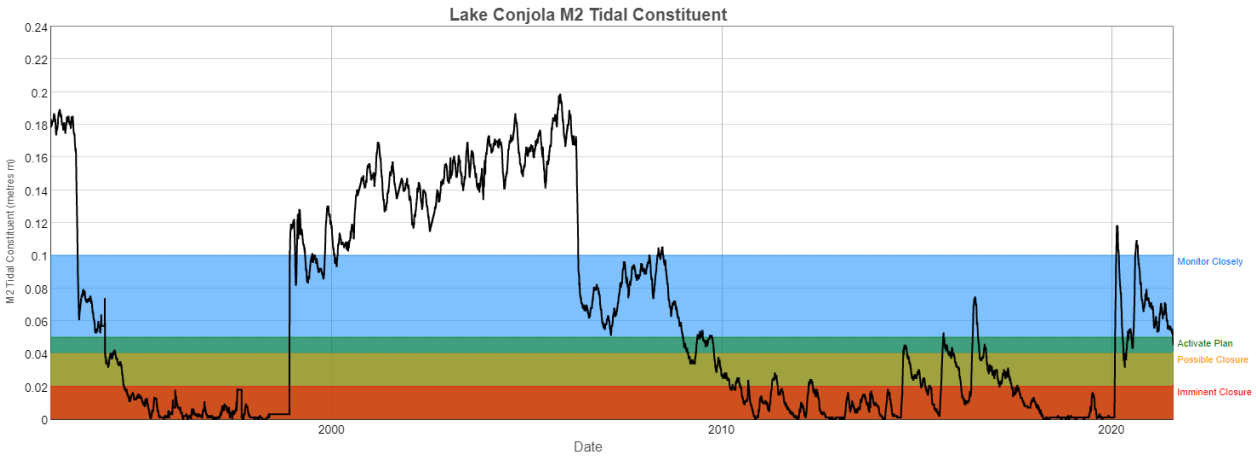

Figure 3-6 Lake Conjola M2 tidal constituent time-series (from: https://mhlfit.net/users/ShoalhavenCityCouncil-LakeConjolaM2)

3.4.2 Wave Data

Offshore wave data from the MHL offshore Waverider buoys at Port Kembla and Batemans Bay was supplied by Council for the study - refer **Table 3-5** below.

Table 3-5 Summary of offshore wave data

Data Set	ID	Availability
Port Kembla Waverider Buoy - Non-Directional	PTKMOW	Feb 1974 - Aug 2013
Port Kembla Waverider Buoy - Directional	PTKMOW	Aug 2013 - Present
Batemans Bay Waverider Buoy - Non-Directional	BATBOW	May 1986 - Feb 2001
Batemans Bay Waverider Buoy - Directional	BATBOW	Feb 2001 - Present

3.4.3 Sea Level Rise

In 2009 the Sea Level Rise Policy Statement (NSW Government) was adopted. It provided councils with sea level rise (SLR) planning benchmarks of 40 cm and 90 cm above 1990 sea levels by 2050 and 2100, respectively (SCC, 2018). In the same year, coastal hazard studies for nine Shoalhaven beaches were updated, incorporating these state government benchmarks.

In 2012 the NSW Government withdrew the benchmarks so that councils could consider coastal hazards, and select benchmarks, locally.

In 2015, following completion and consideration of the South Coast Regional Sea Level Planning and Policy Framework as a joint Shoalhaven City Council-Eurobodalla Shire Council project, Council adopted sea level rise projections of (SCC, 2018):

- 0.10m by 2030 (Representative Concentration Pathway (RCP) 6.0 - High);
- 0.23m by 2050 (RCP6.0 High); and
- 0.36m by 2100 (RCP6.0 Low).

At that time, Council also resolved to review these projections at least every seven years to ensure that the policy is newly informed as better information about SLR becomes available (SCC, 2018).

In addition to the above Council SLR benchmarks, (with reference to WRL, CSIRO, NCCARF; 2015, which provides “Projection of Sea Level Rise Relative to the Coast, Averaged Along the New South Wales Coast, from 1996 to 2100”, RHDHV have assessed tidal and coastal inundation for the following SLR values:

- 0.6m;
- 0.9m; and
- 1.2m by 2120 (100-year SLR as per the mandatory requirements of the Coastal Management Act).

4 Modelling Approach

4.1 Introduction

Modelling of the Lake Conjola system and physical processes required the use of the calibrated MIKE 21 FM hydrodynamic model system.

The overarching approach of the hydrodynamic part of this flood study was:

- Modelling of tidal inundation of Lake Conjola following design events (utilising a post-storm bathymetric description) – hydrodynamics only;
- Modelling of design events (ocean storm events) – hydrodynamic modelling (including sediment transport).

A range of projected Sea Level Rise scenarios was investigated (refer **Section 3.4.3**). In regard to the entrance bed level, (OEH, 2015) states (emphasis added in **bold**):

- *Testing the implications for sea level rise on flooding can best be undertaken by examining a specific design event, such as the one per cent AEP flood which is typically used for defining the flood planning level with an appropriate freeboard.* ***Sea level rise will impact upon both oceanic inundation levels and the configuration of entrances and their dynamics, which will have implications for flood behaviour.*** *Assuming that the nature of the estuary remains the same, the implications of these changes will vary depending upon the estuary group and specifics of the location. It is recommended that the following changes to conditions be tested*.
    - *For estuaries with Entrance Waterway Type C (ICOLLS) the* ***assessment of the impact of change can be assessed by directly adding the sea level rise projection to****:*
        - *ocean water level boundary conditions;*
        - ***starting conditions for entrance configuration****; and*
        - *initial water level conditions in the waterway*.

Based on the above, RHDHV have utilised the ‘bed raised’ scenario only.

4.1.1 Coincident Events

The *Coastal Risk Management Guide - Incorporating sea level rise benchmarks in coastal risk assessments* (OEH 2010) states (emphasis added in **bold**):

- *Coastal inundation assessments should also incorporate increased still water levels resulting from sea level rise projections (see section 4.2). In most instances, dunal systems along the open coastline are sufficiently elevated that episodic threat from oceanic inundation due to wave runup and overtopping of coastal dunes or barriers is negligible. Notwithstanding, the threat of oceanic inundation along the open coast in the vicinity of low-crested dunal barriers (less than 5 mAHD) should also be considered where this is relevant. Around lower lying estuarine foreshores, the threat from tidal inundation will be significantly exacerbated with a projected rise in mean sea level.* ***The interaction between this issue and catchment flooding is particularly important for coastal councils and has been considered in the companion document Flood Risk Management Guide – Incorporating sea level rise benchmarks in flood risk assessments (DECCW, 2010)***

The *Floodplain Risk Management Guide - Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways* (OEH 2015) states (emphasis added in **bold**):

- "This guide updates advice previously provided in Appendix A of Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments by the NSW Government (DECCW, 2010)."
- ***Catchment flooding and oceanic inundation can occur due to the same storm cell and therefore design flood levels in a lower coastal waterway will be influenced by a combination of these sources****. Whilst the degree of coincidence of the storm related factors varies significantly between storm events the approaches below provide reasonable estimates considering the information on coincidence in the relatively short length of available records.* ***If oceanic inundation or catchment flooding were examined on their own the flood levels derived are unlikely to be fit for purpose for making informed floodplain risk management decisions in the lower portions of coastal waterways*****.**

However, as it currently stands, RHDHV have been directed by Council and DPIE the use of the **coastal (oceanic) inundation only** scenario.

4.2 Model Systems

4.2.1 MIKE 21 FM

The MIKE 21 software package has been adopted for use in this study. MIKE 21 is a computer program that simulates flows, waves, sediment transport and ecology in rivers, lakes, estuaries, bays, coastal areas and seas in two dimensions. MIKE is developed by DHI.

The Flexible Mesh (FM) version of MIKE 21 has been adopted as it allows the spatial resolution of the computational grid to be locally increased in areas of interest, e.g. at the lake entrance, while the resolution in other areas can be coarser to help maintain acceptable model run times (main lake body, offshore). The spatial discretisation of the equations in MIKE 21 FM is performed using a cell-centred finite volume method. A single MIKE 21 model is used in the present study:

- MIKE 21 FM Hydrodynamic (HD).

The model is described in DHI (2021) and a very brief description is given here as:

- Hydrodynamic (HD) module which calculates the depth integrated phase averaged mean currents and surface elevation by solving the non-linear shallow water equations.

4.3 Hydrodynamic Modelling of Tidal Inundation

4.3.1 Introduction

An assessment has been undertaken of the threat posed by the peak of high spring tide episodes (in the absence of wave processes and catchment derived flood events) submerging low-lying foreshore landforms, structures and infrastructure in the Lake Conjola region. As a small wave dominated barrier estuary system, there is likely to be significant attenuation of tidal range through the confined Lake Conjola entrance and a gradual attenuation of tidal range from the entrance towards the tidal limits.

Tidal water levels in estuaries vary from those offshore depending on the estuary type (drowned river valley, barrier estuary, tidal lake or ICOLL). Morris *et al*. (2013) showed that the so-called 'bathtub

approach' to modelling tidal inundation in estuaries, which assumes the water level in the estuary is the same as offshore, can lead to under or over estimation of the risks since tidal characteristics are not taken into account. Hence, in order to map the extent of estuarine areas inundated by the peak of high spring tides, RHDHV proposed a more complex approach informed by the use of numerical modelling. This approach comprised the following tasks:

- The calibrated hydrodynamic model was used to model the reduction (or possibly amplification for sea level rise scenarios) of the tidal range throughout the estuary from the ocean entrance upstream to the tidal limit.
- Hydrodynamic modelling was then conducted for a range of sea level rise projections; 0.1m at 2030, 0.23m at 2050 and 0.36m at 2100 (currently adopted by Council), as well as additional SLR values of 0.6m, 0.9m and 1.2m (refer **Section 3.4.3**). Based on **Section 4.1**, simulations were conducted for the scenario where the bed of the entrance (noting that the Lake Conjola entrance in this case is defined as the area from the ocean entrance to 'The Steps', at the upstream end of the entrance channel) has risen at the same rate as sea level rise.

Consequently, a total of seven simulations has been conducted - one for the present-day sea level condition and one for each SLR scenario, see **Table 4-1**.

Table 4-1 Tidal inundation scenarios

SLR Scenario	Number of Simulations	Description
0m (Present Day)	1	To spatially assess tidal range throughout the estuary
0.10m (2030)	1	1 x Entrance bed has risen 0.10m with SLR
0.23m (2050)	1	1 x Entrance bed has risen 0.23m with SLR
0.36m (2100)	1	1 x Entrance bed has risen 0.36m with SLR
0.6m	1	1 x Entrance bed has risen 0.6m with SLR
0.9m	1	1 x Entrance bed has risen 0.9m with SLR
1.2m	1	1 x Entrance bed has risen 1.2m with SLR

4.3.2 Model Setup

The hydrodynamic model system was established using a flexible mesh model that covers both the Lake Conjola catchment and estuary and also extends offshore into the Tasman Sea to a depth of approximately -60 m AHD. For the purposes of computational efficiency, grid cell resolution (grid cell size) differs between the various areas of the domain - refer **Table 4-2**:

Table 4-2 Hydrodynamic model resolution

Model Area	Grid Cell Resolution (m)
Lake Conjola (main body)	50
Lake Conjola (entrance channel)	10
Berringer Lake	50
Nearshore (approx. 1km from the lake entrance)	50

Offshore Transition Zone (approx. 1-4 km from the lake entrance)	250
Offshore	600

The topographic and bathymetric data incorporated into the model are outlined in **Section 3.3**. The model bathymetry of the Lake Conjola model domain is depicted in **Figure 4-1**.

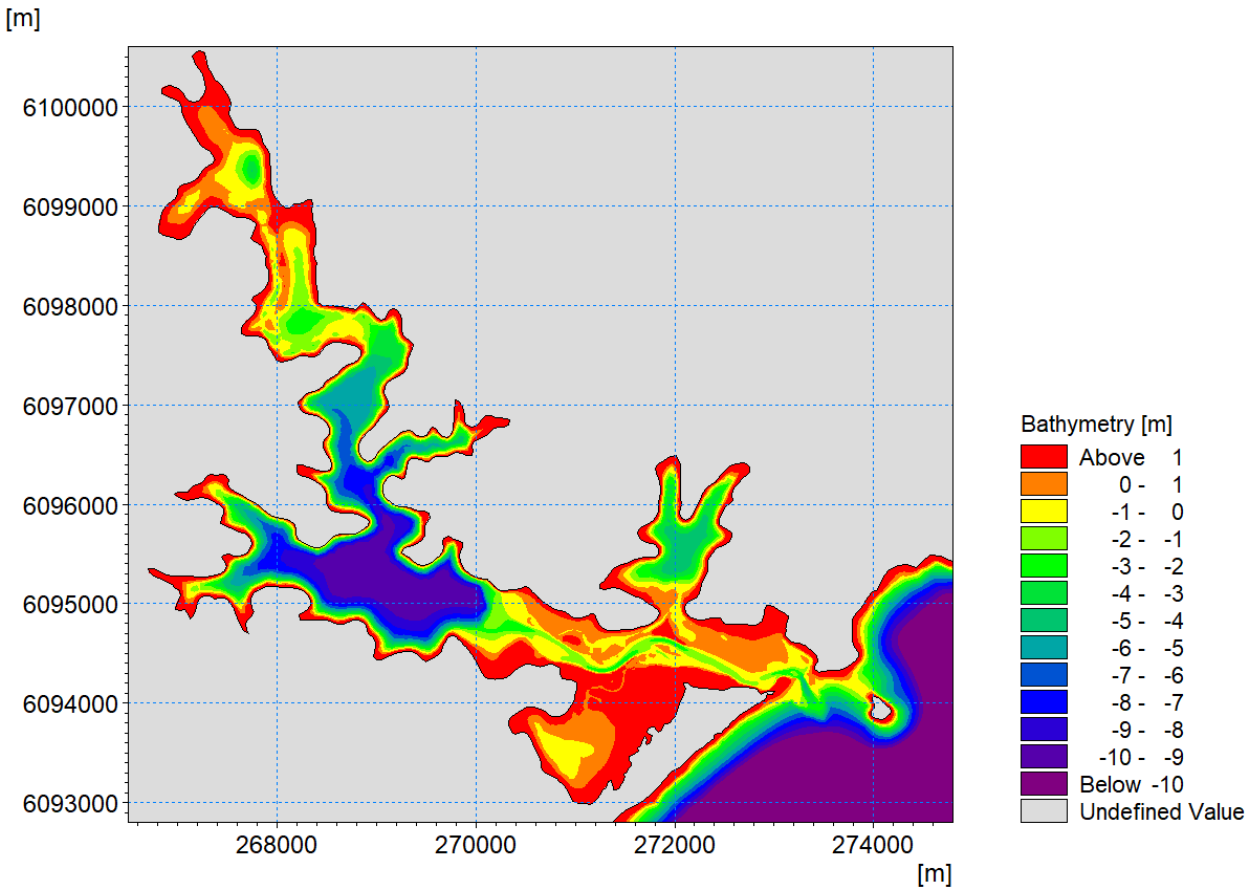

Figure 4-1 Lake Conjola tidal inundation model bathymetry (Present Day)

The bathymetry comprises a post-storm (scoured) entrance condition which was obtained in a separate hydrodynamic model simulation, whereby a 100-year ARI catchment event (based on BMT WBM, 2007) was applied to the BMT WBM (2007) model bathymetry (refer **Section 3.2**). Catchment inflows for this event are presented below in **Figure 4-2**.

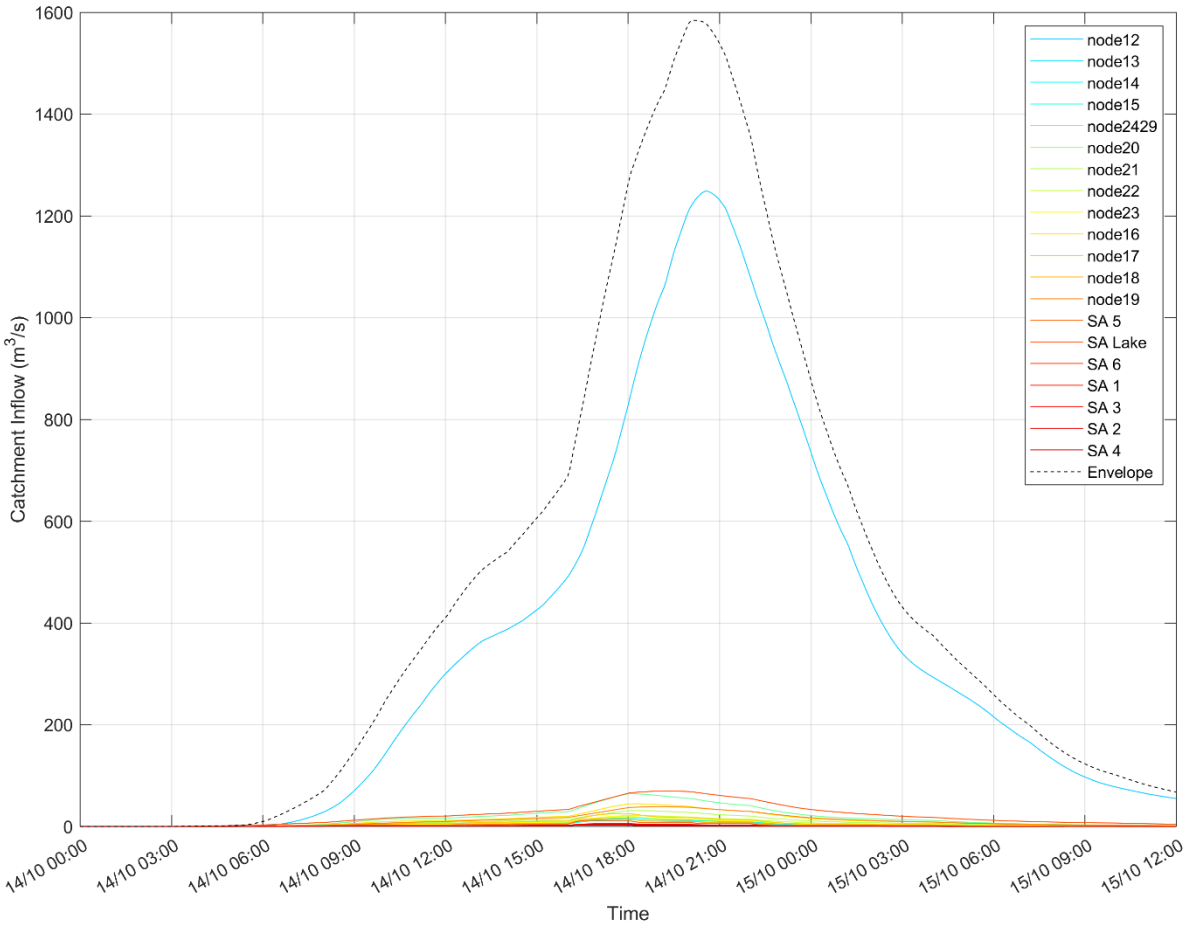

Figure 4-2 Catchment Inflows for the 1% AEP Design Event

4.3.3 Sensitivity Analyses

Sensitivity of the lake water level (or tidal inundation) to the entrance channel condition was assessed for the following two cases:

- 'choked' vs. open (post-storm) entrance; and
- post-storm entrance scoured due to a 5-year ARI catchment event vs. a 100-year ARI catchment event.

It was ascertained that an open, post-storm entrance yields higher peak lake water levels compared to a 'choked', more everyday entrance. Similarly, comparison of water levels in the main body of Lake Conjola for simulations with a scoured entrance channel due to a 5-year catchment event and a 100-year catchment event showed that the latter case leads to higher lake water levels (refer **Figure 4-3**).

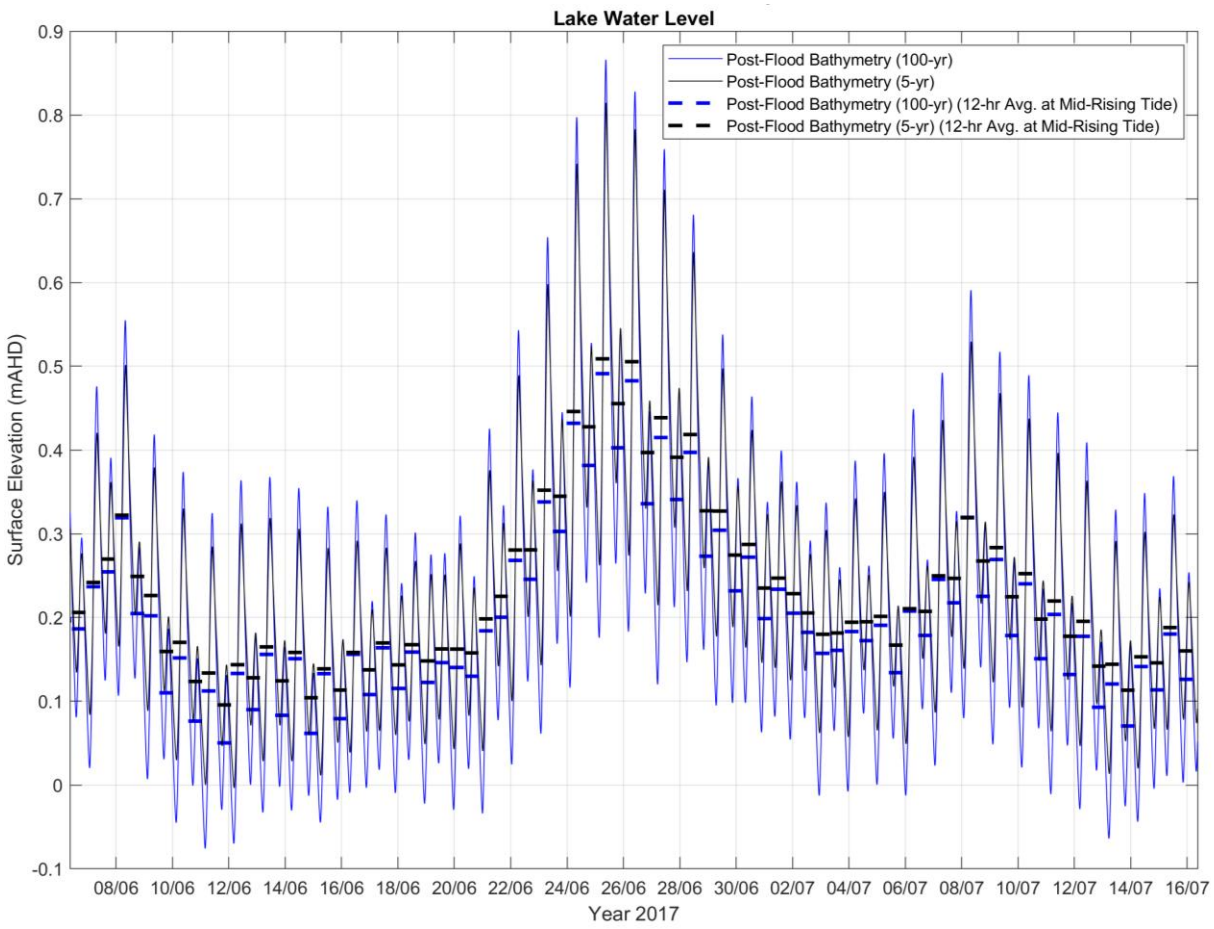

Figure 4-3 Sensitivity analysis of entrance channel scour degree

4.3.4 Model Calibration

The hydraulic model has been calibrated to “typical” tide conditions (i.e., a period of low wave conditions and minimal rainfall). The adopted calibration period comprised a two-week duration and coincided with the most recent period where the entrance to Lake Conjola was open and both (entrance) bathymetry data as well as lake gauge data (refer **Section 3.4.1**) was available - June 2008 was the nominated period.

4.3.5 Model Boundary Conditions

The offshore boundary of the hydrodynamic model is driven by recorded tide levels from nearest ocean tide gauge at Ulladulla (refer **Section 3.4.1**).

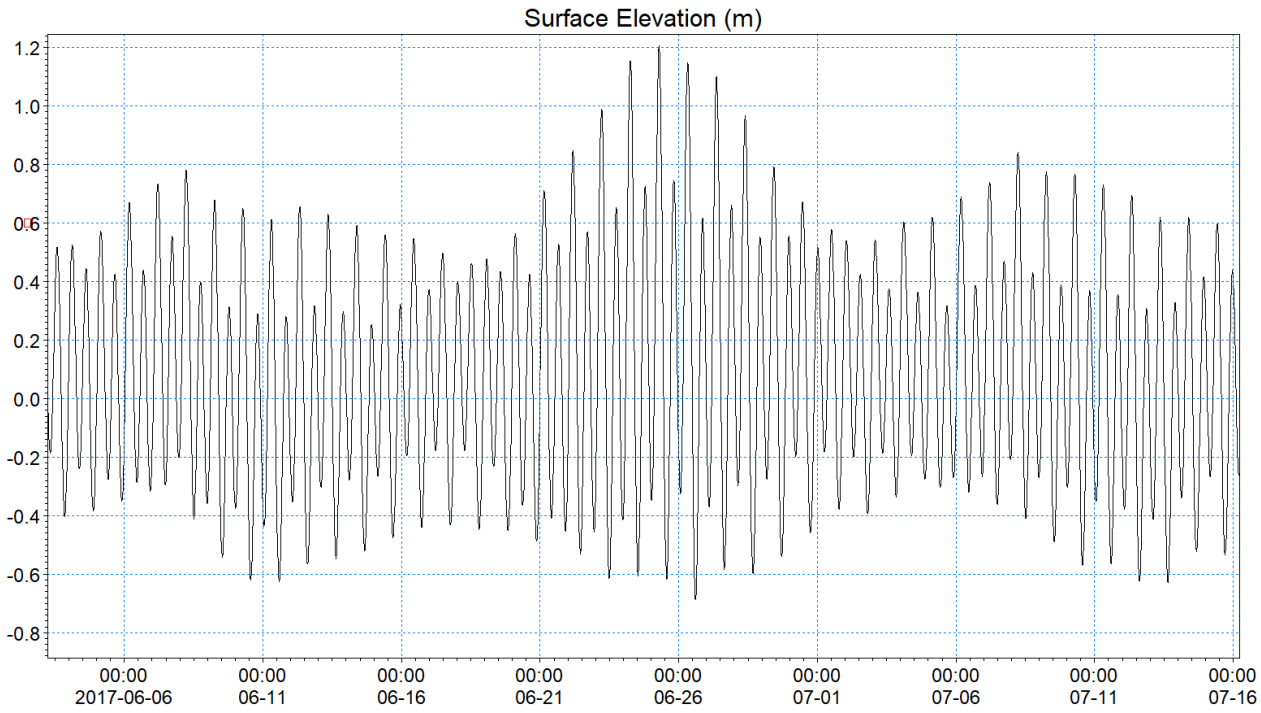

Figure 4-4 Tidal inundation ocean boundary (present day)

The simulation period for all seven tidal inundation model runs is 4 June 2017 until 16 July 2017. This time period includes three full spring-neap cycles with a peak water level of +1.20mAHD (refer **Figure 4-4**), which is equal to Highest Astronomical Tide (HAT) of the Ulladulla ocean tide gauge record- refer **Table 3-4**.

4.4 Hydrodynamic Modelling of Coastal Inundation

4.4.1 Introduction

Lake Conjola is a wave-dominated barrier estuary which is exposed to inundation risk from both catchment and coastal flooding. Catchment flooding will tend to dominate in the upper reaches while coastal flooding is likely to dominate towards the downstream boundary (the ocean entrance). However, the upstream and downstream estuary boundaries comprise a relatively small proportion of the overall estuary foreshore, and so inundation risk at any given location within the estuaries will depend on the balance of coastal and catchment flood processes, the estuaries' local geography, and their degrees of connectivity to the ocean.

However, as outlined in **Section 4.1.1**, RHDHV have been directed by Council and DPIE the use of the coastal flooding only scenario.

Design storm modelling was conducted in which ocean flooding only was considered. The design inputs to the model were determined to be:

- Design still water level; and
- Design wave set-up conditions.

Hydrodynamic and morphological modelling was conducted for the present day as well as a range of sea level rise projections (refer **Section 4.3.1**). Similar to tidal inundation (refer **Section 4.3.1**), simulations

were conducted for the scenario where the bed of the entrance (noting that the Lake Conjola entrance in this case is defined as the area from the ocean entrance to 'The Steps', at the upstream end of the entrance channel) has risen at the same rate as sea level rise.

Consequently, a total of seven simulations has been conducted - one for the present-day sea level condition and one for each SLR scenario, see **Table 4-3**.

Table 4-3 Coastal inundation scenarios

SLR Scenario	Number of Simulations	Description
0m (Present Day)	1	1 x 100-yr ARI ocean event only - bed not risen
0.10m (2030)	1	1 x 100-yr ARI ocean event only - bed risen (0.10m)
0.23m (2050)	1	1 x 100-yr ARI ocean event only - bed risen (0.23m)
0.36m (2100)	1	1 x 100-yr ARI ocean event only - bed risen (0.36m)
0.6m	1	1 x 100-yr ARI ocean event only - bed risen (0.6m)
0.9m	1	1 x 100-yr ARI ocean event only - bed risen (0.9m)
1.2m	1	1 x 100-yr ARI ocean event only - bed risen (1.2m)

4.4.2 Model Setup

The model bathymetry of the Lake Conjola model domain utilised for the coastal inundation assessment is depicted in **Figure 4-5**. This bathymetry is based on BMT WBM (2007) and represents a typical, non-scoured entrance condition suitable for the coastal inundation assessment. For details of the flexible mesh reference is made to the tidal inundation assessment (**Table 4-2**).

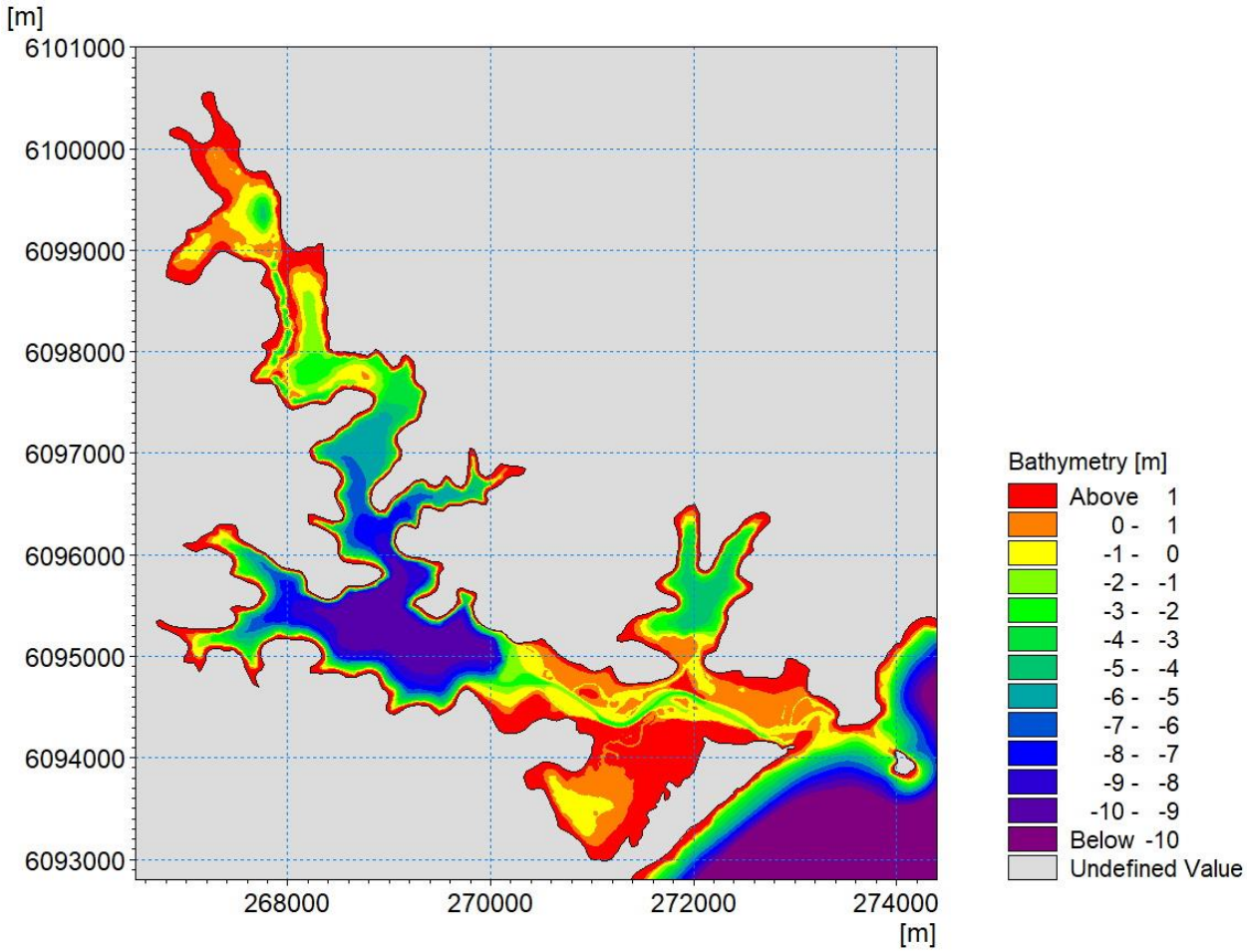

Figure 4-5 Lake Conjola coastal inundation model bathymetry (Present Day)

4.4.3 Sensitivity Analyses

Sensitivity of the lake water level (or coastal inundation) to the entrance channel condition was assessed for the following two cases:

- 'choked' entrances (2x) vs. open (post-storm) entrance; and
- 100-year ARI catchment event only vs. a combined 5-year ARI catchment and 100-year ARI catchment event.

The following observations can be made from **Figure 4-6**:

- Peak lake water levels are relatively insensitive to entrance condition in the case of a combined 5-year ARI catchment and 100-year ocean event; and
- In case of an ocean event only, a scoured (post-flood) bathymetry leads to higher peak water levels compared to the 'choked' entrance, which is due to the higher conveyance of the entrance channel.

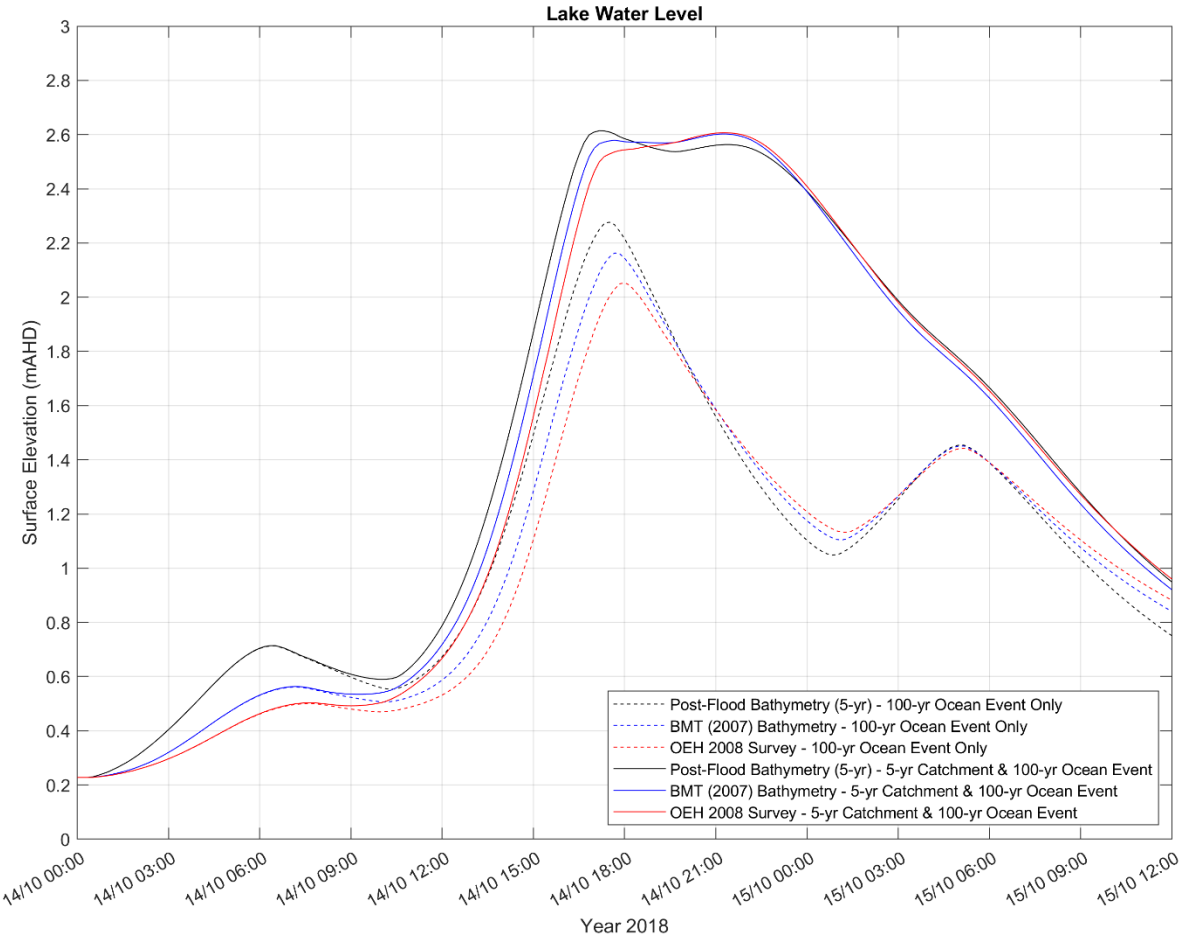

Figure 4-6 Coastal inundation sensitivity analyses

4.4.4 Model Calibration

The model has been calibrated against the BMT WBM (2007) flood study peak water results for:

- 5-year ARI catchment event (with neap tides), and
- 100-year ocean tide event (with 5-year catchment inflows).

4.4.5 Model Boundary Conditions

For coastal inundation, an ocean boundary using a 1% AEP ocean water was required to be applied. Methodology and input parameters for coastal inundation modelling considered the Floodplain Risk Management Guide (OEH, 2015).

OEH (2015) prescribes a 1% AEP (100-year ARI) ocean water level for design, applicable to the Lake Conjola area, of +2.55mAHD for a 'Waterway Entrance Type C' (ICOLLs). This water level comprises a 100-year Design Still Water Level of +1.45mAHD (OEH, 2015) and hence a wave set-up component of 1.1m. This wave set-up is valid for a typical coast without a river or estuary entrance. Applying the full wave set-up component as per OEH (2015) would be overly conservative, as wave set-up cannot manifest itself fully against an open entrance.

Typically, as a rule of thumb, wave set-up is approximately 15% of wave height. Based on Zaki (2020), who investigated wave set-up at open entrances, and an approximate average Lake Conjola entrance channel depth of 1m and offshore 100-year ARI significant wave height of 7.8m (one-hour exceedance) for the Batemans Bay wave buoy (Glatz *et al*., 2017), a reduced wave set-up of 0.12*7.8 = 0.94m was calculated. Combined with the above Design Still Water Level of +1.45mAHD, a peak design ocean level of approximately +2.4mAHD was utilised in the coastal inundation assessment (instead of +2.55mAHD). Ocean storm time-series were taken from BMT WBM (2007) and scaled to the correct peak level based on the above as well as the relevant SLR scenario.

5 Tidal Inundation Flooding

5.1 Results

Results of the tidal inundation modelling are presented in the form of maps showing inundation depth for the tidal plane High High Water Solstice Springs (HHWSS) as well as the tidal extent in Lake Conjola. HHWSS was calculated by extracting water level time-series in each of the grid (with varying resolution - refer **Table 4-2**) points inside Lake Conjola. Subsequently, a tidal harmonic analysis of each of these time-series (provided that that particular output location did not fall dry or was disconnected from tidal influence at any point in time) was performed. The simulation time (six weeks) provided a sufficiently long period to enable the identification of the required tidal constituents and their frequencies and amplitudes. The following formula and tidal constituents (amplitudes) were then used to calculate the HHWSS tidal plane (Morris *et al*., 2013):

$$HHWSS = M2 + S2 + (1.4 * (K1 + O1)) [m]$$

Where: M2 = principal lunar semidiurnal constituent, S2 = principal solar semidiurnal constituent, K1 = luni-solar declinational diurnal constituent, and O1 = principal lunar declinational diurnal constituent

Lastly, the HHWSS level was extrapolated to determine the flood extent of the different scenarios, utilising the available topographic data (which was a combination of a DEM from BMT WBM (2013) and more recent 2018 Marine LiDAR data set near the lake entrance).

Tidal inundation maps depicting inundation depth and flooding extent for the HHWSS level inside Lake Conjola for the different scenarios showing are presented in **Appendix A**.

5.2 Discussion

Figure 3-5 and **Figure 3-6** show that the HHWSS tidal plane for the Lake Conjola tide gauge, for a typical, generally non-scoured entrance condition (e.g., between 2000 and 2005) is in the order of +0.6mAHD. Consistent with a more open entrance caused by catchment flooding and entrance scour, the modelled, HHWSS tidal plane in the vicinity of the Lake Conjola tide gauge is in the order of 0.1m to 0.2m higher for these post-flood simulations (Present Day, see **Figure 5-1**).

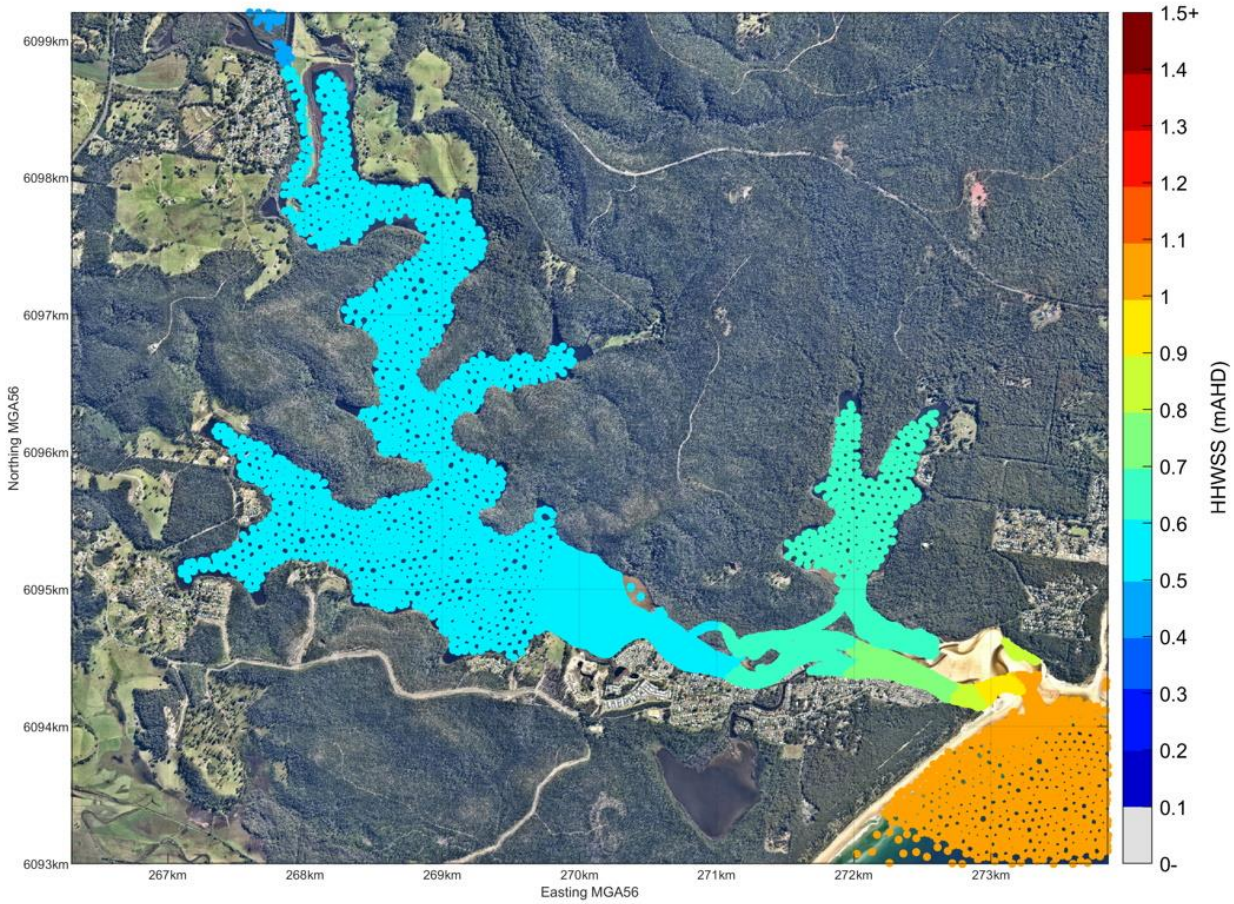

Figure 5-1 Attenuation of the HHWSS tidal plane for the Present Day

Figure 5-1 to **Figure 5-3** show that the tide range inside Lake Conjola is reduced significantly with respect to the ocean tide range, as a result of the presence of the relatively long and narrow entrance. Comparing **Figure 5-2** and **Figure 5-3** (bed not raised vs. bed raised for the 2120 case), it can be seen that this effect is reduced inside Lake Conjola when the sea bed does not rise with the sea level. In other words, there is less attenuation of the tide inside Lake Conjola and a (slightly) larger tidal extent depending on foreshore slopes.

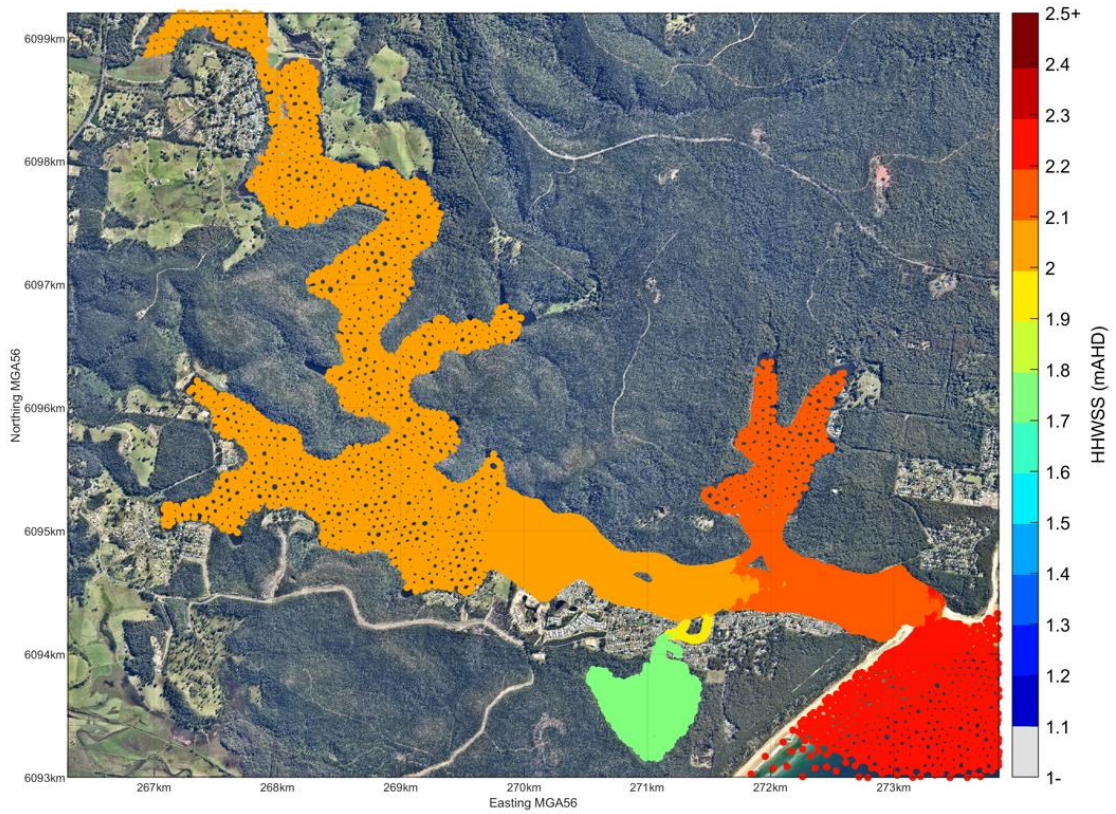

Figure 5-2 Attenuation of the HHWSS tidal plane for 2120 (bed not raised)

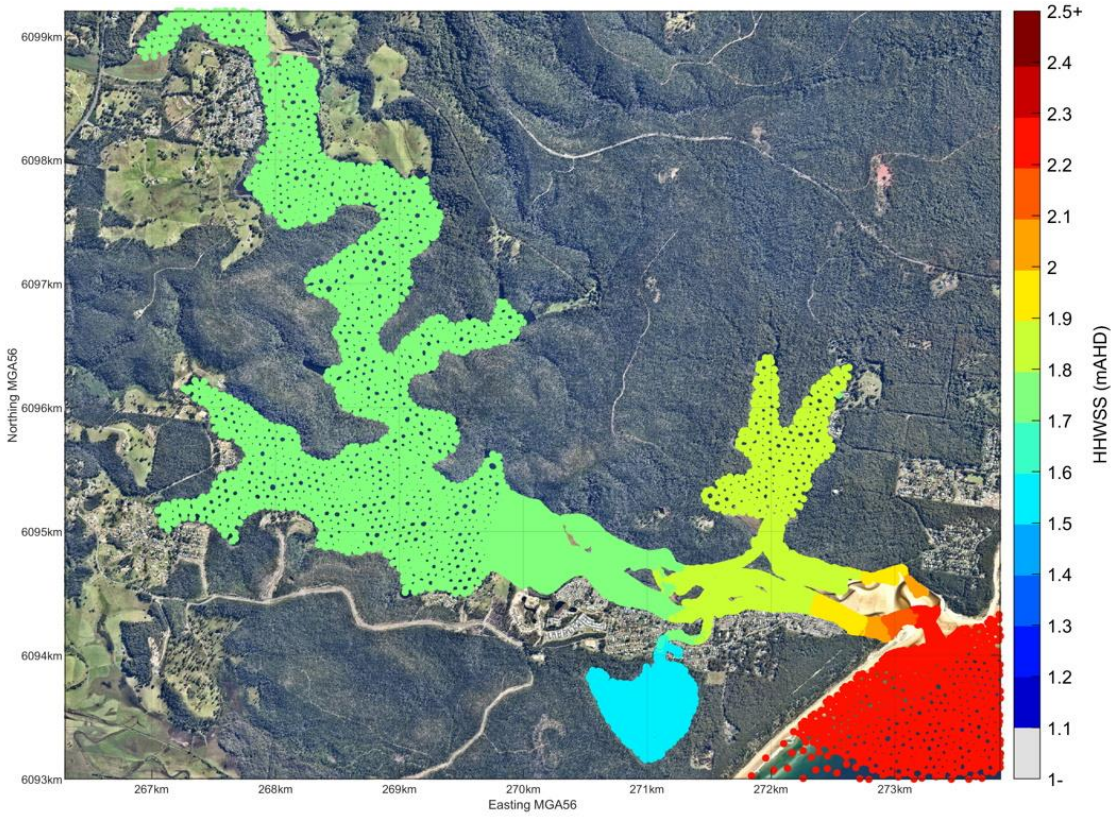

Figure 5-3 Attenuation of the HHWSS tidal plane for 2120 (bed raised)

6 Coastal Inundation Flooding

6.1 Results

Results are presented in the form of maximum water depth maps for the Present Day as well as the SLR scenarios described in **Section 4.4.1** (refer **Table 4-3**). The maximum water depth was calculated by taking the maximum depth, in each of the grid (with varying resolution - refer **Table 4-2**) points inside Lake Conjola that were 'wet' at some stage during a simulation. The results are presented in **Appendix B**.

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Appendix B - Tidal Inundation Depth Static Maps - all SLR ranges

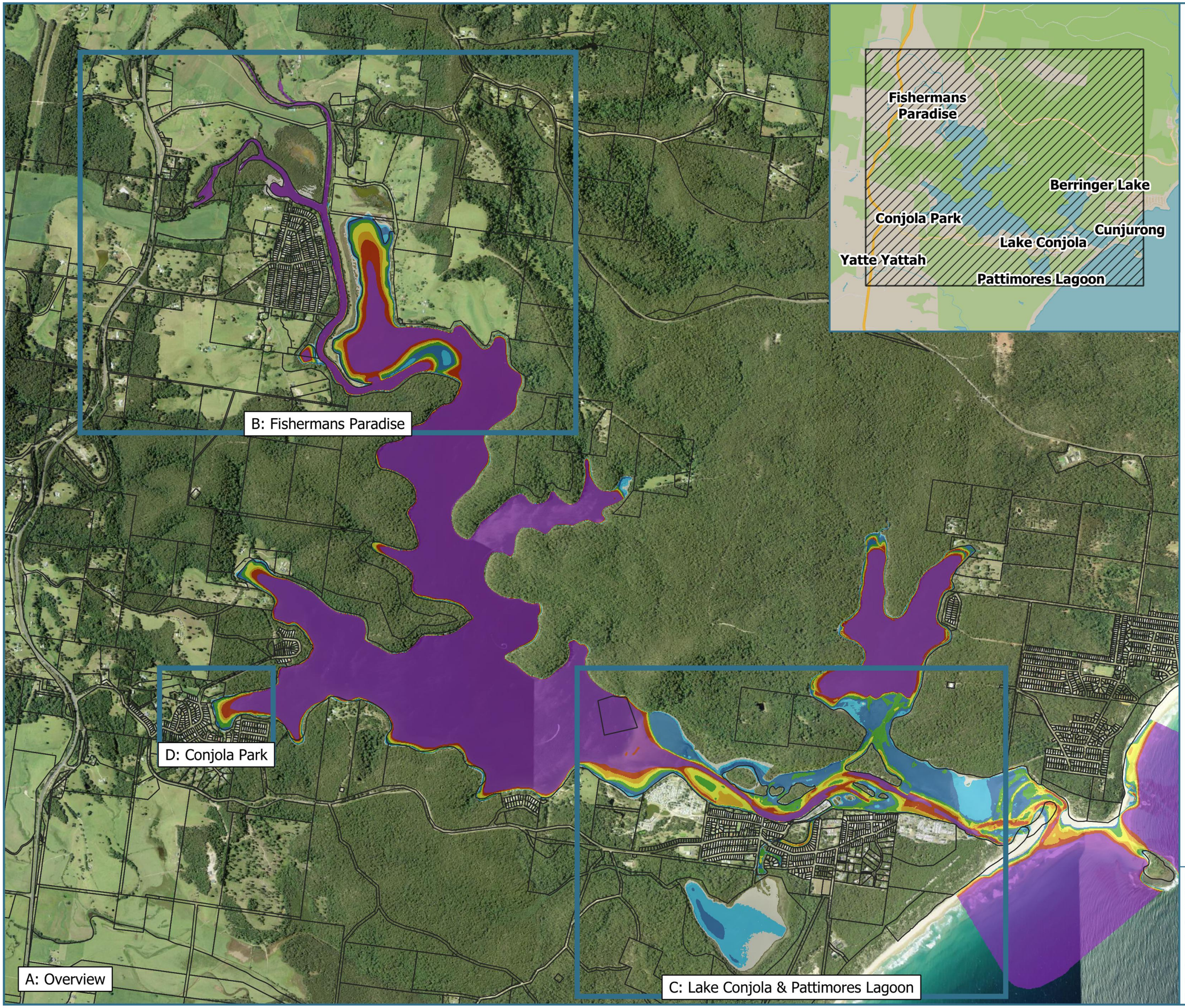

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Figure A-01
Tidal Inundation
SLR 0 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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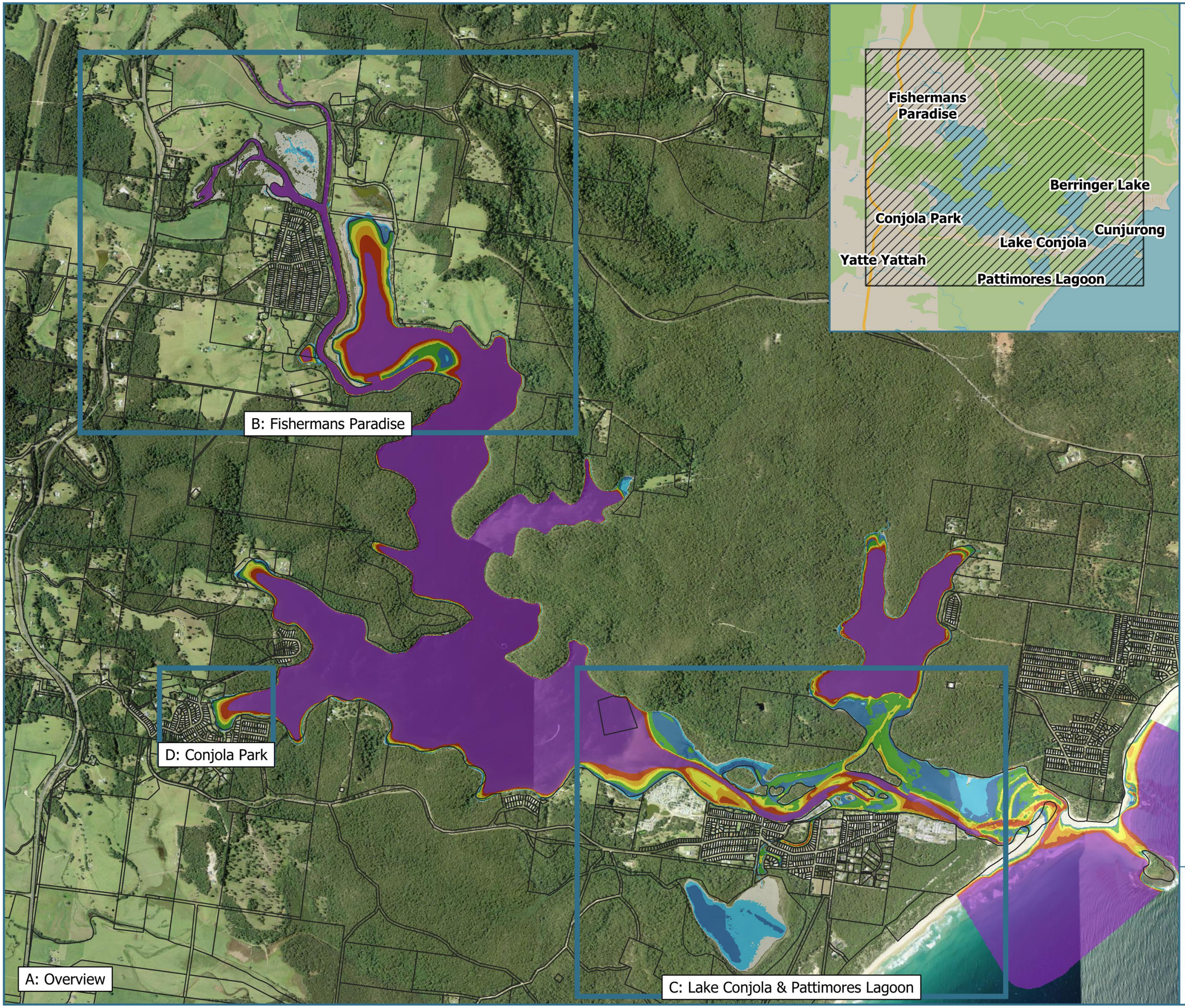

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Figure A-02
Tidal Inundation
SLR 0.1 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

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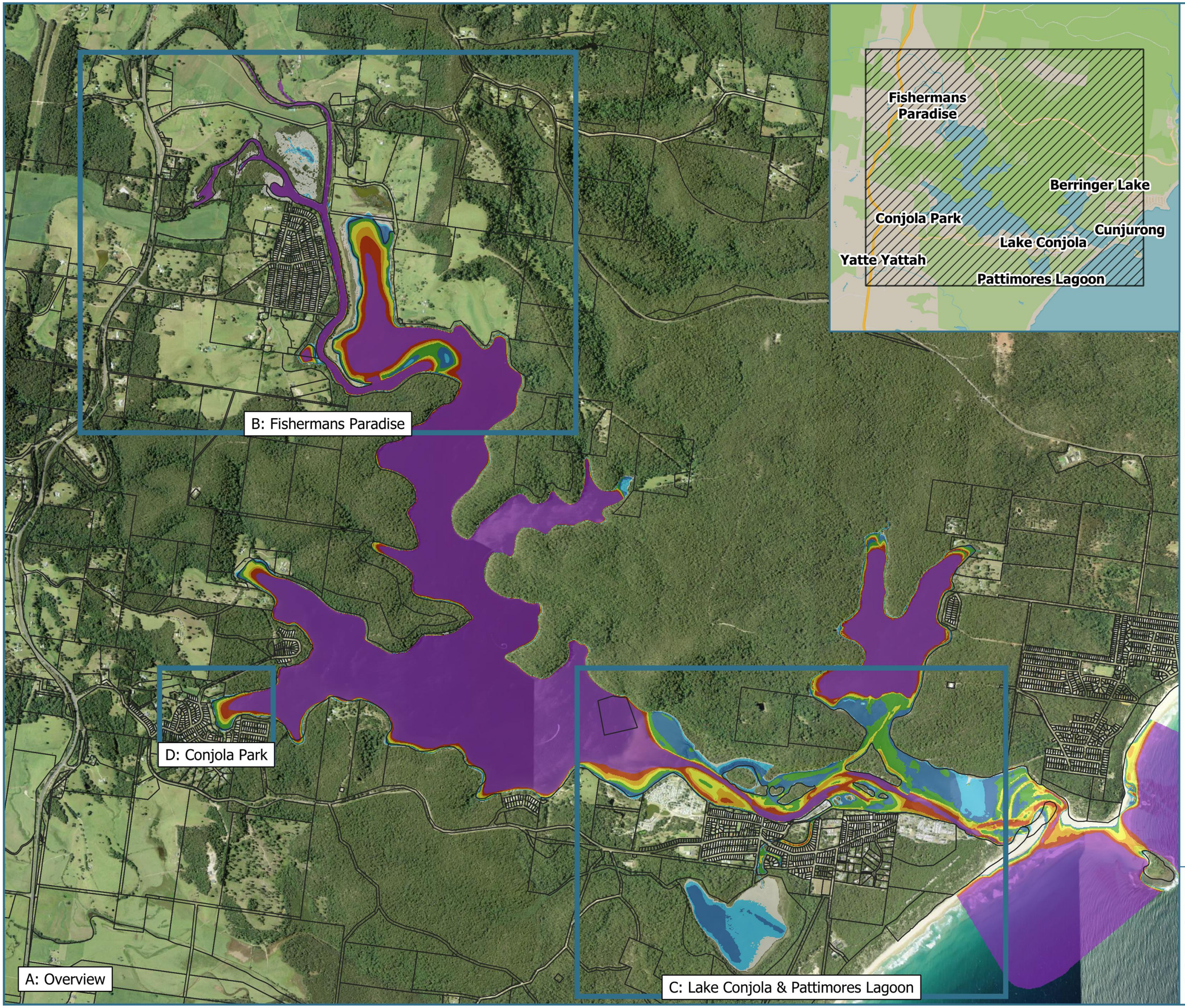

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Figure A-03
Tidal Inundation
SLR 0.1 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

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GDA2020 / MGA zone 56
Scale at A4

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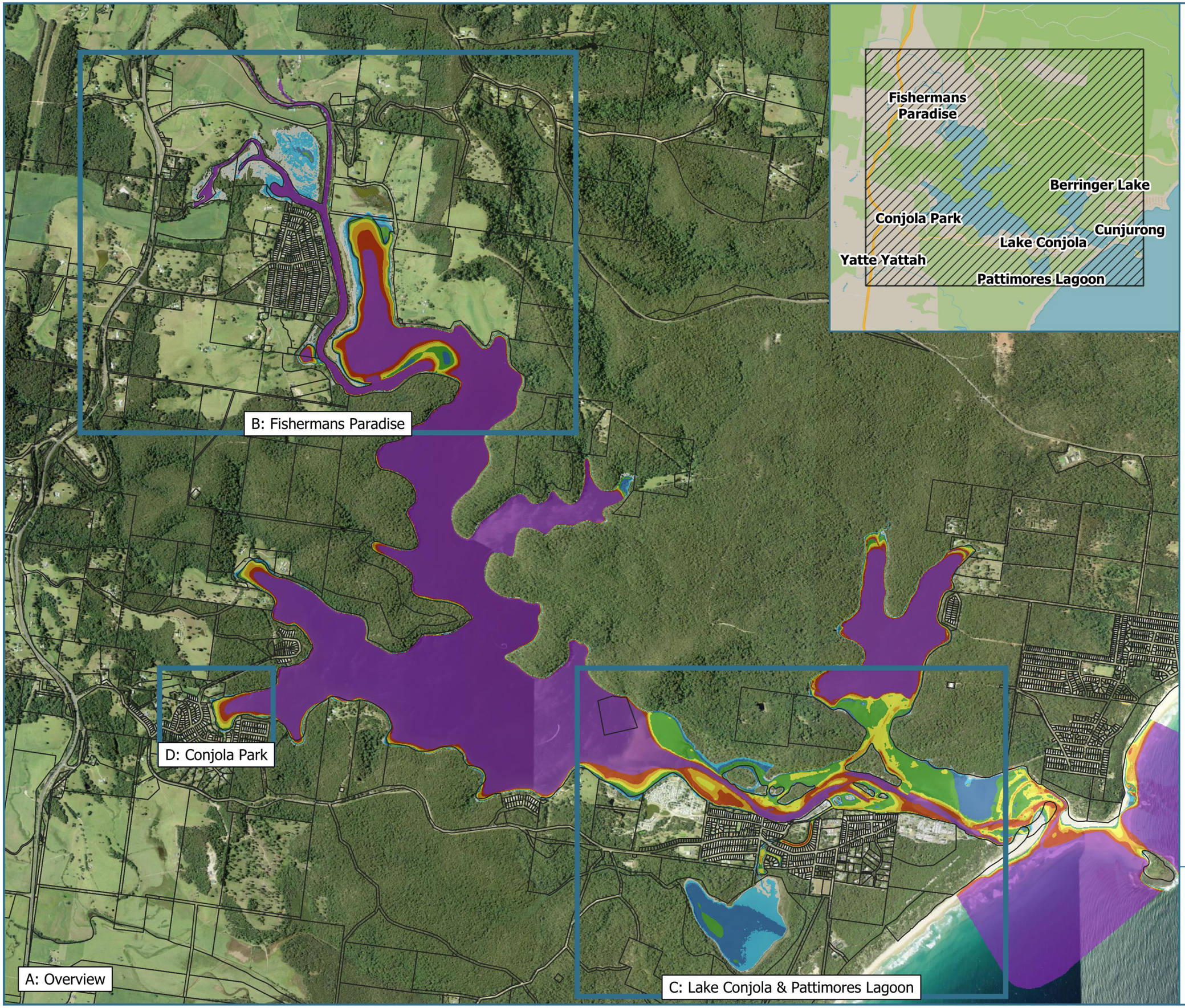

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Figure A-04
Tidal Inundation
SLR 0.23 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

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Basemap: NSW Six Maps
Aerial Image: 08-12-2013

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Scale at A4

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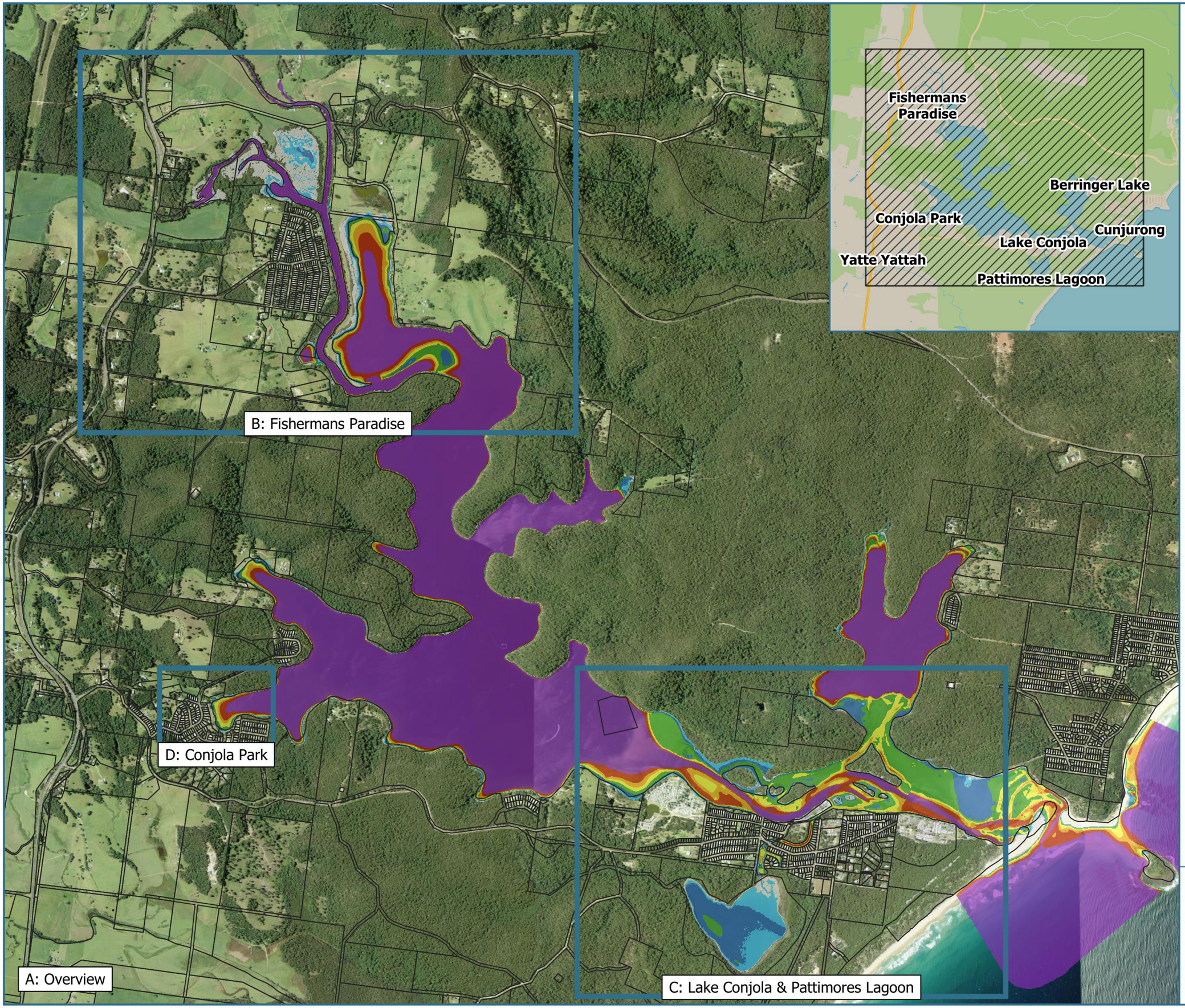

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Figure A-05
Tidal Inundation
SLR 0.23 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

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Basemap: NSW Six Maps
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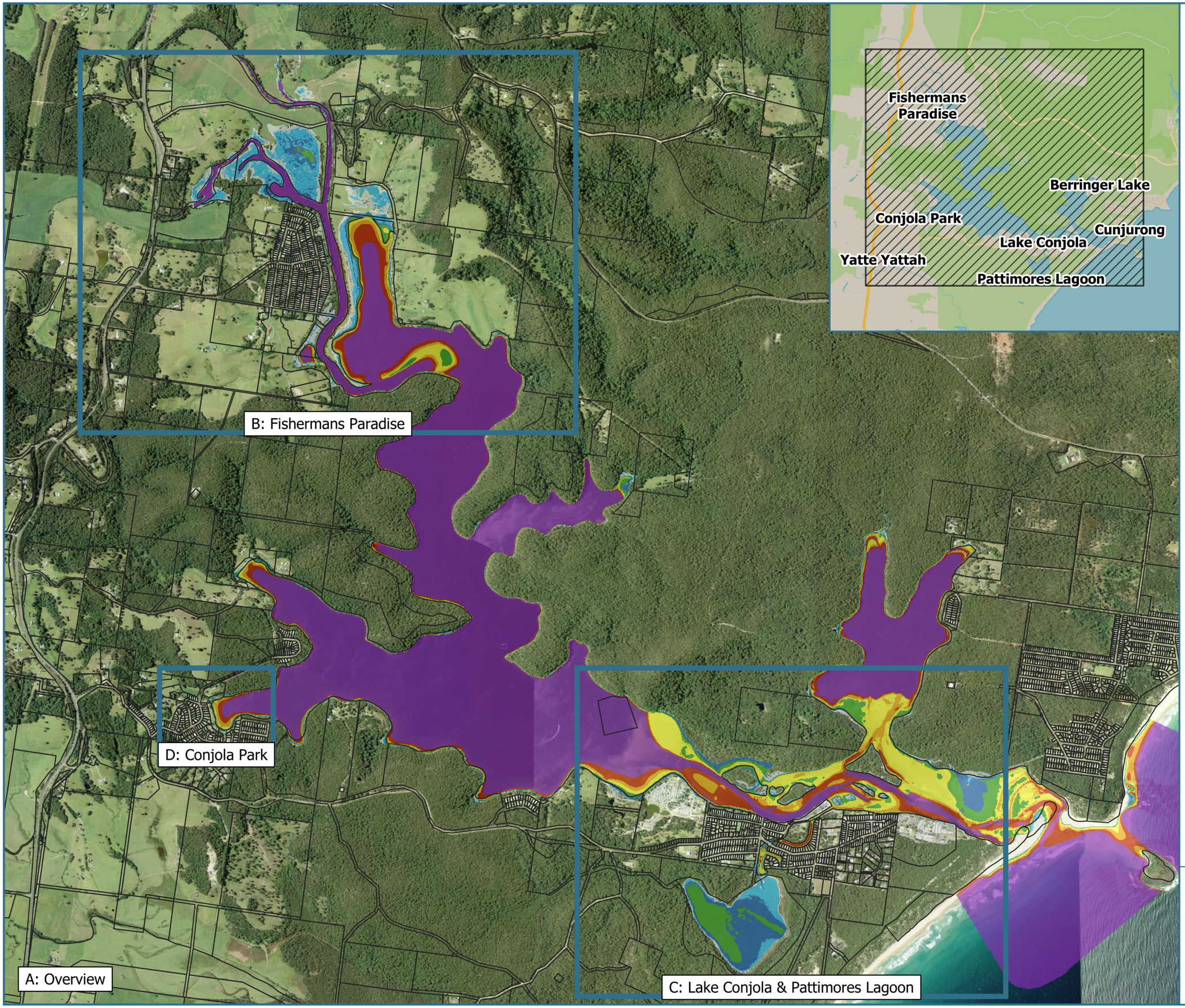

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Figure A-06
Tidal Inundation
SLR 0.36 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

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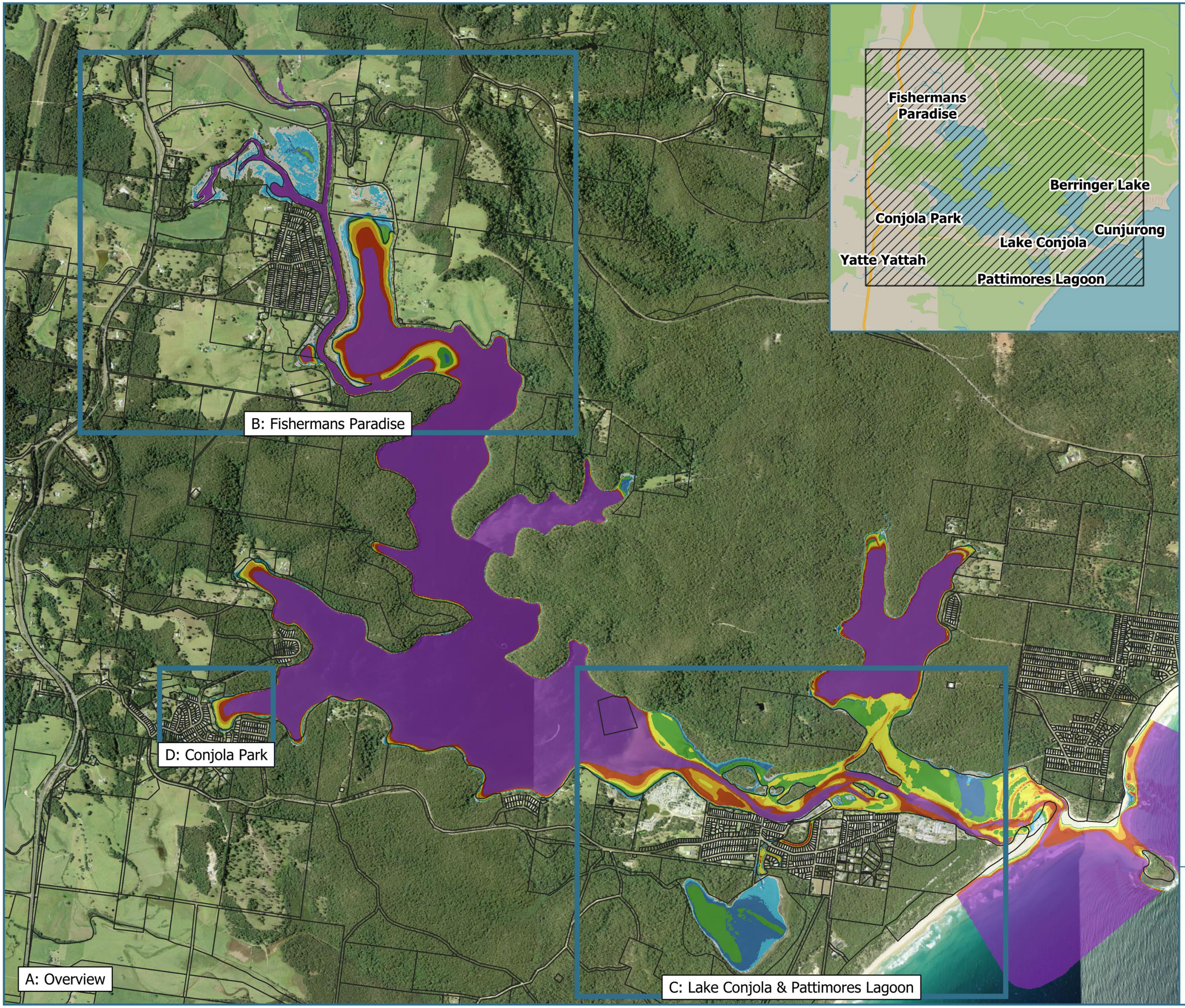

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Figure A-07
Tidal Inundation
SLR 0.36 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

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Scale at A4

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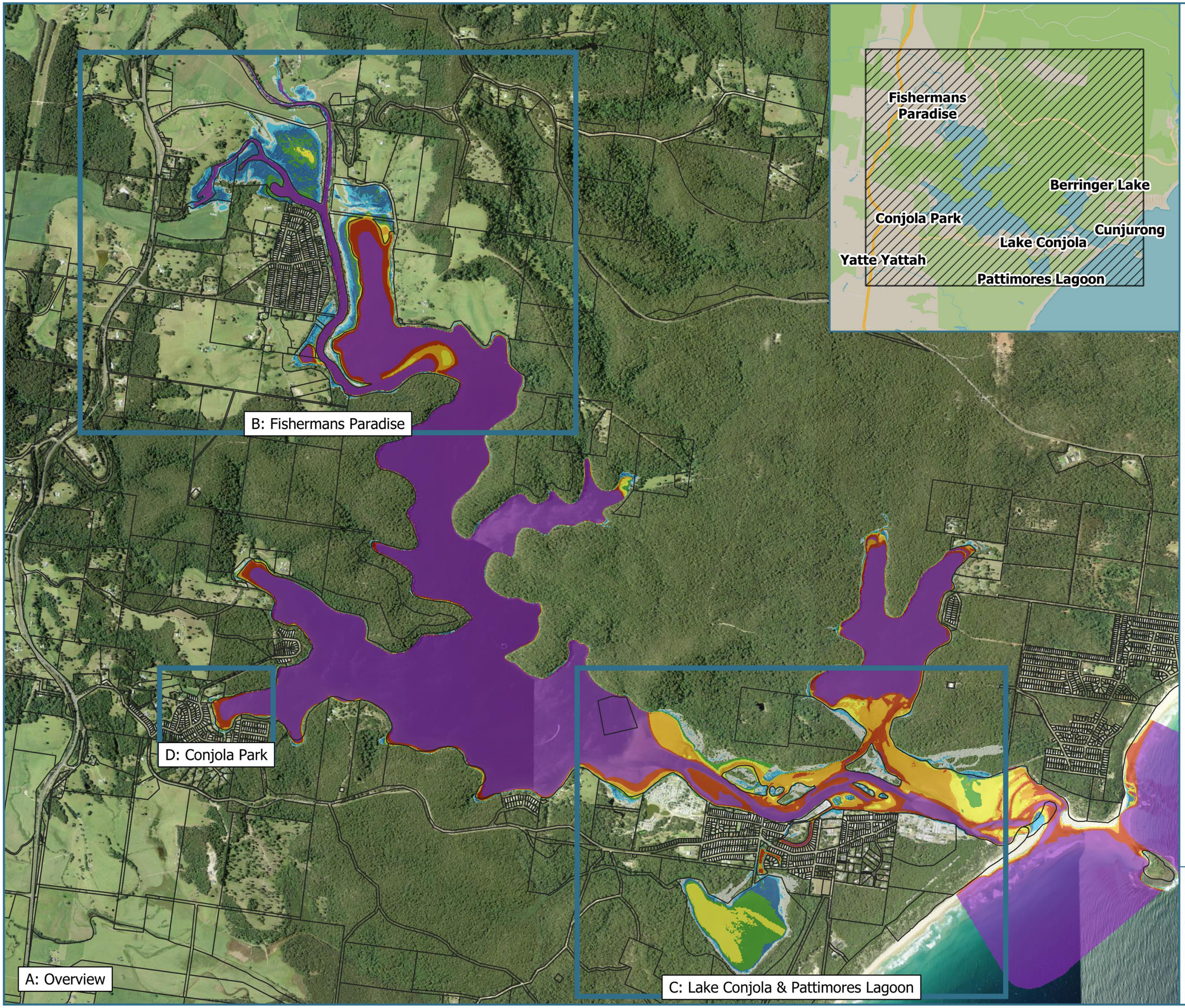

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Figure A-08
Tidal Inundation
SLR 0.6 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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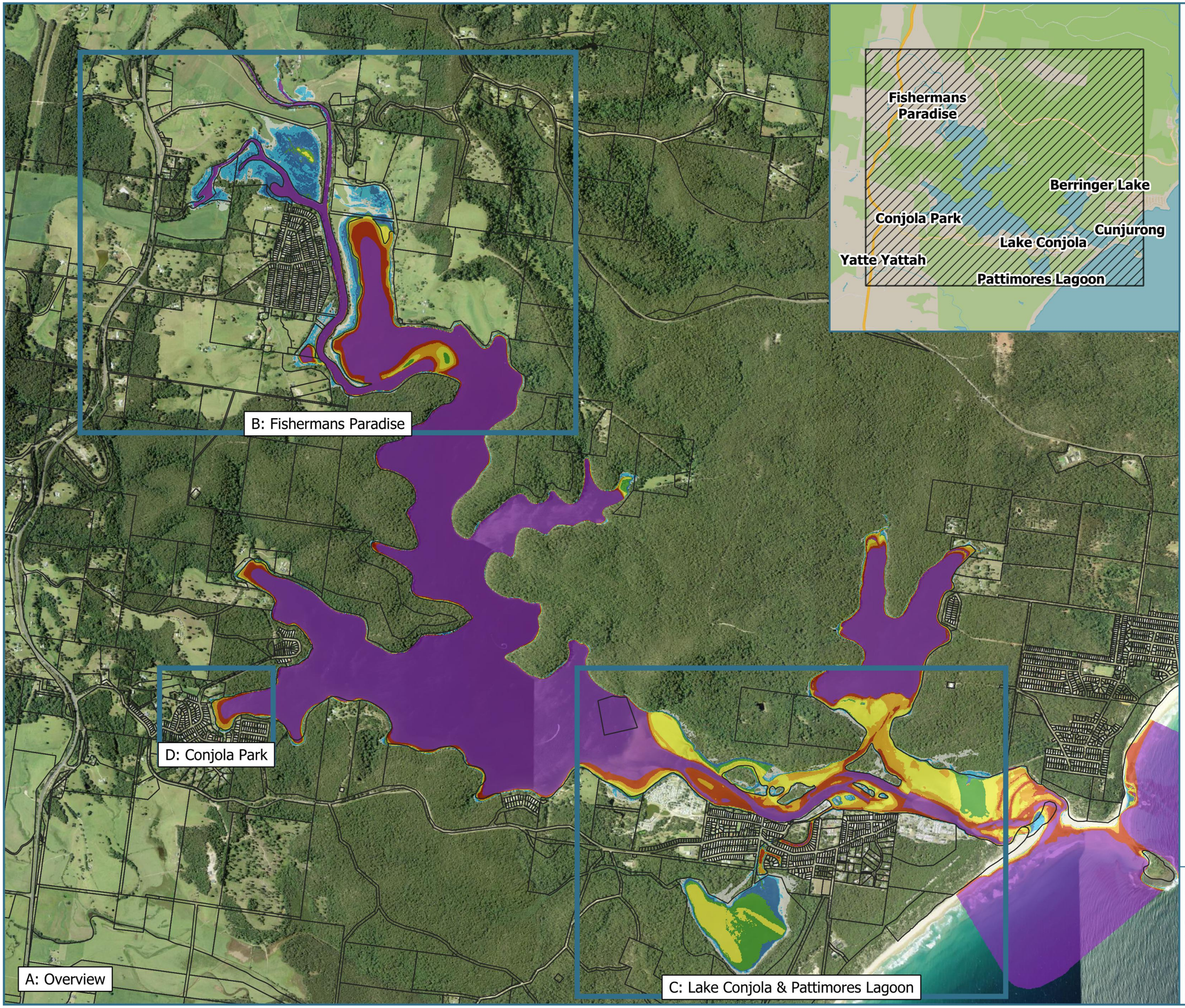

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Figure A-09
Tidal Inundation
SLR 0.6 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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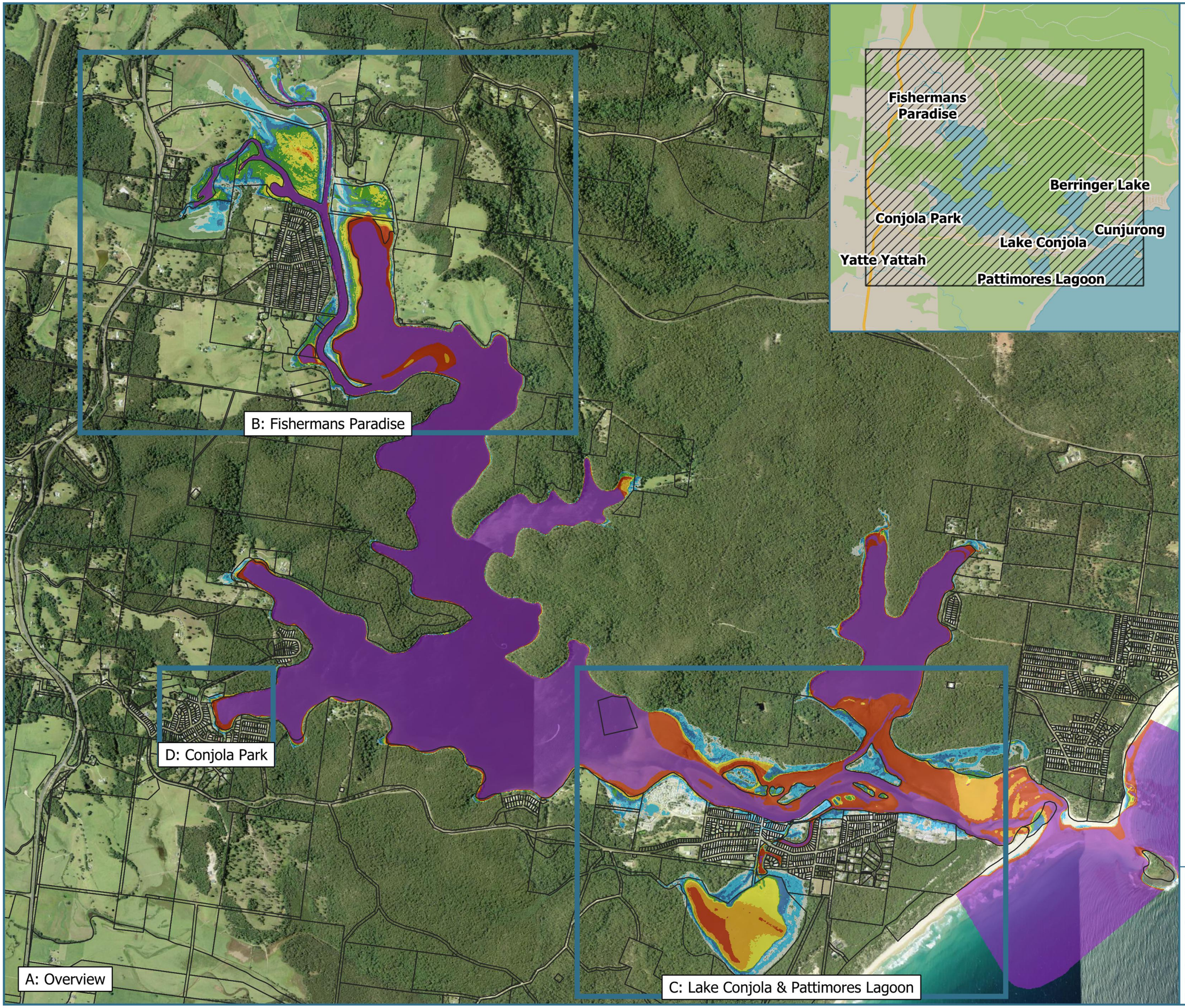

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Figure A-10
Tidal Inundation
SLR 0.9 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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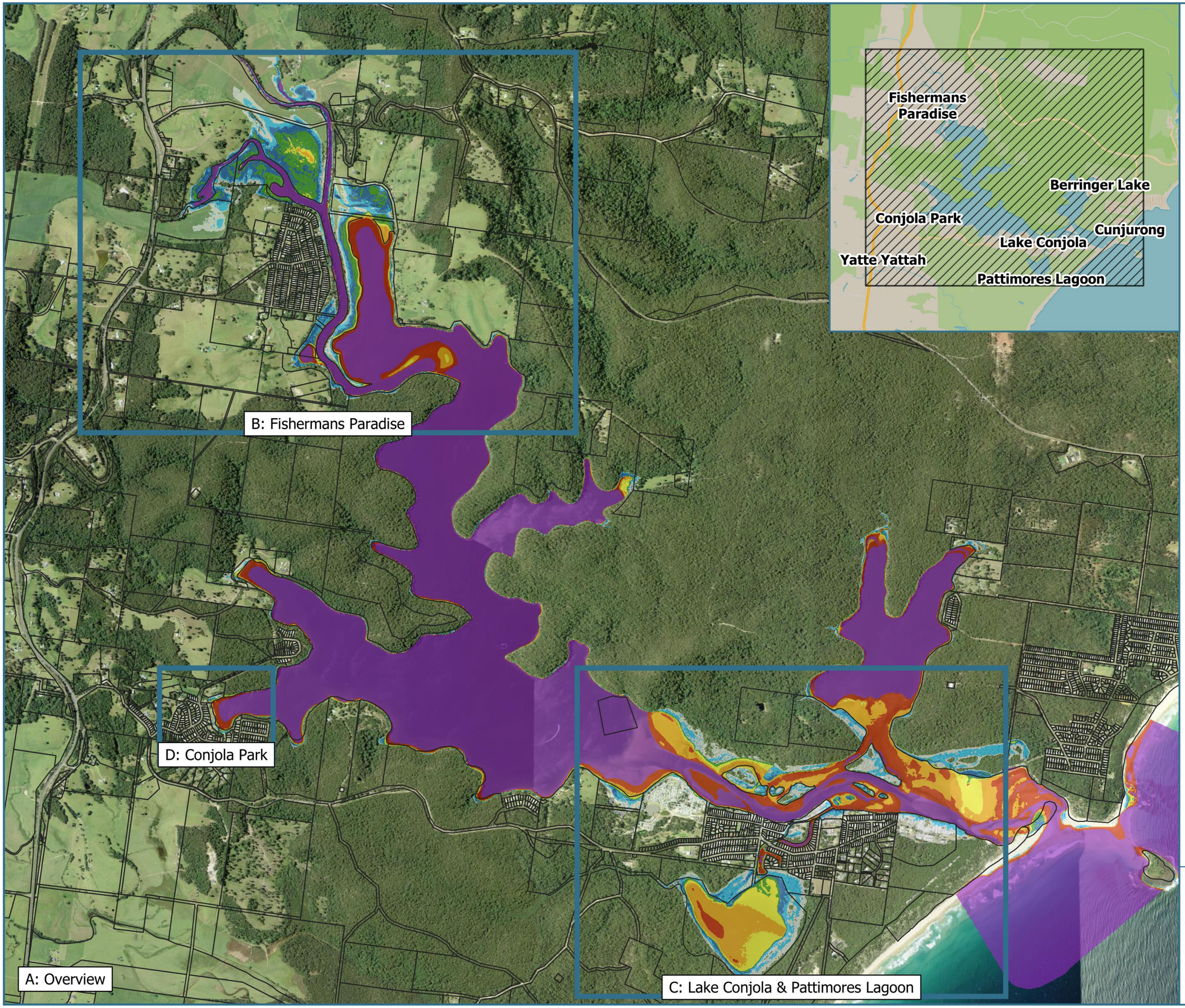

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Lake Conjola Coastal Management Program

Figure A-11
Tidal Inundation
SLR 0.9 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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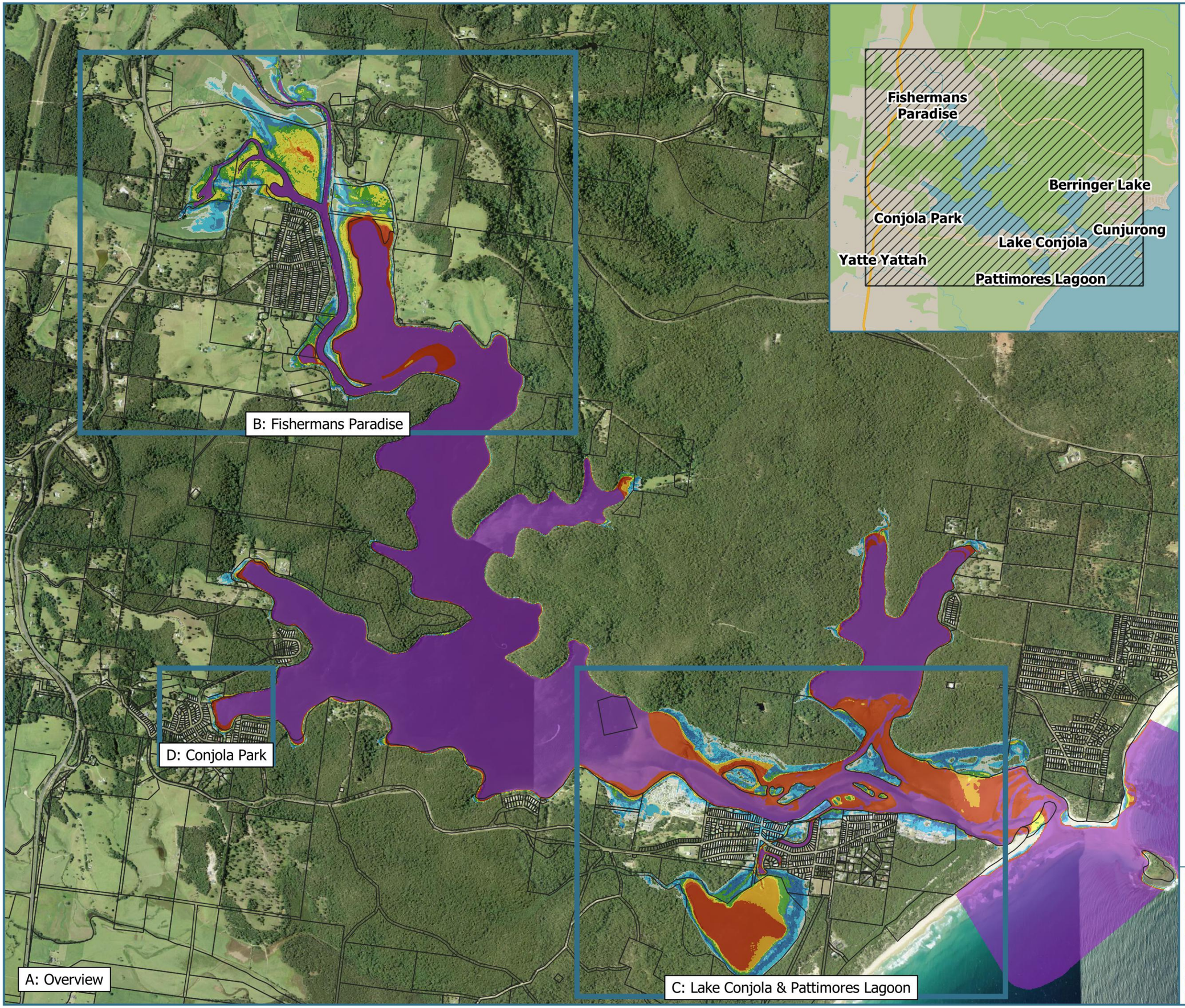

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Lake Conjola Coastal Management Program

Figure A-12
Tidal Inundation
SLR 1.2 m
Bed Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-14
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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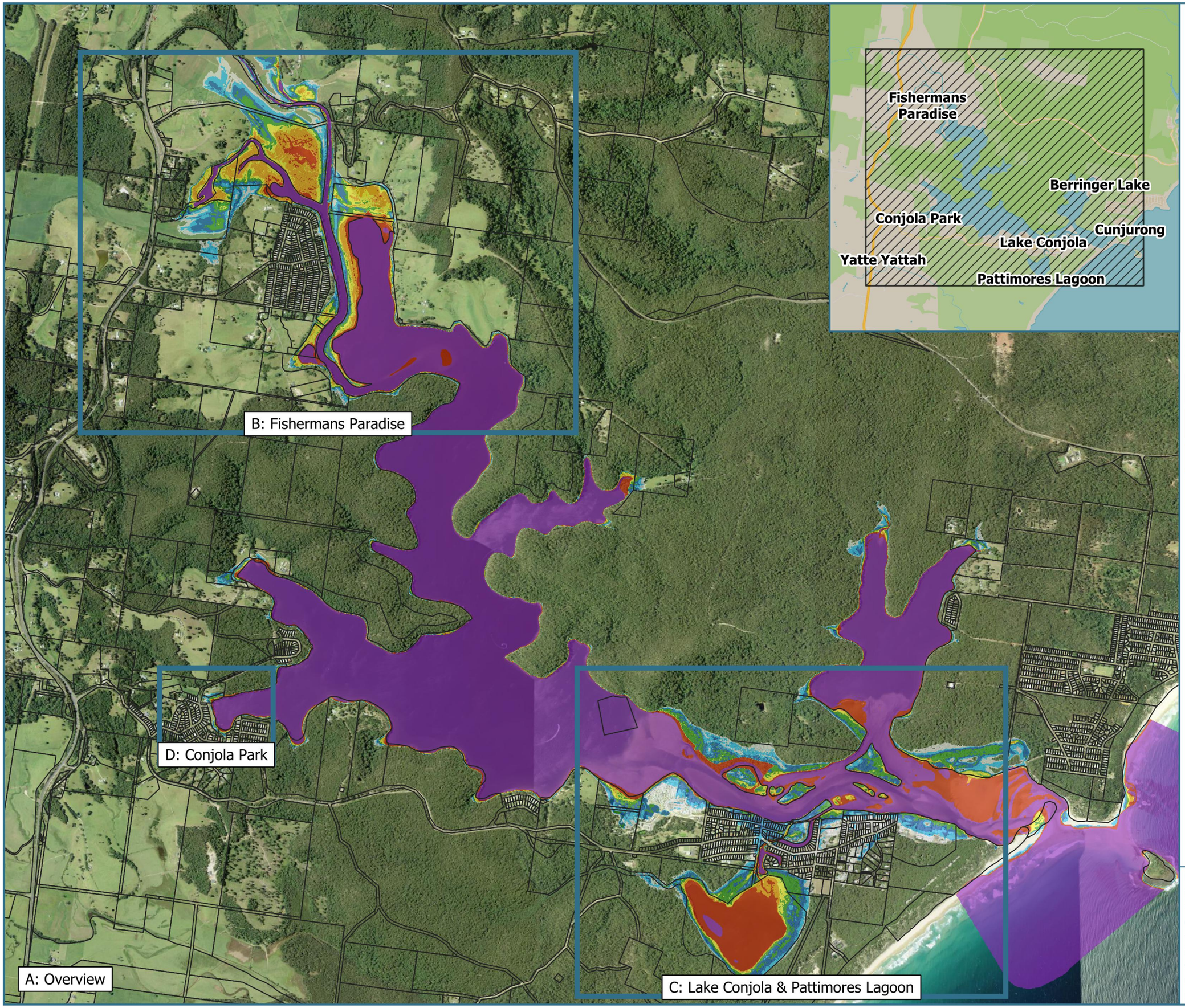

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Lake Conjola Coastal Management Program

Figure A-13
Tidal Inundation
SLR 1.2 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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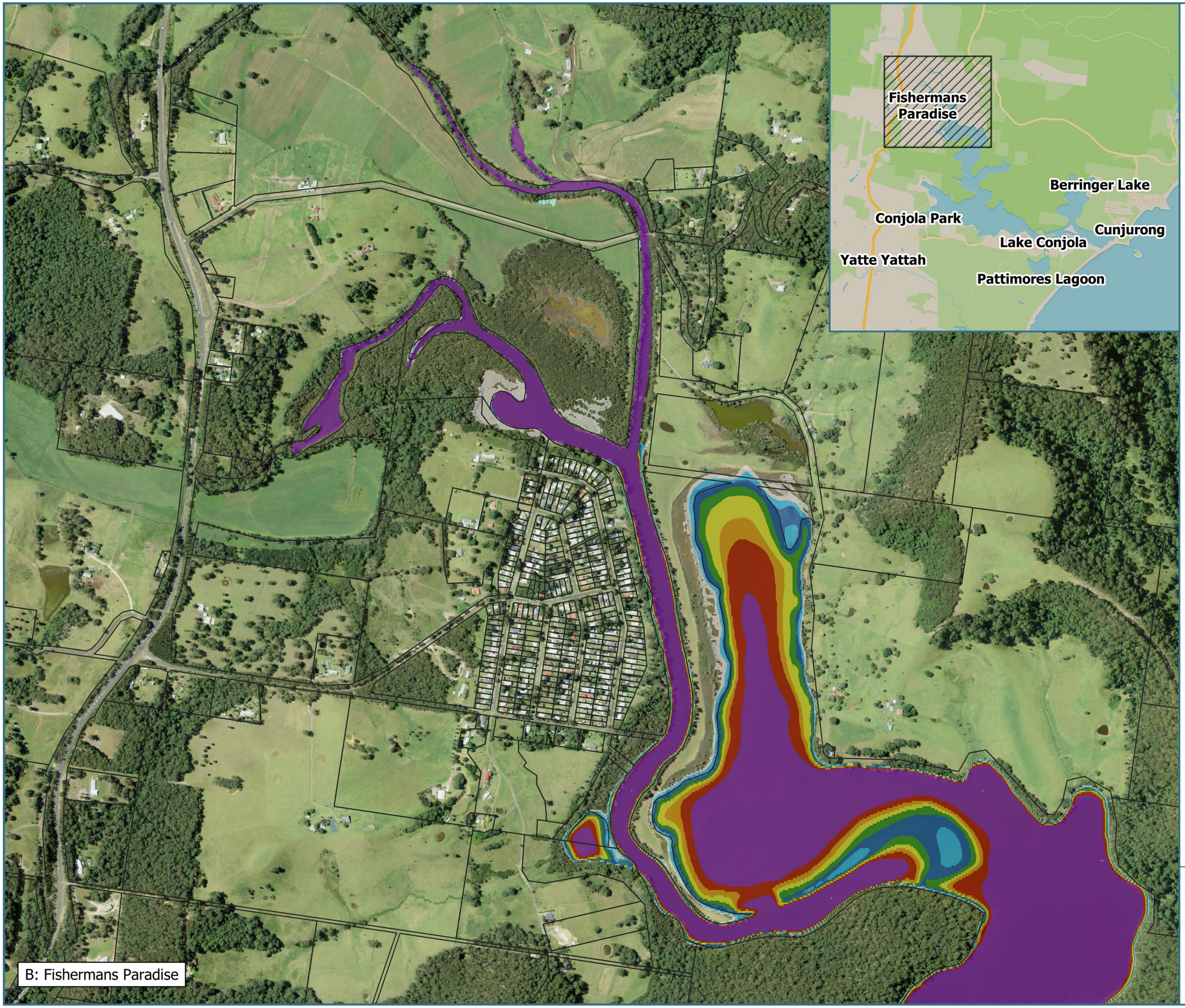

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Figure B-01
Tidal Inundation
SLR 0 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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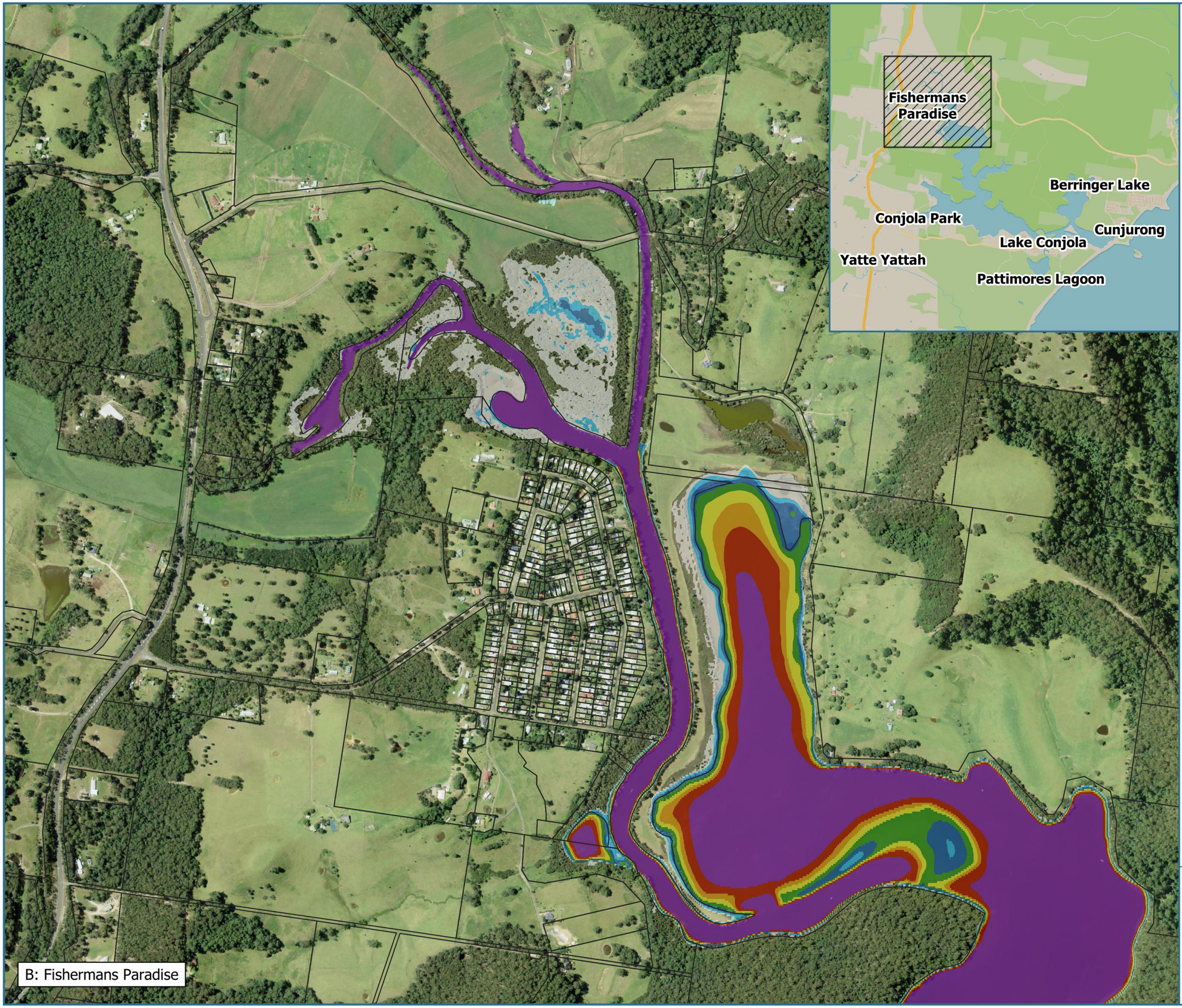

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-02
Tidal Inundation
SLR 0.1 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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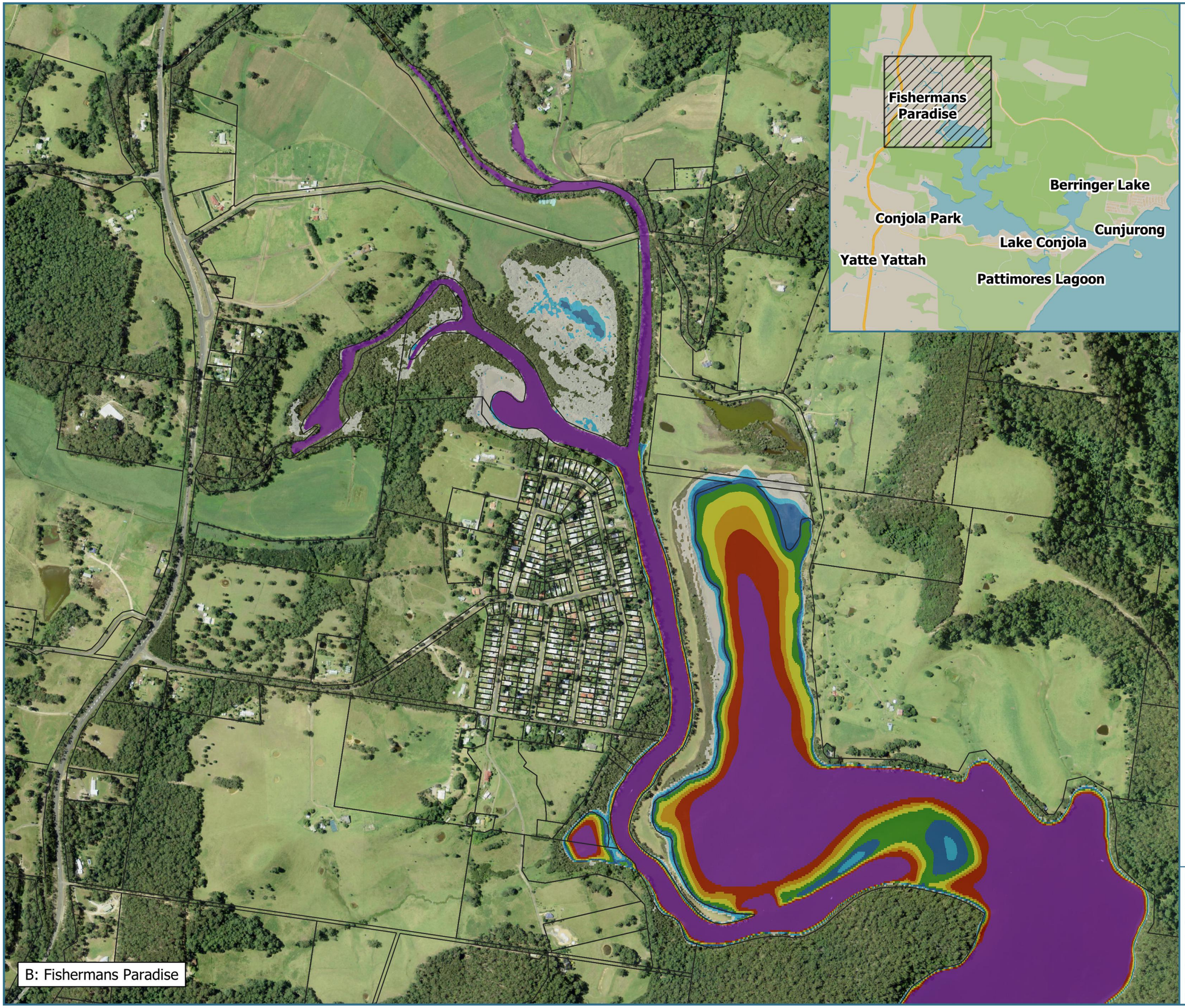

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-03
Tidal Inundation
SLR 0.1 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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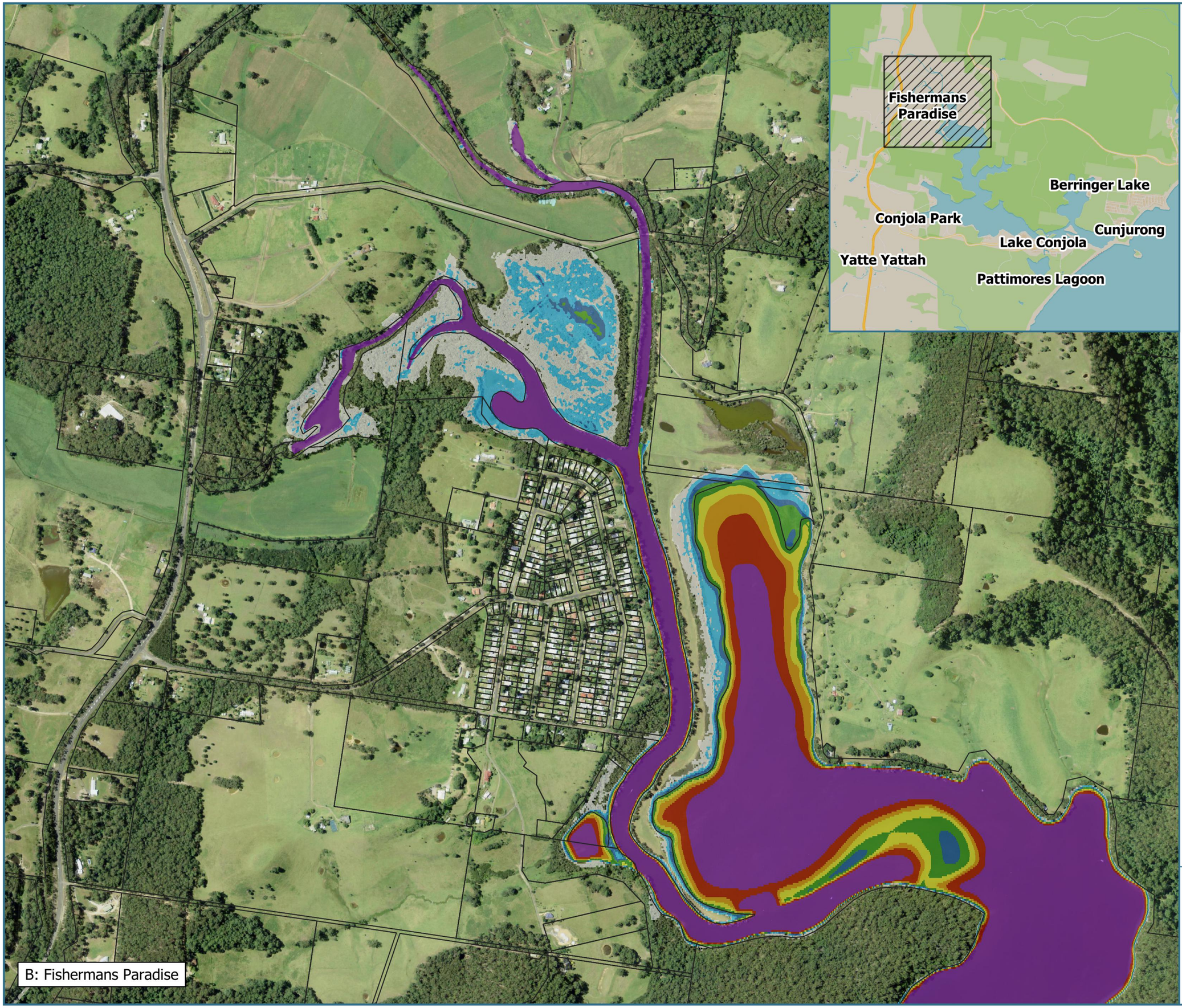

B: Fishermans Paradise

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Figure B-04
Tidal Inundation
SLR 0.23 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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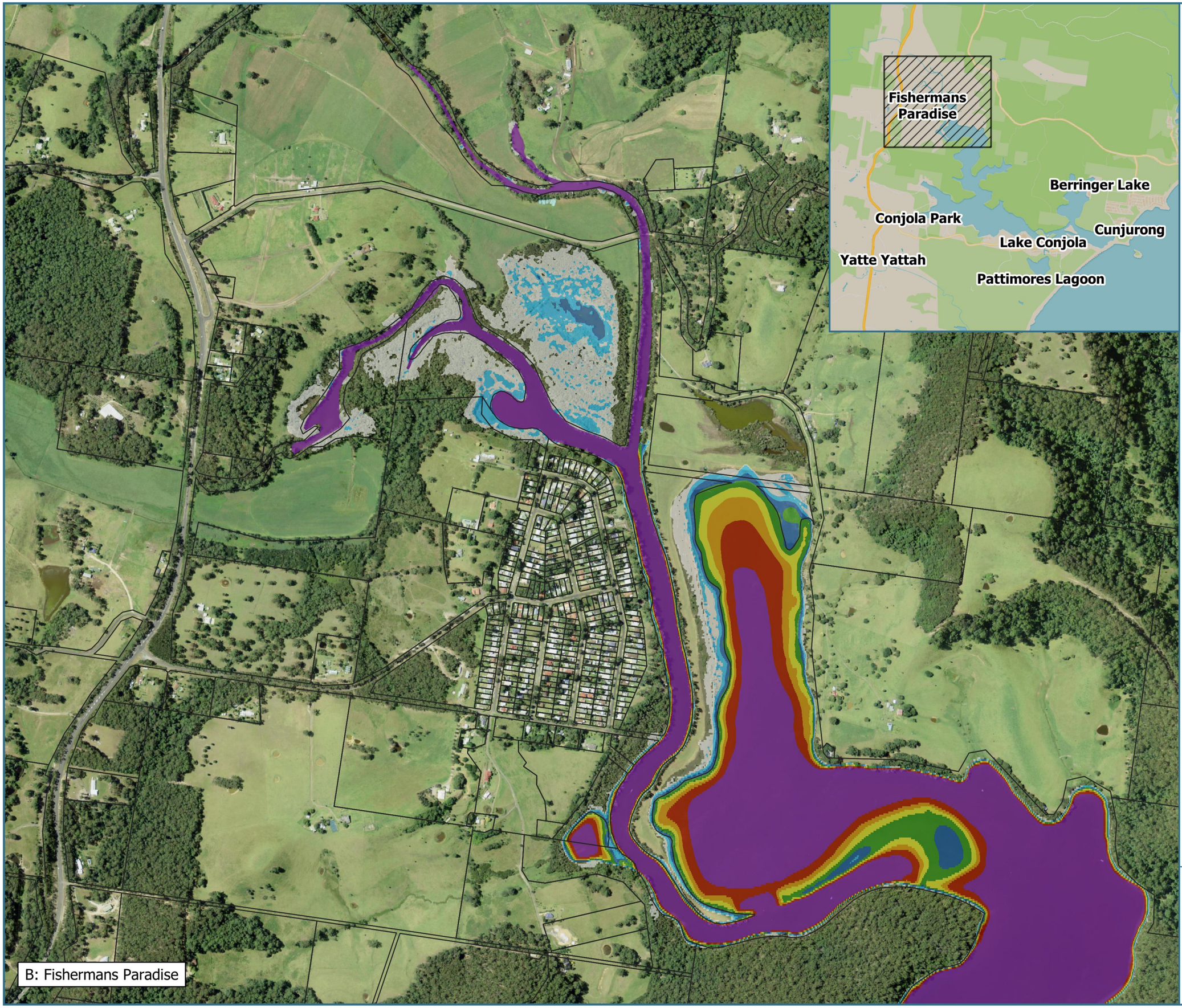

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Figure B-05
Tidal Inundation
SLR 0.23 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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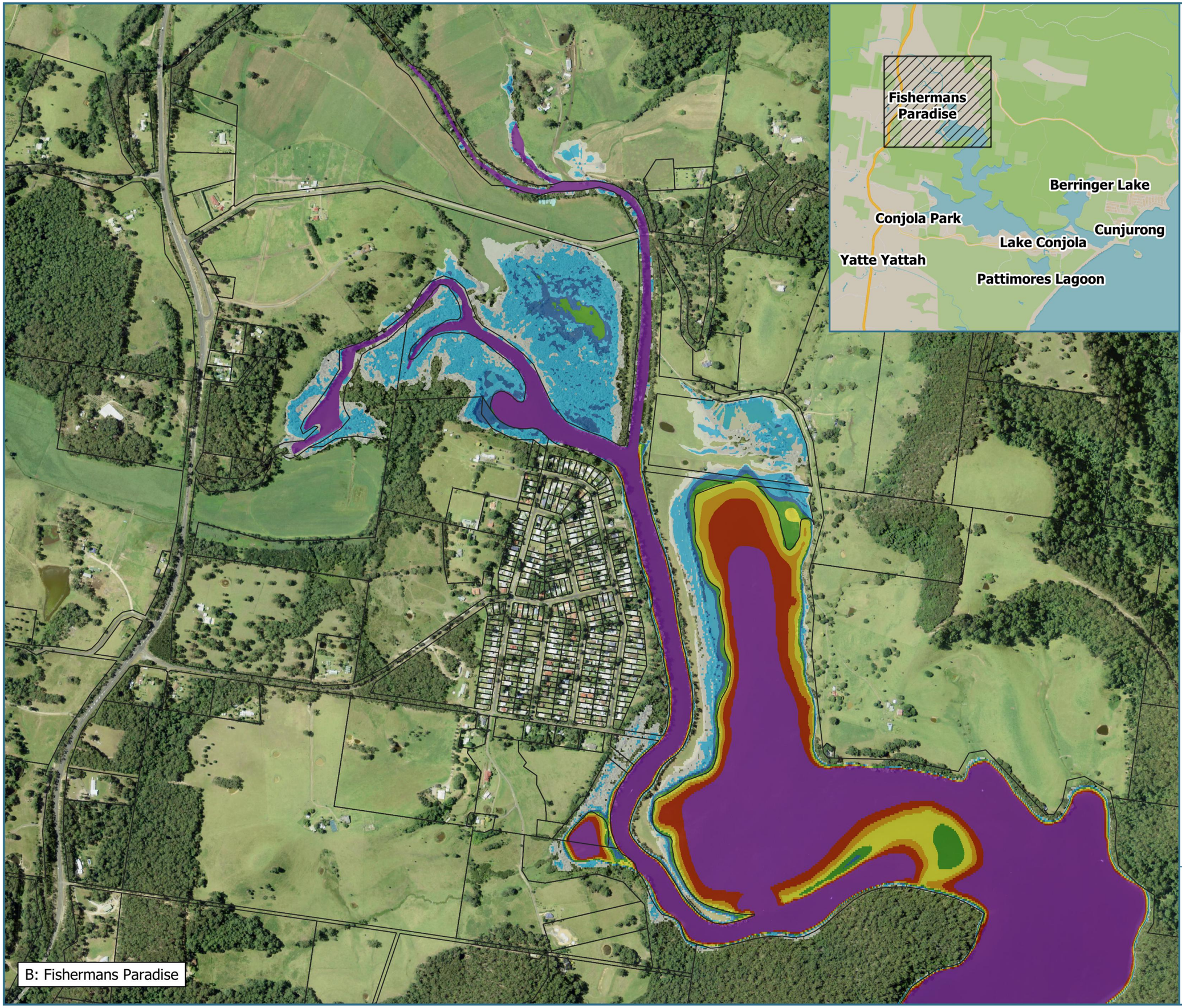

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-06
Tidal Inundation
SLR 0.36 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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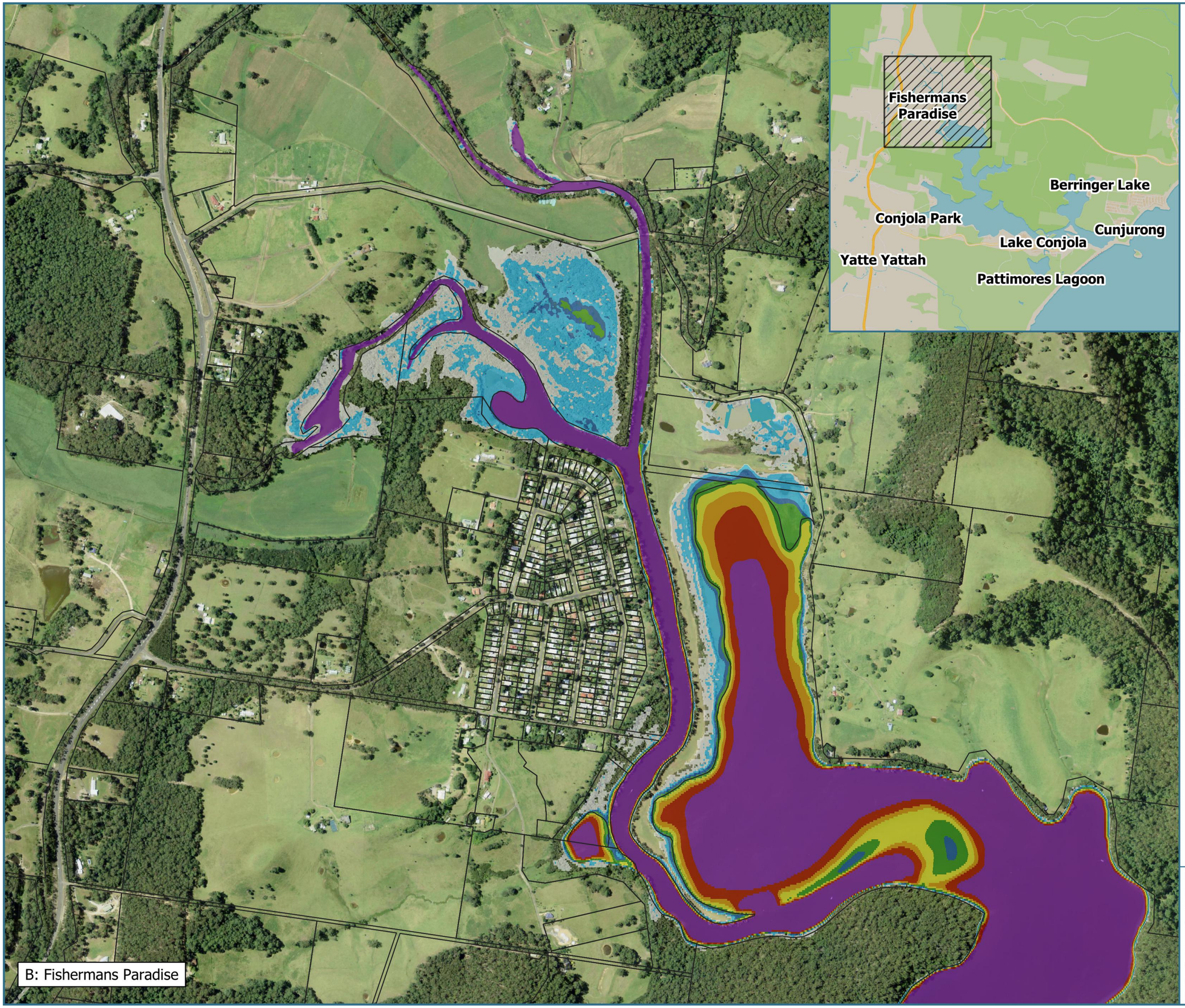

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Lake Conjola Coastal Management Program

Figure B-07
Tidal Inundation
SLR 0.36 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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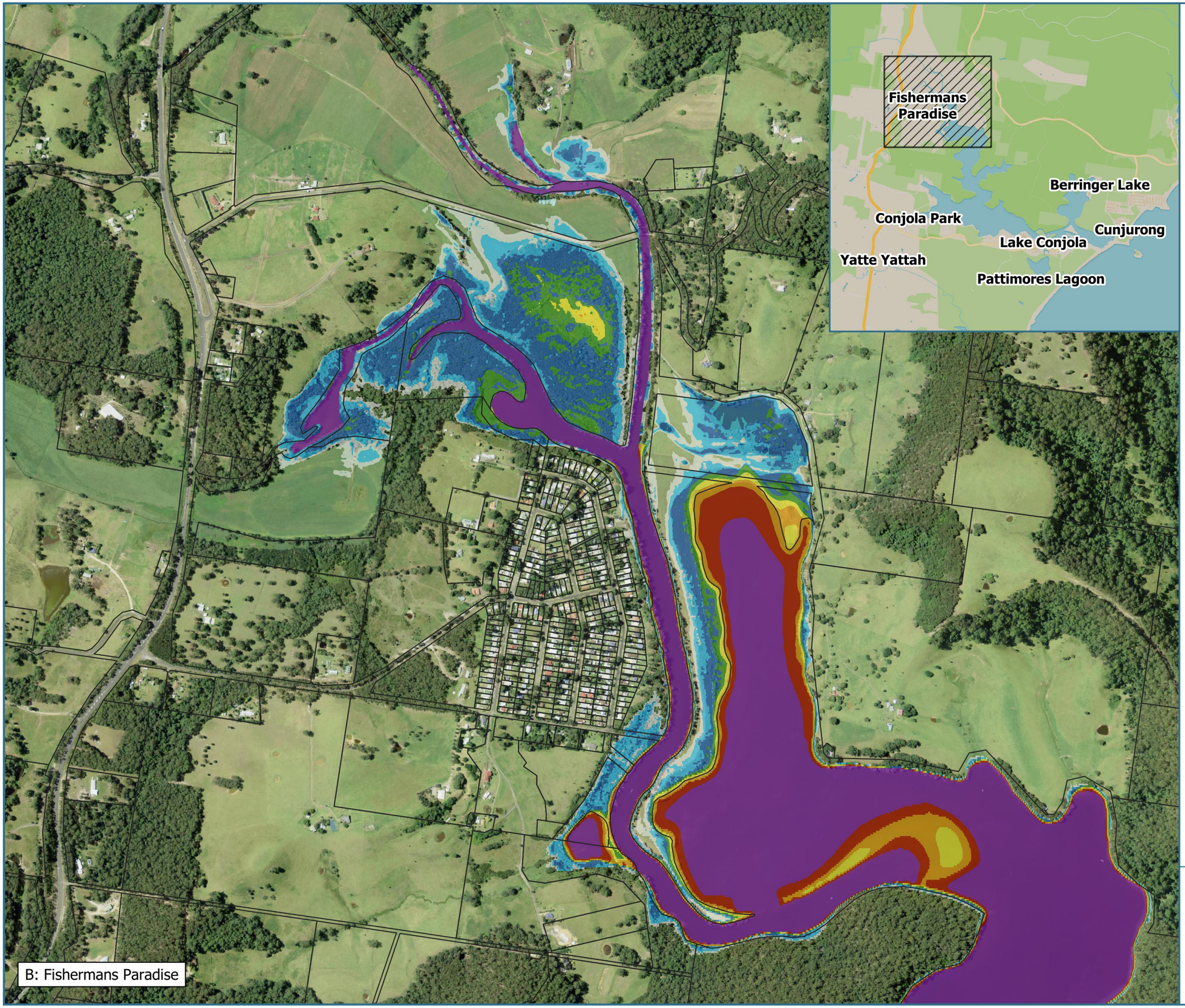

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Lake Conjola Coastal Management Program

Figure B-08
Tidal Inundation
SLR 0.6 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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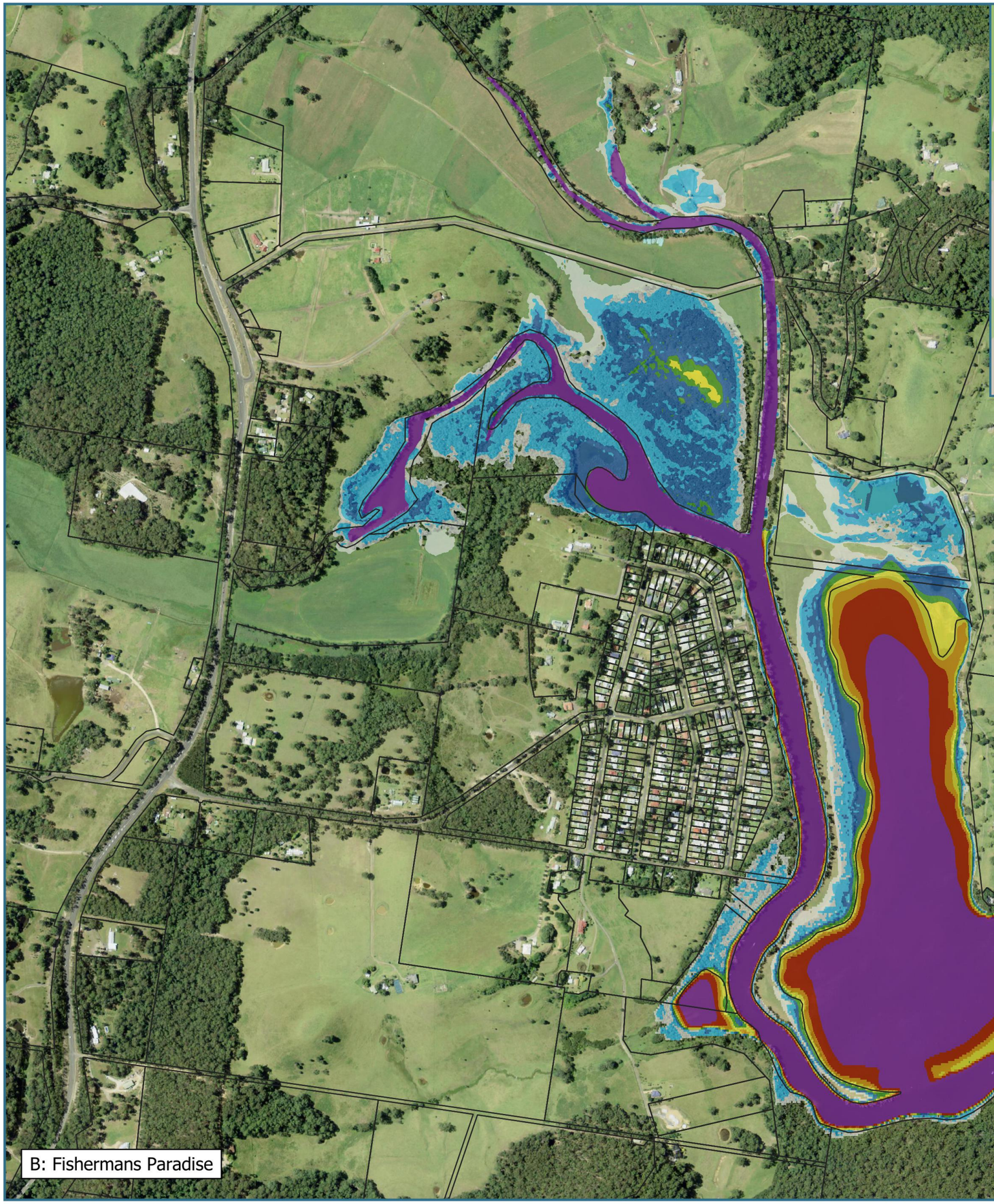



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Lake Conjola Coastal Management Program

Figure B-09
Tidal Inundation
SLR 0.6 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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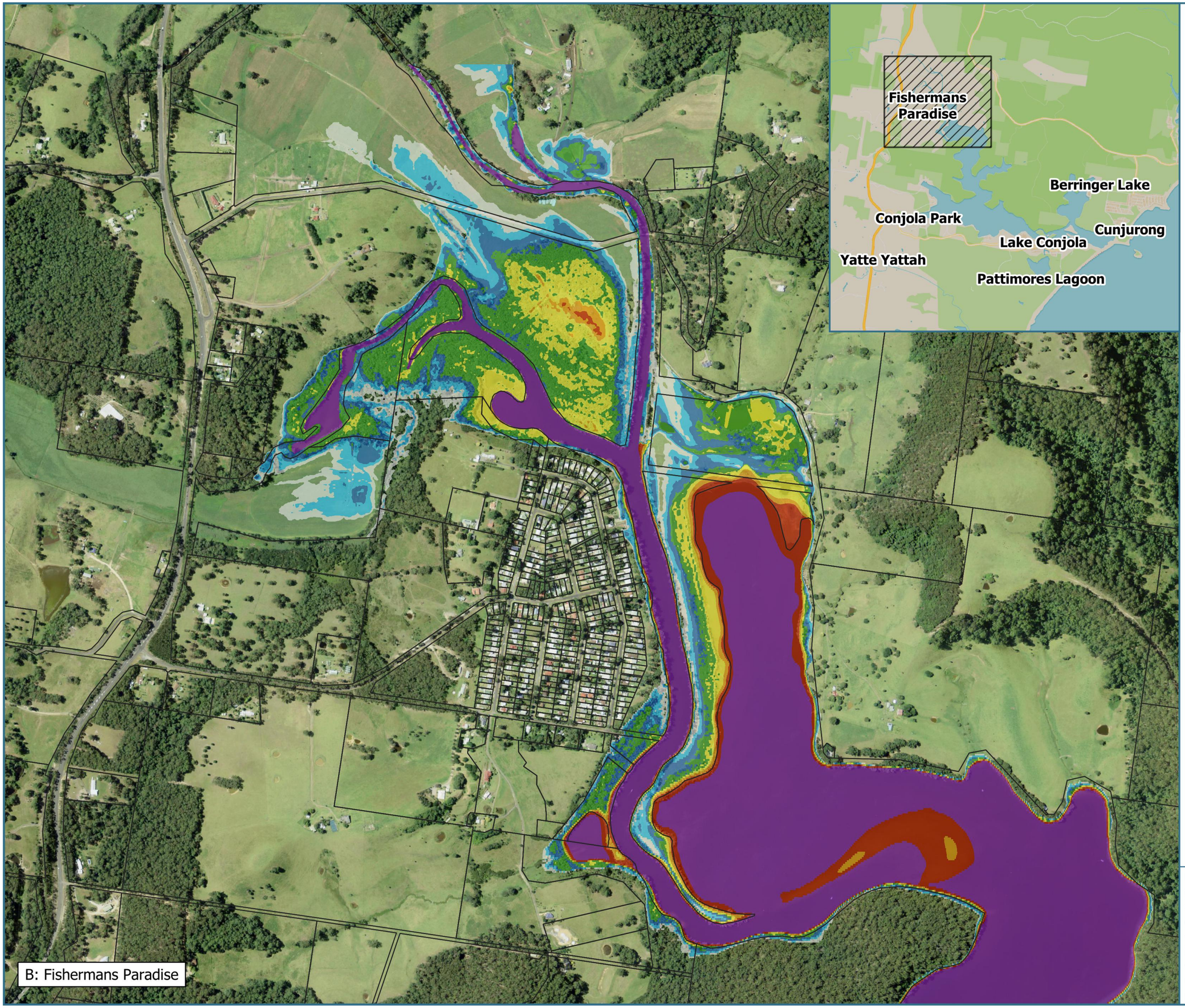

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-10
Tidal Inundation
SLR 0.9 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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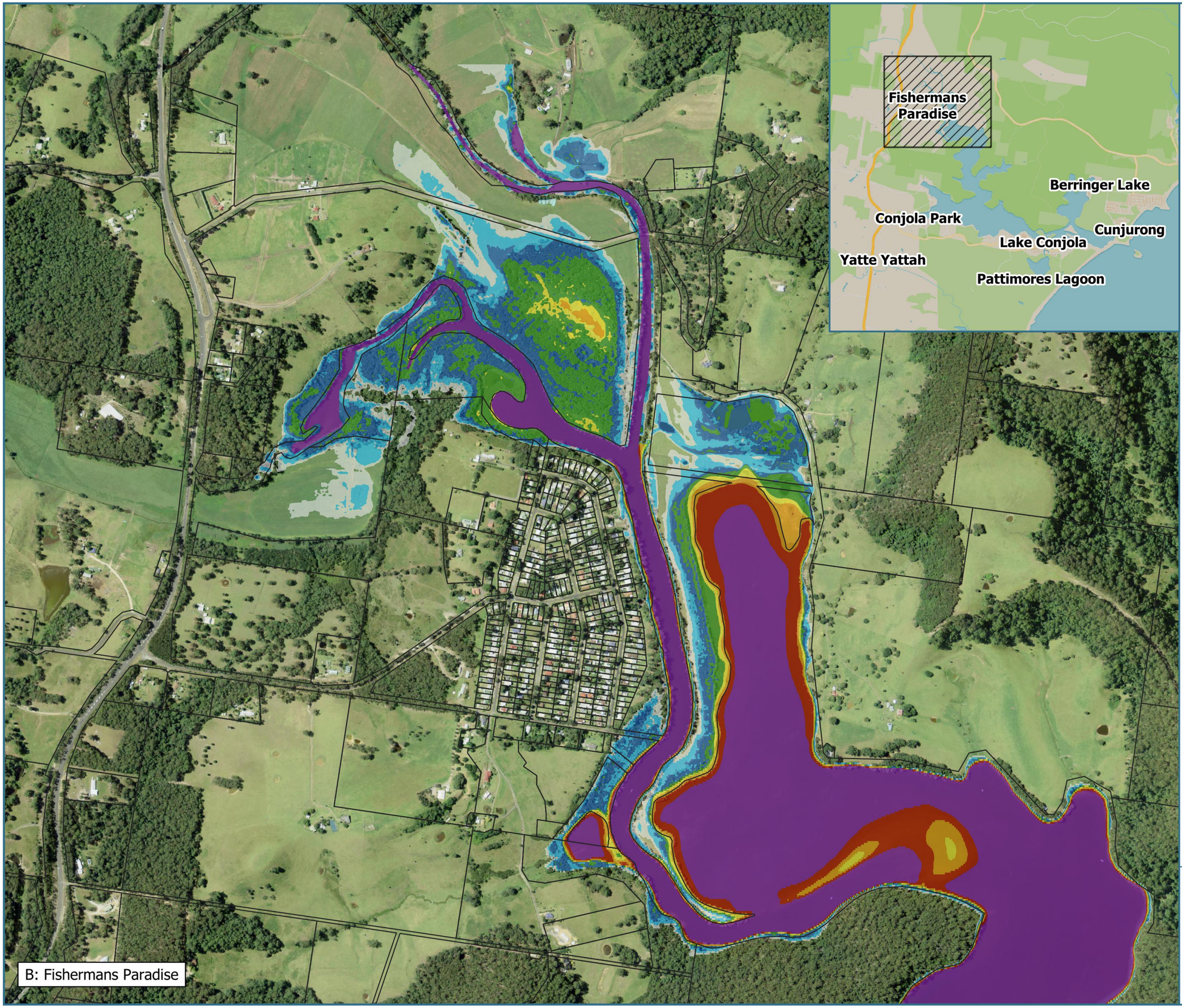

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Lake Conjola Coastal Management Program

Figure B-11
Tidal Inundation
SLR 0.9 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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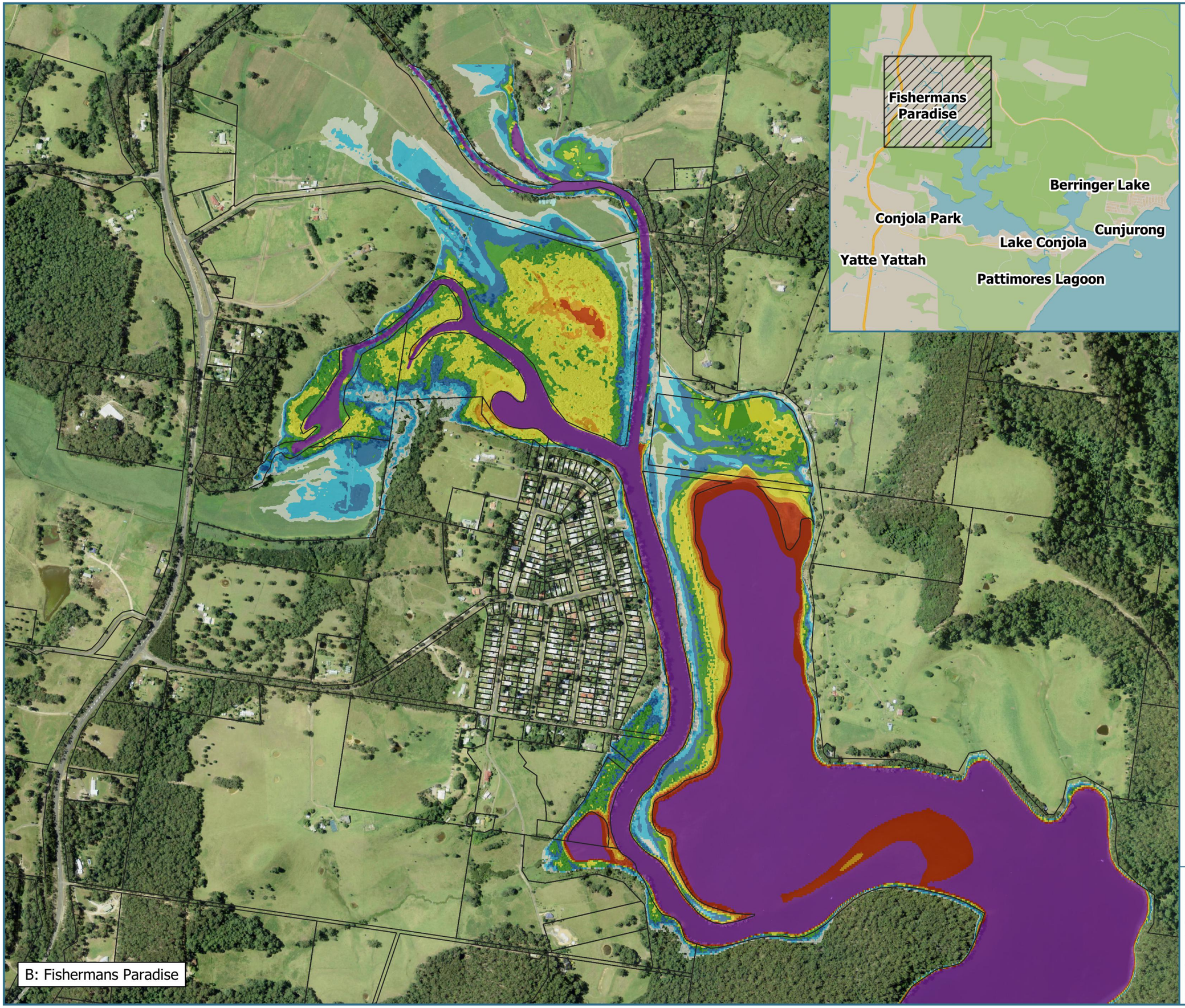

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Lake Conjola Coastal Management Program

Figure B-12
Tidal Inundation
SLR 1.2 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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Lake Conjola Coastal Management Program

Figure B-13
Tidal Inundation
SLR 1.2 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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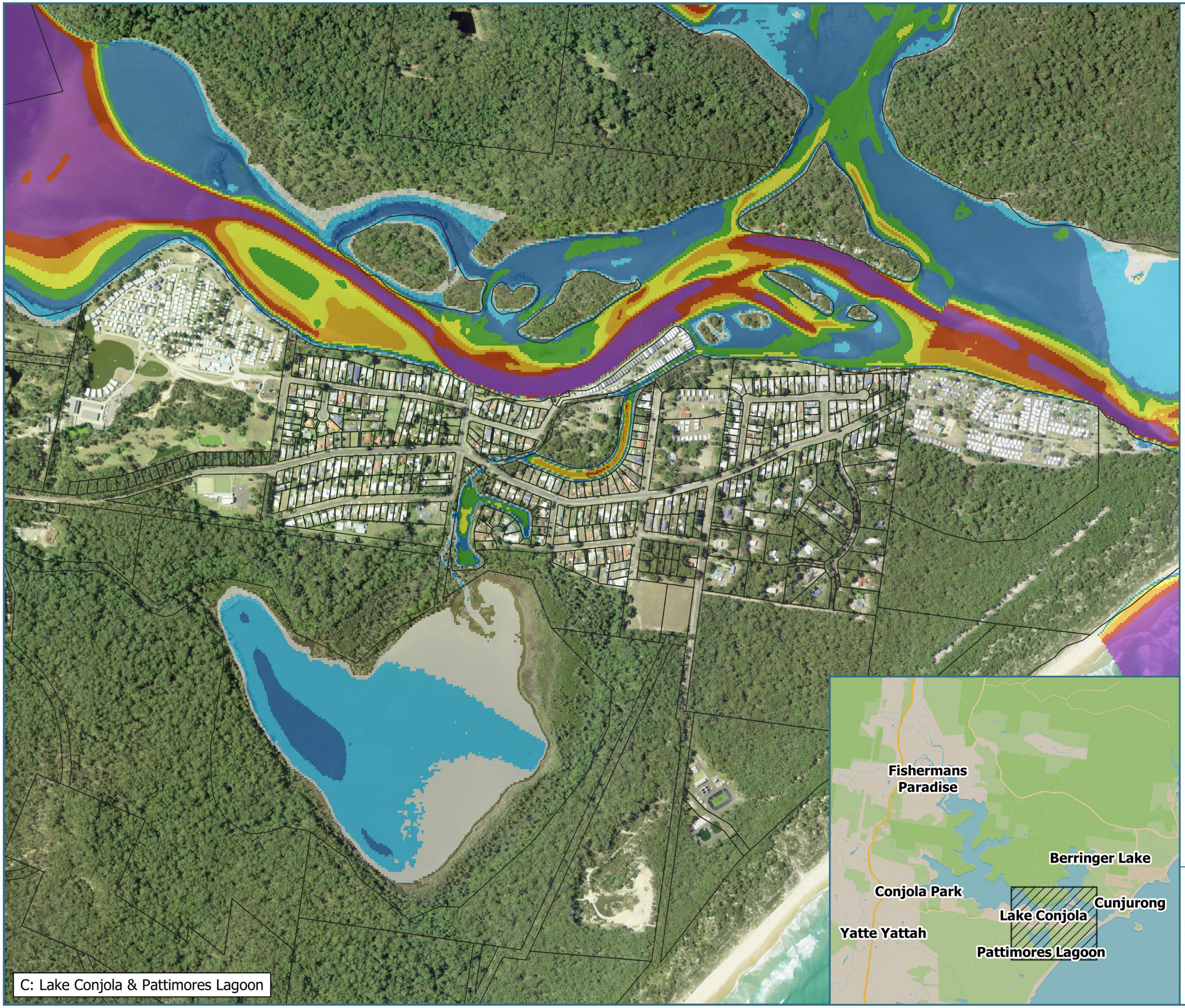
B: Fishermans Paradise



C: Lake Conjola & Pattimores Lagoon

Royal HaskoningDHV
Enhancing Society Together

Lake Conjola Coastal Management Program

Figure C-01
Tidal Inundation
SLR 0 m
Bed Not Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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Lake Conjola Coastal Management Program

Figure C-02
Tidal Inundation
SLR 0.1 m
Bed Not Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

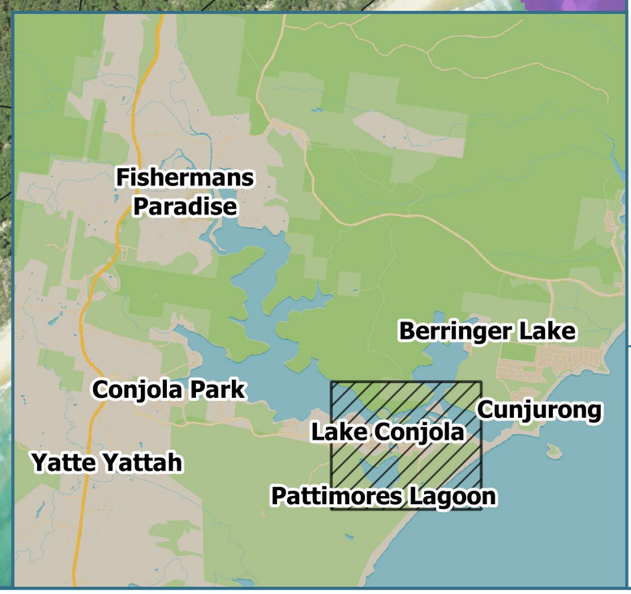
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Lake Conjola Coastal Management Program

Figure C-03
Tidal Inundation
SLR 0.1 m
Bed Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

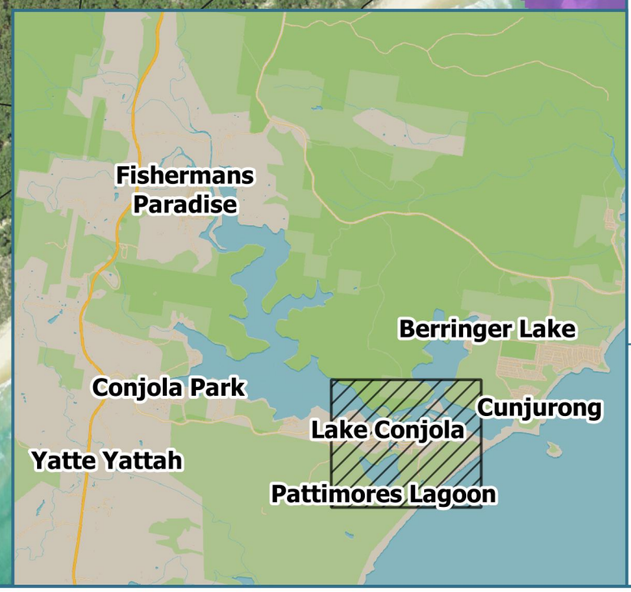
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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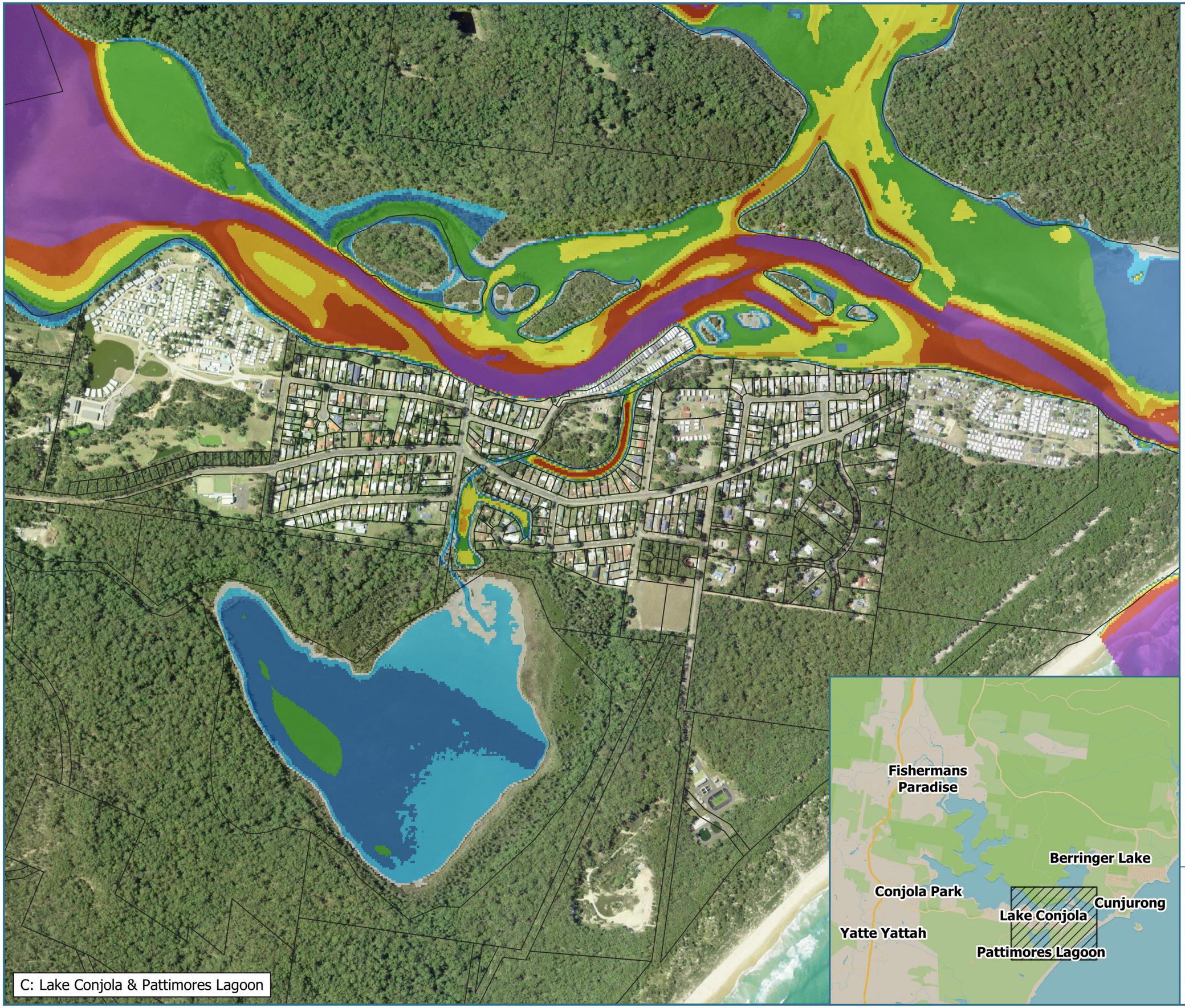

C: Lake Conjola & Pattimores Lagoon

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Figure C-04
Tidal Inundation
SLR 0.23 m
Bed Not Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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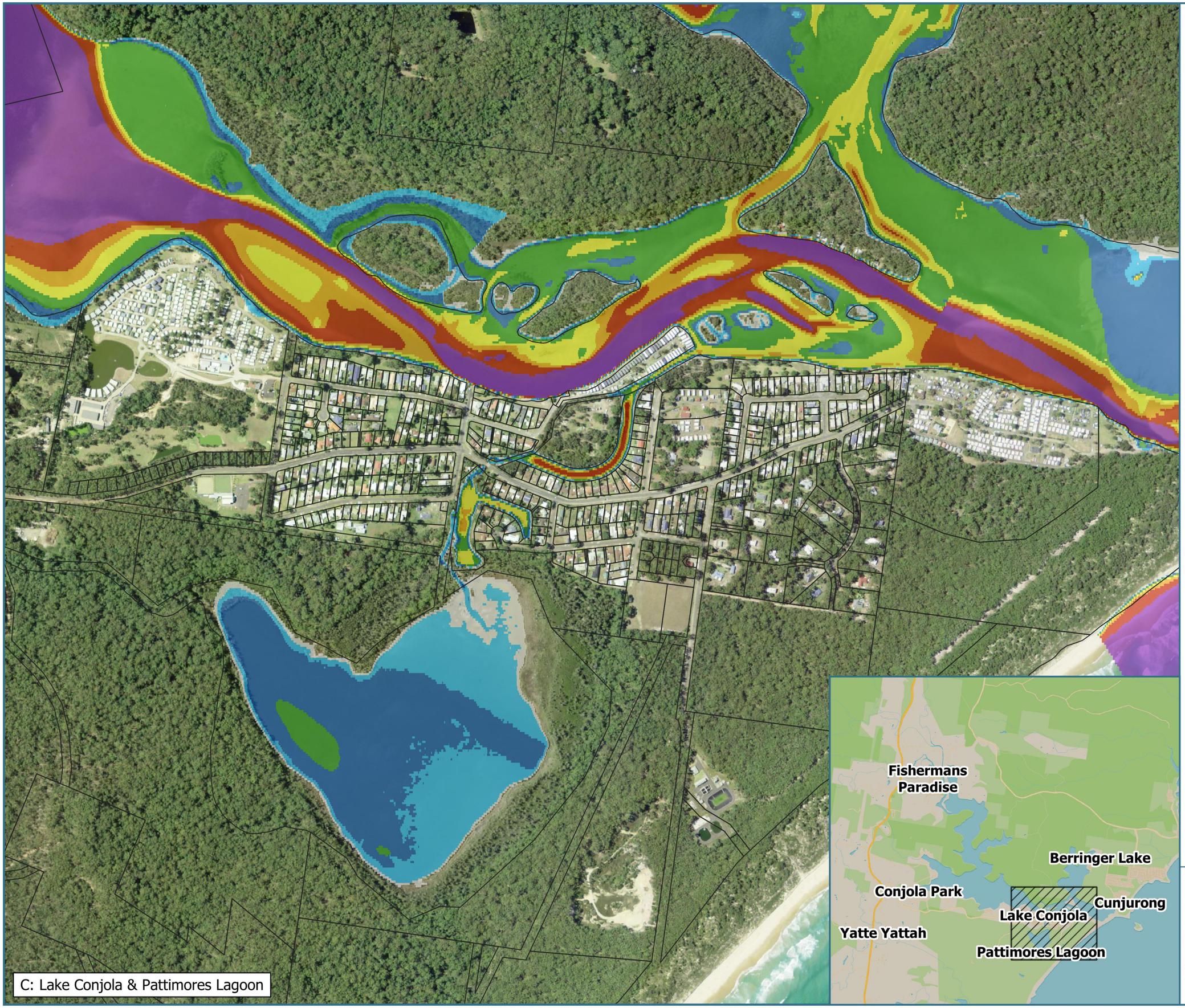

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Lake Conjola Coastal Management Program

Figure C-05
Tidal Inundation
SLR 0.23 m
Bed Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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Figure C-06
Tidal Inundation
SLR 0.36 m
Bed Not Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

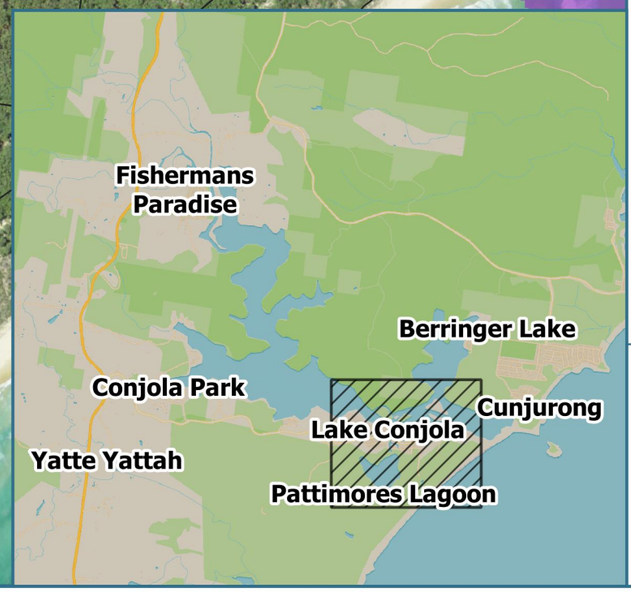
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-07
Tidal Inundation
SLR 0.36 m
Bed Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

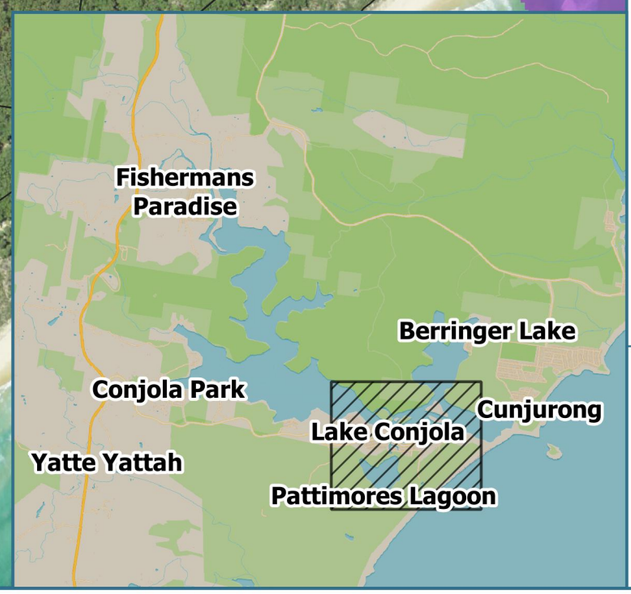
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-08
Tidal Inundation
SLR 0.6 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

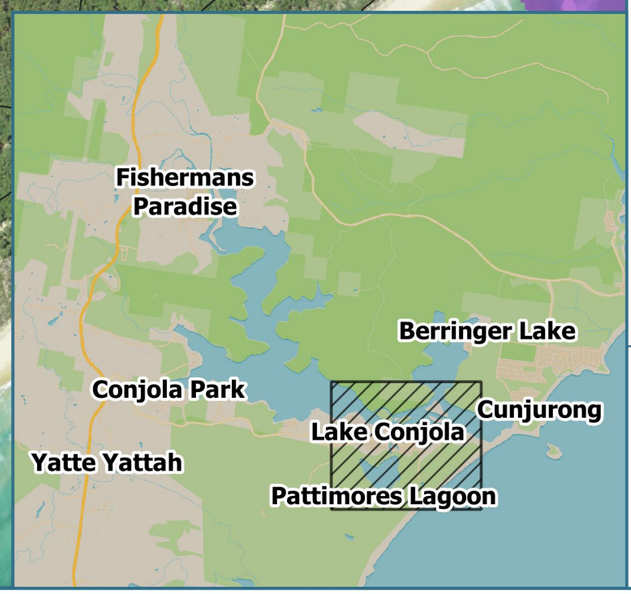
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-09
Tidal Inundation
SLR 0.6 m
Bed Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

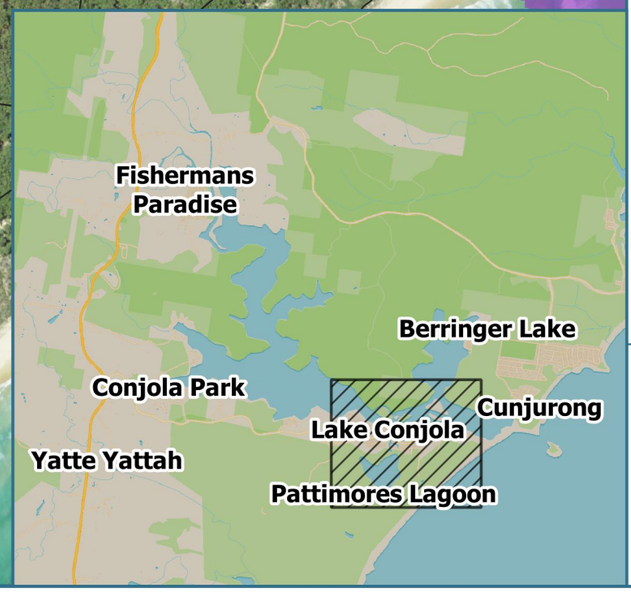
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-10
Tidal Inundation
SLR 0.9 m
Bed Not Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

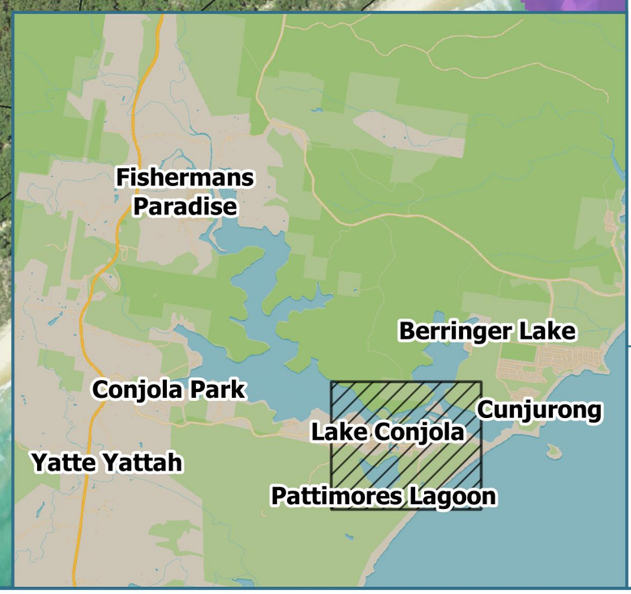
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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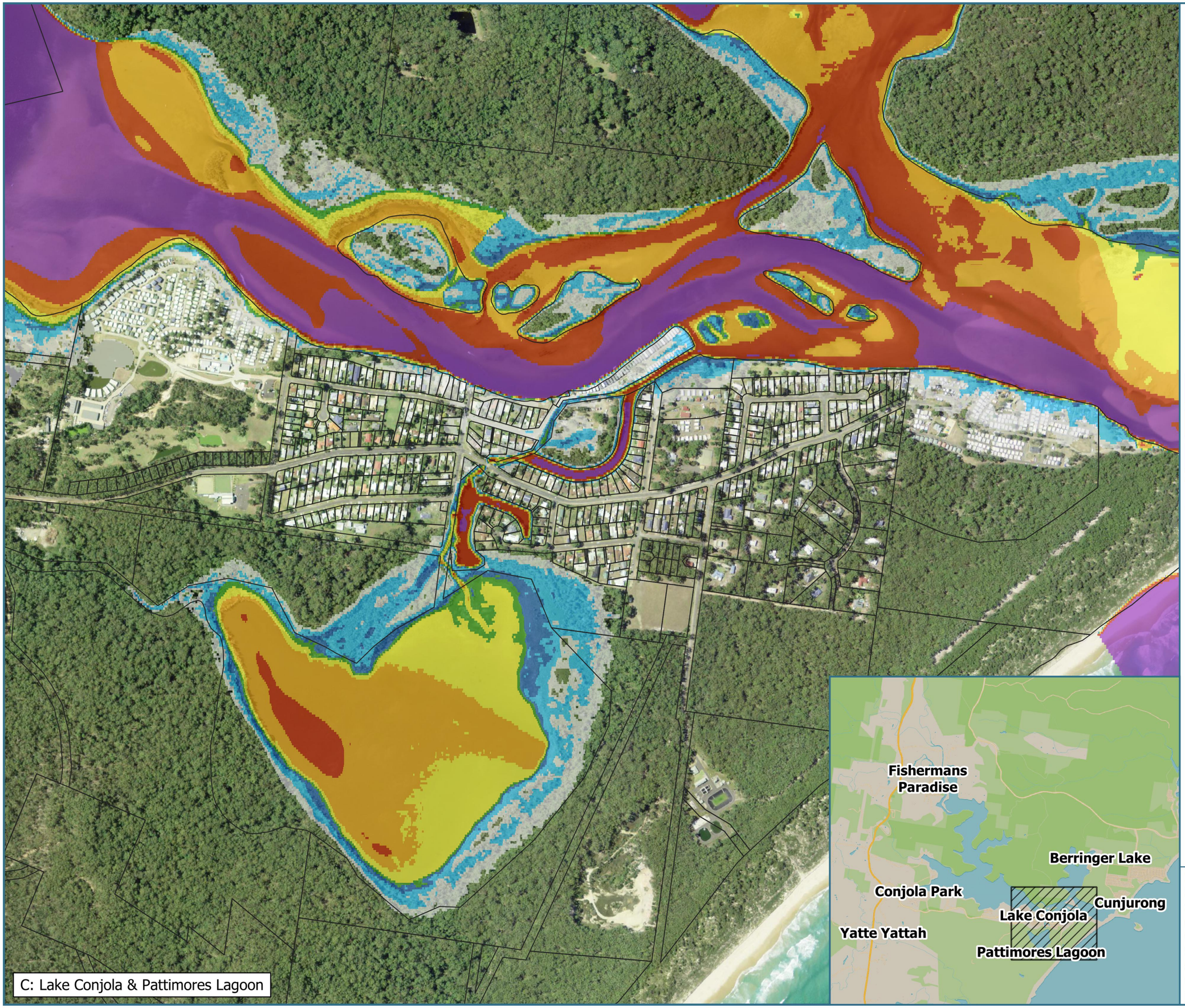

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Figure C-11
Tidal Inundation
SLR 0.9 m
Bed Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

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Figure C-12
Tidal Inundation
SLR 1.2 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

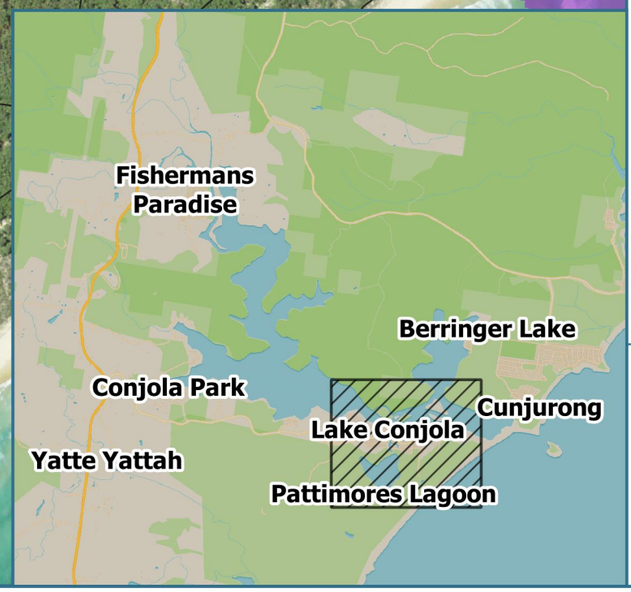
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-13
Tidal Inundation
SLR 1.2 m
Bed Not Raised
Tidal Plane: HHWSS

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

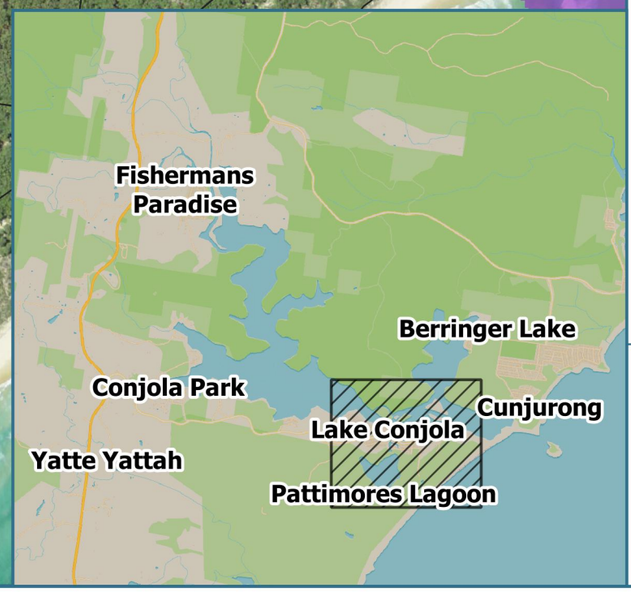
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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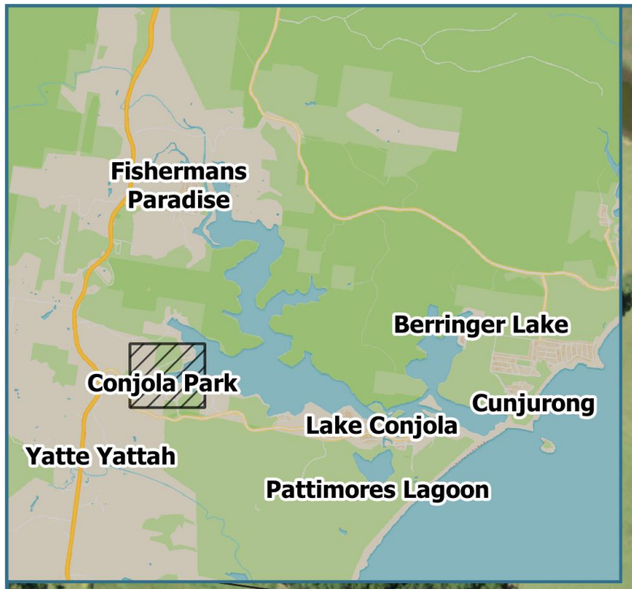

D: Conjola Park

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Figure D-01
Tidal Inundation
SLR 0 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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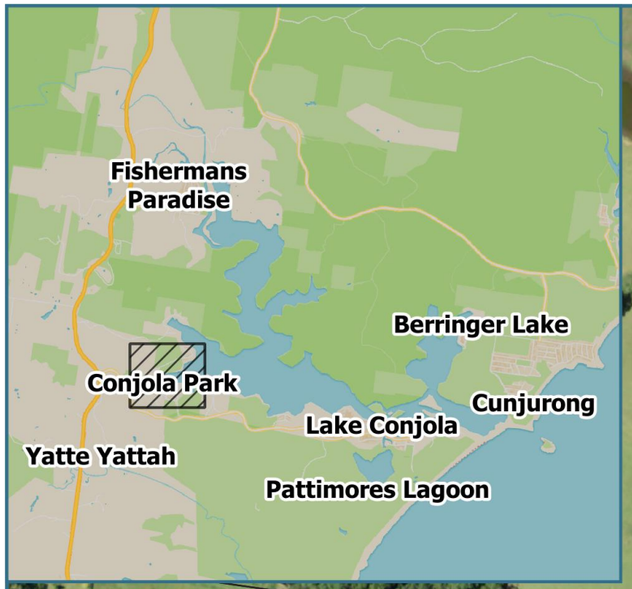

D: Conjola Park

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Figure D-02
Tidal Inundation
SLR 0.1 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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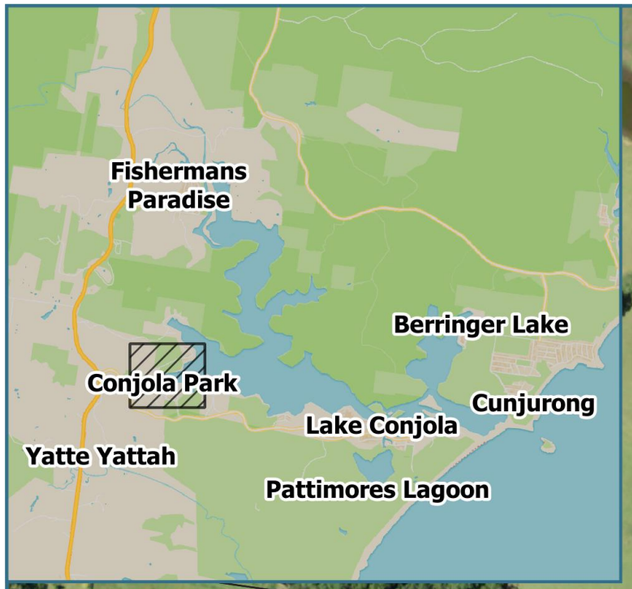

D: Conjola Park

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Lake Conjola Coastal Management Program

Figure D-03
Tidal Inundation
SLR 0.1 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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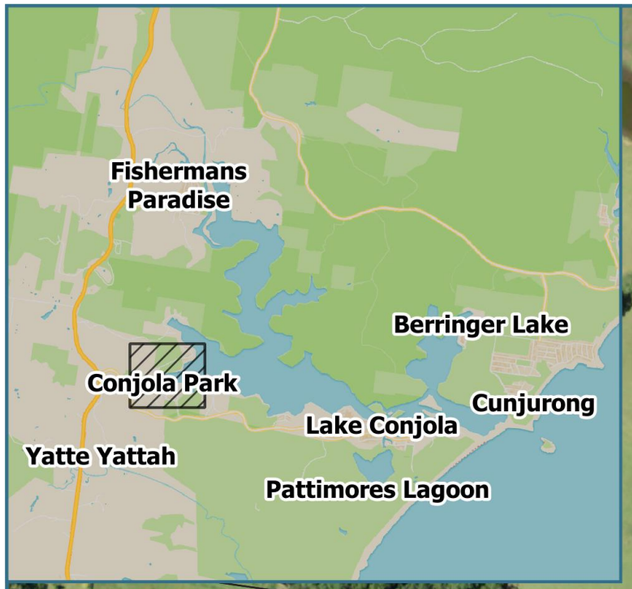

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Figure D-04
Tidal Inundation
SLR 0.23 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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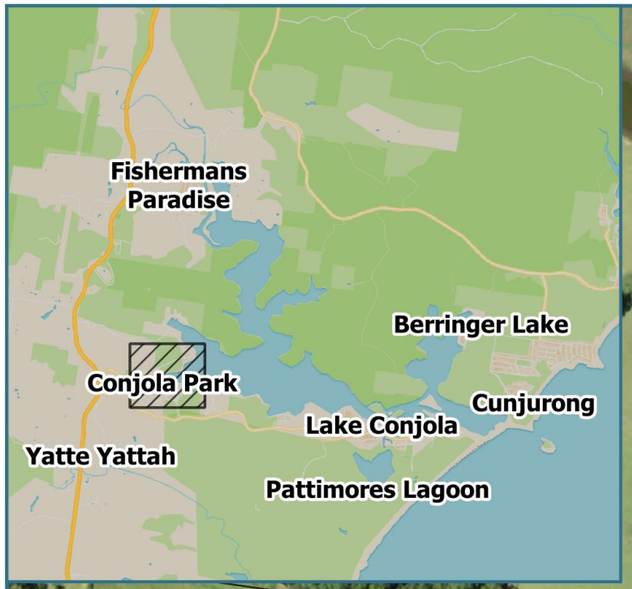
D: Conjola Park



D: Conjola Park

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Figure D-05
Tidal Inundation
SLR 0.23 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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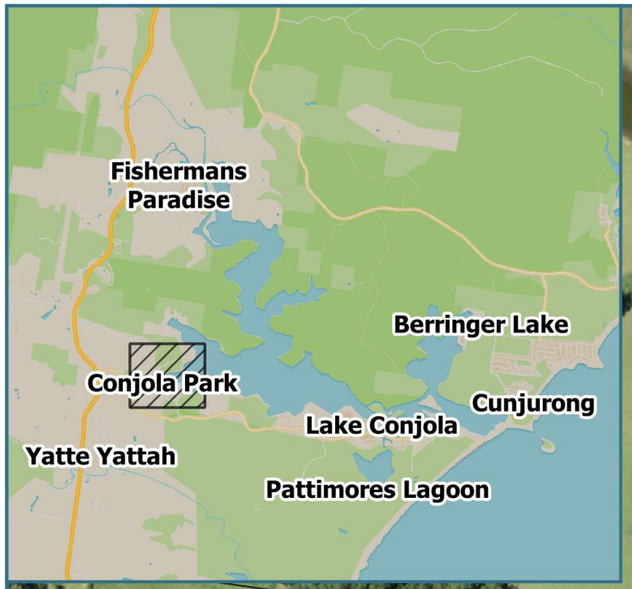

D: Conjola Park

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Figure D-06
Tidal Inundation
SLR 0.36 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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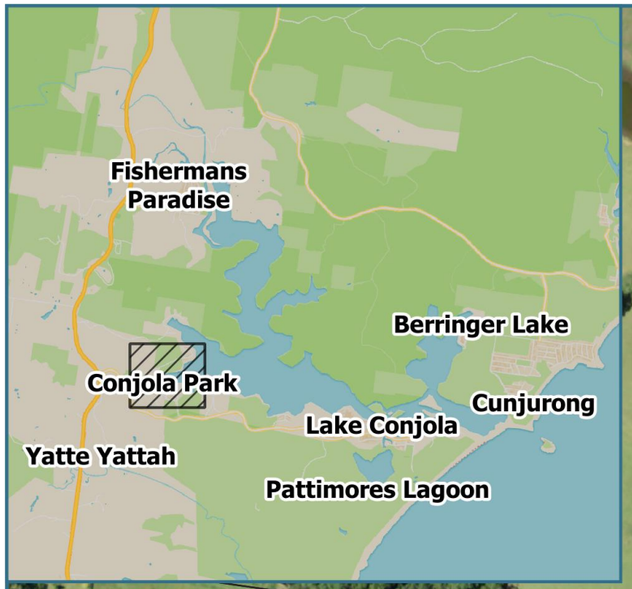

D: Conjola Park

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Figure D-07
Tidal Inundation
SLR 0.36 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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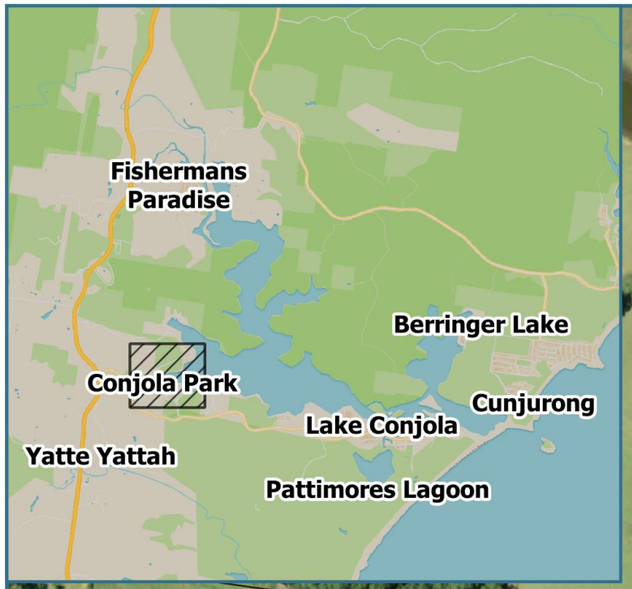

D: Conjola Park

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Figure D-08
Tidal Inundation
SLR 0.6 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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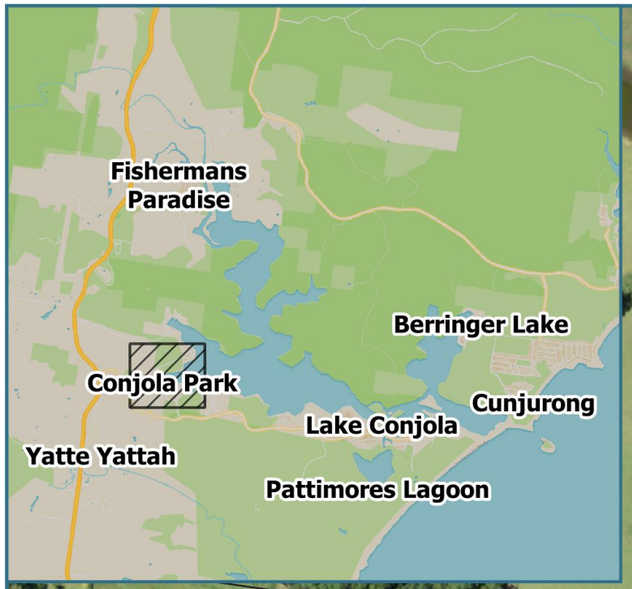

D: Conjola Park

Royal HaskoningDHV
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Lake Conjola Coastal Management Program

Figure D-09
Tidal Inundation
SLR 0.6 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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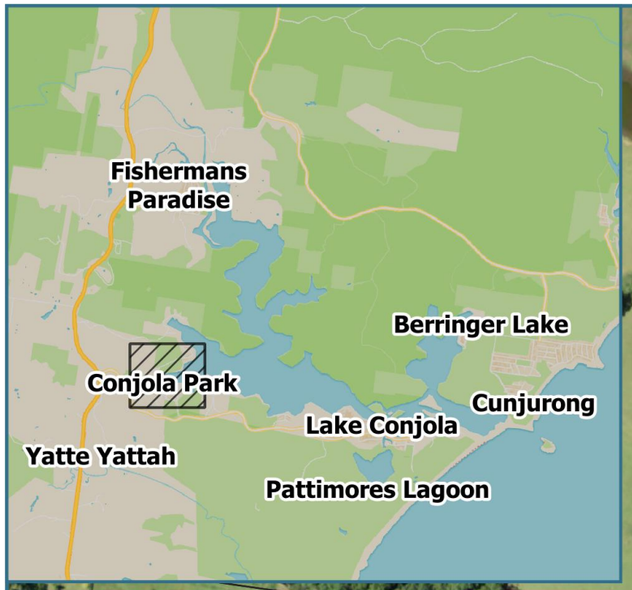

D: Conjola Park

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Lake Conjola Coastal Management Program

Figure D-10
Tidal Inundation
SLR 0.9 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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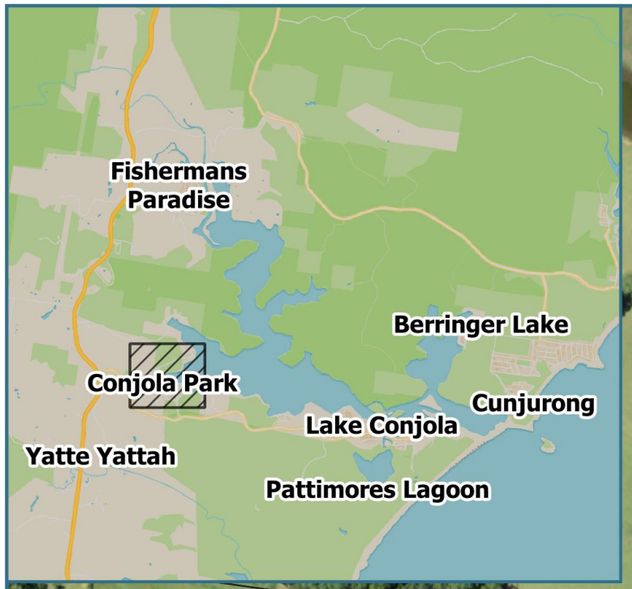

D: Conjola Park

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Lake Conjola Coastal Management Program

Figure D-11
Tidal Inundation
SLR 0.9 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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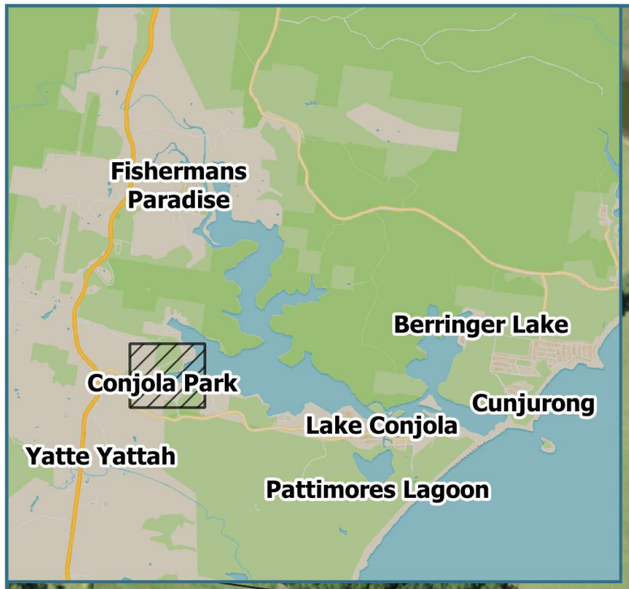

D: Conjola Park

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Lake Conjola Coastal Management Program

Figure D-12
Tidal Inundation
SLR 1.2 m
Bed Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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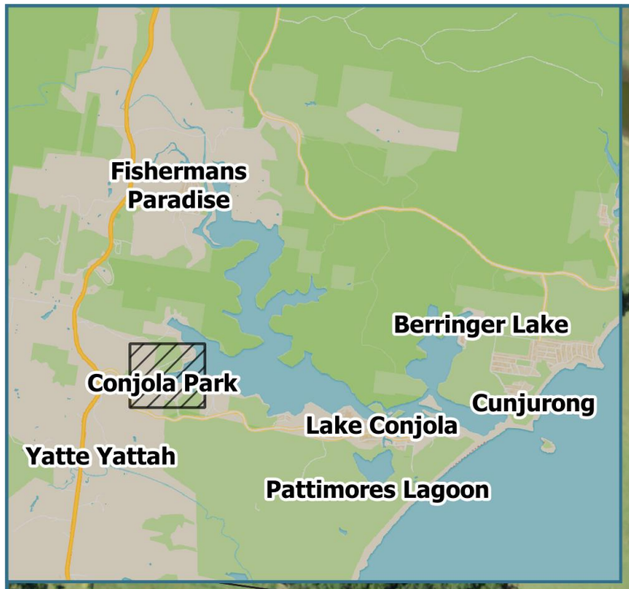

D: Conjola Park

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Lake Conjola Coastal Management Program

Figure D-13
Tidal Inundation
SLR 1.2 m
Bed Not Raised
Tidal Plane: HHWSS

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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Appendix C - Tidal Inundation Duration % Static Maps - all SLR ranges



Lake Conjola Coastal Management Program

Figure A-1 of 13
Inundation Duration (%)
SLR 0 m
Bed Not Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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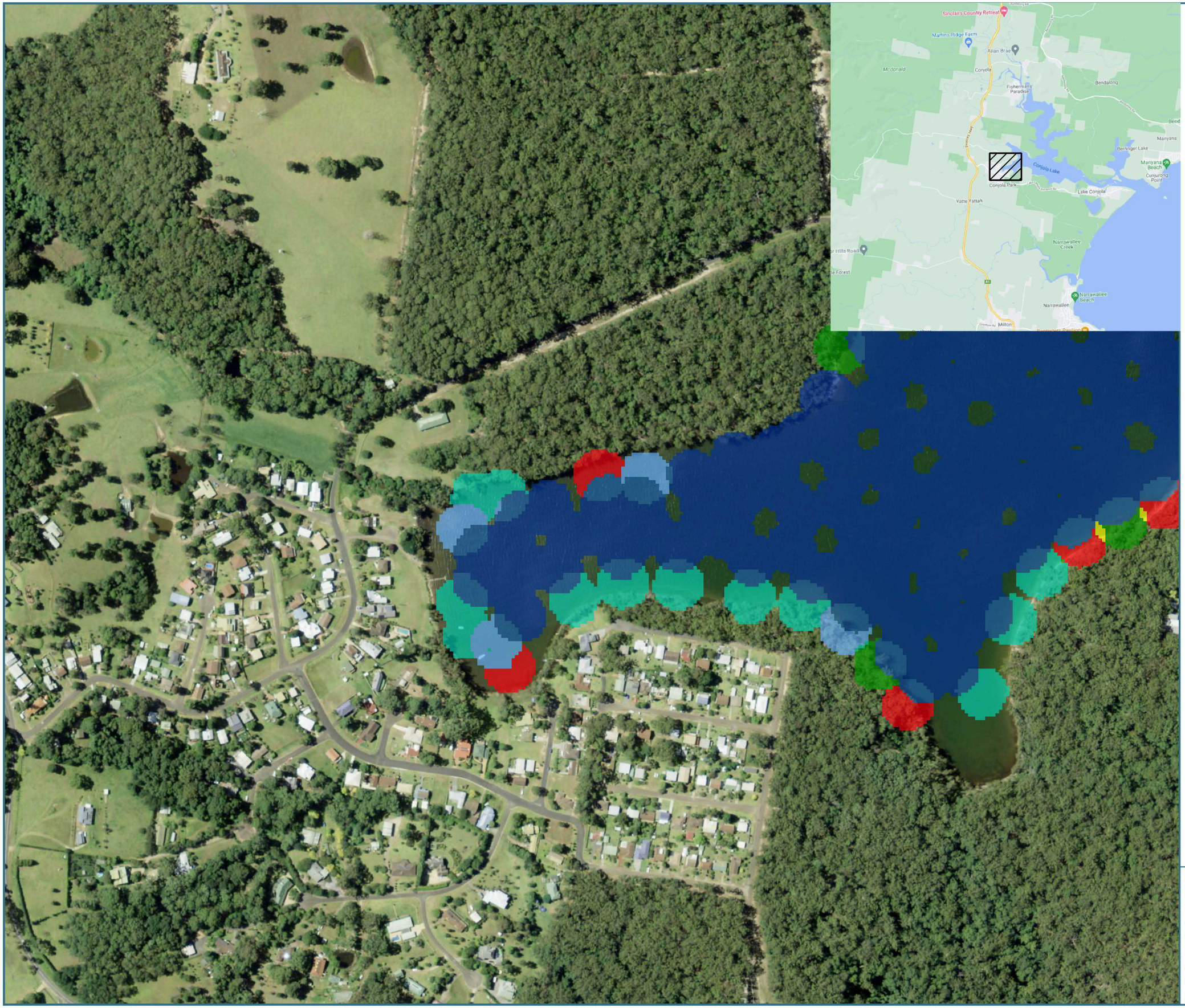

Lake Conjola Coastal Management Program

Figure A-2 of 13
Inundation Duration (%)
SLR 0.1 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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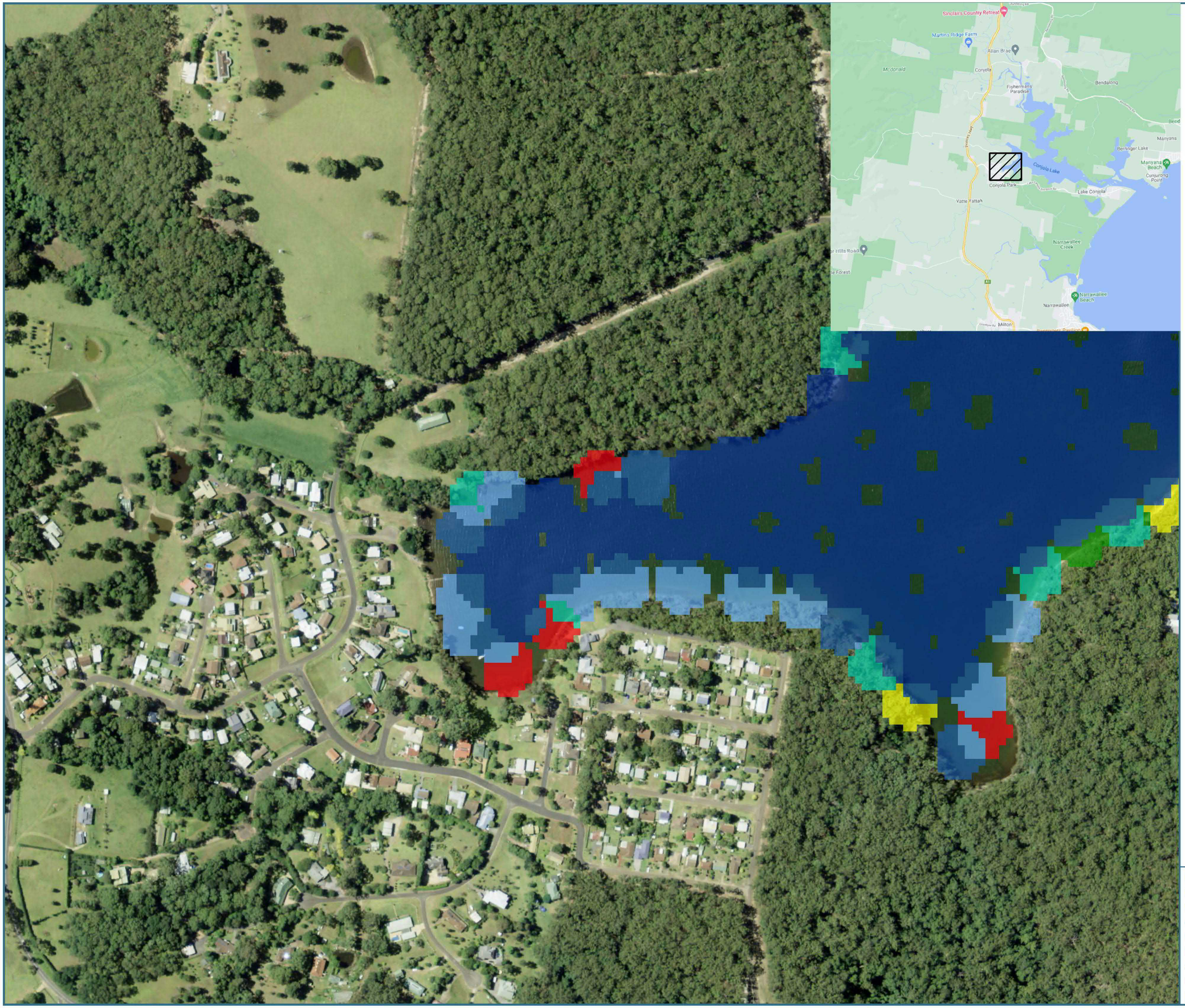

Lake Conjola Coastal Management Program

Figure A-5 of 13
Inundation Duration (%)
SLR 0.23 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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Lake Conjola Coastal Management Program

Figure A-7 of 13
Inundation Duration (%)
SLR 0.36 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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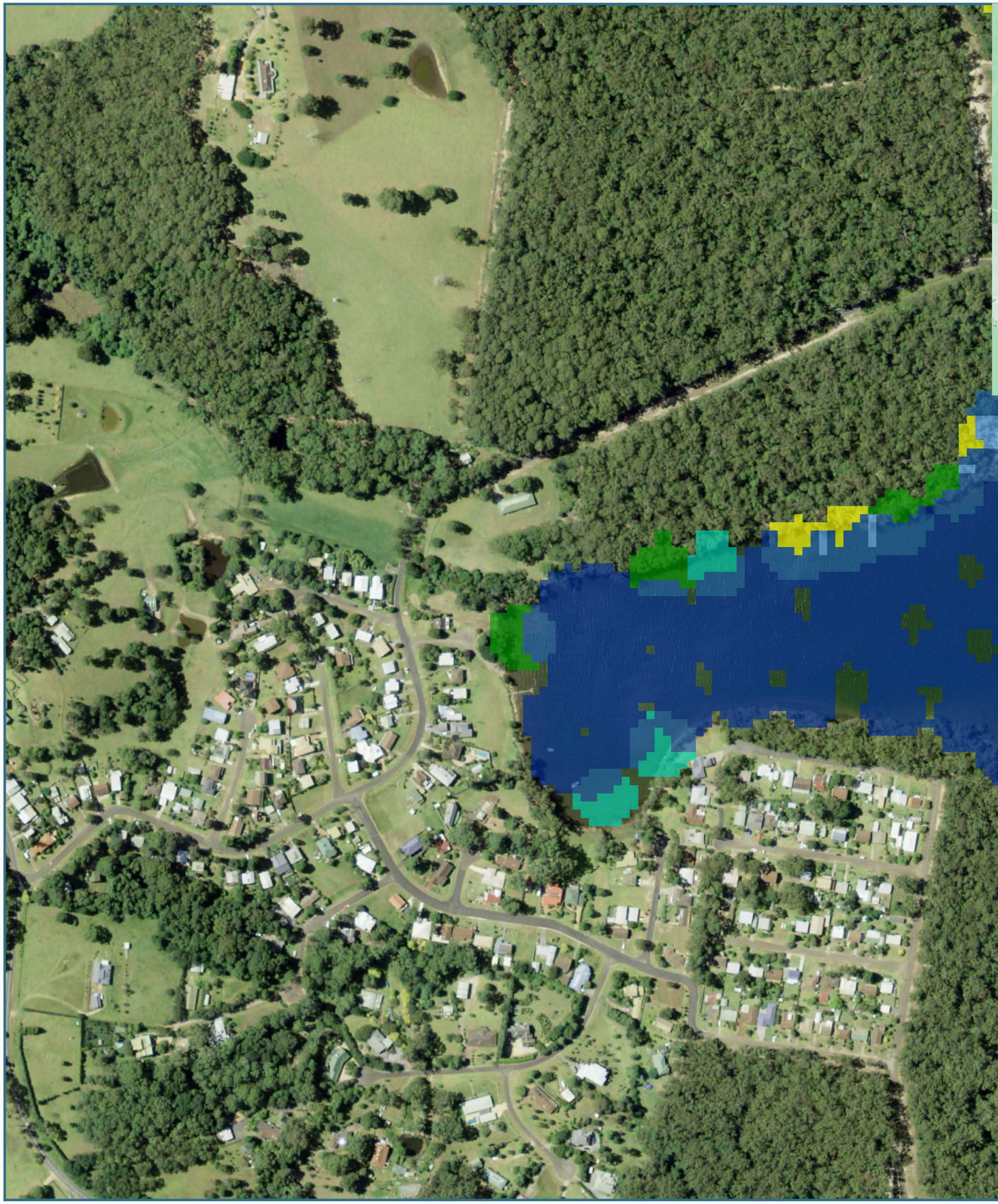

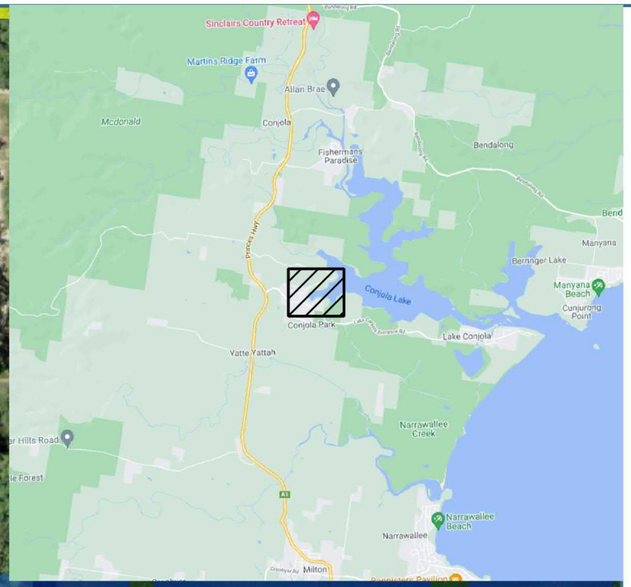

Lake Conjola Coastal Management Program

Figure A-9 of 13
Inundation Duration (%)
SLR 0.6 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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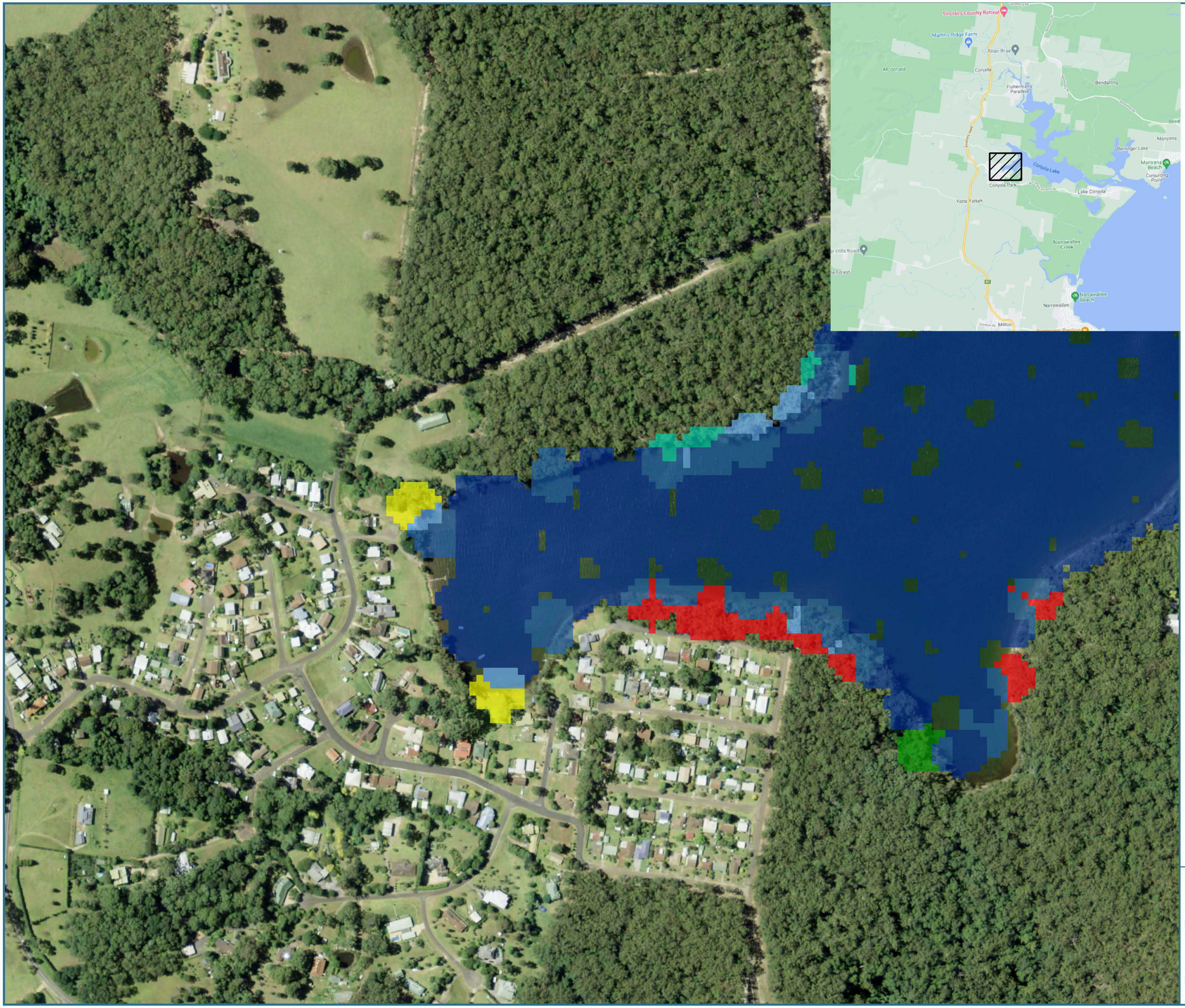

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Lake Conjola Coastal Management Program

Figure A-11 of 13
Inundation Duration (%)
SLR 0.9 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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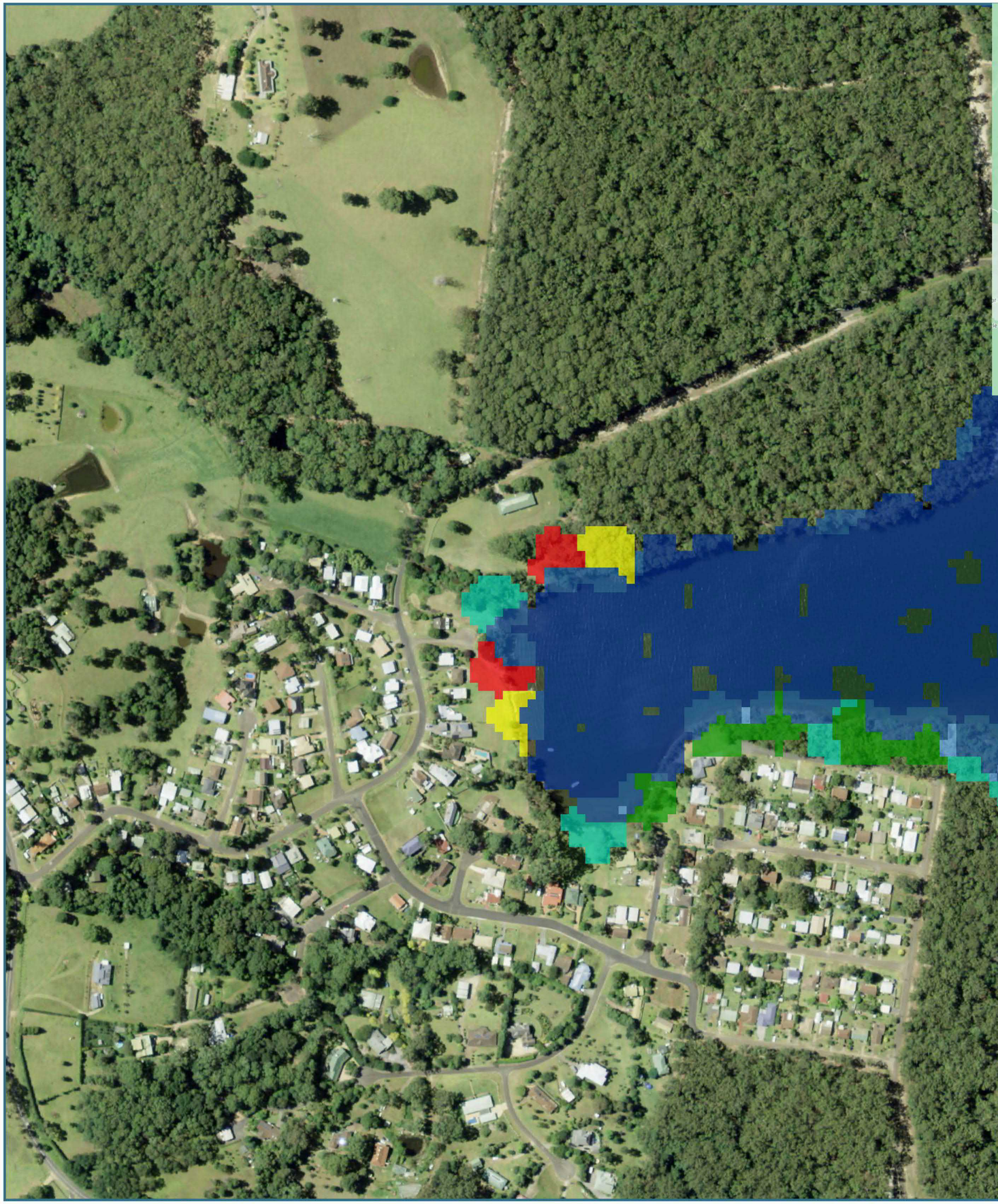

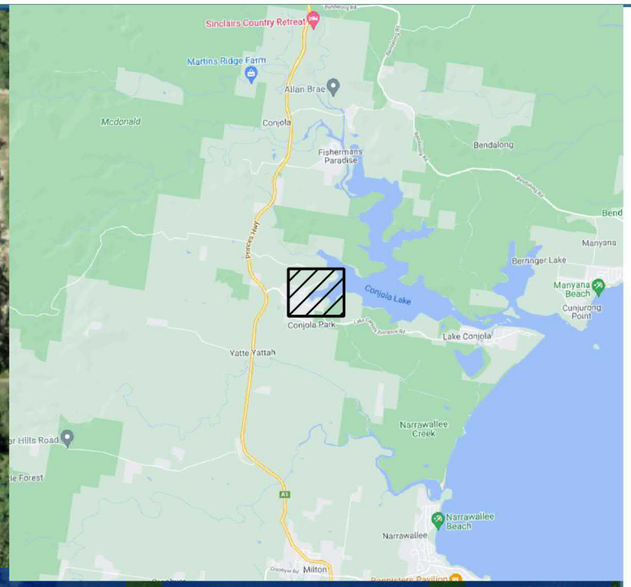

Lake Conjola Coastal Management Program

Figure A-13 of 13
Inundation Duration (%)
SLR 1.2 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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Lake Conjola Coastal Management Program

Figure B-1 of 13
Inundation Duration (%)
SLR 0 m
Bed Not Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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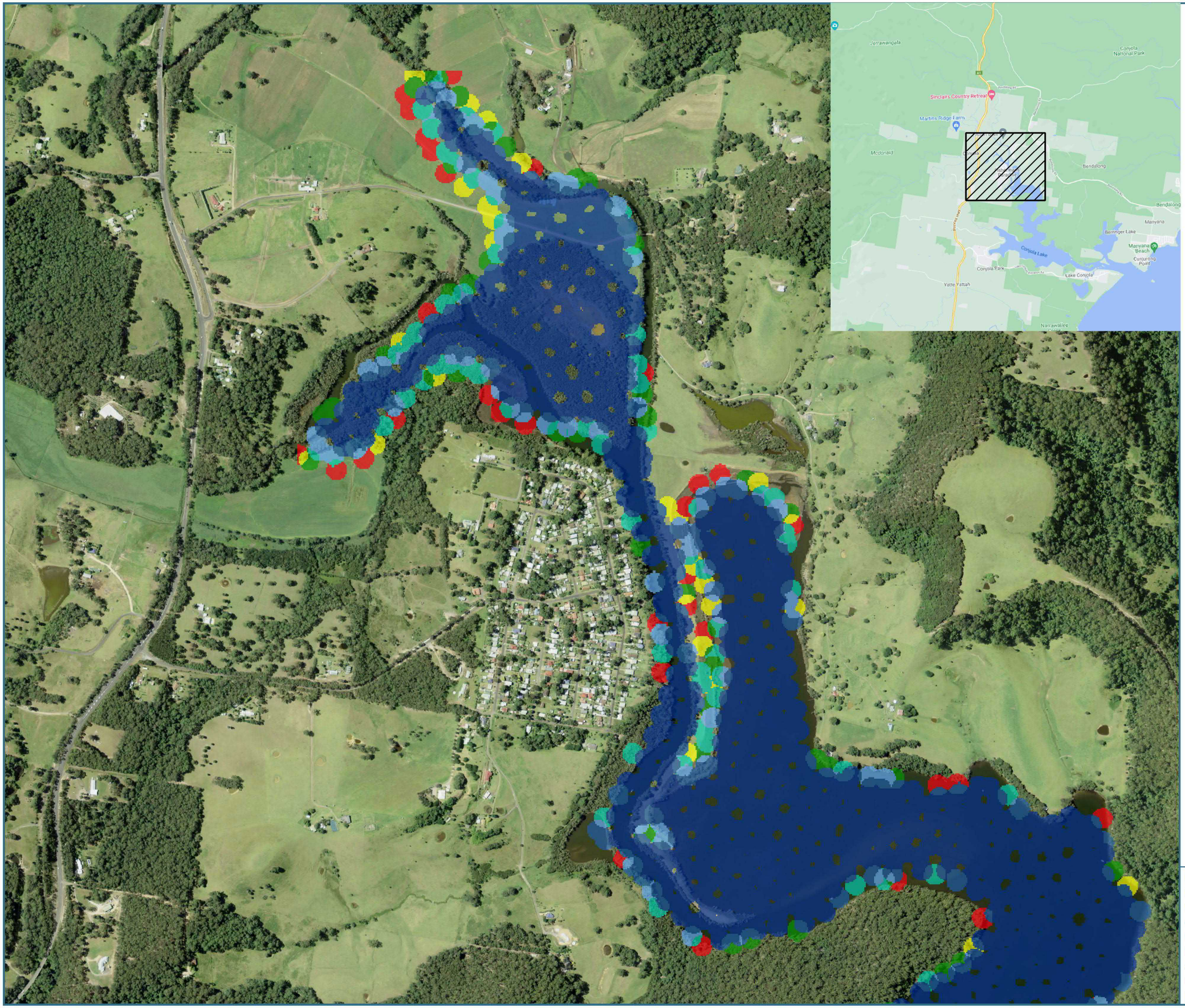

Lake Conjola Coastal Management Program

Figure B-2 of 13
Inundation Duration (%)
SLR 0.1 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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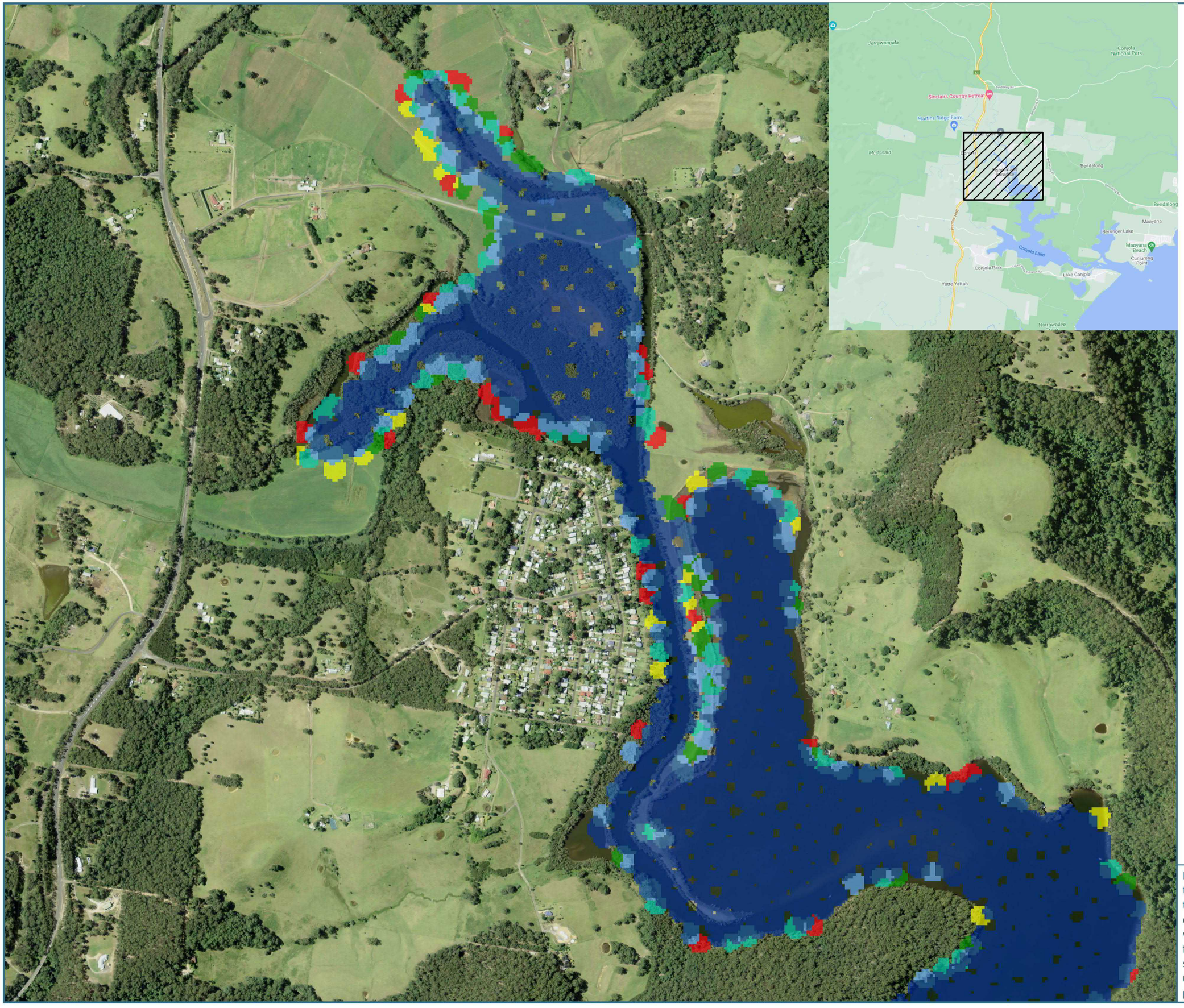

Lake Conjola Coastal Management Program

Figure B-5 of 13
Inundation Duration (%)
SLR 0.23 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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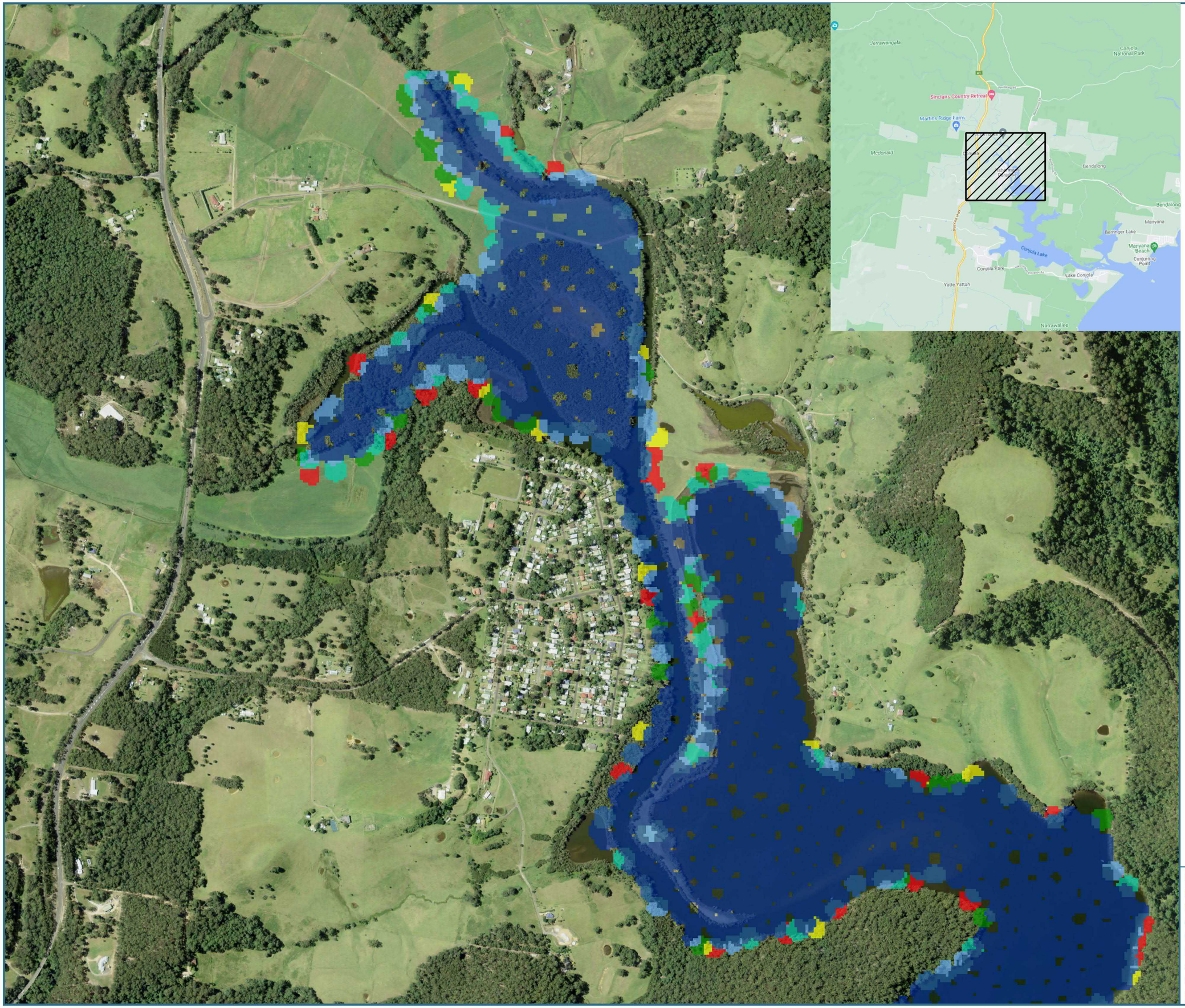

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Lake Conjola Coastal Management Program

Figure B-7 of 13
Inundation Duration (%)
SLR 0.36 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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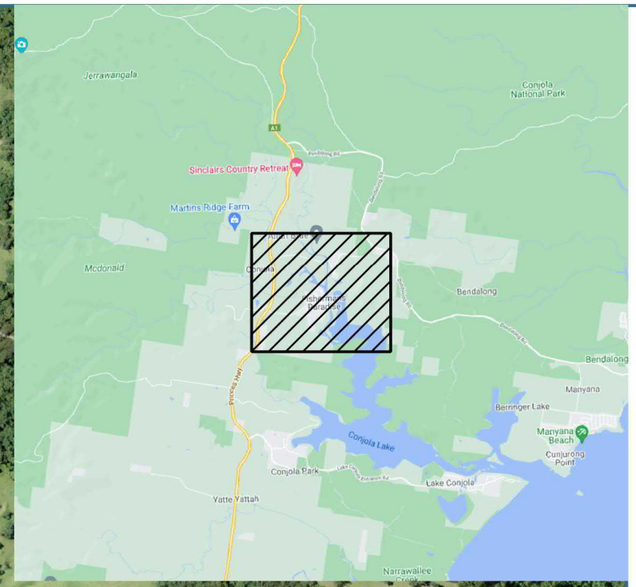

Royal HaskoningDHV
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Lake Conjola Coastal Management Program

Figure B-9 of 13
Inundation Duration (%)
SLR 0.6 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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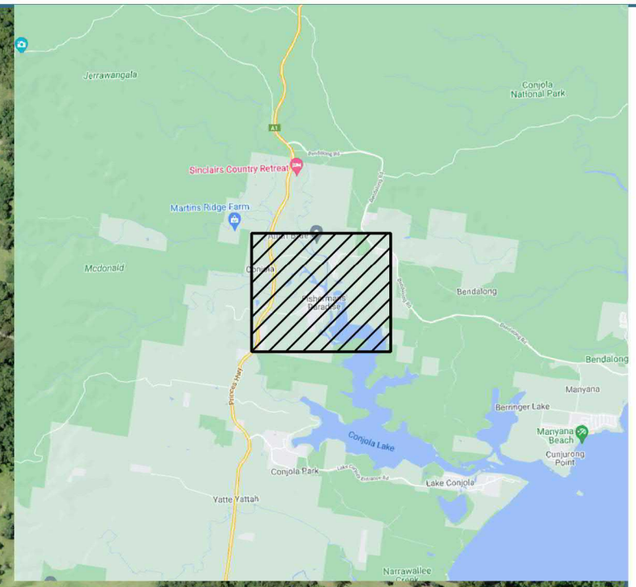

Lake Conjola Coastal Management Program

Figure B-11 of 13
Inundation Duration (%)
SLR 0.9 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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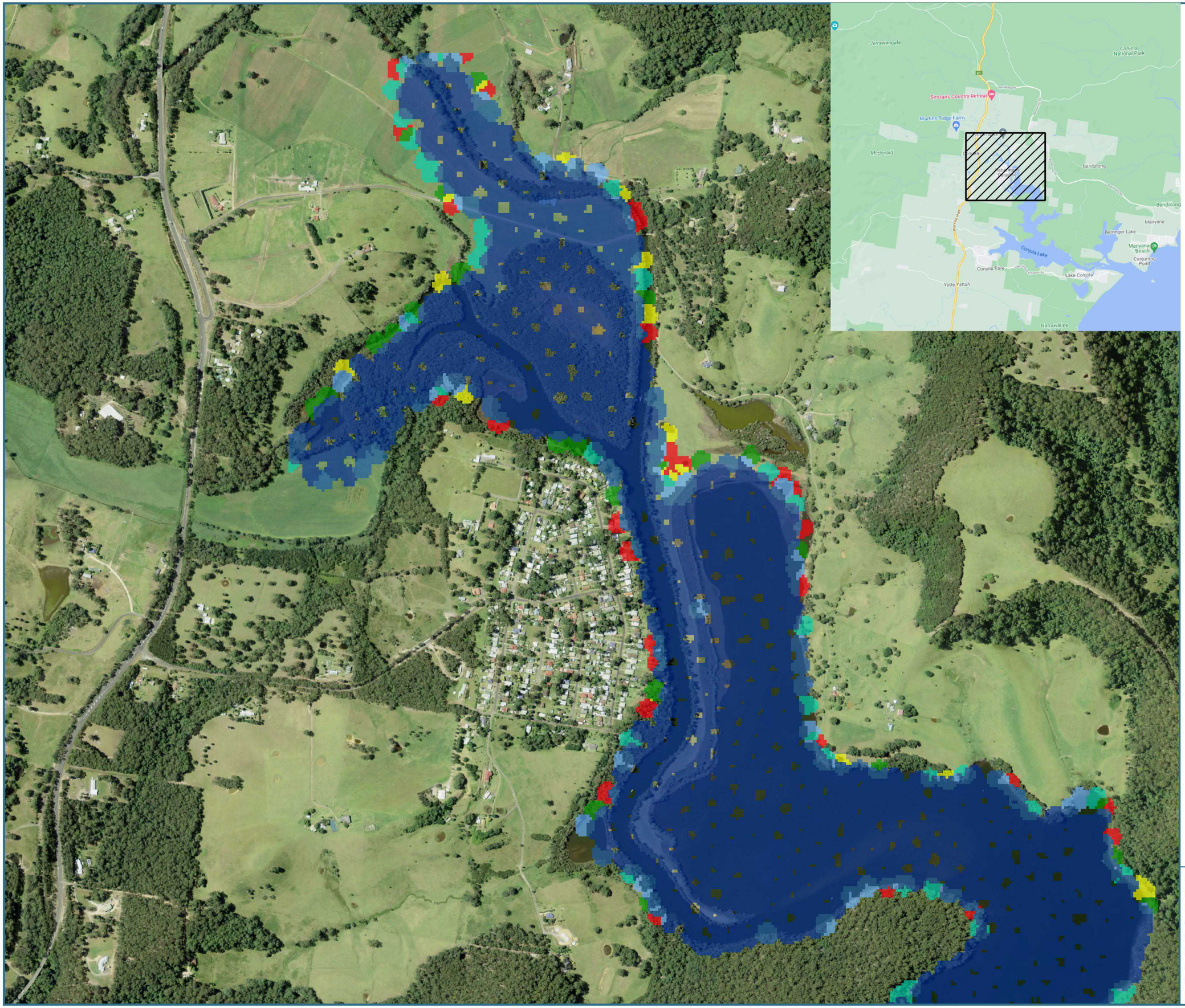

Lake Conjola Coastal Management Program

Figure B-13 of 13
Inundation Duration (%)
SLR 1.2 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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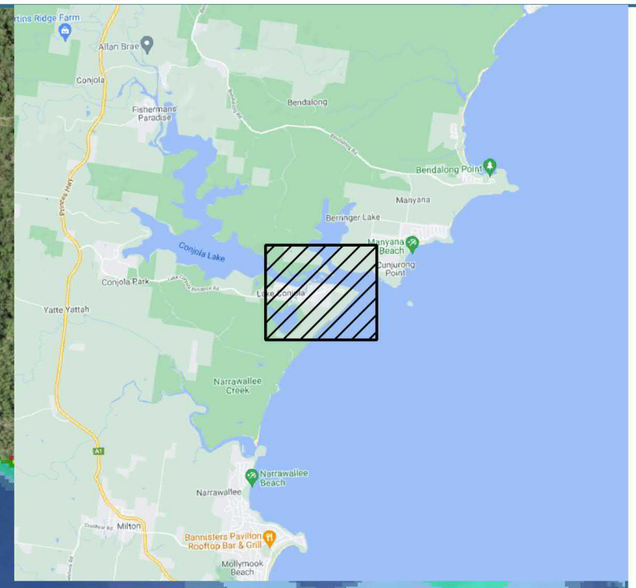

Lake Conjola Coastal Management Program

Figure C-1 of 13
Inundation Duration (%)
SLR 0 m
Bed Not Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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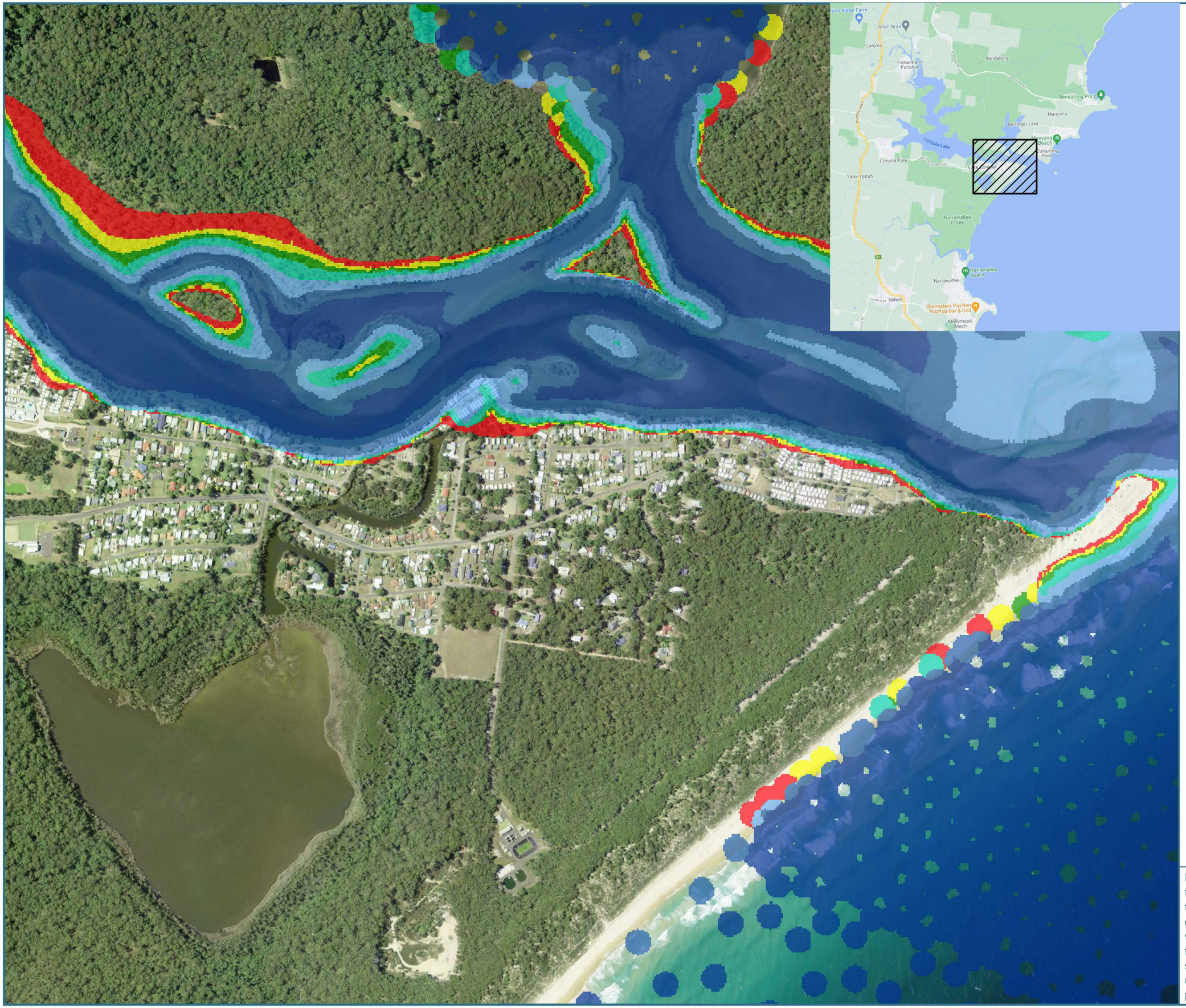

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Lake Conjola Coastal Management Program

Figure C-2 of 13
Inundation Duration (%)
SLR 0.1 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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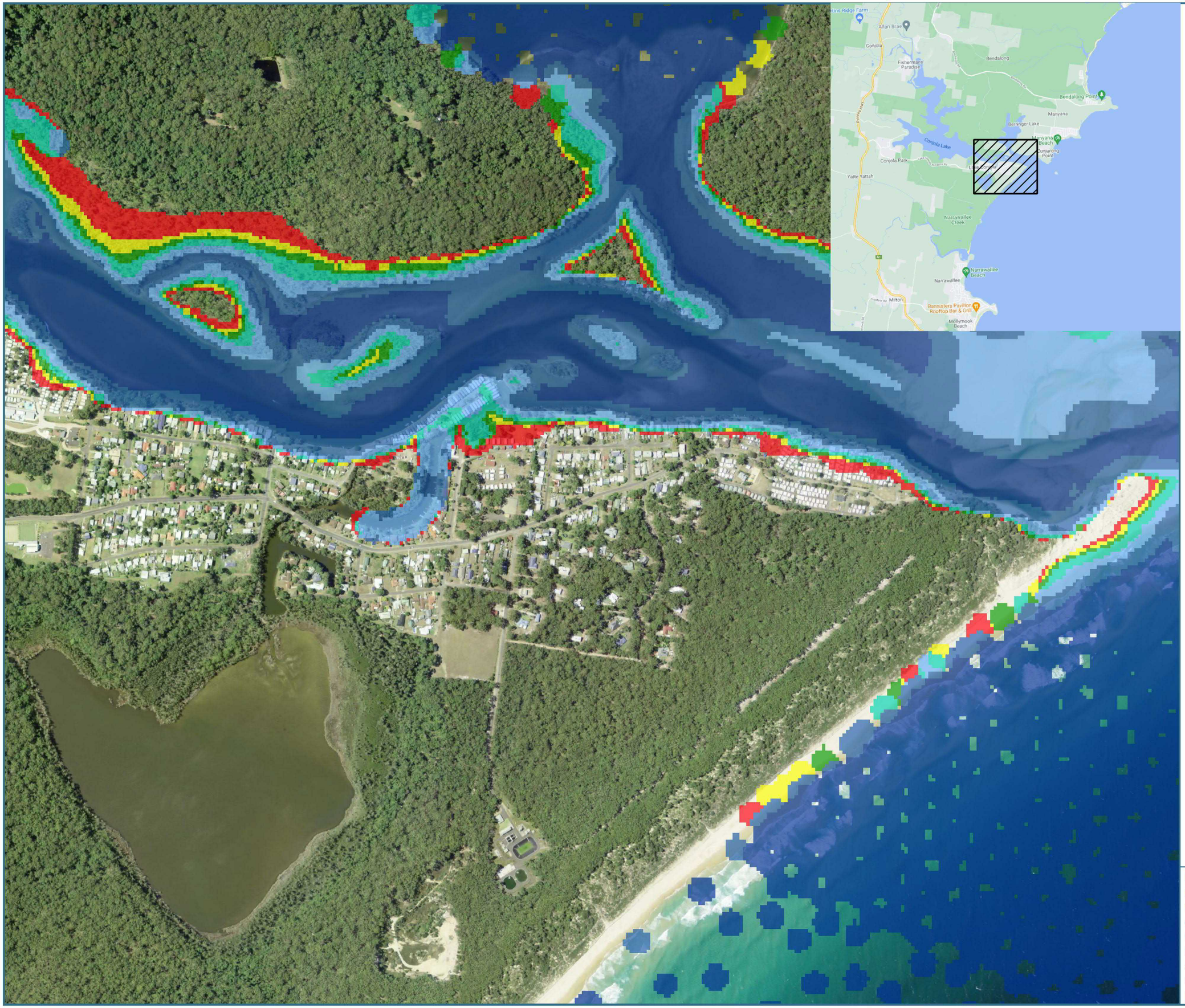

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Lake Conjola Coastal Management Program

Figure C-5 of 13
Inundation Duration (%)
SLR 0.23 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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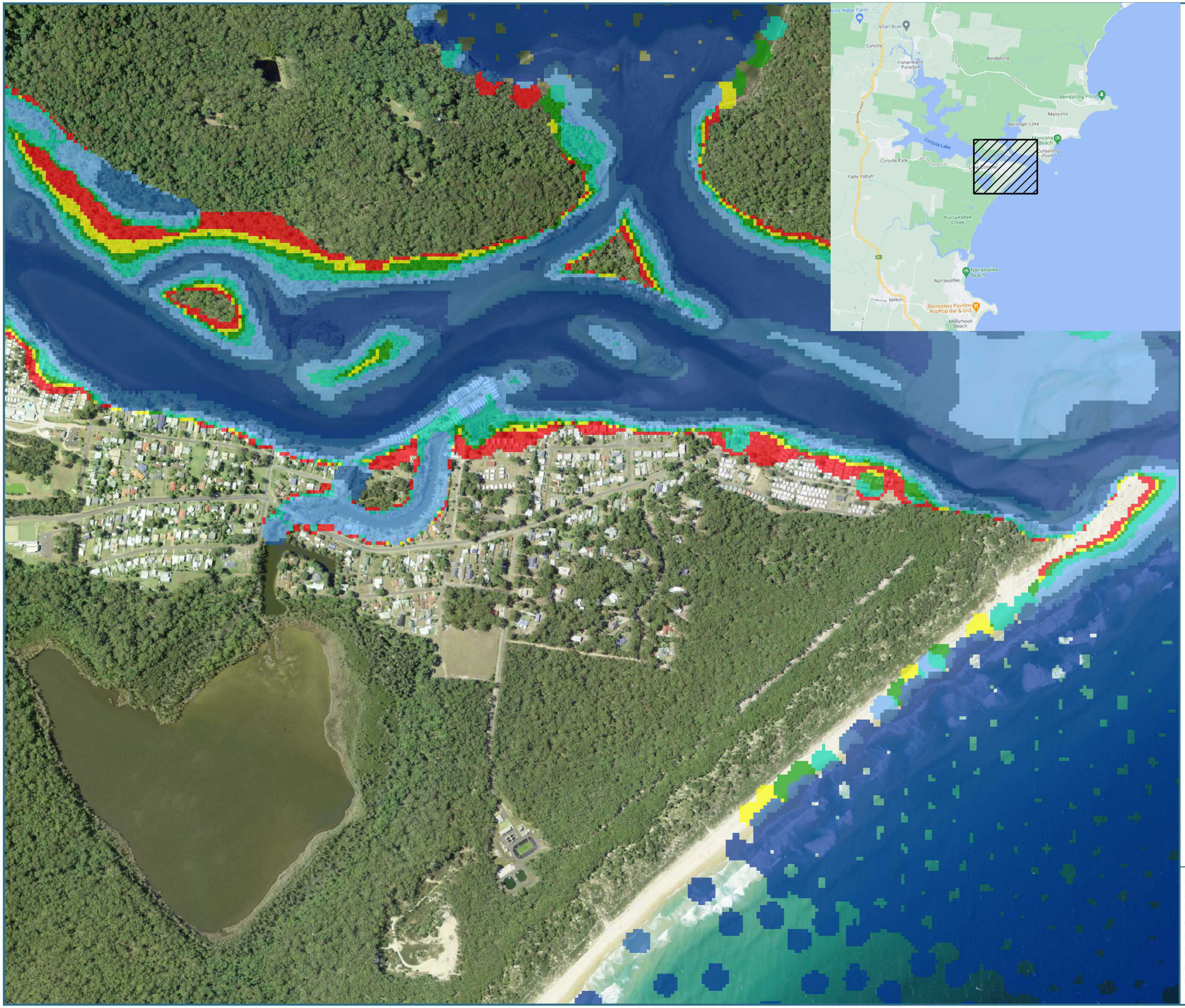

Lake Conjola Coastal Management Program

Figure C-7 of 13
Inundation Duration (%)
SLR 0.36 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

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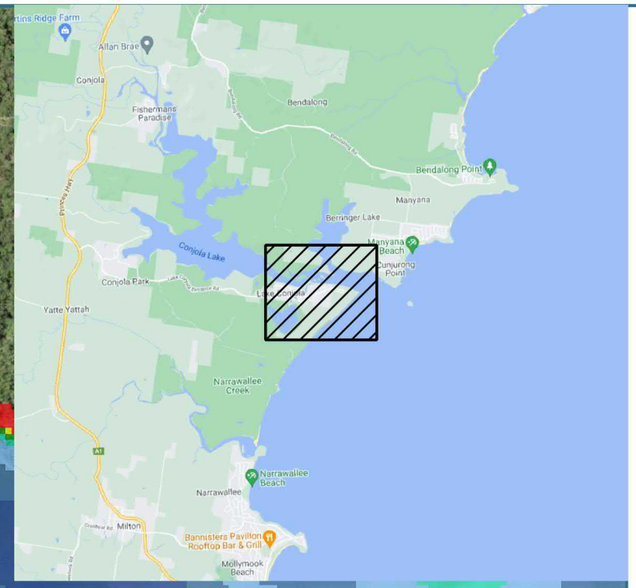

Lake Conjola Coastal Management Program

Figure C-9 of 13
Inundation Duration (%)
SLR 0.6 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

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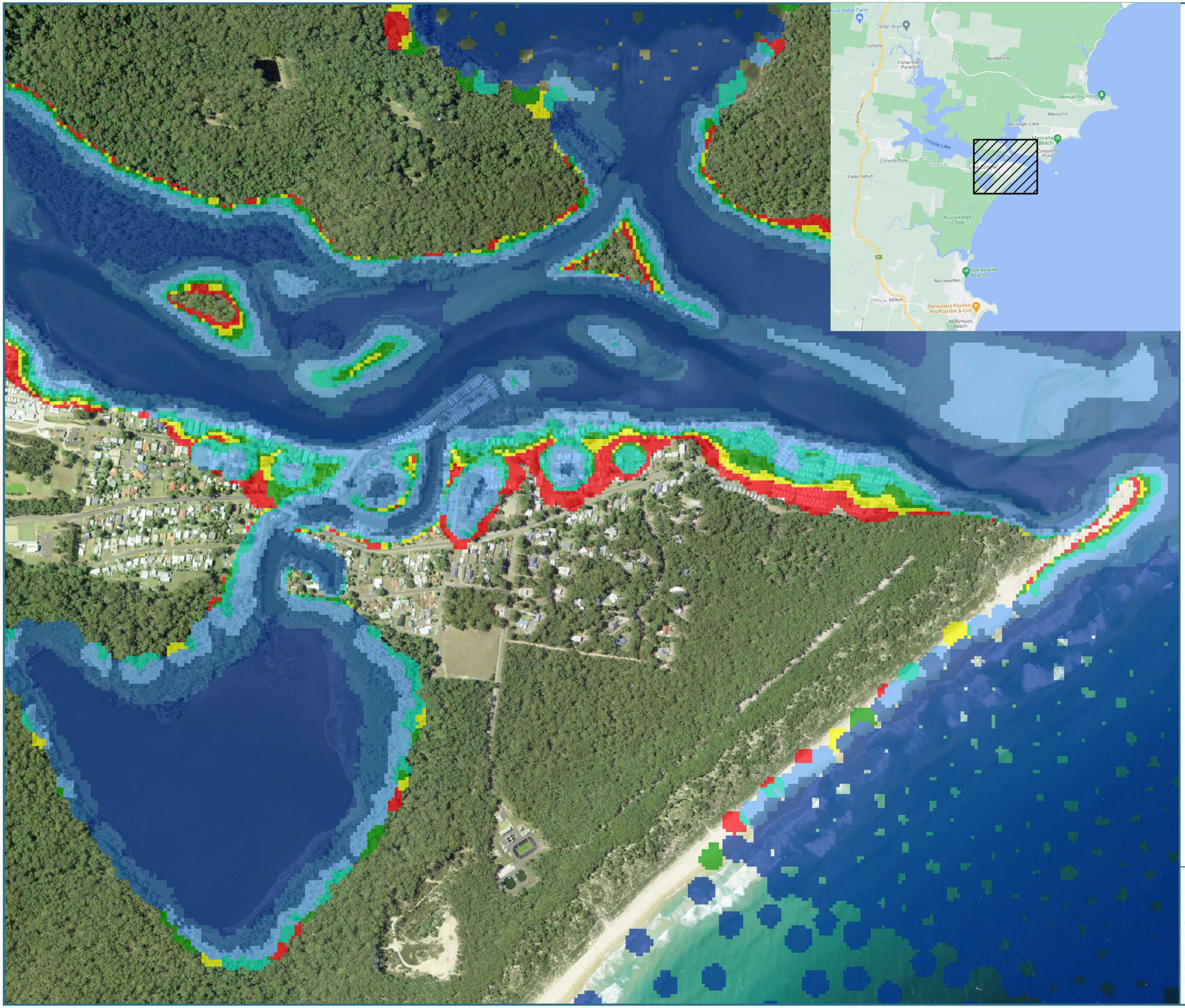

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Lake Conjola Coastal Management Program

Figure C-11 of 13
Inundation Duration (%)
SLR 0.9 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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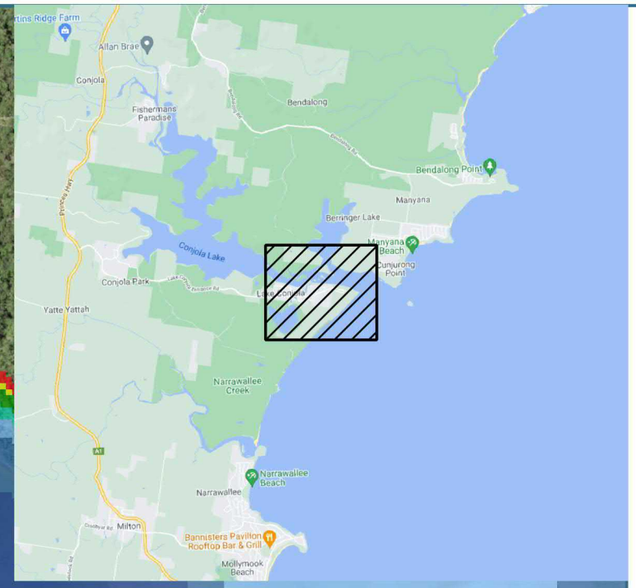

Lake Conjola Coastal Management Program

Figure C-13 of 13
Inundation Duration (%)
SLR 1.2 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

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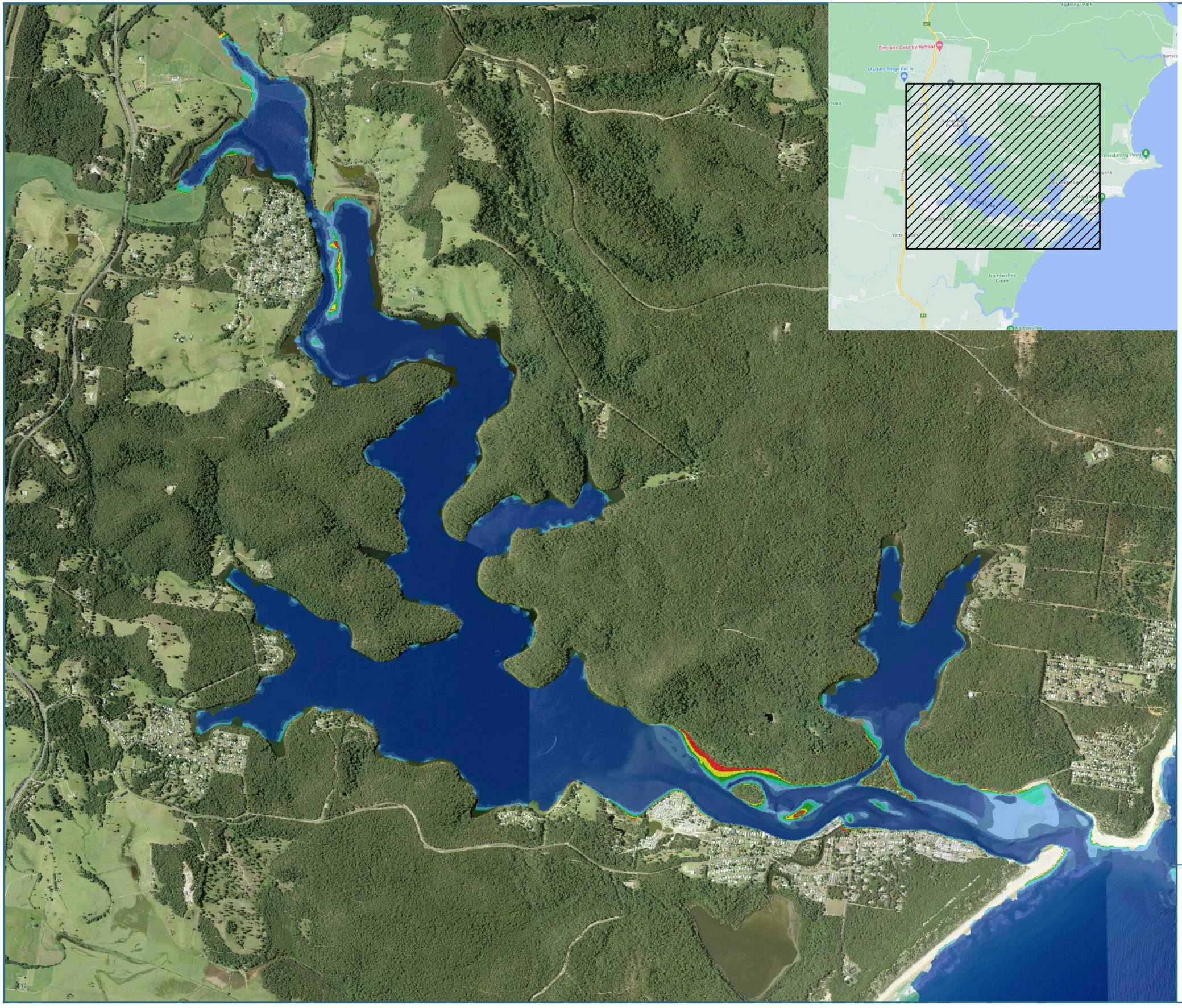

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Lake Conjola Coastal Management Program

Figure D-1 of 13
Inundation Duration (%)
SLR 0 m
Bed Not Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

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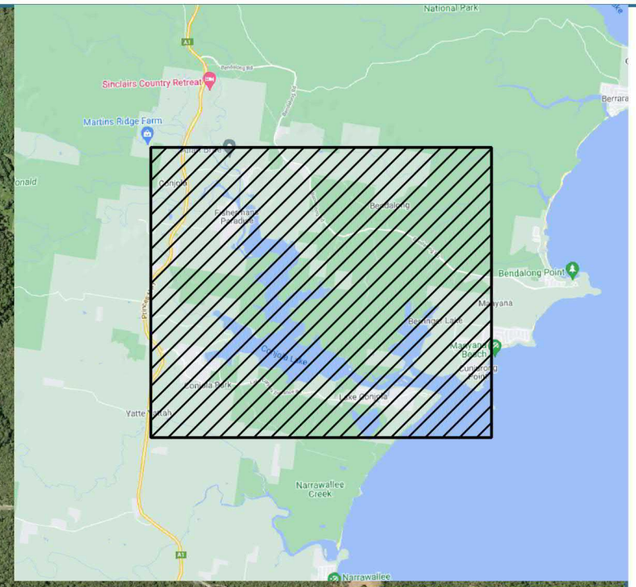

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Lake Conjola Coastal Management Program

Figure D-2 of 13
Inundation Duration (%)
SLR 0.1 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

Shoalhaven City Council

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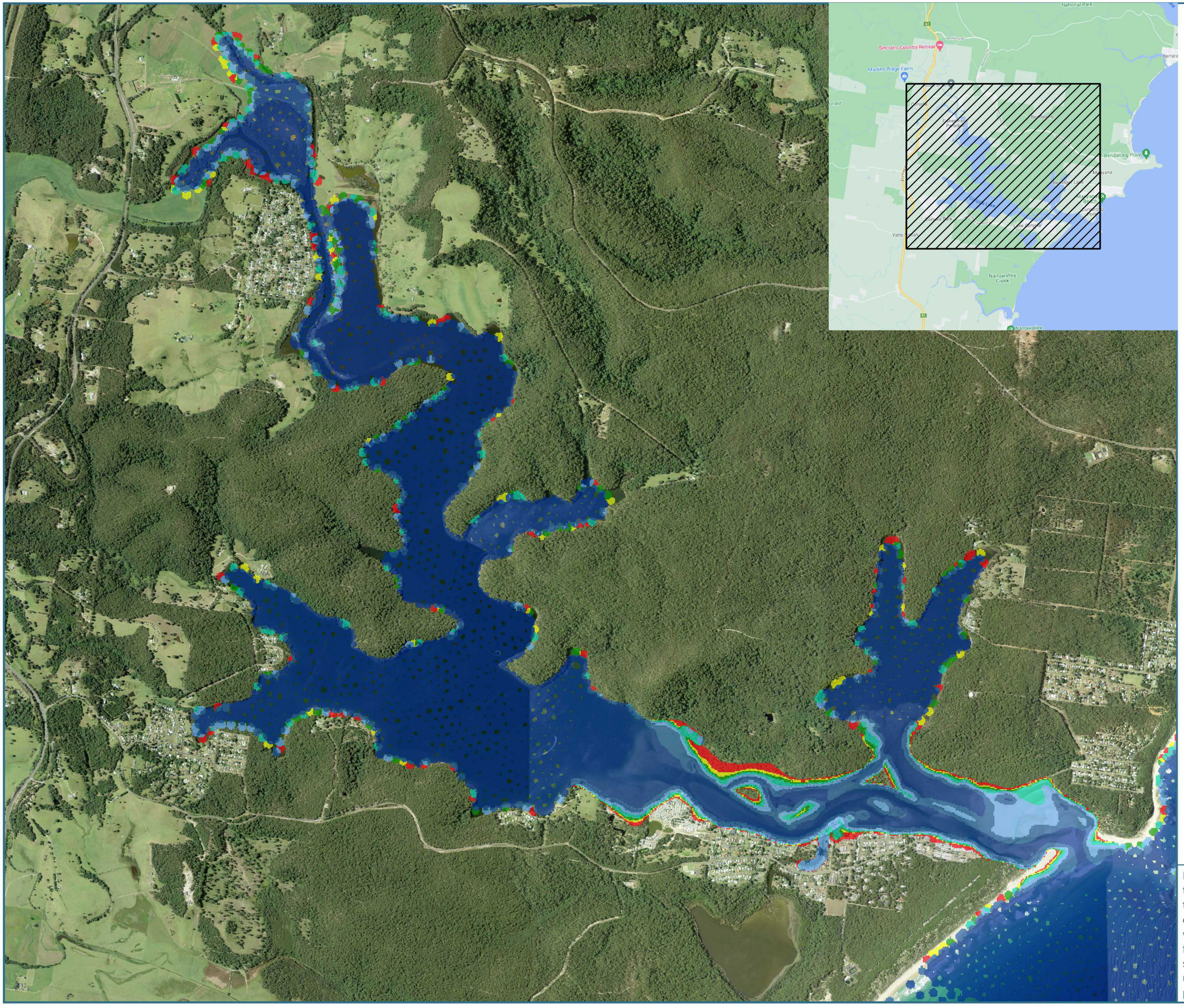

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Lake Conjola Coastal Management Program

Figure D-5 of 13
Inundation Duration (%)
SLR 0.23 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

Shoalhaven City Council

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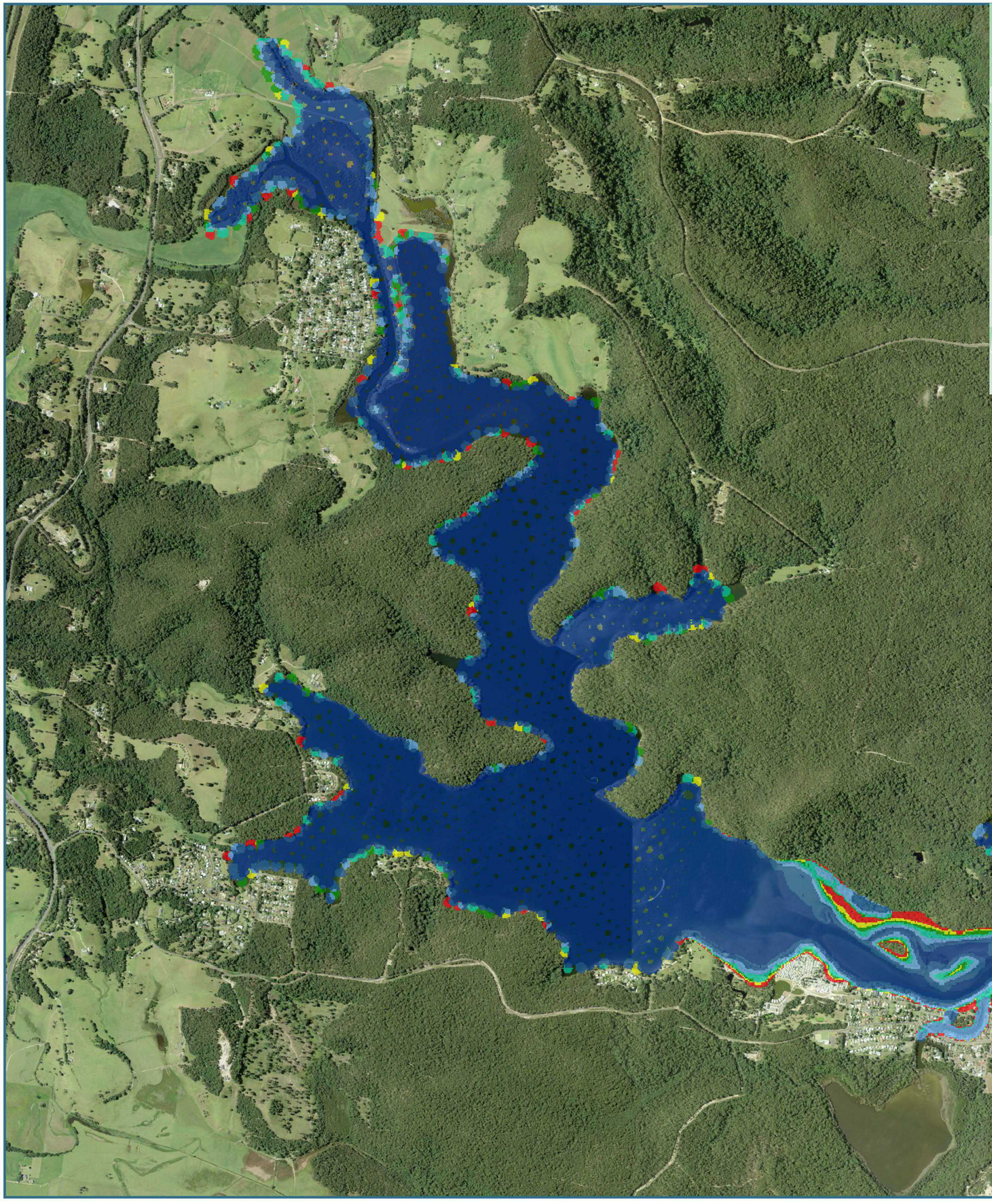

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Lake Conjola Coastal Management Program

Figure D-7 of 13
Inundation Duration (%)
SLR 0.36 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

Shoalhaven City Council

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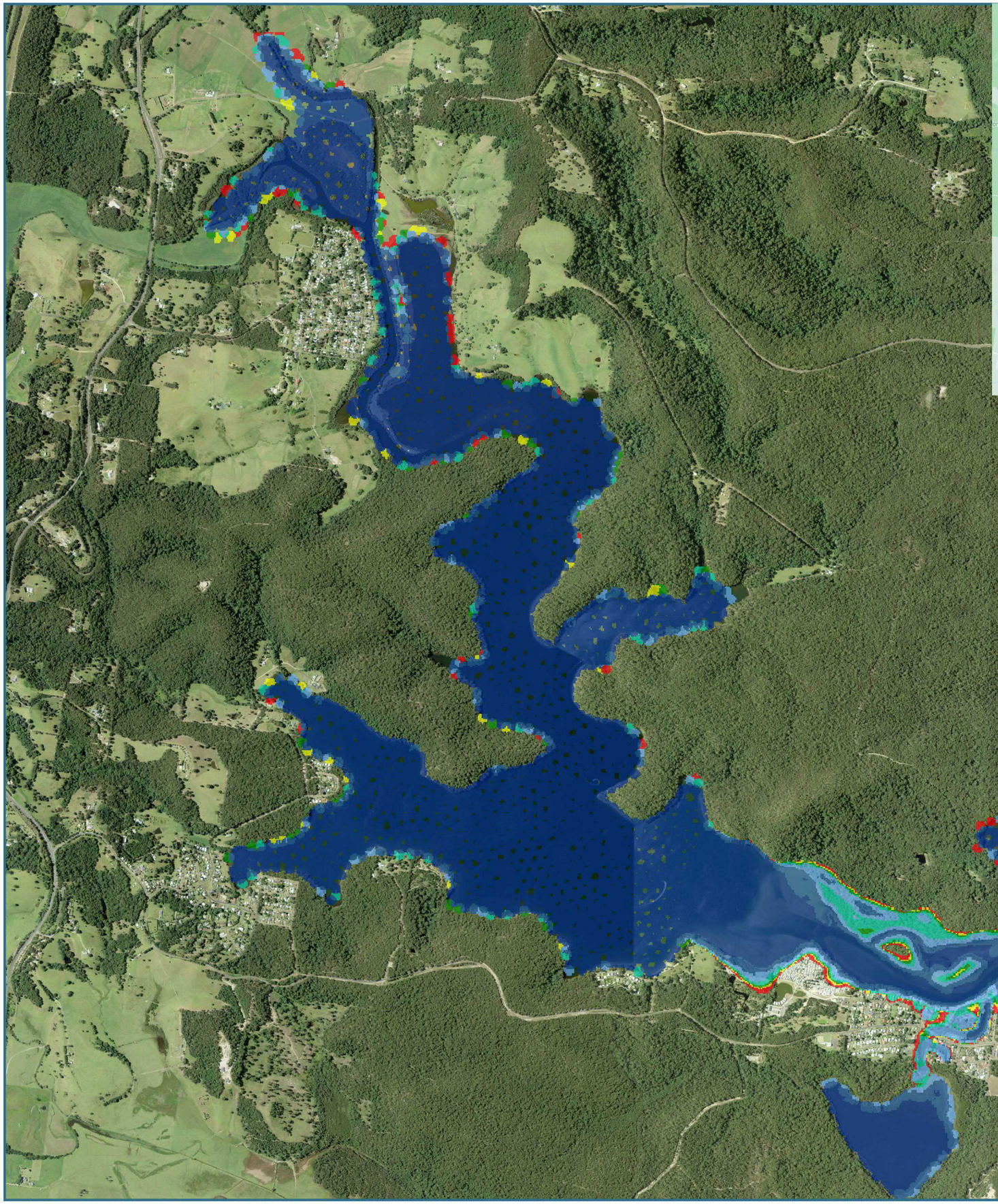

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Lake Conjola Coastal Management Program

Figure D-9 of 13
Inundation Duration (%)
SLR 0.6 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

Shoalhaven City Council

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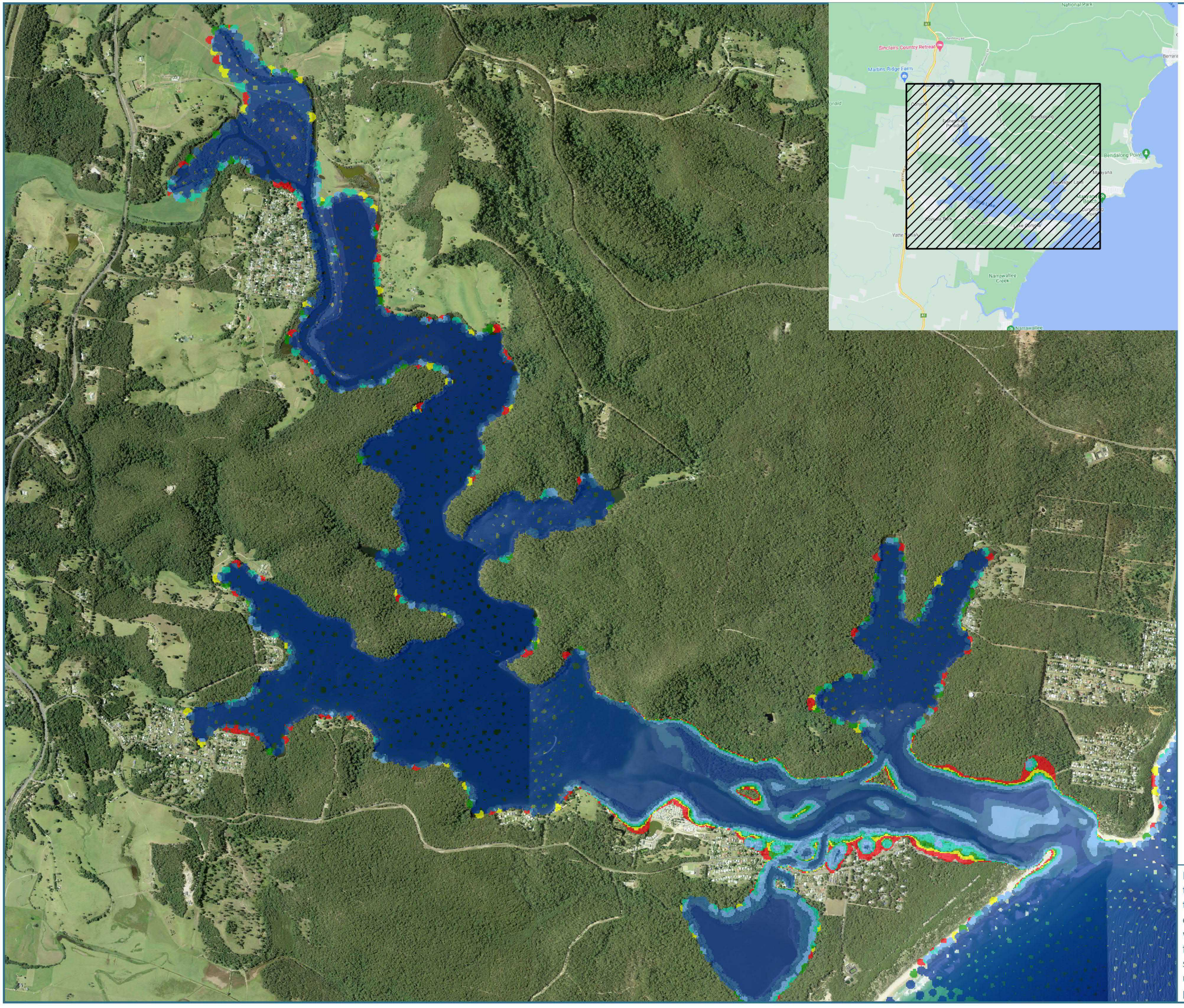

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Lake Conjola Coastal Management Program

Figure D-11 of 13
Inundation Duration (%)
SLR 0.9 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

Shoalhaven City Council

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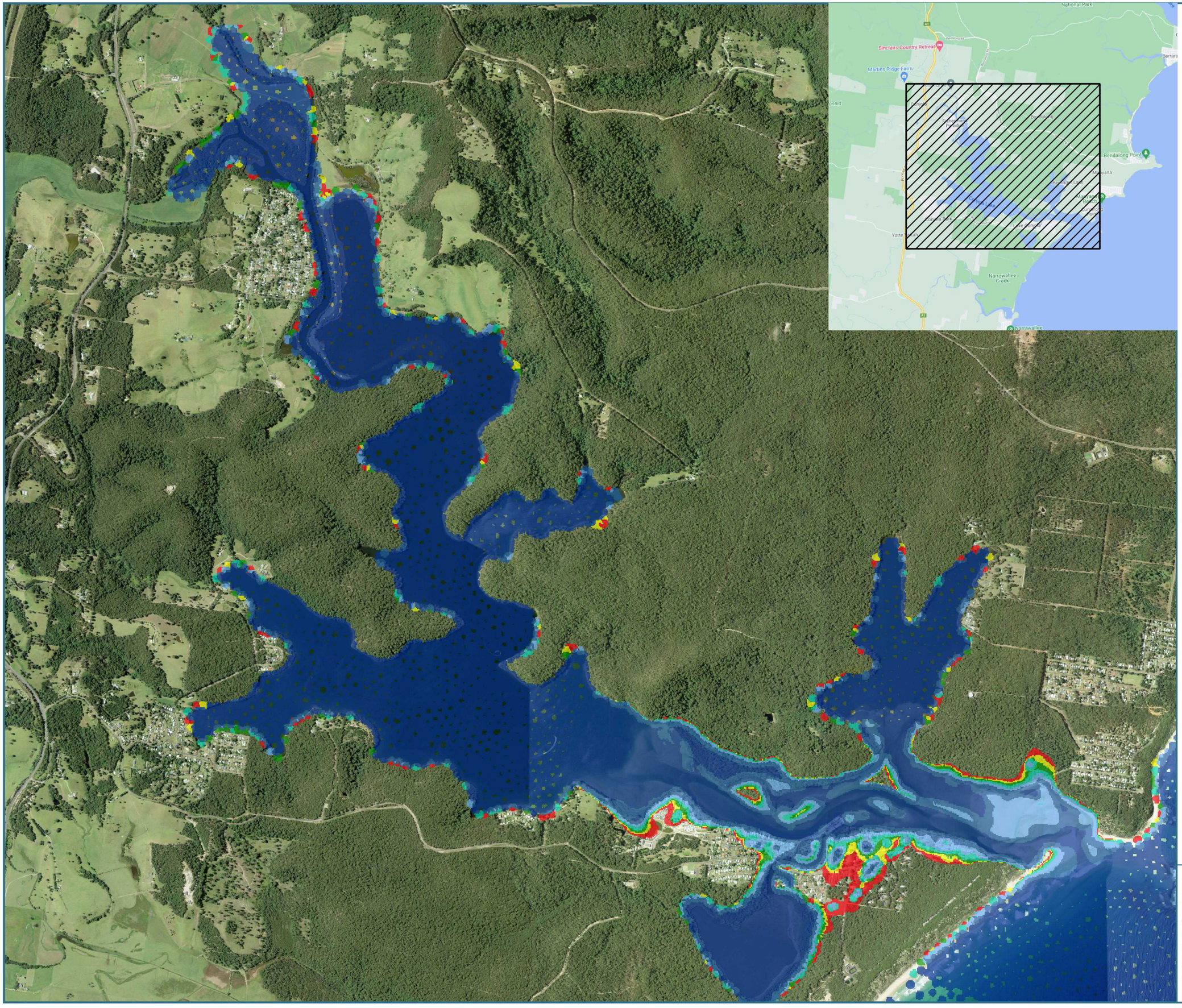

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Lake Conjola Coastal Management Program

Figure D-13 of 13
Inundation Duration (%)
SLR 1.2 m
Bed Raised
6-Week Simulation Period

Legend

% Time Inundated

- <= 1.00
- 1.00 - 2.00
- 2.0 - 5.0
- 5.0 - 20.0
- 20.0 - 50.0
- 50.0 - 90.0
- > 90.0

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2021-10-20
GDA2020 / MGA zone 56
Scale at A4

1:24,500

N

0 400 800 1,200 m

Shoalhaven City Council

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Appendix D - Tidal Inundation Duration and Frequency Data - by Location

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Locations for assessment of Tidal Inundation Depth, Duration and Frequency, with 0.36m and 1.2m Sea Level Rise

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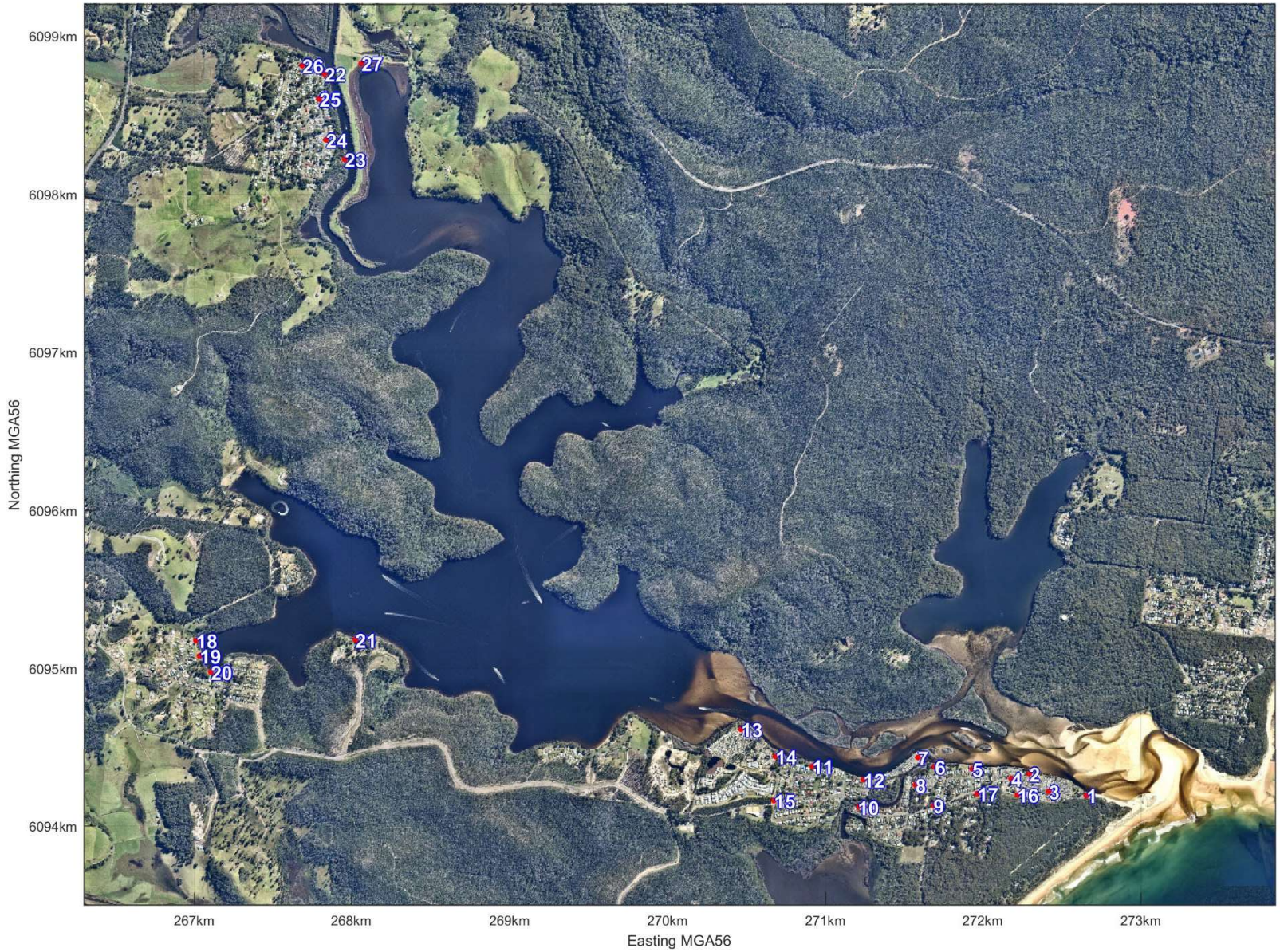
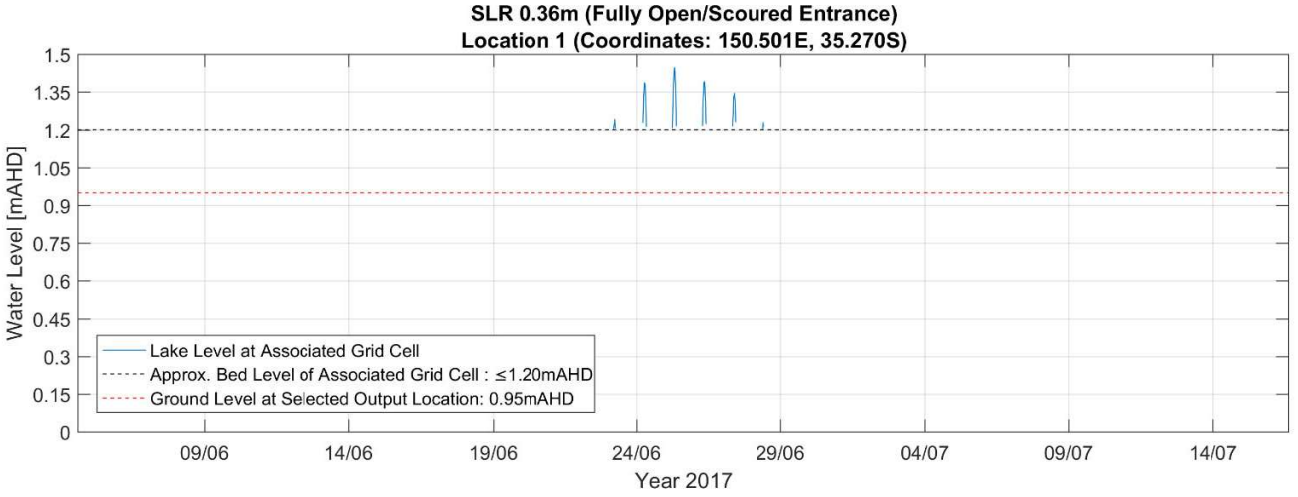


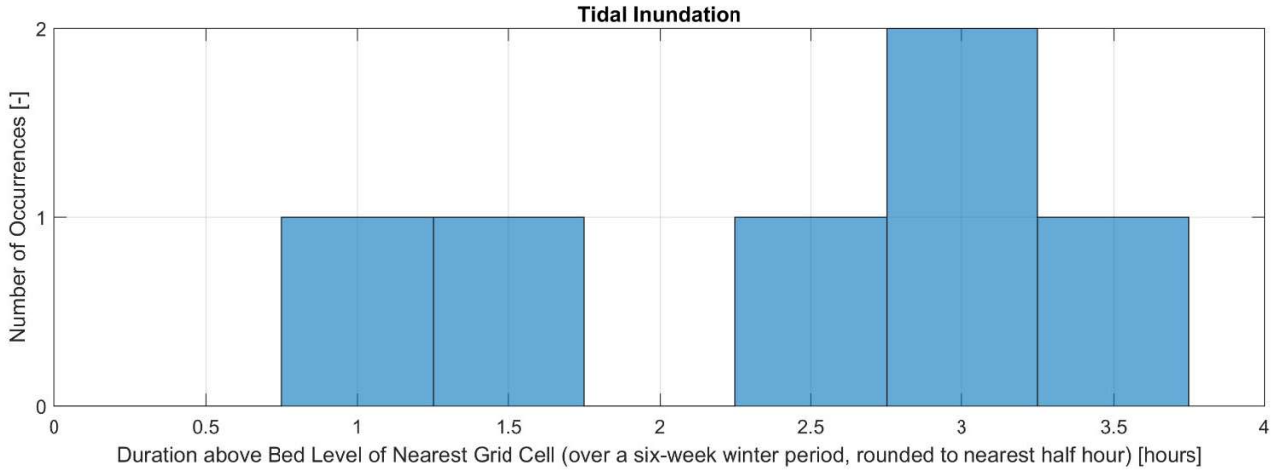

5
4
2
17
16
3
1

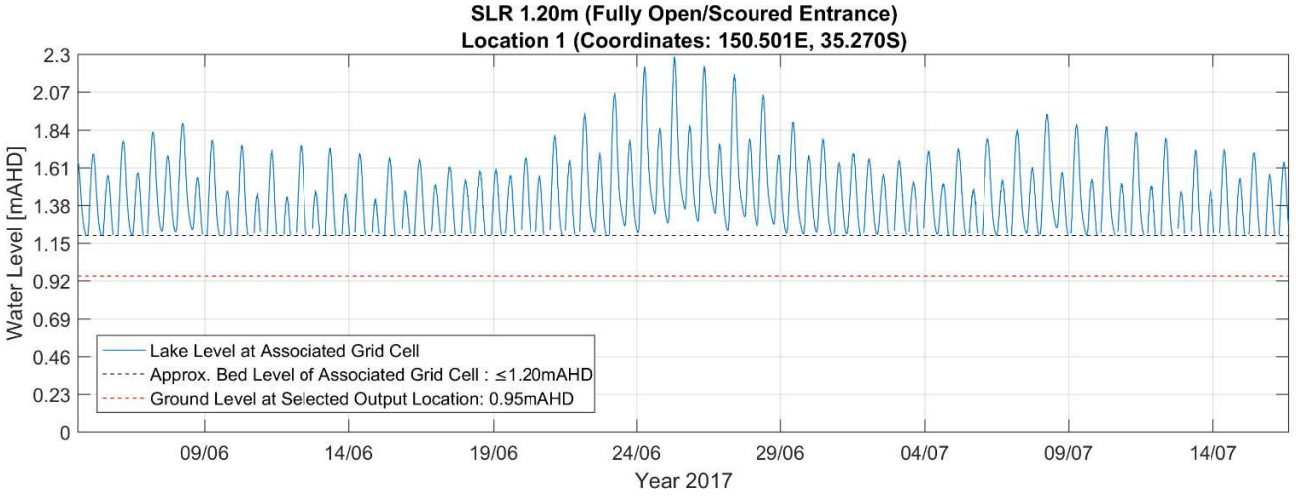
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.0	1
1.5	1
2.5	1
3.0	2
3.5	1

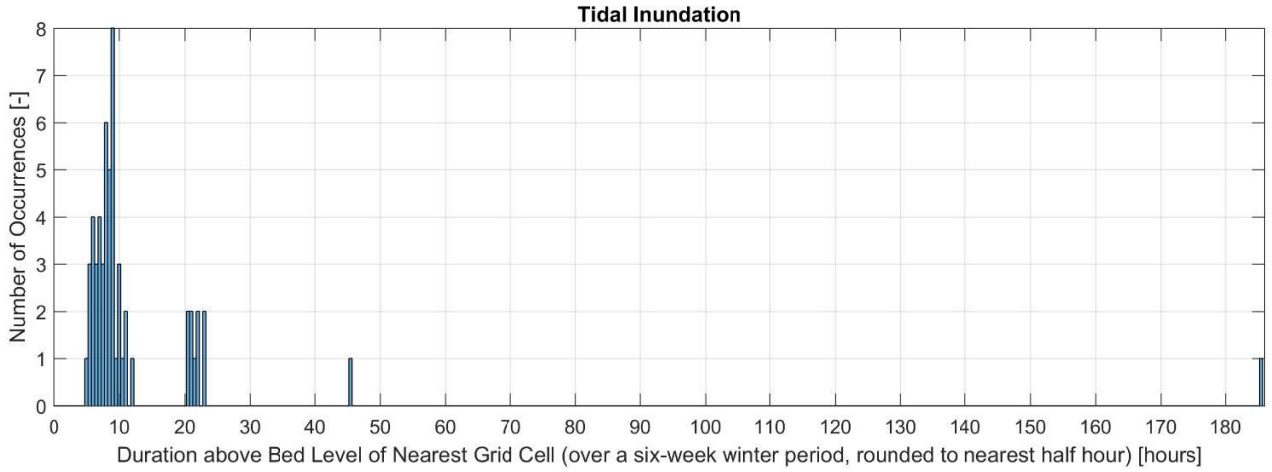
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
6	14.5
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
14.5 hours / 6 occurances	**2.4 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
6 occurrence x 52 weeks (calendar) / 6 weeks (modelled)	**52 Occurrences per calendar year**

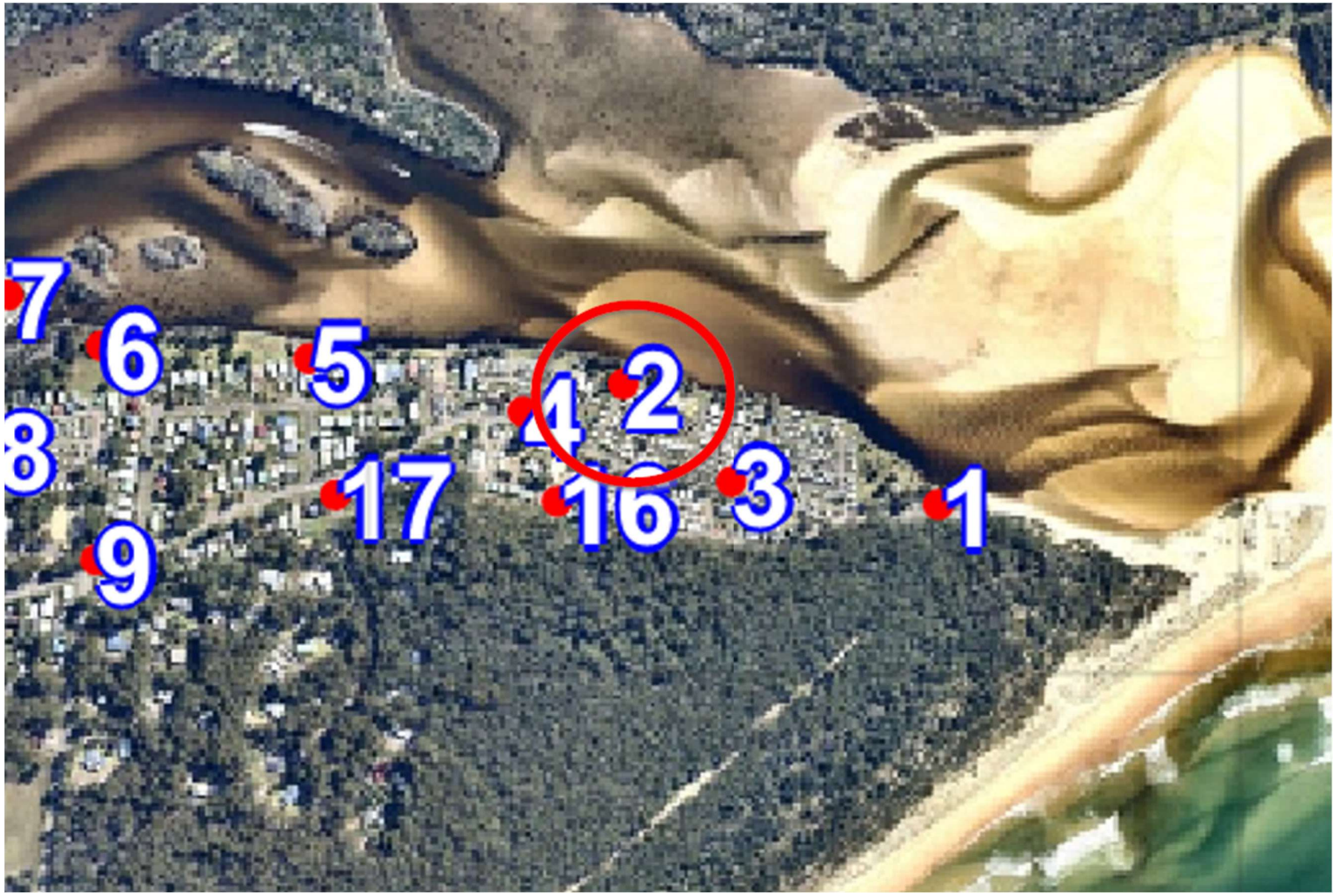
SLR 1.20m		
Inundation duration [hrs]	**Number of occurrences [-]**	**Total inundation duration (duration length x occurrences)**
5.0	1	5.0
5.5	3	16.5
6.0	4	24.0
6.5	3	19.5
7.0	4	28.0
7.5	3	22.5
8.0	6	48.0
8.5	5	42.5
9.0	8	72.0
9.5	1	9.5
10.0	3	30.0
10.5	1	10.5
11.0	2	22.0
12.0	1	12.0
20.5	2	41.0
21.0	2	42.0
21.5	1	21.5
22.0	2	44.0
23.0	2	46.0
45.5	1	45.5
185.5	1	185.5
	Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
	56.0	788
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences		
787.5 hours / 56 occurances	**14.1**	**Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)		
56 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**485**	**Occurrences per calendar year** ***NOTE: may be more than one event per day due to semi-diurnal (twice daily) tidal cycle***


SLR 0.36m (Fully Open/Scoured Entrance)
Location 1 (Coordinates: 150.501E, 35.270S)
Water Level [mAHD]
1.5
1.35
1.2
1.05
0.9
0.75
0.6
0.45
0.3
0.15
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.20mAHD
Ground Level at Selected Output Location: 0.95mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 1 (Coordinates: 150.501E, 35.270S)
Water Level [mAHD]
2.3
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.20mAHD
Ground Level at Selected Output Location: 0.95mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

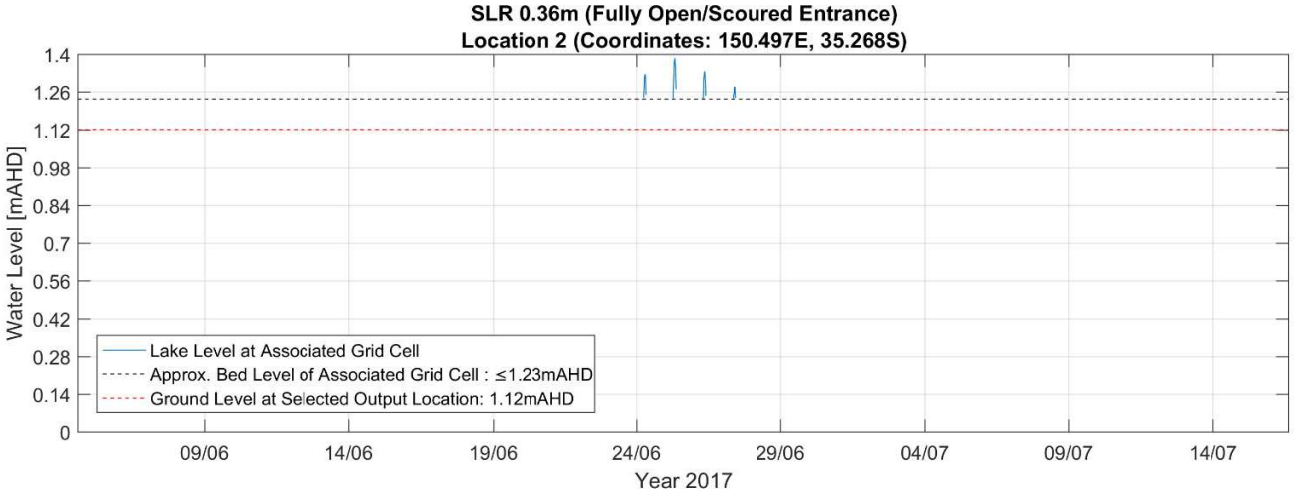

7
6
5
4
2
8
17
16
3
1
9

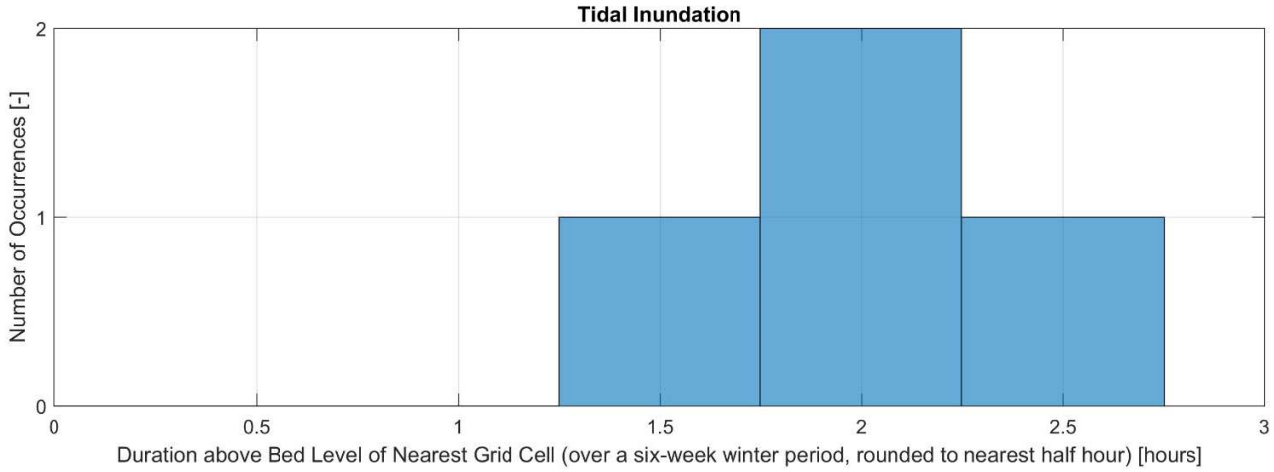
SLR 0.36m		
Inundation duration [hrs]	**Number of occurrences [-]**	**Total inundation duration (duration length x occurrences)**
1.5	1	1.5
2.0	2	4.0
2.5	1	2.5

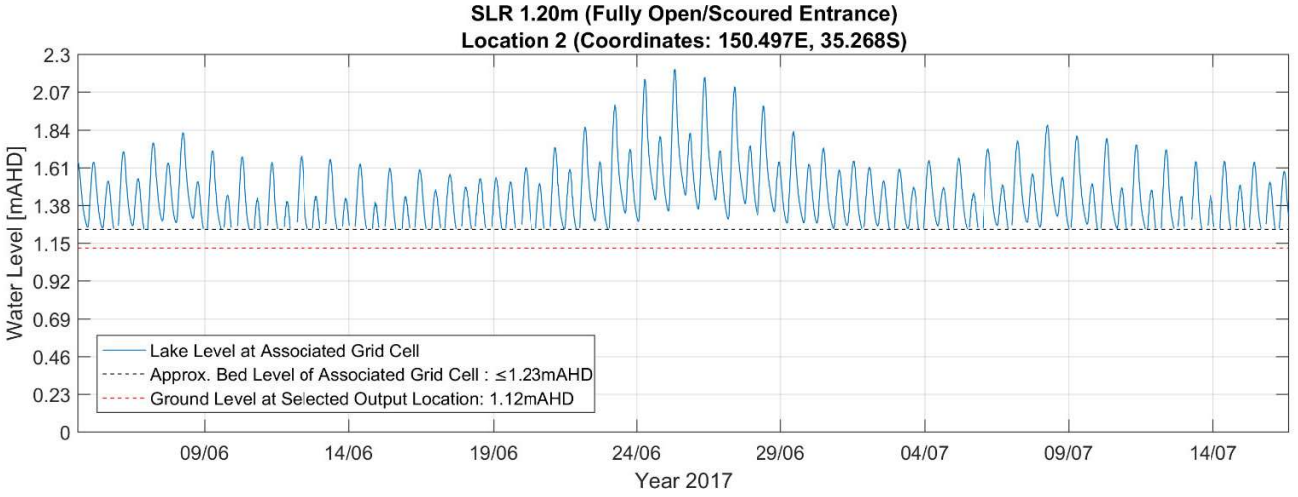
	Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
	4.0	8
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences		
8 hours / 4 occurances	**2.0**	**Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)		
4 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**35**	**Occurrences per calendar year**

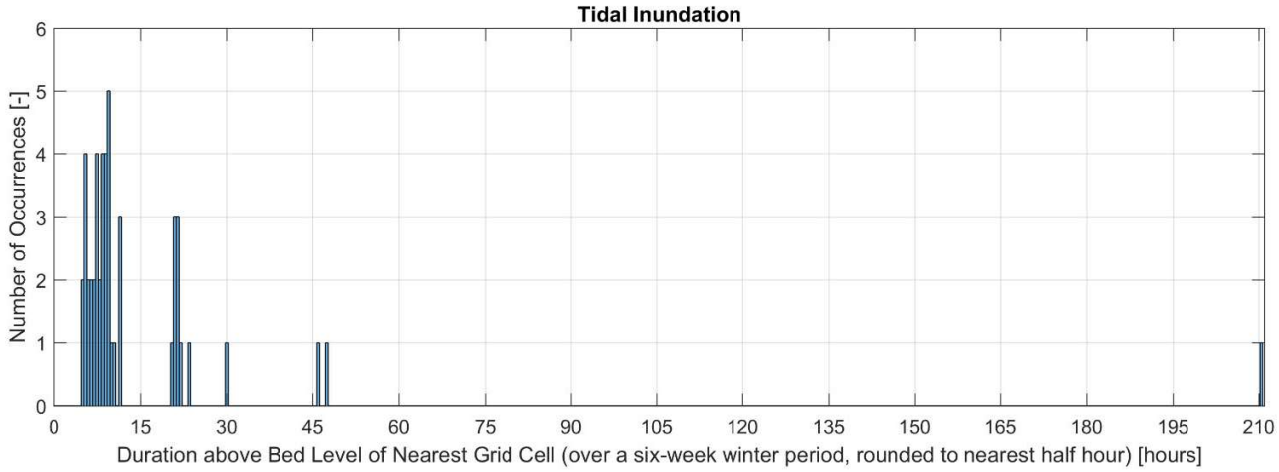
SLR 1.20m		
Inundation duration [hrs]	**Number of occurrences [-]**	**Total inundation duration (duration length x occurrences)**
5.0	2	10.0
5.5	4	22.0
6.0	2	12.0
6.5	2	13.0
7.0	2	14.0
7.5	4	30.0
8.0	2	16.0
8.5	4	34.0
9.0	4	36.0
9.5	5	47.5
10.0	1	10.0
10.5	1	10.5
11.5	3	34.5
20.5	1	20.5
21.0	3	63.0
21.5	3	64.5
22.0	1	22.0
23.5	1	23.5
30.0	1	30.0
46.0	1	46.0
47.5	1	47.5
210.5	1	210.5

	Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
	49.0	817
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences		
817 hours / 49 occurances	**16.7**	**Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)		
49 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**425**	**Occurrences per calendar year** ***NOTE: may be more than one event per day due to semi-diurnal (twice daily) tidal cycle***


SLR 0.36m (Fully Open/Scoured Entrance)
Location 2 (Coordinates: 150.497E, 35.268S)
Water Level [mAHD]
1.4
1.26
1.12
0.98
0.84
0.7
0.56
0.42
0.28
0.14
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.23mAHD
Ground Level at Selected Output Location: 1.12mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

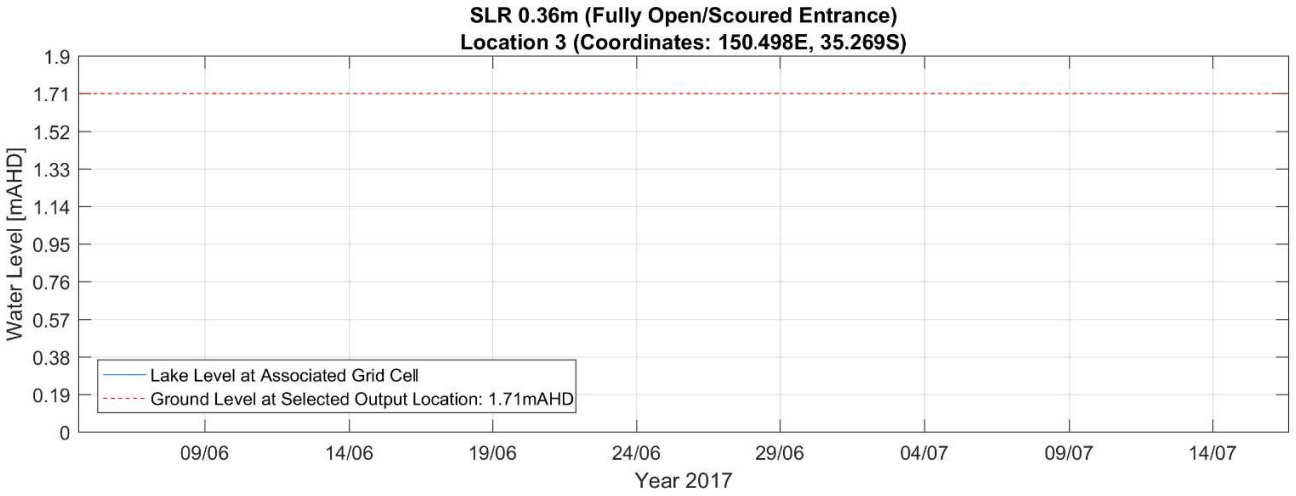

SLR 1.20m (Fully Open/Scoured Entrance)
Location 2 (Coordinates: 150.497E, 35.268S)
Water Level [mAHD]
2.3
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.23mAHD
Ground Level at Selected Output Location: 1.12mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

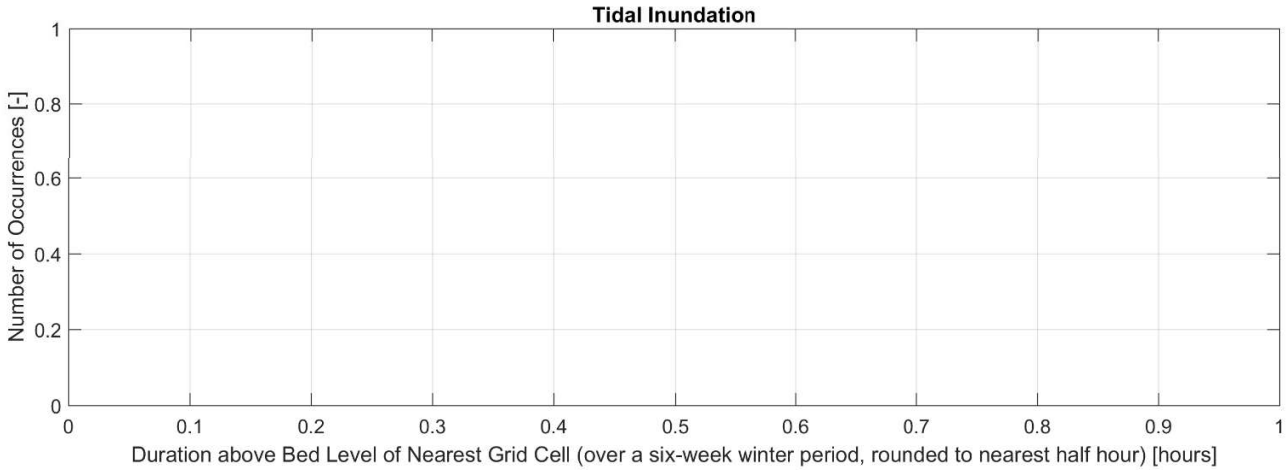

Tidal Inundation
Number of Occurrences [-]
6
5
4
3
2
1
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

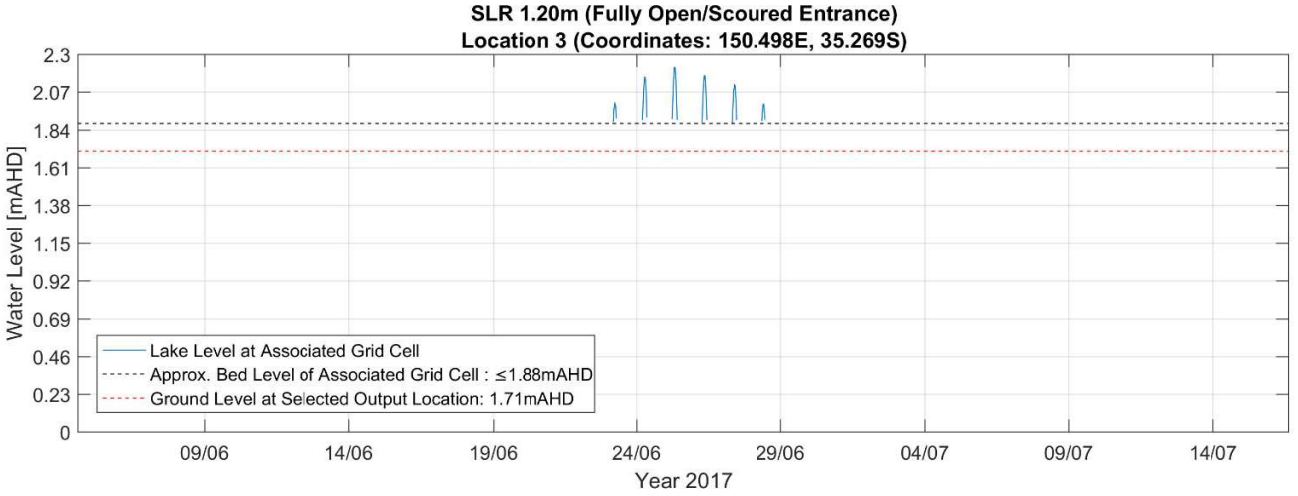

6
5
4
2
17
16
3
1
9

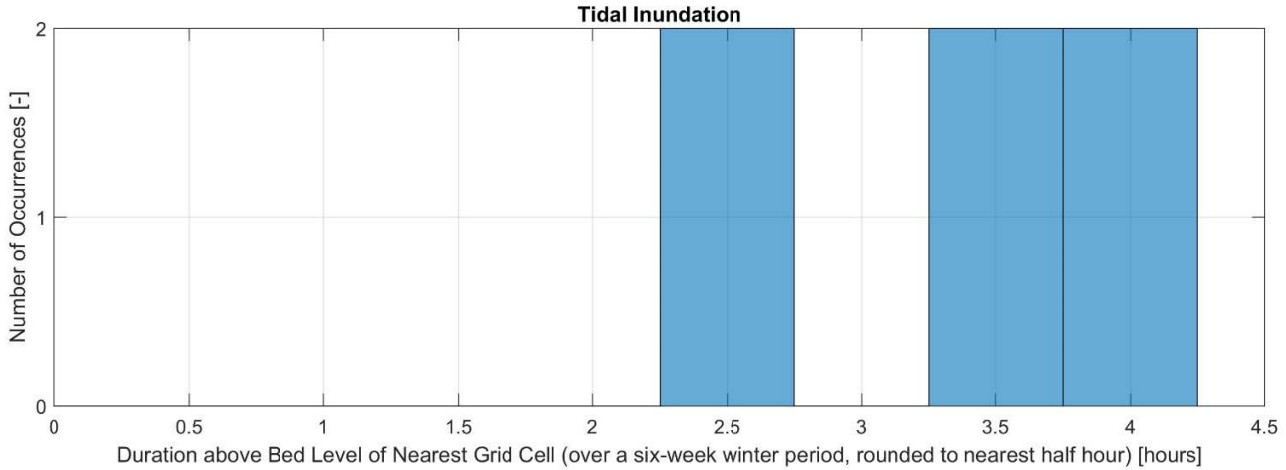
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

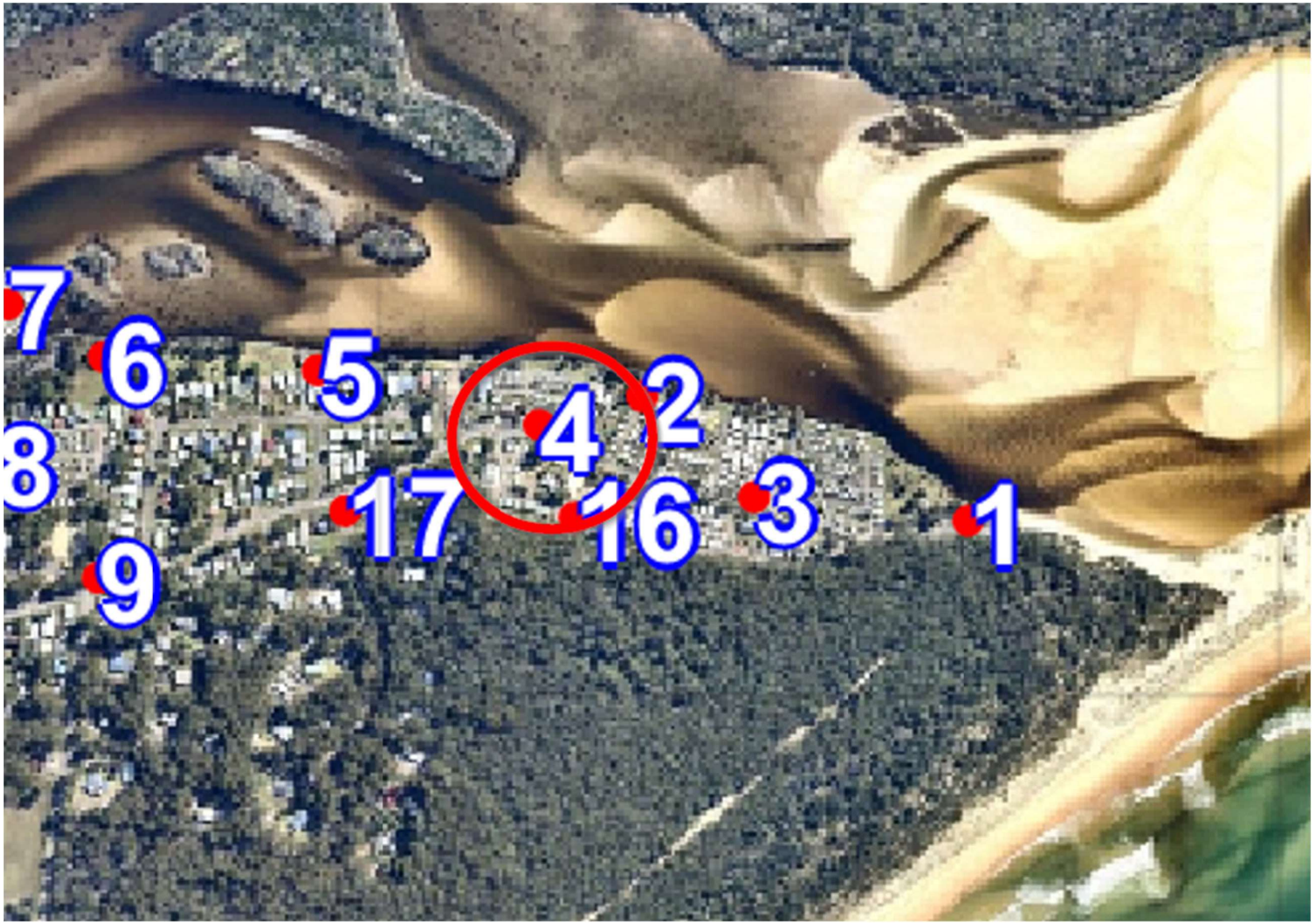
SLR 1.20m		
Inundation duration [hrs]	**Number of occurrences [-]**	**Total inundation duration (duration length x occurrences)**
2.5	2	5.0
3.5	2	7.0
4.0	2	8.0
	Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
	6.0	20
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences		
20 hours / 6 occurances	**3.3**	**Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)		
6 occurrences x 52	**52**	**Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 3 (Coordinates: 150.498E, 35.269S)
Water Level [mAHD]
1.9
1.71
1.52
1.33
1.14
0.95
0.76
0.57
0.38
0.19
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.71mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

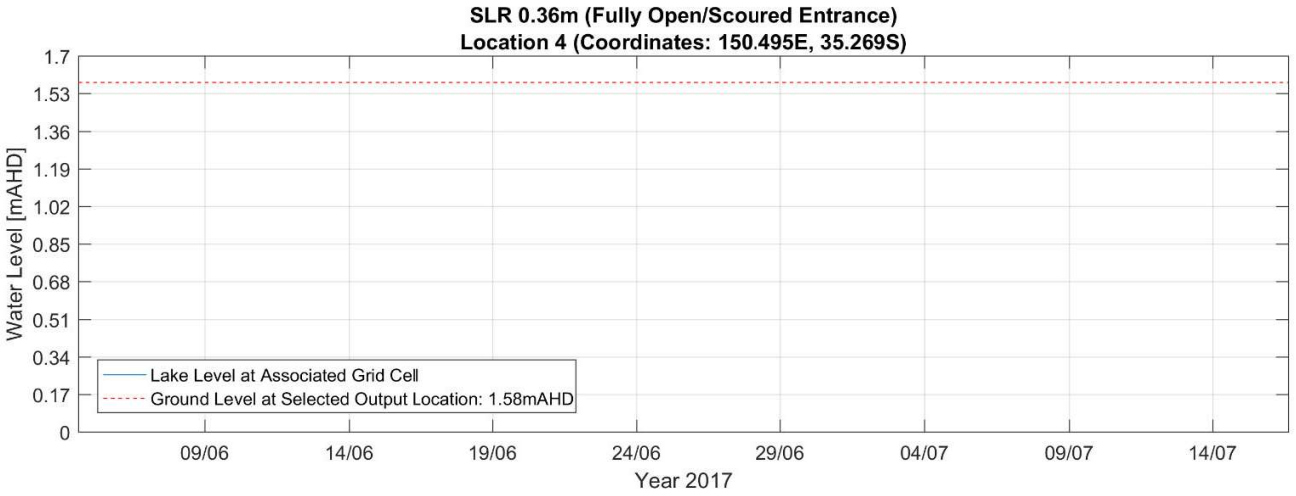

SLR 1.20m (Fully Open/Scoured Entrance)
Location 3 (Coordinates: 150.498E, 35.269S)
Water Level [mAHD]
2.3
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.88mAHD
Ground Level at Selected Output Location: 1.71mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

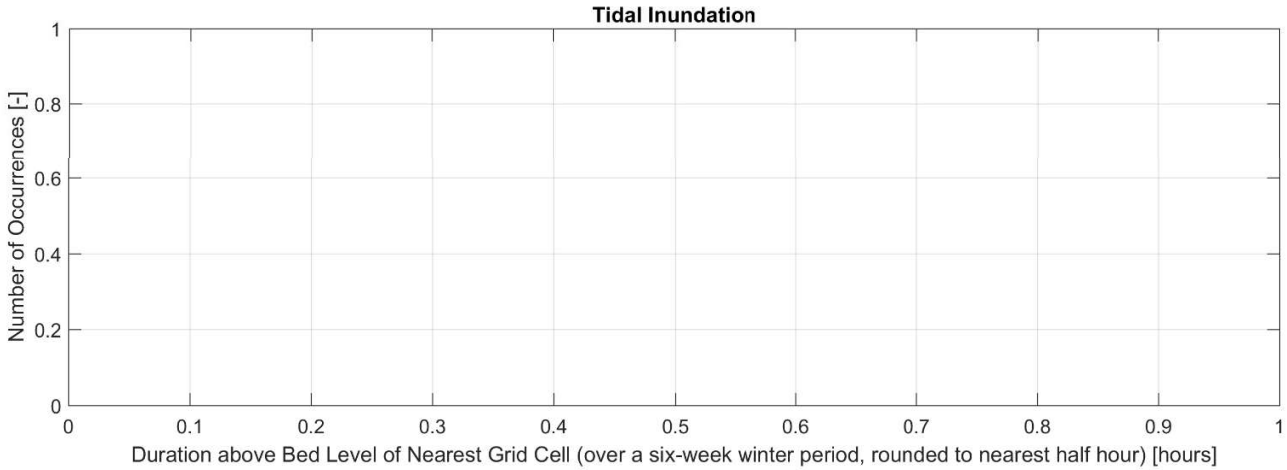

Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

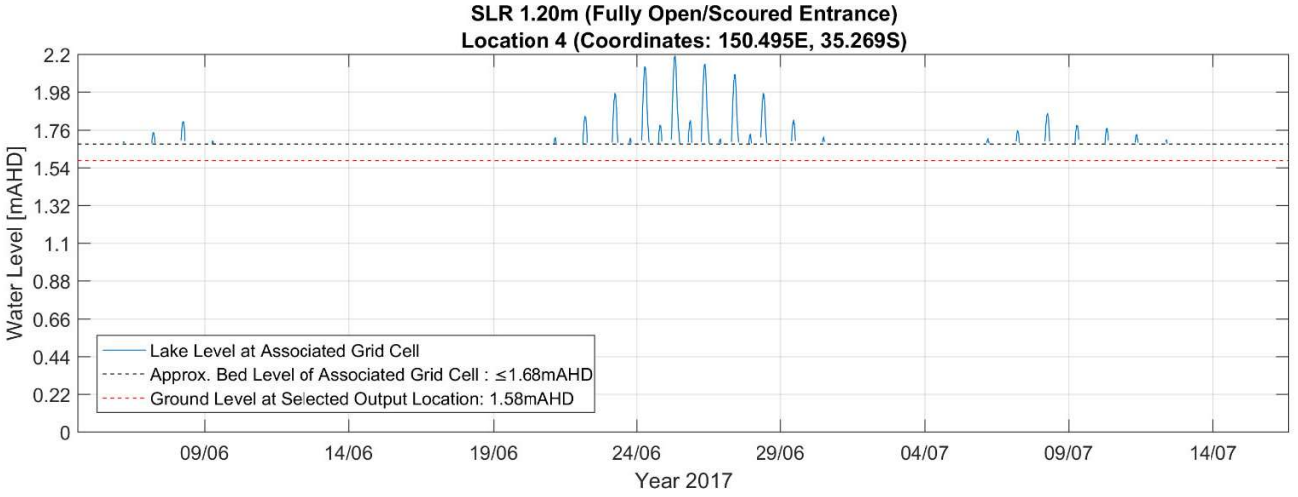

7
6
5
4
2
8
17
16
3
1
9

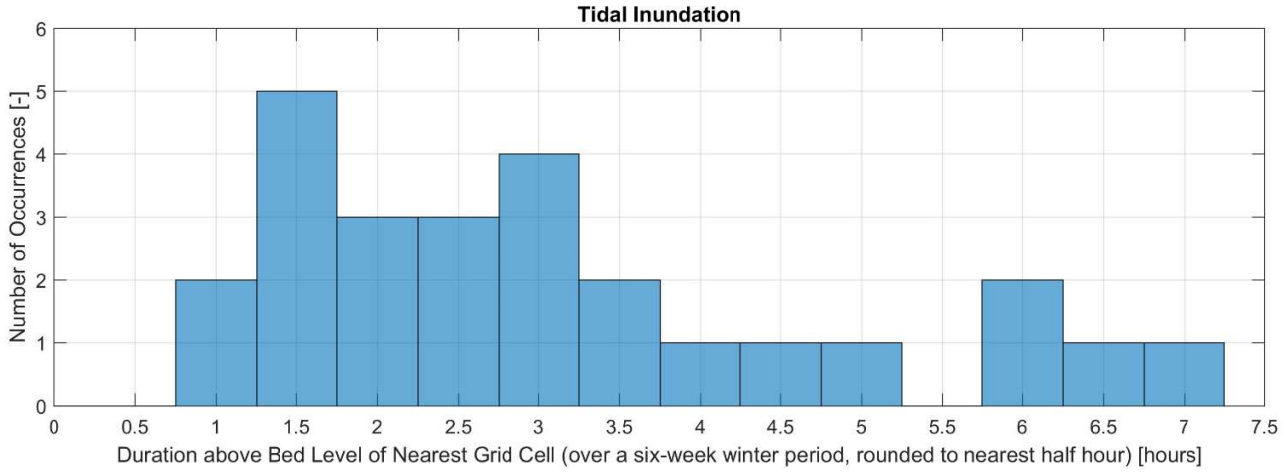
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m		
Inundation duration [hrs]	**Number of occurrences [-]**	**Total inundation duration (duration length x occurrences)**
1.0	2	2.0
1.5	5	7.5
2.0	3	6.0
2.5	3	7.5
3.0	4	12.0
3.5	2	7.0
4.0	1	4.0
4.5	1	4.5
5.0	1	5.0
6.0	2	12.0
6.5	1	6.5
7.0	1	7.0
	Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
	26	**81.0**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences		
81 hours / 26 occurances	**3.1**	**Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)		
26 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**225**	**Occurrences per calendar year *NOTE: may be more than one event per day due to semi-diurnal (twice daily) tidal cycle***


SLR 0.36m (Fully Open/Scoured Entrance)
Location 4 (Coordinates: 150.495E, 35.269S)
Water Level [mAHD]
1.7
1.53
1.36
1.19
1.02
0.85
0.68
0.51
0.34
0.17
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.58mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

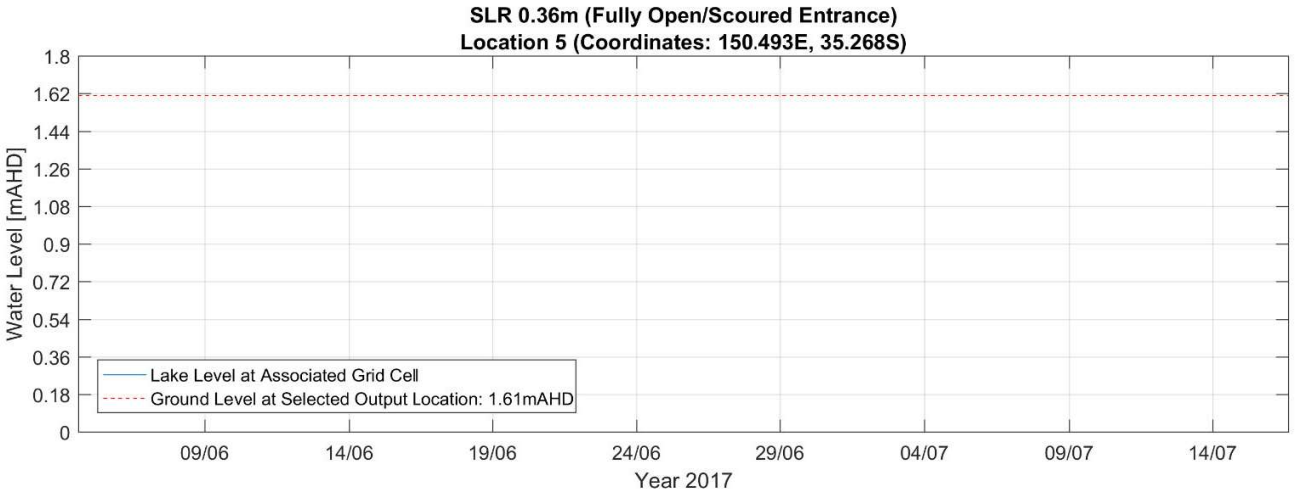

SLR 1.20m (Fully Open/Scoured Entrance)
Location 4 (Coordinates: 150.495E, 35.269S)
Water Level [mAHD]
2.2
1.98
1.76
1.54
1.32
1.1
0.88
0.66
0.44
0.22
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.68mAHD
Ground Level at Selected Output Location: 1.58mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

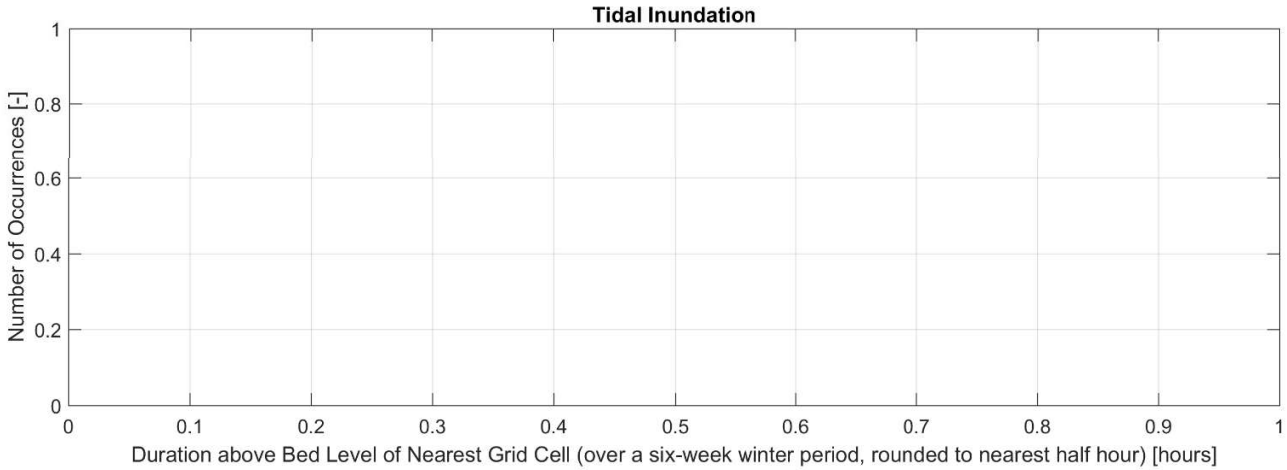

Tidal Inundation
Number of Occurrences [-]
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

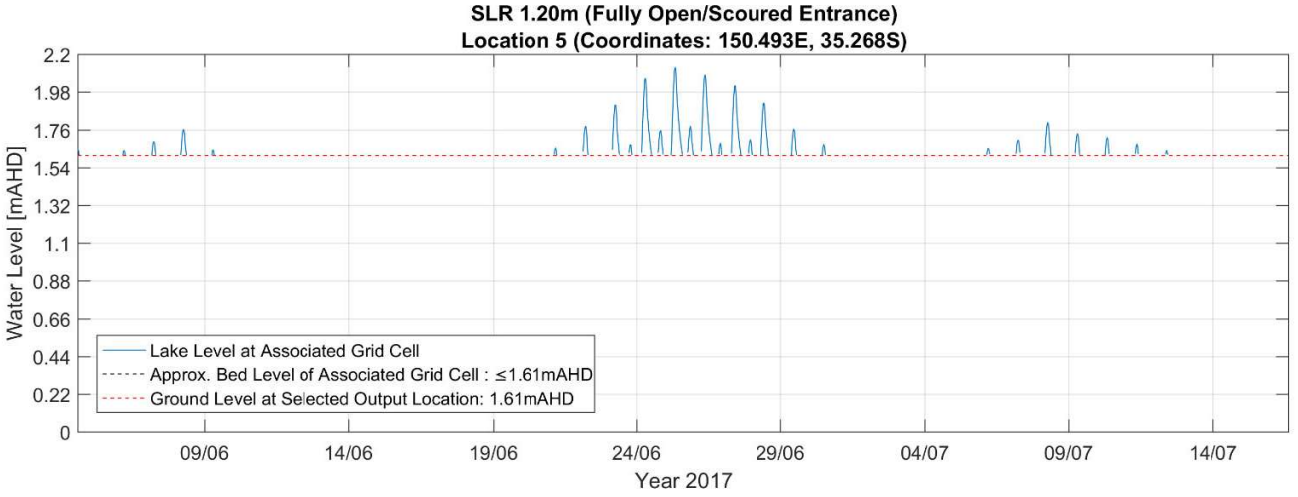

7
6
5
4
2
8
17
16
3
9

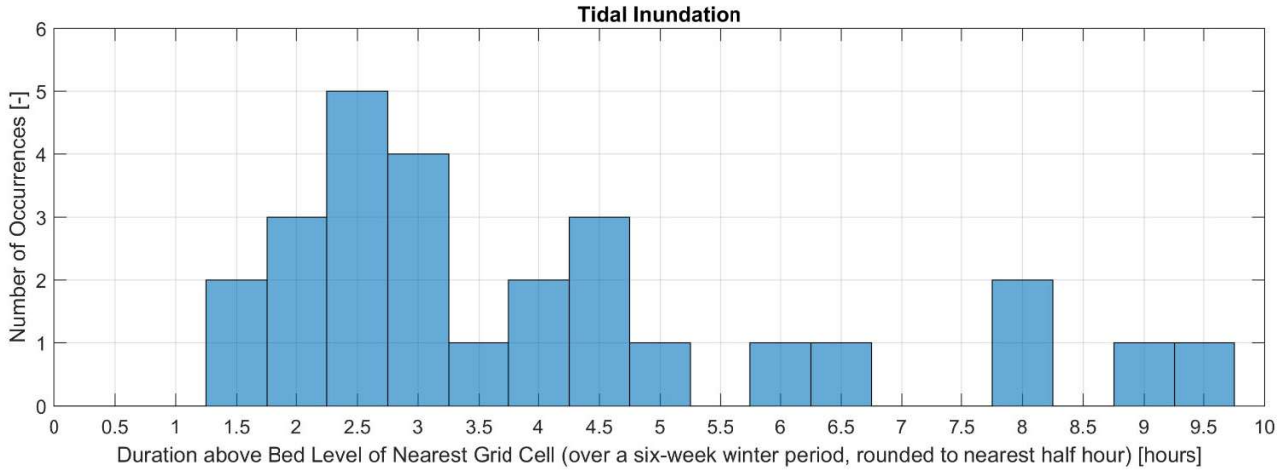
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.5	2
2.0	3
2.5	5
3.0	4
3.5	1
4.0	2
4.5	3
5.0	1
6.0	1
6.5	1
8.0	2
9.0	1
9.5	1
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
27	**110.5**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
110.5 hours / 27 occurances	**4.1 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
27 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**234 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 5 (Coordinates: 150.493E, 35.268S)
Water Level [mAHD]
1.8
1.62
1.44
1.26
1.08
0.9
0.72
0.54
0.36
0.18
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.61mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 5 (Coordinates: 150.493E, 35.268S)
Water Level [mAHD]
2.2
1.98
1.76
1.54
1.32
1.1
0.88
0.66
0.44
0.22
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.61mAHD
Ground Level at Selected Output Location: 1.61mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

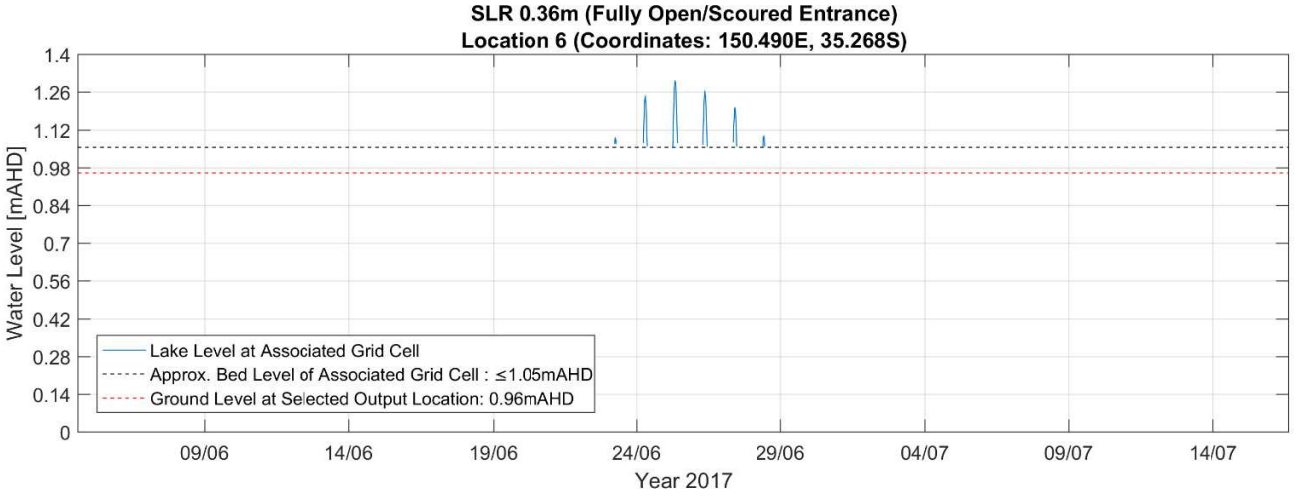

Tidal Inundation
Number of Occurrences [-]
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

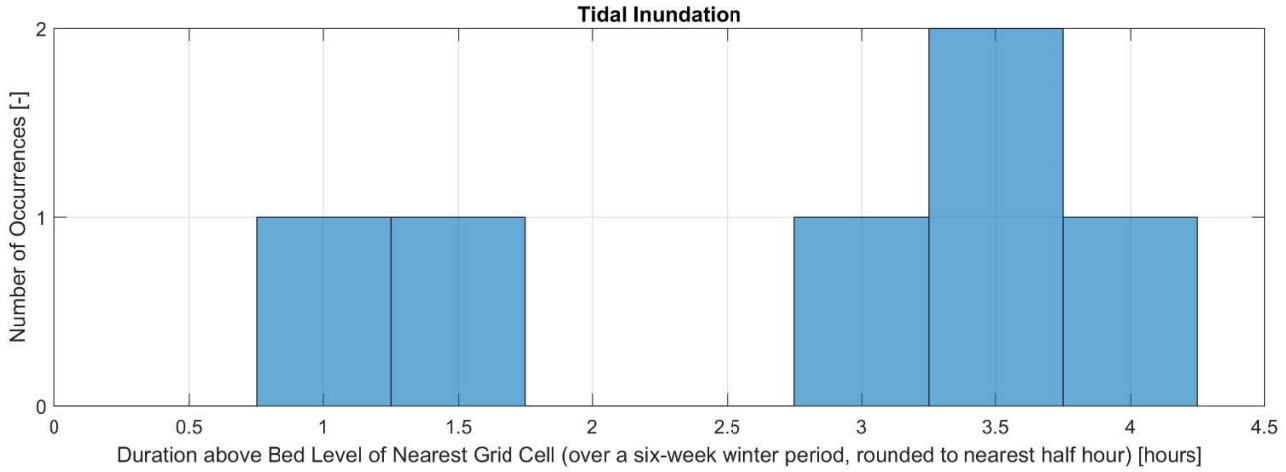

7
6
5
12
8
4
2
17
16
10
9

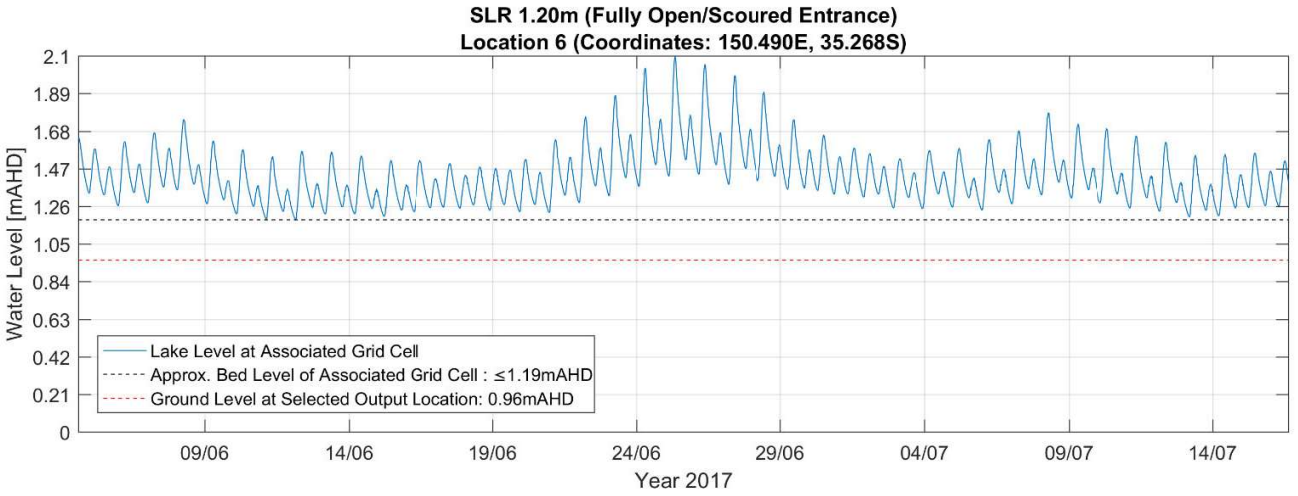
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.0	1
1.5	1
3.0	1
3.5	2
4.0	1

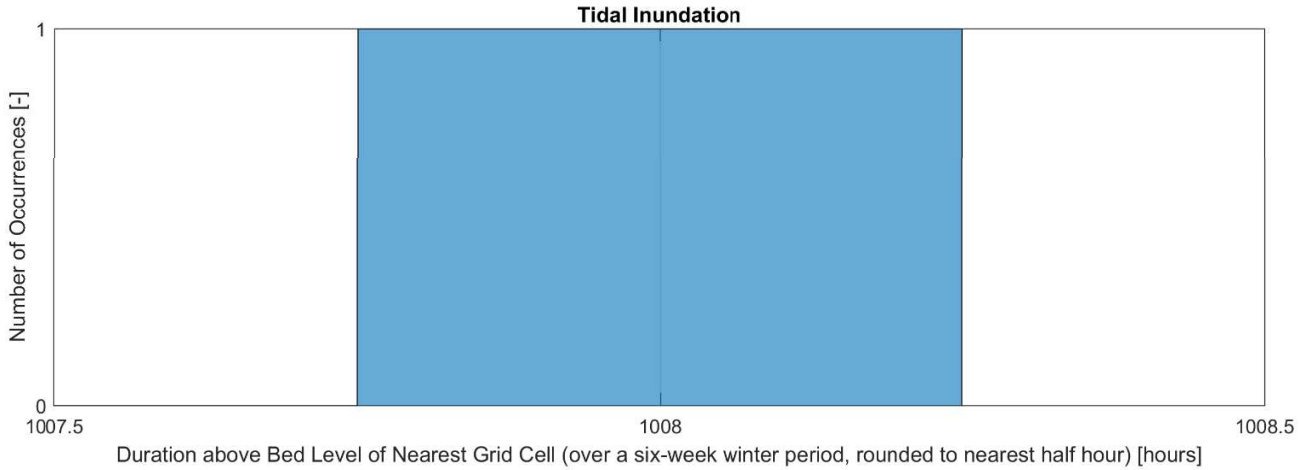
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
6	**16.5**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
16.5 hours / 6 occurances	**2.8 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
6 occurrence x 52 weeks (calendar) / 6 weeks (modelled)	**52 Occurrences per calendar year**

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always wet)	(always wet)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 6 (Coordinates: 150.490E, 35.268S)
Water Level [mAHD]
1.4
1.26
1.12
0.98
0.84
0.7
0.56
0.42
0.28
0.14
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.05mAHD
Ground Level at Selected Output Location: 0.96mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 6 (Coordinates: 150.490E, 35.268S)
Water Level [mAHD]
2.1
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.19mAHD
Ground Level at Selected Output Location: 0.96mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

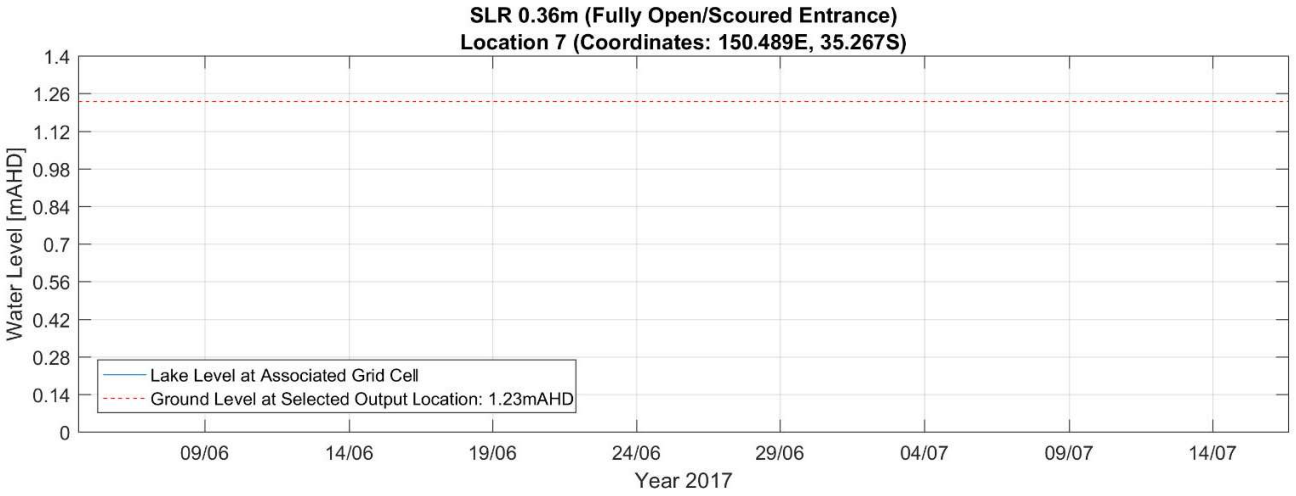

Tidal Inundation
Number of Occurrences [-]
1
0
1007.5
1008
1008.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

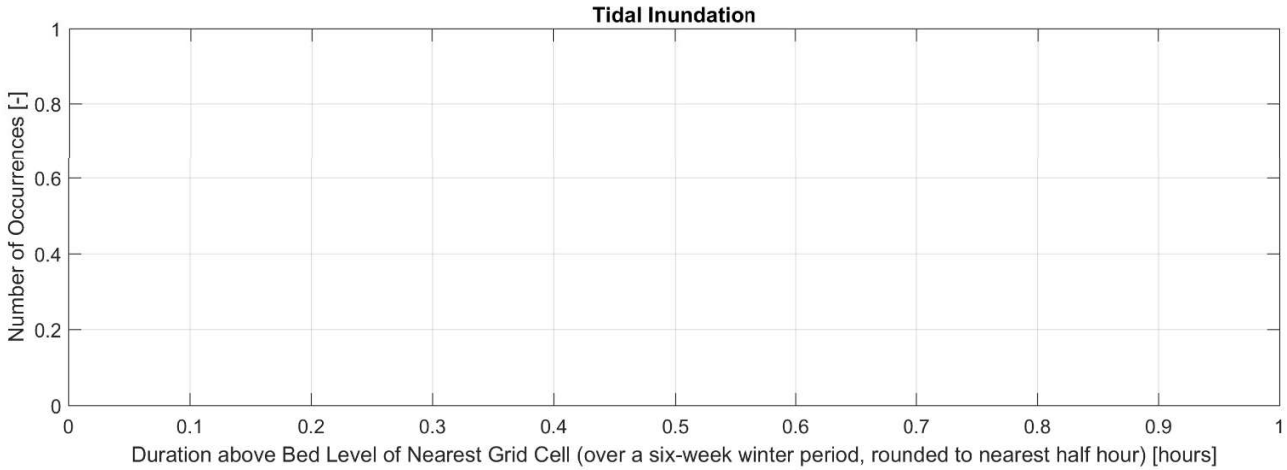

7
6
5
4
12
8
17
10
9

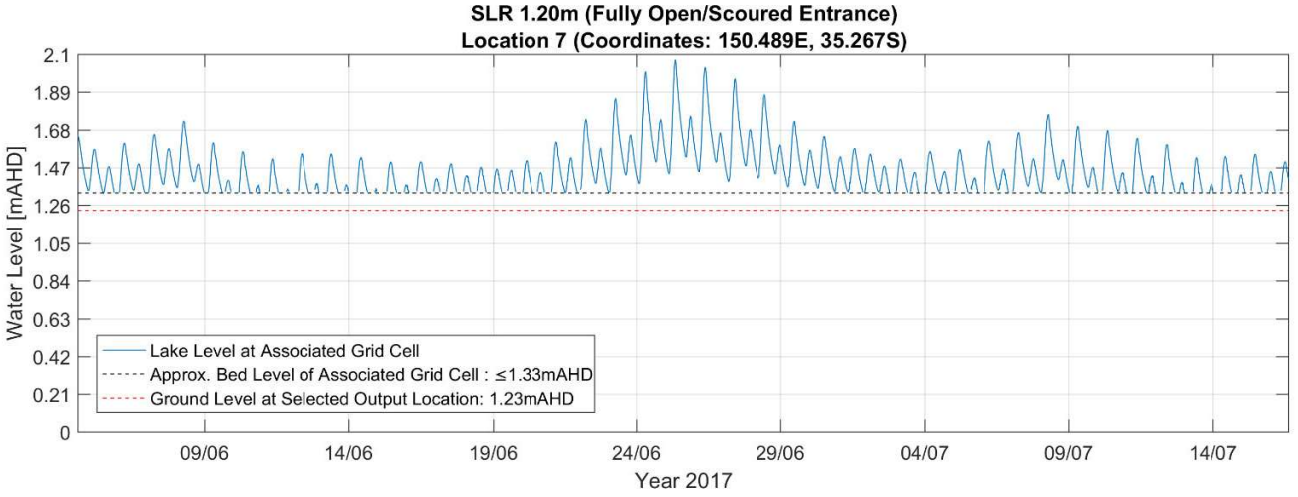
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

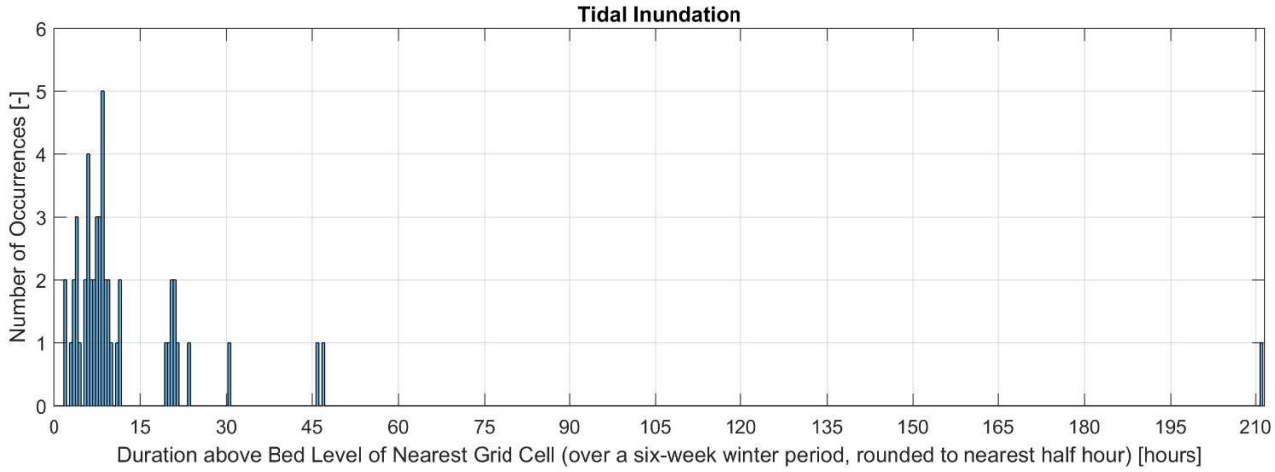
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
2.0	2
3.0	1
3.5	2
4.0	3
4.5	1
5.5	2
6.0	4
6.5	2
7.0	2
7.5	3
8.0	3
8.5	5
9.0	2
9.5	2
10.0	1
11.0	1
11.5	2
19.5	1
20.0	1
20.5	2
21.0	2
21.5	1
23.5	1
30.5	1
46.0	1
47.0	1
211.0	1

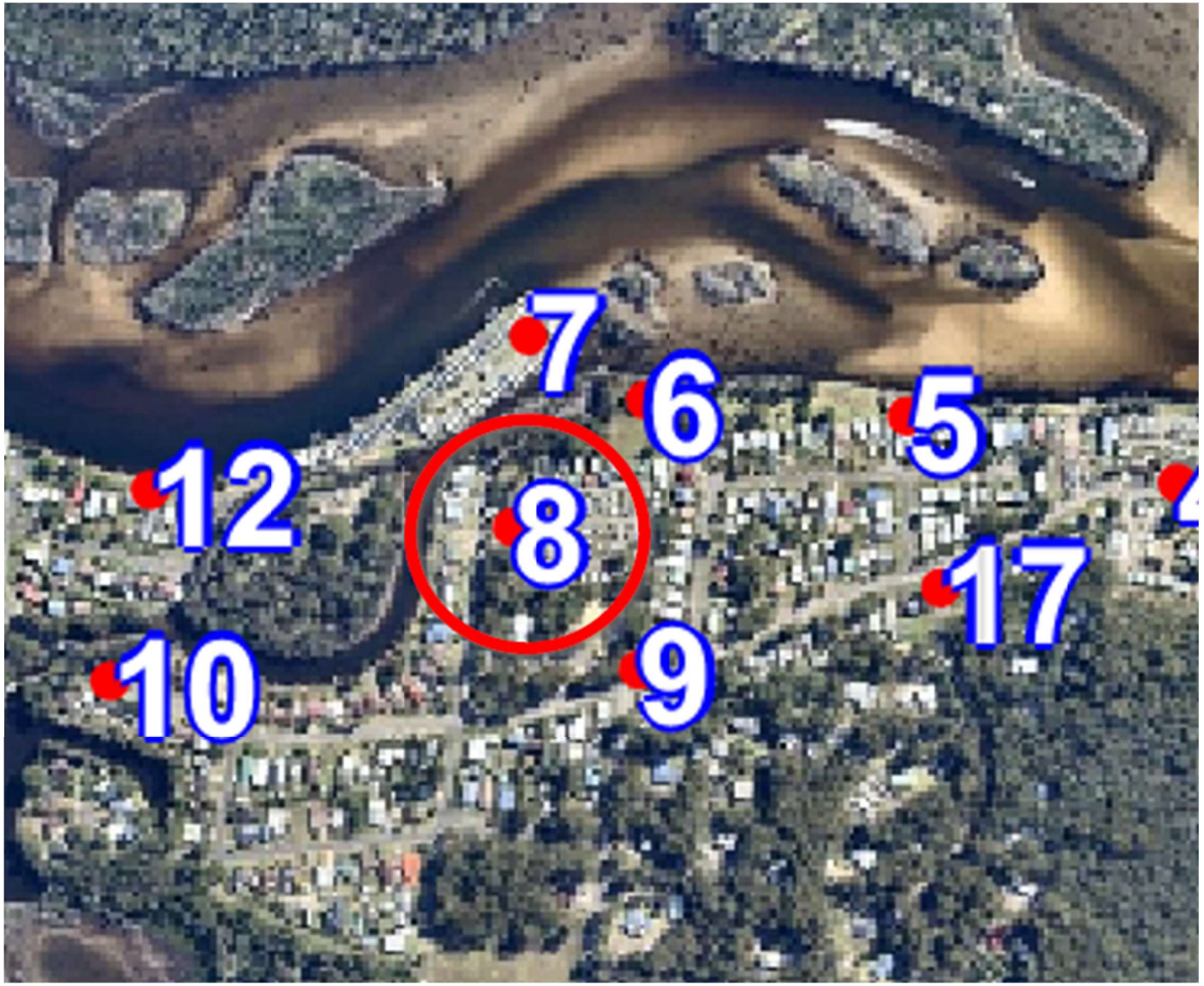
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
50	764.5
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
764.5 hours / 50 occurances	**15.3 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
50 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**433 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 7 (Coordinates: 150.489E, 35.267S)
Water Level [mAHD]
1.4
1.26
1.12
0.98
0.84
0.7
0.56
0.42
0.28
0.14
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.23mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 7 (Coordinates: 150.489E, 35.267S)
Water Level [mAHD]
2.1
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.33mAHD
Ground Level at Selected Output Location: 1.23mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

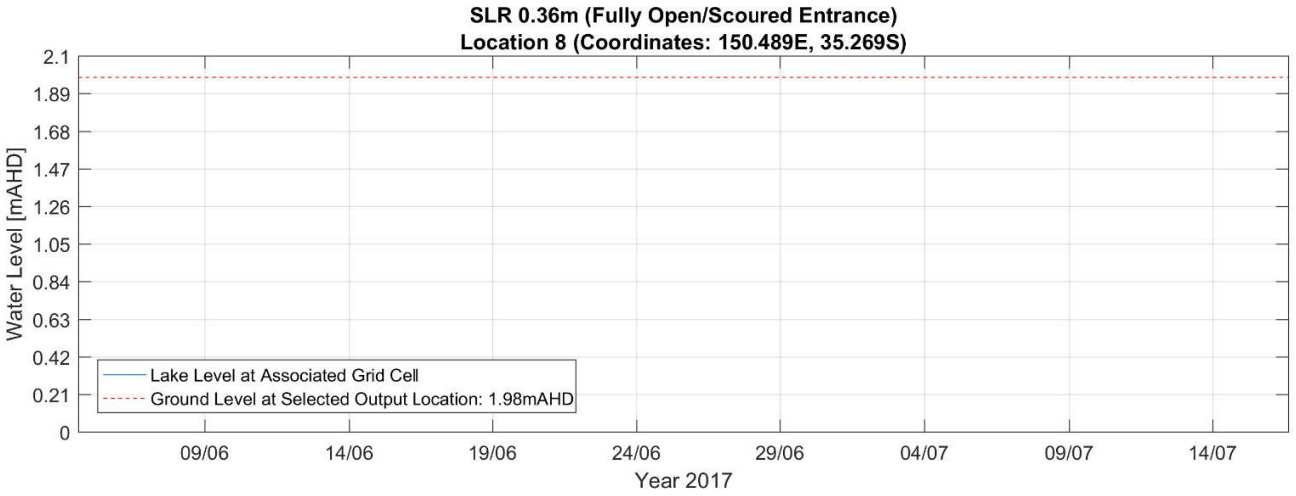

Tidal Inundation
Number of Occurrences [-]
6
5
4
3
2
1
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

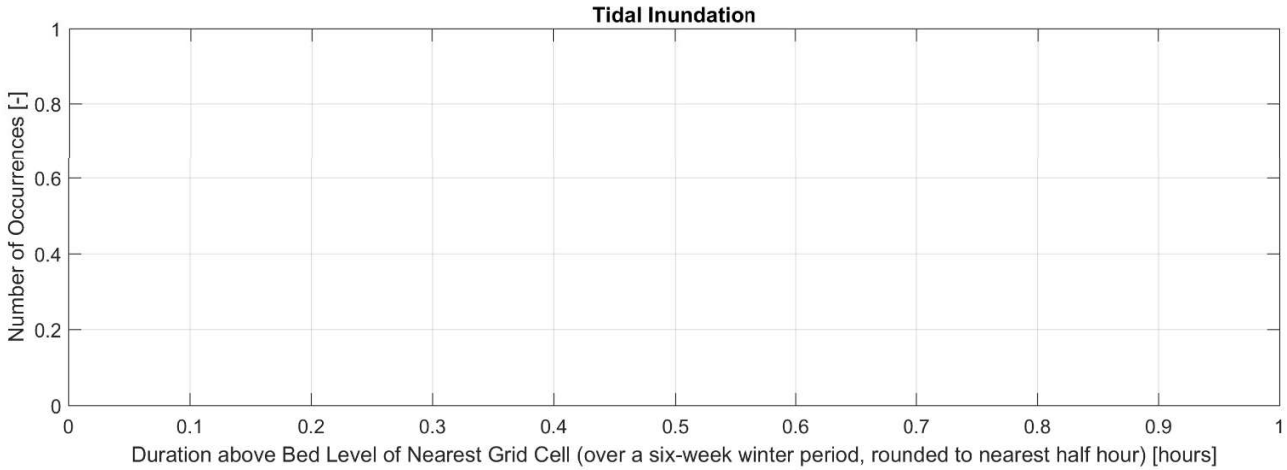

7
6
5
12
8
17
10
9

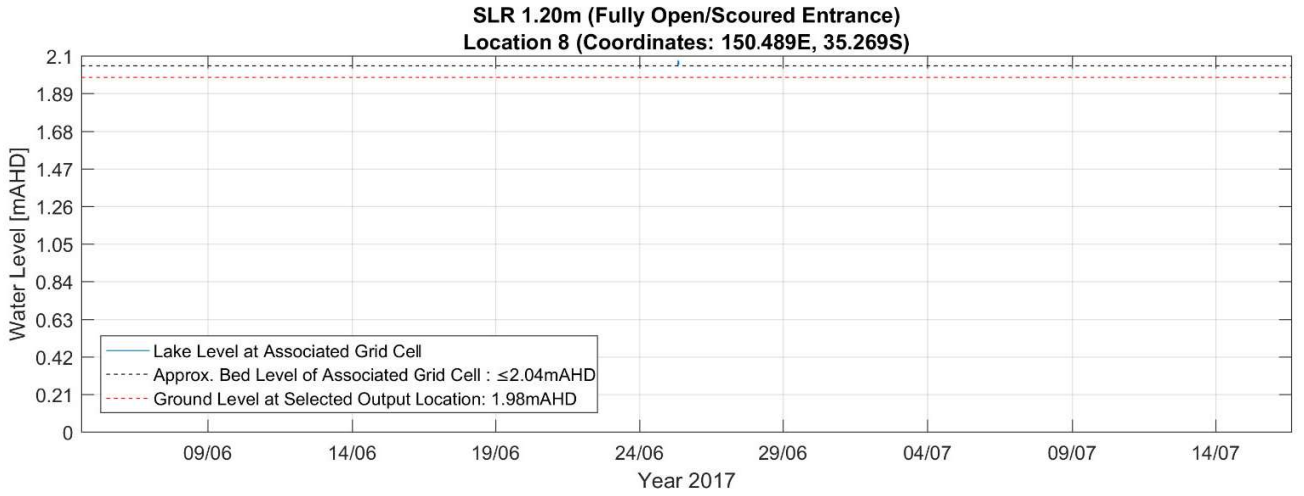
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

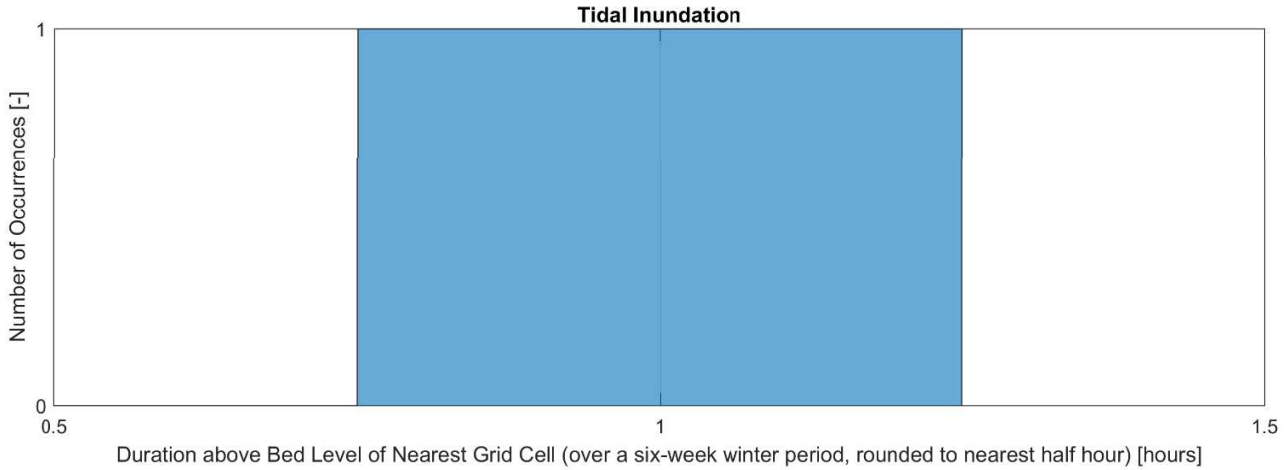
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.0	1

Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
1	1
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
1 hours / 1 occurances	**1 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
1 occurrence x 52 weeks (calendar) / 6 weeks (modelled)	**9 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 8 (Coordinates: 150.489E, 35.269S)
Water Level [mAHD]
2.1
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.98mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

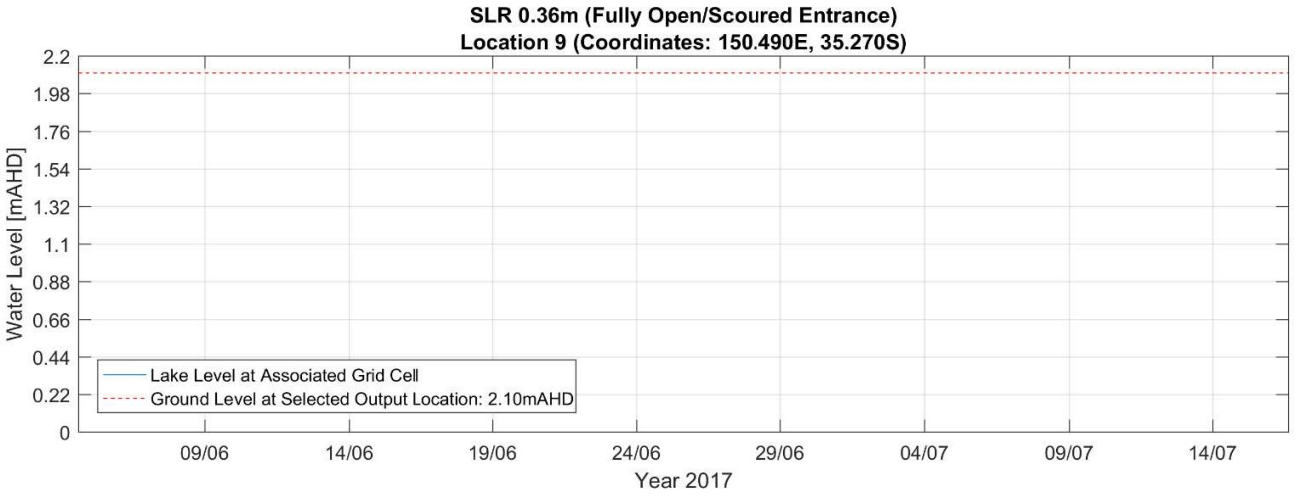

SLR 1.20m (Fully Open/Scoured Entrance)
Location 8 (Coordinates: 150.489E, 35.269S)
Water Level [mAHD]
2.1
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤2.04mAHD
Ground Level at Selected Output Location: 1.98mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

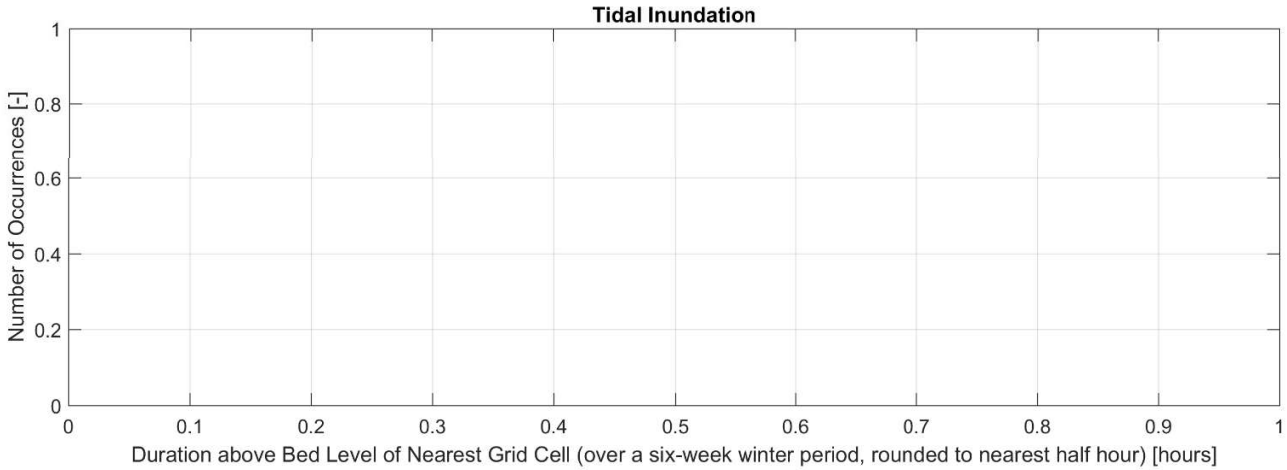

Tidal Inundation
Number of Occurrences [-]
1
0
0.5
1
1.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

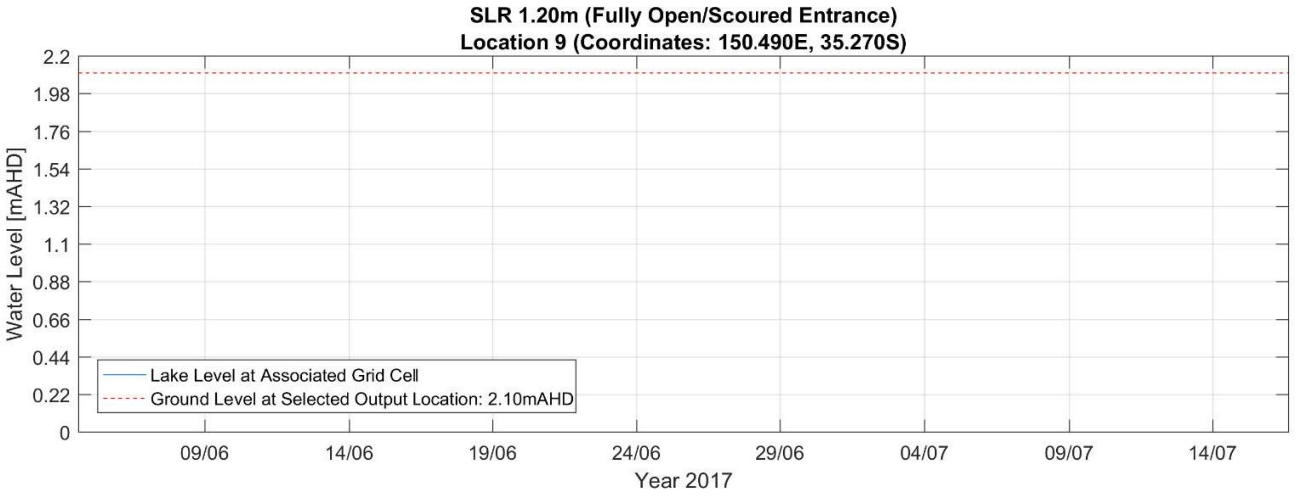

7
6
5
2
12
8
4
17
16
10
9

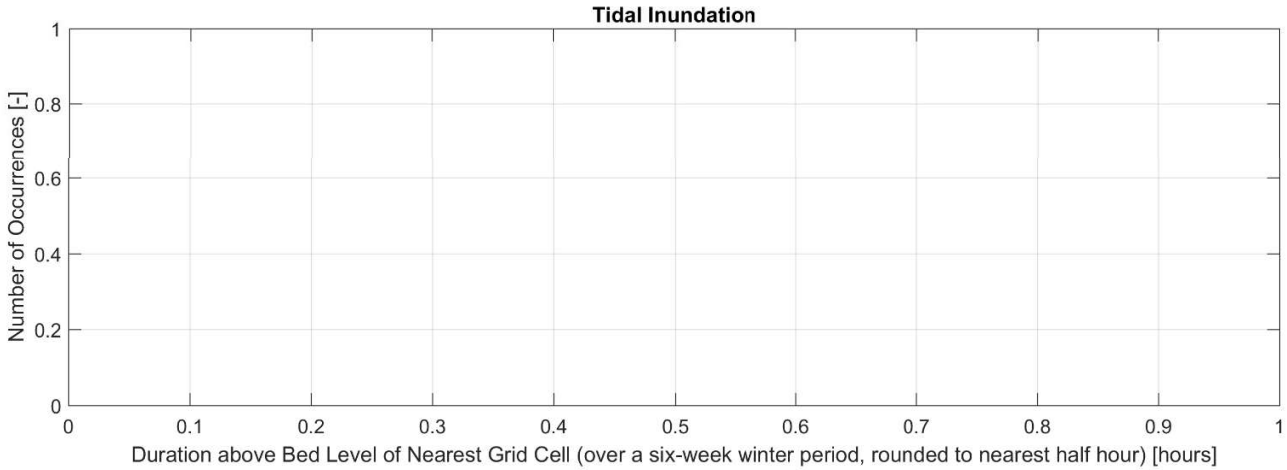
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

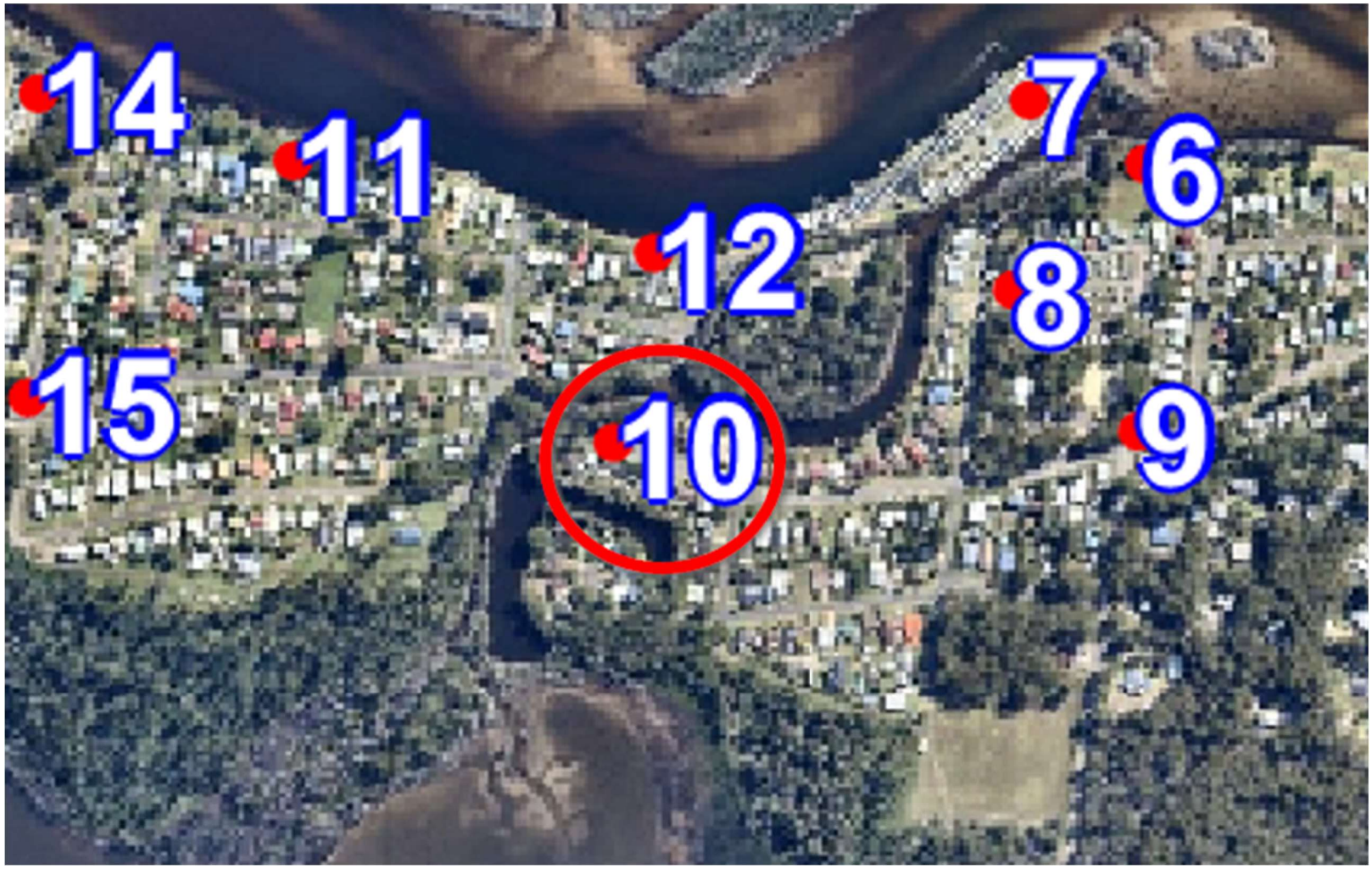
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 9 (Coordinates: 150.490E, 35.270S)
Water Level [mAHD]
2.2
1.98
1.76
1.54
1.32
1.1
0.88
0.66
0.44
0.22
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 2.10mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

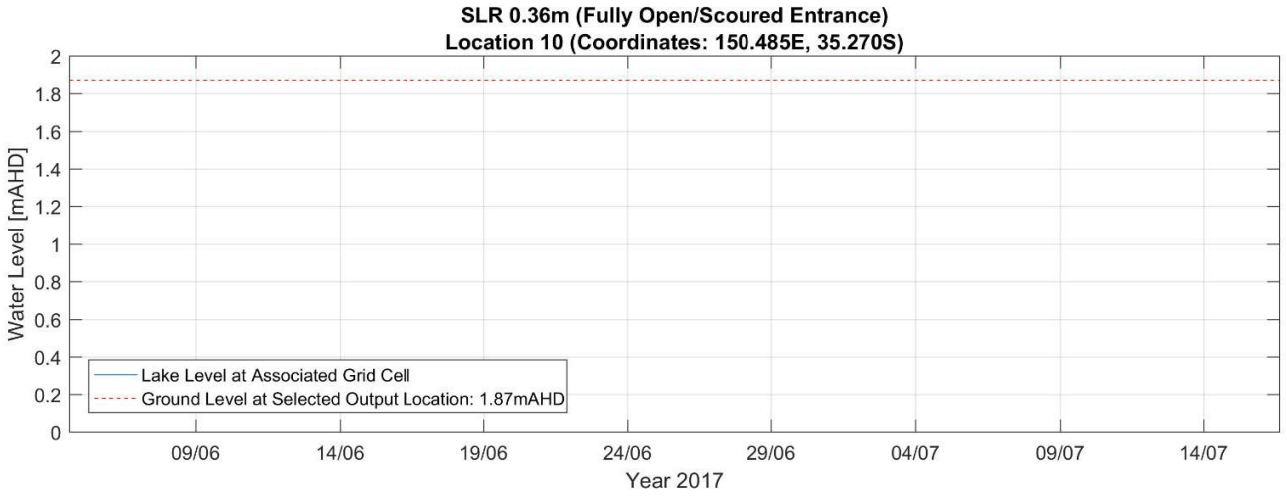

SLR 1.20m (Fully Open/Scoured Entrance)
Location 9 (Coordinates: 150.490E, 35.270S)
Water Level [mAHD]
2.2
1.98
1.76
1.54
1.32
1.1
0.88
0.66
0.44
0.22
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 2.10mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

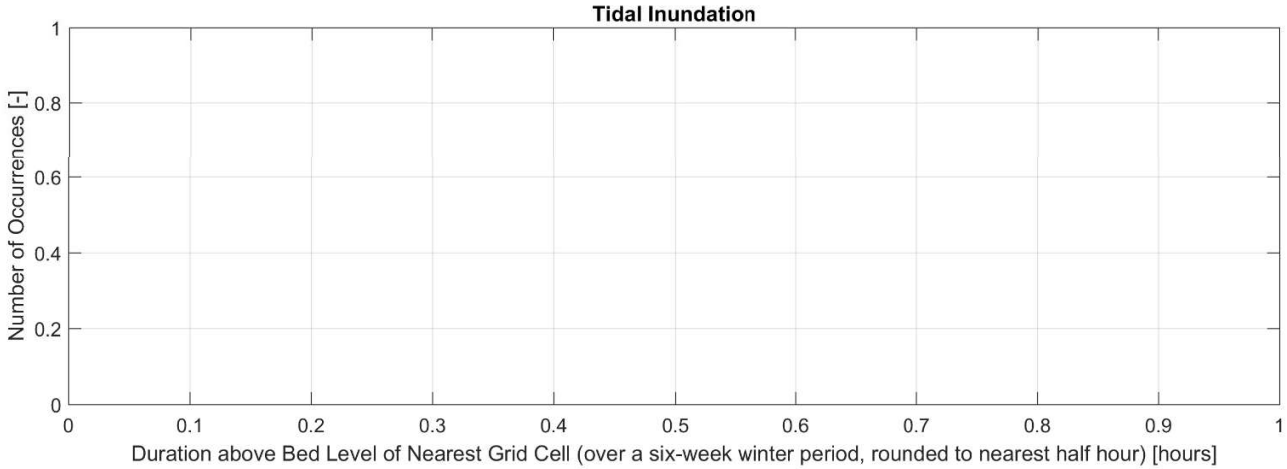

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

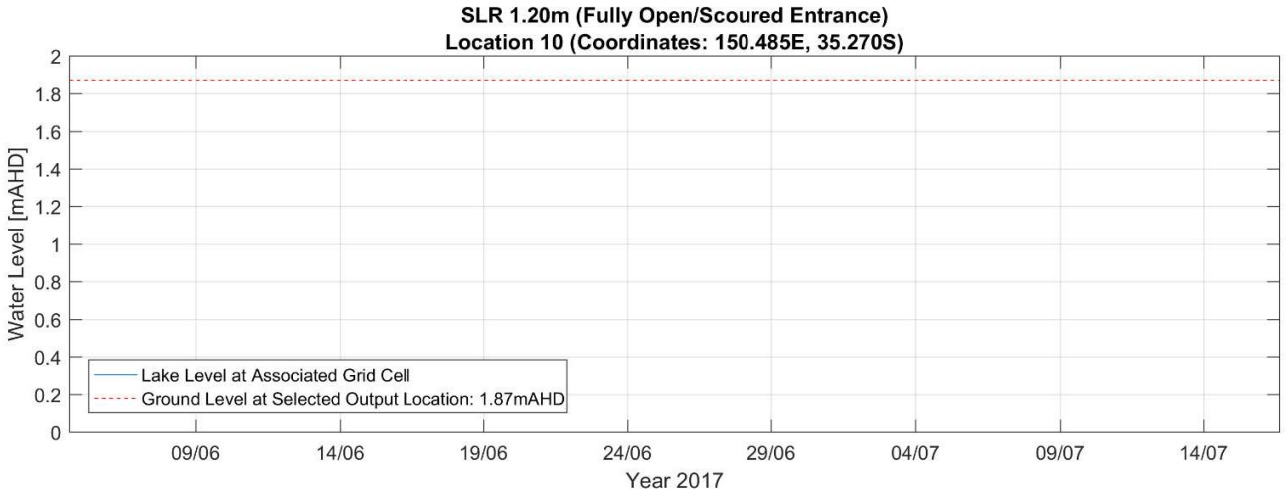

14
11
12
7
6
8
15
10
9

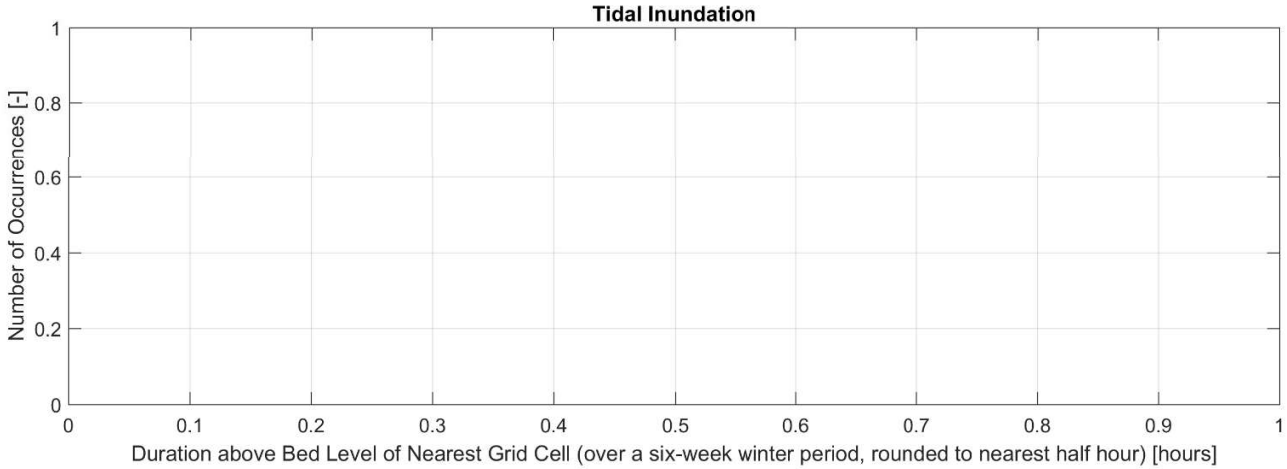
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

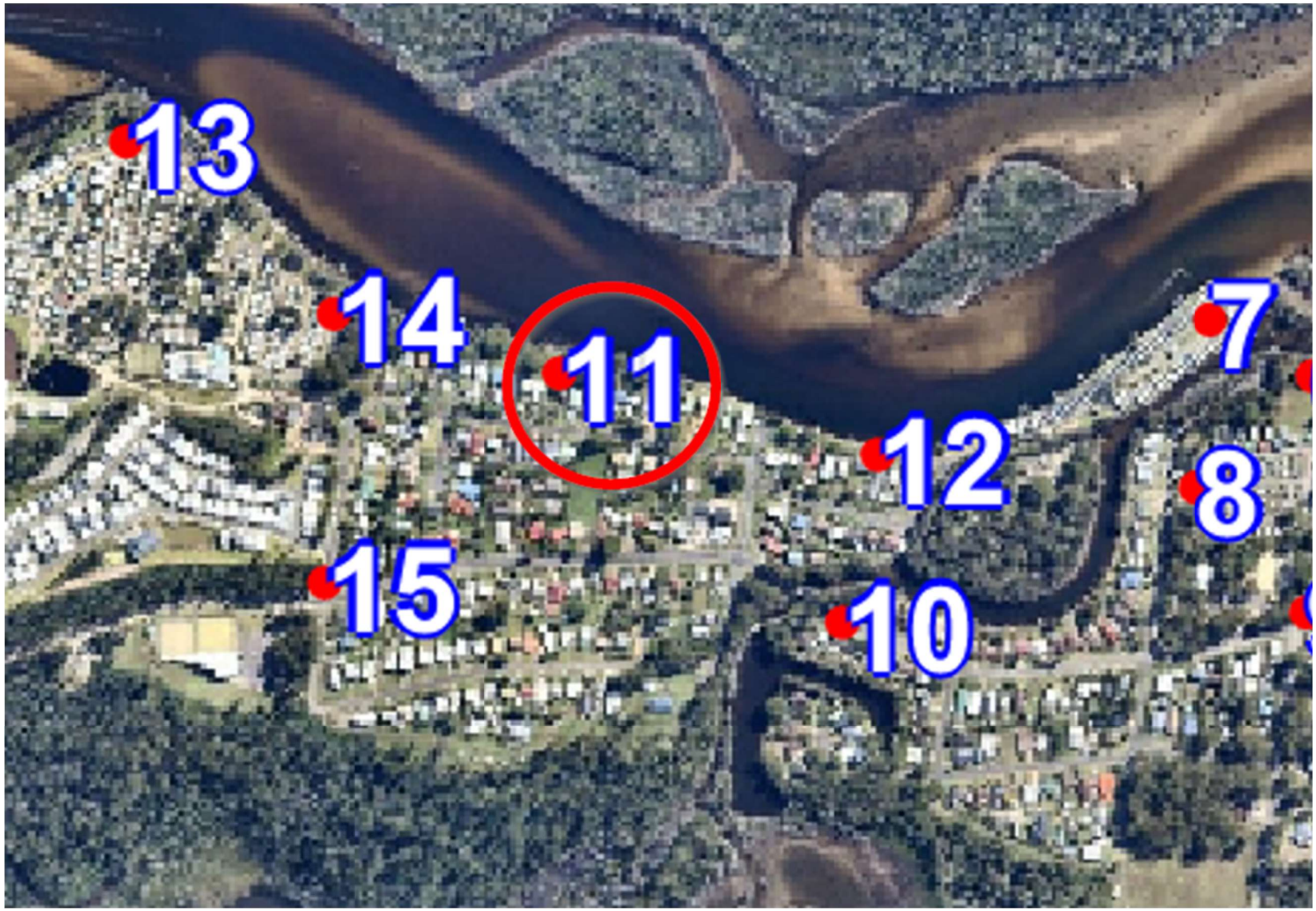
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 10 (Coordinates: 150.485E, 35.270S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.87mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 10 (Coordinates: 150.485E, 35.270S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.87mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

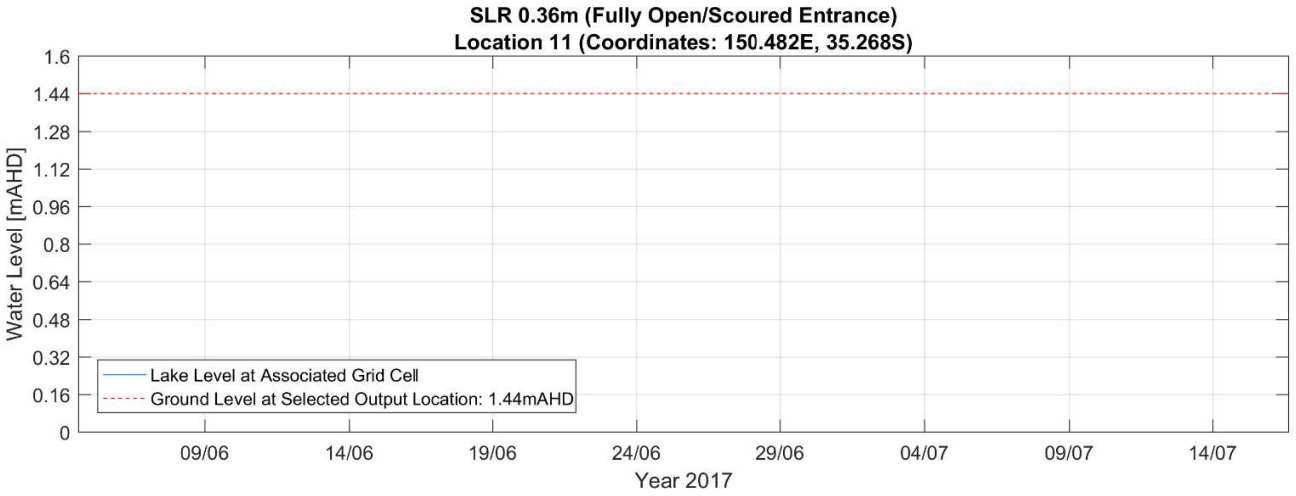

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

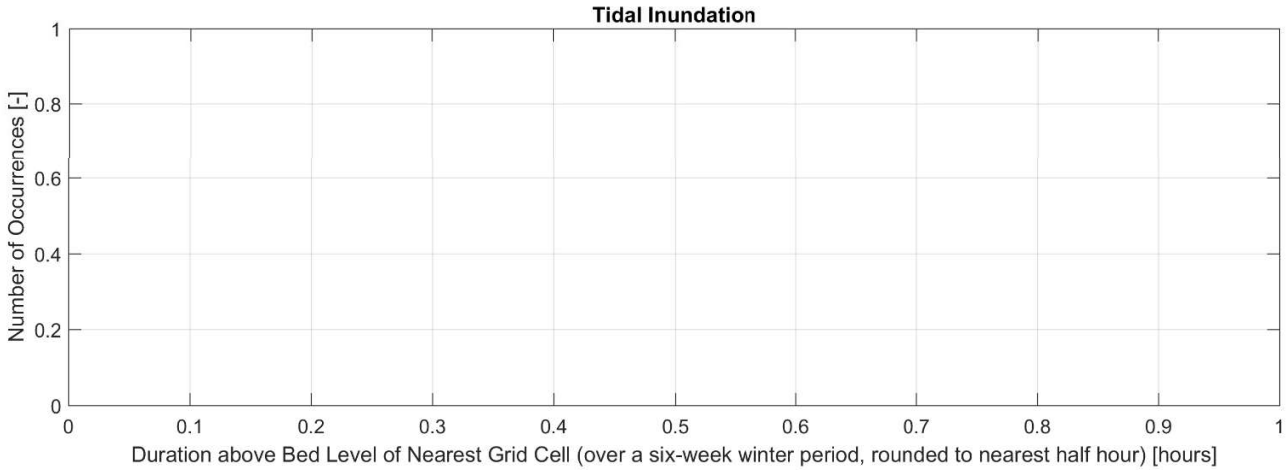

13
14
11
7
12
8
15
10

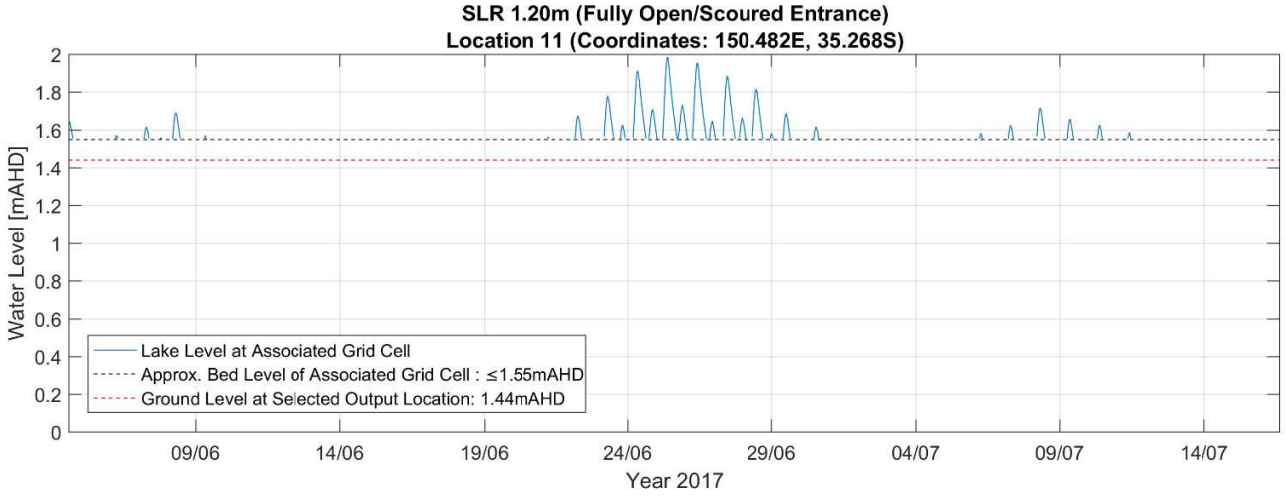
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

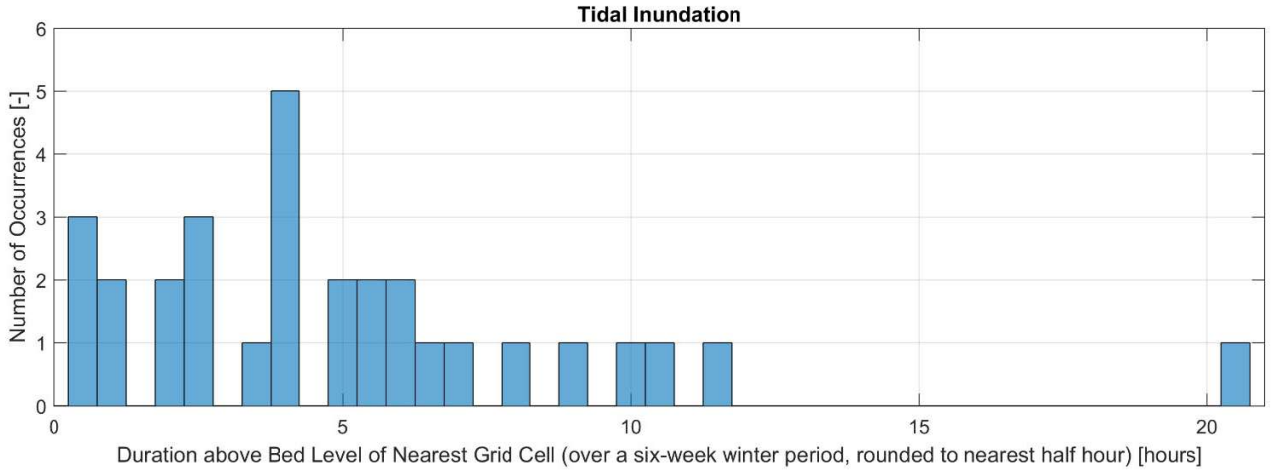
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
0.5	3
1.0	2
2.0	2
2.5	3
3.5	1
4.0	5
5.0	2
5.5	2
6.0	2
6.5	1
7.0	1
8.0	1
9.0	1
10.0	1
10.5	1
11.5	1
20.5	1

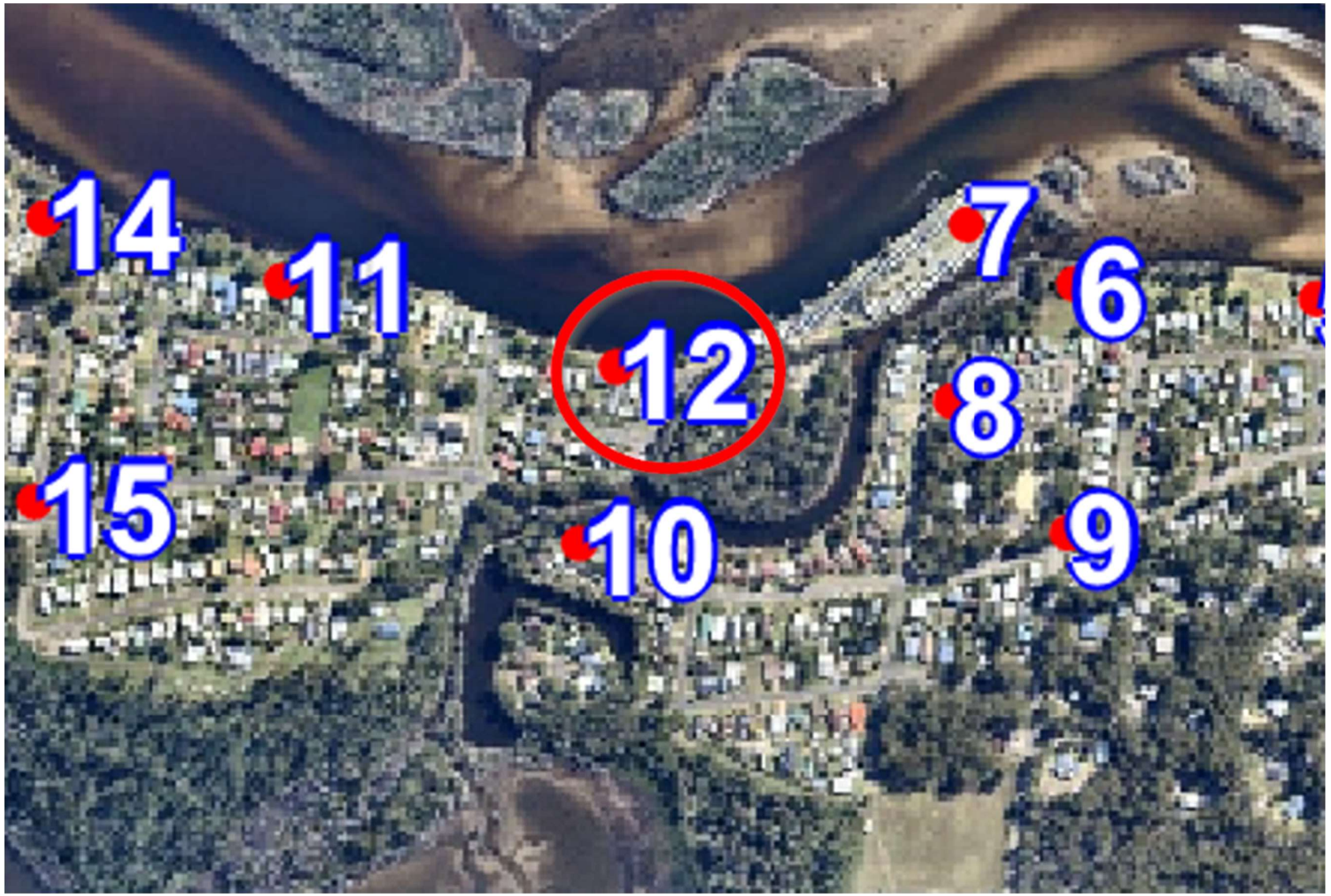
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
30.0	154.5
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
154.5 hours / 30 occurances	**5.2 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
30 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**260 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 11 (Coordinates: 150.482E, 35.268S)
Water Level [mAHD]
1.6
1.44
1.28
1.12
0.96
0.8
0.64
0.48
0.32
0.16
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.44mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 11 (Coordinates: 150.482E, 35.268S)
Water Level [mAHD]
Year 2017
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.55mAHD
Ground Level at Selected Output Location: 1.44mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07

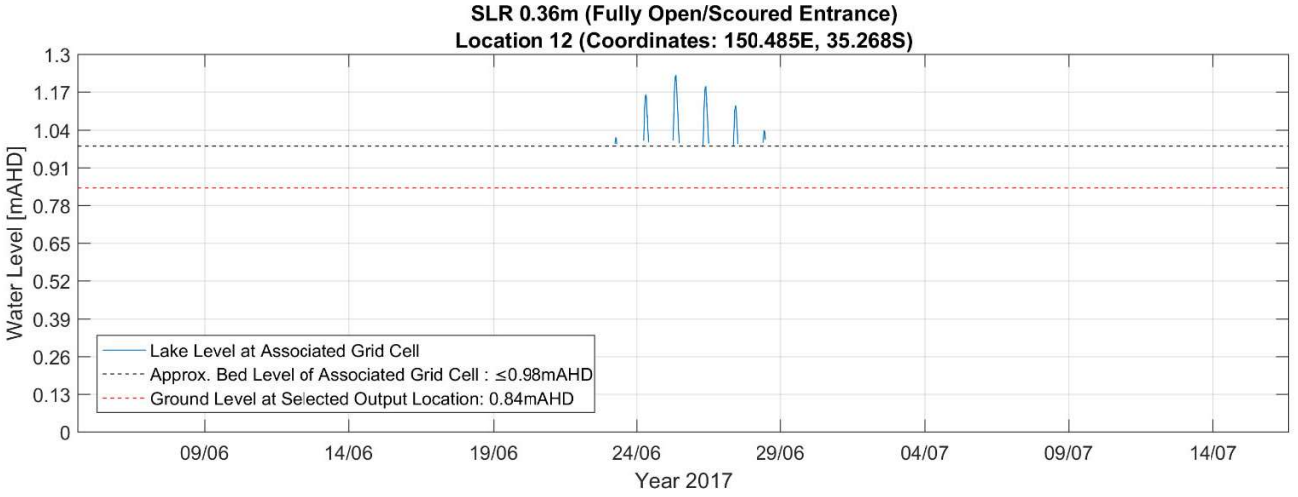

Tidal Inundation
Number of Occurrences [-]
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

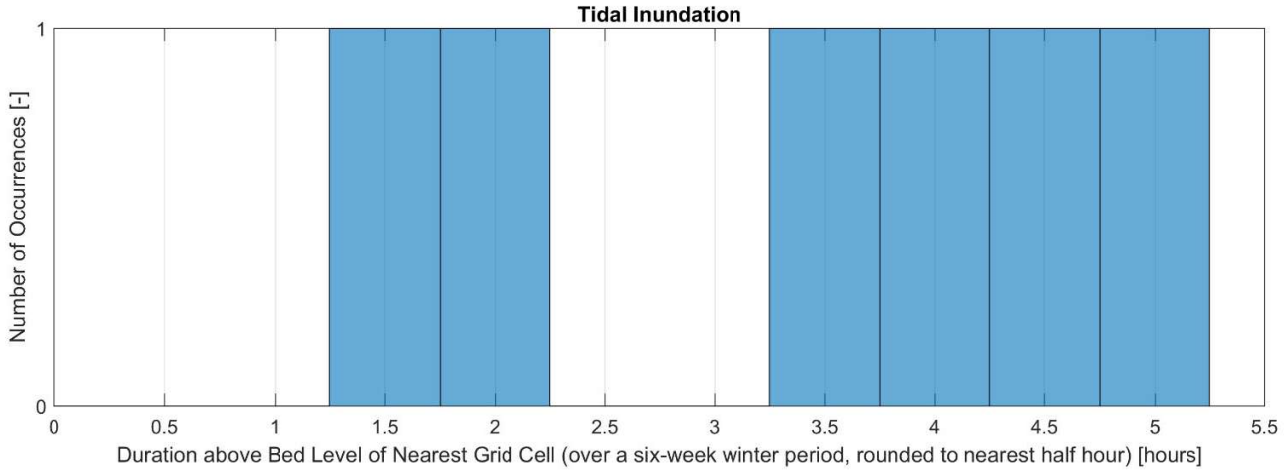

14
11
12
7
6
8
15
10
9

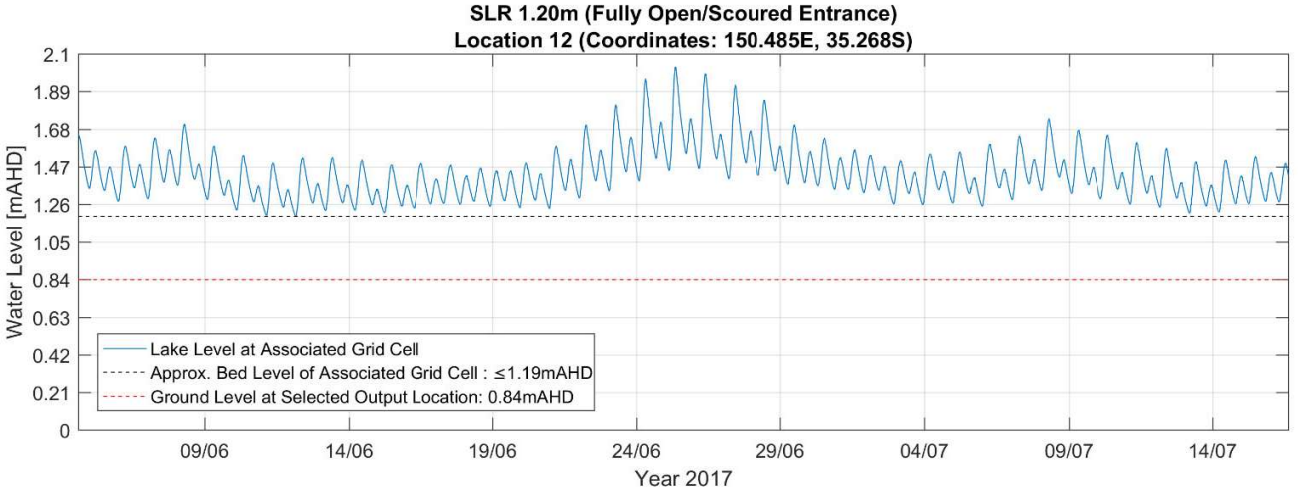
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.5	1
2.0	1
3.5	1
4.0	1
4.5	1
5.0	1

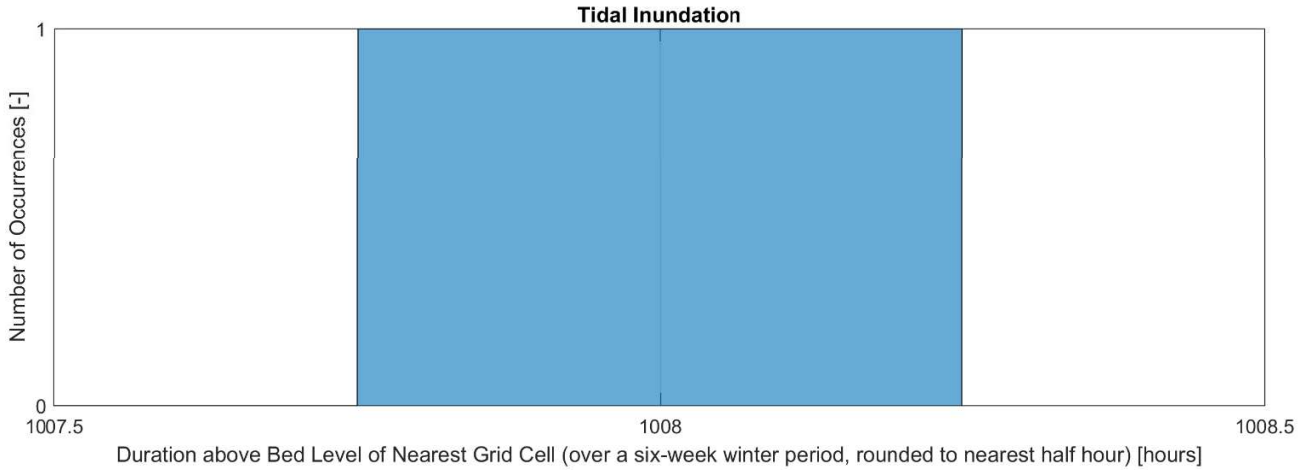
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
6	21
Average inundation duration during 6 week modelled period = total	
20.5 hours / 6 occurances	**3.4 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total*	
6 occurrence x 52 weeks (calendar) / 6 weeks (modelled)	**52 Occurrences per calendar year**

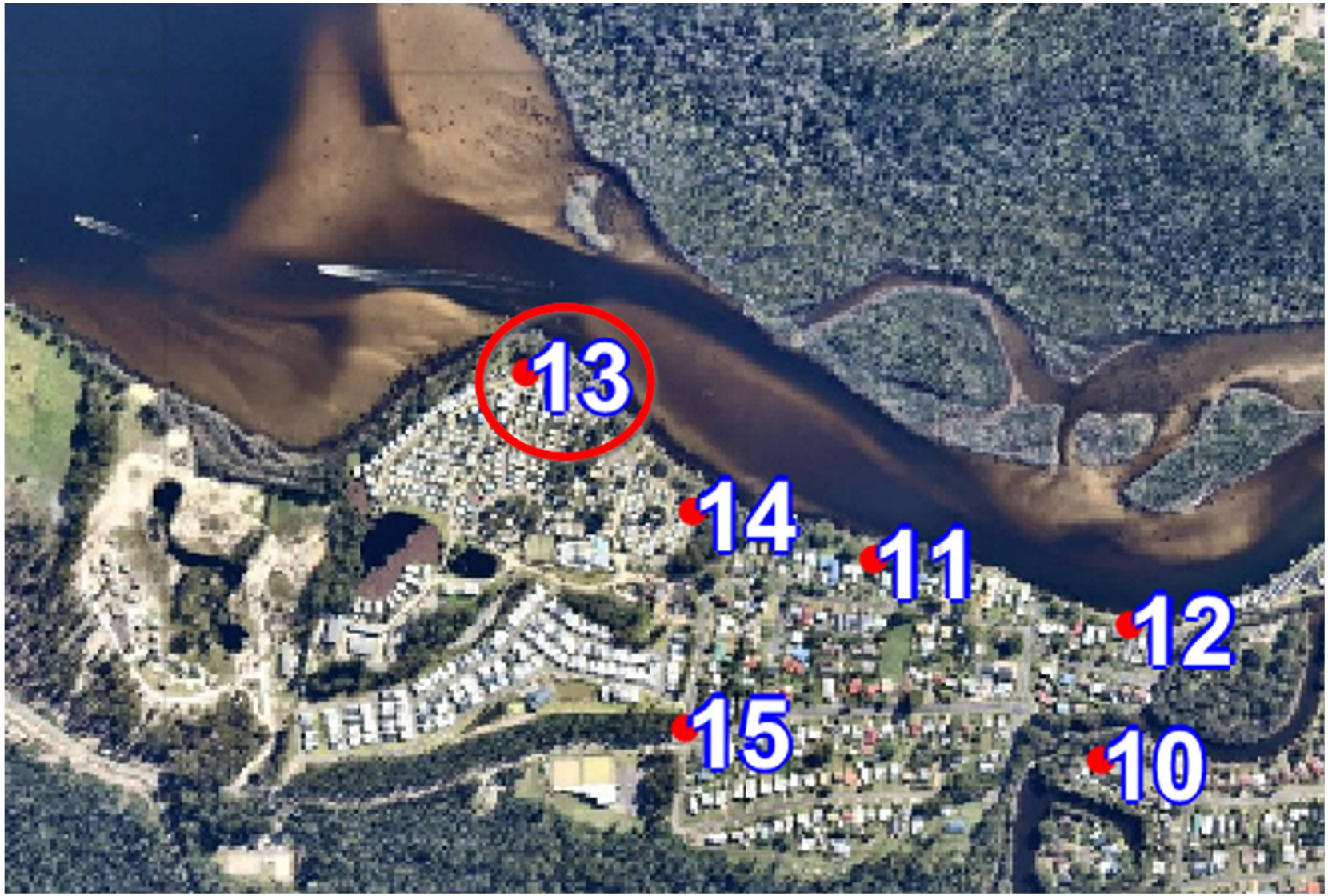
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always wet)	(always wet)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 12 (Coordinates: 150.485E, 35.268S)
Water Level [mAHD]
1.3
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤0.98mAHD
Ground Level at Selected Output Location: 0.84mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

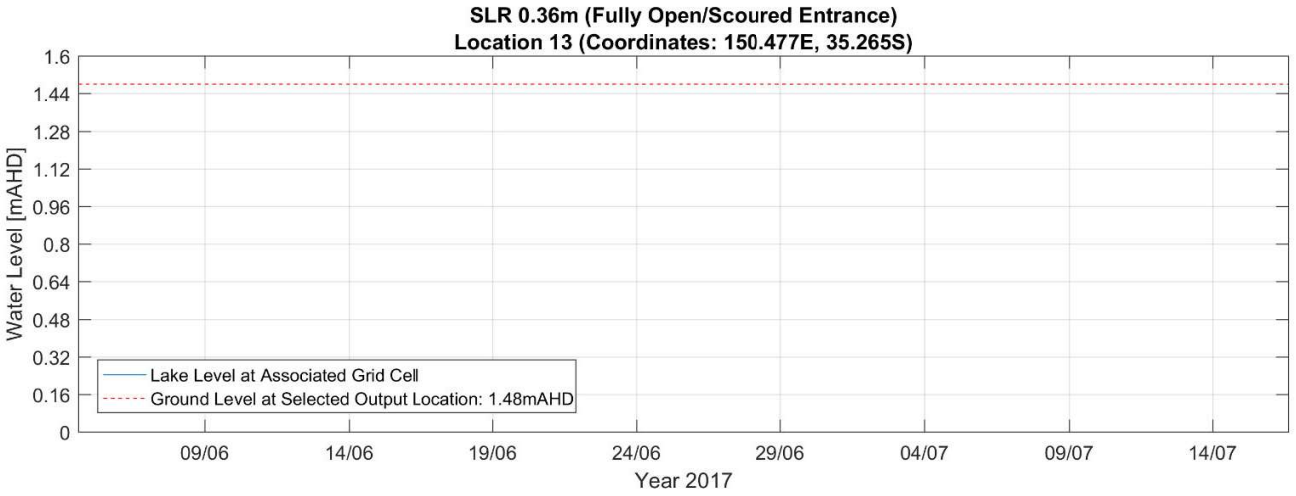

SLR 1.20m (Fully Open/Scoured Entrance)
Location 12 (Coordinates: 150.485E, 35.268S)
Water Level [mAHD]
2.1
1.89
1.68
1.47
1.26
1.05
0.84
0.63
0.42
0.21
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.19mAHD
Ground Level at Selected Output Location: 0.84mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

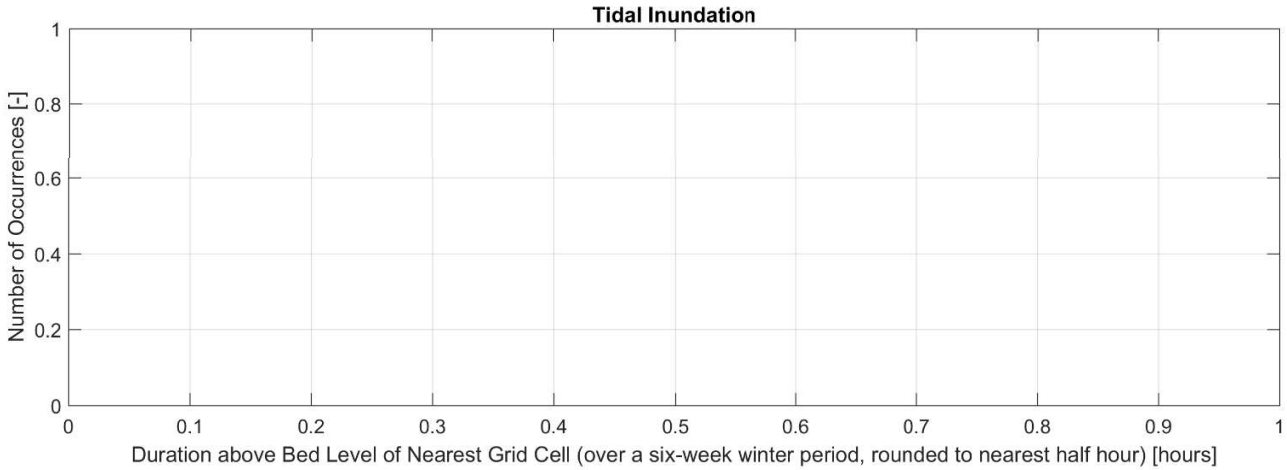

Tidal Inundation
Number of Occurrences [-]
1
0
1007.5
1008
1008.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

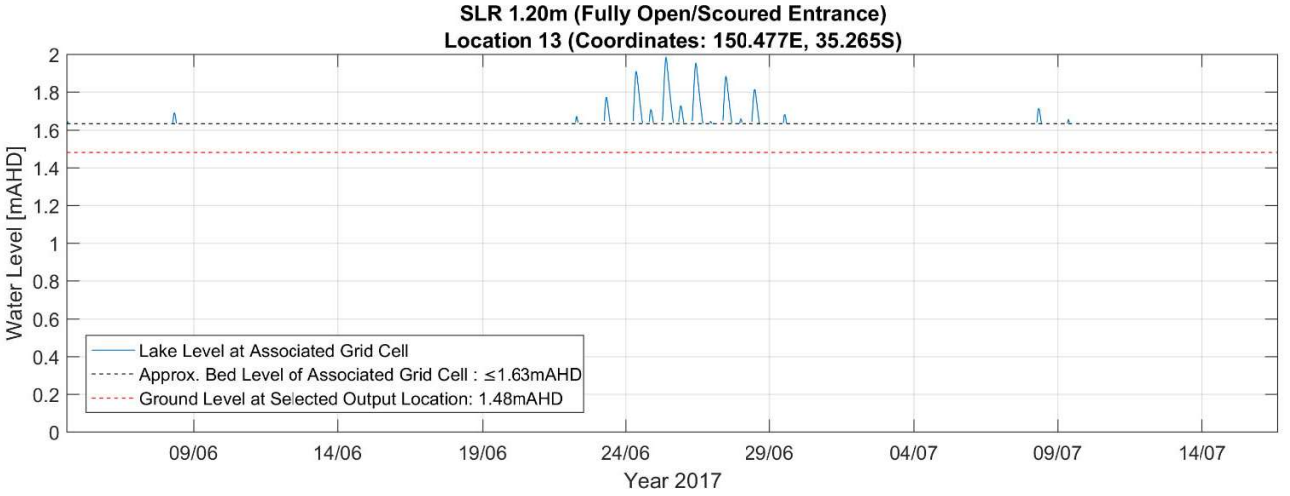

13
14
11
12
15
10

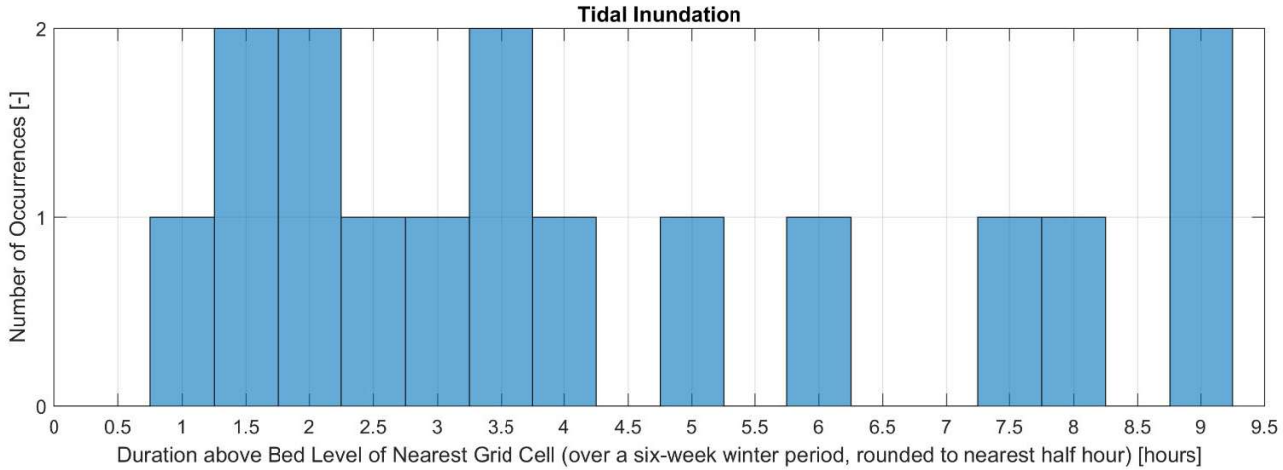
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

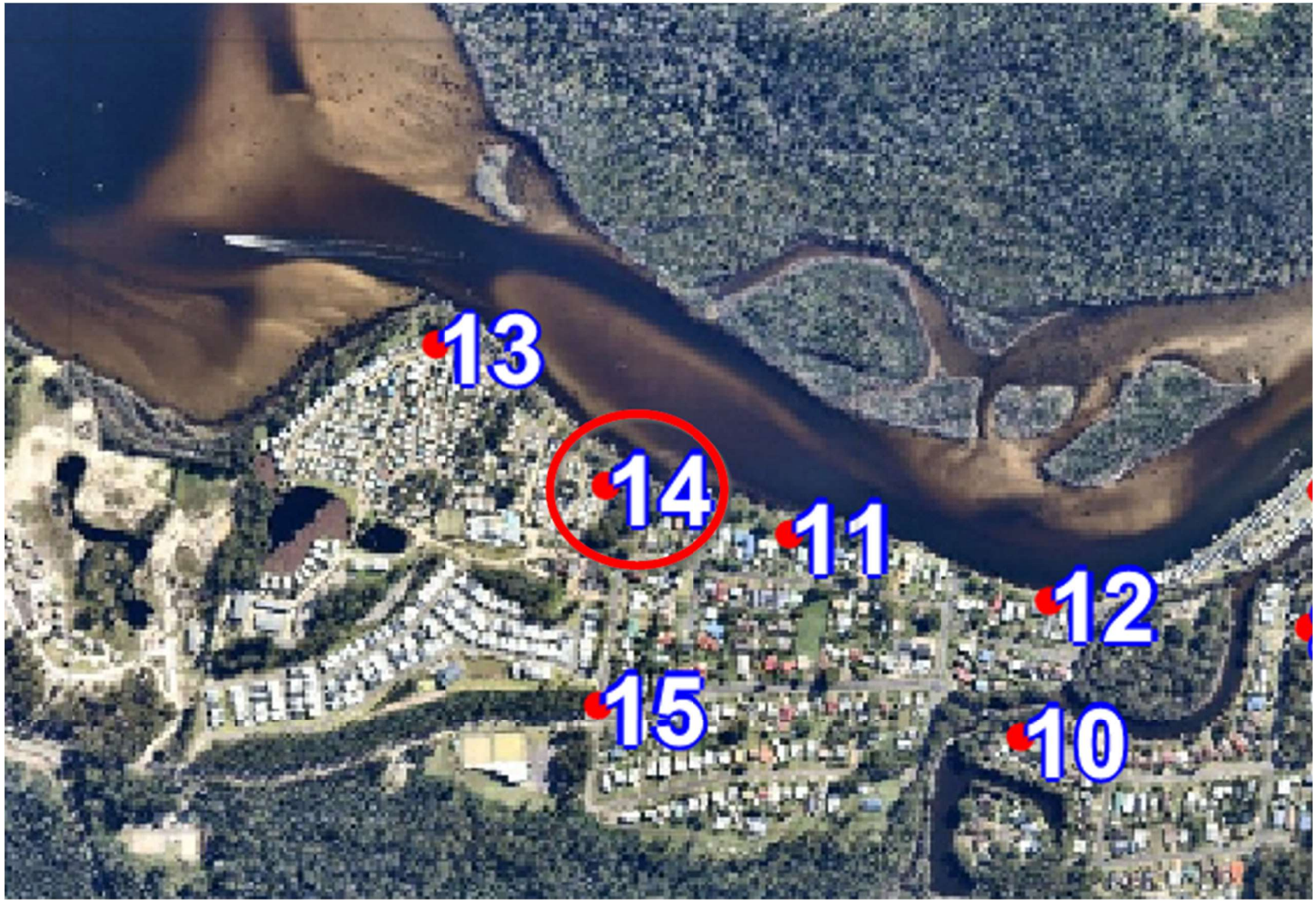
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.0	1
1.5	2
2.0	2
2.5	1
3.0	1
3.5	2
4.0	1
5.0	1
6.0	1
7.5	1
8.0	1
9.0	2
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
16	**69**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
69 hours / 16 occurances	**4.3 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
16 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**139 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 13 (Coordinates: 150.477E, 35.265S)
Water Level [mAHD]
1.6
1.44
1.28
1.12
0.96
0.8
0.64
0.48
0.32
0.16
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.48mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 13 (Coordinates: 150.477E, 35.265S)
Water Level [mAHD]
Year 2017
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.63mAHD
Ground Level at Selected Output Location: 1.48mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07

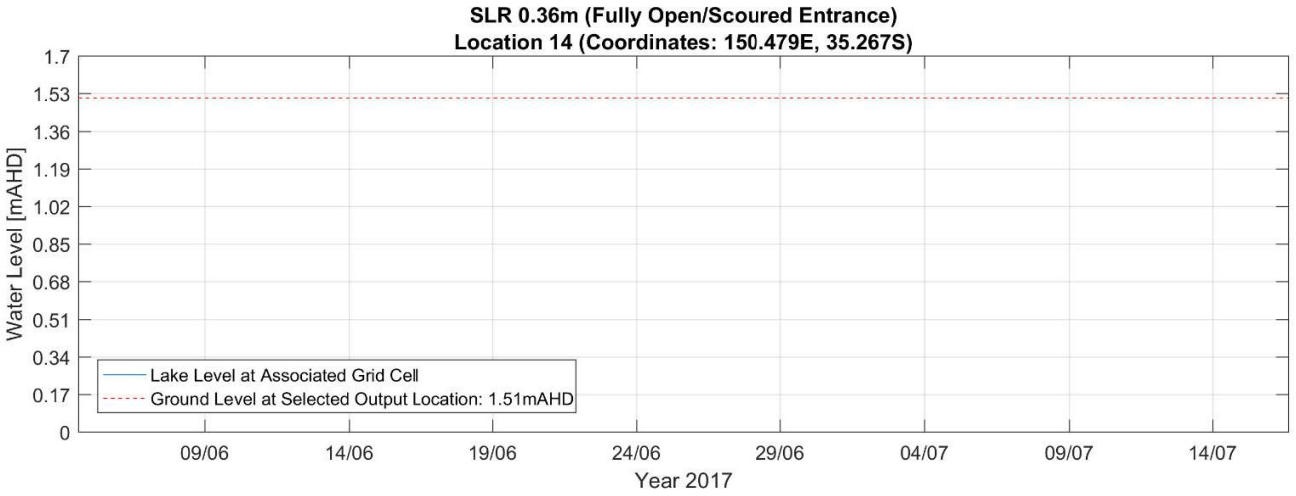

Tidal Inundation
Number of Occurrences [-]
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

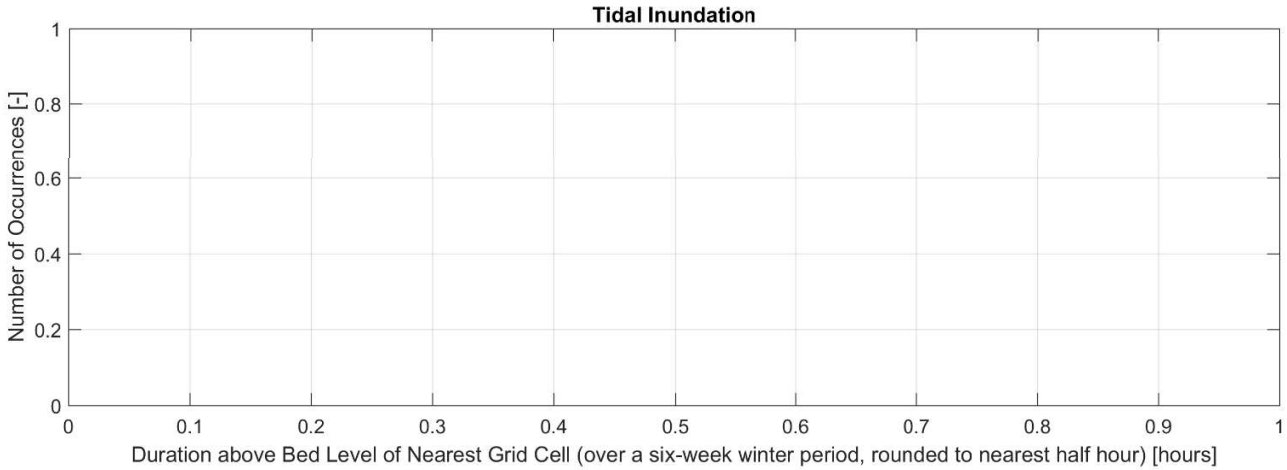

13
14
11
12
15
10

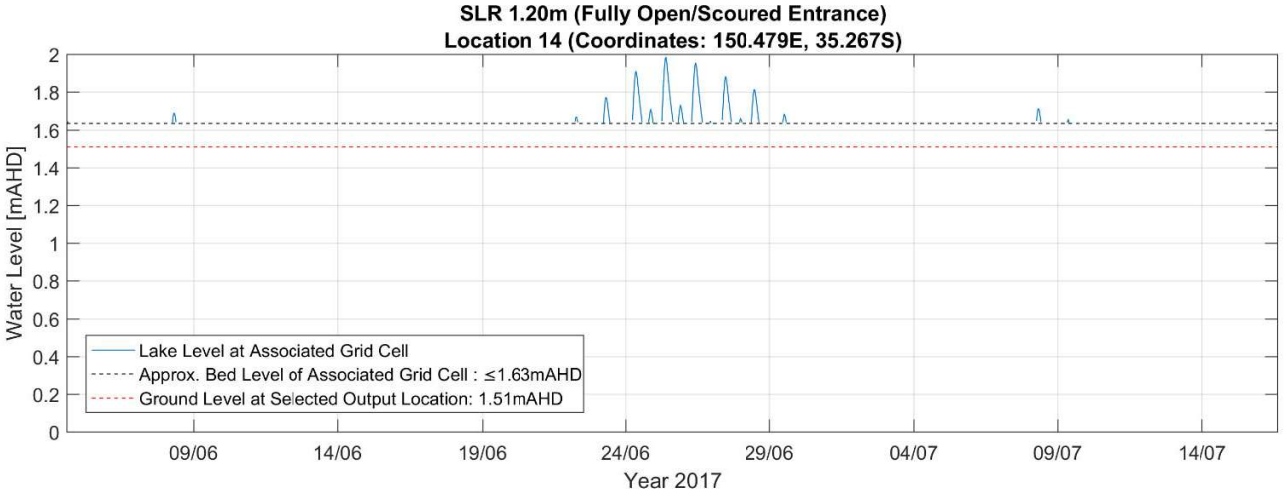
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

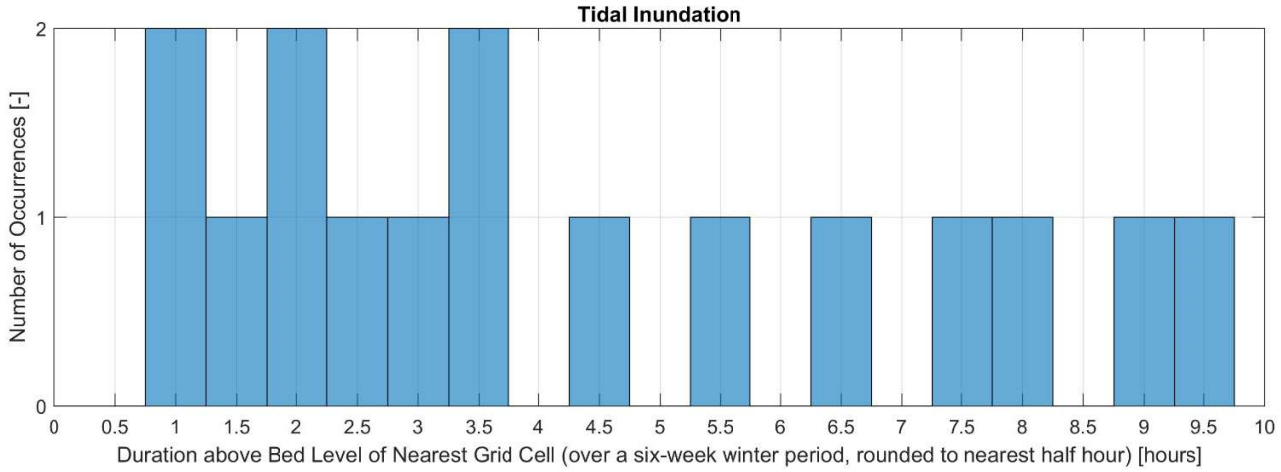
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.0	2
1.5	1
2.0	2
2.5	1
3.0	1
3.5	2
4.5	1
5.5	1
6.5	1
7.5	1
8.0	1
9.0	1
9.5	1

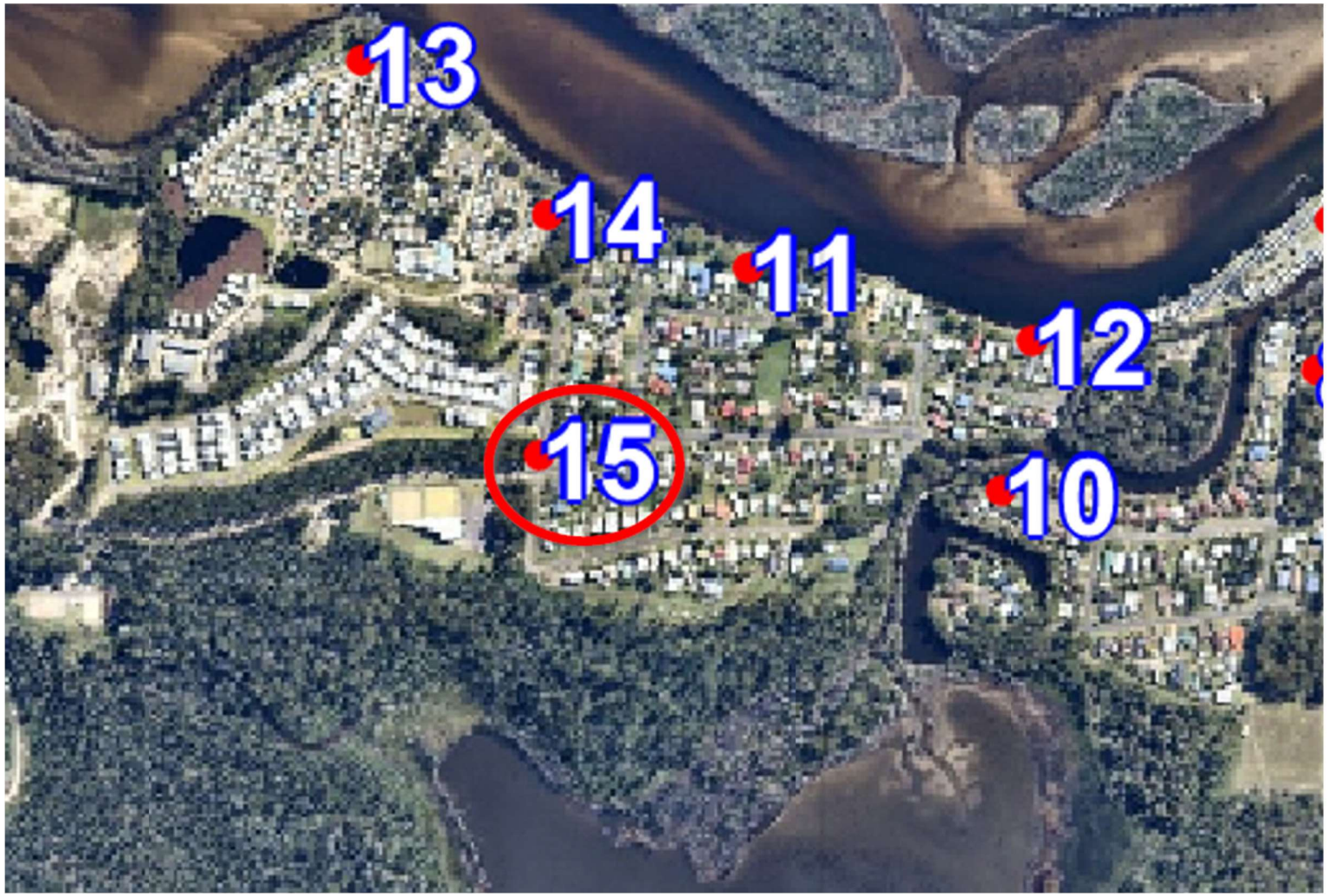
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
16	**71**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
70.5 hours / 16 occurances	**4.4 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
16 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**139 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 14 (Coordinates: 150.479E, 35.267S)
Water Level [mAHD]
1.7
1.53
1.36
1.19
1.02
0.85
0.68
0.51
0.34
0.17
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.51mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

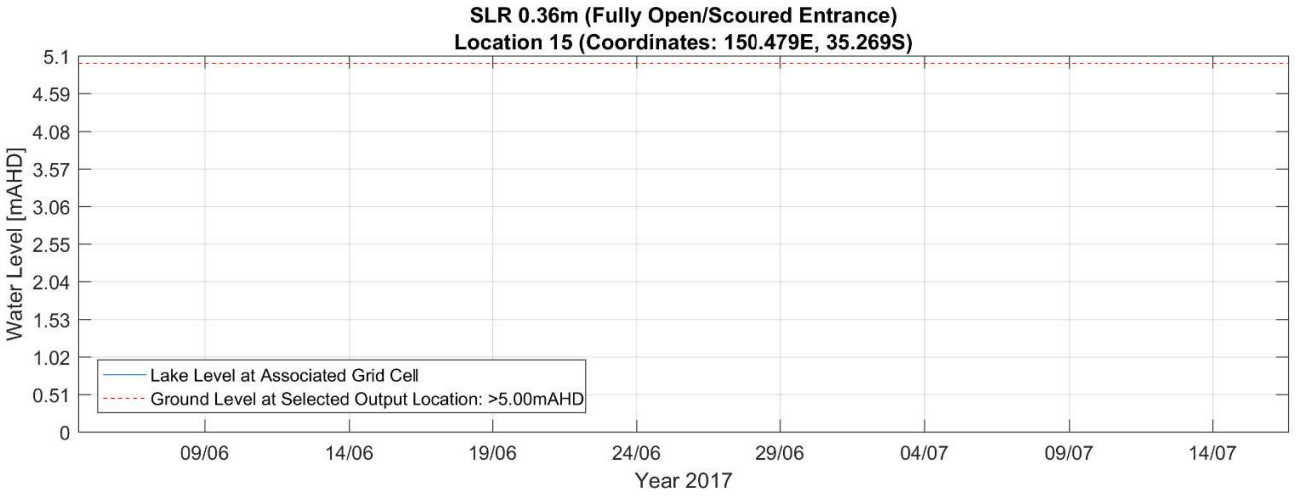

SLR 1.20m (Fully Open/Scoured Entrance)
Location 14 (Coordinates: 150.479E, 35.267S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.63mAHD
Ground Level at Selected Output Location: 1.51mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

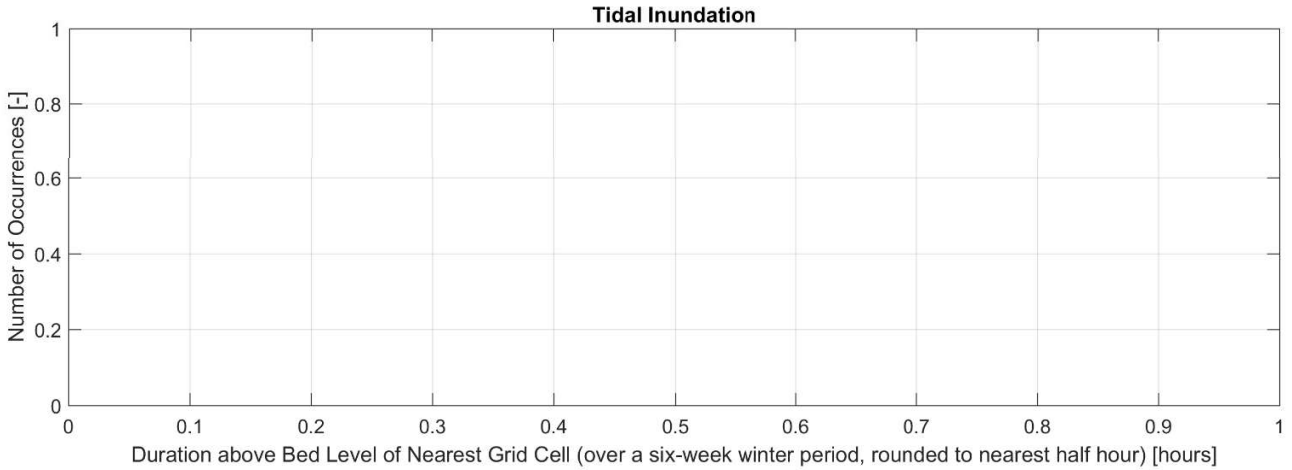

Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

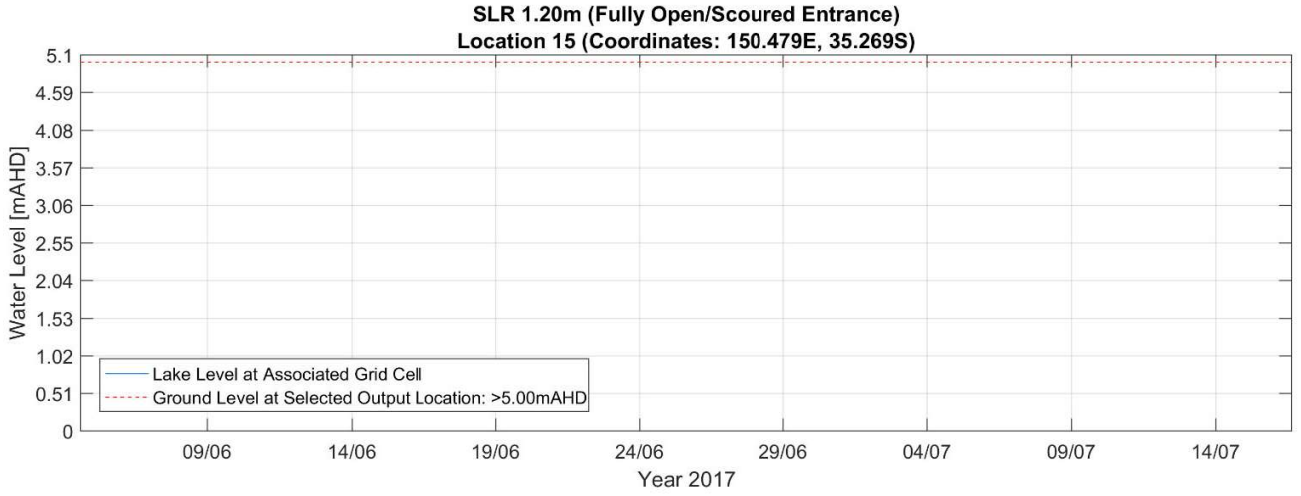

13
14
11
12
15
10

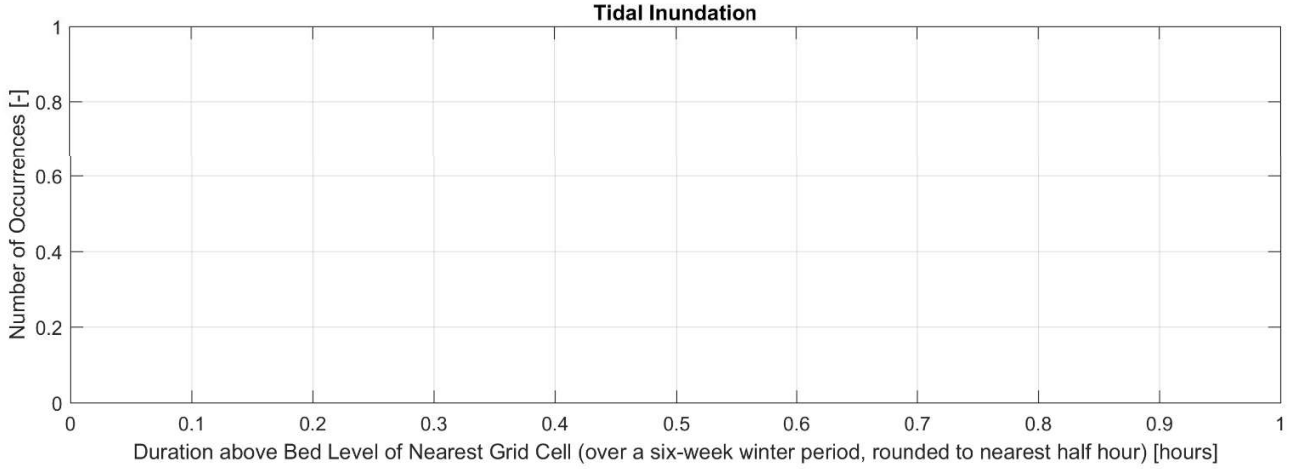
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 15 (Coordinates: 150.479E, 35.269S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

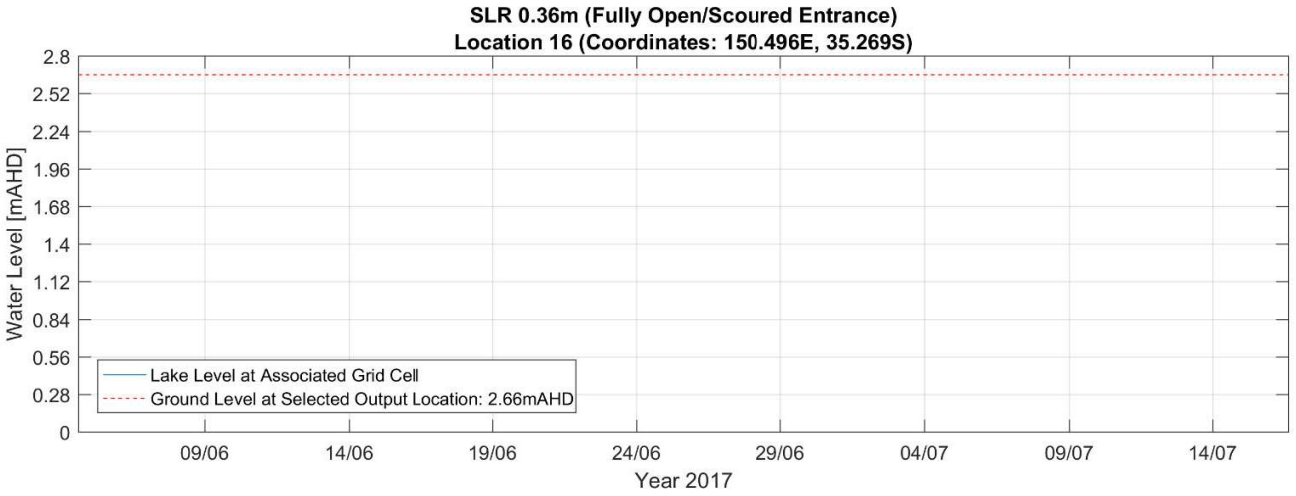

SLR 1.20m (Fully Open/Scoured Entrance)
Location 15 (Coordinates: 150.479E, 35.269S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

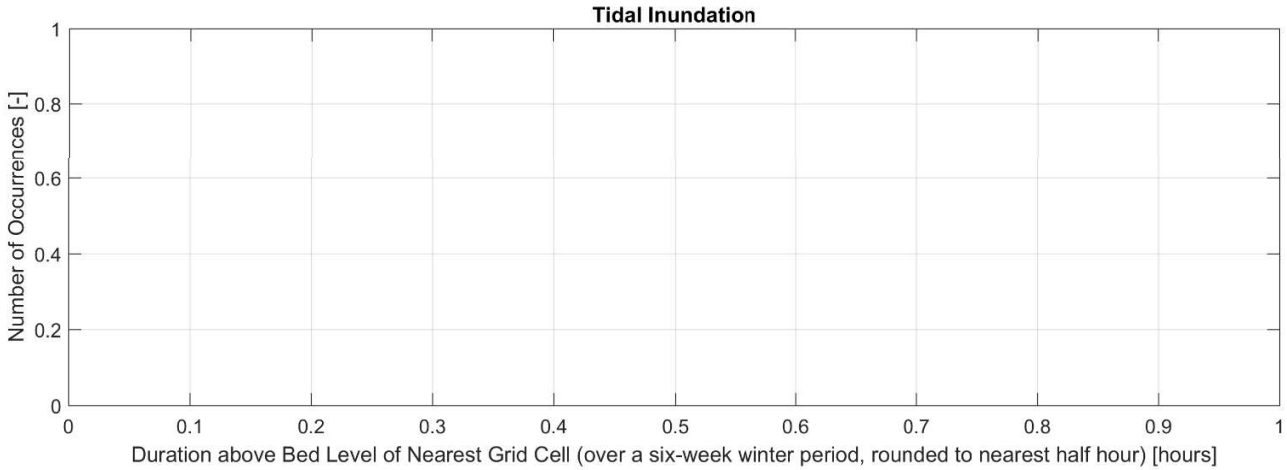

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

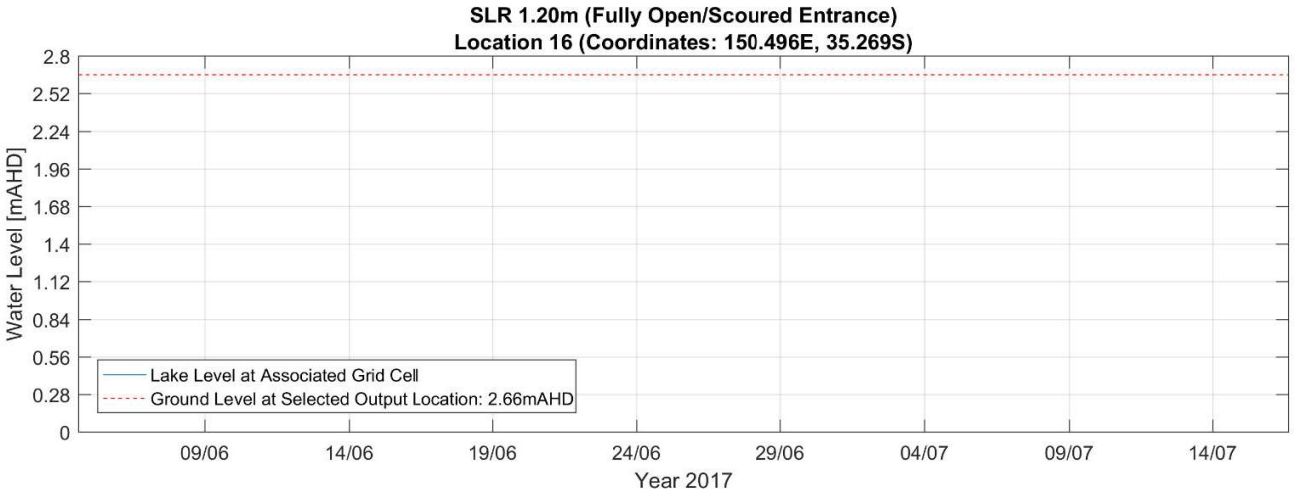

6
5
4
2
17
16
3
1
9

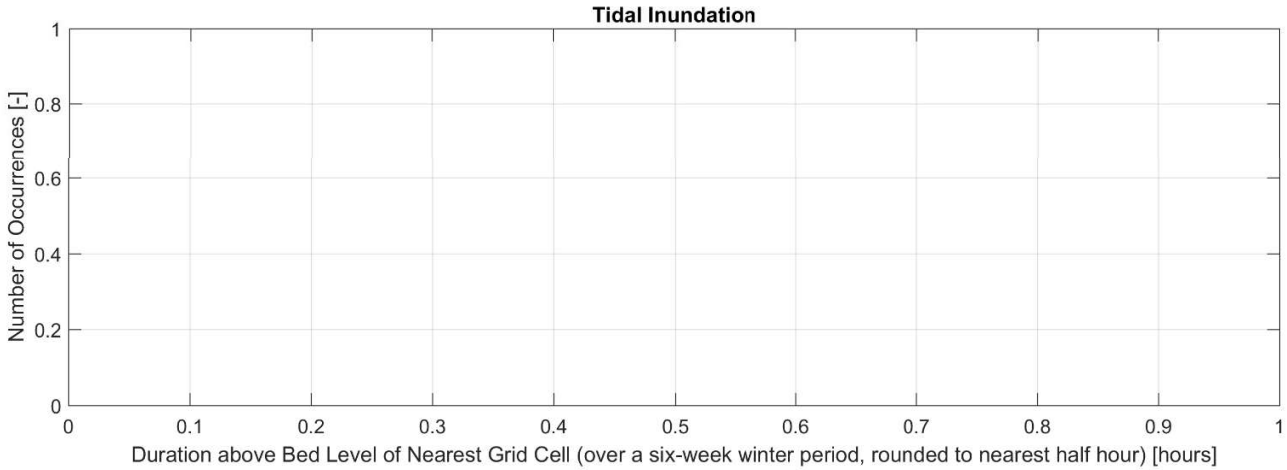
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

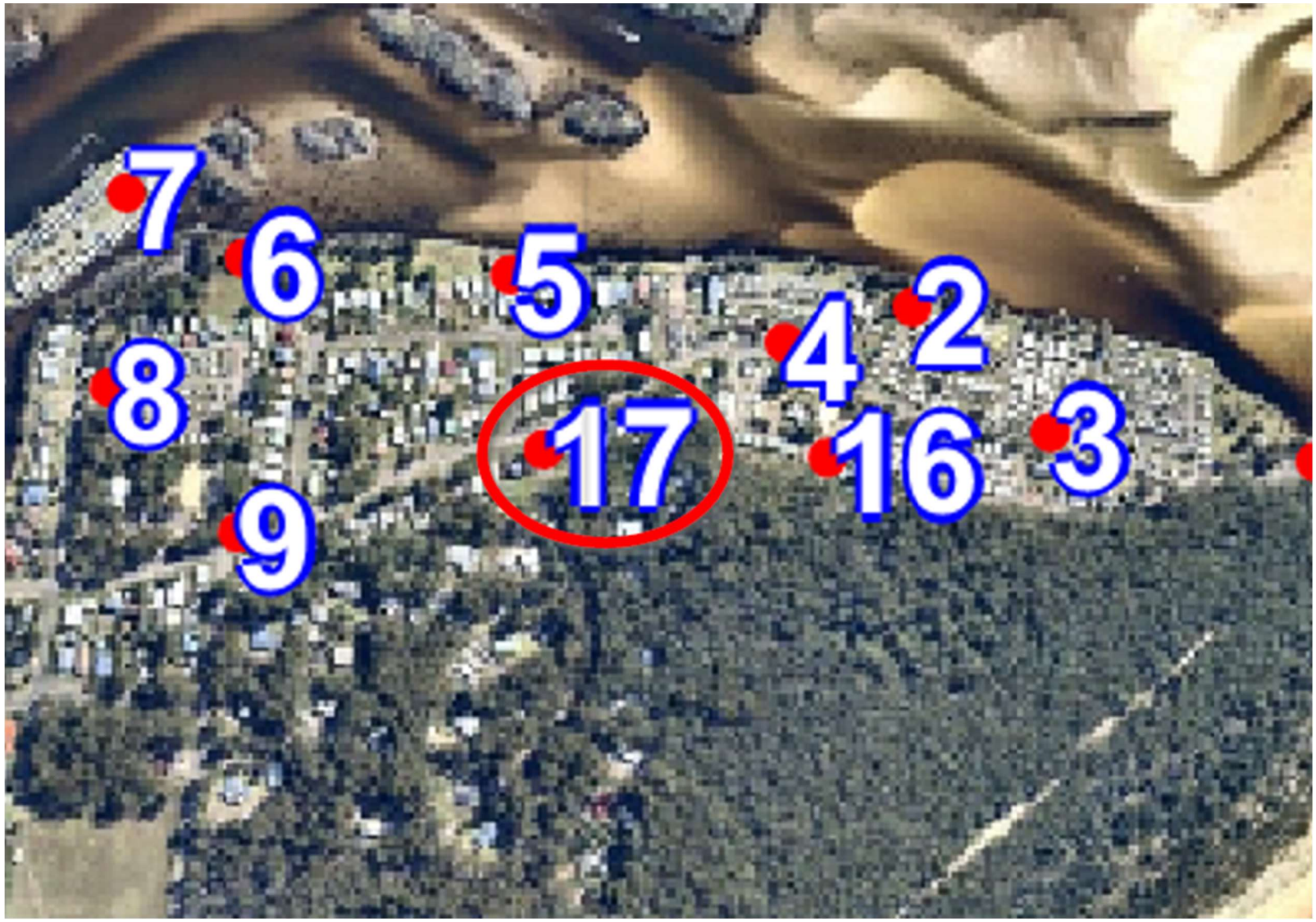
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 16 (Coordinates: 150.496E, 35.269S)
Water Level [mAHD]
2.8
2.52
2.24
1.96
1.68
1.4
1.12
0.84
0.56
0.28
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 2.66mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

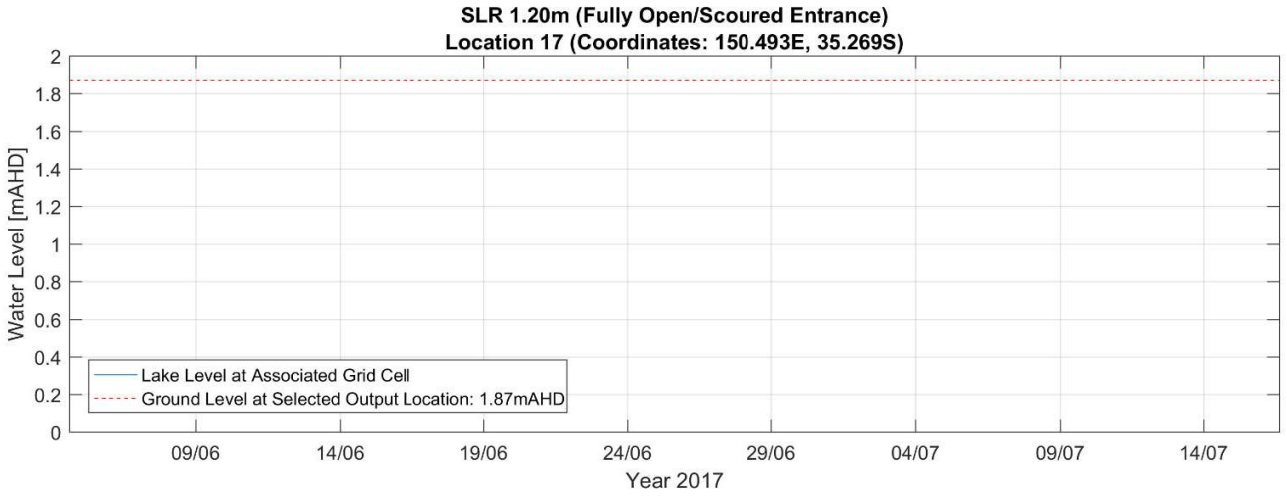

SLR 1.20m (Fully Open/Scoured Entrance)
Location 16 (Coordinates: 150.496E, 35.269S)
Water Level [mAHD]
2.8
2.52
2.24
1.96
1.68
1.4
1.12
0.84
0.56
0.28
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 2.66mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

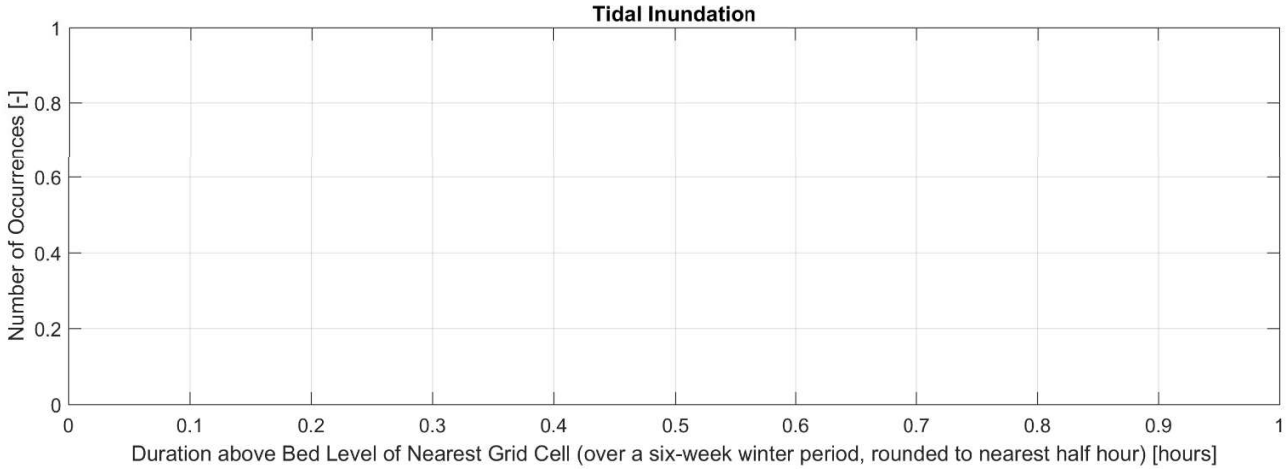

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

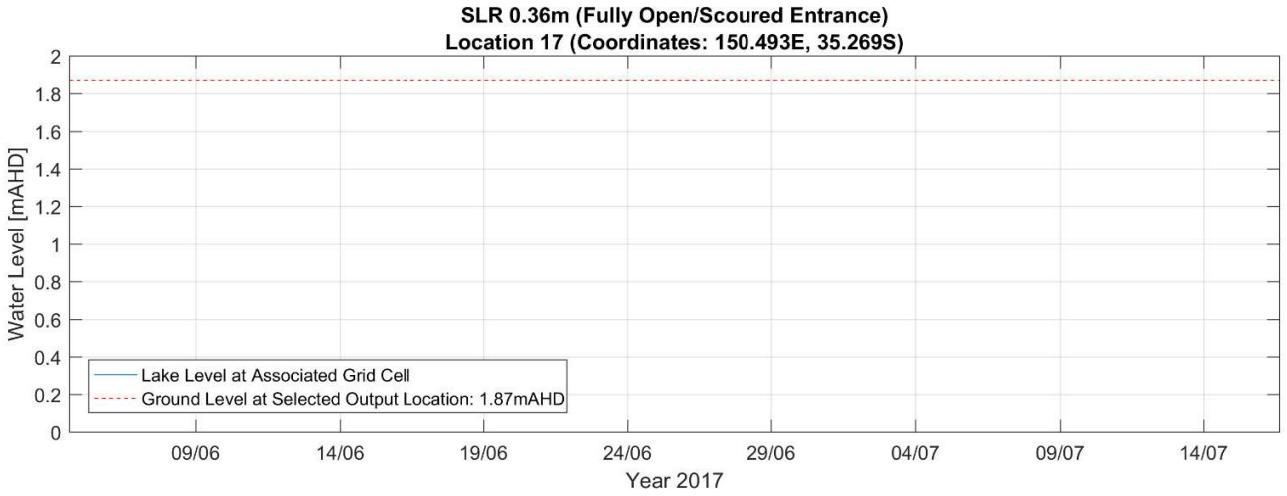

7
6
5
4
2
8
17
16
3
9

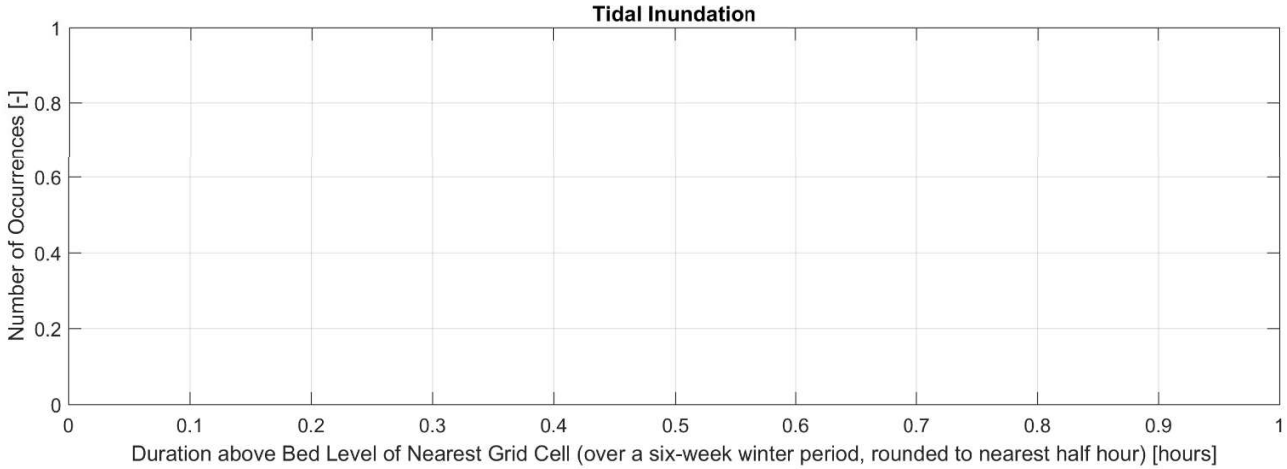
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 1.20m (Fully Open/Scoured Entrance)
Location 17 (Coordinates: 150.493E, 35.269S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.87mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

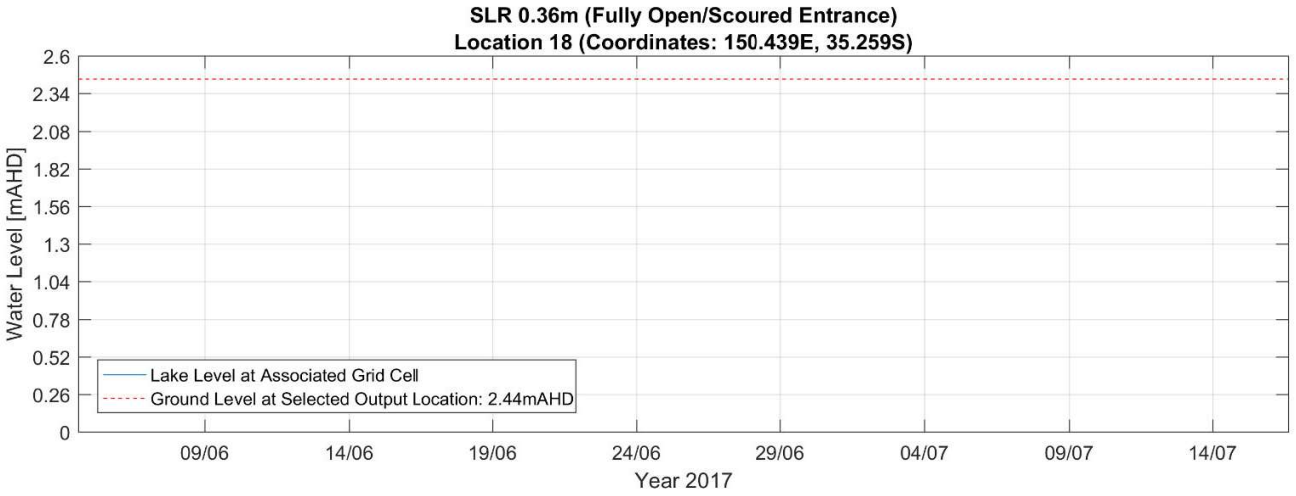

SLR 0.36m (Fully Open/Scoured Entrance)
Location 17 (Coordinates: 150.493E, 35.269S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.87mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

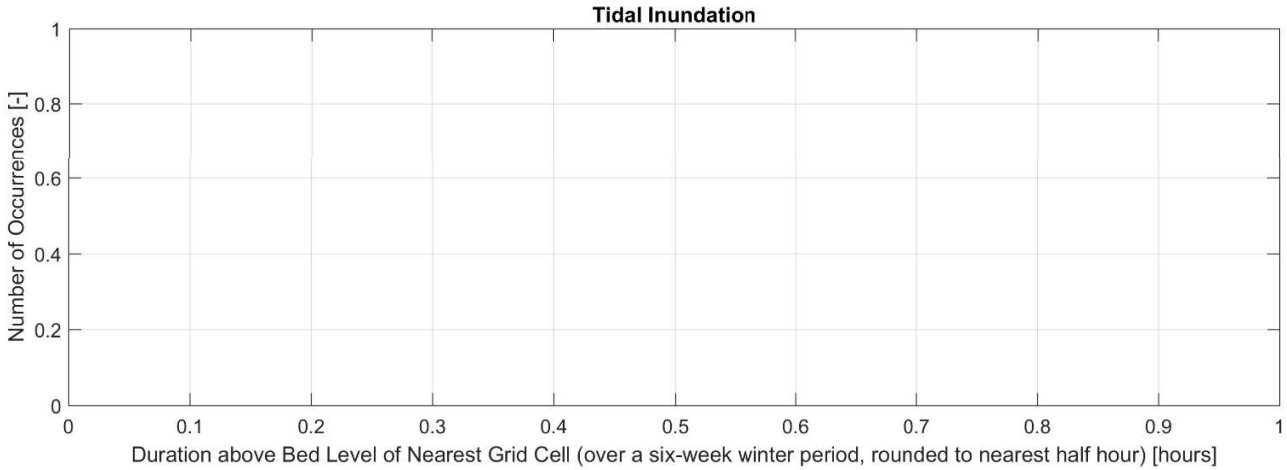

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

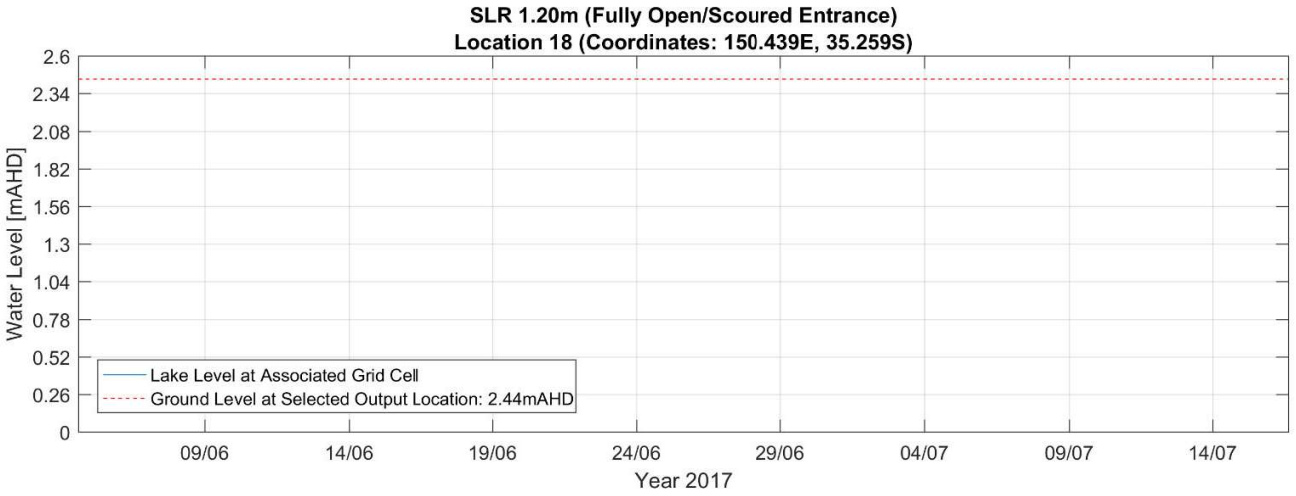

18
19
20

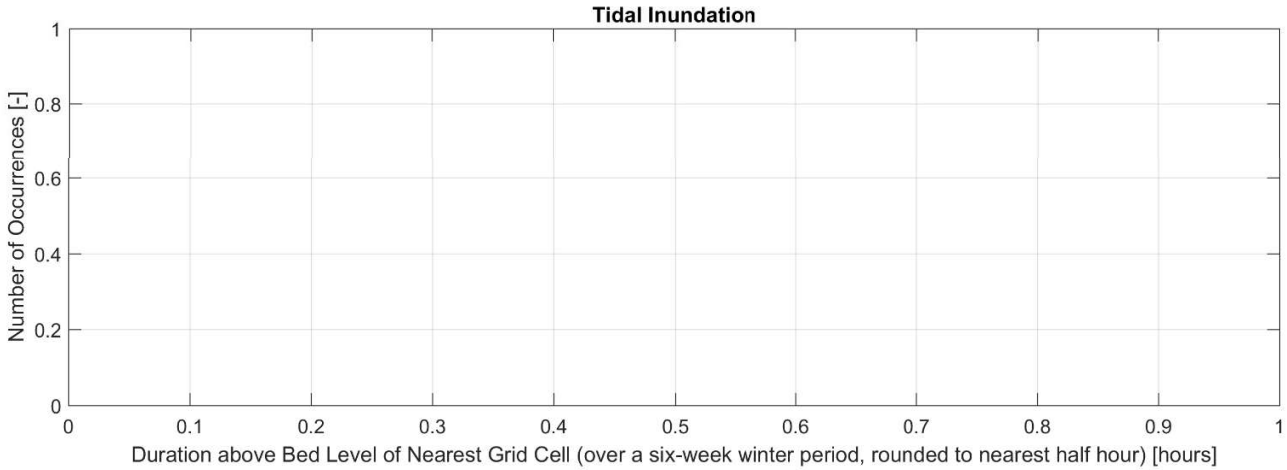
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 18 (Coordinates: 150.439E, 35.259S)
Water Level [mAHD]
2.6
2.34
2.08
1.82
1.56
1.3
1.04
0.78
0.52
0.26
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 2.44mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

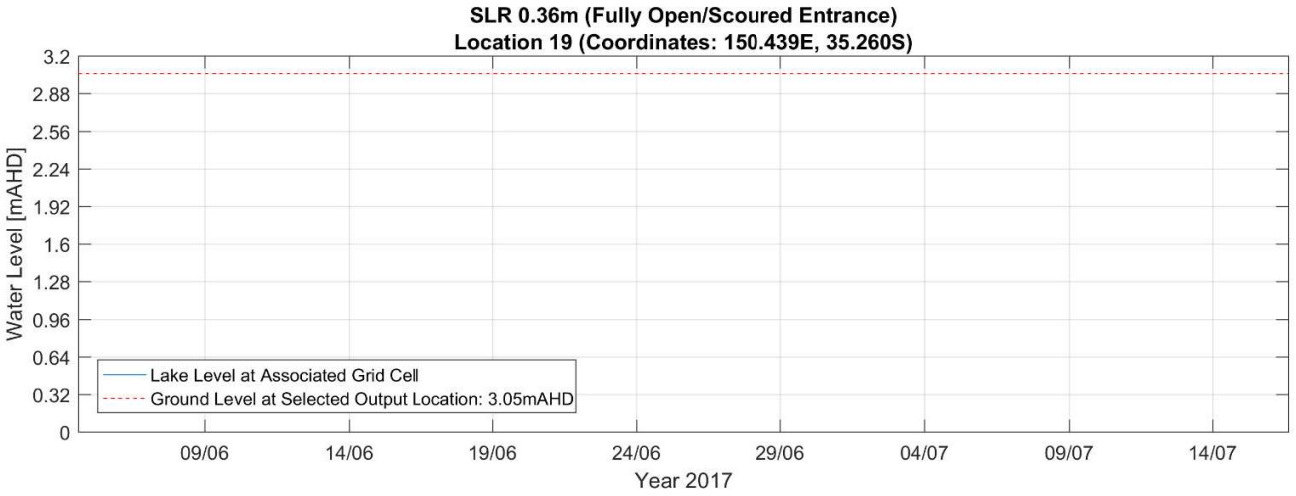

SLR 1.20m (Fully Open/Scoured Entrance)
Location 18 (Coordinates: 150.439E, 35.259S)
Water Level [mAHD]
2.6
2.34
2.08
1.82
1.56
1.3
1.04
0.78
0.52
0.26
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 2.44mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

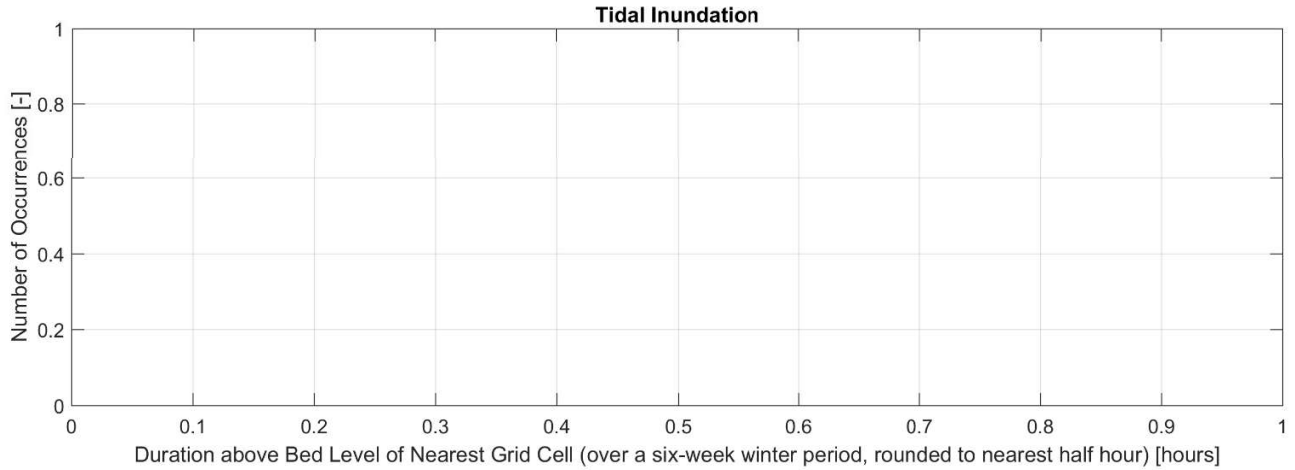

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

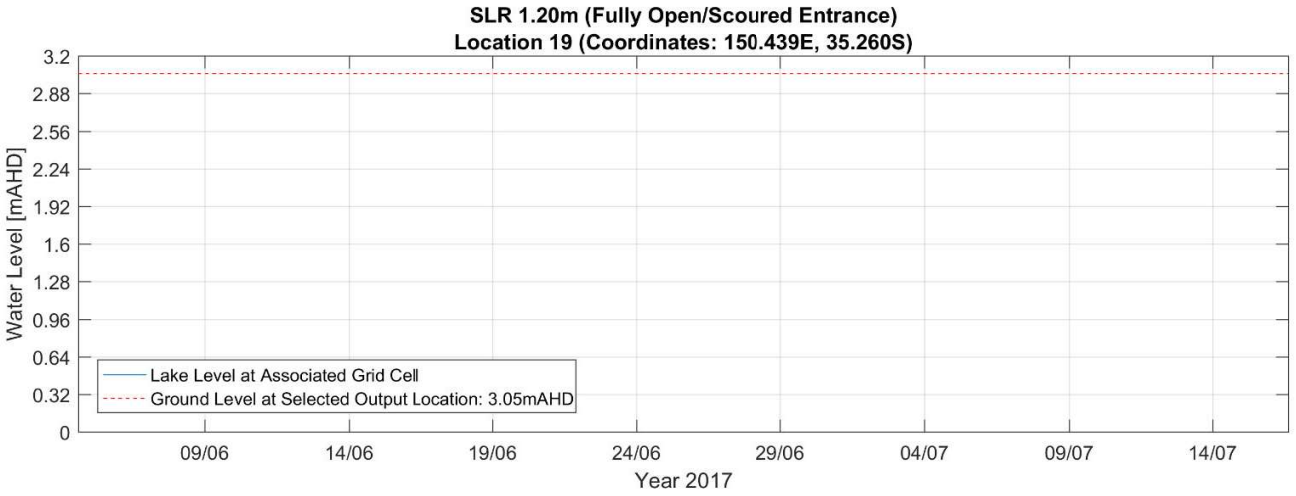

18
19
20

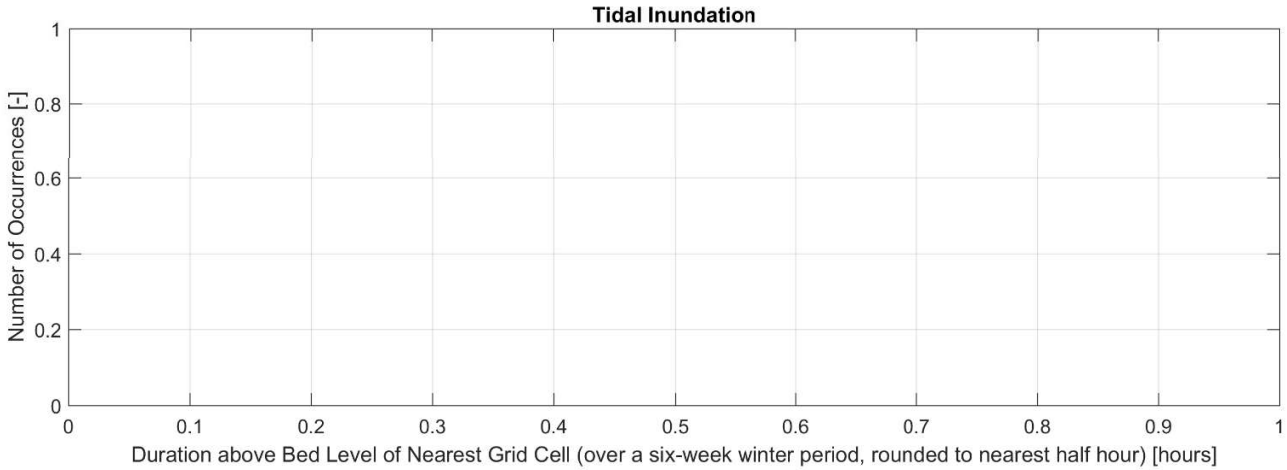
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

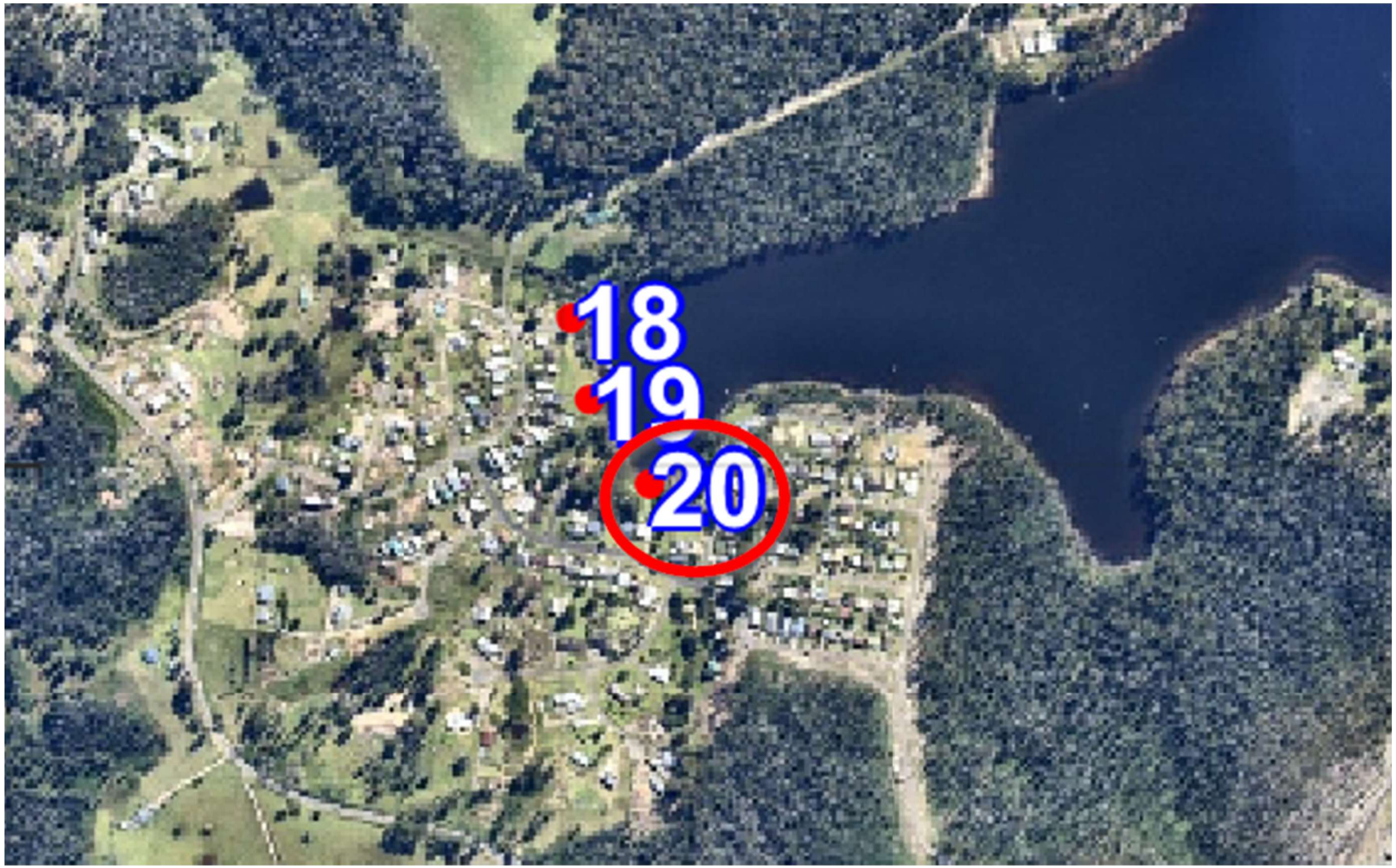
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 19 (Coordinates: 150.439E, 35.260S)
Water Level [mAHD]
3.2
2.88
2.56
2.24
1.92
1.6
1.28
0.96
0.64
0.32
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 3.05mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

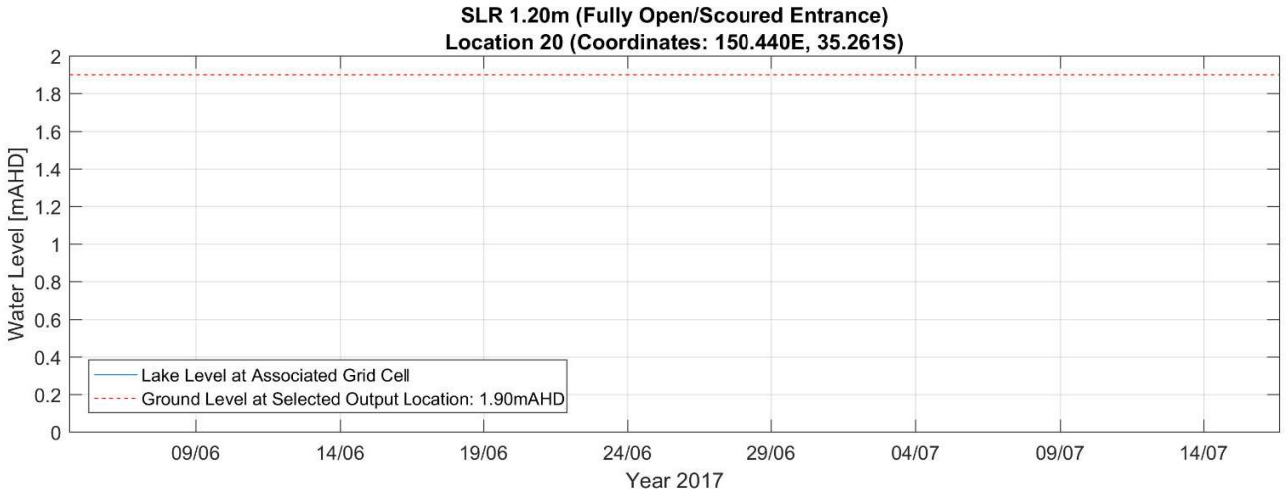

SLR 1.20m (Fully Open/Scoured Entrance)
Location 19 (Coordinates: 150.439E, 35.260S)
Water Level [mAHD]
3.2
2.88
2.56
2.24
1.92
1.6
1.28
0.96
0.64
0.32
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 3.05mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

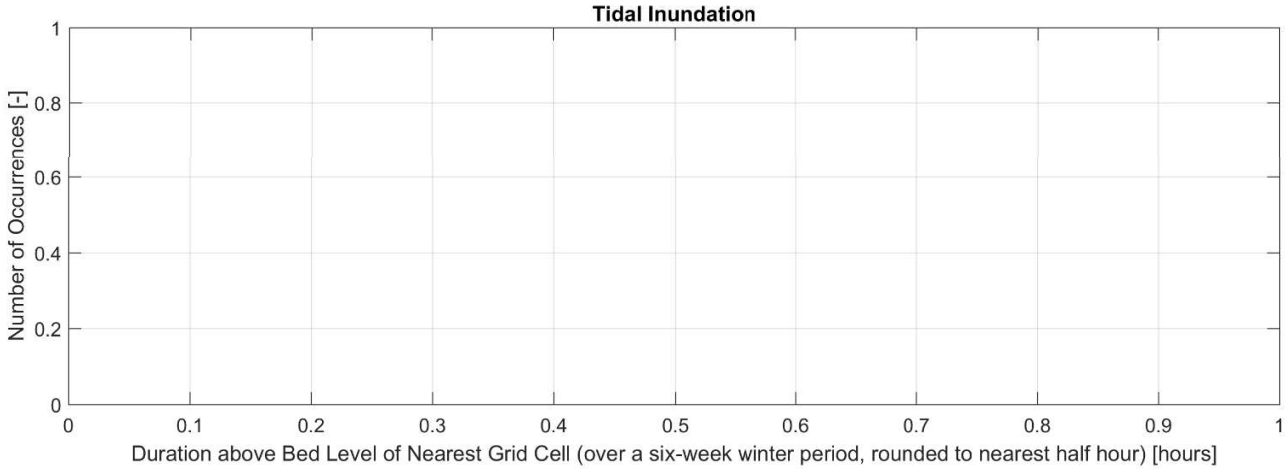

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

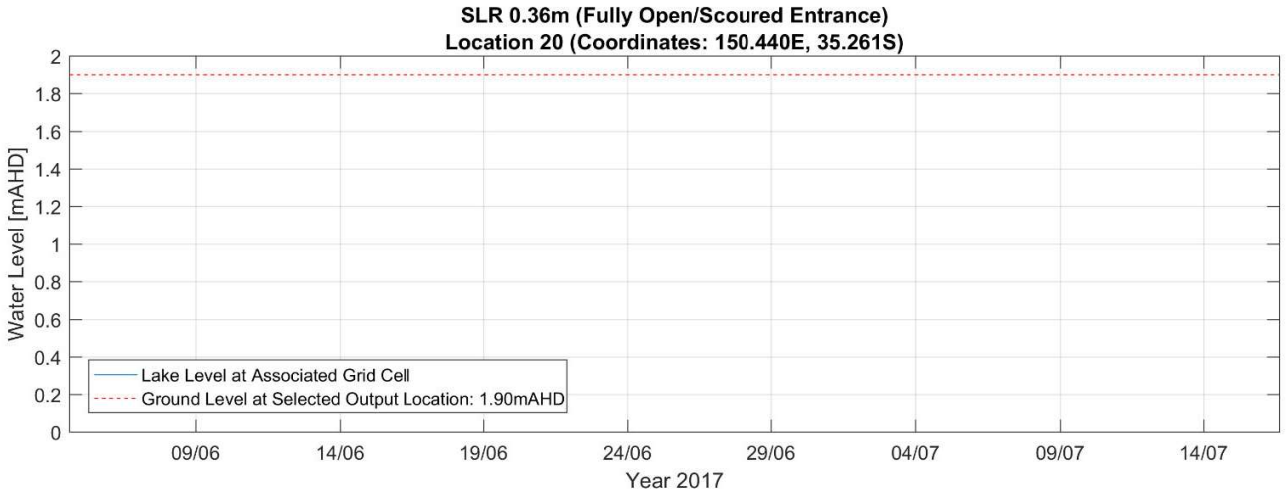

18
19
20

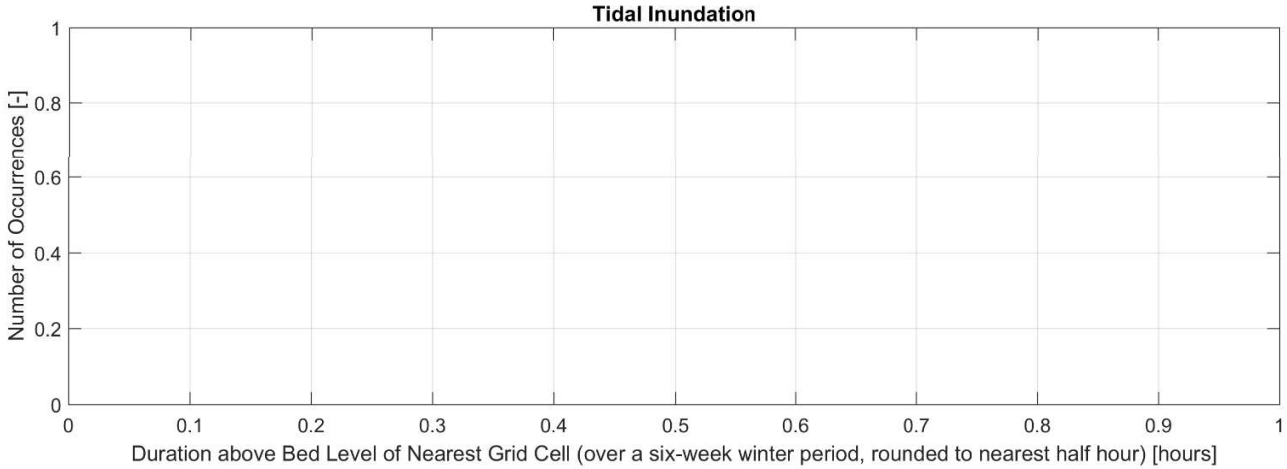
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 1.20m (Fully Open/Scoured Entrance)
Location 20 (Coordinates: 150.440E, 35.261S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.90mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

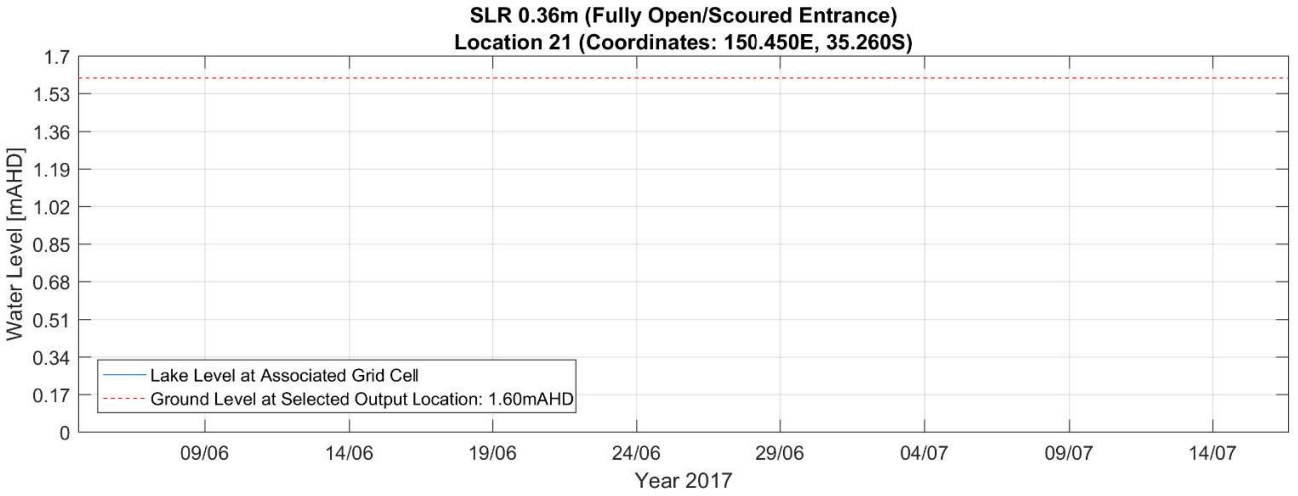

SLR 0.36m (Fully Open/Scoured Entrance)
Location 20 (Coordinates: 150.440E, 35.261S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.90mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

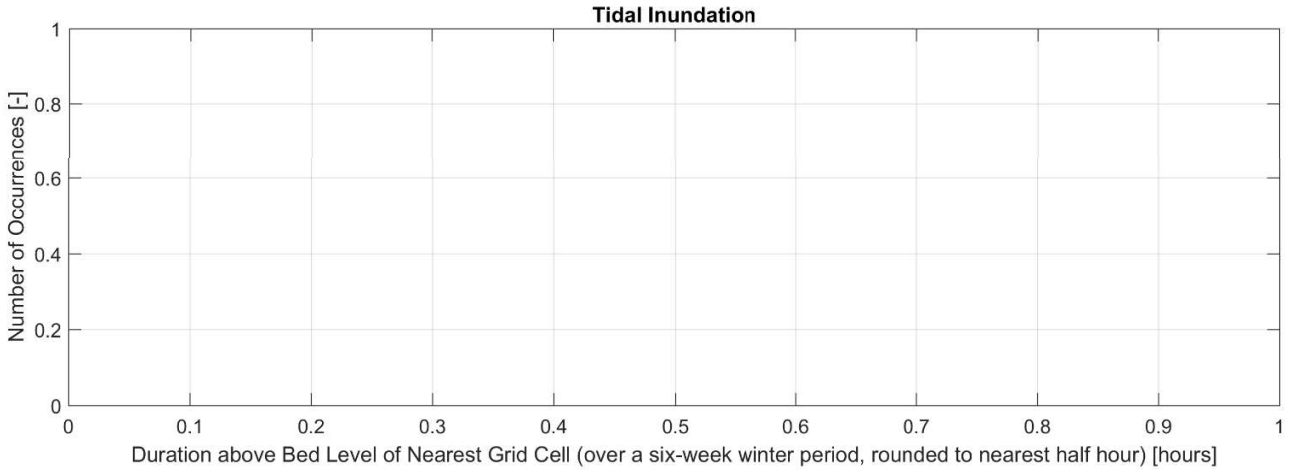

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

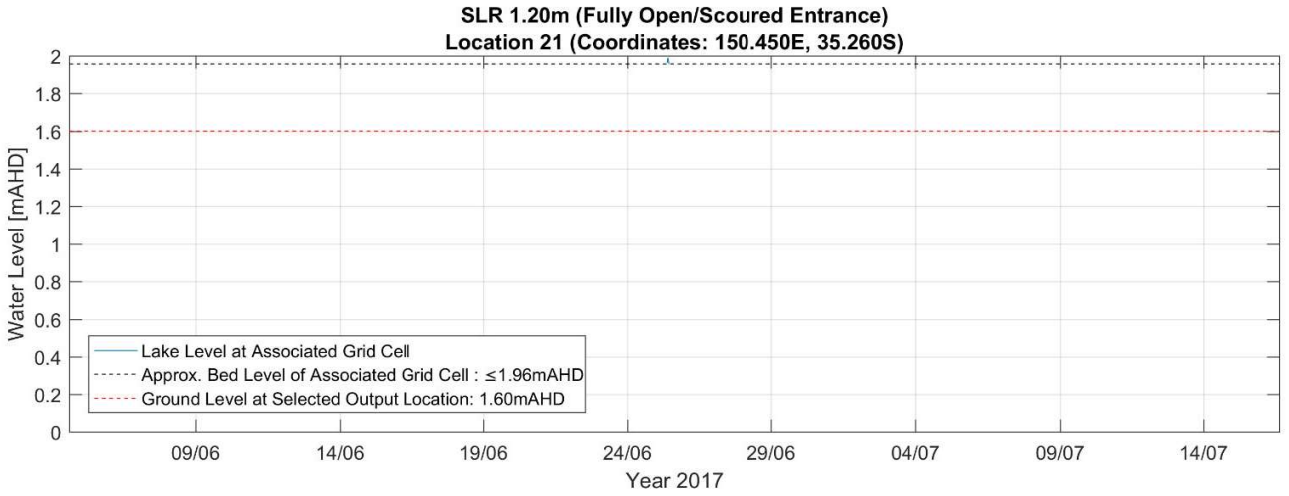

21

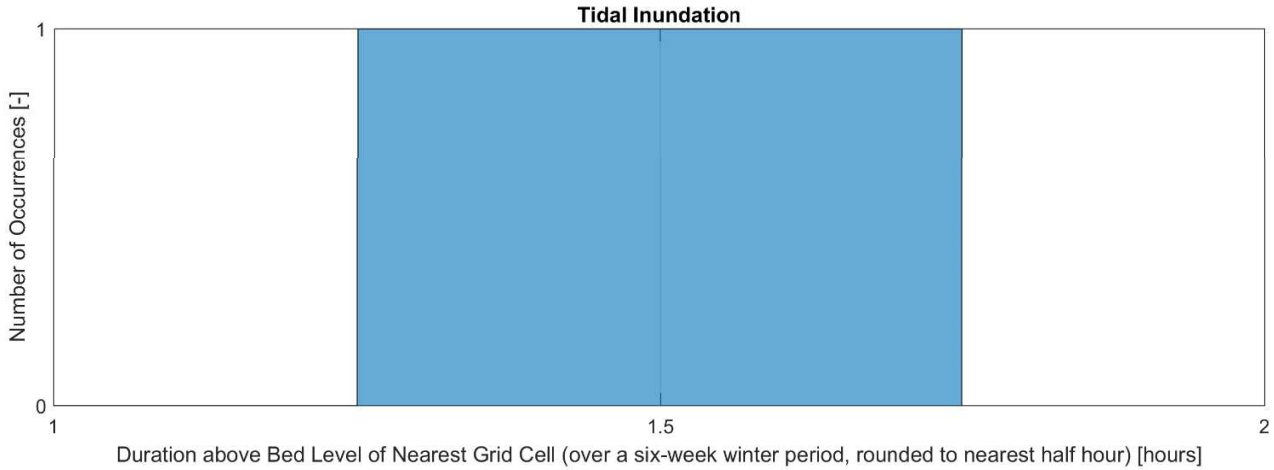
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
1.5	1
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
1	**1.5**
Average inundation duration during 6 week modelled period = total inundation	
1.5 hours / 1 occurances	**1.5 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
1 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**9 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 21 (Coordinates: 150.450E, 35.260S)
Water Level [mAHD]
1.7
1.53
1.36
1.19
1.02
0.85
0.68
0.51
0.34
0.17
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 1.60mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 21 (Coordinates: 150.450E, 35.260S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.96mAHD
Ground Level at Selected Output Location: 1.60mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

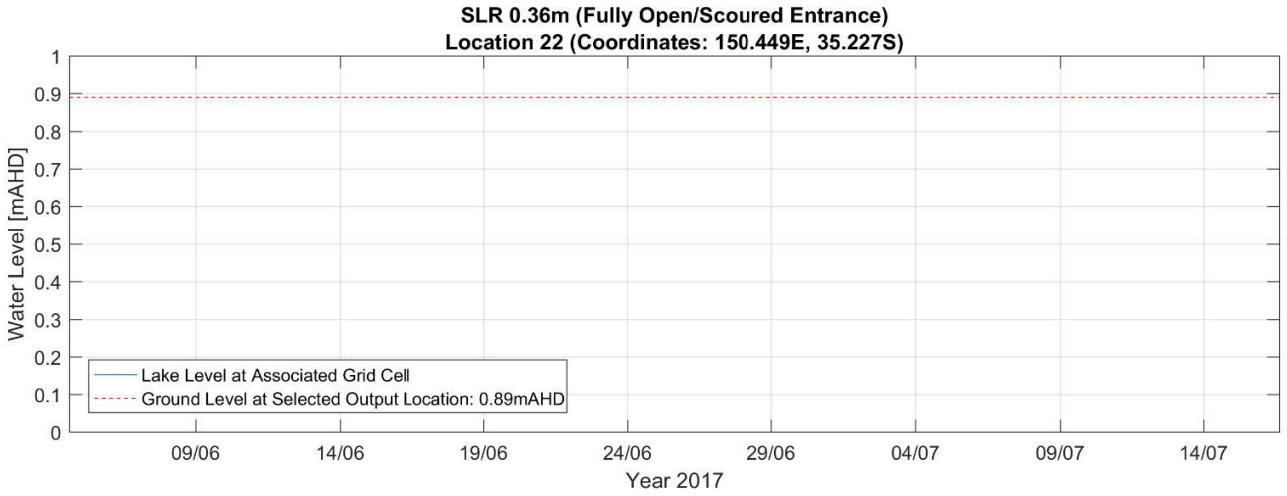

Tidal Inundation
Number of Occurrences [-]
1
0
1
1.5
2
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

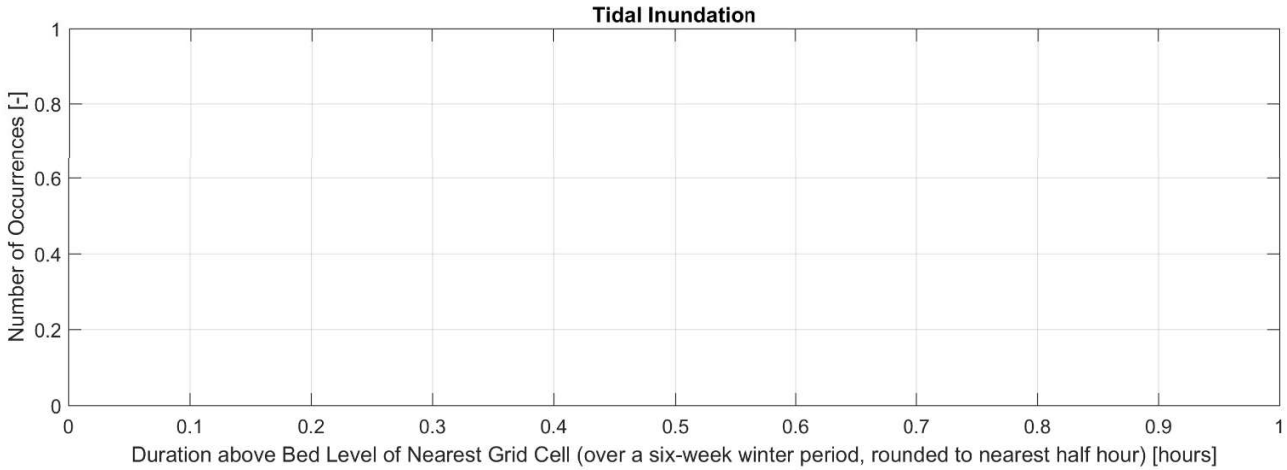

22
27
25
24
23

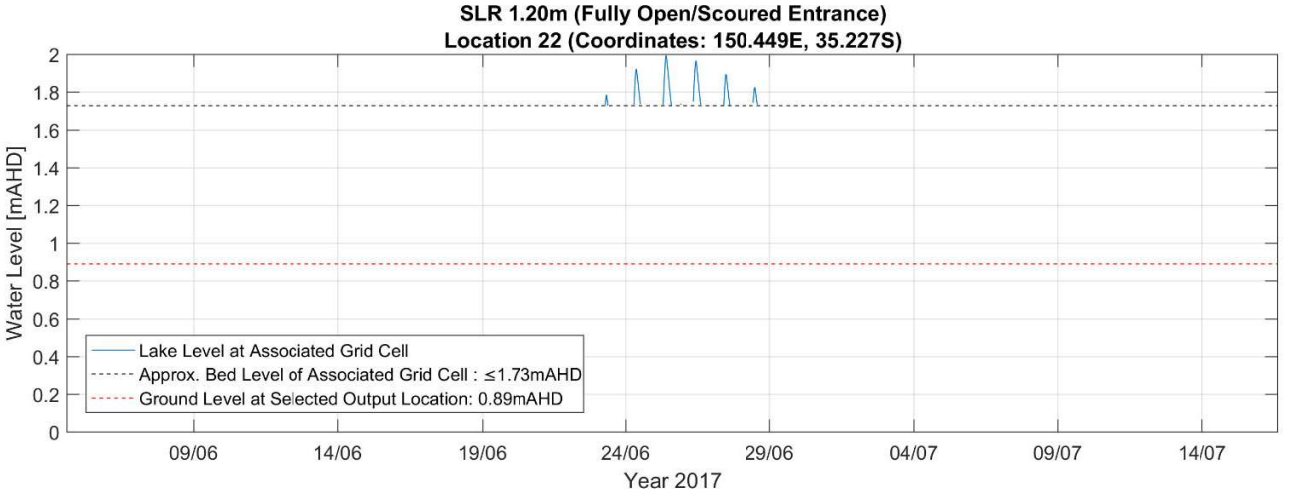
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

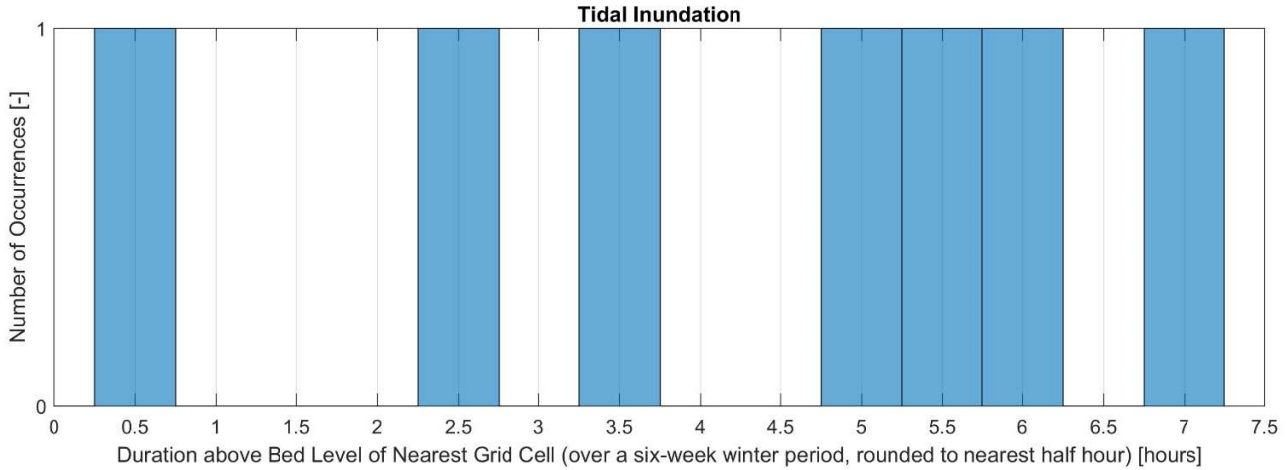
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
0.5	1
2.5	1
3.5	1
5.0	1
5.5	1
6.0	1
7.0	1

Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
7	**30**
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
30 hours / 7 occurances	**4.3 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
7 occurrences x 52 weeks (calendar) / 6 weeks (modelled)	**61 Occurrences per calendar year**


SLR 0.36m (Fully Open/Scoured Entrance)
Location 22 (Coordinates: 150.449E, 35.227S)
Water Level [mAHD]
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: 0.89mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 22 (Coordinates: 150.449E, 35.227S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.73mAHD
Ground Level at Selected Output Location: 0.89mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

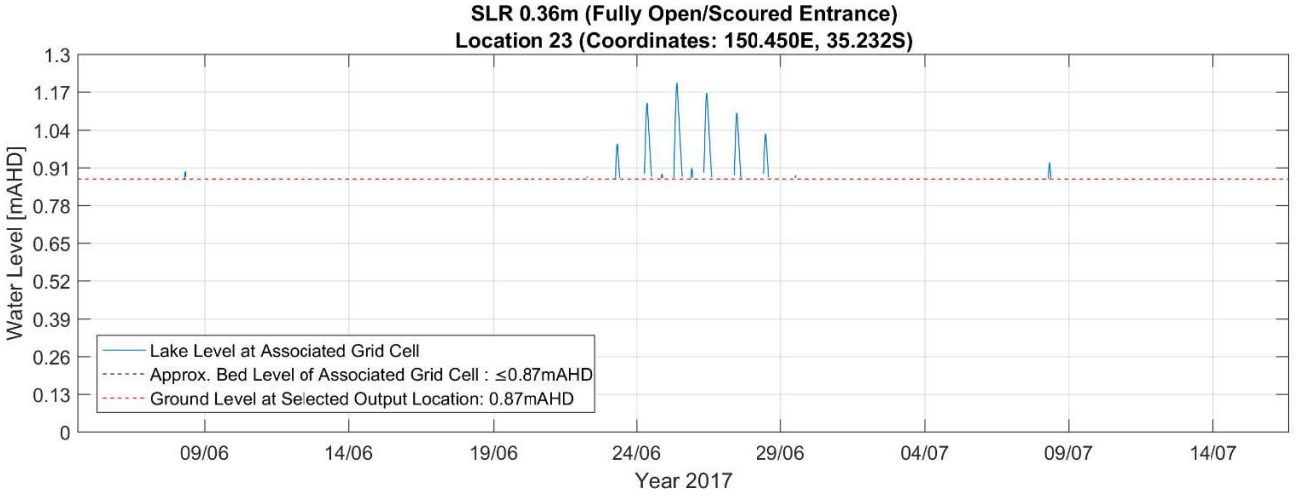

Tidal Inundation
Number of Occurrences [-]
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

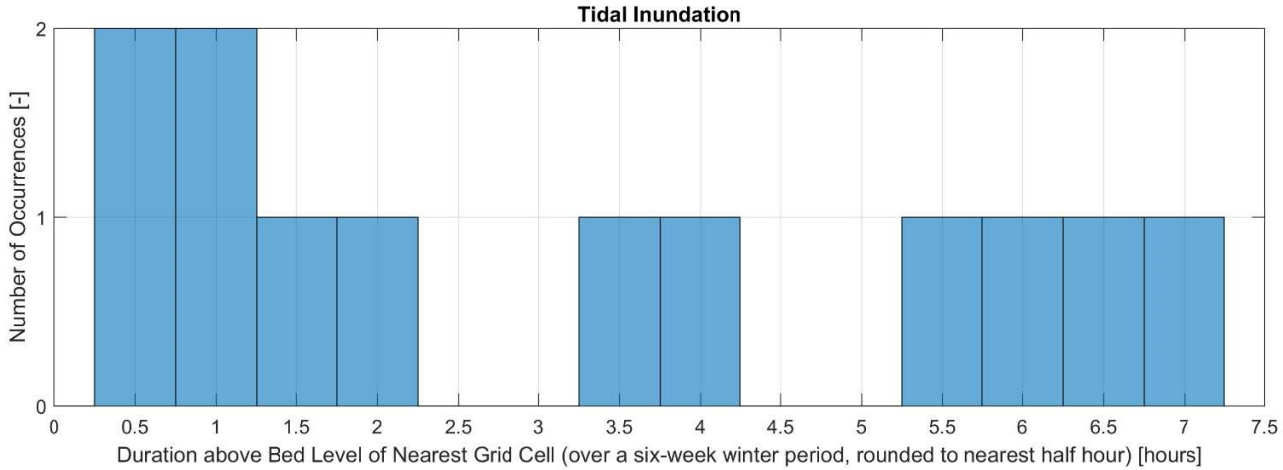

26
22
27
25
24
23

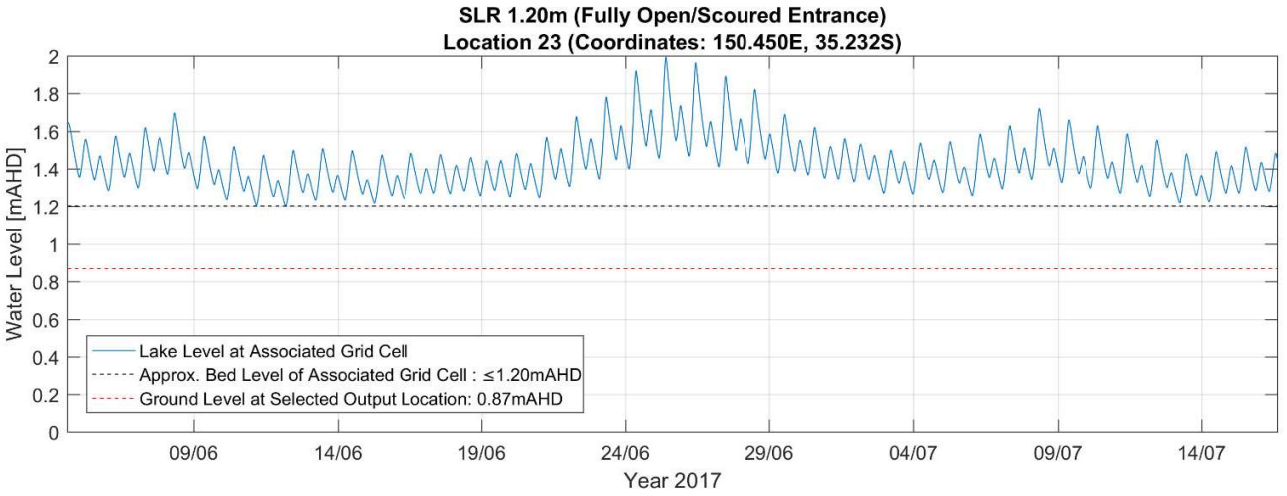
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
0.5	2
1.0	2
1.5	1
2.0	1
3.5	1
4.0	1
5.5	1
6.0	1
6.5	1
7.0	1

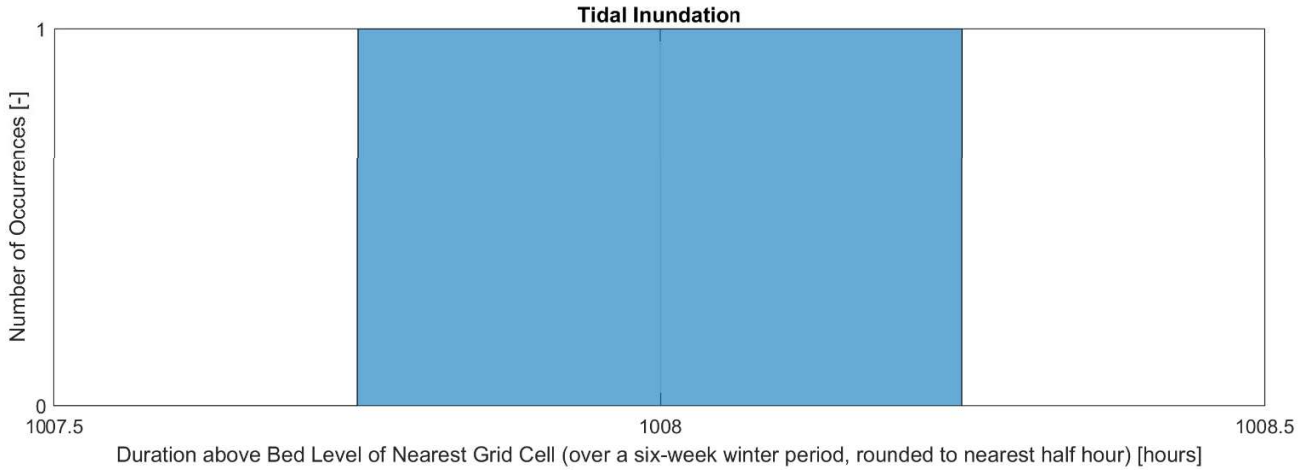
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
12	39
Average inundation duration during 6 week modelled period = total inundation hours / total occurrences	
39 hours / 12 occurances	**3.3 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply *Total occurrences over 6 week modelled period* by 52 weeks (calendar year) / 6 weeks (modelled period)	
12 occurrence x 52 weeks (calendar) / 6 weeks (modelled)	**104 Occurrences per calendar year**

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always wet)	(always wet)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 23 (Coordinates: 150.450E, 35.232S)
Water Level [mAHD]
1.3
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤0.87mAHD
Ground Level at Selected Output Location: 0.87mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

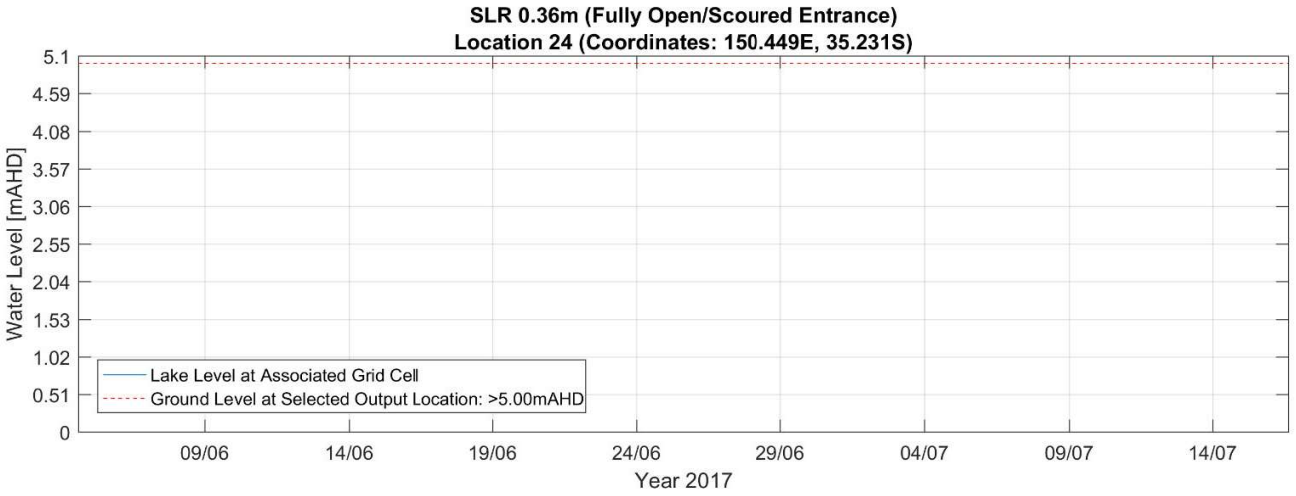

SLR 1.20m (Fully Open/Scoured Entrance)
Location 23 (Coordinates: 150.450E, 35.232S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.20mAHD
Ground Level at Selected Output Location: 0.87mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

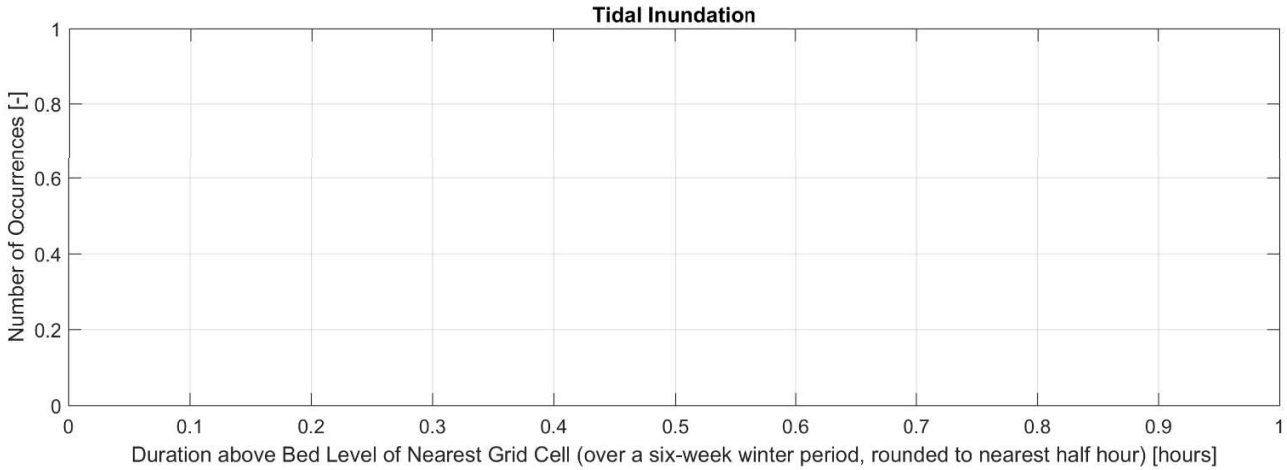

Tidal Inundation
Number of Occurrences [-]
1
0
1007.5
1008
1008.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

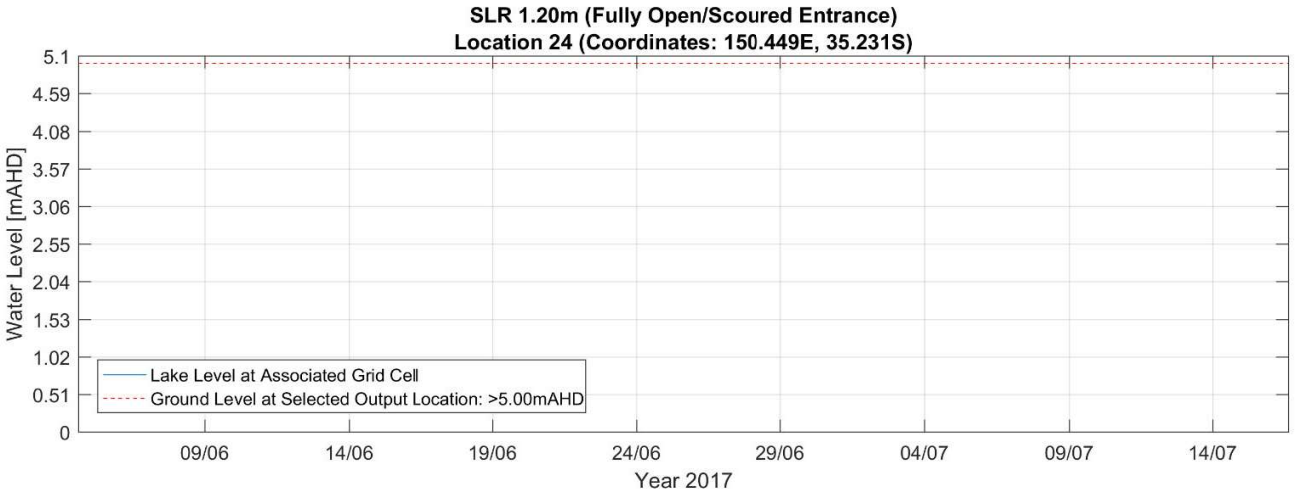

26
22
27
25
24
23

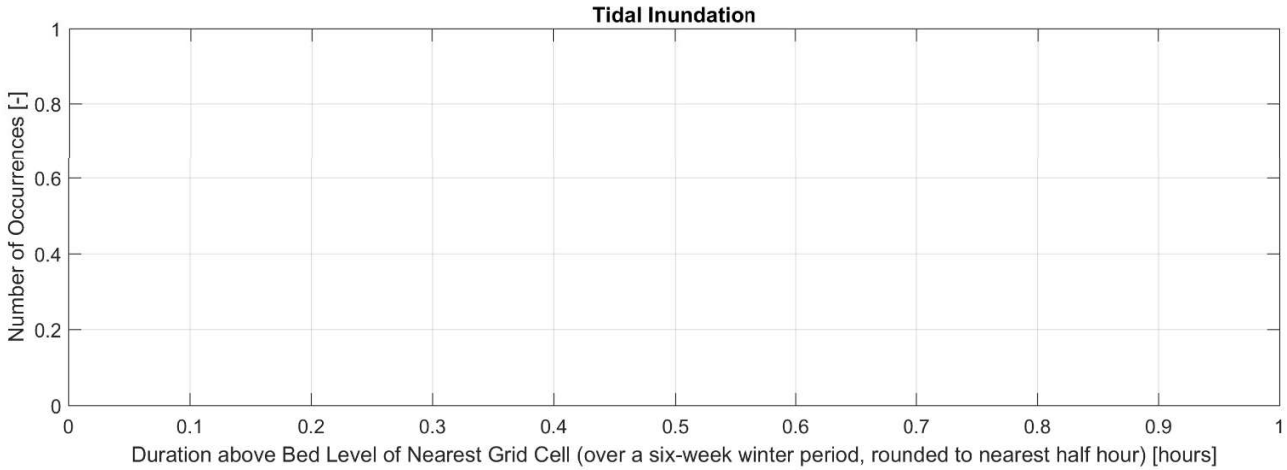
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 24 (Coordinates: 150.449E, 35.231S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

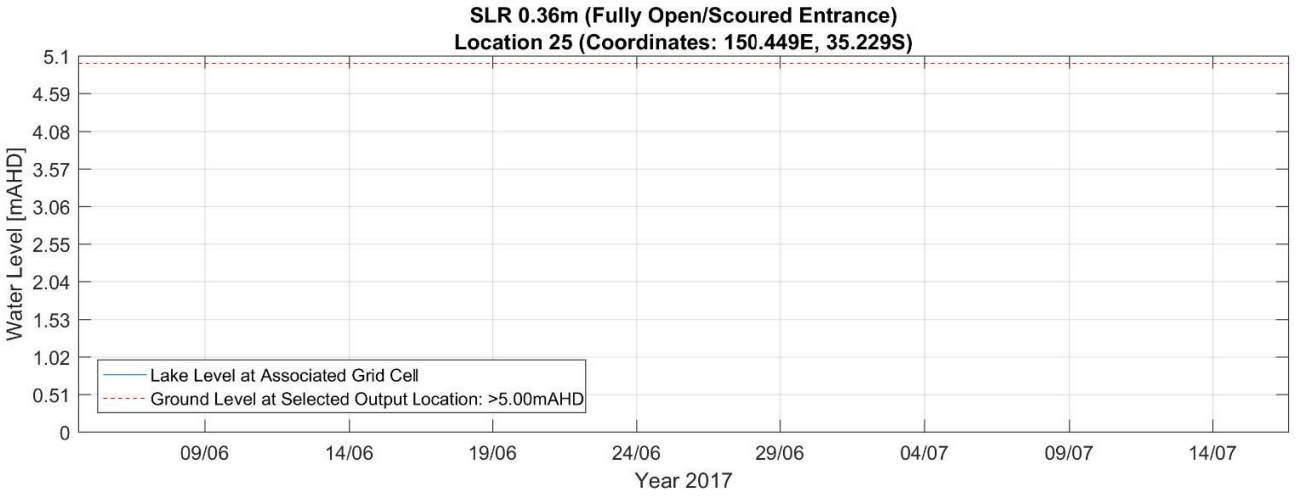

SLR 1.20m (Fully Open/Scoured Entrance)
Location 24 (Coordinates: 150.449E, 35.231S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

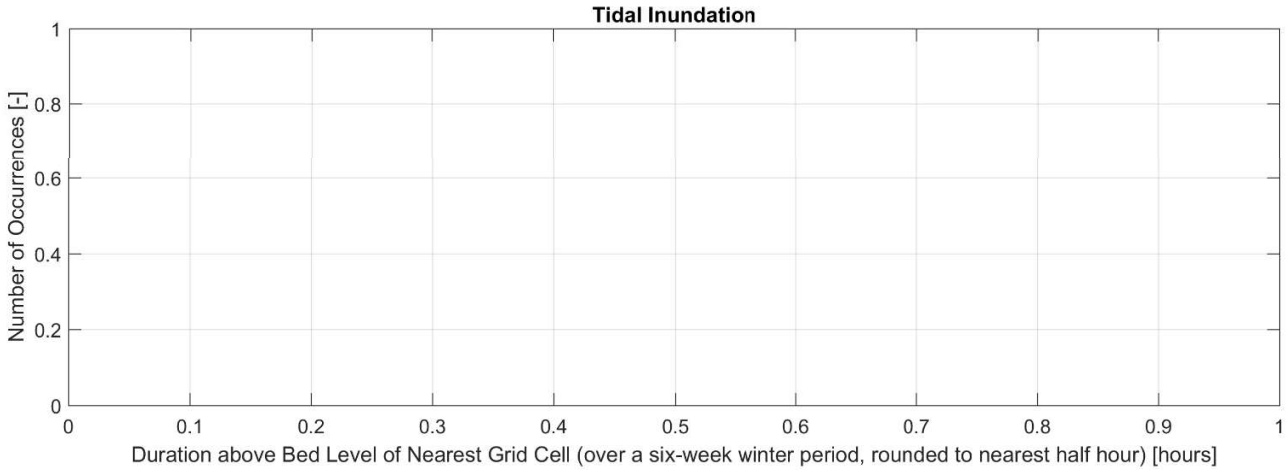

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

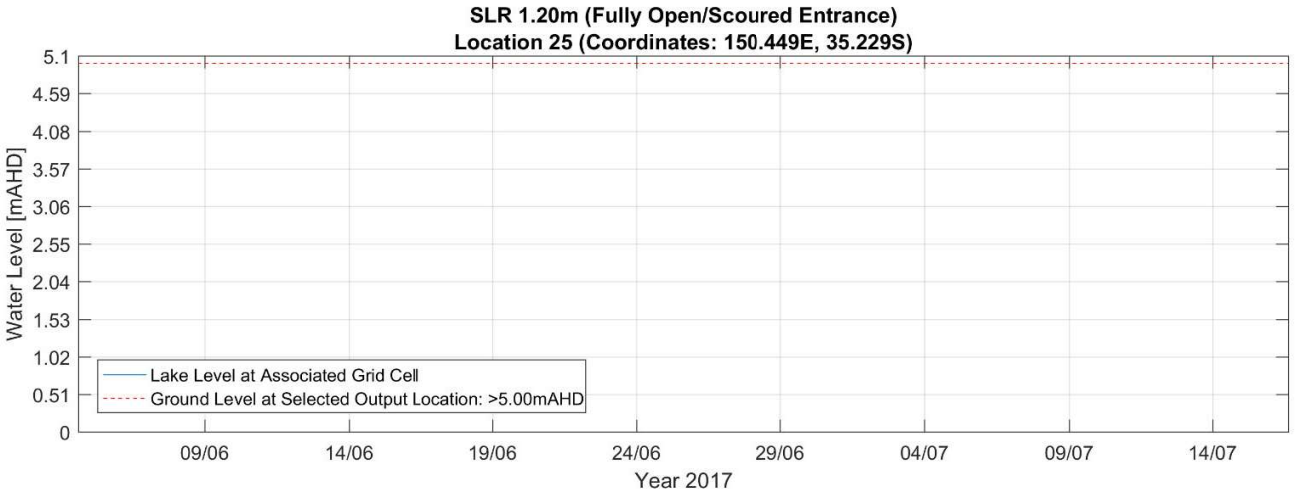

26
22
27
25
24
23

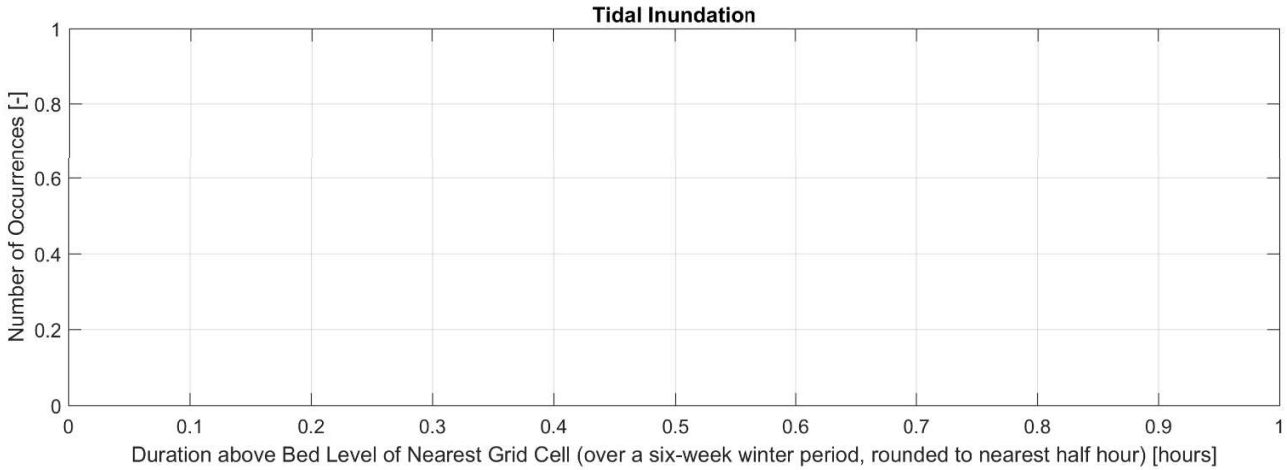
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 25 (Coordinates: 150.449E, 35.229S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

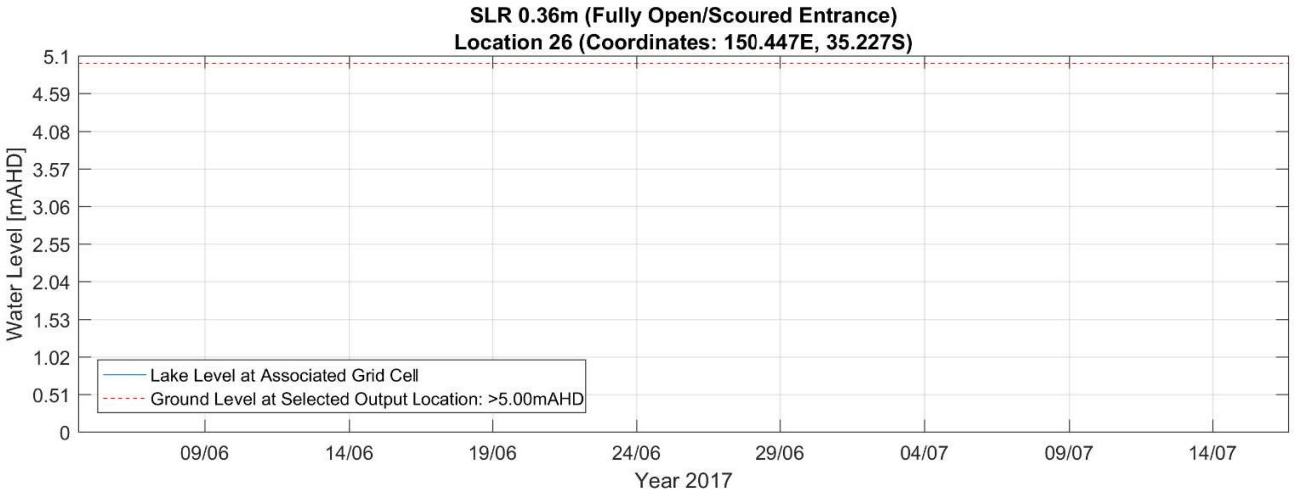

SLR 1.20m (Fully Open/Scoured Entrance)
Location 25 (Coordinates: 150.449E, 35.229S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

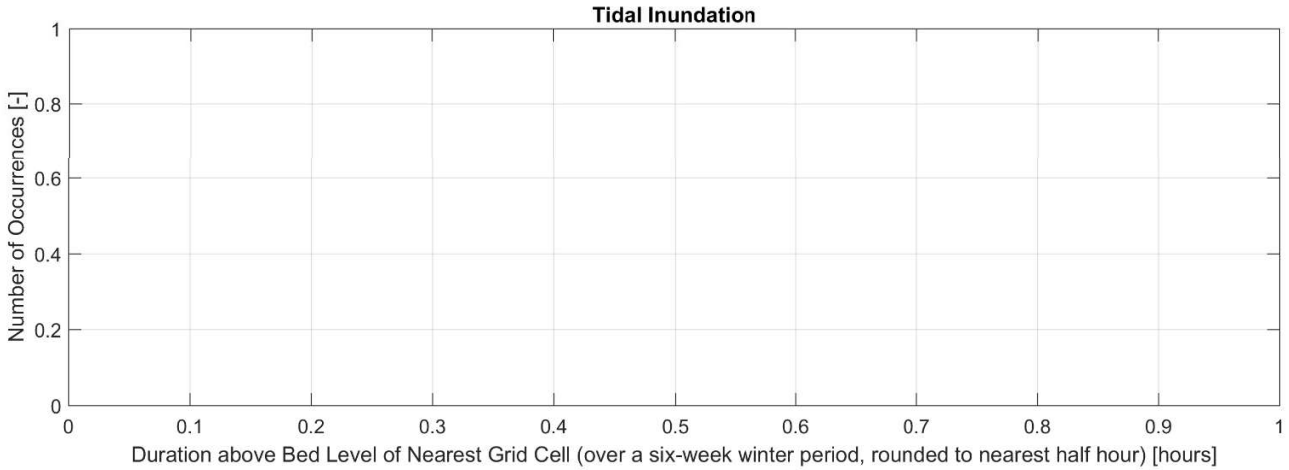

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

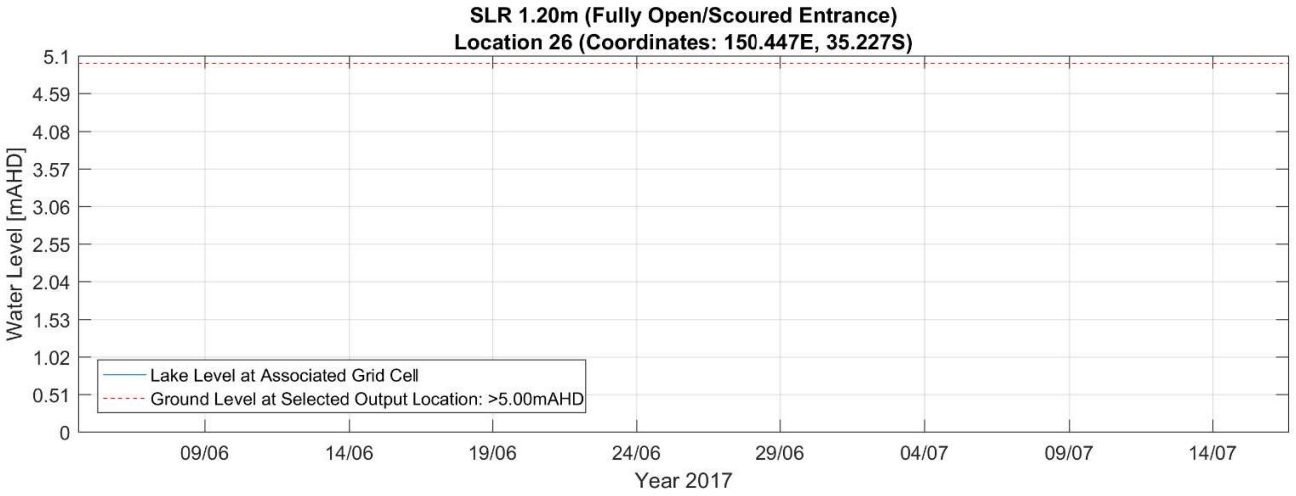

26
22
27
25
24
23

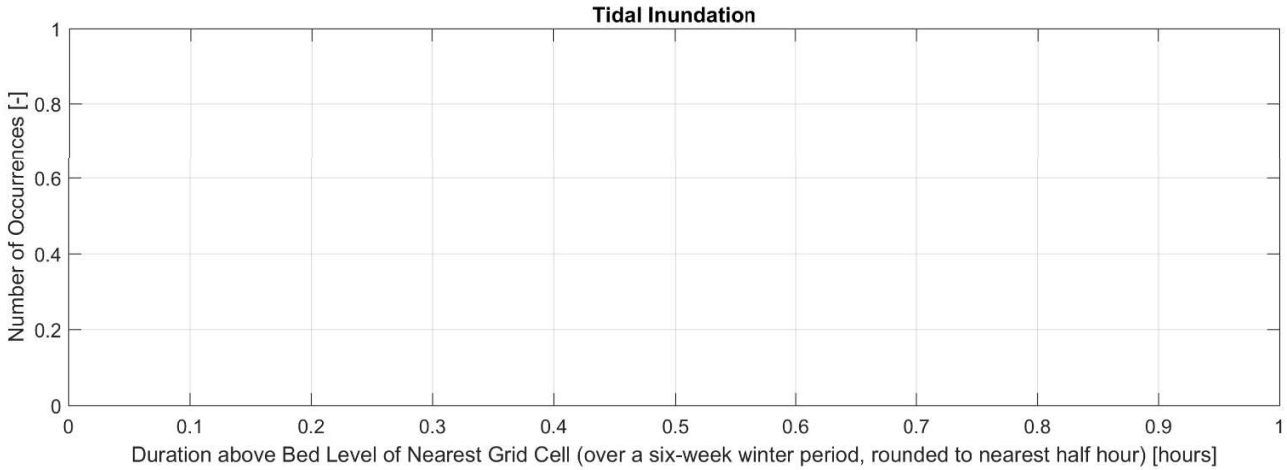
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)

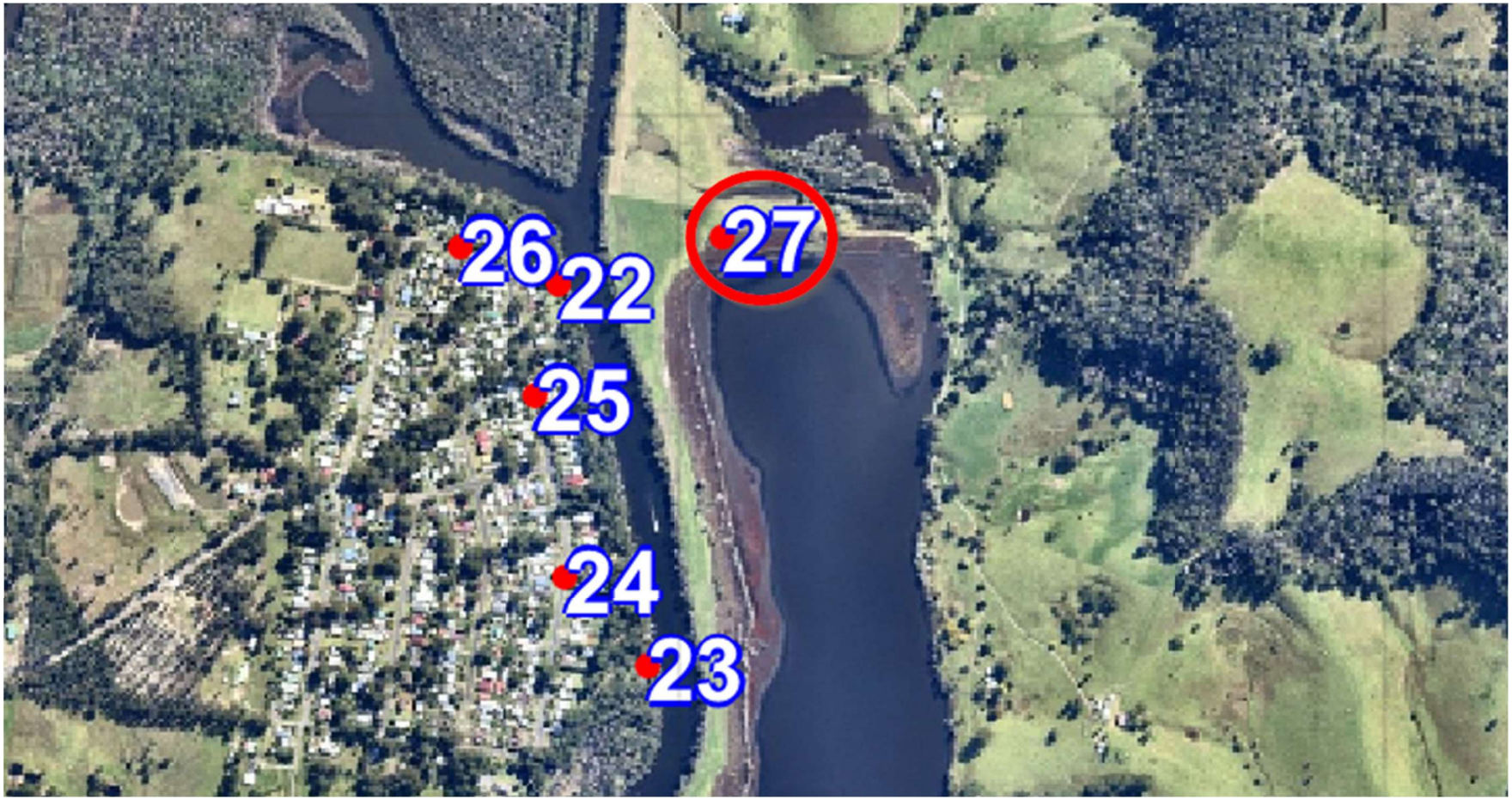
SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always dry)	(always dry)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 26 (Coordinates: 150.447E, 35.227S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 26 (Coordinates: 150.447E, 35.227S)
Water Level [mAHD]
5.1
4.59
4.08
3.57
3.06
2.55
2.04
1.53
1.02
0.51
0
Lake Level at Associated Grid Cell
Ground Level at Selected Output Location: >5.00mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017

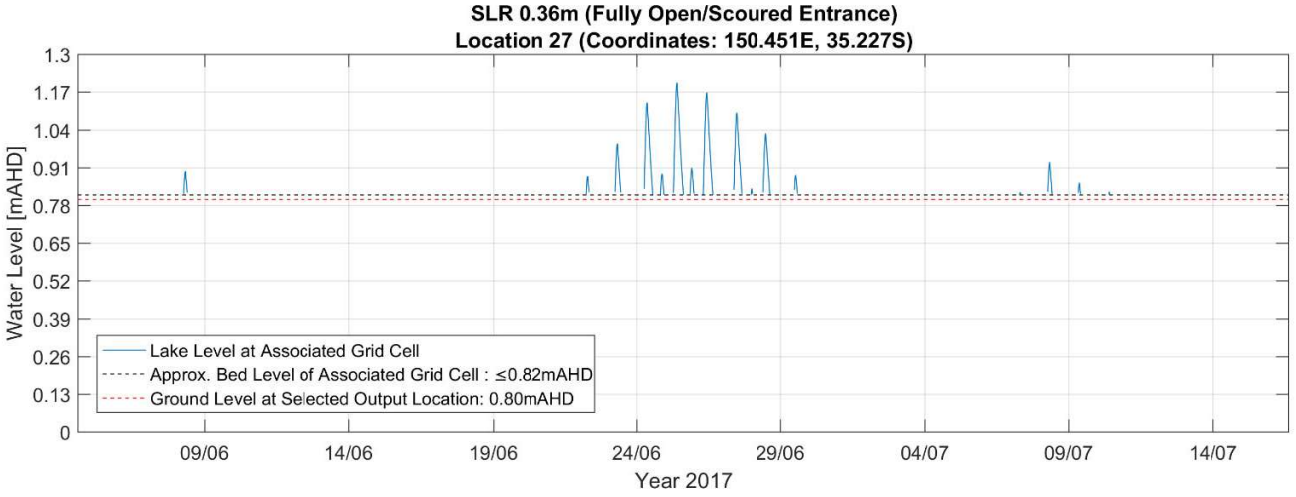

Tidal Inundation
Number of Occurrences [-]
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

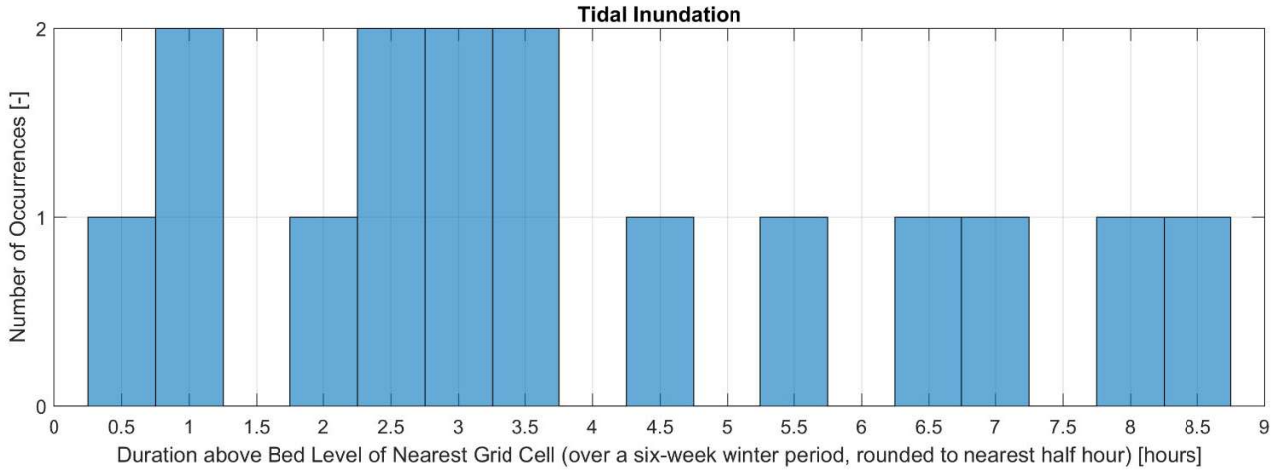

26
22
27
25
24
23

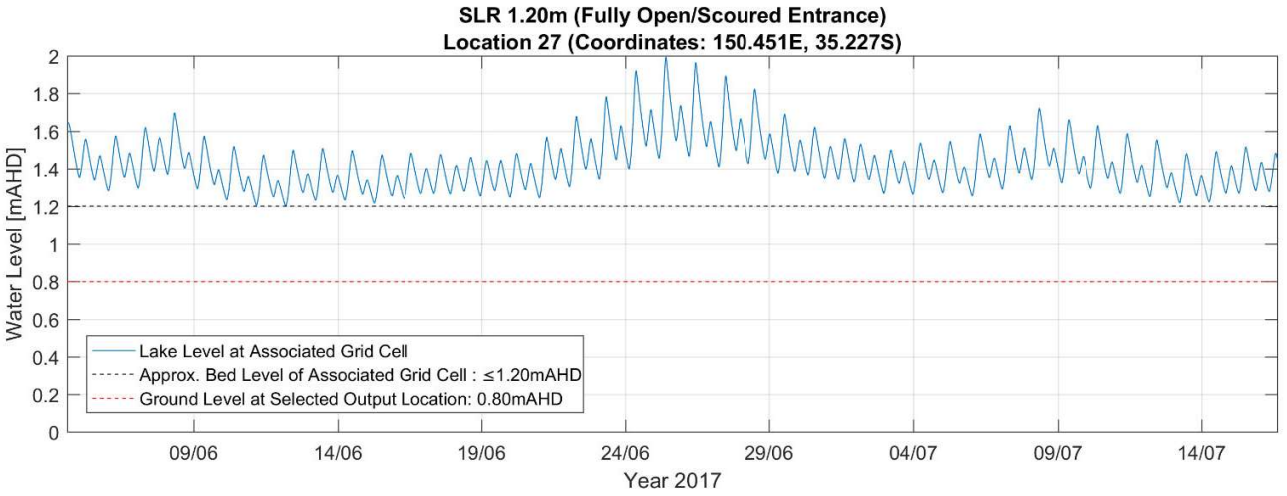
SLR 0.36m	
Inundation duration [hrs]	**Number of occurrences [-]**
0.5	1
1.0	2
2.0	1
2.5	2
3.0	2
3.5	2
4.5	1
5.5	1
6.5	1
7.0	1
8.0	1
8.5	1

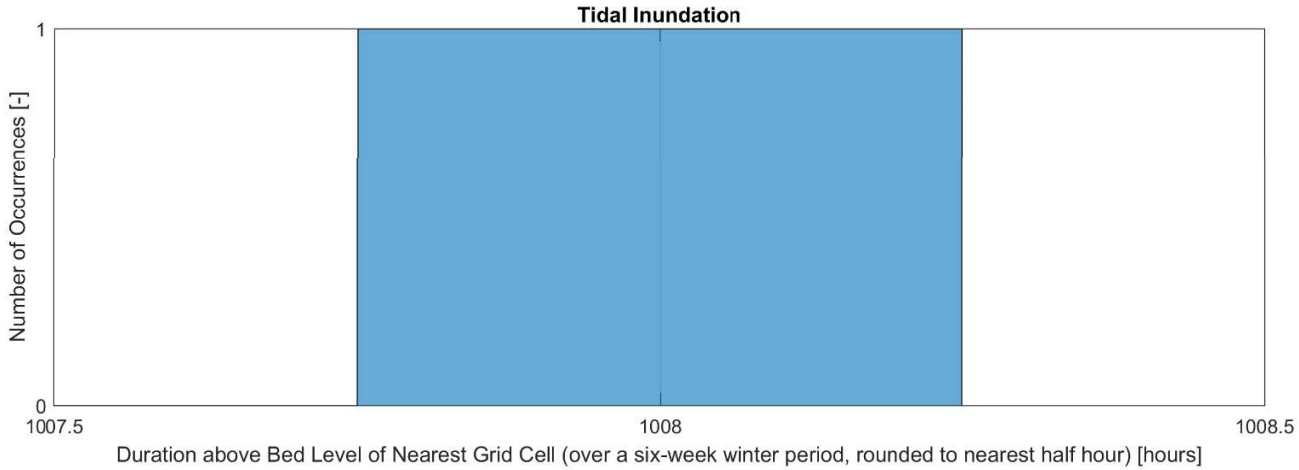
Total occurances over 6 week modelled period	**Total inundation hours over 6 week period**
16	63
Average inundation duration during 6 week modelled period =	
62.5 hours / 16 occurances	**3.9 Hours average inundation per occurrence**
Annualised number of occurrences (conservative), multiply	
16 occurrence x 52 weeks (calendar) / 6 weeks (modelled)	**139 Occurrences per calendar year**

SLR 1.20m	
Inundation duration [hrs]	**Number of occurrences [-]**
(always wet)	(always wet)


SLR 0.36m (Fully Open/Scoured Entrance)
Location 27 (Coordinates: 150.451E, 35.227S)
Water Level [mAHD]
1.3
1.17
1.04
0.91
0.78
0.65
0.52
0.39
0.26
0.13
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤0.82mAHD
Ground Level at Selected Output Location: 0.80mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]


SLR 1.20m (Fully Open/Scoured Entrance)
Location 27 (Coordinates: 150.451E, 35.227S)
Water Level [mAHD]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Lake Level at Associated Grid Cell
Approx. Bed Level of Associated Grid Cell : ≤1.20mAHD
Ground Level at Selected Output Location: 0.80mAHD
09/06
14/06
19/06
24/06
29/06
04/07
09/07
14/07
Year 2017


Tidal Inundation
Number of Occurrences [-]
1
0
1007.5
1008
1008.5
Duration above Bed Level of Nearest Grid Cell (over a six-week winter period, rounded to nearest half hour) [hours]

Appendix E - Coastal Inundation Static Maps - all SLR ranges

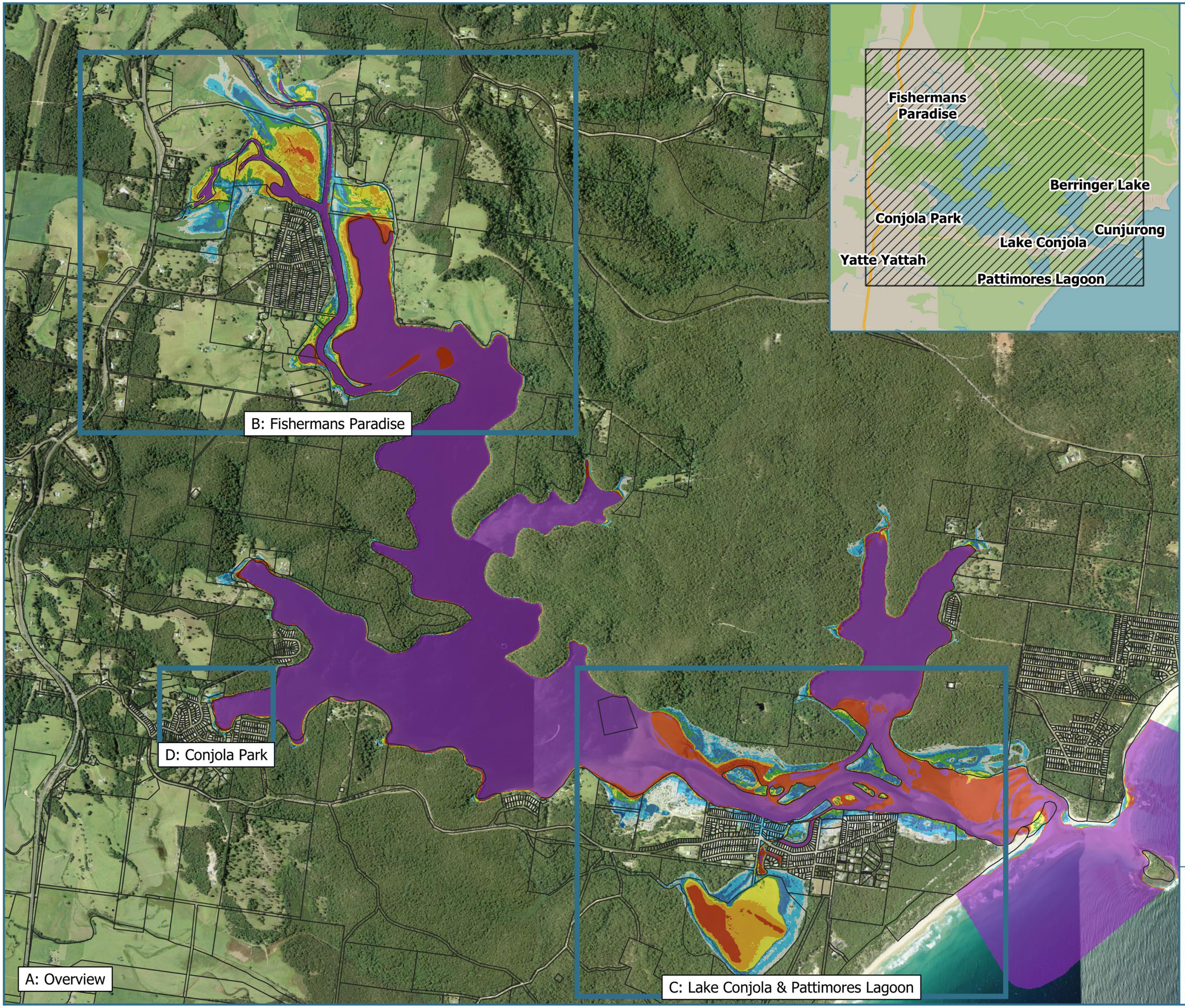


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Figure A-01
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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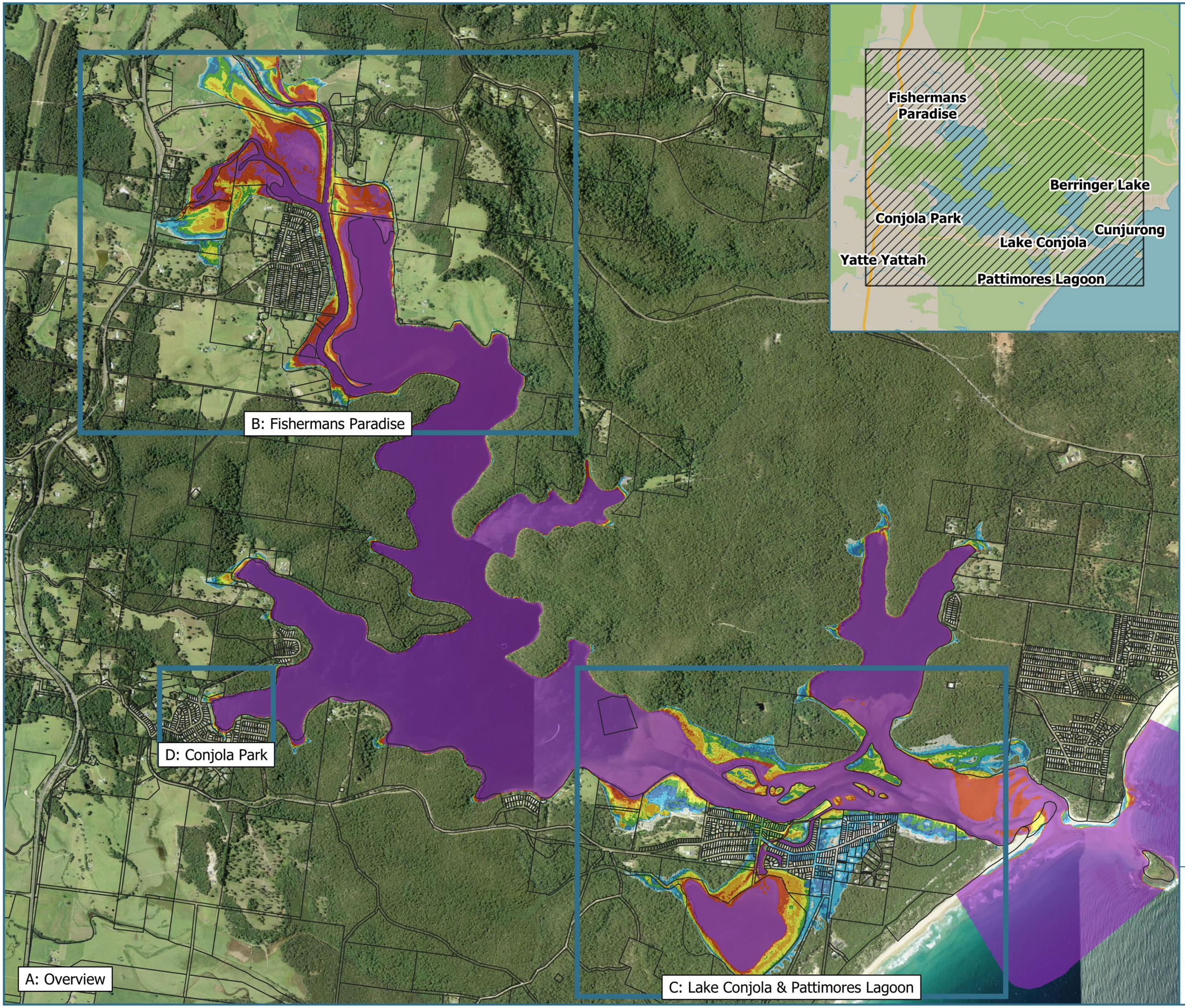

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Figure A-02
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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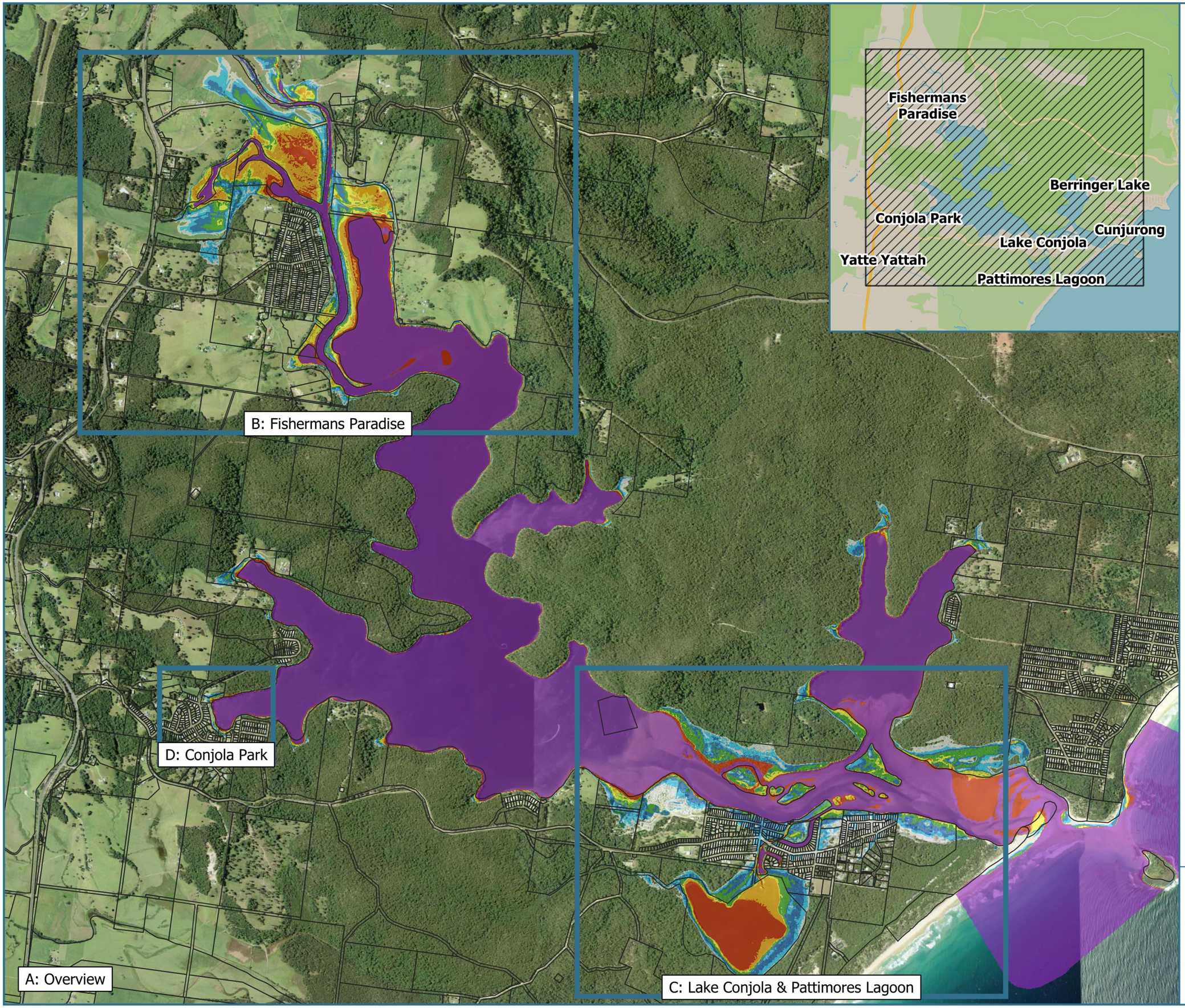

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Figure A-03
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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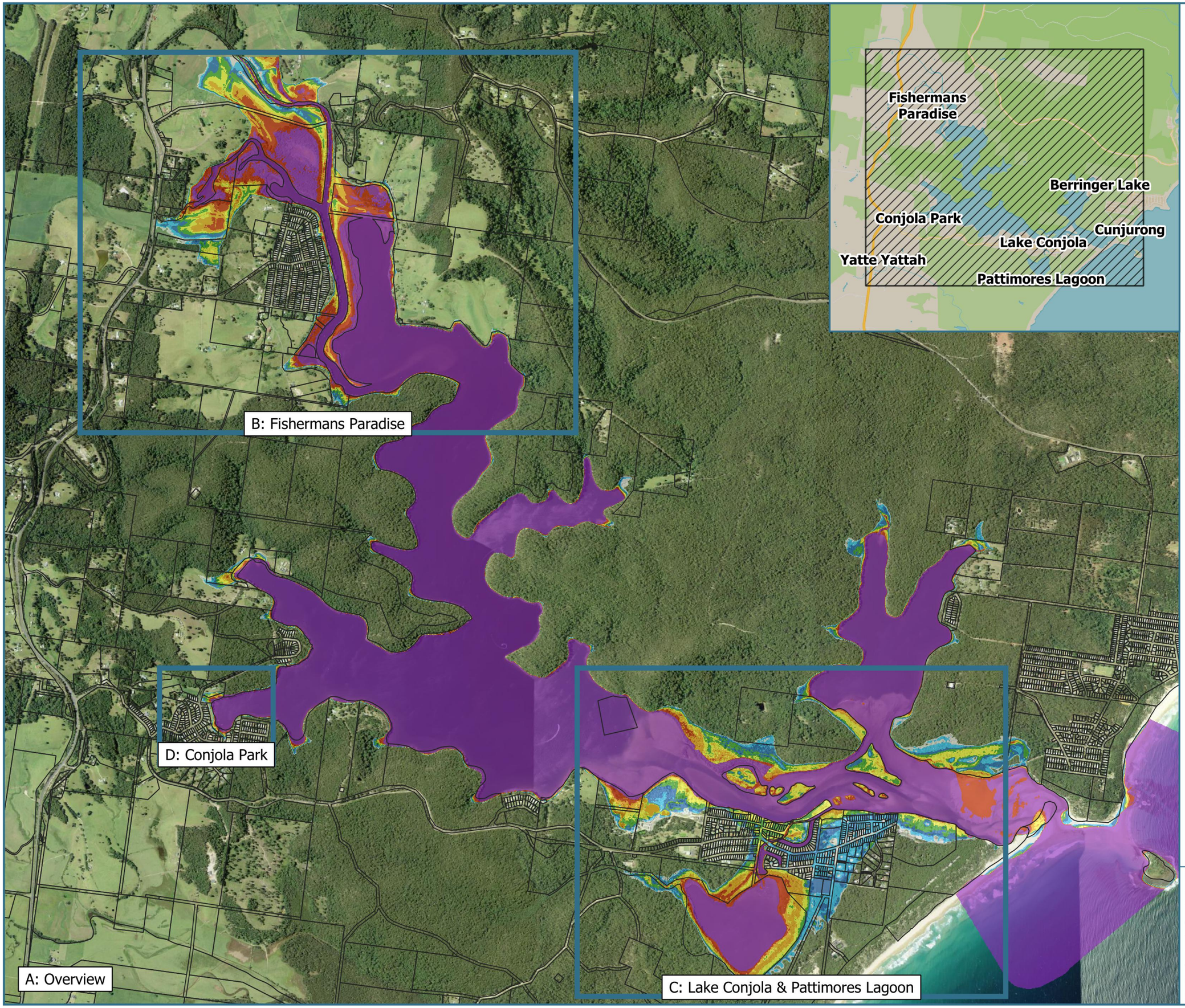

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Figure A-04
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr
Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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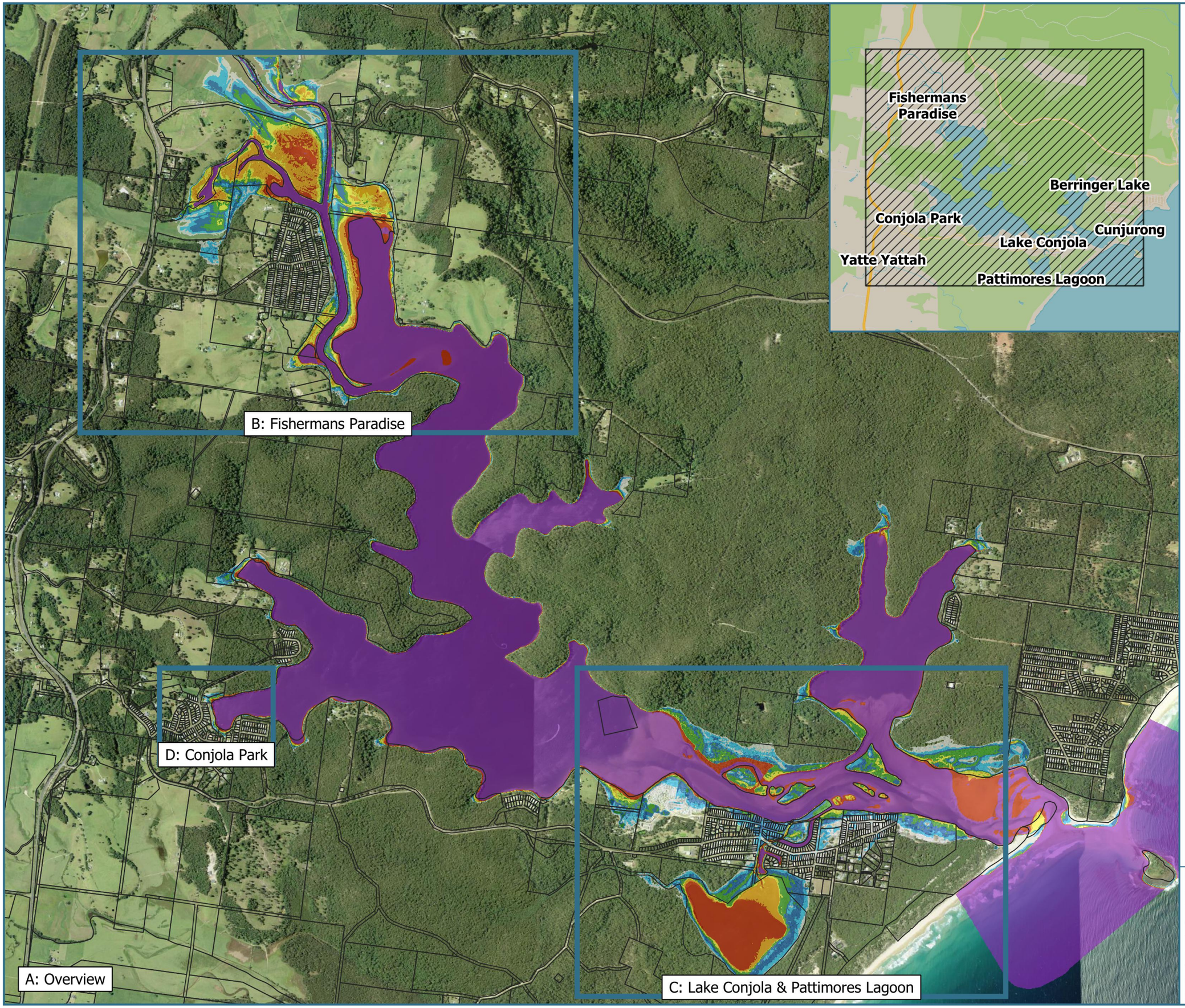

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Figure A-05
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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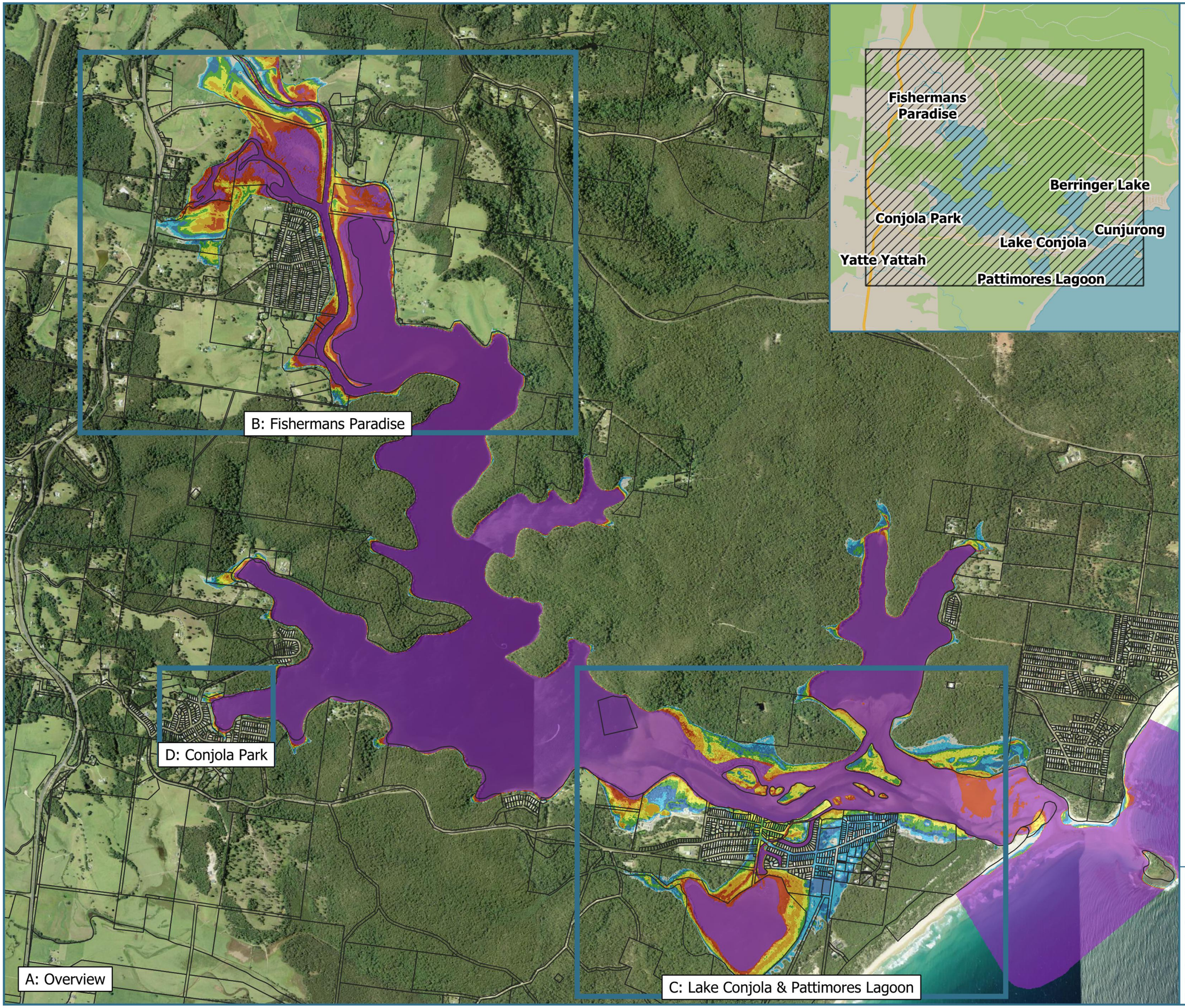

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Figure A-06
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr
Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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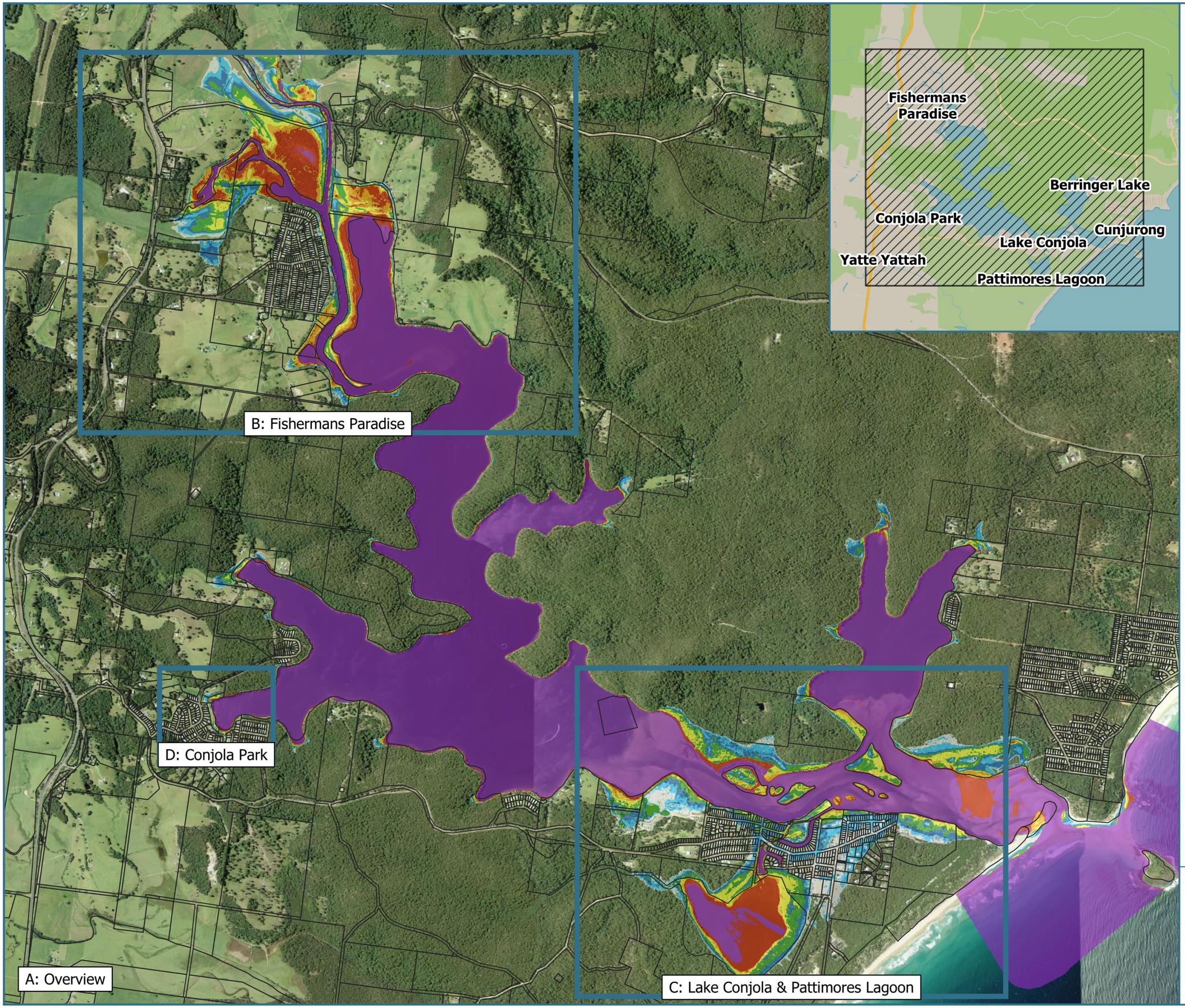

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Figure A-07
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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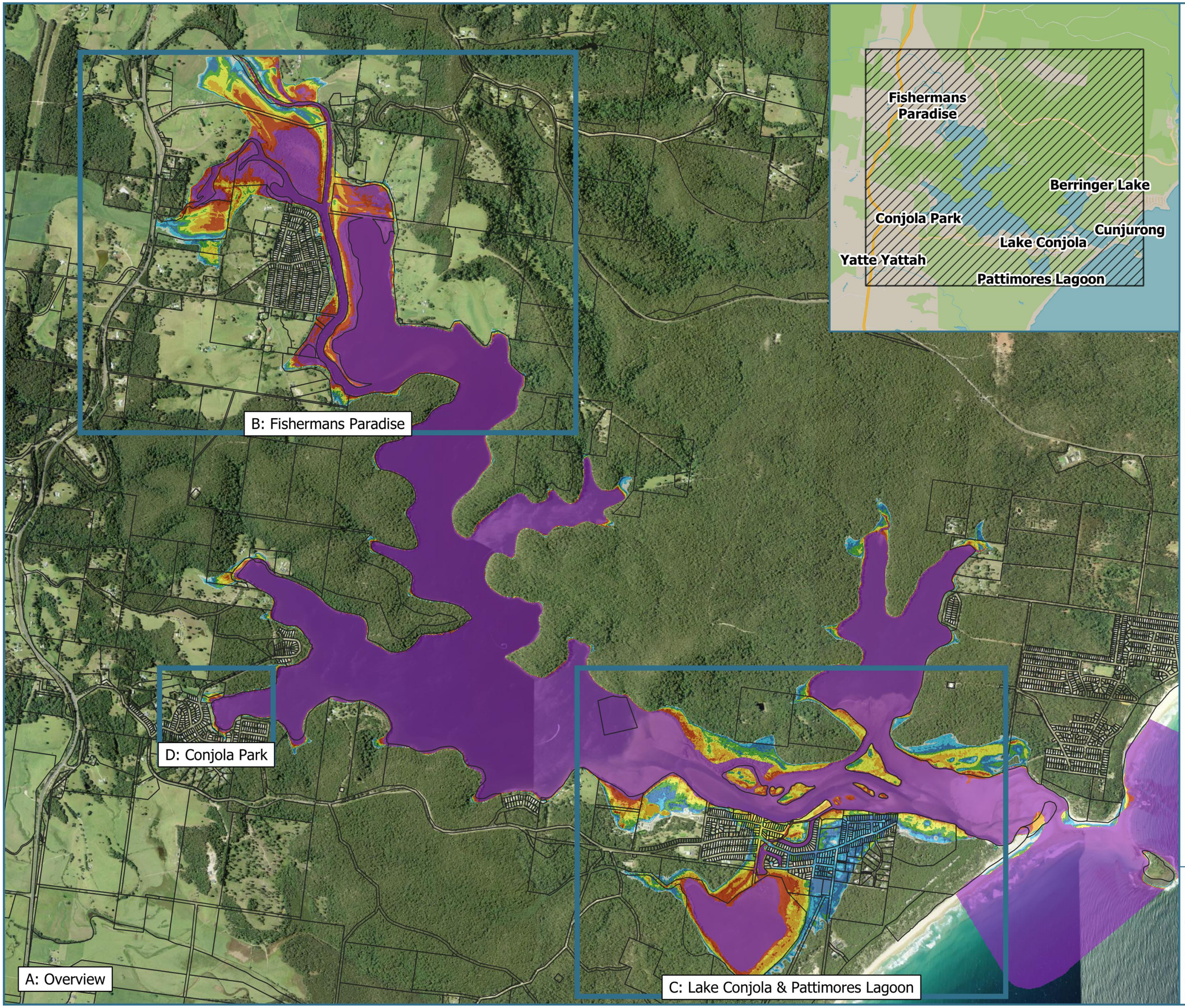

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Figure A-08
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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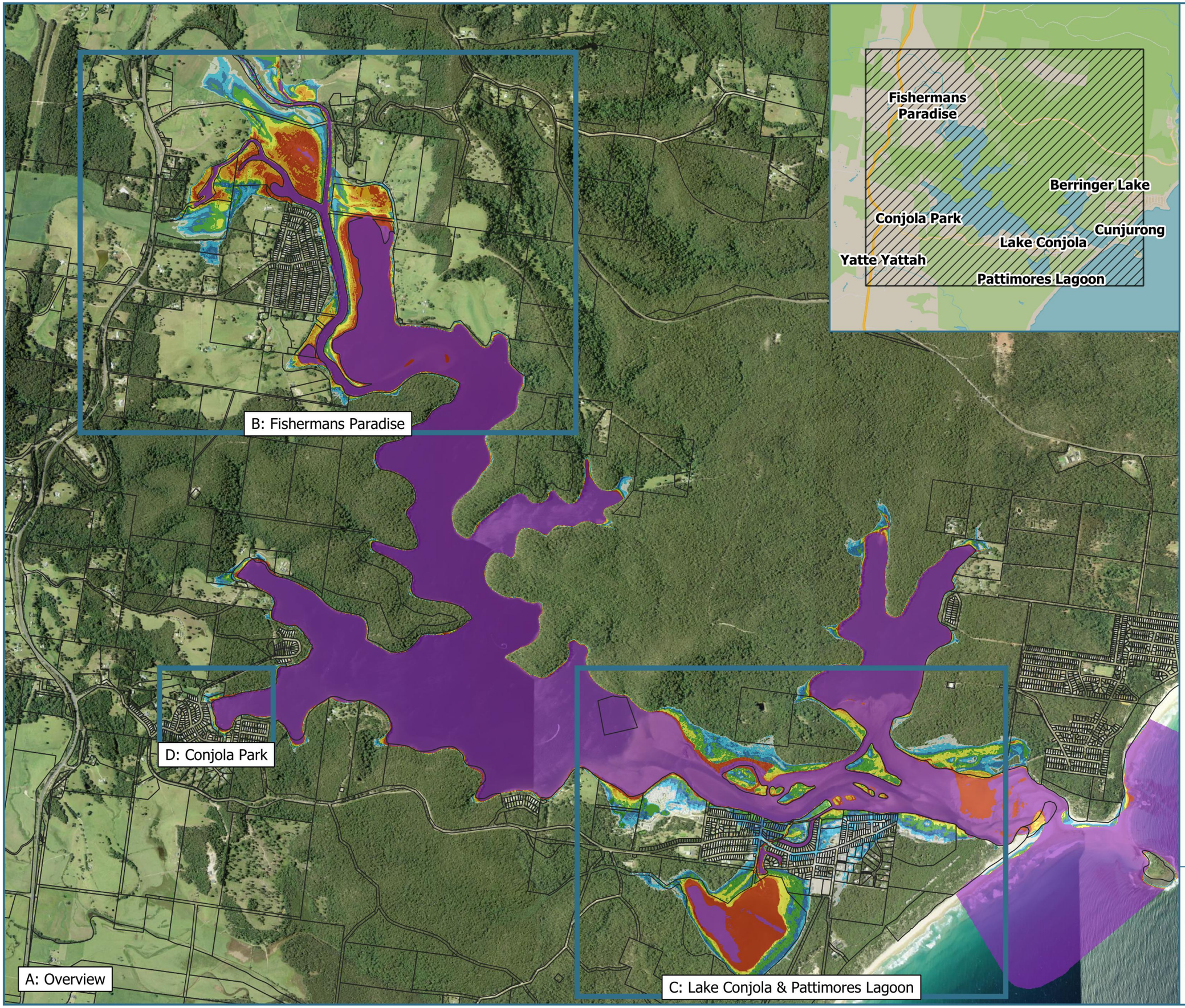

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Figure A-09
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

Disclaimer: While all reasonable care has been taken to ensure the information contained on this output is up to date and accurate, it contains data from a number of sources - no warranty is given that this information is free from error or omission. Any reliance placed on such information shall be at the sole risk of the user. Please verify the accuracy of all information prior to using it. This is not a design document.

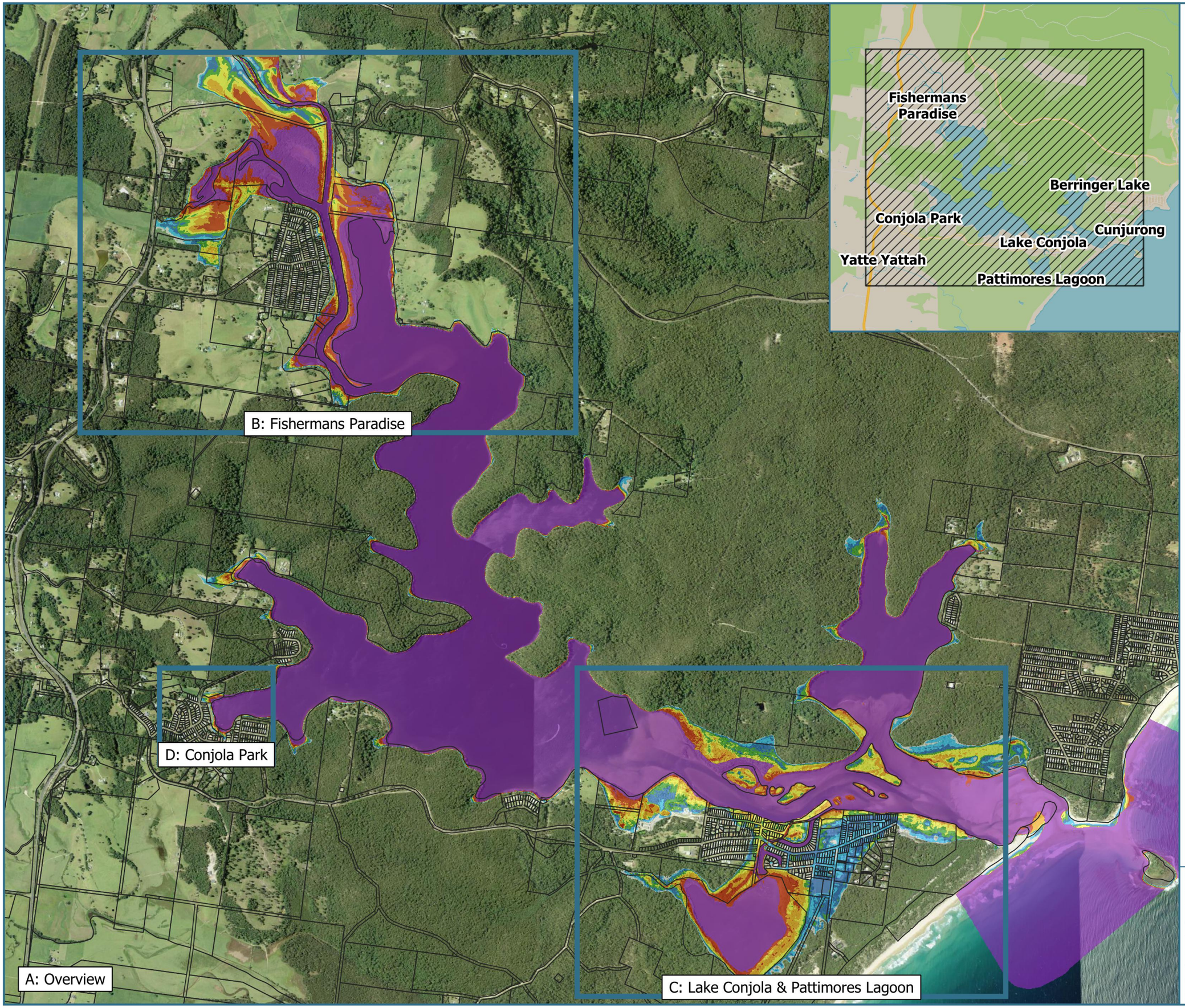

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Figure A-10
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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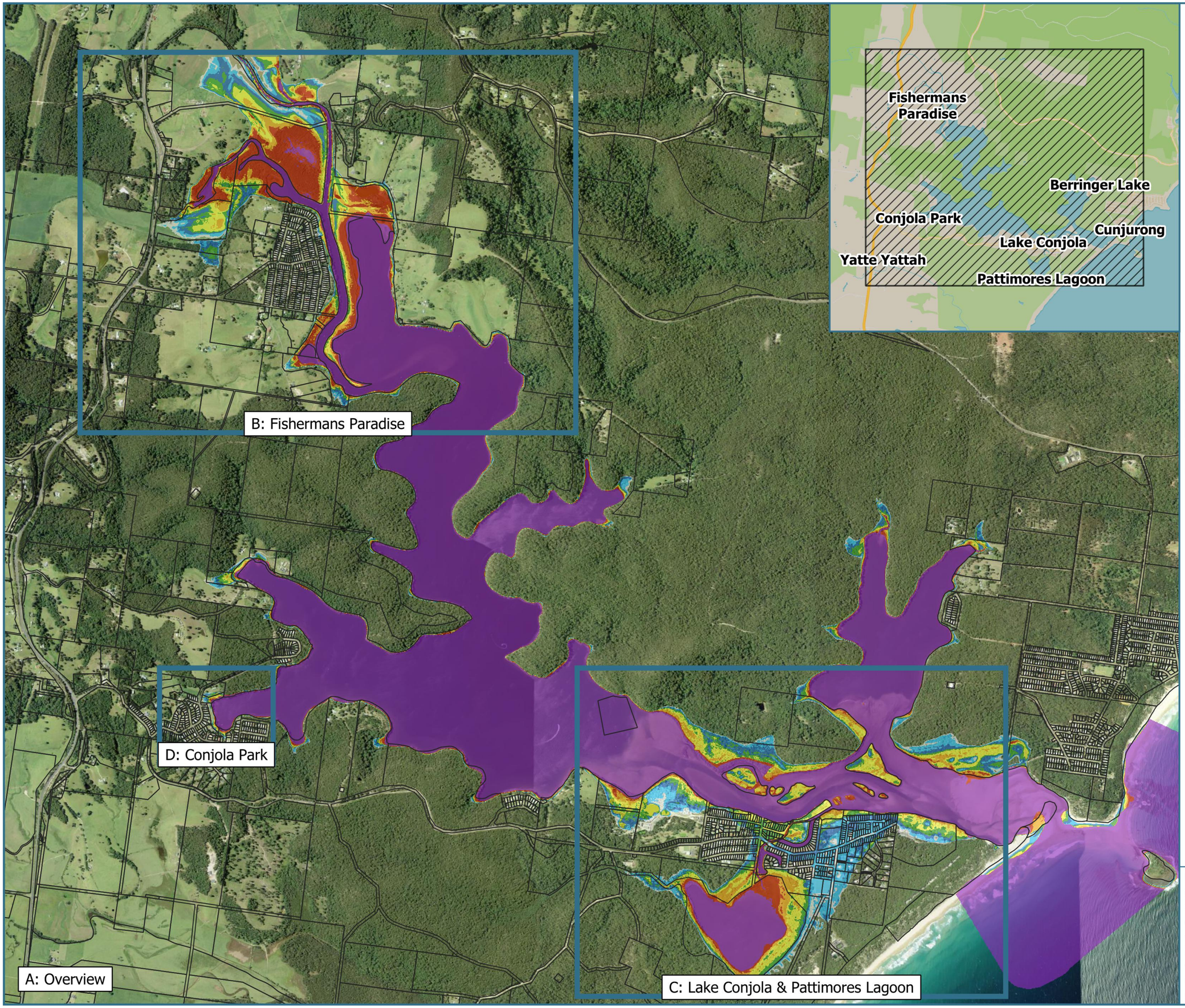

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Lake Conjola Coastal Management Program

Figure A-11
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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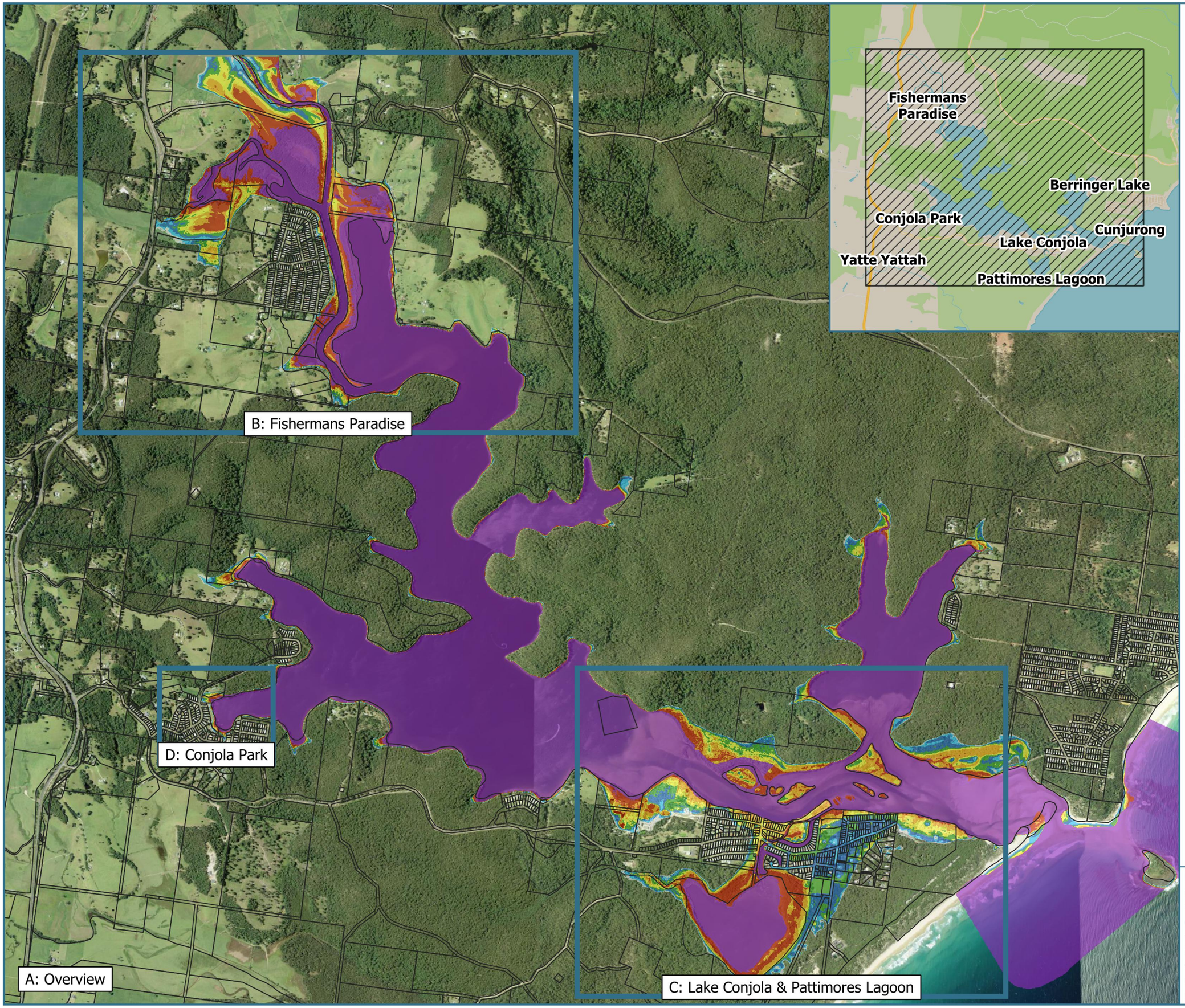

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Lake Conjola Coastal Management Program

Figure A-12
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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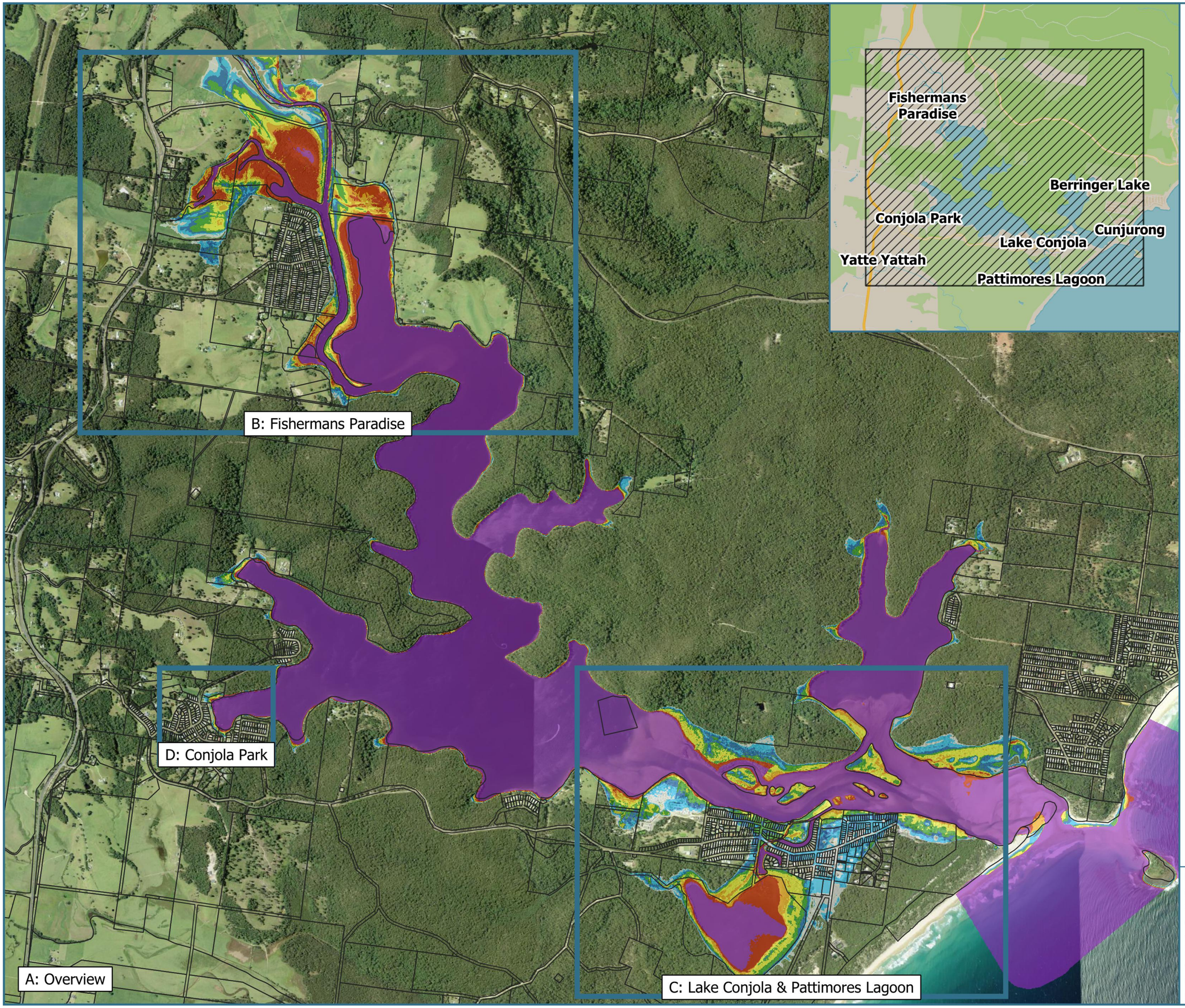

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Figure A-13
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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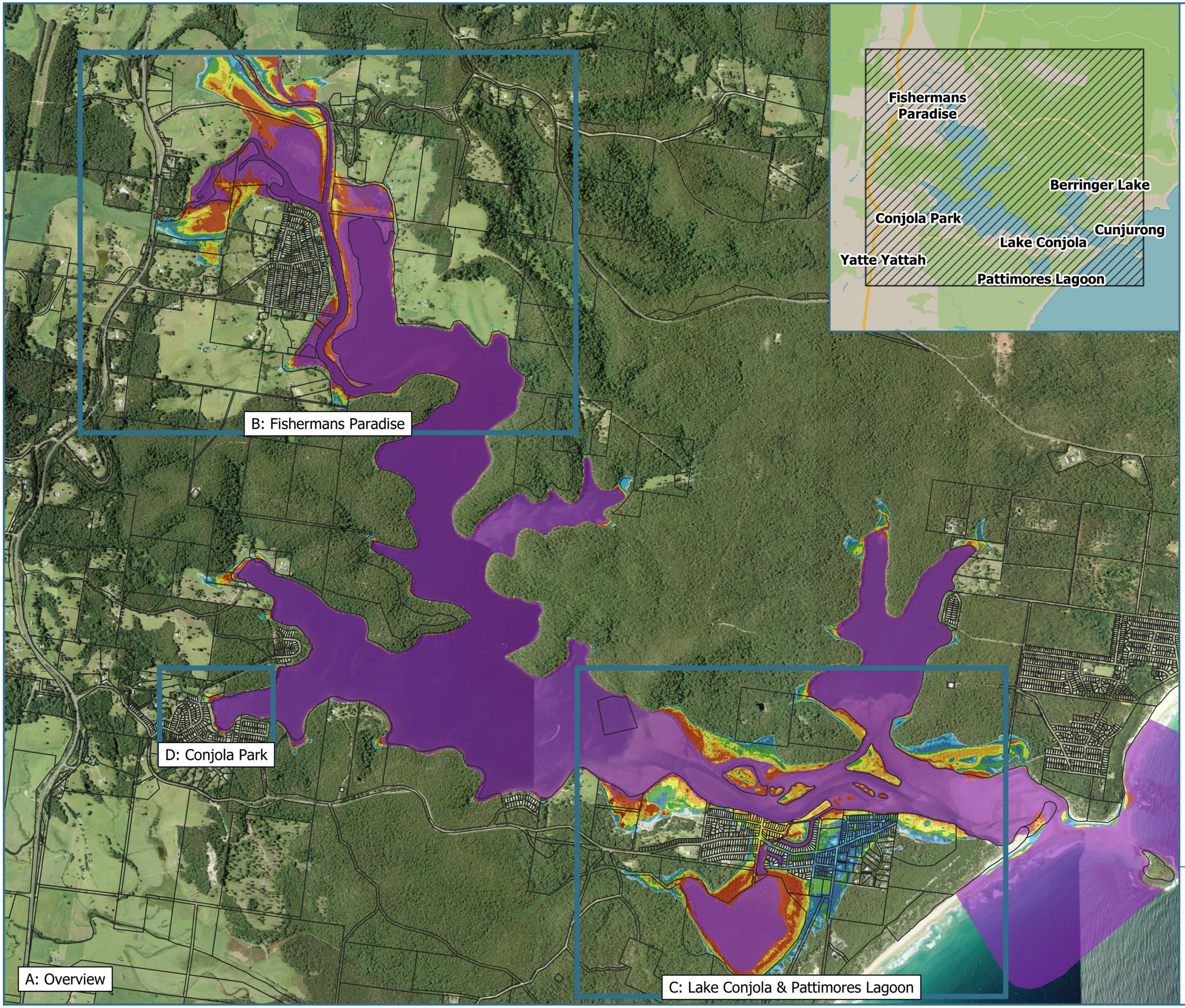

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Figure A-14
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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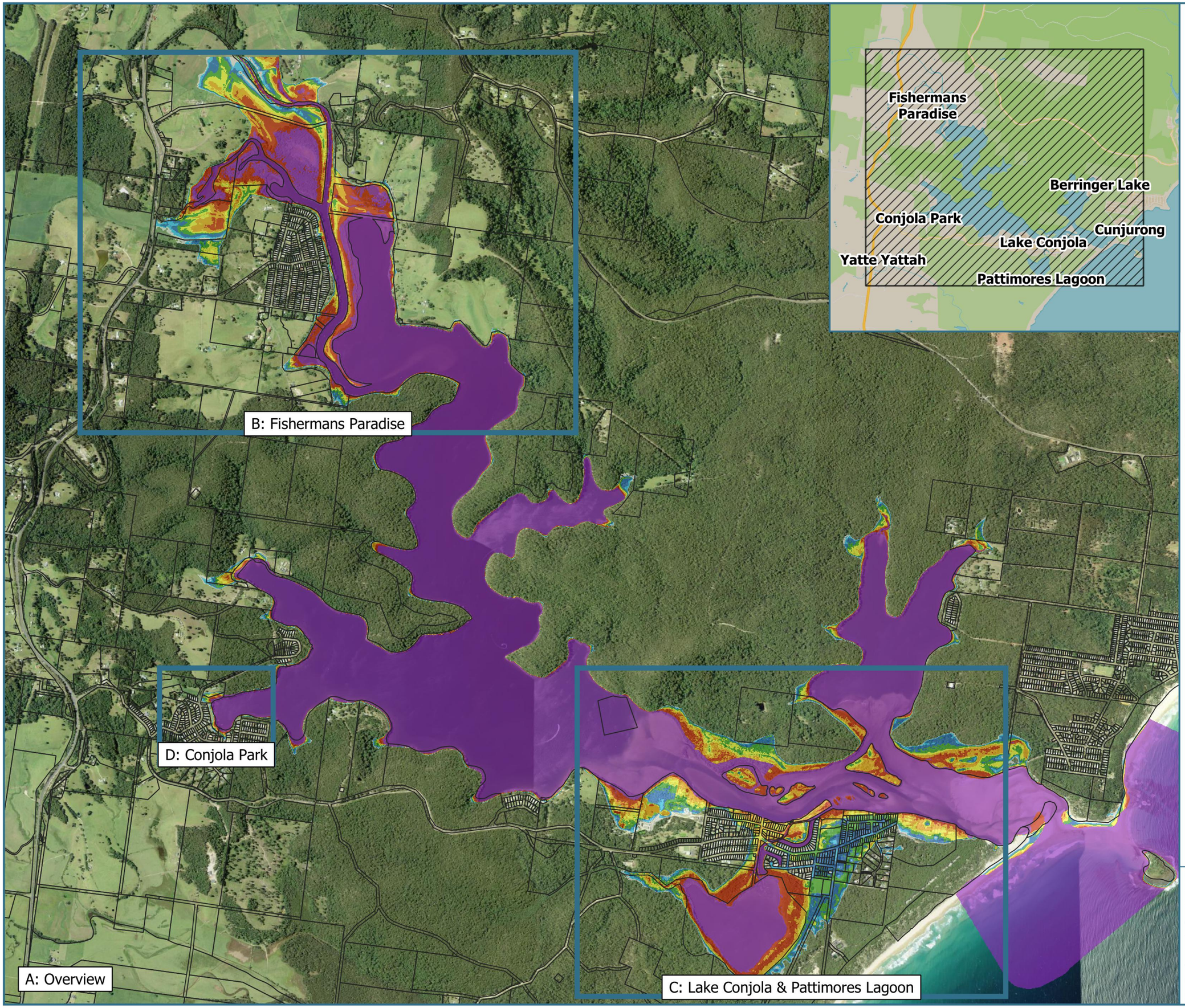

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Figure A-15
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

- ≥ 2.00
- 1.50 - 2.00
- 1.25 - 1.50
- 1.00 - 1.25
- 0.75 - 1.00
- 0.50 - 0.75
- 0.25 - 0.50
- 0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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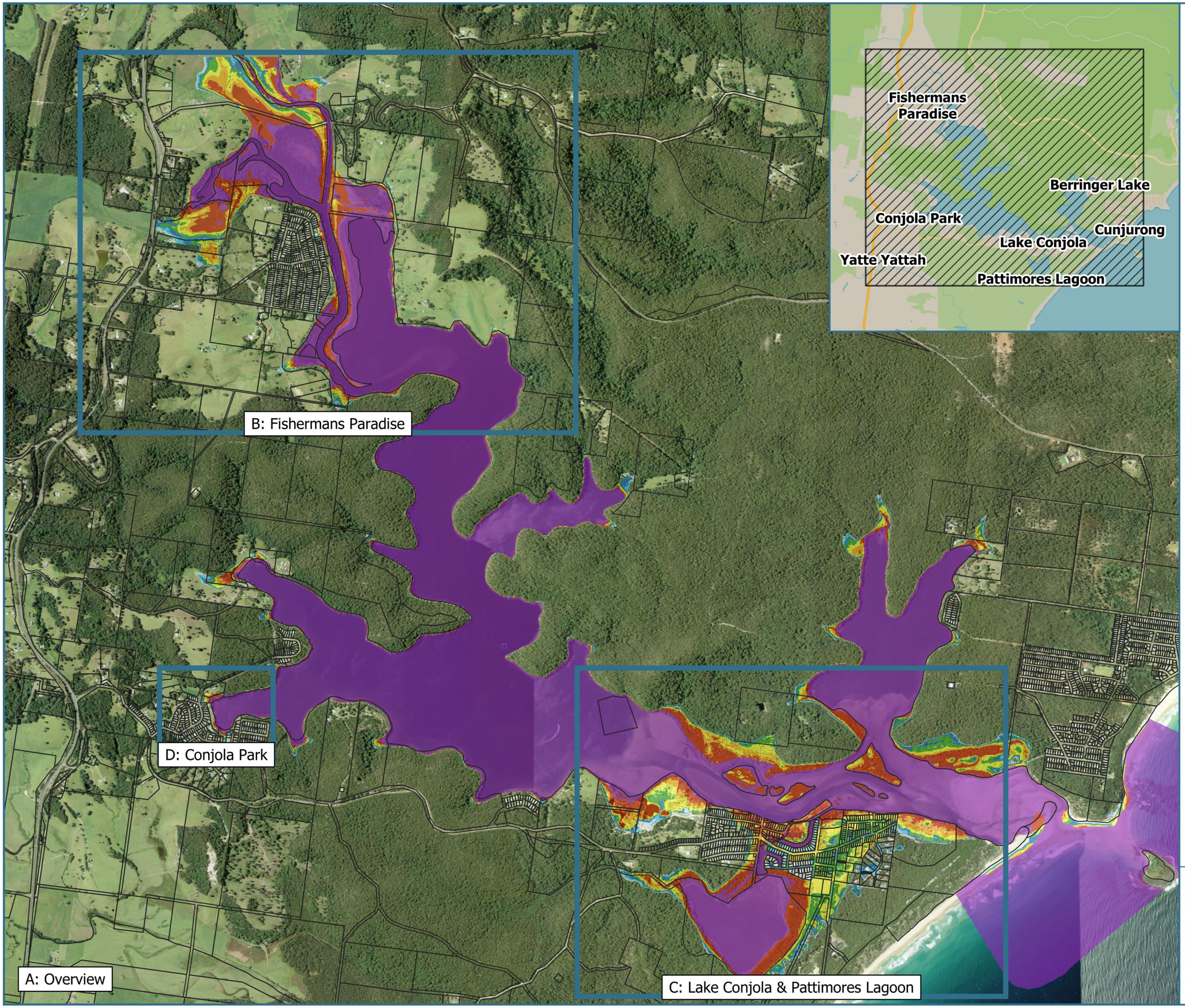

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Figure A-16
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

Shoalhaven City Council

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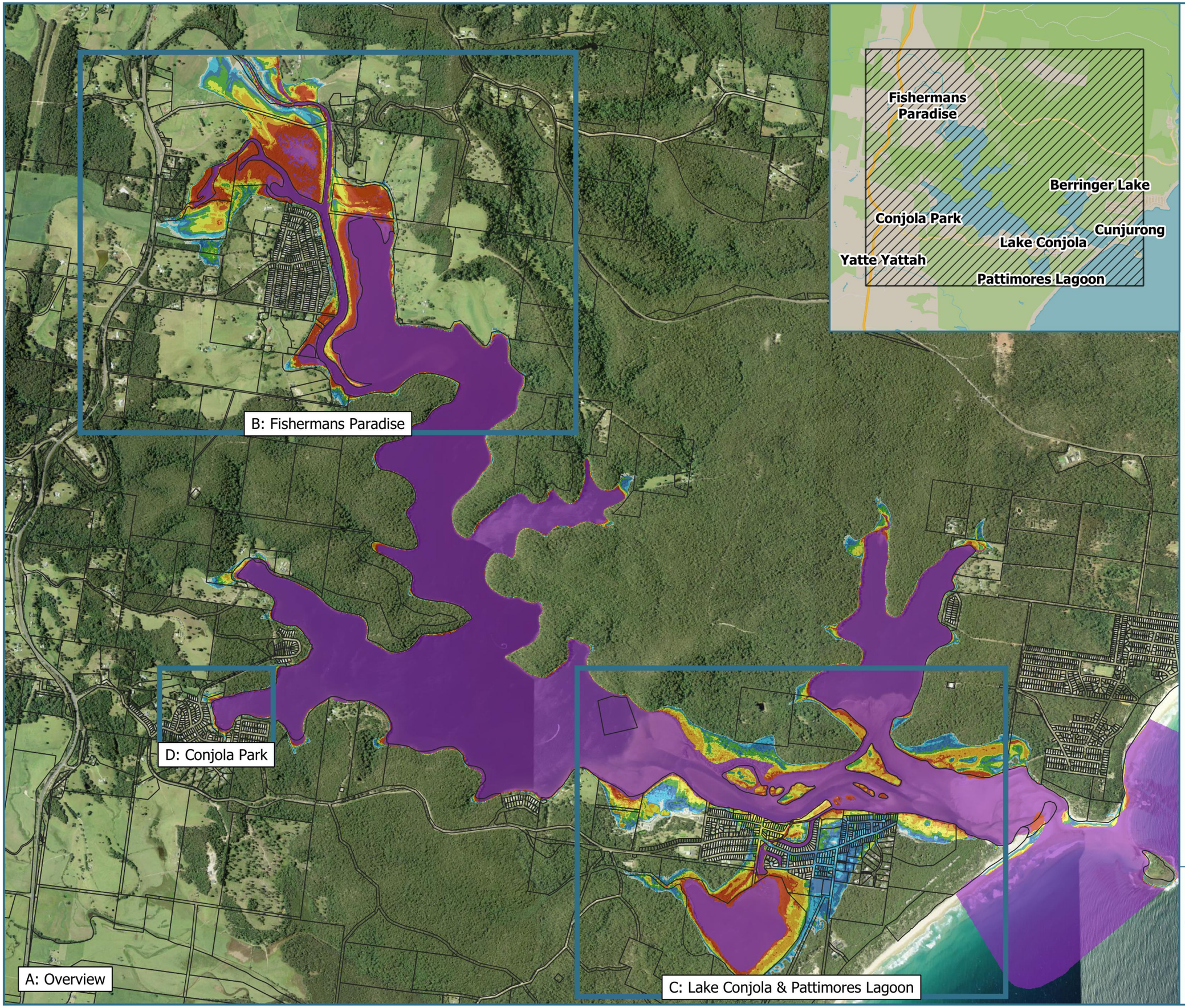

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Figure A-17
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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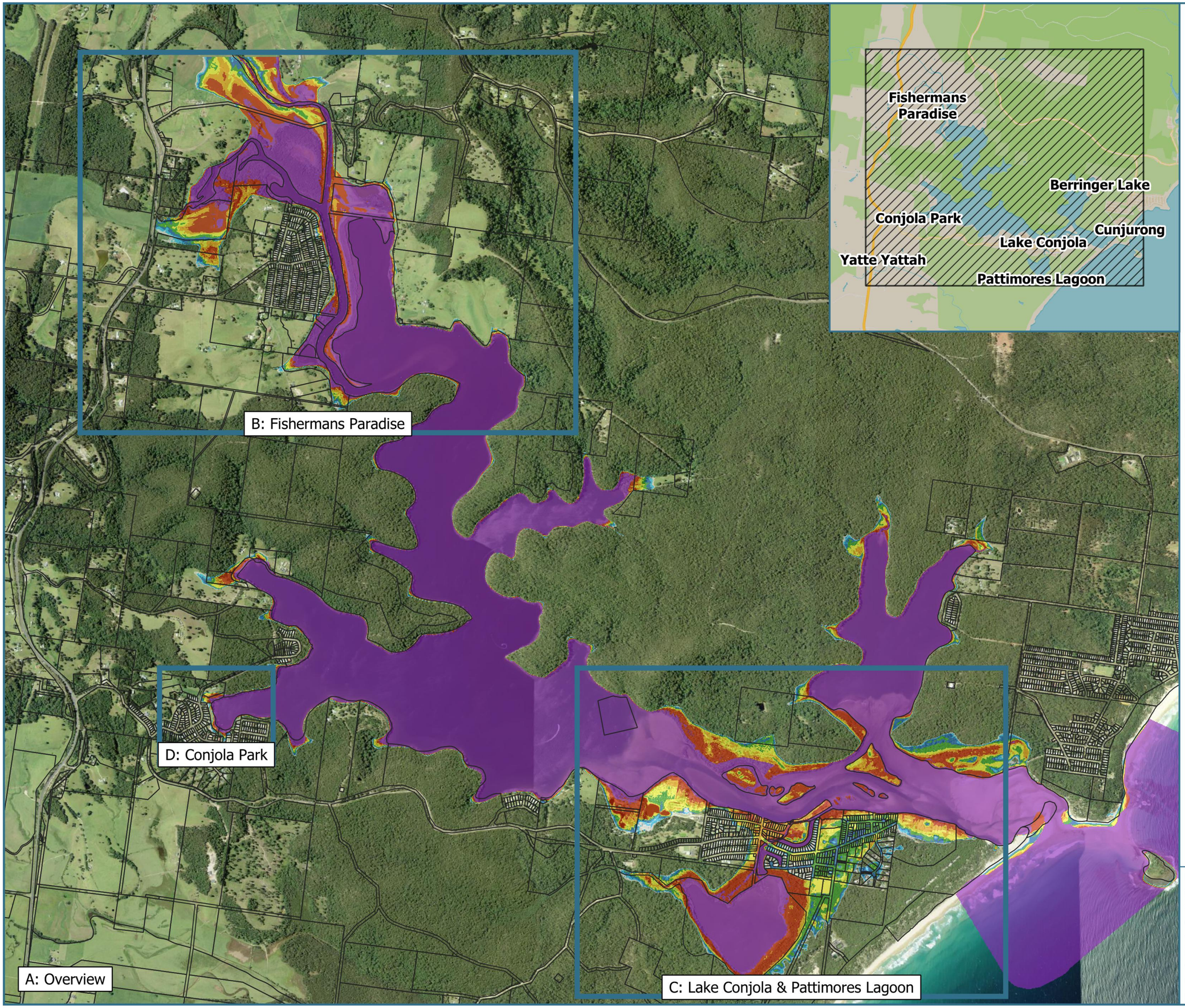

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Figure A-18
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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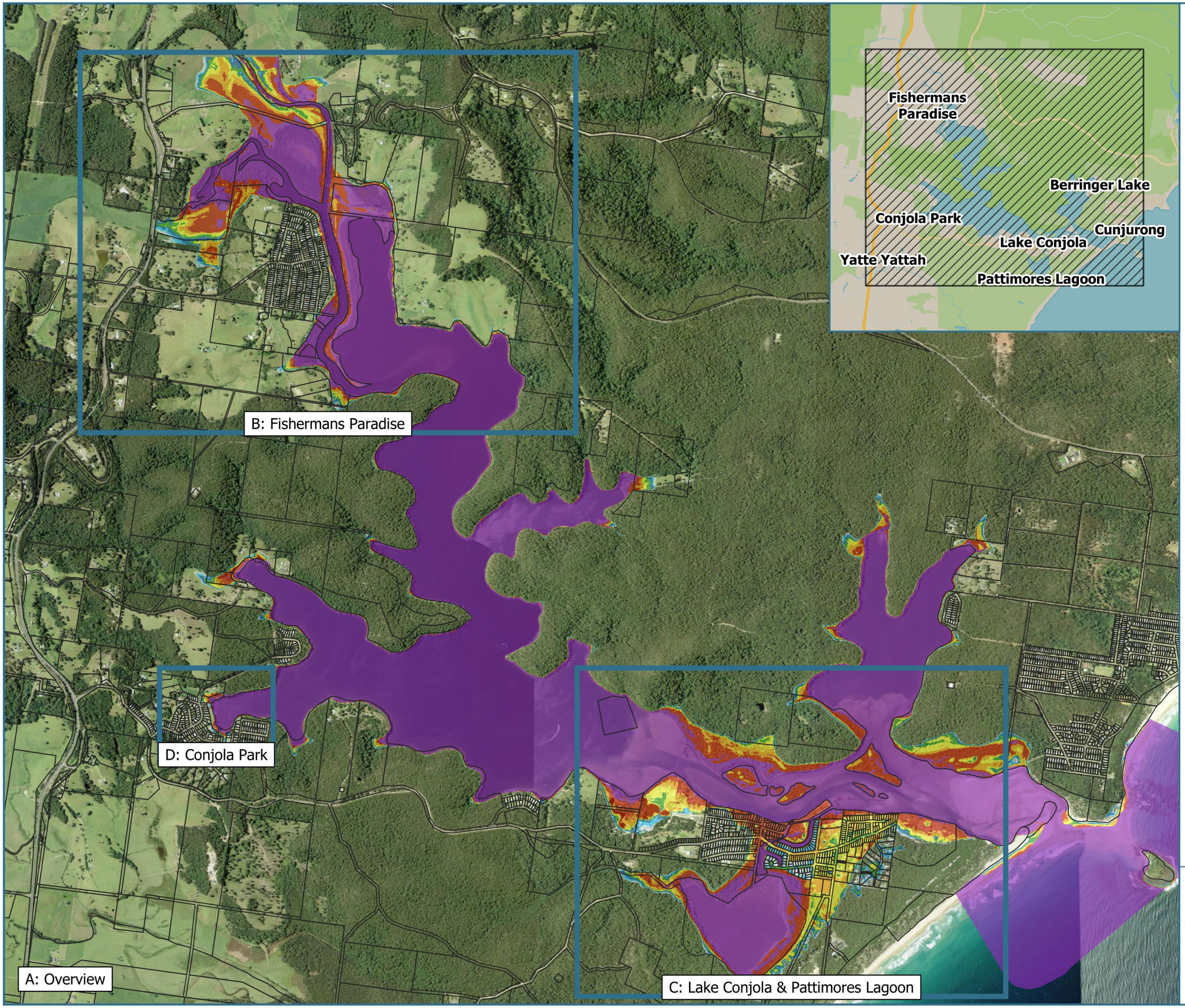

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Figure A-19
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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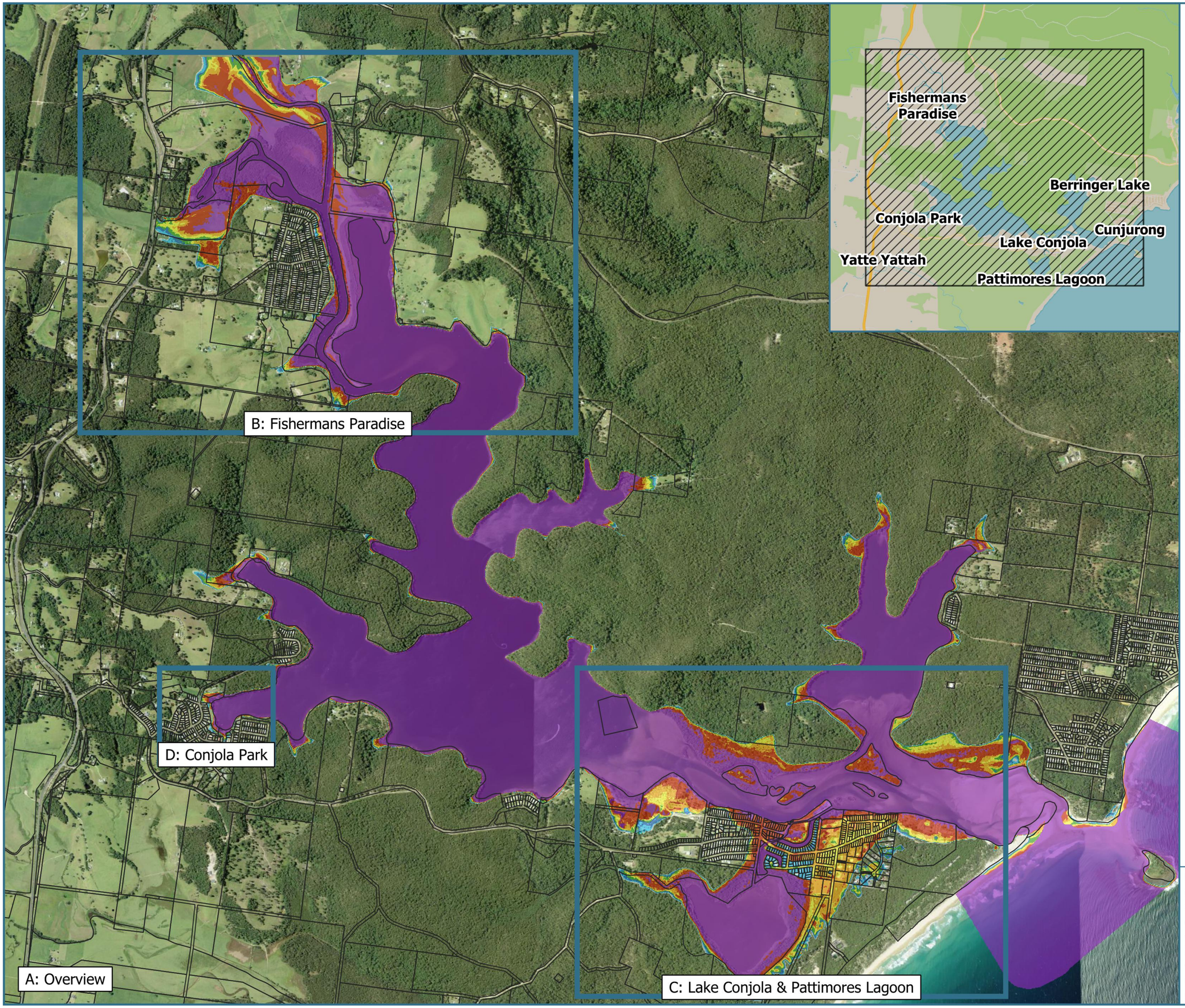

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Figure A-20
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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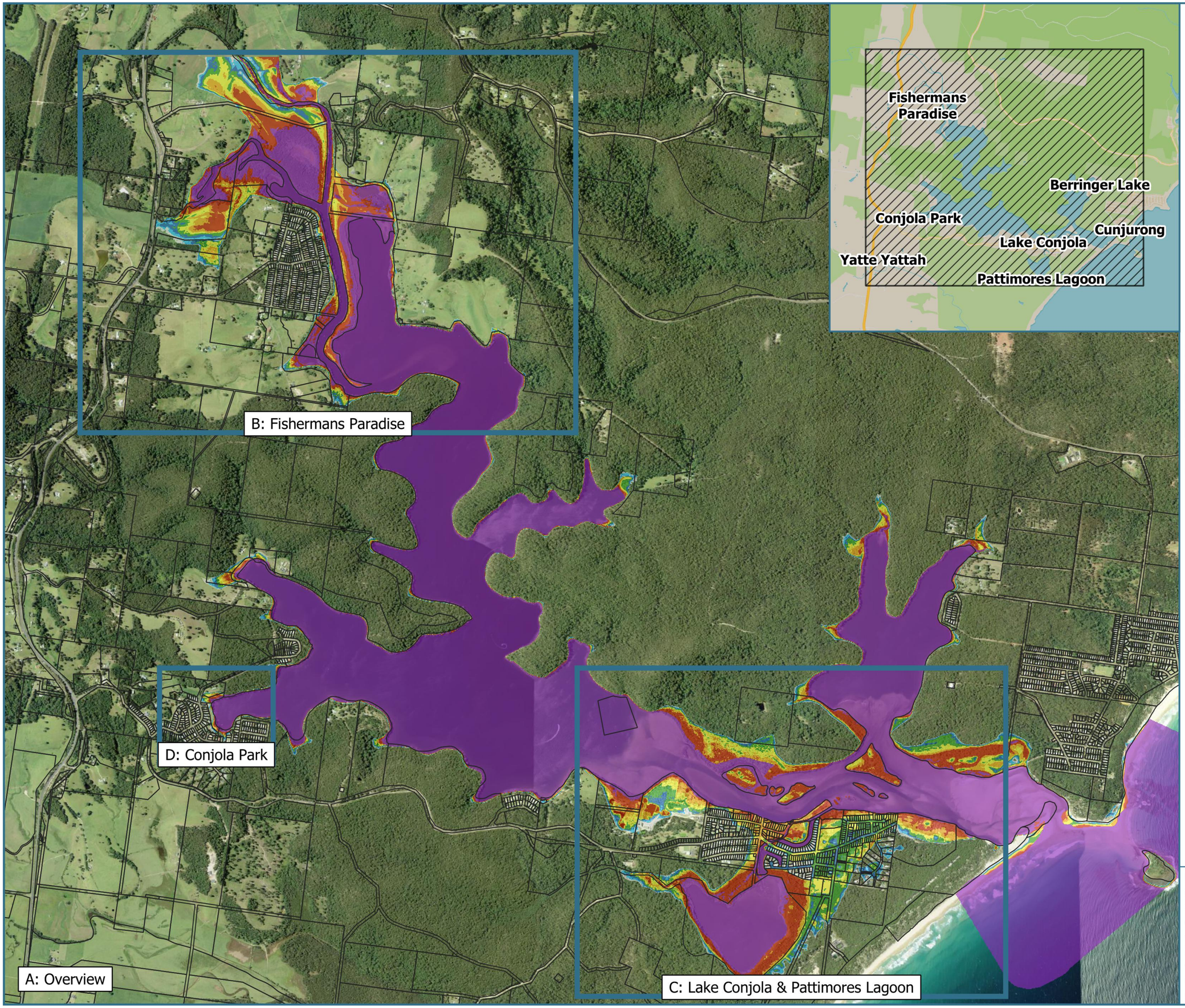

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Figure A-21
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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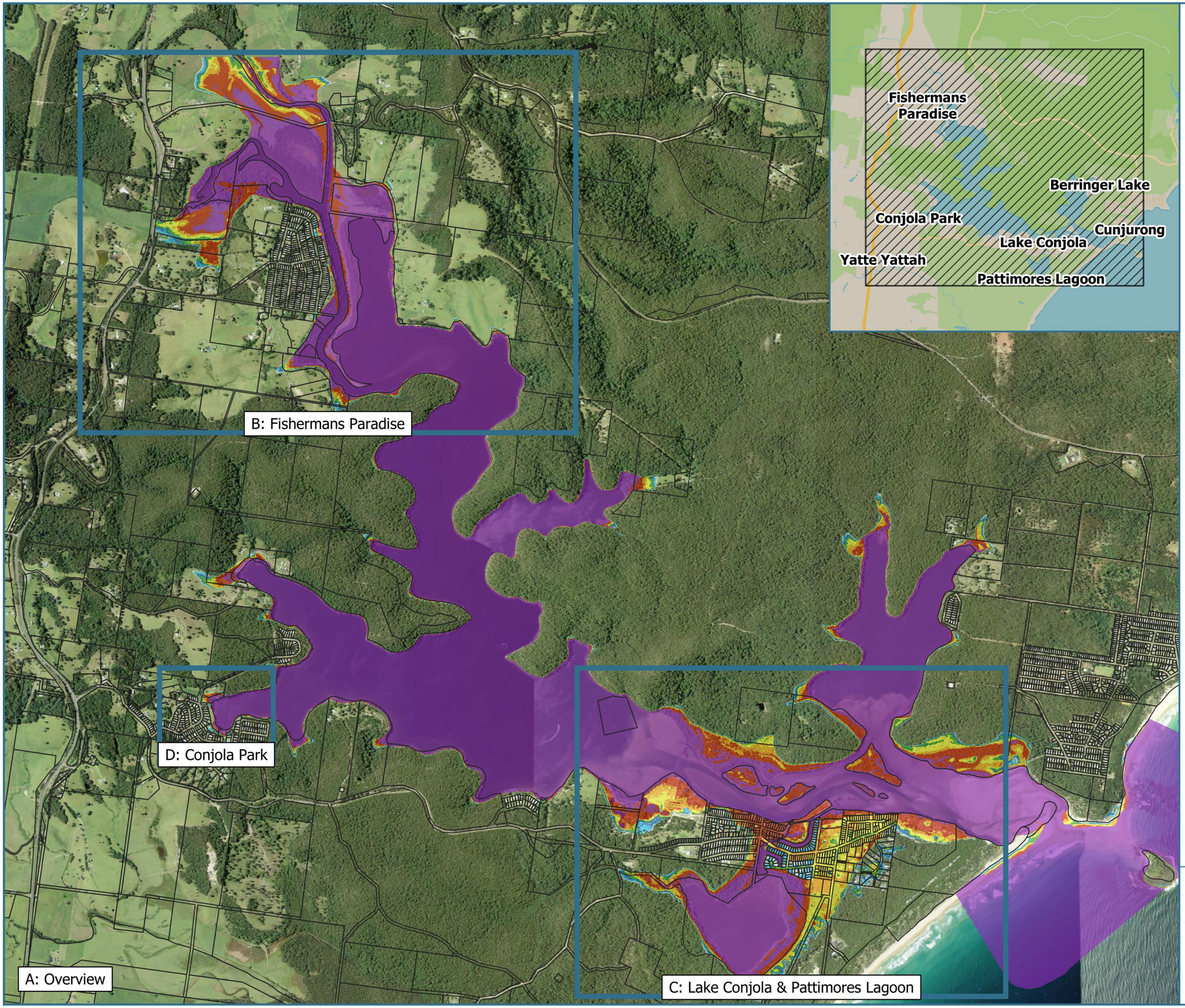

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Figure A-22
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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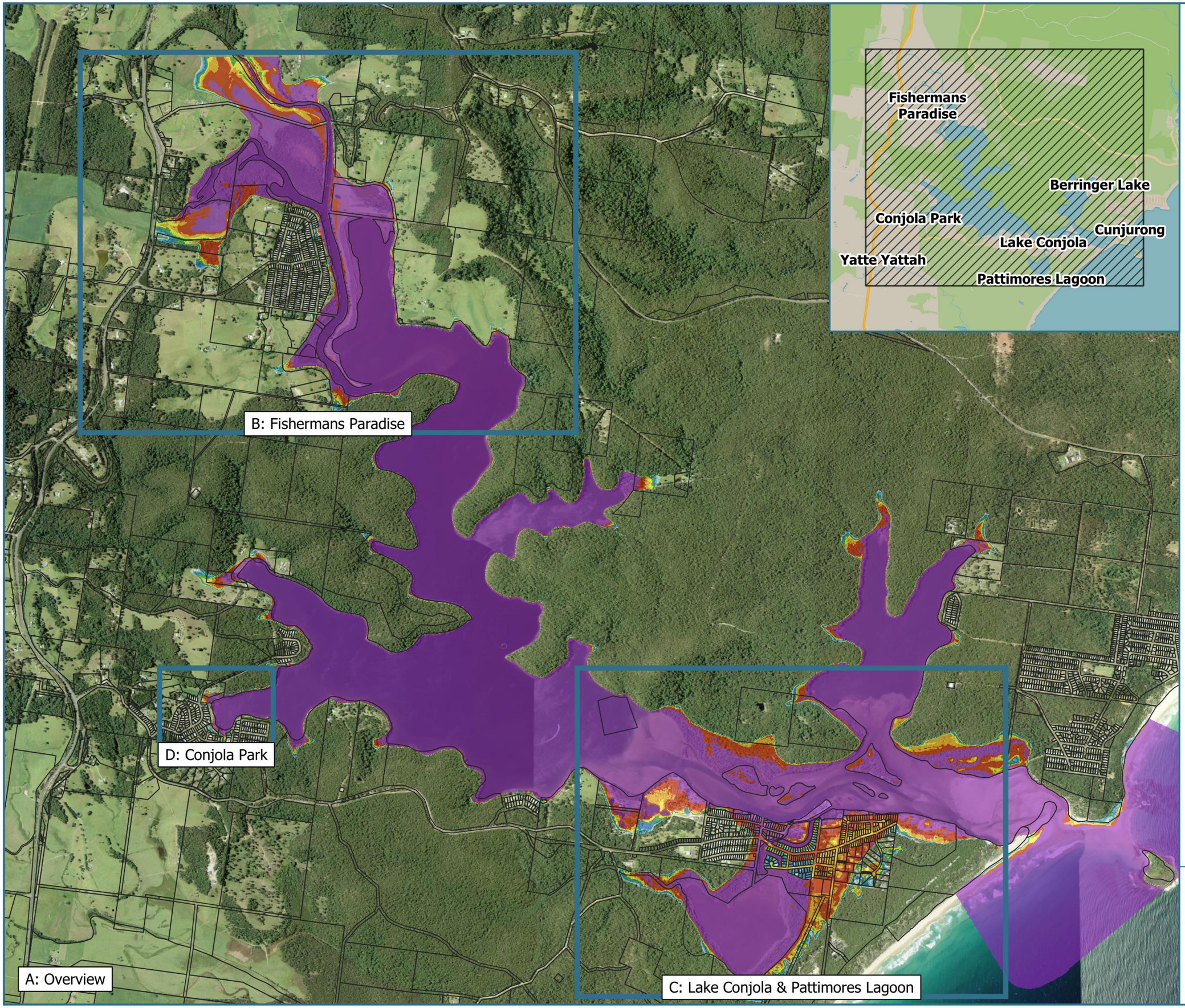

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Figure A-23
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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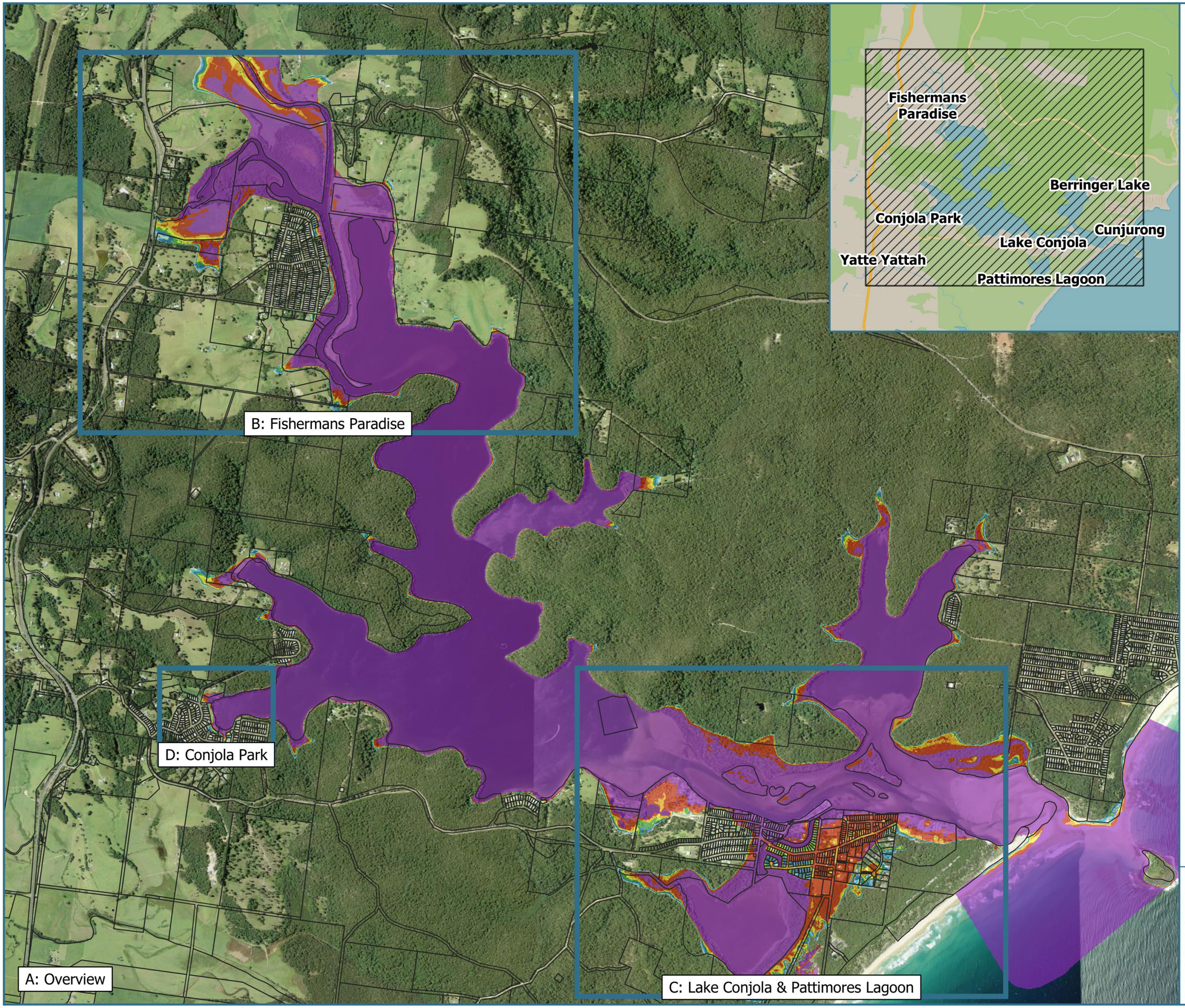

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Figure A-24
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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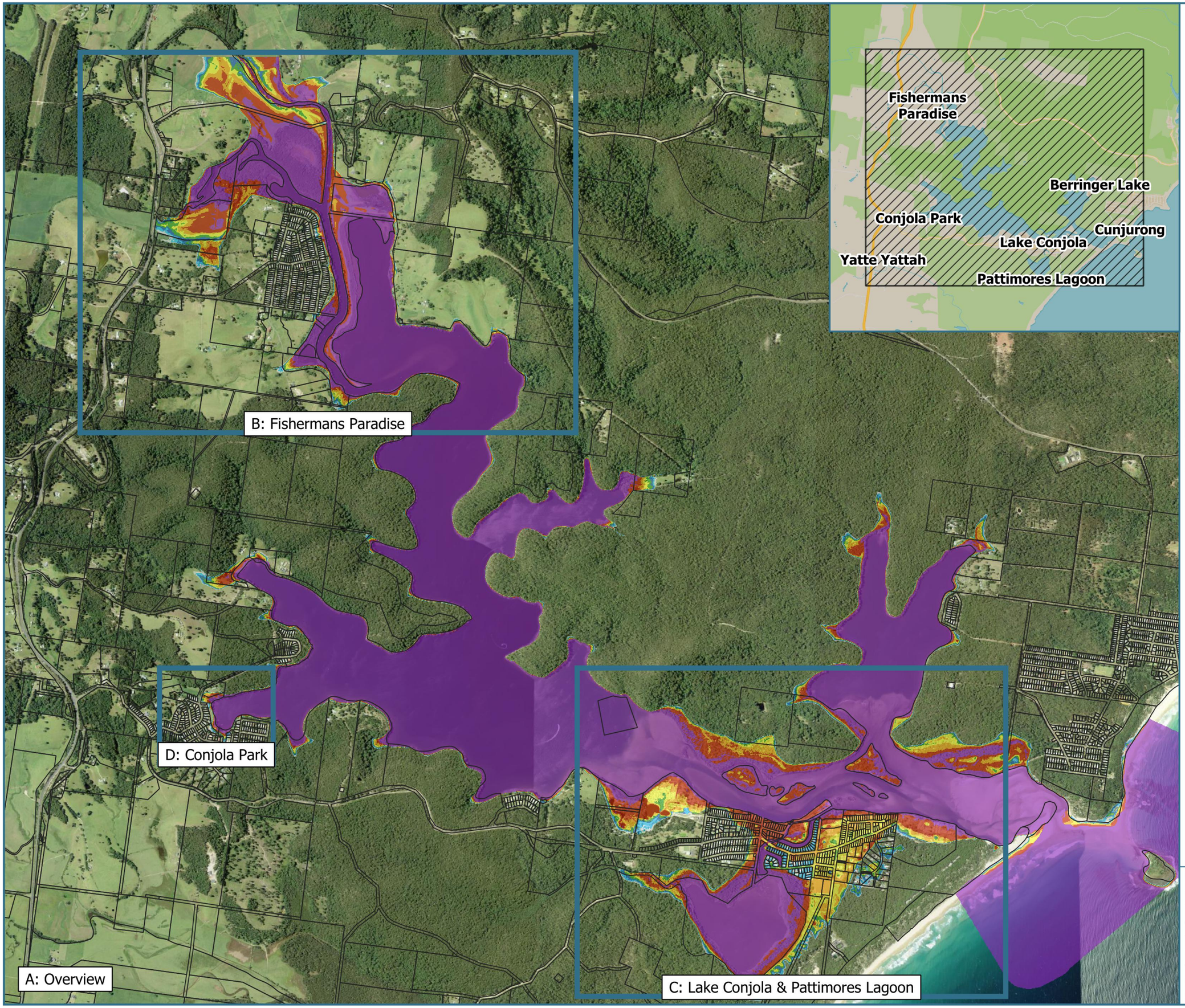

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Figure A-25
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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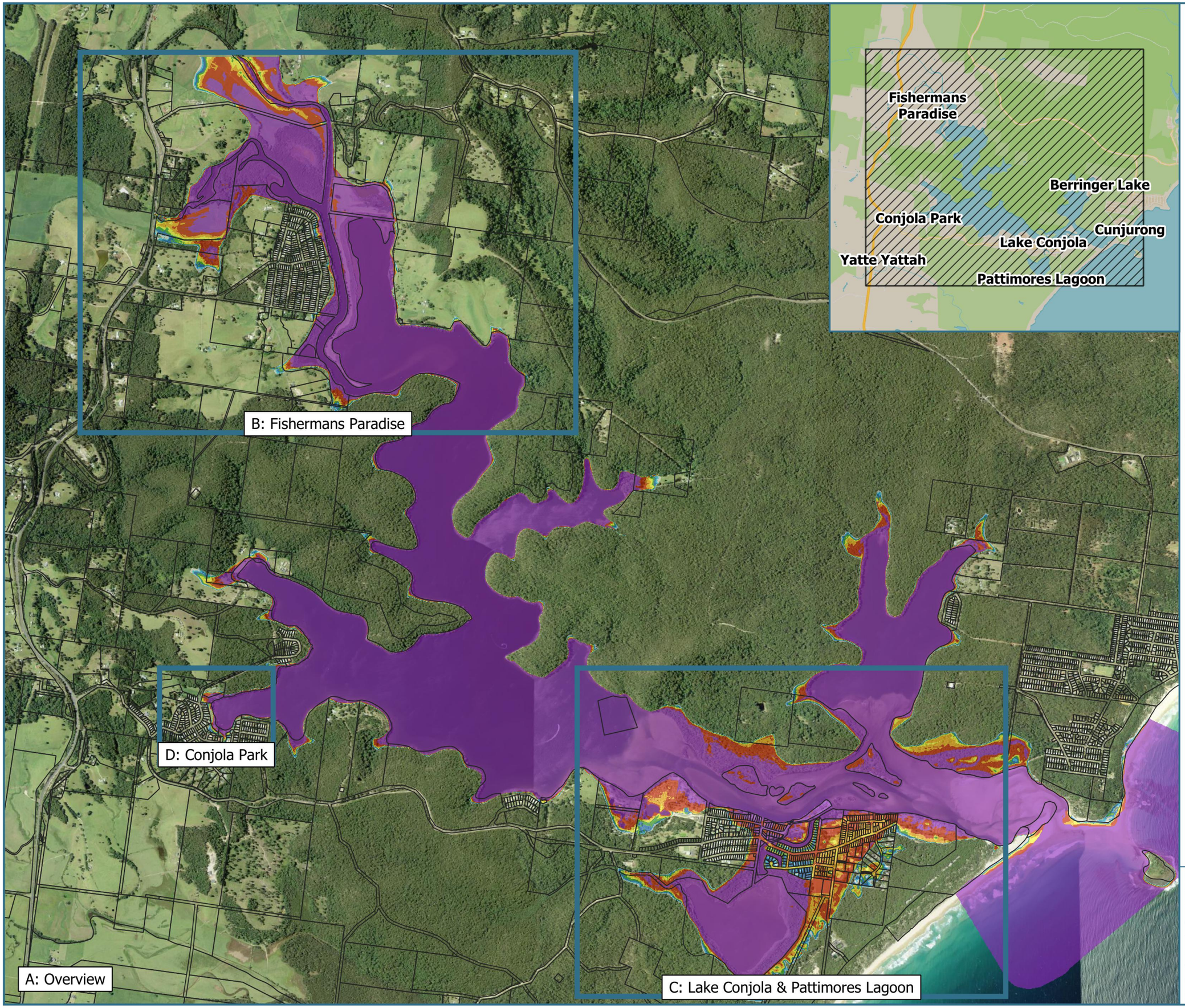

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Figure A-26
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:26,000

N

0 400 800 1,200 m

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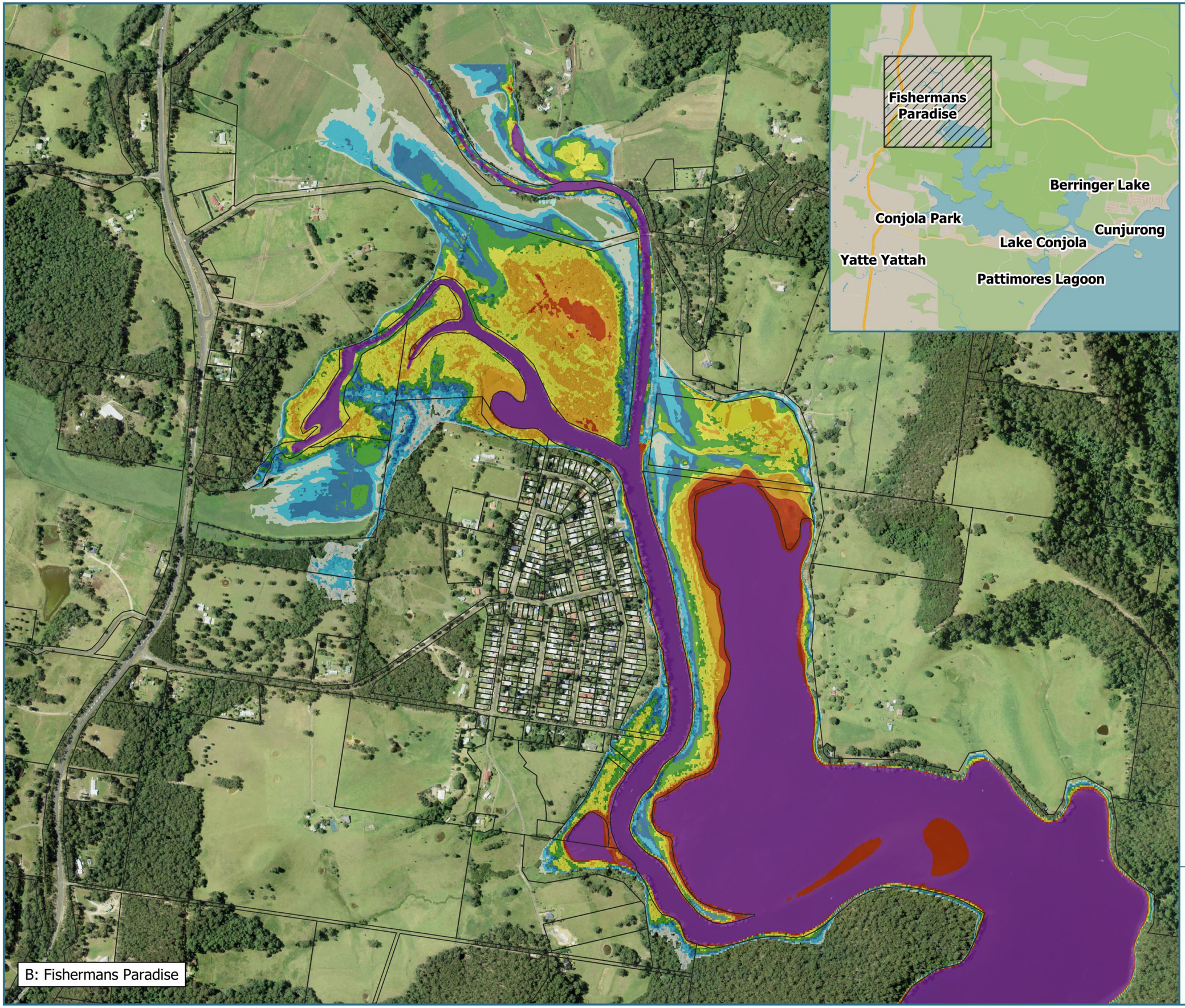

B: Fishermans Paradise

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Figure B-01
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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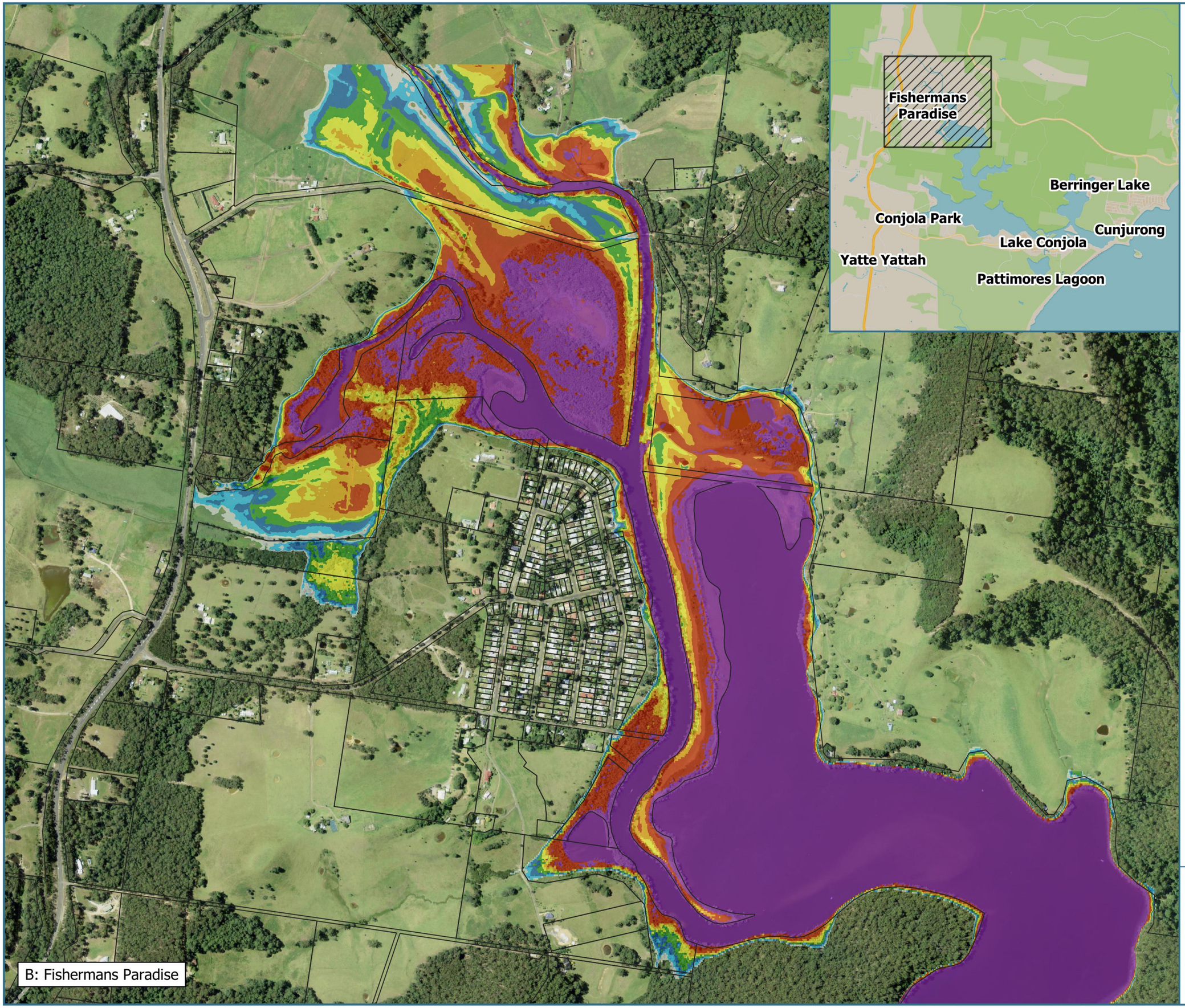

B: Fishermans Paradise

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Figure B-02
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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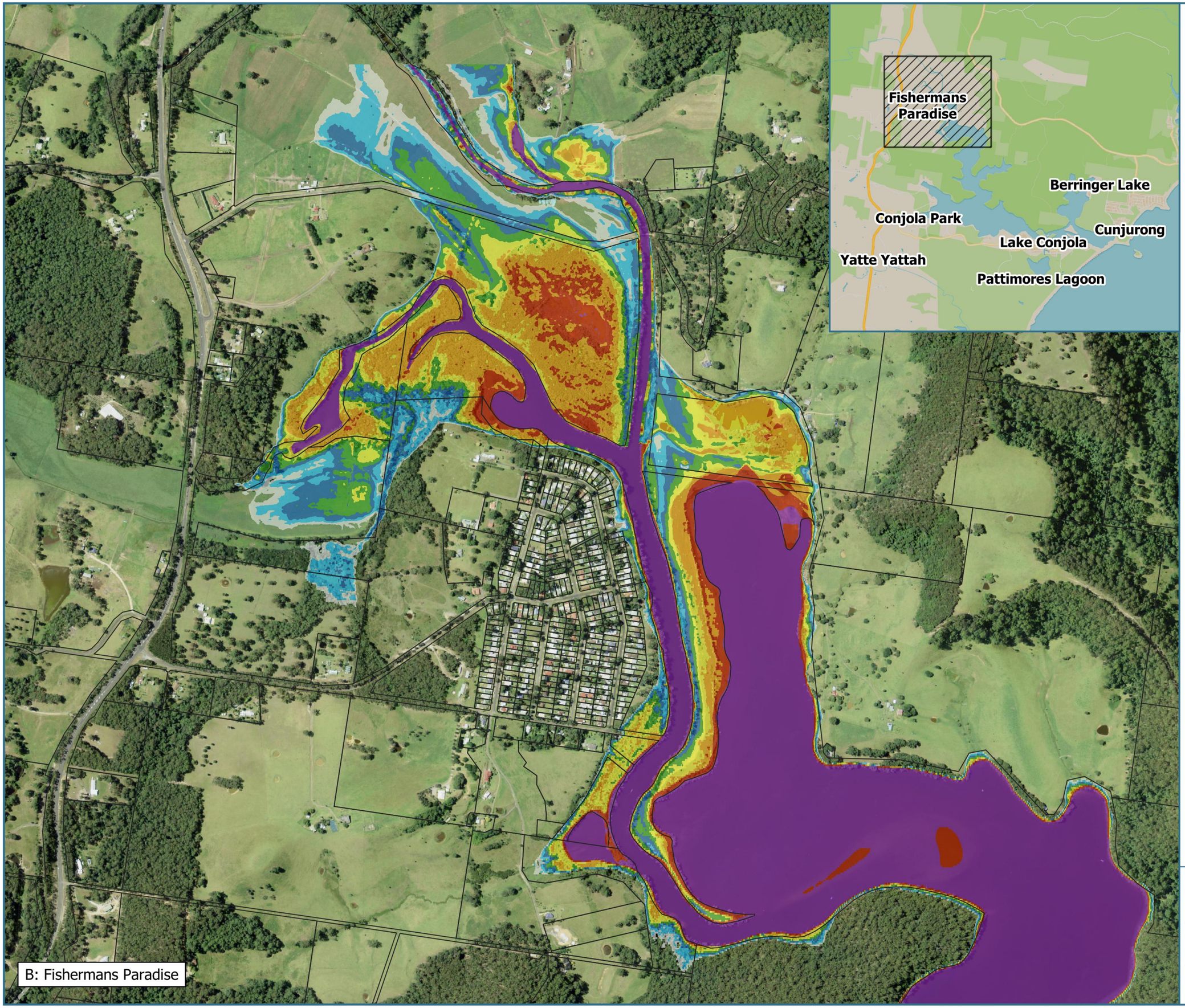

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-03
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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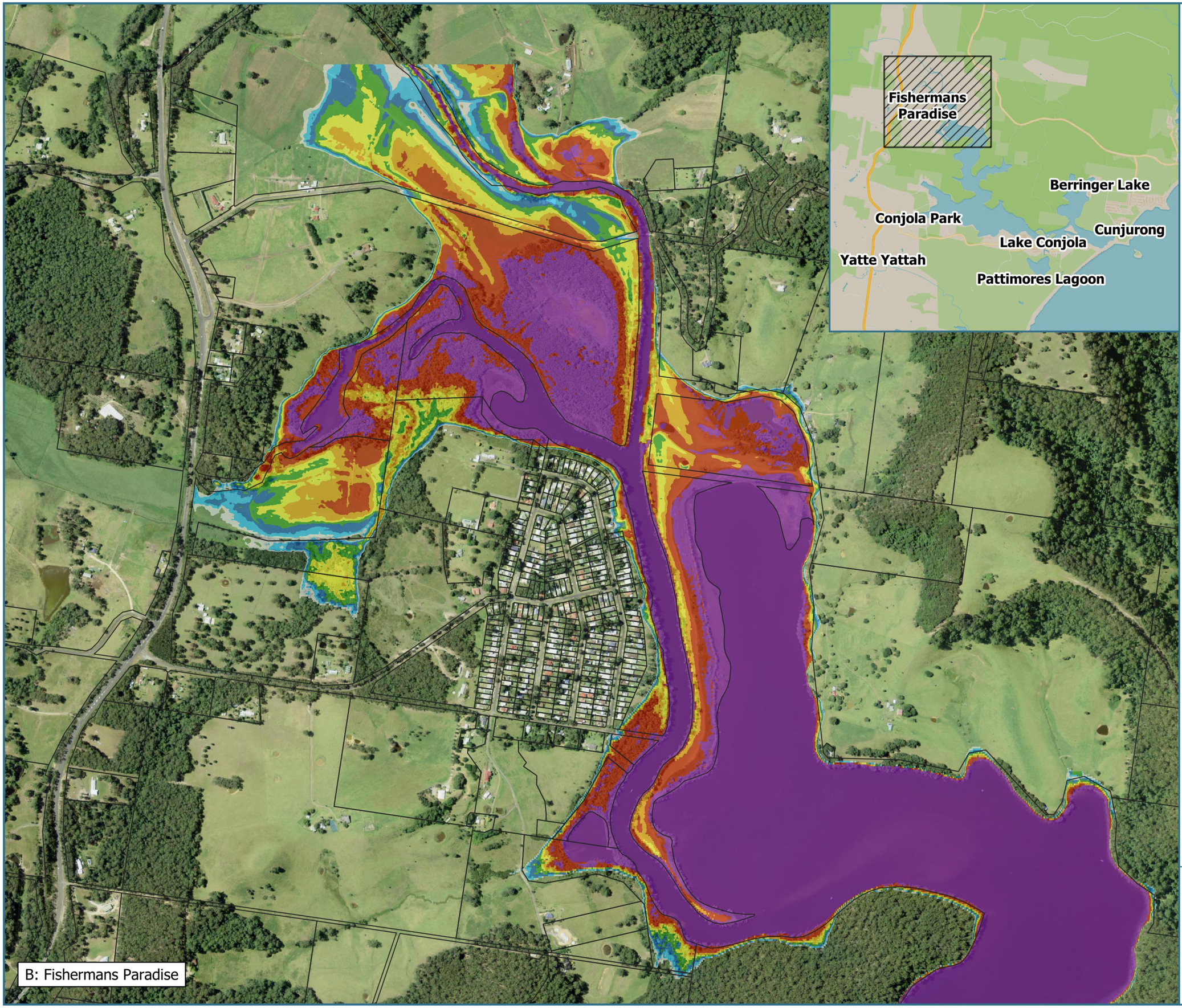

B: Fishermans Paradise

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Figure B-04
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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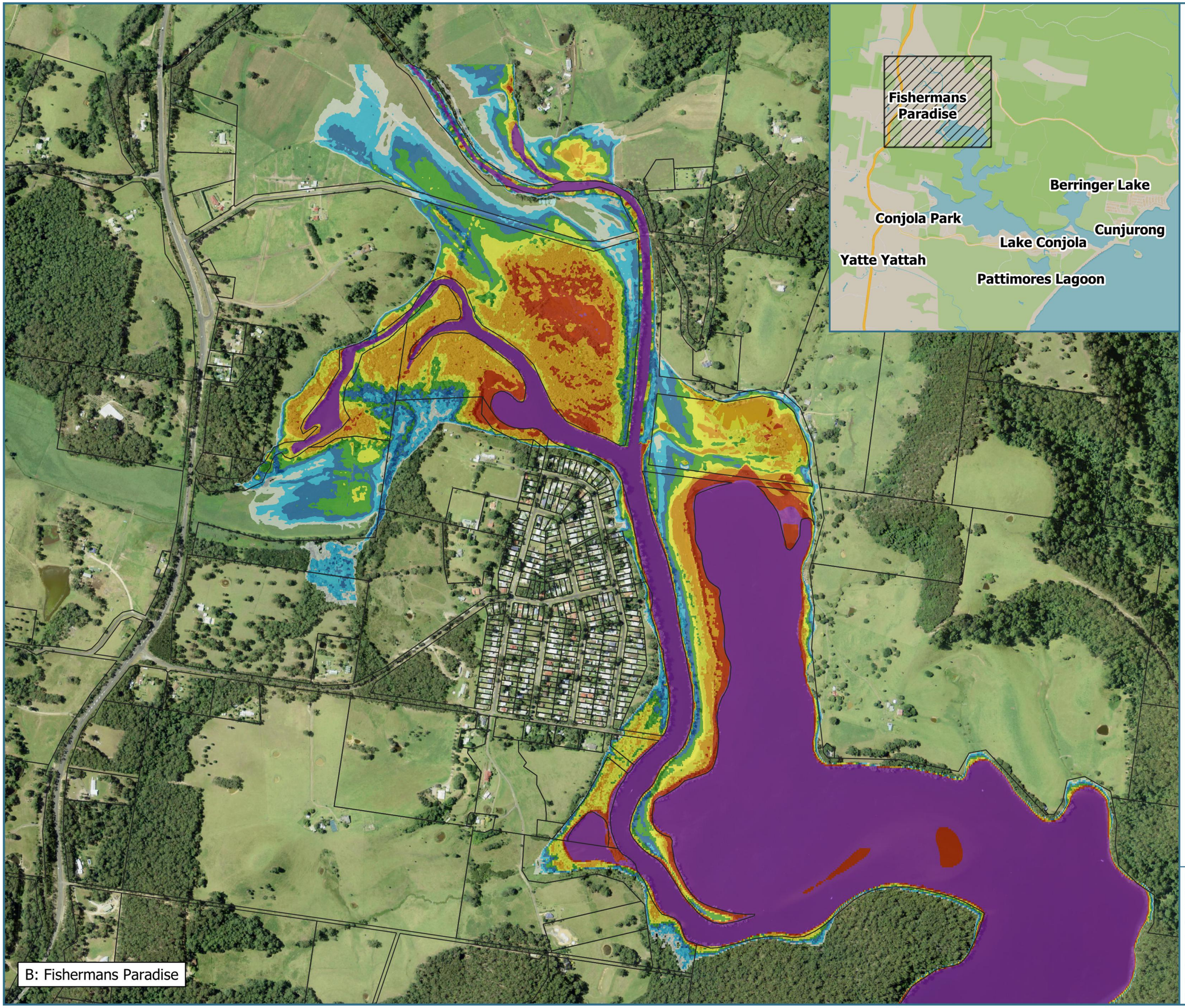

B: Fishermans Paradise

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Figure B-05
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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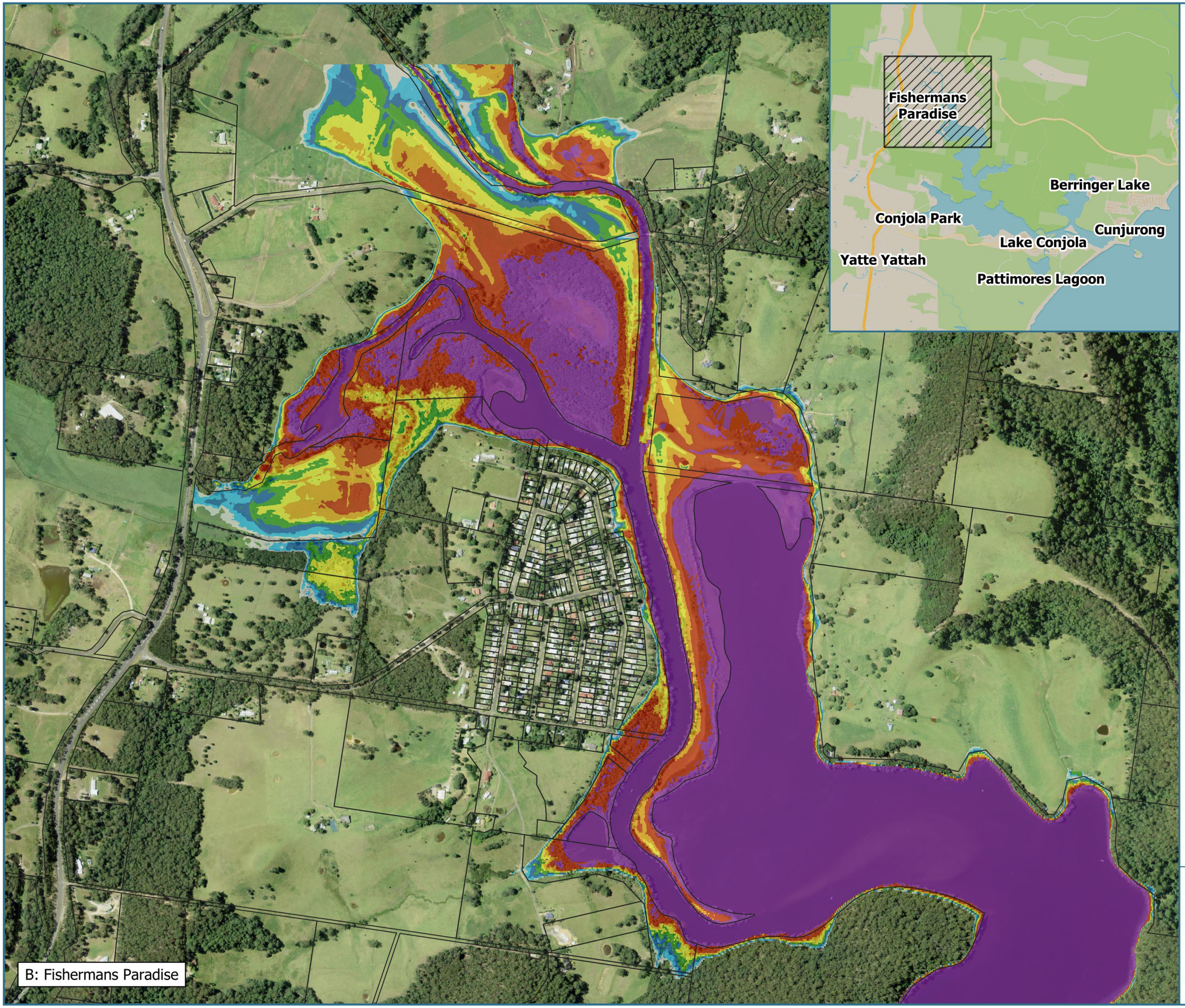

B: Fishermans Paradise

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Figure B-06
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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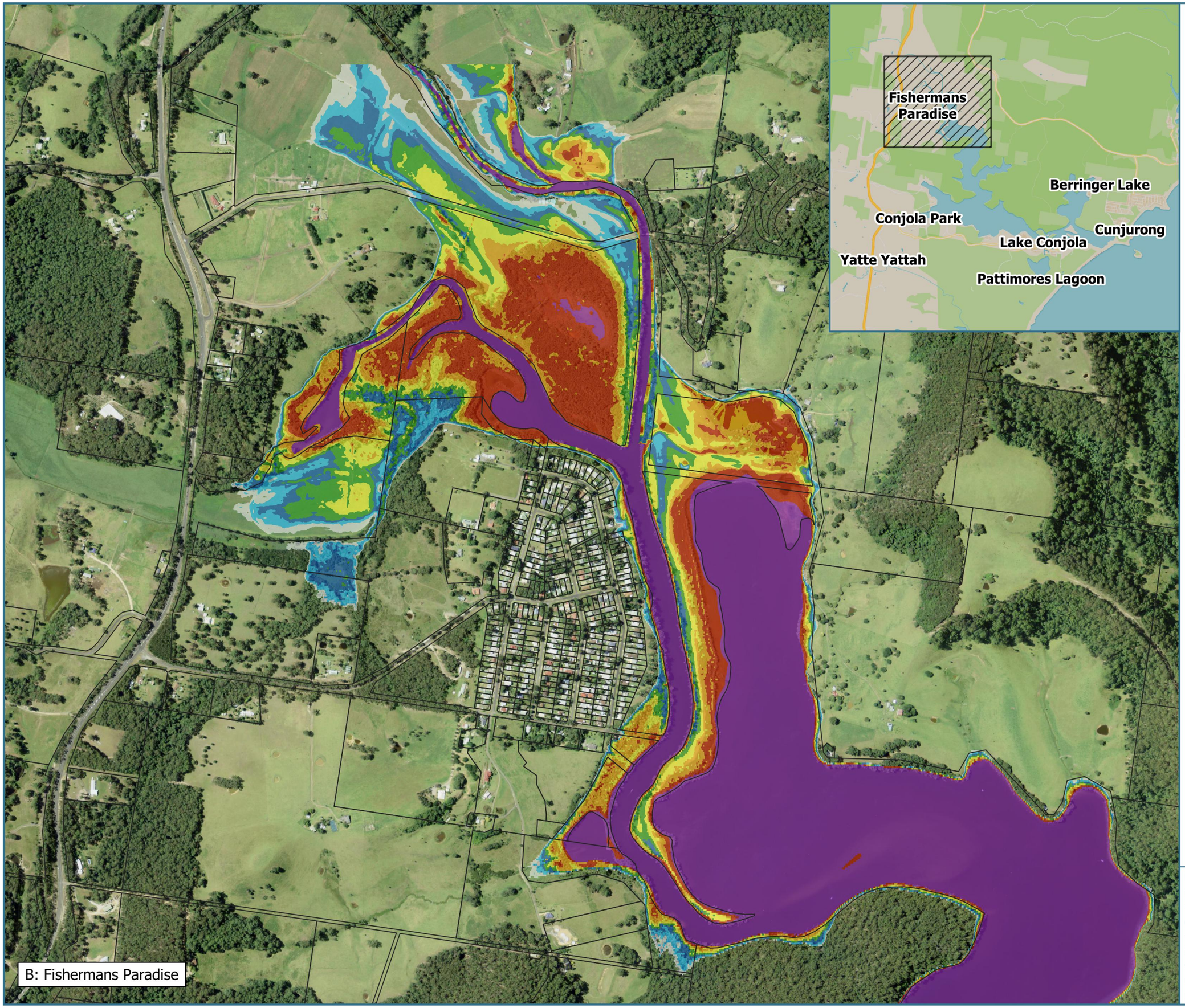

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Figure B-07
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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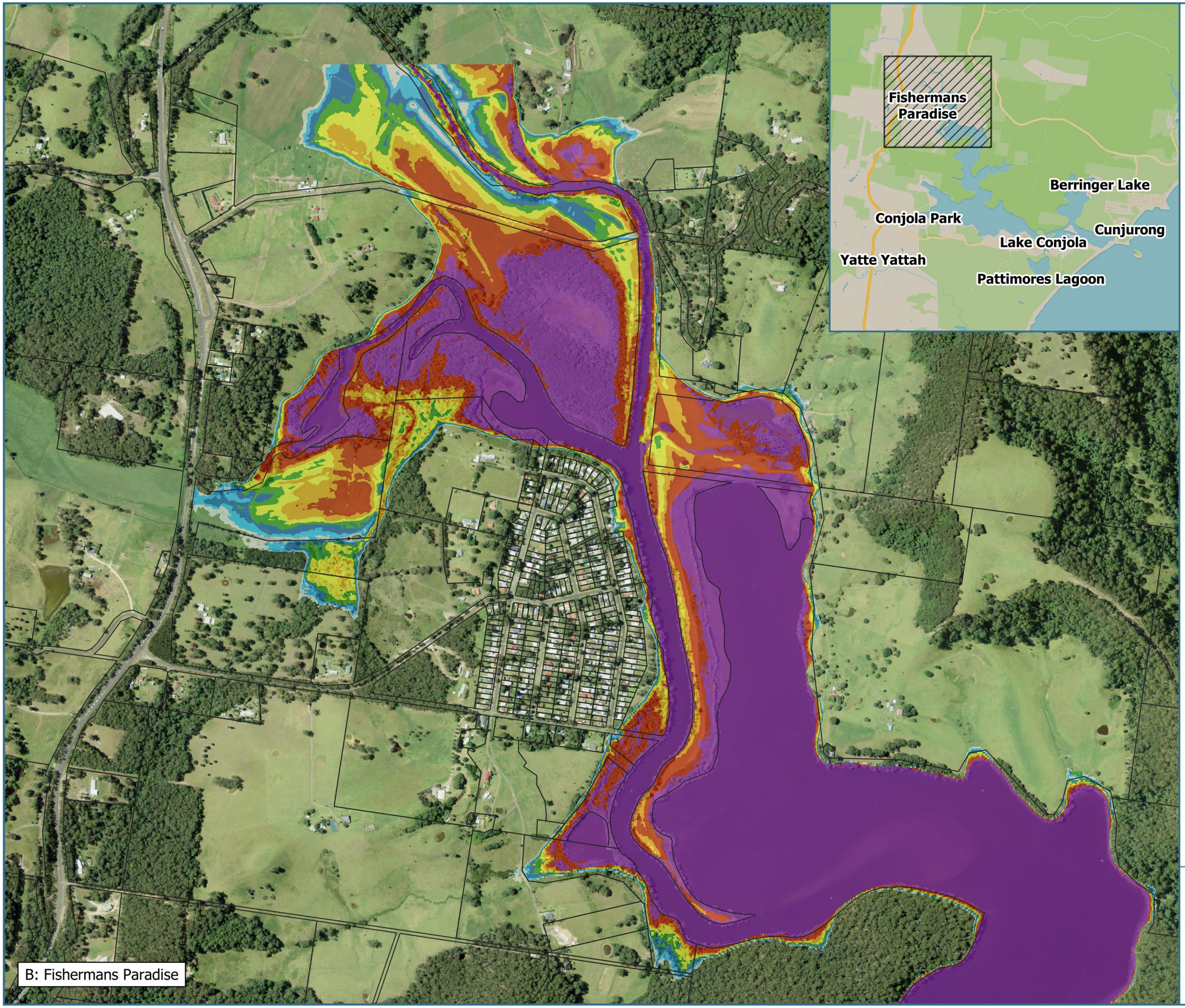

B: Fishermans Paradise

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Figure B-08
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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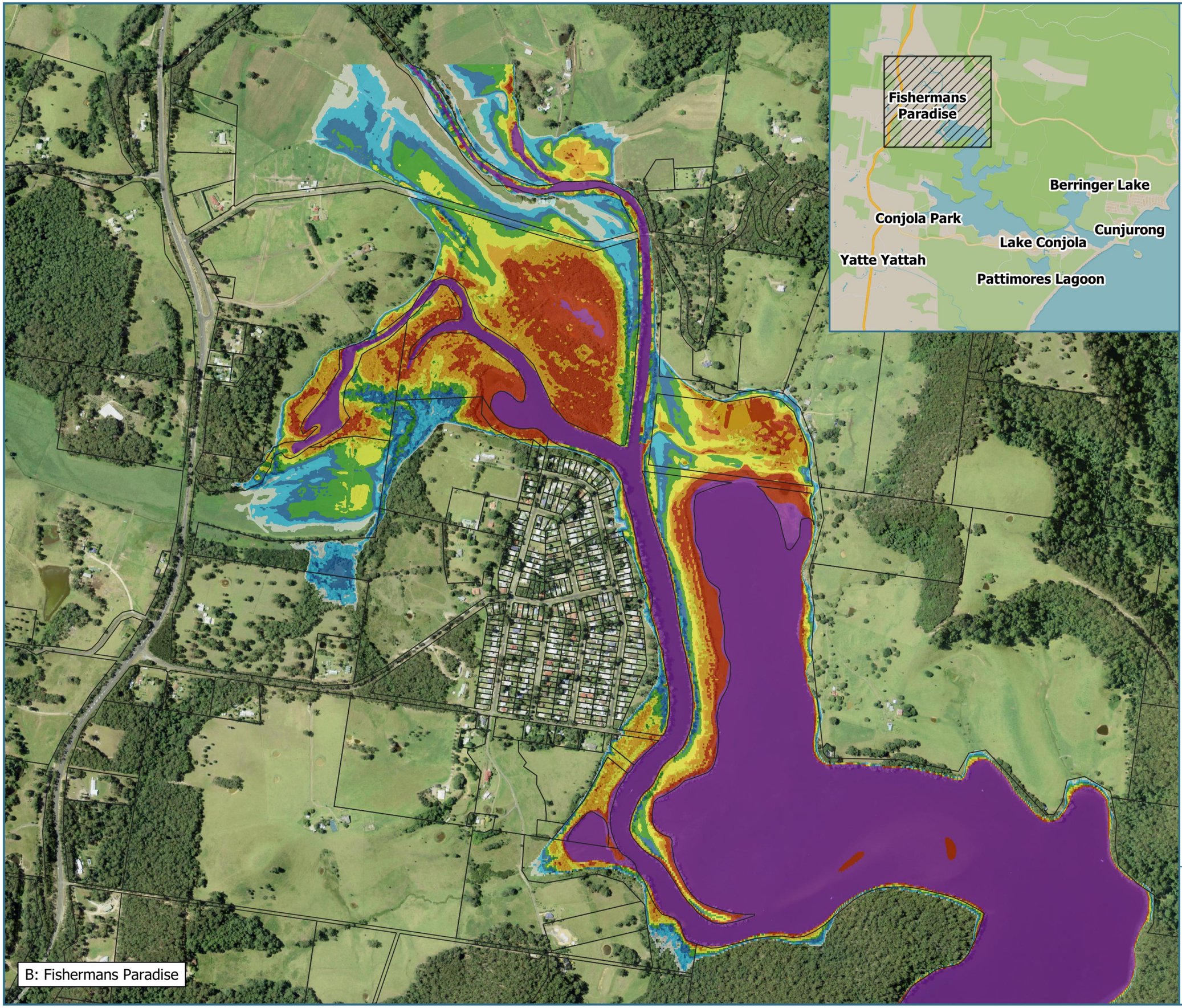

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Figure B-09
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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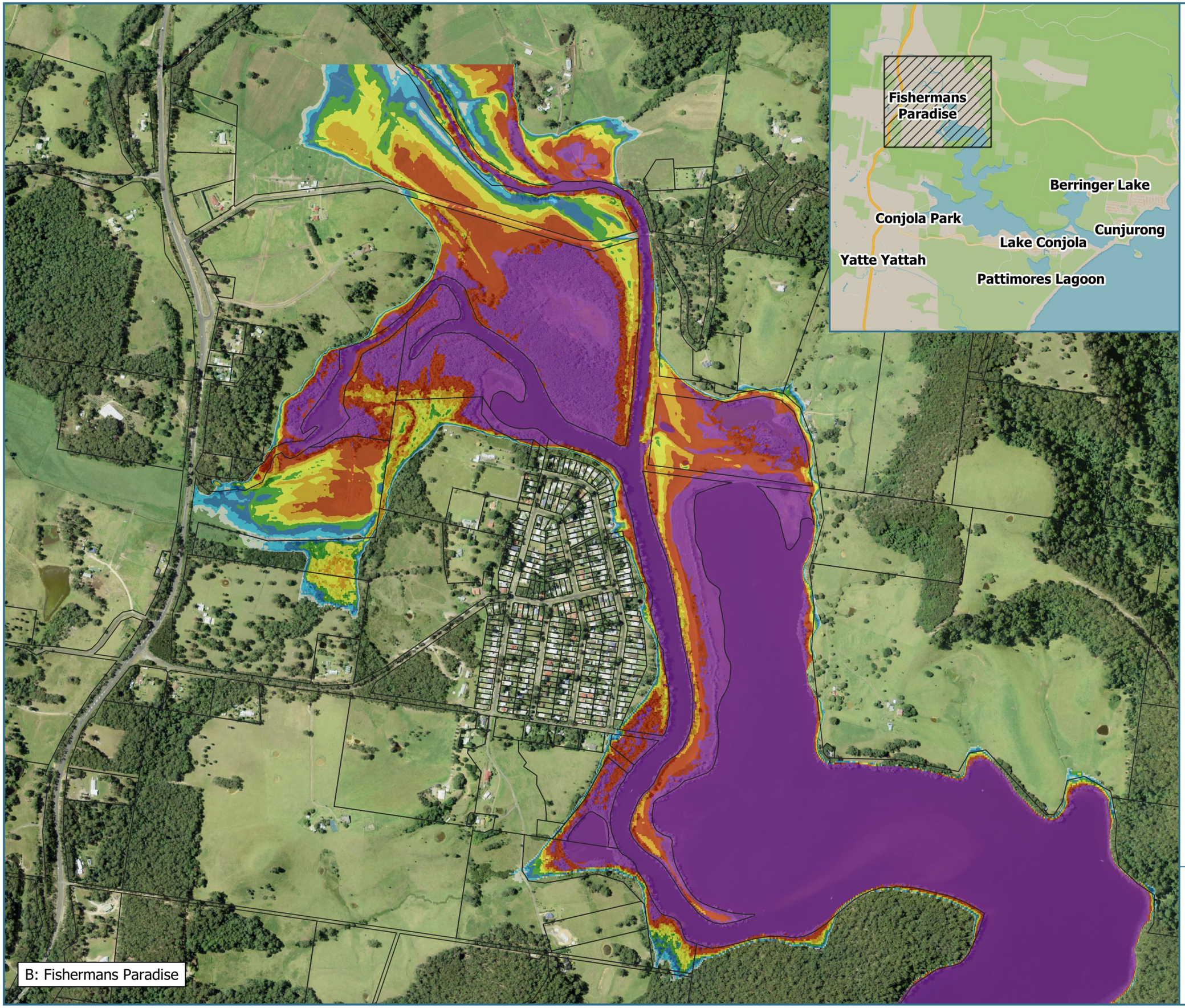

B: Fishermans Paradise

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Figure B-10
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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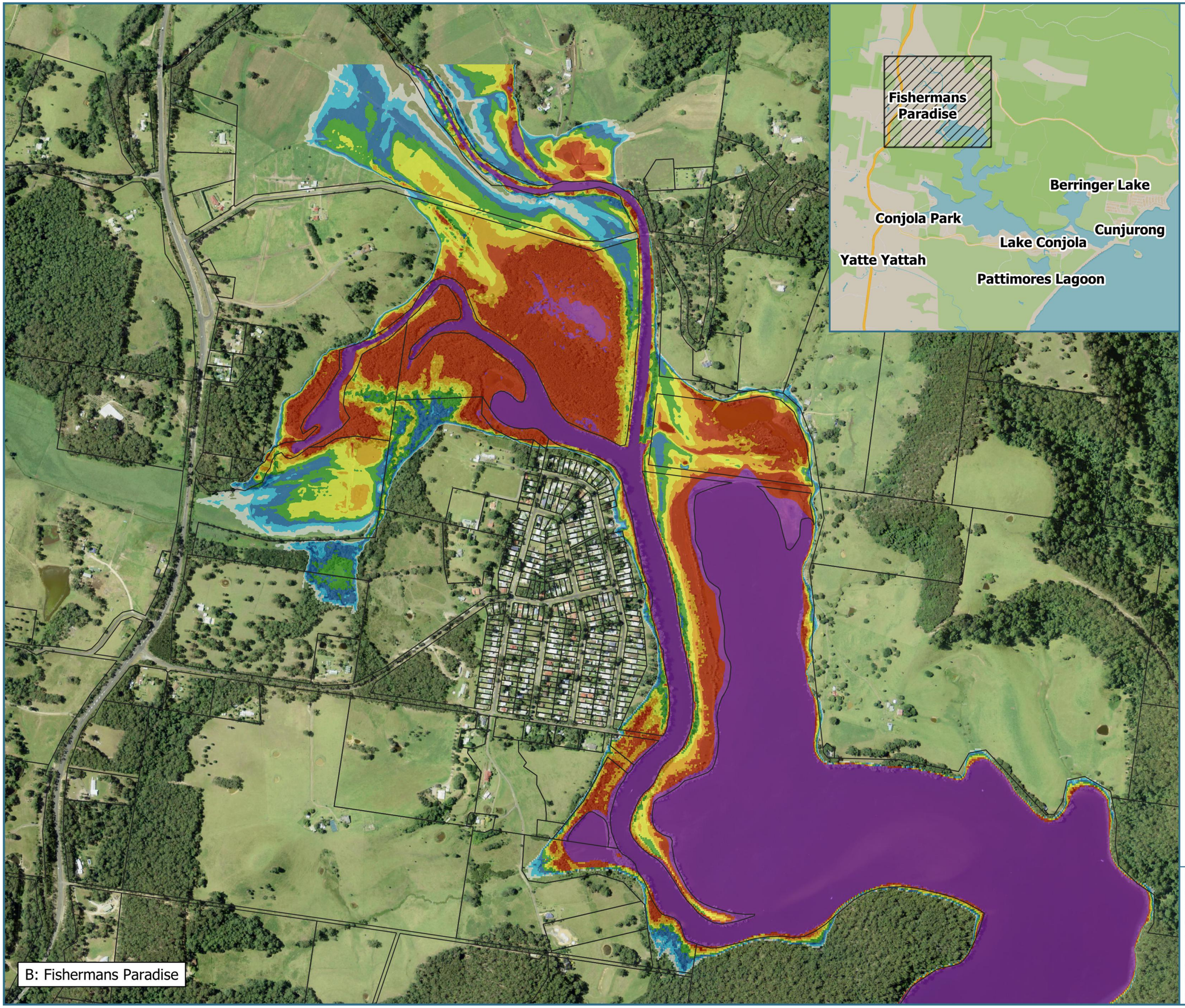

B: Fishermans Paradise

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Figure B-11
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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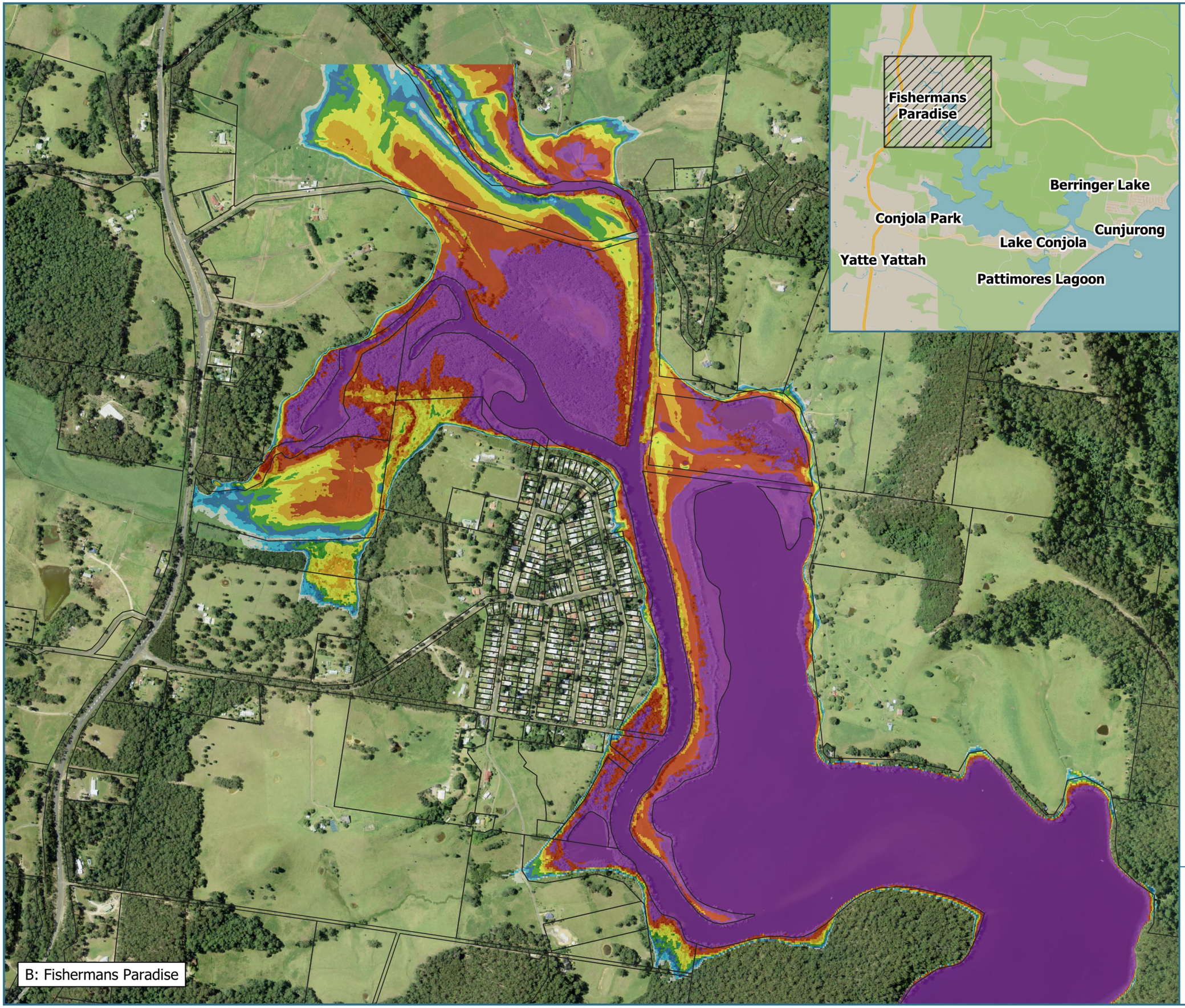

B: Fishermans Paradise

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Figure B-12
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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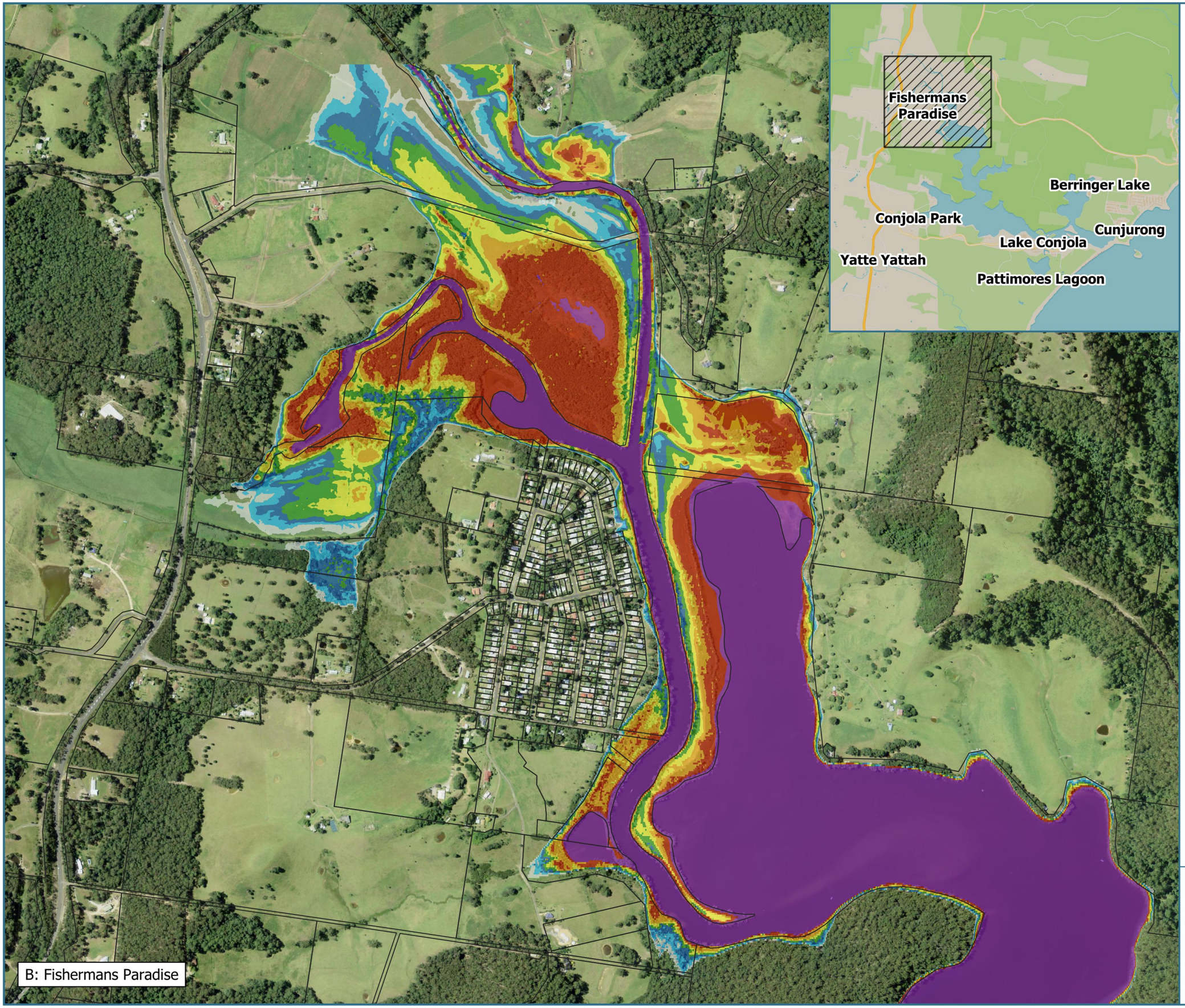

B: Fishermans Paradise

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Figure B-13
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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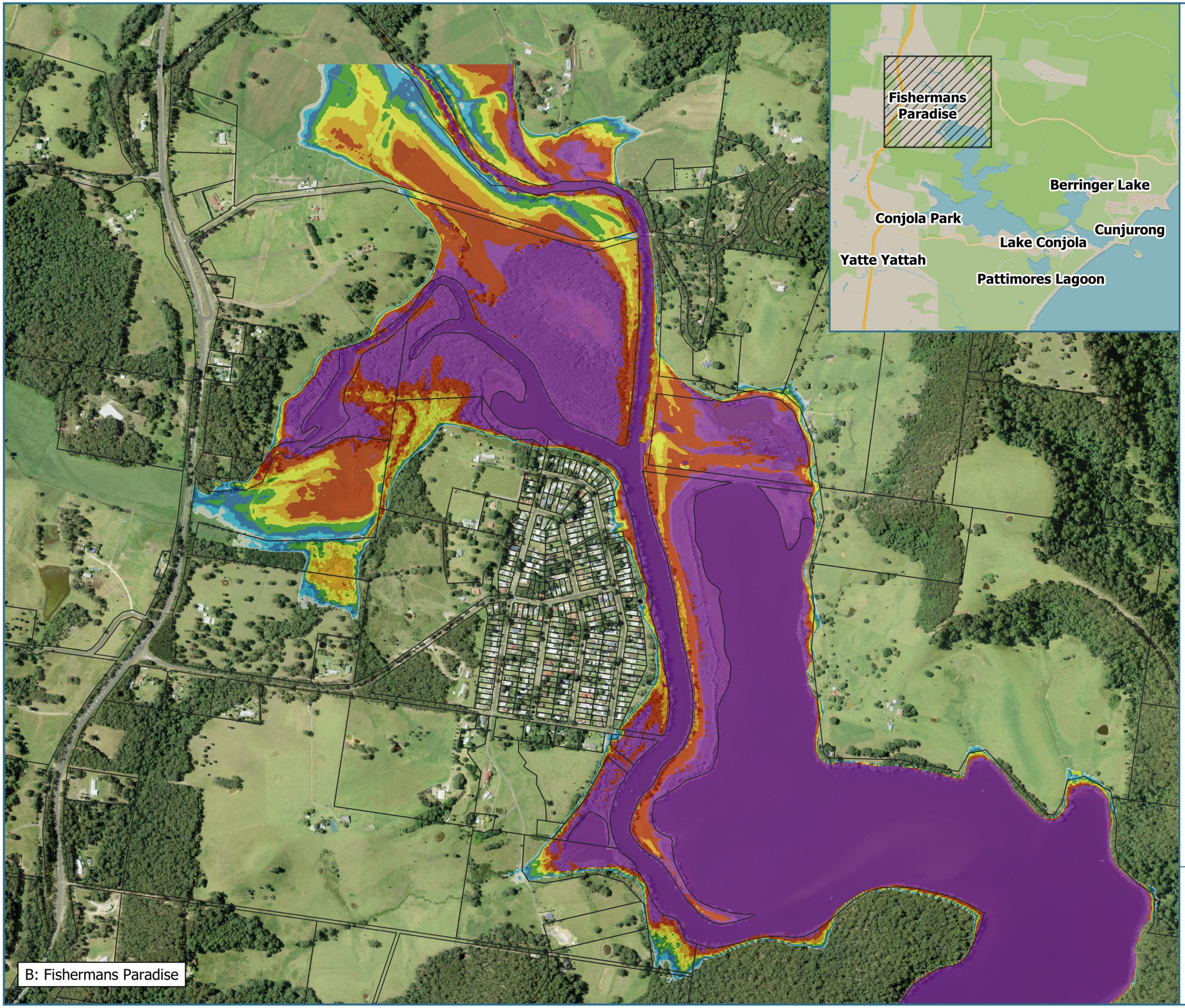

B: Fishermans Paradise

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Figure B-14
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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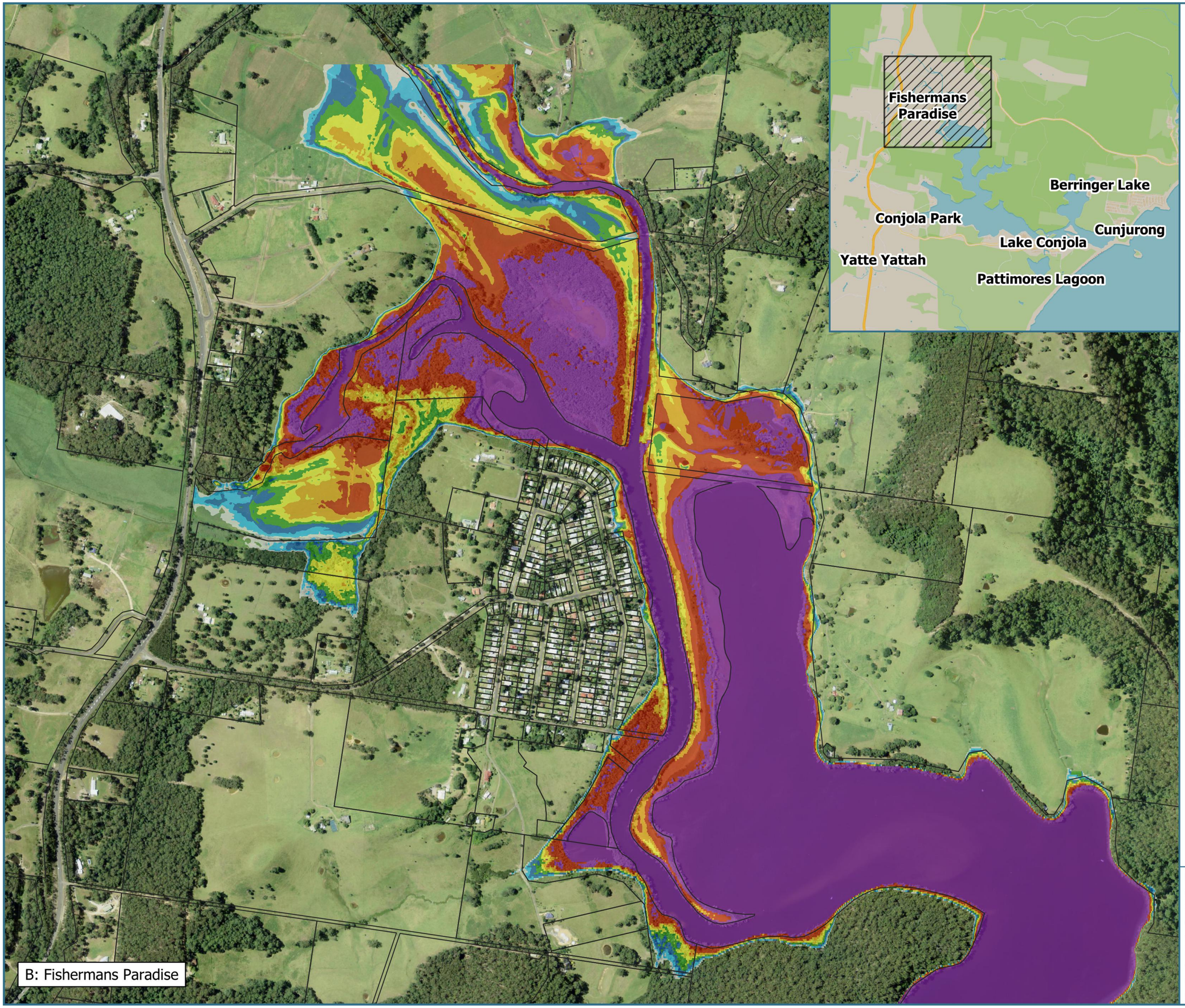

B: Fishermans Paradise

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Figure B-15
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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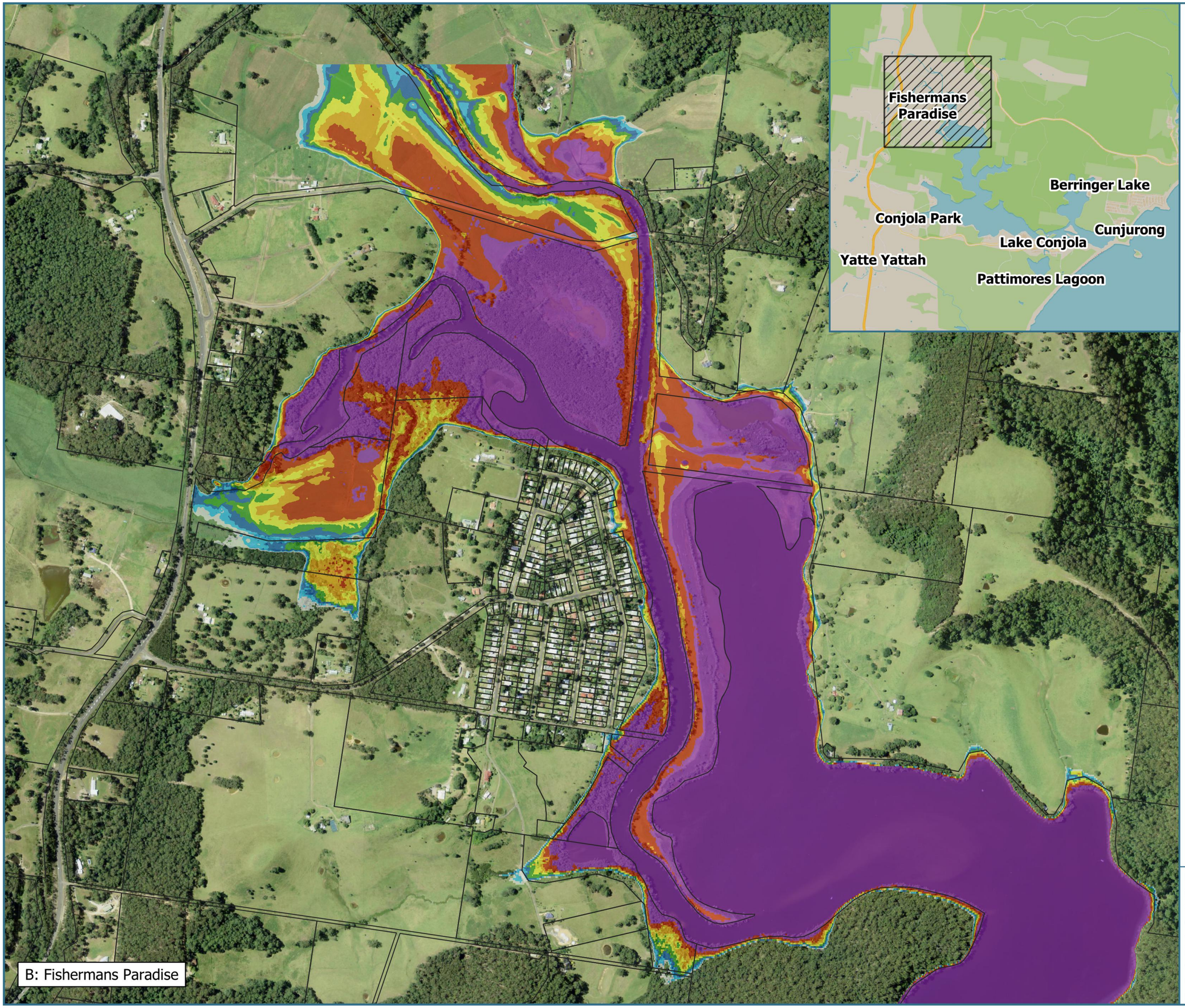

B: Fishermans Paradise

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Figure B-16
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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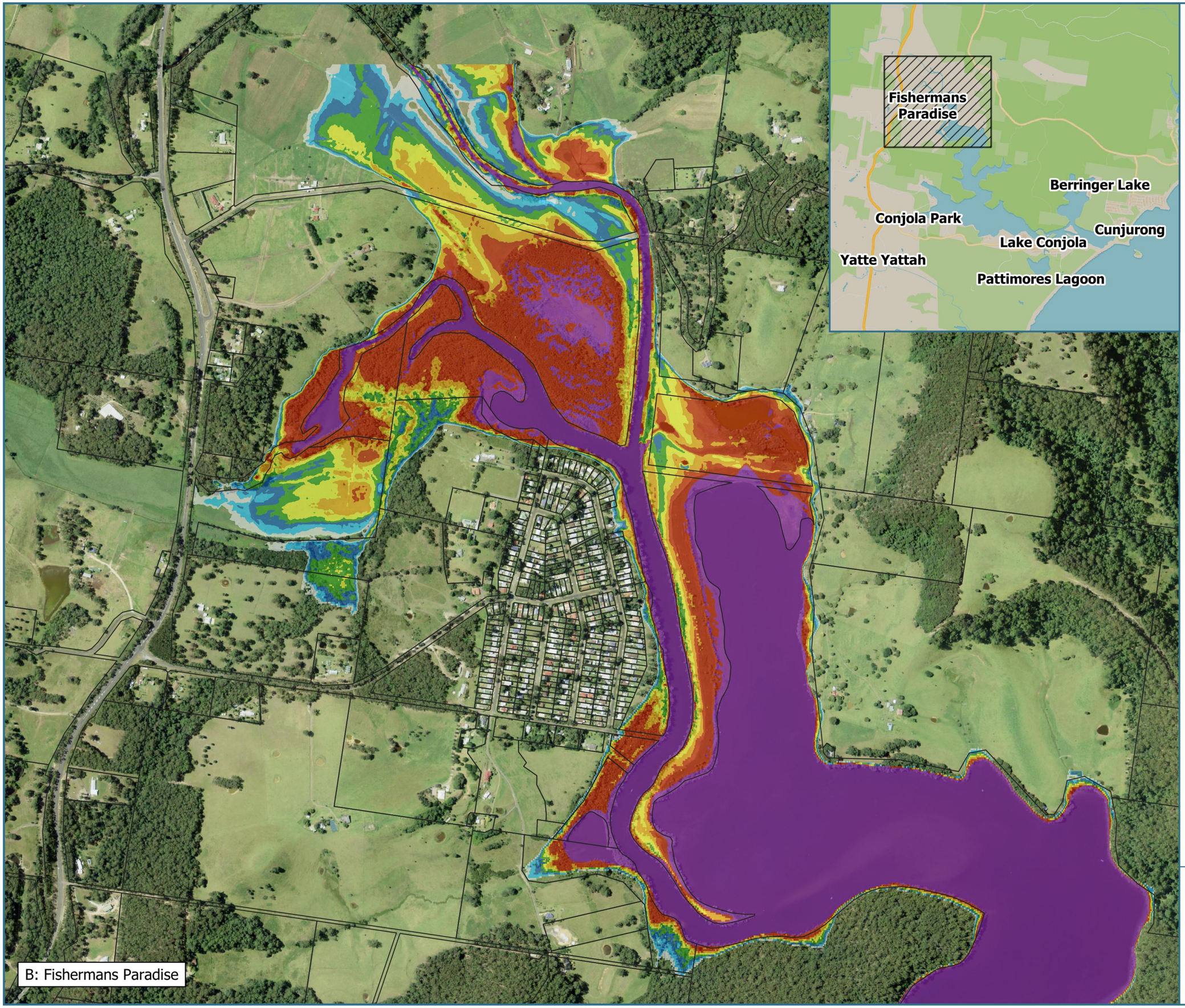

B: Fishermans Paradise

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Figure B-17
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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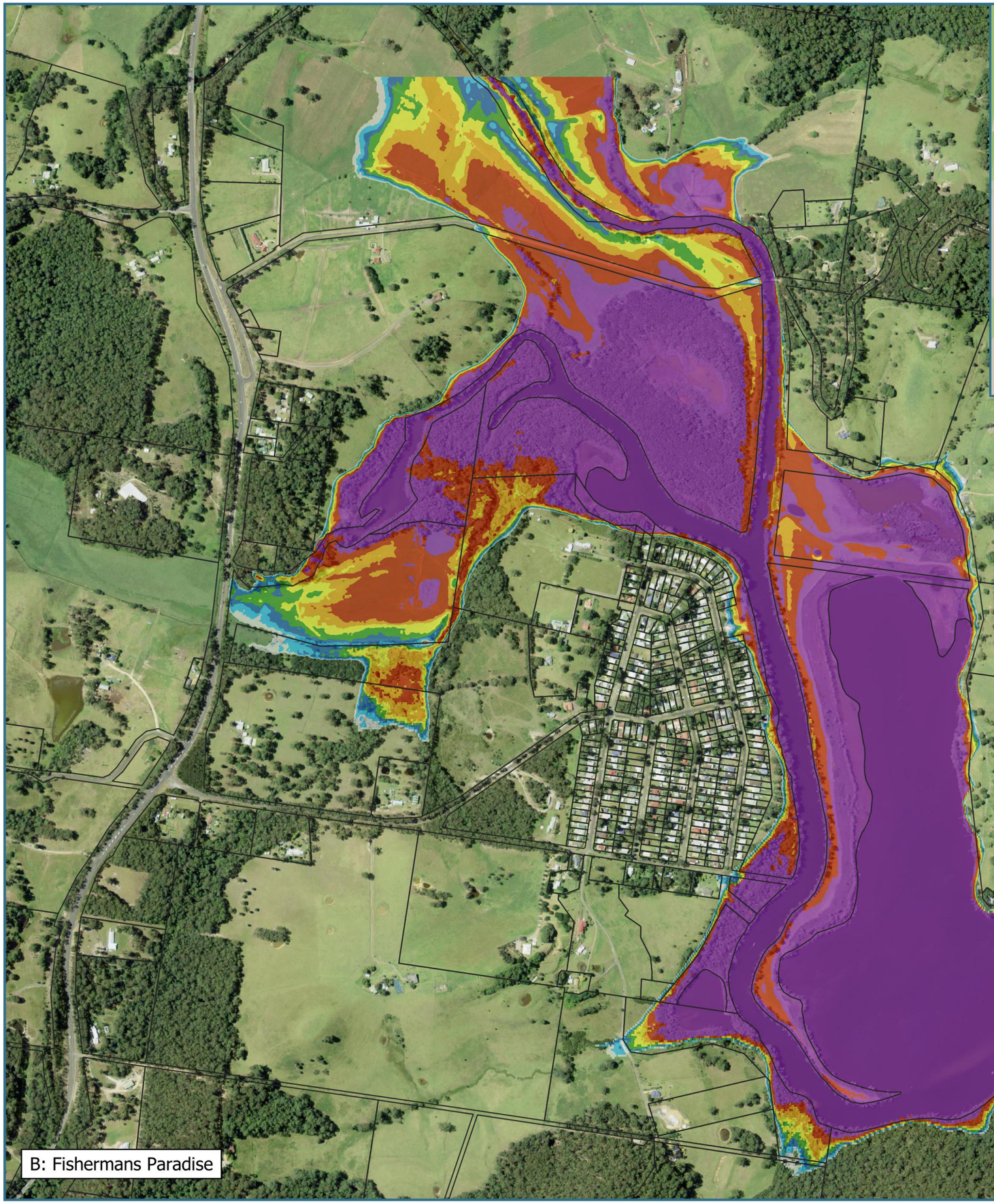



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Lake Conjola Coastal Management Program

Figure B-18
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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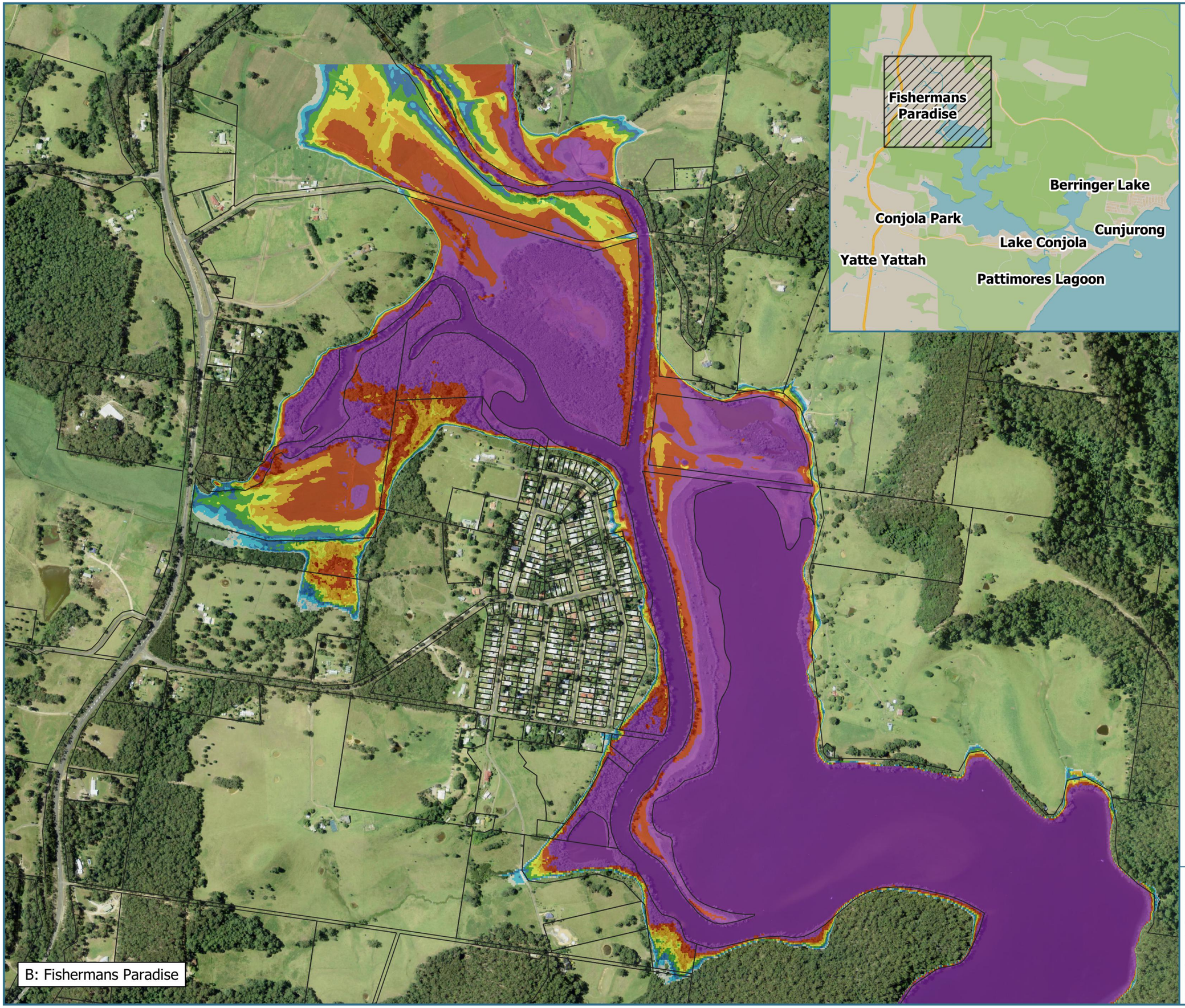

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-19
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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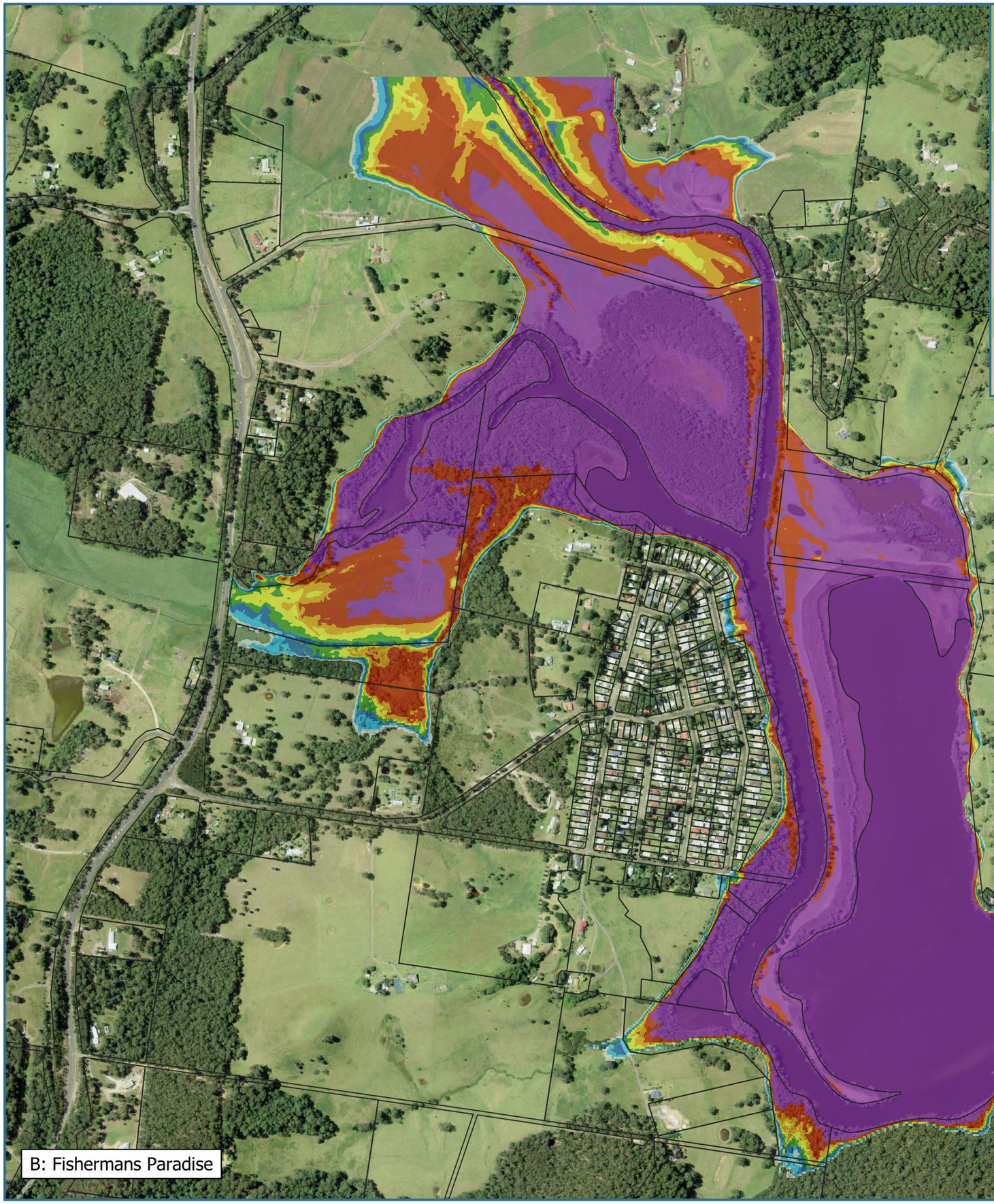

B: Fishermans Paradise

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Figure B-20
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

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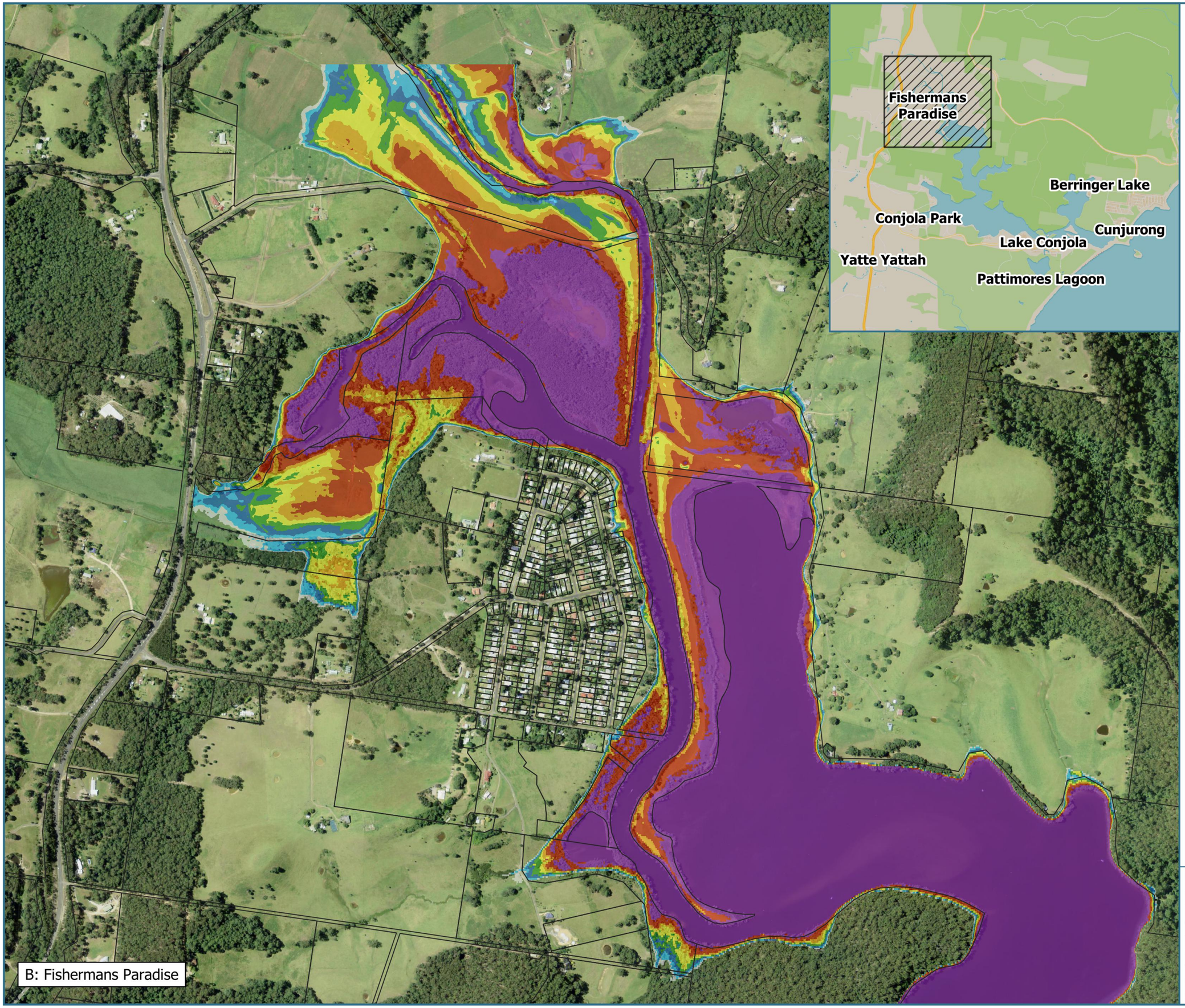

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-21
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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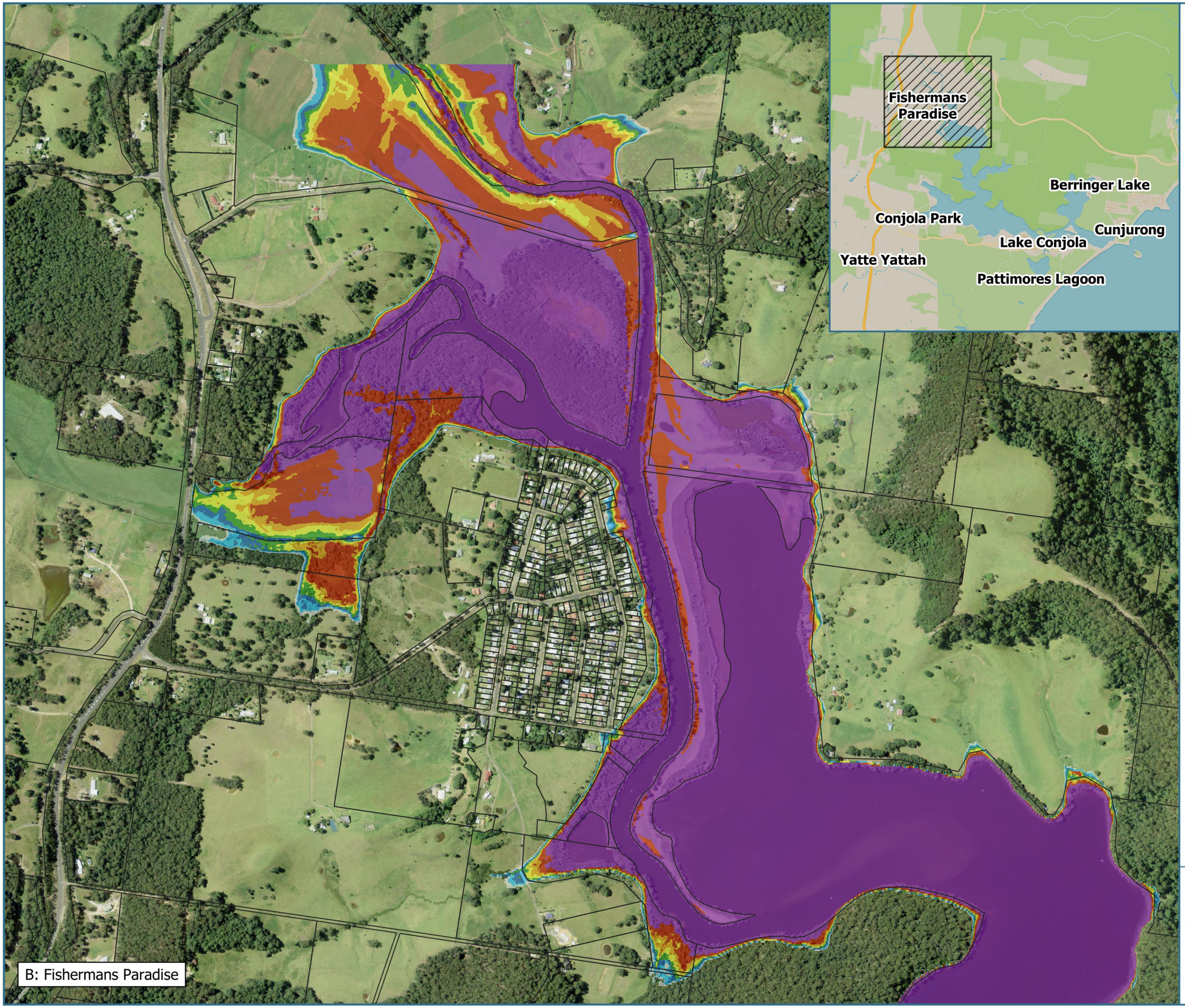

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-22
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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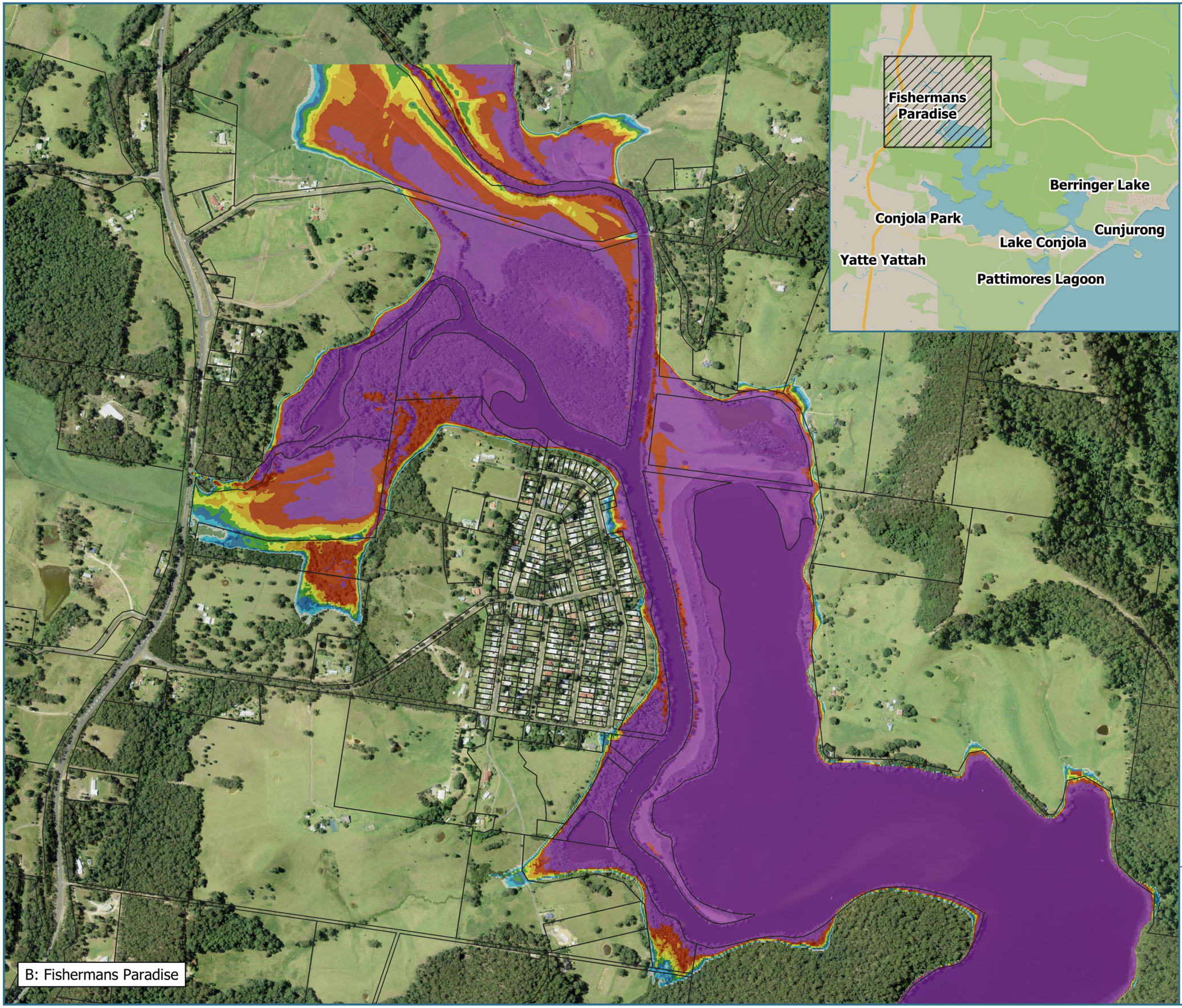

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Figure B-23
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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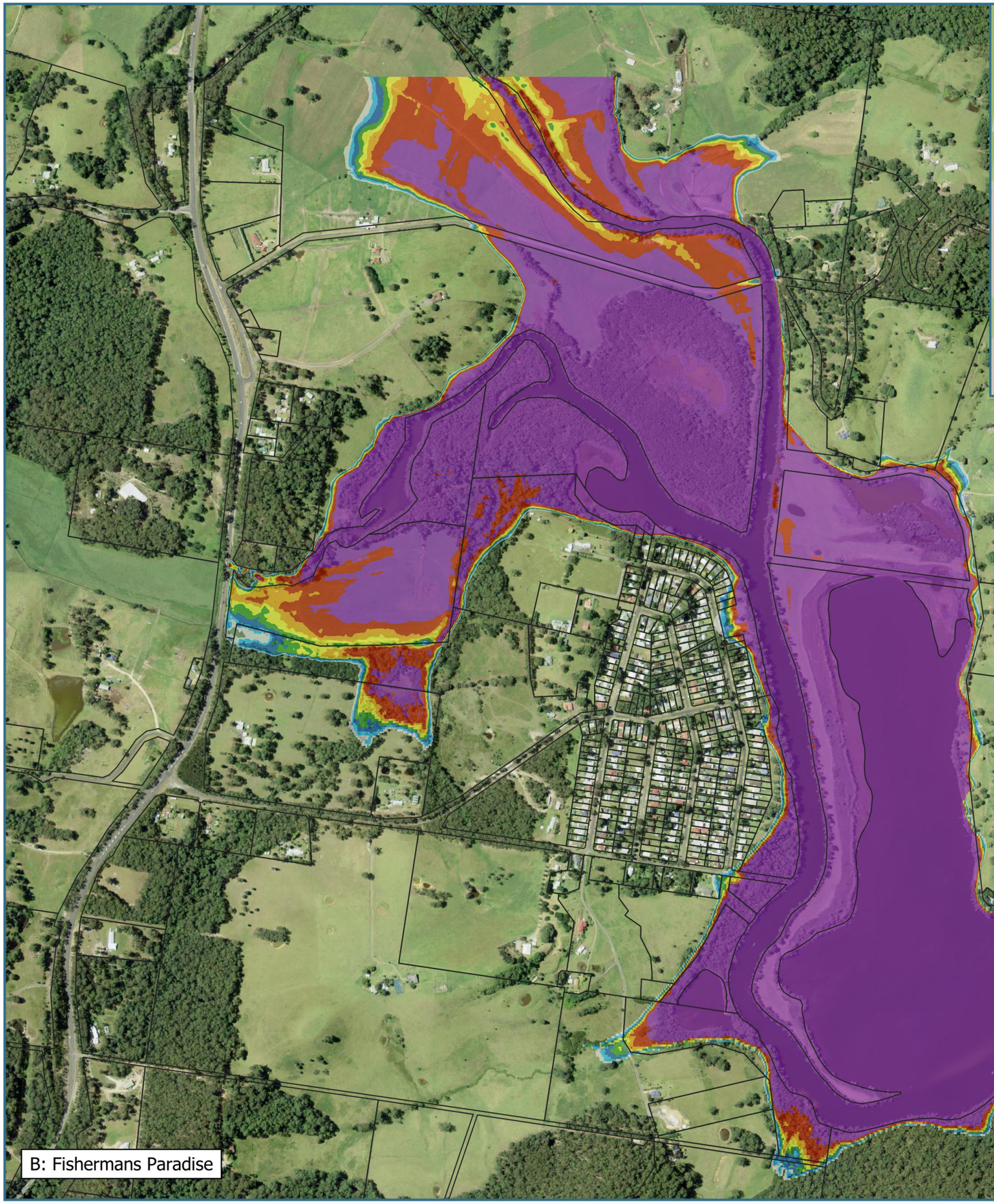



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Lake Conjola Coastal Management Program

Figure B-24
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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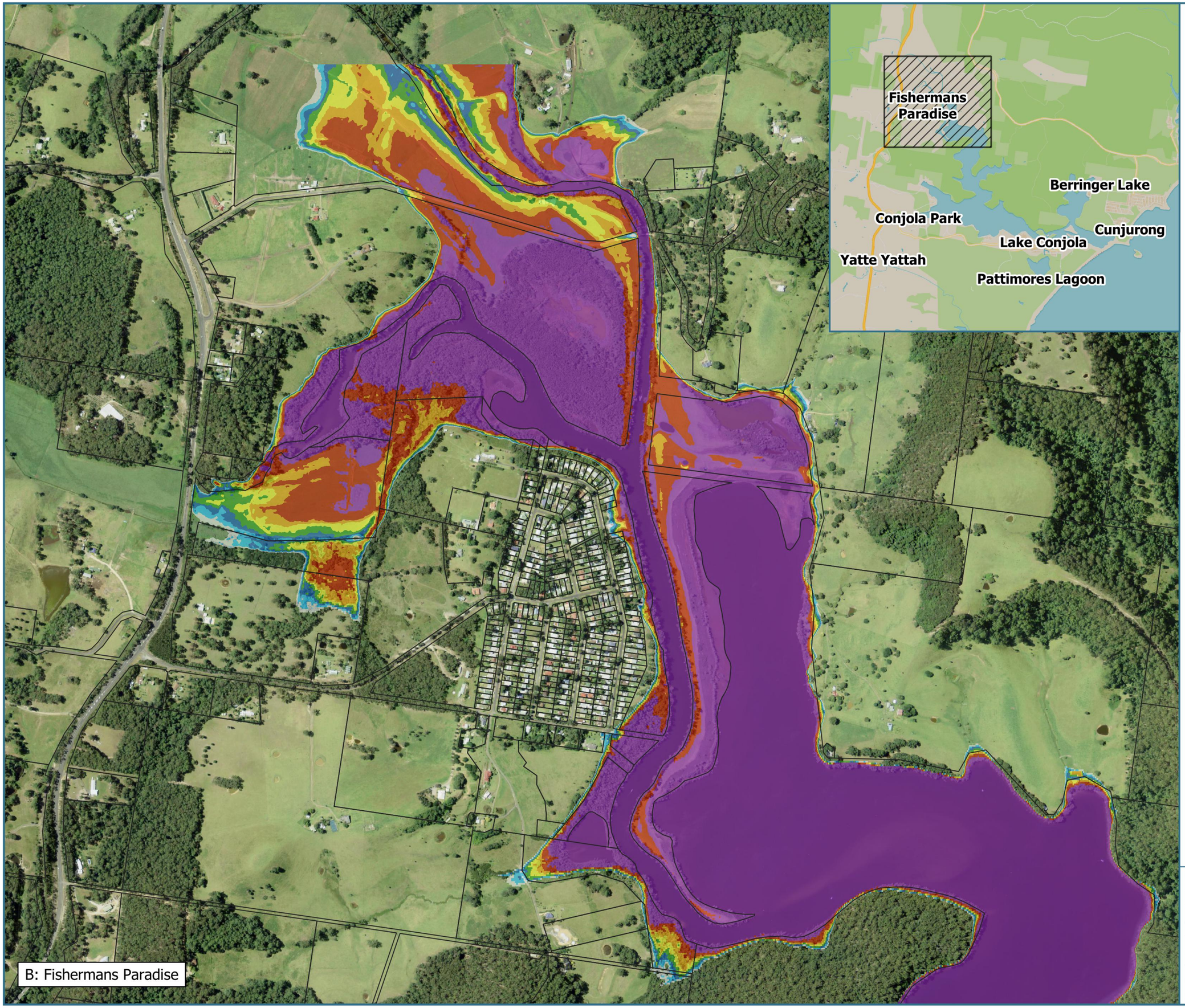

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Lake Conjola Coastal Management Program

Figure B-25
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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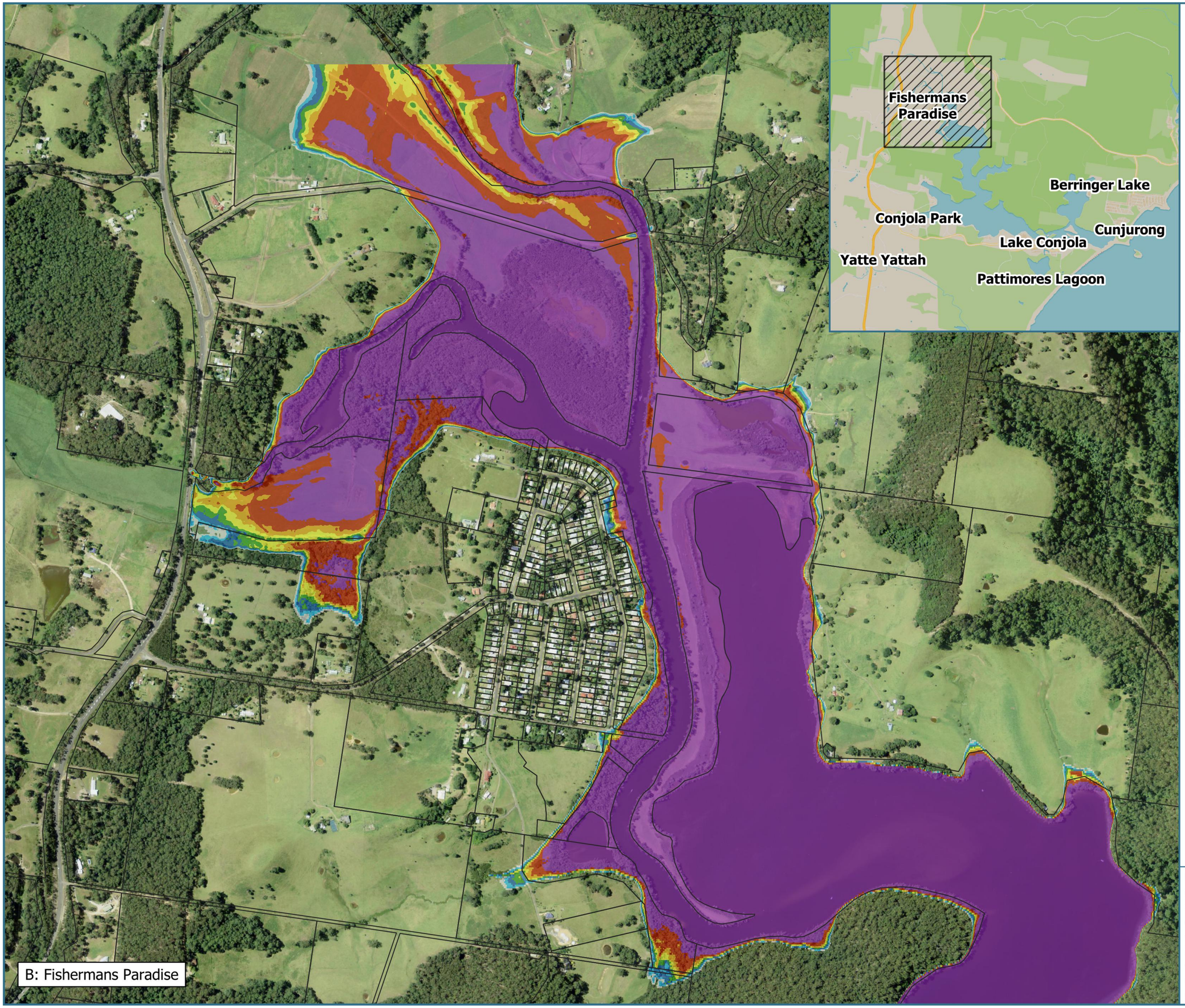

B: Fishermans Paradise

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Lake Conjola Coastal Management Program

Figure B-26
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:10,000

N

0 100 200 300 m

Shoalhaven City Council

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Lake Conjola Coastal Management Program

Figure C-01
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

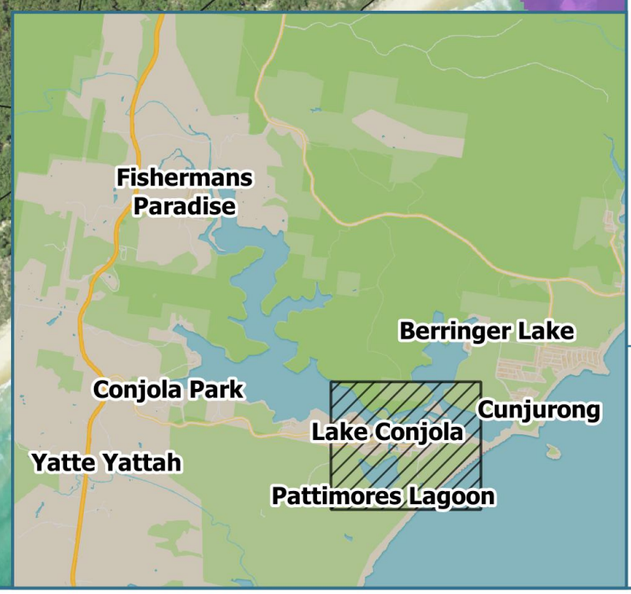
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Lake Conjola Coastal Management Program

Figure C-02
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

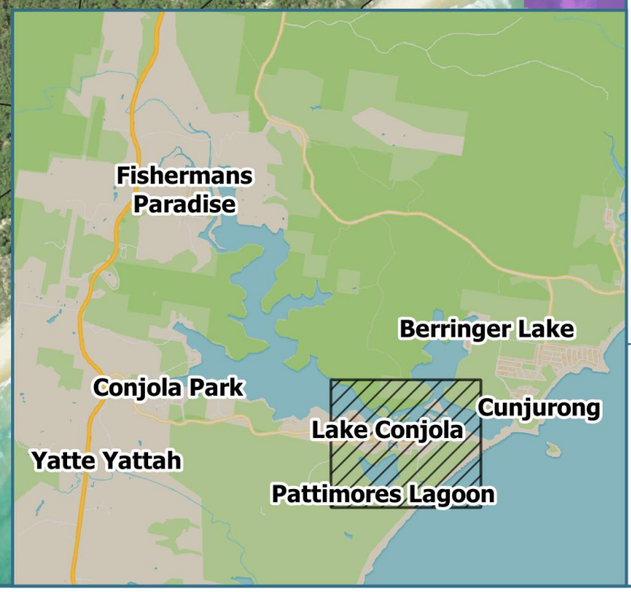

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Figure C-03
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

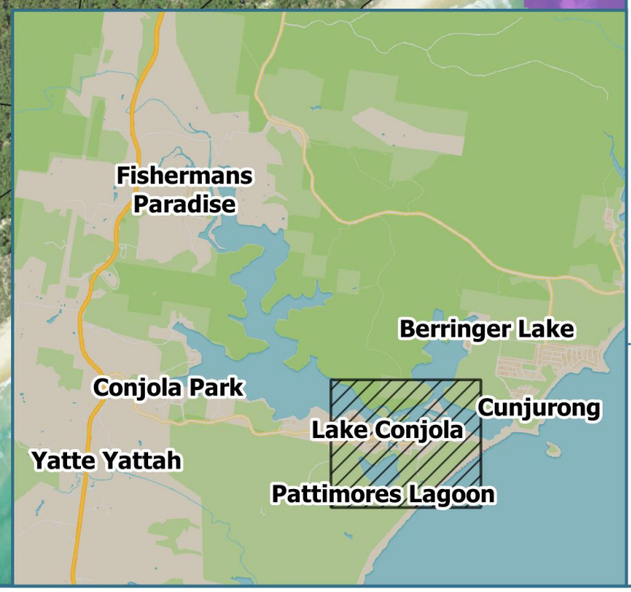
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-04
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

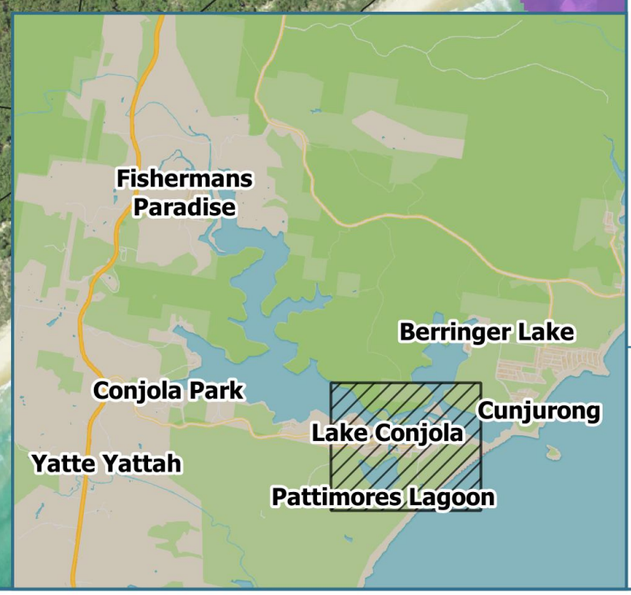

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Figure C-05
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

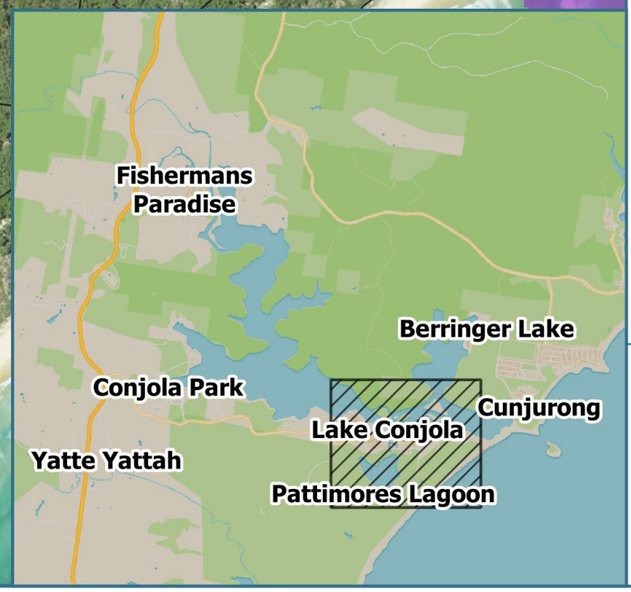

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Figure C-06
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

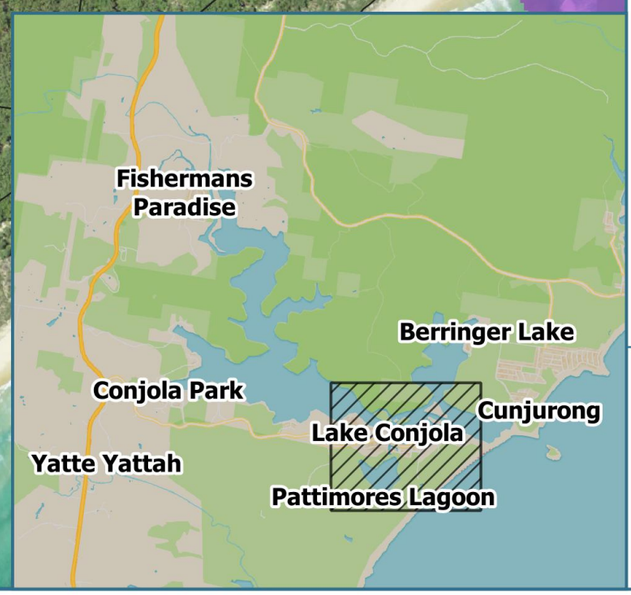

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Figure C-07
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

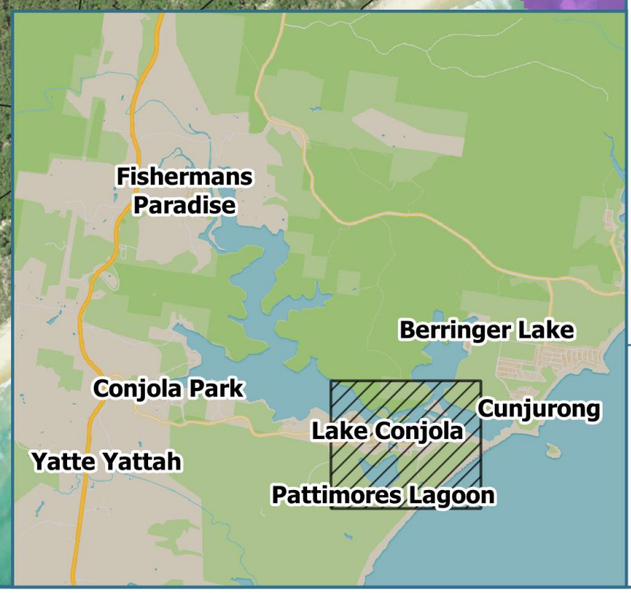
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-08
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

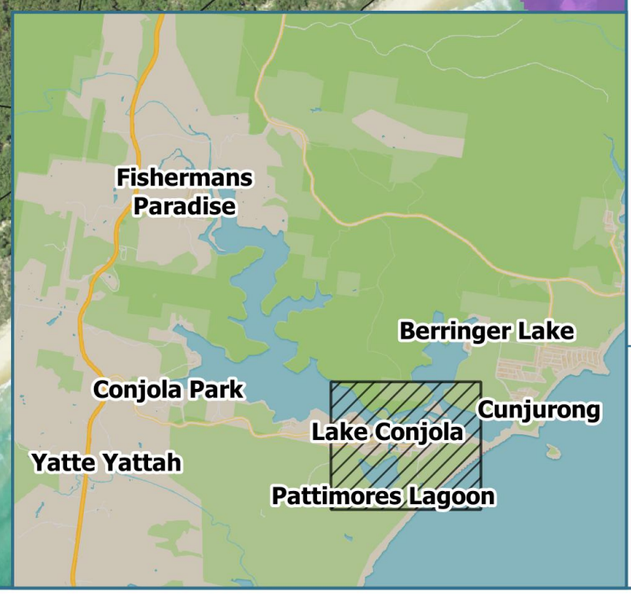
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-09
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

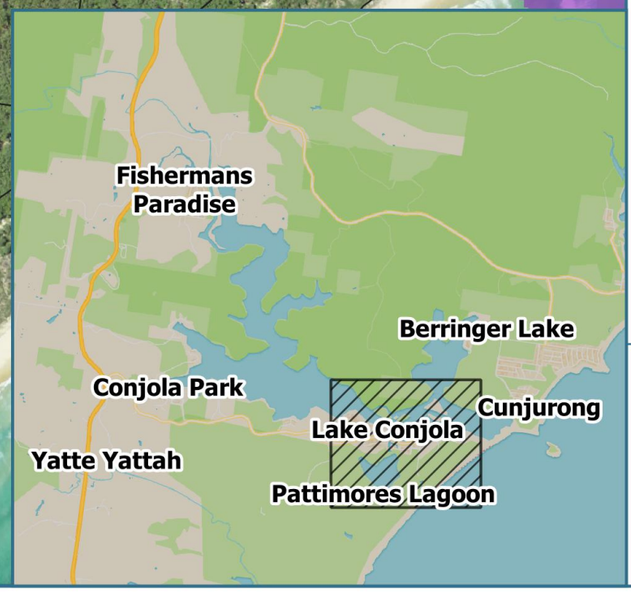
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-10
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

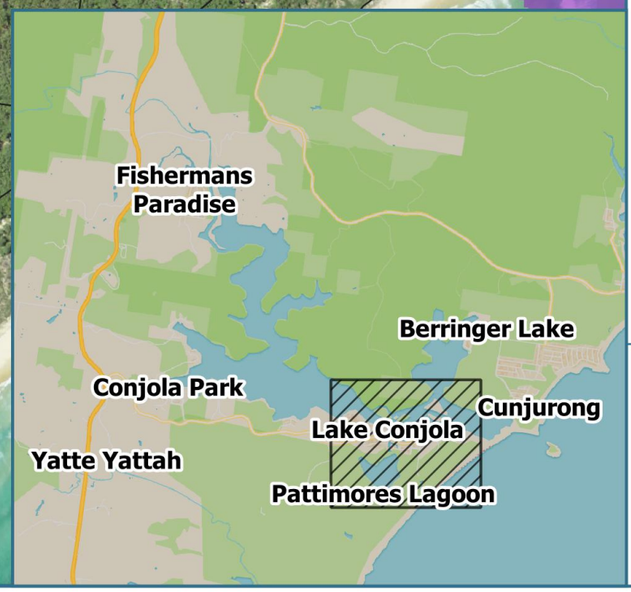
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Lake Conjola Coastal Management Program

Figure C-11
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

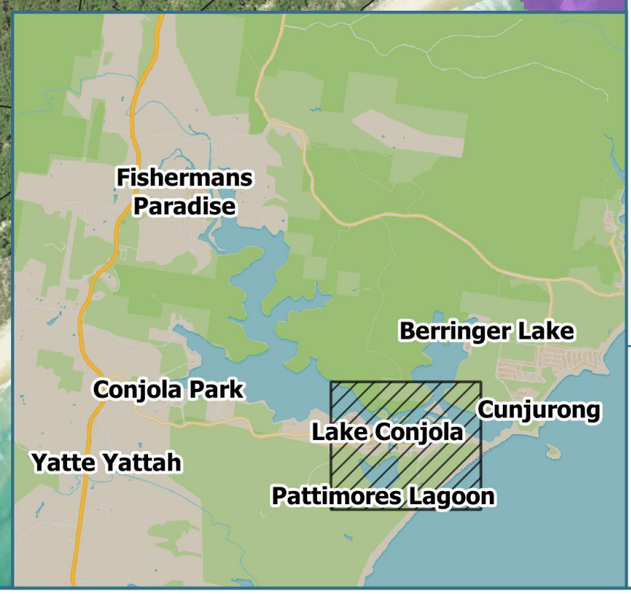
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-12
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

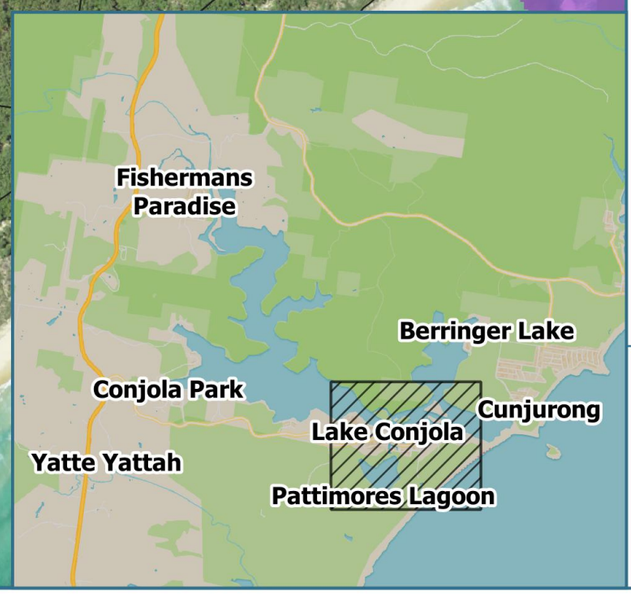
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-13
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

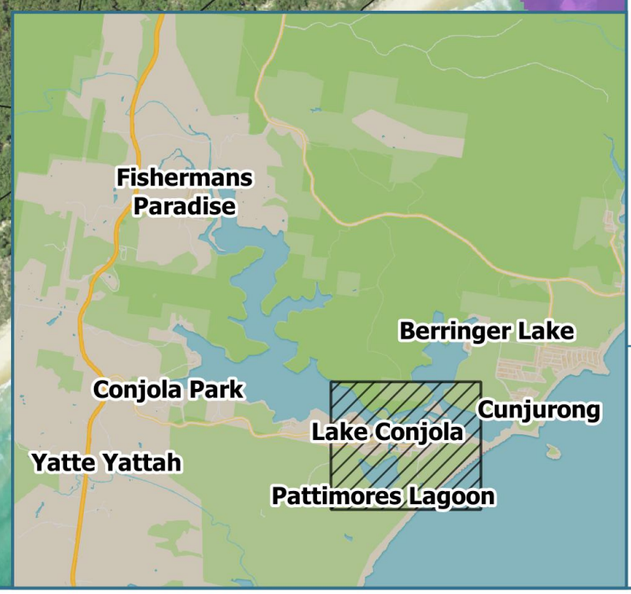
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-14
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

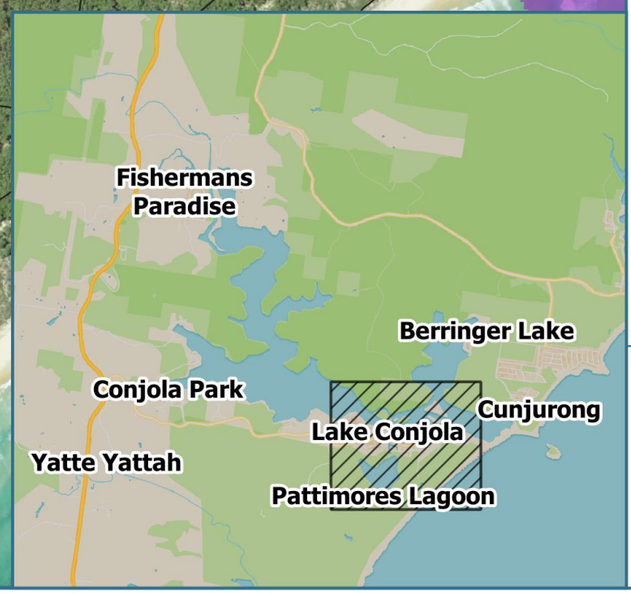
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-15
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

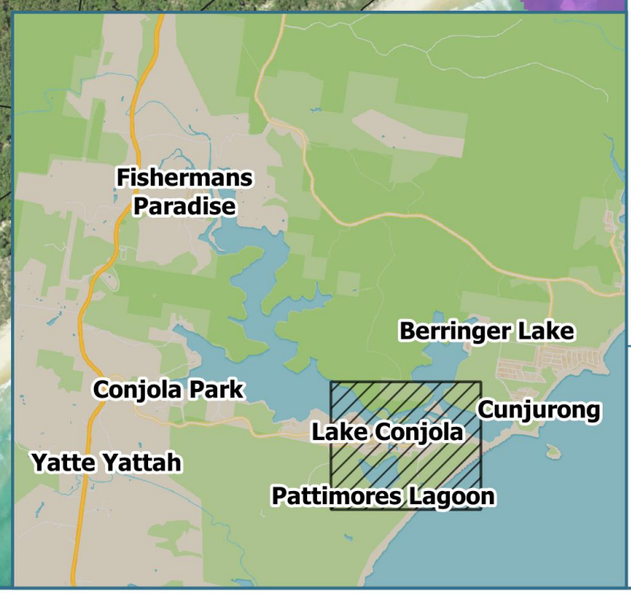
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-16
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

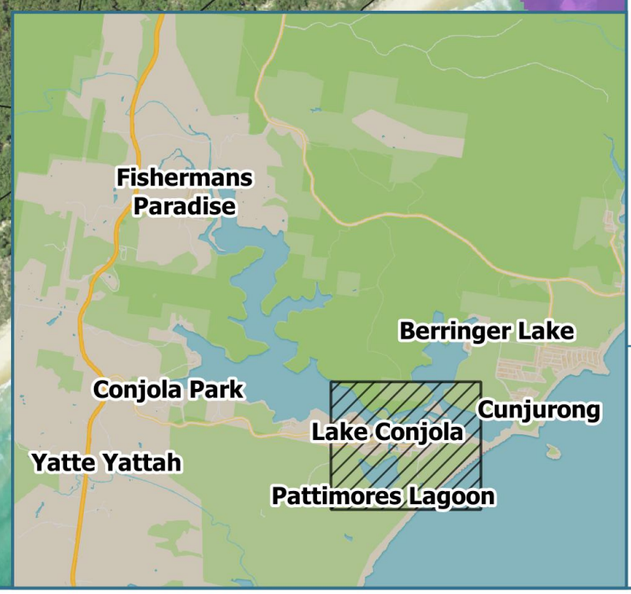
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-17
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

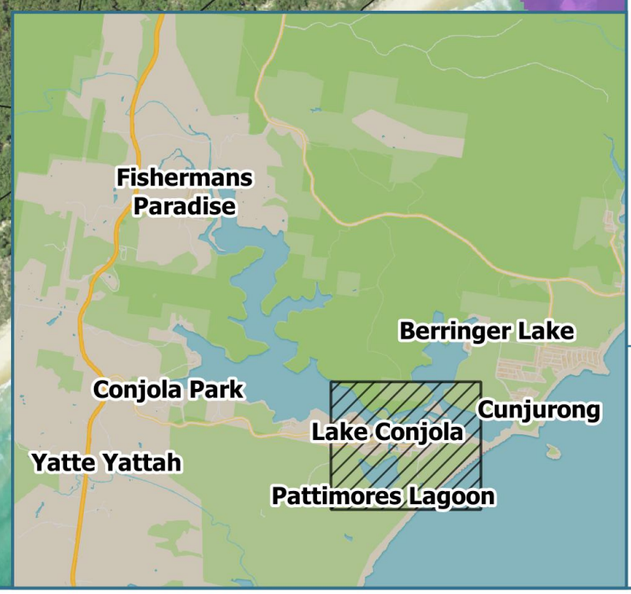
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-18
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

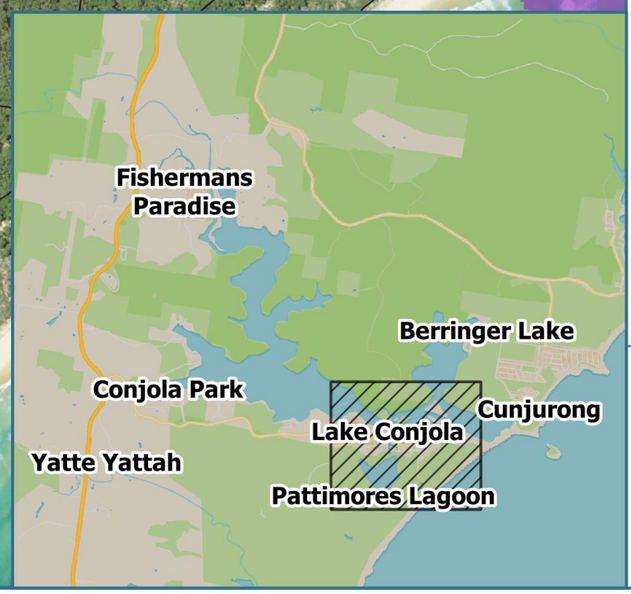
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-19
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

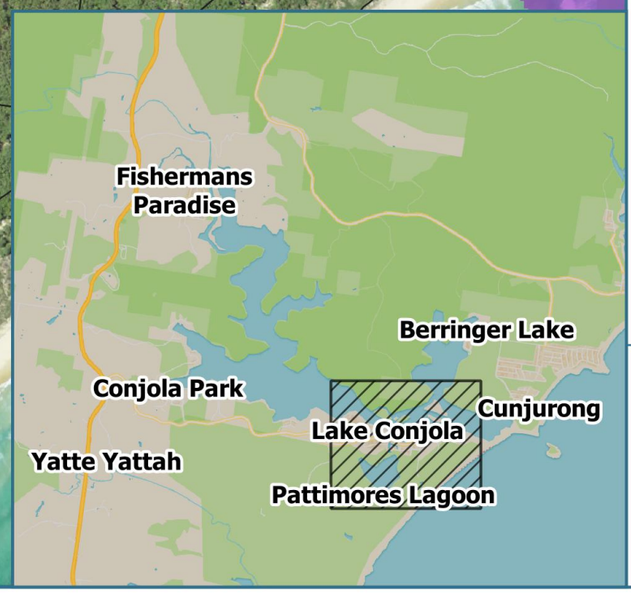
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-20
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

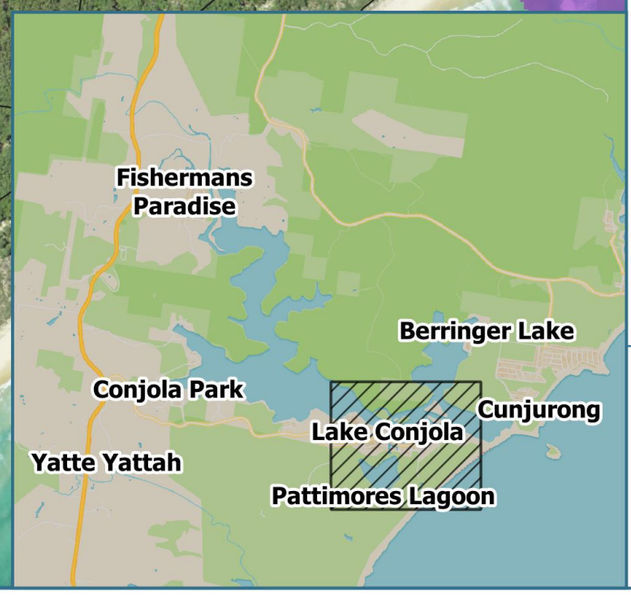
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-21
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

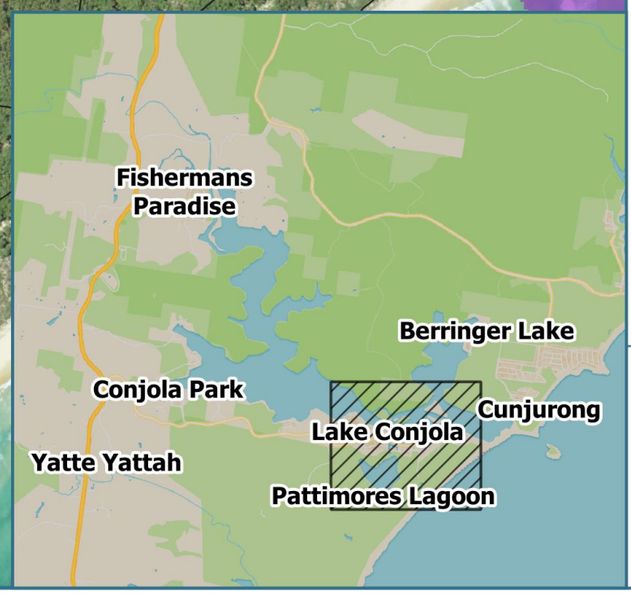
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-22
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

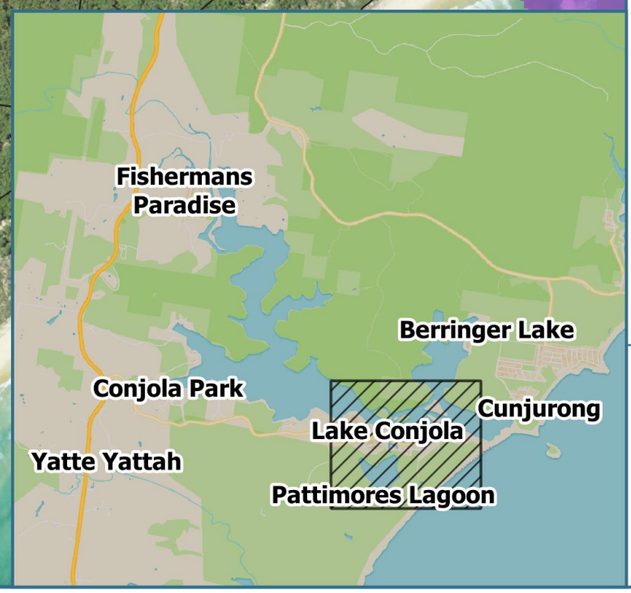
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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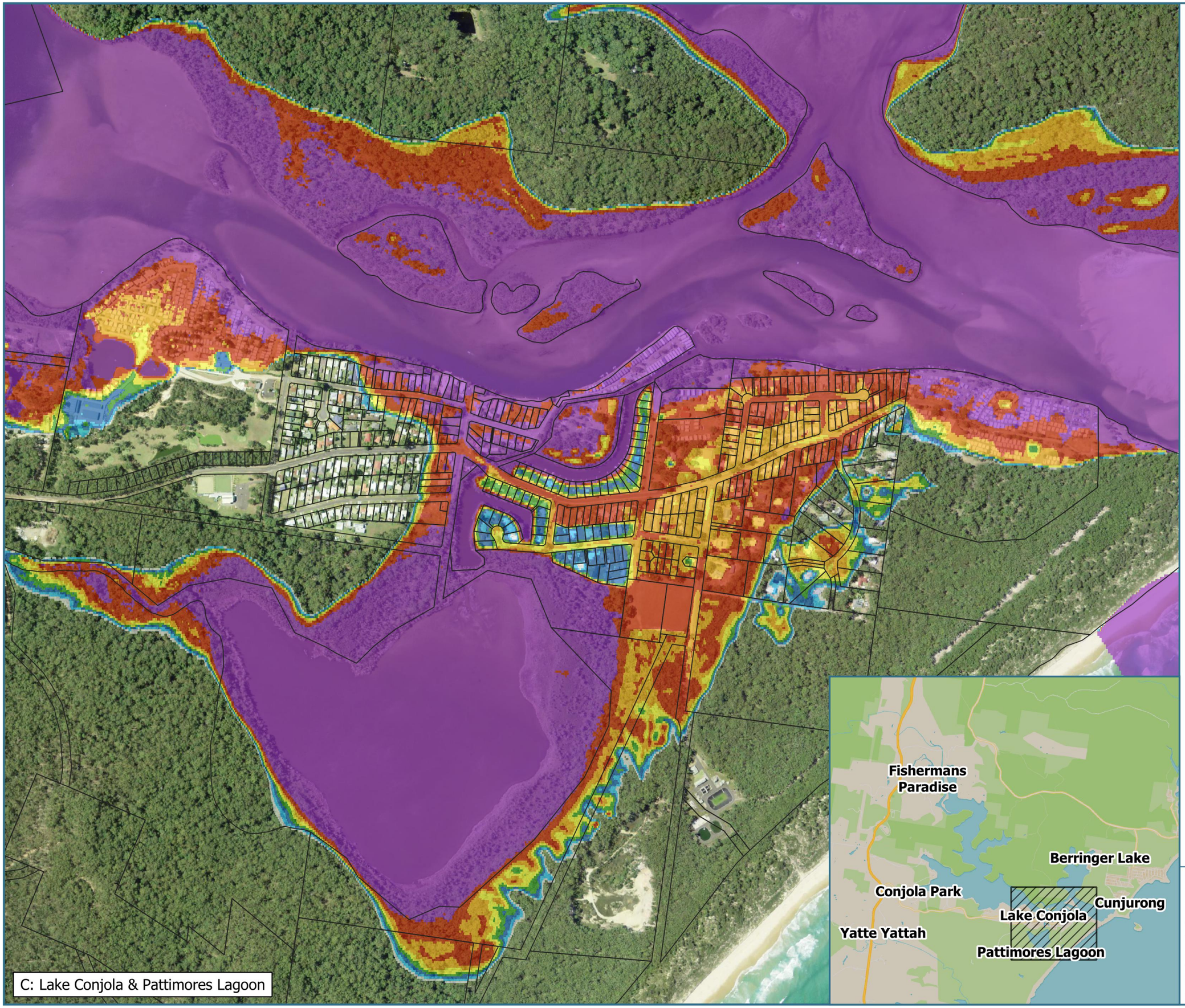

C: Lake Conjola & Pattimores Lagoon

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Figure C-23
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council

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Figure C-24
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

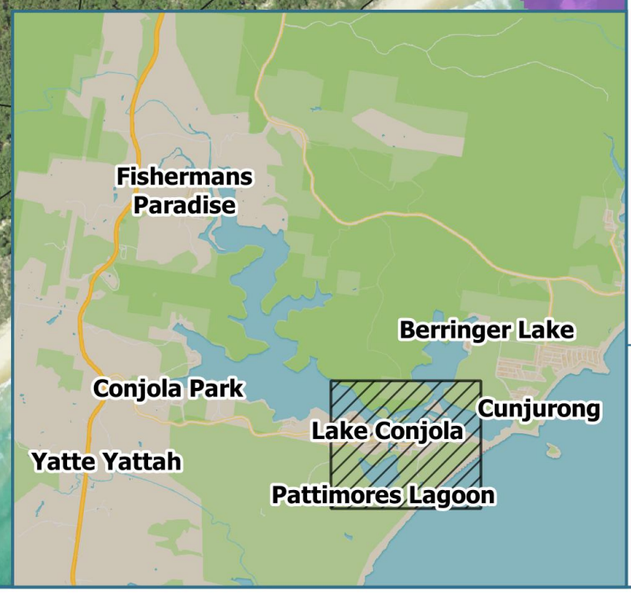
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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Figure C-25
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

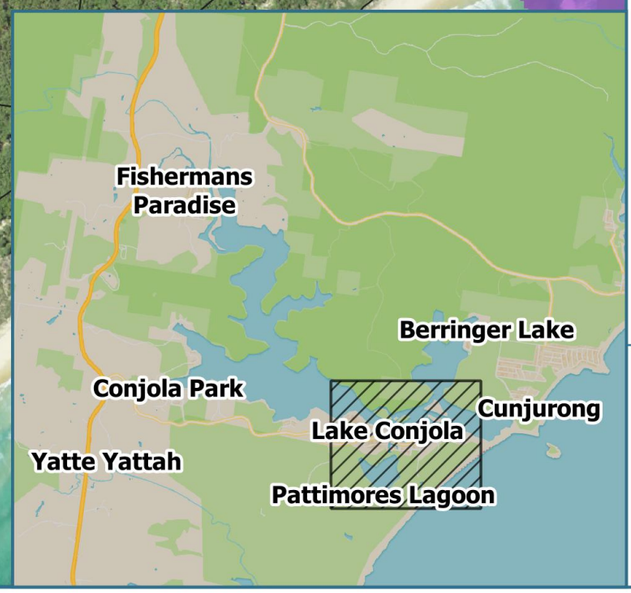
PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

Shoalhaven City Council



C: Lake Conjola & Pattimores Lagoon

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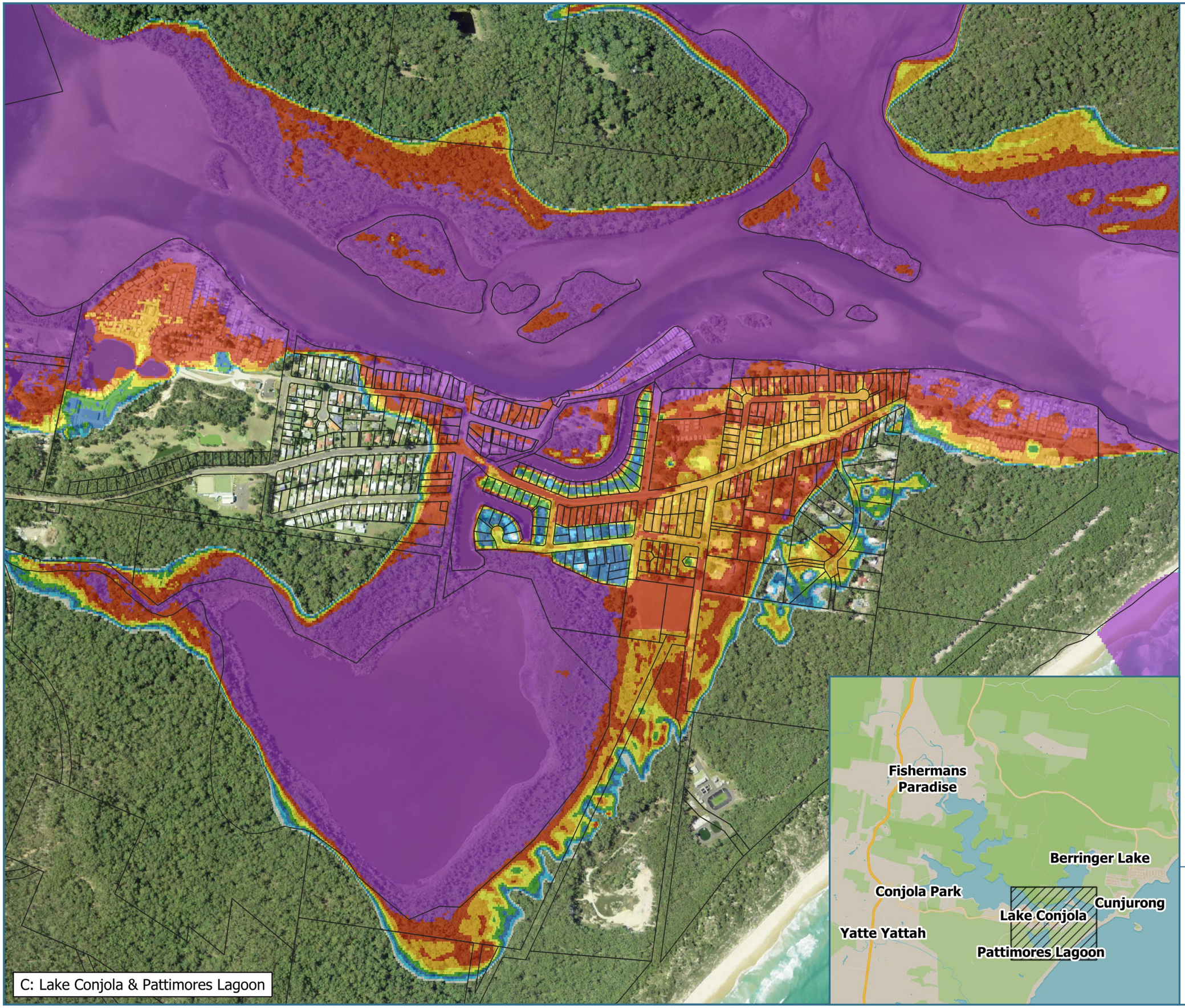

C: Lake Conjola & Pattimores Lagoon

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Figure C-26
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:8,000

N

0 100 200 300 m

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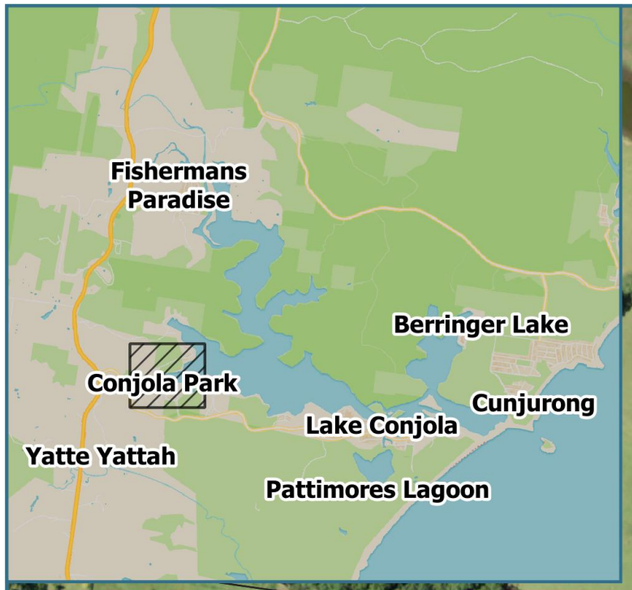

D: Conjola Park

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Figure D-01
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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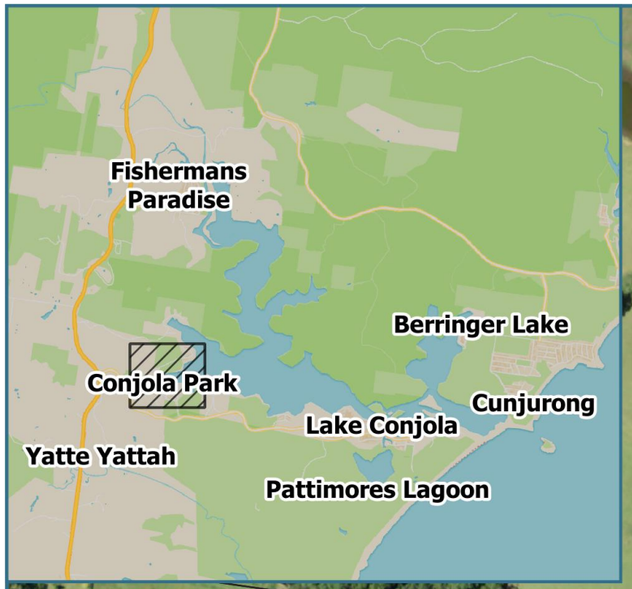

D: Conjola Park

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Figure D-02
Coastal Inundation
SLR 0 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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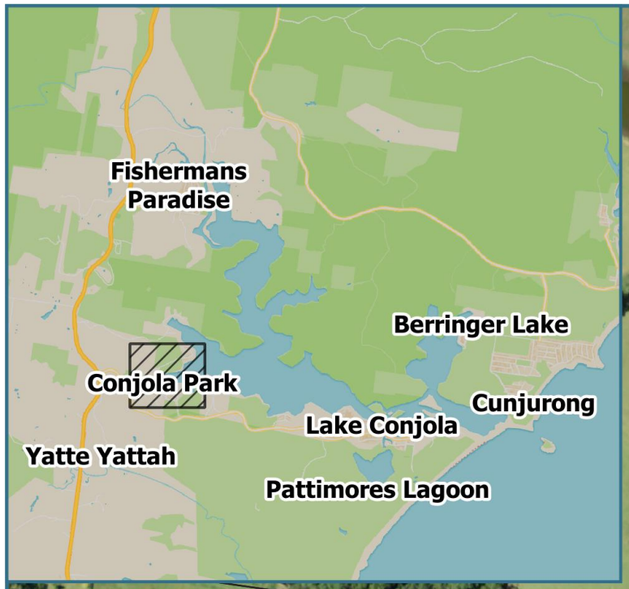

D: Conjola Park

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Figure D-03
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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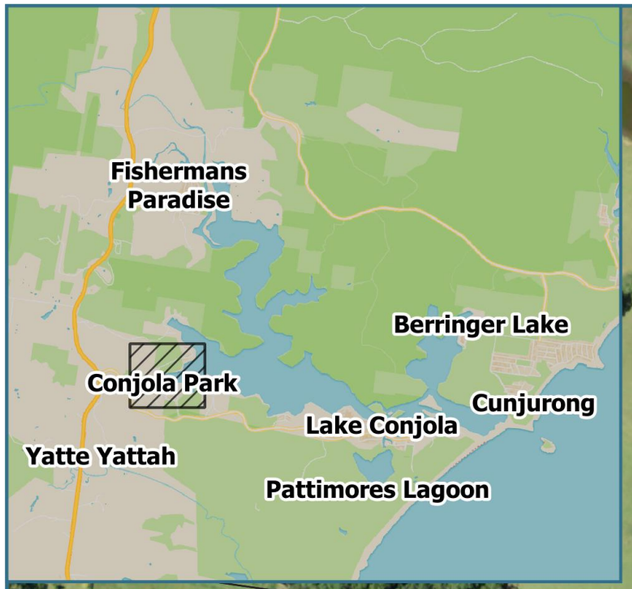

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Figure D-04
Coastal Inundation
SLR 0.1 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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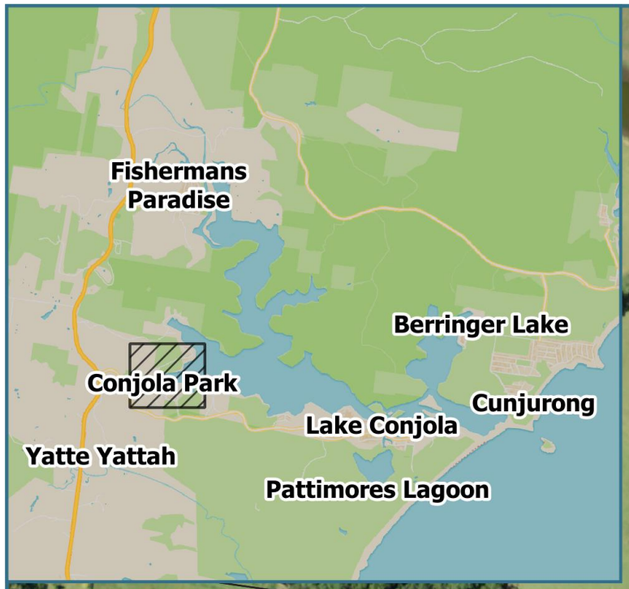
D: Conjola Park



D: Conjola Park

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Figure D-05
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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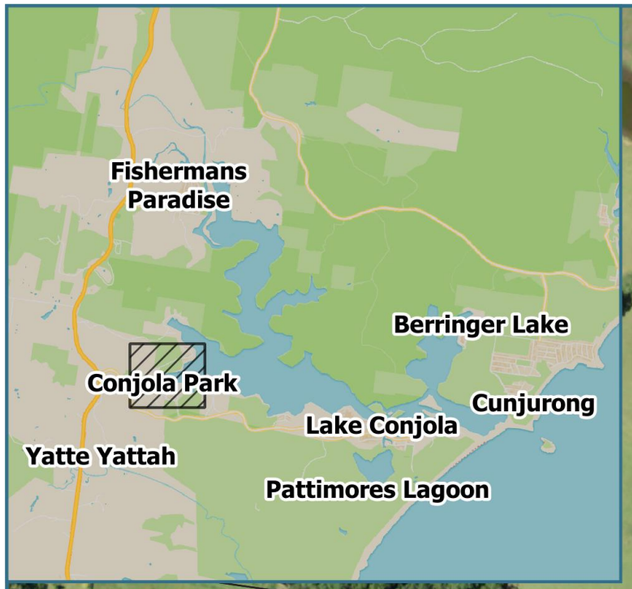

D: Conjola Park

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Figure D-06
Coastal Inundation
SLR 0.1 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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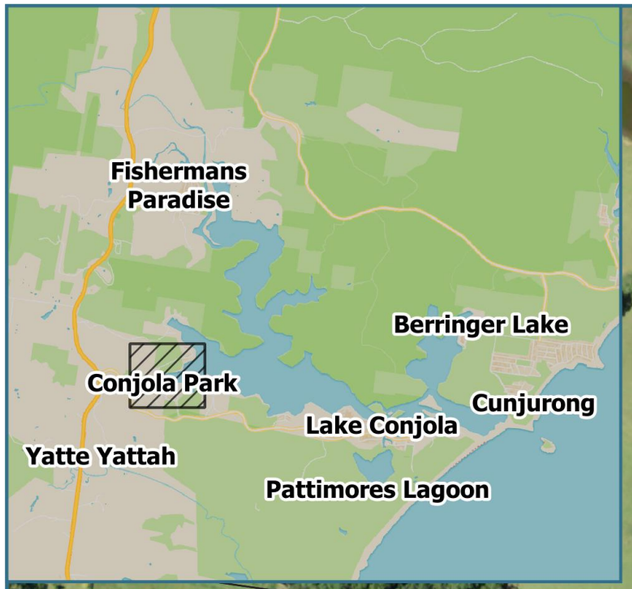

D: Conjola Park

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Figure D-07
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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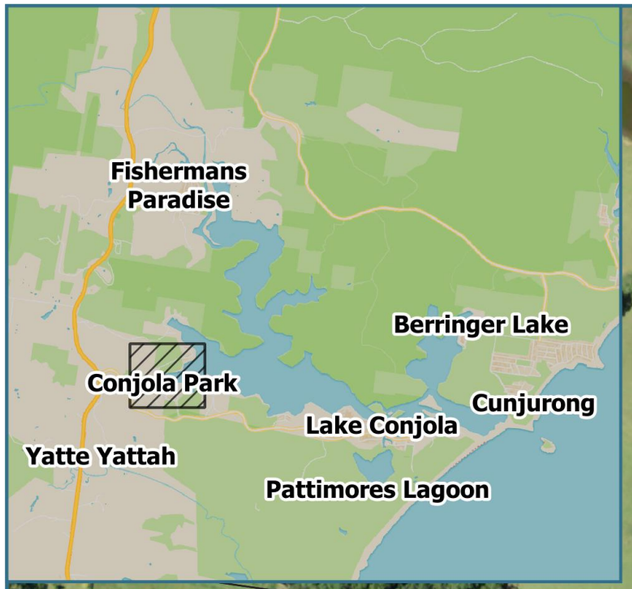

D: Conjola Park

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Figure D-08
Coastal Inundation
SLR 0.23 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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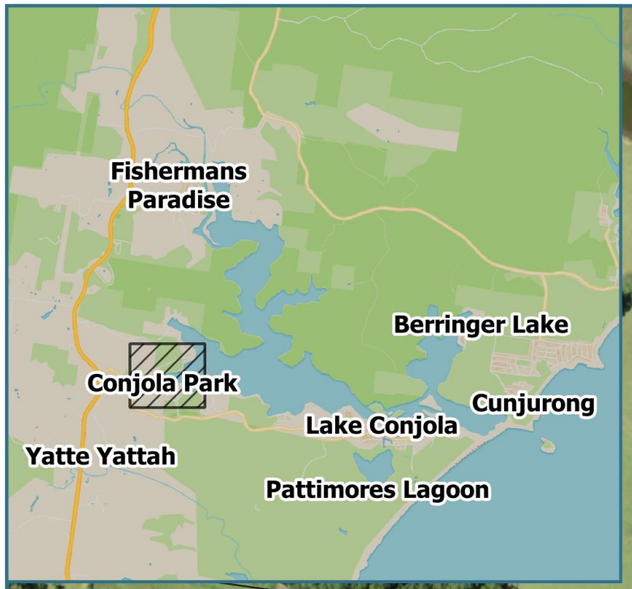

D: Conjola Park

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Figure D-09
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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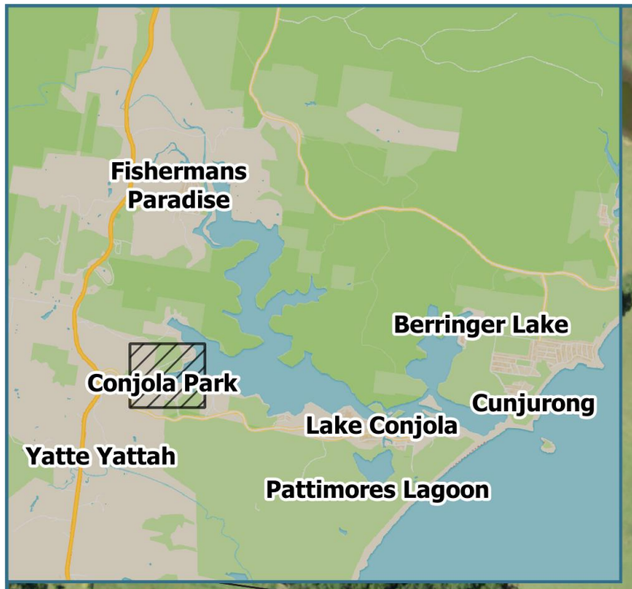

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Figure D-10
Coastal Inundation
SLR 0.23 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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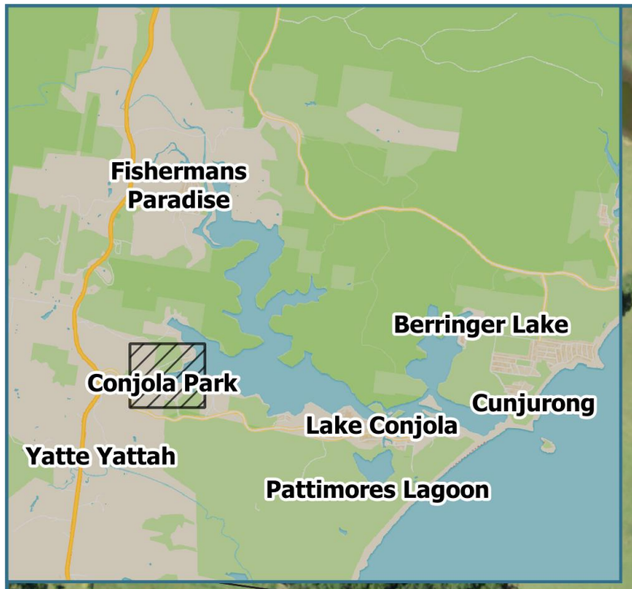
D: Conjola Park



D: Conjola Park

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Figure D-11
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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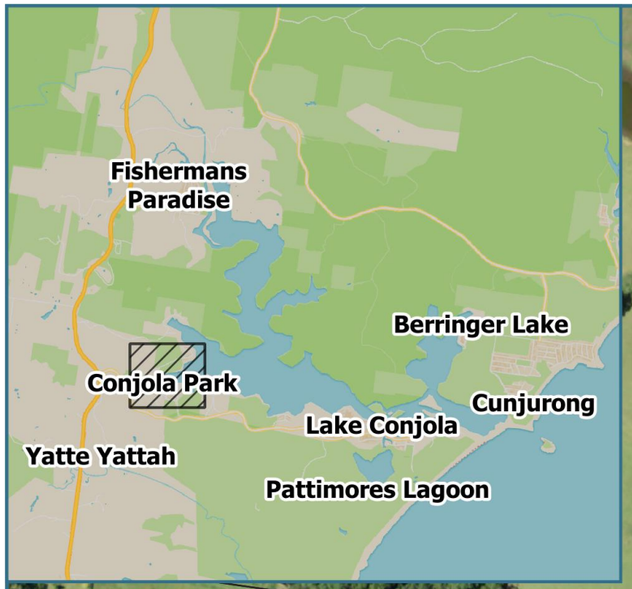

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Figure D-12
Coastal Inundation
SLR 0.36 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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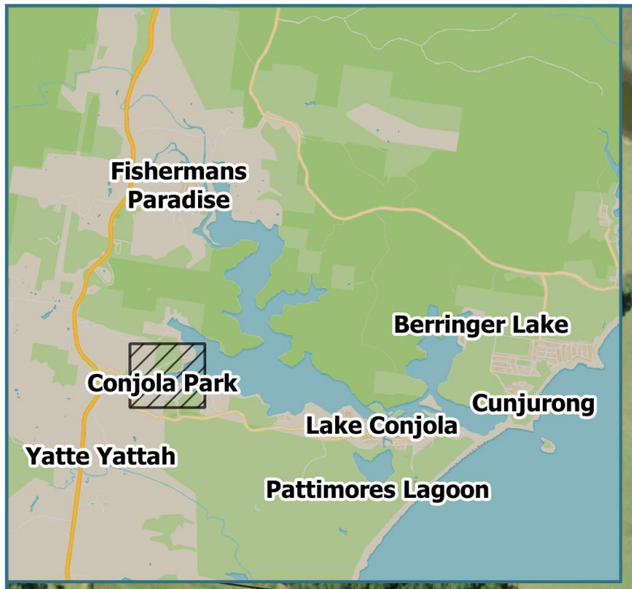
D: Conjola Park



D: Conjola Park

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Figure D-13
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 100 yr Ocean Only

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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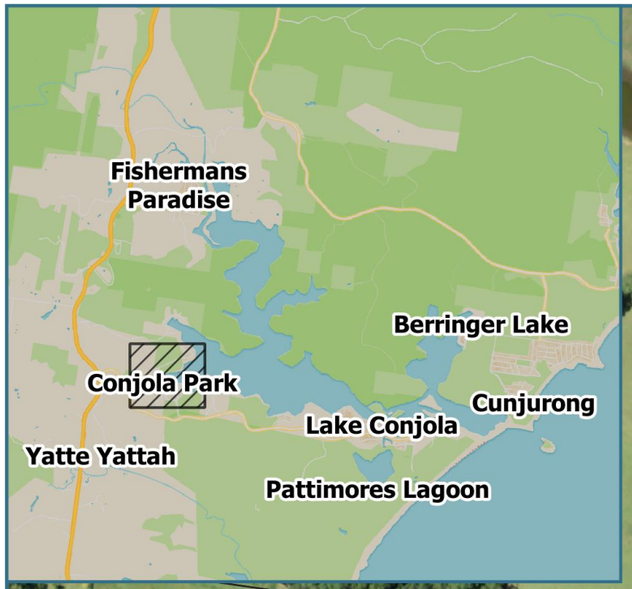

D: Conjola Park

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Figure D-14
Coastal Inundation
SLR 0.36 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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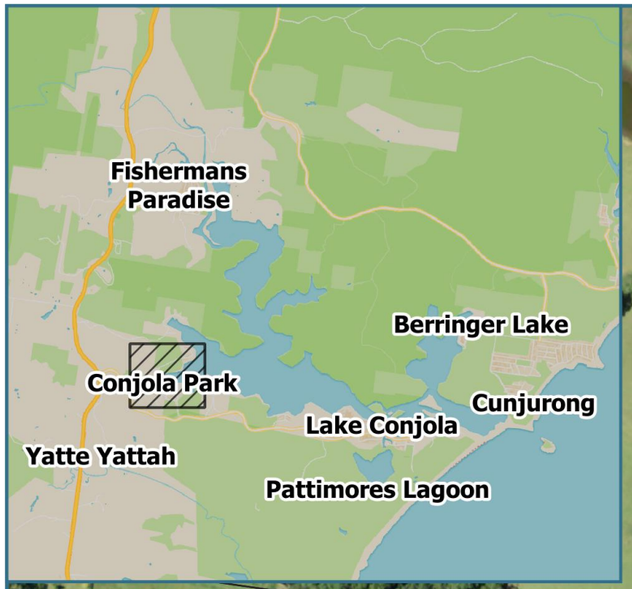

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Figure D-15
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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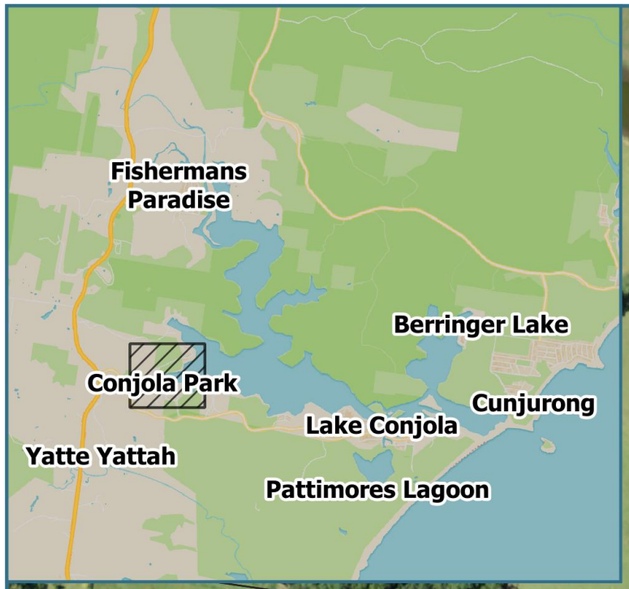
D: Conjola Park



D: Conjola Park

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Figure D-16
Coastal Inundation
SLR 0.6 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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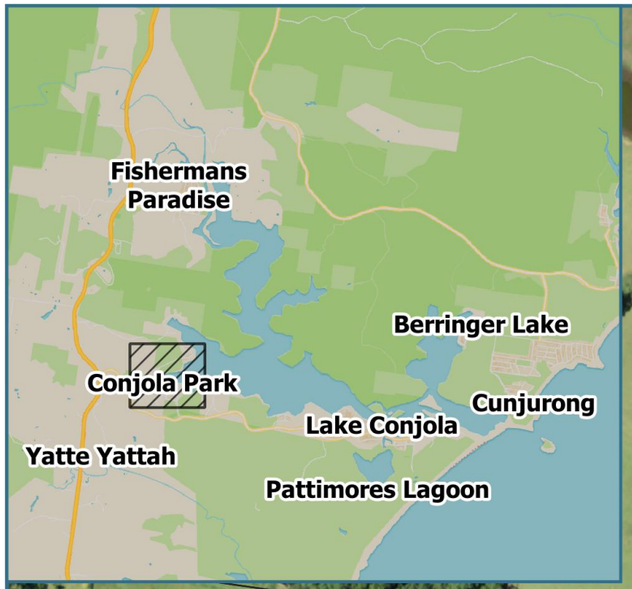

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Figure D-17
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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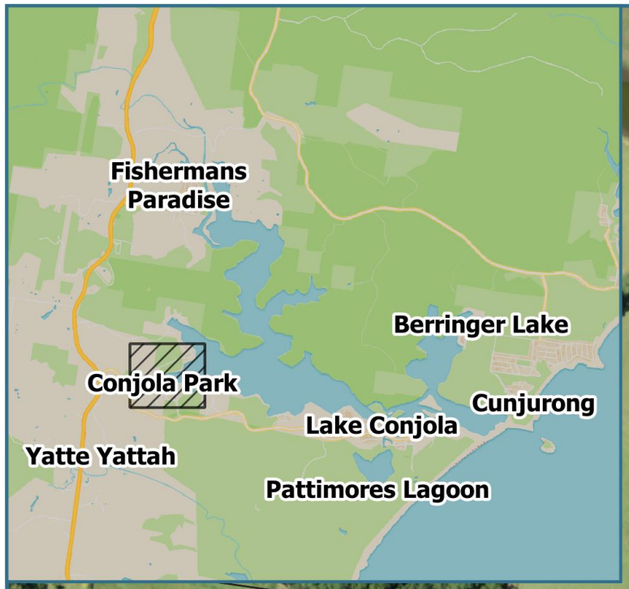
D: Conjola Park



D: Conjola Park

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Figure D-18
Coastal Inundation
SLR 0.6 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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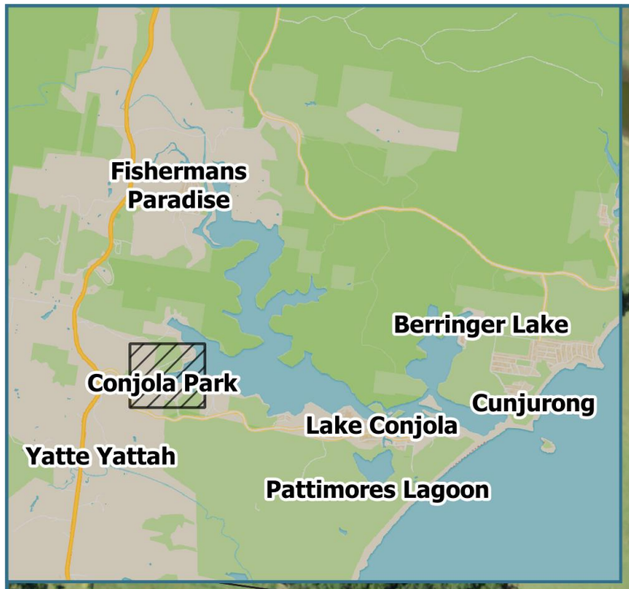

D: Conjola Park

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Figure D-19
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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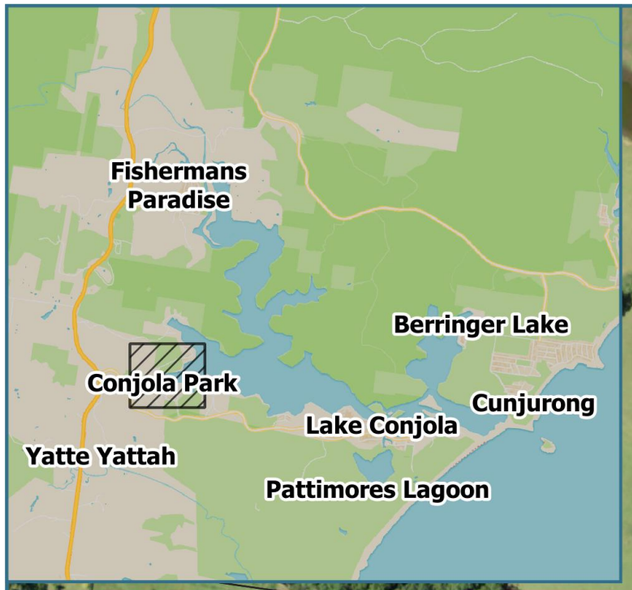

D: Conjola Park

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Figure D-20
Coastal Inundation
SLR 0.9 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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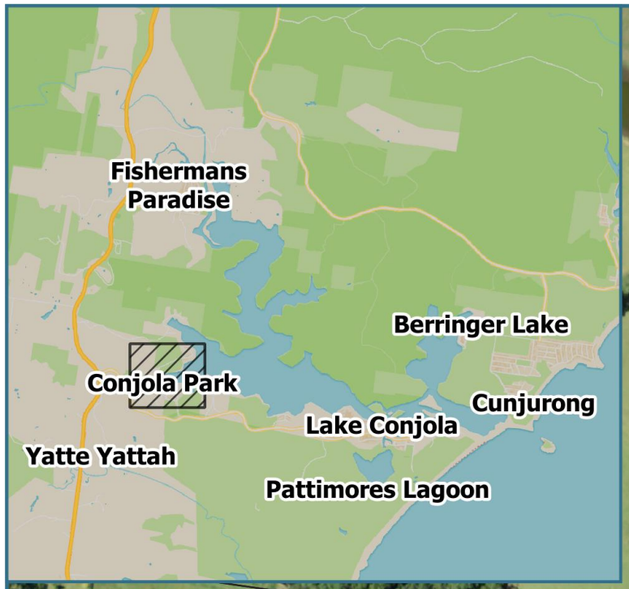

D: Conjola Park

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Figure D-21
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 100 yr Ocean Only

Legend
Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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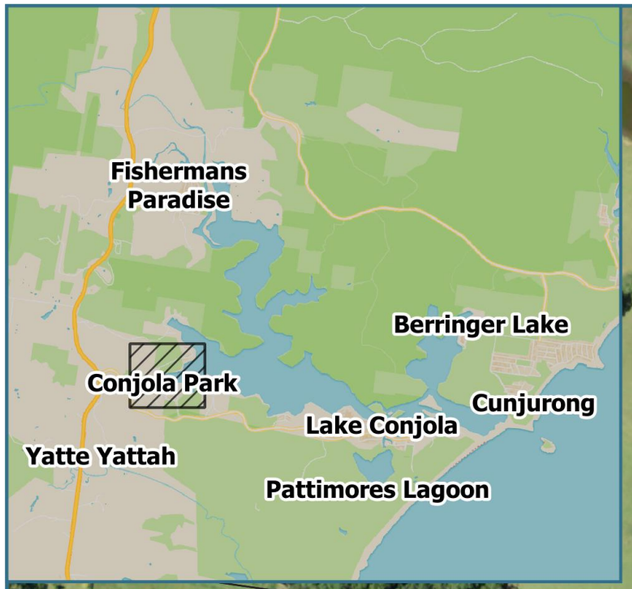

D: Conjola Park

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Figure D-22
Coastal Inundation
SLR 0.9 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

Shoalhaven City Council

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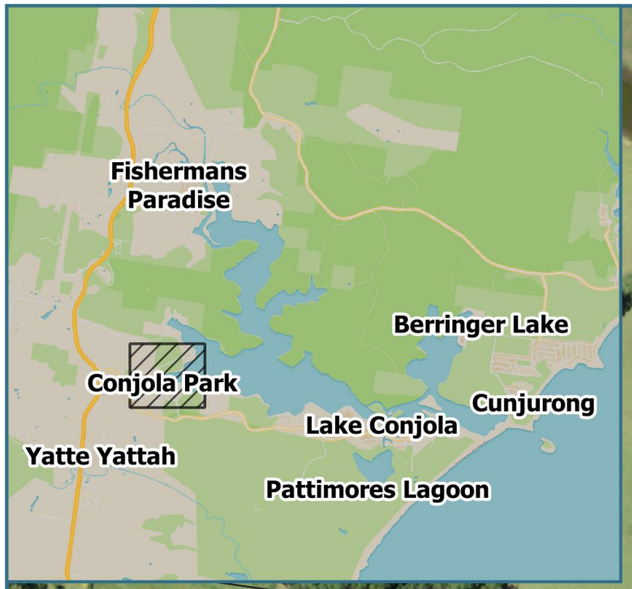

D: Conjola Park

Royal HaskoningDHV
Enhancing Society Together

Lake Conjola Coastal Management Program

Figure D-23
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
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Scale at A4

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N

0 70 140 210 m

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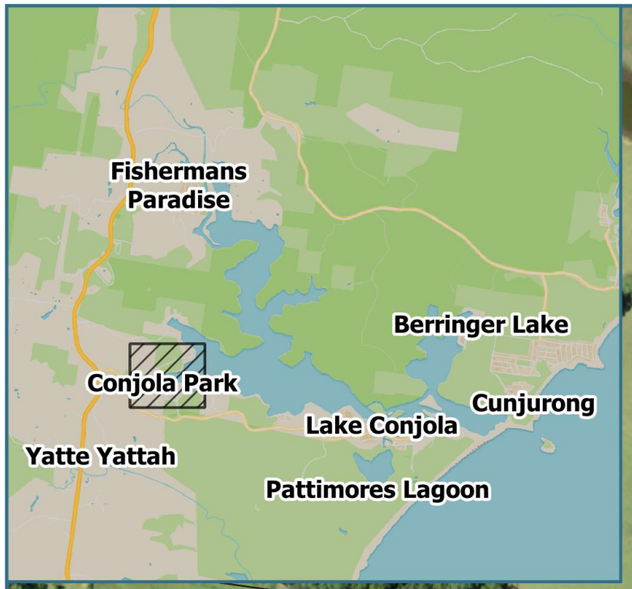

D: Conjola Park

Royal HaskoningDHV
Enhancing Society Together

Lake Conjola Coastal Management Program

Figure D-24
Coastal Inundation
SLR 1.2 m
Bed Not Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
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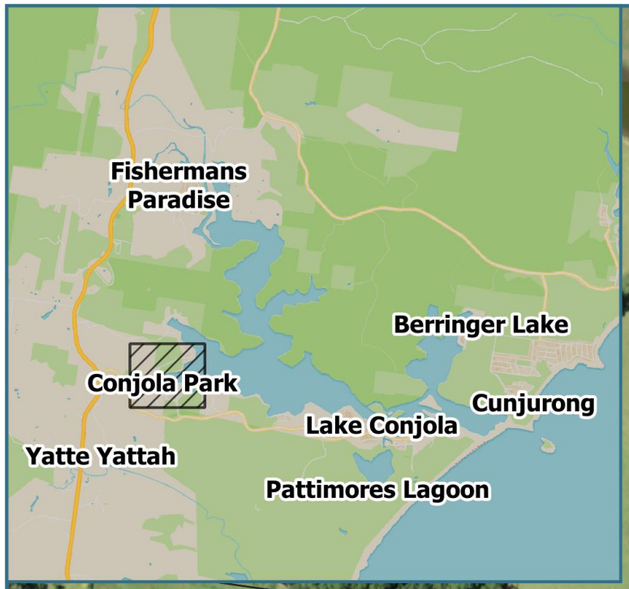

D: Conjola Park

Royal HaskoningDHV
Enhancing Society Together

Lake Conjola Coastal Management Program

Figure D-25
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 100 yr Ocean Only

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

1:4,000

N

0 70 140 210 m

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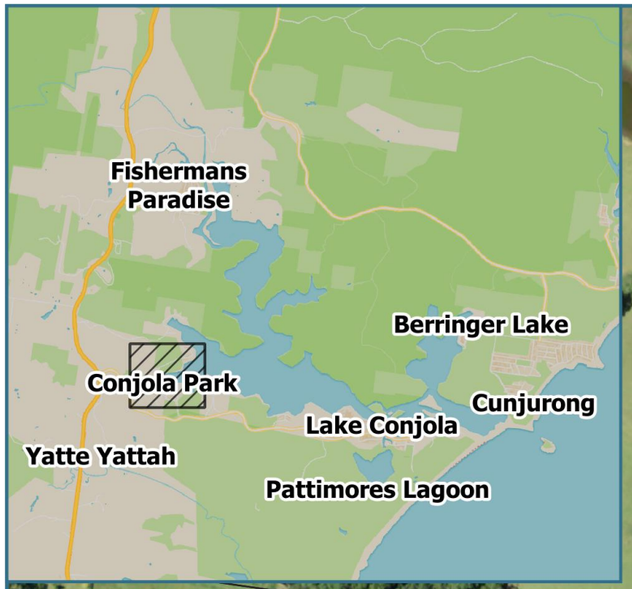

D: Conjola Park

Royal HaskoningDHV
Enhancing Society Together

Lake Conjola Coastal Management Program

Figure D-26
Coastal Inundation
SLR 1.2 m
Bed Raised
Event: 5 yr Catchment Inc.100 yr Ocean Event

Legend

Inundation Depth (m)

≥ 2.00	0.75 - 1.00
1.50 - 2.00	0.50 - 0.75
1.25 - 1.50	0.25 - 0.50
1.00 - 1.25	0.00 - 0.25

PA2591
Basemap: NSW Six Maps
Aerial Image: 08-12-2013

PA2591 / 2022-11-02
GDA2020 / MGA zone 56
Scale at A4

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N

0 70 140 210 m

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Appendix F - Shoalhaven Estuary Health Risk Assessment Mapping

Shoalhaven Local Government Area Estuary Health Diffuse Source Pollution Risk Assessment Mapping

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Contents

1. Introduction 1
2. Summary 5
3. High Priority Estuaries 6
   3.1. Shoalhaven River 6
   3.2. Lake Conjola 11
   3.3. St Georges Basin 16
4. Medium Priority Estuaries 21
   4.1. Burrill Lake 21
   4.2. Lake Tabourie 26
   4.3. Willinga Lake 32
   4.4. Lake Wollumboola 36
   4.5. Currambene Creek 41
   4.6. Moona Moona Creek 46
   4.7. Swan Lake 51
   4.8. Currarong Creek 56
   4.9. Narawallee Inlet 61
5. Low Priority Estuaries 66
   5.1. Berrara Creek 66
   5.2. Butlers Creek 68
   5.3. Callala Creek 69
   5.4. Cararma Creek 70
   5.5. Meroo Lake 71
   5.6. Termeil Lake 72
   5.7. Nerrindillah Creek 73
6. Other Estuaries 74
   6.1. Flat Rock Creek 74

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6.2. Captains Beach Lagoon 75
6.3. Telegraph Creek 76

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Table of Maps

Map 1: Shoalhaven Local Government Area (LGA) Estuary Drainage Catchments 4
Map 2-a: Shoalhaven River Catchment Landuse (2007) 7
Map 2-b: Shoalhaven River Catchment Diffuse Source Pollution Risk Assessment 8
Map 2-c: Shoalhaven River Catchment Total Suspended Solids 9
Map 2-d: Shoalhaven River Catchment Total Nitrogen 10
Map 2-e: Shoalhaven River Catchment Total Phosphorus 11
Map 3-a: Lake Conjola Landuse (2007) 12
Map 3-b: Lake Conjola Diffuse Source Pollution Risk Assessment 13
Map 3-c: Lake Conjola Total Suspended Solids 14
Map 3-d: Lake Conjola Total Nitrogen 15
Map 3e: Lake Conjola Total Phosphorus 16
Map 4-a: St Georges Basin Landuse (2007) 17
Map 4-b: St Georges Basin Diffuse Source Pollution Risk Assessment 18
Map 4-c: St Georges Basin Total Suspended Solids 19
Map 4d: St Georges Basin Total Nitrogen 20
Map 4-e: St Georges Basin Total Phosphorus 21
Map 5-a: Burrill Lake Catchment Landuse (2007) 22
Map 5-b: Burrill Lake Catchment Diffuse Source Pollution Risk Assessment 23
Map 5-c: Burrill Lake Catchment Total Suspended Solids 24
Map 5-d: Burrill Lake Catchment Total Nitrogen 25
Map 5-e: Burrill Lake Catchment Total Phosphorus 26
Map 6-a: Lake Tabourie Catchment Landuse (2007) 27
Map 6-b: Lake Tabourie Catchment Diffuse Source Pollution Risk Assessment 28
Map 6-c: Lake Tabourie Catchment Total Suspended Solids 29
Map 6-d: Lake Tabourie Catchment Total Nitrogen 30
Map 6-e: Lake Tabourie Catchment Total Phosphorus 31
Map 7-a: Willinga Lake Catchment Landuse (2007) 32
Map 7-b: Willinga Lake Catchment Diffuse Source Pollution Risk Assessment 33
Map 7-c: Willinga Lake Total Suspended Solids 34
Map 7-d: Willinga Lake Total Nitrogen 35
Map 7-e: Willinga Lake Total Phosphorus 36
Map 8-a: Lake Wollumboola Catchment Landuse (2007) 37
Map 8-b: Lake Wollumboola Catchment Diffuse Source Pollution Risk Assessment 38
Map 8-c: Lake Wollumboola Catchment Total Suspended Solids 39
Map 8-d: Lake Wollumboola Catchment Total Nitrogen 40
Map 8-e: Lake Wollumboola Catchment Total Phosphorus 41
Map 9-a: Currambene Creek Catchment Landuse (2007) 42
Map 9-b: Currambene Creek Catchment Diffuse Source Pollution Risk Assessment 43
Map 9-c: Currambene Creek Catchment Total Suspended Solids 44
Map 9-d: Currambene Creek Catchment Total Nitrogen 45
Map 9-e: Currambene Creek Catchment Total Phosphorus 46
Map 10-a: Moona Creek Catchment Landuse (2007) 47

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Map 10-b: Moona Creek Catchment Diffuse Source Pollution Risk Assessment 48
Map 10-c: Moona Creek Catchment Total Suspended Solids 49
Map 10-d: Moona Creek Catchment Total Nitrogen 50
Map 10-e: Moona Creek Catchment Total Suspended Solids 51
Map 11-a: Swan Lake Catchment Landuse (2007) 52
Map 11b: Swan Lake Catchment Diffuse Source Pollution 53
Map 11-c: Swan Lake Catchment Total Suspended Solids 54
Map 11-d: Swan Lake Catchment Diffuse Source Pollution 55
Map 11-e: Swan Lake Catchment Diffuse Source Pollution 56
Map 12-a: Currarong Creek Landuse (2007) 57
Map 12-b: Currarong Creek Catchment Diffuse Source Pollution Risk Assessment 58
Map 12-c: Currarong Creek Catchment Total Suspended Solids 59
Map 12-d: Currarong Creek Catchment Total Nitrogen 60
Map 12-e: Currarong Creek Catchment Total Phosphorus 61
Map 13-a: Narawallee Inlet Catchment Landuse (2007) 62
Map 13-b: Narawallee Inlet Catchment Diffuse Source Pollution Risk Assessment 63
Map 13-c: Narawallee Inlet Catchment Total Suspended Solids 64
Map 13-d: Narawallee Inlet Catchment Total Nitrogen 65
Map 13-d: Narawallee Inlet Catchment Total Phosphorus 66
Map 14-a: Berrara Creek Catchment Diffuse Source Pollution Risk Assessment 67
Map 15-a: Butlers Creek Catchment Diffuse Source Pollution Risk Assessment 68
Map 16-a: Callala Creek Catchment Diffuse Source Pollution Risk Assessment 69
Map 17-a: Cararma Creek Catchment Diffuse Source Pollution Risk Assessment 70
Map 18-a: Meroo Lake Creek Catchment Diffuse Source Pollution Risk Assessment 71
Map 19-a: Termeil Lake Catchment Diffuse Source Pollution Risk Assessment 72
Map 20-a: Nerrindillah Creek Catchment Diffuse Source Pollution Risk Assessment 73
Map 20-a: Flat Rock Creek Catchment Diffuse Source Pollution Risk Assessment 74
Map 21-a: Captains Creek Catchment Diffuse Source Pollution Risk Assessment 75
Map 22-a: Telegraph Creek Catchment Diffuse Source Pollution Risk Assessment 76

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Shoalhaven Estuary Health Diffuse Source Pollution Risk Assessment Mapping

1. Introduction

Department of Planning, Industry and Environment (DPIE) followed the first two steps in the 'Risk-based framework for conducting waterway health outcomes in strategic land-use planning decisions' to prepare diffuse source pollution risk assessment maps to help inform the preparation of Coastal Management Programs (CMPs) for Shoalhaven estuaries.

This dataset is intended to be used as a 'first-pass' assessment to help inform the priorities of where management actions might be undertaken to contribute to achieving outcomes for the health of estuaries and to support the management objectives of the *Coastal Management SEPP 2018.* These maps, when used with other detailed information sources, may help identify the potential priority areas for managing sediment and nutrient runoff (e.g. through riparian revegetation). The maps should be used to inform further detailed assessments through fieldwork to identify other factors that influence estuary health including bank erosion. They can also help to identify high risk areas where land use intensification (e.g. converting forest to urban or agriculture) should be avoided as these areas are likely to have a greater influence on estuary health. Where land use intensification is to occur, neutral or beneficial effect on estuary water quality through the application of stringent pollutant reduction targets may need to be applied for developments in these areas.

The estuary health risk assessment is based on a coupled series of catchment runoff and estuary (hydraulic or hydrodynamic and ecological response) models. Likelihood represents the extent and intensity of land use pressure from each sub-catchment. Whilst consequence represents the extent of impact on estuary health. These likelihood and consequence scores were combined to determine a risk rating of high, medium or low for each estuary sub-catchment. The risk assessment methodology used was consistent with guidance provided in the NSW Treasury Risk Management Toolkit and risk management standard (ISO 31000).

The catchment runoff modelling uses standard export rates for total nitrogen (TN), total phosphorus (TP) and total suspended solid (TSS) based on land use (along with other parameters including soil type and climate). These export coefficients are then multiplied by the modelled surface flows. The model is a prediction of sediment and nutrient export to the estuary but has only been calibrated based on generalised land use data. Other pollutant types and sources (e.g. stream bank erosion) are not considered. Land use data is based on the 2007 mapping which in some cases may now be outdated. This is acknowledged as a limitation that needs to be considered when interpreting the maps.

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Further detail on the dataset and methodology is available in *NSW Estuary Health Risk Dataset – A first pass risk assessment to assist with the prioritisation of catchment management actions*. Note the risk assessment scores are relative within each catchment and should not be compared between catchments.

Each estuary drainage catchment within the Shoalhaven Local Government Area (LGA) are shown on Map 1. The following maps are presented for high and medium priority estuaries:

- risk to estuary health for each sub-catchment;
- land use; and
- modelled export of TSS, TN and TP.

Just risk to estuary health maps are presented for low priority estuaries.

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Map 1: Shoalhaven Local Government Area (LGA) Estuary Drainage Catchments

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2. Summary

A summary of the priority areas where management actions might be undertaken to contribute to achieving outcomes for the health of estuaries and to support the management objectives of the *Coastal Management SEPP 2018* is provided in Table 1.

Table 1: Potential priority areas for catchment management actions based on the NSW estuary health risk dataset

Estuary	Priority areas for detailed investigation to minimise diffuse source pollution
High Priority Estuaries	
Shoalhaven River	Lower Estuary – Primarily agricultural and urban land
Lake Conjola	Lower Estuary - Urban foreshore areas including Lake Conjola, Conjola Park and agricultural land
St Georges Basin	Lower Estuary – Urban areas including St Georges Basin, Sanctuary Point, Old Erowal Bay, Sussex Inlet and Wandandian
Medium Priority Estuaries	
Burrill Lake	Lower Estuary – Urban areas including Burrill Lake and grazed areas
Lake Tabourie	Lower Estuary – Urban areas of Lake Tabourie and along roads and tracks
Willinga Lake	Lower Estuary – Urban Areas including Bawley Point and agricultural areas
Lake Wollumboola	Lower Estuary – Urban Areas including Culburra Beach and agricultural areas
Currambene Creek	Middle Catchment – Urban and agricultural areas including Woollamia and Falls Creek
Moona Moona Creek	Lower Estuary – Urban areas including Huskisson and Vincentia.
Swan Lake	Lower Estuary – Urban areas including Swan Lake and Swanhaven
Currarong Creek	Likely Lower Estuary – Urban area of Currarong. Note: landuse mapping and risk assessment needs to be updated in Stage 2 of the CMP process to properly assess.
Narawallee Inlet	Further investigation required – possible southern part of the lower estuary including urban and agricultural areas
Low Priority Estuaries	
Berrara Creek	Lower Estuary – Urban Areas including Berrara Village and protect from future development
Butlers Creek	Minimal works likely to be required as low risk and minimal urban area. Protection from future development
Callala Creek	Lower Estuary – Urban Areas including Callala Beach village. Protection from future development
Cararma Creek	Protection from future development
Meroo Lake	Upper and middle catchment – Rural residential and agricultural areas
Termeil Lake	Lower and Middle catchment – Rural residential and agricultural areas
Nerrindillah Creek	Lower Estuary – Urban areas of North Bendalong
Other Estuaries	
Flat Rock Creek	Located on the border of LGA with Boderee National Park. Protection from future development and impacts from Naval Base and airport
Captains Beach Lagoon	Protection from future development and impacts from Naval Base, airport and Jervis Bay village. Managed by Boderee National Park
Telegraph Creek	Protection from future development and road runoff. Managed by Boderee National Park

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3. High Priority Estuaries

3.1. Shoalhaven River

The Shoalhaven River catchment extends well beyond the boundaries of the Shoalhaven Local Government Area (LGA). The upper reaches of the catchment are largely forested, whilst the lower floodplain areas are predominantly agricultural. The main urban centre is Nowra which is located inland from the coast within the lower estuary (Map 2a).

The highest risk areas identified within the Shoalhaven River catchment are those in these lower agricultural and urban areas (Map 2b). These high risk areas correspond to areas where there are predicted to be high TN, TP and TSS export rates. These high export rates are predominantly related to areas that are identified as being irrigated pasture (Maps 2 c, d and e). The predicted nutrient and sediment export rates for the irrigated pasture areas within the Shoalhaven River catchment are higher than those predicted for other estuaries within the Shoalhaven LGA.

The Shoalhaven River catchment is a high priority for potential management actions to improve water quality. These would include minimising nutrient and sediment runoff from the lower agricultural catchment areas, particularly where there are irrigated pastures.

High risk areas are where land use intensification (e.g. converting forest to urban or agriculture) is best avoided, as these areas are likely to have a greater influence on estuary health. Where land use intensification is to occur, the aim should be for neutral or beneficial effect on estuary water quality through stringent pollutant reduction targets being applied to developments in these areas.

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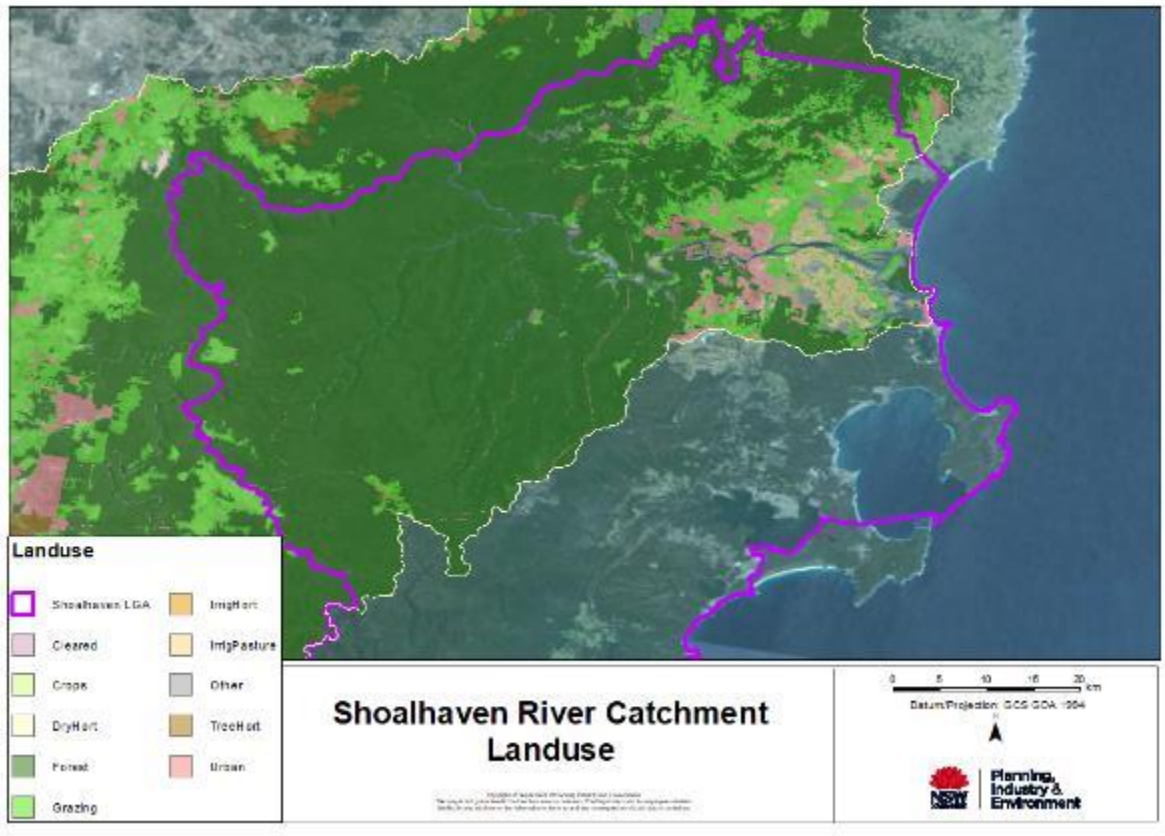

Map 2-a: Shoalhaven River Catchment Landuse (2007)

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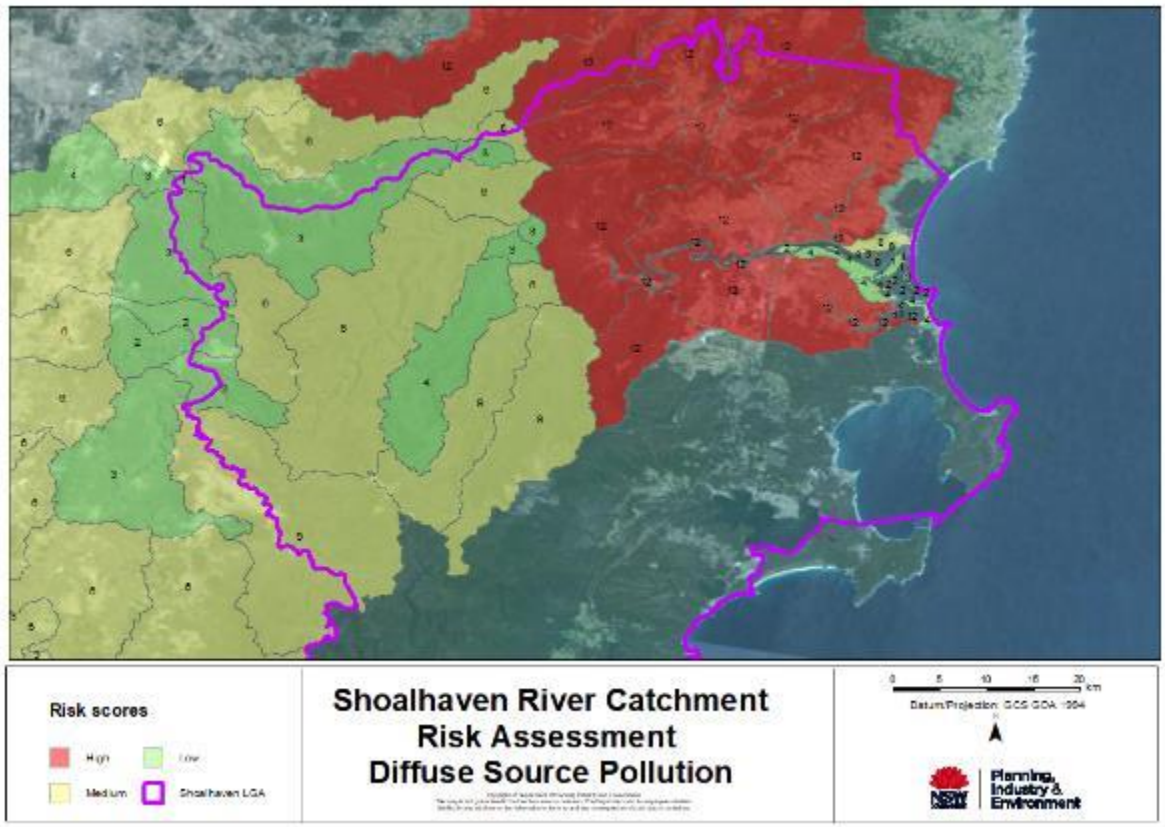

Map 2-b: Shoalhaven River Catchment Diffuse Source Pollution Risk Assessment

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Map 2-c: Shoalhaven River Catchment Total Suspended Solids

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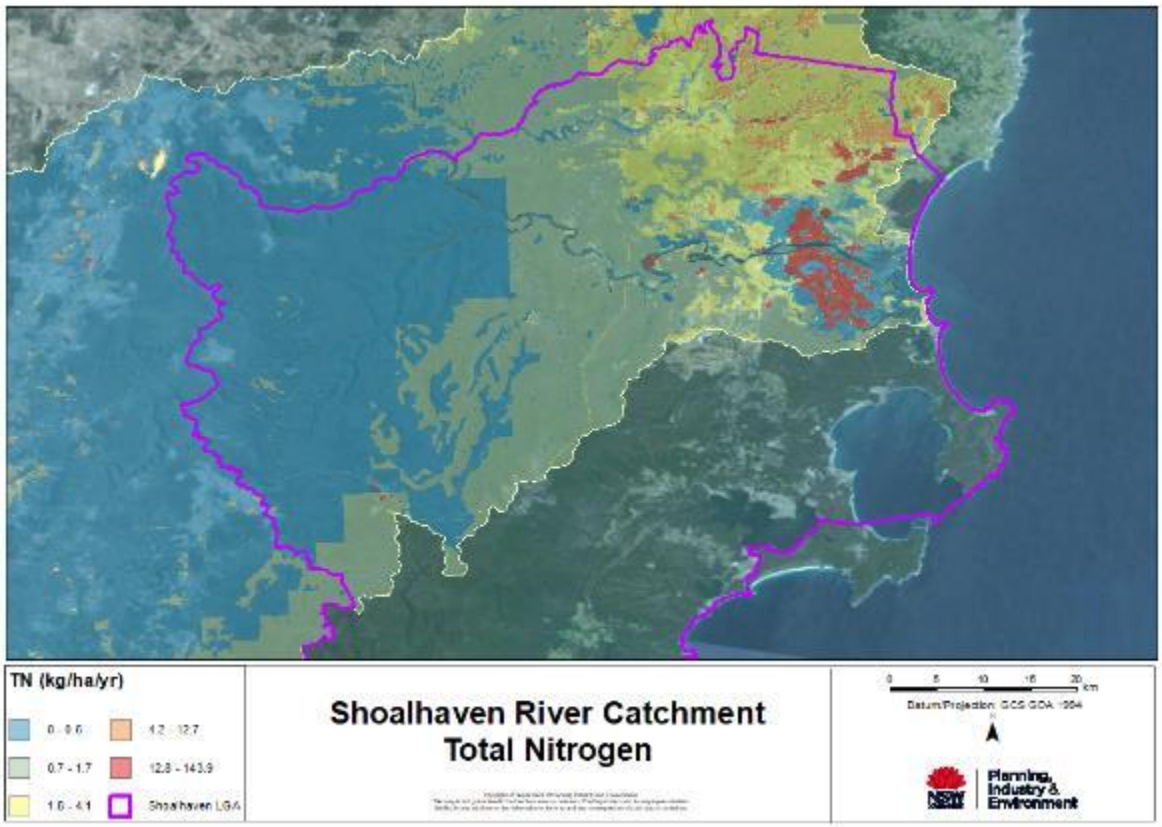

Map 2-d: Shoalhaven River Catchment Total Nitrogen

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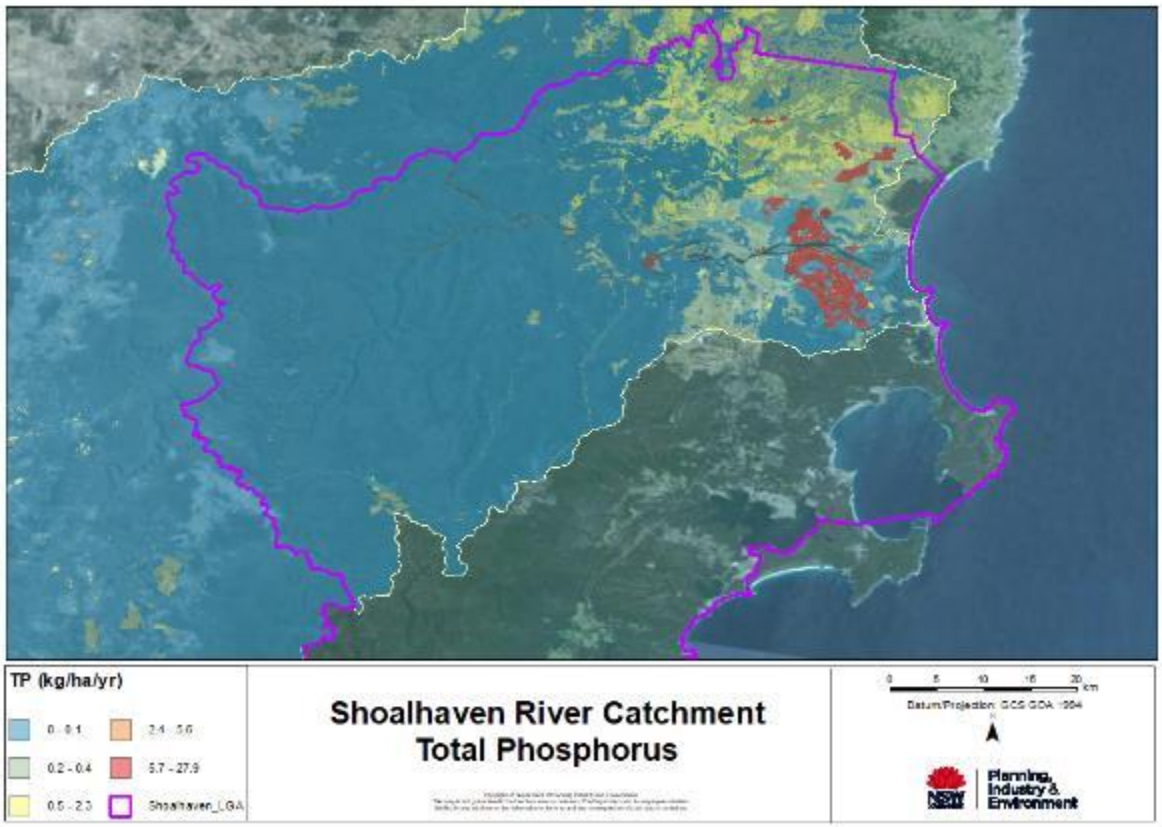

Map 2-e: Shoalhaven River Catchment Total Phosphorus

3.2. Lake Conjola

The majority of the Lake Conjola catchment is forested with some small urban settlements and grazed areas located within the middle and lower catchment. The settlements of Fisherman's Paradise, Conjola Park and Lake Conjola are located close to the lake foreshore (Map 3a).

The highest risk sub-catchments identified are those in the steeper upper catchment and areas surrounding the lake foreshore (Map 3b). These sub-catchments represent areas where land use intensification should be avoided. It should be noted that the landuse mapping used in the analysis is quite coarse and has missed some parts of the urban areas located on the foreshore of Lake Conjola. This has potentially led to a lower risk score for parts of the Lake Conjola urban area.

TN export rates were generally highest in the steeper grazed and urban areas, with TSS export rates also generally highest in the steeper areas (Map 3d). This highlights the importance of maintaining these areas in a forested state.

Priority areas for further detailed investigation of potential management actions within the Lake Conjola catchment include the urban areas nearest the foreshore, as well as the areas with grazing landuse (Map 3a).

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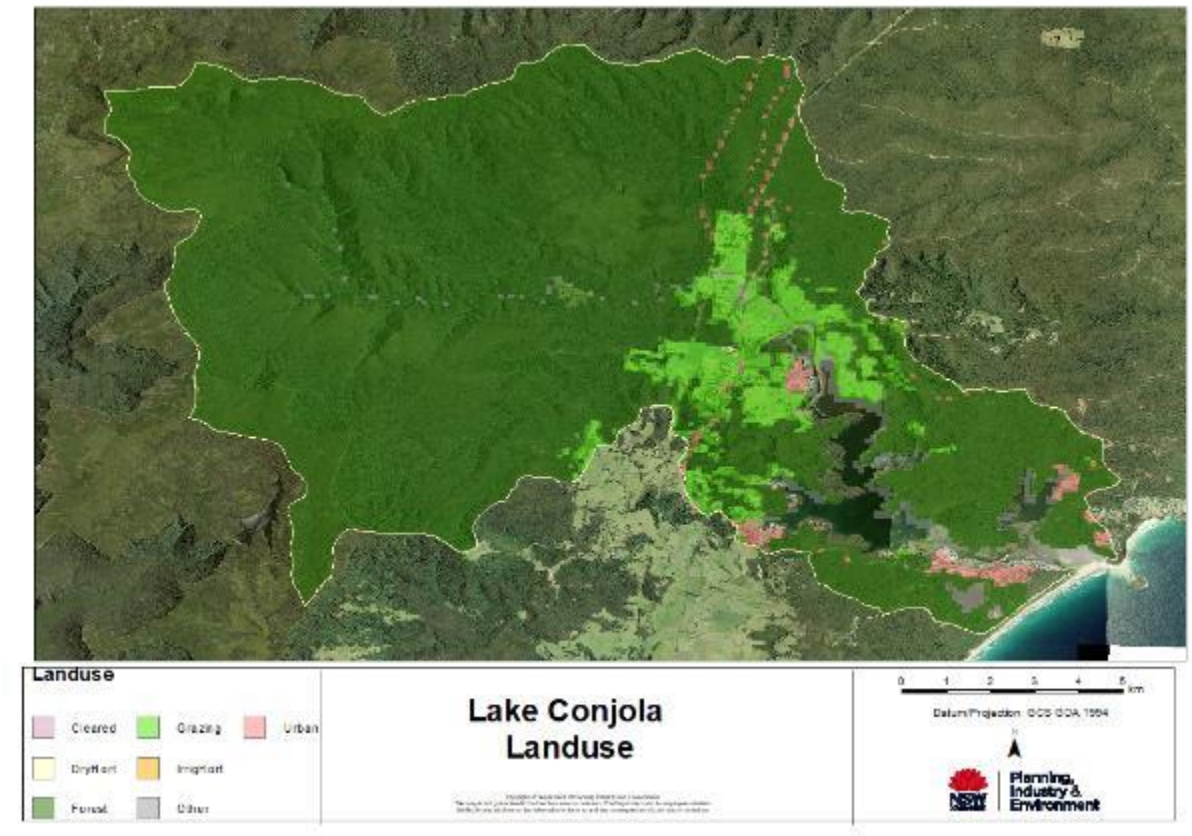

Map 3-a: Lake Conjola Landuse (2007)

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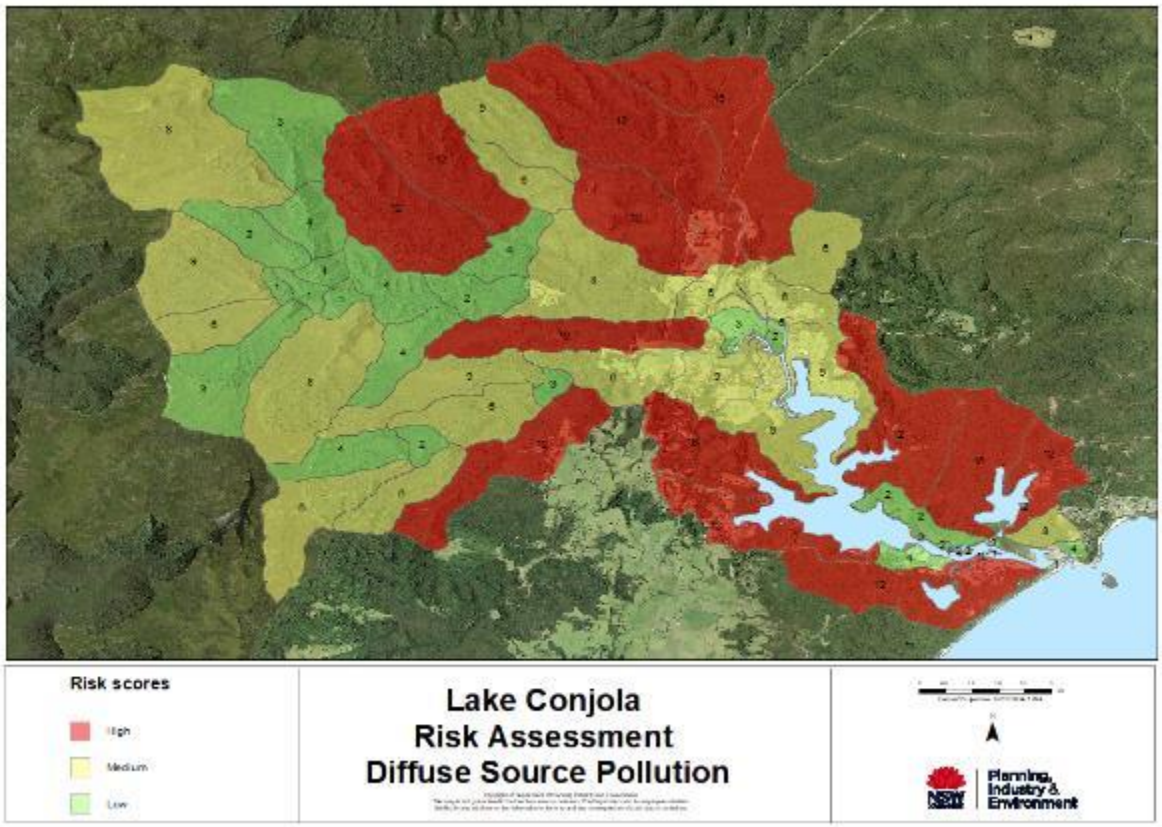

Map 3-b: Lake Conjola Diffuse Source Pollution Risk Assessment

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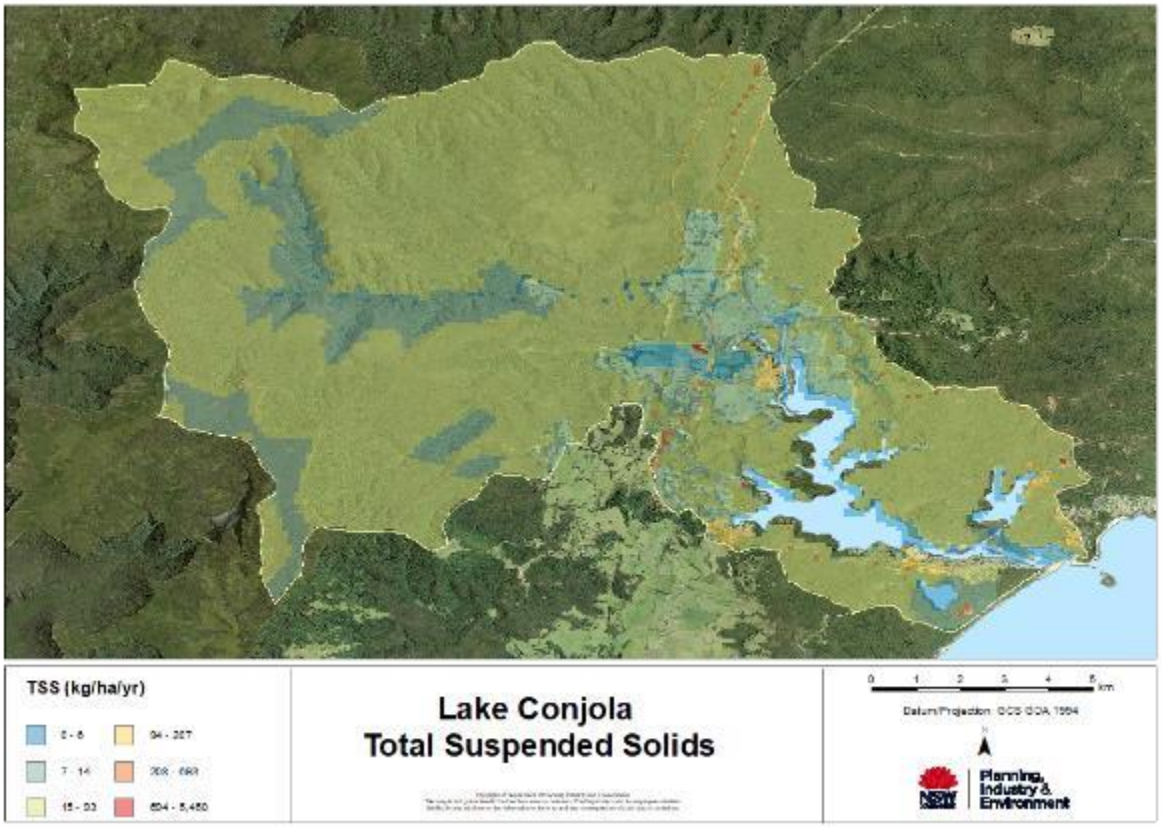

Map 3-c: Lake Conjola Total Suspended Solids

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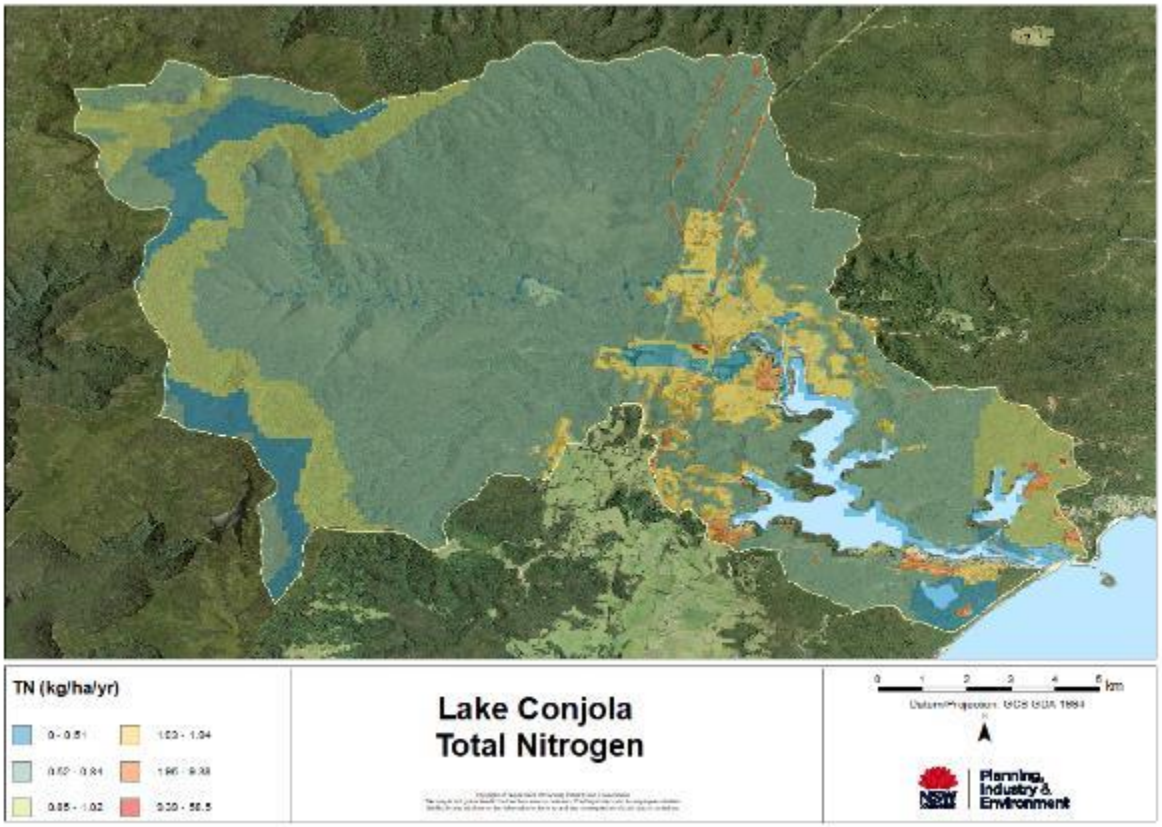

Map 3-d: Lake Conjola Total Nitrogen

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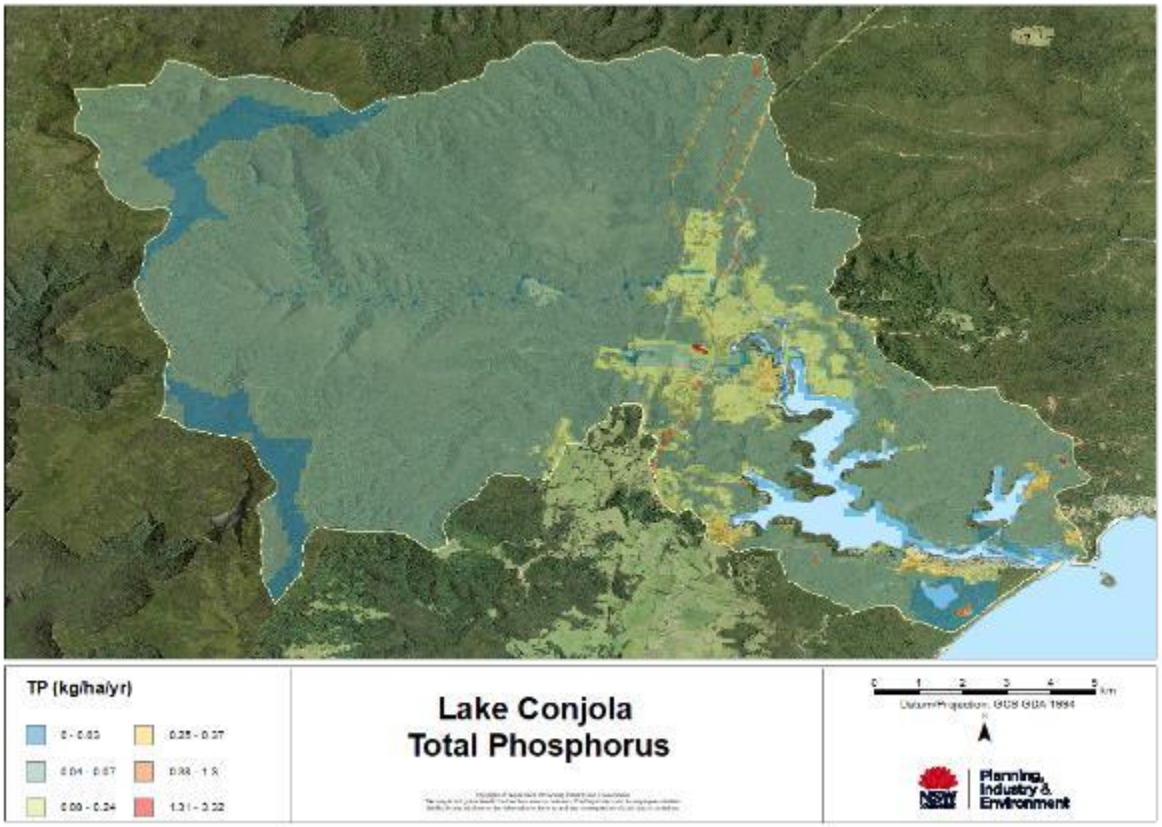

Map 3e: Lake Conjola Total Phosphorus

3.3. St Georges Basin

The majority of the St Georges Basin catchment is forested with urban settlements including St Georges Basin, Sanctuary Point, Old Erowal Bay, Sussex Inlet and Wandandian located in the lower catchment areas. Some agricultural areas are located in the middle of the catchment, particularly along Wandandian Creek (Map 4a).

The highest risk sub-catchments identified are generally those that contain urban areas that drain into the lake and Wandandian Creek (Map 4b). These higher risk areas also correspond to the higher TSS, TN and TP diffuse source pollution export rates (Map 4 c, d and e). Higher risk areas, particularly those that are forested, are where land use intensification should be avoided.

TSS, TN and TP export rates were similar to that found for Lake Conjola and Moona Creek estuaries.

Priority areas for further detailed investigation of potential management actions within the St Georges Basin catchment include the urban areas of St Georges Basin, Sanctuary Point, Old Erowal Bay, Sussex Inlet and Wandandian. Minimising diffuse source pollution from these areas entering waterways is likely to have the greatest benefit.

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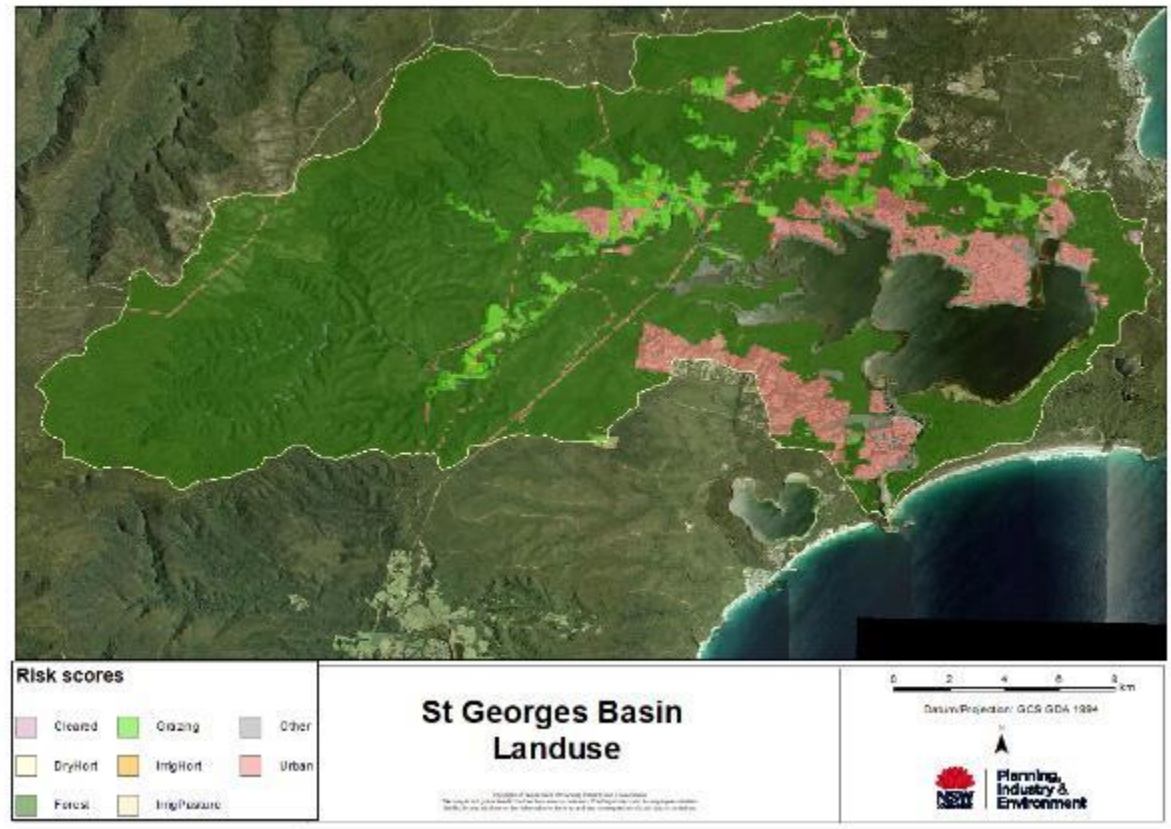

Map 4-a: St Georges Basin Landuse (2007)

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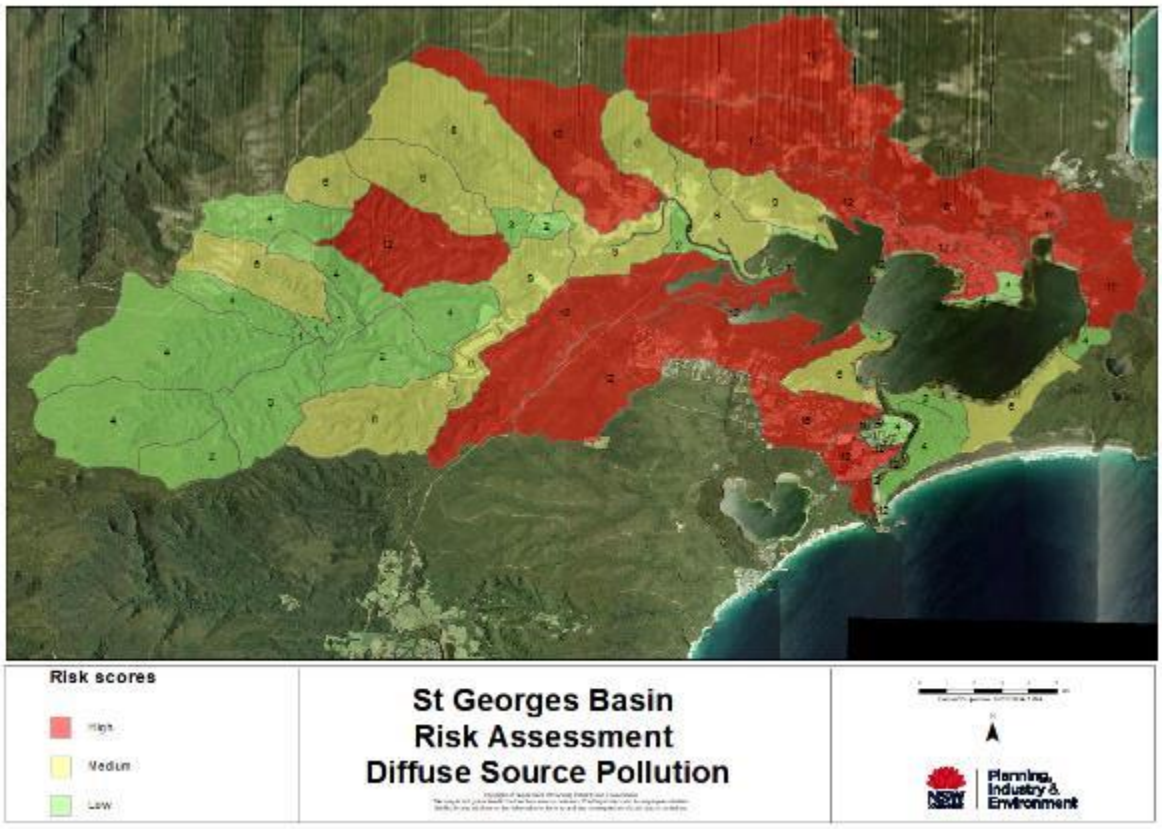

Map 4-b: St Georges Basin Diffuse Source Pollution Risk Assessment

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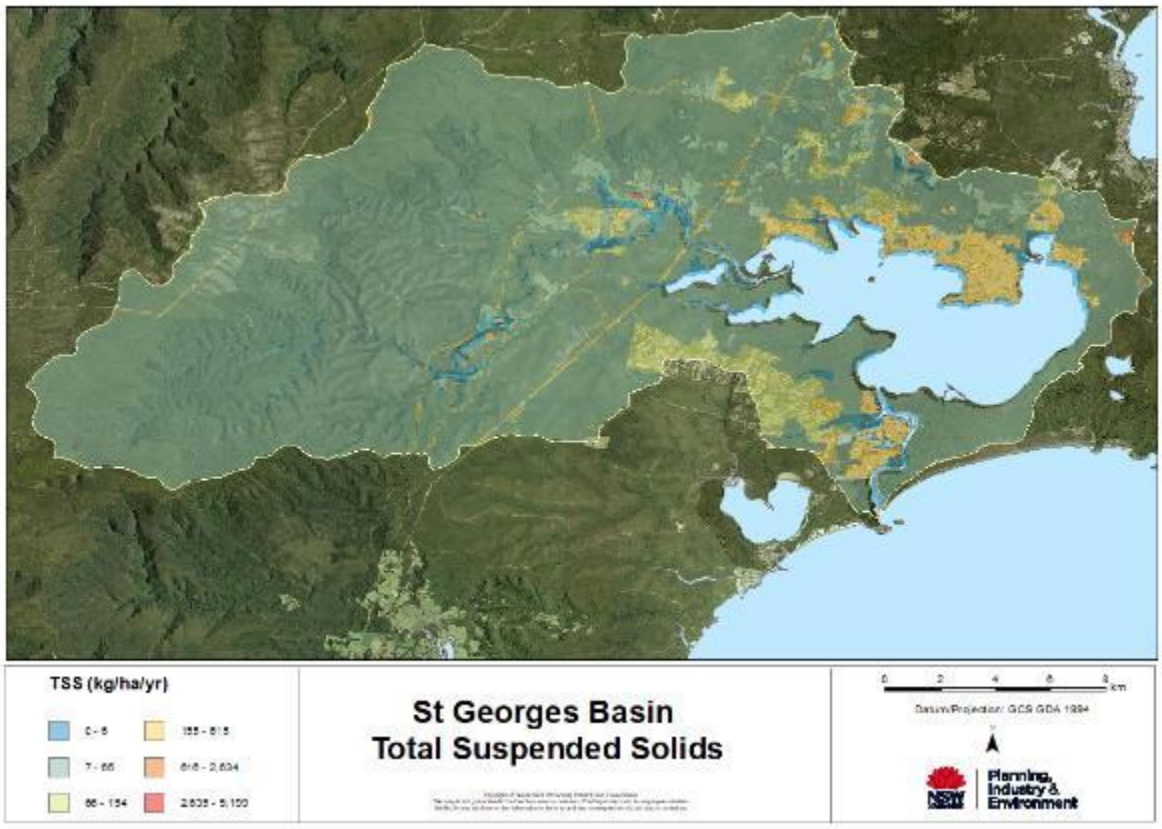

Map 4-c: St Georges Basin Total Suspended Solids

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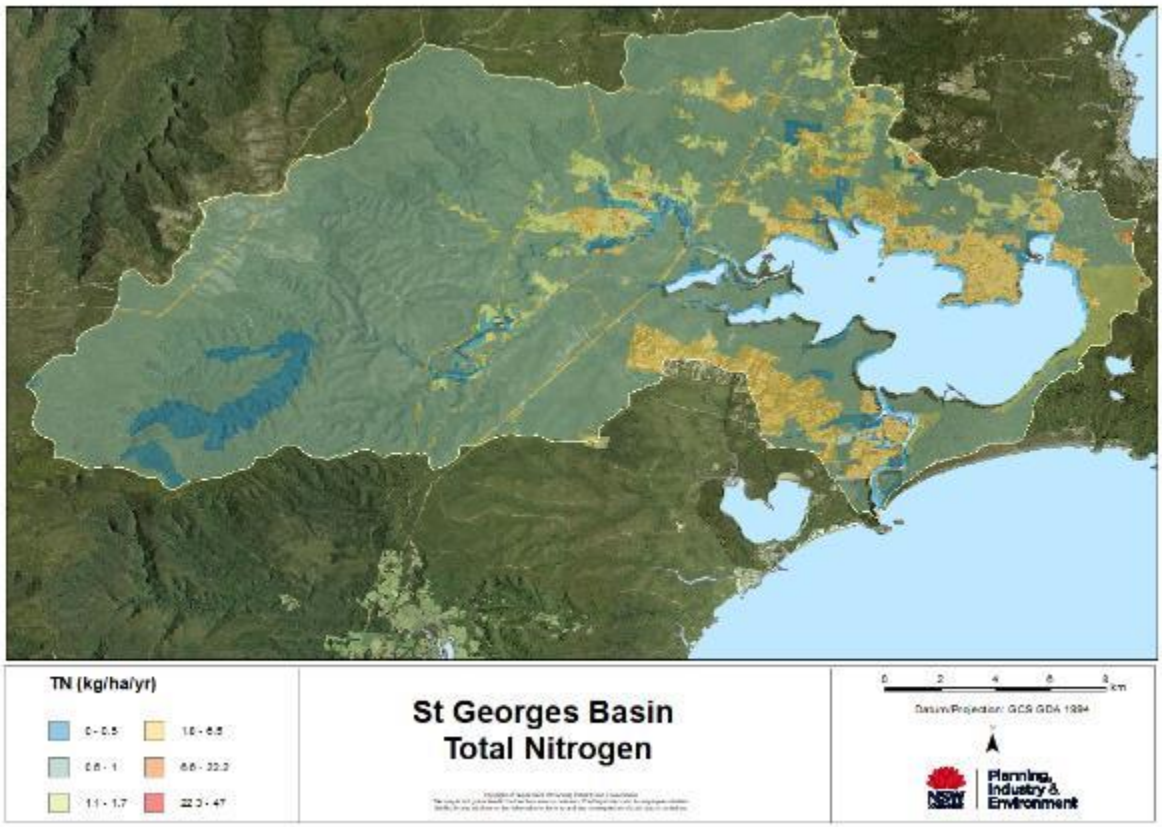

Map 4d: St Georges Basin Total Nitrogen

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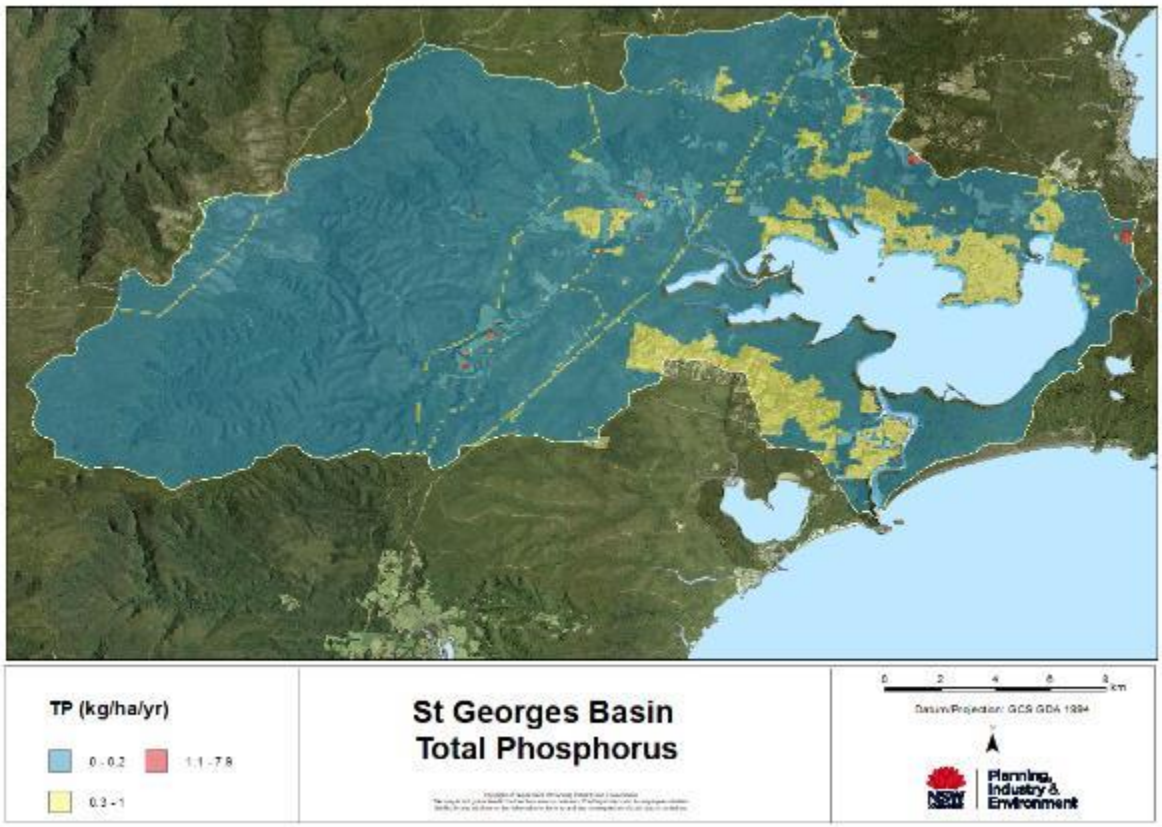

Map 4-e: St Georges Basin Total Phosphorus

4. Medium Priority Estuaries

4.1. Burrill Lake

Much of the upper Burrill Lake catchment is forested. Lowland areas are predominantly agricultural with a number of urban settlements including Burrill Lake, Kings Point, Woodburn, Woodstock and the very edge of Ulladulla located within the catchment (Map 5a).

The highest risk sub-catchments identified are generally those that contain urban areas of Ulladulla, the southern half of Burrill Lake and Woodburn (Map 5b). These higher risk urban areas also correspond to the predicted higher TSS, TN and TP diffuse source pollution export rates (Map 5c, d and e).

Priority areas for further detailed investigation of potential management actions within the Burrill Lake catchment include the urban areas and where grazing landuse corresponds to high risk areas. Minimising diffuse source pollution from these areas entering waterways should be prioritised.

Avoiding land use intensification in high risk areas or ensuring neutral or beneficial effect on estuary water quality through stringent pollutant reduction targets being applied to future developments will help to minimise additional future impacts on Burrill Lake.

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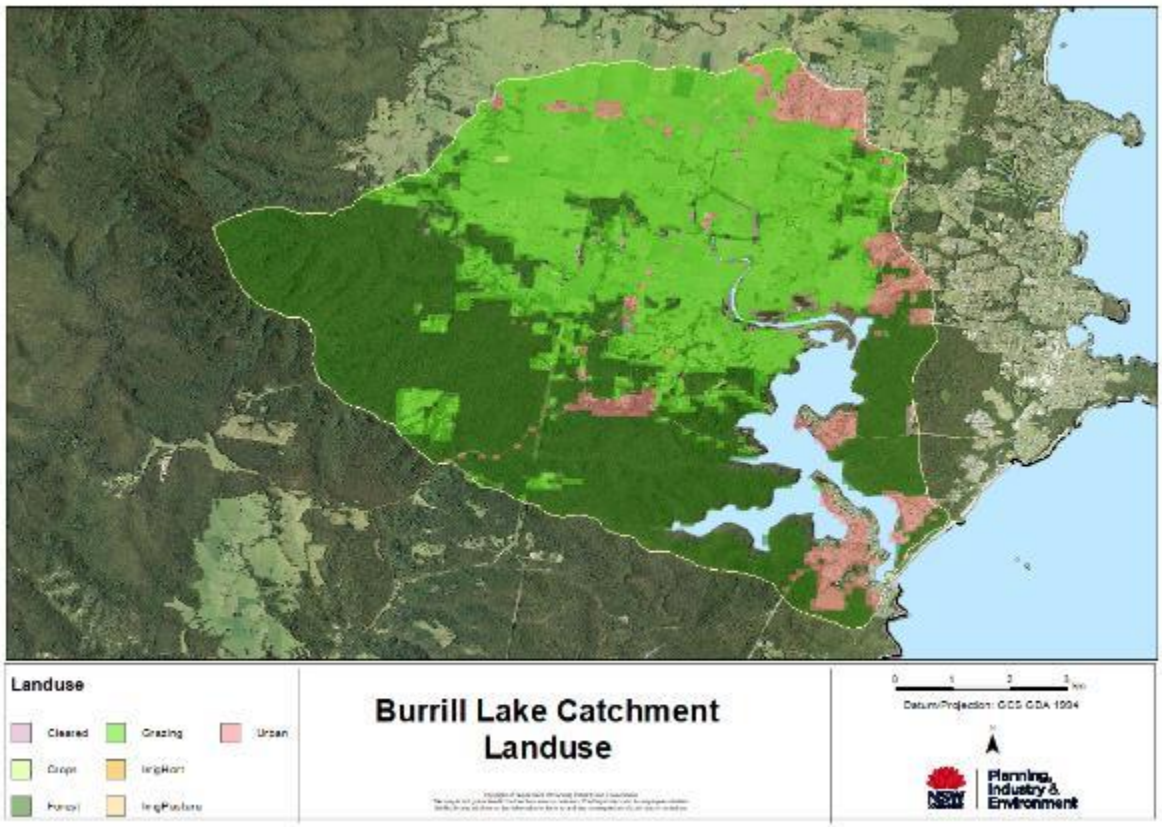

Map 5-a: Burrill Lake Catchment Landuse (2007)

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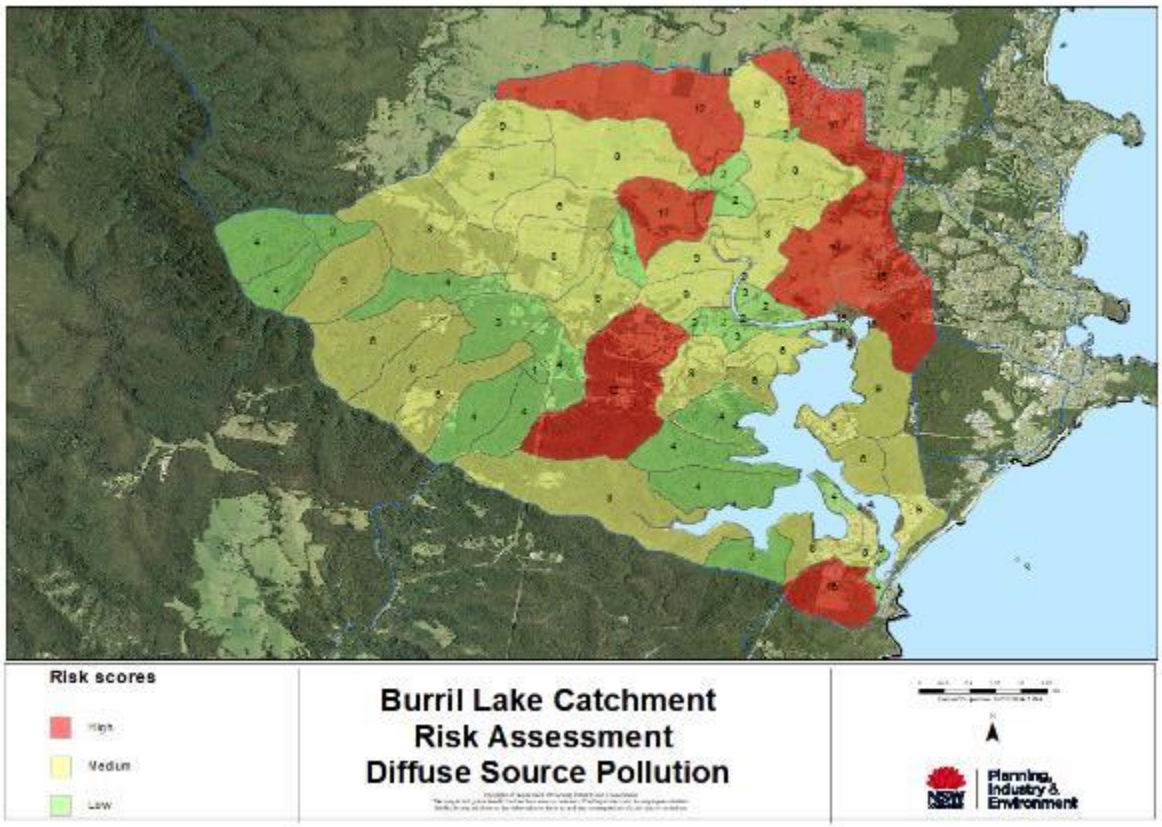

Map 5-b: Burrill Lake Catchment Diffuse Source Pollution Risk Assessment

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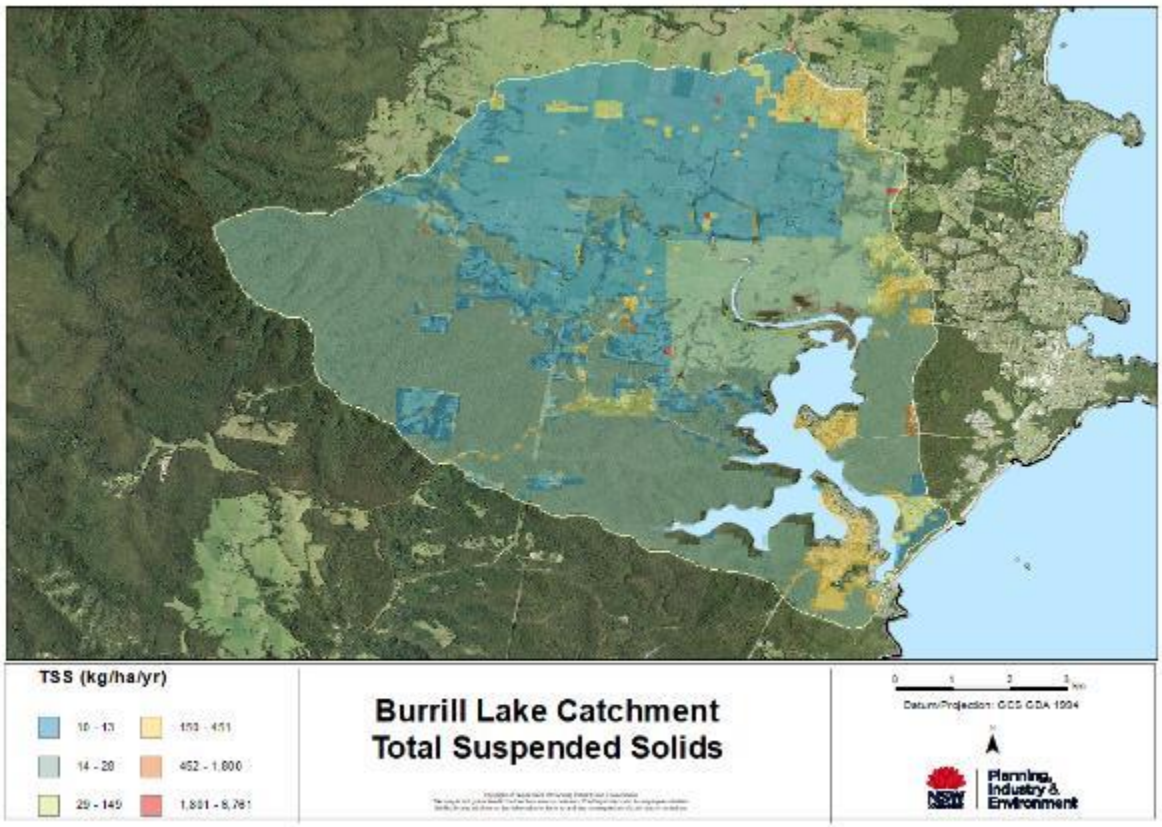

Map 5-c: Burrill Lake Catchment Total Suspended Solids

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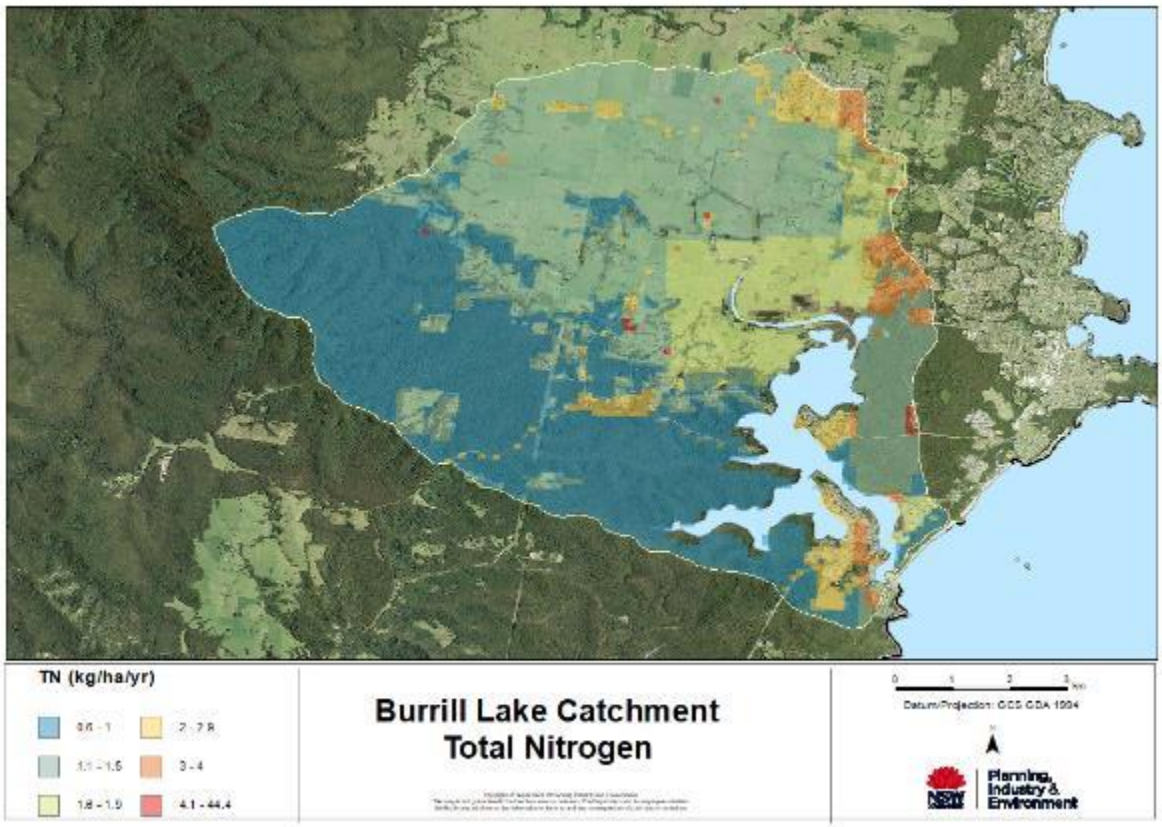

Map 5-d: Burrill Lake Catchment Total Nitrogen

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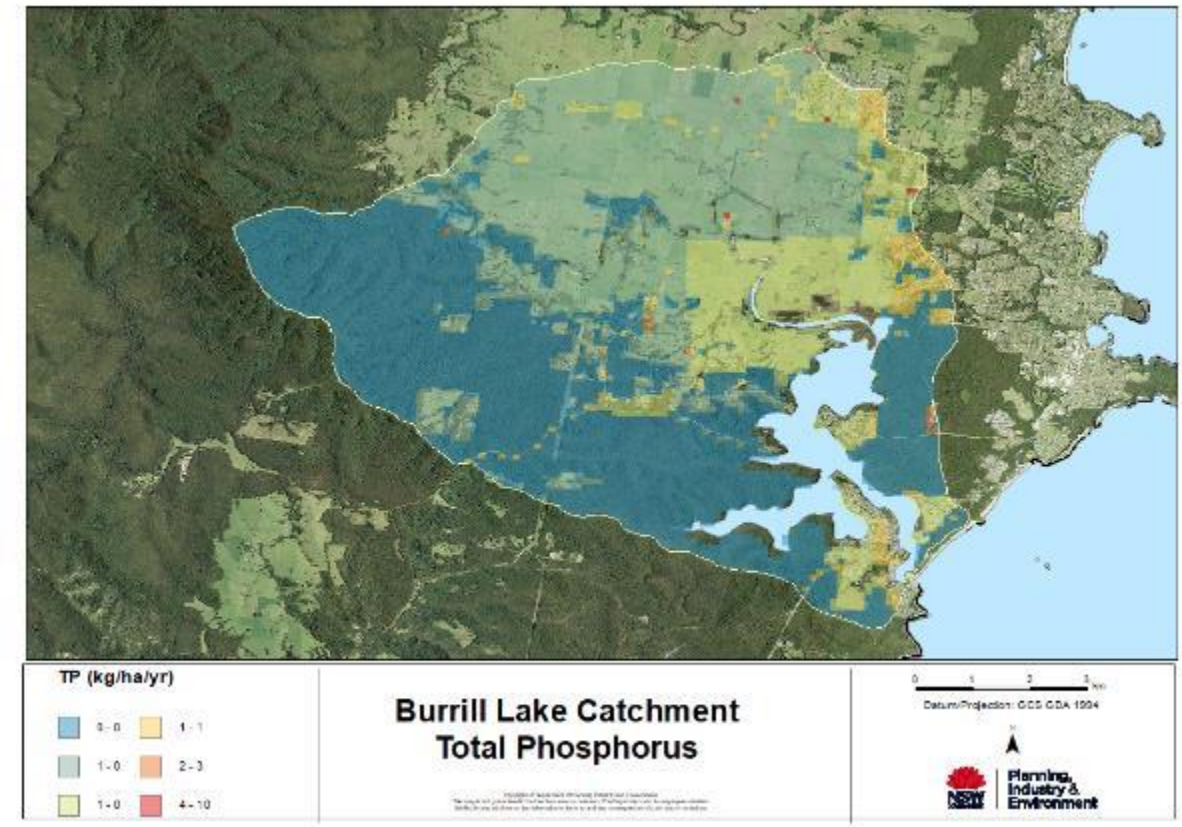

Map 5-e: Burrill Lake Catchment Total Phosphorus

4.2. Lake Tabourie

The majority of the Lake Tabourie estuary catchment is forested, with patches of agricultural land and a small proportion of urban development on the estuary foreshore at Lake Tabourie (Map 6a).

The highest risk sub-catchments identified are generally those that are in the steeper upper forested catchments as well as within the Lake Tabourie urban area (Map 6b). These are the areas where land use intensification is best avoided. These higher risk areas also generally correspond to the higher TSS, TN and TP diffuse source pollution export rates (Map 6 c, d and e). The cleared tracks below powerlines have also been identified as a potential source of pollutants, however these areas have been incorrectly identified as being urban in the landuse layer potentially increasing the risk level assigned.

TSS, TN and TP export rates were generally comparatively low compared to other estuaries within the Shoalhaven LGA.

Priority areas for further detailed investigation of potential management actions within the Lake Tabourie catchment include the urban areas of Lake Tabourie and potentially along roads and tracks. Minimising diffuse source pollution from these areas entering waterways should be prioritised,

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including controlling runoff from roads and tracks.



Map 6-a: Lake Tabourie Catchment Landuse (2007)

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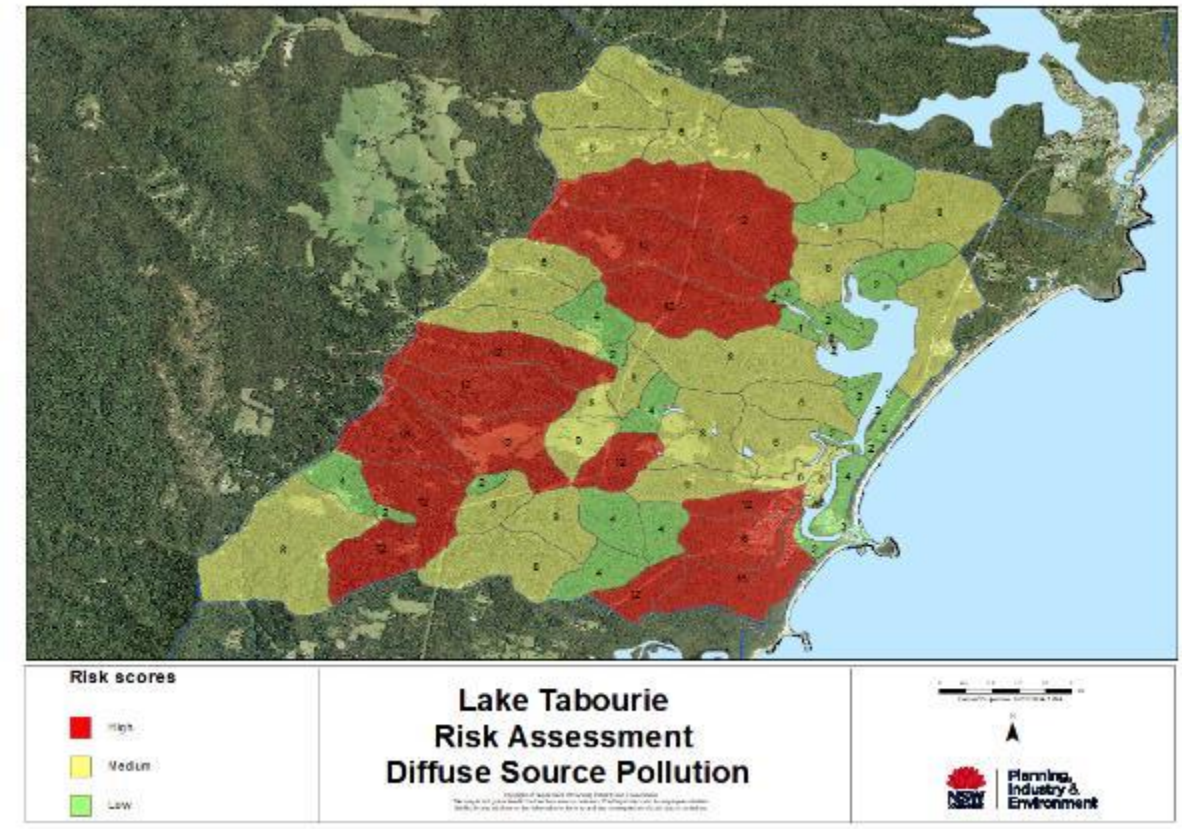

Map 6-b: Lake Tabourie Catchment Diffuse Source Pollution Risk Assessment

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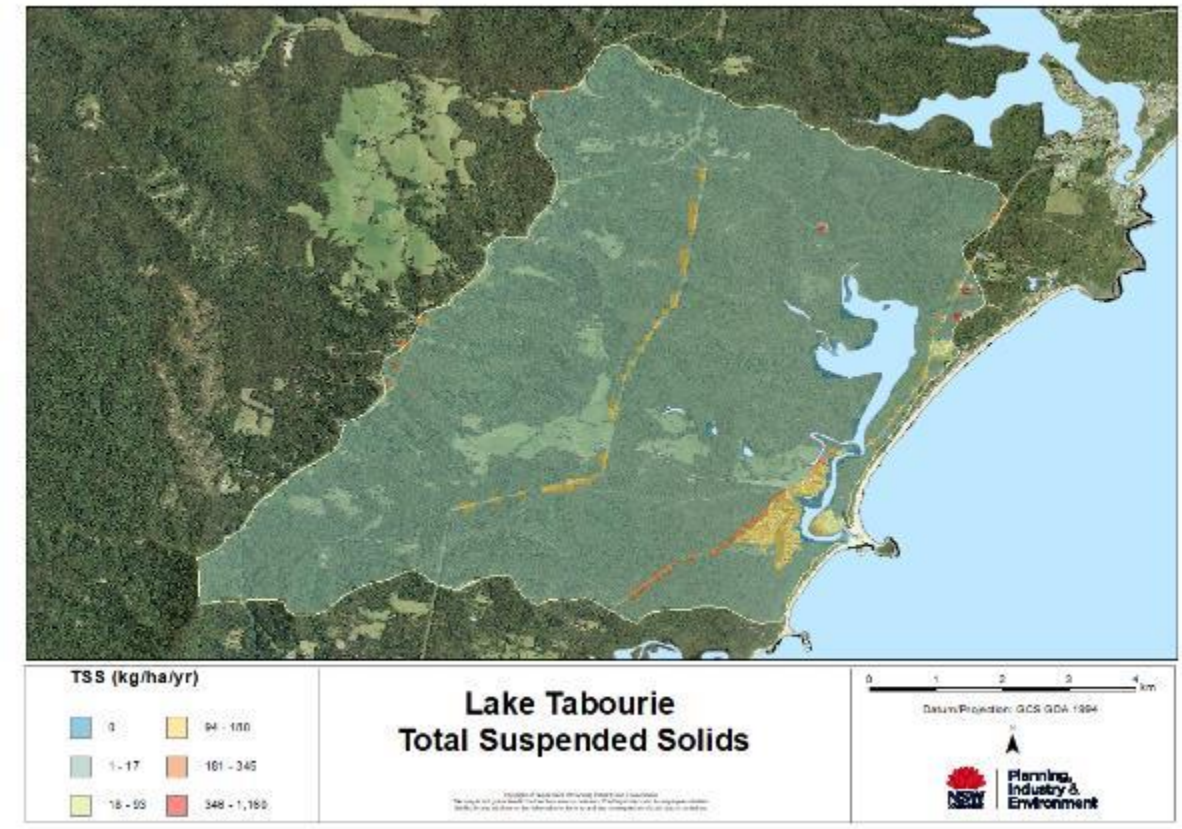

Map 6-c: Lake Tabourie Catchment Total Suspended Solids

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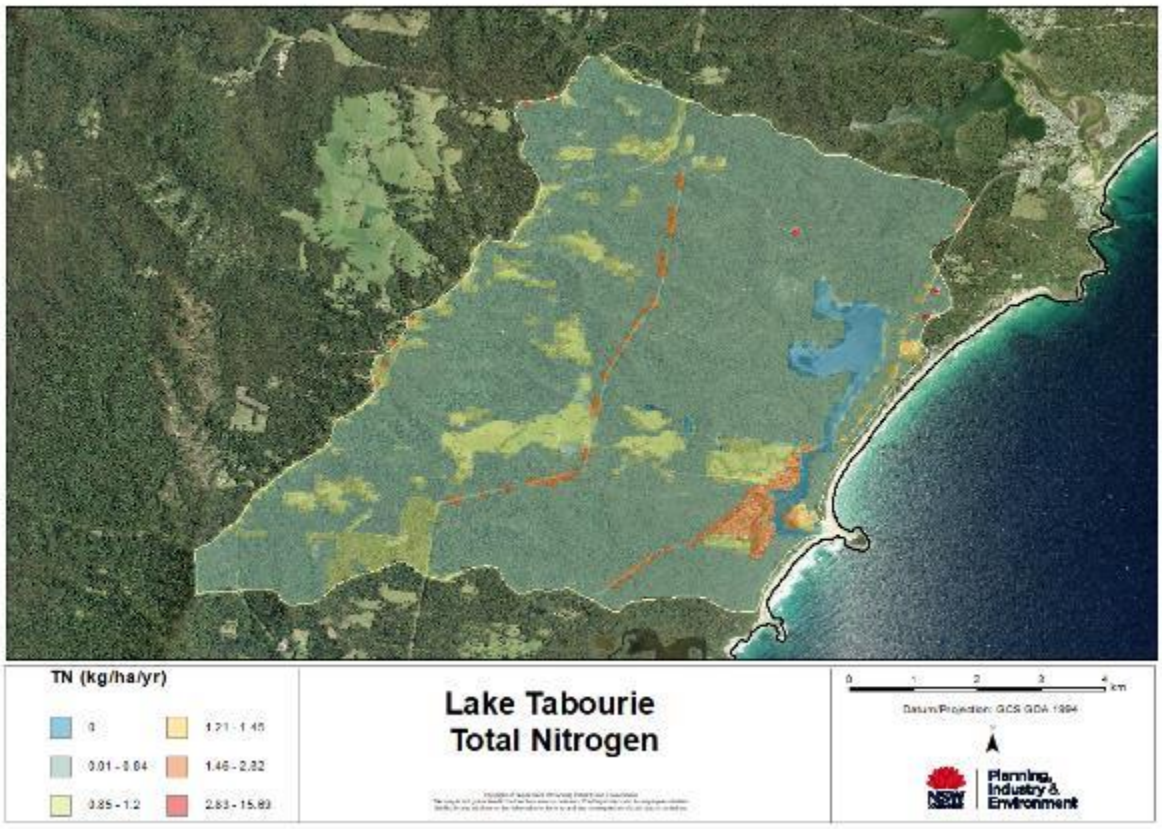

Map 6-d: Lake Tabourie Catchment Total Nitrogen

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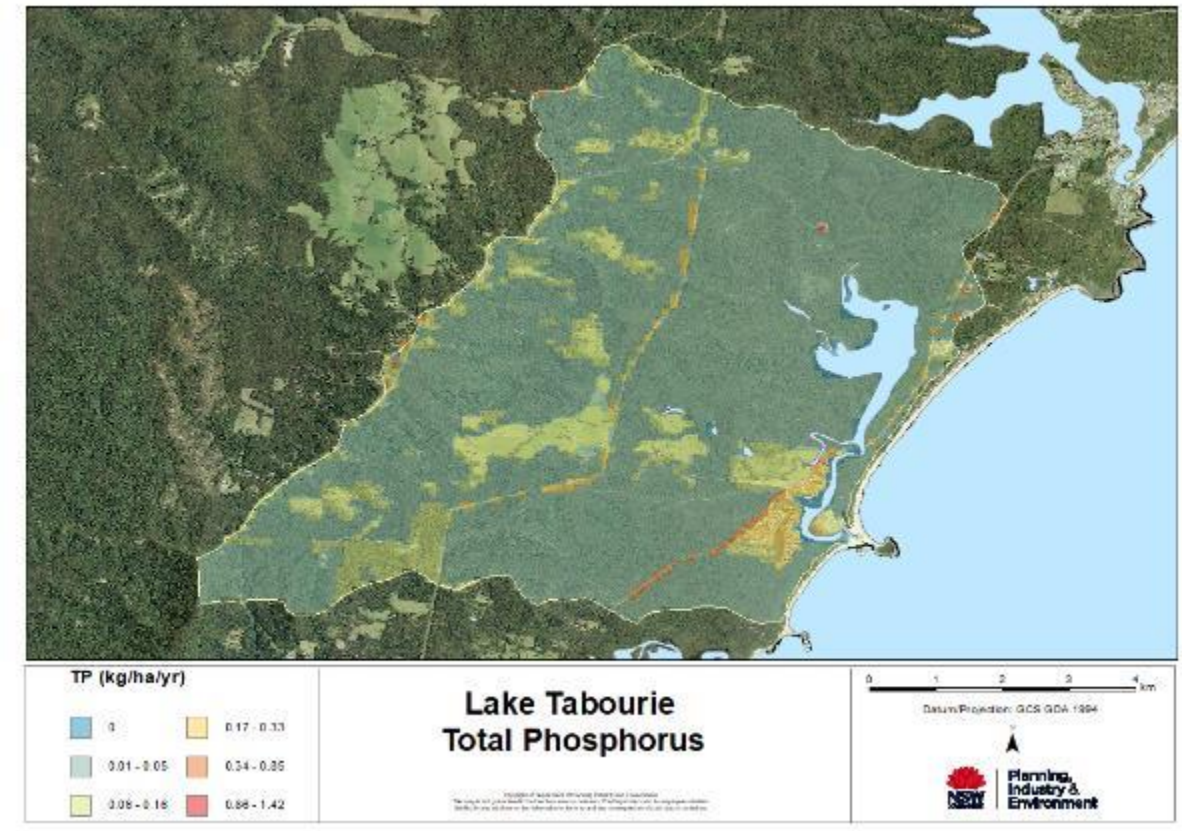

Map 6-e: Lake Tabourie Catchment Total Phosphorus

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4.3. Willinga Lake

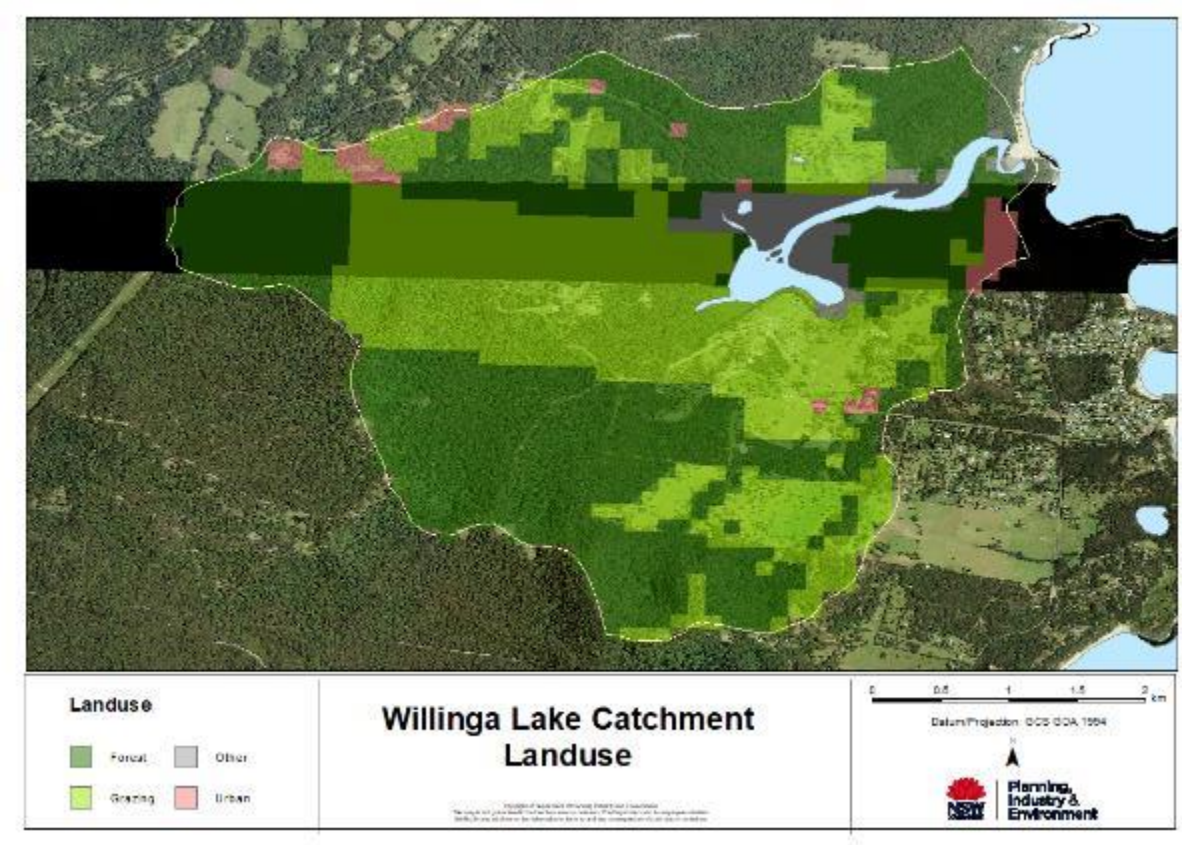
The majority of the Willinga Lake estuary catchment is forested, with patches of grazed agricultural land and urban development. These urban areas include parts of Bawley Point as well as other scattered dwellings (Map 7a).

The landuse mapping utilised within the risk assessment has overestimated the grazed areas within the catchment and underestimated the actual forested areas. As such, the risk ratings may not be accurate and may require updating in the next stage of the CMP development.

The highest risk sub-catchments identified are those that are in the upper catchments and include the Bawley Point urban area (Map 7b). These higher risk areas generally correspond to the higher predicted TSS, TN and TP diffuse source pollution export rates (Map 7c, d and e).

The TSS, TN and TP export rates for Willinga Lake are considered to be relatively low compared to other estuaries within the Shoalhaven LGA.

Priority areas for further detailed investigation of potential management actions within the Willinga Lake catchment include preventing diffuse source pollution from entering waterways from the urban areas of Bawley Point and areas with agricultural land use. Minimising diffuse source pollution from these areas entering waterways should be prioritised.



Map 7-a: Willinga Lake Catchment Landuse (2007)

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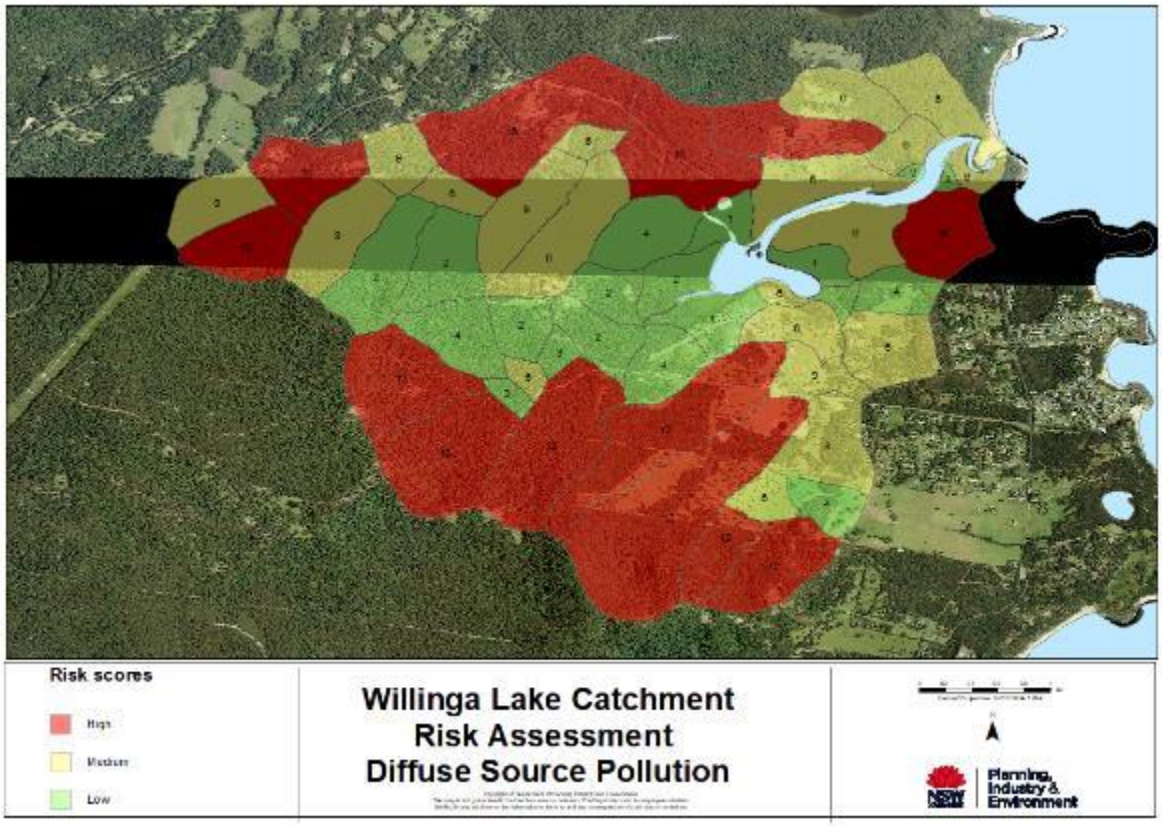

Map 7-b: Willinga Lake Catchment Diffuse Source Pollution Risk Assessment

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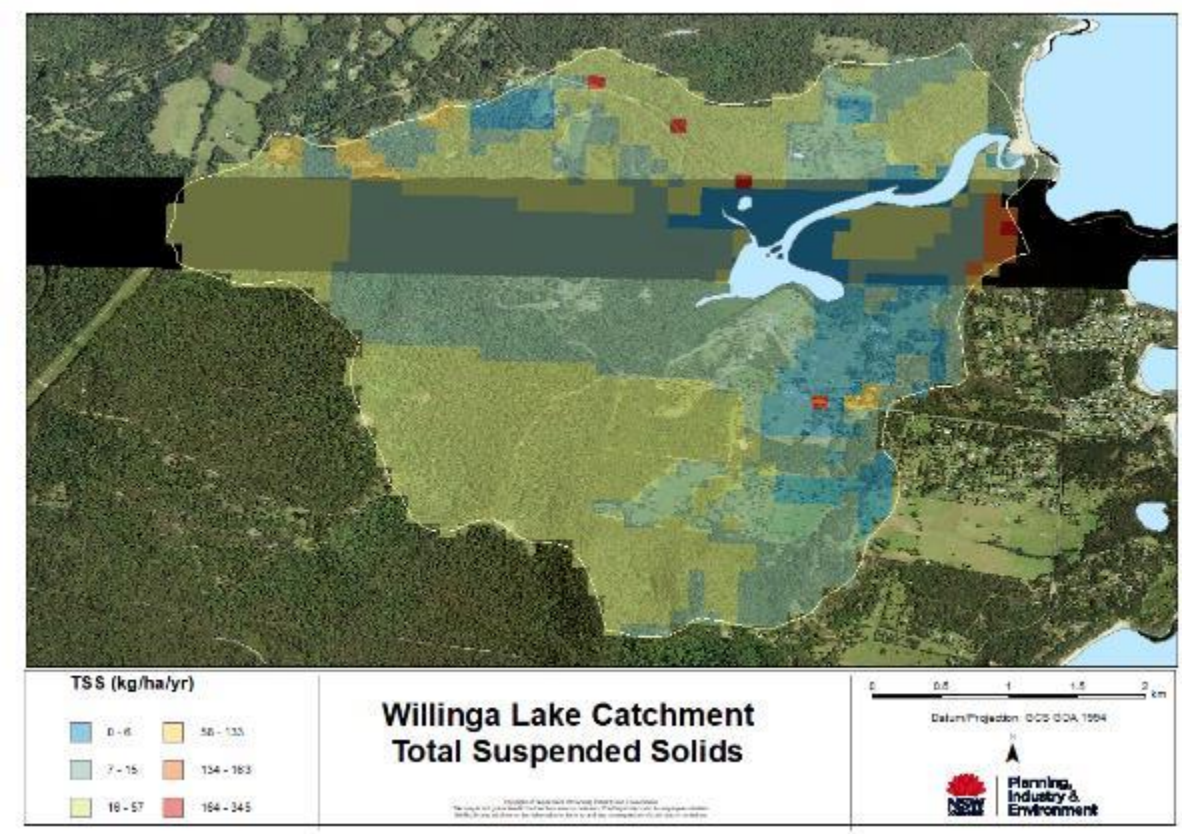

Map 7-c: Willinga Lake Total Suspended Solids

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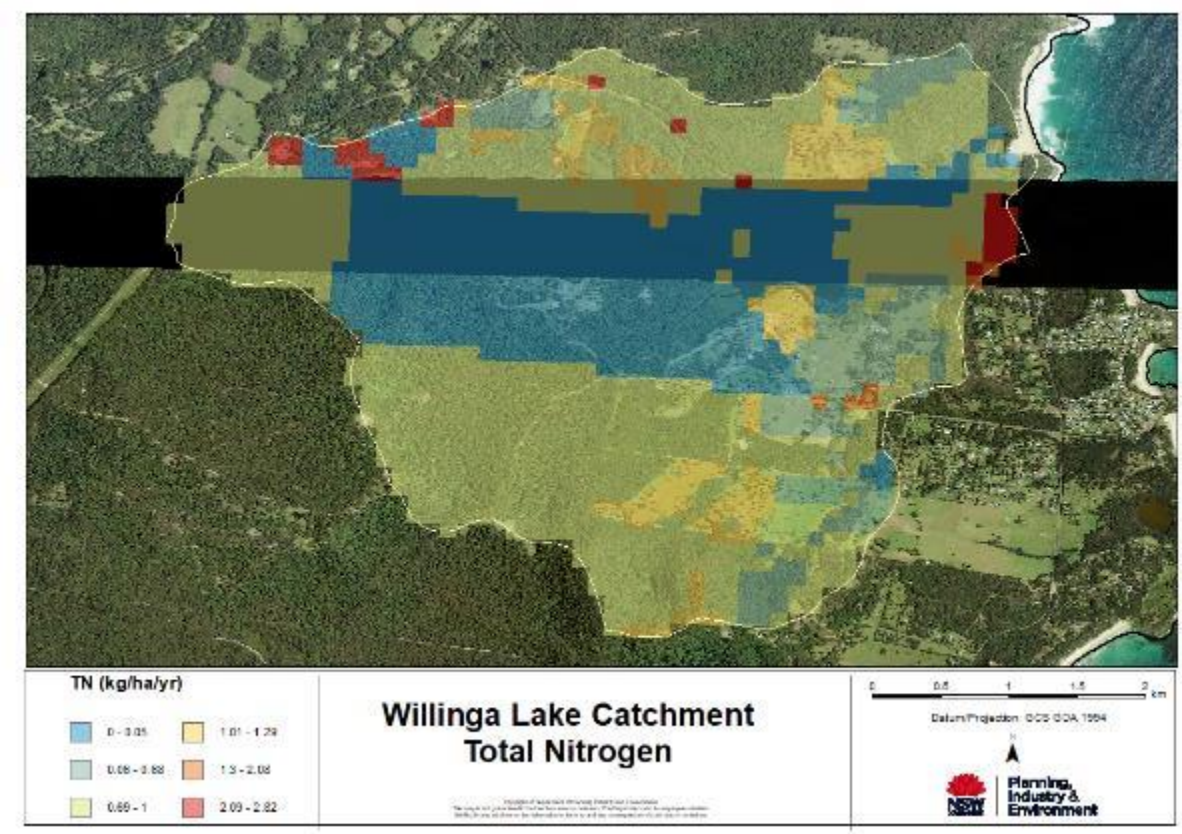

Map 7-d: Willinga Lake Total Nitrogen

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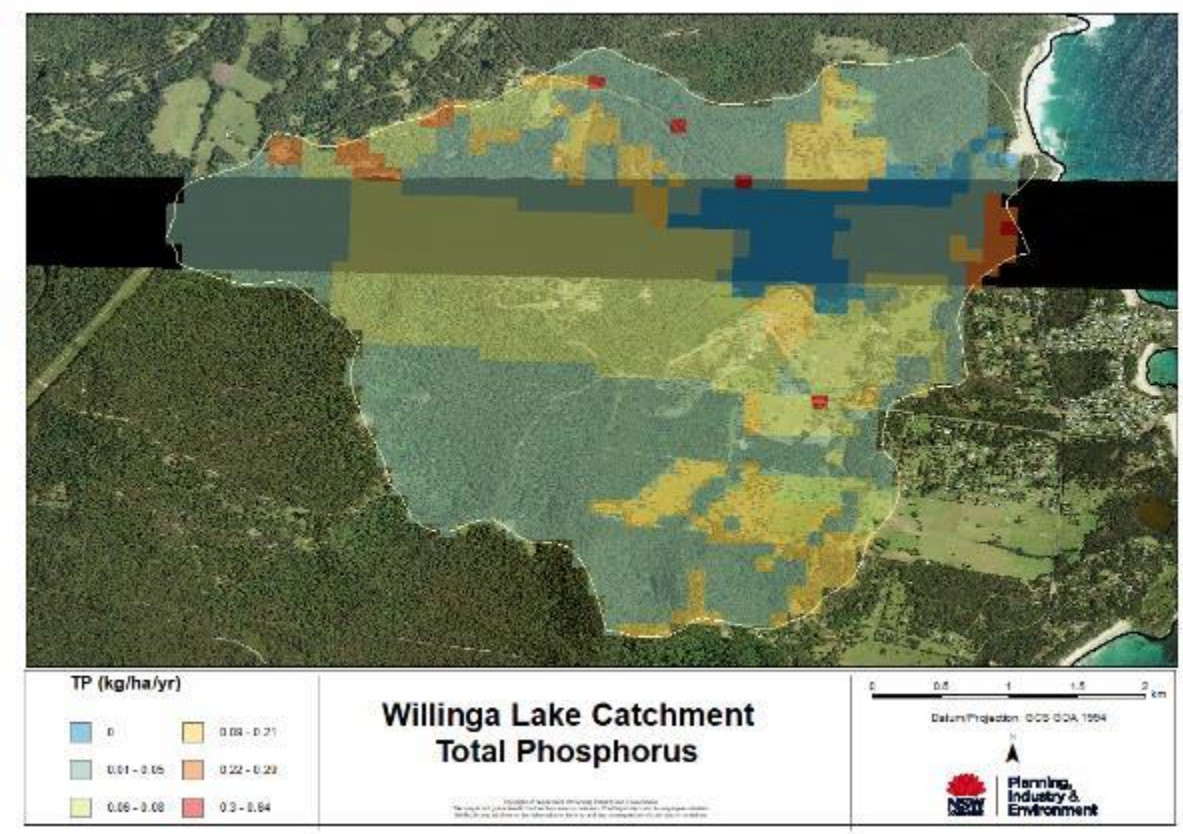

Map 7-e: Willinga Lake Total Phosphorus

4.4. Lake Wollumboola

The majority of the Lake Wollumboola estuary catchment is forested, with patches of grazed agricultural land and a small proportion which is urban. This urban area includes parts of Culburra Beach on the estuary foreshore . Some scattered areas of the catchment appear to have been incorrectly identified as being urban within the land use layer used in the modelling. Therefore, the results for these areas should be treated with caution, with further ground-truthing required (Map 8a).

The highest risk sub-catchments identified are generally those in the lower half of the catchment and include all the sub-catchments with urban and agricultural land uses.(Map 8b). These higher risk areas also generally correspond to the higher TSS and TN diffuse source pollution export rates (Map 8c, d and e).

The TSS, TP and TN export rates for Lake Wollumboola are considered to be relatively low compared to some of the other estuaries within the Shoalhaven LGA.

The priority for further detailed investigation of management actions are within the lower catchment areas includes preventing runoff from the Culburra Beach urban areas and areas that have been historically cleared and are grazed.

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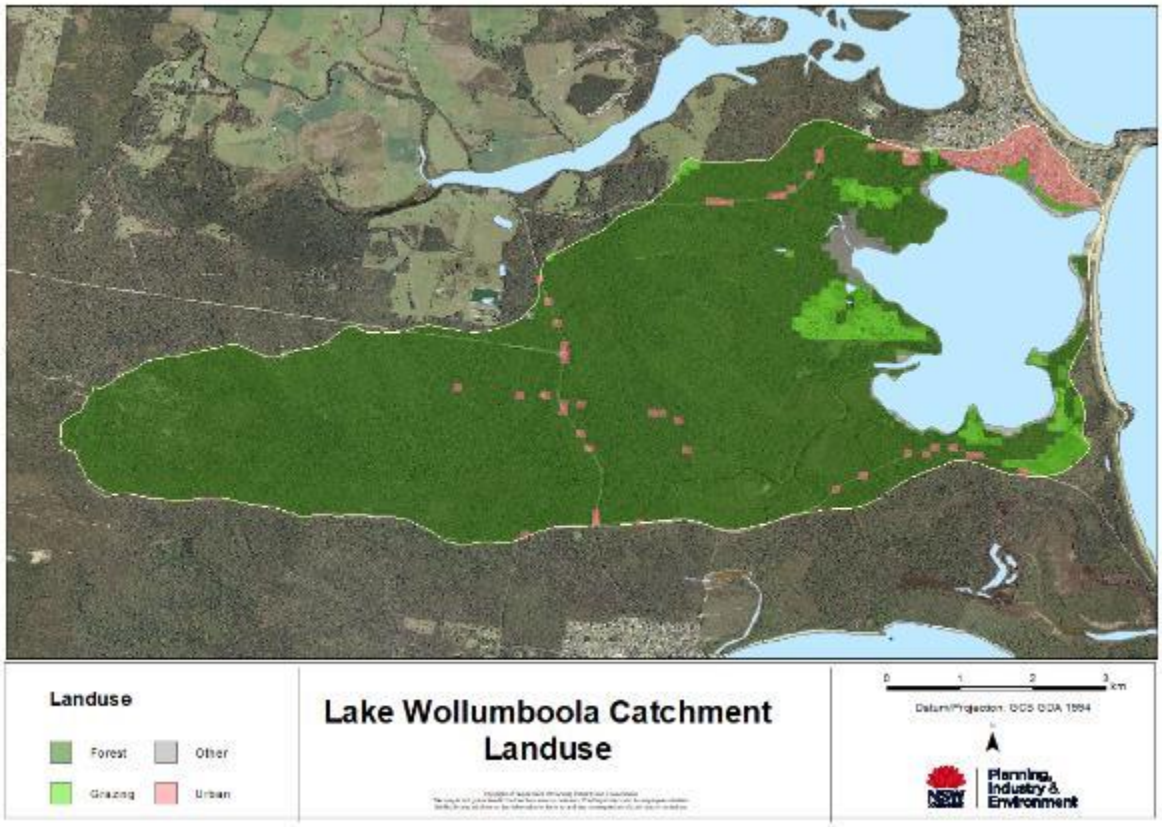
Avoiding any landuse intensification, particularly in the high risk areas, is also critical to maintaining estuary health at Wollumboola.



Map 8-a: Lake Wollumboola Catchment Landuse (2007)

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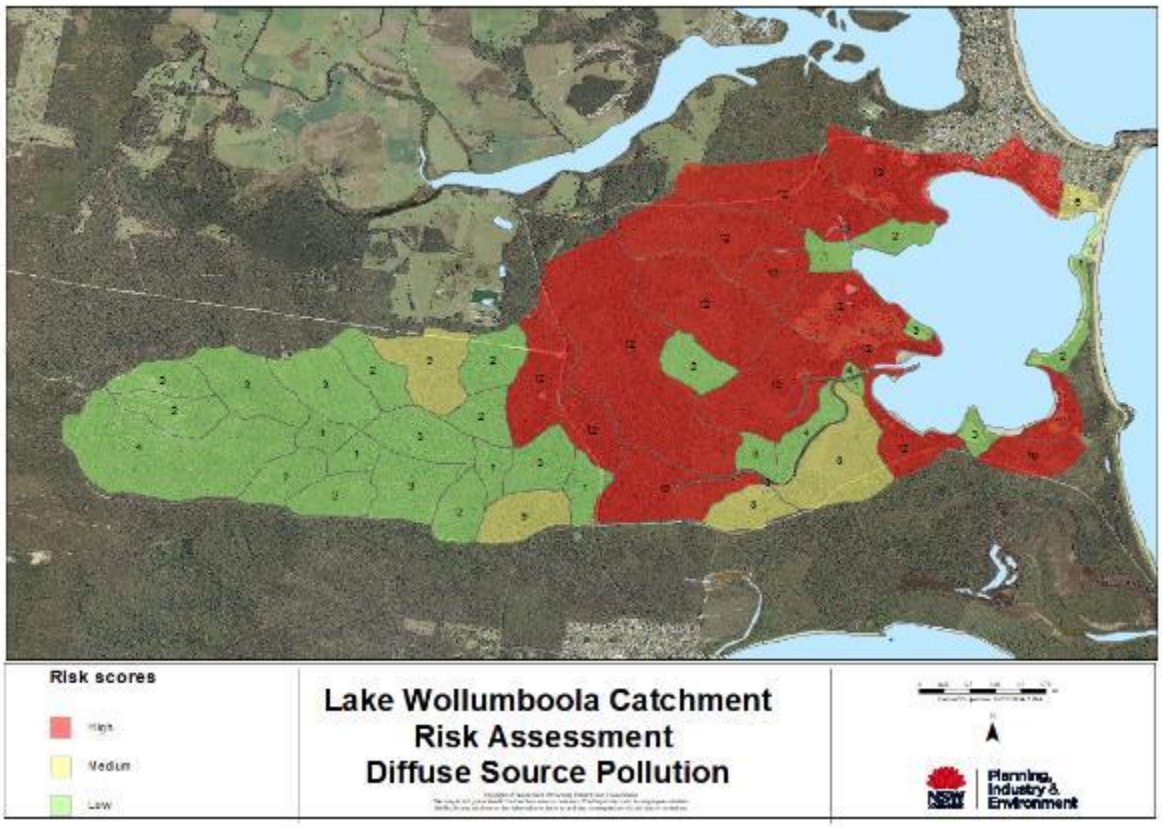

Map 8-b: Lake Wollumboola Catchment Diffuse Source Pollution Risk Assessment

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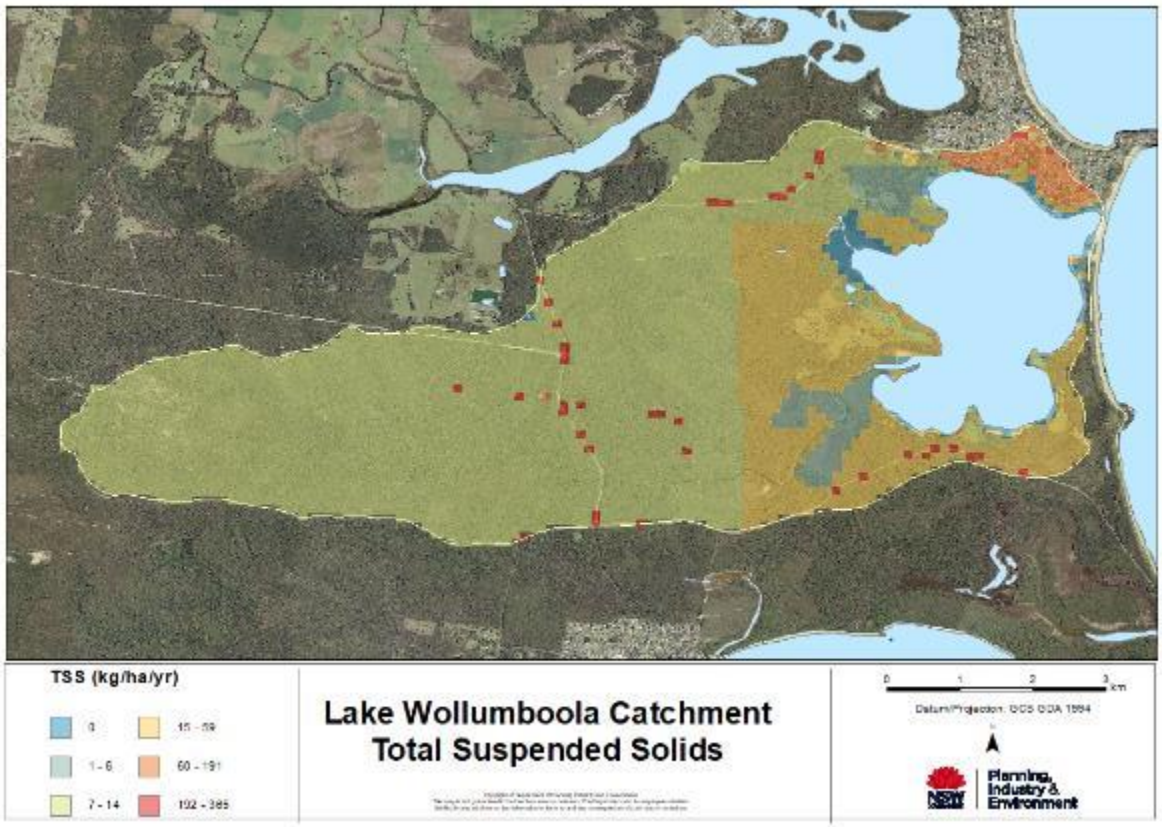

Map 8-c: Lake Wollumboola Catchment Total Suspended Solids

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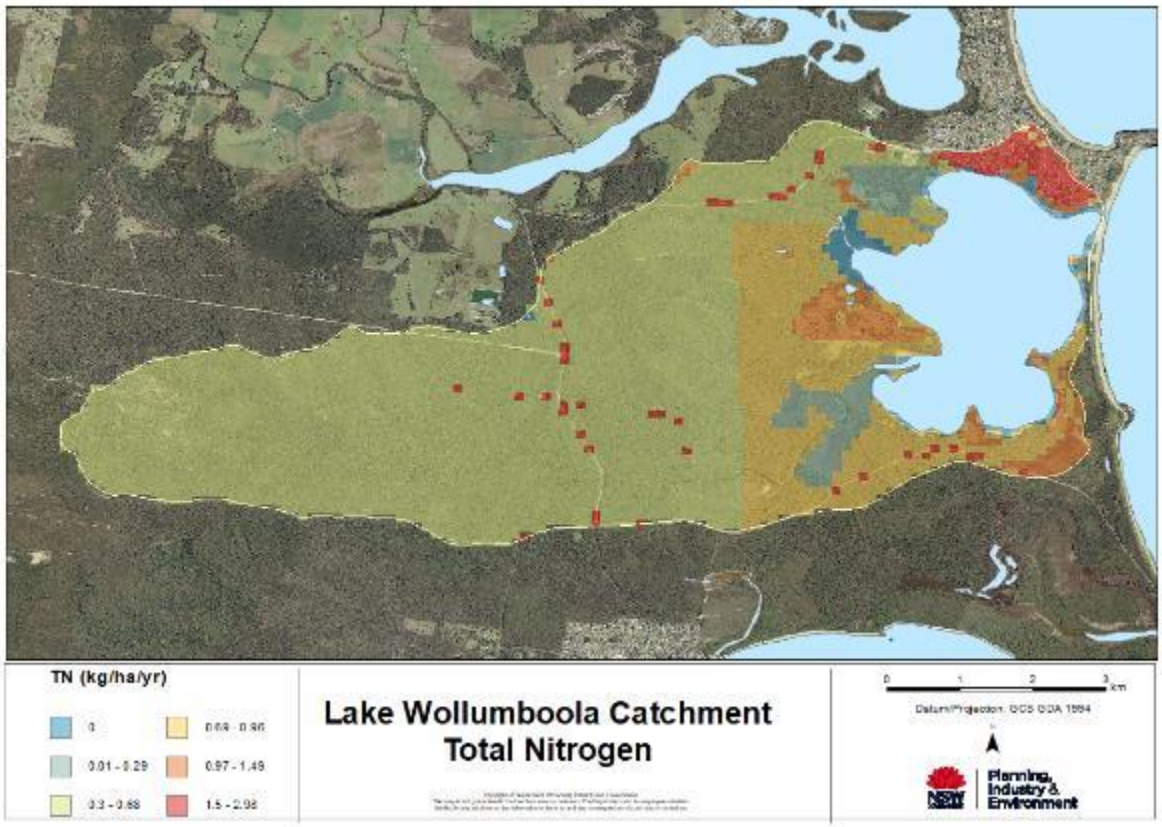

Map 8-d: Lake Wollumboola Catchment Total Nitrogen

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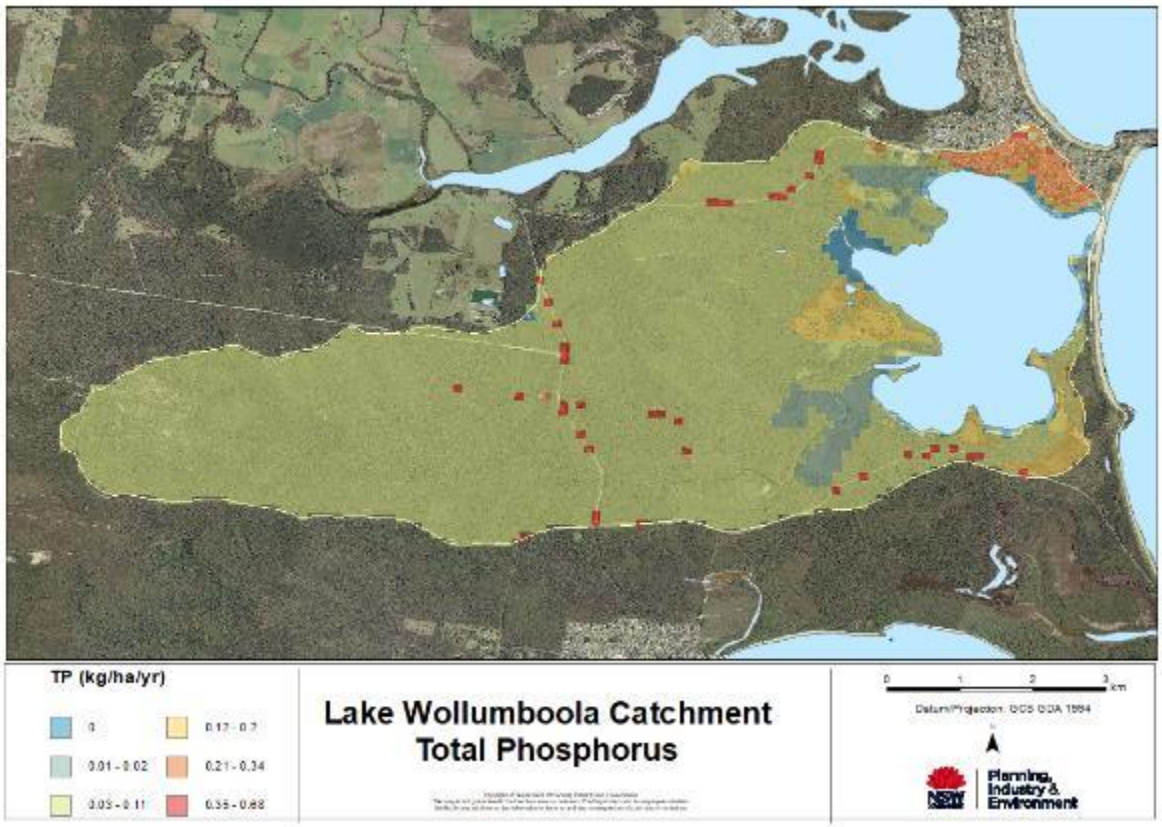

Map 8-e: Lake Wollumboola Catchment Total Phosphorus

4.5. Currambene Creek

Around half of the Currambene Creek catchment is forested, with the remainder either agricultural or urban. Urban areas include Woollamia, Tomerong, Falls Creek, Nowra Hill and the Nowra Airport (Map 9a).

The highest risk sub-catchments identified are generally those in the steeper upper slopes or in the cleared and more urbanised areas (Map 9b). These indicate areas where land use intensification should be avoided. These higher risk areas also correspond to the higher TP and TN diffuse source pollution export rates (Map 9c, d and e).

The priority areas for further detailed investigation of potential management actions would be the middle catchment within the urban and agricultural areas that flow into Currambene Creek, particularly around Woollamia and Falls Creek. Minimising diffuse source pollution from these areas entering waterways should be prioritised.

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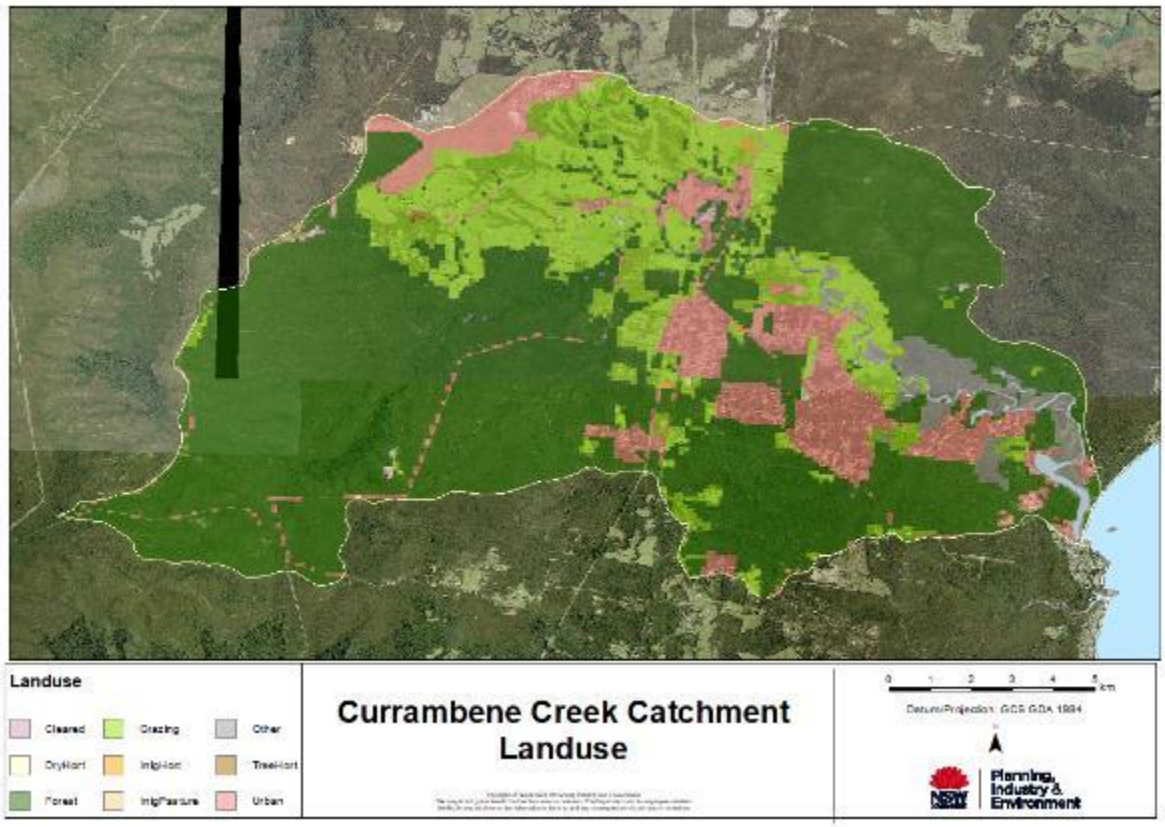

Map 9-a: Currambene Creek Catchment Landuse (2007)

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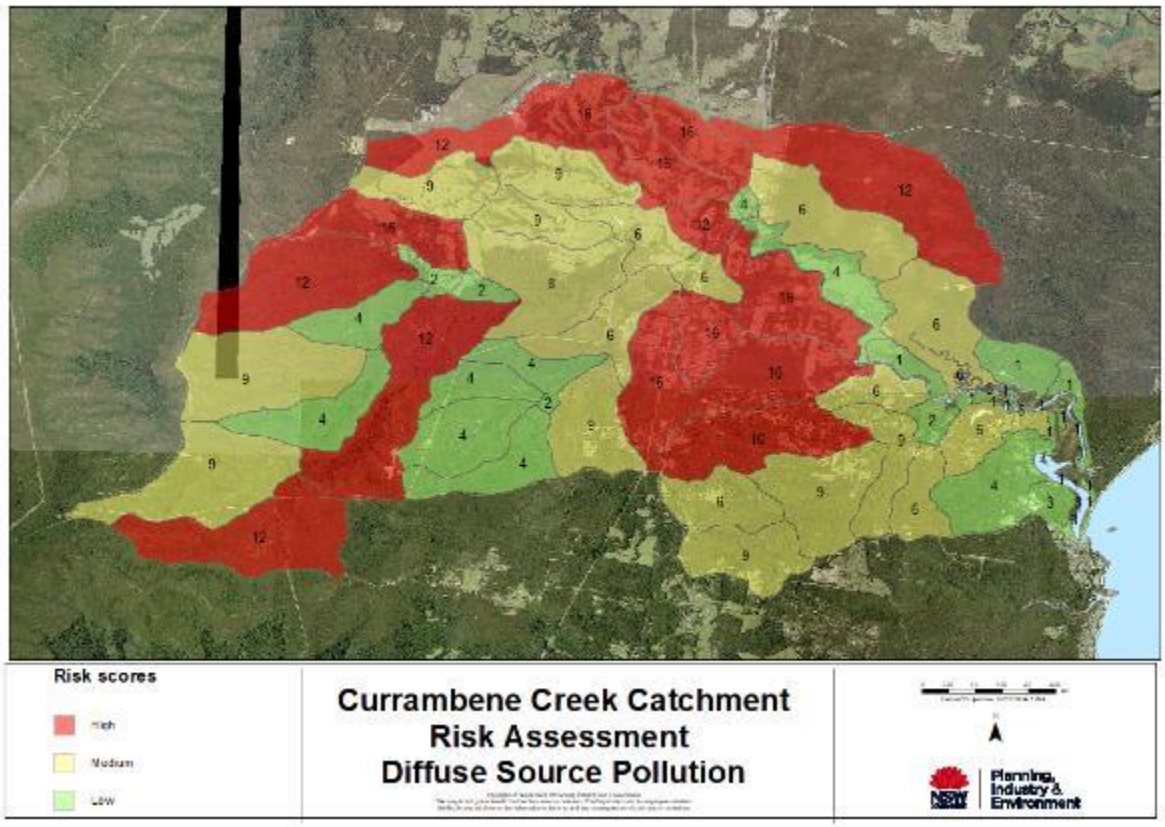

Map 9-b: Currambene Creek Catchment Diffuse Source Pollution Risk Assessment

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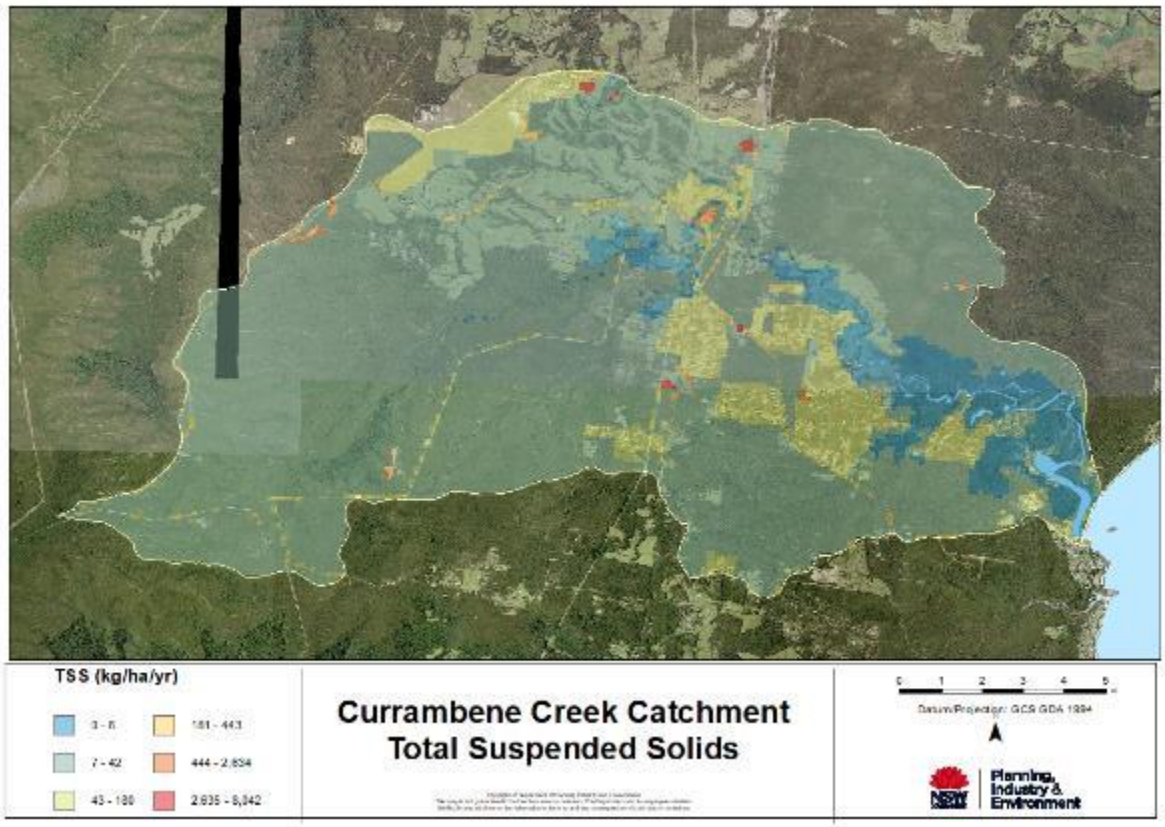

Map 9-c: Currambene Creek Catchment Total Suspended Solids

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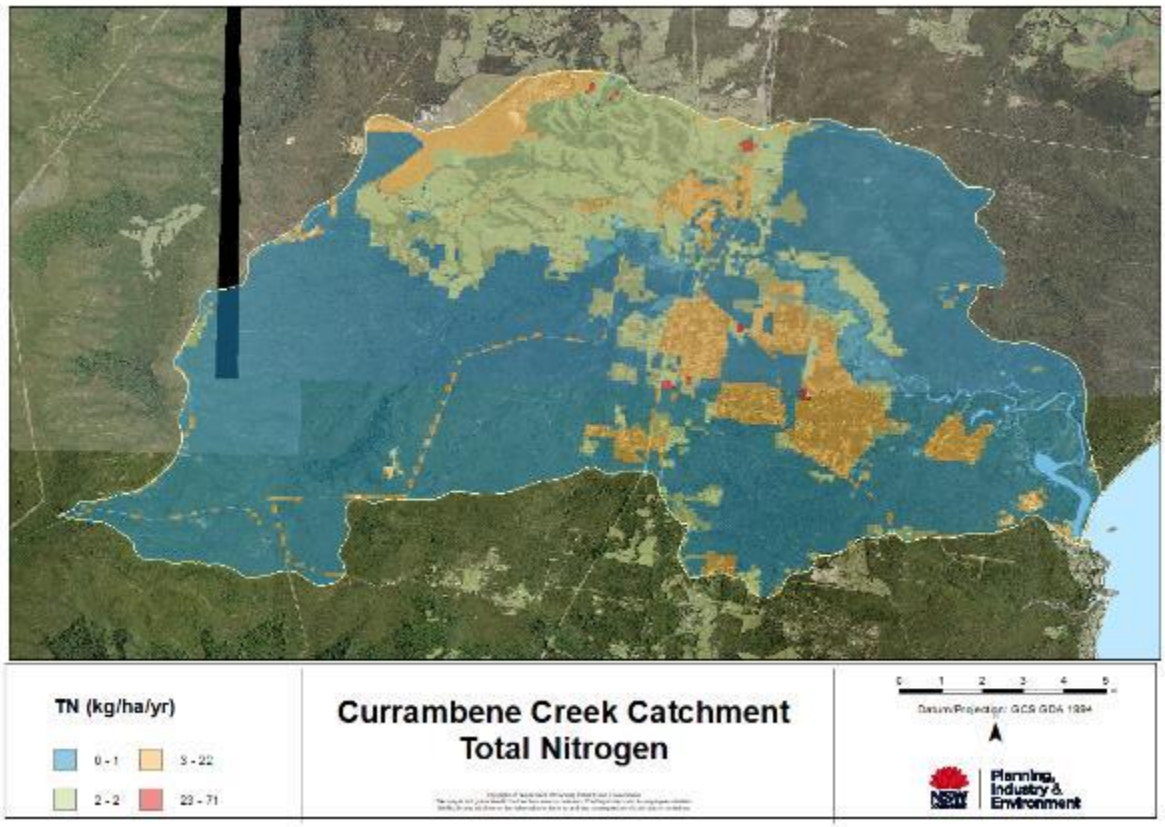

Map 9-d: Currambene Creek Catchment Total Nitrogen

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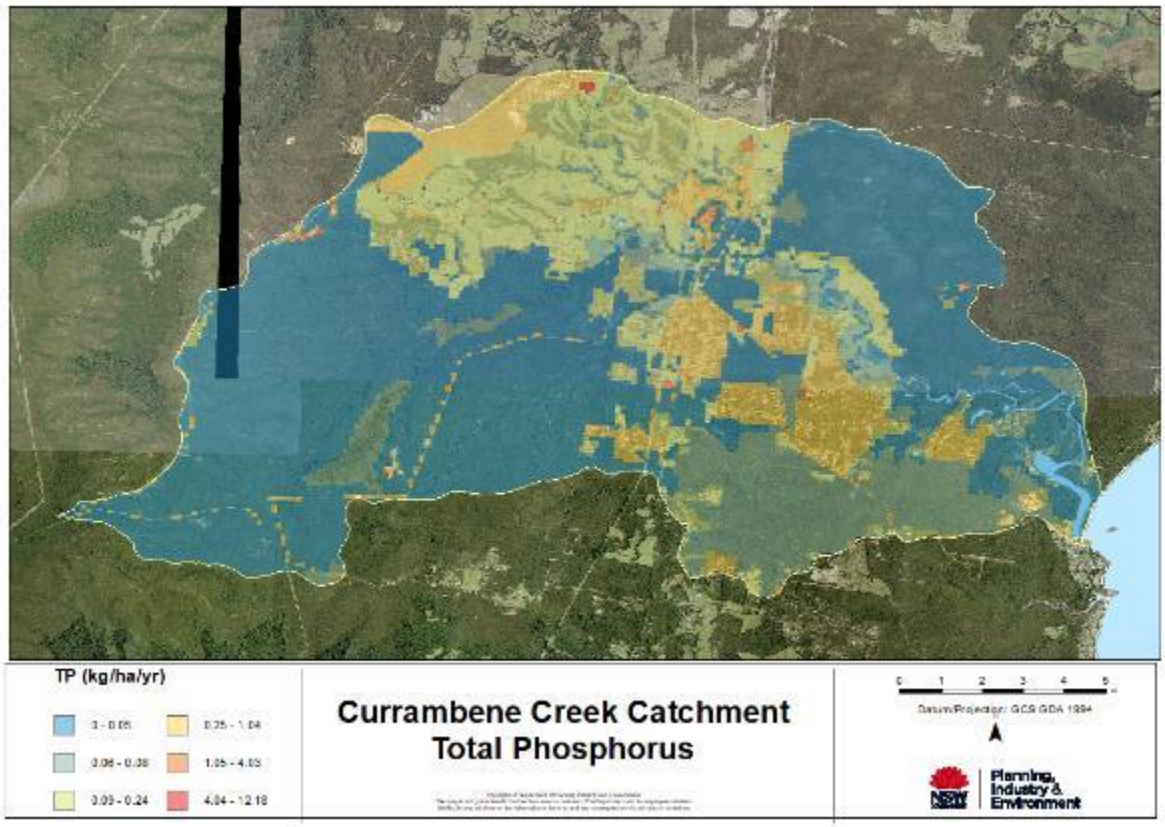

Map 9-e: Currambene Creek Catchment Total Phosphorus

4.6. Moona Moona Creek

The majority of the Moona Moona Creek catchment is forested with the remainder agricultural or urban. Urban areas include the townships of Huskisson, parts of Vincentia and some rural residential areas within the upper part of the catchment (Map 10a). Some urban areas off Naval College Road in the south of the catchment have been built since 2007. As such the risk of this area may have been underestimated in the modelling and may need to be reviewed in future CMP stages.

The highest risk sub-catchments identified are generally those that include the urban and rural residential development (Map 10b). These indicate areas in the upper catchment where land use intensification should be avoided. These higher risk areas also correspond to the higher TP and TN diffuse source pollution export rates (Map 10 d and e). Export rates within Moona Moona Creek catchment were moderate compared with other Shoalhaven catchments.

The priority areas for further detailed investigation of potential management actions would be the urban areas flowing into Moona Moona Creek, particularly around Huskisson and Vincentia. Minimising diffuse source pollution from these areas entering waterways should be prioritised.

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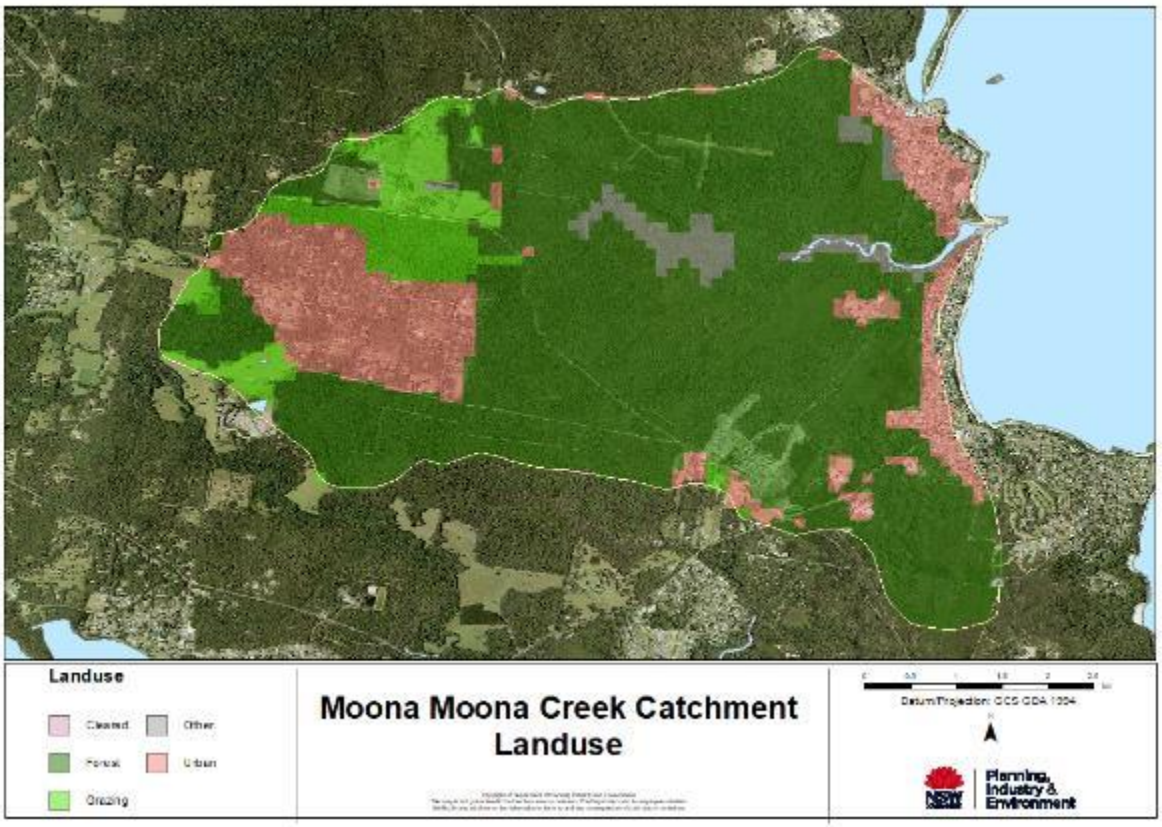

Map 10-a: Moona Creek Catchment Landuse (2007)

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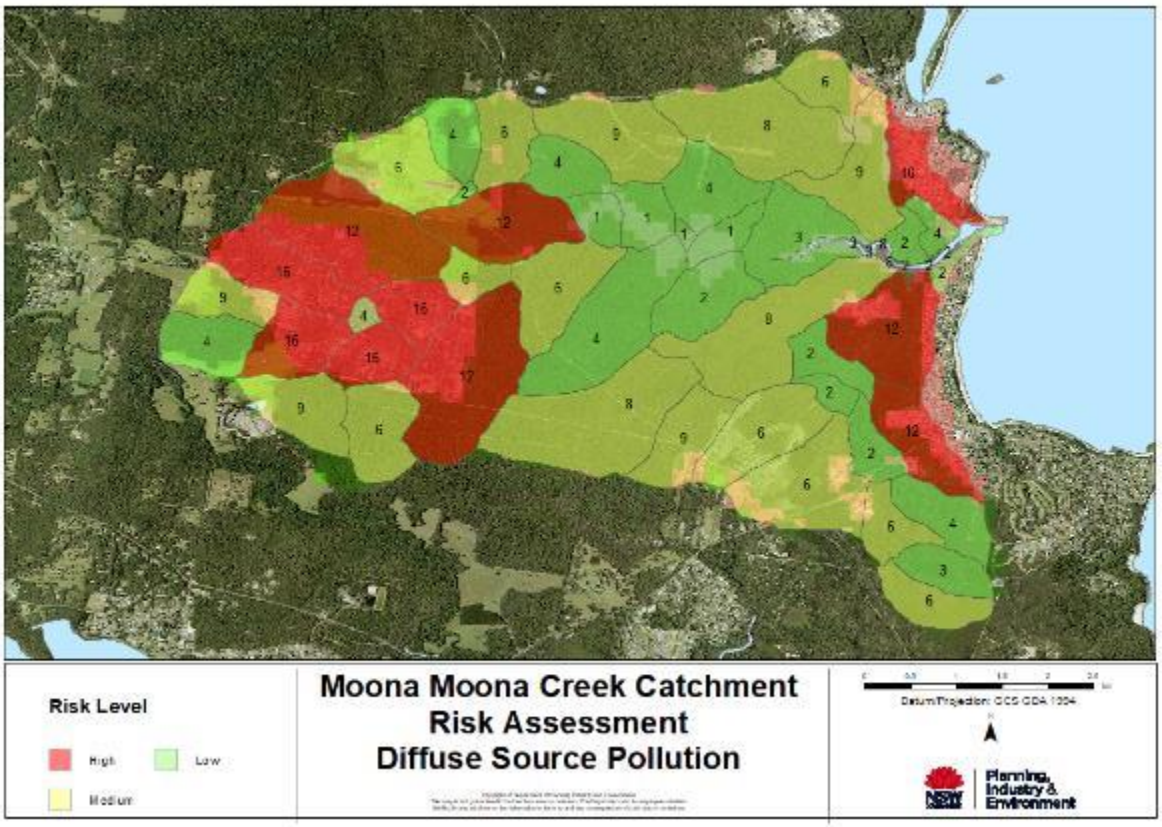

Map 10-b: Moona Creek Catchment Diffuse Source Pollution Risk Assessment

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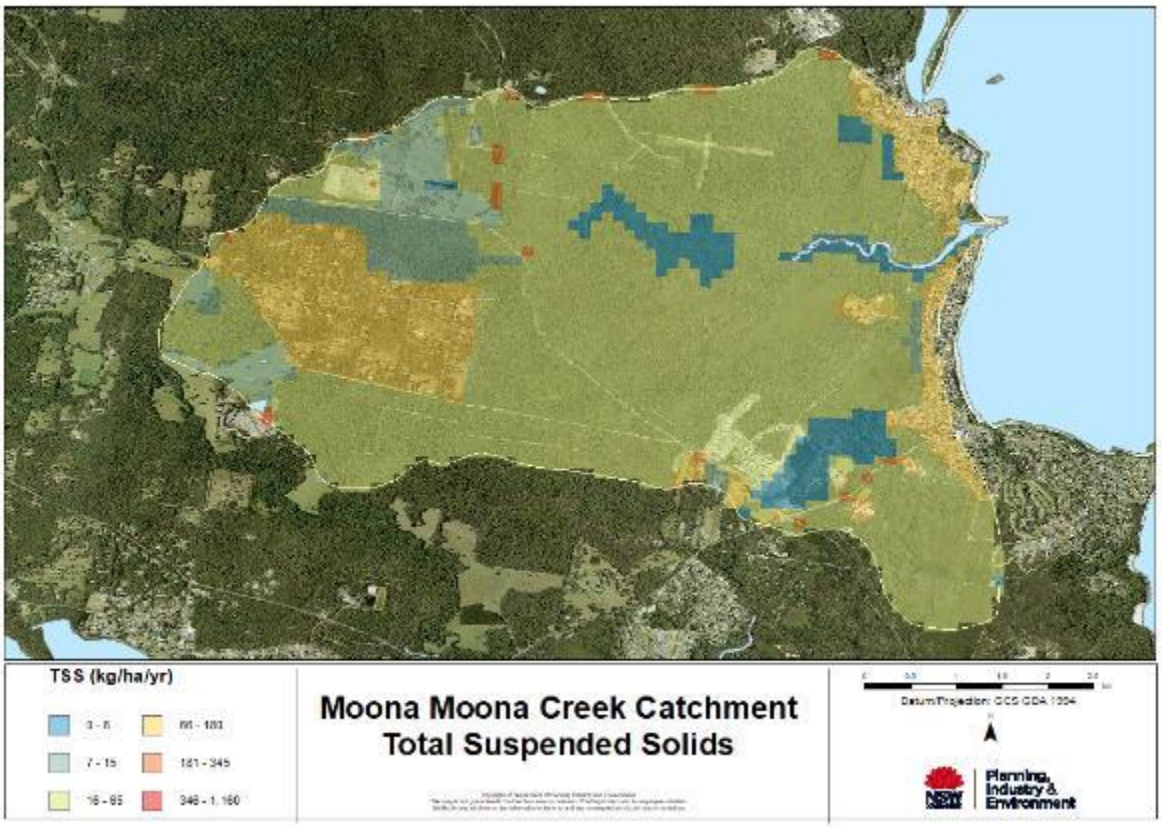

Map 10-c: Moona Creek Catchment Total Suspended Solids

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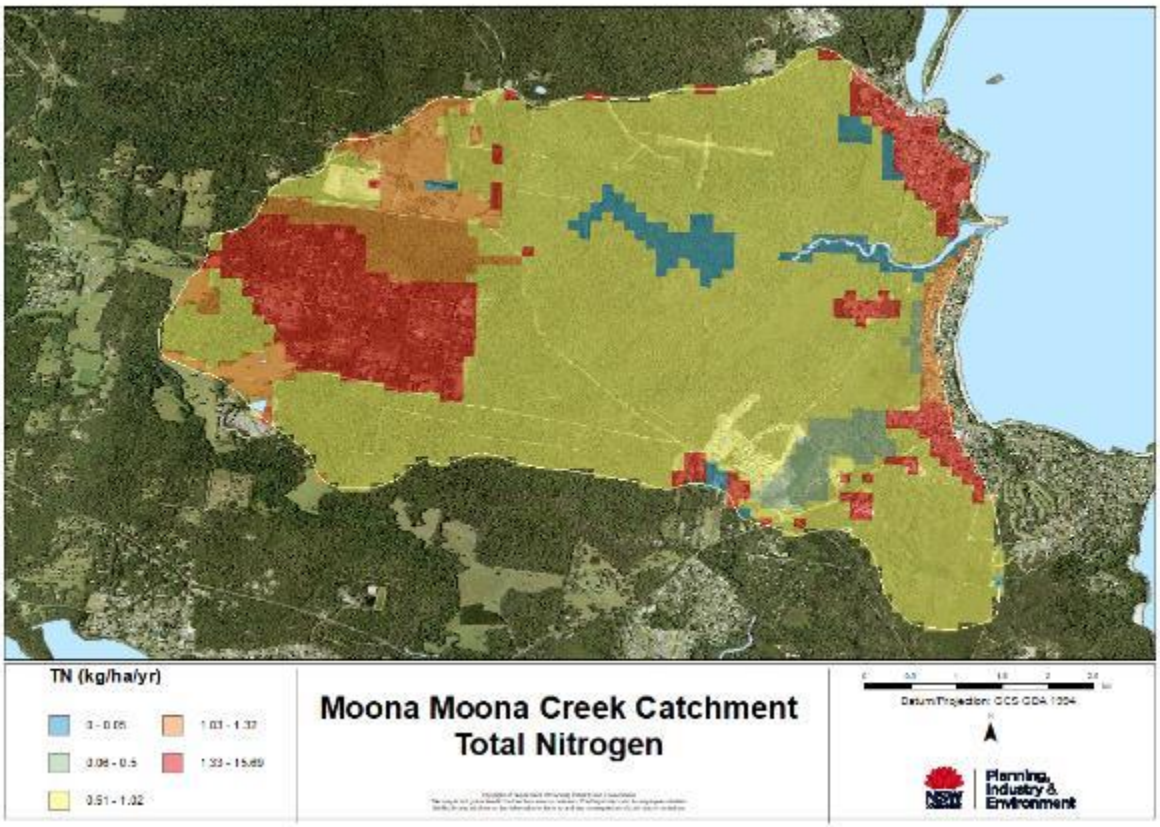

Map 10-d: Moona Creek Catchment Total Nitrogen

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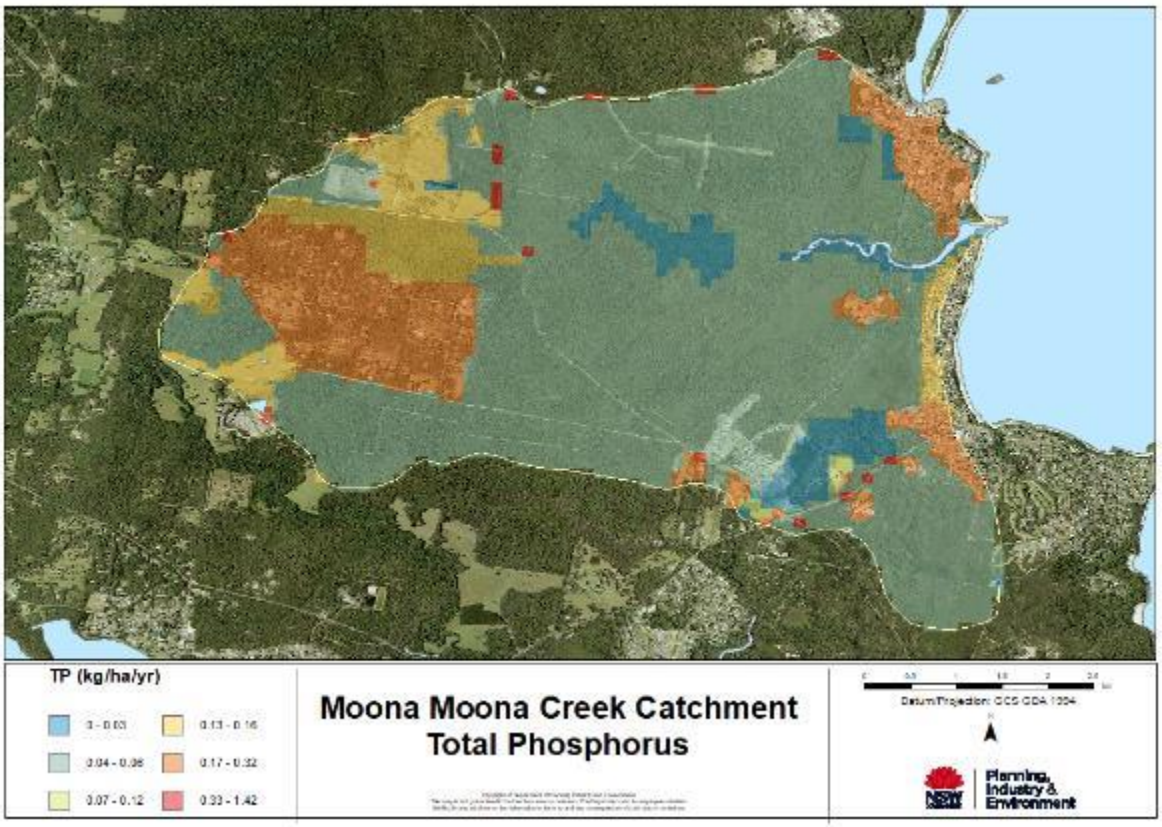

Map 10-e: Moona Creek Catchment Total Suspended Solids

4.7. Swan Lake

Most of the Swan Lake Catchment is forested, with the remainder either rural residential or urban (Map 11a). Urban areas include the villages of Cudmirrah and Swanhaven, which are located near the lake's foreshore.

The highest risk sub-catchments identified are generally those in the steeper upper slopes and in the more urbanised areas (Map 11b). These indicate areas where further landuse intensification should be avoided. These higher risk areas also correspond to the higher TP and TN diffuse source pollution export rates (Map 11c, d and e).

The priority areas for further detailed investigation of potential management actions to prevent pollution runoff would be within the urban areas of Swan Lake and Swanhaven close to the estuary foreshore. Minimising diffuse source pollution from these areas entering waterways should be prioritised.

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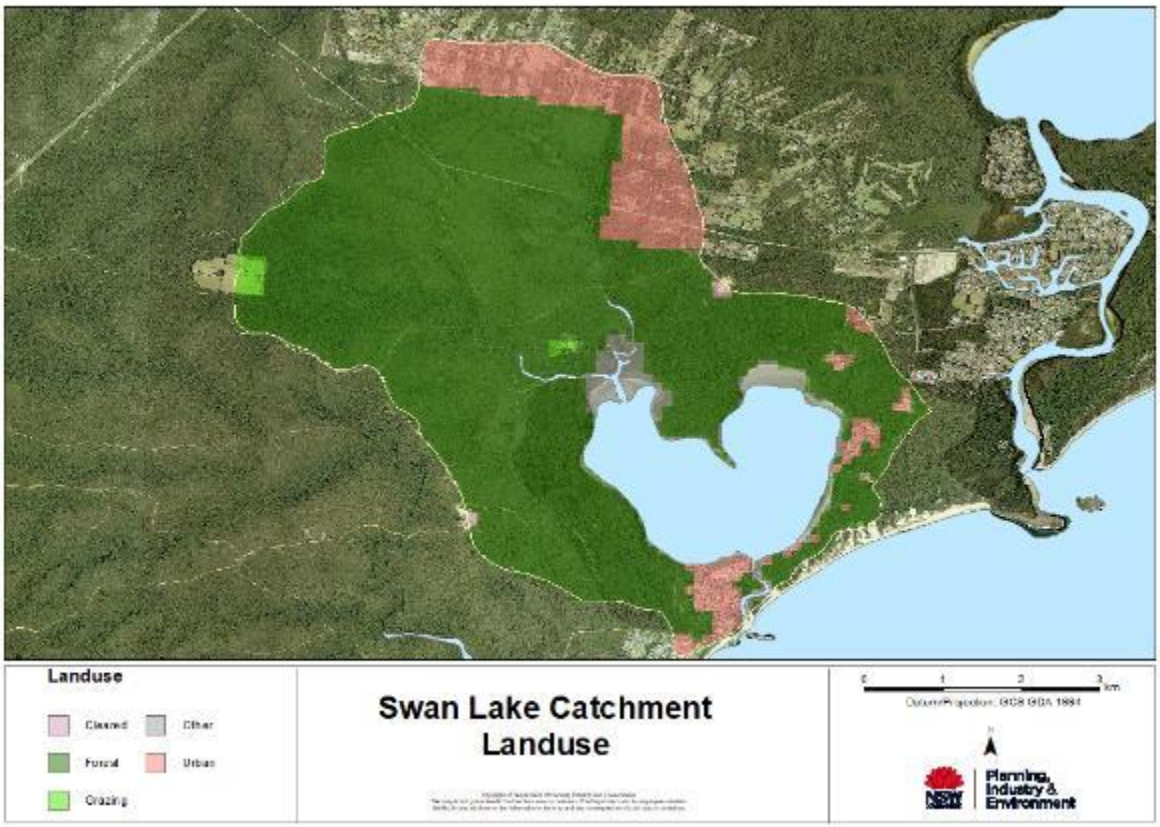

Map 11-a: Swan Lake Catchment Landuse (2007)

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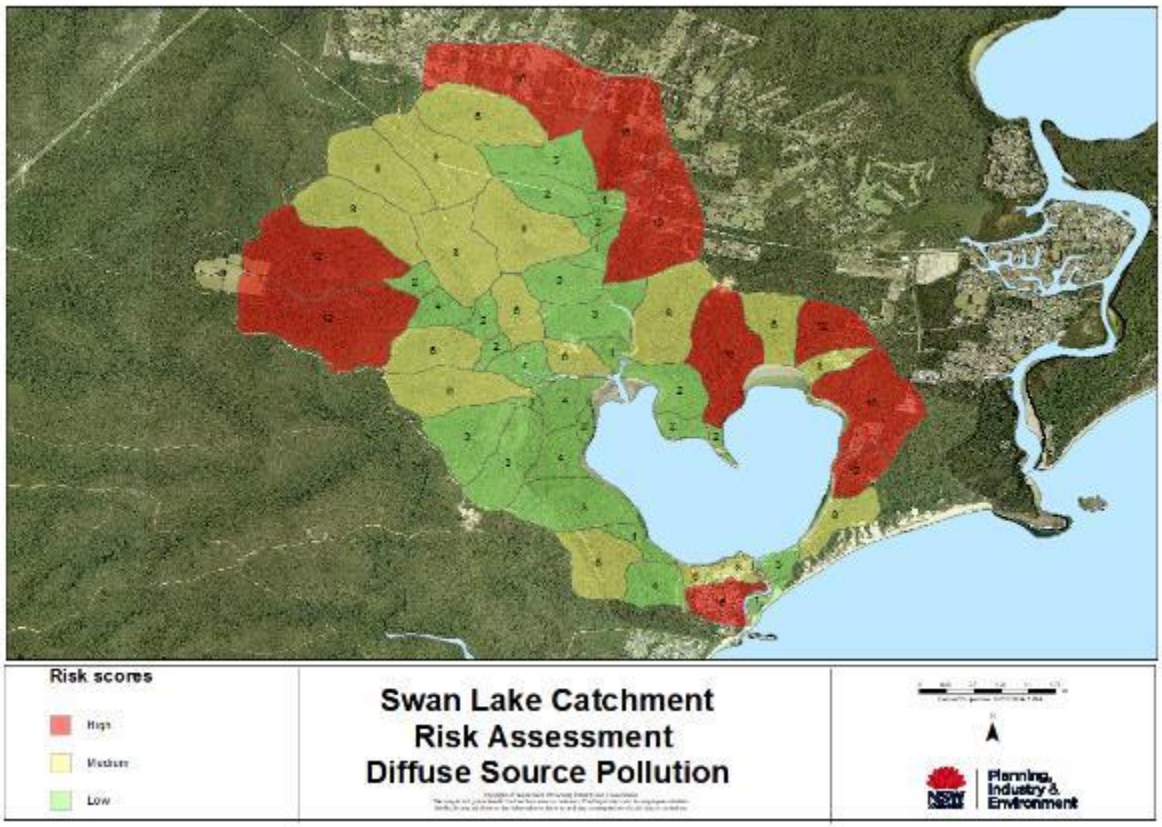

Map 11b: Swan Lake Catchment Diffuse Source Pollution

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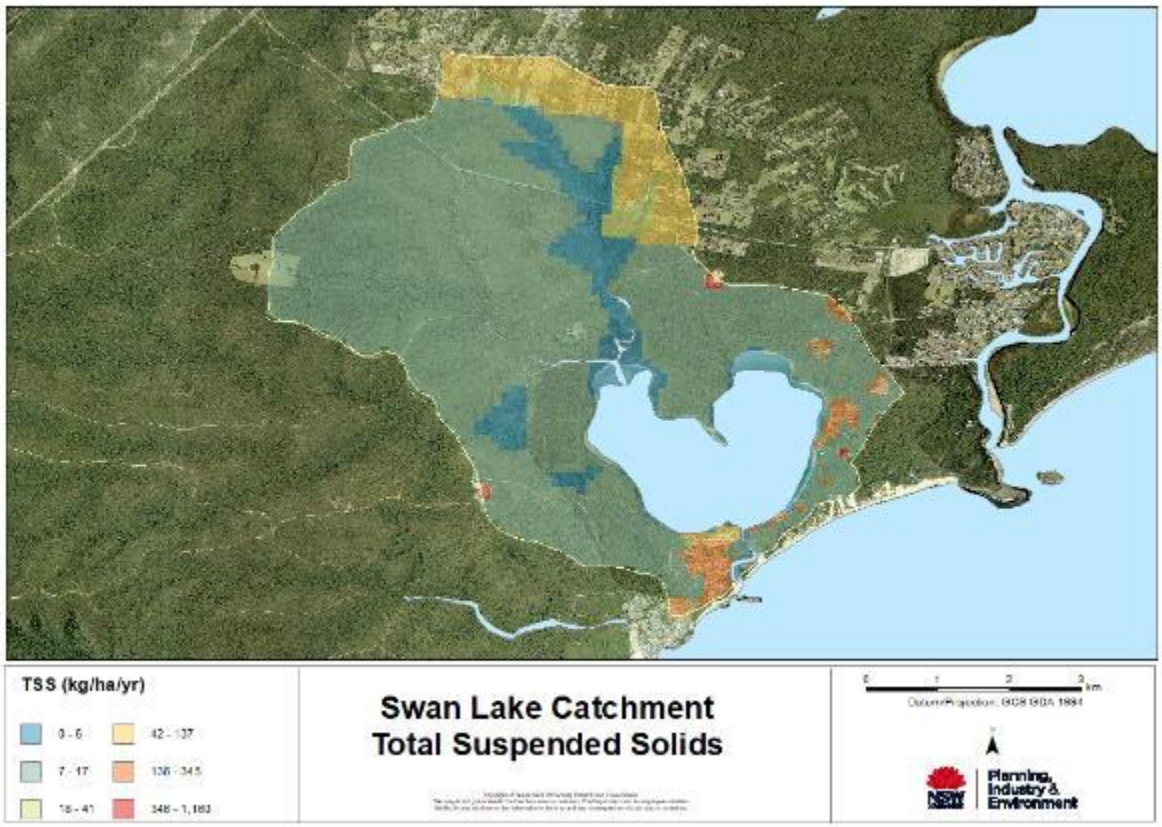

Map 11-c: Swan Lake Catchment Total Suspended Solids

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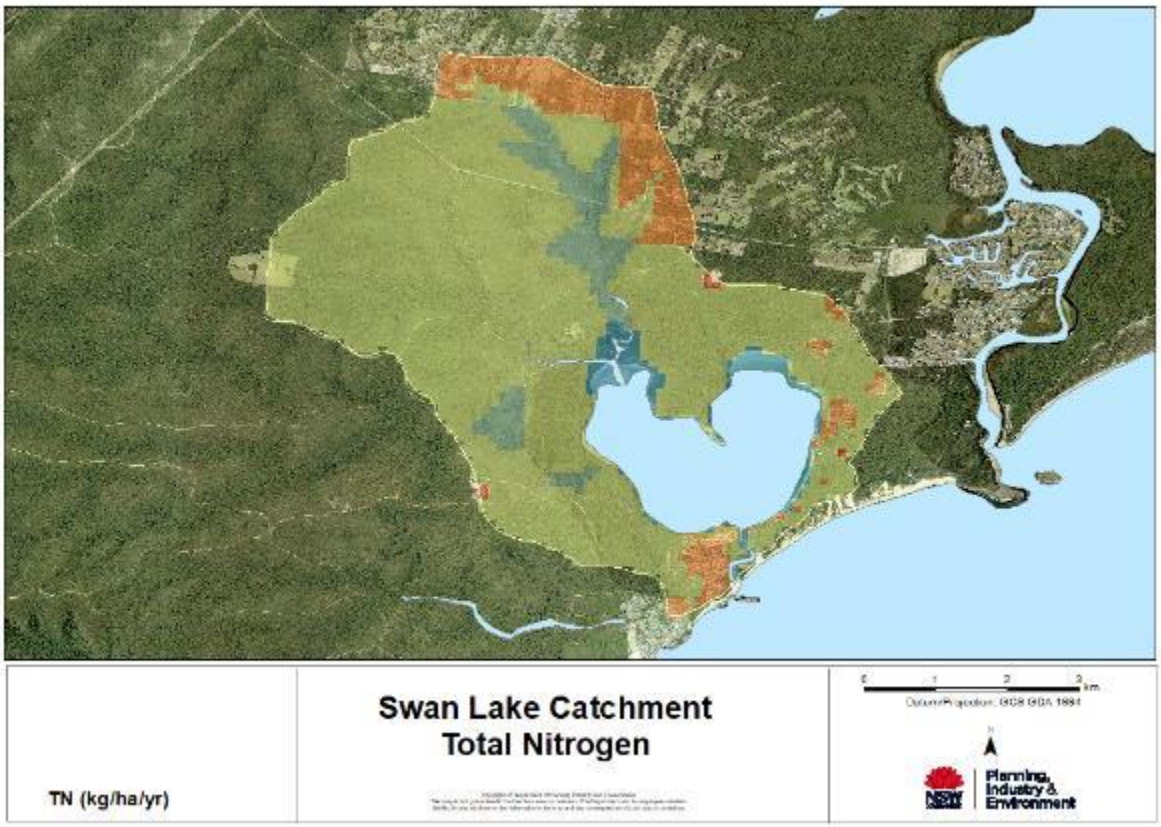

Map 11-d: Swan Lake Catchment Diffuse Source Pollution

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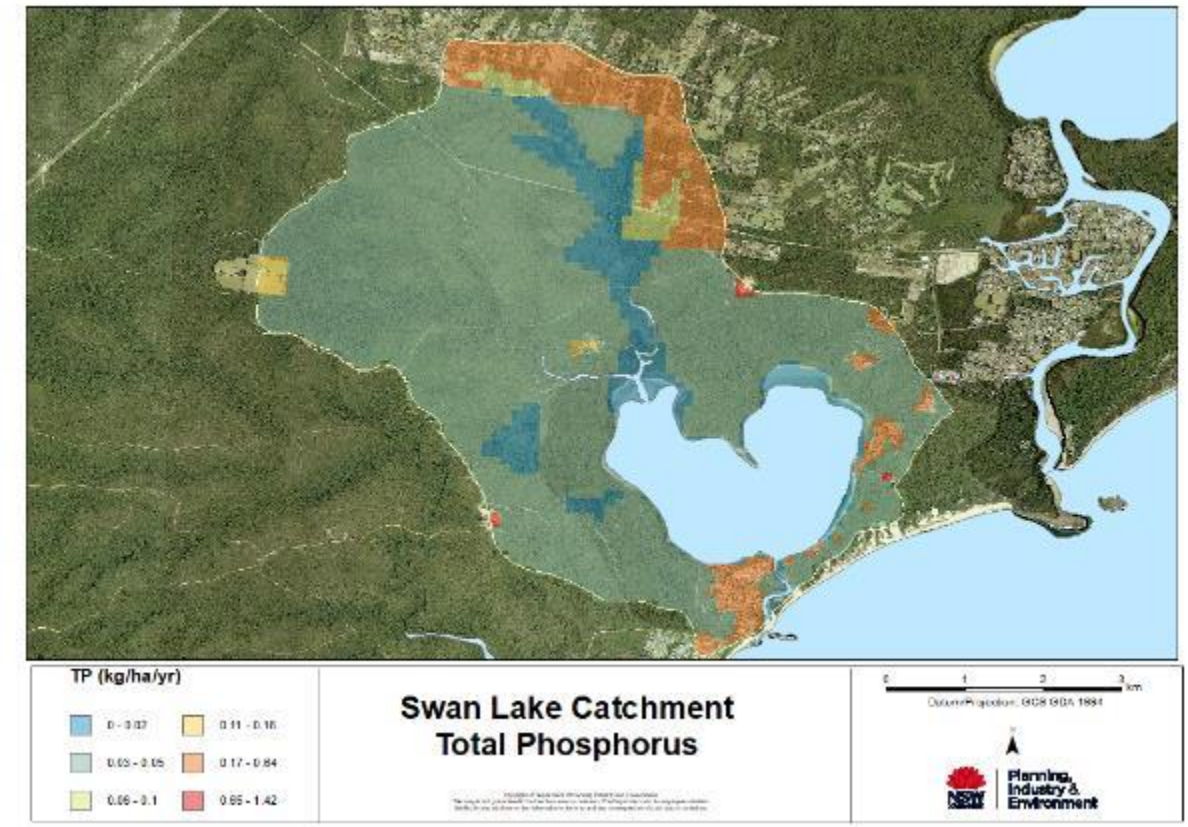

Map 11-e: Swan Lake Catchment Diffuse Source Pollution

4.8. Currarong Creek

The mapping used within the risk assessment identified that the majority of the Currarong Creek catchment is urban (Map 12a). However, as can be seen in the aerial photograph this is incorrect. Much of the area identified as being urban is in fact part of the Currarong Flora Park. The risk assessment results are therefore not likely to be a true representation of the actual risk and nutrient and TSS export rates are likely to have been overestimated (Map 12b, c, d and e).

The majority of the catchment is forested with the urban area of Currarong surrounding the estuary foreshore (Map 11a). It would be anticipated that the highest risk and therefore priority areas for action are likely to be within the Currarong urban areas.

It is recommended that the landuse mapping and risk assessment be updated within Stage 2 of the CMP process and ground truthing be undertaken to determine what actions are required, particularly to prevent pollution runoff from Currarong urban areas.

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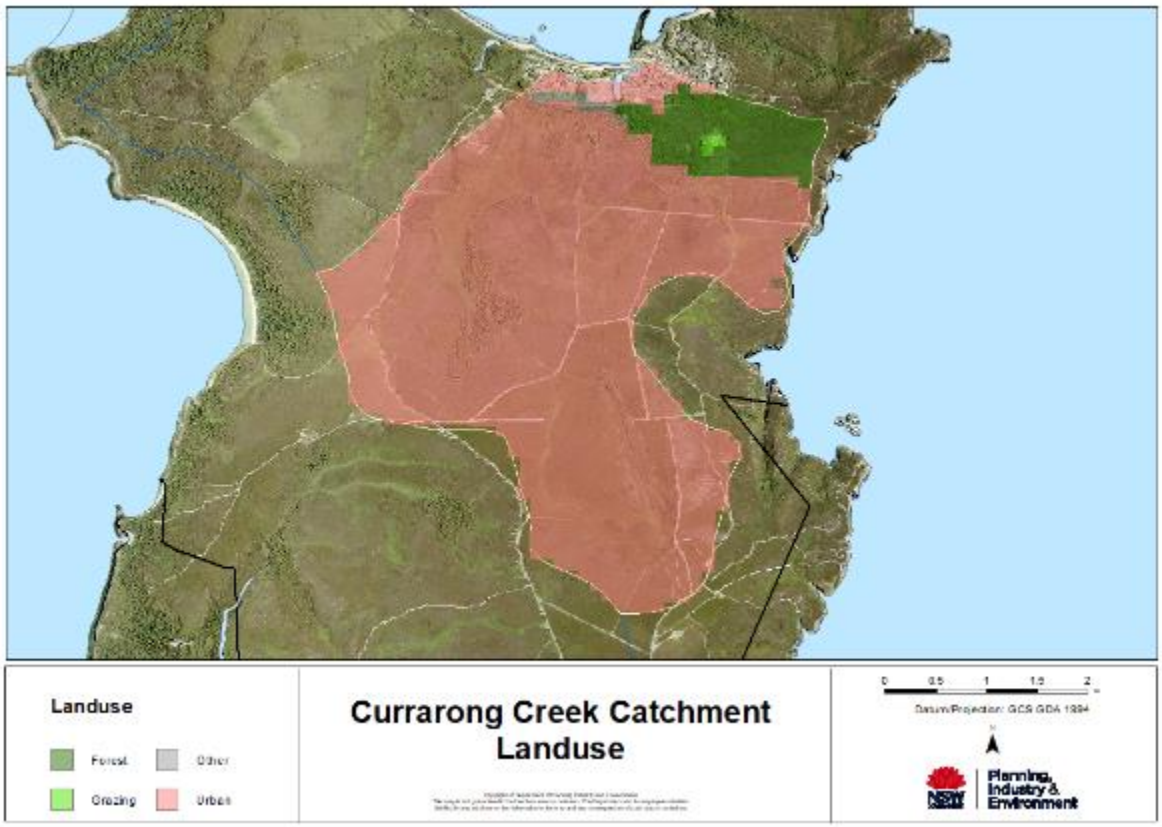

Map 12-a: Currarong Creek Landuse (2007)

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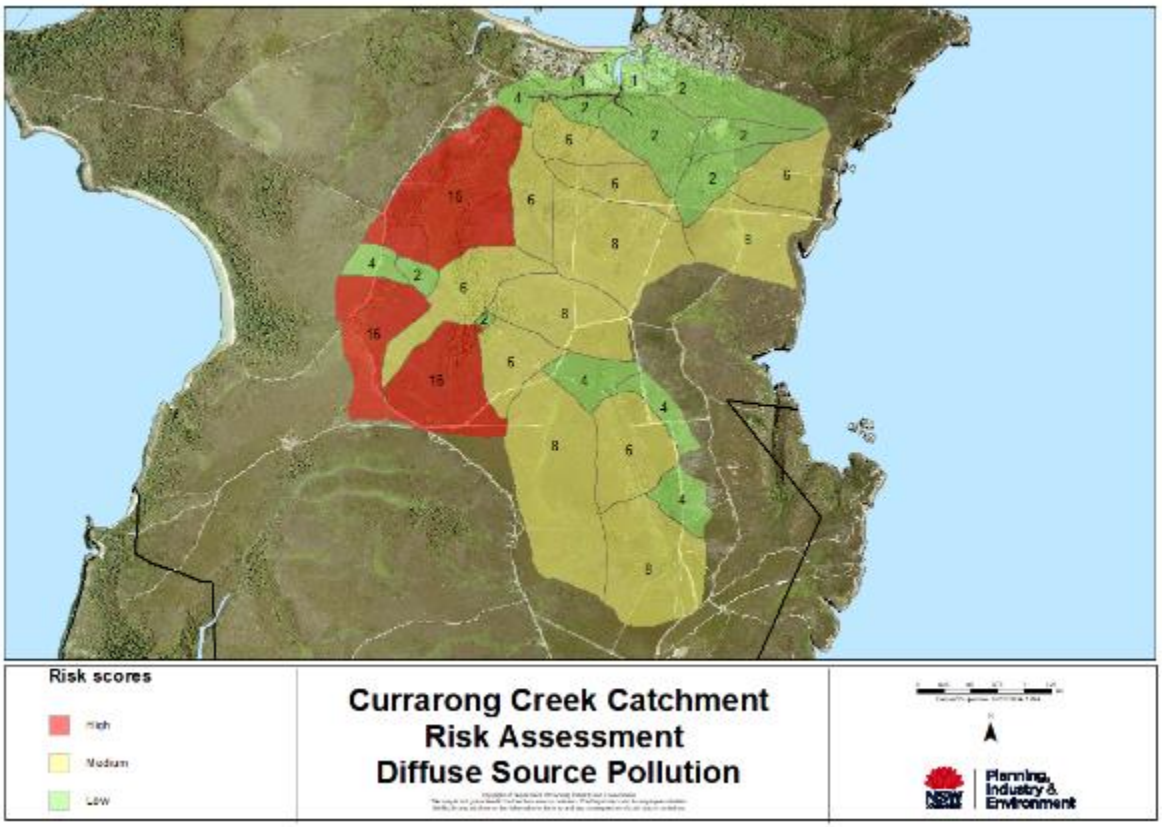

Map 12-b: Currarong Creek Catchment Diffuse Source Pollution Risk Assessment

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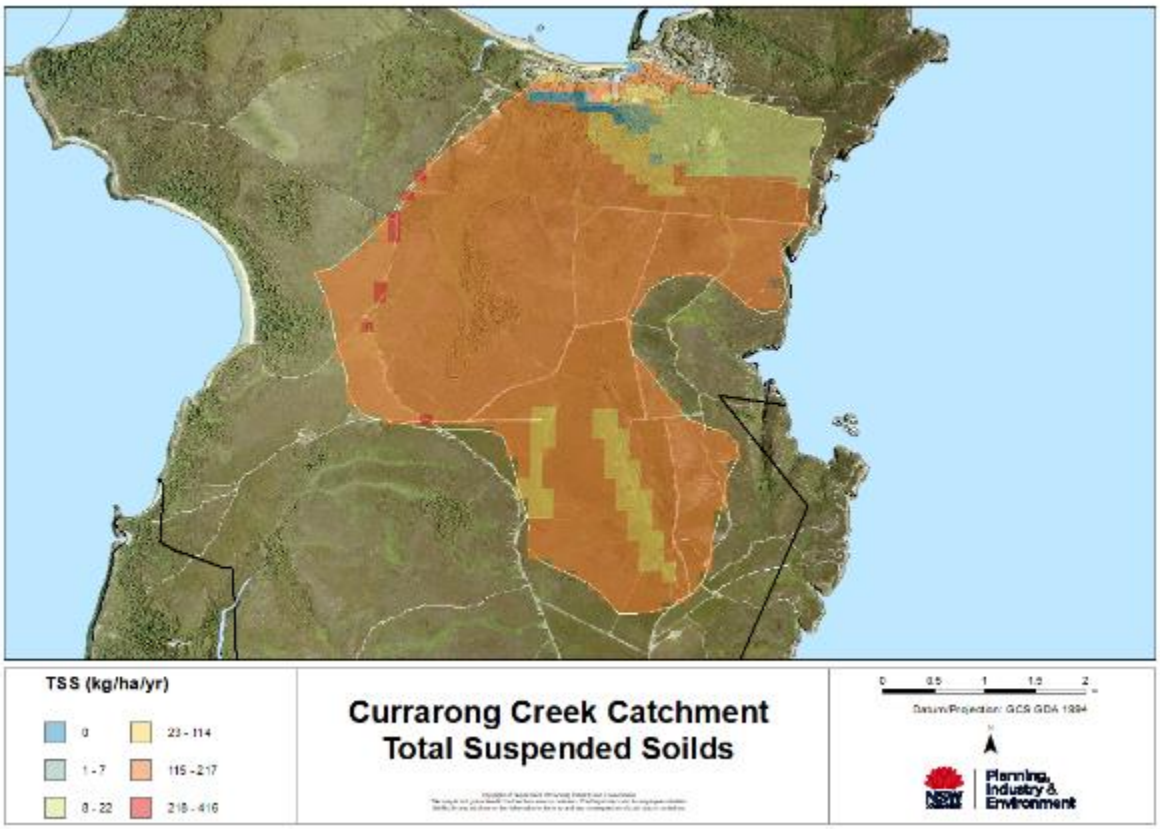

Map 12-c: Currarong Creek Catchment Total Suspended Solids

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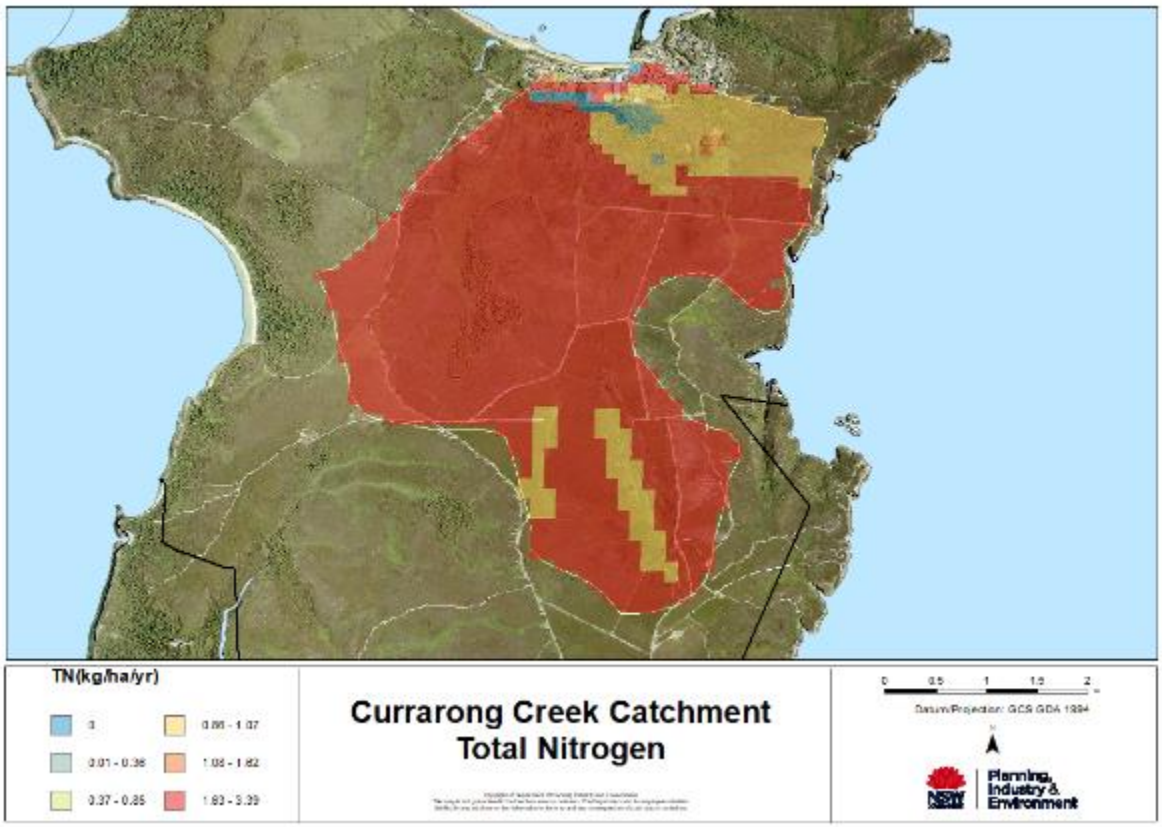

Map 12-d: Currarong Creek Catchment Total Nitrogen

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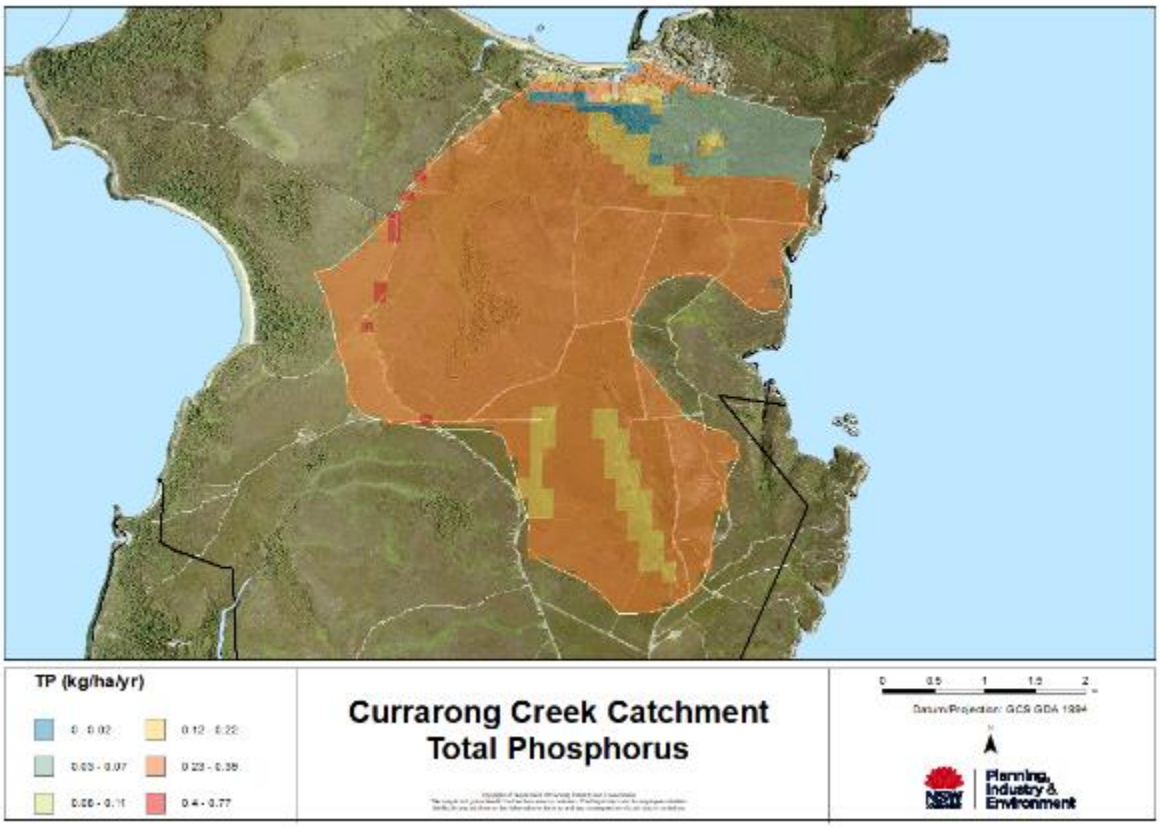

Map 12-e: Currarong Creek Catchment Total Phosphorus

4.9. Narawallee Inlet

Around half of the Narawallee Inlet catchment is forested with the remainder agricultural and urban. The urban areas include Little Forest and the very edges of the villages of Milton and Narawallee. Narawallee is located on the foreshore of the estuary, whilst Milton and Little Forest are further inland (Map 13a).

The highest risk sub-catchments identified are generally those in the steeper upper slopes and include urbanised areas (Map 13b). These indicate areas where landuse intensification should be avoided. These higher risk areas also generally correspond to the higher TP and TN diffuse source pollution export rates (Map 13c, d and e).

Further ground truthing is required to help identify priority areas for action within this catchment. It is recommended that this investigation should start near the southern side of the estuary in the lower catchment as this area has been assessed as being high risk.

Priority areas for further detailed investigation of potential management actions within the Narawallee Inlet catchment include the urban areas and where grazing landuse occurs around drainage lines and creeks. Minimising diffuse source pollution from these areas entering waterways should be prioritised.

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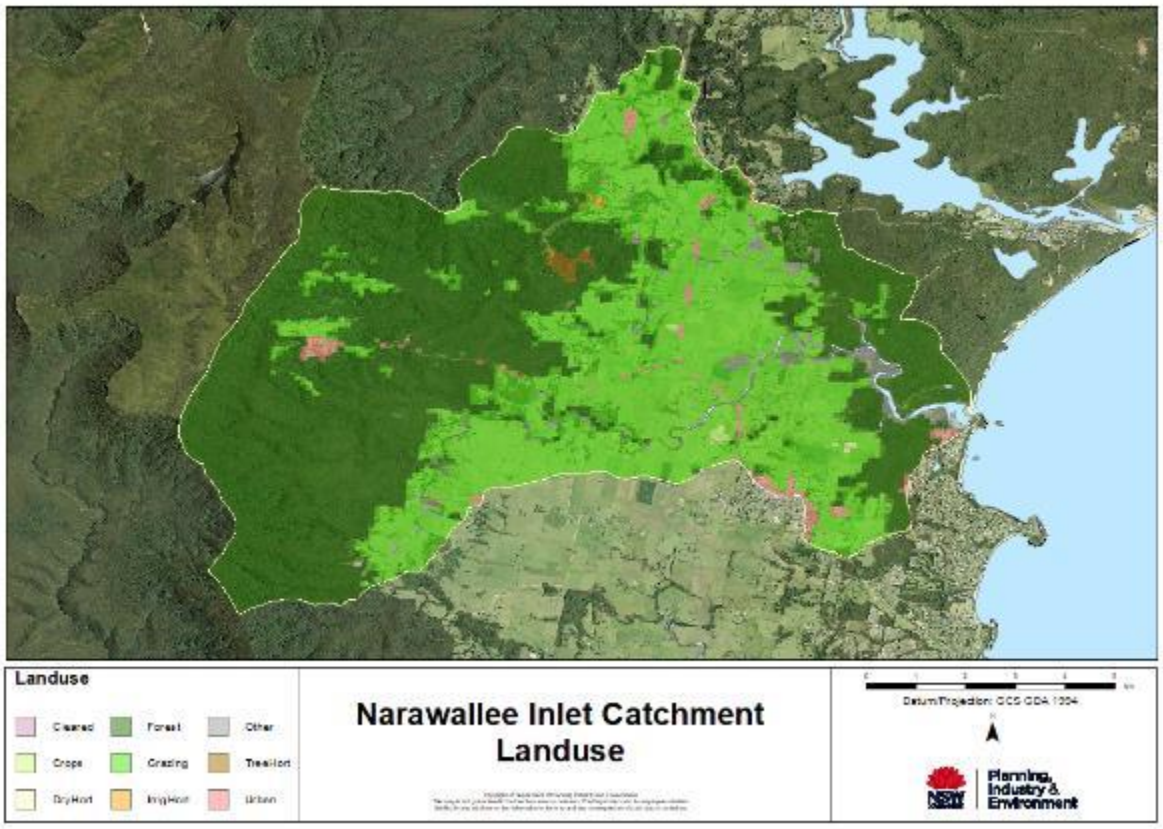

Map 13-a: Narawallee Inlet Catchment Landuse (2007)

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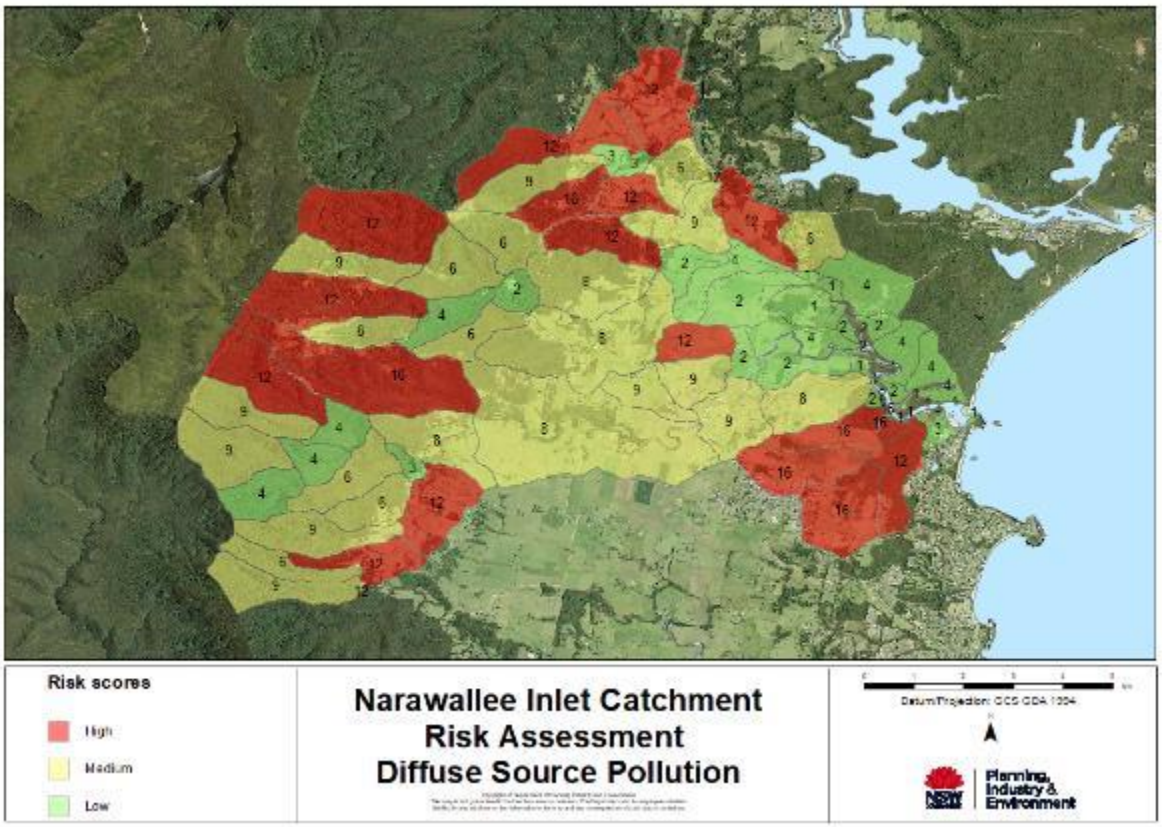

Map 13-b: Narawallee Inlet Catchment Diffuse Source Pollution Risk Assessment

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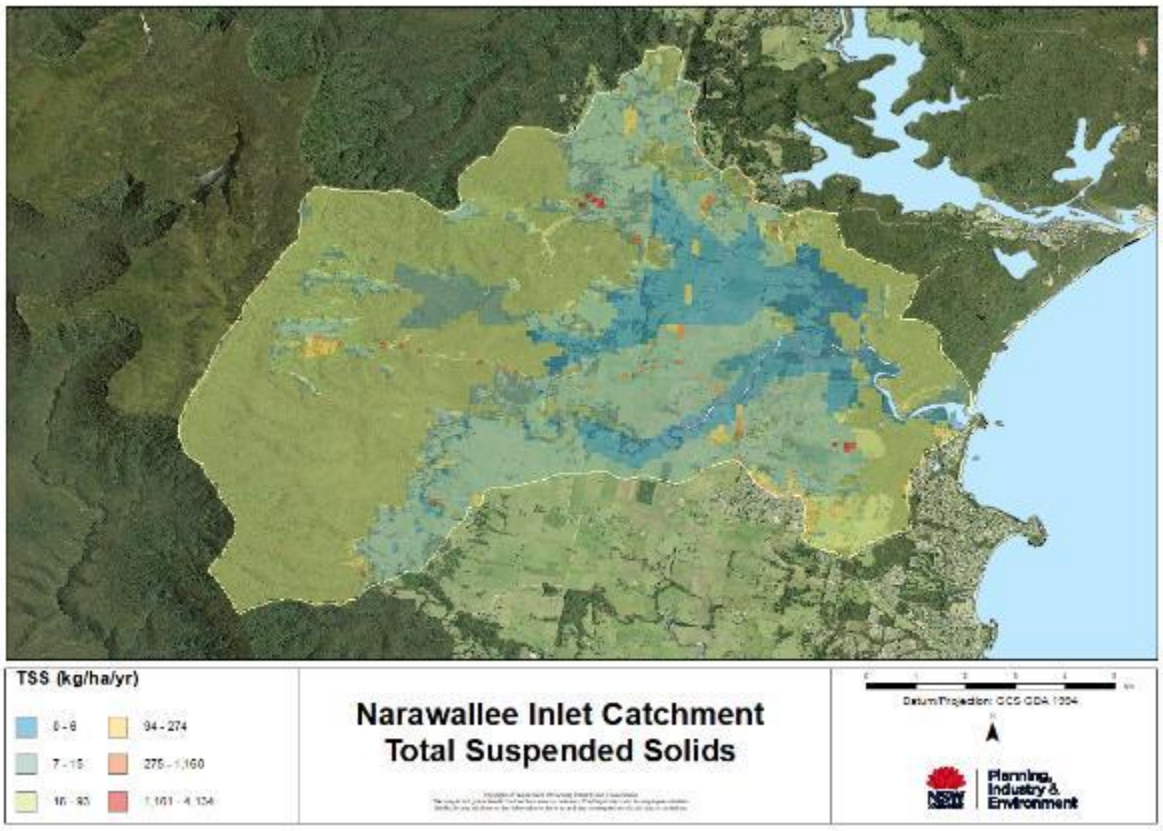

Map 13-c: Narawallee Inlet Catchment Total Suspended Solids

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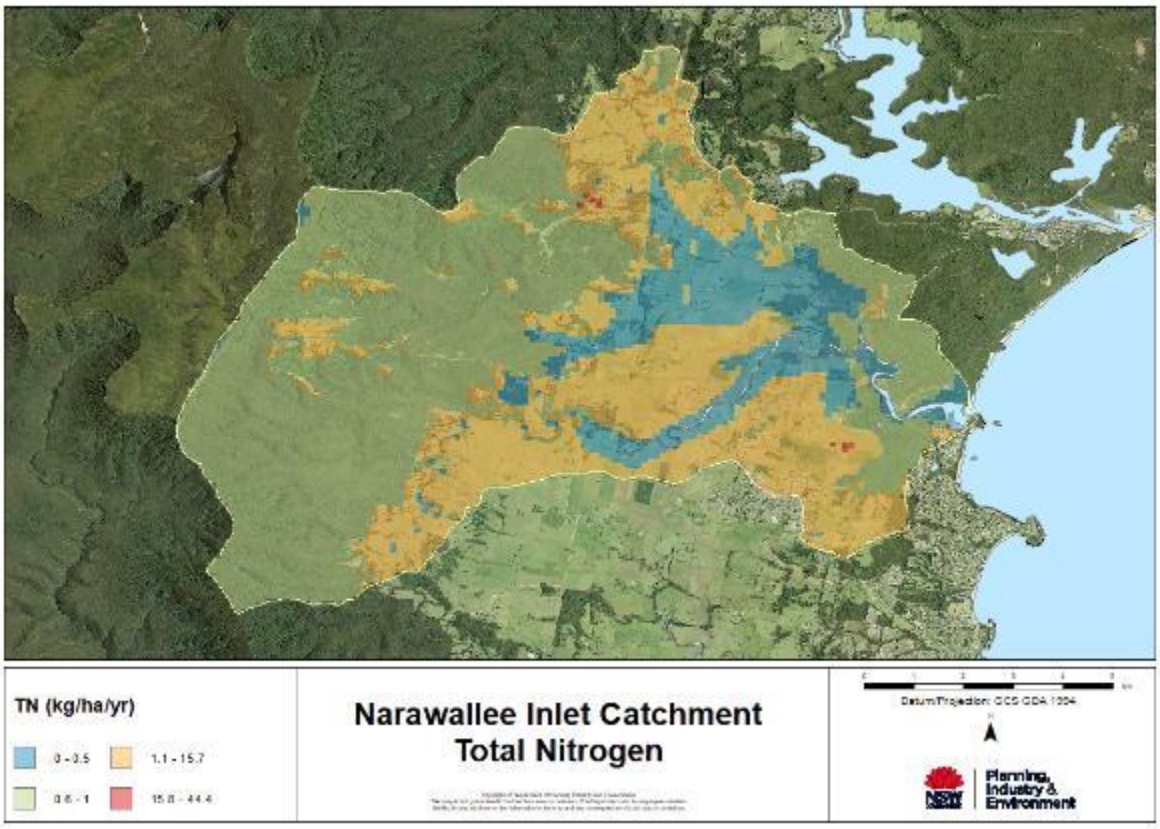

Map 13-d: Narawallee Inlet Catchment Total Nitrogen

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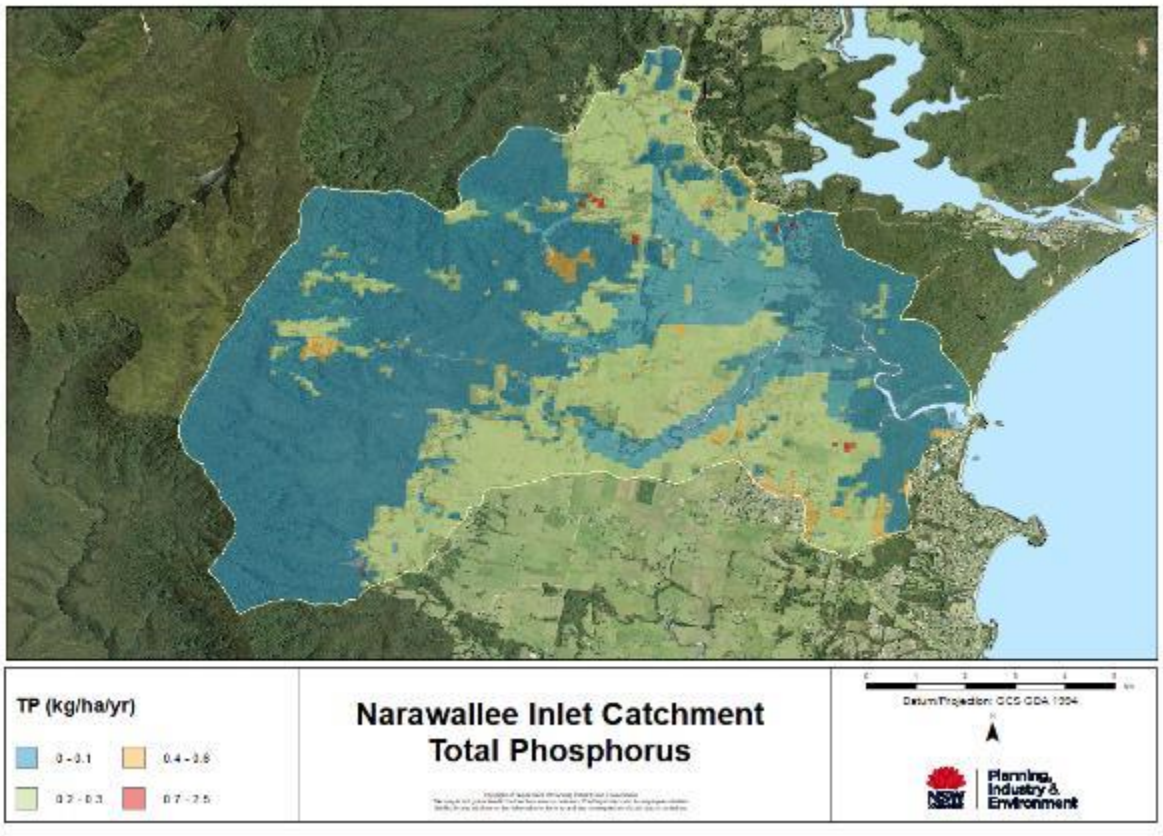

Map 13-d: Narawallee Inlet Catchment Total Phosphorus

5. Low Priority Estuaries

5.1. Berrara Creek

The Berrara Creek catchment is mostly forested and contains a very small proportion of urban development. The village of Berrara is located at the mouth of the estuary.

The highest risk sub-catchments identified are those in the steeper upper slopes as well as the urban area of Berrara in the lower catchment. Other sub-catchments surrounding the estuary foreshore are largely undisturbed and have a low risk of pollutants (Map 14a).

Priority CMP actions within this catchment are likely to be those that reduce pollution runoff from Berrara village into the estuary and protect the area from future development runoff.

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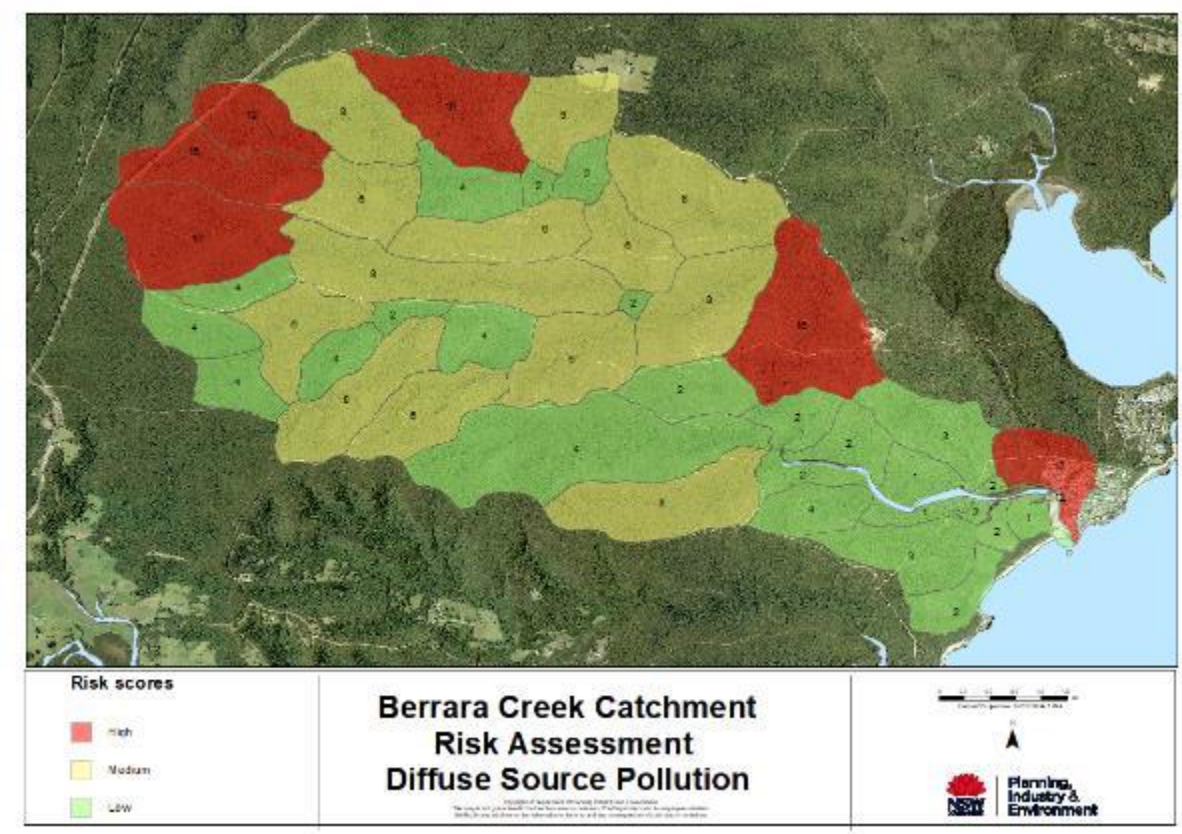

Map 14-a: Berrara Creek Catchment Diffuse Source Pollution Risk Assessment

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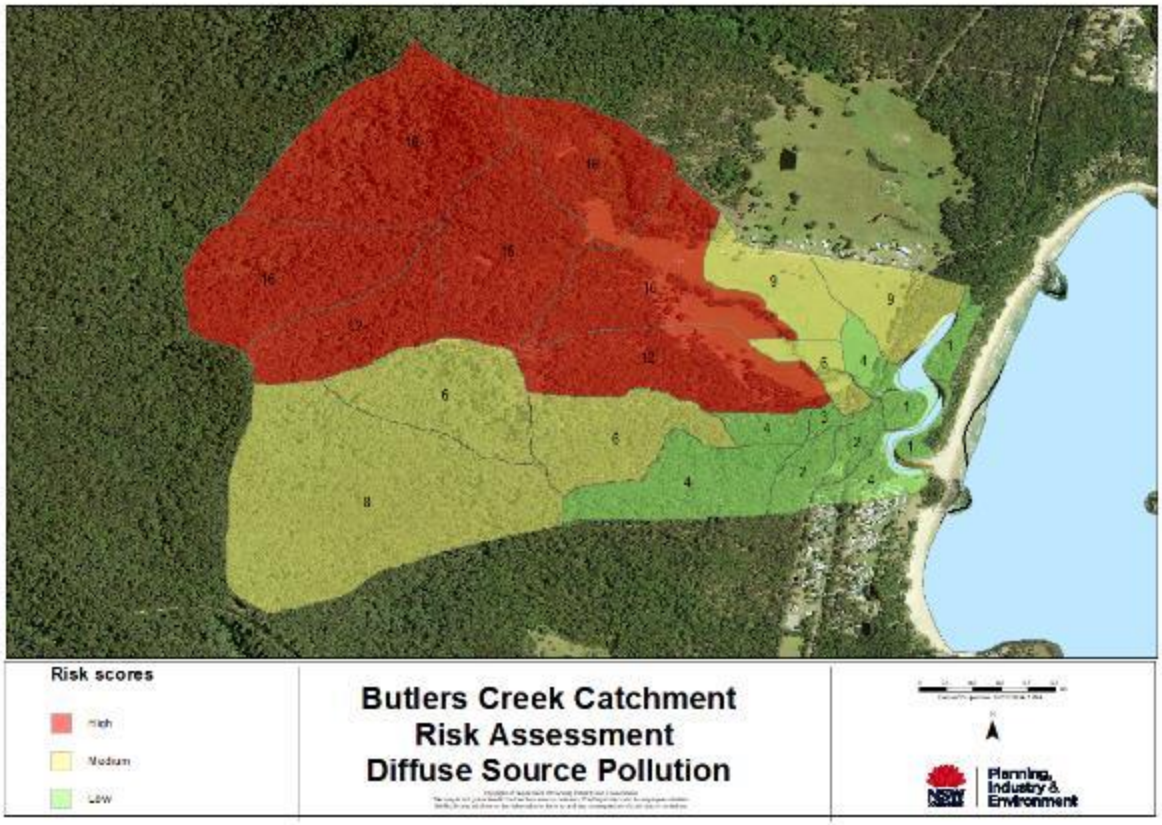
5.2. Butlers Creek

The Butlers Creek catchment is mostly forested with some rural areas. The catchment is on the very edge of the urban area of Kiola.

The highest risk sub-catchments identified are generally those in the steep upper, mainly forested slopes. These indicate areas where landuse intensification should be avoided. The sub-catchments directly surrounding the estuary foreshore have a low risk of pollutants (Map 15a).

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be low and there are only small areas of catchment disturbance. Protection from runoff from future development would also be a priority.



Map 15-a: Butlers Creek Catchment Diffuse Source Pollution Risk Assessment

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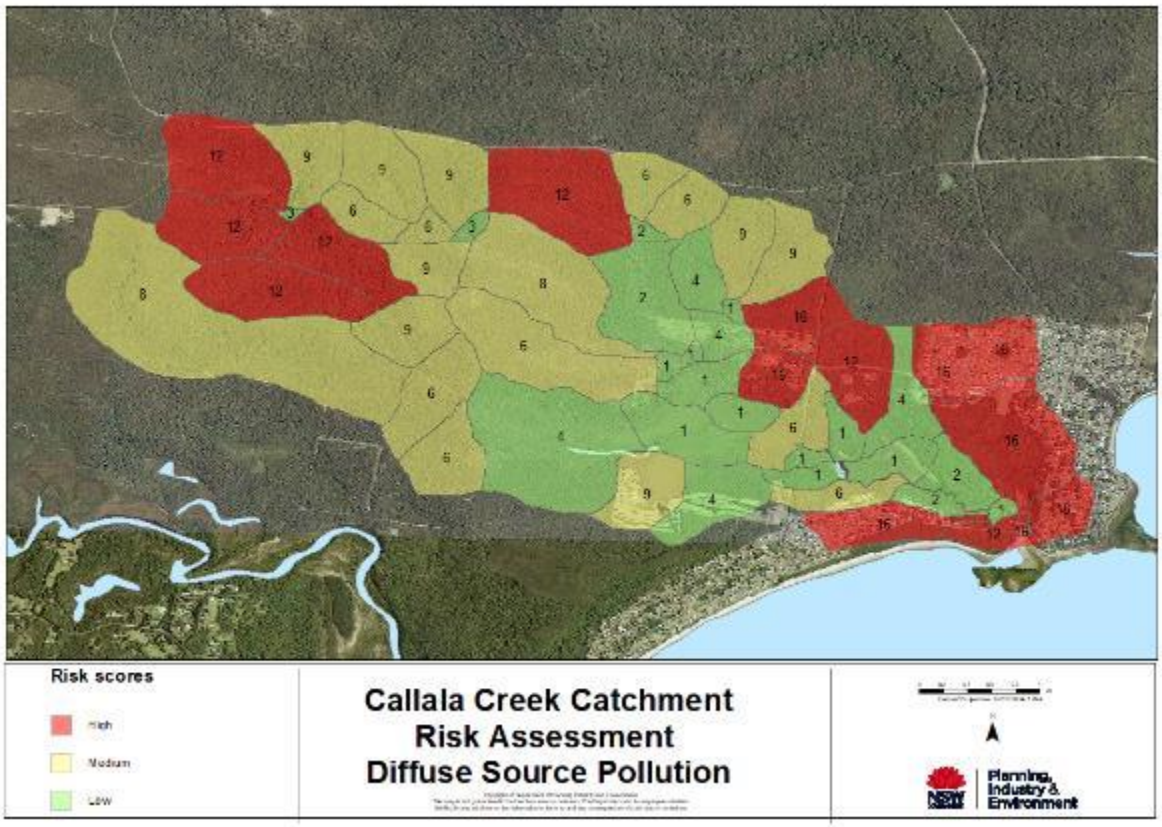
5.3. Callala Creek

The Callala Creek catchment is mostly forested and includes part of the urban areas of Callala Beach.

The highest risk sub-catchments identified are generally those in the steep upper forested slopes and the more urbanised areas (Map 16a). These indicate areas where further landuse intensification should be avoided.

Priority CMP actions within this catchment are likely to include those that reduce pollution runoff from Callala Beach village into the estuary. Protection from runoff from future development would also be a priority.



Map 16-a: Callala Creek Catchment Diffuse Source Pollution Risk Assessment

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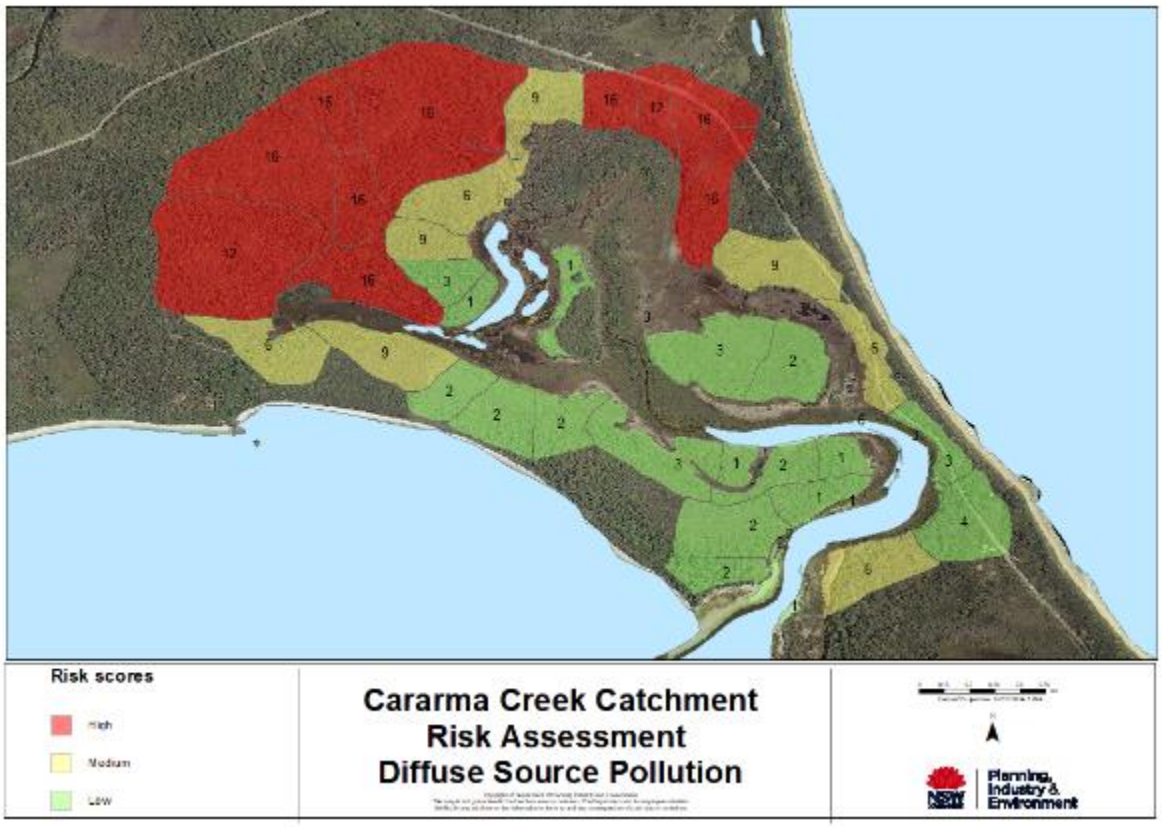
5.4. Cararma Creek

The Cararma Creek catchment is mostly forested and includes large wetland areas. It does not include any urban areas and apart from one road has no other catchment disturbance.

The highest risk sub-catchments identified are generally those in the steeper areas (Map 17a). These indicate areas where land use intensification is best avoided.

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be low. Protection from development impacts would be a priority for future management.



Map 17-a: Cararma Creek Catchment Diffuse Source Pollution Risk Assessment

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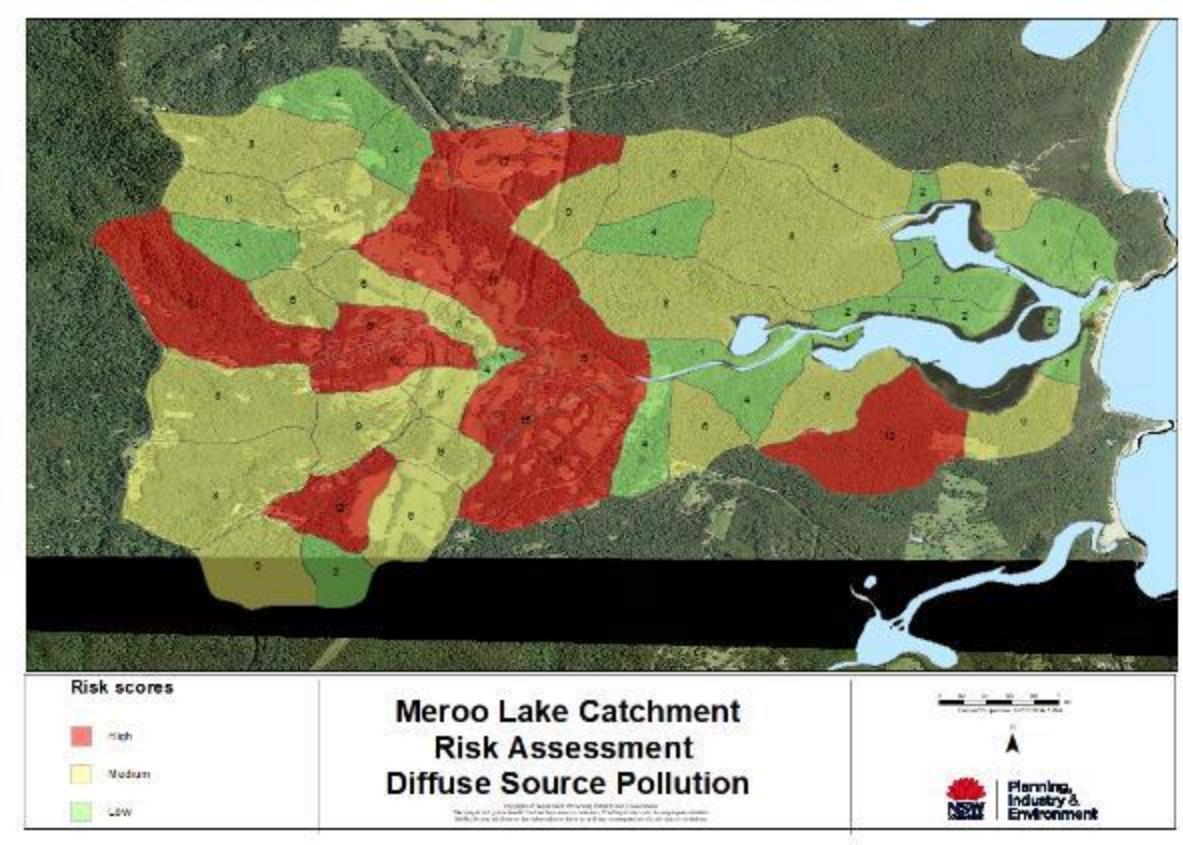
5.5. Meroo Lake

The Meroo Lake catchment is mostly forested. It contains some rural residential and agricultural areas in its upper and middle catchment near Termeil.

The highest risk sub-catchments identified are predominantly within the steeper forested slopes, rural residential and agricultural areas. These indicate areas where land use intensification should be avoided. Most other sub-catchments within the lower half of the catchment adjoining the estuary have a lower risk (Map 18a).

Any actions are likely to include preventing runoff from the rural residential and agricultural areas that adjoin the tributaries feeding into Meroo Lake in the upper and middle of the catchment.



Map 18-a: Meroo Lake Creek Catchment Diffuse Source Pollution Risk Assessment

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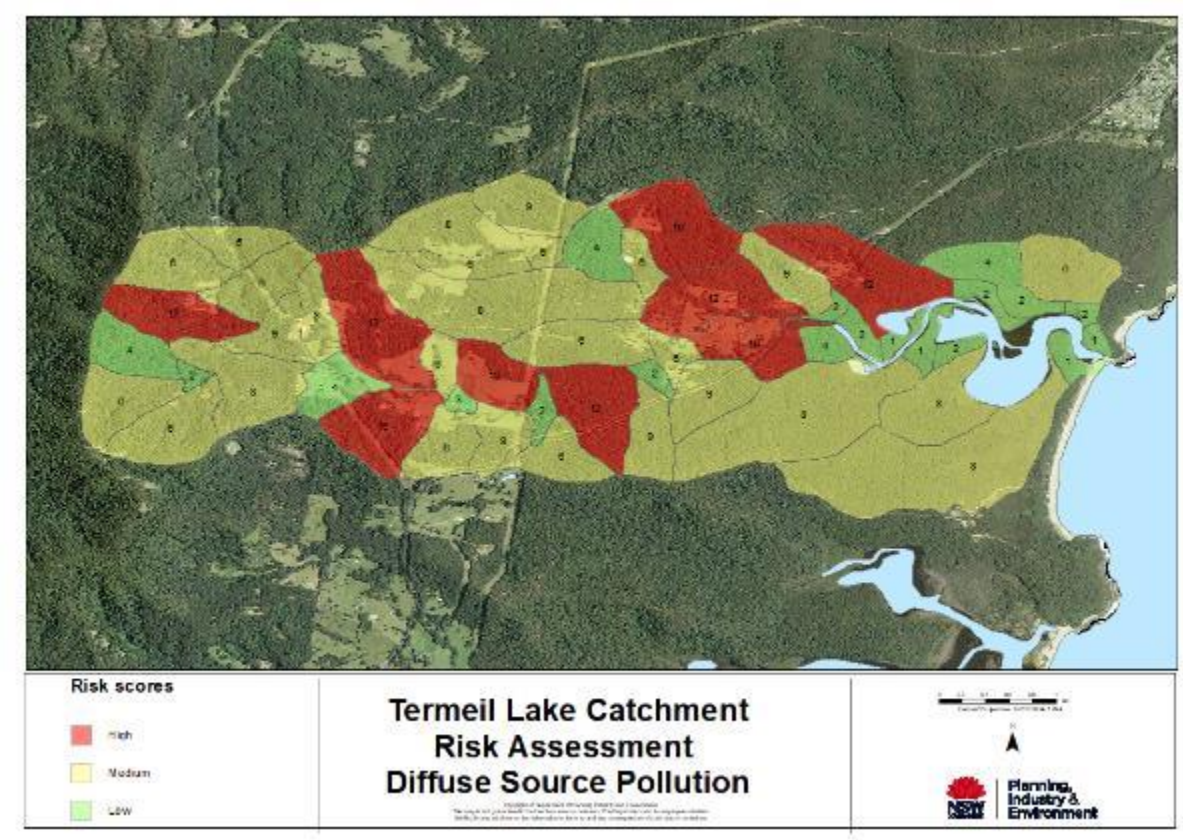
5.6. Termeil Lake

The Termeil Lake catchment is mostly forested. It contains some rural residential and agricultural areas in its upper and middle catchment.

The highest risk sub-catchments identified include steeper forested slopes, rural residential and agricultural areas. These indicate areas where land use intensification should be avoided. Some of these rural agricultural areas adjoin the main tributary feeding into the lake as well as along the lakes north western foreshore. There is generally a lower risk within the sub-catchments surrounding the remainder of the estuary foreshore, which is largely undisturbed (Map 19-a).

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be relatively low. Any actions are likely to include preventing runoff from the agricultural areas that adjoin the lake itself as well as the main tributary feeding into Termeil Lake.



Map 19-a: Termeil Lake Catchment Diffuse Source Pollution Risk Assessment

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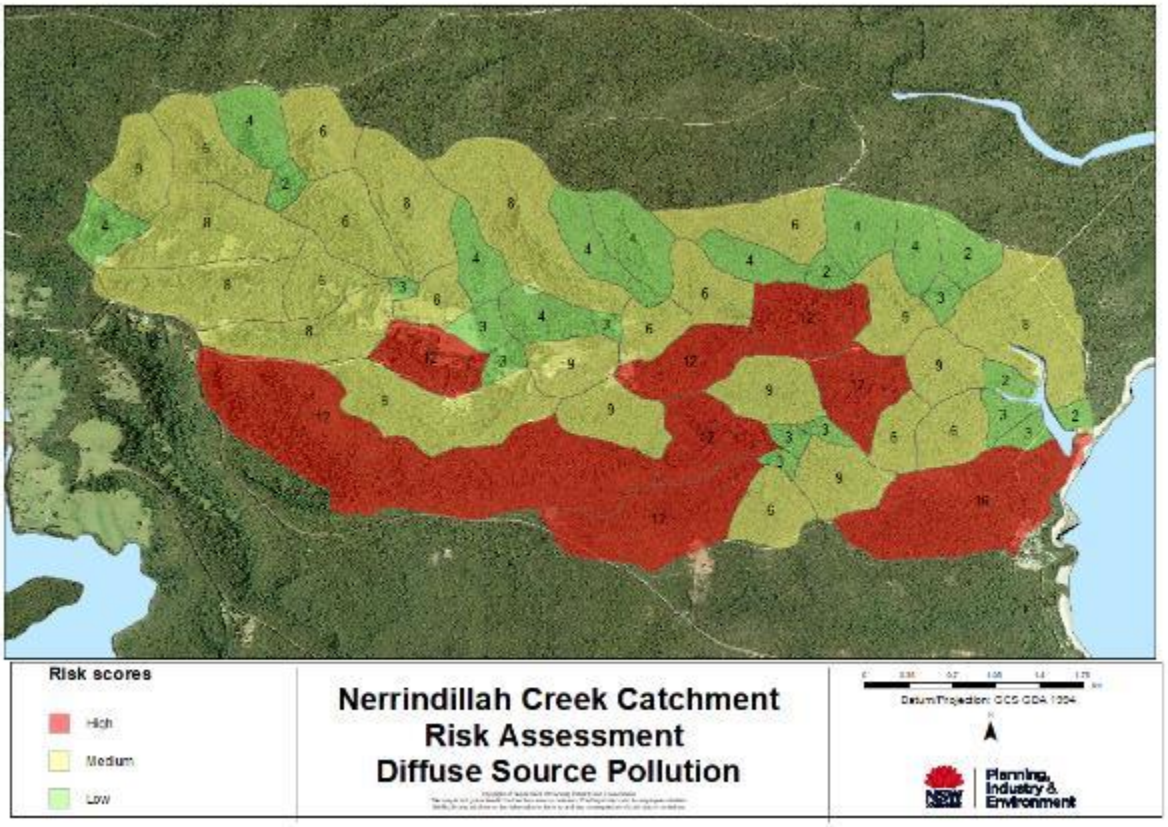
5.7. Nerrindillah Creek

The Nerrindillah Creek catchment is mostly forested. It contains some rural residential and agricultural areas in its upper and middle catchment and is located on the very edge of the small settlement of North Bendalong.

The highest risk sub-catchments identified include those in the steeper upper catchment slopes as well as the area containing part of the North Bendalong settlement. These indicate areas where land use intensification is best avoided. There is generally a lower risk in the sub-catchments surrounding the remainder of the estuary foreshore, which is largely undisturbed (Map 20a).

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be relatively low. Any actions are likely to include preventing runoff from the North Bendalong urban area into Nerrindillah Creek.



Map 20-a: Nerrindillah Creek Catchment Diffuse Source Pollution Risk Assessment

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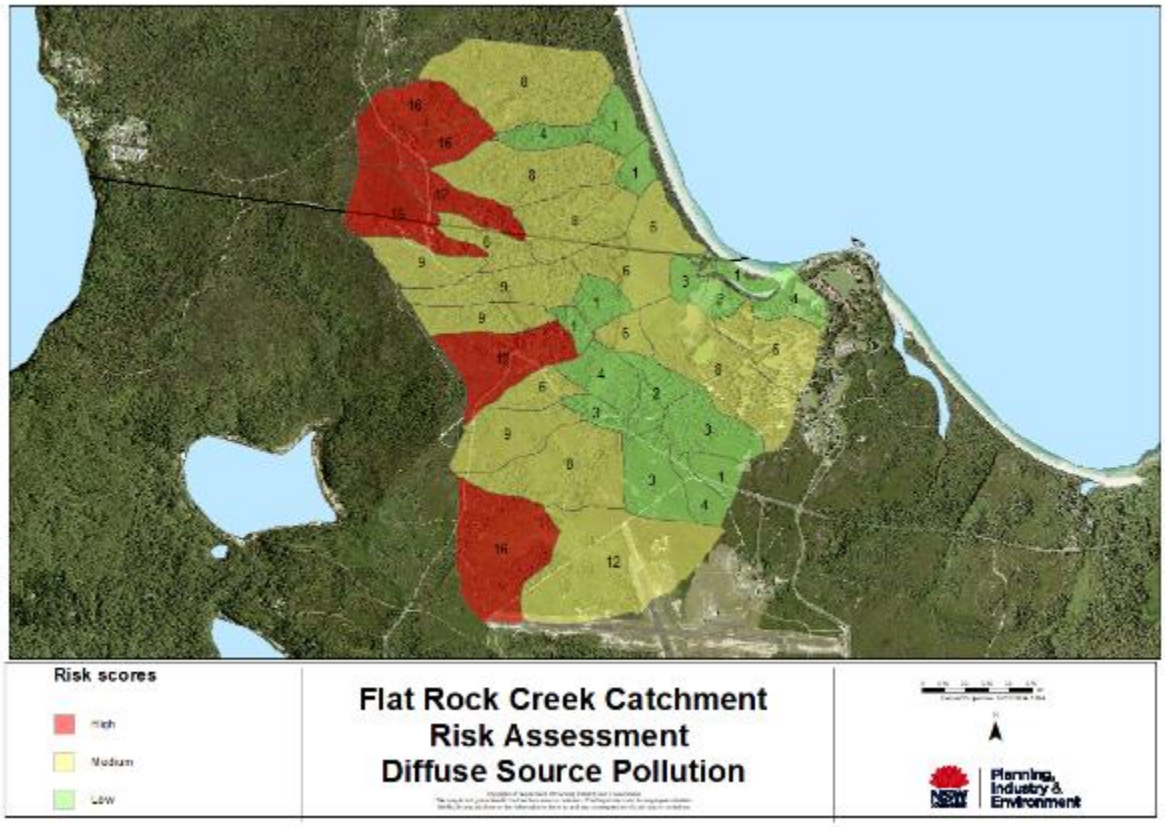
6. Other Estuaries

6.1. Flat Rock Creek

The Flat Rock Creek catchment is mostly forested or else wetland located on the border of Shoalhaven City Council and Boderee National Park. It contains part of the Jervis Bay HMAS Creswell Navy Base and part of the Jervis Bay Airport.

The highest risk sub-catchments identified are predominantly within forested areas. There is lower risk within the sub-catchments closer to the estuary itself (Map 20a).

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be relatively low. It would be useful to ground truth to ensure runoff pollution from the naval base and airport is being minimised and identify if further actions are required. Protection from any future development impacts would also be a priority for future management.



Map 20-a: Flat Rock Creek Catchment Diffuse Source Pollution Risk Assessment

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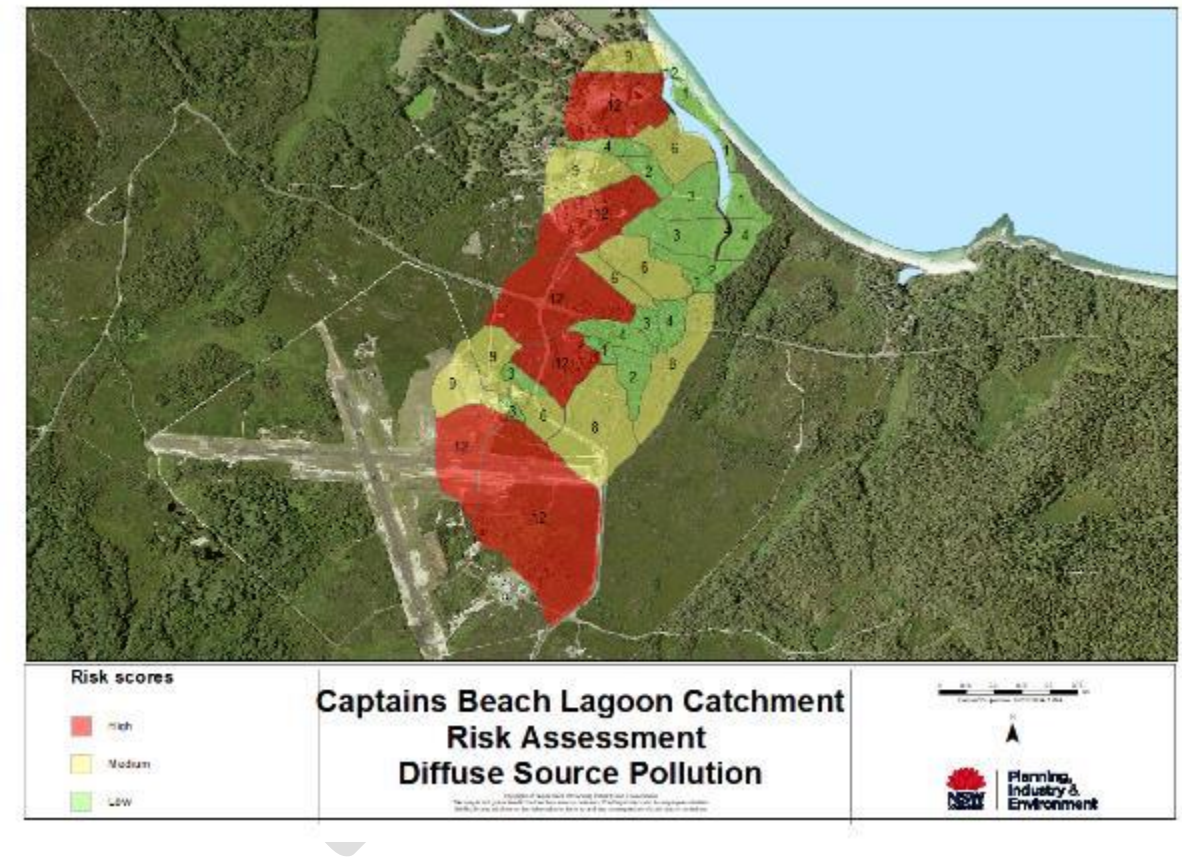
6.2. Captains Beach Lagoon

The Captains Beach Lagoon catchment contains wetland and forested areas. It is located within Boderee National Park and as such is not managed by Shoalhaven City Council. It contains the Village of Jervis Bay, part of the Jervis Bay HMAS Creswell Navy Base and part of the Jervis Bay Airport.

The highest risk sub-catchments identified are those that contain the urbanised areas of Jervis Bay and the Navy base, as well as part of the airport (Map 21a).

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be relatively low. Priority areas for potential action within this catchment would be to ensure runoff pollution from the naval base, airport and Jervis Bay township is controlled. Protection from runoff from roads and development impacts would be a priority for future management.



Map 21-a: Captains Creek Catchment Diffuse Source Pollution Risk Assessment

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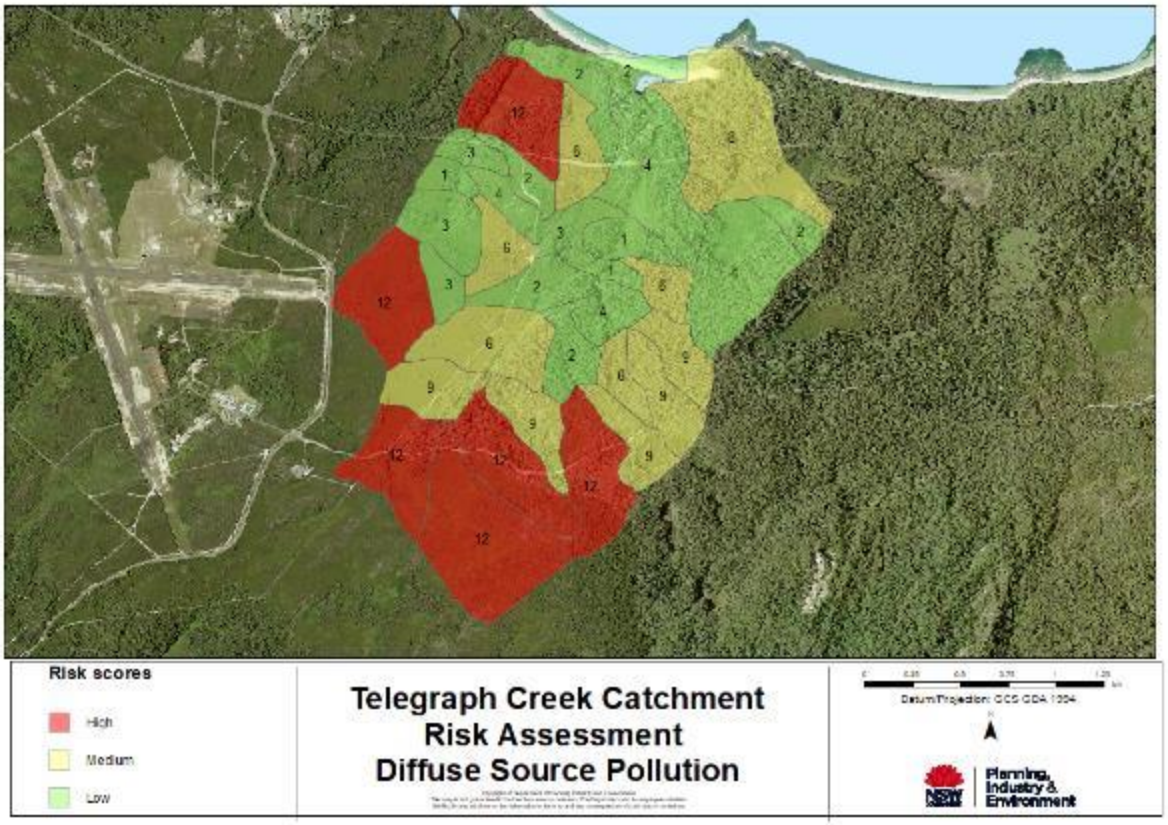
6.3. Telegraph Creek

The Telegraph Creek catchment contains largely undisturbed forest and wetland areas within the Boderee National Park and as such is not managed by Shoalhaven City Council. There are some roads present, but no other urban development.

The highest risk sub-catchments identified are predominantly within the upper catchment areas with lower risks closer to the estuary itself (Map 22a).

This catchment would be a lower priority for CMP actions given risks within the lower catchment are considered to be relatively low due to its undisturbed landuse. Protection from future development impacts would be a priority for future management.



Map 22-a: Telegraph Creek Catchment Diffuse Source Pollution Risk Assessment

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Appendix G - Lake Conjola CMP - Threat Based Risk Assessment

Project: **PA2591 Lake Conjola Coastal Management Program**

Threat-Based Hazard and Risk Assessment

Risk assessment undertaken by:
Shoalhaven City Council : Nigel Smith
DPE: Daniel Wiecek
RHDHV: Greg Britton, Matt Potter
Agency Representatives:
Date:

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
1. Public Safety Risk Assessment															
1.1	Stormwater erosion	- Injury to public due to the erosion and instability of erosion scarps caused by stormwater outlets and runoff	2	2	**4**	2	2	**4**	2	3	**6**	2	3	**6**	- Consider diversion of hazardous stormwater runoff - Establish ongoing monitoring program to inform actions - Stabilisation of existing stormwater outlets as required - Installation of warning signage near stormwater outlets - Improve energy dissipation at stormwater outlets
1.2	Tidal inundation	- Injury or drowning caused by collision with submerged objects and structures on land or in waterways (e.g. jetties) - Injury or drowning caused by public access into inundated areas	5	1	**5**	5	1	**5**	5	1	**5**	5	3	**15**	- Review/Amend/Implement flood and inundation development and planning controls within LEP/DCP that are applied to new development - Consider amending flood controls within DCP to allow raising property grounds levels through use of fill - Consider temporary road closures depending on extent of inundation - Installation of informative signage/education campaign - Investigate/enforce appropriate and permissible use of public foreshores by private interests (e.g. retaining walls, jetties, watercraft); in collaboration with TfNSW, Crown Lands, Fisheries - Relocation/reconstruction of assets that could be submerged
1.3	Coastal inundation	- Injury or drowning caused by collision with submerged objects and structures on land - Injury or drowning caused by public access into inundated areas	5	2	**10**	5	2	**10**	5	2	**10**	5	3	**15**	- Implementation of the Shoalhaven Flood Plan (a Subplan of the Shoalhaven EMPLAN) - Prepare and implement Coastal Zone Emergency Action Subplan (CZEAS) - Installation of temporary warning signage - Temporary fencing to prevent public access to hazardous areas - Review/Amend/Implement flood and inundation development and planning controls within LEP/DCP that are applied to new development - Consider amending flood controls within DCP to allow raising property grounds levels through use of fill - Consider temporary road closures depending on extent of inundation - Arrange alternative temporary access (e.g. waterborne access with vessels) to manage bridge/road closures - Installation of informative signage/education campaign (in collaboration with SES) - Investigate/enforce appropriate and permissible use of public foreshores by private interests (e.g. retaining walls, jetties, watercraft); in collaboration with TfNSW, Crown Lands, Fisheries - Relocation/reconstruction of assets that could be submerged - Develop/Implement Lake water level forecasting system to inform emergency entrance management interventions and community response

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
1.4	Coastal inundation and catchment flooding (combined)	- Injury or drowning caused by floodwaters moving through low-lying residential areas - Injury caused by structures and/or debris mobilising during flood events - Injury or drowning caused by collision with submerged objects and structures on land - Injury or drowning caused by public access into inundated areas	5	2	**10**	5	3	**15**	5	3	**15**	5	4	**20**	- Implementation of the Shoalhaven Flood Plan (a Subplan of the Shoalhaven EMPLAN) - Prepare and implement Coastal Zone Emergency Action Subplan (CZEAS) - Installation of temporary warning signage - Temporary fencing to prevent public access to hazardous areas - Review/Amend/Implement flood and inundation development and planning controls within LEP/DCP that are applied to new development - Consider amending flood controls within DCP to allow raising property grounds levels through use of fill - Consider road closures depending on extent of inundation - Arrange alternative temporary access (e.g. waterborne access with vessels) to manage bridge/road closures - Installation of informative signage/education campaign (in collaboration with SES) - Investigate/enforce appropriate and permissible use of public foreshores by private interests (e.g. retaining walls, jetties, watercraft); in collaboration with TfNSW, Crown Lands, Fisheries - Relocation/reconstruction of assets that could be submerged - Develop/Implement Lake water level forecasting system to inform emergency entrance management interventions and community response
1.5	Lake Conjola entrance dynamics; artificial opening of entrance; inappropriate community initiated openings	- Injury to beach and Lake users caused by the instability of scarps adjacent to breakout channel - Injury/drowning to public due to high water velocity / currents within entrance area - Injury/drowning of surfers riding standing waves during artificial entrance openings	5	1	**5**	5	2	**10**	5	2	**10**	5	3	**15**	- Consideration of inappropriate community initiated openings in entrance management policy - Installation of temporary warning signage - Temporary fencing to create exclusion zones and prevent public access to hazardous areas (e.g. during mechanical entrance openings) - Re-grading to restore beach profile by Council maintenance staff - Improve public education of the impacts and safety risks of Lake openings
1.6	Water quality (surface water)	- Illness suffered by Lake users caused by poor water quality resulting from a variety of surface water inflows (stormwater runoff/agricultural runoff/sewer overflows) and inadequate infrastructure maintenance	3	2	**6**	3	3	**9**	3	3	**9**	3	4	**12**	- Continue and refine surface water monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Investigate and manage sewage overflows - Support volunteer based foreshore rehabilitation initiatives such as Bushcare - Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) or raingardens in private development activities - Undertake maintenance of existing stormwater improvement devices - Review/Amend/Implement water quality development and planning controls within LEP/DCP that are applied to new development - Consider development and implementation of water quality targets for existing and future land use within the Lake Conjola catchment, utilising the "Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions" (OEH, 2017) - Improve/manage riparian vegetation - Stormwater management system improvements - Improve community education on the factors influencing water quality and on mitigation actions - Work with farmers/landowners to support change in farming practices (e.g. stock access to water) - Collaboration with agencies e.g. LLS to provide support for changing detrimental land use practices
1.7	Water quality (groundwater)	- Illness suffered by Lake users caused by poor water quality resulting from migration of the groundwater plume containing effluent from the Conjola Regional Sewerage Scheme	3	1	**3**	3	3	**9**	3	3	**9**	3	3	**9**	- Continue groundwater monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Future review of entrance management policy - Consider opportunities for sewage treatment and discharge improvements - Identify and monitor potential source sites that could leach contaminants into the Lake (e.g. landfill)

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
1.8	Navigation Safety	Injury or drowning caused by: - shallow water and running aground - strong currents and shallow water for navigation through the entrance shoals - hazardous entrance bar conditions for offshore access due to wave action - navigation hazards created by floating or submerged debris following catchment flood events	5	3	**15**	5	3	**15**	5	3	**15**	5	2	**10**	- Consider review of navigation aids (e.g. channel markers) - Review boating speed limits - Review boat ramp advisory signage

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
2. Infrastructure Risk Assessment															
2.1	Tidal inundation	- Damage to public and private infrastructure and property caused by tidal inundation	4	1	**4**	4	1	**4**	4	1	**4**	4	4	**16**	- Remove valuable assets from ground floor areas - Retrofit or relocate public infrastructure - Review/Amend land-use controls and categorisation - Review/Amend/Implement flood and inundation development and planning controls within LEP/DCP that are applied to new development
2.2	Coastal inundation	- Damage to public and private infrastructure and property caused by increased water levels, particularly in low lying residential areas	3	1	**3**	3	2	**6**	3	3	**9**	3	4	**12**	- Remove valuable assets from ground floor areas - Retrofit or relocate public and private infrastructure - Review/Amend land-use controls and categorisation - Review/Amend/Implement flood and inundation development and planning controls within LEP/DCP that are applied to new development - Allow water to pass through buildings (e.g. Caravan Park) with less damage by opening doors/entry points
2.3	Coastal inundation and catchment flooding (combined)	- Damage to public and private infrastructure and property caused by raised water levels - Damage to public and private infrastructure and property caused by debris and structures mobilising in floodwaters during coastal storm events, particularly in low lying residential areas	4	1	**4**	4	2	**8**	4	3	**12**	5	4	**20**	- Implementation of the Shoalhaven Flood Plan (a Subplan of the Shoalhaven EMPLAN) - Consideration of emergency entrance management interventions - Remove valuable assets from ground floor areas - Retrofit or relocate public and private infrastructure - Review/Amend land-use controls and categorisation - Review/Amend/Implement flood and inundation development and planning controls within LEP/DCP that are applied to new development - Allow water to pass through buildings (e.g. Caravan Park) with less damage by opening doors/entry points

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
3. Environmental Risk Assessment															
3.1	Tidal inundation	- Change to habitat type and distribution - Potential damage to heritage places - Loss of wetland habitat through 'coastal squeeze', where landward migration is limited by natural rising land or structures/development - Damage to Aboriginal heritage sites of significance and groups of coastal sites such as middens - Damage caused by tidal inundation in low-lying coastal areas	1	1	**1**	2	3	**6**	2	3	**6**	4	5	**20**	- Identification and mapping of sites of archaeological and cultural heritage significance within the LEP/DCP - Mapping of Aboriginal heritage sites within Council's GIS system - Cultural Heritage Assessment required as part of development assessment process for all development proposals - Manage/Improve riparian vegetation - Increased support and collaboration with volunteers and agencies (e.g. NPWS) within the South Coast Shorebird Recovery Program - Reservation of land to allow for spatial migration of vegetation/habitat
3.2	Coastal inundation	- Damage to habitats caused by ponding of water in low-lying coastal areas during coastal storms, noting that these habitats have cultural values - Introduction of hazardous materials/pollutants into the marine/estuarine environment	3	1	**3**	3	2	**6**	3	3	**9**	3	4	**12**	- Identification and mapping of sites of archaeological and cultural heritage significance within the LEP/DCP - Mapping of Aboriginal heritage sites within Council's GIS system - Cultural Heritage Assessment required as part of development assessment process for all development proposals - Consider sand scraping to reinforce vegetated dune for protection purposes - Reservation of land to allow for spatial migration of vegetation/habitat - Increased support and collaboration with volunteers and agencies (e.g. NPWS) within the South Coast Shorebird Recovery Program - Repair damage to habitats following storm/inundation events - Review/change land-use controls
3.3	Coastal inundation and catchment flooding (combined)	- Damage to habitats caused by ponding of water in low-lying coastal areas during coastal storms, noting that these habitats have cultural values - Introduction of hazardous materials/pollutants into the marine/estuarine environment	3	1	**3**	3	2	**6**	3	3	**9**	4	4	**16**	- Consideration of emergency entrance management interventions - Identification and mapping of sites of archaeological and cultural heritage significance within the LEP/DCP - Mapping of Aboriginal heritage sites within Council's GIS system - Cultural Heritage Assessment required as part of development assessment process for all development proposals - Reservation of land to allow for spatial migration of vegetation/habitat - Consider sand scraping to reinforce vegetated dune for protection purposes - Repair damage to habitats following storm/inundation events - Review/amend catchment land-use controls within LEP/DCP - Increased support and collaboration with volunteers and agencies (e.g. NPWS) within the South Coast Shorebird Recovery Program - Consider acquisition and protection of key locations, notably Coastal Wetlands and Littoral Rainforest areas

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
3.4	Water quality	- Various adverse impacts on aquatic ecology due to poor water quality caused by a variety of catchment inflows (stormwater runoff/agricultural runoff/sewer overflows), inadequate infrastructure maintenance, and potentially worsened by migration of the groundwater plume containing effluent from the Conjola Regional Sewerage Scheme - The ecological and biodiversity attributes of the Lake also have social and cultural values that would be adversely impacted	3	1	**3**	3	3	**9**	3	4	**12**	4	5	**20**	- Continue groundwater monitoring and reporting program - Continue and refine surface water monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Review entrance management guidelines for mechanical openings of Lake Conjola - Investigate and manage sewage overflows - Improve/manage riparian vegetation - Consider opportunities for sewage treatment and discharge improvements - Future review of entrance management policy - Stormwater management system improvements - Support volunteer based foreshore rehabilitation initiatives such as Bushcare - Review/Amend/Implement water quality development and planning controls within LEP/DCP that are applied to new development - Consider development and implementation of water quality targets for existing and future land use within the Lake Conjola catchment, utilising the "Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions" (OEH, 2017) - Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) or raingardens in private development activities - Undertake maintenance of existing stormwater improvement devices - Identify and monitor potential source sites that could leach contaminants into the Lake (e.g. landfill) - Improve community education on the factors influencing water quality and mitigation actions - Work with farmers/landowners to support change in farming practices (e.g. stock access to water) - Undertake rehabilitation works in damaged vegetated areas - Collaboration with agencies e.g. LLS to provide support for changing detrimental land use practices
3.5	Stormwater discharge	- Adverse impacts on water quality - Reduction in the health of ecosystems - Reduced biodiversity value - The ecological and biodiversity attributes of the Lake also have social and cultural values that would be adversely impacted	2	5	**10**	2	5	**10**	3	5	**15**	3	5	**15**	- Continue and refine surface water monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Stormwater management system improvements - Improve/manage riparian vegetation - Installation of Stormwater Quality Improvement Devices (SQIDs) at some stormwater outlets - Consider the relocation or diversion of particular stormwater outlets - Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) or raingardens in private development activities - Undertake maintenance of existing stormwater improvement devices - Review/Amend/Implement water quality development and planning controls within LEP/DCP that are applied to new development - Consider development and implementation of water quality targets for existing and future land use within the Lake Conjola catchment, utilising the "Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions" (OEH, 2017)
3.6	Sewage / septic overflows / groundwater plume migration from the Conjola Regional Sewer Scheme	- Adverse impacts on terrestrial and marine habitat and water quality, potentially worsened by migration of the groundwater plume containing effluent from the Conjola Regional Sewerage Scheme and sewer overflows - Reduction in the health of ecosystems - Reduced biodiversity value - The ecological and biodiversity attributes of the Lake also have social and cultural values that would be adversely impacted	3	1	**3**	3	3	**9**	4	4	**16**	4	5	**20**	- Continue and refine surface water monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Continue groundwater monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Improve inspection/maintenance/management procedures - Consider opportunities for sewage treatment and discharge system improvements - Investigate locations of any remaining active septic systems and assess potential impacts on Lake water quality - Future review of entrance management policy

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
3.7	Exotic/pest species	- Loss of native vegetation caused by weed infestation - Loss of native flora and fauna due to intensification of pest species (e.g. foxes and deer) and weed infestation - Loss of threatened species - Damage to dune areas and National Park(s) - Potential impacts on Aboriginal cultural heritage associated with dune areas	3	1	**3**	3	2	**6**	4	2	**8**	4	4	**16**	- Dune, foreshore and wetland maintenance programs undertaken by Council and contractors - Implementation of weed and pest control programs by Council/external agencies - Council support for community based revegetation campaigns - Increased support and collaboration with volunteers and agencies (e.g. NPWS) within the South Coast Shorebird Recovery Program - Improve community education on both native and pest species, how to identify species, and how to report pest species - Identification and mapping of sites of archaeological and cultural heritage significance within the LEP/DCP - Mapping of Aboriginal heritage sites within Council's GIS system - Cultural Heritage Assessment required as part of development assessment process for all development proposals - Community engagement and behaviour change programs to address underlying causes
3.8	Population growth & coastal development	- Loss of habitats - Reduction in the health of ecosystems - Reduced biodiversity value - Loss of migratory waders and shorebirds - Loss of threatened species - Increased use of the coastal zone from residents and tourists resulting in impacts on the health of ecosystems, biodiversity, habitats, and water quality - Increased pedestrian and vehicle traffic in wetlands, saltmarsh, dunes, and other sensitive areas resulting in damage to habitats - Change in land-use impacting water quality of Lake Conjola - Greater pressure on heritage places	3	1	**3**	3	2	**6**	3	3	**9**	4	4	**16**	- Review current and potential future zoning of land within the Lake Conjola catchment - Review DCP Pollution reduction targets for new developments to ensure consistency with risk-based framework and avoid landuse intensification in high risk areas - Review/Amend/Implement development and planning controls within LEP/DCP that are applied to new development - Undertake rehabilitation works in damaged vegetated areas - Install signage and fencing in key areas to protect habitats - Identification and mapping of sites of archaeological and cultural heritage significance within the LEP/DCP - Mapping of Aboriginal heritage sites within Council's GIS system - Cultural Heritage Assessment required as part of development assessment process for all development proposals - Improve public education on how people impact the environment - Enforcement of existing policies/controls on access restrictions - Council support for community based revegetation campaigns and other community "ownership" projects - Increased support and collaboration with volunteers and agencies (e.g. NPWS) within the South Coast Shorebird Recovery Program - Community engagement and behaviour change programs to address underlying causes
3.9	Clearing of riparian/wetland/dune habitat	- Loss of habitats - Reduction in the health of ecosystems - Reduced biodiversity value - Loss of migratory waders and shorebirds - Loss of threatened species	2	4	**8**	2	5	**10**	3	5	**15**	4	5	**20**	- Consider Vegetation Vandalism Policy - Encourage dune maintenance programs undertaken by Council or contractors - Undertake rehabilitation works in damaged vegetated areas - Install signage and fencing in key areas to protect vegetation - Increased support and collaboration with volunteers and agencies (e.g. NPWS) within the South Coast Shorebird Recovery Program - Review/Amend/Implement development and planning controls within LEP/DCP that are applied to new development - Community engagement and behaviour change programs to address underlying causes - Council support for community based revegetation campaigns
3.10	Recreational use of the coastal zone (including wetlands, saltmarsh) and ad hoc access into sensitive areas	- Damage to terrestrial and aquatic habitats (including impacts of recreational vessels on seagrass beds) - Adverse impacts on terrestrial flora and fauna, avian species - Adverse impacts on water quality and aquatic ecology - Reduced biodiversity value - Cultural aspects of these uses and environments, and increased pressure	2	5	**10**	2	5	**10**	3	5	**15**	3	5	**15**	- Encourage dune maintenance programs undertaken by Council or contractors - Undertake rehabilitation works in damaged vegetated areas - Identification and mapping of sites of archaeological and cultural heritage significance within the LEP/DCP - Mapping of Aboriginal heritage sites within Council's GIS system - Cultural Heritage Assessment required as part of development assessment process for all development proposals - Improve public education on how people impact the environment - Install signage and fencing in key areas to protect vegetation - Review/Amend/Enforce Council policies on the use of open spaces and the coastal zone - Council support for community based revegetation campaigns - Community engagement and behaviour change programs to address underlying causes - Improve community education on the impacts of recreational activites on the coastal zone

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
3.11	Lake Conjola entrance dynamics; artificial opening of entrance; inappropriate community initiated openings	- Direct impact on ecology (e.g. shorebird disturbance)	2	1	**2**	2	3	**6**	2	3	**6**	2	4	**8**	- Consideration of inappropriate community initiated openings in entrance management policy - Improve community education on the impacts of community initiated Lake openings
3.12	Catchment land-use	- Damage/clearing/thinning of habitats - Adverse impacts on water quality, resulting from intensification and changes in land-use within the catchment, and activities like stock grazing - Reduction in the health of ecosystems - Cultural aspects of these uses and environments, and increased pressure	2	3	**6**	3	3	**9**	4	4	**16**	4	5	**20**	- Review current and potential future zoning of land within the Lake Conjola catchment - Review/amend land-use controls and categorisation - Review/Amend/Implement development and planning controls within LEP/DCP that are applied to new development - Consider development and implementation of water quality targets for existing and future land use within the Lake Conjola catchment, utilising the "Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions" (OEH, 2017) - Improve community education on the effects of land-use - Work with farmers/landowners to support change in farming practices (e.g. stock access to water) - Community engagement and behaviour change programs to address underlying causes - Undertake rehabilitation works in damaged vegetated areas - Collaboration with agencies e.g. LLS to provide support for changing detrimental land use practices - Council support for community based revegetation campaigns

Risk ID	Threat(s)	Hazards and Impacts	Risk Current			Risk 20 yr Planning Horizon (0.23m SLR)			Risk 50 yr Planning Horizon (0.36m SLR)			Risk 100yr + Planning Horizon (1.2m SLR)			Broad Indicative Control Measures
			Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	
4. Public Amenity Risk Assessment															
4.1	Stormwater erosion	- Reduced Lake amenity and access resulting from erosion caused by stormwater discharge or surface runoff	2	2	**4**	2	2	**4**	2	3	**6**	2	3	**6**	- Re-grading of eroded areas to restore foreshore profile by Council maintenance staff - Consider redirection of surcharge flows - Improve energy dissipation at stormwater outlets, consider creation of raingardens
4.2	Tidal inundation	- Reduced public amenity in low-lying areas	3	1	**3**	3	1	**3**	3	1	**3**	3	5	**15**	
4.3	Population growth; coastal development; & human use of the coastal zone	- Increased visitation from residents and visitors resulting in more crowding, less available parking, conflicts between user groups - increased requirement for maintenance of accessways and other assets etc. - Reduced public amenity due to increased/damaging private coastal/foreshore development	1	5	**5**	2	5	**10**	3	5	**15**	3	5	**15**	- Collaborate with TfNSW appropriate management of users, e.g. number of vessels within Lake Conjola - Investigate/enforce appropriate and permissible use of public foreshores by private interests e.g. retaining walls, jetties, watercraft; in collaboration with TfNSW, Crown Lands, Fisheries - Create/enforce time limits on parking in highly popular locations - Create/enforce Council policies on the use of open spaces and the coastal zone - Review/Amend/Implement development and planning controls within LEP/DCP that are applied to new development - Council support for community based revegetation campaigns and other community "ownership" projects
4.4	User conflict	- Potential conflict due to variety of recreational uses; such as personal watercraft, recreational powered watercraft, passive recreation	2	2	**4**	2	3	**6**	2	3	**6**	2	3	**6**	- Collaborate with TfNSW to implement appropriate actions within the "Boating Plan of Management - Lake Conjola Estuary" (NSW Maritime Authority, March 2005) - Consider collaboration with TfNSW regarding reviewing and enforcement of current and potential controls on watercraft
4.5	Water quality (surface water)	- Various adverse impacts on public amenity due to poor water quality caused by a variety of surface water inflows (stormwater runoff/agricultural runoff/sewer overflows) and inadequate infrastructure maintenance	3	2	**6**	3	3	**9**	3	3	**9**	3	4	**12**	- Continue and refine surface water monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Investigate and manage sewage overflows - Support volunteer based foreshore rehabilitation initiatives such as Bushcare - Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) or raingardens in private development activities - Undertake maintenance of existing stormwater improvement devices - Review/Amend/Implement water quality development and planning controls within LEP/DCP that are applied to new development - Consider development and implementation of water quality targets for existing and future land use within the Lake Conjola catchment, utilising the "Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions" (OEH, 2017) - Improve/manage riparian vegetation - Stormwater management system improvements - Improve community education on the factors influencing water quality and on mitigation actions - Work with farmers/landowners to support change in farming practices (e.g. stock access to water) - Collaboration with agencies e.g. LLS to provide support for changing detrimental land use practices
4.6	Water quality (groundwater)	- Various adverse impacts on public amenity resulting from migration of the groundwater plume containing effluent from the Conjola Regional Sewerage Scheme	3	1	**3**	3	3	**9**	3	3	**9**	3	3	**9**	- Continue groundwater monitoring and reporting program - Increased review and public dissemination of Aquadata water quality monitoring results - Future review of entrance management policy - Consider opportunities for sewage treatment and discharge improvements - Identify and monitor potential source sites that could leach contaminants into the Lake (e.g. landfill)

Appendix H - Lake Conjola CMP - Asset Based Risk Assessment

Project: PA2591 **Lake Conjola Coastal Management Program**

Tidal Inundation Hazard and Risk Assessment

Risk assessment undertaken by:
Shoalhaven City Council : Nigel Smith
DPE: Daniel Wiecek
RHDHV: Greg Britton, Matt Potter, Daniel Horton

Date:

				Current (SLR 0.0m)						20-50 yr Planning Horizon (SLR 0.36m)						100 yr + Planning Horizon (SLR 1.2m)								
				Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Closest relevant assessed Location (n/r if not relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurence (hours)	Current	20-50 yr	20-50 yr	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurence (hours)	20-50 yr	100 yr +	100 yr +	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurence (hours)	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Community Asset	Carpark\Carpark	Berringer Lake boat ramp car park	Berringer Lake	1	1	n/r	0	0	1	1	1	11	0	0	1	2	5	11	260	5.2	10	Low elevation near foreshore, portion frequently unusable with 1.2m SLR, requires consideration of materials used to construct the car park. Location 11 used as proxy for comparison of inundation frequency and duration due to similar elevation	Modification of the car park may be required	When asset condition declines to pre-established rating and/or becomes unusable
Community Asset	Carpark\Carpark	Yooralla Bay boat ramp car park	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Open Space / Reserves / Parks	Picnic Bay	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Open Space / Reserves / Parks	Yooralla Bay Reserve	Conjola Park	1	1	18	0	0	1	1	5	18	Portion always Inundated	Portion always Inundated	5	1	5	18	Portion always Inundated	Portion always Inundated	5	minor inundation of foreshore area under SLR (max 0.5m); negligible consequences for infrastructure and environment		
Community Asset	Open Space and Recreation\Park Furniture\Play Equipment	Play Equipment	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Community Building	RFS Brigade building	Cunjurong	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Natural Area	Cunjurong Point	Cunjurong	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Carpark\Carpark	Cunjurong boat ramp car park	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	5	n/r	0	0	5	Low elevation near foreshore, portion frequently unusable with 1.2m SLR, requires consideration of materials used to construct the car park;		
Community Asset	Carpark\Carpark	Lake Conjola boat ramp car park	Fishermans Paradise	1	1	23	0	0	1	1	5	23	104	3.3	5	3	5	23	Near pernanent inundation	Near pernanent inundation	15	Low elevation, near permanent inundation with 1.2m SLR, requires consideration of materials used to construct the car park; moderate consequences on infrastruture	Modification of the car park may be required	When asset condition declines to pre-established rating and/or becomes unusable
Community Asset	Community Building	RFS Brigade building	Fishermans Paradise	1	1	22	0	0	1	1	1	22	0	0	1	1	1	22	0	0	1	Minor inundation of property under SLR (0-0.5m), but no threat to RFS building		
Community Asset	Open Space / Reserves / Parks	Hazel Robotham Reserve	Fishermans Paradise	1	1	22	0	0	1	1	4	22	0	0	4	1	5	22	61	4.3	5	Frequent minor inundation of low-lying foreshore areas under 0.36m SLR (0-0.25m), becoming more severe under 1.2m SLR (0.5-0.75m)		
Community Asset	Carpark\Carpark	Lake Conjola Community Centre	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Carpark\Carpark	Holiday Haven boat ramp car park	Lake Conjola	1	5	1	0	0	5	2	5	1	52	2.4	10	3	5	1	485	14.1	15	Suggested consequences are to Asset & Infrastructure (3) Reputation (2) and Financial (2) *There are likely to be "Severe" (5) financial consequence for the Caravan Park, though still rated "Minor" (2) for Council overall, as defined by the Risk Matrix – defined as: "Minor financial loss (up to 3% of Council's budget). Minimal impact on business operation."* . requires consideration of materials used to construct the car park	Remove and/or relocate assets Consider raising ground level to mitigate inundation (amendment of Flood Planning Controls required)	Decision on preferred option(s) and preparation of plans can commence in short to medium term. Implementation may relate to monitoring of triggers, e.g. frequency of inundation
Community Asset	Community Building	Lake Conjola Community Centre	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Community Building	RFS Brigade building	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Natural Area	Conjola Beach	Lake Conjola	1	5	n/r	Portion always Inundated	Portion always Inundated	5	1	5	n/r	Portion always Inundated	Portion always Inundated	5	1	5	n/r	Portion always Inundated	Portion always Inundated	5	Lowest consequence as natural occurance, noting likely spatial adjustment due to SLR		
Community Asset	Natural Area	Narrawallee Creek Nature Reserve	Lake Conjola	1	1	n/r	0	0	1	1	4	n/r	Portion frequently Inundated	Portion frequently Inundated	4		5	n/r	Portion always Inundated	Portion always Inundated	0	As adjacent to Pattimores Lagoon, small portion of Nature Reserve inundation		
Community Asset	Open Space / Reserves / Parks	Edwin Avenue Reserve	Lake Conjola	1	1	11	0	0	1	1	1	11	0	0	1	2	5	11	260	5.2	10	Frequent inundation (0.25 - 0.75m) of low-lying foreshore areas, which also threatens privat property located adjacent to the reserve		
Community Asset	Open Space / Reserves / Parks	Leaning Oak Point	Lake Conjola	1	1	13	0	0	1	1	1	13	0	0	1	2	5	13	138.7	43	10	Frequent inundation (0.25 - 0.75m) of low-lying foreshore areas, which also threatens caravan sites adjacent to the reserve		
Community Asset	Open Space / Reserves / Parks	Roberts Point	Lake Conjola	1	1	13	0	0	1	1	1	13	0	0	1	1	1	13	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Bowling Club	Lake Conjola	1	1	15	0	0	1	1	1	15	0	0	1	1	1	15	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Community Centre tennis court	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Sports Field - off Thorne Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Natural Assets	Ecological Area	Key Fish Habitat	Berringer Lake	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Lowest consequence as natural habitat		
Natural Assets	EEC	Coastal Saltmarsh	Berringer Lake	1	5	n/r	Tolerable current inundation	Tolerable current inundation	5	1	5	n/r	Frequently Inundated	Frequently Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Currently very limited saltmarsh extents, but potential for new habitats with SLR of 1.2m at northern end of Berringer Lake (although small in size)		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Berringer Lake	1	4	n/r	Tolerable current inundation	Tolerable current inundation	4	1	4	n/r	Portion occasionally inundated	Portion occasionally inundated	4	2	5	n/r	Portion frequently Inundated	Portion frequently Inundated	10	Increasing tidal inundation may cause dying of low elevated trees due to changes in tidal inundation regime		
Natural Assets	EEC	Swamp sclerophyll forest	Berringer Lake	1	1	n/r	0	0	1	1	4	n/r	Portion occasionally inundated	Portion occasionally inundated	4	2	5	n/r	Portion occasionally inundated	Portion occasionally inundated	10	Increasing tidal inundation may cause dying of low elevated trees due to changes in tidal inundation regime		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Berringer Lake	1	1	13	0	0	1	1	4	13	0	0	4	2	5	13	Portion always Inundated	Portion always Inundated	10	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP	Relocate trails, consider spatial area for "migration" of wetlands etc. and establishment of new habitat locations	When trails become frequently impassable
Natural Assets	SEPP Coastal Management	Littoral Rainforest	Berringer Lake	1	1	12	0	0	1	1	1	12	52	3.4	1	1	5	12	Always Inundated	Always Inundated	5	foreshore area indundated; no impact on littoral rainforest anticipated		
Natural Assets	Ecological Area	Key Fish Habitat	Conjola Park	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Lowest consequence as natural habitat		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Conjola Park	1	1	27	0	0	1	2	5	27	139	3.9	10	2	5	27	Portion always Inundated	Portion always Inundated	10	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP	Relocate trails, consider spatial area for "migration" of wetlands etc. and establishment of new habitat locations	When trails become frequently impassable
Natural Assets	Ecological Area	Key Fish Habitat	Cunjurong Beach	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Lowest consequence as natural habitat		
Natural Assets	EEC	Bangalay Sand Forest	Cunjurong Beach	1	1	n/r	0	0	1	1	4	n/r	Portion occasionally inundated	Portion occasionally inundated	4	1	5	n/r	Portion frequently Inundated	Portion frequently Inundated	5	Many patches of EEC, foreshore locations inundated		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Cunjurong Beach	1	1	n/r	0	0	1	1	4	n/r	Portion occasionally inundated	Portion occasionally inundated	4	1	5	n/r	Portion frequently Inundated	Portion frequently Inundated	5	Many patches of EEC, foreshore locations inundated		
Natural Assets	EEC	Swamp sclerophyll forest	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as not inundated		
Natural Assets	SEPP Coastal Management	Littoral Rainforest	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Natural Assets	Coastal Wetlands	Saltmarsh	Fishermans Paradise	1	5	23	24	1	5	2	5	23	104	3.3	10	3	5	23	Always Inundated	Always Inundated	15	Increased environmental impact due to current lack of location to "migrate" (colonise), being adjacent farmland	Consider purchasing adjacent farmland to enable migration	Monitor extent / condition of Saltmarsh, purchase once decreasing / degrading
Natural Assets	Ecological Area	Key Fish Habitat	Fishermans Paradise	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5		Always Inundated	Always Inundated	5	Lowest consequence as natural habitat condition		
Natural Assets	EEC	Coastal Saltmarsh	Fishermans Paradise	1	5	27	24	1	5	2	5	27	139	3.9	10	3	5	27	Always Inundated	Always Inundated	15	Increased environmental impact due to current lack of location to "migrate" (colonise), being adjacent farmland	Consider purchasing adjacent farmland to enable migration	Monitor extent / condition of Saltmarsh, purchase once decreasing / degrading
Natural Assets	EEC	Swamp Oak Floodplain Forest	Fishermans Paradise	1	4	27	24	1	4	2	5	27	139	3.9	10	2	5	27	Always Inundated	Always Inundated	10	Increasing tidal inundation may cause dying of low elevated trees due to changes in tidal inundation regime		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Fishermans Paradise	1	1	27	0	0	1	2	5	27	139	3.9	10	2	5	27	Portion always Inundated	Portion always Inundated	10	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP	Relocate trails, consider spatial area for "migration" of wetlands etc. and establishment of new habitats	When trails become frequently impassable
Natural Assets	SEPP Coastal Management	Coastal Wetland	Fishermans Paradise	1	4	27	Frequent Inundation	Frequent Inundation	4	2	5	27	139	3.9	10	3	5	27	Always Inundated	Always Inundated	15	Increased environmental impact due to current lack of location to "migrate" (colonise), being adjacent farmland	Consider acquisition of adjacent farmland to enable migration	Monitor extent / condition of Saltmarsh, purchase once decreasing / degrading

				Current (SLR 0.0m)						20-50 yr Planning Horizon (SLR 0.36m)						100 yr + Planning Horizon (SLR 1.2m)								
				Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating			
Asset Category	Asset Type	Asset Name / Location	Suburb	Current	Current	Closest relevant assessed Location (n/r if not relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	Current	20-50 yr	20-50 yr	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	20-50 yr	100 yr +	100 yr +	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	100 yr +	Comments on Consequence	Suggested management options or existing control	Timeframe / Trigger for Implementation
Natural Assets	Ecological Area	Key Fish Habitat	Lake Conjola	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Lowest consequence as natural habitat		
Natural Assets	EEC	Bangalay Sand Forest	Lake Conjola	1	1	6	Tolerable current inundation	Tolerable current inundation	1	2	4	6	Portion frequently Inundated	Portion frequently Inundated	8	2	5	6	Portion frequently Inundated	Portion frequently Inundated	10	Many patches of EEC, foreshore locations inundated		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Lake Conjola	1	5	n/r	Tolerable current inundation	Tolerable current inundation	5	2	5	n/r	Portion frequently Inundated	Portion frequently Inundated	10	3	5	n/r	Portion always Inundated	Portion always Inundated	15	Many patches of EEC, foreshore locations inundated; Increasing tidal inundation may cause dying of low elevated trees due to changes in tidal inundation regime		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Lake Conjola	1	1	13	0	0	1	1	5	13	0	0	5	2	5	13	Portion always Inundated	Portion always Inundated	10	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP	Relocate trails, consider spatial area for "migration" of wetlands etc. and establishment of new habitat areas	When trails become frequently impassable
Natural Assets	Ecological Area	Key Fish Habitat	Pattimores Lagoon	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Lowest consequence as natural habitat		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Pattimores Lagoon	1	4	12	Tolerable current inundation	Tolerable current inundation	4	2	4	12	52	3.4	8	3	5	12	Always Inundated	Always Inundated	15	Increasing tidal inundation may cause dying of low elevated trees due to changes in tidal inundation regime		
Natural Assets	EEC	Swamp Sclerophyll Forest	Pattimores Lagoon	1	1	12	Tolerable current inundation	Tolerable current inundation	1	2	4	12	52	3.4	8	3	5	12	Always Inundated	Always Inundated	15	Increasing tidal inundation may cause dying of low elevated trees due to changes in tidal inundation regime		
Natural Assets	SEPP Coastal Management	Coastal Wetland	Pattimores Lagoon	1	5	12	Tolerable current inundation	Tolerable current inundation	5	1	5	12	52	3.4	5	1	5	12	Always Inundated	Always Inundated	5	Increased tidal inundation may threaten existing wetlands, but natural environment surrouding the Lagoon provides spaces for "migration" to higher elevation		
Transport Assets	Boat Ramp	Berringer Lake boat ramp	Berringer Lake	1	5	n/r	Portion always Inundated	Portion always Inundated	5	1	5	n/r	Portion always Inundated	Portion always Inundated	5	3	5	n/r	Portion always Inundated	Portion always Inundated	15	Near permanent inundation with 1.2m SLR, requires consideration raising/relocation, as well as type of materials used to construct the boat ramp	Modification of the boat ramp may be required	When asset condition declines to pre-established rating and/or becomes unusable
Transport Assets	Roads Minor	Berringer Cres	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Berringer Rd	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Donnelley St	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Yooralla Bay Boat Ramp	Conjola Park	1	5	18	Portion always Inundated	Portion always Inundated	5	1	5	18	Portion always Inundated	Portion always Inundated	5	3	5	18	Portion always Inundated	Portion always Inundated	15	Lower elevation than Location 18. Near permanent inundation with 1.2m SLR, requires consideration raising/relocation, as well as type of materials used to construct the boat ramp	Modification of the boat ramp may be required	When asset condition declines to pre-established rating and/or becomes unusable
Transport Assets	Jetty	Yooralla Bay Jetty	Conjola Park	1	1	18	0	0	1	1	5	18	Frequent inundation	Frequent inundation	5	3	5	18	Always Inundated	Always Inundated	15	Will become redundant asset	Reconstruct as floating jetty, with vertical capacity to adjust with SLR	When infratructure becomes frequently unuseable
Transport Assets	Roads Minor	Cameron St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Coolibah Ave	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Cottee Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Esme St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Havilland St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Hoddle Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Holylake Gr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Kurrajong Cres	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Lakeside Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Sandra St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Stewart St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Valley Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Wheatley Pl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Windemere St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Cunjurong boat ramp	Cunjurong Beach	1	5	n/r	Portion always Inundated	Portion always Inundated	5	1	5	n/r	Portion always Inundated	Portion always Inundated	5	2	5	n/r	Portion always Inundated	Portion always Inundated	10	Near permanent inundation with 1.2m SLR, requires consideration raising/relocation, as well as type of materials used to construct the boat ramp	Modification of the boat ramp may be required	When asset condition declines to pre-established rating and/or becomes unusable
Transport Assets	Roads Minor	York St	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Alma Ave	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Anglers Parade	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Fishermans Paradise Rd	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Lake Conjola boat ramp	Fishermans Paradise	1	5	23	Portion always Inundated	Portion always Inundated	5	1	5	23	104	3.3	5	2	5	23	Near pernanent inundation	Near pernanent inundation	10	Near permanent inundation with 1.2m SLR, requires consideration raising/relocation, as well as type of materials used to construct the boat ramp	Modification of the boat ramp may be required	When asset condition declines to pre-established rating and/or becomes unusable
Transport Assets	Bridge Minor	Murrays Road bridge	Fishermans Paradise	1	1	27	0	0	1	1	1	27	0	0	1	2	5	27	Frequent Inundation	Frequent Inundation	10	Higher elevation than Location 27, however inundated by 1.2m SLR		
Transport Assets	Roads Minor	Murrays Road	Fishermans Paradise	1	1	27	0	0	1	1	1	27	0	0	1	2	5	27	Frequent Inundation	Frequent Inundation	10	Higher elevation than Location 27, however inundated by 1.2m SLR		
Transport Assets	Roads Minor	Wattle St	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Aney St	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	1	4	8	9	1	4	Most nothern end of road frequently inundated by 0-0.75m under 1.2m SLR		
Transport Assets	Roads Minor	Beach Road	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Boeing Ave	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Carroll Ave	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Conley Ave	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Craig Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Edwin Ave	Lake Conjola	1	1	12	0	0	1	1	1	12	52	3.4	1	3	5	12	Always inundated	Always inundated	15	Western end of road frequently inundated by up to 0.5m for SLR of 1.2m, no inundation for 0.36m SLR and current conditions		
Transport Assets	Roads Minor	Garrad Way	Lake Conjola	1	1	7	0	0	1	1	1	7	0	0	1	4	5	7	433	15.3	20	Near permanent inundation with 1.2m SLR		
Transport Assets	Roads Minor	Lake Conjola Drive	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	1	5	8	9	1	5	Minor inundation in a small area at the foreshore end of the road under SLR of 1.2m (0-0.25m)		
Transport Assets	Boat Ramp	Holiday Haven boat ramp	Lake Conjola	1	5	1	Portion always Inundated	Portion always Inundated	5	3	5	1	52	2.4	15	4	5	1	485	14.1	20	Near permanent inundation with 1.2m SLR, requires consideration raising/relocation, as well as type of materials used to construct the boat ramp	Modification of the boat ramp may be required	When asset condition declines to pre-established rating and/or becomes unusable
Transport Assets	Boat Ramp	Norman Street trailer launch ramp	Lake Conjola	1	5	1	Portion always Inundated	Portion always Inundated	5	3	5	1	52	2.4	15	4	5	1	485	14.1	20	Near permanent inundation with 1.2m SLR, requires consideration raising/relocation, as well as type of materials used to construct the boat ramp	Modification of the boat ramp may be required	When asset condition declines to pre-established rating and/or becomes unusable
Transport Assets	Bridge Major	Lake Conjola Entrance Road bridge	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	2	5	10	Frequent Inundation	Frequent Inundation	10	situated between Location 12 (always inundated) and Location 10 (never inundated) at 1.2m SLR		
Transport Assets	Roads Minor	Lake Conjola Entrance Road	Lake Conjola	1	1	4	0	0	1	1	1	4	0	0	1	2	5	4	225	3.1	10	While recognising the long spatial extent of this road, Location 4 was utilised for likelihood as the "worst case" portion of the asset, although inundation of the intersection with Milham Street should be noted.		
Transport Assets	Roads Major	Lake Conjola Entrance Road	Lake Conjola	1	1	4	0	0	1	1	1	4	0	0	1	2	5	4	225	3.1	10	While recognising the long spatial extent of this road, Location 4 was utilised for likelihood as the "worst case" portion of the asset, although inundation of the intersection with Milham Street should be noted.		
Transport Assets	Roads Minor	Marshal Ave	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Milham St	Lake Conjola	1	1	12	0	0	1	1	1	12	0	0	1	4	5	12	Always inundated	Always inundated	20	No inundation at current conditions and SLR of 0.36m, always inundated by up to 0.5m under SLR of 1.2m		
Transport Assets	Roads Minor	Narrawallee Creek Rd	Lake Conjola	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Norman St	Lake Conjola	1	1	14	0	0	1	1	1	14	0	0	1	2	5	14	139	4.4	10	Moderate inundation in a small area at the foreshore end of the road under SLR of 1.2m (0.5m depth).		
Transport Assets	Roads Minor	Sandgroper Cres	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		

				Current (SLR 0.0m)						20-50 yr Planning Horizon (SLR 0.36m)						100 yr + Planning Horizon (SLR 1.2m)								
				Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating			
Asset Category	Asset Type	Asset Name / Location	Suburb	Current	Current	Closest relevant assessed Location (n/r if not relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	Current	20-50 yr	20-50 yr	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	20-50 yr	100 yr +	100 yr +	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	100 yr +	Comments on Consequence	Suggested management options or existing control	Timeframe / Trigger for Implementation
Transport Assets	Roads Minor	Spinks Ave	Lake Conjola	1	1	12	0	0	1	1	5	12	52	3.4	5	1	5	12	Always inundated	Always inundated	5	Minor inundation in a small area at the eastern end of the road under SLR of 1.2m (0-0.25m)		
Transport Assets	Roads Minor	Thorne Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Residental Development	Residental Development	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Rural Land	Rural Land	Berringer Lake	1	1	11	0	0	1	1	1	11	0	0	1	1	1	11	260	5.2	1	Partial inundation of properties at northern extent		
Urban Development	Residental Development	Residental Development	Conjola Park	1	1	18	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Rural Land	Rural Land	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Heritage (LEP)	Conjola Timber Trestle Bridge	Fishermans Paradise	1	1	26	0	0	1	1	1	26	0	0	1	1	1	26	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Residental Development	Residental Development	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Rural Land	Rural Land	Fishermans Paradise	1	1	27	0	0	1		5	27	139	3.9	0		5	27	Portion always Inundated	Portion always Inundated	0	Impact on use of low lying land	Consider change in land use / zoning	
Urban Development	Commercial Development	Tilly & Mo	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Urban Development	Commercial Development	Lake Conjola Liquor & General Store - LPO	Lake Conjola	1	1	12	0	0	1	1	1	12	0	0	1	3	5	12	Always Inundated	Always Inundated	15	no inundation at current conditions and SLR of 0.36m, moderate inundation under 1.2m SLR (0.25-0.5m)		
Urban Development	Heritage (LEP)	Whitaker's Island View Resort (former)	Lake Conjola	1	1	6	0	0	1	1	1	6	0	0	1		5	6	Frequent Inundation	Frequent Inundation	0	situated between Location 6 (always inundated) and Location 8 (never inundated) at 1.2m SLR		
Urban Development	Residental Development	Residental Development	Lake Conjola	1	1	12	0	0	1		5	12	52	3.4	0		5	12	Portion always Inundated	Portion always Inundated	0			
Urban Development	Rural Land	Rural Land	Lake Conjola	1	1	12	0	0	1		5	12	52	3.1	0		5	12	Portion always Inundated	Portion always Inundated	0			
Urban Development	Tourist Park	Holiday Haven Lake Conjola	Lake Conjola	1	3	2	12	1	3	2	5	2	34.7	2	10	3	5	2	424.7	16.7	15	Suggested consequences are to Asset & Infrastructure (3) Reputation (2) and Financial (2) *There are likely to be "Severe" (5) financial consequence for the Caravan Park, though still rated "Minor" (2) for Council overall, as defined by the Risk Matrix – defined as: "Minor financial loss (up to 3% of Council's budget). Minimal impact on business operation."; no inundation under current conditions and very minor foreshore inundation under SLR of 0.36m, moderate inundation under SLR of 1.2m (up to 0.75m)*	Remove and/or relocate assets Consider raising ground level to mitigate inundation (amendment of Flood Planning Controls required)	Decision on preferred option(s) and preparation of plans can commence in short to medium term. Implementation may relate to monitoring of triggers, e.g. frequency of inundation
Urban Development	Tourist Park	Ingenia Holidays Lake Conjola	Lake Conjola	1	1	13	0	0	1	1	1	13	0	0	1	3	5	13	138.7	43	15	No inundation at current conditions and SLR of 0.36m, moderate inundation under SLR of 1.2m (up to 0.5m)		
Urban Development	Tourist Park	Lake Conjola Deepwater Resort	Lake Conjola	1	1	7	0	0	1	1	1	7	0	0	1	3	5	7	433.3	15.3	15	Near permanent inundation with 1.2m SLR (up to 0.75m deep)		
Urban Development	Tourist Park	Lake Conjola Waterfront Holiday Park	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	1	5	8	8.7	1	5	No inundation at current conditions and SLR of 0.36m, limited moderate inundation under SLR of 1.2m (up to 0.5m)		
Urban Development	Tourist Park	The Leaning Oak Holiday Lifestyle	Lake Conjola	1	1	13	0	0	1	1	1	13	0	0	1	2	5	13	138.7	43	10	No inundation at current conditions and SLR of 0.36m, moderate inundation under SLR of 1.2m (up to 0.75m)		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Berringer Cres	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Berringer Cres	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Berringer Cres	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Berringer Rd	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Berringer Rd	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Berringer Rd	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Donnelley St	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Donnelley St	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Donnelley St	Berringer Lake	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Cameron St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Cameron St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Cameron St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Coolibah Ave	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Coolibah Ave	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Coolibah Ave	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Cottee Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Cottee Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Cottee Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Esme St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Esme St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Esme St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Havilland St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Havilland St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Havilland St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Hoddle Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Hoddle Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Hoddle Cl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Holyoake Gr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Holyoake Gr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Holyoake Gr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	2	5	18	0	0	10	Stormwater outlet draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Kurrajong Cres	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Kurrajong Cres	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Kurrajong Cres	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Lakeside Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Lakeside Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Lakeside Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Sandra St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Sandra St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Sandra St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	2	5	18	0	0	10	One stormwater outlet draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Stewart St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Stewart St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Stewart St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Valler Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Valler Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Valler Dr	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Wheatley Pl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Wheatley Pl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Wheatley Pl	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Windemere St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Windemere St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Windemere St	Conjola Park	1	1	18	0	0	1	1	1	18	0	0	1	1	1	18	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure	Public Toilet	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	York St	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	York St	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	York St	Cunjurong Beach	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Alma Ave	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Alma Ave	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Alma Ave	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Anglers Parade	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Anglers Parade	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	3	3	25	0	0	9	Sewer pumping station (GIS ID 233007) inundated by 0-0.25m water under SLR of 1.2m, which can cause damage to electrics. Potential impacts to the environment caused by overflowing sewers		
Water Infrastructure	Stormwater Infrastructure	Anglers Parade	Fishermans Paradise	1	1	25	0	0	1	2	4	10	0	0	8	2	5	10	Frequent Inundation	Frequent Inundation	10	One stormwater outlet draining into the Lake submerged under SLR of 0.36m and 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Fishermans Paradise Rd	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Fishermans Paradise Rd	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Fishermans Paradise Rd	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		

				Current (SLR 0.0m)						20-50 yr Planning Horizon (SLR 0.36m)						100 yr + Planning Horizon (SLR 1.2m)								
				Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating			
Asset Category	Asset Type	Asset Name / Location	Suburb	Current	Current	Closest relevant assessed Location (n/r if not relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	Current	20-50 yr	20-50 yr	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	20-50 yr	100 yr +	100 yr +	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	100 yr +	Comments on Consequence	Suggested management options or existing control	Timeframe / Trigger for Implementation
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Murrays Road	Fishermans Paradise	1	1	27	0	0	1	1	1	27	0	0	1	1	5	27	Frequent Inundation	Frequent Inundation	5	Higher elevation than Location 27, however inundated by 1.2m SLR; inundated but no infrastructure		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Murrays Road	Fishermans Paradise	1	1	25	0	0	1	1	1	27	0	0	1	1	5	27	Frequent Inundation	Frequent Inundation	5	Higher elevation than Location 27, however inundated by 1.2m SLR; inundated but no infrastructure		
Water Infrastructure	Stormwater Infrastructure	Murrays Road	Fishermans Paradise	1	1	27	0	0	1	1	1	27	0	0	1	1	5	27	Frequent Inundation	Frequent Inundation	5	Inundated frequently but ouncil GIS does not indicate stormwater infrastructure		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Wattle St	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Wattle St	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Wattle St	Fishermans Paradise	1	1	25	0	0	1	1	1	25	0	0	1	1	1	25	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Aney St	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	1	4	8	9	1	4	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Aney St	Lake Conjola	1	1	8	0	0	1	2	4	8	0	0	8	3	4	8	9	1	12	Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Aney St	Lake Conjola	1	1	8	0	0	1	2	4	8	0	0	8	2	5	8	Frequent Inundation	Frequent Inundation	10	Two stormwater outlets draining into the Lake submerged under SLR of 0.36m and 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Beach Road	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Beach Road	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Beach Road	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Boeing Ave	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Boeing Ave	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	No impacts expected as inundation does not affect the sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Boeing Ave	Lake Conjola	1	1	10	0	0	1	2	4	10	0	0	8	2	5	10	Frequent Inundation	Frequent Inundation	10	One stormwater outlets draining into the Lake submerged under SLR of 0.36m and 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Carroll Ave	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Carroll Ave	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	No impacts expected as inundation does not affect the sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Carroll Ave	Lake Conjola	1	1	9	0	0	1	1	4	9	0	0	4	2	5	9	Frequent Inundation	Frequent Inundation	10	Two stormwater outlets draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Conley Ave	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Conley Ave	Lake Conjola	1	1	10	0	0	1	1	1	10	0	0	1	1	1	10	0	0	1	No impacts expected as inundation does not affect the sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Conley Ave	Lake Conjola	1	1	10	0	0	1	2	4	10	0	0	8	2	5	10	Frequent Inundation	Frequent Inundation	10	Two stormwater outlets draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Craig Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Craig Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Craig Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Edwin Ave	Lake Conjola	1	1	12	0	0	1	1	5	12	52	3.4	5	1	5	12	Always inundated	Always inundated	5	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Edwin Ave	Lake Conjola	1	1	12	0	0	1	1	5	12	52	3.4	5	3	5	12	Always inundated	Always inundated	15	Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Edwin Ave	Lake Conjola	1	1	12	0	0	1	2	5	12	52	3.4	10	3	5	12	Always inundated	Always inundated	15	Multiple stormwater outlets draining into the Lake submerged under SLR of 0.36m and 1.2m, which could lead to widespread nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Garrad Way	Lake Conjola	1	1	7	0	0	1	1	1	7	0	0	1	1	5	7	433	15.3	5	Near permanent inundation with 1.2m SLR, but unclear if potable water infrastructure would be impacted		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Garrad Way	Lake Conjola	1	1	7	0	0	1	1	1	7	0	0	1	3	5	7	433	15.3	15	Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Garrad Way	Lake Conjola	1	1	7	0	0	1	1	1	7	0	0	1	3	5	7	433	15.3	15	Two stormwater outlets draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Drive	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	1	5	8	9	1	5	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Drive	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	2	5	8	9	1	10	Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Lake Conjola Drive	Lake Conjola	1	1	8	0	0	1	1	1	8	0	0	1	1	5	8	9	1	5	Mildly inundated under SLR of 1.2m (0-0.25m) but ouncil GIS does not indicate stormwater infrastructure		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Entrance Road	Lake Conjola	1	1	4	0	0	1	1	1	4	0	0	1	1	5	4	225	3.1	5	While recognising the long spatial extent of this road, Location 4 was utilised for likelihood as the "worst case" portion of the asset, although inundation of the intersection with Milham Street should be noted. No impact to potable water infrastructure expected		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Entrance Road	Lake Conjola	1	1	4	0	0	1	1	1	4	0	0	1	2	5	4	225	3.1	10	While recognising the long spatial extent of this road, Location 4 was utilised for likelihood as the "worst case" portion of the asset, although inundation of the intersection with Milham Street should be noted. Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Lake Conjola Entrance Road	Lake Conjola	1	1	4	0	0	1	1	1	4	0	0	1	3	5	4	225	3.1	15	While recognising the long spatial extent of this road, Location 4 was utilised for likelihood as the "worst case" portion of the asset, although inundation of the intersection with Milham Street should be noted. Two stormwater outlets draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding and cutting off this main entrance road		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Marshal Ave	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Marshal Ave	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Marshal Ave	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Milham St	Lake Conjola	1	1	12	0	0	1	1	1	12	0	0	1	1	5	12	Always inundated	Always inundated	5	Near permanent inundation with 1.2m SLR, but unclear if potable water infrastructure would be impacted		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Milham St	Lake Conjola	1	1	12	0	0	1	1	1	12	0	0	1	3	5	12	Always inundated	Always inundated	15	Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Milham St	Lake Conjola	1	1	12	0	0	1	1	1	12	0	0	1	3	5	12	Always inundated	Always inundated	15	Multiple stormwater outlets draining into the Lake submerged under SLR of 1.2m, which could lead to widespread nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Narrawallee Creek Rd	Lake Conjola	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Narrawallee Creek Rd	Lake Conjola	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Narrawallee Creek Rd	Lake Conjola	1	1	n/r	0	0	1	1	1	n/r	0	0	1	1	1	n/r	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Norman St	Lake Conjola	1	1	14	0	0	1	1	1	14	0	0	1	1	5	14	139	4.4	5	No impacts to potable water infrastructure expected from tidal inundation		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Norman St	Lake Conjola	1	1	14	0	0	1	1	1	14	0	0	1	2	5	14	139	4.4	10	Potential impacts to the environment caused by overflowing sewer infrastructure		
Water Infrastructure	Stormwater Infrastructure	Norman St	Lake Conjola	1	1	14	0	0	1	1	1	14	0	0	1	2	5	14	139	4.4	10	Potentially one stormwater outlet draining into the Lake submerged under SLR of 1.2m, which could lead to localised nuisance flooding (asset location not clear)		
Water Infrastructure	Sewer Infrastructure	Public Toilet - Beachside Court	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure	Public Toilet - Closest to Conjola Beach	Lake Conjola	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	On higher ground level		

				Current (SLR 0.0m)						20-50 yr Planning Horizon (SLR 0.36m)						100 yr + Planning Horizon (SLR 1.2m)								
				Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating	Consequence	Likelihood				Risk Rating			
Asset Category	Asset Type	Asset Name / Location	Suburb	Current	Current	Closest relevant assessed Location (n/r if not relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	Current	20-50 yr	20-50 yr	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	20-50 yr	100 yr +	100 yr +	Closest relevant assessed Location (n/r if none relevant)	Average Annual Tidal Inundation Occurences	Average Tidal Inundation Duration per occurrence (hours)	100 yr +	Comments on Consequence	Suggested management options or existing control	Timeframe / Trigger for Implementation
Water Infrastructure	Sewer Infrastructure	Public Toilet - Holiday Haven	Lake Conjola	1	1	3	0	0	1	1	1	3	0	0	1	3	5	3	52	3.3	15	No inundation and current conditions and SLR of 0.36m, moderate inundation under SLR of 1.2m (0.5-0.75m)		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Sandgroper Cres	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Sandgroper Cres	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Sandgroper Cres	Lake Conjola	1	1	17	0	0	1	1	1	17	0	0	1	1	1	17	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure	Sewage Infiltration System	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure	Sewage Treatment Plant	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Spinks Ave	Lake Conjola	1	1	12	0	0	1	1	5	12	52	3.4	5	1	5	12	Always inundated	Always inundated	5	Near permanent inundation with 1.2m SLR, but unclear if potable water infrastructure would be impacted		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Spinks Ave	Lake Conjola	1	1	12	0	0	1	1	5	12	52	3.4	5	3	5	12	Always inundated	Always inundated	15	Sewer pumping station (GIS ID 233213) inundated by 0-0.25m water under SLR of 1.2m, which can cause damage to electrics. Potential impacts to the environment caused by overflowing sewers		
Water Infrastructure	Stormwater Infrastructure	Spinks Ave	Lake Conjola	1	1	12	0	0	1	2	5	12	52	3.4	10	3	5	12	Always inundated	Always inundated	15	One stormwater outlets draining into the Lake submerged under SLR of 0.36m and 1.2m, which could lead to localised nuisance flooding		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Thorne Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs	n/r	n/r
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Thorne Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs	n/r	n/r
Water Infrastructure	Stormwater Infrastructure	Thorne Street	Lake Conjola	1	1	9	0	0	1	1	1	9	0	0	1	1	1	9	0	0	1	Lowest consequence as no inundation occurs	n/r	n/r
Waterways	Natural waterways	Berringer Lake	Berringer Lake	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Negligible consequence for natural waterways	NA	NA
Waterways	Recreational waterways	Berringer Lake	Berringer Lake	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Natural situation	NA	NA
Waterways	Natural waterways	Lake Conjola	Lake Conjola	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Negligible consequence for natural waterways	NA	NA
Waterways	Recreational waterways	Lake Conjola	Lake Conjola	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	1	5	n/r	Always Inundated	Always Inundated	5	Natural situation	NA	NA

Project: PA2591

Lake Conjola Coastal Management Program

Coastal Inundation Hazard and Risk Assessment

Risk assessment undertaken by:
Shoalhaven City Council : Nigel Smith
DPE: Daniel Wiecek
RHDHV: Greg Britton, Matt Potter, Daniel Horton

Date:

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Community Asset	Carpark\Carpark	Berringer Lake boat ramp car park	Berringer Lake	1	1	1	2	2	4	2	3	6	temporary minor inundation of boat ramp and car park at current SL (0.25m), becoming more severe with SLR (up to 1m under 1.2m SLR)		
Community Asset	Carpark\Carpark	Yooralla Bay boat ramp car park	Conjola Park	1	1	1	1	2	2	2	3	6	no inundation at current conditions and SLR of 0.36m, moderate temporary inundation of car park under 1.2m SLR (0.25-0.5m)		
Community Asset	Open Space / Reserves / Parks	Picnic Bay	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Community Asset	Open Space / Reserves / Parks	Yooralla Bay Reserve	Conjola Park	2	1	2	2	2	4	2	3	6	Moderate temporary inundation of reserve under current conditions, becoming more severe under both SLR scenarios (up to 1m)		
Community Asset	Open Space and Recreation\Park Furniture\Play Equipment	Play Equipment	Conjola Park	1	1	1	1	2	2	1	3	3			
Community Asset	Community Building	RFS Brigade building	Cunjurong	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Community Asset	Natural Area	Cunjurong Point	Cunjurong	1	1	1	1	2	2	1	3	3	Lowest consequence as natural occurance, noting likely spatial adjustment due to SLR; risk of foreshore erosion due to elevated tidal levels		
Community Asset	Carpark\Carpark	Cunjurong boat ramp car park	Cunjurong Beach	1	1	1	2	2	4	3	3	9	no inundation at current SL, but only very minor inundation impacting boat ramp car park under both SLR scenarios; access road temporarily inundated during 1.2m SLR (by up to 0.5m)		
Community Asset	Carpark\Carpark	Lake Conjola boat ramp car park	Fishermans Paradise	2	1	2	2	2	4	3	3	9	moderate temporary inundation of car park at current SL (0.25-0.5m), becoming more severe under 0.36m SLR (0.75-1m) and 1.2m SLR (>1.0m)		
Community Asset	Community Building	RFS Brigade building	Fishermans Paradise	1	1	1	1	2	2	3	3	9	Temporary inundation of property across all scenarios. RFS building affected by minor temporary inundation under 1.2m SLR (0-0.5m) with implications for RFS operations.		
Community Asset	Open Space / Reserves / Parks	Hazel Robotham Reserve	Fishermans Paradise	1	1	1	1	2	2	2	3	6	Temporary inundation of reserve across all scenarios, varying in magnitude between 0 - 1 m depending on elevation. Some private properties affected under SLR of 1.2m.		
Community Asset	Carpark\Carpark	Holiday Haven boat ramp car park	Lake Conjola	2	1	2	2	2	4	3	3	9	severe temporary inundation (> 1m) of car park under all scenarios, with potential damage to infrastructure (repairable)		
Community Asset	Carpark\Carpark	Lake Conjola Community Centre	Lake Conjola	2	1	2	3	2	6	4	3	12	temporary inundation across alll scenarios, being minor currently (0-0.25m), moderate under 0.6m SLR (0.25-0.5m), and severe under 1.2m SLR (>1m)		
Community Asset	Community Building	Lake Conjola Community Centre	Lake Conjola	2	1	2	3	2	6	4	3	12	temporary inundation across alll scenarios, being minor currently (0-0.25m), moderate under 0.6m SLR (0.25-0.5m), and severe under 1.2m SLR (>1m)		
Community Asset	Community Building	RFS Brigade building	Lake Conjola	1	1	1	2	2	4	4	3	12	no inundation at current SL, but minor temporary inundation under SLR of 0.36m (0-0.25m), becoming severe under 1.2m SLR (0.5-1m). Medium-term impact on operational services of RFS		
Community Asset	Natural Area	Conjola Beach	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as natural occurance, noting likely spatial adjustment due to SLR; risk of foreshore erosion due to elevated tidal levels		
Community Asset	Natural Area	Narrawallee Creek Nature reserve	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Community Asset	Open Space / Reserves / Parks	Edwin Avenue Reserve	Lake Conjola	2	1	2	4	2	8	5	3	15	particularly eastern part of the reserve severly inundated (>1m) under 1.2m SLR, moderate inundation under 0.36m SLR. Adjacent private property affected by inundation		
Community Asset	Open Space / Reserves / Parks	Leaning Oak Point	Lake Conjola	2	1	2	4	2	8	5	3	15	severly inundated (>1m) under 1.2m SLR, moderate inundation under 0.36m SLR. Adjacent caravan sites affected by inundation		
Community Asset	Open Space / Reserves / Parks	Roberts Point	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Bowling Club	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Community Centre tennis court	Lake Conjola	1	1	1	2	2	4	3	3	9	no inundation at current SL, minor inundation at 0.36m SLR (<0.25m), major inundation with 1.2m SLR (0.75-1m); however, impacts on infrastructure are assumed to be minor / repairable		
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Sports Field - off Thorne Street	Lake Conjola	1	1	1	2	2	4	3	3	9	no inundation at current SL, moderate inundation at 0.36m SLR (0.25-0.5m), major inudnation with 1.2m SLR (>1m); however, impacts on infrastructure are assumed to be minor / repairable		
Natural Assets	EEC	Coastal Saltmarsh	Berringer Lake	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Berringer Lake	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Swamp sclerophyll forest	Berringer Lake	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Berringer Lake	1	1	1	2	2	4	2	3	6	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP		
Natural Assets	SEPP Coastal Management	Littoral Rainforest	Berringer Lake	1	1	1	2	2	4	2	3	6	Potentially some temporary inundation of low-lying Littoral Rainforest		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Conjola Park	1	1	1	2	2	4	2	3	6	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP		
Natural Assets	EEC	Bangalay Sand Forest	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Natural Assets	EEC	Swamp sclerophyll forest	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Natural Assets	SEPP Coastal Management	Littoral Rainforest	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Natural Assets	Coastal Wetlands	Saltmarsh	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Coastal Saltmarsh	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Fishermans Paradise	1	1	1	2	2	4	2	3	6	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP		
Natural Assets	SEPP Coastal Management	Coastal Wetland	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Bangalay Sand Forest	Lake Conjola	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Lake Conjola	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Lake Conjola	1	1	1	2	2	4	2	3	6	Some impact on e.g. foreshore trails and low-lying habitats (wetlands etc.), though minimal in respect to the scale of the NP		
Natural Assets	EEC	Swamp Oak Floodplain Forest	Pattimores Lagoon	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	EEC	Swamp Sclerophyll Forest	Pattimores Lagoon	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Natural Assets	SEPP Coastal Management	Coastal Wetland	Pattimores Lagoon	1	1	1	1	2	2	1	3	3	Negligible consequences as inundation is only temporary		
Transport Assets	Boat Ramp	Berringer Lake boat ramp	Berringer Lake	1	1	1	2	2	4	2	3	6	temporary minor inundation of boat ramp and car park at current SL (0.25m), becoming more severe with SLR (up to 1m under 1.2m SLR)		
Transport Assets	Roads Minor	Berringer Cres	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Berringer Rd	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Donnelley St	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Yooralla Bay Boat Ramp	Conjola Park	1	1	1	1	2	2	2	3	6	no inundation at current conditions and SLR of 0.36m, moderate temporary inundation of car park under 1.2m SLR (0.25-0.5m)		
Transport Assets	Jetty	Yooralla Bay Jetty	Conjola Park	1	1	1	2	2	4	3	3	9	Will become redundant asset	Reconstruct as floating jetty, with vertical capacity to adjust with SLR	When infratructure becomes frequently unuseable
Transport Assets	Roads Minor	Cameron St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Coolibah Ave	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Cottee Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Esme St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Havilland St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Hoddle Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Holylake Gr	Conjola Park	1	1	1	1	2	2	1	3	3	potentially very minor temporary inundation at the foreshore end of the street (0-0.25m)		
Transport Assets	Roads Minor	Kurrajong Cres	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Lakeside Dr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Sandra St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Stewart St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Valley Dr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Wheatley Pl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Windemere St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Cunjurong boat ramp	Cunjurong Beach	1	1	1	1	2	2	2	3	6	no inundation at current SL, but only moderate inudnation impacting boat ramp under both SLR scenarios; access road temporarily inundated during 1.2m SLR (by up to 0.5m)		
Transport Assets	Roads Minor	York St	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Lake Conjola boat ramp	Fishermans Paradise	2	1	2	2	2	4	3	3	9	moderate inundation at current conditions (0.25-0.5m), more severe with SLR (> 1m)		
Transport Assets	Bridge Minor	Murrays Road bridge	Fishermans Paradise	2	1	2	2	2	4	3	3	9	Consequences difficult to estimate as height of bridge unknown - but given the road is inundated, similar impacts to adjacent road		
Transport Assets	Roads Minor	Alma Ave	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Anglers Parade	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Fishermans Paradise Rd	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Murrays Road	Fishermans Paradise	2	1	2	2	2	4	3	3	9	Road severely inundated for all scenarios (>1m)		
Transport Assets	Roads Minor	Wattle St	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Boat Ramp	Holiday Haven boat ramp	Lake Conjola	2	1	2	3	2	6	3	3	9	severe inundation at current conditions and for both SLR SLR scenarios (> 1m)		
Transport Assets	Boat Ramp	Norman Street trailer launch ramp	Lake Conjola	2	1	2	2	2	4	3	3	9	moderate inundation at current conditions (0.25-0.5m), more severe with SLR (> 1m)		
Transport Assets	Bridge Major	Lake Conjola Entrance Road bridge	Lake Conjola	2	1	2	3	2	6	4	3	12	Minor inundation for parts of the road (e.g. intersection with Milham St) under current conditions (0-0.25m), moderate temporary inundation east of Milham St under SLR of 0.36m (0.5-0.75m), and severe temporary inundation under SLR 0f 1.2 m (>1m), leading to isolation of more easterly parts of Lake Conjola		
Transport Assets	Roads Major	Lake Conjola Entrance Road	Lake Conjola	2	1	2	3	2	6	4	3	12	Minor inudnation for parts of the road (e.g. intersection with Milham St) under current conditions (0-0.25m), moderate temporary inundation east of Milham St under SLR of 0.36m (0.5-0.75m), and severe temporary inundation under SLR 0f 1.2 m (>1m), leading to isolation of more easterly parts of Lake Conjola		

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Transport Assets	Roads Minor	Aney St	Lake Conjola	2	1	2	2	2	4	3	3	9	Minor inudnation of most of the road for current conditions (0-0.25m), moderate temporary inundation under SLR of 0.36m (0.5-0.75m), and severe temporary inundation under SLR 0f 1.2 m (>1m)		
Transport Assets	Roads Minor	Beach Road	Lake Conjola	1	1	1	2	2	4	3	3	9	Parts of the road temporarily inundated by up to 0.5m under SLR of 0.36m, more severe inudnation under SLR of 1.2m (> 1m).		
Transport Assets	Roads Minor	Boeing Ave	Lake Conjola	1	1	1	2	2	4	3	3	9	No inundation at current conditions, minor temporary inundation under SLR of 0.36m (0-0.25m), more severe under SLR of 1.2m (> 1m).		
Transport Assets	Roads Minor	Carroll Ave	Lake Conjola	2	1	2	3	2	6	3	3	9	Minor inudnation of parts of the road for current conditions (0-0.25m), moderate more widespread temporary inundation under SLR of 0.36m (0.25-0.5), and severe temporary inundation under SLR 0f 1.2 m (>1m)		
Transport Assets	Roads Minor	Conley Ave	Lake Conjola	1	1	1	2	2	4	3	3	9	No inundation under current conditions, localised minor inundation at eastern end of the road under 0.36m SLR (0-0.25m), severe temporary inundation of 0.75-1m+ under SLR of 1.2m		
Transport Assets	Roads Minor	Craig Street	Lake Conjola	1	1	1	2	2	4	3	3	9	No inudnation under current conditions, minor-moderate inudnation of parts of the road under SLR of 0.36m (0-0.5), and severe temporary inundation under SLR 0f 1.2 m (>1m)		
Transport Assets	Roads Minor	Edwin Ave	Lake Conjola	2	1	2	2	2	4	3	3	9	Minor to moderate temporary inundation at the eastern end of road for current conditions (0-0.5m), similar extent but slightly higher depths under SLR of 0.36m (0.5-1), similar extent but exceeding 1m under SLR of 1.2m).		
Transport Assets	Roads Minor	Garrad Way	Lake Conjola	2	1	2	3	2	6	3	3	9	entirely temporarily inundated by 0.25-1m under current conditions, severly inundated under SLR of 0.36m and 1m (> 1m).		
Transport Assets	Roads Minor	Lake Conjola Drive	Lake Conjola	2	1	2	3	2	6	3	3	9	Minor inudnation of parts of the road for current conditions (0-0.25m), moderate more widespread temporary inundation under SLR of 0.36m (0.25-0.5), and severe temporary inundation under SLR 0f 1.2 m (>1m)		
Transport Assets	Roads Minor	Lake Conjola Entrance Road	Lake Conjola	2	1	2	3	2	6	3	3	9	Minor inudnation for parts of the road (e.g. intersection with Milham St) under current conditions (0-0.25m), moderate temporary inundation east of Milham St under SLR of 0.36m (0.5-0.75m), and severe temporary inundation under SLR 0f 1.2 m (>1m)		
Transport Assets	Roads Minor	Marshal Ave	Lake Conjola	2	1	2	2	2	4	3	3	9	Minor inudnation of parts of the road for current conditions (0-0.25m), moderate more widespread temporary inundation under SLR of 0.36m (0.25-0.5), and severe temporary inundation under SLR 0f 1.2 m (>1m)		
Transport Assets	Roads Minor	Milham St	Lake Conjola	2	1	2	3	2	6	3	3	9	Mostly inundated by 0-0.5m under current conditions, becoming more severe under SLR of 0.36m (<1m) and most severly under SLR of 1.2m (>1m).		
Transport Assets	Roads Minor	Narrawallee Creek Rd	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Transport Assets	Roads Minor	Norman St	Lake Conjola	2	1	2	2	2	4	2	3	6	Small area at the foreshore end of the road temporarily inundated under current conditions (0.25-0.75m), becoming more sever under SLR (>1m).		
Transport Assets	Roads Minor	Sandgroper Cres	Lake Conjola	1	1	1	2	2	4	3	3	9	No inundation under current conditions, minor to moderate inundation at the most nothern and western end of the road under SLR of 0.36m (0.25-0.75m), severe inundation under SLR of 1.2m (> 1m).		
Transport Assets	Roads Minor	Spinks Ave	Lake Conjola	1	1	1	2	2	4	2	3	6	No inundation under current condtions, minor-moderate temporary inundation at the eastern end of the road under SLR of 0.36m (0-0.5m), becoming more severe under SLR of 1.2m (> 1m) but still localised		
Transport Assets	Roads Minor	Thorne Street	Lake Conjola	1	1	1	2	2	4	3	3	9	No inundation under current conditions, widespread minor-moderate temporary inundation under SLR of 0.36m (0-0.5m), becoming severe under SLR of 1.2m (>1m).		
Urban Development	Residental Development	Residental Development	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Urban Development	Rural Land	Rural Land	Berringer Lake		1	0		2	0		3	0			
Urban Development	Residental Development	Residental Development	Conjola Park		1	0		2	0		3	0			
Urban Development	Rural Land	Rural Land	Conjola Park		1	0		2	0		3	0			
Urban Development	Heritage (LEP)	Conjola Timber Trestle Bridge	Fishermans Paradise		1	0		2	0		3	0			
Urban Development	Residental Development	Residental Development	Fishermans Paradise		1	0		2	0		3	0			
Urban Development	Rural Land	Rural Land	Fishermans Paradise		1	0		2	0		3	0			
Urban Development	Commercial Development	Lake Conjola Liquor & General Store - LPO	Lake Conjola	1	1	1	1	2	2	2	3	6	Moderate inundation at current conditions (0.75m), more severe under SLR of 0.36m (up to 1m), becoming severe under SLR of 1.2m (>1m)		
Urban Development	Commercial Development	Tilly & Mo	Lake Conjola	1	1	1	2	2	4	3	3	9	No inundation at current conditions, minor temporary inundation under SLR of 0.36m (0-0.25m), more severe under SLR of 1.2m (> 1m).		
Urban Development	Heritage (LEP)	Whitaker's Island View Resort (former)	Lake Conjola		1	0		2	0		3	0			
Urban Development	Residental Development	Residental Development	Lake Conjola		1	0		2	0		3	0			
Urban Development	Rural Land	Rural Land	Lake Conjola		1	0		2	0		3	0			
Urban Development	Tourist Park	Holiday Haven Lake Conjola	Lake Conjola	2	1	2	3	2	6	3	3	9	Moderate temporary inundation at current conditions (0.75m), more severe under SLR of 0.36m (up to 1m), becoming severe under SLR of 1.2m (>1m)		

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Urban Development	Tourist Park	Ingenia Holidays Lake Conjola	Lake Conjola	2	1	2	3	2	6	3	3	9	Moderate temporary inundation at current conditions (0.75m), more severe under SLR of 0.36m (up to 1m), becoming severe under SLR of 1.2m (>1m)		
Urban Development	Tourist Park	Lake Conjola Deepwater Resort	Lake Conjola	2	1	2	3	2	6	3	3	9	Moderate temporary inundation at current conditions (0.75m), more severe under SLR of 0.36m (up to 1m), becoming severe under SLR of 1.2m (>1m)		
Urban Development	Tourist Park	Lake Conjola Waterfront Holiday Park	Lake Conjola	2	1	2	3	2	6	3	3	9	Moderate temporary inundation at current conditions (0.75m), more severe under SLR of 0.36m (up to 1m), becoming severe under SLR of 1.2m (>1m)		
Urban Development	Tourist Park	The Leaning Oak Holiday Lifestyle	Lake Conjola	2	1	2	3	2	6	3	3	9	Moderate temporary inundation at current conditions (0.75m), more severe under SLR of 0.36m (up to 1m), becoming severe under SLR of 1.2m (>1m)		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Berringer Cres	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Berringer Rd	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Donnelley St	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Berringer Cres	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Berringer Rd	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Donnelley St	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Berringer Cres	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Berringer Rd	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Donnelley St	Berringer Lake	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Cameron St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Coolibah Ave	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Cottee Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Esme St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Havilland St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Hoddle Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Holyoake Gr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Kurrajong Cres	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Lakeside Dr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Sandra St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Stewart St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Valler Dr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Wheatley Pl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Windemere St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Cameron St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Coolibah Ave	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Cottee Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Esme St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Havilland St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Hoddle Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Holyoake Gr	Conjola Park	1	1	1	1	2	2	2	3	6	Sewer pumping station temporarily inundated by 0-0.25m water under SLR of 1.2m, which can cause damage to electrics. Potential impacts to the environment caused by overflowing sewers		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Kurrajong Cres	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Lakeside Dr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Sandra St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Stewart St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Valler Dr	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Wheatley Pl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Windemere St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Cameron St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Coolibah Ave	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Cottee Cl	Conjola Park	1	1	1	1	2	2	2	3	6	One stormwater outlet draining into the Lake submerged under SLR of 1.2m, which could lead to localised temporary ponding of water		
Water Infrastructure	Stormwater Infrastructure	Esme St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Havilland St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Hoddle Cl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Holyoake Gr	Conjola Park	2	1	2	2	2	4	3	3	9	One stormwater outlet draining into the Lake submerged under all scenarios, which could lead to localised temporary ponding of water becoming more severe with SLR		
Water Infrastructure	Stormwater Infrastructure	Kurrajong Cres	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Lakeside Dr	Conjola Park	2	1	2	2	2	4	2	3	6	One stormwater outlet draining into the Lake submerged under all scenarios, which could lead to localised temporary ponding of water becoming more severe with SLR		
Water Infrastructure	Stormwater Infrastructure	Sandra St	Conjola Park	2	1	2	2	2	4	2	3	6	One stormwater outlet draining into the Lake submerged under all scenarios, which could lead to localised temporary ponding of water becoming more severe with SLR		
Water Infrastructure	Stormwater Infrastructure	Stewart St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Water Infrastructure	Stormwater Infrastructure	Valler Dr	Conjola Park	1	1	1	1	2	2	1	3	3	One stormwater outlet draining into the Lake submerged under 0.36m and 1.2 m SLR, which could lead to localised temporary ponding of water		
Water Infrastructure	Stormwater Infrastructure	Wheatley Pl	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Windemere St	Conjola Park	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	York St	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure	Public Toilet	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	York St	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	York St	Cunjurong Beach	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Alma Ave	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Anglers Parade	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Fishermans Paradise Rd	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Murrays Road	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Wattle St	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Alma Ave	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Anglers Parade	Fishermans Paradise	1	1	1	1	2	2	3	3	9	Two sewer pumping stations (GIS ID 233007 & 233109) inundated by up to 0.75m water under SLR of 1.2m, which can cause damage to electrics. Potential impacts to the environment caused by overflowing sewers		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Fishermans Paradise Rd	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Murrays Road	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Inundated but no infrastructure		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Wattle St	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Alma Ave	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Anglers Parade	Fishermans Paradise	1	1	1	2	2	4	3	3	9	One stormwater outlet draining into the Lake submerged under all scenarios, which could lead to localised temporary ponding of water. Multiple outlets affected under SLR of 0.36 and 1.2m		
Water Infrastructure	Stormwater Infrastructure	Fishermans Paradise Rd	Fishermans Paradise	1	1	1	1	2	2	2	3	6	One stormwater outlet draining into the Lake submerged under SLR of 1.2m, which could lead to localised temporary ponding of water		
Water Infrastructure	Stormwater Infrastructure	Murrays Road	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Widespread inundation of Murrays Rd but council GIS shows no stormwater infrastructure		
Water Infrastructure	Stormwater Infrastructure	Wattle St	Fishermans Paradise	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Aney St	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Beach Road	Lake Conjola	1	1	1	1	2	2	1	3	3	No potable water infrastructure in Councils GIS		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Boeing Ave	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Carroll Ave	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Conley Ave	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Craig Street	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Edwin Ave	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Garrad Way	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Drive	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Entrance Road	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Marshal Ave	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Milham St	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Narrawallee Creek Rd	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Norman St	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Sandgroper Cres	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Spinks Ave	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Thorne Street	Lake Conjola	1	1	1	1	2	2	1	3	3	No impacts to potable water infrastructure from temporary inundation expected		
Water Infrastructure	Sewer Infrastructure	Public Toilet - Beachside Court	Lake Conjola	2	1	2	3	2	6	3	3	9	moderate inundation at current conditions (0.25-0.5m), more severe with SLR (> 1m) leading to environmental impacts from overflow and potential damages to infrastructure		
Water Infrastructure	Sewer Infrastructure	Public Toilet - Closest to Conjola Beach	Lake Conjola	1	1	1	1	2	2	2	3	6	no inundation at current conditions and SLR of 0.36m, moderate-severe temporary inundation under 1.2m SLR (0.5-1m) leading to environmental impacts from overflow and potential damages to infrastructure		
Water Infrastructure	Sewer Infrastructure	Public Toilet - Holiday Haven	Lake Conjola	2	1	2	3	2	6	3	3	9	moderate inundation at current conditions (0.5-0.75m), becoming more severe with SLR (>1m) leading to environmental impacts from overflow and potential damages to infrastructure		
Water Infrastructure	Sewer Infrastructure	Sewage Infiltration System	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure	Sewage Treatment Plant	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Aney St	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Beach Road	Lake Conjola	1	1	1	1	2	2	1	3	3	No sewer infrastrucutre in councils GIS		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Boeing Ave	Lake Conjola	1	1	1	2	2	4	3	3	9	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained small scale impacts to the environment) and SLR of 1.2m (contained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Carroll Ave	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Conley Ave	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Craig Street	Lake Conjola	1	1	1	2	2	4	4	3	12	Potential impacts to the environment caused by overflowing sewers under SLR of 0.36m (contained small scale impacts to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Edwin Ave	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Garrad Way	Lake Conjola	3	1	3	4	2	8	4	3	12	Potential impacts to the environment caused by overflowing sewers under current conditions and SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Drive	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Lake Conjola Entrance Road	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Marshal Ave	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Milham St	Lake Conjola	2	1	2	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained widespread impact to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Narrawallee Creek Rd	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Norman St	Lake Conjola	1	1	1	2	2	4	2	3	6	Potential impacts to the environment caused by overflowing sewers under SLR of 0.36m and 1.2m (contained small scale impacts to the environment).		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Sandgroper Cres	Lake Conjola	1	1	1	2	2	4	3	3	9	Potential impacts to the environment caused by overflowing sewers, particularly under SLR of 0.36m (contained small scale impacts to the environment) and SLR of 1.2m (contained widespread impact to the environment)		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Spinks Ave	Lake Conjola	1	1	1	3	2	6	3	3	9	Potential impacts to the environment caused by overflowing sewers under SLR of 0.36m and 1.2m (contained small scale impacts to the environment). Sewer pumping station (GIS ID 233213) inundated by 0-0.25m water under SLR of 1.2m, which can cause damage to electrics.		
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Thorne Street	Lake Conjola	1	1	1	3	2	6	4	3	12	Potential impacts to the environment caused by overflowing sewers under SLR of 0.36m (contained widespread impacts to the environment) and SLR of 1.2m (uncontained widespread impact to the environment)		
Water Infrastructure	Stormwater Infrastructure	Aney St	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Beach Road	Lake Conjola	1	1	1	1	2	2	1	3	3	Inundation of the road under SLR of 0.36 and 1.2m, but council GIS displays no stormwater infrastructure		
Water Infrastructure	Stormwater Infrastructure	Boeing Ave	Lake Conjola	2	1	2	3	2	6	3	3	9	One stormwater outlet draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions, and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Carroll Ave	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR		

				Current (SLR 0.0m)			20-50 yr Planning Horizon (SLR 0.36m)			100 yr + Planning Horizon (SLR 1.2m)					
				Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating	Consequence	Likelihood	Risk Rating			
Asset Category	**Asset Type**	**Asset Name / Location**	**Suburb**	Current	Current	Current	20-50 yr	20-50 yr	20-50 yr	100 yr +	100 yr +	100 yr +	**Comments on Consequence**	**Suggested management options or existing control**	**Timeframe / Trigger for Implementation**
Water Infrastructure	Stormwater Infrastructure	Conley Ave	Lake Conjola	1	1	1	2	2	4	3	3	9	Most stormwater outlets draining into the Lake submerged under SLR of 0.36m and 1.2m, leading to localised temporary ponding or prolonged inundation under SLR of 1.2m		
Water Infrastructure	Stormwater Infrastructure	Craig Street	Lake Conjola	1	1	1	2	2	4	3	3	9	One stormwater outlet draining into the Lake submerged under SLR of 0.36m and 1.2m, leading to localised temporary ponding or prolonged inundation under SLR of 1.2m		
Water Infrastructure	Stormwater Infrastructure	Edwin Ave	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Garrad Way	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Lake Conjola Drive	Lake Conjola	1	1	1	1	2	2	1	3	3	Inundated under all scenarios, but council GIS does not indicate stormwater infrastructure		
Water Infrastructure	Stormwater Infrastructure	Lake Conjola Entrance Road	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR; main access road into Lake Conjola affected		
Water Infrastructure	Stormwater Infrastructure	Marshal Ave	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Milham St	Lake Conjola	2	1	2	3	2	6	3	3	9	Most stormwater outlets draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Narrawallee Creek Rd	Lake Conjola	1	1	1	1	2	2	1	3	3	Lowest consequence as no inundation occurs		
Water Infrastructure	Stormwater Infrastructure	Norman St	Lake Conjola	2	1	2	2	2	4	2	3	6	Potentially one stormwater outlet draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water (asset location not clear)		
Water Infrastructure	Stormwater Infrastructure	Sandgroper Cres	Lake Conjola	1	1	1	2	2	4	3	3	9	Most stormwater outlets draining into the Lake submerged under SLR of 0.36m and 1.2m, leading to localised temporary ponding or prolonged inundation under SLR of 1.2m		
Water Infrastructure	Stormwater Infrastructure	Spinks Ave	Lake Conjola	2	1	2	2	2	4	3	3	9	One stormwater outlet draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions, and potentially prolonged inundation under SLR		
Water Infrastructure	Stormwater Infrastructure	Thorne Street	Lake Conjola	1	1	1	2	2	4	3	3	9	One stormwater outlet draining into the Lake submerged in all scenarios, leading to localised temporary ponding of water under current conditions, and potentially prolonged inundation under SLR		

ASSET TYPE	MANAGEMENT OPTIONS / CONTROLS
Boat Ramp	raise carpark level, subject to flood impact assessment
	raise boat ramp crest level
	raise on-ramp pontoon abutment level
	close boat ramp during periods of inundation
	relocate boat ramp
Bridge Major	monitor frequency of inundation and public amenity and public safety (e.g. evacuation) impacts
	raise road approach level, subject to flood impact assessment
	raise bridge deck level
	consider installation of flood levees, subject to flood impact assessment
	investigate new road/bridge access
	arrange alternative temporary access (e.g. waterborne access with vessels)
Bridge Minor	monitor frequency of inundation and public amenity and public safety (e.g. evacuation) impacts
	raise road approach level, subject to flood impact assessment
	raise bridge deck level
	consider installation of flood levees, subject to flood impact assessment
	install flood gates and detour signage for alternate routes during times of inundation
	investigate new road/bridge access
	arrange alternative temporary access (e.g. waterborne access with vessels)
Carpark\Carpark	raise carpark level, subject to flood impact assessment
	close carpark during periods of inundation
	consider relocation of asset to higher ground
	consider installation of flood levees, subject to flood impact assessment
	revise design standards
Coastal Wetlands	monitor extent/condition of coastal wetlands
	allow natural migration of wetland (e.g. saltmarsh) to occur into adjacent land
	limit public access into vulnerable coastal wetland and migration areas
	consider purchase of adjacent farmland/private land to enable migration of wetland (e.g. saltmarsh)
Commercial Development	consider raising of floor levels for existing buildings or new development
	consider raising of land, subject to flood impact assessment
	consider installation of flood levees, subject to flood impact assessment
	consider relocation of asset to higher ground
Community Building	consider raising of floor levels for existing buildings or new development
	consider raising of land, subject to flood impact assessment
	consider installation of flood levees, subject to flood impact assessment
	consider relocation of asset to higher ground
Ecological Area	natural waterway habitat not affected by inundation
EEC	monitor extent/condition of EEC
	allow natural migration of EEC to occur into adjacent land
	limit public access into vulnerable EEC and migration areas
	consider purchase of adjacent farmland/private land to enable migration of EEC
	active management of EEC, including transplanting and planting of EEC species
Heritage (LEP)	monitor condition of heritage asset
	consider relocation of asset (e.g. museum or public display)
	consider installation of flood levees, subject to value of asset and flood impact assessment
	record/document the heritage item
Jetty	monitor frequency of inundation and condition of asset
	reconstruct as floating jetty, with vertical capacity to adjust with SLR
National Parks / Nature Reserves	monitor frequency of inundation of foreshore trails and reserve areas
	relocate impacted foreshore trails to alternate routes
	allow natural migration of foreshore habitats (e.g. wetlands) to occur into adjacent land
Natural Area	allow natural adjustment due to SLR
Natural waterways	natural waterway habitat not affected by inundation
Open Space / Reserves / Parks	monitor frequency of inundation and public amenity impact
	consider landward setback if adjacent land is available
	consider raising of land, subject to flood impact assessment
	consider installation of flood levees, subject to flood impact assessment
	consider relocation of asset to higher ground
Open Space and Recreation\Park Furniture\Play Equipment	monitor frequency of inundation and public amenity impact
	consider landward setback if adjacent land is available
	consider raising of land, subject to flood impact assessment
	consider installation of flood levees, subject to flood impact assessment
	consider relocation of asset to higher ground
Potable Water Infrastructure - Reticulation/Pumping Station/Mains	no impacts to potable water infrastructure expected from temporary inundation
Recreational waterways	recreational waterways not affected by inundation
Residential Development	implement planning controls for new development (e.g. location and floor level)
Roads Major	monitor frequency of inundation and public amenity and public safety (e.g. evacuation) impacts
	raise road level, subject to flood impact assessment
	consider realignment of road through higher ground
	consider installation of flood levees, subject to flood impact assessment
Roads Minor	monitor frequency of inundation and public amenity and public safety (e.g. evacuation) impacts
	raise road level, subject to flood impact assessment
	consider installation of flood levees, subject to flood impact assessment
	install flood gates and detour signage for alternate routes during times of inundation
Rural Land	consider change in land use / zoning
	implement planning controls for new development (e.g. location and floor level)
SEPP Coastal Management	monitor extent/condition of SEPP Coastal Management habitat
	allow natural migration of foreshore habitats (e.g. wetlands) to occur into adjacent land
	consider purchase of adjacent farmland/private land to enable migration of habitat
Sewer Infrastructure	raise ground levels in vicinity of asset, subject to flood impact assessment
	raise floor level of asset (e.g. public toilet)
	consider relocation of asset to higher ground
Sewer Infrastructure - Reticulation/Pumping Station/Mains	raise ground levels in vicinity of asset, subject to flood impact assessment
	retrofit asset with waterproof materials/housing
	replace asset with waterproof infrastructure
	consider relocation of asset to higher ground
Sports Ground / Recreational Clubs	monitor frequency of inundation and public amenity impact
	consider raising of land, subject to flood impact assessment
	consider raising of floor levels for existing buildings or new development
	consider relocation of asset to higher ground
Stormwater Infrastructure	monitor frequency of stormwater outlet inundation and associated ponding impacts
	consider feasibility of raising outlet level
	consider re-routing of stormwater to unaffacted outlets
	consider installation of surcharge pit to reduce upstream ponding impacts
	consider installation of 'duckbill' valves or flood gates on outlets to limit backflow from tidal/coastal inundation
Tourist Park	monitor frequency of inundation and associated impacts
	consider raising of land, subject to flood impact assessment
	consider raising of floor levels for existing buildings or new development
	consider relocation of asset to higher ground


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