Covering Note

This report contains sensitive information relating to location of Aboriginal Cultural Heritage sites. To protect this sensitive information Council has removed the relevant pages.

Pages 31-32 of this report have been removed to protect culturally sensitive information that has been presented in the original report.

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REPORT

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

Report A - “Environmental, Social & Cultural Assets and Attributes”

Client: Shoalhaven City Council

Reference: PA2951-SCC-CMP-Stage 2 Report A-0001

Status: Final/5.0

Date: 23 February 2023

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The Lake Conjola Coastal Management Program has been prepared by Royal HaskoningDHV for Shoalhaven City Council with financial assistance from the NSW Government through its Coastal and Estuary Grants Program. This document does not necessarily represent the opinions of the NSW Government or the Department of Planning and Environment.

Revision history

Revision	Date	Description	Prepared	Checked	Approved
1.0	23/06/2022	Draft Report	Adrian Turnbull	Greg Britton, Matt Potter	Greg Britton
2.0	16/09/2022	Draft Report	Adrian Turnbull	Matt Potter	Greg Britton
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4.0	20/12/2022	Draft Report	Adrian Turnbull	Matt Potter	Greg Britton
5.0	23/02/2023	Final Report	Adrian Turnbull	Matt Potter	Greg Britton

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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 key environmental threats, as well as current and future coastal hazards, and outline 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 (Advisian, 2020), 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 raises awareness of current and future coastal management issues, constraints and opportunities, to define the scope of subsequent CMP stages.

This report, 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, summarised below, as well as noting the various pieces of legislation that afford protection to these attributes.

Companion documents to this report, CMP Stage 2 Report B – "*Threats and Risk Assessment*" and Report C - "*Entrance Processes and Entrance Management Options*", describe the range of, extent, and potential impact of threats posed by coastal hazards on these attributes, as well as providing initial consideration of potential mitigation options and actions.

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 5 km 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 at the lake entrance during the summer period.

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 1,200-1,400 permanent residents, primarily based in three villages (Lake Conjola, Conjola Park and Fishermans

Paradise), the region is an extremely popular tourism destination, hosting approximately 5,000 additional people during the peak summer period.

From observation, and 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 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, 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 (which is presented in CMP Stage 2 - Report B). The location of these residential properties in relation to distance from the lake foreshore varies, as does the land level at 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 (which is presented in CMP Stage 2 – Report B). These include a range of built structures and assets (such as carparks, roads, boat ramps, stormwater and sewerage network, and a caravan park), as well as natural assets (such as Endangered Ecological Communities).

1 Introduction

1.1 Objective, Purpose, Vision and Strategic Directions of the Lake Conjola CMP

1.1.1 Objective

Aligned with directives provided by the *Coastal Management Act 2016* (CM Act), the objective of the Lake Conjola Coastal Management Program (CMP) is to provide an integrated, adaptive and long-term strategy for the co-ordinated management of Lake Conjola. The Lake Conjola CMP will confirm the focus of coastal zone management by Council and by public authorities and co-ordinate the delivery of priority management actions.

The Lake Conjola CMP seeks to guide the informed and coordinated management, and environmentally sustainable development, of the dynamic environment of Lake Conjola, in order to protect the social, cultural, economic and environmental values, and identity of the region, against current and future coastal hazards and threats to the environment.

1.1.2 Vision and Purpose

The Community Vision Statement, created by Council and the community during development of the Community Strategic Plan "*Shoalhaven 2027*", has strong relevance to the Lake Conjola CMP.

We will work together in Shoalhaven to foster a safe and attractive community for people to live, work, stay and play; where sustainable growth, development and environmental protection are managed to provide a unique and relaxed lifestyle.

The Southern Coastal Management Program Advisory Committee, with the support of Council and RHDHV, have refined the Vision and Purpose for the Lake Conjola CMP.

The overarching ***Vision*** of the Lake Conjola CMP is:

"We care for and protect Lake Conjola in a responsible manner so that current & future generations continue to be safe, refreshed & inspired by their coastal experience."

The overarching ***Purpose*** of the Lake Conjola CMP is:

"To develop a plan for the future management of Lake Conjola in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being and safety of the people of the Shoalhaven."

1.1.3 Strategic Directions

Following the guidance of, and in accordance with, the NSW Coastal Management Manual and framework, the Lake Conjola CMP will provide coastal management actions to be implemented over the next 10 years, and each potential action will be measured against the Vision and Purpose, to ensure that they are aligned with these statements.

Consistent with the *Coastal Management Act 2016* (CM Act), the objectives of the Lake Conjola CMP are to manage the coastal environment in a manner that is consistent with the principles of ecologically

sustainable development for the social, cultural and economic well-being of the people of the Lake Conjola area.

The following overarching and specific *Strategic Objectives* of the Lake Conjola CMP, which drive the overall strategy behind the CMP, have been lightly amended from the adopted Shoalhaven Scoping Study Strategic Objectives to be locally relevant, with the key themes highlighted in ***bold***:

- Give effect to all relevant ***NSW legislation and policy***, as applied to the coastal zone, in the Lake Conjola context;
- Manage all coastal systems in an ***integrated manner that recognises the links*** between catchment, lake, estuary and open coast processes;
- Manage the coastal zone ***adaptively***, with a clear process for ***modifying management approaches*** as new knowledge becomes available;
- Invest in effective and efficient strategies to achieve ***positive natural, social, cultural and economic outcomes*** within Council's responsibilities;
- Take ***coastal hazards*** into account in Council's ***land use planning***;
- 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;
- ***Align*** the Coastal Management Program with Local Environment Plan 2014, Development Control Plan 2014 and Integrated Strategic Plan;
- ***Engage with the community*** in the review and preparation of coastal management programs; and,
- Keep the ***community informed*** about coastal processes and management responses.

The overarching *Specific Objectives* of the Lake Conjola CMP, based on the objectives of the CM Act, are presented below with the key themes highlighted in ***bold****:*

- to ***protect*** and enhance natural ***coastal processes*** and ***coastal environmental values*** including natural character, scenic value, biological diversity and ecosystem integrity and resilience of Lake Conjola and its catchment;
- to support the ***social and cultural values*** of the coastal zone and maintain public access, amenity, use and safety;
- to ***acknowledge and protect Aboriginal peoples'*** spiritual, social, customary and economic use of the coastal zone;
- to recognise the coastal zone as a vital ***economic*** zone and support sustainable coastal economies;
- to facilitate ***ecologically sustainable development*** in the coastal zone and promote sustainable land use planning decision-making;
- to ***mitigate current and future risks*** from coastal hazards, taking into account the effects of ***climate change***;
- to recognise that the ***local and regional scale*** effects of coastal processes and the inherently ambulatory and dynamic nature of the shoreline may result in the loss of coastal land to the sea (including estuaries and other arms of the sea), and to ***manage coastal use and development*** accordingly;
- to promote ***integrated*** and co-ordinated coastal planning, management, reporting and response;

- to encourage and promote plans and strategies to improve the ***resilience*** of coastal ***natural and built assets*** to the impacts of an uncertain climate future including impacts of extreme storm events;
- to ensure ***co-ordination*** of the policies and activities of government and public authorities relating to the coastal zone and to facilitate the proper integration of their management activities;
- to support ***public participation*** in coastal management and planning and greater public ***awareness, education*** and ***understanding*** of coastal processes and management actions;
- to facilitate the ***identification of land*** in the coastal zone for acquisition by public or local authorities in order to promote the protection, enhancement, maintenance and restoration of the environment of the coastal zone; and,
- to support the objects of the *Marine Estate Management Act 2014*.

1.2 Project Reporting Overview

Stage 2 of the Lake Conjola CMP is presented in three (3) separate, complimentary companion reports to reflect and respond to the range of knowledge and interests within and between stakeholders.

It is noted that the Shoalhaven CMP Scoping Study (Advisian, 2020) was necessarily high-level due to its large spatial extent in covering the entire Shoalhaven Local Government Area (LGA). As a consequence, limited detail was provided in that document for each of the catchment areas (such as Lake Conjola), which are subsequently the focus for site-specific CMPs.

To address this gap in background information, this report **Lake Conjola CMP Stage 2 - Report A - "*Environmental, Social and Cultural Assets and Attributes*"** provides a history and description of the attributes and assets of the Lake Conjola catchment, as well as noting the various pieces of legislation that afford protection to these attributes, as understanding these physical and social values provides an important baseline for assessment of the risks posed by coastal hazards.

This report, **CMP Stage 2 – Report A – "*Environmental, Social & Cultural Assets and Attributes*"**, has been prepared as a companion report to be read in conjunction with:

- **CMP Stage 2 – Report B – "*Threats and Risk Assessment*"**, which provides a description of the range, extent, and potential impact of threats posed by coastal hazards on the physical, environmental, cultural and social attributes and assets of the Lake Conjola catchment, as well as initial consideration of potential mitigation options and actions for further development during Stage 3 of the CMP process.; and

- **CMP Stage 2 – Report C – "*Entrance Processes and Entrance Management Options*"**, which provides an overview of the physical processes in the entrance area, sets out the history of entrance management including previous options, plans and policies, and the current interim entrance management policy and licence, describes selected mechanical openings in recent years, and outlines the management options proposed to be considered and evaluated for entrance management during Stage 3 of the CMP process.

1.3 Report Structure

This report, **CMP Stage 2 - Report A - "*Environmental, Social & Cultural Assets and Attributes*"**, is set out in the following manner:

- **Section 2** provides an overview of the Lake Conjola CMP project background;
- **Section 3** provides a bio-physical description of the wider region and the Lake Conjola CMP study area;
- **Section 4** describes the geological evolution and characteristics of Lake Conjola;
- **Section 5** describes the Aboriginal and post-settlement heritage of the area;
- **Section 6** provides an overview of community demographics;
- **Section 7** describes the legislative framework for protection of the environment and coastal management; and,
- **Section 8** describes the terrestrial and marine ecology of the Lake Conjola region.

2 Project Background

2.1 General

Coastal management is NSW is guided by the *Coastal Management Act 2016* (CM Act), the *State Environmental Planning Policy (Resilience and Hazards) 2021* (RH SEPP) and the NSW Coastal Management Manual (OEH, 2018). This legislation and manual sets out the requirement for councils to prepare Coastal Management Programs (CMPs).

The first stage (Stage 1) of the CMP process outlined within the Coastal Management Manual (the Manual) requires the preparation of a CMP Scoping Study. The Shoalhaven CMP Scoping Study (Scoping Study), which was completed by Advisian for Council in 2020, provided a high-level overview of the entire coastal zone and estuarine catchments along the Shoalhaven Local Government Area (LGA) coastline, including Lake Conjola.

The Scoping Study noted that CMPs will generally not cover National Parks and Wildlife Service (NPWS), or Marine Park managed areas, unless there are cross boundary or other shared issues that need to be addressed, as these assets already have their own management plans.

Lake Conjola (also referred to as 'the Lake') is a medium sized barrier estuary on the New South Wales (NSW) south coast, located approximately 210 km south of Sydney, and approximately 50 km south of Nowra, in the Shoalhaven Local Government Area (LGA) as shown in **Figure 2-1**.

The open coastal area to the south of Lake Conjola consists of approximately 6.5 km of east facing sandy beaches, with Lake Conjola Ocean Beach transitioning through Buckleys Point to Buckleys Beach, which extends to the northern shore of Narrawallee Inlet, adjacent to Preservation Rock. The rocky northern shoreline from Cunjurong Point extends past Green Island to the nearly 1 km long Manyana Beach, which is bounded by Inyadda Point, with Inyadda Beach extending further north towards Bendalong.

The open coast areas of Lake Conjola, and the potential impact of coastal hazards upon them, will be considered and addressed within the *Open Coast and Jervis Bay Coastal Management Program* being prepared by Council.

2.2 Study Area

Lake Conjola is primarily an estuarine water body with a surface area of approximately 6.9 km^2, made up of three identified basins (Lake Conjola, Berringer Lake and Pattimores Lagoon), within a coastal catchment area of 145 km^2, and seven main reference locations, as shown in **Figure 2-2**. The Lake entrance occasionally closes, sometimes requiring Council intervention to mitigate potential flooding of low-lying areas, however it is predominantly open to the ocean and receives tidal interchange of marine waters.

The study area for the purposes of the Lake Conjola CMP extends from the entrance of the lake westward into the upper catchment, as shown in **Figure 2-3**. While primarily focused on the Coastal Management Areas identified by the CM Act and RH SEPP (discussed further in **Section 7.2**), consideration is also given to potential hazards, risks and opportunities within the broader catchment area.

Figure 2-1: Lake Conjola Locality Map (source: BMT WBM, 2013)

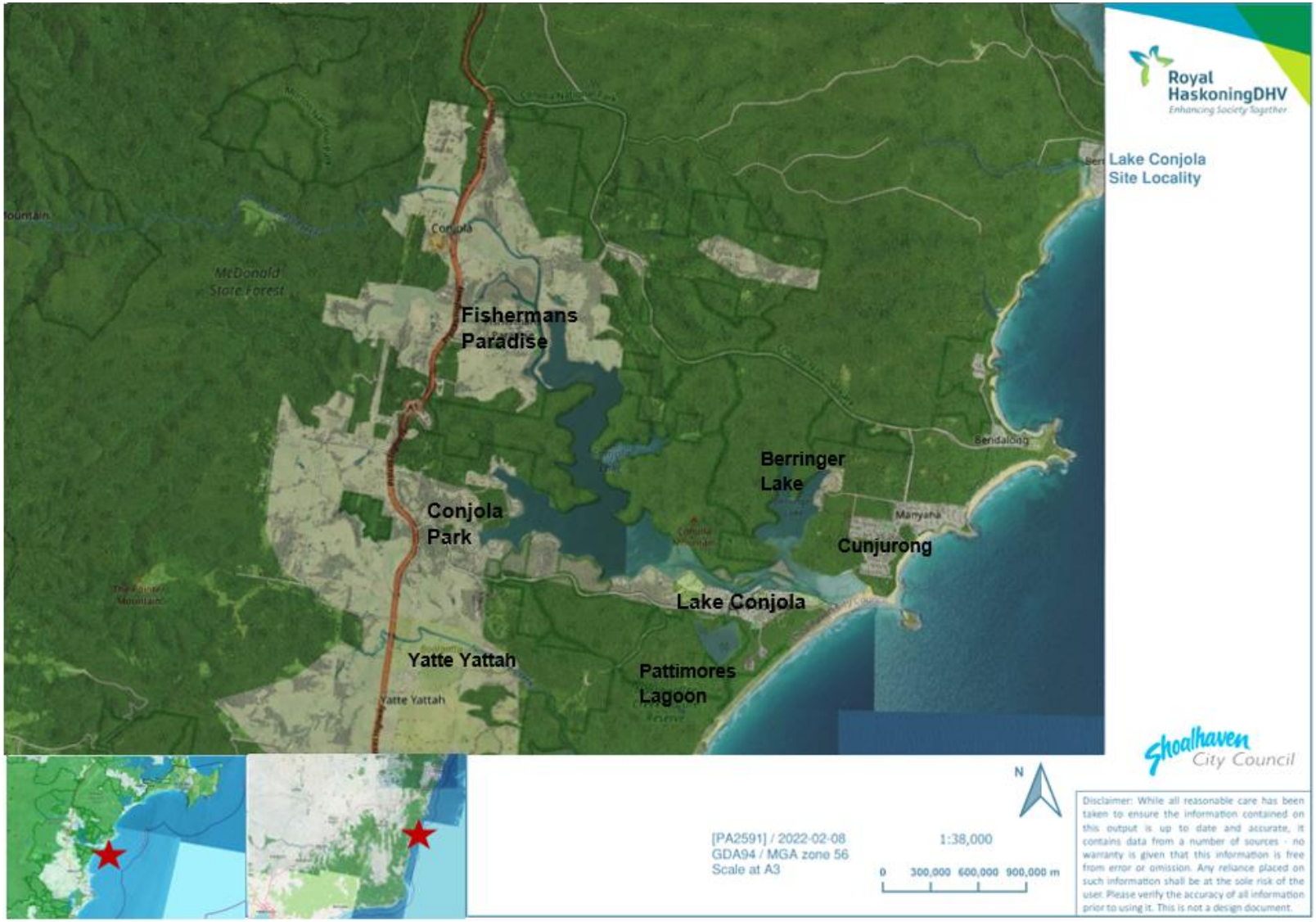

Figure 2-2: Lake Conjola Site Locality Plan

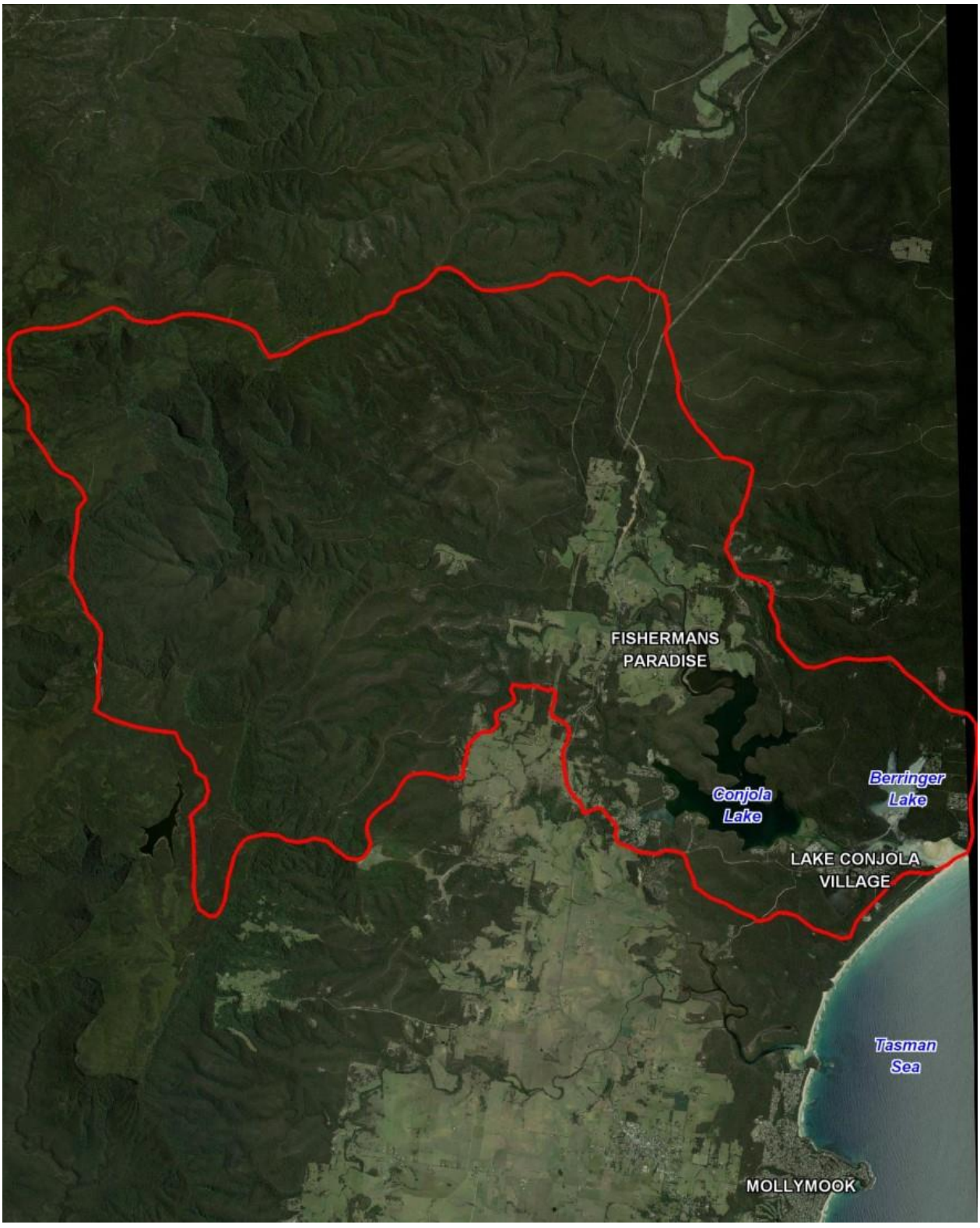

Figure 2-3: Lake Conjola Catchment Area (source: BMT WBM, 2013)

2.3 History of Lake Conjola Management

Lake Conjola has been actively managed by Council for decades. Seeking to address management considerations at the time, Council developed and adopted the Lake Conjola Estuary Management Plan (EMP) in 1998 (Council, 1998), in accordance with the requirements of a former NSW government coastal management framework. The EMP sought to establish a framework of integrated strategies to restore, protect and conserve the natural resources of Lake Conjola, and to ensure their use is ecologically sustainable in the long term. At the time of the development, six management areas were identified as being of significance to Lake Conjola:

- Water Quality;
- Erosion and Sedimentation;
- Flooding;
- Lake Ecology;
- Recreation and Tourism; and,
- Lake Entrance Conditions.

A review of the EMP in 2015 (EMP Review) noted that of the 72 actions outlined, approximately 86% had been completed or implemented as ongoing action items (GHD, 2015). The EMP Review recommended a number of additional strategies and actions, as well as grouping the strategies and actions into new management areas that were aligned with (then current) NSW Government Guidelines and Council's documentation.

The new management areas (with sub-categories), along with relevant management strategies and actions, were defined as:

- Catchment Inputs and their Impacts
    - Water Quality and Sedimentation
    - Urban Stormwater
    - Onsite Effluent Management
    - Sewerage Scheme
    - Acid Sulfate Soils
- Biodiversity and Ecosystem Protection and Rehabilitation
    - Terrestrial Habitat
    - Riparian Habitat
    - Aquatic Habitat
    - Fish
- Access, Recreation and Tourism
    - Foreshore Access
    - Aquatic Recreation
    - Boating Navigability
- Entrance Management
- Flooding
- Adapting to Climate Change
    - Lake Level
    - Sea Level Rise

- Cultural Heritage

The issues, objectives, strategies and actions contained within the EMP have been used as the basis for management of Lake Conjola up until the present time, and are generally still considered relevant. The Lake Conjola CMP will take greater account of the complexity of this dynamic estuarine environment by incorporating updated technical understanding of estuarine processes and coastal hazards since the EMP was developed.

The Lake Conjola CMP will build on existing knowledge, lessons learnt from the implementation of management actions from the 1998 EMP and 2015 EMP review, as well as awareness of current and future coastal management issues, constraints and opportunities such as those raised within the CMP Scoping Study and the CMP Stage 2 process, to define the scope of subsequent CMP stages.

The Final Lake Conjola CMP will reflect the large body of knowledge and positive work undertaken by Council and the community over many decades, while addressing current development and land use, community interests and legislative requirements.

3 Lake Conjola Catchment and Waterbody

The catchment of Lake Conjola, shown in **Figure 2-3**, is relatively undisturbed with 85% remaining as bushland, including areas of Conjola and Morton National Parks, with some small urban settlements and grazed areas located within the middle and lower catchment. The majority of the catchment remains undeveloped and mostly forested, with approximately 75% of the forested areas managed by either State Forests or National Parks and Wildlife Service (NPWS) (GHD, 2015).

Urban and rural residential development areas associated with Fishermans Paradise, Conjola Park, Lake Conjola and Yatte Yattah, as shown on **Figure 2-2**, occupy about 10% of the catchment, are relatively minor and generally confined to the southern side of the Lake entrance and the upper reaches of the Lake. It is a popular tourist and recreational area, with the permanent residential population surpassed by an influx of tourists during peak holiday periods (DPE website, 2022).

The Lake entrance is located at latitude (ºS) 35.27, longitude (ºE) 150.51, and comprises a tidal delta of clean marine sand, with pronounced sand lobes, which are elevated at up to 1 m above mean sea level, as shown in **Figure 3-1**.

Figure 3-1: Lake Conjola entrance channel, tidal delta and sand lobes (source: DPE)

Directly west from the entrance and tidal delta, a shallow inlet channel is the predominant formation within the lower section of the estuary. This shallow reach includes extensive intertidal muddy sand flats, with an average channel depth in the order of 1-2m, extending for approximately 3 km until a change of depth at a location often referred to as 'The Steps', as shown in **Figure 3-2**.

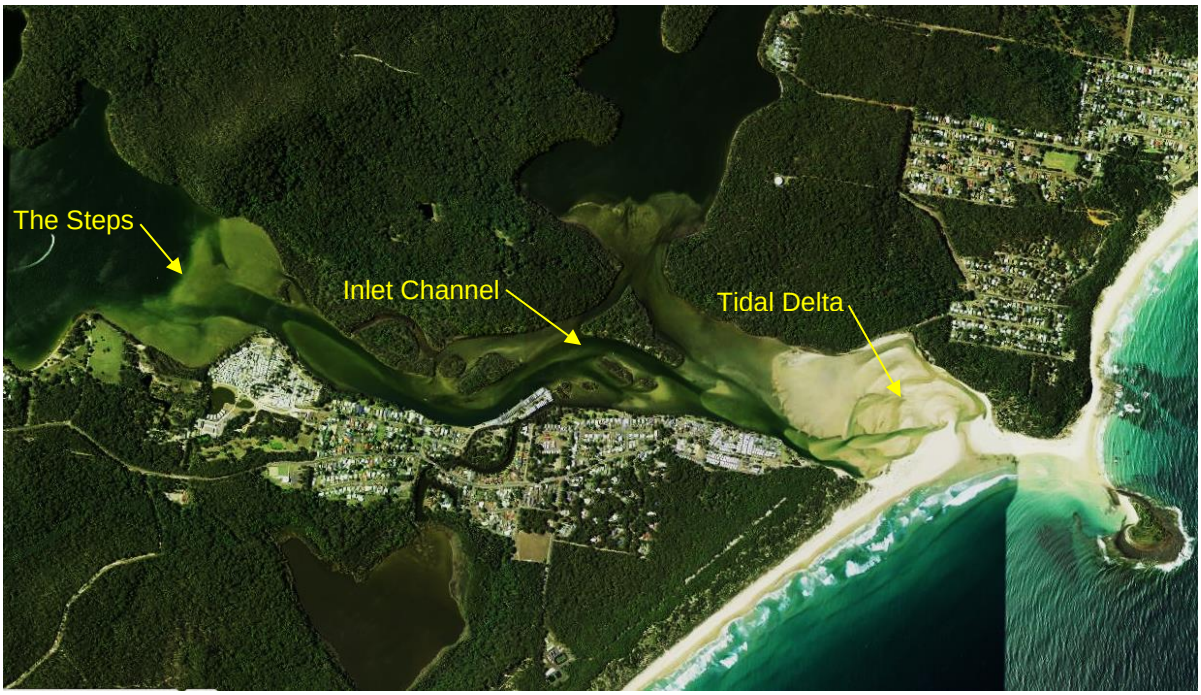

Figure 3-2: Lake Conjola entrance channel, shallow shoal extending approximately 3 km until "The Steps" into deeper water

Conjola Creek is the main fluvial inlet to the estuary system and has formed an elongate delta in the northwest of the basin. The body of Lake Conjola comprises three main water basins: Lake Conjola itself, with a surface area of 5.8 km^2 and water depths reaching 10 m; Lake Berringer, a northern limb of the estuary with a surface area of 0.8 km^2 and depths less than 5 m; and Pattimores Lagoon, a small coastal lagoon forming a southern limb with a surface area of 0.3 km^2 and maximum water depth of 3 m (Sloss et al., 2010), as shown in **Figure 3-3**.

Collectively, the three basins act as a sediment sink for a 145 km^2 river catchment, have a maximum depth of 10 m, an average depth of 4 m, and hold approximately 26,800 megalitres (ML), (DPE website, 2022).

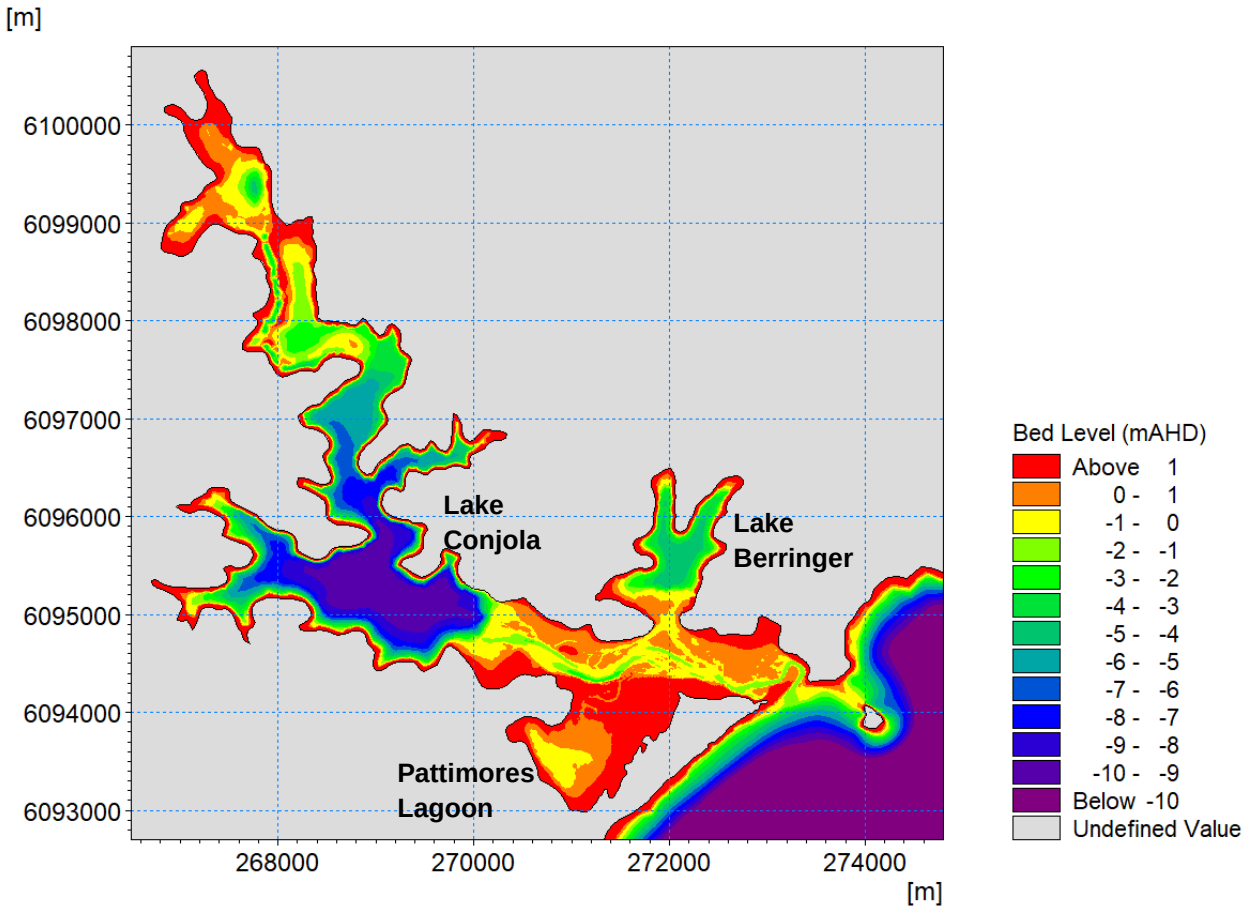

Figure 3-3: Bathymetry of Lake Conjola, including low-lying coastal foreshores (lake bathymetry sourced from BMT WBM, 2013; entrance bathymetry sourced from OEH 2018 LiDAR; topographic survey sourced from OEH 2011 LiDAR)

Note: AHD = Australian Height Datum, approximately mean sea level at present, and that average lake water level is approximately 0.27m AHD.

The entrance channel is characterised by a high level of attenuation of the ocean tide range both via initial loss through the constricted entrance and further frictional losses along the entrance channel itself. The lake tide is in the order of 20% of the ocean tide when the entrance is open and relatively scoured (McLean et al., 2003).

Entrance processes and entrance management are discussed in detail within **CMP Stage 2 – Report C**.

4 Evolution and Geology of Lake Conjola

4.1 Geological Formation of Lake Conjola

The catchment of Lake Conjola is constrained to the west by the Eastern Highlands, which form a steep escarpment roughly parallel with the main trend of the coastline. Seaward of Lake Conjola, the coast is bordered by a narrow (<50 km wide) and relatively deep (approximately 200 m) continental shelf (Roy et al., 1980).

Based on the NSW Coastal Quaternary Geology Maps (Troedson, A. et al., 2004), Lake Conjola's geology comprises alluvial and estuarine deposits underlain by sedimentary bedrock. The coastline and lake are dominated by Quaternary alluvial sediments, comprising sands, silts, clays and gravels.

The sedimentary bedrock underlying Lake Conjola is the Snapper Point Formation, a unit of the Shoalhaven Group formed in the Cisuralian age (circa 290.1 - 283-5 million years ago (Mya)). This unit comprises fine- to very coarse-grained sandstone, siltstone, pebbly sandstone and polymictic pebble conglomerate, as shown in **Figure 4-1**.

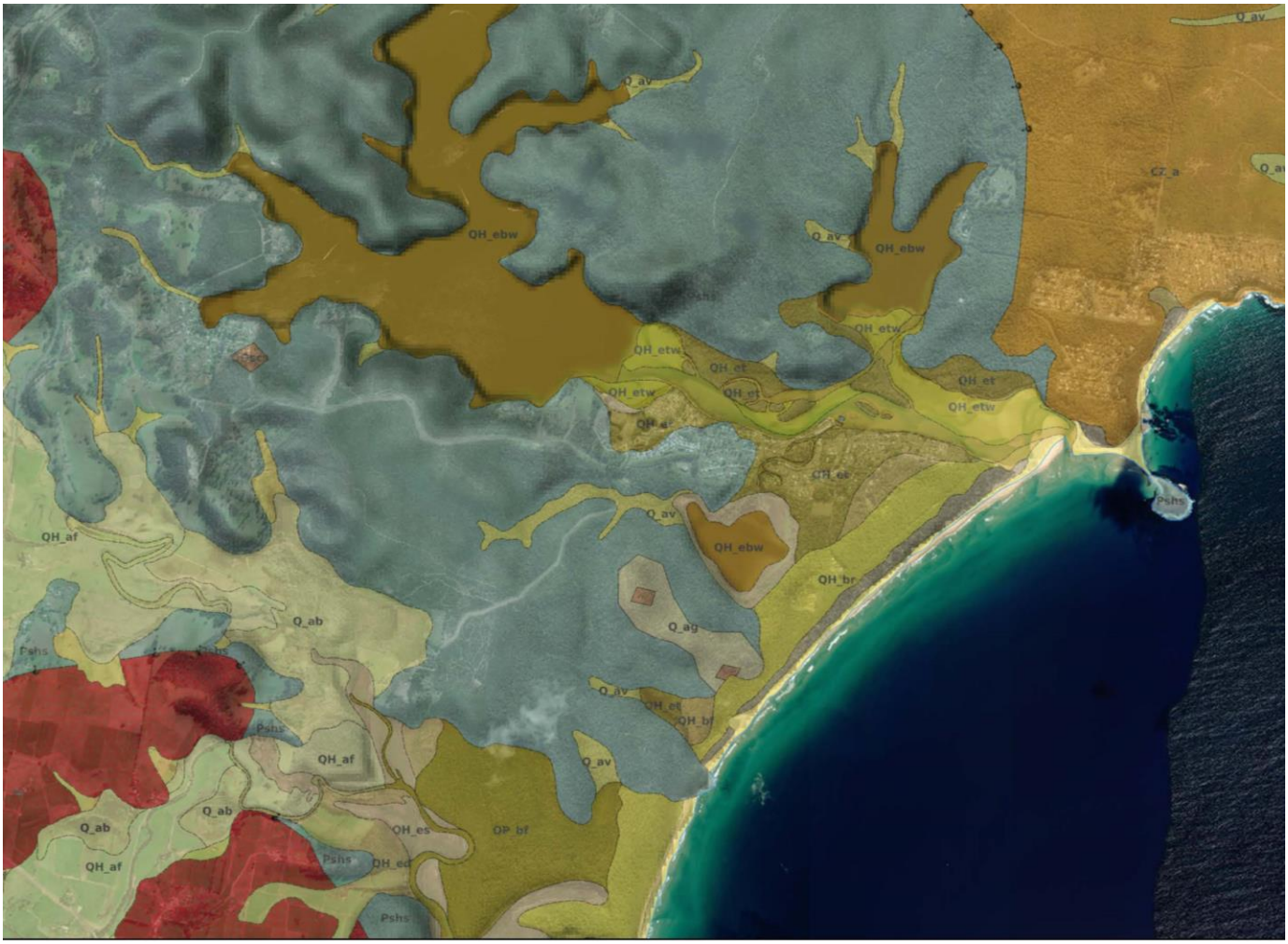

Figure 4-1: Lake Conjola Geology (MinView, 2022)

Around 15 million years ago, when the climate was much wetter, sand grains were cemented in the soil to form a near surface layer of silica rock or 'silicrete' after other more soluble minerals were leached (several of these silica deposits at Lake Conjola were mined until the 1950s). Sea level has fluctuated significantly over the past 1.8 million years (i.e. during the Pleistocene Ice Age) with the most recent rise of more that 120m occurring around 20,000 years ago. This sea level rise flooded low lying coastal land so that creeks formed numerous 'estuarine lakes' such as Burrill Lake, Lake Conjola, Narrawallee Inlet and Lake Tabourie, which became cut off by coastal sand spits (MUHS website, accessed 2022).

From 7,500 to 4,000 years ago sediment continued to accumulate within the mouth of the incised valley, forming an extensive flood-tide delta within the drowned river estuary. Marine influences were restricted by further sediment accumulation at the mouth of the estuary, leading to the development of mid-Holocene barrier and back-barrier depositional environments (Sloss et al., 2010).

The geomorphological evolution of Lake Conjola over time is shown in **Figure 4-2**, depicting:

(a) lowstand fluvial incision into the bedrock basement and the antecedent Pleistocene land surface;
(b) deposition of the Holocene marine transgressive sandsheet from circa 7500 to 5500 years ago and subsequent sea-level highstand;
(c) restriction of the open ocean marine influence associated from circa 3000 years ago due to the growth of a Holocene proto-barrier resulting in the development of the low-energy back-barrier lagoon; and,
(d) further restriction of marine influences associated with the fully emergent Holocene barrier, the shoaling of the inlet channel and the initiation of the progradation of fluvial bay-head deltas from circa 3000 years ago.

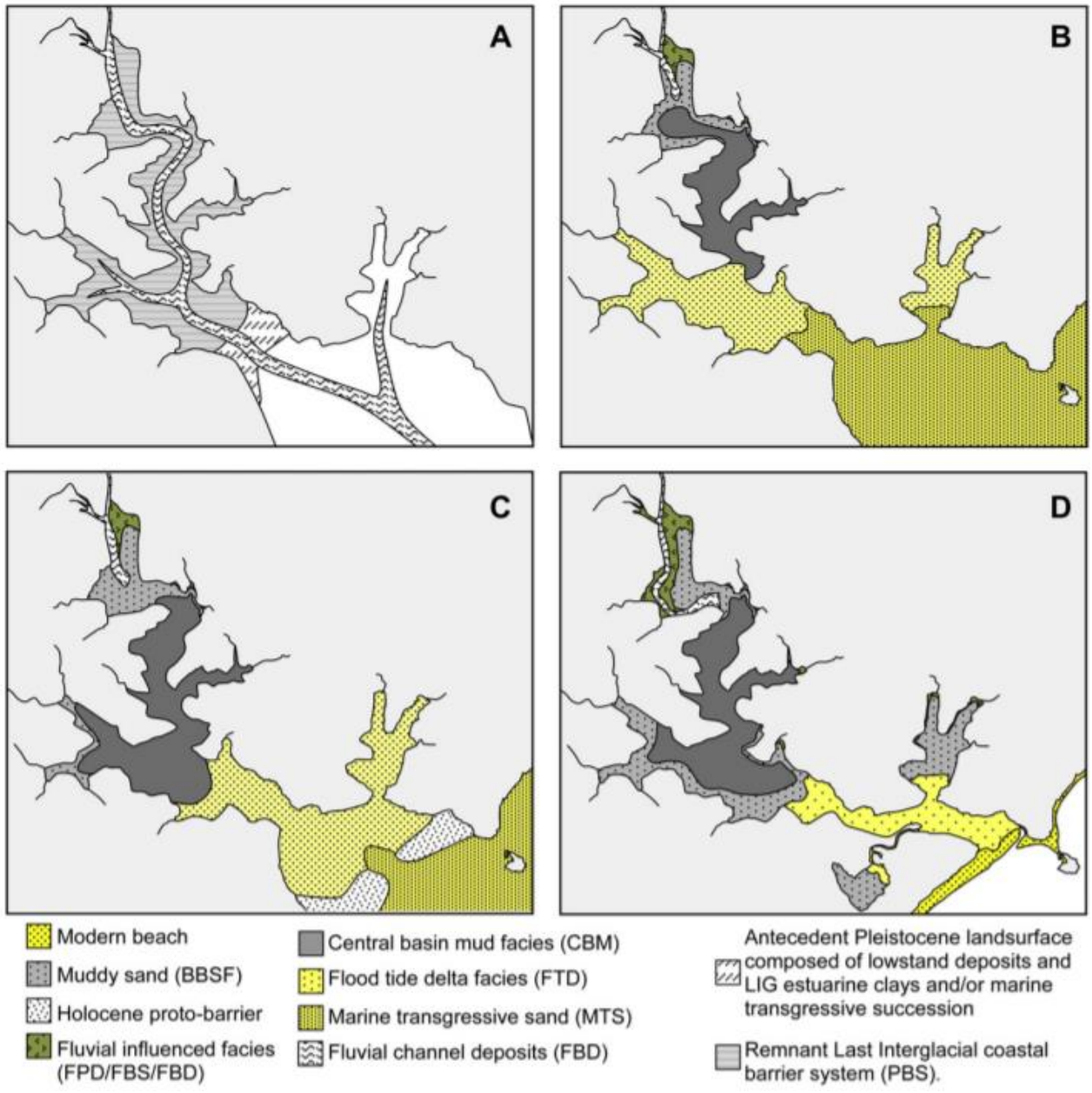

Figure 4-2: The geomorphological evolution of Lake Conjola (Sloss et al., 2010)

4.2 Lake Conjola Sediments

The present day underlying sedimentary deposition, as identified through core collection and sediment analysis, is shown in **Figure 4-3**. A schematic cross-section through the marine-influenced facies showing the Last Interglacial barrier deposits and Holocene sedimentary facies associations in the entrance to Lake Conjola is provided in **Figure 4-4** (Sloss et al., 2010).

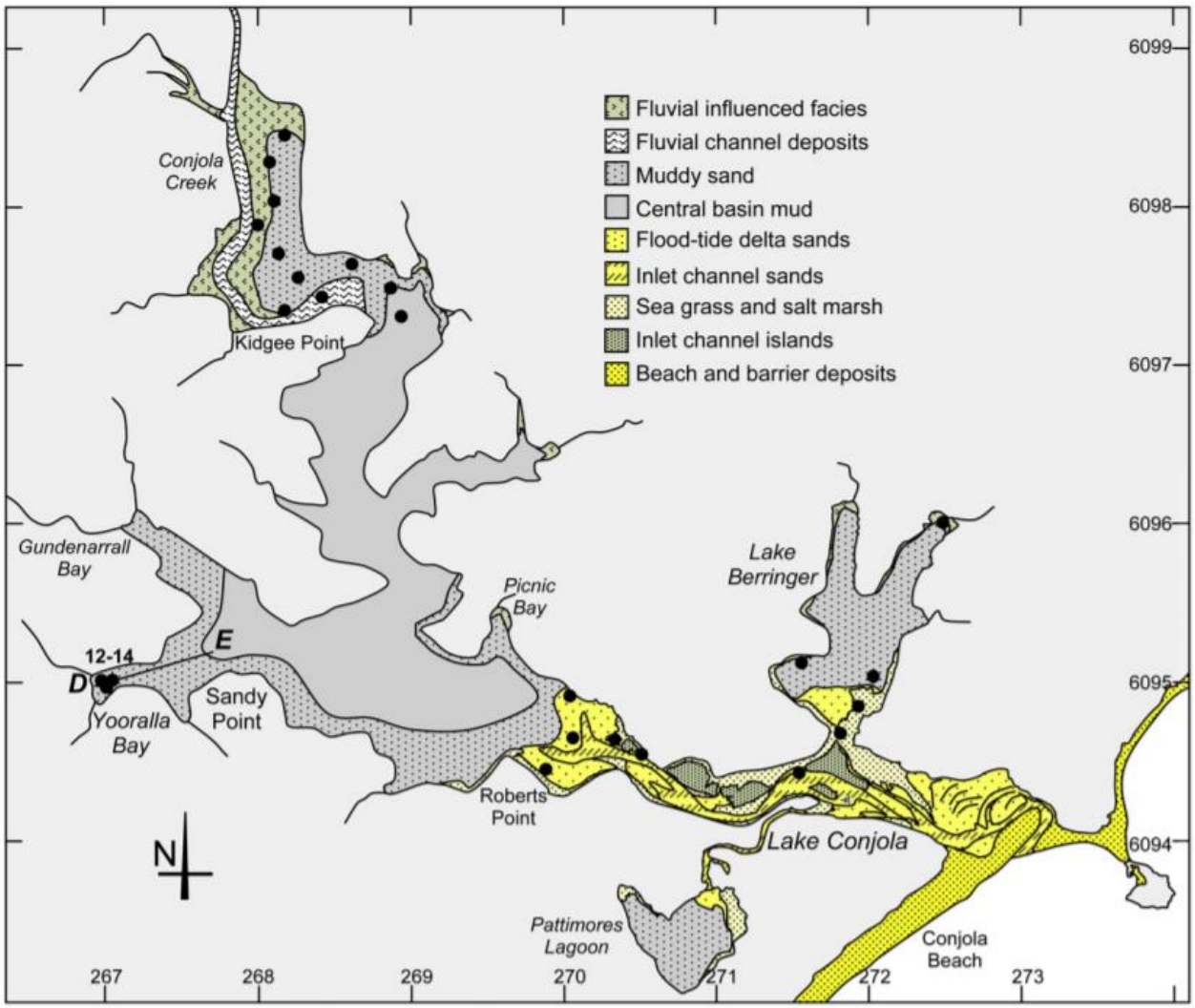

Figure 4-3: Sedimentary facies divisions and vibrocore locations within the Lake Conjola barrier estuary (Sloss et al., 2010)

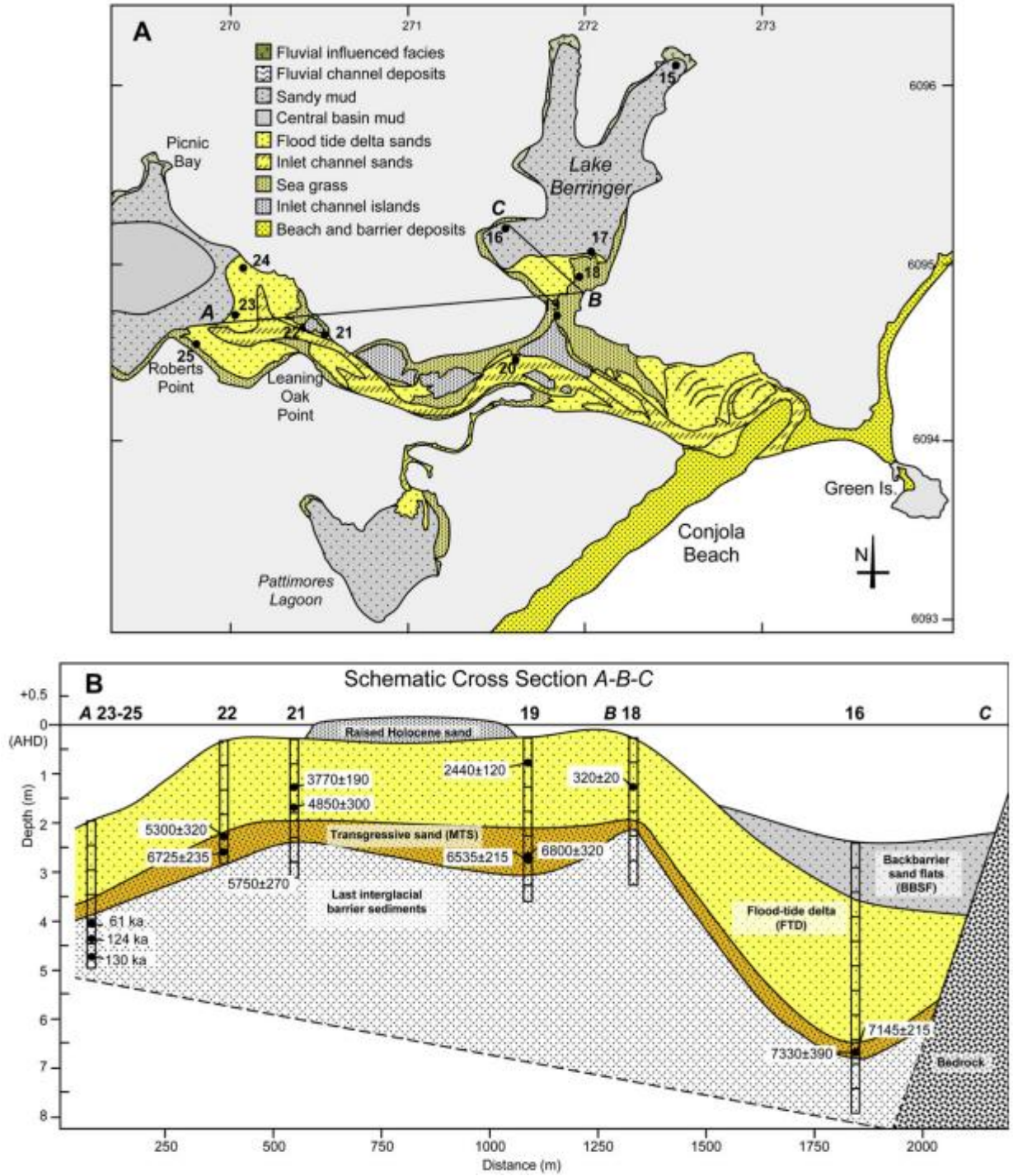

Figure 4-4: Core locations (A) and schematic cross-section (B) through the marine-influenced facies showing the Last Interglacial barrier deposits and Holocene sedimentary facies associations in the entrance to Lake Conjola (Sloss et al., 2010)

4.3 Acid Sulfate Soils

The complex pattern of weathering, sedimentation and changes in sea level along the NSW coastline has resulted in a diverse range of estuary and riverine habitat that reflects the underlying geology. One of the by-products of this process is the development of acid sulfate soils (ASS), which are naturally occurring soils, sediments or organic substrates (e.g. peat) that are formed under waterlogged conditions. These soils contain iron sulfide minerals (predominantly as the mineral pyrite) or their oxidation products. In an undisturbed state below the water table, acid sulfate soils are benign. However, if the soils are drained, excavated or exposed to air by a lowering of the water table, the sulfides react with oxygen to form sulfuric acid (DoE, 2006).

Release of this sulfuric acid from the soil can in turn release iron, aluminium, and other heavy metals and metalloids (particularly arsenic) within the soil. Once mobilized in this way, the acid and metals can create a variety of adverse impacts: killing vegetation, seeping into and acidifying groundwater and surface water bodies, killing fish and other aquatic organisms, and degrading concrete and steel structures to the point of failure (DoE, 2006).

It is expected that ASS are present throughout the bed and coastal areas of Lake Conjola, with the mapped extent of probability of occurrence shown in **Figure 4-5**. Understanding the location of Potential Acid Sulfate Soils or Actual Acid Sulfate Soils is an important factor when considering physical actions or mitigation measures to address any issues within the Lake Conjola area.

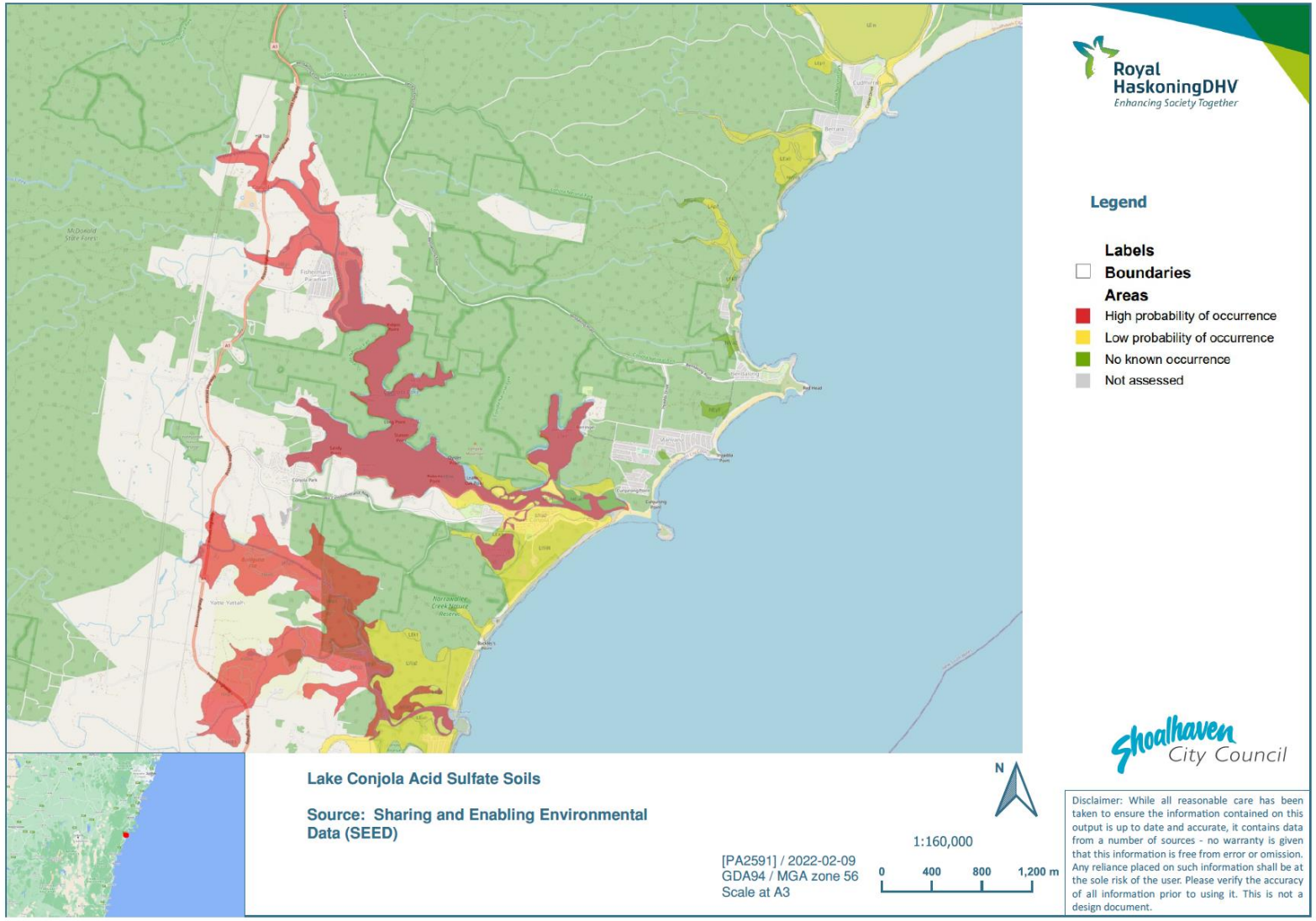

Figure 4-5: Probability of occurrence of Acid Sulfate Soils within Lake Conjola area (source: NSW SEED dataset)

4.4 Sediment Compartments

The NSW government has enshrined consideration of primary, secondary and tertiary scale sediment compartments within the CM Act, so as to ensure CMPs take into account potential impacts on adjoining locations and local government areas. Lake Conjola is located within primary sediment compartment NSW02, secondary sediment compartment NSW02.05, and tertiary scale sediment coastal sediment compartment "Conjola North NSW02.05.05", as shown in **Figure 4-6** and **Figure 4-7**.

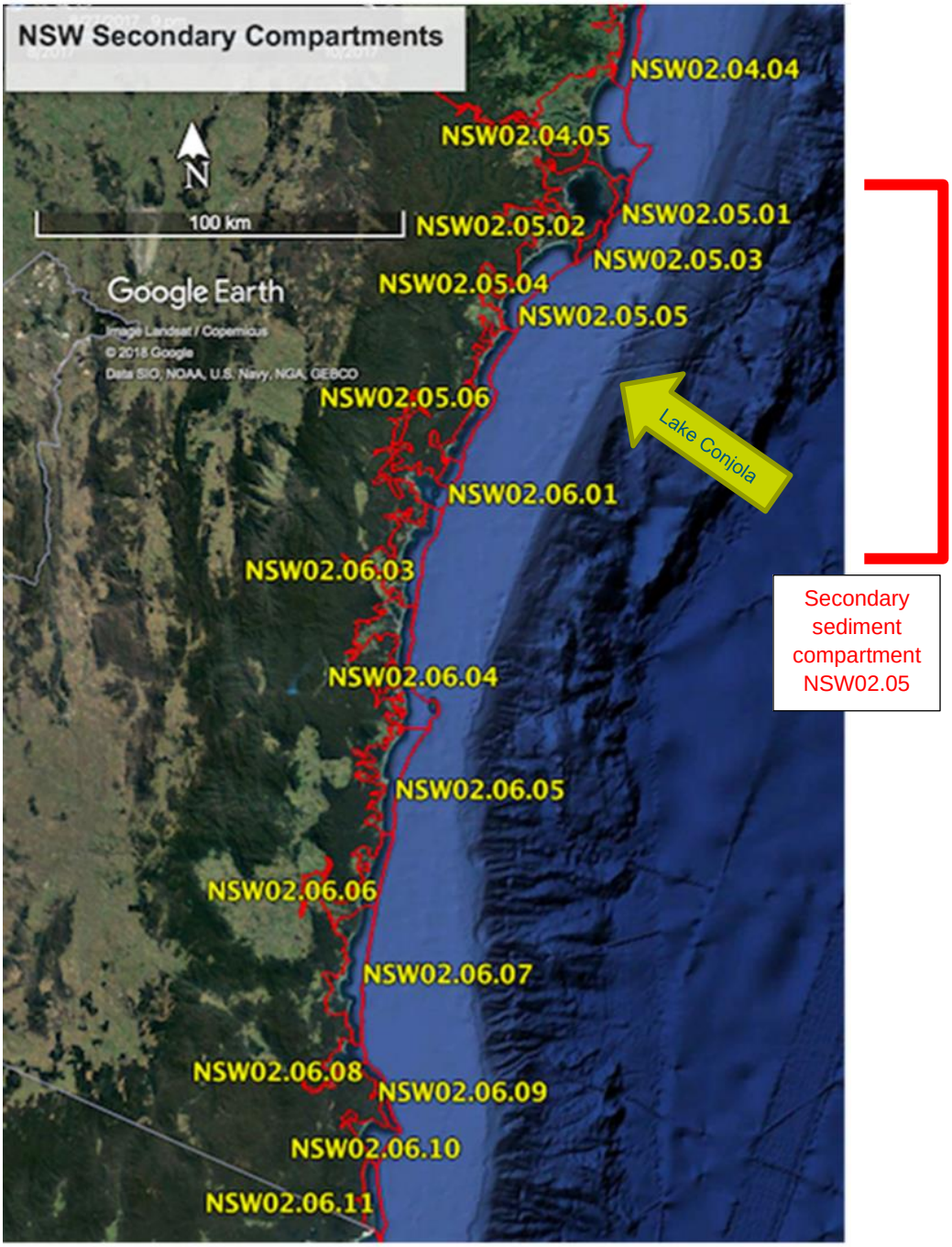

Figure 4-6: NSW Secondary and Tertiary Coastal Sediment Compartments (Short & Thom, 2018)

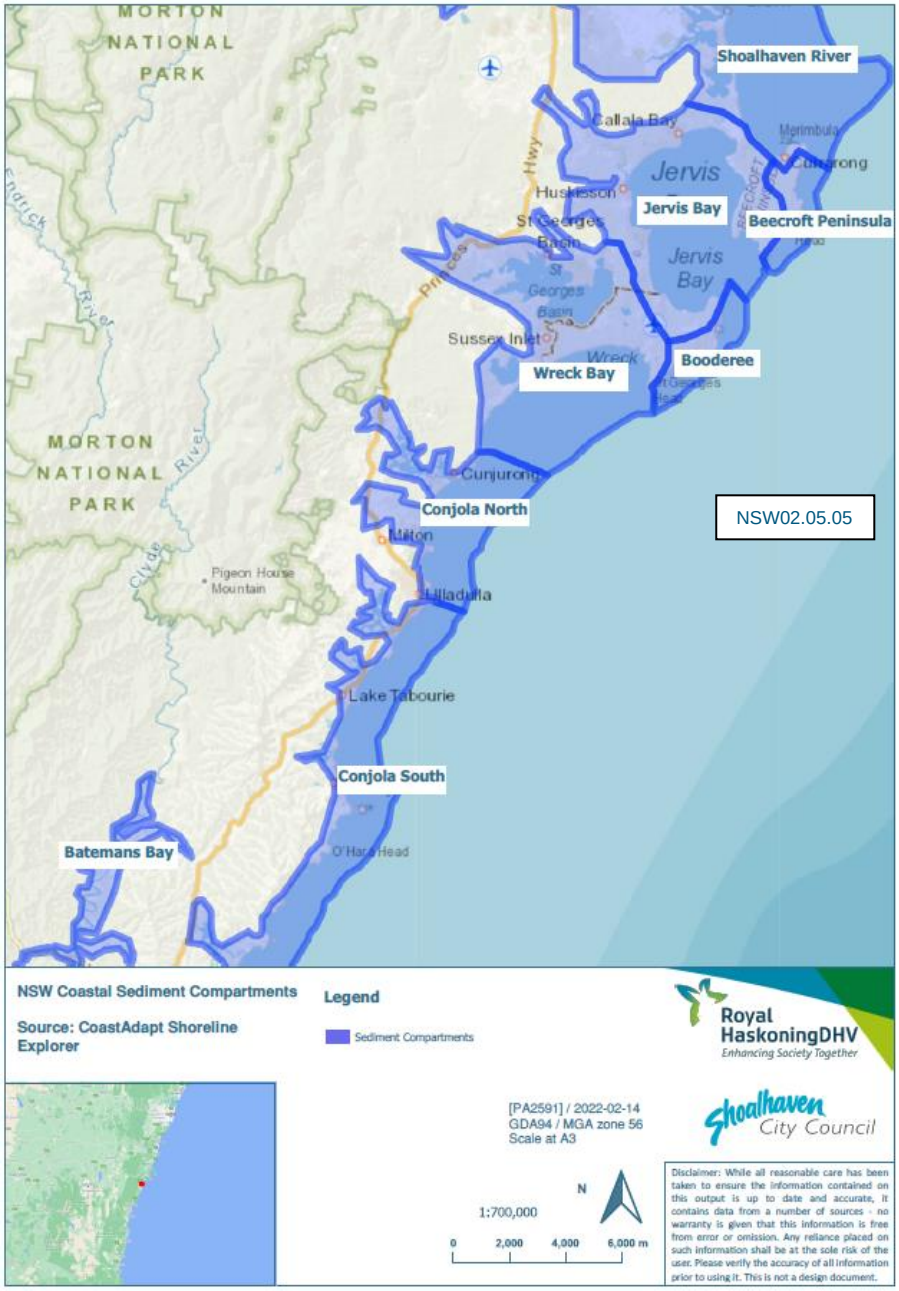

Figure 4-7: Shoalhaven Regional Tertiary Coastal Sediment Compartments (source: NCCARF)

The National Climate Change Adaptation Research Facility (NCCARF, 2019) described the regional setting of this tertiary coastal sediment compartment as “Conjola North NSW02.05.05”, extending from Red Head (Bendalong) to Warden Head, shown in **Figure 4-8**, stating:

> *The dominant regional processes influencing coastal geomorphology in this region are the humid warm to cool temperate climate, micro-tides, south-easterly Tasman Sea swells, easterly seas, dominantly quartz (terrigenous) sediments with northerly longshore transport in the northern part, and the El Nino Southern Oscillation (driving beach erosion/accretion cycles, cyclone frequency). Regional hazards or processes driving large scale rapid coastal changes include East Coast Lows (extra-tropical cyclones), mid-latitude cyclones (depressions), and storm surges (<1m).*

The entrance to Lake Conjola is dynamic and the adjacent beaches vary in width according to entrance conditions. Narrawallee Inlet is less dynamic and the beaches in the centre of this compartment appear stable. Mollymook Beach is a crescentic beach south of Bannisters Point; there have been several concerns about erosion along this beach (moderately sensitive). Ulladulla has an active fishing fleet that operates from a harbour within a deep bedrock-fringed embayment.

Each compartment is given a sensitivity rating from 1 (low) to 5 (high) which evaluate sensitivity to erosion and flooding. Sensitivity rating of Conjola North NSW02.05.05 is listed as a 3 overall, although the erosion identified at Lake Conjola and Mollymook earns these areas a higher local rating of 4 (NCCARF, 2019).

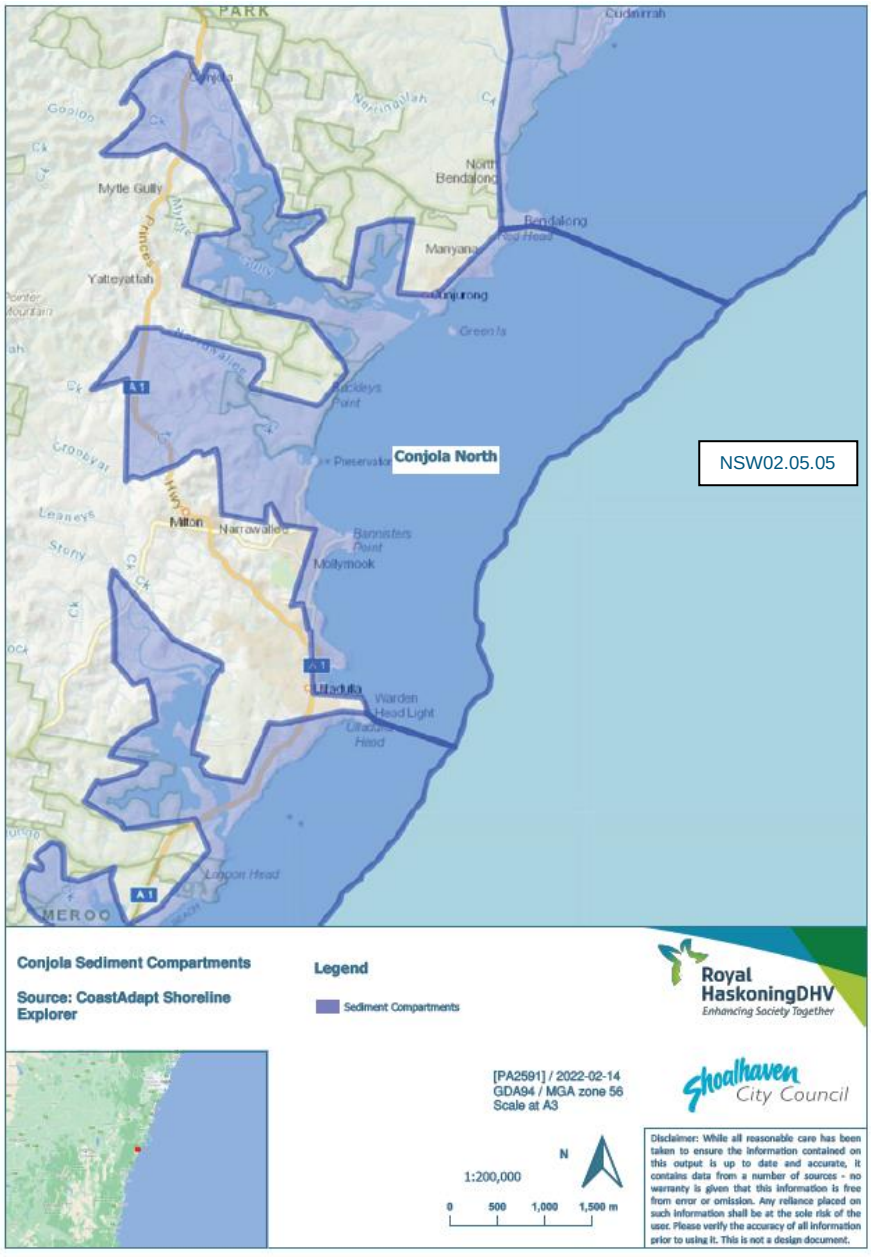

Figure 4-8: "Conjola North NSW02.05.05" Tertiary Coastal Sediment Compartment (source: NCCARF)

The Lake Conjola CMP does not include open coast processes, however, the Stage 2 risks, vulnerabilities and opportunities assessment has identified that open coast sediment transport is a factor in the dynamics of the fluctuating entrance condition.

While open coast coastal processes (including sediment transport) will be considered in detail during development of the *Open Coast and Jervis Bay CMP*, it is still relevant to recognise that the entire study area of the Lake Conjola CMP is contained within the Conjola North tertiary sediment compartment. Further refinement of NSW sediment compartments was undertaken by Carvalho and Woodroffe (2015). This work included the definition of the tertiary sediment compartment including Lake Conjola as extending from Red Head (Bendalong) in the north to Bannisters Point in the south (refer to compartment 21b shown in **Figure 4-9**. It is noted that this refined sediment compartment excludes Mollymook Beach and Ulladulla Harbour to the south, which were previously included in the NCCARF sediment compartment definition (refer **Figure 4-8**).

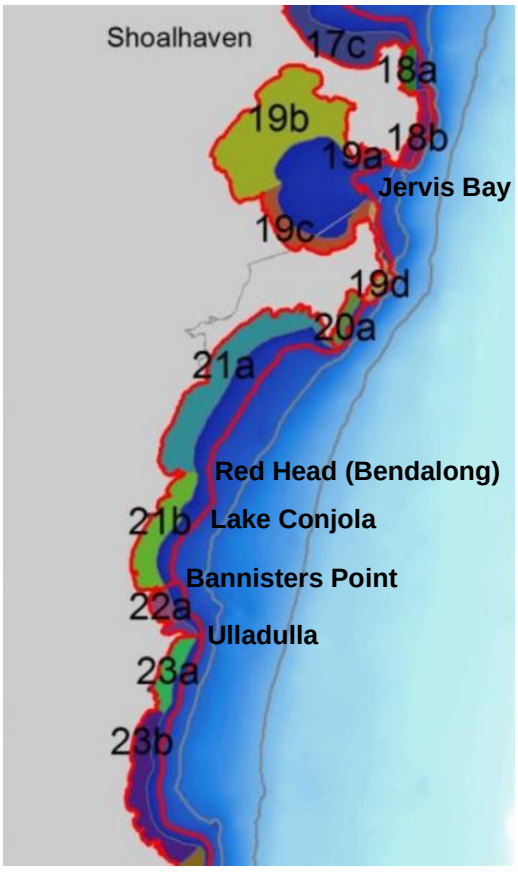

Figure 4-9: Refined NSW Sediment Compartments (source: Carvalho and Woodroffe, 2015)

5 Cultural Heritage Protection

The Lake Conjola area contains a number of European and Aboriginal heritage items and heritage conservation areas that are to be protected by Council policy and planning document and State legislation. These assets may also be threatened by future natural process and usage of the lake, hence their relevance for consideration within the Lake Conjola CMP. The following provides a summary of existing Council policy and planning documents and the known European and Aboriginal heritage items and locations within the CMP study area.

5.1 Council Policy and Planning Documents

Recognising the importance of Aboriginal and colonial history, Council developed and adopted a heritage protection policy in 2009, which in its current incarnation (last amended in 2021) is titled the *Shoalhaven Heritage Strategy 2021-2024*, Policy Number: POL21/11 (Heritage Strategy) (Council, 2021a). Key objectives and actions within the Heritage Strategy include a commitment to manage local heritage in a positive manner, and states that:

> *"Much of Shoalhaven is undeveloped and contains a range of natural and modified landscapes that are an important reminder of both Indigenous and early colonial settlement. Following colonisation, the landscape was quickly transformed as it was developed for timber supplies and farming and the resulting landscape is an important element in the character of the area. Development pressures close to towns and villages, and subdivision and development in rural areas can lead to a loss of buildings, plantings and landscape features that can erode this character.".*

Providing additional support for heritage conservation and protection, the Shoalhaven Local Environmental Plan 2014 (SLEP) provides specific reference to:

> **5.10 Heritage conservation**
>
> (1) **Objectives** The objectives of this clause are as follows—
> (a) to conserve the environmental heritage of Shoalhaven,
> (b) to conserve the heritage significance of heritage items and heritage conservation areas, including associated fabric, settings and views,
> (c) to conserve archaeological sites,
> (d) to conserve Aboriginal objects and Aboriginal places of heritage significance

Additional protection for *heritage items and heritage conservation areas* is provided through the *Shoalhaven Development Control Plan 2014 (SDCP)*, notably *Chapter 2: General and Environmental Considerations*, which states that:

> **Section 3 - European heritage**
>
> *There are a number of heritage items and heritage conservation areas identified throughout the Shoalhaven. These buildings, works, relics, places and conservation areas hold heritage significance because of their associations, their history, or their intrinsic qualities. Any new development is to maintain the heritage significance that already exists and conservation is encouraged.*
>
> 3.1 Application
>
> *This Section applies to heritage items and heritage conservation areas identified in the Shoalhaven Local Environmental Plan 2014.*

Section 4 - Aboriginal cultural heritage

Aboriginal cultural heritage is legally protected in NSW. There are many sites of special significance to Aboriginal communities in the Shoalhaven. These sites should be preserved for all people, as a part of our heritage. The National Parks and Wildlife Act 1974 (NPW Act), administered by the NSW Office of Environment and Heritage (OEH) is the primary legislation for managing and conserving Aboriginal objects or places. It is your responsibility to seek the necessary approval under the NPW Act, separate to Council's Development Assessment process.

OEH maintains a register of notified Aboriginal objects and declared Aboriginal places in NSW - the Aboriginal Heritage Information Management System (AHIMS). You can search AHIMS to discover if an Aboriginal object has been recorded or an Aboriginal place declared on a parcel of land.

5.2 Shoalhaven LEP 2014 Listed Heritage Items within Greater Lake Conjola Area

The heritage items and heritage conservation areas within the greater Lake Conjola area that are listed within *SLEP 2014 Schedule 5 - Environmental Heritage* are shown in **Table 5-1** and mapped in **Figure 5-1**, and reflect a number of post-colonisation locations and items.

Table 5-1: Heritage items and heritage conservation areas within greater Lake Conjola listed within Shoalhaven LEP 2014 Schedule 5 - Environmental Heritage

Suburb	Description	Location
Lake Conjola	Whitaker's Island View Resort (former)	2 Aney Street
Conjola	Conjola timber trestle bridge	Murrays Road
Conjola	Murray Family Cemetery	40 Murrays Road
Conjola	Conjola Cemetery	Princes Highway
Yatte Yattah	The Sheaffe Family Cemetery	Pointer Road
Yatte Yattah	Roman Catholic Church (former) and cemetery (former)	Princes Highway
Yatte Yattah	Yatte Yattah Nature Reserve and 2 Waterfalls	Princes Highway and 67B Skye Farm Lane
Yatte Yattah	"Woppindally"—early Victorian Georgian farmhouse and dairy farm complex	E280 Princes Highway
Yatte Yattah	"Kendall Dale"—dairy farm complex including homestead and garden	E379A Princes Highway
Yatte Yattah	Quercus robur (English Oak trees - 2) on driveway entrance	E379A Princes Highway
Yatte Yattah	"Kirmington"—Mid-Victorian Georgian farmhouse, dairy farm complex and Henry Kendall monolith	E379B Princes Highway
Yatte Yattah	Industrial building (former Yatte Yattah cheese factory)	E380 Princes Highway
Yatte Yattah	"Boolgatta"—Victorian residence, dairy farm complex and barn	E402D Princes Highway
Yatte Yattah	Former Yatte Yattah Public School and schoolmaster's residence	8A Tierney Road
Yatte Yattah	"Hillview" Private Cemetery	8B Tierney Road

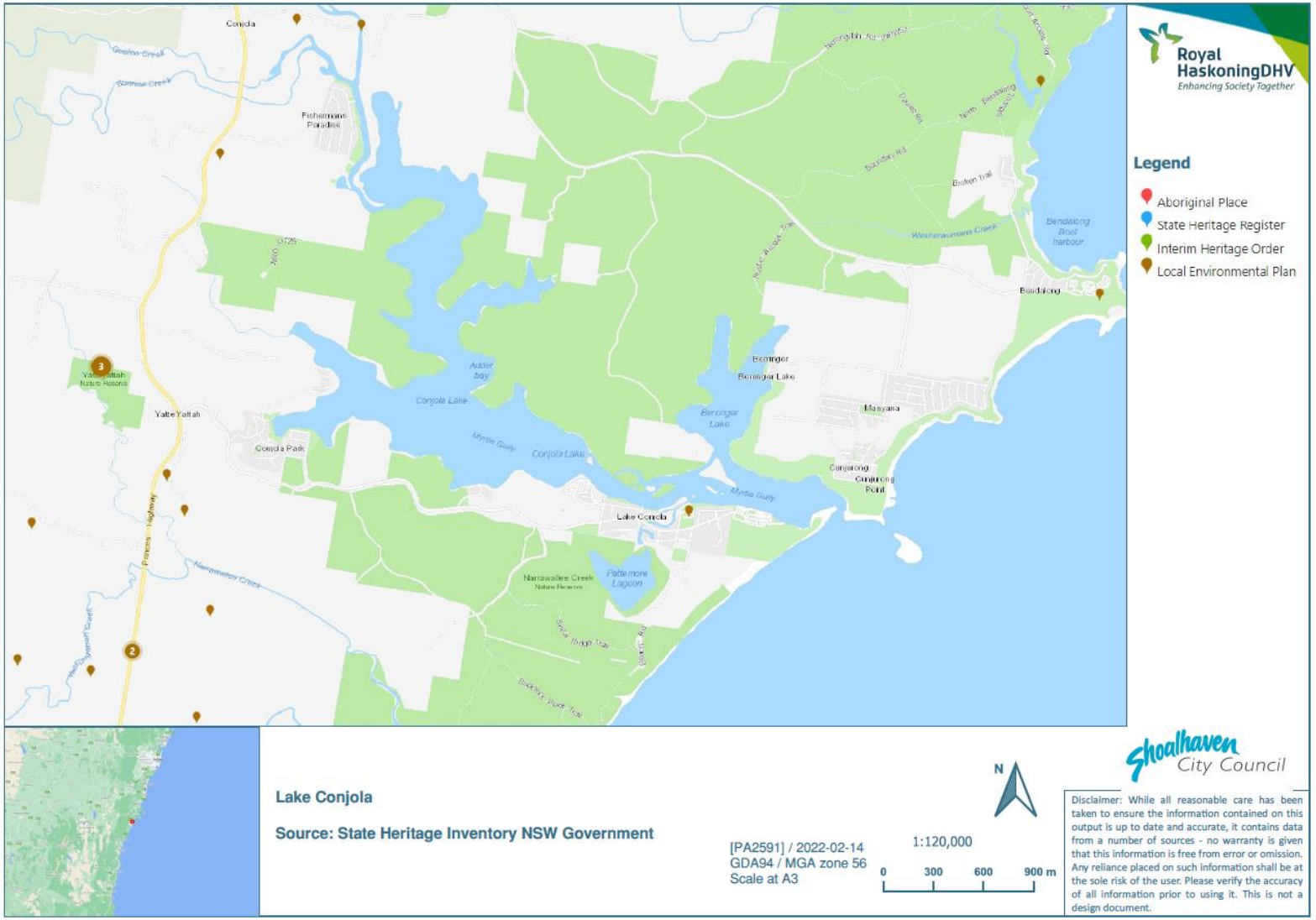

Figure 5-1: State Heritage inventory of registered heritage items within the Lake Conjola area

5.2.1 Chinamans Island

Chinamans Island, several hundred metres offshore from Lake Conjola Village, is Crown Land, and in 1947 the Crown Lands Department offered 12 lots for lease (by ballot) on a permissive occupancy agreement to reside on the island (SMH news report, 20 May 2020). The reported terms of the lease were that all houses and outbuildings must be demolished, and the land returned to a natural state, upon the death of the permissive occupancy holder. A number of cottages were subsequently built, and for over 60 years these cottages were mostly retained in the families that built them, with some having had permanent long term residents.

However, the 2019 and 2020 bush fires in New South Wales burned large sections of the Lake Conjola region and resulted in a significant number of homes and outbuildings being destroyed on Chinamans Island (along with many other areas of the catchment). The last remaining dwelling on Chinamans Island following the bushfires is shown in **Figure 5-2**.

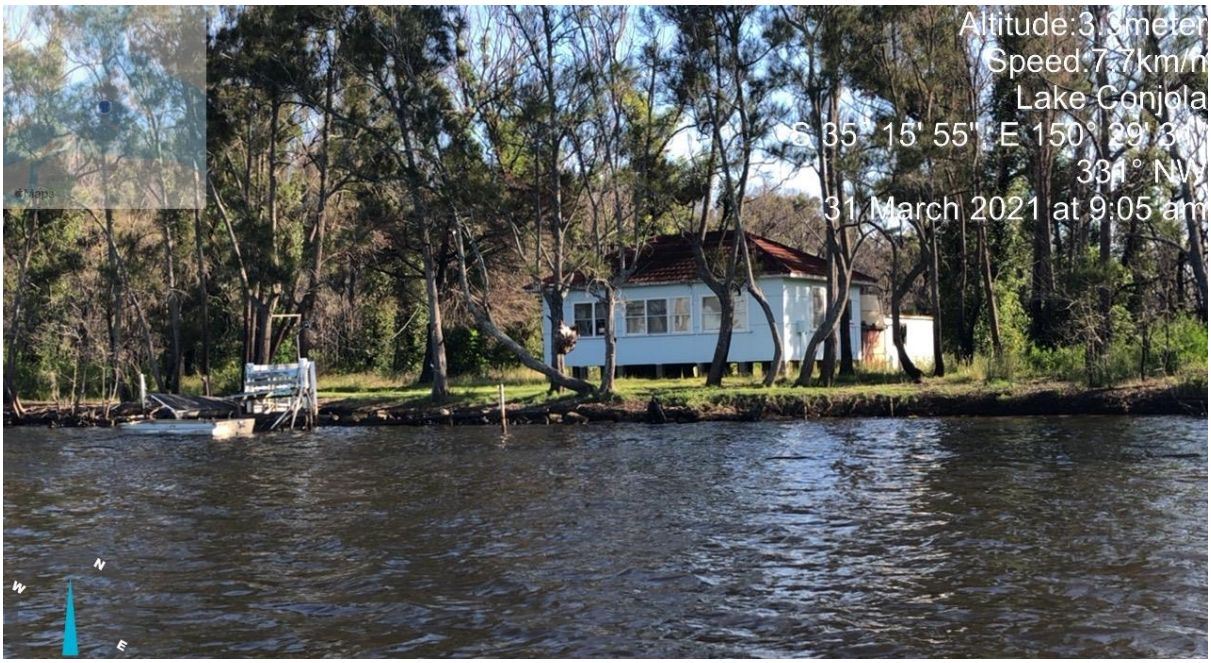

Figure 5-2: The sole remaining dwelling on Chinamans Island in March 2021

The NSW Government made available emergency funding for the remediation of uninsured homes burned down during the 2019/2020 bush fires (including those within Lake Conjola), possibly due to the potential health risk of fire damaged asbestos in many of the homes. Minister for Water, Property and Housing, Melinda Pavey stated that the NSW Government would conduct a clean-up of bushfire debris on the island to allow this coastal landmark to be remediated and reopened to the public once it is declared safe (Ulladulla Info news report, 8 December 2020). It is understood that this clean-up work has now been completed.

5.3 Aboriginal Heritage Items and Locations within Greater Lake Conjola Area

Aboriginal (and non-Aboriginal) people place cultural values on natural areas including aesthetic, social, spiritual and recreational values. Cultural values may be attached to the landscape as a whole or to

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6 Lake Conjola Community Demographics and Considerations

6.1 Lake Conjola Area Community Demographics

Lake Conjola is situated within the “district” identified as “Coastal Mid” within the national Census of Population and Housing undertaken by the Australian Bureau of Statistics (ABS) as shown in **Figure 6-1**.

The available ABS data on the “Coastal Mid” locality includes all areas within the Lake Conjola catchment (Bendalong, Berringer Lake, Conjola, Conjola Park, Cunjurong Point, Fishermans Paradise, Lake Conjola). However, it also includes a number of areas outside the Lake Conjola CMP spatial extent (Manyana, Mondayong and Yatte Yattah).

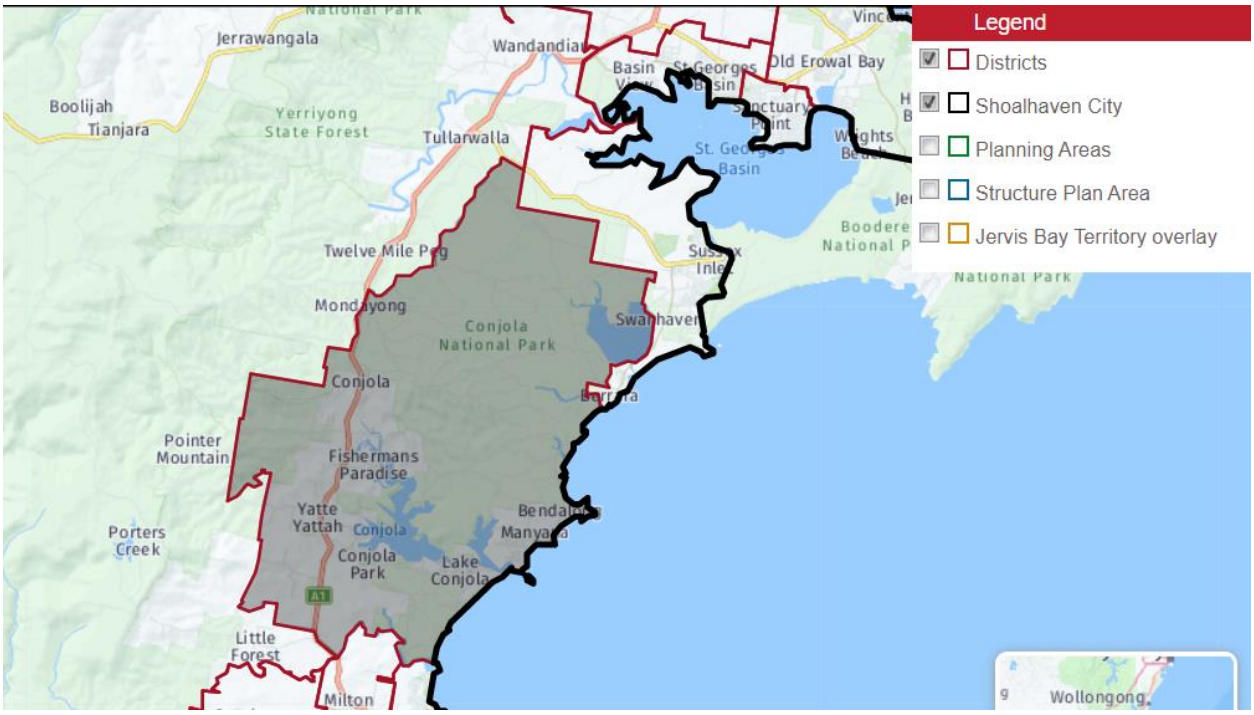

Figure 6-1: The "Coastal Mid " district that includes the catchment of Lake Conjola (source: profile.id, 2022)

With a land area of approximately 191 km^2 (including significant tracts of Conjola National Park), the usual resident population of Coastal Mid in 2016 was 2,304 people (ABS, 2016), while the 2020 Estimated Resident Population for Coastal Mid was 2,544, with a population density of 13.34 persons per km^2. The population growth rate of Coastal Mid has increased markedly in recent years, from less than half that of the wider Shoalhaven LGA in 2013, to nearly double the wider Shoalhaven rate of increase by 2020 (refer **Figure 6-2**) (profile.id, 2022).

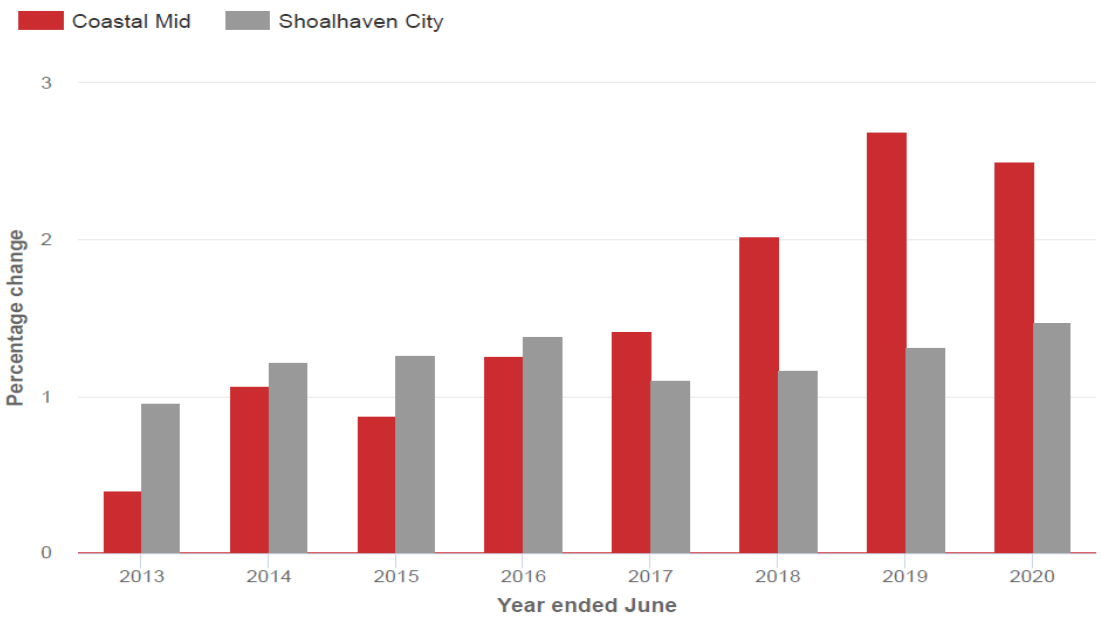

Figure 6-2: Resident population growth rate Coastal Mid vs Shoalhaven "City" 2013 – 2020

The labour force data is indicative of a predominantly retired or semi-retired local population, with a total labour force participation rate of around 40%. The employment status of "eligible" residents (aged 15 or more) in 2016, indicates that there was a 13% lower participation rate within the workforce compared to regional NSW, as well as 10% higher number of people "not in the labour force" compared to regional NSW (profile.id, 2022).

Within the Lake Conjola catchment area are four main "suburbs", being Lake Conjola, Conjola Park, Fishermans Paradise and Conjola. In the 2016 census, the combined population of the four suburbs was recorded at 1402 residents (ABS, 2016). While not having the same range of consolidated statistics than was available for the Coastal Mid locality, the four main villages do have "suburb" based 2016 Census QuickStats that provide location specific information. Noting the comparison between the NSW median of 38 years of age, and the median age of residents in Conjola (50 years), Fishermans Paradise and Conjola Park (51 years), Lake Conjola (61 years), and the comparison between the NSW median employment status of "both not working" of 21% and Conjola Park (25%), Conjola (29%), Fishermans Paradise (46%) and Lake Conjola (61%), it is apparent that the Conjola area comprises predominantly older, retired community members (ABS, 2016).

Lake Conjola is a popular tourist destination and during peak holiday periods the population may, at least, triple. There are four tourist parks in Lake Conjola which can, in total, accommodate around 3,000 people (GHD, 2015), as well as many private or semi-private holiday accommodation opportunities that together can increase the population of the Lake Conjola area further, up to approximately 5,000 people (Conjola Connected Communities Masterplan, 2020). A large proportion of the tourist facilities are located on low lying land along Lake Conjola Entrance Road, within the Lake Conjola Village and generally near the beach.

It is estimated that the value added by tourism to the Lake Conjola area is approximately $1.4 million per year, representing 5.8% of the total value added by all industries in this area. This figure appears to be somewhat skewed by the inclusion of "ownership of dwellings", with added value of $8.1 million, ranking as the highest contributing form of employment, as shown in **Figure 6-3** (Remplan Economy data, Council website 2022).

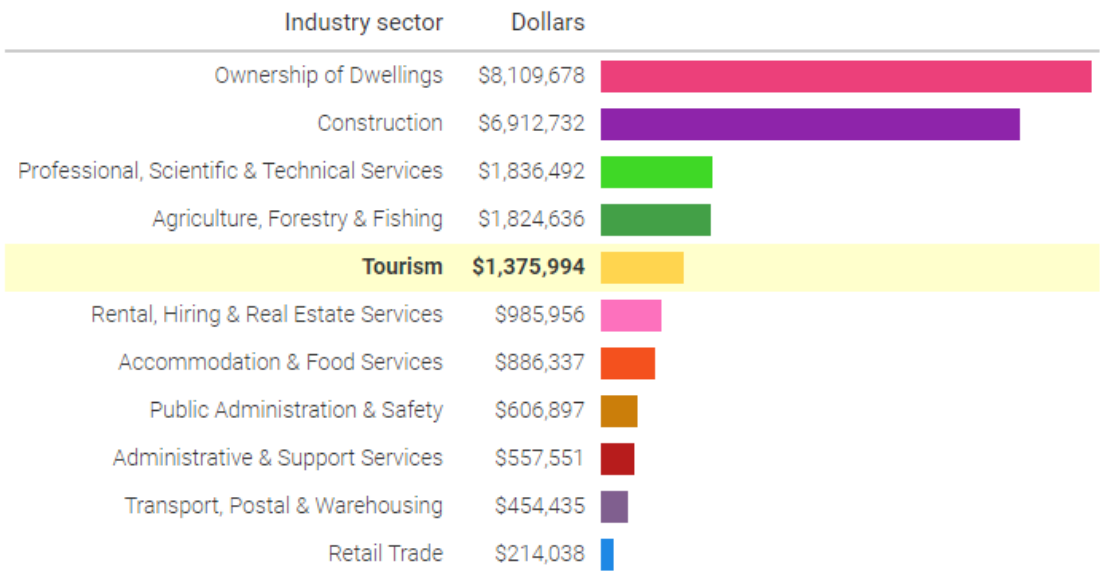

Figure 6-3: The value added by forms of employment within the greater Lake Conjola area (source: Remplan Economy data, Council website 2022)

6.2 Recreational use of Lake Conjola – Benefits and Controls

South Coast villages such as Lake Conjola have a heavy reliance on tourism for their livelihood. From observation, and discussion with residents, tourist accommodation proprietors, Council staff and other stakeholders, it is readily apparent that tourist visitors travel to Lake Conjola because of the beaches and waterways, and that a large number of residents and visitors to Lake Conjola are boating enthusiasts.

The regional economy benefits from tourism by a number of possible outlets:

- Accommodation
- Grocery, take-away food shops and restaurants
- Fuel suppliers and mechanical repairs
- Bait and fishing equipment outlets
- Sports and hardware stores
- Clubs

The economic benefits of tourism activity are difficult to allocate to specific local areas, as not all of these commercial outlets are available within the villages of Lake Conjola, Conjola Park, Fishermans Paradise, Manyana and Bendalong. However, the cumulative benefits of boating pursuits and waterway access to the regional economy is undoubtedly very significant.

While recreational fishing is a popular pastime for residents and visitors to Lake Conjola, consideration of cultural heritage and environmental attributes (including threatened species and other aquatic and terrestrial environmental matters) and the potential impacts of boating activity on these attributes as well as user conflict led to development of the "*Boating Plan of Management - Lake Conjola Estuary*" in 2005 by (then) NSW Maritime Authority (now a group within Transport for New South Wales (TfNSW)).

NSW Maritime Authority considered that a reasonably high level of regulation on Lake Conjola existed, more than on many other coastal lakes and estuaries. While identifying and addressing boating safety and carrying capacity of Lake Conjola, much of this regulation is related to protection of environmentally sensitive areas, including a focus on protection of eroding estuary foreshores. The causes of bank erosion

are noted to include flooding, wind-wave action, human and cattle activities, bank susceptibility, vessel traffic and the size, speed and distance-off of vessels.

6.2.1 Current Lake Conjola boating regulations

Management 'tools' within the Lake Conjola boating regulations designed to address actual or potential conflicts between different waterway activities, in particular between high-speed power boats and passive waterway users, include:

- Four knot speed limits
- 'No Wash' zones
- 'No Skiing' restrictions
- Distance-off marks
- Restricted access
- Allocation of time or space to conflicting user classes

The spatial application of boating regulations has been mapped within the Lake Conjola Boating Plan of Management (2005), as shown in **Figure 6-4**.

The Plan of Management states that it will be subject to review on a five yearly basis, both internally by NSW Maritime Authority and with reference to Shoalhaven City Council and the Southern Shoalhaven Natural Resource & Floodplain Management Committee. It is understood that there have been no updates since this time, and that the 2005 Plan of Management is still current and able to be enforced by TfNSW.

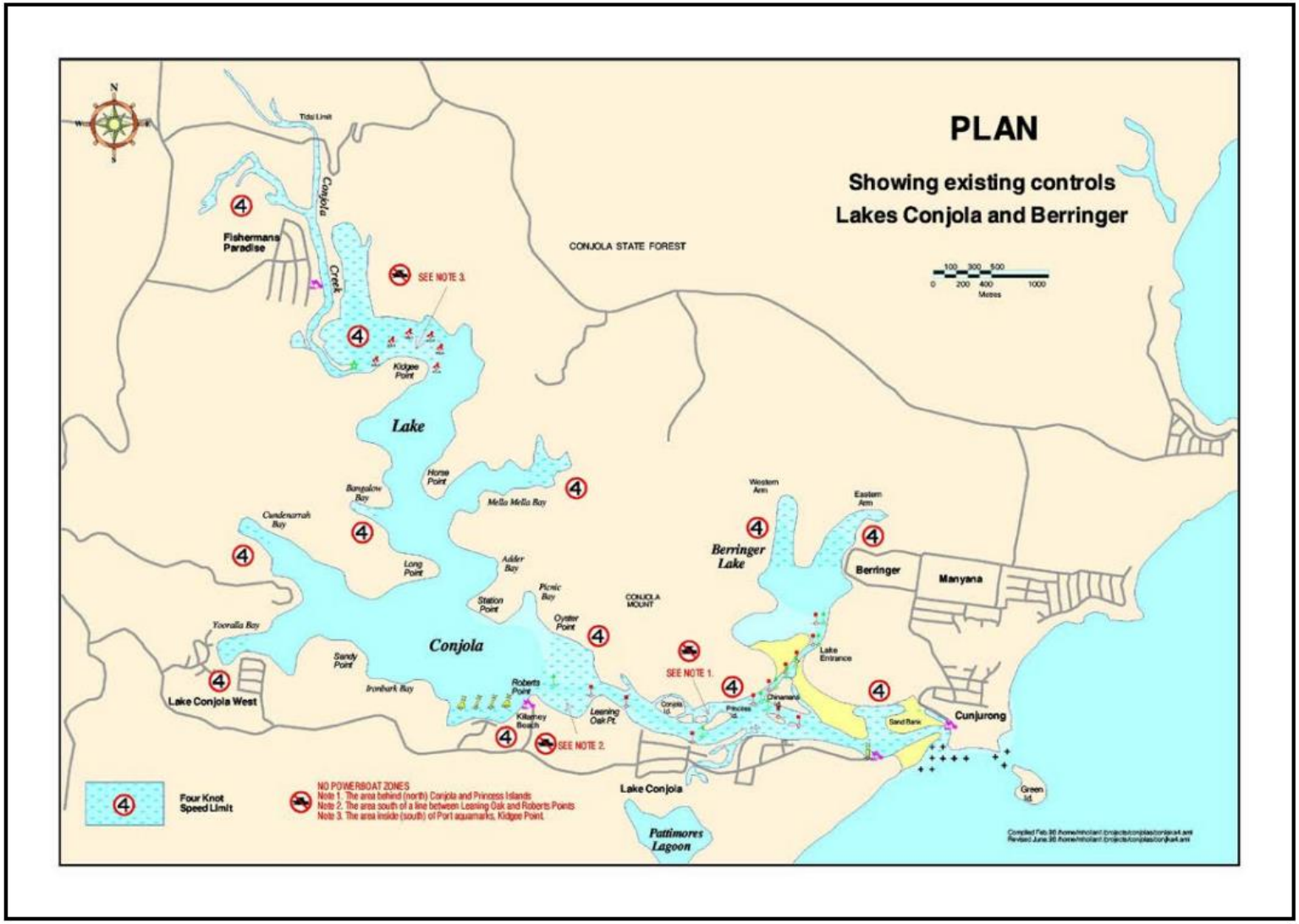

Figure 6-4: Map of Lake Conjola boating regulations (NSW Maritime Authority, 2005)

6.2.2 Spearfishing

Spearfishing in NSW is a popular form of recreational fishing and has been recognised for its selective fishing practices (DPI, 2016).

Spearfishing is prohibited in freshwater as well as many entrances, coastal lagoons and other tidal waters by DPI Fisheries. Specific restrictions are in place for Lake Conjola and Berringer Lake (refer **Figure 6-5**) which comprise the closure of the following area to spearfishing: eastwards of a line drawn from the northern extremity of Roberts Point to the western extremity of Station Point, downstream to the South Pacific Ocean (DPI, 2016).

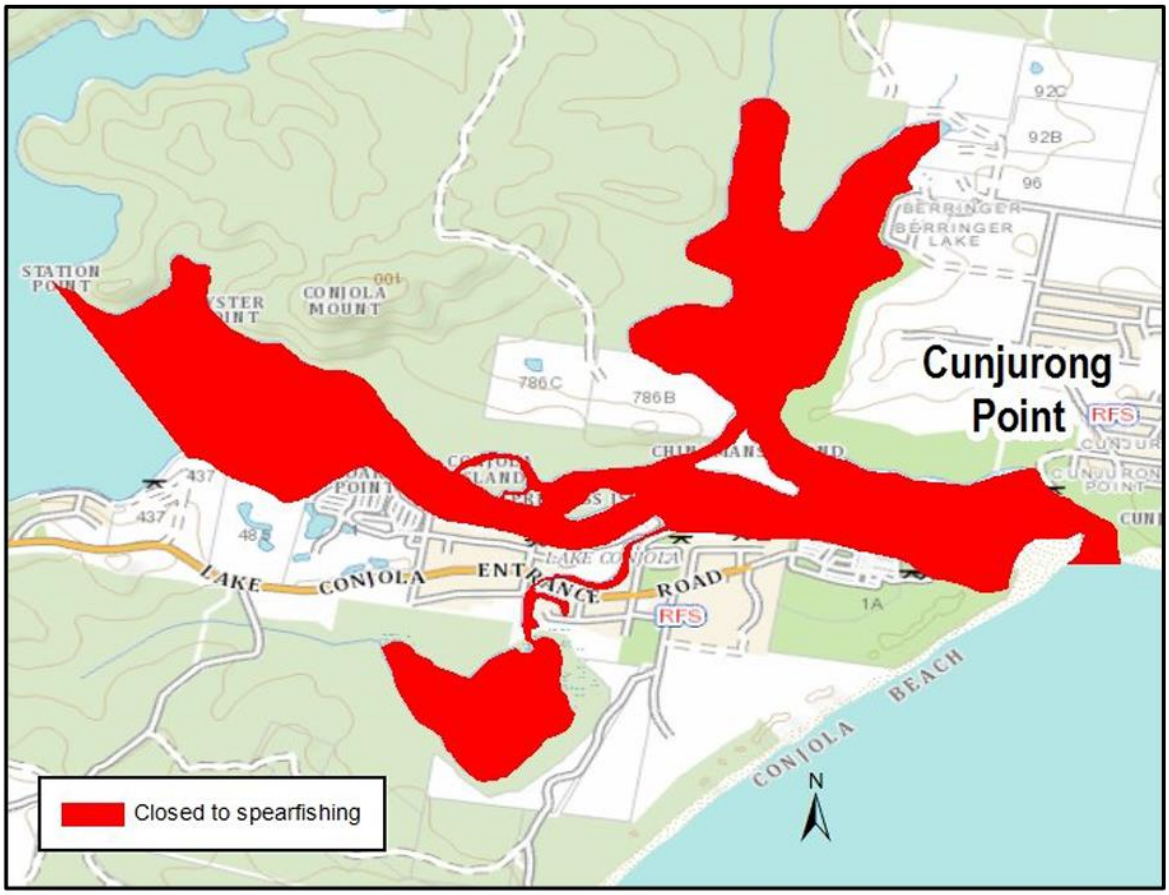

Figure 6-5: Spatial extent of "no spearfishing" area within Lake Conjola

6.3 Current Built Assets within Lake Conjola

As previously noted, 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 (discussed in **CMP Stage 2 - Report B**).

In addition, in order to assist Council's immediate and long-term asset management planning, RHDHV identified 247 Council owned and/or managed assets within the greater Lake Conjola area that have been included within the Asset-Based Risk Assessment process (**CMP Stage 2 – Report B**). These include a

range of built structures and assets (such as carparks, roads, boat ramps, stormwater and sewerage network, and a caravan park), as well as natural assets (such as Endangered Ecological Communities). Please see **Table 6-1** for an excerpt from the Asset-Based Risk Assessment spreadsheet.

The Asset-Based Risk Assessment has been completed by Council asset managers in collaboration with RHDHV, and relevant actions will be included within the Lake Conjola CMP action plan and business plan.

Table 6-1: Example of Council owned/managed assets within greater Lake Conjola

Asset Category	Asset Type	Asset Name / Location	Suburb
Water Infrastructure	Potable Water Infrastructure - Reticulation/Pumping Station/Mains	Wattle St	Fishermans Paradise
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Alma Ave	Fishermans Paradise
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Anglers Parade	Fishermans Paradise
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Fishermans Paradise Rd	Fishermans Paradise
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Murrays Road	Fishermans Paradise
Water Infrastructure	Sewer Infrastructure - Reticulation/Pumping Station/Mains	Wattle St	Fishermans Paradise
Water Infrastructure	Stormwater Infrastructure	Alma Ave	Fishermans Paradise
Water Infrastructure	Stormwater Infrastructure	Anglers Parade	Fishermans Paradise
Water Infrastructure	Stormwater Infrastructure	Fishermans Paradise Rd	Fishermans Paradise
Water Infrastructure	Stormwater Infrastructure	Murrays Road	Fishermans Paradise
Water Infrastructure	Stormwater Infrastructure	Wattle St	Fishermans Paradise
Community Asset	Carpark\Carpark	Holiday Haven boat ramp car park	Lake Conjola
Community Asset	Carpark\Carpark	Lake Conjola Community Centre	Lake Conjola
Community Asset	Community Building	Lake Conjola Community Centre	Lake Conjola
Community Asset	Community Building	RFS Brigade building	Lake Conjola
Community Asset	Natural Area	Conjola Beach	Lake Conjola
Community Asset	Natural Area	Narrawallee Creek Nature reserve	Lake Conjola
Community Asset	Open Space / Reserves / Parks	Edwin Avenue Reserve	Lake Conjola
Community Asset	Open Space / Reserves / Parks	Leaning Oak Point	Lake Conjola
Community Asset	Open Space / Reserves / Parks	Roberts Point	Lake Conjola
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Bowling Club	Lake Conjola
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Community Centre tennis cou	Lake Conjola
Community Asset	Sports Ground / Recreational Clubs	Lake Conjola Sports Field - off Thorne Stree	Lake Conjola
Natural Assets	EEC	Bangalay Sand Forest	Lake Conjola
Natural Assets	EEC	Swamp Oak Floodplain Forest	Lake Conjola
Natural Assets	National Parks / Nature Reserves / Natural Areas	Conjola National Park	Lake Conjola
Transport Assets	Boat Ramp	Holiday Haven boat ramp	Lake Conjola
Transport Assets	Boat Ramp	Norman Street trailer launch ramp	Lake Conjola
Transport Assets	Bridge Major	Lake Conjola Entrance Road bridge	Lake Conjola
Transport Assets	Roads Major	Lake Conjola Entrance Road	Lake Conjola
Transport Assets	Roads Minor	Aney St	Lake Conjola
Transport Assets	Roads Minor	Beach Road	Lake Conjola
Transport Assets	Roads Minor	Boeing Ave	Lake Conjola
Transport Assets	Roads Minor	Carroll Ave	Lake Conjola
Transport Assets	Roads Minor	Conley Ave	Lake Conjola

7 Statutory Framework for Protection of the Environment and for Coastal Management

Council shares management of the coastline and its coastal zone in collaboration with DPE in respect to National Parks and Crown Land. Features such as beaches, rocky foreshores and the open coast below the mean high water mark are generally designated as Crown Land.

DPE - Crown Lands is responsible for the administration and/or management of Crown Land under the *Crown Land Management Act 2016*. Crown Land includes submerged Crown Land, seabed and subsoil to three nautical miles from the coastline of NSW that is within the limits of the coastal waters of the State. Crown Land includes much of the submerged land within estuaries and intertidal areas (below mean high water mark), as well as foreshore reserves and beaches.

There are a number of Crown Reserves within Shoalhaven for which Council is the Reserve Trust Manager or Trustee, with any works or actions required to appropriately manage these lands identified within Plans of Management prepared and adopted by Council. A number of Crown Land reserves and foreshores within the Lake Conjola study area are under the Care Control and Management (CCM) of Council and are subject to similar provisions. Where management actions are proposed on Crown Land, relevant authorisations and approvals may need to be obtained under the *Crown Land Management Act 2016* (CLM Act).

Any proposed development within the Lake Conjola catchment, and elsewhere in NSW, must undertake an environmental impact assessment that considers the provisions of the:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- NSW *National Parks and Wildlife Act 1974* (NP&W Act);
- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Aboriginal Land Right Act 1983* (ALR Act);
- *Biodiversity Conservation Act 2016* (BC Act);
- *Coastal Management Act 2016* (CM Act);
- *State Environmental Planning Policy (Resilience and Hazards) 2021* (RH SEPP)
- *Fisheries Management Act 1994* (FM Act);
- Shoalhaven Local Environmental Plan 2014 (SLEP);
- Shoalhaven Development Control Plan 2014 (SDCP); and,
- other legislation relevant to Matters of National Environmental Significance, the protection of threatened flora and fauna species, Endangered Ecological Communities (EECs) and appropriate management of the NSW coast.

7.1 Environmental Protection Provisions within the Shoalhaven Local Environmental Plan 2014

Of relevance to the Lake Conjola CMP, environmental protection provisions within the Shoalhaven Local Environmental Plan 2014 (SLEP) include:

Section 7.5 Terrestrial biodiversity

The objective of this clause is to maintain terrestrial biodiversity, by:

(a) protecting native fauna and flora,

(b) protecting the ecological processes necessary for their continued existence, and
(c) encouraging the conservation and recovery of native fauna and flora and their habitats.

Biodiversity corridors for faunal and avian movement, as well as delineating areas of significant vegetation, have been formally recognised and mapped within the SLEP, with the Biodiversity Map for the Lake Conjola area shown in **Figure 7-1**. Proposed development (as defined under the EP&A Act) that may impact on biodiversity habitat corridors and/or significant vegetation are required to meet a range of development controls that are applied through the associated Shoalhaven Development Control Plan (SDCP) 2014.

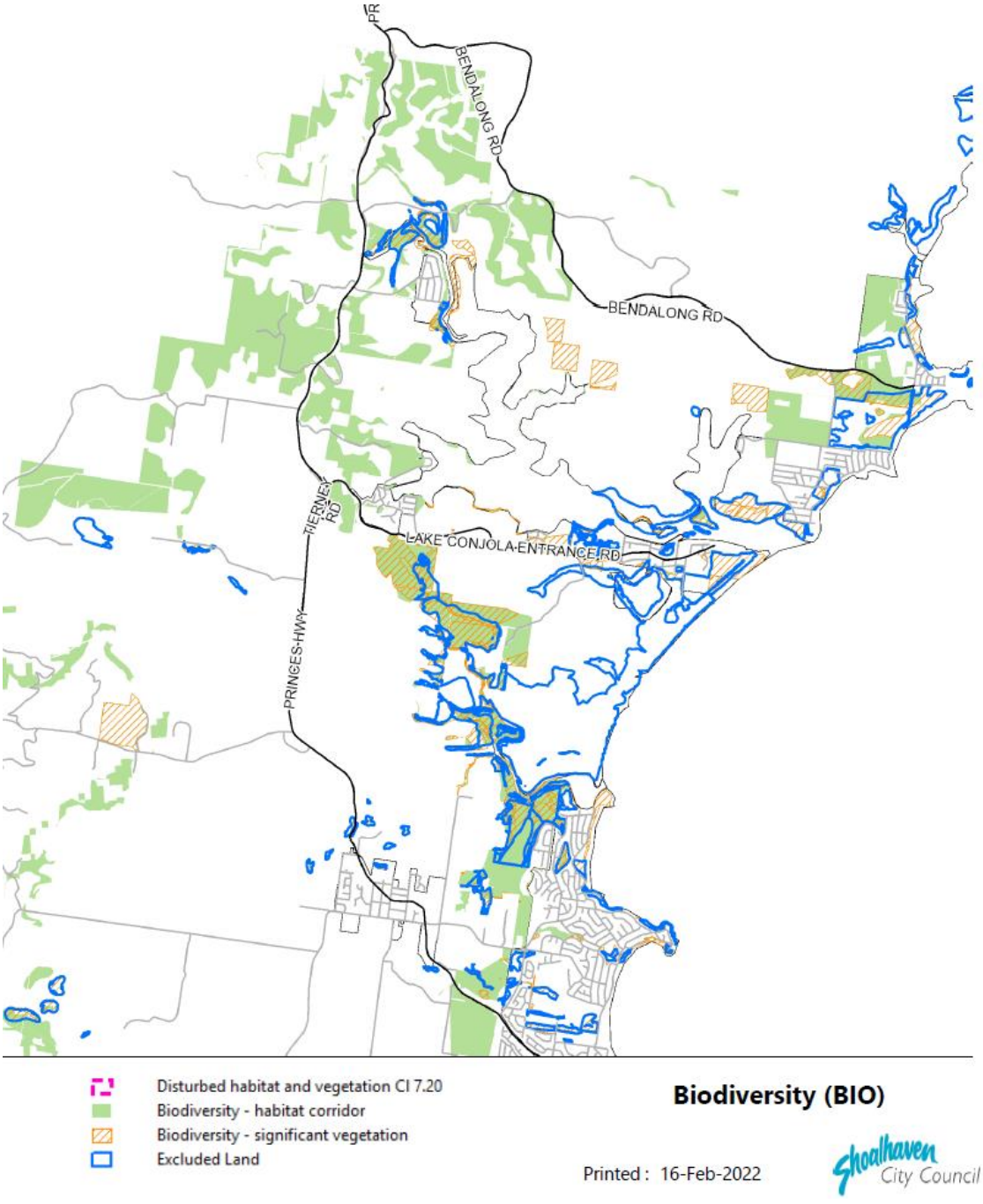

Figure 7-1:Shoalhaven LEP 2014 - Biodiversity Mapping – Lake Conjola Area

Section 7.6 Riparian land and watercourses

(1) The objective of this clause is to protect and maintain the following—
  (a) water quality within watercourses,
  (b) the stability of the bed and banks of watercourses,
  (c) aquatic and riparian habitats,
  (d) ecological processes within watercourses and riparian areas.

(2) This clause applies to all of the following—
  (a) land identified as “Riparian Land” on the Riparian Lands and Watercourses Map (refer to **Figure 7-2** and **Figure 7-3**),
  (b) land identified as “Watercourse Category 1”, “Watercourse Category 2” or “Watercourse Category 3” on that map,
  (c) all land that is within 50 metres of the top of the bank of each watercourse on land identified as “Watercourse Category 1”, “Watercourse Category 2” or “Watercourse Category 3” on that map.

Riparian Lands and Watercourses have been formally recognised and mapped within the SLEP (refer to **Figure 7-2** and **Figure 7-3**). Proposed development (as defined under the EP&A Act) that may impact on Riparian Lands and Watercourses are required to meet a range of development controls that are applied through the associated Shoalhaven Development Control Plan (SDCP) 2014.

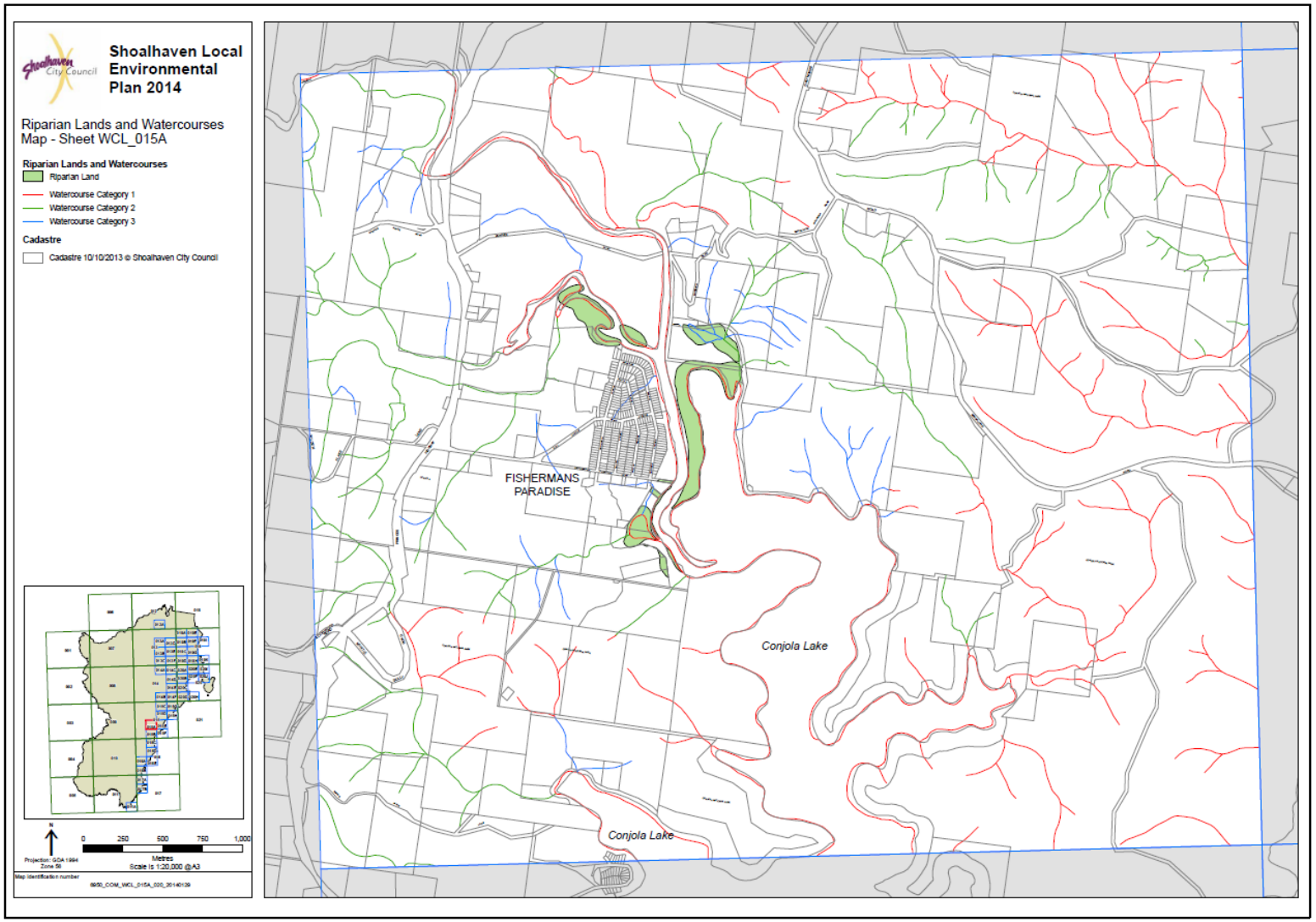

Figure 7-2: Shoalhaven LEP Riparian Lands and Watercourses Map 15A

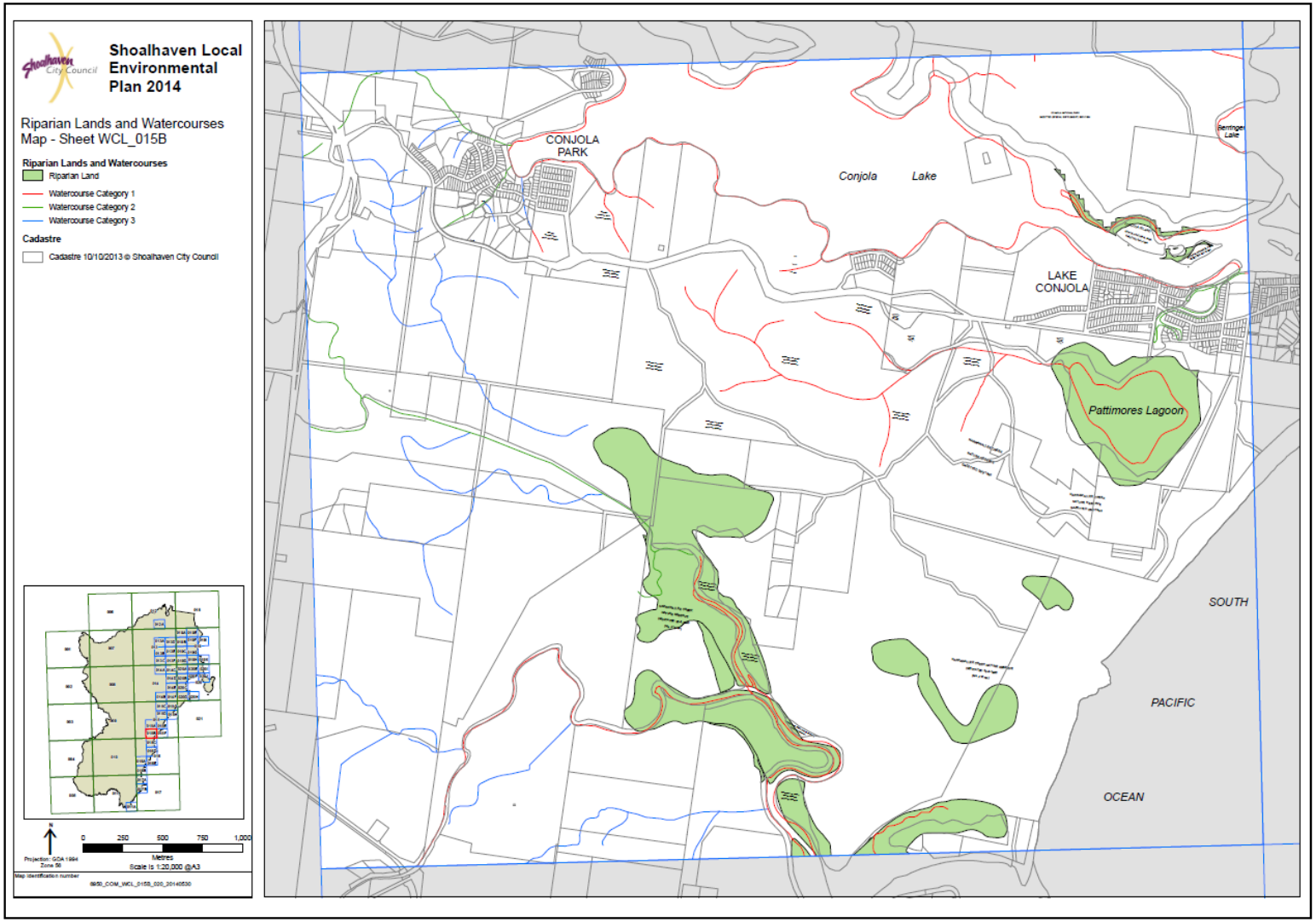

Figure 7-3: Shoalhaven LEP Riparian Lands and Watercourses Map 15B

7.2 Statutory framework for Coastal Management in NSW

The statutory and policy framework for coastal and marine management is governed by the *Coastal Management Act 2016* and the *Marine Estate Management Act 2014* (MEM Act). The *Coastal Management Act 2016* (CM Act) has practical effect through the requirements of the *State Environmental Planning Policy (SEPP) (Resilience and Hazards) 2021*. Local councils and public authorities are required to manage their coastal areas and activities in accordance with relevant state legislation, policies and plans.

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*.

Local councils in NSW are required to undertake their planning and reporting activities in accordance with the *Local Government Act 1993* (LG Act) and the Local Government (General) Regulation 2005 (Regulation). The Act and Regulation provides guidelines for councils to follow to ensure community involvement is central to the formation of strategic plans that drive council's long-term planning and day to day operations. The Integrated Planning and Reporting Framework (shown in **Figure 7-4**) is the name given to that section of the Act and Regulation that deals with Council's planning processes and the community's involvement.

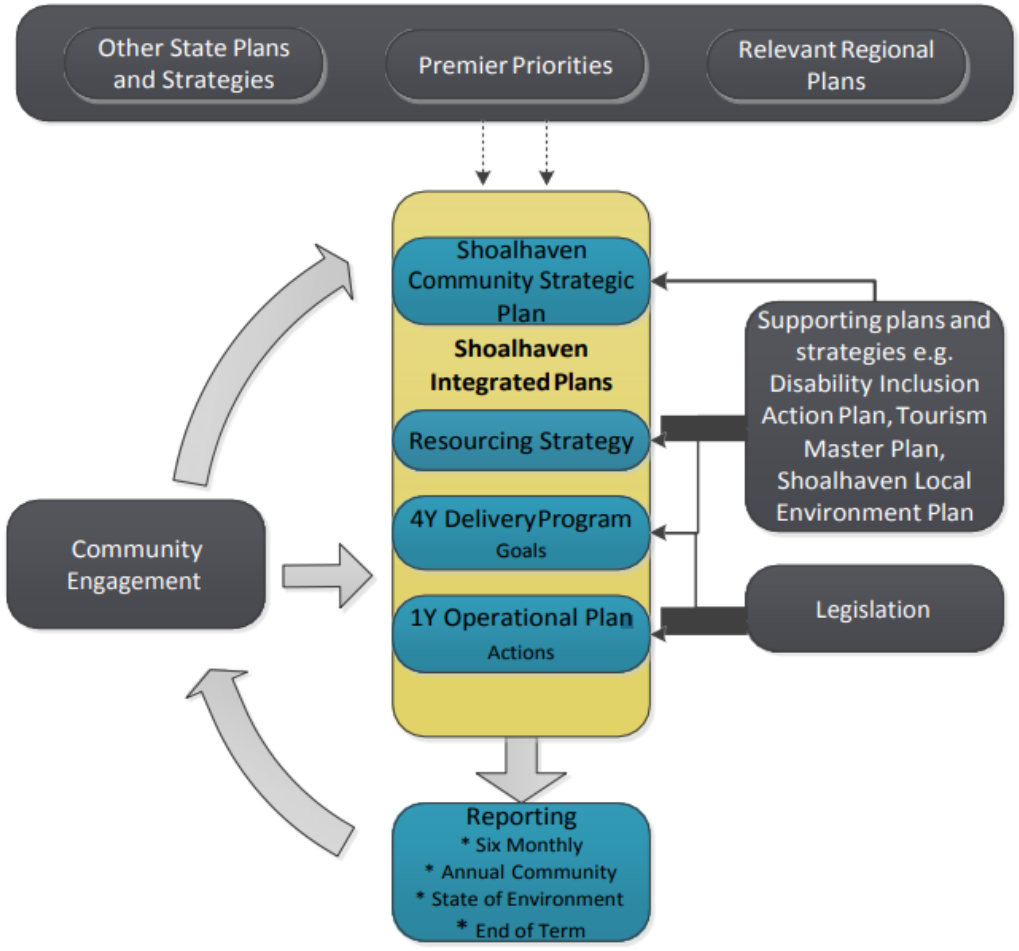

Figure 7-4: Shoalhaven City Council Integrated Planning and Reporting Framework

The Integrated Planning and Reporting (IP&R) Framework seeks to ensure responsible and sustainable decision-making by Councils, and, as a stated core aim, the Coastal Management SEPP has to establish a framework for land use planning to guide decision-making in the coastal zone. The CM Act and the RH SEPP, as well as the *Local Government Act 1993*, are integrated 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 MEM Act and its associated planning requirements. Key issues have been identified within the Threat and Risk Assessment (TARA) for the Marine Estate, and have been used to inform the identification of coastal management issues within the Lake Conjola CMP (further details are provided within **Stage 2 – Report B**).

The statutory framework for managing the NSW coast as shown in **Figure 7-5**, and described in further detail below, includes:

- *Coastal Management Act 2016* (CM Act);
- *State Environmental Planning Policy (Resilience and Hazards) 2021* (RH SEPP); and,
- Coastal Management Programs (CMPs) prepared in accordance with the NSW Coastal Management Manual (the Manual).

Other NSW legislation is relevant to the management of the environmental, social and economic values of the coastal zone, including:

- *Marine Estate Management Act 2014* (MEM Act);
- *Crown Land Management Act 2016* (CLM Act);
- *Aboriginal Land Right Act 1983* (ALR Act);
- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Protection of the Environment Operations Act 1997* (PoEO Act);
- *Local Government Act 1993* (LG Act);
- *National Parks and Wildlife Act 1974* (NP&W Act);
- *Fisheries Management Act 1994* (FM Act);
- *Local Land Services Act 2013* (LLS Act); and,
- *Biodiversity Conservation Act 2016* (BC Act).

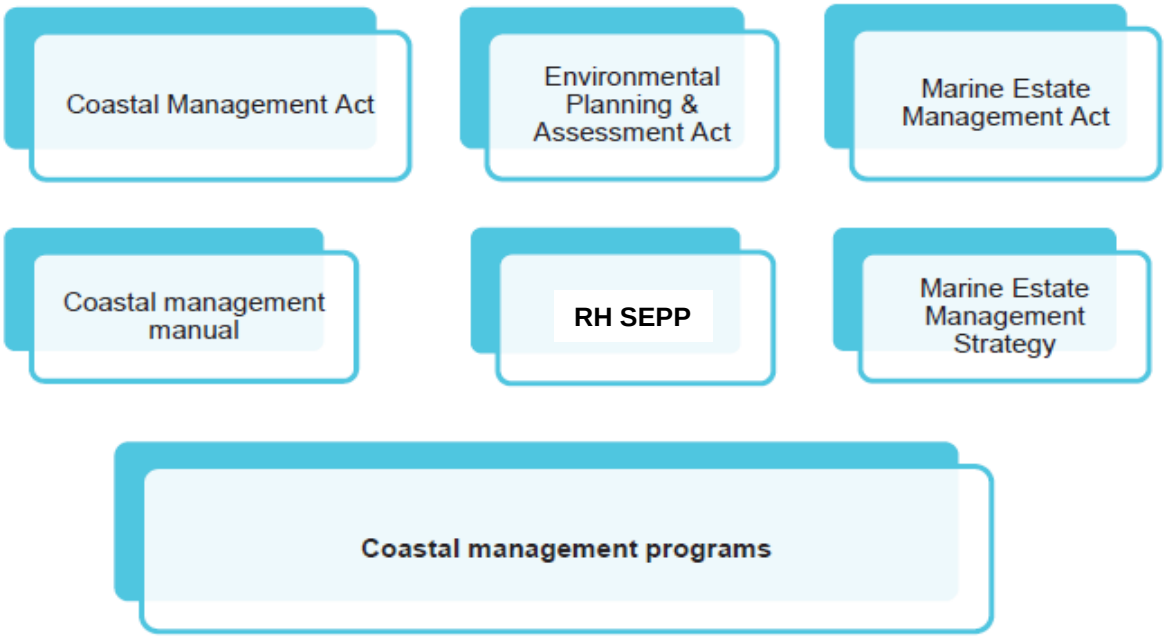

Figure 7-5: NSW Coastal Management Framework (NSW Coastal Management Manual, OEH, 2018).

7.2.1 *Coastal Management Act 2016* (CM Act)

The *Coastal Management Act 2016* (CM Act) declares that the purpose of a CMP is to set the long-term strategy for the co-ordinated management of land within the coastal zone with a particular focus on achieving the objects outlined within the CM Act. The CM Act defines the coastal zone as being made up of four coastal management areas, while the *State Environmental Planning Policy (Resilience and Hazards) 2021* (RH SEPP) identifies the parts of NSW that fall into each of these coastal management areas (described below in **Section 7.2.3**).

The CM Act underpins the management of the coastal zone of NSW, with objectives of the CM Act that include:

(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, and
(c) to acknowledge Aboriginal peoples' spiritual, social, customary and economic use of the coastal zone, and
(d) to recognise the coastal zone as a vital economic zone and to support sustainable coastal economies, and
(e) to facilitate ecologically sustainable development in the coastal zone and promote sustainable land use planning decision-making, and,
(f) to mitigate current and future risks from coastal hazards, taking into account the effects of climate change.

Part 3 of the CM Act led to the *NSW Coastal Management Manual* being published in 2018 by the Office of Environment and Heritage (OEH, now DPE), which provides guidance on the preparation, development, adoption, implementation, amendment, review, and the contents of coastal management programs that are developed by local councils.

7.2.2 State Environmental Planning Policy (Resilience and Hazards) 2021

State Environmental Planning Policy (Resilience and Hazards) 2021, known as the Resilience and Hazards SEPP (RH SEPP) gives effect to the objectives of the CM Act. The RH SEPP defines the coastal zone and establishes state-level planning priorities and development controls to guide decision-making for development within the coastal zone. The RH SEPP commenced on 1 March 2022 and seeks to promote an integrated and coordinated approach to land use planning in the coastal zone, that is consistent with the objects of the CM Act 2016.

The focus of the RH SEPP is on ecologically sustainable development that:

- protects and enhances sensitive coastal environments, habitats and natural processes
- strategically manages risks from coastal hazards
- maintains and enhances public access to scenic areas, beaches and foreshores
- supports the objectives for our marine environments under the *Marine Estate Management Act 2014*
- protects and enhances the unique character, cultural and built heritage of our coastal areas, including Aboriginal cultural heritage.

Under the previous *Coastal Protection Act 1979*, the coastal zone comprised of a single area. It is now comprised of four distinct coastal management areas, enabling more targeted management of the diversity of environments, associated pressures and interests in the coast, which are:

- Coastal Wetlands and Littoral Rainforests Area - defined as areas with particular hydrological and ecological characteristics
- Coastal Vulnerability Area - defined as the area affected by any one of seven coastal hazards
- Coastal Environment Area - defined as the coastal waters of the state, estuaries, coastal lakes and foreshores including beaches, dunes, headlands and rock platforms as well as surrounding land
- Coastal Use Area - defined as land adjacent to the coast, where development is or may be carried out.

The RH SEPP includes digitised maps for three of the four Coastal Management Areas (the Coastal Vulnerability Area has not been mapped). Targeted development controls apply to each area and are designed to achieve the specific management objectives for that area as set out in the CM Act.

Some land may be mapped as more than one coastal management area. In these cases, development controls for all of the relevant coastal management areas will apply. In accordance with the Act, in the event of any conflict, the priority order (highest to lowest) of the management objectives and controls for overlapping coastal management areas is: coastal wetlands and littoral rainforests area, coastal vulnerability area, coastal environment area and coastal use area.

7.2.3 Coastal Management Areas

7.2.3.1 Coastal Wetlands and Littoral Rainforests Area

The CM Act defines the Coastal Wetlands and Littoral Rainforests Area (CWLRA) as the land which displays the hydrological and floristic characteristics of coastal wetlands or littoral rainforests, as well as a surrounding proximity area to manage impacts of adjacent development. Coastal wetlands mapped in NSW for the development of the RH SEPP include those that are dominated by the following vegetation types: mangroves, saltmarshes, melaleuca forests, casuarina forests, sedgelands, brackish and

freshwater swamps, and wet meadows. The CWLRA mapping provided in the RH SEPP for Lake Conjola is depicted in **Figure 7-6**.

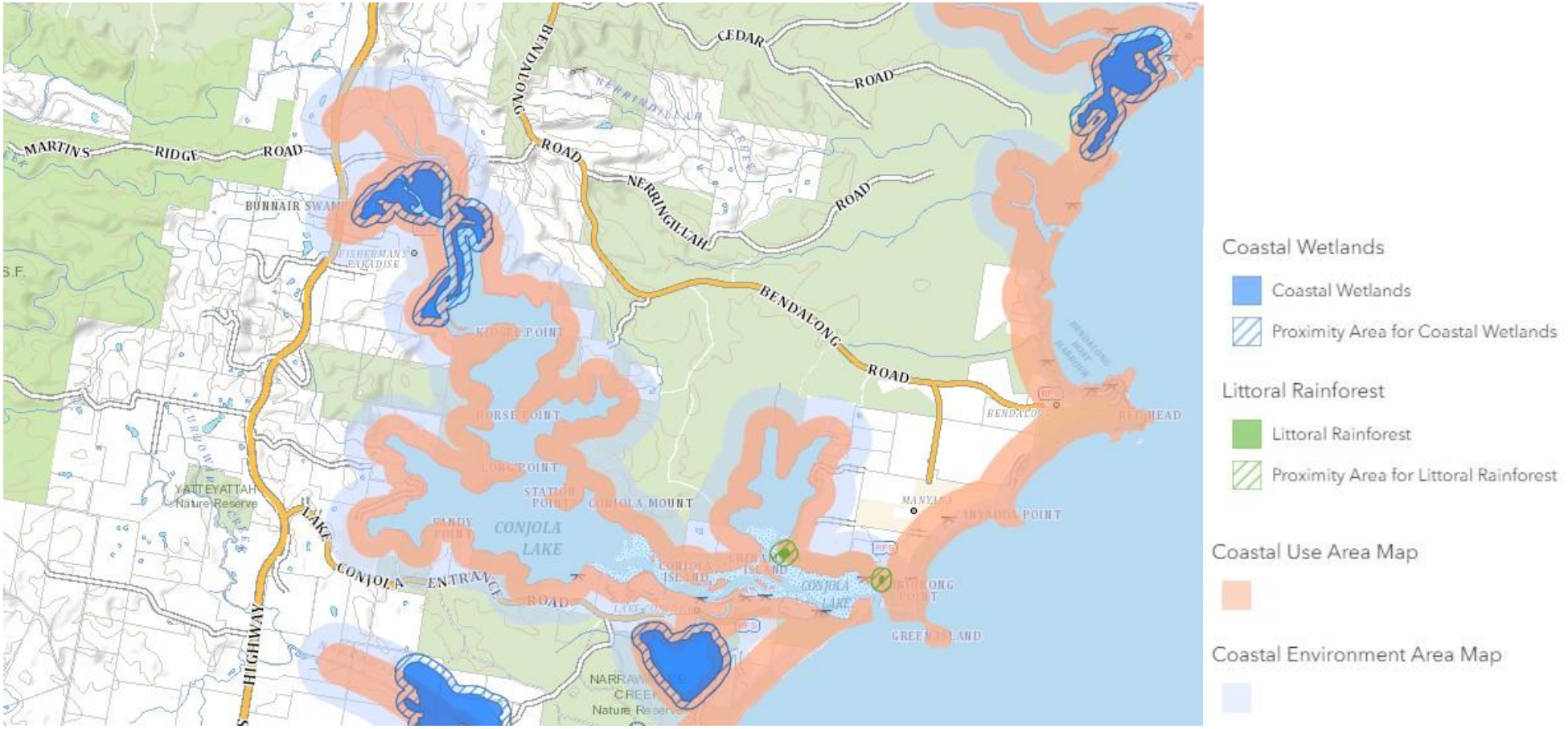

Figure 7-6: RH SEPP Coastal Management Area Mapping (source: NSW ePlanning Spatial Viewer)

7.2.3.2 Coastal Vulnerability Area

The Coastal Vulnerability Area (CVA) is defined in the Act as land which is subject to coastal hazards. The area focusses on identifying land subject to current and future coastal hazards, and to ensure land use management and development undertaken in these areas recognise coastal risk and is subsequently appropriate. The Act provides for the management of seven coastal hazards:

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

It is important to note that the CMP hazard mapping identifies a range of risk exposures (current and future) for several different hazards (listed above). At the time of preparing this report, there was no map published under the RH SEPP to identify the CVA across the study area.

7.2.3.3 Coastal Environment Area

The CM Act defines the Coastal Environment Area (CEA) as land containing coastal features such as the coastal waters of the States, estuaries, coastal lakes, coastal lagoons, and land adjoining those features including headlands and rock platforms. Beaches dunes and foreshores are included in this area. Within estuaries, the coastal environment area extends upstream to the extent of tidal influence.

The area of land adjacent to the open coast, estuary or coastal lake / lagoon is also included in the coastal environment area. This is to ensure nearby development takes into account potential impacts on the coastal environment. The RH SEPP mapping for the coastal environment area therefore includes the following buffers around these coastal features for regional area such as the Shoalhaven:

- For estuaries and coastal lakes: a 500 m landwards buffer;
- For beaches, dunes, headlands, rock platforms and foreshore: a 250 m landwards buffer.

The coastal environment area mapping provided in the RH SEPP is depicted in **Figure 7-6**.

Consideration may be given to utilisation of hydrological boundaries within the catchment of Lake Conjola to describe and map the Coastal Environment Area of Lake Conjola, as shown in **Figure 7-7**. Use of hydrological boundaries would provide a degree of consistency as to consideration of the physical extent of the catchment, ensuring that development within the influencing catchment would have appropriate controls applied.

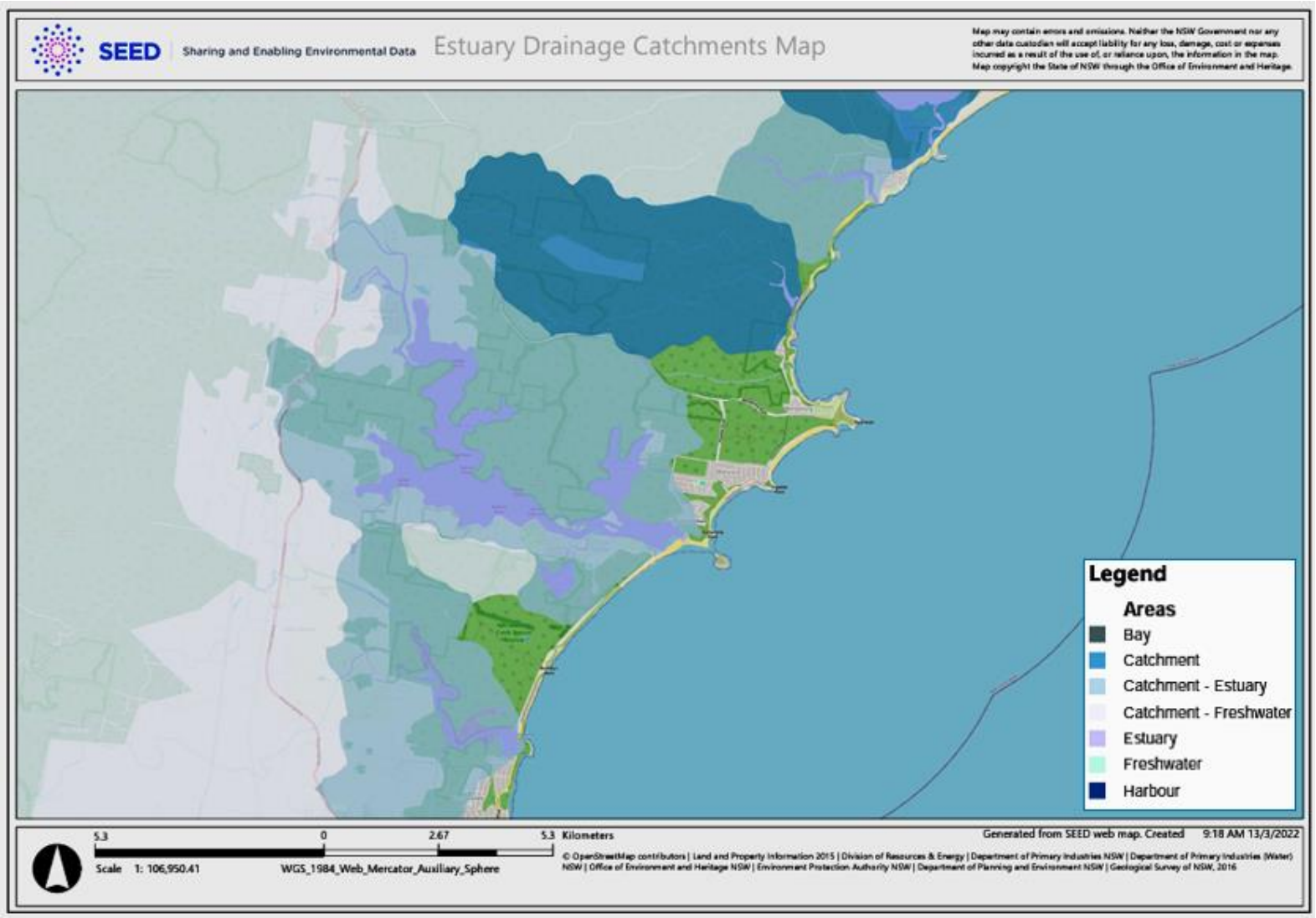

Figure 7-7: Lake Conjola Region Estuary Drainage Catchment Map

7.2.3.4 Coastal Use Area

The CM Act defines the Coastal Use Area (CUA) as being land adjacent to coastal waters, estuaries, coastal lakes and lagoons where development is or may be carried out (at present or in the future), and impacts of development on the scenic and cultural values and use and enjoyment of the beaches, foreshores, dunes, headlands, rock platforms, estuaries, lakes and the ocean need to be considered.

In regional NSW (including Lake Conjola), the coastal use area is defined as the 500 m landward extent from the open ocean boundary of LGAs, and a 250 m landward extent from the boundaries of estuaries.

The CUA mapping provided in the RH SEPP is depicted in **Figure 7-6**.

7.2.4 *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, 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).

The objectives of the MEM Act are as follows:

(a) to provide for the management of the marine estate of New South Wales consistent with the principles of ecologically sustainable development in a manner that:
  (i) promotes a biologically diverse, healthy and productive marine estate, and
  (ii) facilitates:
    - economic opportunities for the people of New South Wales, including opportunities for regional communities, and
    - the cultural, social and recreational use of the marine estate, and
    - the maintenance of ecosystem integrity, and
    - the use of the marine estate for scientific research and education,

(b) to promote the co-ordination of the exercise, by public authorities, of functions in relation to the marine estate,

(c) to provide for the declaration and management of a comprehensive system of marine parks and aquatic reserves.

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.

Consistency between the Marine Estate Management Strategy and CMPs is an essential element listed in the Coastal Management Manual (the Manual) (DPIE, 2018). 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.

7.2.5 Shoalhaven Local Environmental Plan 2014

The purpose of the Shoalhaven Local Environmental Plan 2014 (SLEP) is to make local environmental planning provisions for land in Shoalhaven in accordance with the relevant standard environmental planning instrument under section 3.20 of the EP&A Act. The specific section of the SLEP that is potentially relevant to development of the Lake Conjola CMP is:

Section 7.4 Coastal risk planning

(1) The objectives of this clause are as follows:
  (a) to avoid significant adverse impacts from coastal hazards,
  (b) to ensure uses of land identified as coastal risk are compatible with the risks presented by coastal hazards,
  (c) to enable the evacuation of land identified as coastal risk in an emergency,
  (d) to avoid development that increases the severity of coastal hazards.

(2) This clause applies to the land identified as “Coastal Risk Planning Area” on the Coastal Risk Planning Map, as shown in **Figure 7-8**.

As can be seen from **Figure 7-8**, the “Coastal Risk Planning Area” does not include any area at Lake Conjola and hence Section 7.4 of the SLEP does not apply to development of the CMP.

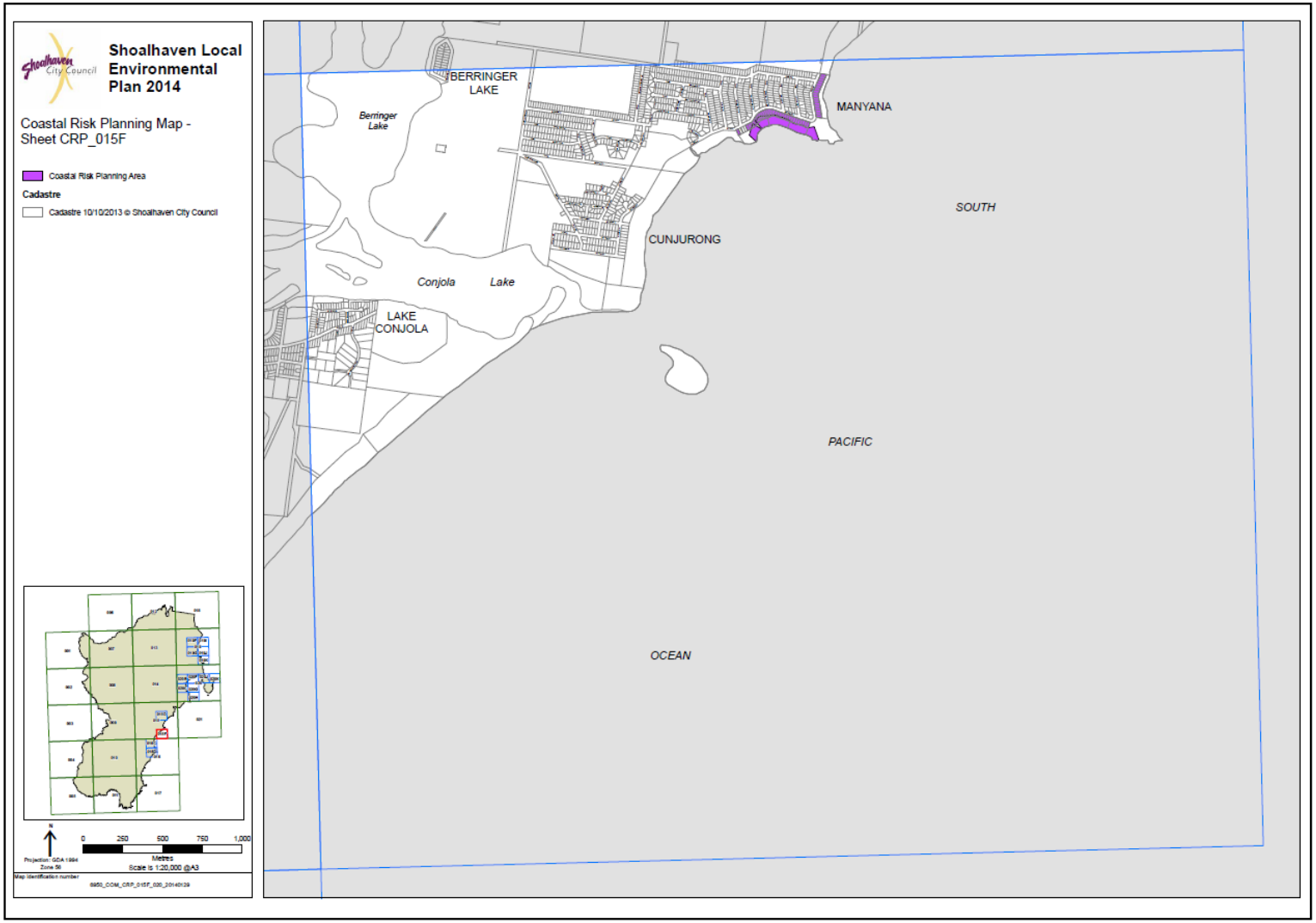

Figure 7-8: Shoalhaven Local Environmental Plan 2014 - Coastal Risk Planning Map

8 Terrestrial, Estuarine and Marine Ecology

8.1 Context of Lake Conjola within Commitments of Council

The ecological value of the natural environment is a key consideration in the sustainable management of the greater Lake Conjola area, as the coastal, estuarine and upper catchment zones support a diverse range of flora and fauna within their range of ecosystems.

As previously noted, the Lake has a surface area of approximately 6.9 km^2 and a catchment area of approximately 145 km^2. 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 catchment of Lake Conjola is relatively undisturbed with 85% remaining as bushland, including areas of Conjola and Morton National Parks.

The majority of the catchment remains undeveloped and mostly forested, with approximately 75% of the forested areas managed by either State Forests or National Parks and Wildlife Services (NPWS) (GHD, 2015). Urban and rural residential development areas associated with Fishermans Paradise, Conjola Park, Lake Conjola and Yatte Yattah occupy about 10% of the catchment, are relatively minor and generally confined to the southern side of the Lake entrance and the upper reaches of the Lake (DPE "Estuaries of NSW" online, 2022).

8.2 Terrestrial Ecology of Shoalhaven and the Lake Conjola area

Specific Threatened / Endangered Ecological Communities that are present in the Lake Conjola area and relevant to the CMP are listed in **Table 8-1**, with their physical distribution shown in **Figure 8-1**.

Table 8-1: Listed Threatened Ecological Communities with the Lake Conjola area (source: DPE BioNet Atlas)

Name / Category	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South-East Queensland ecological community	Endangered	Community likely to occur within area
Coastal Swamp Sclerophyll Forest of New South Wales and South-East Queensland	Endangered	Community known to occur within area
Illawarra and south coast lowland forest and woodland ecological community	Critically Endangered	Community likely to occur within area
Illawarra-Shoalhaven Subtropical Rainforest of the Sydney Basin Bioregion	Critically Endangered	Community likely to occur within area
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Natural Temperate Grassland of the South-eastern Highlands	Critically Endangered	Community may occur within area
River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria	Critically Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

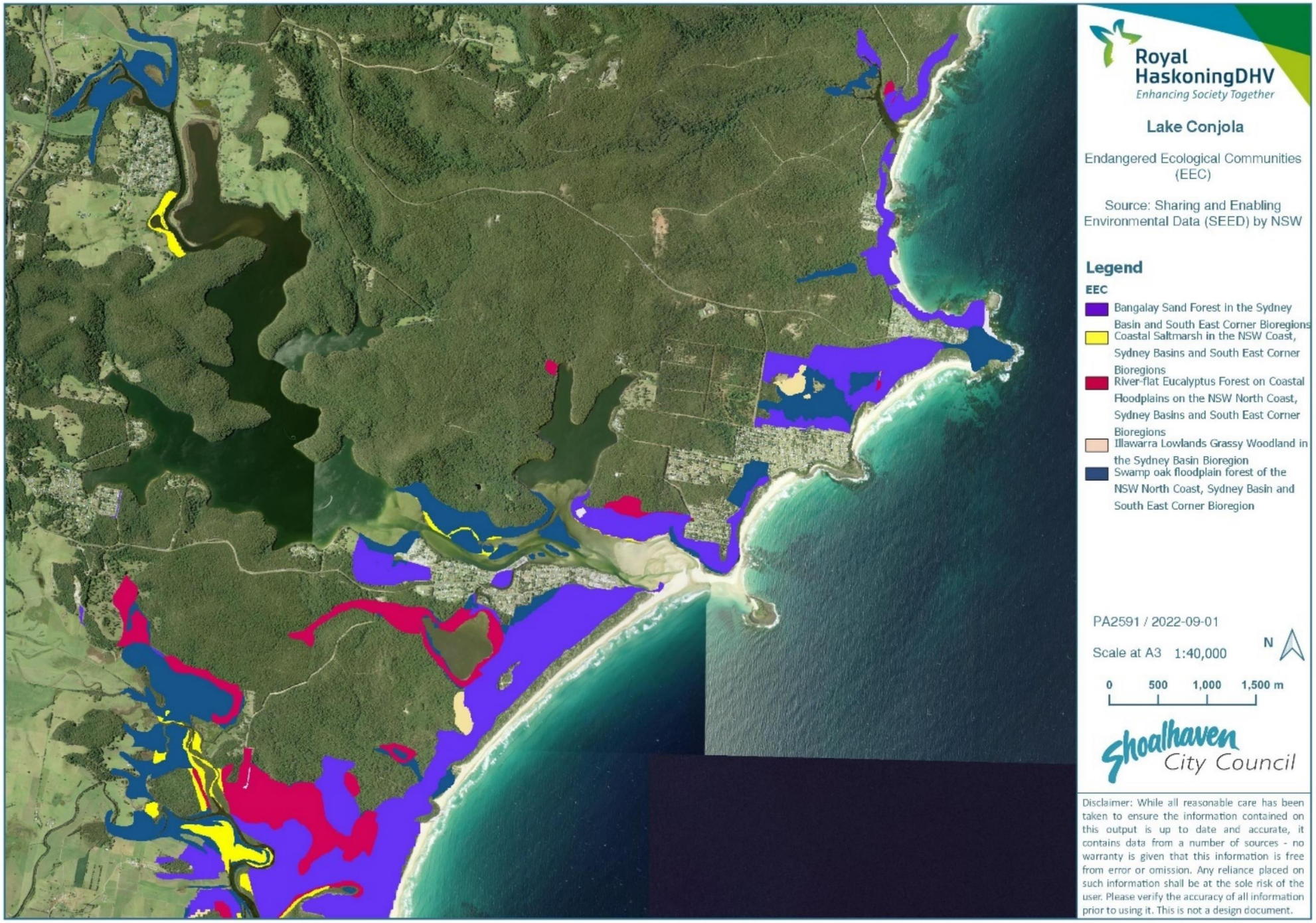

Figure 8-1: Distribution and category of Endangered Ecological Communities within the Lake Conjola Area (source: NSW SEED dataset)

In order to inform strategic planning for management of EECs within Shoalhaven, Council undertook Endangered Ecological Community Mapping across the LGA in 2010 (Hunt, 2010). The focus of the investigation was to revise and refine the mapping of EECs listed under the (current at the time) NSW *Threatened Species Conservation Act 1995* (TSC Act) across priority lands managed by Council and selected private lands in the LGA.

Conjola Reserve and Narrawallee Reserve are both in fair to good condition with Conjola Reserve being consistently good throughout, due to its relative isolation from intense urbanisation. Narrawallee Reserve is recorded as impacted by the intensive urbanisation along its eastern boundary, and although weeds had not spread extensively into the bushland there are tracks, rubbish dumping and informal camp sites especially in its northern area, and all these factors degrade the quality of the reserve (Hunt, 2010).

EEC maps were prepared by Hunt (2010) for priority areas in Conjola Park and Yatte Yattah (refer **Figure 8-2** and **Figure 8-3**). An assessment of EEC condition in each of these priority areas with reference to the land area numbering on the maps is summarised in **Table 8-2**.

Table 8-2: Condition of EECs in Priority Areas (source: Hunt, 2010)

Land Number	Vegetation Community	Broad Condition/Value	Threat
1a	Swamp Oak Floodplain Forest - EEC	**Good condition**. Intact community dominated by native species. Forms part of a large intact forested area including national park.	Weed invasion and edge effects from the west.
1b	Swamp Sclerophyll Forest - EEC	**Good condition**. Intact community dominated by native species. Forms part of a large intact forested area including national park.	Weed invasion and edge effects from adjoining cleared rural residential block.
1c	Coastal Saltmarsh	**Good condition**. Intact community dominated by native species. Forms part of a large intact forested area including national park.	In general saltmarsh communities are susceptible to run off and sedimentation.
2a	Swamp Oak Floodplain Forest - EEC	**Poor condition**. Past grazing and clearing has resulted in degraded vegetation communities.	Weed invasion and nutrient enrichment from adjacent agriculture.
2b	Cleared	**Very poor condition**. Complete clearing of the block for grazing makes it unlikely that restoration could proceed without extensive intervention including substantial planting of native vegetation.	On-going land use.
3	Cleared / Turpentine – Blackbutt Forest	**Poor condition**. Past grazing and clearing has resulted in degraded riparian communities although restoration work is	Weed invasion and nutrient enrichment

Land Number	Vegetation Community	Broad Condition/Value	Threat
		currently being undertaken. Forested areas supply important links from Narrawallee Creek to Pointer Mountain.	from adjacent agriculture.
4a	Cleared / Turpentine – Blackbutt Forest	**Good condition**. Although there are tracks, signs of minor personal logging and edge effects this area is largely weed free and forms a contiguous area with wilderness to the west.	Edge effects.
4b	Milton Ulladulla Subtropical Rainforest - EEC	**Good condition**. Although this patch of rainforest is adjacent to a powerline easement this area is largely weed free and forms a contiguous area with wilderness to the west and represents an EEC which has been substantially cleared and is spatially restricted.	Edge effects and weed invasion from upstream.

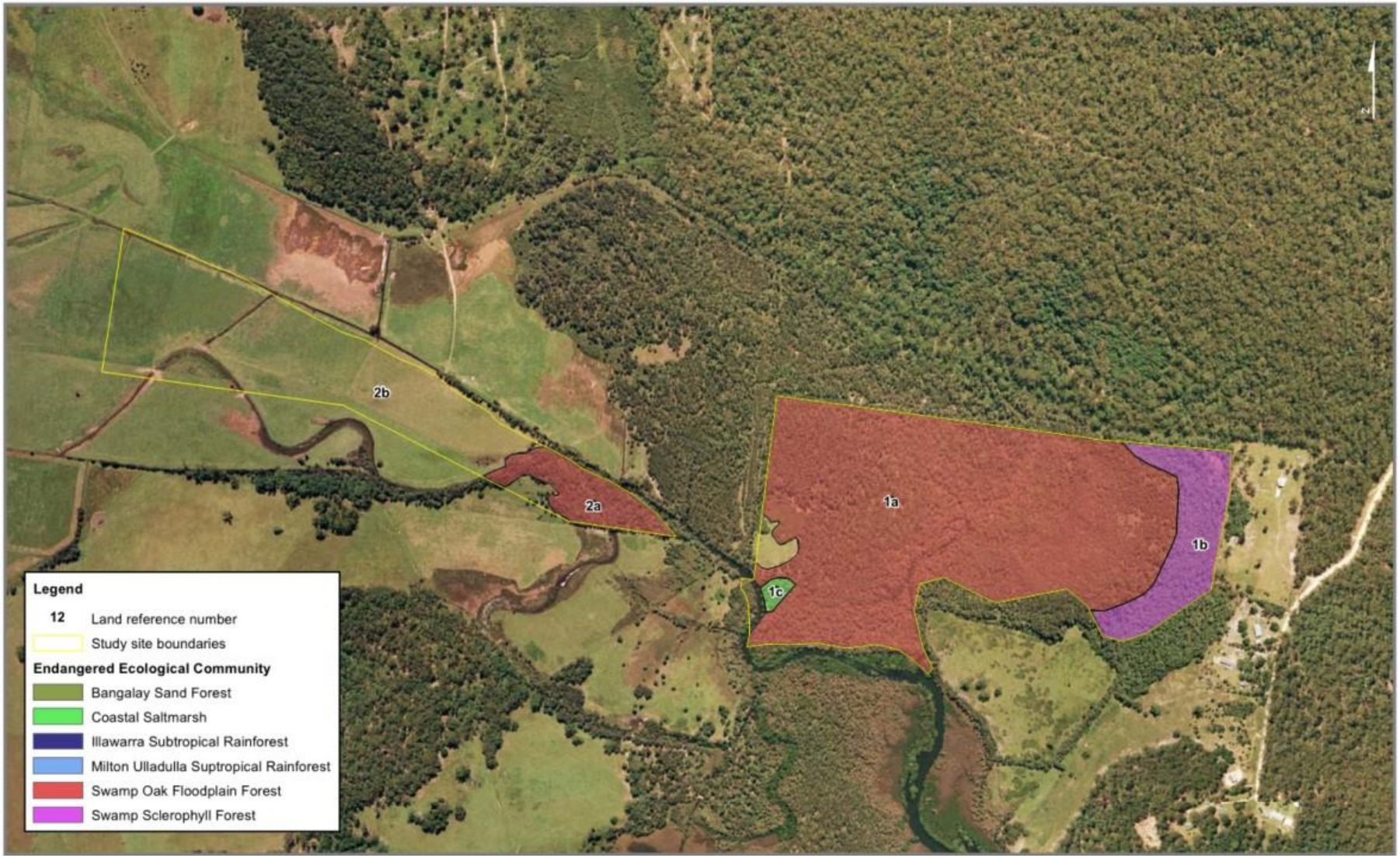

Figure 8-2: EEC Mapping at Conjola Park (source: Hunt, 2010)

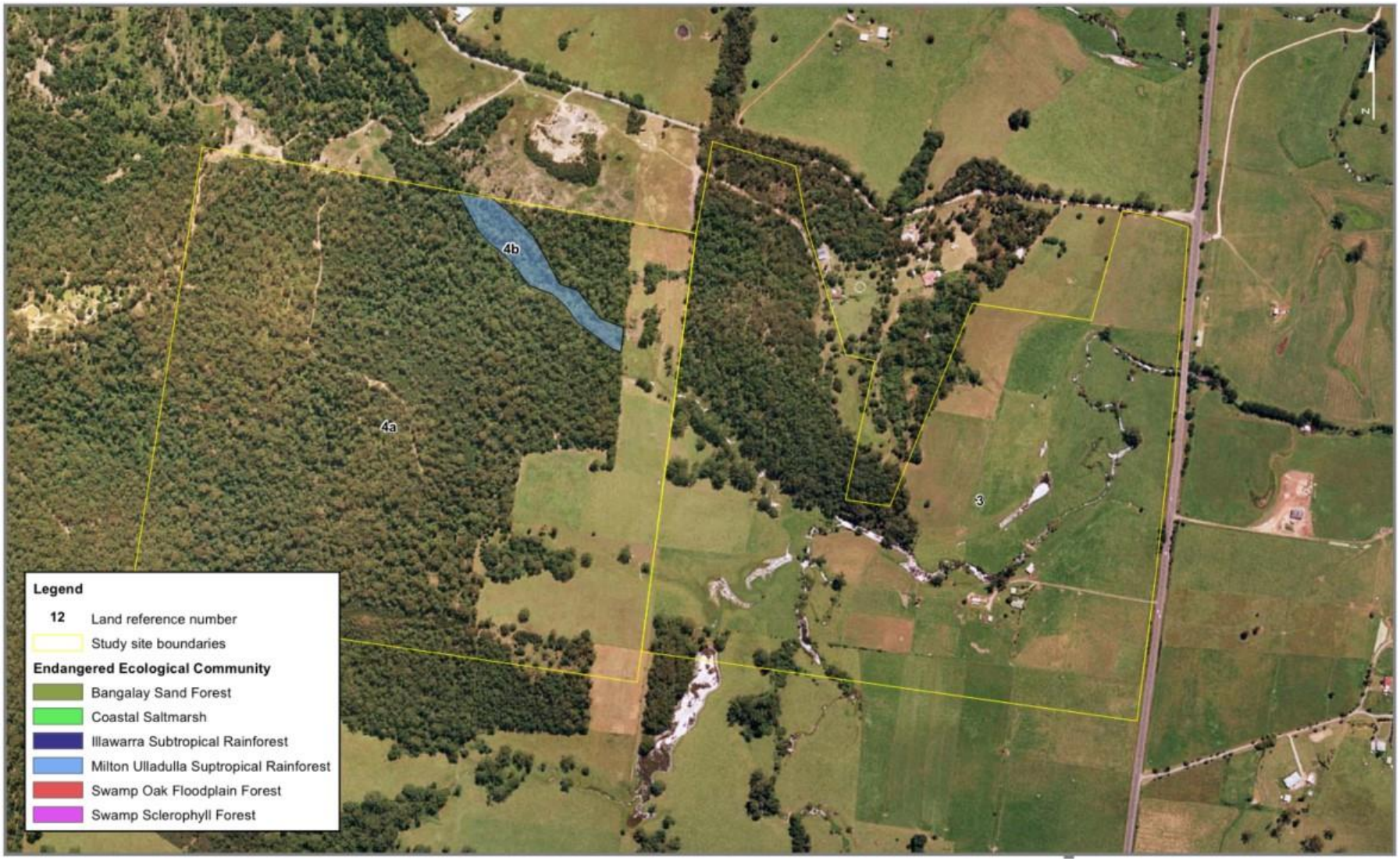

Figure 8-3: EEC Mapping at Yatte Yattah (source: Hunt, 2010)

Council's current EEC mapping project aims to map and ground truth EECs that are at likely risk of future coastal inundation. The scope of works involved site inspections at Lake Conjola to ground truth the existing EEC mapping using verification plots, and condition assessments using the Biodiversity Assessment Methodology. At Lake Conjola, EECs at risk from future coastal inundation are mainly located at the entrance area, as well as at Fisherman's Paradise.

Benefitting from such a large proportion of the catchment of Lake Conjola within (protected) National Parks, as well as other undeveloped areas, the region is recognised as providing habitat for a significant number of native species of birds, mammals, reptiles, plants, amphibians and fish. A search of the Atlas of Living Australia database provides records of nearly 1,600 different species (of all taxa) that have been identified within a 5 km radius of Lake Conjola Village.

Of the significant number of flora and fauna within the study area, many are recognised as threatened or endangered under Commonwealth and/or NSW legislation. Within a 10 km radius of Lake Conjola, an EPBC Act Protected Matters Report (DAWE, 2022) records numerous Matters of National Environmental Significance (as defined by the EPBC Act), 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.

A map of recorded sightings of threatened or endangered species is provided as **Figure 8-4**.

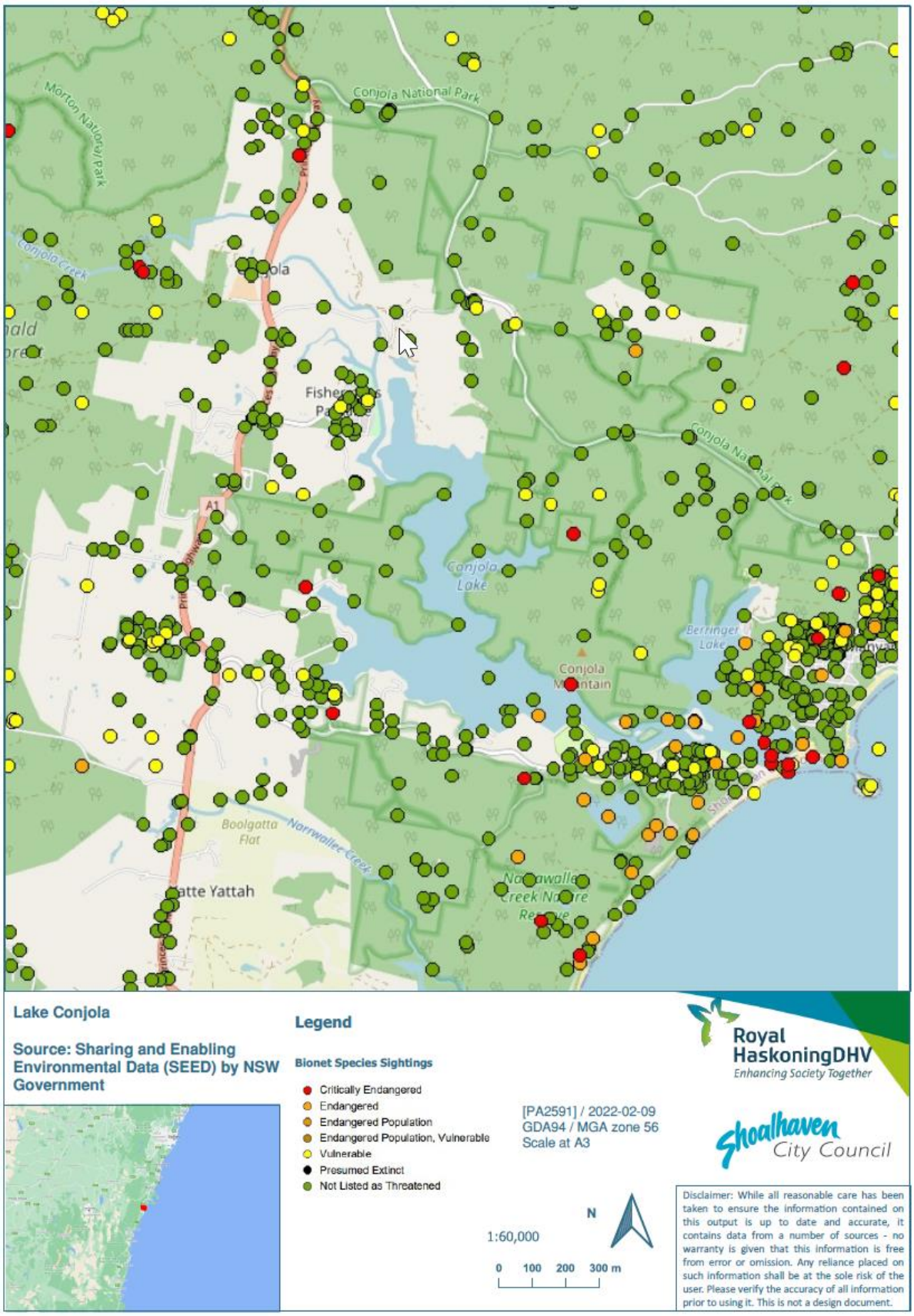

Figure 8-4: Map of Threatened and Endangered species sightings within the Lake Conjola area (source: DPE SEED database)

While the majority of the species sightings listed above are expected to be relevant, it should be noted that site specific biodiversity assessment is required to be undertaken prior to delivery of “development’ actions within the Lake Conjola CMP to determine current (at time of assessment) presence /absence of biodiversity. For example, while Koalas are listed within the EPBC Act Protected Matters Report (DAWE, 2022), the last recorded sightings as shown in **Figure 8-5** are noted as occurring in 1999 (alive) and 1980 (roadkill).

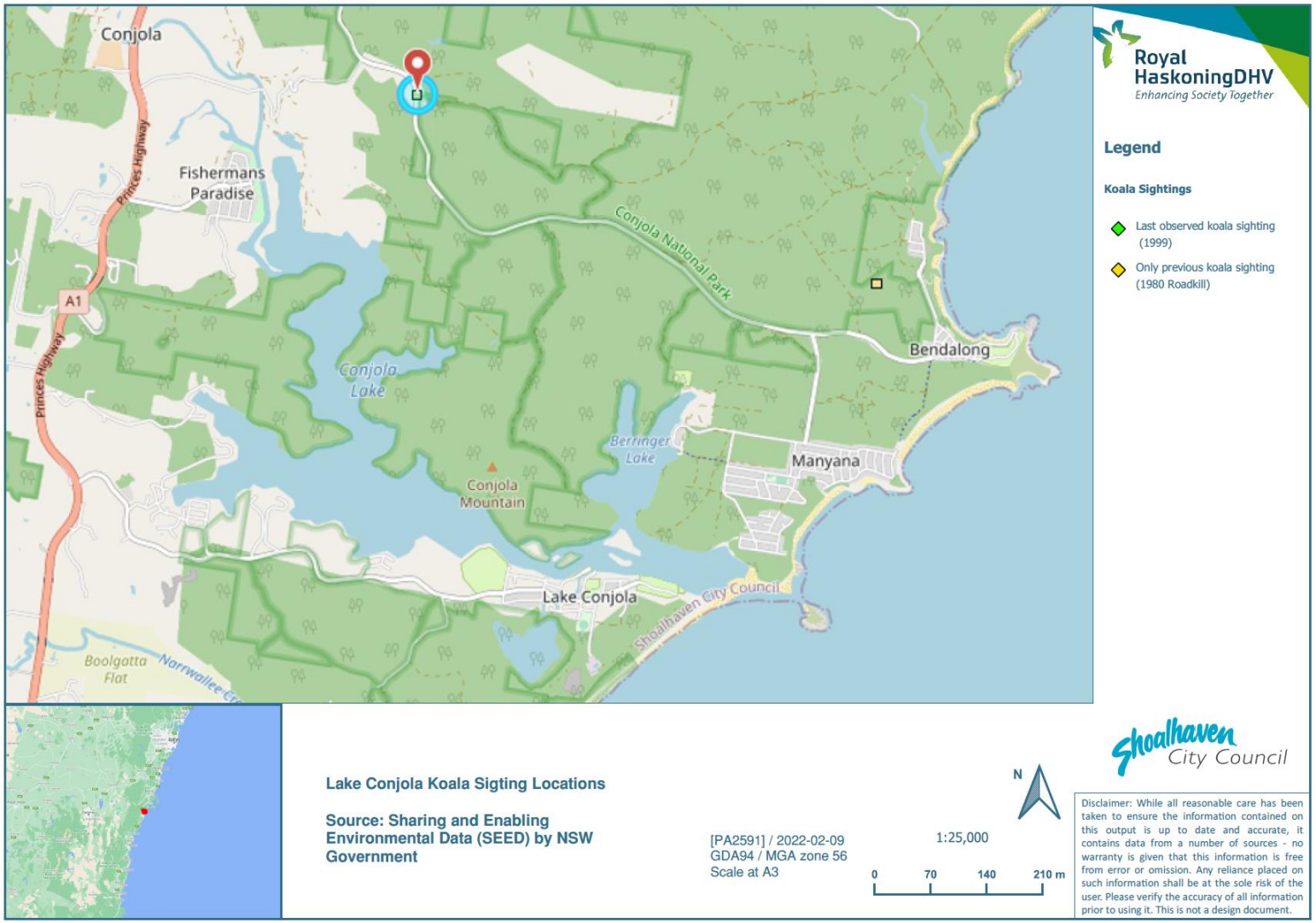

Figure 8-5: Recorded Koala sightings within Lake Conjola area (source: DPE SEED database, 2022)

While the range of a number of species is relatively limited (i.e. semi-permanently located within the greater Lake Conjola area), most birdlife within the region (and elsewhere in NSW/Australia) is recognised as being highly transitory, following migration and/or seasonal variations in location and distribution.

Due in part to the wide range of habitats within the region, including heath, woodland, riverine, rainforest, wetland, beach, estuary, rock platforms, cliffs, as well as urban and suburban gardens, the Shoalhaven area is noted as a popular birdwatching location, with a number of active groups such as Bird Life Shoalhaven. A general overview of Shoalhaven bird watching locations/walks and a list of birds can be found at Bird Trails of the Shoalhaven Area (Council, date unknown).

"Birdata", Bird Life Australia's national bird monitoring and citizen science initiative, has recorded over 360 species of birds for the Shoalhaven area (birdlifeshoalhaven.org, 2022), while 'Avibase' ("*the world bird database*") notes some 406 species recorded within the LGA (*Bird Life Australia note: because of the nature of the data collection, some of the bird identification on the list may not be completely accurate*).

8.3 Shorebirds

8.3.1 General

The South Coast Shorebird Recovery Program was established in 1999 by the NSW National Parks and Wildlife Service (NPWS), to reduce the rate of decline of threatened shorebirds and recover populations by enhancing breeding success. Their website lists four main shorebird species of concern in the south coast region, which comprise:

- Little Tern;
- Hooded Plover;
- Pied Oystercatcher; and,
- Sooty Oystercatcher.

The Little Tern, Hooded Plover and Pied Oystercatcher have been observed to nest at Lake Conjola. However, the Sooty Oystercatcher has primarily been observed on the offshore islands of the south coast region and does not reside at Lake Conjola.

8.3.2 Little Tern[1]

The Little Tern (*Sterna albifrons, subspecies sinensis*) is Australia's smallest representative of the family Laridae (gulls and terns) and is an important consideration for management of the entrance to Lake Conjola. Exclusively coastal in its distribution, this piscivorous (feeding on fish) species nests on ocean beaches, sand spits and sand islands within or adjacent to the estuaries of rivers, creeks and coastal lakes, and is listed as an endangered species in NSW on Schedule 1 of the *Biodiversity Conservation Act 2016* (BC Act).

The Little Tern is a small, slender, migratory seabird. At less than 25 cm long it is two-thirds to half the size of any other south-eastern tern. Migrating between eastern Asia and Australia, the Little Tern is found on the north, east and south-east Australian coasts. In NSW, it arrives from September to November, occurring mainly north of Sydney, with smaller numbers found south to Victoria. It breeds in spring and summer along the entire east coast and is seen until May, with only occasional birds seen in winter months. The beach berm at Lake Conjola is noted as a minor but still important breeding location, with annual residence of Little Terns during the breeding season, as shown in **Figure 8-6**. It is reported that

[1] *Acknowledgement is made that the majority of the information in this section has been sourced from the DPE Threatened Species web page on Little Terns*

Little Terns usually nest near the entrance to Lake Conjola and that in the 2020/2021 season there were more than 70 nests and almost 200 eggs laid on the entrance sand spit.

Figure 8-6: Little terns in breeding plumage at Lake Conjola (source: australiaswonderfulbirds.com.au)

Through consideration of the potential environmental impact on migratory shorebirds from mechanical opening of Lake Conjola (which is generally undertaken to alleviate flooding), a range of mitigation measures have been incorporated into the current (Council, 2021b) and previous Review of Environmental Factors (REF) prepared to guide on-ground mechanical entrance openings, as well as to accompany Crown Land licence applications (required for Council to undertake works on Crown Land).

Most relevant for the Lake Conjola CMP, the REF requires that entrance management works will be, as far as practicable, undertaken outside of important nesting periods for threatened shorebirds, including the Little Tern (September through to March inclusive). Works are not to impact on threatened shorebird nesting areas. A general minimum buffer distance of 20 m is to apply to the nesting area.

8.3.3 Hooded Plover

The Hooded Plover is listed as a Critically Endangered Species on Schedule 1 of the NSW *Threatened Species Conservation Act 1995* (TSC Act). This species is also listed as a Vulnerable Species on Schedule 1 of the *Commonwealth Endangered Species Protection Act 1992*.

Within NSW, the Hooded Plover occurs along the southern coast, north to Jervis Bay. Occasional vagrants may be sighted further north at Wollongong. Following a survey in 1988 (Morris, 1989), it was estimated that the NSW population might be as low as 62 individuals, all of which are resident within the area of the South Coast Shorebird Recovery Program.

The Hooded Plover (refer **Figure 8-7**) is a medium-sized, robust plover with a prominent black hood contrasting with a red bill tipped black and red ring around the eye. The upperparts are predominantly pale brownish-grey with a white collar at the base of the black hood and a black and white tail and outer

wing. The underparts are completely white apart from the black neck and pale brownish-grey edges on the wings.

Figure 8-7: Hooded Plover (source: https://www.southcoastshorebirds.com.au/main-shorebird-species/)

In south-eastern Australia, the Hooded Plover is found most often on long stretches of sandy shore, backed by tussock and creeper-covered dunes with nearby inland lakes. Its preferred habitat has a wide wave wash zone with beachcast seaweed for feeding, backed by sparsely vegetated sand dunes for shelter and nesting (Murlis, 1989). Individuals also regularly use near-coastal saline and freshwater lakes and lagoons (Bransbury, 1988).

The Hooded Plover has previously been found to nest on the sand spit at the entrance to Lake Conjola, but in limited numbers of 1-2 breeding pairs.

8.3.4 Pied Oystercatcher

The Pied Oystercatcher is listed as an Endangered Species on Schedule 1 of the NSW *Threatened Species Conservation Act 1995* (TSC Act).

The Pied Oystercatcher has a thinly scattered distribution throughout Australia, where it prefers sandy beaches and sandy-shored estuaries. Small groups and individuals are found scattered along the beaches and estuaries along the entire NSW South Coast, at times flocking up into larger groups. Pairs usually occupy one territory during the breeding season and defend this aggressively from other individuals. During the non-breeding season pairs can disperse and large, noisy groups of non-breeding birds can gather at suitable feeding sites along the coast.

With their bright pied plumage (i.e. black and white), Pied Oystercatchers (refer **Figure 8-8**) are a distinct large species of shorebird. Their upper parts including the head, wings and tail are black, with a contrasting white breast and undertail. This coloration is contrasted with a bright red to orange-red eye, bill and legs. The male and female show little differentiation except that the males generally sport a

shorter, wider beak. Immature birds have a more brownish-black plumage, with grey-brown legs and a bill with a darkish brown tip.

The Pied Oystercatcher has previously been found to nest on the sand spit at the entrance to Lake Conjola and on the eastern islands (south of Chinamans Island), but in limited numbers of 1-2 breeding pairs.

Figure 8-8: Pied Oystercatcher (source: https://www.southcoastshorebirds.com.au/main-shorebird-species/)

8.4 Key Threatening Processes to the Ecology of Lake Conjola

Key threatening processes threaten - or could threaten - the survival or evolutionary development of species, populations, or ecological communities, and are described and listed in the Biodiversity Conservation Act 2016.

A search of the Key Threatening Processes database held within BioNet (DPE) identified that 37 of the 39 key threatening processes listed in NSW are present within the greater Lake Conjola area. Key Threatening Process that are most relevant to the Lake Conjola CMP comprise:

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
  - *changes in water levels within the lake as a result of entrance dynamics and future sea level rise may have an impact on wetland areas*
- Clearing of native vegetation
  - *clearing of riparian vegetation results in degradation of lake foreshore areas, and bank erosion leading to sedimentation that affects aquatic communities*
- Invasion of native plant communities by bitou bush and boneseed
  - *dominance of bitou bush over native dune vegetation can destabilise dune systems that provide protection at the lake entrance from ocean storm wave washover, which can cause entrance closure*

8.5 Marine and Estuarine Ecology of the Lake Conjola area

Estuaries like Lake Conjola provide a habitat for many species of fish, invertebrates, birds and plants from both marine and freshwater systems within differing spatial locations. Plants and animals living in estuaries have adapted to the variability of the environment, and often support the recreational and

commercial value of the site. A diverse range of habitats including seagrass beds, mangroves, saltmarsh, shoals, wetlands and rocky outcrops exist within Lake Conjola.

The behaviour of intermittently closed estuaries is particularly sporadic in the south-east region of NSW due to the unpredictable nature of rainfall, as well as whether the entrance is in an open/closed state (discussed further in **CMP Stage 2 - Report B**). It is noted that at 89%, the percentage of time as a long term average that Lake Conjola entrance is open is relatively high in comparison to DPE historical records which show that about 70% of the intermittently closed estuaries in NSW are closed for the majority of the time (i.e. greater than 50% of the time) (DPE, online 2022).

An assessment of marine ecology during the mid- to late-1980's compared the fish species found within (predominantly open) Lake Conjola against the fish species composition within Swan Lake and Lake Wollumboola, which are two nearby intermittently open (predominantly closed) estuaries. The disparity on the findings indicated that there was significant differences between the locations, seemingly correlated with the entrance open state (Pollard, 1994).

Overall, Lake Conjola was found to contain well over twice the number of fish species (~100 spp., 52 of commercial importance) compared with each of the two intermittently open lagoons, Swan Lake (39 spp., 22 commercial) and Lake Wollumboola (41 spp., 26 commercial). However, when comparing the commercial fisheries (including finfish, crustaceans and molluscs) from the three lagoons, both of the intermittently open coastal lagoons showed higher catches in terms of both body weight and value than Lake Conjola (Pollard, 1994).

Like the majority of coastal, estuarine and freshwater locations within NSW, Lake Conjola and it's contributing catchment tributaries are identified as 'Key Fish Habitats', being those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally, and the survival and recovery of threatened aquatic species. One of the objectives of the *Fisheries Management Act 1994* is to 'conserve key fish habitats', and any management actions proposed within Lake Conjola and its catchment must consider the requirements of the FM Act.

Assessment of "Fish communities and threatened species distributions of NSW" undertaken by DPI Fisheries indicated that the majority of aquatic habitat and aquatic biodiversity in NSW river systems was in "Fair", "Poor" and "Very Poor" condition. In comparison, while the catchment tributaries of Lake Conjola have been recorded as being in "Fair" condition, the main waterbody was recorded as being in "Very Good" condition, as shown in **Figure 8-9**, indicating the ecological value of Lake Conjola (DPI, 2016).

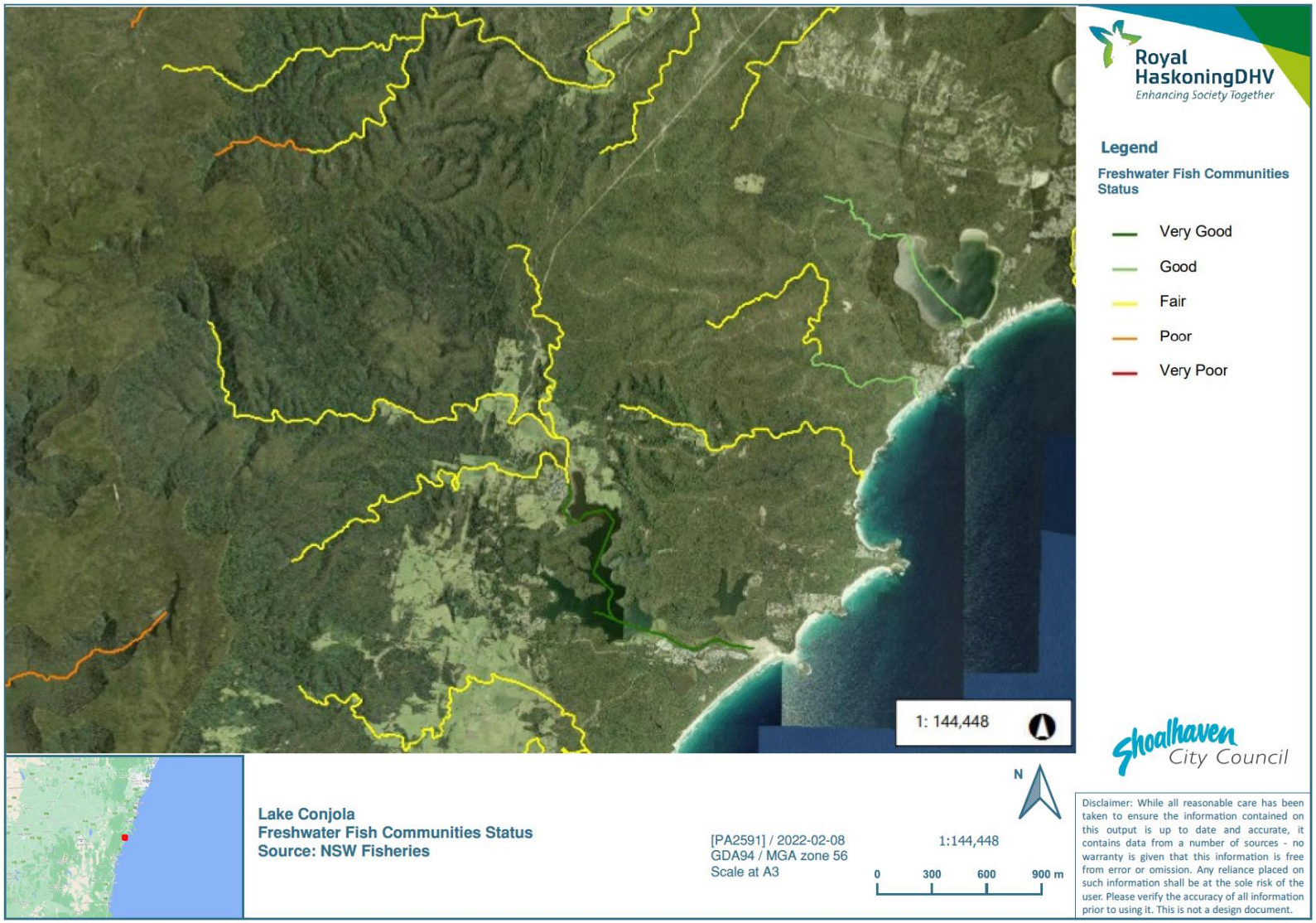

Figure 8-9: Fish Community Status of Lake Conjola NSW

8.6 Commercial Aquaculture within Lake Conjola

Seeking to bolster the recreational and commercial fishing opportunities within the region, in 2021 the NSW DPI Fisheries Marine Stocking program released 14,000 Dusky Flathead fingerlings in Lake Conjola and another 25,000 in St George Basin. The 25mm fingerlings were bred by Narooma Aquaculture from wild brood stock caught on the South Coast, and are part of a project seeking to evaluate the growth of the fish, their movements and impact of fish releases on the recreational fishery (2ST / DPI Fisheries, 2021).

The only known commercial aquaculture within Lake Conjola are a number of aquaculture (oyster) leases that are located close to the entrance of Berringer Lake, mid-way upstream of the main Lake Conjola Channel, and on the northern bank approximately at the westward extent of “The Step” sand shoal.

While these oyster leases are listed by DPI Fisheries as Priority Oyster Aquaculture Areas (POAA), they are currently not occupied. It is noted that these POAA are located over mapped areas of seagrass, as shown in **Figure 8-10**. In accordance with DPI Fisheries aquaculture lease conditions, due to the presence of seagrass within these lease areas, the lessee is required to comply with the following specific lease conditions:

- The lessee during all farming operations must make reasonable attempts to minimise the impact on seagrasses within the leased area.
- Unless approved by NSW DPI – Fisheries, post and rail supported tray and rack infrastructure is NOT permitted within the lease area due to shading impacts on seagrass.
- Cultivation methods within the leases area will be restricted to the use of longline systems using cylinders or baskets in order to reduce the effect of shading on seagrasses.
- The lessee may be directed to modify farming methods or operations if impact on seagrasses is identified.

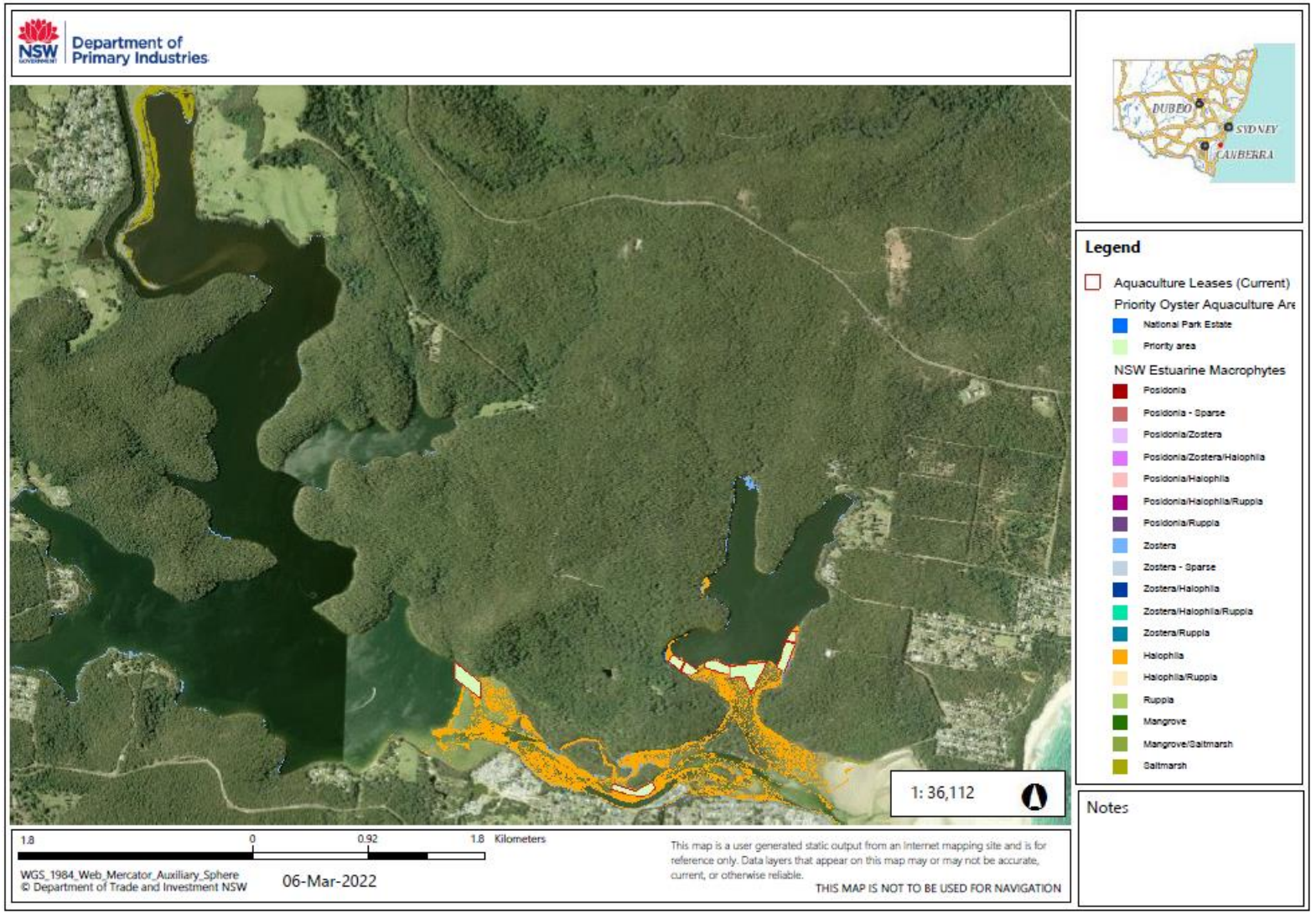

Figure 8-10: Current aquaculture (oyster) leases within Lake Conjola overlaid on seagrass mapping (source: DPI Fisheries)

8.7 Estuarine Macrophytes

Of the many habitats found in estuaries, macrophytes such as seagrasses, mangroves and saltmarshes are under considerable threat globally and play important ecological roles (Airoldi & Beck 200, Waycott et al., 2009, Morrisey et al., 2010).

Seagrasses are significantly affected by environmental and physical disturbances. Increased turbidity, changes in salinity, storm events, dredging, moorings, boat anchoring and propeller scarring are all known to have a significant impact on the health and distribution of seagrasses in NSW (Evans et al., 2018, Glasby and West 2018, Larkum and West 1990, West 2012). Mangrove and saltmarsh are impacted by land clearing, agricultural, urban and industrial uses, stormwater runoff, dumping of waste and human access resulting in losses in area leading to increased habitat degradation and fragmentation (Feller et al. 2017, Stewart and Fairfull 2008, Rogers et al. 2014, Daly 2013).

All seagrass and mangrove species, as well as saltmarsh communities within NSW are protected under the *Fisheries Management Act 1994* and are specifically dealt with as “protected marine vegetation”. Sea level rise and the potential expansion of mangroves is also problematic as this may be at the expense of saltmarsh, which may have limited available habitat to expand into (Ross & Adam, 2013, Rodrígue et al., 2017). Coastal saltmarsh in NSW is listed as an Endangered Ecological Community under the NSW *Biodiversity Conservation Act 2016* (West, 2018).

Seagrasses, mangroves and saltmarshes play numerous ecological roles, including acting as sources of food and shelter for juvenile and adult stages of numerous species (Mazumder et al., 2006, Sheaves et al., 2015), cycling nutrients (Maxwell et al., 2017) and storing carbon (Macreadie et al., 2017). Seagrasses normally occur as extensive beds in shallow water, and seagrass beds often support a rich variety of animals and algae, and act as sources of food (mainly indirectly via epiphytes and detritus) and shelter for numerous species (Keough and Jenkins, 1995).

Loss of seagrass can result in the destabilisation of sediments, removal of potential nursery habitats for fishes, and a decrease in primary productivity of estuaries. Depending on the species of seagrass, recovery of beds from disturbances can be slow. For all these reasons, seagrass beds are seen as critically important biogenic habitats in estuaries, and consequently their distribution patterns and changes in their size over time have been documented as a means of monitoring the ecological health of estuaries (Williams et al. 2007, Roper et al. 2009).

Mangroves are highly productive habitats and supply nutrients and organic matter to estuaries, in addition to being important habitats for the larvae of juveniles of many species (Mazumder et al. 2005a, 2005b; Connolly and Lee 2007). Coastal development and its associated anthropogenic activities are causing the reduction of mangroves in many parts of the world (Connolly and Lee, 2007).

Saltmarsh occurs on the extreme upper tidal limits of estuarine shores on soft, muddy sediments often adjacent to mangroves. Saltmarshes are important foraging areas for shorebirds, and studies have suggested that NSW saltmarsh communities are an important habitat for crabs, and that the export of crab larvae from areas of saltmarsh is an important food source for juvenile fish (Mazumder et al., 2006).

8.7.1 Extent of Macrophytes in Lake Conjola

As one of the indicators for assessment of ecosystem health within the NSW Natural Resources Monitoring, Evaluation and Reporting Program (OEH, 2016) (discussed further in **CMP Stage 2 – Report B**), the NSW government periodically undertake assessment of the distribution and composition of macrophyte assemblages within estuaries.

Using a range of data sources (Land and Property Information photo runs, Nearmap aerial imagery and high-resolution imagery provided by AAM), the Fisheries NSW Spatial Data Portal provides online mapping of the distribution and abundance of seagrass, mangrove and saltmarsh in NSW estuaries that reflects the 2000 – 2019 temporal extent[2].

The majority of the seagrass located within Lake Conjola is *Halophila*, which is found within the entrance to Lake Conjola and Berringer Lake and is generally associated with the shallower "steps" of shoaled sand, as shown in **Figure 8-11**.

A number of locations around Conjola Park and the northern extent of Berringer Lake have smaller areas of "fringing" *Zostera*, as shown in **Figure 8-12**.

There are relatively large extents of saltmarsh adjacent to Fishermans Paradise, along with smaller areas of "fringing" *Zostera*, as shown in **Figure 8-13**.

[2] *Dataset: "NSW Estuarine Macrophytes Metadata" https://webmap.industry.nsw.gov.au/Geocortex/Essentials/Fisheries4101/REST/sites/Fisheries_Data_Portal/virtualdirectory/Metadata/NSW_DPI_EstuarineMacrophytes.html*

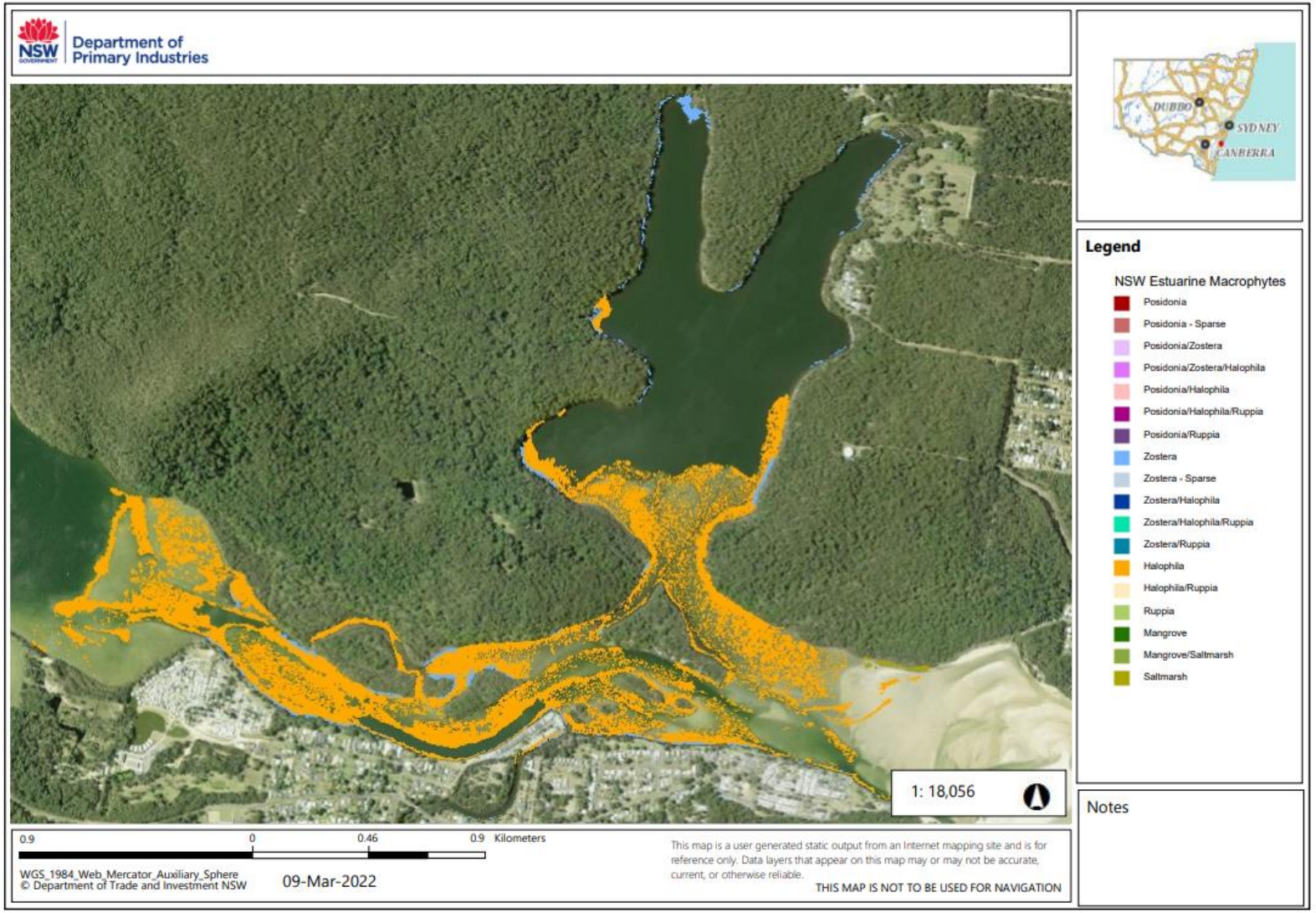

Figure 8-11: Estuarine Macrophyte distribution and type in Lake Conjola and Berringer Lake (source: DPI Fisheries)

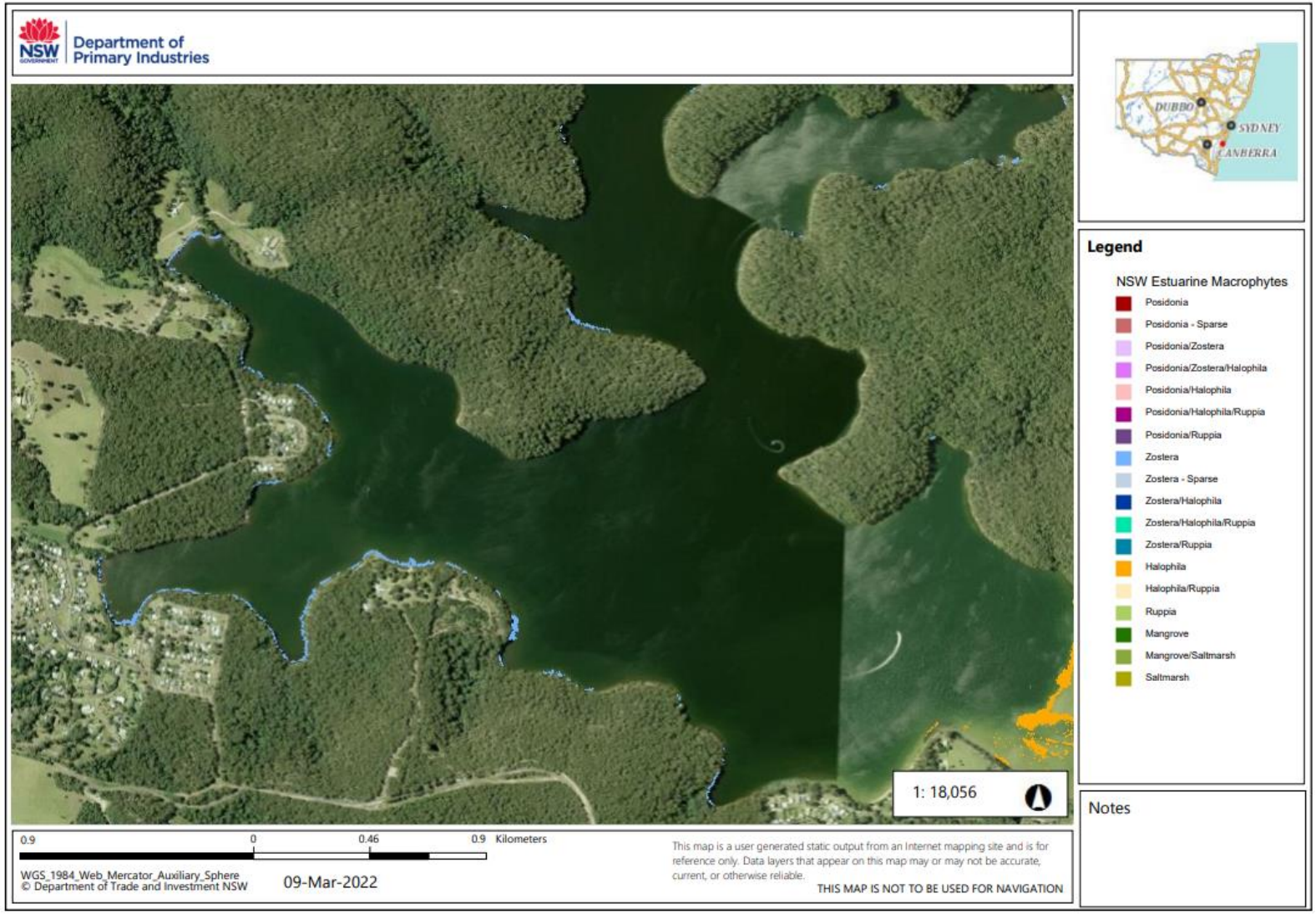

Figure 8-12: Estuarine Macrophyte distribution and type at Conjola Park (source: DPI Fisheries)

Figure 8-13: Estuarine Macrophyte distribution and type at Fishermans Paradise (source: DPI Fisheries)

8.7.2 Assessment of Lake Conjola Ecosystem Health Based on Macrophyte Distribution and Composition

Evaluating the long-term trend of ecosystem health based on macrophyte distribution and composition is challenging, as extensive time series data are only available for a small number of estuaries in NSW.

While research into the factors controlling estuarine macrophyte distribution and extent so as to define an 'ideal mix' of seagrass, mangrove and saltmarsh in any given system is ongoing (such as Roper et al., 2011), in the interim the recommended approach is to report on the change in macrophyte extent based on consecutive surveys using consistent methodologies; the initial survey should be used as the baseline against which change should be assessed (OEH, 2016).

The NSW sampling, data analysis and reporting protocols for evaluation of seagrass and saltmarsh extent (i.e. gain or loss over time) recommend the grades provided in **Table 8-3** (OEH, 2016)**.**

Table 8-3: Scoring grades for seagrass and saltmarsh extent (OEH, 2016)

Seagrass & Saltmarsh			
Score Criteria	**Rating**	**Grade**	**Value**
≥ 10% gain	Very Good	A	5
< 10% gain to -10% loss	Good	B	4
>-10 to -40% loss	Fair	C	3
>-40 to -70% loss	Poor	D	2
>-70 to -100% loss	Very Poor	E	1

Establishing a methodology for scoring and rating mangroves is recognised as being problematic, as increase in mangrove extent could be due to a number of factors. The NSW sampling, data analysis and reporting protocols recommend that a stable mangrove extent (change between –10% to +10%) over consecutive surveys is considered good, as shown in **Table 8-4**, while any change outside that range will require further interpretation and investigation to determine the condition (OEH, 2016).

Table 8-4: Scoring grade for mangrove extent (OEH, 2016)

Mangroves			
Score Criteria	**Rating**	**Grade**	**Value**
Between -10 to +10 % change	Good	B	4

8.7.3 Assessment of Lake Conjola Ecosystem Health

Council, OEH and DPI collaborated to develop the *Lake Conjola Estuary Ecosystem Health Report Card 2010-11* based on the macrophyte distribution methodology described above. This is the only *Ecosystem Health Report Card* that has been produced for Lake Conjola.

The *Lake Conjola Estuary Ecosystem Health Report Card 2010-11* (refer **Figure 8-14**) reported that:

- Saltmarsh in Lake Conjola increased by 108% between 1985 and 2006, and received a Grade A.

- There is a very limited area of mangroves in Lake Conjola so no comparison can be made.
- Seagrasses in Lake Conjola decreased by 68% between 1985 and 2006 and therefore received a poor Grade of D.

Figure 8-14: Lake Conjola Estuary Ecosystem Health Report Card 2010-11

Utilising the same methodology, an updated assessment of macrophyte extent and composition has been undertaken by DPE using two available datasets from 2006 and 2019 (DPE, 2021; data supplied). While an *Ecosystem Health Report Card* has not been developed, DPE have assessed macrophyte distribution and composition within Lake Conjola in 2019, allowing additional comparison.

Utilising the mapped spatial area of macrophyte distribution in 2006 as a Year 1 baseline, a comparison against Year 2 mapped spatial area of macrophyte distribution in 2019 is provided in **Table 8-5**.

Table 8-5: Lake Conjola macrophyte distribution and composition 2006 and 2019 (DPE, 2021)

Estuary	Year 1 (2006) Distribution (km^2)			Year 2 (2019) Distribution (km^2)		
	Seagrasses	Mangroves	Saltmarsh	Seagrasses	Mangroves	Saltmarsh
Lake Conjola	0.166010	0.000714	0.027075	0.306445		0.073797

The measured change in spatial area (in km^2 as well as a percentage of the Year 1 baseline) of each macrophyte between 2006 and 2019 is provided in **Table 8-6**. Both seagrass and saltmarsh communities increased their actual and percentage of spatial areas (85% and 173% respectively), however the relatively small initial extent of mangroves in 2006 (714 m^2) was not recorded at all in 2019 (i.e. 100% loss).

Table 8-6: Spatial and Percentage change in Lake Conjola macrophyte distribution and composition 2006 to 2019 (DPIE, 2021)

Estuary	Change (km^2) from 2006 - 2019			Change % from 2006 - 2019		
	Seagrasses	Mangroves	Saltmarsh	Seagrasses	Mangroves	Saltmarsh
Lake Conjola	0.140435	-0.000714	0.046722	85%	-100%	173%

Based on the OEH scoring grades provided in **Table 8-3**, a Lake Conjola *Ecosystem Health Report Card 2019* would receive grades of A and scores of 5 for the increase in seagrasses and saltmarsh, while mangroves would not receive a grading, potentially due to the relatively small spatial extent of the loss, as summarised in **Table 8-7**.

Table 8-7: Lake Conjola Estuarine Macrophyte estuary health rating 2006-2019 (DPE, supplied 2021)

Grade 2006-2019			Scores 2006-2019		
Seagrasses	Mangroves	Saltmarsh	Seagrass	Mangroves	Saltmarsh
A		A	5		5

8.7.4 Accuracy of Lake Conjola Macrophyte Extents

The West et al. (1985) hardcopy maps have been digitised and are now more comparable with more recent estuarine macrophyte mapping, enabling more accurate assessments of areal change over time. By integrating the revised West et al., 1985 dataset (West, 2018) into the Lake Conjola estuarine condition assessment based on datasets some 13 years apart (2006 and 2019) the time period of available data more than doubles, providing greater insight into the ecological health trend of Lake Conjola. A comparison of the available datasets is provided in **Table 8-8**, with the recommended datasets for longer-term trend comparison shown in **bold**.

Table 8-8: Available datasets of estuarine macrophyte distribution and composition

Source / Year	Seagrasses Distribution (km^2)	Mangroves Distribution (km^2)	Saltmarsh Distribution (km^2)
West et al., 1985 (revised in 2018)	**0.711**	**0.022**	**0.017**
DECC, 2006	0.166010	0.000714	0.027075
Creese et al., 2009	0.166	0.001	0.027
DPIE, 2019	**0.306445**	**0.0**	**0.073797**

** Area too small to map at the original 1:25 000 scale*

Table 8-9 demonstrates the benefit of utilising alternative temporal datasets (with a longer period of time between each).

Table 8-9: Lake Conjola Estuarine Macrophyte estuary health rating using alternative temporal and corrected datasets

Estuary Year 1	Year 1 Distribution (m2)			Year 2 (2019) Distribution (m2)			Change (m2)			Change %		
	Seagrasses	Mangroves	Saltmarsh	Seagrasses	Mangroves	Saltmarsh	Seagrasses	Mangroves	Saltmarsh	Seagrasses	Mangroves	Saltmarsh
Lake Conjola 2006	166010	714	27075	306445	0	73797	140435	-714	46722	85%	-100%	173%
Lake Conjola 1985 (corrected)	711000	22000	17000	306445	0	73797	-404555	-22000	56797	-57%	-100%	334%

Based on the NSW sampling, data analysis and reporting scoring grades shown in **Table 8-3** (OEH, 2016), evaluation of macrophyte distribution and composition within Lake Conjola for the alternative temporal ranges and corrected datasets is summarised in **Table 8-10**.

Table 8-10: Lake Conjola Estuarine Macrophyte estuary health grades using alternative temporal and corrected datasets

Lake Conjola	Grade			Scores		
	Seagrasses	Mangroves	Saltmarsh	Seagrass	Mangroves	Saltmarsh
DECC 2006 vs DPIE 2019	A	E	A	5	1	5
West et al., 1985 (*revised in 2018*) vs DPIE, 2019	D	E	A	2	1	5

Assessment of a longer temporal dataset provides a more accurate understanding of trends within an ecosystem:

- The change in spatial distribution of saltmarsh has shown a positive trend of expansion, with an increase in distribution between 1985 and 2006, increasing further in 2019.
- The change in spatial distribution of mangroves has shown a negative trend of reduction, with a decrease in distribution between 1985 and 2006, decreasing further to complete loss in 2019.
- The most significant difference between these datasets is that Row 1 indicated a positive trend of expansion of seagrasses over the assessment period between 2006 and 2019, being rated as Grade A.
    - However, the seemingly significant increase of 85% increase between 2006 and 2019 does not take into account the loss of nearly 70% of seagrasses between 1985 and 2006.
    - While the data indicates that seagrasses are recovering in recent years, overall, there is a decrease of 57% in spatial distribution between 1985 and 2019.
    - The longer temporal datasets between 1985 and 2019 indicate that Lake Conjola is rated a Grade D in relation to seagrass.

8.8 Invasive Weeds

Invasive weeds have been present in dune vegetation at Lake Conjola, with work undertaken by Lake Conjola Bushcare group to restore the Conjola Beach dunes by controlling weeds to increase biodiversity by enabling natural regeneration. Target weeds have included Bitou Bush, Prickly Asparagus, Climbing Asparagus, Pampas Grass and Moth Vine.

Lake Conjola became well-known in the early 2000's for the presence of the invasive marine species *Caulerpa taxifolia* (Caulerpa). Caulerpa is a bright green, fast growing alga that originates from tropical areas of the Indo-Pacific, including northern Australia, though it is not native to NSW (except Lord Howe Island). It was first identified in Port Hacking in 2000 and quickly spread to 14 estuaries and coastal lakes throughout NSW. Once a popular aquarium plant Caulerpa is banned in NSW as it became recognised as a marine pest due to its hardy nature and ease of translocation. The species caused severe impacts in the

Mediterranean and when first detected in NSW it was feared that similar aquatic habitat impacts would be possible (DPI Fisheries, 2016).

By 2009, although there was no evidence to that date that Caulerpa had outcompeted and displaced native seagrass, there were concerns that there may be more subtle indirect impacts on some of the fauna that live in, or are closely associated with, the estuarine seafloor, as indications of such impacts had been documented as particularly abundant in Burrill Lake and Lake Conjola, which was at the time the most dense aggregation of Caulerpa in NSW (Creese at al., 2009). However, it has not been seen in either lake since 2013 (NSW EPA, 2018).

However, by 2016, after fifteen years of scientific research into Caulerpa in NSW, results indicated that the impacts on native seagrasses were not as severe as once thought. While still listed as a marine pest in legislation, prohibiting possession and sale of the species, management practices have changed. Recognising that Caulerpa populations may disappear by natural means without significant intervention, the policy of eradication shifted to minimising spread from affected estuaries (DPI Fisheries, 2016).

8.9 Pattimores Lagoon[3]

Pattimores Lagoon is a small coastal lagoon connected to Lake Conjola. Prior to 1964 it is believed that Pattimores Lagoon was a perched brackish wetland, undergoing a natural transition to an increasingly freshwater system, with tidal exchange limited to large spring tides and unusually high water levels in Lake Conjola.

Between 1964 and 1984 a number of open channel drains and canals were excavated, and an artificial canal estate built along and around the original creek path. This changed the volume, shape and entrance point of the canal connecting Pattimores Lagoon to Lake Conjola, increasing connectivity between the systems. This increased connection, including modifying the entrance point into Pattimores Lagoon from the north-west corner to the north-east, had considerable effects on the tidal regime within Pattimores Lagoon, and resulted in sediment movement, vegetation changes, as well as increasingly variable salinity.

In 1976, environmental concerns about the effects of the canal development on the lagoon were raised, and subsequently in 1982 an artificial weir was placed in the channel near the southern entrance of the lagoon, as shown in **Figure 8-15**, with the aim of reducing the tidal exchange in the lagoon and returning the system to its pre-existing condition.

In the mid-1980's the weir collapsed, reducing its effectiveness (Shoalhaven Lakes & Estuaries Management Committee, 1996). The current weir height was not able to be measured in AHD by Clarke (2012), due to tree cover blocking satellite connection, it was assumed that the weir is roughly 0.45 m AHD, and/or becomes ineffective at this level.

[3] *Acknowledgement for information within this section is made to the Honours Thesis of Ashlee R. Clarke, 2012, University of Wollongong, entitled "The Environmental history and tidal regime of Pattimore's [sic] Lagoon, a modified coastal wetland"*

Figure 8-15: The weir being installed at the entrance of Pattimores Lagoon in 1982 by Shoalhaven City Council (Clarke, 2012)

The current tidal range within Pattimores Lagoon has been recorded to be around 5 cm, and it is believed that this tidal range is enough to significantly alter the ecosystem within the lagoon from its pre-existing state, though supporting data is limited (Findlay, 1988, Shoalhaven Lakes & Estuaries Management Committee, 1996; quoted in Clarke, 2012). Pattimores Lagoon is less affected by tides then the rest of the estuary due to the long artificial canal estate which connects Pattimores Lagoon to Lake Conjola, as well as the partially collapsed weir at the entrance to the lagoon (Manly Hydraulics Laboratory, 2009).

In 1987 requests for Council to dredge the artificial canal were rejected on the basis that dredging the canal would increase tidal flow. Since the weir had already collapsed at this point, this would increase tidal flow into Pattimores Lagoon even more, and this was expected to 'significantly affect the environment' (Council personal communication, Clarke 2012).

The 1998 Lake Conjola Estuary Process Study highlighted poor water quality and siltation in the canal as an issue, but it was concluded that upgrading the entire canal to a well-designed uniform cross section would increase tidal range to 0.20m and would "impose fatal stress levels" on Pattimores Lagoon flora and fauna (Shoalhaven Lakes Estuaries Management Committee, 1996). This process study recommended "redesigning the present canal layout to improve tidal flushing and reduce sedimentation, without further modifying the tidal influence of Pattimores Lagoon" or alternatively "filling in the canals to create parkland and restoring the pre-existing ecosystem in Pattimores Lagoon".

The obvious indicator of the degree of change resulting from the development of the canal estate is a large sediment delta which has built up at the new channel entrance. Clarke (2012) observed that the delta had built up at an average rate of 300 m^2 per year since at least 1972. At the original channel entrance, there was a relatively small delta, indicating that before the canal development, there was not enough tidal flow to bring significant amounts of sediment into Pattimores Lagoon to form a significant delta. The development of the sediment delta at the new channel entrance indicates that the channel now carries an increased tidal flow into Pattimores Lagoon.

Clarke (2012) noted a significant change within Pattimores Lagoon was the increase in mangroves around the lagoon. In 1988 two ~0.5 m high mangrove trees were recorded in Pattimores Lagoon (Findlay, 1988). Some thirty years later more than 40 mangrove trees were present, many of which were relatively large mature trees over 3 m tall. The appearance of mangroves after the development of the canal estate, and their subsequent increase in abundance, indicates that this change is likely to have been driven by construction of the canal estate, which allowed mangroves to flourish.

As presented in **Section 8.7**, the latest estuarine macrophyte mapping undertaken by DPI in 2019 does not show that any mangroves exist in Lake Conjola, although the mapping does not appear to extend into Pattimores Lagoon. Notwithstanding, the die-off and colonisation of mangroves is a natural cycle in ICOLLs, with mangrove die-off occurring during periods of extended entrance closures. As such, the die-off of mangroves in the broader lake is also likely to have been reflected in Pattimores Lagoon (although this would need to be confirmed with an updated macrophyte survey). It is important to note that mangrove die-off during periods of closure is not considered to be a reason to keep the entrance open, as closed conditions favour the growth of saltmash which compete with mangroves in intertidal areas.

Other than ongoing monitoring of water quality and estuarine macrophytes, it is not considered that any significant management intervention is required at Pattimores Lagoon.

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*
CMP	Coastal Management Program (prepared under the Coastal Management Act 2016)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Council	Sutherland Shire Council
CZMP	Coastal Zone Management Plan (prepared under the former Coastal Protection Act 1979)
DCP	Development Control Plan
DECC	Department of Environment and Climate Change (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
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
NSR	National Surfing Reserve
NSW GIS	New South Wales Geographic Information System
OEH	Office of Environment and Heritage (previously DECCW, now DPIE)
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
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.

Aboriginal Cultural Heritage - includes tangible (physical) and intangible (non-physical) aspects – it is the landscapes, places, objects, customs and cultural traditions and practices that communities have inherited from the past and wish to conserve as part of their Country for the benefit of current and future generations.

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.

Alongshore or Longshore – parallel to and near the shoreline.

Ambulatory – in relation to the coastal foreshore, this means the movement of the foreshore seaward or landward over time, in response to coastal processes and sediment budgets. The movement of the foreshore may occur at different rates or in different directions along a beach or within a sediment compartment.

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

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.

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

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.

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

Cliff – a high, steep face of rock; a precipice.

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 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 RH 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 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 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 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 risk – a risk that relates to the likelihood and consequences of coastal hazards or threats affecting coastal values.

Coastal sediment compartment – an area of the coast defined by its sediment flows and landforms. Coastal sediment compartments may be mapped at primary, secondary or tertiary (local) scales. Boundaries are generally defined by structural features related to the geologic frameworks that define the planform of the coast.

Coastal use area – land identified by the CM Act and RH 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 RH 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 RH 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.

Community objectives – local scale objectives for management of the coast, based on the aspirations and priorities of local communities. When included in a coastal management program, these objectives will be based on, and must align with, the objectives expressed in a council's Community Strategic Plan.

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

Drowned river valley – a type of wave-dominated estuary, usually a deep bedrock embayment, with a wide, deep mouth.

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.

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.

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.

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.

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'.

Geomorphology – that branch of physical geography which deals with the form of the earth, the general configuration of its surface, the distribution of the land, water, etc.; or the investigation of the history of geologic changes through the interpretation of topographic forms.

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.

Holocene – an epoch of the Quaternary period, from the end of the Pleistocene, about 8000 years ago, to the present time.

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.

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

Inundation - See definition for Flood.

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.

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.

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.

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 or Washover – 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.

Progradation – the building forward or outward toward the sea of a shoreline or coastline (as with a beach, delta, or fan) by nearshore deposition of river-borne sediments or by continuous accumulation of beach material thrown up by waves or moved by longshore drifting.

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.

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.

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

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

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.

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 cells (tertiary) – small and relatively contained sediment compartments. A tertiary sediment cell may apply to a single beach/embayment.

Sediment transport – the process whereby sediment is moved offshore, onshore or along shore by wave, current or wind action.

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

Southern Oscillation Index – the normalised mean atmospheric pressure difference between Tahiti and Darwin, measured at sea level. The SOI is negative during El Niño and positive during La Niña.

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

State objectives – the state's objectives for the coast are set out in the CM Act.

Sustainable management – develops and implements proposals that meet the needs of present communities without compromising the ability of future generations to meet their own needs.

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 delta – where an inlet of a barrier estuary or open coastal lake is dominated by tidal processes, a flood tide delta develops inside the entrance, as tidal currents transport marine sand into the estuary. Ebb tide deltas may also occur, outside the mouth of an estuary.

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.

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.

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