Hydrosphere Consulting

Richmond River Coastal Management Program – Protecting our Catchment and Estuary

Stage 1: Scoping Study Supporting Information: Literature Review

November 2021

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Hydrosphere Consulting acknowledges the Bundjalung peoples, Traditional Custodians of the lands discussed in this Scoping Study and pay tribute and respect to the Elders both past and present and emerging of the Bundjalung nations.

Hydrosphere Consulting Pty Ltd
Suite 6, 26-54 River Street
PO Box 7059, BALLINA NSW 2478
hydrosphere.com.au

JOB 21-016 RICHMOND RIVER COASTAL MANAGEMENT PROGRAM SCOPING STUDY
INTERIM DELIVERABLE 2: LITERATURE REVIEW

REV	DESCRIPTION	AUTHORS	REVIEW	APPROVAL	DATE
0	Draft for client review	K.Pratt, K.Menzies, R. Campbell, J. Fullerton	R.Campbell, M. Howland	M. Howland	13 July 2021
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EXECUTIVE SUMMARY

This literature review has been prepared to provide a compilation of background information relevant to the Richmond River as part of the development of the Scoping Study for the Richmond River Coastal Management Program (CMP). It presents a whole-of-catchment understanding of the social, cultural, economic and environmental context and key influences on river and estuary health. Existing studies, plans, mapping and other documentation relevant to the Richmond River have been reviewed to better define the issues to be addressed, document the adequacy of current management and identify gaps in the current knowledge and management approaches.

The original occupation and custodianship of the lands and waters comprising the Richmond River CMP study area by First Nations people dates back many thousands of years. The Bundjalung Nation peoples are the traditional custodians of the Richmond River catchment. First Nations heritage and connection to land and water country are inseparable aspects.

Since European settlement of the Far North Coast region in the mid-1800s, the Richmond River catchment has been significantly modified from its natural state. Broadscale clearing of native forests, draining of floodplain wetlands and conversion of natural areas to agricultural and urban lands occurred and was historically supported by the Commonwealth and state governments through a range of incentive schemes to improve productivity and economic prosperity at that time. These major landscape modifications and the ongoing land use in the catchment continue to have a significant impact on the health and function of the Richmond River catchment waterways. Urban development has affected estuarine processes through changes to hydrologic characteristics and vegetation and the discharge of pollutants through stormwater runoff and point source pollution such as treated sewage discharges. Agricultural land has been shown to contribute significant sediment, chemical and nutrient loads to the estuary primarily during runoff (rain) events. There are also natural physical and climatic characteristics of the catchment that interact with and exacerbate the impact of human pressures. These include the highly erodible soils and moderate to steep slopes in the mid and upper catchment, acid sulfate soils (ASS) on the floodplain/ tidal flats, high annual rainfall and regular occurrence of flood events as a result of ex-tropical cyclones and east coast lows that occur close to the coast. Together these factors contribute to the degradation of the waterway and occurrence of undesirable events such as poor water quality episodes and fish kills, particularly following some flood events.

Today the majority of the Richmond River catchment waterways are in a degraded state. Environmental monitoring and assessment have repeatedly reported poor aquatic ecosystem health across a number of indicators including water quality, riparian and bank condition and the diversity, abundance and physical condition of living organisms. Major fish kills have occurred repeatedly at various locations in the mid and lower estuary during episodes of extremely poor water quality often following floods with severe examples in 2001, 2008 and to a lesser extent in 2020.

The Richmond River is highly valued for various forms of recreational use and these pursuits constitute the dominant use of the study area waterways. Fisheries resources are an important value of the Richmond River and although there have been improvements in technology and fisheries management there is general community concern about fish stocks in the estuary and a desire to ensure that recreational and commercial fisheries are preserved on a sustainable basis into the future.

A Coastal Zone Management Plan for the Richmond River was prepared in 2011 to provide a ten-year strategic plan for the implementation of key actions to address identified estuary issues (certified in 2012). A large number of technical studies and investigations have been carried out in the Richmond River over the last few decades and particularly in recent years with the roll out of the Marine Estate Management Strategy (MEMS) and a large number of MEMS pilot projects focusing on the Richmond River catchment. A large proportion of this work has been focused on the technical assessment of floodplain management options in priority locations to address ASS and blackwater issues. Other research and programs have focused on water quality monitoring and modelling, reducing fertiliser use, estuarine vegetation management, riparian revegetation and bank stabilisation and fisheries enhancement. There is currently a high level of understanding of the nature and extent of environmental issues, causative factors and the management actions required to address the majority of issues. There appears to be many opportunities for integrating the MEMS with the CMP to draw on the work done to date and collaborate with future projects.

There is a growing community sentiment towards actively addressing environmental issues and improving the health of the Richmond River and this has been reflected in state, regional and local planning policy as well as industry guidelines. Implementation of on-ground actions is occurring across the catchment as a part of many different local and state government supported projects, community programs and industry-led initiatives. Actions aim to improve soil health, revegetate and rehydrate landscapes and riparian zones, remove stock access to waterways, address bank erosion, improve management of floodplain infrastructure to reduce ASS and blackwater impacts and better manage stormwater and wastewater systems in urban areas. Some local councils and industry groups have had success offering ‘opt-in’ incentive programs for landholders to carry out on-ground works, highlighting the co-benefits of farm productivity improvements and positive environmental outcomes.

Despite the high level of technical knowledge and growing community support for addressing the identified issues, there remains several barriers to effective implementation of the recommended on-ground works at a sufficient scale to significantly improve the health of the Richmond River. A number of studies have evaluated the challenges to implementation of recommended actions. While there may be opportunities to undertake initial strategic works on public land (e.g. council owned land or Crown land), the majority (73%) of the Richmond River catchment is freehold land under private ownership and effective change in catchment and waterway health will require active engagement and participation of landholders. Previous studies have highlighted that in order to achieve uptake, incentives to engage landholders in catchment management activities need to outweigh impediments to participation, such as transition costs and other time and monetary costs. A major impediment is the perceived loss of income and reduction in resale value that is expected to result from the land use changes required to achieve environmental benefits. As there are no policy, regulatory or financial mechanisms in place to encourage or enforce land use change, landowner goodwill and desire is required to implement these changes. A focus on engaging landholders in catchment management solutions is required to continue to build on the work already undertaken and the growing support for sustainable land use practices and improved environmental outcomes. Other barriers to achievement of ecohealth improvements are related to the difficulties in regulating diffuse water pollution, the long-term acceptance of established land uses, the lack of incentive and/or reward in some industries to invest in environmental outcomes and the expectation that restoration of private land will be funded by governments.

Due to the large size of the Richmond River catchment combined with the range of complex and often competing interests and threats to be addressed, the implementation of management actions can be hampered by the current governance arrangements. The local and state government agencies involved in the management of the study area have a range of functions and responsibilities which can influence natural resource management on both private and public land. Despite these functions and responsibilities, these stakeholders are constrained by the current planning and legislative framework and by the funding and resources available to implement actions that will significantly improve the health of the Richmond River.

CONTENTS

FIGURES

PLATES

TABLES

1. INTRODUCTION

Hydrosphere Consulting was engaged by Rous County Council (RCC) on behalf of Ballina Shire Council (BaSC), Lismore City Council (LCC) and Richmond Valley Council (RVC), to prepare the Coastal Management Program (CMP) Scoping Study for the Richmond River.

This literature review presents the whole-of-catchment understanding of the key influences on river and estuary health. Existing studies, plans, mapping and other documentation relevant to the Richmond River have been reviewed to better define the issues to be addressed, document the adequacy of current management and identify gaps in the current knowledge and management approaches.

2. STUDY AREA

The Richmond River catchment extends from the Queensland border in the north, Tenterfield Shire and Clarence Valley Council areas in the west to the Clarence River catchment at its south-eastern border. The headwaters of the Richmond River originate in the Border Ranges National Park, Nightcap Ranges and Richmond Ranges and flow through floodplains entering the Pacific Ocean at Ballina. The main tributary of the Richmond River is the Wilsons River, which enters the Richmond River on the coastal plain at Coraki. The tidal influence extends upstream of Tatham on the Richmond River and upstream of Lismore on the Wilsons River. Eden Creek, Shannon Brook and Bungawalbin Creek are significant tributaries draining the western and southern areas of the Richmond catchment. The Evans River is connected to the Richmond River by a canal at Woodburn. The Evans River flows for approximately 20 km to the ocean entrance at Evans Head.

The influence of the catchment on the health of the estuary and coastal zone was recognised in the *Coastal Zone Management Plan for the Richmond River Estuary* (Richmond River CZMP, Hydrosphere Consulting, 2011) although management actions were focussed in the 12 management zones of the estuary (Section 28.1). While there are a number of localised management plans and on-ground catchment management actions currently being implemented within the Richmond River catchment, there is not currently a whole-of-catchment management plan or similar document cognisant of the diverse nature of existing catchment characteristics, linkages and current actions to comprehensively guide future management and investment in the region.

Through stakeholder consultation, the *Richmond River Governance and Funding Framework* (Alluvium, 2019b) identified the need for a whole-of-catchment approach to ensure inclusive and equitable governance, recognising the interests of the large number of stakeholders and the need to support and promote collaboration and effective communication. While governance barriers exist, stakeholders agree on the need to focus on whole-of-catchment protection and enhancement of these values. Collaboration relies on a shared catchment understanding of the whole-of-system needs. The Richmond River CMP will provide a whole-of-catchment perspective for the coastal management planning process which recognises the influence of the catchment issues and activities on the health of the coastal zone.

Plate 1: Richmond River waterways

Clockwise from top left: Roseberry Creek in the upper catchment; Wilsons River at Boatharbour mid-catchment; Wilsons River at Wyrallah on the upper floodplain; Lower Richmond River at West Ballina

The Richmond River estuary is situated within three local government areas (Ballina Shire, Lismore City and Richmond Valley). RCC is the flood mitigation authority, with responsibility for associated natural resource management activities. Parts of the Richmond River catchment are also within the LGAs of Kyogle (Kyogle Council, KC), Byron (Byron Shire Council, BySC) and Clarence Valley (Clarence Valley Council, CVC). The study area excludes detailed consideration of the coastal zone areas that are covered in existing plans that are either certified or planned to be certified (Coastal Zone Management Plans (CZMPs) and CMPs) or as part of the future coastline CMPs. The study area for the CMP Scoping Study is defined by the catchment boundary of the Richmond River to the marine extent of the Richmond River and Evans River estuaries but not including the urban areas or coastline at Ballina and Evans Head or the North Creek catchment. The spatial extents of the study area and the local government areas are illustrated on Figure 1.

Figure 1: Study area for the Richmond River CMP Scoping Study

Cultural Context

3. CULTURE AND HERITAGE

The original occupation and custodianship of the lands and waters comprising the Richmond River CMP study area by First Nations people dates back many thousands of years. The Bundjalung Nation (also known as Bunjalung, Bandjalang, Banjalang) are the traditional custodians of the northern NSW coast, with territory stretching from Logan River in Queensland as far south as Grafton on the Clarence River (Remnant, 2017). The Bundjalung Nation is made up of approximately 15 separate groups (Ainsworth Heritage, 2013).

Prior to European settlement, First Nations people managed the Richmond River catchment and its resources for thousands of years. Abundant food resources in the area allowed a more settled life than many other Australian First Nations groups although seasonal changes prompted some movement between areas as different sea and land foods came into season (Sharpe, 1985). First Nations people also utilised the landscape and its features as what has been described as similar to an archiving system (Neale and Kelley, 2020) where mythological sites are integrated into stories and song so that knowledge, history, lore and culture can be recalled and passed down orally through the generations.

First Nations heritage and connection to nature are inseparable aspects. First Nations people continue to contribute to the management of the landscape and natural resources of the region and have previously expressed that they would like more direct input into water management decision making (DPIE, 2020). In recent decades First Nations people have formed their own organisations and peak bodies to ensure the continuation of their connection to the land through cultural and land management practices. The ongoing use of and relationship to the land is legally recognised in Native Title determinations and Indigenous Land Use Agreements (ILUA) over various parts of the study area as detailed in Section 22.

Plate 2: "Bing-ging" (turtle) diving, Richmond River, Gullibul Country (left); Minyumai Indigenous Protection Area Bandjalang Ranger team performing asset protection burns (right)

Source: Left: McClean (2013), Right: Minyumai IPA (2019)

Known and recorded heritage sites in NSW are recorded in the Aboriginal Heritage Information Management System (AHIMS) (Heritage NSW, 2021). Places of local heritage significance and conservation areas are also identified in Local Environment Plans and cultural mapping projects (Appendix 2). Not all cultural sites

are recorded and the sites often form part of a wider cultural landscape which is not readily understood nor captured.

The first Europeans to arrive in the region in the mid-1800s were runaway convicts, followed by the cedar getters who came to harvest red cedar (*Toona ciliata*) (Rous County Council, 2017a). This in turn opened the way for land selection in the area. Most of the lowland subtropical rainforest was cleared for agriculture by 1890. Land clearing and conversion to agriculture was supported by the Commonwealth and State Governments through a range of incentive schemes to improve productivity and economic prosperity. Cedar getting activities began in 1842 and were the dominant economic activity of the region for the following 20 years, which led to Ballina becoming an important port (Ainsworth Heritage, 2013). From the late 1830s until the 1850s sheep and cattle graziers occupied large areas of Crown lands and land leased from the NSW government, however due to an unsuitable climate and terrain, many grazing operations were abandoned at that time except for in some areas around Casino and further west (Ainsworth Heritage 2013; Richmond River Historical Society, 2021a; Lismore City Council, 2021c).

Plate 3: Wood cutters, Big Scrub rainforest (left) and gathering sugarcane with bullocks (right)

Source: Byron Bay Historical Society (2021), Richmond River Historical Society (2021a)

As the ‘Big Scrub’ was felled dairy farmers began settling. Timber resources began to deplete which saw dairying overtake cedar-getting as the dominant industry by the 1890s and continued this dominance until the early 1970s when market deregulation made production financially unsustainable for many producers (Ainsworth Heritage 2013; Richmond River Historical Society, 2021b; Lismore City Council, 2021c). In the 1860s many farmers took up sugarcane and corn farming which did not require refrigeration and provided a quick profit compared with dairying (Ainsworth Heritage 2013; Richmond River Historical Society, 2021a). In the late 1800s and early 1900s flood mitigation works commenced including wetland draining in low-lying floodplain areas to facilitate cropping (Cavanagh *et al*., 2007). Banana farming became a popular activity between the early 1930s to the 1960s (Ainsworth Heritage 2013). In the 1960s the first large-scale macadamia orchards were planted (Richmond River Historical Society, 2021a). Today the main urban centres within the study area are Lismore and Ballina with the smaller towns of Kyogle, Casino, Alstonville, Bangalow and Nimbin. Urban areas are growing, particularly on the coast as demand for housing increases in regional areas.

Environmental Context

4. CLIMATE

The Northern Rivers region experiences a subtropical climate, with warm humid summers and mild winters. The ocean controls the climate of the coastal towns, with more inland centres such as Lismore, Casino and Kyogle experiencing higher maximums and lower minimum temperatures. There is a high degree of seasonal variation in rainfall demonstrating a clear wet/dry seasonal pattern, which is typical of a subtropical environment. The highest rainfall typically occurs during summer and in early autumn (approximately 65% of average yearly rainfall total) with the lowest rainfall occurring in late winter and early spring. Subsequently, catchment flows are typically highest from December to June and lowest from July to November. Climate change and implications for the health of the Richmond River are discussed in Section 19.

5. TOPOGRAPHY

The Richmond River is one of the major coastal drainage systems in northern NSW with a catchment area of approximately 7,000 km^2 with the vast majority of the catchment less than 300 m above sea level (Figure 2). Higher elevations up to 1,100 m above sea level exist in the upper reaches of the Nightcap Ranges to the north-east, the Border Ranges to the north and the Richmond Ranges to the west. Approximately 40% of the catchment is flat (slopes less than 3°), 40% is undulating (3 - 15°) and 20% mountainous (slopes exceed 15°) (Gosper, 1986, cited in WBM, 2006).

The eastern part of the catchment is defined by a very large coastal floodplain, which covers an area of over 1,000 km^2 in major floods. Elevations on the floodplain range from 0 mAHD to approximately 10 mAHD, depending on the magnitude of the flood. Approximately 12% of the floodplain consists of land that is less than 1 mAHD (1m above sea level). Figure 3 highlights low-lying floodplain land from 0-1 mAHD within the study area including large areas of the Tuckean Swamp, Rocky Mouth Creek and floodplain areas in close proximity to Emigrant Creek and Maguires Creek to the north.

Figure 2: Study area elevation

Source: Mapping data provided by Geoscience Australia (2020)

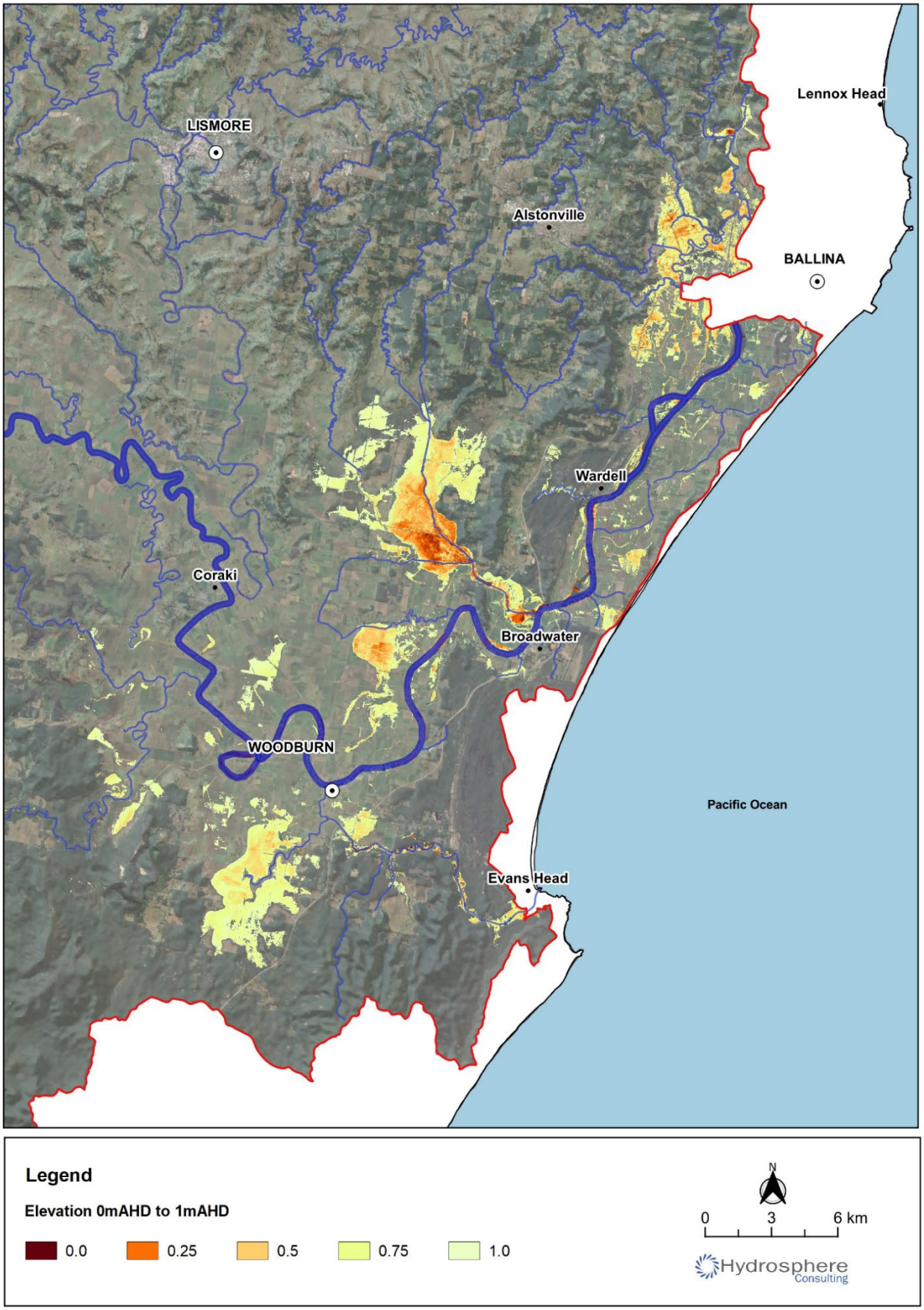

Figure 3: Low-lying floodplain areas, below 1 mAHD

Source: Mapping data provided by Geoscience Australia (2020), excluding waterways

6. GEOLOGY, SOILS AND GEOMORPHOLOGY

6.1 Geology and Soils

The geology and soil types of the Richmond River catchment are shown on Figure 4 and Figure 5 respectively. A summary of the dominant geology and soils within the catchment is summarised in Table 1. The two major underlying soil characteristics present in the catchment that contribute to poor waterway health are highly erodible soils in the mid and upper catchment and acid sulfate soils (ASS) on the floodplain/ tidal flats (Section 6.4).

Table 1: Summary of geology and soils of the catchment

Area description[1]	Dominant geology[1]	Predominant soils[1]	Notes on soil type[2]	Erosion hazard[3]
Upper northern reaches	Tertiary basalt	Predominantly ferrosols	Ferrosols have high free iron clay contents. They may be degraded by erosion and compaction caused by cropping practices and may suffer from acidification.	Ferrosols are prone to water erosion if left bare.
Western headwaters	Triassic quartz sandstones	Predominantly kurosols	Kurosols are strongly acid soils with an abrupt increase in clay.	Kurosols are highly erodible once cleared.
Upper southwestern reaches	A mix of Cretaceous conglomerates and lithic sandstones, siltstones and claystones, as well as Quaternary alluvium.	A mix of kurasols and hydrosols with some rudosols and tenosols	Rudosols are soils with minimal soil development. Tenosols are weakly developed soils with poor water retention.	Both Rudosols and Tenosols are highly erodible.
Lower reaches	Quaternary coastal dunes	Hydrosols	Hydrosols are seasonally or permanently wet soils.	Given their location and high clay content, Hydrosols have a low erosion hazard. However, acid scalds may be subject to wind erosion.

Area description[1]	Dominant geology[1]	Predominant soils[1]	Notes on soil type[2]	Erosion hazard[3]
Mid reaches	Quaternary alluvium	Vertosols and Dermasols	Vertosols are clay soils that shrink, and swell and crack as the soil dries. Dermasols are moderately deep and well-drained soils.	Vertosols have very low erosion hazard given its high clay content and low position in the landscape, but sheet erosion is common when groundcover is removed. Dermosols have moderate to high erosion hazard depending on slope and groundcover.
Tidal flat areas	Quaternary alluvium and quaternary coastal dunes	Vertosols, Hydrosols and Dermasols. Potential and actual ASS are common, especially in the low-lying areas associated with the Tuckean Swamp, Rocky Mouth Creek and Bungawalbin/ Sandy Creek.	Drainage of potentially acid sulfate soils can pose engineering and environmental problems and lead to acidification.	Vertosols and Hydrosols have a low erosion hazard, however, acid scalds may be subject to wind erosion. Dermosols have moderate to high erosion hazard depending on slope and groundcover.

Sources: Adapted from 1. Ryder *et al.* (2015); 2. CSIRO (2021a); 3. Alt *et al.* (2009)

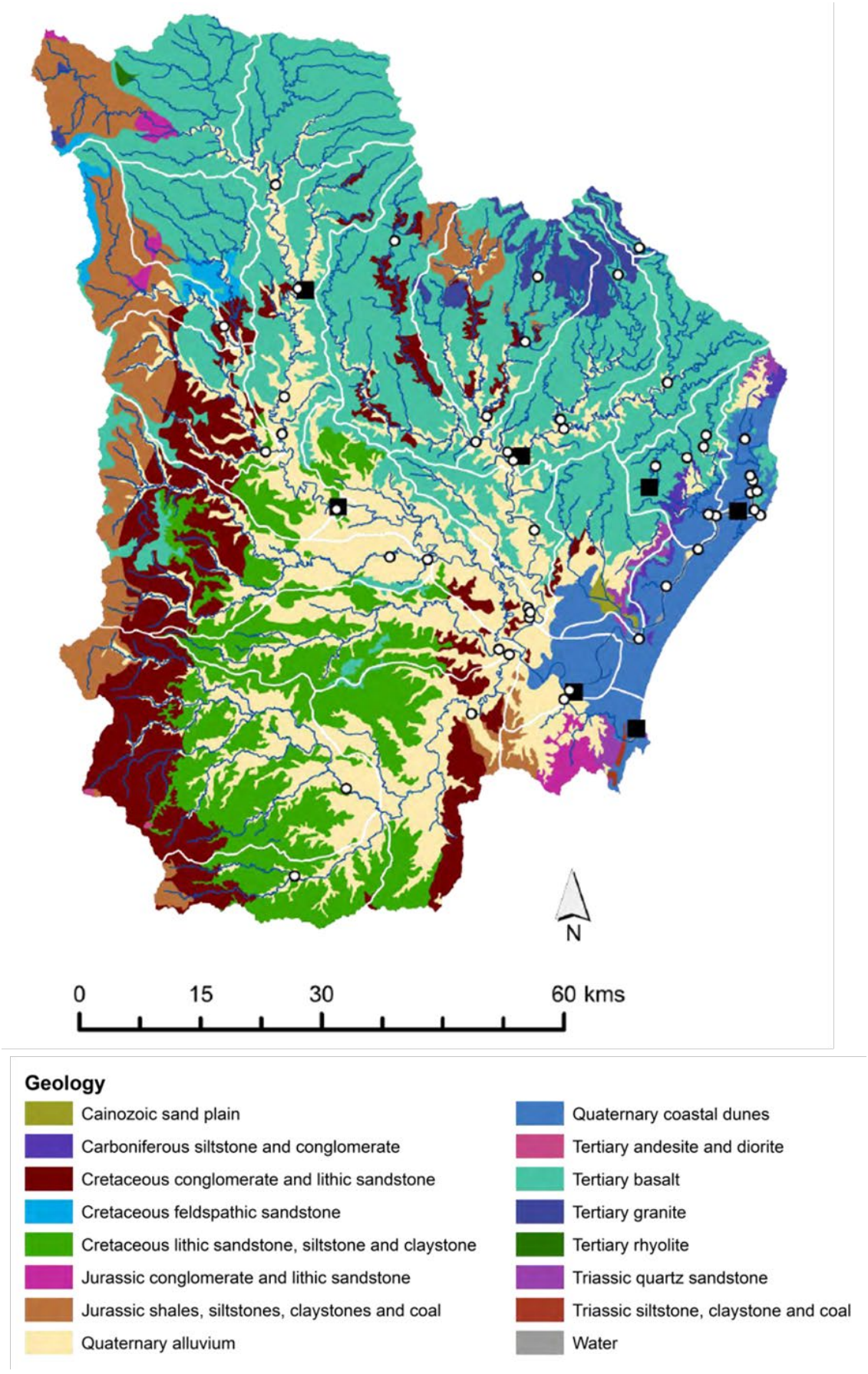

Figure 4: Geology of the Richmond River catchment

Source: Ryder *et al*. (2015)

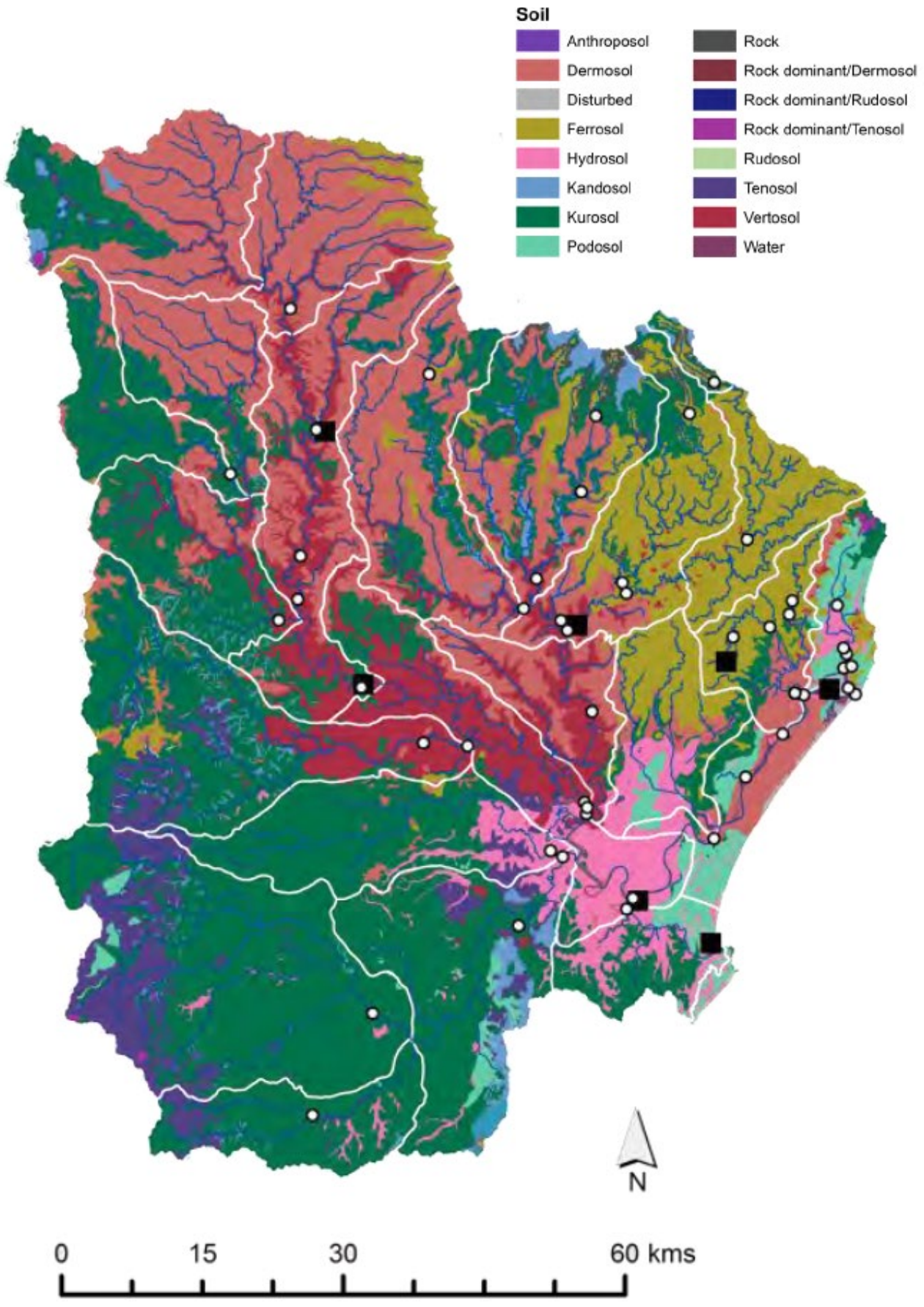

Figure 5: Soils of the Richmond River catchment

Source: Ryder *et al*. (2015)

6.2 Geomorphology

To manage waterways effectively, there is a need to understand the existing geomorphic condition of the system, its sensitivity to change and likelihood of recovery (DPIE - Water, 2021c). The *NSW River Styles Framework* classifies waterways based on geomorphic qualities that include river type (Figure 6), fragility, sensitivity to disturbance, condition and recovery potential. The NSW River Styles Database (DPIE - Water, 2021d) is a publicly available online mapping tool providing the River Styles classifications for NSW. The NSW Department of Planning, Industry and Environment – Water (DPIE – Water) recommends using the River Styles Framework to support and improve river management.

Figure 7 and Table 2 provide a summary of geomorphic condition scores for the Richmond River catchment as assessed in 2012 (Alluvium, 2012). Across the catchment, just 18% of waterways were considered to be in good geomorphological condition, 59% of waterways were in moderate condition and 23% of waterways were in poor condition. Ryder *et al.* (2015) further assessed the geomorphic condition of Richmond River catchment waterways incorporating a review of River Styles mapping combined with ground-truthing at selected sites. The study found that the upper freshwater reaches i.e. “headwaters” (67%) were predominantly in good or moderate condition, particularly those in conservation reserves (Plate 4). Estuarine reaches were mostly in poor condition with evidence of active erosion predominantly comprised of “planform controlled”, “meandering sand-bed channels” (25%) and “channelised fill” (19%). Figure 7 shows that many mid-catchment reaches were also assessed as having poor geomorphological condition during the River Styles assessment.

It is important to note that the River Styles mapping for the Richmond River was completed almost 10 years ago, and geomorphic condition in some areas may have changed since that time. However, it is considered that the overall results still provide a good indication of the condition of waterways and may be useful when considering future catchment-wide riparian zone prioritisation.

Plate 4: Headwaters in the Border Ranges (left); Richmond River reach downstream of Kyogle (right)

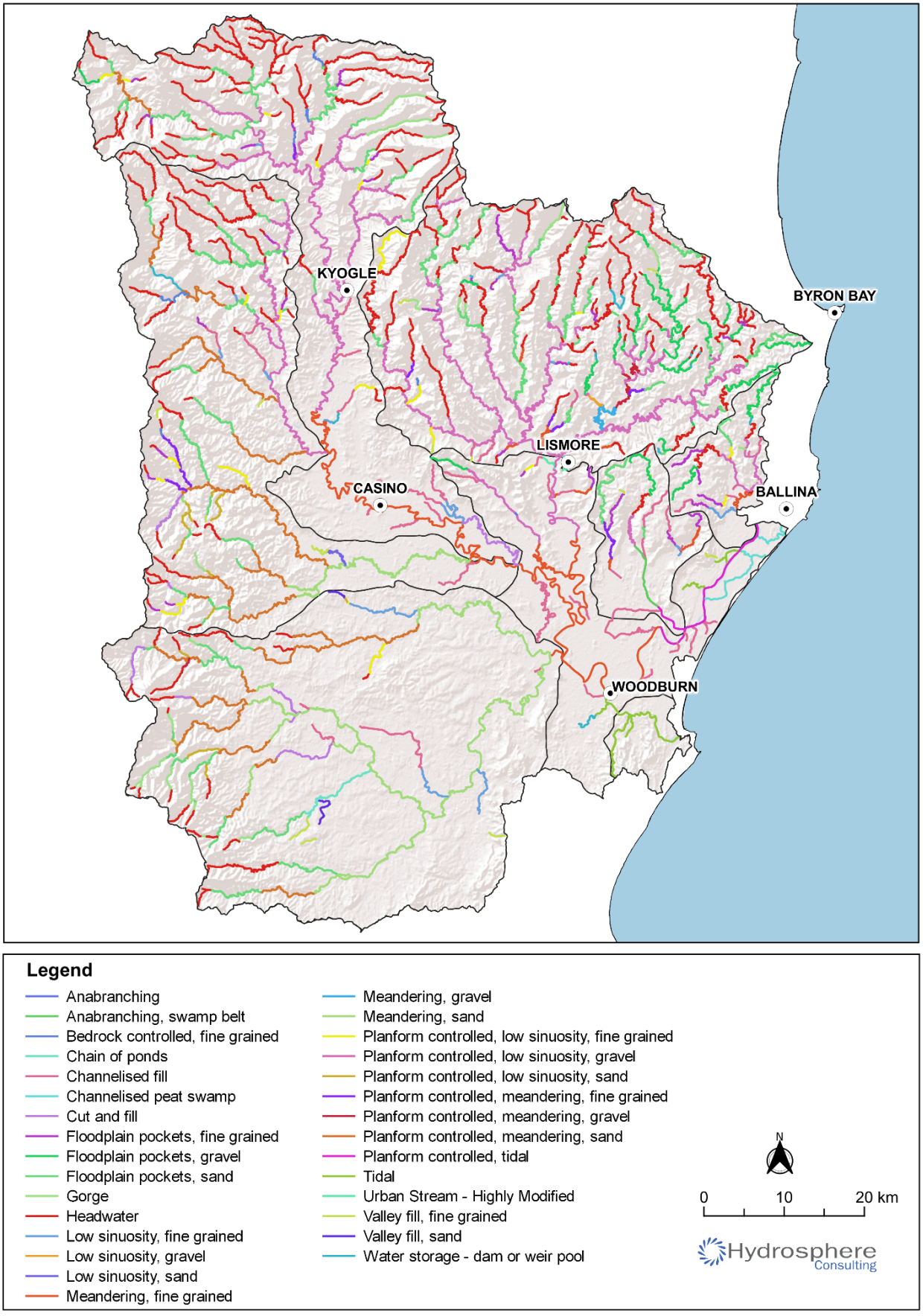

Figure 6: Riverstyles of the Richmond River catchment

Source: Mapping data provided by DPIE - Water (2021d) from mapping completed in 2012

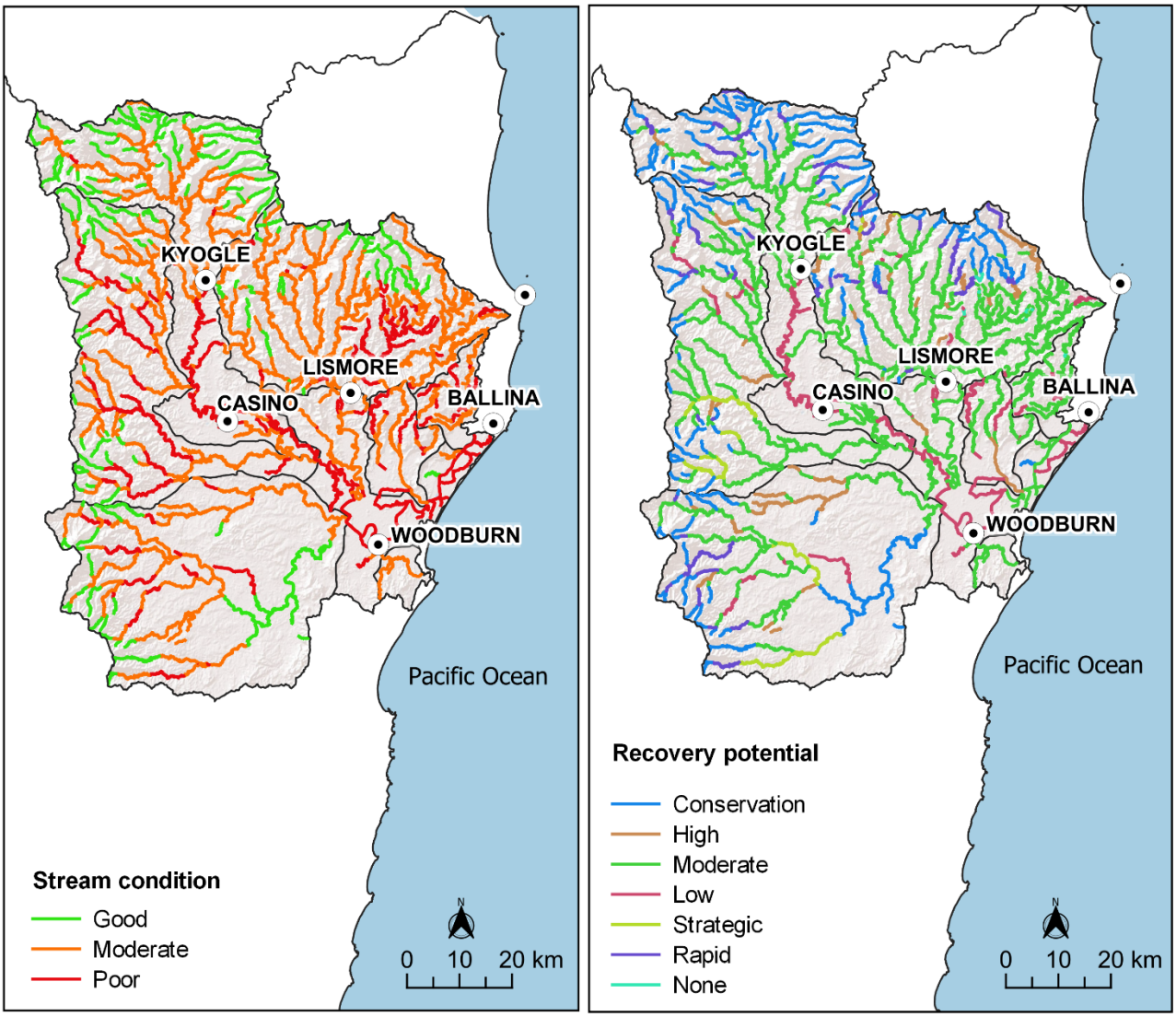

Figure 7: River Styles attributes – stream condition(left) and recovery potential (right)

Source: Mapping data provided by DPIE - Water (2021b) from mapping completed in 2012

The recovery potential mapping and statistics (Table 2) shows that 18% of Richmond River waterways were classified as “Conservation” recovery potential, which generally coincides with headwaters in good condition, most of which are already protected within conservation reserves. Only 6% of waterways were considered to have high recovery potential and these are scattered throughout the catchment including stretches in the lower Tuckean Swamp (including Henderson’s Drain through the Tuckean Nature Reserve and approximately 1.6 km immediately upstream of the reserve), mid-upper reaches of Sandy Creek and several locations in the upper Wilson River catchment. The majority of waterways are assessed as having moderate recovery potential (58%) with locations in the lower Richmond and Evans Rivers and the majority of mid-catchment waterways. Low recovery potential was assigned to 9% of waterways including a large section of the main stem of the Richmond River. Rapid recovery and strategic recovery potential were assigned to 6% and 3% of catchment waterways respectfully.

Table 2: River Styles attribute classes as a percentage of the Richmond River catchment waterways

Attribute	Total length (km)	% of Richmond River waterways
Stream condition		
Good	622	18%
Moderate	2065	59%
Poor	813	23%
Recovery Potential		
Conservation	622	18%
High Recovery Potential	214	6%
Moderate Recovery Potential	2031	58%
Low Recovery Potential	300	9%
Strategic	115	3%
Rapid	211	6%
None	8	0.2%

Source: Adapated from mapping data provided by DPIE - Water (2021d) from mapping completed in 2012

6.3 Sediment Compartments

Sediment compartments are used to compartmentalise sections of the Australian coastline and marine areas with similar characteristics and processes. A sediment compartment is a section of coast (extending into rivers) which shares a common sediment resource with clearly defined physical boundaries (Short, 2018). A compartment may be open, leaky or closed at either or both boundaries and the sediment budget may be positive, stable or negative. The sediment compartment concept uses a hierarchy classification including province, division, region, primary and secondary. The coastal extent of the study area lies within the temperate province, southeast division and central eastern region and is within the primary coastal sediment compartments which extends from the Clarence River to Point Danger (Tweed Heads). The secondary sediment compartments within the study area are Cape Byron to Richmond River (Cape Byron to Ballina), Richmond River to Evans Head (Broadwater), Evans Head to Yamba Point (Bundjalung), which are described in Table 2 and illustrated on Figure 8.

Table 3: Sediment compartments

Compartment	Bundjalung	Broadwater	Cape Byron to Ballina
Extent	Evans Head to Yamba Point	Richmond River to Evans Head	Cape Byron to Richmond River
LGA	RVC, CVC	BaSC, RVC	BySC, BaSC, LCC, RVC, CVC
Geomorphology	Sandstone and conglomerate headlands, zeta-form bays, large and small embayed beaches, extensive Pleistocene prograded beach ridge plain, dunes, Holocene prograded barriers.	Zeta-form sandy beach, Pleistocene indurated sand, transgressive dunes, backbarrier flats.	Volcanic and metasedimentary headlands, zeta-form bays, sandy beaches, and narrow foredune ridges, few active blowouts, Richmond River mouth and estuary.
Sensitivity rating[1]	Sensitivity rating is a 4, with several sections already 5.	Sensitivity rating is a 4.	Sensitivity rating is a 4, with several sections likely to be 5. The southern end of one beach is eroding and Pleistocene dune sands are exposed in places.
Confidence rating[2]	Medium to high.	Medium	Medium

1. Relevant sensitivity rating from 1 (low) to 5 (high): 3 - Relatively stable shorelines which may be subject to periodic erosion followed by recovery (accretion), but no long-term recession expected in the next few decades since the sediment budget remains sufficiently balanced over time from offshore, alongshore or terrestrial sources. 4 - Shorelines that currently do not show evidence of long-term recession but are likely to begin receding with continuing sea-level rise (based on sediment availability onshore and offshore). 5 - Shoreline recession is occurring now (typically documented by historical shifts in shoreline position) and the shoreline is likely to continue to recede as sea level rises (possibly at a faster rate depending on local conditions).

2. Confidence rating: Medium - Some information is available on changes to landforms, from multiple sources, which may include recent landform change from site descriptions and irregular aerial photographs over the past decade. High - detailed information is available identifying changes to coastal landforms spanning the historical period and includes regular remotely sensed information over the past 30 years or more.

Source: CoastAdapt (2017b)

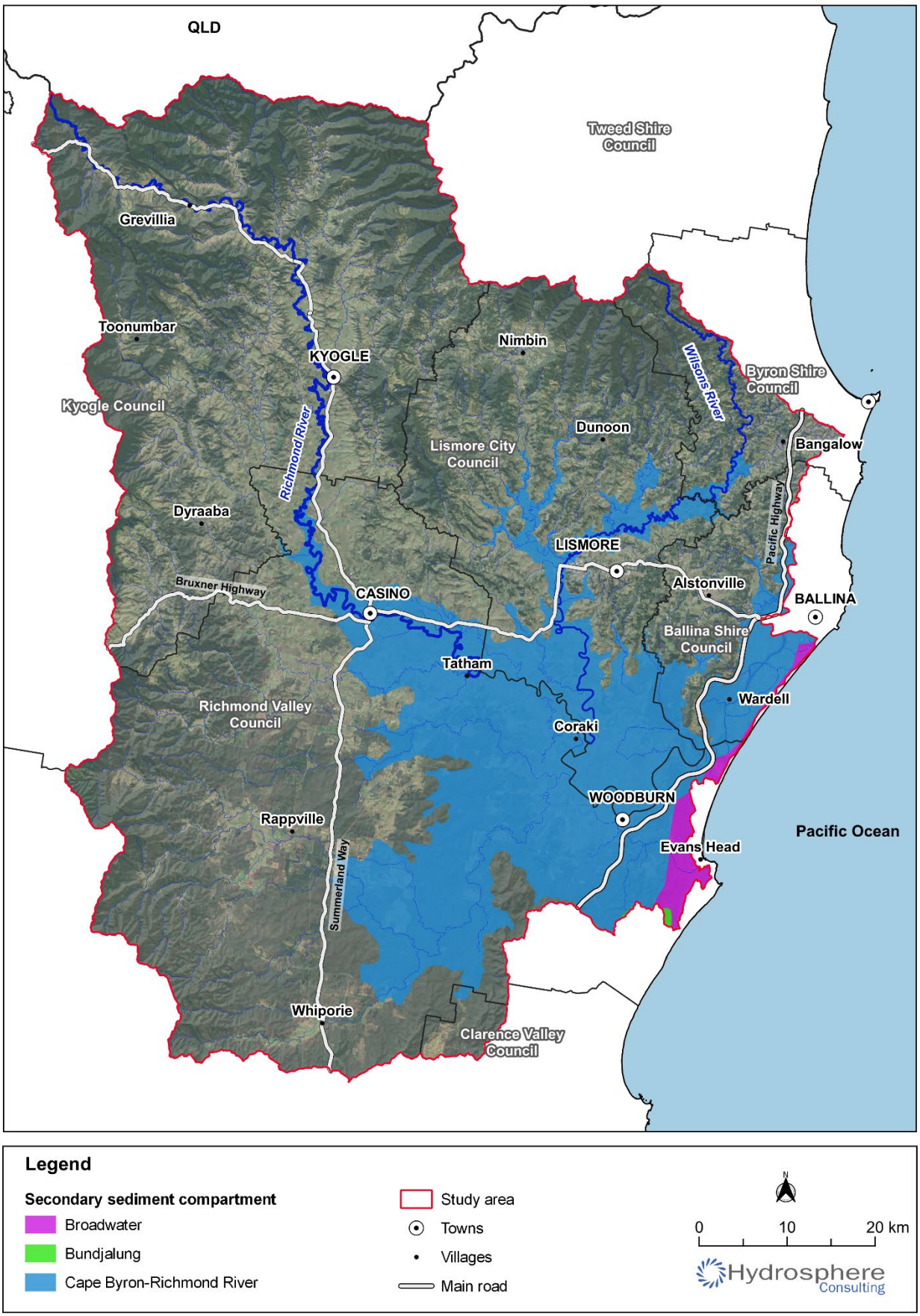

Figure 8: Coastal sediment compartments

Source: Mapping data provided by Geoscience Australia (2015)

6.4 Acid Sulfate Soils

ASS is the common name given to naturally occurring sediments and soils containing iron sulfides. These sediments are benign when permanently inundated in natural swamp lands (Harrison *et al.,* 2021). However, the exposure of these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid often also releasing high concentrations of metal by-products into the receiving estuarine waters (Naylor *et al*., 1998). State-wide ASS risk mapping was originally prepared by Naylor *et al.* (1998) which mapped approximately 350 km^2 of high-risk ASS below an elevation of 5 m on the Richmond River floodplain (Figure 9). Several subsequent studies and investigations have confirmed the extent and severity of ASS on the Richmond River floodplain (Tulau, 1999; Moore, 2007; ABER, 2008; Harrison *et al.,* 2020; Rayner *et al.,* 2020a). Water quality issues associated with ASS are discussed in Section 10.2.

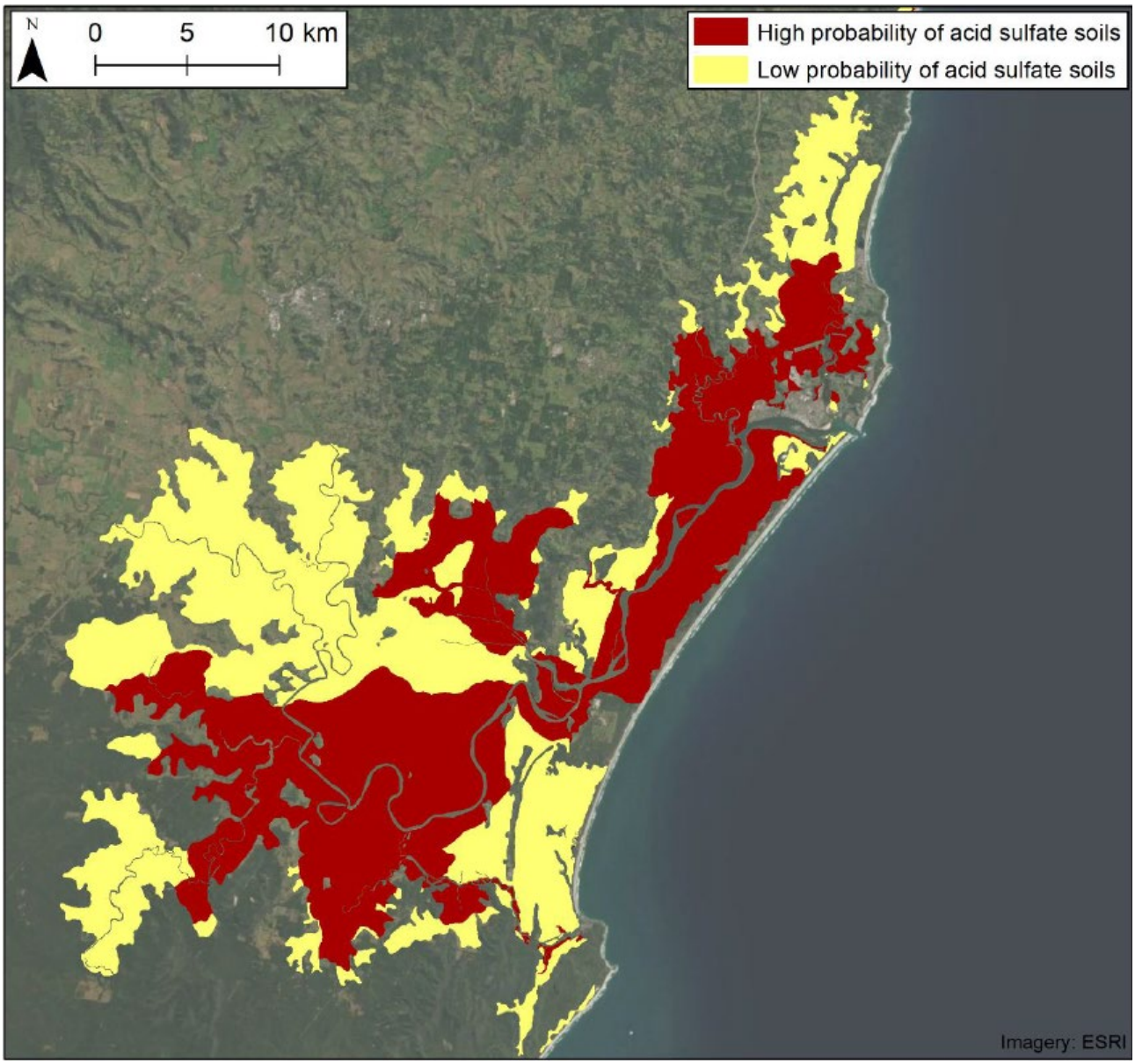

Figure 9: NSW Government ASS risk map of the Richmond River floodplain

Source: Risk mapping by Naylor *et al.* (1998) reported in Harrison *et al*., (2020)

7. BIODIVERSITY

The North Coast region of NSW is renowned as one of the most biologically diverse areas in Australia. The study area occurs in the McPherson-Macleay Overlap area, where the temperate and tropical zones intersect and extending from the McPherson Range (in the Border Ranges) in the North to the Macleay River in the south. This is an area of extremely high biodiversity, resulting from the wide range of soil types, climate and topography across the region. This overlap area has the third highest level of biodiversity in Australia (Richmond Regional Vegetation Committee, 2002). The study area contains parts of the Gondwana Rainforests of Australia which was inscribed on the UNESCO World Heritage list in 1986 for its biological and geomorphic values (UNESCO, 2020).

The *Regional State of the Environment Report 2016* for the North Coast asserts that "*appropriate management of pressures on biodiversity and vegetation is essential to ensure current condition is maintained or improved"*. The main pressures on the regions biodiversity and vegetation include habitat loss, clearing, habitat modifications, invasive species and loss of genetic diversity (North Coast Region State of the Environment Report Working Group, 2016; NPWS, 2010b).

7.1 Vegetation Communities

The study area supports a diversity of vegetation communities and species (NPWS 2004; Hydrosphere Consulting, 2011a; NPWS, 2012). Broad vegetation groups within the Richmond River catchment, area and percentage of the catchment area (686,000 ha) are listed in Table 4.

Table 4: Broad vegetation groups within the Richmond River catchment

Broad Vegetation Group	Vegetation Community	Approximate area (ha)	% of catchment area
Estuarine vegetation	Mangrove, Saltmarsh, Seagrass	695	0.10%
Wetlands	Sedgeland	575	0.65%
	Sedgeland with Swamp Sclerophyll Forest and Woodland	194	
	Swamp Sclerophyll Forest & Woodland	1,288	
	Swamp Sclerophyll Mallee Shrubland	12	
	Swamp Sclerophyll Shrubland	484	
	Swamp Sclerophyll Shrubland with Wet Heathland	24	
	Fernland	3	
	Undifferentiated Coastal Wetlands	1,005	
	Undifferentiated Freshwater Wetlands	897	

Broad Vegetation Group	Vegetation Community	Approximate area (ha)	% of catchment area
Heathland	Dry Heathland	537	0.38%
	Wet Heathland/Sedgeland	2,038	
	Graminoid Clay Heathland	24	
Mixed Sclerophyll communities	Dry Sclerophyll Forest to Woodland	18,547	3.42%
	Dry Sclerophyll Mallee Forest to Shrubland	617	
	Dry Sclerophyll Shrubland	768	
	Wet Sclerophyll Forest to Woodland	3,510	
Grassland	Native Grassland	18	0.003%
Rainforest	Subtropical Rainforest	12	0.07%
	Littoral Rainforest	47	
	Undifferentiated Rainforest	412	
Riparian vegetation	Riparian Forest	22	0.003%
Coastal complex	Mixed Heathland, Sedgeland, Wetlands and Sclerophyll communities	9,514	1.41%
	Foredune complex	132	
	Headland complex	24	
Disturbed	Disturbed communities	14,977	2.18%
	Regrowth	9	

Source: Adapted from NSW NPWS (2005); CMA, (2005) cited in WBM (2006)

Within the study area, the Lower Bungawalbin catchment wetland complex and the Tuckean Swamp are listed in the Directory of Important Wetlands in Australia (Figure 10, Department of Agriculture, Water and the Environment, 2021). These wetlands provide habitat for a large number of migratory waders including federally listed threatened species (Hydrosphere Consulting, 2011a).

The Richmond River estuary supports a number of rare and threatened communities such as Coastal Wetlands and Endangered Ecological Communities including Coastal Saltmarsh, Swamp Oak Floodplain and Littoral Rainforest. The estuarine wetlands host important species including mangroves, saltmarsh and seagrass, promote nutrient cycling and provide habitat for fish nurseries and breeding grounds. The intricate network of permanent and ephemeral waterways also sustains a diversity of plants and animals (NPWS, 2004). The riparian zone provides important ecological functions including habitat connectivity, bank stabilisation and acts a buffer to reduce sediment levels in overland runoff. Additionally, riparian vegetation cover provides shade which reduces water temperature, increases aquatic habitat and reduces aquatic weed.

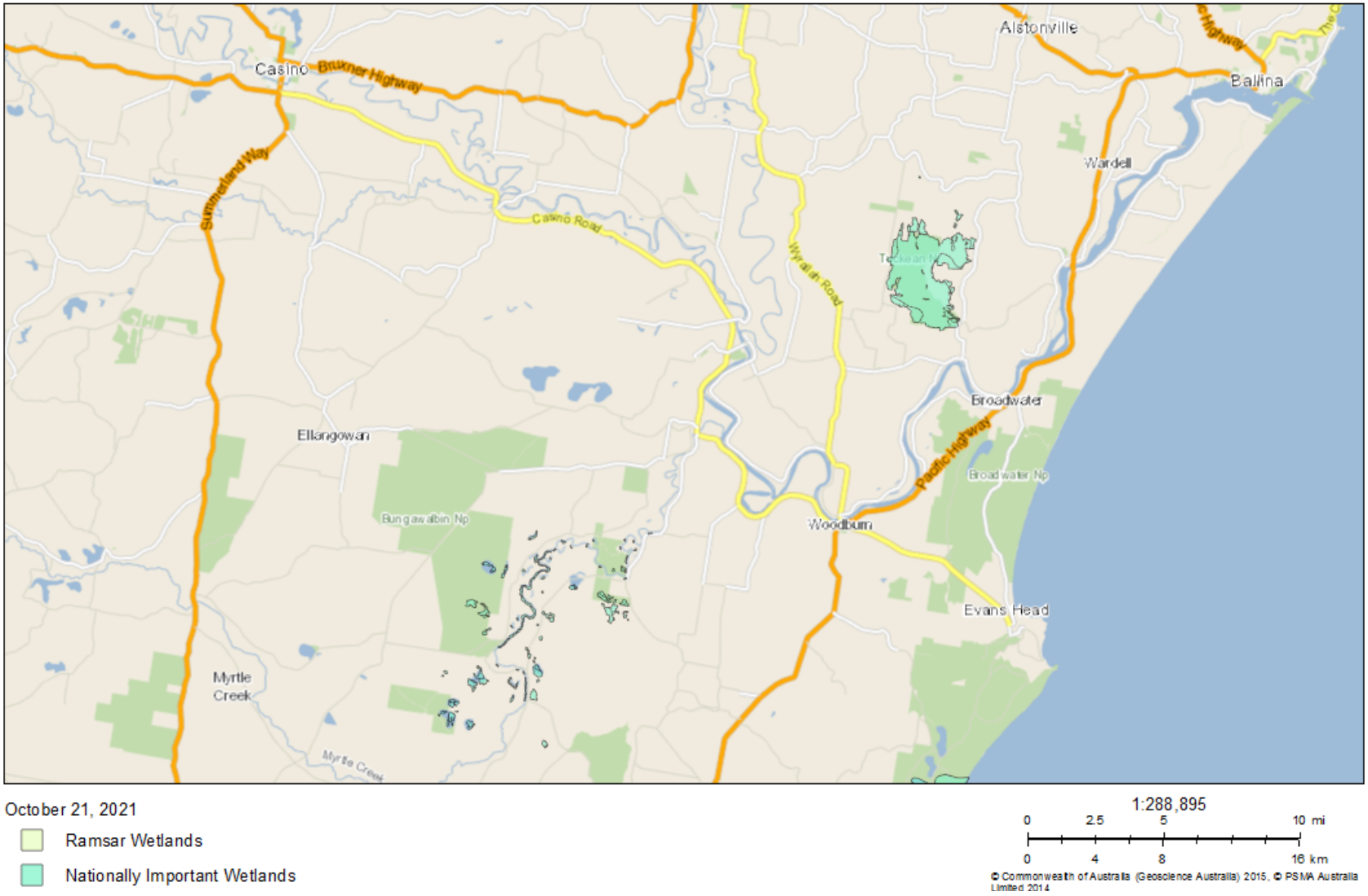

Figure 10: Nationally Important Wetlands in the Richmond River catchment (Tuckean Swamp and Lower Bungawalbin)

Source: Department of Agriculture, Water and the Environment (2021)

Forested areas within the study area, particularly the National Parks and State Conservation Areas of the upper catchment, also host a large level of biological diversity. These areas include a range of rainforest types, wet and dry sclerophyll forest and pockets of heath. The *Coastal Zone Management Plan for the Richmond River Estuary, Volume 2: Estuary Management Study* (Richmond River EMS, Hydrosphere Consulting, 2011a) reported on a range of broad vegetation mapping datasets available at the time which estimated that approximately 26% of the study area supports remnant or regrowth native vegetation and estuarine and freshwater wetland habitats, approximately 9% of the study area supports disturbed vegetation communities and habitats and 65% of the study area is cleared or developed land.

The effects of vegetation clearing were summarised in the Richmond River EMS (Hydrosphere Consulting, 2011b) as:

- Loss of vegetation and associated fauna species - clearing of vegetation has reduced the biodiversity values of the Richmond River and its catchment.
- Fragmentation of habitats - remnants within the study area have vegetation corridors forming linkages to other remnants outside the study area. The current long-term viability of the species that rely on vegetated “movement” corridors may be severely compromised by any further broad-scale disturbance. Past vegetation clearing has resulted in many remnants becoming isolated due to the lack of connecting corridors.
- Increase sediment and nutrient loads to the estuary.
- Changes in morphological (erosion, accretion) processes within the estuary.
- Weed encroachment and proliferation where exotic species are able to out-compete native species in areas of disturbance.

Land clearing on the floodplain and the establishment of exotic grasses and crops has resulted in the dominance of flood-intolerant vegetation. The decomposition of organic matter following a flood has been found to be a major contributor to fish kill events through the creation of blackwater (refer Section 10.2.1). This is exacerbated by the decomposition of flood-intolerant pastures and the resulting high oxygen demand. Similarly, the deoxygenation potential of slashed pastures, harvested tea tree and cane trash is high and retention of this vegetative matter on the land also contributes to the risk of blackwater during floods (Hydrosphere Consulting, 2011b).

7.2 Aquatic Habitat and Fauna

The aquatic habitat in the Richmond River catchment comprises freshwater, estuarine, and marine environments. The Richmond River is the seventh largest (by surface area) estuary in NSW, with the fifth largest finfish catch (ABER, 2007). In addition to the high fisheries/productivity value of the estuary, the estuary supports species, habitats and communities of conservation concern. The Richmond River estuary contains approximately 5% of the mangrove forest mapped in NSW (approximately 603 ha). The Richmond River contains all five mangrove tree species confirmed for NSW, dominated by *Avicennia marina*, followed by *Aegiceras corniculatum* and lesser occurrence of *Bruguiera gymnorhiza, Rhizophora stylosa* and *Excoecaria agallocha* (ABER, 2006). The latest mapped areas of saltmarsh measure 59.94 ha and seagrass 23 ha (MEMA, 2017). Saltmarsh species are varied and dependent on location and degree of tidal influence however common species in the Richmond River include *Sporobolus virginicus*, *Juncus kraussii, Baumea*

juncea and *Suaeda australis.* The dominant seagrass species in the Richmond River is *Zostera capricorni* (Creese *et. al*., 2009).

Key fish species within the study area include estuarine target fish such as Dusky flathead, Yellowfin bream, Sand whiting, Luderick, mullets (numerous species, particularly Bully mullet), Mulloway, Mangrove jack, Trevally, Garfish, many smaller fish such as gobies, bennies, mudskippers, herrings, glassfish, pipefish, toadfish, fortescues, etc. Migratory species which are seasonally associated with the estuary, particularly the upper reaches include Australian bass, Estuary perch and eels (usually Long-finned eels). Bull sharks are known to occur in the lower estuary. Fisheries resources are an important value of the Richmond River estuary. As with water quality, the health and productivity of the fish community in the estuary are key indicators of overall estuary health. The estuary is well known as a recreational fishing hotspot and supports a range of commercial fishing activities (including activities undertaken outside the study area). Pressures on fish stocks include (Hydrosphere Consulting, 2011b):

- Habitat availability - the nursery value of estuaries for many species is well known and the degradation or complete removal of important habitats is as a major factor in fisheries management as loss of habitat can lead to fewer fish to share amongst all stakeholders (Sections 9 and 10) .
- The presence of instream barriers such as weirs, floodgates and culverts in the catchment interrupt fish migration and dispersal within the catchment. These migrations are often essential for fish to complete their life cycle and the productivity of the catchment as a whole is reduced when effective fish passage is not available between downstream and upstream habitats (Section 8).
- Poor water quality has a range of effects on fish populations. The most visible effect is evident in the large fish kills such as those experienced in the Richmond River estuary which have been primarily attributed to diffuse pollution (Section 10.2.1). Red Spot Disease (EUS) in fish is a chronic effect of acidified waters. More chronic effects of water quality degradation include effects on fish stocks through restricting fish movement or habitat use in unfavourable areas, reduction on productivity and influences on the food chain and productivity.
- The impact of overfishing can be dramatic as evidenced by the collapse of many fisheries throughout the world. To protect against overfishing, commercial and recreational fishing is regulated through the use of licence restrictions, bag or quota limits, restriction on the size range of fish taken and the establishment of no fishing zones.

Threatened fish species include the Eastern Freshwater Cod and the Oxleyan Pygmy Perch. The Eastern Freshwater Cod is endemic to the Richmond and Clarence Rivers of Northern NSW. It was once abundant in the Richmond River catchment but over-harvesting and habitat degradation have caused a significant decline in the population, with the current small population mainly due to restocking efforts (DPIE - Water, 2016a). Recovery Plans have been developed for these species (DPI Fisheries 2004; DPI Fisheries 2005).

The platypus is an iconic Australian species, endemic to the east coast of Australia and Tasmania. Platypus are found in the Richmond River (Rohweder & Baverstock, 1999; Hawke *et al.*, 2020) and the species is currently listed as ‘near threatened’ under the International Union for Conservation of Nature Red List (Hawke *et al.*, 2020). There is evidence of past and present projected declines in platypus populations (Hawke *et al.*, 2020).

Threatened frog species known to occur in the area include the Fleay's Barred Frog, Giant Barred Frog, Green and Golden Bell Frog, Green-thighed Frog, Loveridge's Frog, Mountain Frog, Olongburra Frog, Pouched Frog, Stuttering Frog and the Wallum Frog (DPIE - Water, 2016a; NSW DPI, 2006c). Three chelonians (Eastern snake-necked turtle, Saw-shelled turtle and Macquarie turtle) are found in the catchment as well as water rats (NSW DPI, 2006c).

Dolphins are an iconic and highly visible aquatic species with cultural significance and high amenity value. A resident Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) population lives in the Richmond River estuary which was estimated at 34 residents by Fury and Harrison (2008). Fury (2009) identified that flooding was the major determinant of dolphin occupancy in the estuary with probabilities of dolphin sightings dropping significantly during floods compared to non-flood periods. Analysis determined changing salinity, turbidity, pH, dissolved oxygen levels (primarily associated with floods) were responsible for this tendency. Dolphin Research Australia is currently undertaking the *Healthy Waterways – Healthy Dolphins Project* which aims to investigate the relationships between estuarine condition and the status of dolphin communities in the Tweed River, Richmond River and Gold Coast Broadwater estuaries. The project uses citizen science data collection to monitor dolphins and also incorporates water quality monitoring data (Dolphin Research Australia, 2021). During surveys conducted in 2018 – 2019 a total of 14 groups of 1 to 28 individual Indo-Pacific bottlenose dolphins were sighted in the Richmond River estuary up to 19 km upstream although one sighting by a member of the public of a mother-calf group was reportedly encountered 65 km upstream of the river entrance. A majority of the groups contained females with dependant calves. Encounter rates and group sizes were greater in the Richmond River estuary than in the Tweed and Gold Coast Broadwater estuaries (Dolphin Research Australia, 2020). Some of the females sighted in these surveys are estimated to have resided in the estuary for over 10 years (pers. comm. Dr. Liz Hawkins). Future work on this project will look at the status, abundance and health of the dolphin population in the estuary and how it relates to overall estuary health. The health of shark populations is also linked to ecosystem health generally in marine (e.g. coral reef) settings and there is increasing interest in the ecosystem role of sharks in estuarine waters. This is particularly true for Bull sharks because the young mature in fresh/brackish areas and these nursery areas are particularly susceptible to impacts. There have been limited studies in the Richmond River on this issue.

The Richmond River estuary is considered one of the two most important estuaries for shorebird locations in northern NSW with 38 different species being recorded within the Richmond River estuary over a 23-year period. The estuary and South Ballina Beach are high priority sites for the Greater Sand Plover, Sanderling and Terek Sandpiper. The Richmond estuary is also a priority site for Great Knot, Lesser Sand Plover and Beach Stone-curlew (DECCW, 2010). Priority population sites and nesting sites for Pied Oystercatchers are also found between the Richmond and Clarence estuaries.

Outbreaks of aquatic weeds are known to occur in several locations within the study area (Hydrosphere Consulting, 2011b). These weeds can reduce the ecosystem values of open water for birds and fish. Aquatic weeds can cause diurnal fluctuations of dissolved oxygen and provide a source of organic matter for the production of monosulfidic black ooze (MBO, Section 8.4), which when mobilised by flood flows can completely deoxygenate the water column. Examples of Lily outbreaks in the Tuckean have been reported as linked to MBO formation (Hydrosphere Consulting, 2011b).

Healthy estuarine and freshwater habitats are essential for conserving aquatic biodiversity. Of the 204 sub-catchments identified in the *North Coast Stressed Rivers Assessment* (DLWC, 1999), 33 were defined as High Conservation Value (HCV) including 11 sub-catchments of the Richmond River system. However, more

than 50% of the sub-catchments assessed were identified as having high environmental stress. Weed encroachment in riparian zones is common in the Richmond River catchment and degrades ecosystem values by reducing habitat value and food resources for native fauna, reduced shading and can reduce bank stability where shallow rooted weed species replace deep rooted native trees.

7.3 Groundwater Dependent Ecosystems

DPIE - Water (2021a) defines groundwater dependent ecosystems (GDEs) as '*ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services'.* GDEs can include cave and karst systems, springs, wetlands, estuarine and marine ecosystems and groundwater dependant endangered ecological communities (EECs). Groundwater dependant wetland ecosystems are typically areas where the water table is at the surface, or periodically at the surface (DPIE - Water, 2016a). The dependence of GDEs on groundwater varies through time, often increasing during droughts, or reducing during higher rainfall periods. They can range in size from a few metres to many square kilometres (DPIE - Water, 2021). While the degree of groundwater dependency is variable, groundwater plays a critical role in wetlands found on alluvial floodplains. Many wetlands are extremely species-rich with a mixture of plants and animals and are often considered to have high conservation value. Because of their dependency on groundwater, GDEs may be threatened by the regular extraction of groundwater and changes in land use or management affecting groundwater.

DPIE - Water (2016a) completed a mapping project that identifies remaining vegetation communities that have a high probability of being groundwater dependent. This project was undertaken as part of the development of the *Richmond River Water Sharing Plan* (WSP). Figure 11 provides the GDE probability mapping for the Richmond River catchment showing large areas of high, medium and low probability GDEs throughout the catchment. Of note is the high probability GDEs identified in the Tuckean Swamp, Bungawalbin and Evans Head and also many small areas located along many tributaries of the Richmond River.

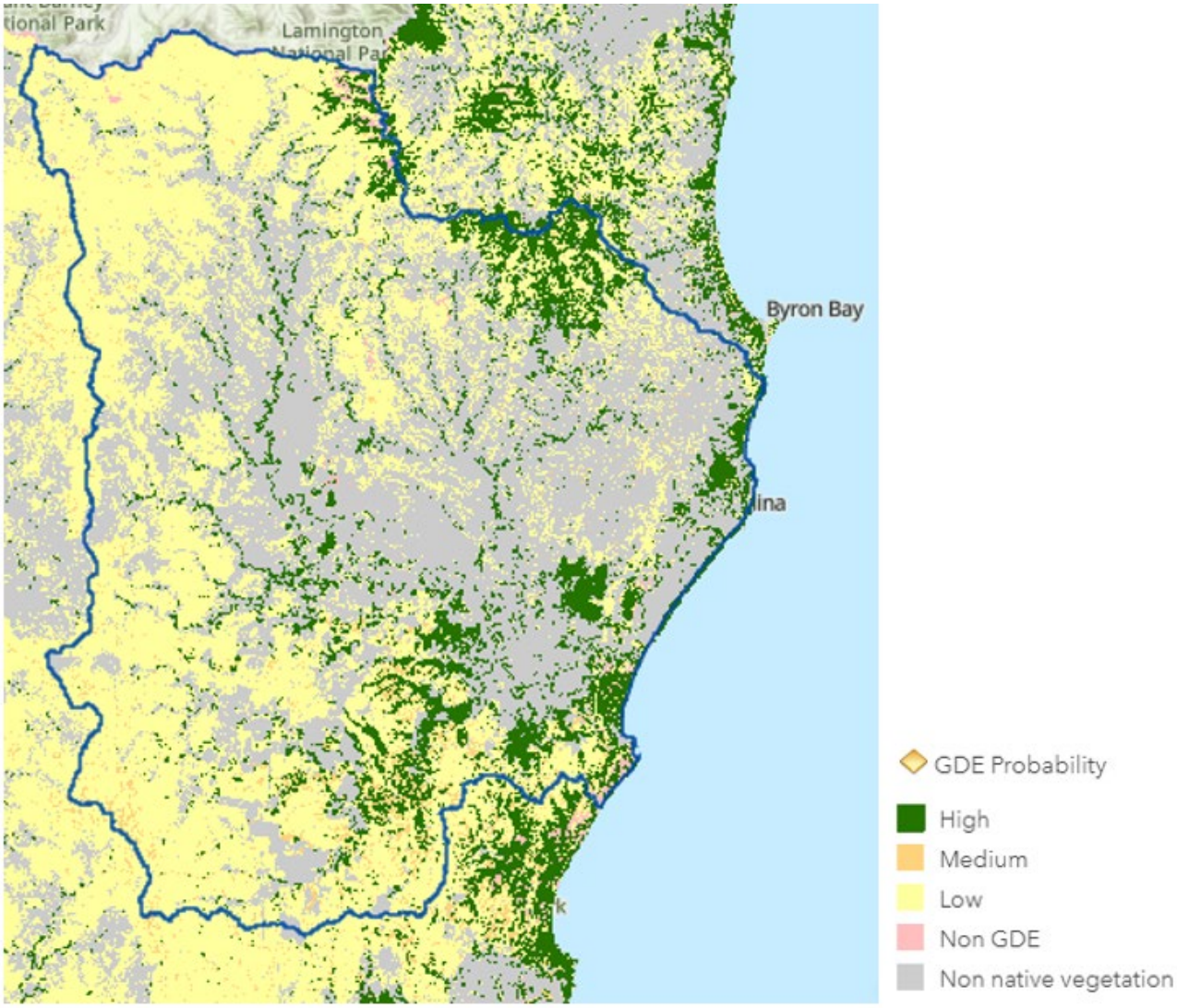

Figure 11: Probable groundwater dependent ecosystems in the Richmond River catchment

Source: Dabovic *et al.* (2016)

8. HYDROLOGY AND CATCHMENT MODIFICATIONS

8.1 Hydrology

The Richmond River CMP study area has been divided into eight hydrological units based on Ferguson (2021) with the addition of the Evans River sub-catchment (Figure 12). The hydrology of each sub-catchment is discussed below including the significant hydrological modifications that have occurred since European settlement. Hydrological modifications are present throughout the catchment from major instream dams and weirs in the upper reaches to extensive floodplain modifications in the form of drains, levees, floodgates and other structures. These hydrological modifications affect natural flow regimes and functions of waterways with impacts on aquatic ecosystem health indicators such as water quality (Section 10.2), fish passage (Section 10.3) and aquatic habitat values (Section 7.2).

8.1.1 Wilsons River

The Wilsons River sub-catchment drains from the upper reaches of Wilsons Creek in the Nightcap Range and flows to the sub-catchment outlet at Lismore. The main tributaries flowing into the upper Wilsons River include Terania Creek, Coopers Creek, and Leycester Creek. The tidal pool of the Wilsons River extends to approximately 5 km upstream from Lismore. The sub-catchment covers an area of 1,384 km^2, or 20% of the Richmond River CMP study area. The major instream structures within the Wilsons River sub-catchment include Rocky Creek Dam (14,000 ML) on Rocky Creek, Mulgum Creek Weir and DE Williams Dam at Nimbin and Laverty's Gap Weir on the upper Wilsons River. The structures are used for town water supply. Water is also extracted from the tidal pool at Howards Grass upstream of Lismore.

8.1.2 Richmond River Main Stem

The Richmond River Main Stem sub-catchment drains the Border Ranges with the headwaters of the Richmond River close to the QLD/NSW border at Mount Lindsay extending downstream to the tidal limit near Tatham. The major tributaries flowing into the Richmond River above Kyogle include Grady's Creek, Roseberry Creek, Findon Creek and Lynches Creek. The Richmond River flows downstream of Kyogle and is joined by Eden Creek approximately 20 km upstream of Casino. The Richmond continues through the town of Casino to the tidal limit where the extensive floodplain begins. The sub-catchment covers an area of 1,354 km^2, or 19% of the Richmond River CMP study area. Major instream structures within the Richmond River Main Stem sub-catchment include Jabour Weir at Casino and Kyogle Weir at Kyogle used for town water supply purposes with an off-stream storage at Kyogle (DPIE - Water, 2016a). The Kyogle town water supply weir was upgraded in 2017 (Plate 7, Section 10.3) to allow for fish friendly passage via a rock ramp fishway.

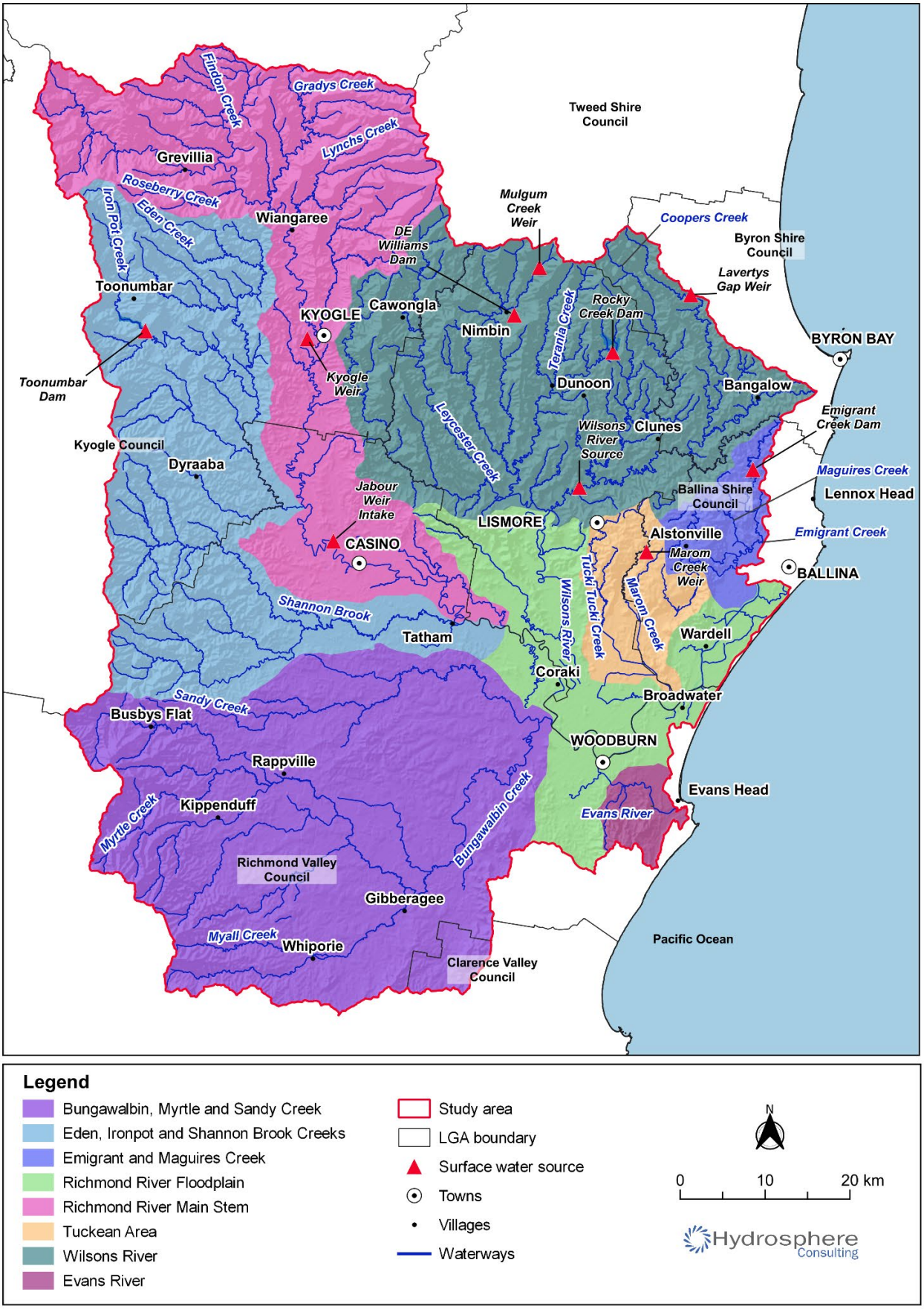

Figure 12: Richmond River CMP sub-catchments and major waterways

Source: Adapted from Ferguson (2021)

8.1.3 Eden, Ironpot and Shannon Brook Creeks

The Eden/ Ironpot/ Shannon Brook Creeks sub-catchment drains the Richmond Range from the western side of the Richmond River catchment, meeting the Richmond River Main Stem at the tidal limit near Tatham. The main tributaries include Eden Creek, Ironpot Creek and Shannon Brook. The sub-catchment covers an area of 1,284 km^2, or 18% of the Richmond River CMP study area. The major instream structure within this sub-catchment is Toonumbar Dam in the upper reaches of Iron Pot Creek with a capacity of approximately 11,000 ML. A 50 km length of Iron Pot and Eden Creeks is regulated through releases from Toonumbar Dam. The junction of Eden Creek and the Richmond River marks the downstream end of the regulated system. Releases from the dam are currently primarily used for irrigation purposes (DPIE - Water, 2016a).

8.1.4 Bungawalbin, Myrtle and Sandy Creeks

The Bungawalbin / Myrtle / Sandy Creeks sub-catchment drains the southwest portion of the Richmond River catchment. The main tributaries include Sandy Creek, Myrtle Creek, Myall Creek and Bungawalbin Creek. The tributaries flow into the Richmond River tidal pool in the mid estuary. This sub-catchment covers an area of 1,778 km^2, or 25% of the Richmond River CMP study area. There are no major instream structures within this sub-catchment however many lower floodplain areas have been modified with floodplain drainage infrastructure (refer Section 8.4).

8.1.5 Emigrant and Maguires Creeks

The Emigrant / Maguires Creeks sub-catchment is small in size compared to other hydrological units. It covers an area of 284 km^2, or 4% of the Richmond River CMP study area. The main tributaries include Emigrant Creek and Maguires Creek, which both drain the Alstonville Plateau. Maguires Creek joins Emigrant Creek at Teven which flows to the lower Richmond River estuary just upstream of Ballina. Emigrant Creek Dam (820 ML) is the largest instream structure in the sub-catchment and forms part of the regional town water supply network. Many lower floodplain areas have been modified with floodplain drainage infrastructure (refer Section 8.4).

8.1.6 Tuckean Swamp

The Tuckean Swamp sub-catchment drains the Alstonville Plateau to the Tuckean Swamp floodplain. Major tributaries include Marom Creek and Tucki Tucki Creek. The sub-catchment covers an area of 220 km^2, or 3% of the Richmond River CMP study area. Marom Creek Weir is located on Marom Creek in the upper reaches and is used for town water supply. The majority of the sub-catchment is comprised of low-lying floodplain where extensive drainage works have been carried out. The Bagotville Barrage is a major instream structure installed in 1971 comprising eight large culverts with one-way floodgates to enable drainage from the floodplain, whilst preventing tidal ingress from the estuary downstream (Rayner *et al*., 2020a).

8.1.7 Richmond River Floodplain

The Richmond River floodplain sub-catchment comprises floodplain areas within the study area with the exception of floodplain areas within the Tuckean Swamp and Evans River and part of the Bungawalbin/

Myrtle/ Sandy Creeks sub-catchment which have been separated due to the unique physical attributes of those systems. The main waterways are the Richmond River downstream of the tidal limit near Tatham and the Wilsons River tidal pool downstream of Lismore to the downstream extent of the study area at West Ballina. Major tributaries include Bungawalbin Creek, Sandy Creek, Rocky Mouth Creek, and the Tuckean Broadwater. The sub-catchment covers an area of 632 km^2 or 9% of the Richmond River CMP study area. The floodplain has been extensively modified with a network of drains, floodgates, levees and other structures to assist in draining floodwaters and wetlands for agricultural and urban land use (Section 8.4).

8.1.8 Evans River

The Evans River sub-catchment is a small coastal catchment extending from the Tuckombil Weir at Woodburn to the upstream extent of urban areas in Evans Head. The Tuckombil Canal is an artificial channel, located downstream of the Rocky Mouth Creek floodgates, which connects Rocky Mouth Creek to the Evans River. The Canal was constructed in 1900 to divert floodwaters from the Richmond River into the Evans River via Rocky Mouth Creek. Various structures (inflatable fabridam, temporary sheet piling and temporary concrete modular tidal barrier have been installed since 1965 to prevent tidal exchange (Tulau, 1999; RCC, 2018). After the temporary barrier was installed, a 2001 study to determine a permanent solution identified several options. The preferred option was chosen as a fixed weir and the temporary measure has remained in place. The fixed weir also prevents deoxygenated and poor water quality from Rocky Mouth Creek entering the Evans River (RCC, 2018).

The Evans River enters the ocean at the river entrance approximately 1 km downstream of this point. The Evans River sub-catchment covers an area of 78 km^2, or 1% of the Richmond River CMP study area. The Evans River occasionally receives floodwaters from the Richmond River when Richmond River water level exceeds the height of the Tuckombil Weir. Most of the Evans River sub-catchment is located within the Bundjalung and Broadwater National Parks.

8.2 Stream Flows

The average annual stream flow from the Richmond River is 1,920,000 ML (DPIE - Water, 2016a). Flows fluctuate from year to year and also between seasons and across the catchment. In the wetter months (summer to early autumn) discharge can be six times greater than the dryer months (late winter to spring). The streams located in the north and north-eastern part of the catchment where rainfall is typically higher, exhibit markedly higher flows than those in the western and south-western part of the catchment which experiences lower rainfall.

There are currently 11 gauging stations across the Richmond River catchment, which monitor stream flows on a daily basis. These are located in the Grady's Creek, Kyogle Area, Richmond Regulated, Bangalow Area, Leycester Creek, Coopers Creek, Shannon Brook and Myrtle Creek Water Sources. There are also historic records of daily flows at gauging stations throughout the catchment which have been discontinued (DPIE - Water, 2016a).

8.3 Flooding

Flooding is a regular event throughout the Richmond River catchment and is often associated with the cyclonic rain depressions that bring intense rainfalls to the region (DPIE - Water, 2016a). Floods are an important feature of the hydrologic cycle which are a vital, natural process that support diverse ecosystems. Floods form part of the environmental flows required to connect wetlands and floodplains with the river, including the Tuckean Swamp, Ballina Nature Reserve and Big Scrub in the lower Richmond River and are responsible for the highly productive soils of the floodplains. Floods also flush rivers and floodplains of organic matter and are important reproductive cues for many fish and invertebrates (DPIE, 2020).

Historically, most floods have occurred in the first half of the year, with the peak period between February and April. This seasonality is the result of ex-tropical cyclones and east coast lows that occur close to the coast (DPIE, 2020). Flooding in the Richmond River catchment is a recurring natural event that poses major risk to local communities, properties and is also associated with poor water quality and other environmental impacts. Major flooding has been experienced many times in the Richmond River catchment with the earliest recorded flood events dating back to 1857 (Rous County Council, 2021d). Seven major floods have been recorded since 1857, with the two largest occurring in 1954 and 1974 caused by tropical cyclones. The Lismore levee, designed to prevent flooding in 1 in 10-year events, was constructed in 2005 and has protected the town in several floods. In March 2017, a major flood was experienced (generated by ex-tropical cyclone Debbie), and the Lismore flood levee was overtopped for the first time, causing one of the most damaging floods in living memory in terms of material and community destruction (Lismore City Council, 2021b). A range of other more localised flood events have occurred though time, with different parts of the Richmond River catchment having been affected at different times.

The Richmond River Flood Mapping Study (BMT WBM, 2011) was prepared to better understand flood behaviour and assist in forming a strategic approach to managing flood prone land and emergency response. Numerous Flood Studies, Floodplain Risk Management Studies and Plans have been prepared to help protect rural communities and urban centres of the Richmond River catchment. These studies have included the whole of the Richmond River floodplain from Kyogle to Ballina and Lismore on the Wilsons River, with particular focus on the urban centres of Kyogle, Casino, Coraki, Lismore, Woodburn, Broadwater, Cabbage Tree Island, Wardell and Ballina (BMT WBM, 2016).

8.4 Floodplain Modifications

The Richmond River floodplain has been extensively modified by a complex network of constructed drains, modified canals, artificial levee banks and floodgates. Installation of floodplain drainage channels began in the late 1800s and accelerated in the early 1900s for the purpose of draining wetlands for agriculture and for flood mitigation. Floodgates were installed to prevent back-flooding of drains, creeks and tributaries and subsequently the inundation of agricultural land on the floodplain during minor flood events or by salt water from high tides. Harrison *et al.* (2021) makes reference to the misleading use of the term ‘flood mitigation’, when in reality the 1950-70s ‘flood mitigation’ schemes were overwhelmingly swamp drainage schemes.

There are many types of floodgates in the Richmond River floodplain, but the majority utilise the simple passive design, where the pressure of the downstream water seals the gate and when the downstream water level drops, the floodgates open to permit drainage. The floodplain infrastructure managed by RCC is

shown on Figure 13 although there is also an extensive network of privately managed drainage infrastructure.

RCC has an active floodgate management program which facilitates tidal exchange to occur between the downstream waterway and the drainage system. Active management refers to the opening of floodgates during non-flood periods to allow this exchange to occur. This improves drain water quality and enhances aquatic habitat and allows fish passage. RCC has an Active Floodgate Management Plan for each of the 55 floodgates that are currently actively managed. Some of these plans are implemented by landowner volunteers with the remainder implemented by RCC. Tidal exchange can improve water quality in drainage systems, however the benefits are limited to dry weather periods and only improves water quality before it is discharged from the system (pers. comm, C. Clay, 2021).

The impacts of historical and on-going drainage works are known to have significant environmental impacts on the estuary. These include the exposure and oxidation of ASS, formation of MBO, blackwater formation, drainage providing a conduit to more effectively convey pollutants to the estuary and disruption of tidal flushing regimes affecting water quality and ecological processes (refer Section 10.2).

Floodgate outlets can accumulate silt over time which encourages mangroves to establish. Landowners have observed that mangroves have colonised in previously clear floodgate outlets, potentially affecting the operation of the floodgate and hydraulic performance of the drain. Many farmers are reporting that water retention on the adjacent agricultural land following heavy rain is caused by the blocked floodgate outlets. This is resulting in poor water quality in the drains and economic loss due to flooding. A significant proportion of the lower Richmond River has been mapped as mangroves and the northern section and banks around Pimlico Island are also mapped as coastal wetlands. All drain outlets to the Richmond River are in high ASS risk/Class 2 ASS under the Ballina 2012 LEP.

Historically these floodgate outlets were maintained by mechanical cleaning. However today, this activity is highly regulated and potentially a large number of permits are required from NSW government agencies resulting in high costs, extended time periods and risk of rejection. There is also uncertainty of who is responsible for maintaining these outlets and whether there are adequate financial resources to keep them at a maintenance standard.

The approval process for maintenance of floodgate outlets is highly dependent on-site characteristics, who is the proponent and the extent of work proposed. Public authorities are subject to reduced approval requirements and have increased resources compared to private landholders. In addition, local government authorities are in a better position to provide consistency of methods and outcomes when drains are not considered in isolation. The development of standardised classifications, assessments and methodologies would provide a consistent and cost-effective approach to meeting planning and approval requirements. There are strategic planning initiatives underway that are also relevant to this issue (coastal management programs, MEMS and provisions in the *Water Management Act 2000* for Drainage Management Plans). DPIE – Water has undertaken an initial round of targeted consultation with key stakeholders, including local councils to gain a better understanding of the issues relating to the regulatory framework for agricultural drainage works and activities on coastal floodplains from the Tweed to the Shoalhaven (including the Richmond), as well as potential solutions. The consultation outcomes have not yet been published. Proposed reforms will be developed during 2021/22.

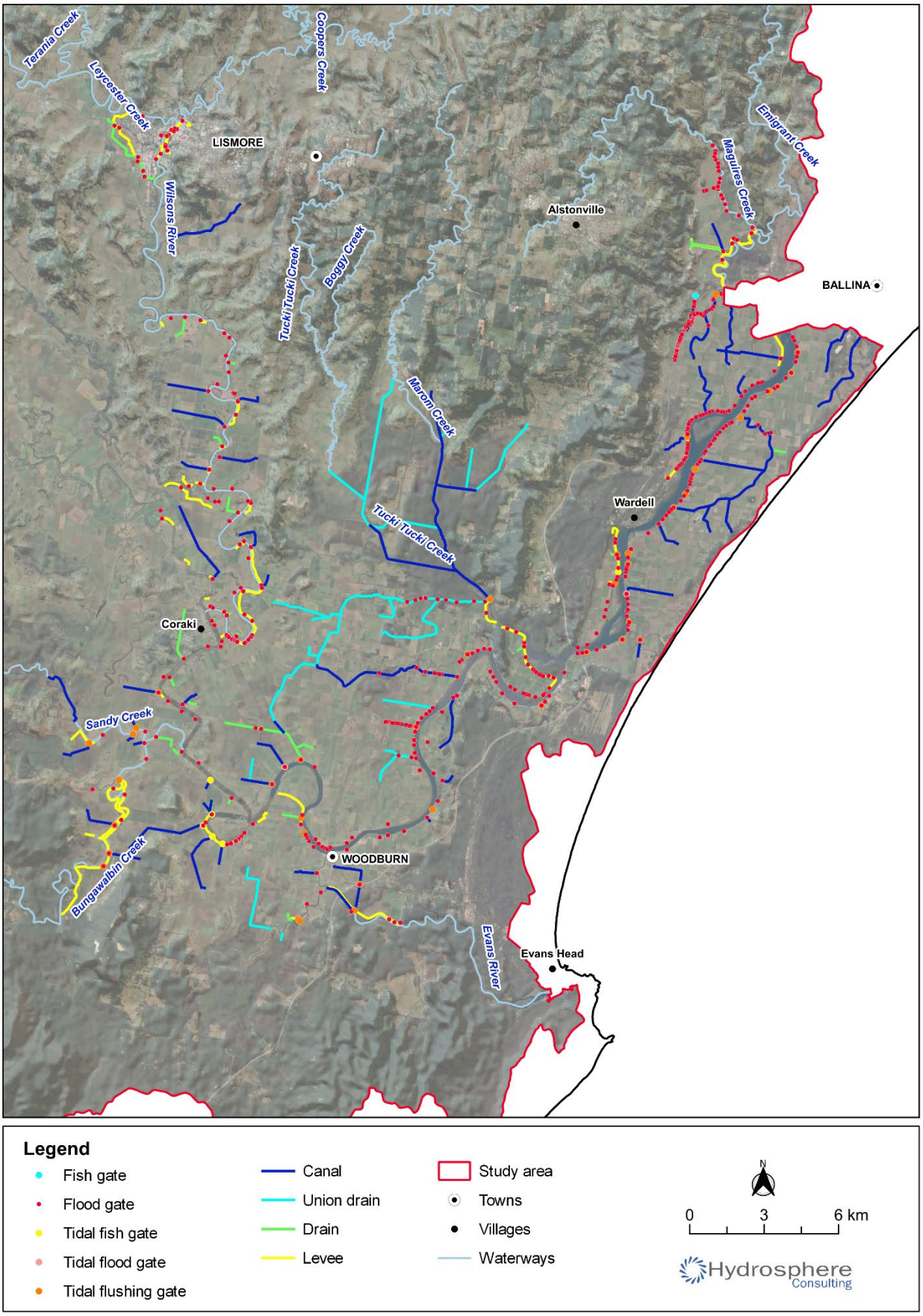

Figure 13: RCC floodplain infrastructure

Source: GIS data supplied by RCC

8.5 Groundwater

Groundwater in the region is found in fractured rocks, coastal sands and smaller alluvial aquifers around rivers and creeks. Groundwater is part of the water cycle and is recharged via infiltration of rainfall through the soil profile to reach the water table. It is also a major contributor to flows in many waterways providing essential flows to ecosystems, base flow to rivers and creeks and also provides water for irrigation, industry and town water supplies (DPIE, 2020). The groundwater sources in the region are shown on Figure 14.

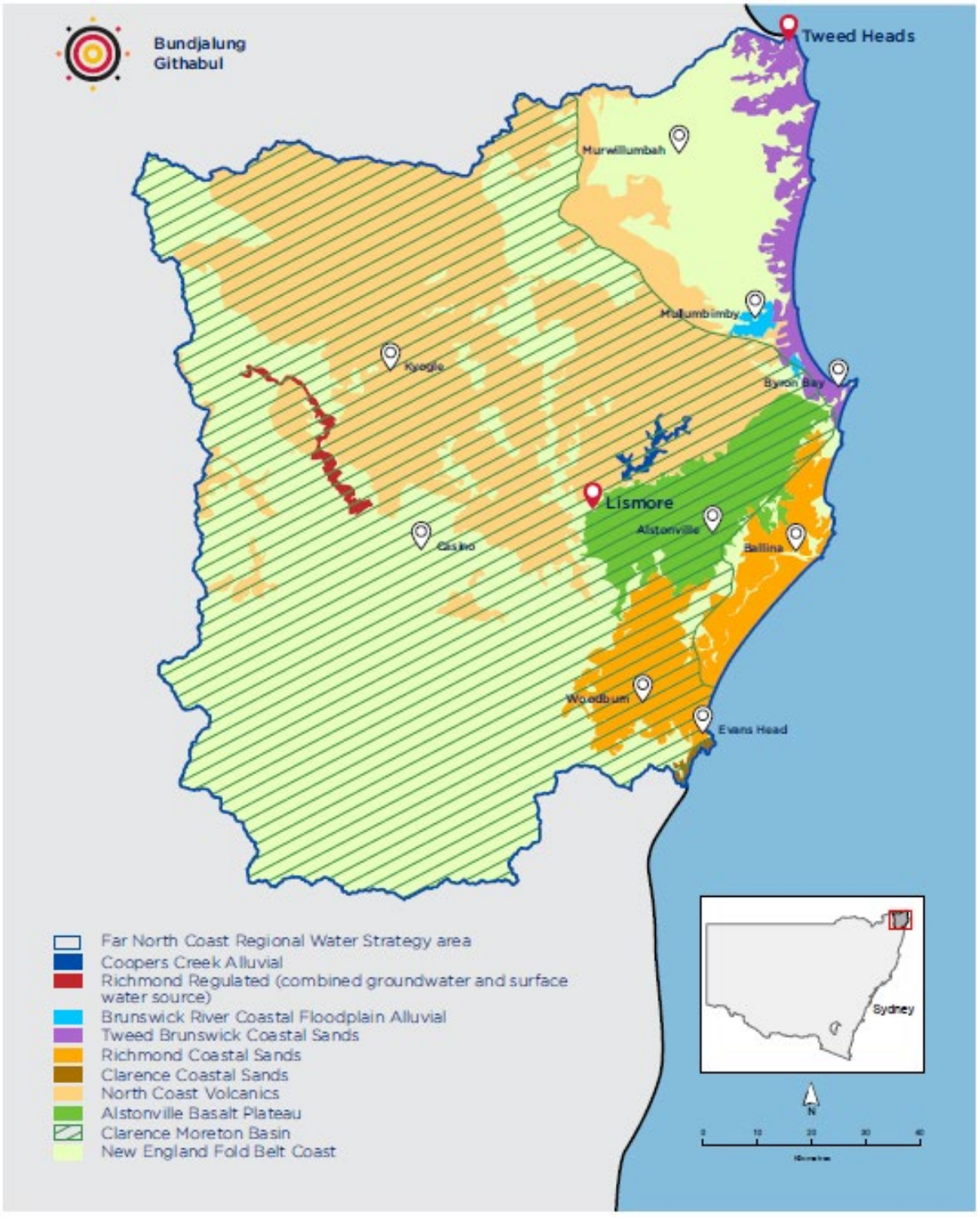

Figure 14: Groundwater sources

Source: DPIE (2020)

8.6 Water Extraction

Water extraction in the Richmond River catchment occurs in many forms for a variety of purposes including town water supply, irrigation of agricultural crops and for stock and domestic use. Water sharing plans set the limits on the amount of water that can be extracted from surface water and groundwater sources. The annual sharing of water is managed through long-term average annual extraction limits (LTAAELs), while daily sharing is managed through cease-to-take rules, which can vary for different categories of licence.

By 2016 there were approximately 2,345 water licences in the area covered by the *Water Sharing Plan for the Richmond River Area Unregulated and Alluvial Water Sources 2010,* totalling 97,407 ML of entitlement (approximately 5% of the average annual flow of 1,920,000 ML in the Richmond River). The majority of these licences are for irrigation, with a significant proportion also used for town water supply. Water is also extracted from watercourses within the Richmond River catchment through Basic Landholder Rights (not requiring a licence). There has been an embargo on granting new surface water licences in both the unregulated and regulated systems of the Richmond River catchment since 1995. Alluvial aquifers were embargoed in 2008 (DPIE - Water, 2016a).

The Water Sharing Plan area map showing the various water sources is given on Figure 15. Most of the demand for water extraction in the Richmond River usually occurs during dry times when streamflow is already low. Increased extraction during these times is likely to further exacerbate water quality issues and impacts on aquatic biology such as restricted fish passage and drought refuge. Continued low flows during dry periods are essential for maintaining water quality, allowing passage over riffles for fish and other fauna to pools used for drought refuge and maintaining those parts of aquatic ecosystems that are most productive. A proportion of the very low flows are protected for the benefit of the environment through access restrictions (cease-to-pump rules). Surface water licences in all unregulated water sources are subject to cease to pump rules (excluding licences held by local water utilities and licences used for food safety and essential dairy care). Water is managed in the regulated system to provide for the environment by mimicking some elements of natural flow variability (providing flushes for the most environmentally valuable part of the system (i.e. the reach immediately downstream of the dam), setting aside a volume of water in the dam to be used for environmental management and ensuring a flow is provided at the end of the system). Extraction rules aim to balance reliable access to water with protecting the environment. However, water for the environment is not actively managed in the Far North Coast region and is largely dependent on rainfall-generated stream flows (DPIE, 2020). Similarly, there is currently no formal mechanism for notification or monitoring of flow conditions and related extraction rules, despite the extraction rules included in the licences and plan rules.

The Water Sharing Plan is currently under review and one of the key areas identified for further work is improved monitoring of extraction within the catchment, particularly during dry periods.

The majority of licences are in the unregulated water sources including the major upstream tributaries, the Bangalow Area (Wilsons River) and Terania Creek Water Sources, the Richmond River tidal pool upstream of Coraki along both arms (Richmond and Wilsons Rivers) and the Alstonville and Tuckean Area Water Sources (Alstonville Plateau). Water is extracted for a range of agricultural purposes including irrigated pastures for dairy and to a lesser extent beef and horticulture. Unregulated river licences account for approximately 62% of all water licence share components.

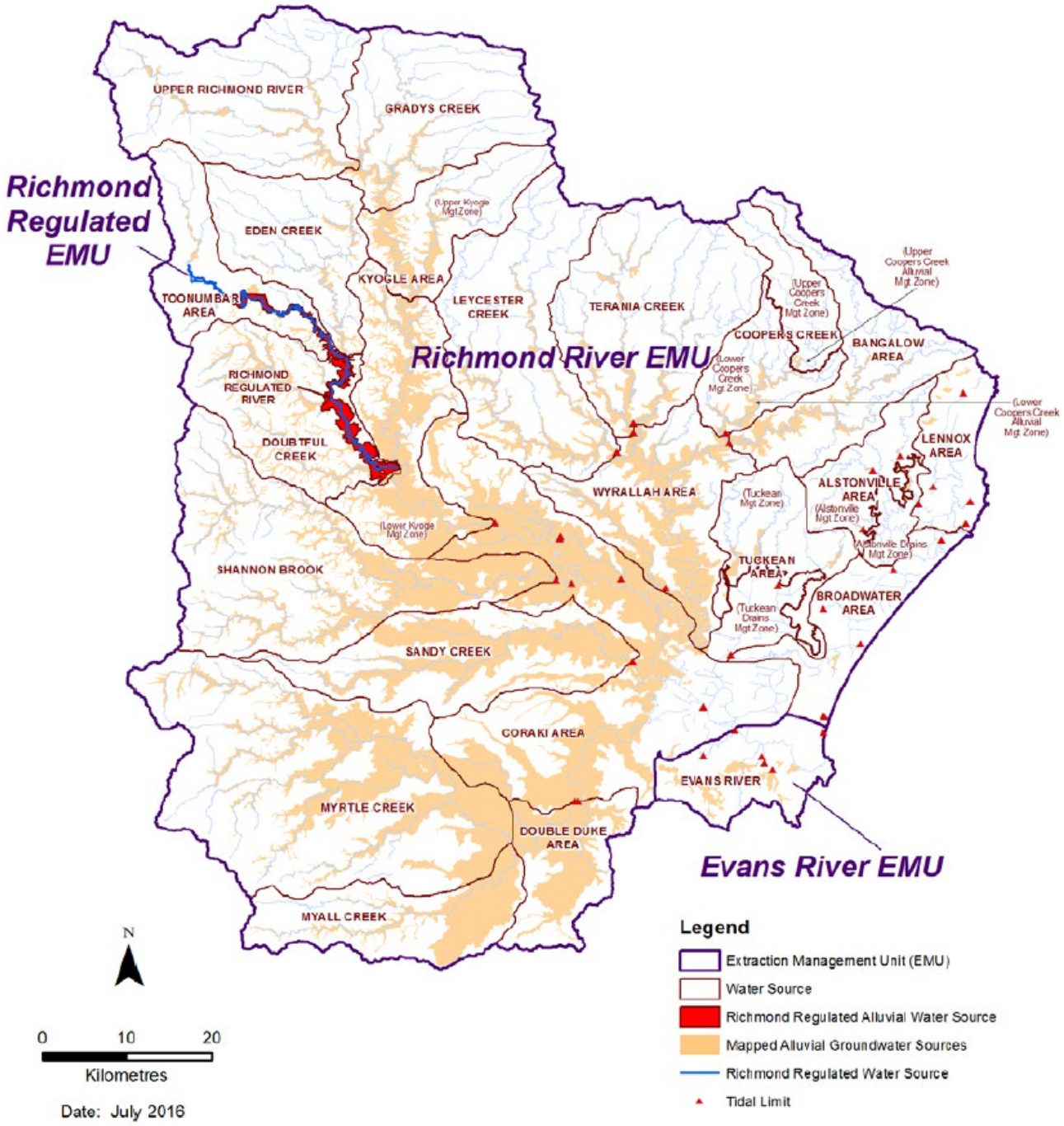

Figure 15: Water sharing plan area map - Richmond River Area Unregulated and Alluvial Water Sources

Source: DPI – Water (2016a)

The majority of licences are in the alluvium along the main trunk of the Richmond River (Kyogle Area Water Source) and on the Richmond Floodplain in the Coraki Area and Wyrallah Area Water Sources. Of the total entitlement in alluvial areas, 47% is for stock and domestic purposes, 34% for irrigation purposes and 18% for industrial purposes.

Toonumbar Dam was constructed on Iron Pot Creek in 1972 to provide a regular supply of water for irrigation and is currently operated by Water NSW. Surface water entitlement in the regulated water source is 10,330 ML, which is held between 68 licence holders. Broad scale metering indicates the current usage rates are

well below the licence entitlement (10,330 ML) with annual usage typically ranging between 1,000 and 2,000 ML/a but increasing with droughts. The primary use of this water is for pasture irrigation. The regulated system experiences considerable losses to groundwater which are in the order of 4,000 – 5,000 ML/a accounting for around 40% of dam capacity.

Water held in cane drains can be used to establish new crops under basic landholder rights (without a licence provided certain conditions are met) although this represents a small proportion of water extraction (approximately 100 ML/a).

Town water supplies include large storages (Rocky Creek Dam, Emigrant Creek Dam), surface water extraction (Wilsons River source extraction from the Richmond River tidal pool), smaller storages (Jabour Weir, Mulgum Creek Weir, DE Williams Dam, Marom Creek Weir, Kyogle Weir and off-stream storage, and Laverty's Gap Weir) and groundwater (Alstonville Plateau and Woodburn). Local water utility licences account for approximately 22% of all water licence share components. In some water sources competition for water during low flows can become an issue between agricultural users and the local water utility. In these cases, water utilities can access very low flows, when other users are suspended. Securing water for towns across the region is a challenge during extended droughts. Poor water quality also impacts on the councils' ability to provide safe drinking water with incidents of toxic cyanobacteria blooms (blue green algae) recurring in some raw water supplies (e.g. Jabour Weir at Casino). Town water supply demand is forecast to exceed secure yield in the Richmond catchment within the next two to five years. The local water utilities are investigating options for securing additional water supplies within the Richmond River catchment. RCC has developed the Future Water Project 2060 primarily based on increased use of groundwater for the regional water supply and BySC is currently investigating options for future water security for Mullumbimby.

Farm dams are constructed to provide storage for individual use, with water either pumped from a surface or groundwater source (licensed dam) or harvested from rainfall runoff (harvestable rights dam). Farm dams require licensing under the *Water Management Act 2000* unless they are defined as a basic right (harvestable right). Harvestable rights dams allow landholders to collect 10% of the average annual runoff from their properties and store it in one or more farm dams up to a certain size. A review of harvestable rights in coastal draining catchments is being undertaken by DPIE – Water to explore the potential benefits and impacts of increasing the harvestable rights percentage, as well as allowing harvestable rights dams on third order streams.

Australian and NSW Native Title and land rights laws, national and state-based water plans recognise First Nations people's right to self-determination and the right to access traditionally owned lands and water. Cultural water access licences (up to 10 ML/a) for drinking, food preparation, washing and watering domestic gardens, as well as for cultural uses (manufacturing traditional artefacts, hunting, fishing, gathering, recreation and ceremonial purposes).

The southern and southwestern part of the Plan area contains considerably fewer licences due to the lower rainfalls and the physical nature of the area. Detailed water use is not available in the unregulated rivers and alluvial aquifers because there is not yet broad scale metering in these water sources.

8.7 Environmental Flows

Environmental flows describe the quantity, timing and quality of water required to sustain freshwater ecosystems. An environmental flow is not just a volume of water that is reserved for the environment, but also the flow regime required to protect and to support natural processes. A combination of different environmental flow components is necessary because each type of flow achieves different purposes at different times. Figure 16 illustrates the important ecological functions of different flow types from cease to flow conditions to flood flows. In the Richmond River catchment, flows are typically naturally low during late winter, spring and early summer and are much higher during late summer, autumn and early winter. Richmond River waterways also naturally experience periods of very low or no flow and at other times there are floods.

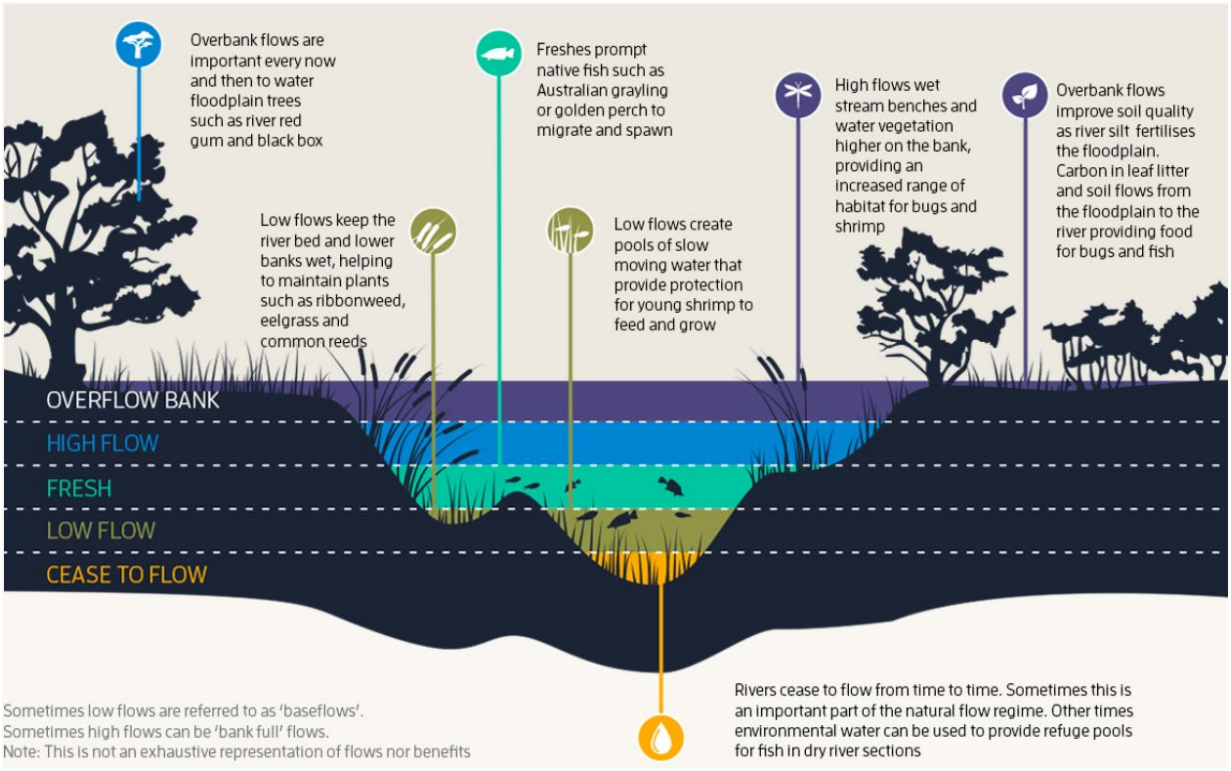

Figure 16: The importance of different flow types

Source: VEWH (2019)

Human-induced changes to hydrology also alters the natural patterns of flow (e.g. through water extraction, physical structures such as dams and weirs and waterway modifications) which affects the local aquatic ecosystems that are adapted to natural flow conditions. Changes to the timing and magnitude of flow events can also remove or alter flow-dependant cues for fish migration affecting species moving between marine, estuarine and freshwater ecosystems (Freshwater Fisheries Advisory Committee, 1996).

Increased sedimentation is often a consequence of low or reduced flow in regulated rivers. Because slower velocities enable more sediment to settle out of suspension, sediment can accumulate and remain in the stream for longer time periods in the absence of high or flushing flows (Wood & Petts, 1999). This can affect water quality and degrade habitats with a variety of impacts on ecosystems including smothering benthic habitats and species and reducing the breeding habitat for key species such as Eastern Freshwater Cod (Section 7.2) which require clean hard surfaces on which to deposit strongly adhesive eggs (DPI Fisheries, 2012).

9. LAND USE

The dominant land use within the study area is grazing, comprising approximately 44% of the catchment (Figure 17 and Table 5) occurring mostly on the dryland floodplains of the mid to upper north and west parts of the catchment. Parks and reserves, comprising 29% of the area and forestry plantations (12%) are found in the upper ranges of the north and south of the catchment. Cropping activities comprise 4% of the study area and dominate the floodplains of the lower catchment and also some areas of the mid catchment. Sugarcane is the predominant crop cultivated on the floodplain in the lower catchment. Horticultural activities comprise approximately 2% of the catchment and include macadamia, avocado, stone fruit, coffee plantations and other mixed horticultural such as vegetables and herbs. Table 5 also provides a breakdown of the land uses on land <1 mAHD (refer Figure 3). Rivers and drainage occupy over half (52%) of this land. Dominant land uses are cropping (primarily sugarcane/soybean) occupying approximately 19%, grazing makes up 15%, followed by parks and reserves comprising 12% of low-lying land. Horticulture occupies approximately 1.4% of low-lying land and this has expanded in recent years with an increase in Macadamia farming on the floodplain.

Table 5: Land use within the study area

	Study area		Low-lying floodplain land (< 1 mAHD)	
Land use	**Area (ha)**	**Area (% of total)**	**Area (ha)**	**Area (% of total)**
Grazing	300,900	43.9%	1,868	15%
Parks and reserves	201,000	29.3%	1,525	12%
Forestry	83,400	12.2%	1	0.01%
Cropping	29,600	4.3%	2,473	19%
River and drainage	23,200	3.4%	6,630	52%
Non-urban residential	18,200	2.7%	18	0.1%
Horticulture	16,800	2.4%	178	1.4%
Infrastructure	8,700	1.3%	61	0.5%
Urban residential	3,400	0.5%	2	0.01%
Quarrying and mining	500	0.1%	0.1	0.001%
Animal production	400	0.1%	-	-
Total	*686,100*	*100%*	*12,756*	*100%*

Source: DPIE (2020)

Permitted land uses within the study area are detailed in the council Local Environmental Plans which are supported by a number of Development Control Plans to provide more detail in relation to controls for specific types and forms of development throughout each LGA (Appendix 2). The major land zonings/land uses in close proximity to the estuary are primarily rural zoned lands, which are used for cropping, grasslands and for grazing cattle (Hydrosphere Consulting, 2011b). WBM (2006) identified examples of poor urban development which have resulted in the loss of significant habitat areas and due to their proximity to

the estuary are likely to be contributing pollutants to the waterways. Other key land uses in the study area in close proximity to the estuary include urban residential living. Although agricultural/urban land uses in the study area are known to be impacting on water quality within the estuary, the land use planning of local Council's currently supports these land uses.

Due to its high rainfall, high rainfall intensities, steep topography and soil types, the Richmond River catchment has a high risk of soil erosion (Alt *et al.*, 2009) as discussed in Section 6.1. Some of the horticulture, grazing and other agricultural land use areas shown in Figure 17 coincide with these highly erodible areas (shown in Figure 5) presenting a high level of erosion risk. Land disturbance during construction activities (land clearing and earthworks) also presents a high level of erosion risk and pollution of waterways.

Figure 17: Land use within study area

Source: Mapping data provided by DPIE (2020)

10. CATCHMENT HEALTH

The key ecosystem health challenges facing the Richmond River estuary are linked to its physical characteristics including the large catchment area (6,860 km^2), large floodplain (> 1,000 km^2) and small water surface (23 km^2) relative to the catchment area, coupled with areas of erosive and acid sulfate soils and the significant catchment modifications that have occurred since European settlement. With this substantial catchment area and land use modifications, the management of the Richmond River catchment has a significant impact on the health of the estuary and coastal zone.

10.1 Richmond River Ecohealth Project 2014

The *Richmond River Ecohealth Project 2014* was the first comprehensive catchment-wide assessment of waterway health in the Richmond River. The project was conducted over a 12-month period in 2014 covering 48 sites (23 freshwater and 25 estuarine sites) providing a snapshot of ecosystem health across the catchment (excluding the Evans River). The project assessed the health of waterways using standardised indicators including hydrology, water quality, riparian vegetation and habitat quality, geomorphic condition and macroinvertebrate assemblages. A report card was generated for the project (with primary ratings ranging from a high of 'A', through intermediate ratings of 'B', 'C' and 'D', to the lowest possible score of an 'F' with secondary grades of + and - included to provide greater resolution within a grade and show improvements over time) and was summarised by Ryder *et al.* (2015) as follows:

"The overall grade for the Richmond catchment was D-, ranging from an F in the Wilsons River and upper Richmond estuary to a C in the headwater streams of the catchment. Twelve of the 17 river systems recorded a score of D or less. The upper freshwater reaches of the Richmond catchment had better water quality, aquatic macroinvertebrates and geomorphic condition than the lower freshwater reaches, but no better riparian condition. The upper estuary (upstream of Woodburn) was consistently in the poorest condition, with very high nutrient concentrations, turbidity and algal biomass. Scores were consistent among indicators within each system, highlighting that the issues with water quality, biota and physical condition are affecting short and long-term condition of the streams."

Figure 18 shows the sub catchment grades for the Richmond River catchment.

Ryder *et al.* (2015) highlighted management priorities based on the findings of the study including:

- A need for significant investment in reducing diffuse sources of fine sediments and associated nutrients. Priorities are:
    - Improve riparian and bank condition throughout the catchment. Active restoration of riparian vegetation and reducing bank erosion as long-term actions are required for improvement across all indicators. This requires a holistic approach to remove stressors (e.g. invasive weeds, stock access to banks, clearing etc.) and undertake assisted regeneration and/or revegetation of riparian zones.
    - Reduce stock access to the steep and fine-grained banks in the upper reaches and revegetating those riparian zones to increase their buffering capacity for terrestrially derived nutrients.

- The poorest water quality was recorded from the sites closest to the tidal limit, highlighting these locations as depositional environments for both freshwater and estuarine contaminants, generally poor tidal flushing and the importance of this zone as a focal point for future monitoring programs.

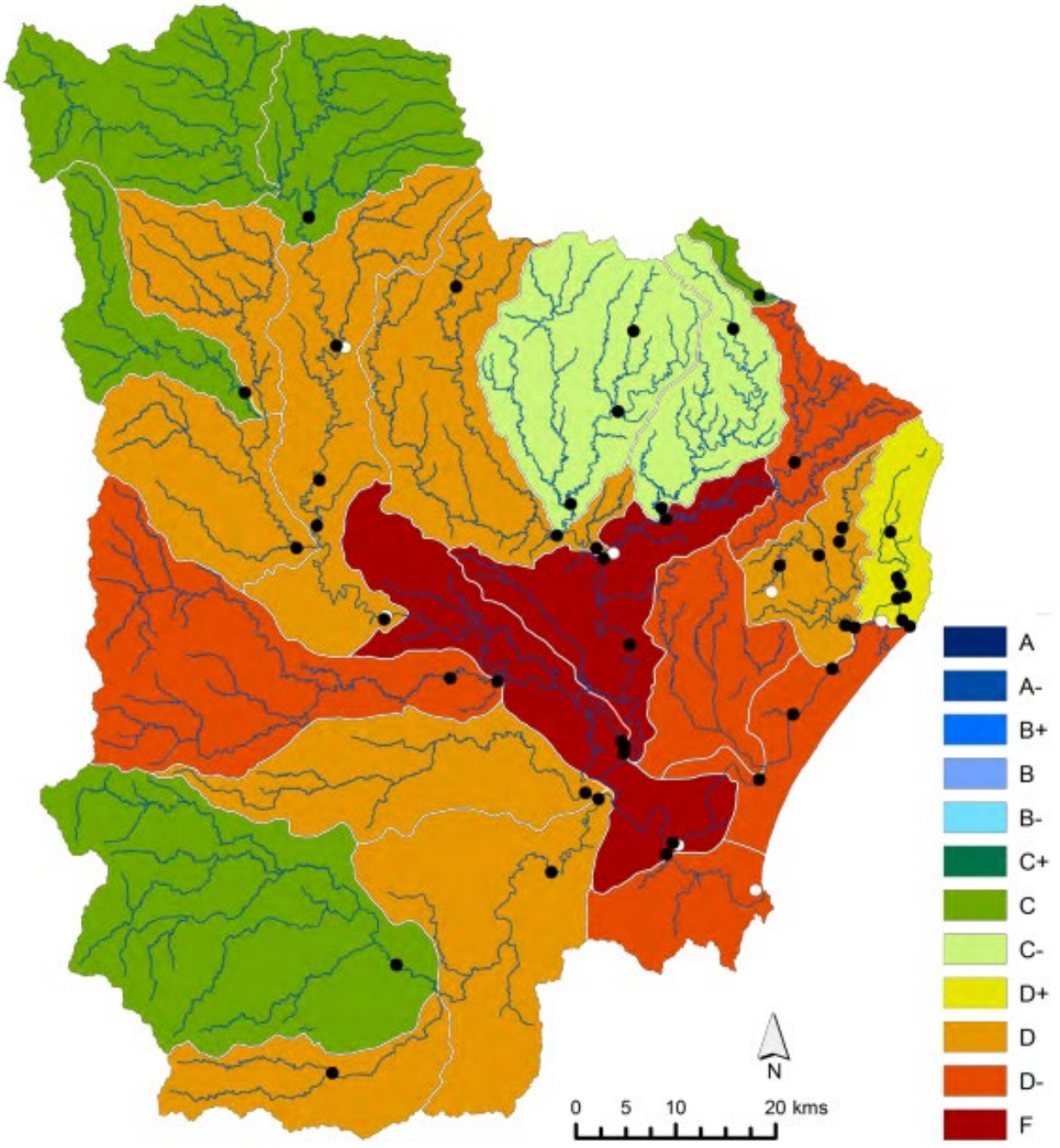

Figure 18: Overall Ecohealth grades for sub-catchments in the Richmond

Source: Ryder *et al*. (2015)

The Ecohealth snapshot provides baseline data collected as part of a standardised assessment tool. It is noted that the 2014 study was undertaken during a lower-than-average rainfall period. Repeat survey following the standardised approach and adequately controlled for seasonal and climatic variables would allow for tracking of the health status of the Richmond River. Ryder *et al.* (2015) stresses the importance of sampling within defined hydrologic periods to remove the influence of flow extremes on sample results. It

was recommended that future sampling be collected during similar flow conditions as the 2014 study and this could be achieved by replicated temporal periods (seasons) within a four-year reporting period (e.g. one sample/season, four seasons/year, for three years = 12 sample events). If desired, a separate program assessing high flow events could be undertaken.

10.2 Water Quality

Water quality is one of the most important estuarine health indicators and clean waterways are highly valued by the community. Many of the key economic industries in the local area rely on good water quality including tourism, aquaculture (oyster production), agriculture and commercial fishing. The sources of water quality degradation are wide and varied but can broadly be categorised into:

- Diffuse sources (pollutant inputs from varied sources over a large area).
- Point sources (defined locations of pollutant input to waterways).

10.2.1 Diffuse source pollution

Poor water quality specifically originating from diffuse sources has been identified as one of the highest priority threats to the environmental assets within NSW estuaries (MEMA TARA, BMT WBM, 2017). Major sources of poor estuarine water quality result from diffuse sediment and nutrient runoff from catchments, ASS discharge and low oxygen 'blackwater' runoff from coastal floodplains. Excess nutrients in waterways, known as eutrophication, can lead to an increase in primary productivity (excessive plant and algal growth) that degrades water quality including the depletion of dissolved oxygen levels and increasing the risk of potentially toxic blooms of cyanobacteria (i.e. blue green algae).

With the exception of a small number of scattered remnants throughout the catchment and larger tracts of conservation areas in the upper catchment, the majority of the catchment has been extensively cleared of native vegetation. Approximately 50% of land in the catchment is currently used for some form of agriculture. Agricultural land was identified by WBM (2006) as one of the major causes of poor water quality in the catchment contributing to a broad range of issues in the estuary including the contribution of significant sediment, chemical and nutrient loads to the estuary during runoff (rain) events. Agricultural fertilisers are reported as a major source of nutrients (WBM, 2006). Transportation of nutrients to waterways during rainfall events dominate the annual nutrient budget for the estuary (ABER, 2007). Unrestricted stock access to waterways creates issues of bank instability and erosion through trampling, damage to riparian vegetation, weed encroachment and direct input of nutrients and pathogenic contaminants from direct contact. Contaminant inputs and increased turbidity have flow-on effects to estuarine ecosystems and productivity in the immediate vicinity and downstream in the estuary (WBM, 2006).

The *NSW Diffuse Source Water Pollution Strategy* (DECC, 2009) identified sediments, nutrients and pathogens as the priority diffuse source water pollutants across NSW. These pollutants can arise from a multitude of sources and the strategy aims to focus management on the sources of these pollutants that are not already regulated. Examples of target areas are some agricultural practices, unsealed roads, urban stormwater and specific urban activities. Sources that are already formally regulated, including sewerage systems, public forestry operations, waste services, intensive farming and some agricultural practices (for example pesticide use) are not covered. The strategy is currently under review as part of the Marine Estate Management Strategy (MEMS) including review of the current governance arrangements and approaches to

managing diffuse source water pollution (Section 25). While not yet available, it is anticipated that this work will initiate a process to improve the management of diffuse source water pollution in NSW (MEMA, 2020b).

Plate 5: Cattle grazing the banks and algal bloom (green water) in the Richmond River near Casino

Source: Hydrosphere Consulting (2011b)

Urbanisation has affected estuarine processes through:

- Changes to the hydrologic characteristics (catchment hardening) of lands making them drain more quickly, partly due to the increased imperviousness of road, roofs, etc.
- The use of hydraulically efficient stormwater pipe systems which remove stormwater to the waterway more quickly.
- Changing the quality of stormwater runoff due to the influence of fertilisers, cars, lawnmowers, domestic animals etc.

Stormwater from urban areas can often discharge significant loads of pollutants to receiving water bodies. These pollutants include litter, nutrients, sediment, oxygen-depleting substances and hydrocarbons, which are transported from the site by urban runoff or stormwater (Hydrosphere Consulting, 2011b). A large proportion of people within the study area resides in, works or engages in recreation within urban centres. Any water quality impacts due to urban stormwater or practices within the urban environment that may contribute to poor urban stormwater quality would subsequently be more likely to be observed by people within these urban areas relative to those occurring in rural areas not frequented by the public (eg. acidic runoff discharge from drainage channels). The importance of managing urban stormwater will also become increasingly important as the extent of urban development increases to accommodate the increase in populations within the study area (Hydrosphere Consulting, 2011b).

NSW Estuary Health Risk Dataset – modelling nutrient and sediment export

DPIE - Environment, Energy and Science (DPIE – EES) developed an estuary health risk dataset for each estuarine catchment in NSW (Dela-Cruz, *et al.*, 2019) to support development of CMP Scoping Studies under the NSW Risk-based Framework. The dataset identifies land use pressures and the consequent risks of impacts based on sub-catchment scaled attributes such as land use, soil type and climate and provides

modelled estimates of surface flows and the nutrient and total suspended solids loads. The intent of the dataset is to help identify strategic priorities for managing nutrient and sediment runoff throughout a catchment so that estuary health is protected, maintained and/or improved. The overall risk score for each sub-catchment provides a relative rank for use in prioritisations. It is important to note that the dataset only models broad risk to estuarine health from catchment export of nutrients and sediment. When used as part of CMP Scoping Studies, the dataset can be used to help map where further studies and/or management actions in a catchment would contribute to achieving some of the management objectives relating to nutrient and sediment load reduction. Risks from other pressures such as ASS, blackwater events, bank erosion, pesticides, point source pollution and other catchment contaminants are not considered in the risk assessment.

The current Richmond River dataset is based on 2008 climate and land use data and DPIE-EES has indicated it plans to update the model with more recent data, however this was not yet available at the time of this review (pers. comm. J. Dela-Cruz, 2021). The Evans Head catchment is not included within the Richmond River model but has been modelled separately therefore it is not possible to compare the relative risk of this catchment to the Richmond River catchment. The current estuary health risk results are mapped for the catchment on Figure 19. The results for the Richmond River catchment are broadly summarised as follows:

- Very high risk (equating to a score of 16 out of 16) was assigned to several catchments in the upper Wilsons River catchment upstream of Lismore, the upper Richmond River catchment upstream of Kyogle, the lower Wilsons River below Lismore and the mid Richmond River downstream of Casino. This indicates that runoff from these sub-catchments poses the greatest risk to the ecological health of the Richmond River estuary. Use of the risk-based framework would require more detailed investigations on the causes of these risks (i.e. as part of Stage 2 of developing the Richmond River CMP).
- High risk (scores of 9 - 12) were assigned to approximately half of the catchment incorporating the majority of the Richmond River main stem, and upper, mid and lower catchment areas.
- Moderate risk (scores 6 - 8) were assigned to large areas of the Eden and Iron Pot Creeks, Shannon Brook hydrological unit as well as small sub-catchments in the upper mid and lower estuaries.
- Low risk (scores 3 - 4) were assigned to the majority of Bungawalbin, Myrtle and Sandy Creeks hydrological unit and the Richmond River floodplain.
- Minimal risk (scores 1 - 2) were assigned to two small sub-catchments on the floodplain downstream of Coraki and the lower Tuckean Swamp area.

The results for the Evans River catchment (Figure 19 inset) are broadly summarised as follows:

- Very high risk (equating to a score of 16 out of 16) was assigned to several sub-catchments throughout the catchment.
- High risk (scores of 9 - 12) were assigned to the majority of the catchment incorporating upper, mid and lower catchment areas.
- Moderate risk (scores 6 - 8) were assigned to areas on lower slopes.

- Low risk (scores 3 - 4) and minimal risk (scores 1 - 2) were assigned to areas in proximity to the river, on low slopes.

There are some differences between the modelled risk provided in the estuary health risk dataset results and the Richmond River Ecohealth Project (Ryder *et al*., 2015) results. These differences are partly explained by the fact that the estuary health risk dataset does not include consideration of some of the major sources of water quality decline in floodplain areas (ASS, blackwater etc.) and is therefore only an indication of the risk due to sediment and nutrient runoff, not overall ecosystem health risks.

The Risk-based Framework has recently been used as part of a MEMS Stage 1 pilot project in the Richmond River catchment to identify priority areas for bank stabilisation, riparian restoration and road sealing by LLS. The aim of the pilot project was to develop a modelling methodology to support, and provide an evidence base for, spatial prioritisation of natural resource management investments (Barrett, 2018). Key findings of this work included:

- The two biggest land-based contributors to total nitrogen, phosphorus and suspended solids loads in the waterways are perennial horticulture and grazing.
- Macadamia plantations make up the largest proportion of perennial horticulture and don't cover a very large area of the catchment but this land use has very high predicted export rates and often occur in areas with high rainfall and surface runoff.
- Grazing land use does not have high export rates but generates large loads due to the extensive area it covers.

The key project output was a high-resolution catchment model to assess the risk of impact of nutrients and sediment on the marine estate (Figure 20). The higher resolution generated through this process has more clearly defined priority areas for targeted works (i.e. riparian restoration, bank stabilisation and road sealing). The Emigrant Creek catchment was identified as the priority catchment and LLS have been implementing on-ground works to improve waterway health as part of the MEMS in collaboration with landholders (refer Section 25). LLS advised that their modelling approach was very specific to the type of work they were targeting to mitigate impacts on the marine estate and it would not be suitable to simply rely on the Barrett (2018) report and mapping output for the purposes of the CMP (pers. comm. S. Morris., 2021). However, a similar approach to refining the Risk-based Framework modified to consider CMP aims and objectives, would assist in targeting on-ground works for implementation in the CMP.

The Richmond River catchment has also been chosen as a pilot study for the application of the Risk-based Framework in a rural catchment as part of the MEMS Stage 1 which aims to further refine the Richmond River estuary health dataset by incorporating further water quality data from the system and potentially an assessment of ASS and blackwater risk. This is discussed further in Section 10.9.

Figure 19: Richmond River estuary health risk assessment results

Source: Dela-Cruz *et al.* (2019)

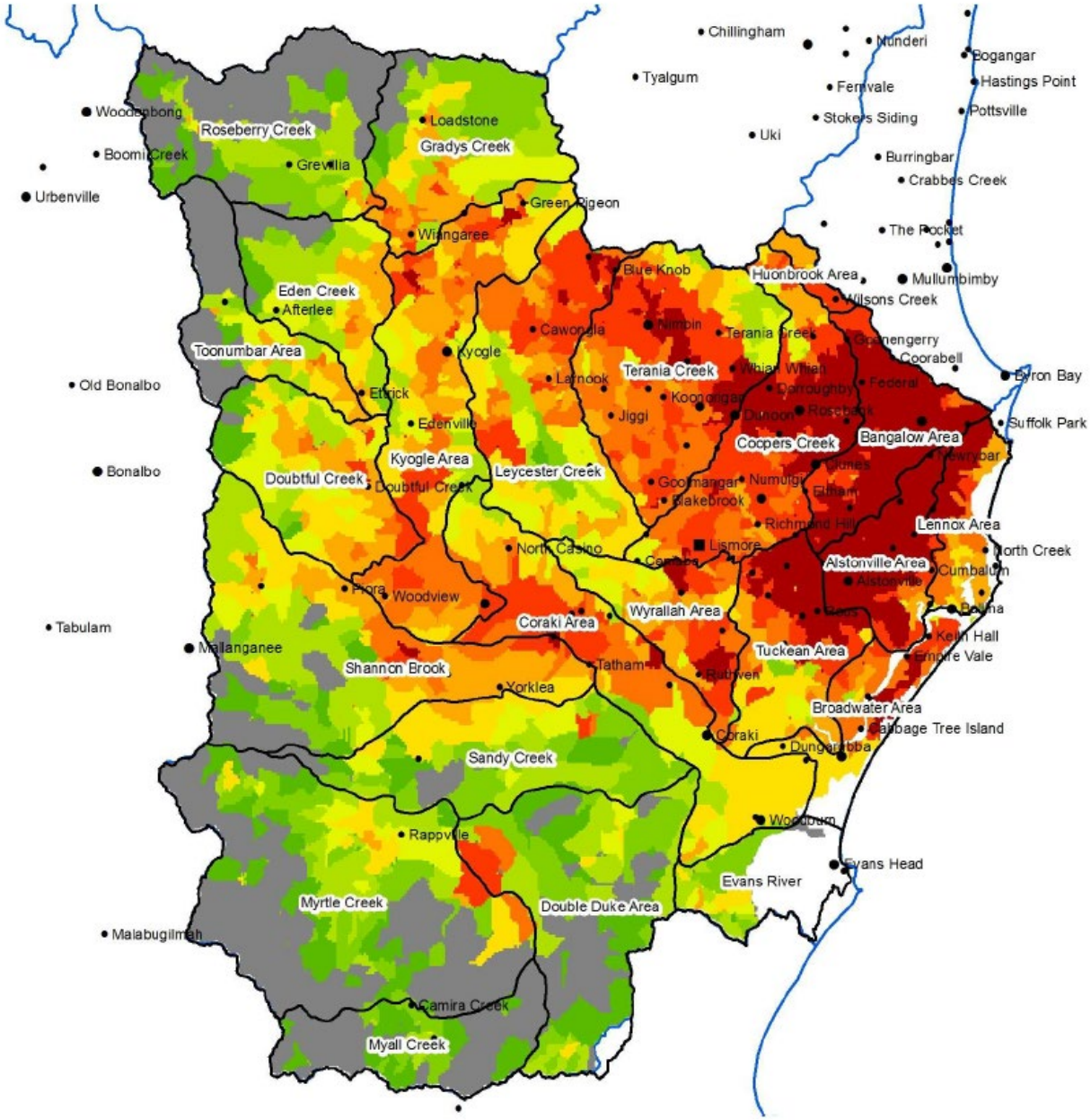

Figure 20: MCAS-S map showing export loads (total suspended solids, total nitrogen, total phosphorous) in the Richmond River catchment

Source: MEMA (2021e), legend/colour scale was not available.

Acid sulfate runoff

ASS are naturally occurring on the Richmond River Floodplain, and when left undisturbed and not exposed to oxygen, the level of acid discharge is minimal. However, disturbance of ASS through floodplain modifications including drainage of low lying backswamp areas has led to widespread oxidation of ASS and generation of high levels of acid runoff which under certain hydrologic conditions is exported to the estuary. Floodplain modifications and associated environmental impacts are discussed further in Section 8.4. Acid discharges along with blackwater events from the Richmond River floodplain have been identified as the key causative factors for fish kill events such as major fish kills occurring in 2001, 2008 and to a lesser extent in

2020 (WBM, 2006; ABER, 2007; Wong *et al.,* 2010a; Hydrosphere Consulting, 2011a; DPI Fisheries, 2021a).

Monosulfidic black ooze (MBO) accumulates in ASS environments and typically occurs at the base of drains. When disturbed and transported during flow events, MBOs have the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways. MBOs are known to occur in the Richmond River estuary and have also been identified as a factor in fish kills (ABER, 2007). The Tuckean Swamp has one of the highest recorded concentrations of MBOs in the world (Bush *et al.,* 2003). A state-wide study of ASS in 1999 (Tulau, 1999) identified five priority areas within the Richmond River to focus management of ASS (Tuckean Swamp, Rocky Mouth Creek, Sandy Creek – Bungawalbin Creek, Maguires Creek - Emigrant Creek, and Newrybar - North Creek).

A recent study across seven NSW coastal floodplains assesses the risk of poor water quality associated with ASS discharge and blackwater runoff. The draft *Richmond River Floodplain Prioritisation Study* (Harrison *et al.,* 2020) and subsequent mapping updates (Harrison, 2021) identifies priority locations across the Richmond River floodplain where the greatest improvements in water quality can be achieved through strategic management actions that reduce the impacts of ASS and blackwater runoff. In terms of ASS risk, the study ranked the five highest priority sub-catchments for acid drainage as Tuckean Swamp (1), Rocky Mouth Creek (2), Bungawalbin Creek/Sandy Creek (3), North Creek (4) and Emigrant Creek/Maguires Creek (5). Figure 21 shows the location of rankings. These sub-catchments were estimated to contribute over 90% of the total acid risk to the estuary. Prioritisation of sub-catchments according to blackwater risk are discussed separately below.

The ranking in the latest study is similar to the results of the Tulau (1999) prioritisation. The similar results from 1999 and 2020 confirm the risk areas and indicate that there has not been any appreciable change over the last 20 years in the underlying factors that pre-dispose these areas to generate acid discharge (e.g. drain depth, floodgate management etc.).

The management options recommended by Harrison *et al.* (2020) are high-level actions designed to guide the overall strategy to be considered by floodplain managers when addressing sources of poor diffuse water quality. The study identified three priority sub-catchments for management action as the Tuckean Swamp, Rocky Mouth Creek and Bungawalbin Creek/Sandy Creek. Harrison *et al*. (2020) concluded that large-scale remediation of the Tuckean Swamp sub-catchment would achieve the most significant improvements in estuarine health compared to any other single sub-catchment on the Richmond River floodplain. The options include actions to address both ASS and blackwater issues for each sub-catchment.

The recommended options comprise:

- Short term options with minimal impacts to existing land uses including:
    - Improved tidal flushing to provide additional acid buffering capacity and increase aquatic connectivity. However, Harrison *et al*., (2020) acknowledges that this is primarily a dry weather strategy and benefits to water quality during wet periods would be limited.
    - Reducing floodplain drainage density.
    - Reshaping drains to reduce interaction with ASS and groundwater drawdown.
    - Use of drop board weir structures, combined with wet pasture management to minimise acidification of soils and promote the growth of water tolerant vegetation.

- Long-term options requiring substantial changes to land management to create effective improvements in water quality outcomes. The greatest improvements can be achieved through large scale transition to coastal wetlands which would involve the following on-ground works:
    - Drain reshaping, drain infilling, removal of floodgates and restoration of natural flow paths.
    - Freshwater retention and restoration of freshwater wetlands to encourage water tolerant vegetation, minimise groundwater drawdown and reduce acid mobilisation.
    - Tidal restoration to greatly increase the natural buffering capacity, reduce acid discharges and encourage estuarine wetland growth.

Harrison *et al*., (2020) recommend that further detailed on-ground investigations are completed prior to the implementation of actions. The study also highlights the fact that targeted landholder consultation was not undertaken as part of the study and would be required as part of detailed on-ground investigations.

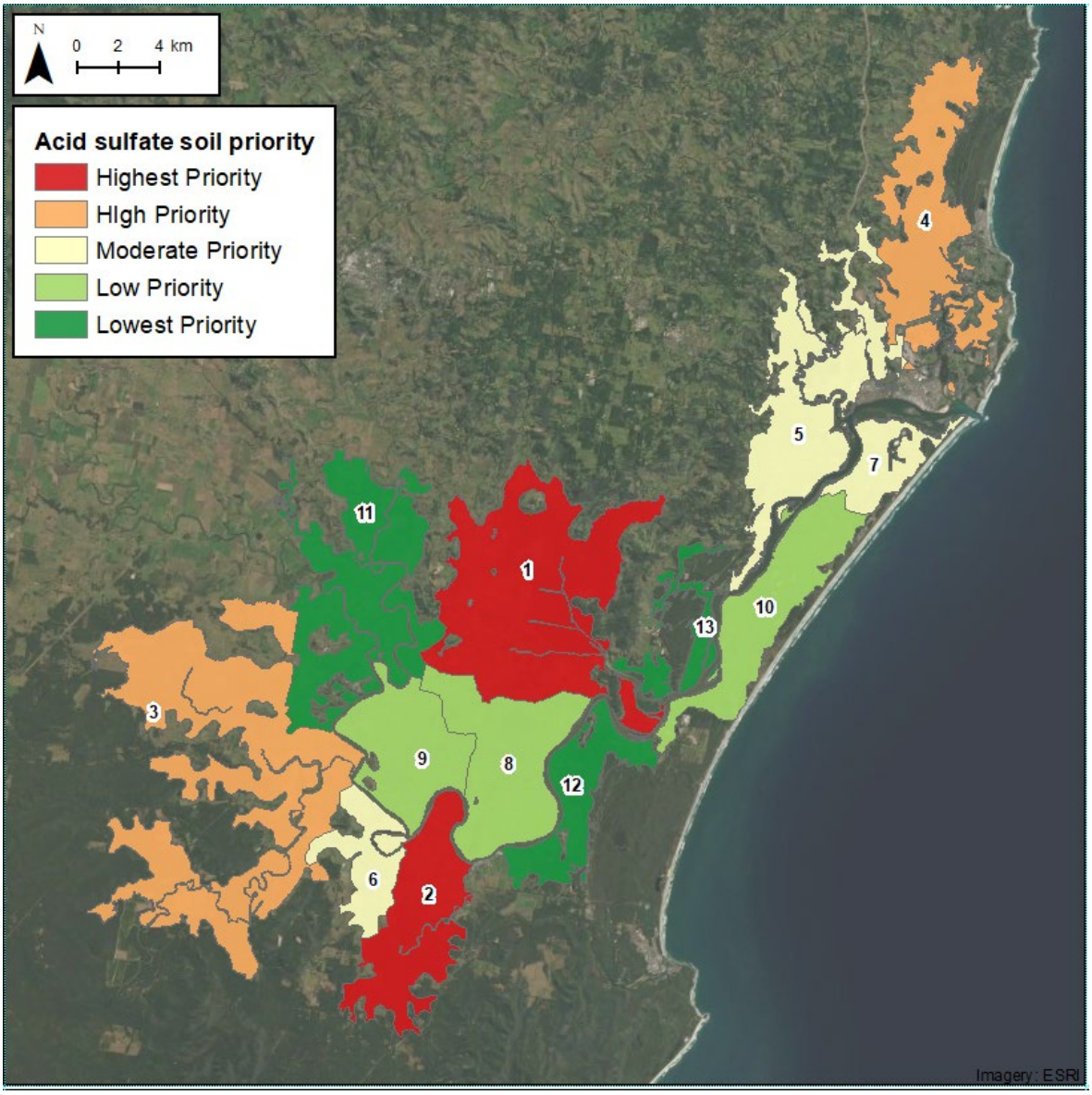

Figure 21: Richmond River floodplain sub-catchment ASS prioritisation

Source: Harrison (2021)

The *Tuckean Swamp Hydrologic Options Study* (Rayner *et al.,* 2020a) further examined potential management options identified by Harrison *et al.* (2021) to mitigate issues associated with ASS in this high priority sub-catchment. The study aims to improve the overall understanding of the hydrology of Tuckean Swamp and floodplain through extensive field data collection and numerical modelling. The study was developed with input from the Tuckean Steering Committee, consisting of representation from OzFish, RCC, BaSC, LCC, RVC, National Parks and Wildlife Service (NPWS), DPIE, Local Land Services (LLS), Jali Local Aboriginal Land Council (LALC), Department of Primary Industries – Fisheries (DPI – Fisheries) and the Nature Conservancy. The project was co-funded by the *Saltwater Recreational Fishing Trust Flagship Fish Habitat Action Plan* and government agencies. Targeted landholder consultation has been recommended as part of the next steps to implement management actions.

Rayner *et al.* (2020a) further prioritised the Tuckean Swamp sub-catchments (Figure 22) with the highest priority areas around Meerschaum Vale and Slatteries Drains and in the lower Tuckean Nature Reserve, which are broadly consistent with the priority areas identified in a previous study (Baldwin, 1997).

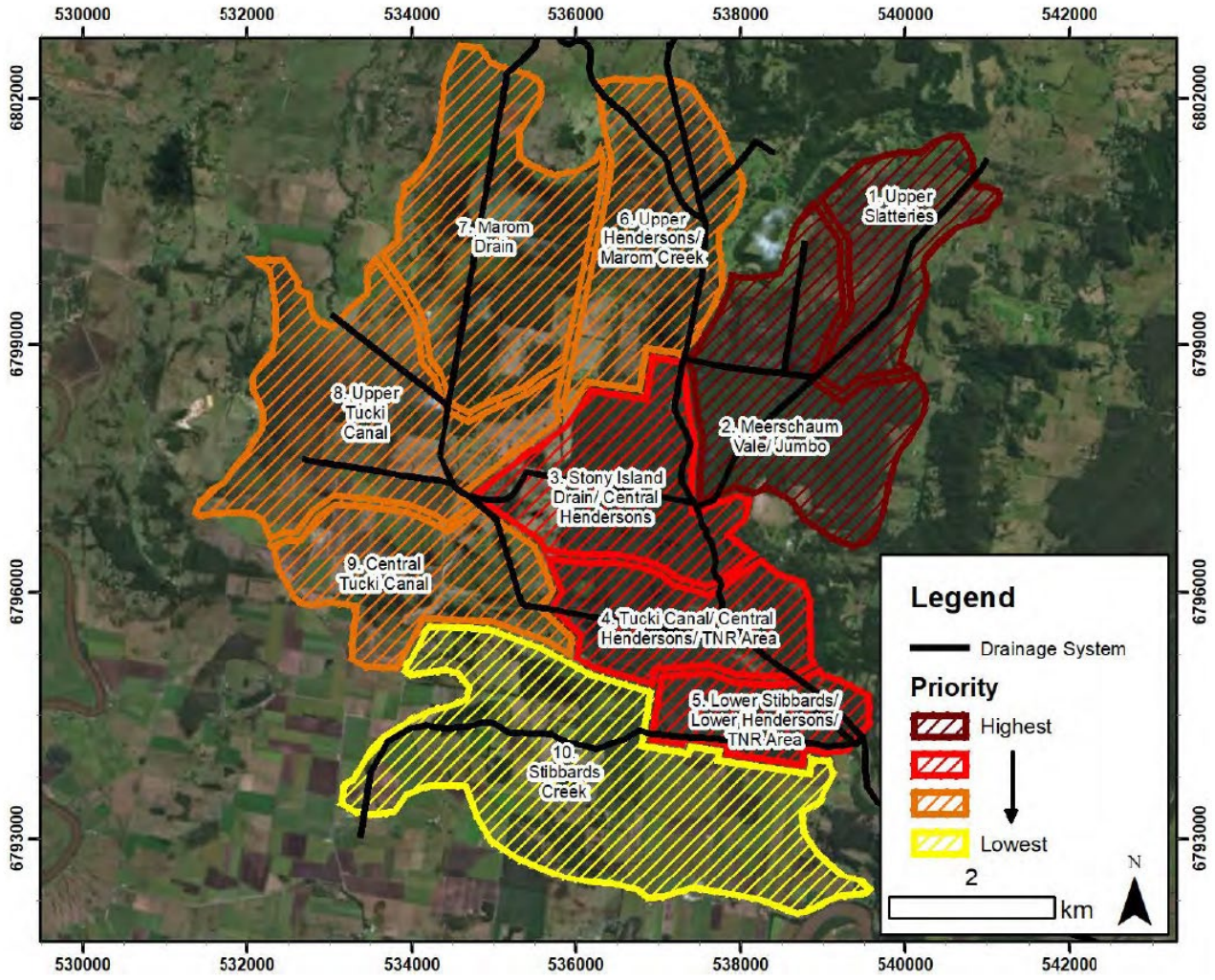

Figure 22: Prioritisation of the Tuckean Swamp floodplain

Source: Rayner *et al.* (2020a)

The study investigated six drainage management options to address ASS issues (Table 6). Modelling scenarios were developed for the six options including the rationale for each scenario and potential impacts to the floodplain and site drainage compared to the existing, present-day base case. Rayner *et al.* (2020a)

highlighted several constraints to implementation for some of the options including uncertainty around landholder consent, acquisition/ compensation for lost productivity of land, disturbance of ASS and social costs of land use changes. The study provided a relative assessment of scenario costs and benefits (actual costs were not estimated). Figure 23 presents the order of magnitude of total costs and benefits associated with each option across a range of indicators. Scenarios 1 - 3 have a lower relative cost to implement but also have a lower relative benefit assigned to them. Conversely Scenarios 4 - 6 have a higher relative cost but will achieve a high relative benefit. Scenario 4 (Opening of the Bagotville Barrage tidal floodgates) was identified as having the highest relative benefit but also the highest cost across social, environmental and economic factors.

Table 6: Summary of Tuckean Swamp model scenarios

Category	Model Description
Current	**Base Case** – the model was run to replicate the site as it operates today and provide present day conditions for comparison.
Freshwater management options *Focus on the north-eastern (Slatteries) corner of the floodplain*	**Scenario 1** – Reshaping of major drains in the north-eastern corner of the floodplain (Slatteries, Meerschaum Vale and Jumbo Drains). **Scenario 2** – Weir implementation at the downstream end of Meerschaum Vale Drain. **Scenario 5** – Reshaping of drains (as per Scenario 1) but encouraging small catchment flows onto the floodplain.
Saltwater management options *Focus on the management of the Bagotville Barrage*	**Scenario 3** – Alternative management of Bagotville Barrage sluice gates during dry periods. **Scenario 4** – Opening of the Bagotville Barrage tidal floodgates. **Scenario 6** – Opening of the Bagotville Barrage floodgates and installing new floodgate control structures upstream of the Tuckean Nature Reserve boundary on all the major drains.

Source: Rayner *et al.* (2020a)

Both the *Richmond River Floodplain Prioritisation Study* and the *Tuckean Swamp Hydrologic Options Study* propose major changes to the physical status of floodplain land in order to address the identified ASS and blackwater issues and substantially improve the health of the Richmond River estuary. These changes will have a considerable impact on the current land uses, land capability and status of floodplain vegetation communities. Rayner *et al.* (2020a) highlight that some of the management options may require the discontinuing of current land management practices on the affected properties and potential need for land acquisition or landholder compensation. A gap identified by both studies is that detailed consultation with landholders potentially affected by the proposed options has not been undertaken to date and it is unclear whether the affected landholders will provide consent for the proposed works. There is also currently no detailed costing available, no assessment of environmental impacts for the scenarios nor a strategic approach to guide potential land acquisition or compensation. Detailed consideration of specific impacts on the Tuckean Nature Reserve has also not been undertaken which would need to consider potential environmental impacts including changes to freshwater EECs (i.e. Swamp Sclerophyll Forest on Coastal Floodplains and Littoral Rainforest) as a result of proposed works. These factors currently present significant knowledge gaps and barriers to implementation of the recommended on-ground works.

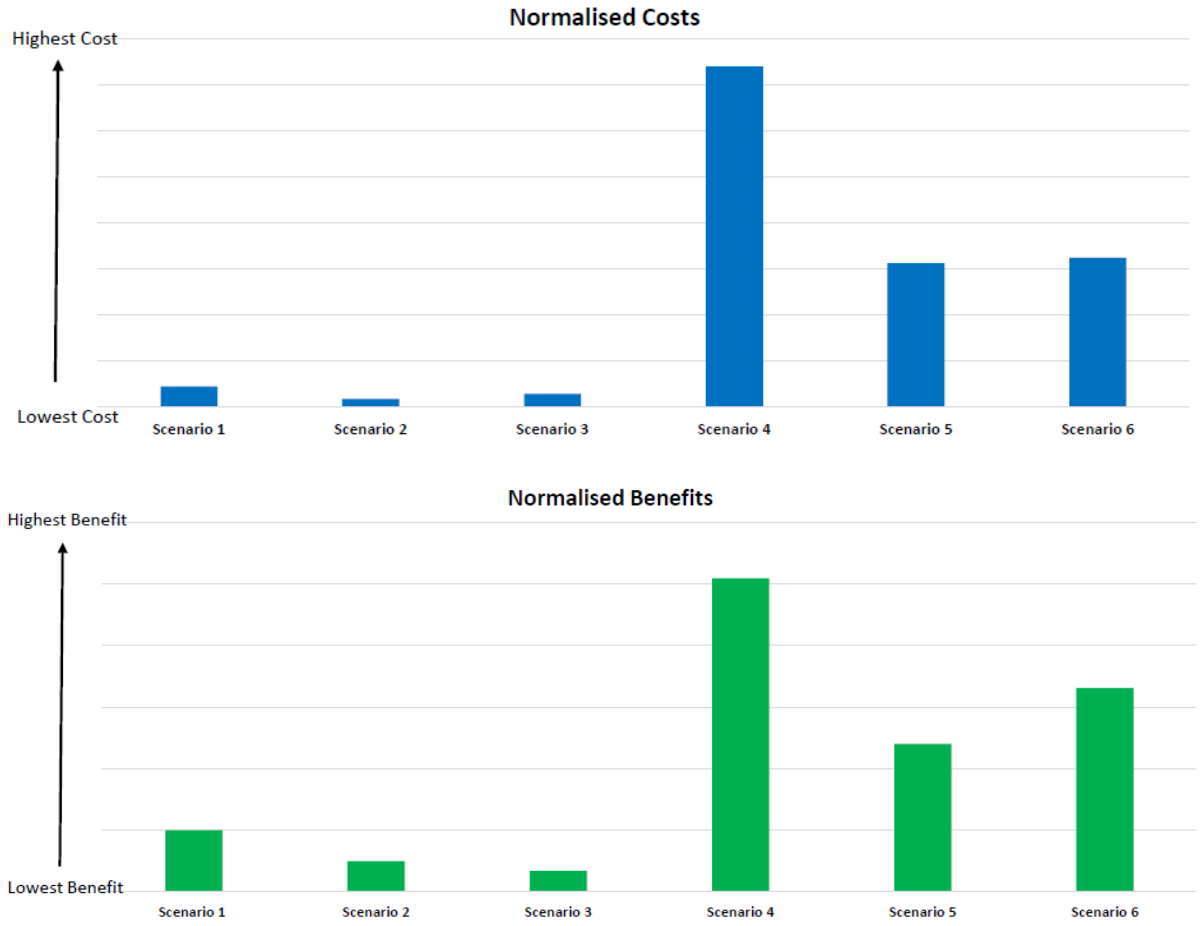

Figure 23: Normalised costs (top) and environmental benefits (bottom) of the six Tuckean management scenarios

Source: Rayner *et al.* (2020a)

To address the above gaps, the Tuckean Steering Committee has commissioned the preparation of an implementation toolkit including design and costing of infrastructure changes and ongoing maintenance costs, a comprehensive values assessment and options for landholder incentives/change for management options to restore hydrological function and water quality within the Tuckean Swamp project area (OzFish, 2021b). The implementation toolkit aims to produce information that will inform stakeholders as well as provide information that can be utilised in further consultation with landholders and the broader community as part of the decision-making framework regarding the long-term management of the Tuckean Swamp. The toolkit will provide designs and costs of each of the options outlined in the *Tuckean Swamp Hydrologic Options Study* (Rayner *et al.,* 2020a), a values assessment (environment, economic/agricultural, social and cultural values of present day compared to the values associated with each option) and stakeholder engagement (OzFish, 2021b).

Another area of current management focus for ASS management is the Keith Hall Drainage System at South Ballina. Some of this drainage network is within the CMP study area and part of the network that discharges to Mobbs Bay is outside the study area, however the project is directly relevant to management across the floodplain. RCC has prepared the *Keith Hall Drainage System Active Floodgate Management Plan 2020-2023* (Rous County Council, 2020a) which outlines an opening strategy for floodgates to allow tidal exchange into the system. RCC in collaboration with BaSC and the University of NSW is also currently undertaking the *Keith Hall Drainage Options Study* to improve understanding of the system and sources of

poor water quality to the lower Richmond River estuary. This information will be used to understand how the system could be changed to address three identified aims (Rous County Council, 2021b):

1. Reducing the impact of flooding and erosion on private land when the No.1 Flood Mitigation drain has a build-up of sediment and vegetation
2. Reducing any downstream impact on Mobbs Bay and the Richmond River from water quality leaving the Keith Hall Flood Mitigation drain.
3. Reducing maintenance of the Keith Hall Flood Mitigation drain for RCC.

Six management options have been selected for detailed investigation. The study recognises that a staged approach is required, any resulting changes will be incremental and the project success will be dependent on landowner goodwill and limited by the existing land uses.

Blackwater

RCC and BaSC have recently prepared a blackwater technical note (Clay *et al*., 2020) which provides an overview of the current scientific understanding of blackwater and results of recent research focussing on the Richmond River floodplain. Key points from this technical note are provided below:

- Blackwater is formed from the decomposition of plants and organic matter in water during prolonged inundation during floods.
- Blackwater is usually dark in colour and contains little or no oxygen.
- The organic matter in blackwater can consume large amounts of dissolved oxygen and if mixed into rivers and creeks can deoxygenate waterways and can cause fish kills as was seen in the 2001 and 2008 floods (Plate 6). Less severe blackwater events can cause fish to be more susceptible to disease, kill smaller and more sensitive animals that some fish feed on and interrupt breeding cycles.

Plate 6: Deep inundation of the Richmond River Floodplain during the 2008 flood

Source: Clay *et al*. (2020)

- Blackwater formation is part of the natural carbon cycling process however drainage of the floodplain has affected the quantity and speed of delivery of blackwater in several ways including:
    - Encouraging flood intolerant plant/pasture species to establish in low-lying areas. These species are more likely to die and decompose when inundated after flooding.

- Accelerating and prolonging the transport of blackwater to the river, particularly when flood levels recede and the river's capacity to dilute this water is reduced. The lowest lying areas, which were former backswamp wetlands, previously stored floodwaters and were inundated for long periods. Floodplain drainage now removes most of the surface water in about 4 - 28 days after the flood peak (Figure 24).

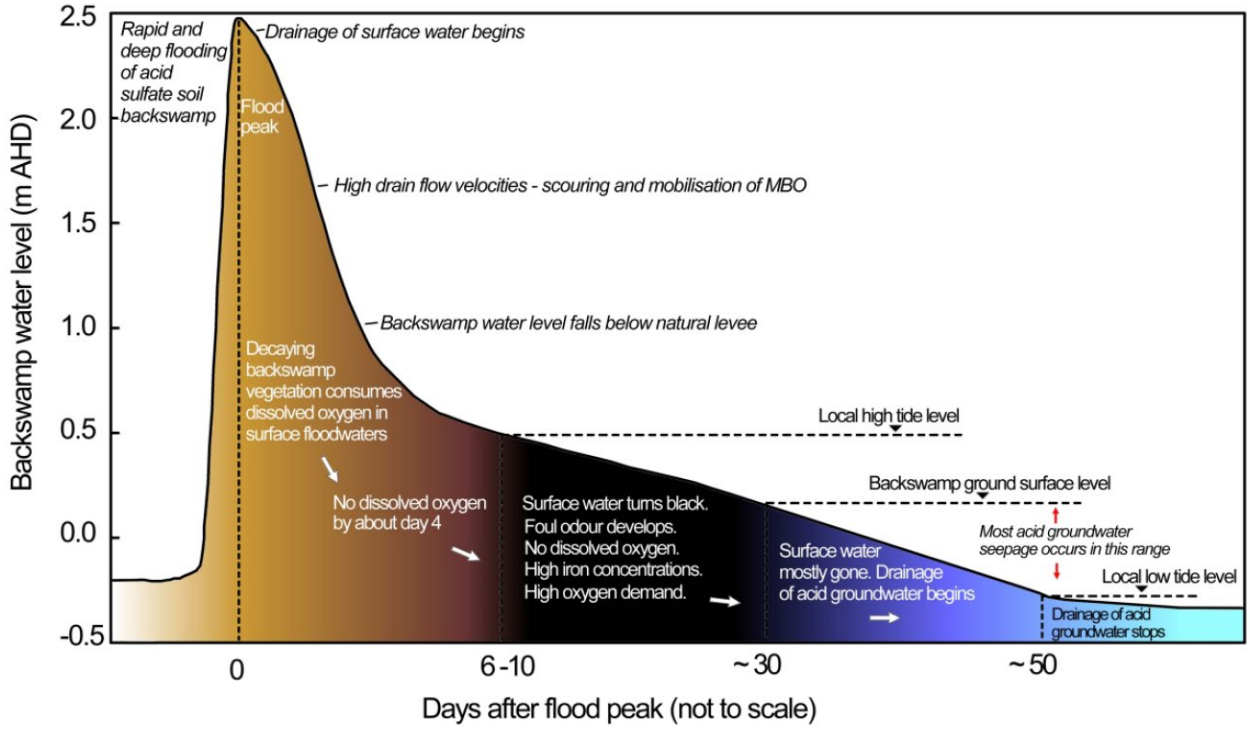

Figure 24: General water quality processes after flooding

Source: Johnston *et al.,* 2003 cited in Clay *et al*. (2020)

- As a general rule, blackwater retained on floodplains for four to eight weeks or more after inundation, will lose most of its capacity to cause deoxygenation of river waters even though it retains the black colour.
- Floodplain drainage was initially a government backed and funded initiative. It was introduced to mitigate the impacts of floods and enhance the perceived agricultural capacity of the land. Agricultural enterprises reliant on this drainage were established and have been in place for decades. In some locations, such as the Tuckean, drainage systems have been established for over 100 years.
- Blackwater formation can be minimised by reducing drainage density, particularly in low-lying areas of the floodplain. This can occur by filling in unneeded drains or reshaping drains, so they are shallower and wider. This will slow drainage rates and retain surface flood waters for longer periods in the lowest lying areas. Reducing drainage density will also encourage native wet-tolerant plant/pasture species in low-lying areas that are more tolerant of flooding. These changes would significantly affect the management and use of floodplain areas for agricultural use.
- Low lying floodplain areas associated with the Tuckean, Rocky Mouth Creek and Bungawalbin/ Sandy Creek, are vegetated by flood intolerant plants/pastures. The majority of blackwater in a major event comes from these three areas. In the first instance, these would be the priority locations

for reducing drainage density and as a result, changing the vegetation growing there. However, in a major flood, higher areas of the floodplain can also form blackwater.

An Australian Research Council project, *Episodic estuarine hypoxia: resolving the geochemistry of coastal floodplain blackwaters* (Southern Cross GeoScience, 2019), aimed to improve the understanding of blackwater events and identify the key factors that produce severe blackwater events. The project investigated common plant species including native wetland species and pasture species found in low-lying floodplain areas and analysed their potential to deoxygenate floodplain waters during flood events. Key plants that contribute to blackwater formation are flood intolerant pastures such as Paspalum, Setaria and Carpet Grass or Compressum.

In addition to ASS management prioritisation, the draft *Richmond River Floodplain Prioritisation Study* (Harrison *et al.,* 2020) and subsequent mapping updates (Harrison, 2021) identified priority locations across the Richmond River floodplain where the greatest improvements in water quality can be achieved through strategic management actions that reduce the impacts of blackwater runoff. In terms of blackwater risk the study ranked the five highest priority sub-catchments as Bungawalbin Creek/Sandy Creek (1), Rocky Mouth Creek (2), Tuckean Swamp (3), East Coraki (4) and Swan Bay (5). Figure 25 shows the location of rankings. These mid-to-upper estuary sub-catchments were estimated to contribute over 80% of the total blackwater generation risk to the estuary. The options recommended to address blackwater issues in the priority catchments are integrated with ASS management solutions discussed above.

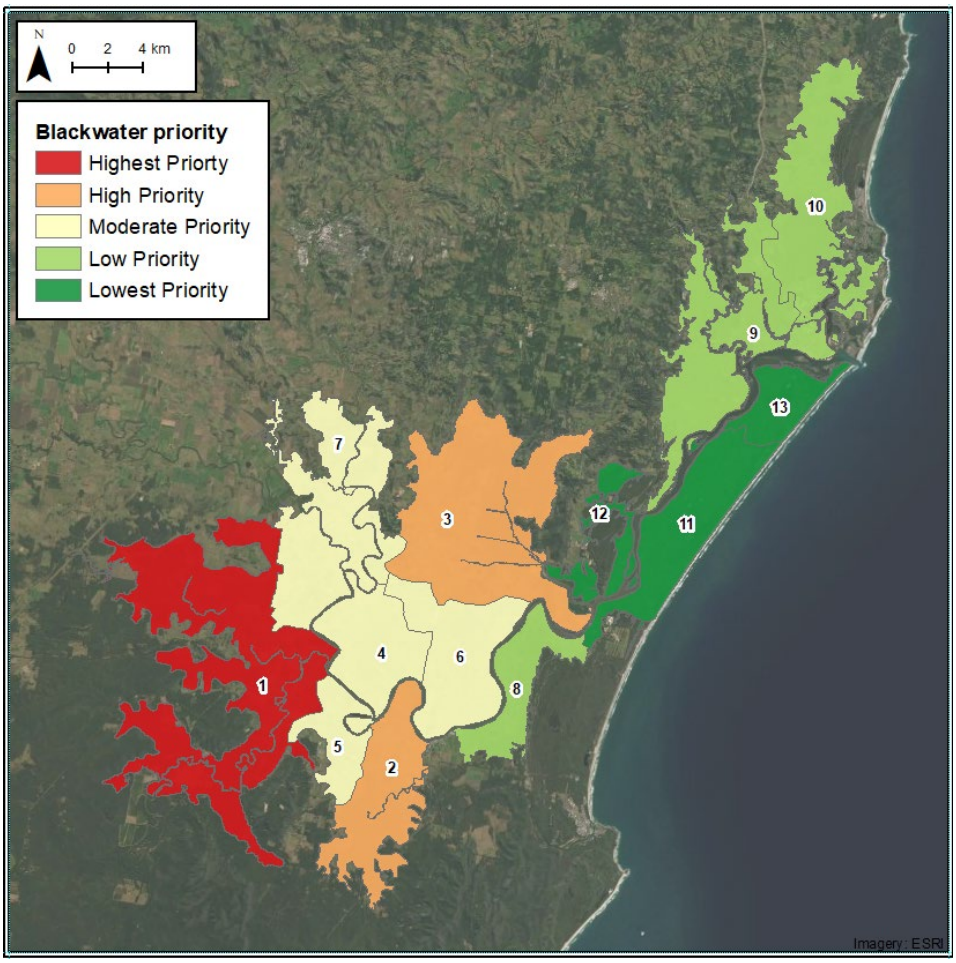

Figure 25: Richmond River floodplain sub-catchment blackwater prioritisation

Source: Harrison (2021)

10.2.2 Point source pollution

Licensed sites

The Environment Protection Authority (EPA) issues environment protection licences to the owners or operators of various industrial premises under the *Protection of the Environment Operations Act 1997* (POEO Act). Licence conditions relate to pollution prevention and monitoring and cleaner production through recycling and reuse and the implementation of best practice. Within the study area, local councils operate centralised sewerage collection and treatment systems at urban centres with STPs discharging treated effluent to Richmond River waterways and managed in line with Environmental Protection Licences issues by the NSW EPA. An abattoir at Booyung, Corndale quarry and the Norco Co-operative milk processing facility at Lismore are also licensed discharge points which discharge to Richmond River waterways. EPA licensed sites are shown on Figure 27(a).

The impact of the STPs on estuary water quality depends on discharge flows and loads of pollutants such as nutrients and faecal coliforms. Pollutant loads from urban inputs become relatively more important to water quality during the dry season when catchment inputs are low. STP input during these dry times are a potential risk to water quality. During rainfall events, nutrient concentrations within the estuary increase by several times as a result of diffuse loads from the catchment. WBM (2006) notes that the impact of nutrient loads from urban runoff and STPs on water quality was negligible in comparison to the impact of diffuse loads.

Wastewater from all other villages, rural properties and National Park campgrounds are managed using on-site wastewater management systems (e.g. septic systems). Poorly designed or located on-site wastewater management systems, or those that are not functioning adequately (e.g. through lack of maintenance, ground conditions, age etc.) can contaminate groundwater and downstream waterways. Potential pollutants from on-site wastewater management systems include pathogens, faecal bacteria, nutrients, suspended solids, pharmaceutical compounds and household detergents and chemicals. On-site Wastewater Management Strategies are implemented by local councils including risk assessment and monitoring activities to manage the risk from these systems and are regulated under the *Local Government Act 1993*.

EPA notified contaminated land sites

There are various EPA notified contaminated sites within the study area, predominantly in the vicinity of Lismore and Casino, and associated with petroleum storage, gasworks, landfill and other industry. A list of these sites and their location is available from the EPA website (EPA, 2021c). If land is declared as 'significantly contaminated', it is regulated under the *Contaminated Land Management Act 1997* and will receive notices relating to the management of this contamination.

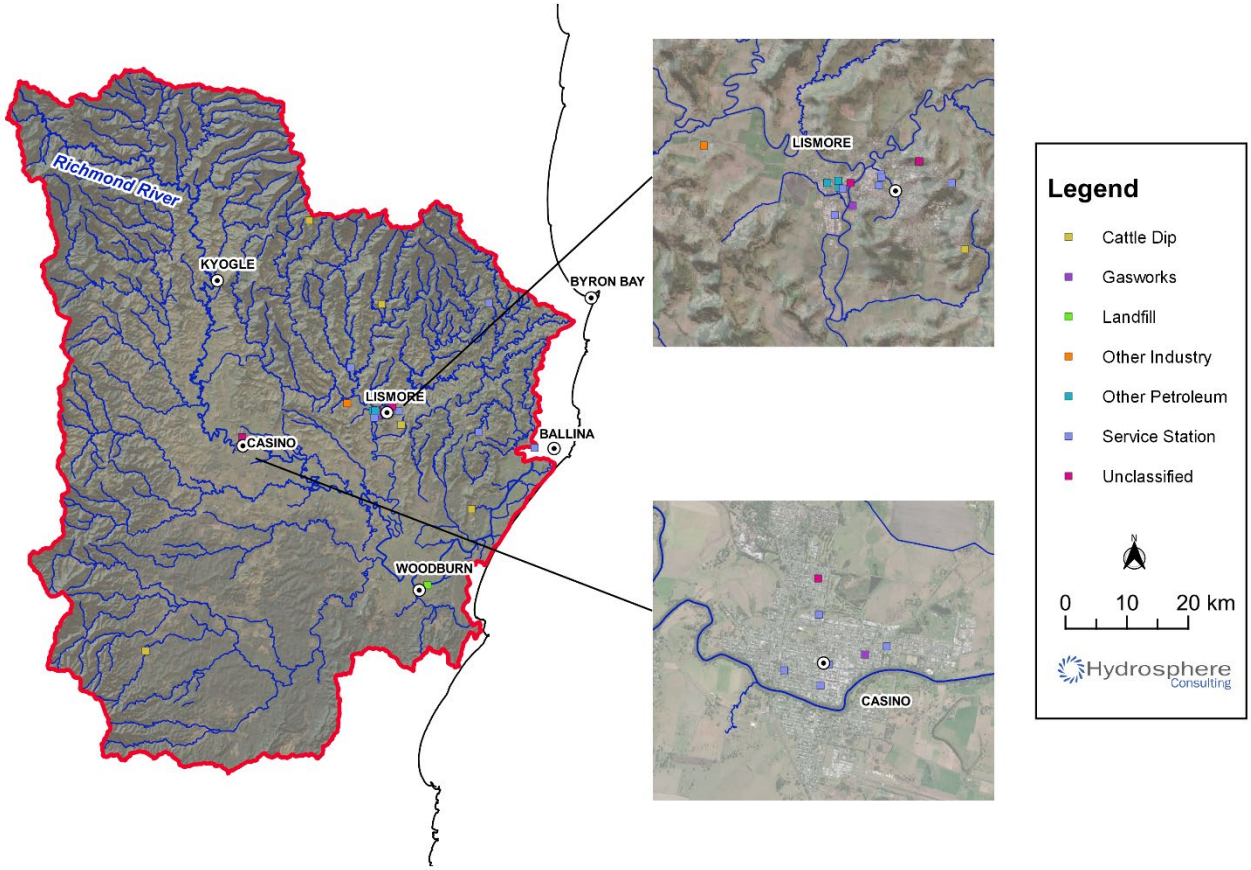

Figure 26: Contaminated Land

Source: EPA (2021c)

Cattle dip sites

Cattle dip sites are sites used to apply chemicals to cattle to control parasites, particularly ticks. DPI maintains an online register of known locations of dip sites and has an ongoing interest in the location and status of each site. Information is updated as provided by public land managers. There are hundreds of cattle dip sites within the study area (Figure 27b), the majority of which are either decommissioned, demolished or remediated.

Past use of dip sites often resulted in contamination of soils surrounding the site. Contaminants historically used in cattle dip sites within the study area included arsenic, Dichlorodiphenyltrichloroethane (DDT) and a variety of other tickicides (e.g. ethion, dioxathion, promacyl, chlordimeform, chlorpyrifos, bromophs ethyl, coumaphos, carbaryl, cymiazole, and diazinon). Both arsenic and DDT are highly persistent in soils as these chemicals (or their compounds) bind strongly to soil (DPI, 2017) making them less bioavailable.

Previous consultation with DPI's dip decommission team in 2019 indicated that dip sites pose a low risk to catchment water quality and stated that high risk sites have already been addressed by DPI (Hydrosphere Consulting, 2020a). Sites exhibiting surface erosion may present a risk of offsite runoff, however cattle facilities typically have good grass cover and any high-risk sites that are close to and/or could collapse into creeks and waterways have already been addressed by DPI. However decommissioned dip sites on public land are not actively managed and have become weed infested (pers. comm. J. Faulks, 2021). Groundwater testing undertaken by DPI indicates no major concerns regarding groundwater transportation of

contaminants from dip sites. A local study by Kimber *et al*. (2002) examined off-site migration of arsenic from 28 dip sites in northern NSW. The study concluded that most dip sites are located on heavier textured soils rich in iron oxides that adsorb arsenic and pose negligible risk to waterways. Dip sites on sandy textured soils pose a greater risk to waterways.

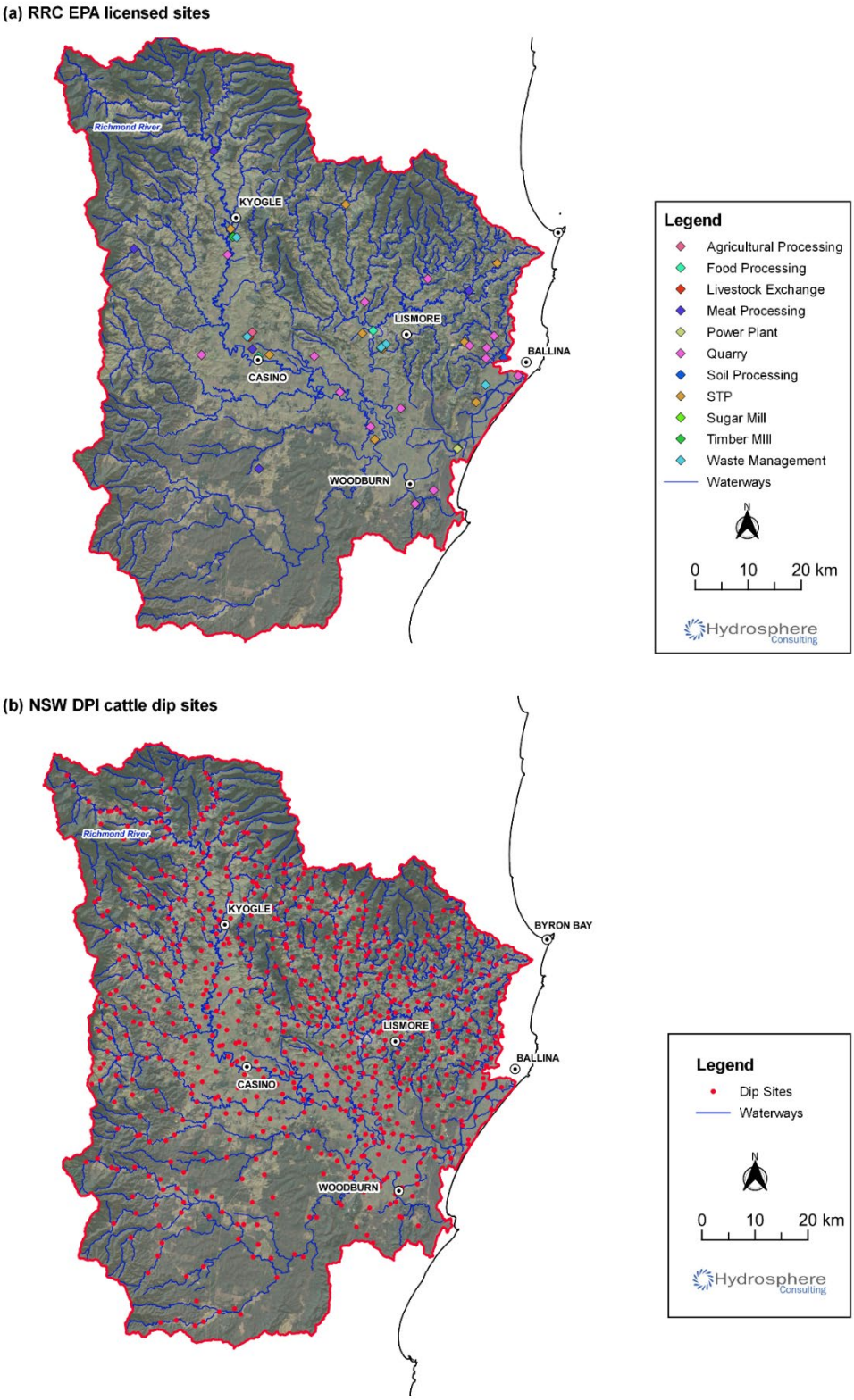

Figure 27: (a) EPA licensed discharges (point sources) and (b) cattle dip sites within the study area

Source: EPA (2021a)

10.3 Fish Passage

Stream connectivity and habitat diversity are critical components of healthy rivers (Industry and Investment, 2009). Physical barriers such as dams, weirs, road crossings and floodgates can interfere with the natural movement and migration patterns of native fish species stopping those species from completing key components of their life cycle. In-stream structures without provision for fish passage can block fish migration, which in some cases and with some species can interfere with breeding cycles. Aggregations of fish at barrier locations are susceptible to increased predation and in some cases are vulnerable as anglers seek to capitalise on the increased concentrations of fish at these points. In-stream structures can also trap sediments which are critical for maintaining physical processes and habitats downstream. In the Richmond River catchment, DPI - Fisheries undertakes an active fish passage program to address this issue. As part of the MEMS, DPI - Fisheries is currently restoring fish passage in northern NSW catchments including several priority sites in the Richmond River catchment. As of June 2021, inspections of 18 sites have been completed and works are progressing on the removal of Cookes Weir upstream of Casino, identified as a high priority site in the Richmond River catchment (MEMA, 2021c; Water NSW, 2021).

Kyogle town water supply weir was upgraded in 2017 and as part of the augmentation, DPI - Fisheries provided additional funding to allow for fish friendly passage via a rock ramp fishway (Plate 7). The fishway has created a passage for more than 26 native fish species to move upstream by converting the existing water supply weir into a ramp with a gradual slope of 5%. It has opened up approximately 1,500 km of inland streams, allowing native fish to cross the weir to spawn, feed and seek refuge in the upper reaches of the Richmond River (PWA, 2021).

Plate 7: V-shaped rock ramp fishway at Kyogle Weir on the Richmond River

Source: Photo by Matt Gordos

10.4 Weeds

Weeds are one of the most significant and costly environmental threats in Australia (Natural Resource Management Ministerial Council, 2006). Once a weed species is established it can place ongoing pressure on biodiversity and the current fragmentation of native vegetation in the Richmond River catchment makes it susceptible to invasion by weeds. Weeds can impact the environment and the community by (LLS, 2021; Lismore County Council, 2015):

- Impacting the landscape amenity which can impact the community's enjoyment of natural areas.
- Disrupting the structure and function of both terrestrial and aquatic ecosystems.
- Invading native vegetation and habitats by out-competing native plants for light, nutrients and water.
- Destroying or degrading native habitats placing pressure on native flora and fauna.
- Causing or influencing bank erosion along waterways.
- Impacting First Nations communities' connection to Country and the ability to undertake cultural activities.

The *North Coast Regional Strategic Weed Management Plan 2017-2022* (LLS, 2021) outlines the primary objectives and strategies for managing priority weeds for the NSW North Coast and the responsibilities of the various stakeholders. RCC is the local control authority responsible for administering the *Biosecurity Act 2015* for weeds in the NSW far north coast region (Kyogle, Lismore, Tweed, Byron, Ballina and Richmond Valley LGAs). RCC's approach to weed management is linked to the *NSW Biodiversity Strategy 2013-2021*, *NSW Invasive Species Plan* (DPI, 2018) and the *NSW Weeds Action Program* (DPI, 2019). Weed management under the *Biosecurity Act 2015* follows a regional risk-based approach contained in the *NSW Weeds Action Program* (funded by the NSW Government) and primarily aims to control new problem weeds before they become a bigger problem in the region (i.e. exclude and eradicate). It is noted that most of the major environmental weeds associated with the Richmond River (e.g. Cats Claw Creeper, Cockspur Coral Tree, Camphor Laurel, Lantana etc.) are not listed as priority weeds and as such are not addressed through the current NSW Weeds Action Program.

Despite ongoing weed management on the NSW North Coast region, the number and extent of priority weed species in the region continues to increase as resources have not been adequate to eradicate all new weeds reported (LLS, 2021). Favourable climatic conditions allow rapid establishment and reproduction of weeds. RCC (pers. comm. P. Courtney, 2021) and North Coast LLS (2021) both indicate that weed management resources are not adequate to address weed management priorities.

10.5 Pest Animal Species

In the Richmond River catchment, pest animals have a significant impact on threatened species and ecological communities, primary production and rural communities (LLS, 2018). Under the *Biosecurity Act 2015*, pest animals can be considered as any species (other than native species) that present a biosecurity threat. Priority pest species on the North Coast are Cane Toad, Feral Cat, Wild Deer, Red Fox, Feral Goat, Wild Horse, Indian Myna, Feral Pig, Wild Rabbit and Wild Dog (LLS, 2018). Pest species impact the health of waterways by contributing to loss of biodiversity, alteration/degradation of native habitats, damage to fences and other infrastructure that may be used to protect riparian zones, increased erosion and bank erosion,

aquatic habitat disturbance and water quality impacts from the introduced fish species (e.g. *Cyprinis carpio*, carp). The introduced Mosquitofish (*Gambusia holbooki*) is widespread throughout the catchment, including brackish waters and is known to impact on ecosystem health through direct predation and competition with small native fish.

Pest animal management if ongoing by various agencies and local government under the *Biosecurity Act 2015*, *North Coast Regional Strategic Pest Animal Management Plan 2018-2023* (LLS, 2018), National Parks and Wildlife Act 1974 and plans of management for specific parks and reserves, state and local biodiversity strategies.

10.6 Riparian Condition

Australian Wetlands (2010) assessed the riparian vegetation of the Richmond River providing written descriptions of the study areas based on on-ground rapid assessment and broad mapping of riparian widths across the catchment. The main findings were that the riparian vegetation bordering the estuary and tributaries was degraded for much of the area. The width of the bank vegetation was often <5 m and few native trees remained. Serious weed invasion was occurring on the banks as there was no natural vegetation to inhibit the growth of weeds. There are some areas of remnant vegetation with good native canopy and mid-storey trees, particularly mid to upper Bungawalbin Creek and tributaries, mid North Creek and parts of the lower estuary, but these are relatively rare within the estuary as a whole. The poor condition of the riparian zone is a key issue affecting overall estuary health with major disturbance factors including (Hydrosphere Consulting, 2011b):

- Clearing of the bank/riparian vegetation.
- Ongoing disturbances associated with unrestricted stock access to banks.
- Lack of suitable buffer zones between land use and waterways, which is particularly significant in areas of high soil disturbance such as cropping areas on steep slopes.
- Disturbance associated with infrastructure including waterfront structures and roads in close proximity to the river.
- Weed invasion.
- Disturbance associated with periodic flooding.

The Richmond River Ecohealth Report (Ryder *et al.* 2015) included a rapid assessment of riparian condition at selected sites throughout the catchment. Riparian condition scores were poor throughout all regions of the Richmond River catchment, with 10 of the 17 river systems recording a score of “D” or lower. Figure 28 provides an overview of the riparian condition grades assigned to each sub-catchment. The scores along the main stem of the Richmond River were particularly poor ranging from a D+ (Kyogle to Casino) to an F (upper estuary between Casino and Woodburn. The main stressors to riparian condition were the dominance of invasive weeds, disturbances from clearing and agriculture and access by livestock. The dominant exotic invasive weeds in estuarine reaches were predominantly Cockspur Coraltree and Coastal Morning Glory Vine. In freshwater reaches, Lantana, Privet, Wild Tobacco Bush and Cat’s Claw Creeper were common. The influence of clearing and physical stressors (trampling and grazing) has reduced the recruitment of native vegetation in the riparian zone. The best riparian condition was located in the upper reaches along Coopers Creek (C+), Terania Creek (C-), Iron Pot Creek (C) and Shannon Brook (C-). Ryder *et al.,* (2015)

recommended that the active restoration of riparian revegetation be a priority in the Richmond River catchment to improve geomorphic condition, water quality and overall ecosystem health.

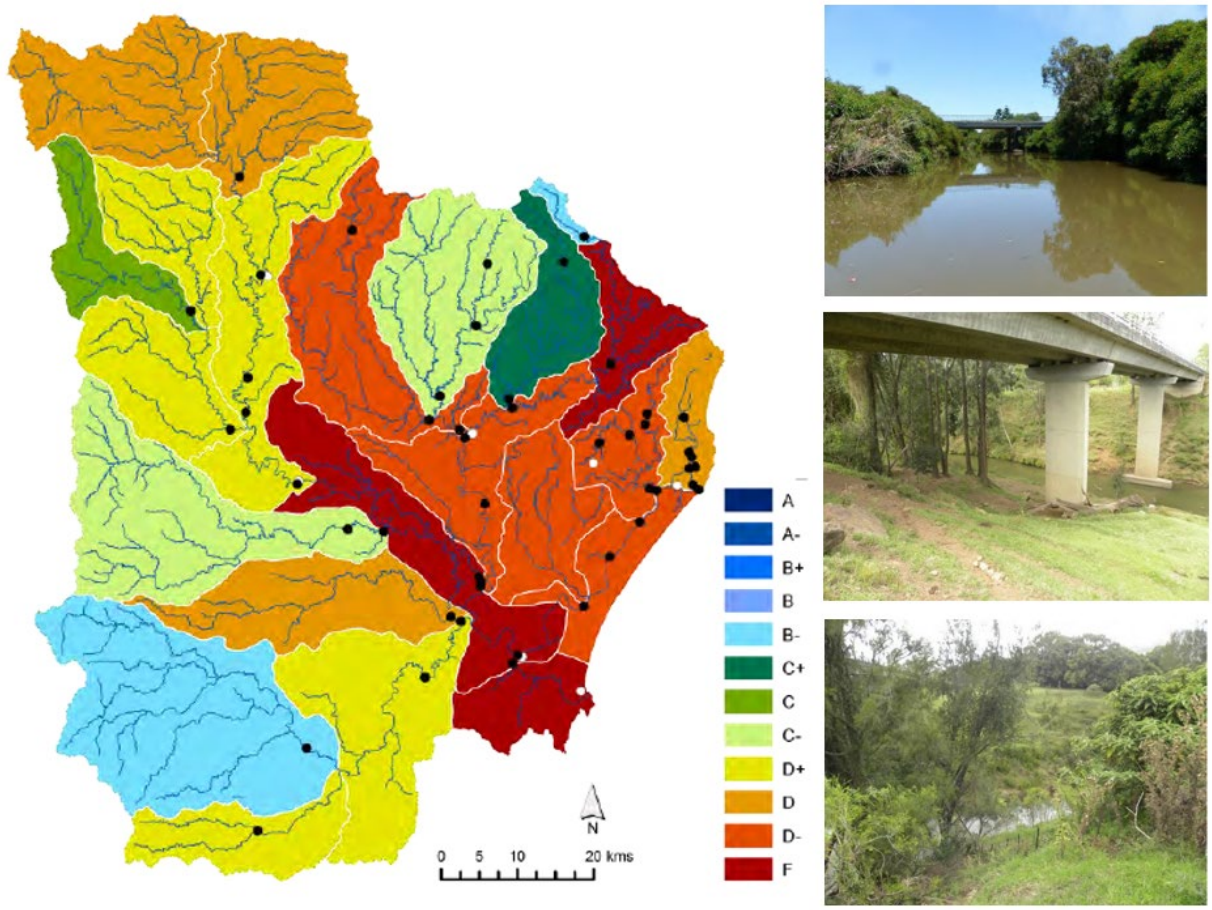

Figure 28: Sub-catchment riparian condition grades and photographs from Ecohealth project field assessments

Source: Ryder *et al.* (2015)

RCC completed a *Riparian Prioritisation and Education Project* in 2014 (Landmark, 2014) with funding from the Estuary Grants Program. Deliverables included a riparian priority assessment of all significant riparian areas in the Richmond River CZMP (Hydrosphere Consulting, 2011) study area (the estuarine extent of the river). The project focussed on water quality and bank stabilisation. The key aim was to identify areas of stream bank that were currently eroding or at risk of erosion (outer bends on erodible soils) where there would be greatest likelihood of successful revegetation by connecting and extending areas of existing good vegetation. Substantial high priority areas for restoration were identified along Walsh's Creek, Pelican's Creek and Duck Creek where there are existing areas of good vegetation interspersed with non-vegetated creek banks, erodible soils and winding streams resulting in a high number of outer bends. Scattered areas were identified as high priority along the Richmond River between Ballina and Broadwater but most of these areas are already vegetated with mangrove and rainforest (Landmark, 2014). Mapping was not included in the report but provided separately as spatial layers. The study was GIS-based with no ground truthing undertaken. The study recommended ground-truthing and establishment of a single, comprehensive, catchment-wide GIS dataset (Landmark, 2014).

A Landholder Survey was undertaken by Bushland Restoration Services (2014) as a follow-up to the prioritisation project. A phone survey was conducted to target landowners with frontage of rivers or creeks in target areas to better understand their values, information needs and willingness to participate in restoration activities. Fifty-six landowners responded to the survey with 30 indicating interest in being involved in riparian restoration (Bushland Restoration Services, 2014). An education kit in the form of a data CD was also prepared as part of the project to introduce the project, provide an overview of objectives and funding and best practice guidelines for managing riparian zones.

A catchment-wide riparian prioritisation study was undertaken by Hobbs (2017) as part of post-graduate research at SCU. The study was based on Landmark (2014) methodology and prioritised restoration programs using a GIS to generate maps of prioritisation categories and riparian condition. Broad costs were estimated for prioritised areas to help direct future planning and funding of restoration efforts in the catchment. Hobbs (2017) reported that the majority of the riparian zones in the catchment are in need of restoration and highest priority sites are located in the middle parts of the catchment, where grazing and agriculture dominates the land use. The price for restoration ranged from $22,000 - $24,000 /ha, including allowance for fencing, weeding and revegetation. Hobbs highlighted that effective engagement with landowners and ensuring ongoing maintenance of the restored riparian zones is vital for restoration to be successful. The study also recommends that restoration efforts start with Council owned land and with landowners who have already been proven to be willing to participate to act as demonstration sites and show a commitment from Council.

Oeding *et al.* (2017) studied diatom and macroinvertebrate community assemblages at 20 sites within the Richmond River catchment to investigate the impacts of forest, macadamia, grazing, sugar cane and urban land uses. The results showed distinctions between land use categories and indicated that the grazing sites had the poorest health of the land use categories, followed by sugar cane and urban areas while the macadamia and forest sites were relatively healthy. The results also indicated that riparian vegetation and instream habitat play an important role and that rehabilitation efforts could potentially improve water quality at a micro-catchment scale and subsequently, result in river health improvement at the catchment scale (Oeding *et al.*, 2017).

Opportunities associated with restoration of riparian zones within the Kyogle LGA were identified by Larsen (2018) as:

- Increased retention of biomass and nutrients in the adjacent landscapes.
- Growth in fish stocks.
- Improved aesthetic appearance of landscapes and waterways.
- Increase in biodiversity through restored habitat connectivity.
- Enhanced quality of life for local people through enjoyment of natural environment (resilience of townships).
- Encourage/increase opportunity for ecotourism.

10.7 Bushfire

Bushfires cause devastating damage to terrestrial flora and fauna. Aquatic environments can also be affected during bushfire events through increases in temperature, instream pH and increase in nutrients from smoke and ash inputs (Lyon *et al*., 2008). Aquatic ecosystems may remain impacted by fire for extended periods following a bushfire due to changes in the landscape. The potential changes to the landscape and water cycle post-fire are depicted in Figure 29.

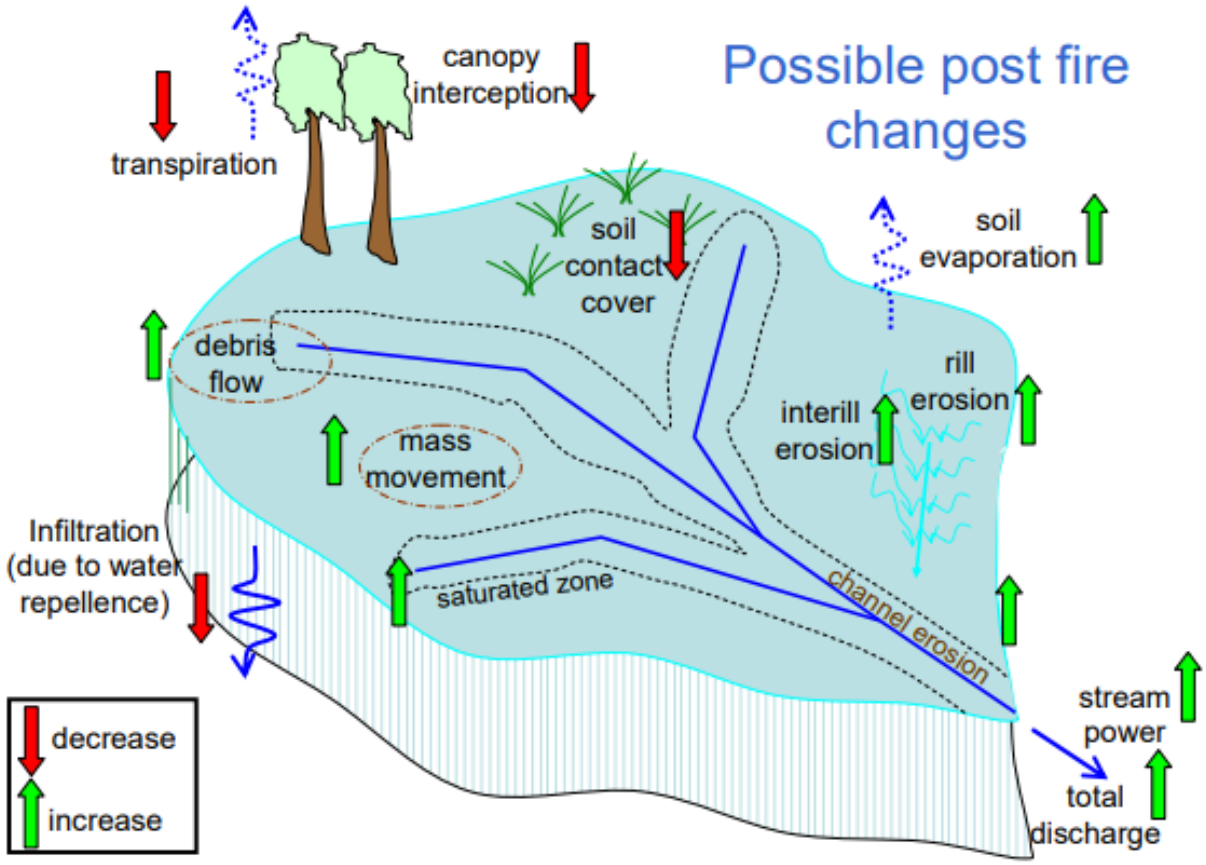

Figure 29: Potential impacts resulting from changes in the landscape post-fire

Source: Smith *et al.* (2011)

In a post-bushfire landscape, the amount of groundcover vegetation and leaf litter covering the soil surface is reduced. In addition, intense temperature increases in soils during fires can cause organic matter within the soil to combust reducing soil binding, and can also cause soils to become hydrophobic, increasing the probability of surface runoff. As a result, runoff and accompanying post-fire rainfall, and in particular heavy rainfall, is liable to cause debris flows and increased sediment loads which can cause fish kills (Lyon *et al*., 2008) as dissolved oxygen levels drop (DPI Fisheries, 2021b). Further, reduced shade resulting from burnt riparian vegetation can increase the temperature of waterways and lead to an increase in algae and a decrease in local insect population, a critical part of the aquatic food chain (DPI, 2021; Smith *et al*., 2011). Other indirect impacts of bushfires on aquatic systems are caused by silting in pool habitats and increased inputs of nutrients and constituents from burnt materials (Lyon *et al*., 2008; DPI, 2021) such as nitrogen and phosphorous, metals (iron, copper, chromium, arsenic, lead and zinc) cyanobacteria, chloride and sulfate (Smith *et al*., 2011).

Chemicals from fire suppression and retardants may also cause impacts to water quality and the construction of earth fire breaks can leave areas of soil exposed and susceptible to erosion which may further increase sediment loads and yields in waterways (Smith *et al*., 2011).

The largest water quality impacts occur due to high magnitude erosion events soon after a fire (such as high intensity rainfall events and flash floods) which mobilise soil and organic matter to waterways. Increased suspended sediment is the most frequently reported impact on water quality post-fire (Smith *et el*., 2011). It is the most significant impact as increased quantities of sediment and organic material to streams increases the turbidity and suspended solids in the water and can also result in increased concentrations of nutrients and metals and decreased concentrations of dissolved oxygen. These impacts can have serious consequences for aquatic ecosystems. The severity of impacts to water quality post-fire depends on factor such as post-fire rainfall patterns, catchment burn extent and severity, catchment erosion processes, location potential suspended sediment sources in relation to streams, The landscape and aquatic environment can take years to fully recover from bushfire events.

Bushfire events in NSW are predicted to increase in frequency in the future while drought and rainfall events are forecast to become more extreme (refer Section 19) hence, the impacts of bushfires on aquatic ecosystems will become increasingly serious and hence responding to these threats is becoming more urgent.

10.8 Water Quality Monitoring

The Richmond River CZMP (Hydrosphere Consulting, 2011b) reported that at that time there was no integrated environmental monitoring and reporting system in place at a scale that was meaningful to assess the on-going health of the estuary over time or to compare relative sources of water quality degradation. There was also no monitoring in place across the catchment that could allow for determining the effectiveness of management and investment in programs and projects that affect the estuary. Since that time, a number of monitoring initiatives have been implemented. The *Richmond River Ecohealth Project 2014* (Ryder *et al.,*2015) provided the first comprehensive snapshot assessment of ecosystem health in the Richmond River catchment (Section 10.1). Other ongoing water quality monitoring initiatives are outlined below.

10.8.1 Rous County Council Water Quality Monitoring Program

RCC has been undertaking regular water quality monitoring at a number of sites in the Richmond River since 2004. A review of RCC water quality monitoring by Rayner *et al*. (2020b) found that the efficacy of data collected from automated water quality monitoring stations in the lower Richmond River since 2004 lacked reliability. Rayner *et al*. (2020b) provided a suite of recommendations for a revised program.

In 2020 RCC commenced a new program to monitor water quality in the Richmond River. The project is funded by a 3-year grant under the NSW Coast and Estuary Grants program in partnership with the constituent councils and with technical advice from DPIE, SCU and the UNSW Water Research Laboratory. A series of permanent monitoring sites within the Richmond River estuary and upstream catchment areas have been installed, measuring pH, salinity, temperature, dissolved oxygen and turbidity. There are seven water quality loggers deployed at the following lower Richmond sites: Rocky Mouth Creek, Tuckean Barrage (upstream), Tuckean Barrage (downstream) and new sites at North Creek (Ross Lane), Bungawalbin Creek,

Wardell and Woodburn. Results from the new data loggers are available in 'real time' from the online water quality dashboard.

10.8.2 RCC Drinking Water Catchment Water Quality Monitoring

RCC has prepared drinking water catchment management plans for Rocky Creek Dam, Wilsons River Source, Emigrant Creek Dam and the potential future Dunoon Dam. RCC monitors water quality in the drinking water catchments in accordance with the *Australian Drinking Water Guidelines* (NHMRC, 2011).

10.8.3 NSW state-wide estuarine water quality monitoring and report cards

DPIE undertakes a state-wide estuary monitoring program to track the condition of estuaries over time by comparing observed data to a range of guideline values specific to NSW estuaries. This monitoring work was originally undertaken as part of the *NSW Monitoring Evaluation and Reporting Program* and is now continued through the MEMS (DPIE, 2021a).

The program collects a range of data to assess the structure, function, composition and condition of estuaries (MEMA, 2021g). Data has been collected in the Richmond River estuary since 2012 and this raw data is publicly available for download from the SEED website for years 2012, 2015, 2016, 2018 and 2019. Report cards are being prepared for each estuary providing both historic and current grades across a number of indicators, however the Richmond River report card was not available at the time of writing.

10.8.4 Draft Richmond River Water Quality Monitoring Strategy

DPIE has prepared a draft *Richmond River Water Quality Monitoring Strategy* (Ferguson, 2021) providing a framework for a staged water quality monitoring program in the Richmond River catchment, initiated as part of the MEMS. The document provides:

- A review of water quality monitoring objectives in the Richmond River catchment in relation to relevant NSW government legislation.
- A detailed review of pressures, stressors and ecosystem health in the Richmond River.
- An audit of the current water quality monitoring efforts in the catchment.
- A proposal for an integrated water quality monitoring strategy that meets all stakeholder needs and rationalises the efficient use of resources and efforts while maximising quality assurance and control.

The strategy is intended to fulfil and coordinate the anticipated needs of local government stakeholders, the MEMS, Coastal Management Programs and the NSW Natural Resource Monitoring Evaluation and Reporting program. The strategy is currently in draft format and has been provided to key stakeholders for discussion and review.

10.8.5 MEMA Review of NSW Water Quality Objectives

The current NSW Water Quality Objectives (WQOs) are based on the *National Water Quality Management Strategy* and are long term goals for how communities use and value their waterways. The objectives provide guidance for assessments of land use impacts based on the community uses of those waters (e.g. primary or secondary contact recreation, protection of aquatic ecosystems, stock watering etc.). There are

specific WQOs assigned to the Richmond River catchment waterways. A review is currently being undertaken to update community and environmental values, assess land use changes and the suitability of indicators used in the WQOs as part of the MEMS (DPIE, 2021b). The review includes extensive community and stakeholder consultation and is expected to be completed towards the end of 2021.

10.9 Water Quality Modelling

The Estuary and Catchments Science unit of DPIE has developed a preliminary Richmond River ecosystem response model (RR-ERM), comprising coupled catchment-hydrodynamic-biogeochemical models, representing the entire Richmond River catchment (Ferguson, 2021). The RR-ERM is currently restricted to assessing the impacts of suspended sediment and nutrients on the receiving waters, however it is intended that sub-models representing blackwater and ASS runoff processes will be developed. The RR-ERM is under review by DPIE with a PhD program aimed at filling key knowledge gaps and updating the model within the MEMS Stage 1. It is intended that the RR-ERM becomes a public asset available to all stakeholders within the Richmond River catchment, with certain functions and outputs available via a web-based portal. The RR-ERM will provide (subject to funding and resourcing):

- The updated risk-based framework, allowing a rigorous effects-based assessment of pollutant loads from different sub-catchments on the receiving waters.
- A contextual framework for the interpretation of water quality monitoring data, including the generation of spatially and temporally dynamic thresholds, as recommended by ANZECC and ARMCANZ (2000).
- The potential for near-real time predictive capabilities for parameters such as human health risk from pathogens.
- A functional understanding of processes in the Richmond River system to support ongoing research into key knowledge gaps.

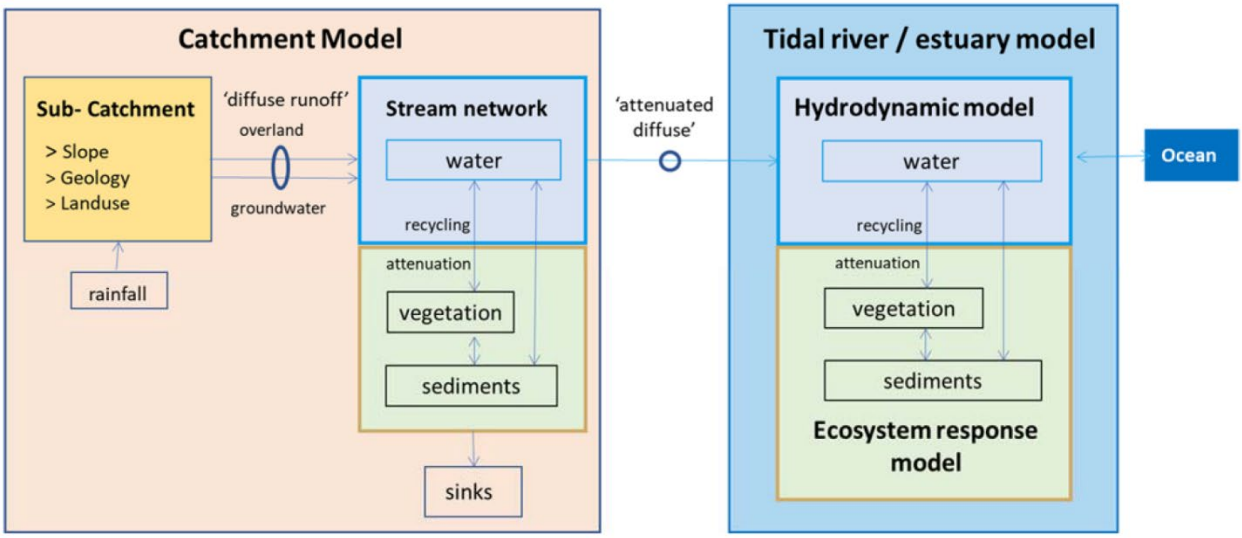

Figure 30: General schematic of the RR-ERM

Source: Ferguson (2021)

Socio-Economic Context

11. POPULATION AND DEMOGRAPHICS

Information on the communities making up the Richmond River catchment LGAs has been analysed and reported from Census data by .id Consulting (2021). The estimated resident population of the combined LGAs was 121,162 in 2020. The resident population is estimated to have increased by 1,677 people (1.4% p.a.) since the 2016 Census. From 2011 to 2016, the combined LGA population increased by 2,136 people (1.8% p.a.).

A summary of .id Consulting (2021) demographic information for the combined LGAs is provided in Table 7. Aboriginal and Torres Strait Islanders made up 4.8% of the combined LGA population (5,558) in 2016. The most common ancestry is Australian and English. The LGA population is generally older than other regional areas with 30% of the population aged 60 years and over. Household income and rent are generally lower than other areas of NSW. There is a lower level of ethnicity than elsewhere in NSW and Australia. As Byron Shire and Clarence Valley LGAs only have a small percentage of their LGA population within the Richmond River catchment they have not been included in this overview.

Table 7: Demographic data for Richmond River catchment LGAs (2016 Census)

Indicator	BaSC	LCC	RVC	KC	Combined LGAs	Regional NSW	NSW	Australia
Median age	47	42	43	50	45	43	38	38
Couples with children	23%	23%	22%	18%	23%	25%	32%	30%
Older couples without children	29%	24%	26%	29%	26%	13%	10%	10%
One parent family	10%	13%	12%	11%	12%	11%	11%	10%
Lone person households	26%	27%	27%	29%	27%	26%	22%	23%
Aboriginal and Torres Strait Islander population	3.3%	5.0%	7.2%	4.3%	4.8%	5.5%	2.9%	2.8%
Medium and high-density housing	28%	15%	14%	21%	20%	17%	33%	27%
Median weekly household income	$1,152	$1,062	$789	$828	$1,026	$1,166	$1,481	$1,431
Median weekly rent	$342	$269	$250	$235	$290	$278	$384	$339
Households renting	26%	27%	27%	21%	26%	26%	30%	29%
Households with a mortgage	25%	29%	26%	25%	27%	29%	30%	32%

Indicator	BaSC	LCC	RVC	KC	Combined LGAs	Regional NSW	NSW	Australia
Overseas born residents	11%	9.4%	5.7%	10%	9.3%	11%	28%	26%
Unemployment rate	5.8%	7.8%	7.8%	8.7%	7.1%	6.6%	6.3%	6.9%
Language at home other than English	3.7%	4.5%	1.7%	2.6%	3.5%	6%	25%	21%
SEIFA index of disadvantage[1]	1,003	954	902	910	959	971	1,001	1,002

Source: .id Consulting (2021)

1. Socio-Economic Indexes for Areas (SEIFA) measure the relative level of socio- economic disadvantage and/or advantage based on a range of Census characteristics. A higher score on the index means a *lower* level of disadvantage. A lower score on the index means a *higher* level of disadvantage.

12. COMMUNITY USES AND VALUES

The Richmond estuary has high cultural and spiritual significance to local First Nations people. Fishing along the river and estuary is an important part of First Nations culture. There are many sites of heritage significance around the estuary and their recognition and protection is of high importance to the community. Healthy waterways and “sea country” are essential for Aboriginal people for health, wellbeing and culture as they allow kinship, connection, stories, song lines and healing. To First Nations people, mythological sites are part of a complex holistic knowledge system which is an integral part of their culture (Neale and Kelly, 2020; LCC, 2021c; Department of Planning, 1988). The many features which make up the landscape are viewed by First Nations people as inseparable and makeup what is known as “Country” to First Nations people (NPWS, 2007).

Connection to Country is explained in a statement from the Widjabul Elders featured on LCC’s website (2021c):

"*As Aboriginal people we have different ideas and views about our existence to that of non-Aboriginal people. We view the world in a holistic manner, seeing people and nature as part of the whole, connected by their very existence and descended from our creator ancestors. The key to our very survival is cooperation and coexistence with the forces of nature, the spirit world, and with our fellow man. We are all part of the natural order and our cultural beliefs and practices should not be subject to Western scientific analysis. In other words, our culture should never be broken down and compartmentalised. If you can’t see the interconnections and interrelations that dominate our culture, then you aren’t looking with an open mind*."

Previous community consultation undertaken as part of the development of the Richmond River CZMP identified (Hydrosphere Consulting, 2011b) other values as follows:

- The estuary and foreshore areas are highly valued by the community and visitors for recreational activities. Activities include fishing, boating, swimming, surfing, walking and bird watching.
- Scenic amenity is valued highly by the local community and visitors.
- The river and estuary provide opportunities for both formal and informal education.

- A number of historic (non-indigenous) cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community.

Recreational uses constitute the dominant use of the estuary. Commercial boats also utilise the estuary for fishing and tourism activities which are also important in the region although activities are concentrated in the lower estuary (outside the CMP study area). Boating forms a vital component of the tourism sector of the Richmond River communities and is a significant lifestyle activity enjoyed by a large proportion of its residents. Many of the communities, particularly those in coastal areas, are reliant on tourism to drive their local economies. The availability of suitable river access points and appropriate and complimentary marine infrastructure is critical to the enjoyment of recreation boating in the estuary. Providing appropriate boating facilities to meet growing demand, ensuring cooperative use of the waterway between various forms of recreational and commercial users while protecting the ecological values of the estuary are key challenges for successful holistic management of the estuary raised in the Richmond River EMS (Hydrosphere Consulting, 2011b).

Public access to foreshore areas is highly valued by the community (Hydrosphere Consulting, 2011b). Existing access facilities including waterfront licences (for jetties, wharves, boatsheds, boat ramps, pontoons and slipways), boat harbours, mooring areas, parks and reserves. Informal access to the foreshore causes bank erosion and trampling of vegetation which are likely to be exacerbated by the potential climate change impacts of sea level rise and increased storminess. Current land-based foreshore access issues were identified in the Richmond River EMS (Hydrosphere Consulting, 2011b) for example in Lismore where the presence of existing foreshore developments restricts public access.

A public consultation survey on New South Wales WQO on the north coast was undertaken as part of the *Marine Estate Management Strategy* (December 2020 – March 2021). The survey asked participants which local waterway is most important to them, how often they visit their local waterway and their perceived importance of healthy local waterways. Results from this survey are expected to be published in 2021.

Plate 8: Pontoon in lower Emigrant Creek (left); Competitor racing in the 2017 Lismore Kayak Marathon Race (right)

Source: Far North Coast Canoe Club (right)

A review of freshwater ecosystem services and functions across the Richmond River catchment was undertaken by Finlayson *et al.* (2019). They took steps to identify and qualitatively value the important ecosystem services and functions associated with the river system, including the remaining coastal swamps. Finlayson *et al.* argue that given a history of ecosystem services being largely ignored and degraded by the natural resource exploitation that has occurred and still dominates economic activity there has been a low

appreciation of what has been lost, and what could be gained through changes in land- and water-management practices. The authors advocate that a key to getting better outcomes is increasing the awareness of ecosystem services.

13. AGRICULTURE

Agriculture is a major driver of the local economy, employing approximately 6.6% of the working population within the study area (including Ballina, Richmond Valley, Lismore City LGAs, the Bangalow and Rural South West of the Byron Shire LGA and Kyogle Council - excluding the Bonalbo – Woodenbong district). Local forms of agriculture include cattle grazing, sugar cane cropping and horticulture. The Alstonville Plateau area has been designated state significant farmland as part of the Northern Rivers Farmland Protection Project. Areas designated as regionally significant farmland include parts of North Creek, Empire Vale and Woodburn (DPI, 2005).

In 2019/20 the agriculture industry accounted for 6.1% of total employment across the four predominant LGAs of the study area (LSC, RVC, BaSC and KC) and the value of agriculture production in these LGAs was over $500 million (.id Consulting, 2021) as shown in Table 8.

Table 8: Agriculture industry snapshot 2019/20

LGA	Value of agriculture production ($'000,000)	Number of persons Employed	% of total employment
Ballina	137.8	905	5.2%
Lismore	159.0	982	4.2%
Richmond Valley	159.2	643	7.4%
Kyogle	136.8	714	22.1%
Total	592.8	3,244	6.1%

Source: .id Consulting (2021)

14. FISHING

Recreational fishing is a popular lifestyle choice for residents and visitors to the estuary with flow-on economic implications for local commerce including boat supplies, bait/tackle shops and tourism (Hydrosphere Consulting, 2011a). Results from a 2013/14 recreational fishing survey indicated that recreational fishing is mostly shore-based and concentrated in estuarine waters followed by inshore coastal waters (West *et al.,* 2015). Fishing activities and practices have spiritual, social and customary significance for First Nations people. 'Aboriginal Cultural Fishing' is recognised under the *Fisheries Management Act 1994.* Where native title is recognised over marine waters, rivers, lakes and estuaries, native title holders can exercise their rights to fish for personal, domestic or non-commercial needs in line with the provisions of the *Native Title Act 1993* (DPI Fisheries, 2017; DPI Fisheries, 2019).

The Richmond River estuary has regionally important commercial and recreational fisheries. Commercial fishers target a wide range of species in particular Bully mullet, School prawn, Long-finned eel and Luderick (WBM, 2006). The Rock Oyster was grown and harvested within the Richmond River up until the mid-1970s (OzFish, 2021c). Since that time, full-cycle (spat to harvest) oyster farming has not occurred on the

Richmond due to poor water quality and the incidence of QX disease. Commercial fishing and oyster farming are important economic activities in the lower reaches of the estuary and ocean (outside the study area) and fishery sustainability is influenced by catchment health.

15. TOURISM

The study area is a popular tourist destination for activities such as camping, kayaking, swimming, wildlife appreciation, food and dining experiences and sightseeing with many camping and accommodation options. National parks with campgrounds include Whian Whian State Conservation Area, Toonumbar and Richmond Ranges National Parks. Tourism and recreation are also major economic drivers for the North Coast Region. Tourism activities include outdoor recreation and sports and nature-based experiences. Popular activities include recreational fishing, boating, swimming, holidaying, day trips, ecotourism, bird watching and nature appreciation. Tourism has been identified as a priority industry for the North Coast Region (ABER, 2007). Annual tourism statistics for Ballina, Lismore, Richmond Valley and Kyogle LGAs are provided in Table 9. It is estimated that over 2.2 million people visit these areas per year directly adding $111 million of value (Tourism Research Australia, 2019).

Table 9: Annual tourism statistics

LGA	Ballina	Lismore	Richmond Valley	Kyogle	Total
Tourism businesses[1]	560	178	184	89	1,011
Number of visitors ('000)[1]	913	789	383	188	2,273
Total number of nights stayed by visitors ('000)[1]	1,284	706	628	331	2,949
Tourist expenditure ('000,000)[1]	$318	$153	$78	$38	$587
Direct Output/sales ('000,000)[2]	$90	$82	$25	$12	$210
Direct employment (persons)[2]	730	819	226	52	1,827
Direct value added ('000,000)[2]	$46	$46	$13	$5.0	$111

Source: 1- Tourism Research Australia (2019) Data based on a four-year average from 2016 to 2019, 2- .id Consulting (2021) data from 2019-20

Coastal Processes and Hazards

The Scoping Study will address the tidal inundation hazards relevant to environmental values (i.e. bank erosion and migration of estuarine vegetation) within the estuary. Other coastal hazards are being addressed in separate coastline management studies for Ballina and Evans Head.

16. TIDAL INUNDATION

The tidal influence extends upstream of Tatham on the Richmond River and upstream of Lismore on the Wilsons River. Eden Creek, Shannon Brook and Bungawalbin Creek are significant tributaries draining the western and southern areas of the Richmond catchment. The Richmond River estuary includes all tidal waters of the Richmond River and incorporates river foreshores and adjacent lands. The lower estuary areas and North Creek are outside the study area for the Richmond River CMP Scoping Study.

Tidal inundation of the stormwater network in Ballina currently occurs with 'king' tides but no serious threats to public safety or built assets have been identified. Similarly, tidal inundation risk in the Evans River is currently not considered significant. Although these lower estuary areas are outside the study area, the coastal hazards of tidal inundation and erosion within estuaries caused by tidal waters are expected to increase in severity and extent under climate change impacts, particularly sea level rise. Estuary bank erosion risks to development and infrastructure adjacent to the estuary is expected to increase in extent and severity under sea level rise scenarios (Hydrosphere Consulting, 2011b).

The Federal government's online tidal inundation model, Coastal Risk Australia (2021) provides a visual indication of those places at risk from tidal inundation in the present day and at 2100 (example shown on Figure 31). The mapping indicates that large areas of the study area may be at risk of tidal inundation, most notably the Richmond River floodplain and adjacent lands. It is important to note that this mapping is a coarse assessment that was completed across Australia to provide a broad overview of predicted tidal inundation risk. It does not consider local conditions such as tidal flows in coastal waterways that will result from different coastal configurations in some locations (i.e. floodgates, drains etc.). Nor does the model take account of the effects of catchment flooding from coincident extreme rainfall events. More detailed local study is required to ensure that particular local circumstances and dynamics are adequately considered in any adaptation response to sea level rise.

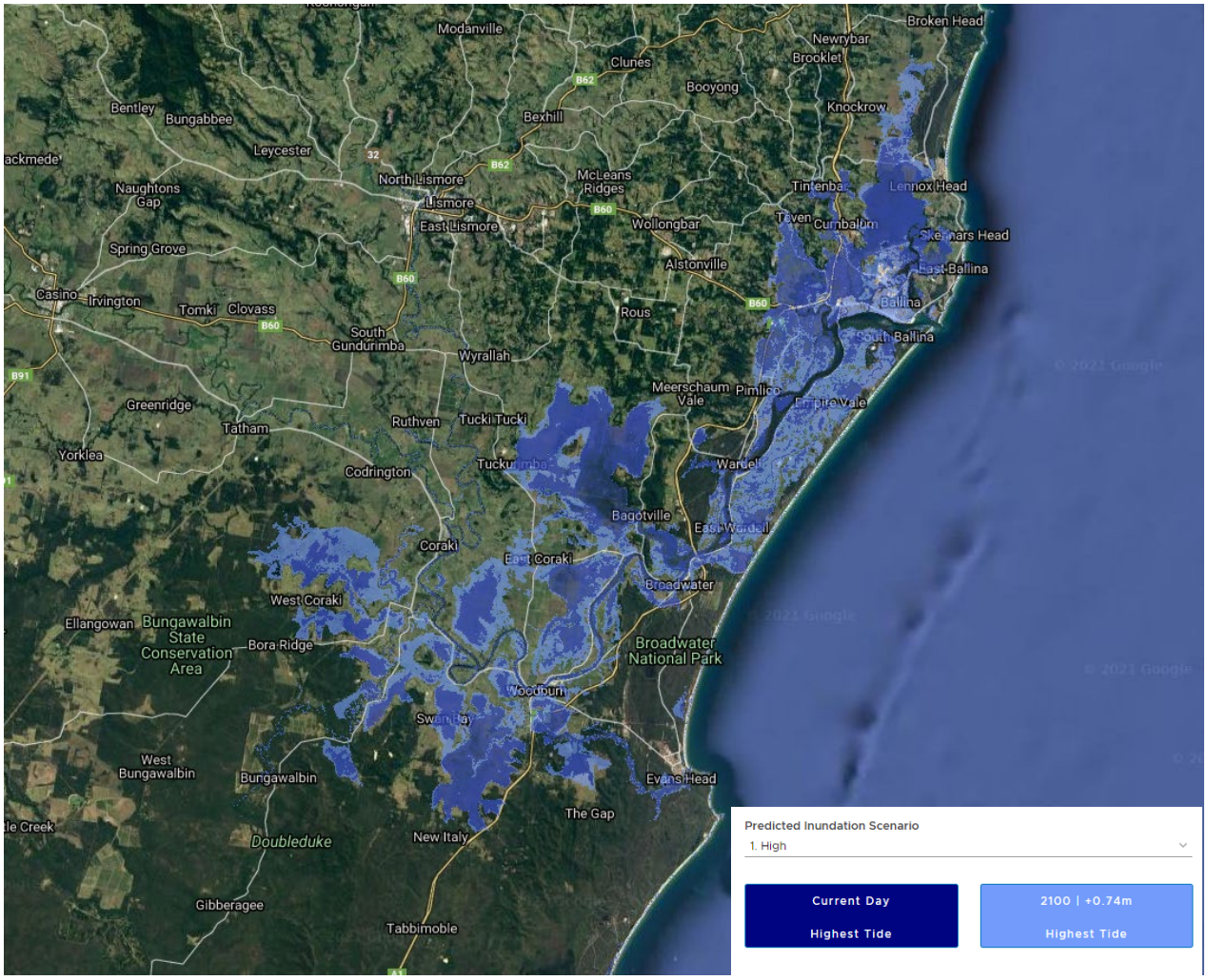

Figure 31: First pass mapping of present-day and 2100 risk from tidal inundation

Source: Coastal Risk Australia (2021)

17. BANK EROSION

Bank erosion can lead to a range of environmental, social and economic problems such as the loss of riverfront property and infrastructure, water quality degradation, destruction of natural and artificial levees, loss or destabilisation of native trees and the destruction of habitat and aquatic plants and animals. Water quality issues associated with erosion include high turbidity and the mobilisation and transportation of nutrients and contaminants associated with sediment from land to waterways. Sedimentation in the main river channel is not considered to be a significant issue as most of this sediment is thought to be transported to the ocean during major events, with very little evidence of sedimentation or infilling of the river channel detected in 2007 river surveys (ABER, 2007). Sediment can however be a major issue in the lower energy creeks where channels have become infilled with sand, such as Six Mile Swamp Creek in the Bungawalbin catchment. Sediment transported from drains can also build mud flats and smother sea grass in the lower estuary (ABER, 2007).

Bank erosion is prevalent in many areas within the estuary and catchment. Bank erosion occurs mainly because of loss of vegetation in key riverbank areas where water velocities are high and banks scour, resulting in undercutting and bank slumping. Additionally, riparian areas can become susceptible to erosion

as a result of trampling by stock, vehicle access, boat wash (Emigrant Creek and North Creek) and unlicensed access to the river. The significance of these impacts varies according to the location along the river system. Large stretches of the Richmond River and its tributaries have been reported as being devoid of good quality riparian vegetation which in many instances coincides with areas of active bank erosion (WBM, 2006). Riparian vegetation is critical for maintaining bank stability and channel integrity as well as decreasing sediment run-off.

Predicted sea level rise due to climate change may increase erosion due to increased estuary water levels and the interaction of tidal waters with catchment floodwater. Climate change impacts are discussed in Section 20).

Plate 9: Severe bank erosion and degraded riparian zone on the Richmond River near Casino

Source: Hydrosphere Consulting (2011b)

The Richmond River Ecohealth Report (Ryder *et al.* 2015) included an assessment of geomorphic condition (bank and bed condition) at selected sites throughout the catchment. Geomorphic condition scores ranged from good to poor throughout the Richmond River catchment with generally good to moderate condition in the upper freshwater reaches and poor condition and evidence of active erosion occurring in the estuarine reaches (Figure 32). The areas of poorest geomorphic condition were in the estuary where the riparian zone had been completely cleared for cropping. In the freshwater reaches, poor geomorphic condition was associated with cattle grazing and stock access to the river.

A bank erosion decision support tool (DST) prototype and accompanying bank assessment methodology is currently being developed by DPI Fisheries to assist the development of Estuary Bank Management Strategies. The approach is aimed at reducing ‘red tape’ in gaining approvals and in prioritising environmentally friendly approaches to bank management. A draft DST and interactive web-based map categorising erosion severity, and best practice management practices along the foreshores of two priority estuaries - Tweed and Brunswick Rivers, have been developed (MEMA, 2021a). Additional pilot studies in other catchments are underway to test and refine the tool. Estuary-wide maps are being prepared to illustrate erosion risk overlayed with best-practice erosion control. The project is being undertaken through the MEMS and the tool should be available for use in later stages of the Richmond River CMP.

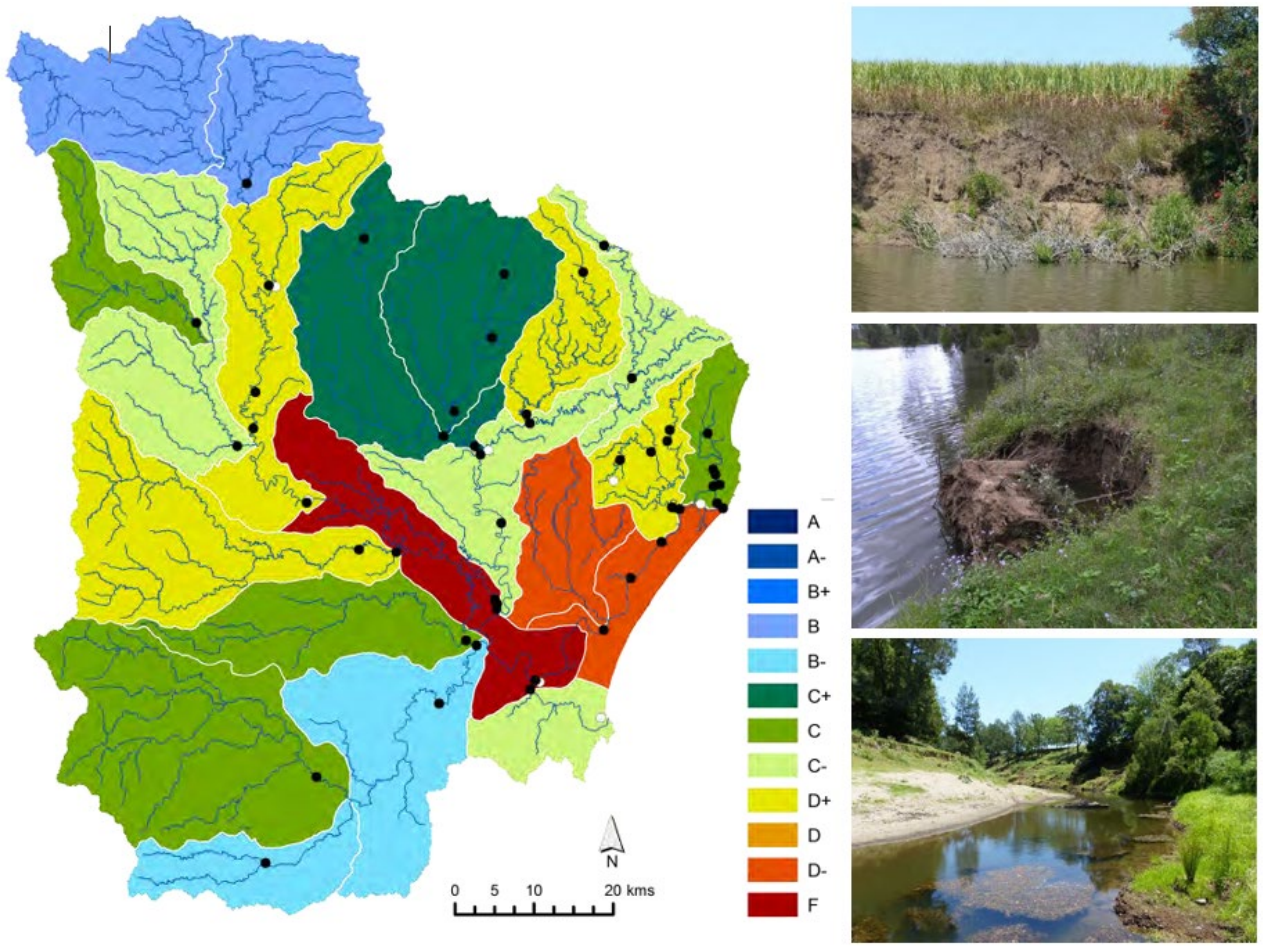

Figure 32: Sub-catchment geomorphic condition grades and photographs from Ecohealth project field assessments

Source: Ryder *et al.* (2015)

Future Context

18. POPULATION GROWTH AND LAND DEVELOPMENT

The economy and population of the Far North Coast regional centres are expected to grow in coming years. Economic growth in the region will be driven by the growing population as well as by tourism, agriculture and industry. Growth is expected to largely occur in the existing urban growth centres including existing major towns (NSW Government, 2016). Population growth in the region is expected to be higher along the coastal fringe, particularly in the Ballina local government area. In recent years, inland parts of the region have grown very little and some areas have seen a decrease in population.

More recently, population growth in regional areas is increasing with the Northern Rivers one of the fastest growing parts of regional NSW:

- Ballina Shire's population is forecast to increase by approximately 8,700 persons to 53,100 people, at an average annual change of 0.90% between 2020 and 2040 (Ballina Shire Council, 2020).
- Lismore's population is forecast to increase by 7,907 persons to 51,750 at an average annual change of 1.0% between 2018 and 2036 (Lismore City Council, 2020c).
- Richmond Valley's population is forecast to increase by 2,251 persons to 25,650 at an average annual change of 0.5% between 2018 and 2036 (Richmond Valley Council, 2020).
- Kyogle's population is forecast to increase by approximately 1,079 persons to 10,246 people, at an average annual change of 0.5% between 2019 and 2041 (Kyogle Council, 2020c).
- Byron's population is forecast to increase by approximately 3,500 persons to 37,500 people, at an average annual change of 0.5% between 2018 and 2036 (Byron Shire Council, 2020b).

19. POTENTIAL LAND USE CHANGES

The Richmond River EMS (Hydrosphere Consulting, 2011b) discussed the barriers to changes to agricultural land uses. More recently, there has been significant effort by industry groups, councils and state government agencies to provide assistance through education, advice and grants. However it is recognised that the costs and benefits of alternative management approaches to high impact activities needs to be undertaken at a farm scale and requires the individual landholders to be involved. A key lack of incentive to alter farming practices is the economic viability of such changes, particularly in the short-term where payback from up-front investment in more sustainable practices may leave significant farm revenue gaps. Economic initiatives that may be available to assist landholders are often dependent on short-term funding that is not consistently available. Additionally, knowledge of such incentives or the time to apply to gain access to such incentives may not be available (Hydrosphere Consulting, 2011b).

A number of studies have evaluated the costs and benefits of a broad range of potential land use changes. Beardmore *et al* (2019) assessed the private on-farm financial impact and the public environmental benefit of land use transition from beef grazing to a mixed beef grazing-forestry system in the Richmond River catchment. They used a farm-scale financial model to assess the costs and benefits associated with transition from grazing to a variety of cattle-forestry mixtures. They also used a multi-criteria approach to assess the environmental outcomes associated with each transition. The results demonstrated that

diversification to a mixed beef grazing-forestry system consistently provides environmental benefit, but the financial impact on landholders varies depending on soil type. Landholders on ferrosol and vertosol soils have favourable options that can simultaneously deliver private and public benefits, whereas landholders on kurosol and dermosol soils are more restricted, with environmental improvements possible only as a trade-off with farm financial performance (Beardmore *et al,* 2019). The study concluded that different policy mechanisms are required to encourage graziers in different parts of the catchment to shift towards mixed cattle-forestry systems. In order to achieve uptake, incentives to engage landholders in on-farm activities need to outweigh impediments to participation, such as transition costs and other time and monetary costs. Beardmore *et al* (2019) suggest that a mixture of strategies is likely to be required including extension services and positive incentives, but each strategy needs to be carefully targeted to specific locations within a catchment.

Larson (2018) discusses the key challenges to riparian restoration relevant to the Kyogle LGA as follows:

- Funding and financial planning – improvements in waterway health can take a long time to accrue following revegetation programs and financial planning needs to consider response times over a number of political cycles. There is currently no levy to fund environmental works in the Kyogle LGA.
- Convincing landholders – the main barriers were identified as time and cost. Loss of fences during flooding, continued maintenance and a perceived lack of necessity for changes to current riparian zone management by some landholders were other impediments identified. This perceived lack of necessity emphasises the need for landholder engagement and agricultural extension. Larsen (2018) also identified the Biodiversity Offsets Scheme (BOS) as a possible avenue to provide monetary compensation to landholders.

Kopf *et al.* (2015) discusses the importance of setting appropriate aims and outcomes for restoration works in human-modified river ecosystems. Past 'pristine' ecosystem condition is unlikely to be an achievable outcome of restoration efforts as many human-modified systems have entered a new and stable state. Kopf *et al.* (2015) propose that alternative targets (Anthropocene baselines) be developed where ecological or socio-economic limitations prevent restoration to a historic baseline condition. The Richmond River CMP will consider a range of management goals for different areas of the catchment according to the level of human-induced modifications and achievable targets at these locations.

20. CLIMATE CHANGE

The Richmond River estuary and catchment will experience broadscale climate change impacts as well as interrelated localised impacts into the future. The Sixth Assessment Report of the IPCC Working Group provides information on climate change within the Australasia region (IPCC, 2021). The findings relevant to the study area are:

- Australian land areas have warmed by around 1.4°C between ~1910 and 2020 (very high confidence), and annual temperature changes have emerged above natural variability in all land regions (high confidence).
- Heat extremes have increased, cold extremes have decreased, and these trends are projected to continue (high confidence).

- Relative sea level rose at a rate higher than the global average in recent decades. Sandy shorelines have retreated in many locations. Relative sea level rise is projected to continue in the 21st century and beyond, contributing to increased coastal flooding and shoreline retreat along sandy coasts throughout Australasia (high confidence).
- The frequency of extreme fire weather days has increased, and the fire season has become longer since 1950 at many locations (medium confidence). The intensity, frequency and duration of fire weather events are projected to increase throughout Australia (high confidence).
- Heavy rainfall and river floods are projected to increase (medium confidence).
- An increase in marine heatwaves and ocean acidity is observed and projected (high confidence).
- Enhanced warming in the East Australian Current region of the Tasman Sea is observed and projected (very high confidence).

Climate change impacts expected within the estuary and throughout the catchment are broad ranging and are summarised in the following sections.

20.1 Sea Level Rise

Global average sea levels increased by around 25 cm since 1880, with the rate of rise accelerating in recent decades. Observations show that the rate of global mean sea level rise increased from 1.5 ± 0.2 cm per decade (1901–2000) to 3.5 ± 0.4 cm per decade (1993–2019) (CSIRO, 2020). However, the rates of sea level rise to the north and south-east of Australia (including the central, south and mid-north NSW coast) have been significantly higher than the global average (CSIRO, 2020). Future sea level rise rates will depend on carbon emission pathways and other influences. Depending on future carbon emission scenarios sea levels around eastern Australia could rise between 0.31 m and 0.88 m (relative to 1986 to 2005) by 2090 (DPIE, 2020). Based on these changes it is expected that sea level rise will result in changes to the study area including:

- Increased tidal propagation into estuaries resulting in changing tidal velocities, storm tide inundation, changed geomorphology (shoaling, bank instability and erosion) and migration of estuarine vegetation communities. Rising sea levels also influence the tidal range and heights within the estuary, which impact on how floodgates operate and the efficiency of drainage systems behind them. The effects of sea level rise may be magnified as freshwater inflows reduce due to climate change.
- Increased salinity in the upper estuary reaches and subsequent impacts on vegetation communities and distribution of fauna species.
- Existing coastal gravity drainage, stormwater infrastructure, sewerage systems and some roads potentially becoming compromised over time as the mean sea level increases.
- Decrease in the level of protection afforded by existing seawalls and other hard engineering structures due to the increasing threat from larger storm surges and inundation at higher projected water levels.
- Increasing salt concentrations in the coastal lowland ASS (CLASS) found in Rocky Mouth Creek and Tuckean swamp and increase in the short-term release of acidity and trace metals (aluminium, iron,

nickel and zinc) (Wong *et al*., 2010b). This is likely to result in rapid, substantial, short-term declines in water quality in backswamp basins containing CLASS following seawater inundation. The interconnectedness of these backswamps to estuaries via artificial drainage channels makes them highly susceptible to surface inundation by seawater as a result of climate change induced sea level rise (Wong *et al*., 2010b). High hydraulic conductivity in the sulfuric horizons is found in some of the CLASS floodplains within the Richmond River catchment (including near Rocky Mouth Creek and Tuckean Swamp) (Johnston *et al.*, 2009b), which may further enhance lateral seawater intrusion and consequently enhance the mobilisation of acidity and metals.

- Increases in the salinity of coastal groundwater aquifers may occur.

20.2 Rainfall Patterns

Extreme rainfall events are associated with storms and flooding. Rainfall extremes in NSW are projected to increase in the near future (2030) and far future (2070) (AdaptNSW, 2020b). The Far North Coast is likely to be subject to more intense storm events, although it is uncertain if the severity of associated flooding will increase (DPIE, 2020).

Climate modelling undertaken for the development of regional water strategies (DPIE, 2020) has found that droughts may be more severe in the future. The region is also likely to see seasonal shifts in rainfall patterns, higher rates of evaporation and more hot days.

Climate modelling also projects a decrease in the number of small to moderate east coast lows (ECLs) in the cool season with little change in these storms during the warm season. However extreme ECLs in the warmer months may increase in number but extreme ECLs in cool seasons may not change (AdaptNSW, 2019a). The severity and frequency of flood-producing rainfall events, such as ECLs as well as impacts due to rising sea levels, may increase. These aspects can increase the risk of flooding particularly in low lying floodplains where ocean influences can also significantly impact flood behaviour. They may also have impacts on blackwater and fish kill events. As sea levels rise and flood producing rainfall events increase in severity, this will increase the exposure of communities to flooding.

20.3 Stream Flows

Water extraction from waterways to meet community and industry demands is likely to increase due to decreases in rainfall and greater evaporative losses. Producers are highly dependent on regular rainfall and therefore highly susceptible to drought. Many of the region's rivers and creeks are already under stress, particularly during low flow periods. Climate modelling shows these pressures could increase, with reductions forecast for river flows and inflows into estuaries, a decrease in the magnitude of both high and low flow events and more cease-to-flow events (DPIE, 2020).

The maximum high tide footprint is expected to increase significantly with sea level rise, potentially putting water extraction in coastal parts of the region at risk. Saline intrusion will make some supplies unfit for use and affect sewage treatment plant operations. Irrigators in tidal pool areas will be affected.

The magnitude of high flow events (ARI >2.5 years) could decrease by 6% in the unregulated rivers, but by up to 10% in Eden Creek, the regulated creek downstream of Toonumbar Dam and 6% in estuaries. This may limit the number of events that trigger fish movement and spawning and also reducing the larger tributary flows that stimulate riverine productivity by transporting dissolved carbon and organic detritus,

micro-organisms, plankton and small animals into the system. There could be an increase in the number of years in which a cease-to-flow event occurs across all regulated, unregulated and estuary inflow systems (DPIE, 2020).

20.4 Related Environmental Impacts

Biodiversity will be impacted by climate change induced rising temperatures, sea levels, fire regimes, water quality and ocean chemistry. This will exacerbate degradation of native communities and expansion of invasive species (DECCW, 2010). Studies suggest climate change could surpass habitat destruction as the greatest threat to biodiversity (Leadley *et al*. 2010). Some of the most vulnerable ecosystems are found within the study area including coastal floodplains and wetlands and saltmarshes and mangroves (EPA, 2021b).

A recent study by Scanes *et al*., (2020) found that in response to climate change the temperature of Australian estuaries has increased on average approximately 2ºC and they have acidified at a rate of 0.09 pH units over the last 12 years. These changes are orders of magnitude faster than predicted in earlier studies. Projected lower flows, higher temperatures and sea level rise may further reduce water quality.

Average and severe fire weather is projected to increase in NSW in the future. Increases in average and severe fire weather are projected to occur mainly in summer and spring, with the largest increases by 2070 to occur in spring (Adapt NSW, 2019c).

20.5 Migration of Estuarine Vegetation

The *Richmond River Estuary Processes Study* (WBM, 2006) states that sea level rise will increase the average depth in the estuary and that tidal propagation up the estuary and potential changes in salinity regime may be expected. It is anticipated that sea level rise will naturally result in the landward recession of fringing estuarine wetland systems. The location of estuarine habitats such as mangrove forests and salt marsh are controlled principally by tidal range and salinity influence and will gradually respond to changes in increases in average water levels and salinity. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, levees, agriculture and urban development on the landward side. Under these conditions the landward side of these important habitats will be fixed but the lower margin will gradually be pared away, leading to a loss of habitat area. Increased estuary levels will affect riparian and other low-lying vegetation in the freshwater reaches of the estuary in a similar way. Waterlogging will gradually kill off the lower vegetation, whereas the upper boundary may be restricted.

Akumu *et al*. (2010) modelled the potential impact of sea level rise on coastal wetland communities in Northern NSW. The model indicated that the area of mangroves, saltmarsh, transitional marshes and estuarine open waters will all increase by the end of the century. The area of tidal flats, non-tidal swamps, inland freshwater marshes and inland open waters all showed decreases according to the model. The modelling did not consider salinity affects, human impacts or physical barriers to migration but provides general indications of vegetation change that could be expected in an unmodified catchment and within the limits of the model. The potential changes in salinity regime and implications for estuarine ecosystems and adjoining land uses has not been fully explored. There may be increasing pressure to reduce saline intrusion into low-lying farm lands and long-term floodgate management policies (see Section 7.5) will need to

consider the implications of sea level rise and potential salinity increases. Similarly, more frequent flooding of low-lying urban areas, such as much of Ballina, creates risks for the estuary in terms of managing urban drainage impacts, potential effects on sewerage infrastructure and overflows.

The Marine Vegetation Strategy (MVS) is a state-wide program currently underway as part of the MEMS to develop estuary specific plans to manage estuarine vegetation. The Marine Vegetation Strategies are being led by DPI Fisheries and aim to provide scientific evidence to support and guide the protection of existing and potential future coastal wetlands. Specifically the strategy for the Richmond River estuary will address the priority threats and risks, maximise wetland values and services, facilitate rehabilitation opportunities and improve resilience for sea-level rise. The strategies aim to take the long-standing NSW policy of 'no net loss of key fish habitats' toward more active management of intertidal systems that maximise and sustain the ecosystem values and services. There is growing recognition that rehabilitation of coastal wetlands is needed to enhance the delivery of important ecosystem services and values such as providing a habitat for terrestrial and aquatic species, improving water quality through filtration, blue carbon sequestration, Aboriginal and cultural heritage values, economic prosperity, fishing and tourism. In particular, there is increasing interest in the rehabilitation of mangroves to allow for improved coastal protection and reduced exposure to coastal hazards. Policy tools and active rehabilitation is required to manage existing wetlands and increase the capacity for mangroves and saltmarsh to migrate inland with sea-level rise.

The MVS use a systematic spatial tool and method for estuary wide prioritisation to map and quantify the potential for mangrove and saltmarsh communities to thrive and deliver social, economic and environmental services under current conditions and into the future under scenarios of sea level rise. The approach integrates datasets which indicate the physical nature of the landscape, anthropogenic exposure and vulnerability to sea level rise to identify high priority areas within estuaries. The high priority areas delimit locations that are ideal priority offset locations and rehabilitation sites and areas where initiatives should be directed to manage existing wetlands and for future trajectories of change. In this way, the MVS can direct rehabilitation projects to the most meaningful locations given the biophysical conditions, anthropogenic exposure and the future wetland trajectory with sea level rise. Outputs include state-wide mapping of macrophyte potential that can be used to identify priority offset locations, rehabilitation sites and areas where management initiatives should be directed. It is anticipated that this work and priority areas in the Richmond River will be available for use in future stages of the Richmond River CMP.

Management Context

21. LAND TENURE

Land tenure within the study area is illustrated on Figure 33 and detailed in Table 10. Most of the study area is freehold land under private ownership (73%). Approximately 12% of land is managed as National Park/Reserve with 9% managed as State Forest primarily in the upper catchment areas of the Kyogle, Lismore and Richmond Valley LGAs with some pockets in the mid catchment and floodplain areas. Crown land that is not managed as part of state forest comprises 0.8% (5,774 ha) of the study area of which 0.02% (138 ha) is managed by local councils and is typically located around urban centres and villages. Council owned land comprises 0.5% (3,608 ha) of the study area. Waterways and riparian land that is not privately owned comprises approximately 1.1% (7,542 ha) of the study area. The beds of most tidal waters and non-tidal waters include Crown land (DPIE-Crown Land, 2021a) however, some private property ownership extends to the middle thread of some waterways, particularly in non-tidal systems.

Table 10: Land tenure within the study area

Land Tenure/LGA	Ballina (ha)	Byron (ha)	Clarence (ha)	Kyogle (ha)	Lismore (ha)	Richmond Valley (ha)	Total (ha)	% of catchment
Freehold land	33,364	21,390	3,704	134,638	109,107	200,907	503,110	73%
National Parks Estate	523	3,438	1,312	45,121	9,020	26,234	85,648	12%
State forest	0	0	0	15,883	1,092	44,929	61,904	9%
Road corridor	1,623	836	104	3,609	4,580	6,940	17,692	3%
Water feature corridor	1,126	369	0	1,511	2,168	2,368	7,542	1%
Crown land	393	74	0	1,424	506	3,378	5,775	1%
Council owned land	301	69	0	139	2,137	962	3,608	1%
Rail corridor	0	69	0	169	114	330	682	0%
Crown land managed by councils	16	10	0	71	24	18	139	0%
Totals	37,346	26,255	5,120	202,565	128,748	286,066	686,100	100%

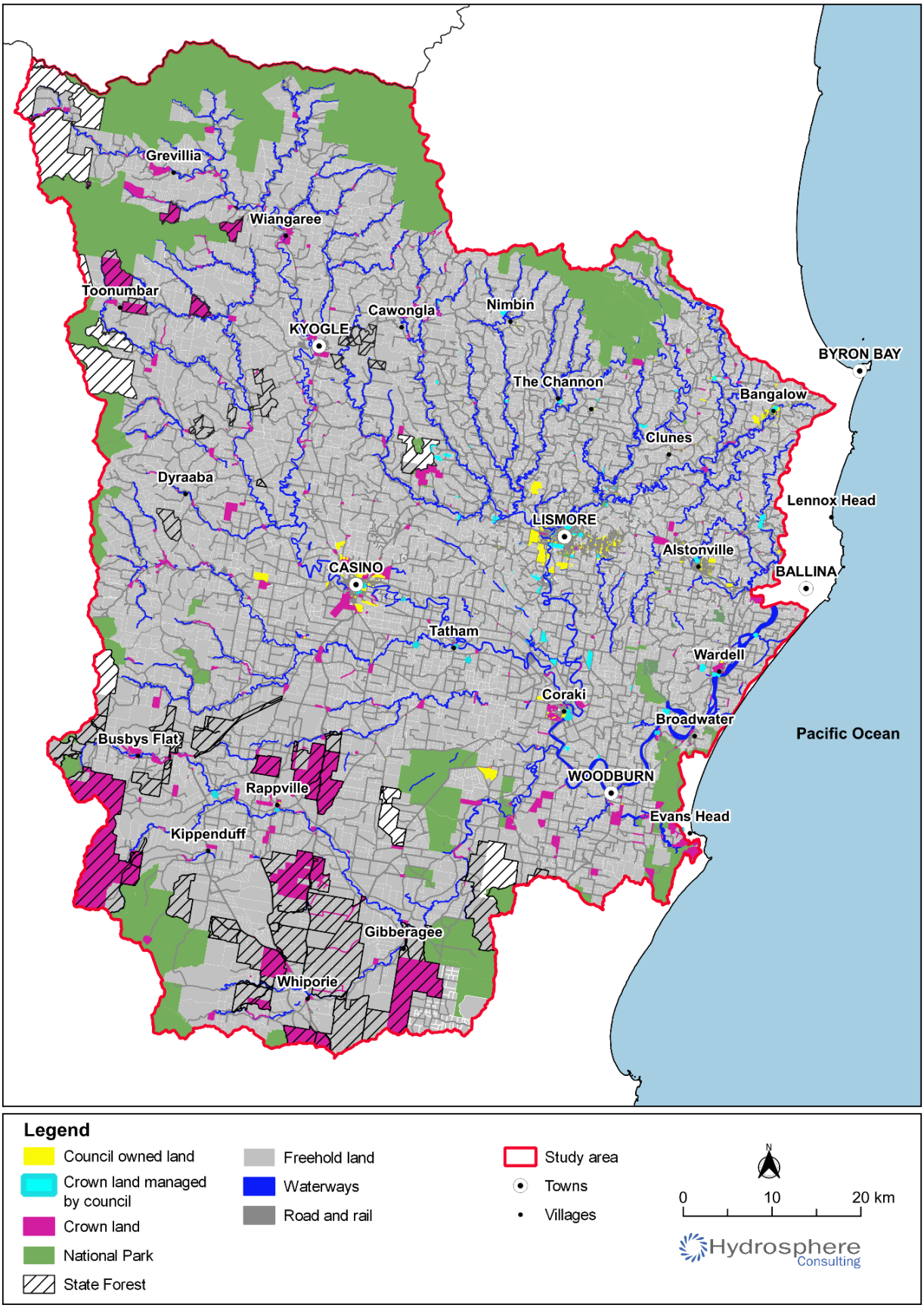

Figure 33: Land tenure within study area

Mapping data supplied by constituent councils and DPIE

22. NATIVE TITLE AND INDIGENOUS LAND USE AGREEMENTS

Australia's native title laws recognise the traditional rights and interests to land and water of First Nations people. Native title holders can take and use water for personal, domestic and non-commercial communal purposes. Native title holders often have water-related aspirations, such as the protection of water, water allocations and advising on water management practices in a determinations area (DPIE, 2020).

The *Native Title Act 1993* (Commonwealth) provides a legal process for recognising the rights and interests of Aboriginal and Torres Strait Islander people in land and waters. Several successful native title determinations and indetermined native title claims exist over parts of the study area (refer Figure 34 and Table 11). All Crown land is considered to be subject to native title rights unless native title is considered to be extinguished (i.e. through granting of freehold estate, mining leases etc.) (DPIE - Crown Land, 2021b; DPIE, 2019). Any activity that impacts on native title is considered to be a 'future act' (specific proposals to deal with land in a way that affects native title and interests) under the *Native Title Act 1993*. Some activities require a notice to be forwarded to the native title claimants' representative body.

Table 11: Native title claims and determinations

Application name	Tribunal file no.	Application status/ Registered Native Title Body Corporate
Native title claims		
Widjabul Wia-bal People	NC2013/005	Active (indetermined)
Native title determinations		
Bandjalang People #1	NCD2013/001	Bandjalang Aboriginal Corporation Prescribed Body Corporate RNTBC
Bandjalang People #2	NCD2013/002	
Bandjalang People #3	NCD2021/001	
Bundjalung People of Byron Bay #3	NCD2019/001	Bundjalung of Byron Bay Aboriginal Corporation (Arakwal)
Western Bunjalung People Part A	NCD2017/002	Ngullingah Jugun (Our Country) Aboriginal Corporation RNTBC
The Githabul People	NCD2007/001	Githabul Nation Aboriginal Corporation RNTBC

Source: National Native Title Tribunal (2021a)

BySC has developed a memorandum of understanding with the Bundjalung of Byron Aboriginal Corporation (Arakwal) recognising the status of the Bundjalung of Byron Bay Arakwal people as traditional owners as established through the Native Title Act and processes. The purpose of this agreement is to establish a clear process and timetable for the delivery of priority projects, participation in governance, cultural and economic development and caring for Country (Byron Shire Council, 2013).

Indigenous Land Use Agreements (ILUAs) are voluntary agreements between native title holders and other people or bodies about the use and management of areas of land and/or waters and act as a contract between the parties (National Native Title Tribunal, 2021a). The ILUAs in place within the study are shown on Figure 34 and Table 12 outlines the subject matters which the ILUAs address.

Table 12: ILUA details

ILUA name	ILUA type	Tribunal file no.	Primary subject matter	Other subject matter(s)
Githabul People ILUA	Area Agreement	NI2006/001	Access	Co-management, consultation protocol, extinguishment, terms of access
Bandjalang Interim Licences ILUA	Body Corporate	NI2018/008	Not specified	
Cavanbah (Byron Bay) Arakwal ILUA	Area Agreement	NI2019/005	Native title settlement	Access, community, consultation protocol
Western Bundjalung Settlement ILUA	Area Agreement	NI2018/001	Government	Consultation protocol, tenure resolution

Source: National Native Title Tribunal (2021a)

Plate 10: Githabul Country – Sheep Station Creek, Border Ranges National Park

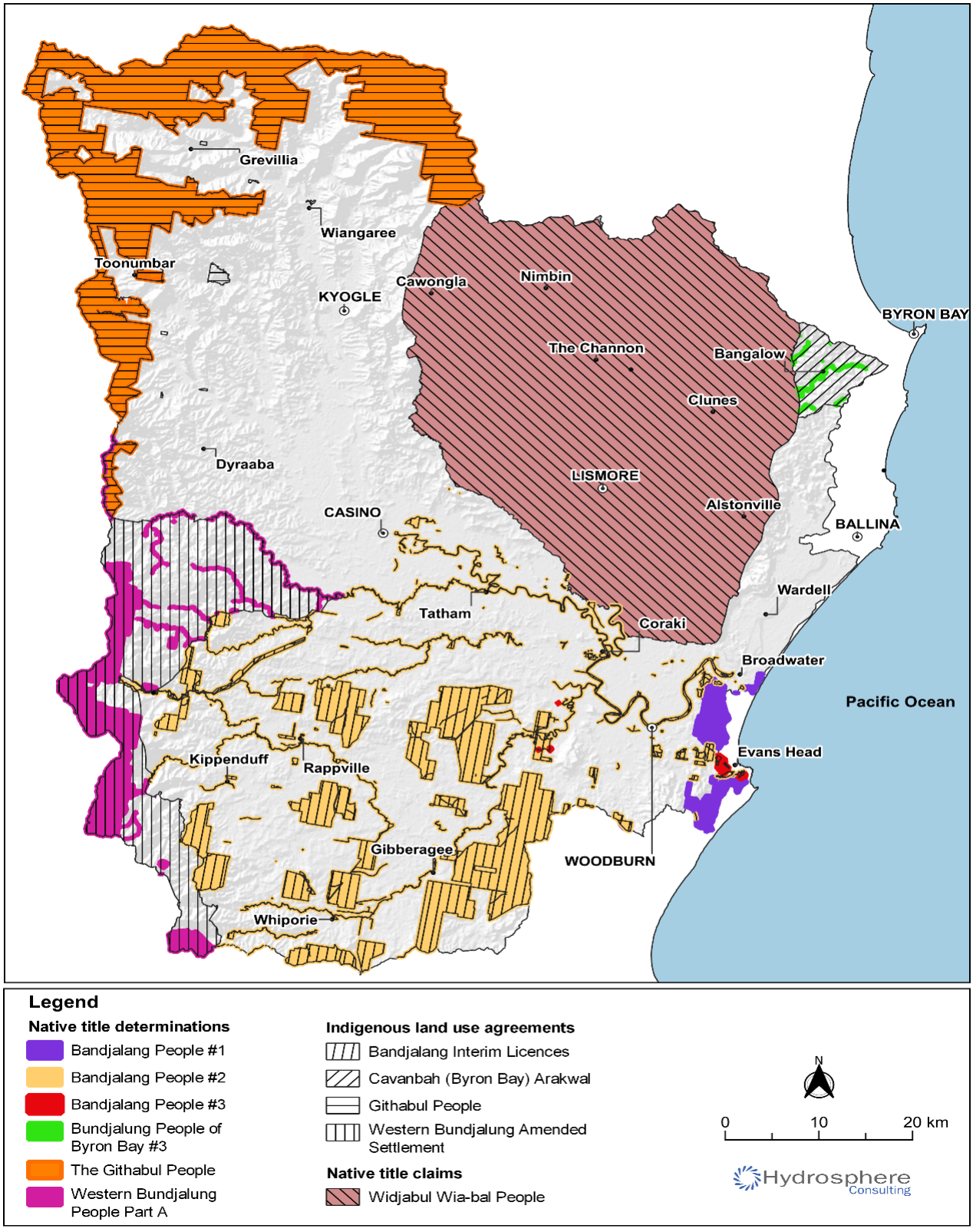

Figure 34: Native title determinations, claims and Indigenous Land Use Agreements

Source: National Native Title Tribunal (2021)

23. MANAGEMENT ROLES AND RESPONSIBILITIES

The study area is managed by local councils, various state government agencies, First Nations groups and private landholders (Table 13). Relevant legislation, regional and local management plans and strategies are discussed in Appendix 1 and Appendix 2. Guidelines and resources relevant to the catchment and estuary are discussed in Appendix 3.

Table 13: Management roles and responsibilities

Agency	Role
BaSC, LCC, BySC, KC, RVC, CVC	Local councils have a central role in managing the waterways, foreshores and catchments of the study area. The councils are responsible for the management of estuarine and catchment assets that include stormwater and drainage infrastructure, waste and wastewater management, open space assets and river foreshore and estuary access points. The councils also manage a range of issues across the study area including cultural heritage, community events, recreational use of foreshore areas, estuary and floodplain management, catchment management and flora and fauna protection and conservation. The councils are also responsible for development planning and controls across the respective LGAs. The objective of these controls is to achieve development that is consistent with the social, economic and environmental values of the study area and to manage the cumulative impact of development in a sustainable manner (refer Section 24).
RCC	RCC is a county council set up to provide the following functions: • Flood mitigation authority and associated natural resource management activities. • Provide water in bulk to the Council areas of Ballina (excluding Wardell), Byron (excluding Mullumbimby), Lismore (excluding Nimbin) and Richmond Valley (excluding land to the west of Coraki). • A wide range of activities to combat the spread of noxious weeds across the local government areas of Ballina, Byron, Lismore and Richmond Valley as well as Kyogle and Tweed Shire as part of a fee for service arrangement, administration of the *Biosecurity Act 2015*, working with landholders and the community throughout the region to address weed biosecurity matters
Native title holders and claimants	Native title exists over many areas of the catchment and several claims remain active (Section 22). Native title holders have traditional ownership of land and waters according to their traditions, laws and customs.
Local Aboriginal Land Councils (LALCs)	The LALCs are constituted under the *Aboriginal Land Rights Act 1983*. LALCs represent their Aboriginal community and aim to protect their interests and further their aspirations. Land is vested in representative land councils who work to deliver tangible economic, social and cultural benefits to Aboriginal communities in NSW. The following LALCs operate within the study area: Tweed Byron LALC, Gugin Gudduba LALC, Muli Muli LALC, Jubullum LALC (Woodenbong), Casino – Boolangle LALC, Bogal LALC, Ngunlingah LALC, Tweed Byron LALC and Jali LALC.

Agency	Role
NPWS	NPWS is responsible for management of National Parks and reserves across the study area. NPWS responsibilities across these areas includes a wide range of activities such as active conservation and habitat protection, fire management, management of tourism and visitation, research and education (refer Section 26)
DPIE – EES	DPIE – EES works closely with local councils and communities to reduce threats from flood risk and coastal storms and ensures that people in NSW are well informed about these risks and better equipped to adapt to climate change. DPIE – EES also works with local councils and communities to maintain or improve the health of estuaries/ lakes and enhance the recreational experience. DPIE - EES provides funding to councils for the development and implementation of CMPs through the Coast and Estuaries Grant Program. DPIE - EES has provided funding to RCC for the development and preparation of this CMP Scoping Study.
DPIE – Crown Lands	DPIE - 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 the estuaries and their associated intertidal areas (below mean high water mark). DPIE – Crown Lands is responsible for the following activities on Crown Land (Section 26): • Crown land management, compliance, bush fire management/ planning, leasing and licensing and reserve administration functions in accordance with the objects and principles outlined in the Act. • Domestic waterfront structures - assessing applications for landowner's consent for domestic waterfront facilities on Crown land, assessing licence applications and issuing licences for the occupation of Crown land for domestic waterfront facilities and ongoing administration, management and regulation of the use and occupation of domestic waterfront facilities on Crown land. • Direct Crown land management responsibilities including activities such as access management, pest plant and animal management.
DPIE - Water	DPIE – Water is responsible for surface and groundwater management including: • Ensuring equitable sharing of surface and groundwater resources and that water entitlements and allocations are secure and tradeable through water sharing plans. • Ensuring water security for NSW. • Managing NSW's water resources through planning, policy and regulation.

Agency	Role
Marine Estate Management Authority (MEMA)	MEMA advises the NSW Government on the management of the NSW marine estate. The Authority brings together the heads of the NSW Government agencies with key marine estate responsibilities (Department of Primary Industries (DPI), DPIE (EES and Planning and Assessment) and Transport for NSW. MEMA ensures policies and programs address priority issues, are well coordinated, efficient, evidence based and result in positive outcomes and undertakes threat and risk assessments, develops management strategies, promotes collaboration between public authorities and fosters consultation with the community.
DPI – Fisheries	DPI - Fisheries administers the *Fisheries Management Act 1994* and the *Marine Estate Management Act 2014* and has jurisdiction over all fish (including oysters, crustaceans, polychaetes), and marine vegetation (saltmarsh, mangroves, seagrass and macroalgae) in State Waters including 'water land' below HAT in the estuaries and extending up to 3 nautical miles offshore. Under the *Fisheries Management Act 1994*, DPI - Fisheries: • Supports economic growth and sustainable access to aquatic resources through commercial and recreational fisheries management, research, aquaculture development, habitat protection and rehabilitation, regulation and compliance. • Mitigates and manages risks from use of land and water. Under the *Marine Estate Management Act 2014*, DPI - Fisheries is responsible for: • Ensuring strategic and integrated management of the whole marine estate – marine waters, coasts and estuaries. • Fisheries and aquaculture management, marine biodiversity, marine protected areas, biosecurity, marine estate research, fisheries compliance, marine estate communications and community engagement.
Heritage NSW	Heritage NSW is responsible for the management and protection of Aboriginal cultural heritage and European heritage in NSW.
Transport for NSW – Maritime (TfNSW – Maritime)	TfNSW – Maritime is the key agency with statutory and policy responsibilities related to the safety and accessibility of NSW waterways for recreational and commercial vessels. The Maritime Infrastructure Delivery Office (MIDO) is a joint initiative between DPIE – Crown Lands and Transport for NSW. A number of relevant DPIE – Crown Lands programs are currently managed through the MIDO including: • Coastal Infrastructure Program (i.e. management of estuary break walls and training walls). • NSW Boating Access Dredging Program. Most activities under these programs are outside the study area (along the coastline and lower estuary areas).

Agency	Role
Landcare/ Bushcare groups	Non-profit community organisations which encourage and support sustainable natural resource management. The organisations undertake a range of projects with landholders, volunteer groups and government agencies including river restoration, farm planning, bush regeneration and some pest control.
EPA	EPA is the primary environmental regulator for NSW. The local councils and other organisations hold environment protection licences issued by the NSW EPA under the *Protection of the Environment Operations Act 1997* for the operation of EPA licensed operations (e.g. sewerage systems, landfill, quarries and other industry etc.).
Natural Resources Access Regulator (NRAR)	NRAR was established in 2018 as an independent regulatory body to oversee water management in NSW. NRAR is responsible for compliance and enforcement of NSW water law and determines when to commence prosecutions or uses other enforcement tools in the event of non-compliance. NRAR also prepares policies and procedures relating to the enforcement powers under natural resources management legislation.
WaterNSW	WaterNSW is the NSW bulk water supplier and operational manager of surface water and groundwater resources. WaterNSW develops and operates infrastructure solutions for water supply security and reliability.
State Emergency Service (SES)	The SES is responsible for provision of emergency and rescue services during times of natural hazard emergencies and disasters, including flooding, storms (including storm tide and severe erosion events) and tsunami events.
North Coast Local Land Services (NCLLS)	NCLLS plays a key role in the management of catchment activities and natural resources relevant to estuary catchments and through the facilitation of relationships between landholders and key environmental organisations. LLS also plays a significant role in relation to vegetation management/clearing in non-urban areas with NSW DPIE - EES providing a compliance role. LLS is also responsible for approval and extension services for private native forestry with the EPA responsible for compliance and enforcement. NCLLS also provides a service to the Federal Government as a vehicle through which federal funding can be distributed to regional and rural landholders. The NCLLS region extends from Tweed Shire Council in the north to Port Macquarie-Hastings Council in the south.
CZMP Implementation Reference Group (IRG)	Oversees implementation of the Richmond River CZMP. The IRG consists of local councils and relevant State Government Agencies.

24. LOCAL GOVERNMENT

Local government is leading the CMP process and is collaborating with land managers, state government agencies, industry and community representatives to provide effective coastal management outcomes. Table 14 and Plate 11 show the proportion of the Richmond River CMP study area within each LGA (refer Figure 1 for study area map). The Richmond Valley LGA makes up the greatest proportion of the catchment comprising 42% of the study area, followed by Kyogle LGA (29%), Lismore LGA (19%), Ballina LGA (5%), Byron LGA (4%) and Clarence Valley LGA (1%).

Table 14: Proportion of Richmond River CMP study area within each LGA

LGA	Area within Richmond River CMP study area (ha)	% of Richmond River CMP study area
Richmond Valley	286,197	42%
Kyogle	202,280	29%
Lismore	128,836	19%
Ballina	37,380	5%
Byron	26,284	4%
Clarence Valley	5,123	1%
Total Area (ha)	686,100	100%

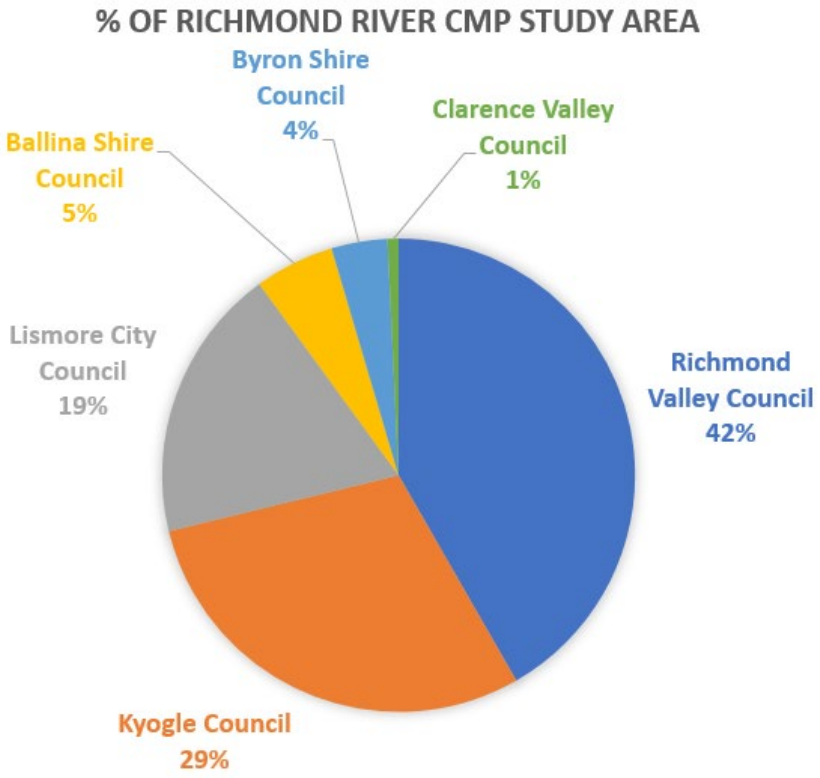

Plate 11: Proportion of Richmond River CMP study area within each LGA

The local councils are responsible for land use allocation and development in the catchment. The councils also have significant planning and development powers as consent authorities under the *Environmental Planning and Assessment Act, 1979.* Together with other government agencies, councils act as an interface between the community and state authorities. As the sphere of government closest to the community, local government is responsible for good governance and the care and protection of local communities within a framework of sustainable development. The Integrated Planning and Reporting Framework (Appendix 2) is the main mechanism by which councils comprehensively plan for and report on their asset management and service delivery responsibilities within the LGA.

As managers of public land and land use planners, local government is responsible for policy development and implementation of land use planning as well as regulating a wide range of activities that may impact upon natural resource management. Local government also has a key role to play in translating the policies of Commonwealth and state governments into on-ground projects.

Local Government has a range of functions, powers and responsibilities at its disposal to influence natural resource management - on both private and public land. These include:

- Strategic planning through land use zoning and statutory controls on all freehold land and locally managed public open space.
- Development control of activities and works on land as specified by Local Environmental Plans (LEPs).
- Enforcement powers for development consent conditions, waste management and unauthorised land uses (e.g. land clearing, drainage, and filling).
- Administrative responsibility for state agency coordination through integrated planning, licensing and development concurrence.
- Stormwater management and control, sewerage and drainage work and flood control.
- Pest, plant and animal risk control measures.
- Influence over land clearance patterns through incentive programs (planning amendments, rate differentials, levies, rural fire management and developer contributions).
- Management of local open space to restore remnant vegetation and recreate habitat.
- Primary advocate for and coordinator of local community groups and interests.

Despite these functions and responsibilities, local government is constrained by the current planning and legislative framework and by the funding and resources available to implement actions that will significantly improve the health of the Richmond River. Due to the large size of the Richmond River catchment combined with the range of complex and often competing threats to be addressed in the study area, the implementation of management actions can be hampered by the lack of financial and human resources. As with many regional council areas, the Richmond River LGAs have relatively small rate payer bases to fund improvement actions, particularly the smaller LGAs of Kyogle and Richmond Valley. The councils rely on external grant funding (e.g. from the NSW Government) to supplement Council revenue although this does not fully overcome the funding limitations faced by some councils. Funding must also be balanced against the many other responsibilities of councils and requirements for funding.

There are many other stakeholders involved in the management of the Richmond River CMP study area. This can create competing interests and priorities and the other agencies involved in catchment, estuary and coastal management are also constrained by the available funding and resources. The councils have established working relationships with other agencies, particularly NPWS, DPIE – EES, MEMA, NCLLS, DPIE- Crown Land and DPI – Fisheries through the CZMP IRG and ongoing management. The councils have also established working relationships with industry and community groups with the joint funding and implementation of a range of actions within the catchment.

25. MARINE ESTATE MANAGEMENT AUTHORITY

The *Marine Estate Management Strategy 2018 - 2028* (MEMS) (MEMA, 2018) provides an overarching strategic approach to the coordinated management of the NSW marine estate, i.e. the coastal waters, estuaries, lakes, lagoons and coastal wetlands. The Strategy considers the ten MEMA management principles as well as priority threats for the marine estate as identified in the NSW marine estate threat and risk assessment (TARA, BMT WBM, 2017).

The TARA identifies and assesses threats and risks to environmental assets and natural attributes and social, cultural and economic benefits (community benefits). Threats and their associated risks were assessed at a state and regional scale. The Richmond River is within the North Region (from Tweed Heads to Stockton). The final state-wide TARA identified water pollution from diffuse sources and stormwater discharge as the number one threat to the marine estate. In the North Region the high priority threats to estuarine waters were identified as (BMT WBM, 2017):

- Extraction, artificial barriers to riverine and estuarine flow (e.g. dams, weirs, waterway crossings, floodgates), urban drainage, impervious surfaces; flood mitigation.
- Urban stormwater discharge.
- Clearing riparian and adjacent habitat including wetland drainage.
- Agricultural diffuse source runoff.
- Climate and sea temperature rise.
- Altered storm/cyclone activity due to climate change.

The MEMS sets out nine initiatives and the actions needed to deliver improved management of the marine estate over 10 years from 2018 - 2028. The initiatives were developed based on the TARA, stakeholder and community feedback and marine estate values:

1. Improving water quality and reducing litter.
2. Delivering healthy coastal habitats with sustainable use and development.
3. Planning for climate change.
4. Protecting the Aboriginal cultural values of the marine estate.
5. Reducing impacts on threatened and protected species.
6. Ensuring sustainable fishing and aquaculture.

7. Enabling safe and sustainable boating.
8. Enhancing social, cultural and economic benefits.
9. Delivering effective governance.

Some MEMS actions have included pilot projects in Stage 1 and Stage 2 (current stage to June 2022) in the Richmond River and other management actions have state-wide benefits. There is significant overlap between the MEMS and the NSW Coastal Management Framework in terms of aims and objectives, issues to be addressed and proposed management actions. This is particularly evident in the Richmond River catchment where a large number of MEMS projects are currently underway to address threats to the Richmond River (Table 15). In addition to these on-ground projects, a number of state-wide projects being undertaken by MEMA are also relevant to the management of the Richmond River catchment. The implementation of the MEMS since 2018 in the Richmond River catchment aims to address many of the key issues impacting on the health of the Richmond River and there appears to be many opportunities for integrating the MEMS with the CMP to draw on the work done to date and collaborate with future projects. However detailed information on many of the ongoing MEMS projects (including location of on-ground works in the catchment and study outcomes) are currently not available to allow for full understanding of the status of actions at this stage. MEMA prepares regular summary updates on the status of MEMS projects and further details are expected to become available during the development of the CMP.

Table 15: Richmond River CMP study area MEMS initiatives (Stage 1 and 2)

No.	MEMS initiative	MEMS icon	Richmond River MEMS initiatives	LGA
1.	Improving water quality and reducing litter.		Risk-based framework for regional waterway health - support the establishment of a new governance framework for the Richmond River catchment to manage diffuse source runoff in a regional area.	Kyogle, Lismore, Ballina, Richmond Valley
			Coastal Floodplain Study - audit existing floodplain infrastructure such as drains and flood gates and prioritise remediation opportunities. Draft report for the Richmond River Floodplain was available May 2021.	Lismore, Ballina, Richmond Valley, Clarence Valley
			Riverbank vegetation improvements - rehabilitating degraded riverbank vegetation to reduce sediment and nutrient runoff into waterways, help stabilise riverbanks and improve biodiversity. Projects were carried out in the Emigrant Creek catchment with 36 landholder agreements and 70 ha of native vegetation protected and enhanced along 38 km (MEMA, 2021e).	Ballina
			Clean coastal catchments research - researching fertiliser use and ways to reduce nutrient and sediment runoff from farms.	Ballina
			Riverbank stabilisation - Protecting riverbanks from erosion to reduce the amount of sediment entering waterways. 2.3 km of bank protection has been undertaken at 5 sites in the Emigrant Creek catchment (MEMA, 2021e).	Ballina
			Improving roads and tracks - Reducing sediment runoff into waterways from gravel roads and tracks by rehabilitation works such as road sealing. 11.6 km of BaSC roads dirt roads were sealed in the Emigrant Creek catchment including known problem and high traffic sites such as Houghlahan's Creek Road, Cumbalum Road and Howards Lane (MEMA, 2021e).	Ballina

No.	MEMS initiative	MEMS icon	Richmond River MEMS initiatives	LGA
2.	Delivering healthy coastal habitats with sustainable use and development.		Domestic waterway structure strategies - developing estuary-wide strategies for jetties, pontoons and boat ramps to streamline approvals while protecting aquatic habitat.	Byron, Lismore, Ballina, Richmond Valley
			Marine vegetation strategies - Developing estuary-wide strategies for rehabilitating and protecting mangroves and saltmarsh so they are more resilient to key threats.	Lismore, Ballina, Richmond Valley
3.	Planning for climate change	-	None focus on Richmond River LGAs however state-wide monitoring, modelling and research will assist in filling knowledge gaps and guide future management actions to prepare for climate change.	-
4.	Protecting the Aboriginal cultural values of the marine estate.		Cultural economic development - increasing the number of people engaged in Aboriginal businesses in the marine estate.	Kyogle, Byron, Lismore, Ballina, Richmond Valley, Clarence Valley
5.	Reducing impacts on threatened and protected species.	-	None focus on Richmond River LGAs however many state-wide programs provide information and assist in improving strategic planning and management to protect threatened and protected marine wildlife from harm.	-
6.	Ensuring sustainable fishing and aquaculture.		Fisheries enhancements - improve fishing access by fish stocking and artificial reef installation at key places and planning fishing platforms (outside study area).	Richmond Valley
7.	Enabling safe and sustainable boating.		Boating Now - working with partners in the Boating Now program to improve safe and sustainable access to the marine estate	Ballina, Richmond Valley, Clarence Valley

Source: MEMA (2021b); LLS (undated).

26. NATIONAL PARKS AND RESERVES

NPWS manages National Parks estate in the Richmond River catchment including:

- Coastal reserves: Bungawalbin National Park (NP) & State Conservation Area (SCA), Yarringully Nature Reserve (NR) and SCA, Tuckean NR, Broadwater NP, Bundjalung NP, Little Pimlico Island NR.
- Catchment reserves: Border Ranges NP, Nightcap Ranges NP, Whian Whian SCA.

Table 16 provides a summary of the significant coastal and catchment reserves identified by NPWS within the Richmond River CMP study area. The table includes details of management plans in place including specific management objectives. Ballina Nature Reserve was included in the study area and Scoping Study for North Creek. South Ballina Nature Reserve is in the study area for the Ballina coastline CMP.

Table 16: NPWS Estate within the study area

NPWS Estate	Summary description	Plan of Management objectives
Tuckean NR	Tuckean NR covers an area of approximately 916 ha on the Tuckean Swamp near Broadwater in far northern NSW. The Reserve is a remnant of the original swamp that has now been largely cleared and drained for agriculture (NPWS, 2002). Runoff from the Tuckean Swamp feeds into the Richmond River and is occasionally a source of poor-quality water. NPWS is currently engaged in floodplain/wetland recovery projects in the Tuckean Swamp sub-catchment.	*Tuckean Nature Reserve Plan of Management* (NPWS, 2002) specific management objectives: • Manage the Reserve as part of a regional network of wetland reserves. • Manage the Reserve as a dynamic, evolving landscape due to the hydrological changes of the area. • Conserve and protect the Reserve's threatened flora and fauna and regionally significant species. • Allow the succession of rainforest species in some sections of the Reserve while recognising the need to protect Melaleuca swamp forest. • Maintain a hydrological regime that minimises the acidification of waters in the Reserve and aims at generally improving the quality of waters discharged from the drainage network. • Provide for the re-establishment of mangrove communities by changing the management of the tidal barrage to restore tidal regimes. • Minimise introduced species and exclude domestic stock from the Reserve.
Broadwater NP	Broadwater NP extends north of Evans Head towards the village of Broadwater and covers approximately 4,290 ha (NPWS, 2012). Native title is registered over the park (NC96/16) "Bandjalang People Number 1". Only the area west of the Evans Head – Broadwater Rd is included in the study area for the CMP. A large area of park drains to the Salty Creek -Salty Lagoon system which is located near the coastline and is not included in the study area.	*Broadwater National Park Plan of Management* (NPWS, 2012b) specific management objectives: • Implementation of threatened species Priorities Action Statements and recovery plans. • Fire and pest management to increase the park's ability to cope with future disturbances, including climate change. • Continued liaison with RVC regarding the Environmental Monitoring Program and Salty Lagoon Rehabilitation Strategy. • Consultation with Bandjalang Native Title Claimants and Jali LALC. • Maintenance of Broadwater Lookout and Broadwater Beach Day Use Areas as the focus for recreation in the park.

NPWS Estate	Summary description	Plan of Management objectives
Bungawalbin NP, SCA & NR and Yarringully NR & SCA	The Bungawalbin and Yarringully parks and reserves are located approximately 30 km west of Evans Head in north-eastern NSW and cover an area of 6,701 ha. The Bungawalbin wetland cluster has been identified as the 'largest tidal water pool in Australia' and has a high level of biodiversity and a large number of threatened species. Lower Bungawalbin Creek is listed as a wetland of national importance (NPWS, 2012a).	*Bungawalbin and Yarringully Parks and Reserves Plan of Management* (NPWS, 2012a) specific management objectives: • Implementation of the Priority Action Statement, recovery actions for threatened species, endangered populations and endangered ecological communities. • Fire and pest management to increase the ability of these reserves to cope with future disturbances including climate change. • Encouragement of research into the natural values of the planning area that will contribute to management and understanding of the area's values. • Liaison with Northern Rivers Catchment Management Authority, RCC and RVC regarding catchment management planning. • Consultation with Bandjalang Native Title Claimants and Bogal LALC about protection of cultural heritage values. • Allowing the continuation of current visitor activities in the planning area and monitoring visitor impacts along Bungawalbin Creek and at Neileys Lagoon to determine appropriate ongoing management, including the need for controls in the future. • Continuation of efforts to inform visitors of permissible access, encourage appropriate visitor behaviour and undertake enforcement as required.

NPWS Estate	Summary description	Plan of Management objectives

Bundjalung NP	Bundjalung NP extends from South Evans Head south to the Clarence River. The Park covers approximately 3,800 ha (NPWS, 1997). Only a small area of the northern part of the park is included in the study area for the CMP.	*Broadwater National Park Bundjalung National Park and Iluka Nature Reserve Plan of Management* (NPWS, 1997) specific management objectives:
		• The protection of the planning area as part of a regionally important system of national parks and nature reserves on the north coast of NSW.
		• The protection of geomorphological and hydrological features within Broadwater and Bundjalung National Parks.
		• The maintenance of biodiversity with priority given to the protection of those communities in the planning area containing endangered and vulnerable species, particularly heathlands and littoral rainforest communities in Iluka Nature Reserve and Bundjalung National Park.
		• Protection of the natural values and the recreational setting of the Esk River within Bundjalung National Park.
		• Protection of the remote natural area setting within the designated Primitive Area of Bundjalung National Park.
		• The protection of Aboriginal sites and places, and the provision of opportunities for the Aboriginal community to be involved in the management of the planning area.
		• Promotion of public awareness and appreciation of the planning area with emphasis on:
		  ○ The importance of the planning area in the regional pattern of conservation areas on the NSW north coast.
		  ○ The physical and biological significance of the coastal environment for the conservation of native plants and animals.
		  ○ Appropriate use of the of the two national parks and the nature reserve.
		  ○ Appreciation of Aboriginal and historic heritage.
		• Ensuring that the pattern and level of outdoor recreation is appropriate to the conservation objectives for the planning area with emphasis on the provision of a range of vehicle and walking access opportunities and low-key facilities.

NPWS Estate	Summary description	Plan of Management objectives
Little Pimlico Island NR	Little Pimlico Island NR is located within the Richmond River estuary1.5 km from Wardell and covers an area of 16 ha. It supports significant areas of natural habitat including wetlands and littoral rainforest (NPWS, 2008).	*Little Pimlico Island Nature Reserve Plan of Management* (NPWS, 2008). Conservation of the reserve's values will be achieved through the following management directions: • Management of the reserve as a part of a regional network of coastal and estuarine reserves. • Conservation of natural habitats within the reserve, with emphasis on the protection of wetland and littoral rainforest habitat of State significance. • Maintaining minimal use of the reserve for recreation activities. • Recognition and protection of the traditional and contemporary Aboriginal cultural heritage values in partnership with the local Aboriginal community.
Border Ranges NP, Nightcap NP, Goonengerry NP & Mount Jerusalem NP	These parks each form part of the Mt Warning shield volcano and are located in the upper-northern extent of the Richmond River catchment. They contain subtropical rainforest, wet and dry sclerophyll forest and pockets of sub-montane heath which provide habitat for a large number of threatened plant and animal species.	*Parks & Reserves of the Tweed Caldera Plan of Management* (NPWS, 2004). Conservation of the values of the Tweed Caldera NPs and NR will be achieved through the following management directions: • Recognition and protection of the World Heritage values through managing fire, introduced species, threatened species habitat and populations and visitor use. • Protection and enhancement of scenic values through the management of visually prominent infrastructure, park facility design and location and the rehabilitation of disturbed sites. • Recognition and protection of traditional and contemporary Aboriginal cultural heritage through cooperative arrangements and cultural site protection. • Recognition and protection of historic heritage through identification and protection of historic resources. • Protection of wilderness area values through limiting management only to works essential for public safety and environmental protection for pre-existing walking tracks and lookout points. • Protection of water catchment values through the management of fire, roads, trails and tracks and visitor areas including waste disposal. • Protection of significant vegetation communities and threatened plant and animal species through managing fire, introduced plants and animals and visitor use. • Protection of habitat on adjoining lands.

NPWS Estate	Summary description	Plan of Management objectives
Border Ranges NP, Nightcap NP, Goonengerry NP & Mount Jerusalem NP (continued)		• Pest species management through strategic planning, control and research programs. • Fire management to protect life, property and biodiversity through fire planning and control programs. • Provision of sustainable public vehicle access to visitor areas through designating the road network, maintenance standards, road and parking improvements and cooperative arrangements with adjoining local government agencies. • Management of existing day use and camping areas in a sustainable and complementary way through designating settings and capacities for each area. • Provision of sustainable and complementary opportunities for bushwalking, horse riding, cycling and adventure activities through identifying appropriate routes and sites, management standards, strategic planning, codes of conduct and cooperative arrangements with recreation groups. • Encouraging commercial tourism opportunities that are sustainable and compatible with park values through licensing appropriate activities, promoting best practices and cooperative planning and management in partnership with tourism operators and agencies. • Integrating and promoting interpretive and educational opportunities through strategic planning, signage, publications and programs to assist in visitor understanding and enjoyment. • Improving knowledge of natural and cultural heritage, corresponding threats and the evaluation of management programs through research and monitoring programs. • Management of pre-existing non-park related uses through licensing, cooperative arrangements and appropriate site management.

NPWS Estate	Summary description	Plan of Management objectives
Whian Whian SCA	Whian Whian SCA is located 35km North of Lismore and 45 km West of Byron Bay, between Nightcap and Goonengerry NPs. It comprises 2,435 ha which forms a large part of the Rocky Creek Dam catchment (NPWS, 2010a), the major water supply source for the region.	*Whian Whian State Conservation Area Plan of Management* (NPWS, 2010a) specific management objectives: • Conserve and protect natural values in the reserve, with emphasis on rainforest, and rare and threatened plants and animals. • Protect the water catchment of Rocky Creek Dam. • Protect traditional and contemporary Aboriginal cultural heritage in partnership with the local Aboriginal community. • Rehabilitate disturbed areas and minimise the impact of pest species. • Manage fire to protect life, property and biodiversity. • Manage roads and trails to provide sustainable public vehicle access and for management purposes and emergency access. • Ensure that recreation and commercial tourism activities are undertaken in a sustainable and complementary way, that integrates with the management of the adjacent Nightcap NP. • Provide interpretive and educational information that assists in visitor understanding and enjoyment of the SCA and promotes appropriate visitor behaviour. Encourage appropriate research into the values of the SCA, and in particular, rare and threatened species.

27. CROWN LAND

Crown land is held by the NSW Government on behalf of the public. It includes land, coastal areas, waterways, built assets, and community infrastructure. It is a unique and complex estate comprising rangelands in the west, forests, grasslands and mountain terrain through to waterways across NSW, expansive stretches of coastline. *Crown Land 2031* (DPIE - Crown Land, 2021c) is the first State Strategic Plan for Crown land and sets the ten-year vision for Crown land in NSW as: "*Crown land supports resilient, sustainable and prosperous communities across NSW*". It reflects government and community aspirations to deliver social, environmental and economic benefits from Crown land. It has been developed with input from community and stakeholders to set a foundation for a new and more flexible approach to the use and management of Crown land. The strategy aims to activate Crown land to grow tourism, support community groups, boost regional economies, advance Aboriginal interests, and provide more green open space. The five overriding priorities of the plan are:

- Strengthen community connections with Crown land.
- Accelerate economic progress in regional and rural NSW.
- Accelerate the realisation of Aboriginal land rights and native title in partnership with Aboriginal people.
- Protect cultural heritage on Crown land.
- Protect environmental assets, improve and expand green space and build climate change resilience.

Crown land parcels in close proximity to waterways and particularly those parcels managed by local council present an opportunity for riparian restoration works to improve water quality and environmental values. Works located on Crown Land that is not council-managed (including all works below mean high water mark) requires landowner's consent and a permit/licence from DPIE - Crown Lands. These opportunities align with the objectives of the CMP and would be carried out in collaboration with native title holders and/or traditional owners. The councils will need to prepare Plans of Management for Crown Reserves under the *Crown Land Management Act 2016* and the *Local Government Act 1993*. Site specific plans contain detailed management strategies that target the unique values of the area, provide for the protection and enhancement of its social, cultural and/or natural attributes, identify likely future pressures and facility/service requirements and outline priorities, actions and work programs for the effective long-term management of the community land or Crown reserve area.

28. COASTAL MANAGEMENT PLANS

28.1 CZMP for the Richmond River Estuary

The Richmond River CZMP (Hydrosphere Consulting, 2011a) was prepared in 2011 to provide a ten-year strategic plan for the implementation of key actions to address identified estuary issues. The CZMP was certified in 2012. The primary goal of the plan was to achieve integrated, balanced, responsible methods to restore and maintain the ecological sustainability of the estuary as well as the recreational and commercial activities associated with it. The study area included the tidal waterways, foreshore and adjacent lands of the

Richmond River estuary, including the entrance and lower reaches of the major tributaries. The study mainly focused on the immediate catchment of the estuary rather than the entire river catchment.

Estuary management zones were developed by the Richmond River Floodplain Committee to divide the floodplain into manageable units that provide a more suitable scale to illustrate geographic features and issues for this expansive floodplain (Figure 35):

- Zone 1 - North Creek (not addressed in the Richmond River CMP Scoping Study).
- Zone 2 - Emigrant / Maguires Creek (parts of this zone within the Ballina urban area and coastline are not addressed in the Richmond River CMP Scoping Study).
- Zone 3 – Back Channel.
- Zone 4 – South Ballina/Empire Vale (parts of this zone within the Ballina urban area and coastline are not addressed in the Richmond River CMP Scoping Study).
- Zone 5 – Riley's Hill.
- Zone 6 – Evans River (parts of this zone within the Evans Head urban area and coastline and Salty Creek/Salty Lagoon catchment are not addressed in the Richmond River CMP Scoping Study).
- Zone 7 – Rocky Mouth Creek.
- Zone 8 – Swan Bay.
- Zone 9 – Kilgin/Buckendoon.
- Zone 10 – Tuckean.
- Zone 11 – Lower Bungawalbin.
- Zone 12 – Upper Richmond/Wilsons River.

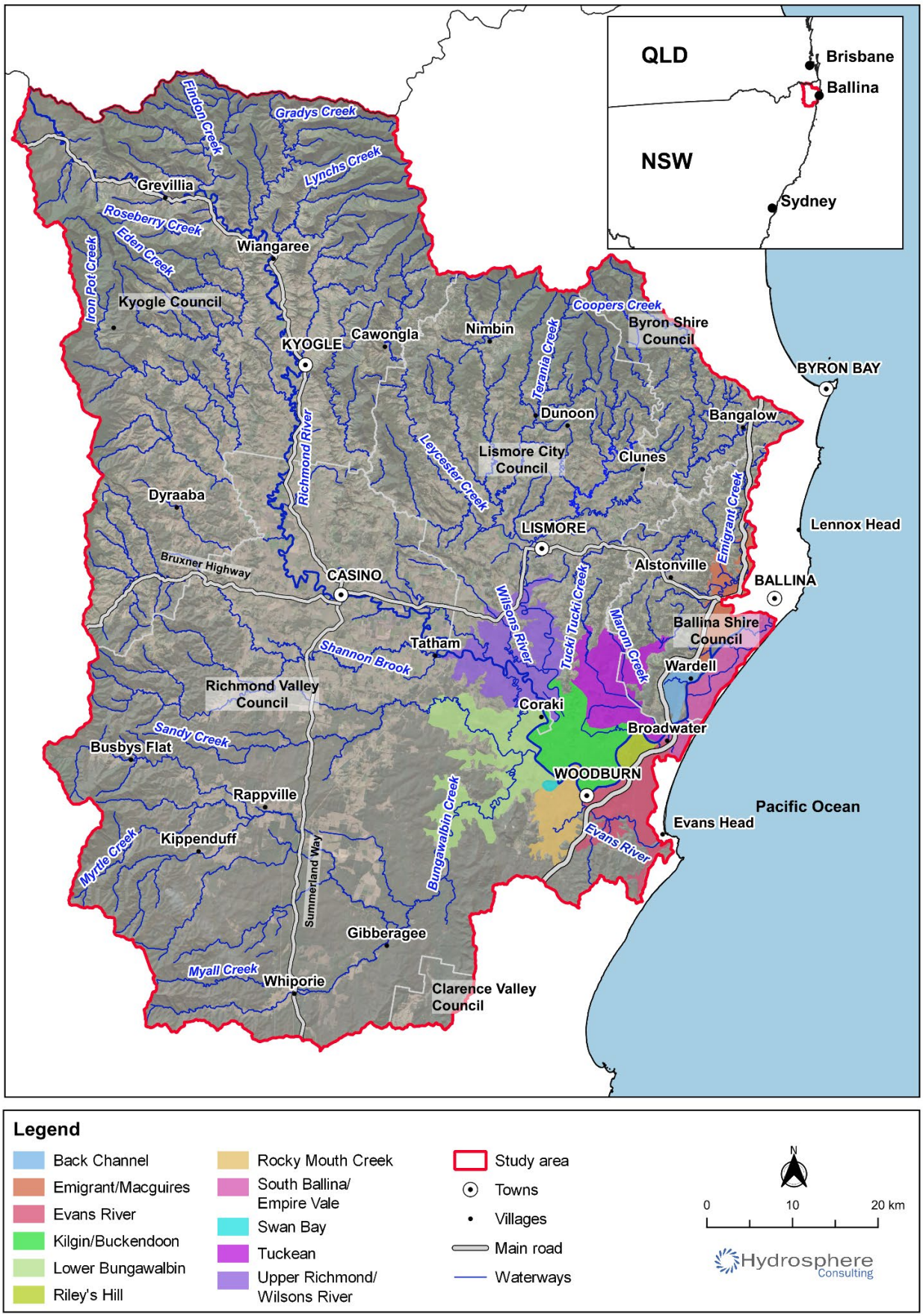

Figure 35: Richmond River CZMP estuary management zones

Source: Adapted from Hydrosphere Consulting (2011a)

The plan was developed from the recommendations and outcomes reported in the *Coastal Zone Management Plan for the Richmond River Estuary – Volume 2: Estuary Management Study* (Richmond River EMS) (Hydrosphere Consulting, 2011b) and supported by scientific knowledge from the Estuary Processes Study (EPS) (WBM, 2006; ABER 2007; ABER 2008). The Richmond River EMS assessed management options in terms of their capacity to address the identified issues, taking into consideration social, environmental and economic factors. The prioritised options were grouped into 13 strategies for on-ground implementation and these strategies formed the basis of Richmond River CZMP. Administration and Governance (strategy 1), Climate Change Adaption (strategy 2) and [on-going] Monitoring, Evaluation and Review (strategy 3) were recognised as important for long-term effective management of the estuary and the successful implementation of the plan and were included as fundamental management activities. Floodplain Infrastructure Management (strategy 4) and Farm Management (strategy 5) were considered the greatest management challenges for the estuary and a high level of resources was recommended for implementing strategies addressing these issues. Medium priority strategies identified in the plan include actions relating to Riparian Zone Management and [bank] Erosion (Strategy 6), [floodplain] Vegetation Management (strategy 7), [community] Education (strategy 8), Waterway Usage (strategy 9), Wastewater Management (strategy 10) and Urban Runoff (strategy 11). All were considered to have a key role in improving estuary health and resilience. Cultural Heritage (strategy 12) and Fishery Management (strategy 13) were identified as important values of the Richmond River estuary.

28.2 CZMP mid-term review

The *CZMP for the Richmond River Estuary: Mid-Term Review* (Hydrosphere Consulting, 2017) documents a review of the implementation progress of the Richmond River CZMP undertaken at the start of year five of the ten-year implementation program. The mid-term review provides a status report on the CZMP implementation progress, expenditure to date, discusses any barriers to successful implementation of the CZMP and identifies the remaining actions and commitments in the CZMP. The review was undertaken by RCC in consultation with the Richmond River CZMP stakeholders (constituent councils and government agencies) and provided information to the stakeholders to inform decisions regarding the future management of the Richmond River.

The mid-term review found that (Hydrosphere Consulting, 2017):

- Of the 27 actions, five were on target or complete in accordance with KPIs, 13 were partially completed, eight had had no progress towards them and one (CZMP review) was not yet required.
- Governance issues were yet to be properly resolved.
- Progress on estuary health projects had mainly been achieved through initiatives planned and delivered independently by the stakeholders and that much of the progress may have been achieved by stakeholders pursuing their own strategic objectives irrespective of their involvement in the CZMP.
- A significant amount of the funding spent (65%) was spent on research and studies, many of which did not fully meet the intentions of the CZMP and/or the recommendations from these studies did not appear to have been implemented in a targeted manner.

- Ineffective governance and administration arrangements and the lack of a clear funding pathway were identified as the main roadblocks to successful implementation of CZMP actions as well as a lack of funding, particularly for works on private land.

The main recommendation of the mid-term review was that stakeholders resolve governance and administration issues as a priority to establish strategic priorities and facilitate a strategic and prioritised approach to implementation.

28.3 CZMP for the Evans Head Coastline and Evans River Estuary

The Evans Head CZMP (Hydrosphere Consulting, 2013) provides a ten-year strategic plan for the implementation of key actions that are recommended to achieve the objectives for management of the Evans Head coastline and Evans River estuary. The main aim of the CZMP is to protect and enhance the key values of this area by increasing resilience of the coastal zone and addressing key threats through efficient, effective and timely management. The Evans Head CZMP was not certified as it did not meet the requirements of revised guidelines published by the NSW Government at the time.

The plan was supported by the scientific knowledge from the *Evans Head Coastline Hazard and Estuarine Water Level Definition Study* (WorleyParsons, 2012), the *Evans River Estuary Processes Study* (PBP, 1999) and the *Evans River Estuary Management Plan* (WBM, 2002) and is consistent with the Richmond River CZMP to support the catchment-wide initiatives, ensuring the detailed issues identified by the Evans Head CZMP were considered appropriately within the context of the Richmond River. The estuarine reaches considered in the study start at the mouth of the Evans River and extend to the upstream extent of Tuckombil Canal at Tuckombil Weir, near Woodburn, including the surrounding Evans River catchment. The Evans Head urban area and coastline will not be addressed in the Richmond River CMP.

The development of the management strategies followed a structured approach to assessing management options built on the current scientific understanding of the estuary and coastline, the identified issues, and the established values and objectives for management of the study area and a quadruple bottom line assessment (i.e. considering environmental, social, economic and governance factors).

The management strategies, which contain one or more actions for implementation, were grouped into three main categories - Coastal Risks, Coastal Ecosystem Health and Community Uses of the Coastal Zone. Many of the strategies and actions are related to issues and areas outside the study area of this Scoping Study (coastline and Evans Head urban area) and the status of these actions has not been addressed in this report.

28.4 North Creek CMP Scoping Study

North Creek is a sub-catchment of the Richmond River joining the main river stem close to the ocean entrance at Ballina. BaSC has prepared the *North Creek Coastal Management Program – Stage 1 Scoping Study* (Alluvium, 2019a). The North Creek catchment is expected to be included in Stages 3 - 5 of the Richmond River CMP.

The following priority management issues were identified by the study (Alluvium, 2019a):

- Catchment runoff – including agricultural diffuse runoff, diffuse urban stormwater and acid sulfate soils runoff. For the purposes of the scoping study, these stressors were combined and referred to collectively as catchment runoff.
- Altered hydrology – including changing patterns of surface and groundwater interactions and altered drainage patters across the catchment.
- Climate change - focusing on the implications of climate change on sea level rise and increasing tidal inundation across the catchment.
- Sand mining and dredging - including sand mining activities in the catchment and dredging in the lower estuary reaches.

The Scoping Study recommended further investigation of the topography, bathymetry and hydrodynamics of the catchment, implementation of a water quality monitoring program and development of a source catchment model to assess pollutant pathways through the catchment. Those Stage 2 detailed studies for North Creek are expected to be undertaken from 2021/22.

29. REVIEW OF GOVERNANCE

The governance of the Richmond River estuary is complicated with no overriding body responsible for its management as a whole. Management activities are currently carried out through a range of different programs, by the various stakeholders and through various sources of funding. For example, RCC floodplain management responsibilities are limited by legislation with funding by the local general purpose councils under Service Level Agreements. Together, the local Councils and various state government agencies are responsible for other natural resource management aspects of the estuary (such as pollution control, climate change, stormwater management, sewerage, environmental water management, land management, Crown lands, agriculture, fisheries and maritime issues). The Richmond River EMS (Hydrosphere Consulting, 2011b) reported that the existing estuary management governance model is disjointed due to the multi-agency and multi-council responsibility, lack of a holistic approach, financial constraints and inefficiencies in the delivery of management programs. The lack of coordination between the various management entities has been identified as a significant barrier to successful estuary management. Community confusion about the role of the various local and state departments in estuary management was also identified as an issue during the community consultation phase of this study. Improved governance arrangements will rely on clearly defined responsibilities and adequate funding to implement these responsibilities. Current legislated responsibilities do not allow any one party to provide the appropriate governance and administration role (Hydrosphere Consulting, 2011b).

Governance was originally raised as an issue in the Richmond River CZMP. Since then there have been various studies reviewing governance arrangements. In the *Review of Governance and Administration Models for the Richmond River – North Eastern NSW,* Stephen Fletcher and Associates (2013) analysed the level of effectiveness of the current governance and administration arrangements for the management of the Richmond River estuary and identified the range of governance models being applied to river management. The report provided two potential structures for further consideration (an incorporated body and a county council model) and recommended that further discussions and consideration of the county council model be undertaken.

In 2018, OEH (now DPIE) and local government commenced the Richmond River Governance and Funding Project. In 2019 a study on governance of the Richmond River was undertaken by Alluvium in collaboration with local councils and key stakeholder organisations to identify, scope and develop a preferred governance strategy (Alluvium, 2019b). The findings were reported in the *Richmond River Governance and Funding Framework* which identified two possible transition pathways towards more effective governance of the Richmond River. The recommended pathway was that a "Richmond River Coordinator" be appointed by the state government (hosted by DPIE) transitioning to an independent Collaborative Partnership. The alternate pathway given was for transition towards role to transition to a lead agency (such as LLS or MEMA) to improve its capacity to deliver the agreed outcomes for the Richmond River. Each local council considered the review and resolved as follows:

- BaSC preferred RCC as a service provider with other requirements for external funding, assistance and working with agencies.
- BySC supported the collaborative partnership option.
- Kyogle Council endorsed the consultant's recommendations.
- RVC supported the intent of the recommendations of the report to appoint (an) agency to have responsibility to drive the improvement of Richmond River health outcomes.
- RCC expressed willingness to be the service provider if effectively resourced.
- LCC supported a co-ordinator/commissioner role with powers to bring people together, major funding to resource on ground options, agencies to deliver actions in accordance with the existing CZMP and natural resource management plans and accountability to the local community.

A Catchment Governance and Waterway Health (Richmond River) project has been funded through the Stage 2 MEMS to focus on the health of the Richmond River using governance and other frameworks to address some of the issues faced (over a 12-month period in 2020-21). The objective of this role is to respond to the recommendations of the Richmond River Governance and Funding Project and the collective commitment of the councils in recognising the benefits of a coordinated approach to improving the health of the catchment and its waterways. This role will aid the CMP process but also work on other complementary projects intended to improve governance and river health outcomes in the catchments including the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (Dela-Cruz, *et al.*, 2019). The key focus of this project is to develop and seek to establish a preferred governance framework for the Richmond River catchment in collaboration with local councils and key stakeholders. The project will seek to define and establish a governance strategy within the Richmond River catchment to improve management of agricultural diffuse source run-off. The outcomes of this project may be relevant to other NSW river catchments to improve both catchment health and the health of the marine estate.

30. NORTHERN RIVERS WATERSHED INITIATIVE

The Northern Rivers Watershed Initiative (NRWI) is a strategy developed by the Northern Rivers Joint Organisation (NRJO) to holistically manage water within catchments using natural flood management strategies that also target improvements in stream bank condition and river health allowing multiple objectives to be met with the same investment (NRJO, 2019). The NRJO represents the Ballina, Byron, Kyogle, Lismore, Richmond Valley and Tweed NSW local government areas.

Since adoption of the NRWI by RCC and the NRJO (and all constituent Councils), the NRJO and local politicians have been making representations to the NSW Government seeking large-scale funding to support the NRWI either in full or in part. RCC is supporting a research application to the Australian Research Council Linkage Program for related research on natural flood mitigation measures. The proposed ARC Linkage research program will run for three years and involve the systematic and strategic evaluation and review of three main strategies to manage flood risk in Northern Rivers rural catchments (NRJO, 2021):

- Increasing infiltration (changing agricultural practices to reduce soil compaction, improve soil quality and promote absorption of water).
- Storing water (restoring functioning floodplains and wetlands).
- Slowing flows (restoring natural processes and landforms to the river corridor, riparian buffer strips, coarse woody debris).

The proposed area of research is considered directly relevant to development of the Richmond River CMP and would contribute to and guide on-ground actions to improve river health.

31. BIODIVERSITY LEGISLATION REFORMS

Biodiversity management legislation in NSW includes the *Biodiversity Conservation Act 2016* and the *State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017*. The Northern Rivers Joint Organisation commissioned a study to define areas of biodiversity loss and potential stewardship sites across the region (NGH, 2021). The project involved a desktop assessment to analyse future growth areas across the region, the extent of unavoidable biodiversity loss, associated offsets likely to be required under the Biodiversity Offsets Scheme and the ability for public land to satisfy all or part of the anticipated credit requirements by identifying potential stewardship sites across the region. The study found a significant shortfall in potential biodiversity offset credits available in the region (67% of credit losses would not be offset through the available stewardship sites on public land in the region). NGH (2021) recommended that the councils investigate potential biodiversity stewardship sites on public land (that create biodiversity credits) as well as biodiversity certification (to provide a more streamlined biodiversity assessment process at the strategic planning stage for areas of land that are proposed for development). Potential stewardship sites were identified on council land and Council-managed Crown land within the Richmond River catchment. The remaining biodiversity credits would need to be provided on private land, on land outside of the region, or through payment into the total fund deposit (NGH, 2021). The study indicates that the Biodiversity Offsets Scheme will lead to a net loss of biodiversity from the region. There are potential opportunities to link CMP on-ground actions (e.g. riparian rehabilitation sites) with the Biodiversity Offsets Scheme and this warrants further consideration in future stages of CMP development.

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GLOSSARY AND ABBREVIATIONS

Acid sulfate soils (ASS)	Acid sulfate soils are the common name given to soils containing iron sulfides. When the iron sulfides are exposed to air and produce sulfuric acid, they are known as actual acid sulfate soils. The soil itself can neutralise some of the sulfuric acid. The remaining acid moves through the soil, acidifying soil water, groundwater and, eventually, surface waters.
AHD	Australian Height Datum
Amenity	A desirable or useful feature or facility of a building or place
Aquatic	Living or growing in water, not on land.
BaSC	Ballina Shire Council
Blackwater	Blackwater is formed from the decomposition of plants and organic matter in water during prolonged inundation during floods. Blackwater is usually dark in colour and contains little or no oxygen. The organic matter in blackwater can consume large amounts of dissolved oxygen and if mixed into rivers and creeks can deoxygenate waterways and can cause fish kills.
BySC	Byron Shire Council
CLASS	Coastal lowland acid sulfate soils
CMP	Coastal Management Program
Coastal hazard	Either or a combination of 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.
CSP	Community Strategic Plan
CZMP	Coastal Zone Management Plan
DECCW	Former (NSW) Department of Environment, Climate Change and Water (now DPIE)
DCP	Development Controls Plan
DO, Dissolved Oxygen	Oxygen dissolved in the water (oxygen saturation).
DPI	(NSW) Department of Primary Industries
DPIE	(NSW) Department of Planning, Industry & Environment
DPI Fisheries	NSW Department of Primary Industries – Fisheries
Ecosystem	Refers to all the biological and physical parts of a biological unit (e.g. an estuary, forest, or planet) and their interconnections.
EES	Environment, Energy and Science (a Division of DPIE)
El Niño	A global climate driver which affects extreme rainfall and flooding, hail and storm frequency
EPA	(NSW) Environmental Protection Agency
Estuarine	Part of the river channel with a mix of fresh water and salt (tidal) water

Foreshore	That part of the shore that lies between the mean high tide mark and the mean low tide mark
GIS	Geographic Information System
Geomorphology	Characteristics, origin and development of landforms.
Ha	Hectares
HAT	Highest Astronomical Tide
Holocene	The current geological epoch which began approximately 11,700 years ago.
Hydrodynamics	The motion of a fluid and interactions with its boundaries
Hydrology	The study of water and its properties, including precipitation onto land and returning to oceans
ICOLL	Intermittently Closed and Open Lake or Lagoon
ILUA	Indigenous Land Use Agreement
Inundation	Rising and spreading of water over land
IP&R	Integrated Planning and Reporting
KC	Kyogle Council
LALC	Local Aboriginal Land Council
La Niña	A global climate driver which affects extreme rainfall and flooding, hail and storm frequency
LCC	Lismore City Council
LEP	Local Environmental Plan
LGA	Local Government Area
Littoral	Related to or near the coastline.
Longshore drift	the movement of material along a coast by waves which approach at an angle to the shore but recede directly away from it i.e. sand moves in the same general direction as the predominant swell direction.
LLS	Local Land Services
MEMA	Marine Estate Management Authority
MEMS	Marine Estate Management Strategy
NPWS	National Parks and Wildlife Service
OEH	Office of Environment and Heritage
Pleistocene	the geological epoch that lasted from about 2,580,000 to 11,700 years ago. The last ice age.
ppt	Parts per thousand (salinity unit)
Quaternary	The current geologic period which began 2.58 million years ago
RLI	Rural Landholder Initiative
Riparian	Of, on or relating to the banks of a watercourse

RCC	Rous County Council
RVC	Richmond Valley Council
Salinity	The level of salt dissolved in the water
Sedimentation	The deposition or accumulation of sediment
SEPP	State Environmental Planning Policy
SLSC	Surf Life Saving Club
STP	Sewage Treatment Plant
TARA	Threat and Risk Assessment
Terrestrial	Living or growing on land (not aquatic)
TfNSW	Transport for NSW
TN	Total Nitrogen - the concentration of inorganic ions of phosphorus (predominately HPO42- and PO43-) in water. These ions are available to be used by aquatic biota
TP	Total Phosphorous - the concentration of phosphorus in natural or anthropogenic substances that contain, or decompose to produce phosphate ions
Turbid	Cloudy or dirty (not clear)
Turbidity	A measure of the amount of light-attenuating particles in a water body

APPENDIX 1 LEGISLATION

This Appendix provides a summary of legislation relevant to catchment, estuary and coastal management in the study area.

Coastal Management Act 2016

The *Coastal Management Act 2016* communicates the NSW Government's vision for coastal management. The Act reflects the vital natural, social, cultural and economic values of our coastal areas and promotes the principles of ecologically sustainable development in managing these values. The Act establishes requirements for the preparation of CMPs under guidance provided by the Coastal Management Manual.

The legislative and policy framework introduced by recent coastal reforms recognises natural coastal processes and the local and regional dynamic character of the coast and promotes land use planning decisions that accommodate them. The reforms ensure coordinated planning and management of the coast and support public participation in these activities.

The Act provides for the integrated management of the coastal environment of NSW consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of the state. The Act:

- Establishes high level statutory objectives for integrated coastal management in NSW.
- Defines the NSW coastal zone as being made up of four distinct 'coastal management areas' and sets out specific management objectives for each of those areas.
- Establishes a new independent coastal advisory body, the NSW Coastal Council.
- Requires local councils to embed coastal management within the Integrated Planning and Reporting (IP&R) framework established in the *Local Government Act 1993*. This approach will ensure that coastal management needs inform, and are informed by, councils' overall service delivery, financial and asset management planning responsibilities.
- Provides for public authorities to take into consideration the objectives and processes to achieve integrated management of the NSW coast.

The objects of the Act are to "*manage the coastal environment of New South Wales in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of the State, and in particular:*

(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, and

(g) 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, and

(h) to promote integrated and co-ordinated coastal planning, management and reporting, and

(i) to encourage and promote plans and strategies to improve the resilience of coastal assets to the impacts of an uncertain climate future including impacts of extreme storm events, and

(j) 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, and

(k) to support public participation in coastal management and planning and greater public awareness, education and understanding of coastal processes and management actions, and

(l) 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

(m) to support the objects of the Marine Estate Management Act 2014."

State Environmental Planning Policy (Coastal Management) 2018

The *Coastal Management SEPP* forms part of the broader land-use planning framework in NSW. This is now the key environmental planning instrument for land-use planning in the coastal zone and delivers the statutory management objectives for each of the four coastal management areas that make up the coastal zone:

- Coastal wetlands and littoral rainforests area (CWLRA): supports high value biodiversity that is particularly sensitive to development. This management area is defined in the Act as land which displays 'the hydrological and floristic characteristics of coastal wetlands or littoral rainforests and land adjoining those features. This area focusses on protecting well established and more extensive vegetation communities (as opposed to single trees or isolated stands). The maps include a 100 m proximity area, applying to all land use zones, around coastal wetlands and littoral rainforests. The objectives of the CWLRA within the Act are to:
    - Protect coastal wetlands and littoral rainforests in their natural state, including their biological diversity and ecosystem integrity.
    - Promote the rehabilitation and restoration of degraded coastal wetlands and littoral rainforests.
    - Improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration.
    - Support the social and cultural values of coastal wetland and littoral rainforest communities.

  - Promote the objectives of State policies and programs for wetlands or littoral rainforest management.

- Coastal vulnerability area (CVA): land which is subject to current and future coastal hazards including beach erosion, shoreline recession, entrance instability, coastal inundation, tidal inundation, slope instability and foreshore tidal erosion. The objectives of the CVA within the Act are to:
  - Ensure public safety and prevent risks to human life.
  - Mitigate current and future coastal hazards.
  - Maintain the presence of beaches, dunes and other natural features.
  - Maintain public access, amenity and use of the coast.
  - Encourage land use that reduces exposure to hazards, including through siting, design, construction and operational decisions.
  - Adopt coastal management strategies that reduce exposure to hazards, in the first instance by restoring or enhancing natural defences such as dunes, and thereafter by taking other action and if taking other action, to:
    - avoid significant degradation or disruption of biological diversity, ecosystem integrity, coastal processes (ecological, biophysical, geological, geomorphological), beach and foreshore amenity, and social and cultural values.
    - avoid adverse offsite impacts, or otherwise restore the land if any impacts are caused by the action to reduce exposure to hazards.
  - Maintain essential infrastructure.
  - Improve community resilience and reduce reliance on emergency responses
- Coastal environment area (CEA): areas that are characterised by natural coastal features such as beaches, rock platforms, undeveloped headlands, coastal lakes and marine and estuarine waters. The area is made up of estuaries and a 100 m landward area, coastal lakes and lagoons and a 500 m landward area and specified sensitive coastal lakes and lagoons. The coastal management area is mapped upstream to one kilometre beyond the highest astronomical tide. The objectives of the CEA within the Act are to:
  - Protect and enhance coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes, coastal lagoons, and enhance natural character, scenic value, biological diversity and ecosystem integrity.
  - Reduce threats to and improve resilience of these coastal environments, including in response to climate change.
  - Maintain and improve water quality and estuary health.
  - Support social and cultural values of the coastal environments.
  - Maintain the presence of beaches, dunes and natural features of the foreshore.
  - Maintain and improve public access, amenity and use of the coast.
- The coastal use area (CUA): land adjacent to coastal waters, estuaries and coastal lakes and lagoons where impacts of development on the use and enjoyment of the beaches, dunes, estuaries and lakes need to be considered. The area starts at the seaward local government boundary,

typically the low water mark and extends to the estuary limit (one km landward of coastal waters, estuaries and coastal lakes). The objectives of the CUA within the Act are to:

- Protect and enhance the scenic, social and cultural values of the coast by ensuring that:
  - the type, bulk, scale and size of development is appropriate for the location and natural scenic quality of the coast.
  - adverse impacts of development on cultural and built environmental heritage are avoided or mitigated.
  - urban design, including water sensitive urban design, is supported and incorporated into development activities.
  - adequate public open space is provided, including for recreational activities and associated infrastructure.
  - the use of the surf zone is considered.
- Accommodate both urbanised and natural stretches of coastline

The SEPP gives effect to the objectives of the *Coastal Management Act 2016* from a land use planning perspective, by specifying how development proposals are to be assessed if they fall within the coastal zone. This becomes relevant to the preparation of the CMP with regards to the intent and description of recommended actions and their intended approval pathways (if required) under the SEPP.

Marine Estate Management Act 2014

The *Coastal Management Act 2016* (s.3(m)) legally supports the objects of the *Marine Estate Management Act 2014*, with the coastal zone forming part of the marine estate. The *Marine Estate Management Act 2014* provides for strategic and integrated management of the whole marine estate – marine waters, coasts and estuaries. The Act does this by:

- Providing for the management of the marine estate consistent with the principles of ecologically sustainable development.
- Establishing two advisory committees, a Marine Estate Management Authority (MEMA) and Marine Estate Expert Knowledge Panel.
- Requiring the development of a Marine Estate Management Strategy to address priority threats identified through the TARA.
- Facilitating the maintenance of ecological integrity, and economic, social, cultural and scientific opportunities.
- Promoting the coordination of government programs.
- Providing for a comprehensive system of marine parks and aquatic reserves.

Crown Land Management Act 2016

DPIE – Crown Land is responsible for the management of the Crown Land estate in accordance with the *Crown Land Management Act 2016*. DPIE – Crown Land may transfer management responsibilities to a reserve trust or to a council. Some areas of Crown land within the study area are under Council Reserve

Trust management. Under the Act, the councils will need to categorise and prepare Plans of Management under the *Local Government Act 1993* for these reserves. Any plans that are prepared will need to be consistent with the CMP.

Actions proposed on public land require an understanding of the boundaries of public land (i.e. survey may be required) and the relevant authorisations and appropriate tenure arrangements from public land managers, in particular, where works are proposed on Crown land not under council management.

Fisheries Management Act 1994

In NSW, threatened fish (both saltwater and freshwater), their habitat, and threatened marine vegetation are protected under the *Fisheries Management Act 1994*. The *Fisheries Management Act* is administered by the NSW Department of Primary Industries – Fisheries (DPI Fisheries). Under the *Fisheries Management Act*, DPI Fisheries is responsible for ensuring that fish stocks are conserved and that there is "no net loss" of key fish habitats upon which those stocks depend. DPI Fisheries achieves this through regulating recreational and commercial fishing and assessing activities under Part 4 and Part 5 of the *Environmental Planning and Assessment Act 1979* that are located on or adjacent to key fish habitats in accordance with the objectives of the *Fisheries Management Act*, the aquatic habitat protection and threatened species conservation provisions in Parts 7 and 7A of the *Fisheries Management Act*, and the associated and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013). Key fish habitats include, but are not limited to, 3rd order and greater freshwater waterways, coastal wetlands and tidal waters up to the Highest Astronomical Tide (HAT) level.

Relevant divisions and sections of the Act under which permit and consultation requirements may apply to a range of coastal management activities necessary under the pending CMP include:

- Division 3, Section 199, 200 and 201 dredging and reclamation of water land.
- Division 4, Section 205 harm to marine vegetation.
- Division 8, Section 219 obstruction of fish passage.

Water Management Act 2000

The objects of the *Water Management Act 2000* are to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations. The Act is administered by NRAR, WaterNSW and DPIE - Water. DPIE – Water is accountable for the development and implementation of water sharing plans which allocate water for direct use, extraction and environmental needs. The *Water Sharing Plan for the Richmond River Area Unregulated and Alluvial Water Sources 2010* applies to the study area.

NRAR regulates activities or works on waterfront land or works that may interfere with an aquifer. Relevant approvals under the Act include:

- Aquifer interference approval, i.e. a water licence (other than where exemptions apply or where water is being taken under a basic landholder right) such as may be required for dewatering and groundwater filling during and post construction activities.

- Controlled activity approvals for works on waterfront land (defined as the bed of any river, lake or estuary, and the land within 40 metres of the river banks, lake shore or estuary mean high water mark). Examples include erosion control works, construction of waterway crossings and roads, and depositing extracted material on waterfront land. Public authorities are exempt from requiring a controlled activity approval. Guidelines for riparian corridors on waterfront land provide recommended widths for vegetated riparian zones based on the stream order under the Strahler System (NSW Office of Water, 2012).
- Water extraction licences.

Native Title Act 1993 (Commonwealth) and Aboriginal Land Rights Act 1983 (NSW)

The *Native Title Act 1993* (Commonwealth) provides a legal process for recognising of the rights and interests of Aboriginal and Torres Strait Islander people in land and waters. Native title rights recognise the native title holders' rights to perform certain activities according to their traditional laws and customs. The *Aboriginal Land Rights Act, 1983* (ALRA) provides land rights for Aboriginal people in NSW. Aboriginal Land Councils can claim land as compensation for historic dispossession of land and to support Aboriginal communities' social and economic development. The principle of self-determination underpins the ALRA. Land is vested in representative land councils that work to deliver tangible economic, social and cultural benefits to Aboriginal communities in NSW. Native title determinations and Indigenous Land Use Agreements are in effect over many parts of the study area.

Other Relevant Legislation

Other legislation relevant to the management of the coast and estuaries include:

- *Biodiversity Conservation Act 2016*.
- *Environmental Planning and Assessment 1979.*
- *Heritage Act 1977.*
- *Local Government Act 1993.*
- *Local Land Services Act 2013.*
- *National Parks and Wildlife Act 1974.*
- *State Emergency and Rescue Management Act 1989.*
- *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth).*

APPENDIX 2 REGIONAL AND LOCAL MANAGEMENT PLANS

This Appendix provides a summary of management plans relevant to catchment, estuary and coastal management in the study area.

Regional Plans

Water Sharing Plan

Water sharing plans (WSPs) set rules for sharing water between water users and the environment managed under the *Water Management Act 2000* (the Act). The *Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources 2010* applies to the Richmond River Extraction Management Unit (comprised of 23 water sources), Evans River Water Source and the Richmond Regulated Water Source, as set out in cl. 4 and cl. 6 of the WSP.

The *Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources 2010* is currently under review with the scheduled review date set at 30th June 2021 (DPIE - Water, 2021b).

North Coast Regional Plan 2036

The *North Coast Regional Plan 2036* (NSW Government, 2016) will guide the NSW Government's land use planning priorities and decisions to 2036. The Plan recognises the spectacular environment and vibrant communities of the region. The regional priority identified in the plan for the LGAs within the study area and relevant to Richmond River Estuary is to identify opportunities to expand nature-based, adventure and cultural tourism by. The plan identifies future urban growth areas across the far north coast to support housing growth.

North Coast Local Strategic Plan

North Coast LLS has developed the *North Coast Local Strategic Plan* (North Coast LLS, 2016) to ensure that it is meeting its mission of improving primary production and better management of natural resources across the North Coast region. The plan outlines a series of strategies through which the four main goals are to be achieved, through the resilience of local communities, improved management of biosecurity, natural resources, agricultural productivity and emergency management (North Coast LLS, 2016). The Strategic Plan has a general focus on communities of the catchment and the ecosystem services provided to them by natural resources such as soils and land, native vegetation and aquatic ecosystems.

Relevant regional priorities include

- Active protection, maintenance and improvement of:
    - Threatened species (e.g. Pied Oystercatcher, Beach Stone Curlew, Eastern Freshwater Cod, Spotted tailed Quoll, Eastern Bristle Bird) and Endangered Ecological Communities (e.g. coastal littoral rainforest, coastal wetlands, coastal themeda headland grassland).
    - Native vegetation extent, corridor connectivity and the condition of natural habitats.
    - Riverine habitat condition and water quality.
    - Coastal floodplain condition.
    - Wetland condition.
    - Estuarine condition.

  - Coastal and marine habitats.
- Supporting Aboriginal people to work on Country.

North Coast Regional Strategic Pest Animal Management Plan 2018-2023

LLS (2018) has developed the *North Coast Regional Strategic Pest Animal Management Plan 2018-2023*. The purpose of the plan is to protect the economy, environment and community, through strategic management of the region's pest animals. The plan outlines how government, industry and the community can work together and share the responsibility to prevent, eradicate, contain or manage pest animals to achieve a balance in economic, environmental and social outcomes.

The plan identifies regional priority pest animal species and goals and activities to manage them. Priority species relevant to the CMP study area include Cane Toad, feral cats, wild dogs, Foxes, wild horses and feral pigs.

North Coast Regional Strategic Weed Management Plan 2017-2022

LLS (2021) has developed the *North Coast Regional Strategic Weed Management Plan 2017-2022* (updated in 2021) to provide a basis for a co-operative and co-ordinated approach to weed management on the North Coast. The plan focuses on managing weeds to improve the region's biosecurity. The vision of the plan is to protect the North Coast's environment, landscape, livelihood, cultural and lifestyle values from weeds by strengthening the sustainability of the natural environment, primary industries and local communities in the region.

The plan outlines a framework and range of priorities and actions to achieve the plans vision, goals and objectives. The general focus of the plan is about community support and fostering relationship between management partners.

Regional Boating Plan for the Tweed - Clarence Valley Region

The *Regional Boating Plan for the Tweed – Clarence Region* (TfNSW, 2015) was developed in part to boost the experience of recreational boating within the region as part of a state-wide initiative. The Plan was developed in consultation with BaSC and RVC, key stakeholders and the community (through an online survey). TfNSW oversees the boating program and is responsible for ensuring the program is progressing, whereas the councils are responsible for implementing actions with funding from TfNSW - Maritime.

The Plan identifies region-wide actions for boating safety, access and infrastructure required to be implemented over five years (to 2020) under the *NSW Boating Now* program including navigational aids and better safety signage.

Regional Water Strategy

The NSW Government is developing a regional water strategy for the far north coast region to identify opportunities and challenges, understand future water needs, identify options to meet the challenges and aspirations of the region and assess and prioritise options. The draft *Far North Coast Regional Water*

Strategy (DPIE, 2020) includes a long list of potential options that focus on maintaining and diversifying water supplies, protecting and enhancing natural systems, supporting water use and delivery efficiency and conservation and strengthening community preparedness for climate extremes. The strategy considers how government and local councils can adopt a more integrated approach to managing surface water, groundwater and their catchments. The final strategy will identify the best actions for the region based on stakeholder feedback and evidence-based assessments.

The policies and plans that guide the management of regional water sources in coastal NSW are illustrated on Figure 36. Regional water strategies align with the NSW Government's strategic planning hierarchy and will be integrated with current land use and regional plans. The Far North Coast Regional Water Strategy will integrate and build on MEMS initiatives and outcomes of coastal management plans, such as improving water quality, planning for climate change and rehabilitation of degraded coastal waterways.

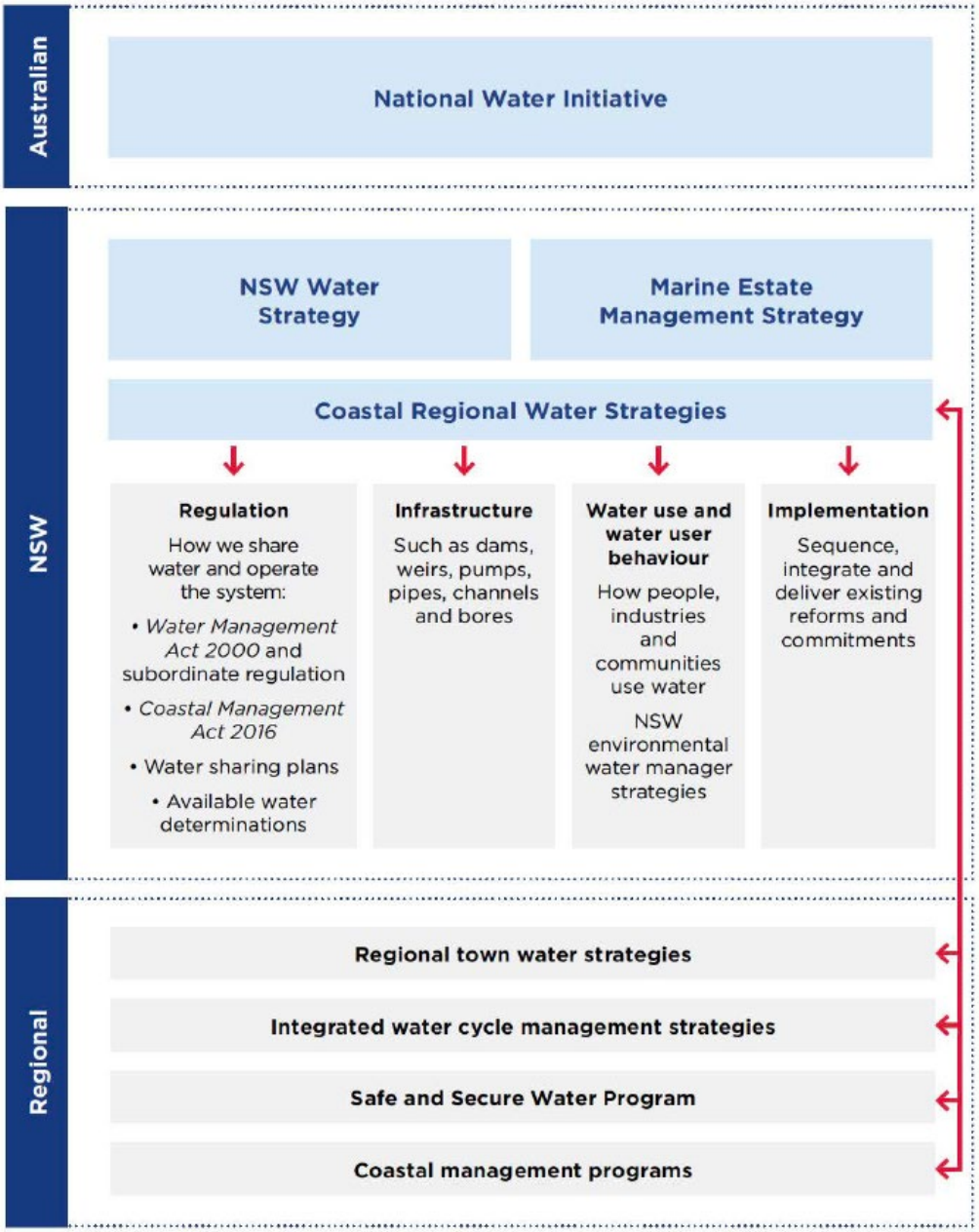

Figure 36: Regional NSW water policy and planning context for coastal catchments

Source: DPIE (2020)

Local Plans and Strategies

Integrated Planning and Reporting

The Integrated Planning and Reporting (IP&R) framework is established under Chapter 13 of the *Local Government Act 1993* and is the main mechanism by which councils comprehensively plan for and report on their asset management and service delivery responsibilities within the LGA. The *Coastal Management Act 2016* requires that CMPs are given effect through the IP&R framework. This will include performance auditing powers to ensure that programs are appropriately implemented. This means that CMPs and identified coastal management activities are aligned with broader community strategic plans, reflect community priorities and are feasible, financially viable and able to be resourced.

Each local council has developed a Community Strategic Plan (CSP) involving extensive public engagement. The plans reflect the community's aspirations and sets the broad parameters that guide decision making for the period of the plan. The delivery program sets out what is to be achieved over four years and the operational plan details projects that are to be completed each year (Figure 37).

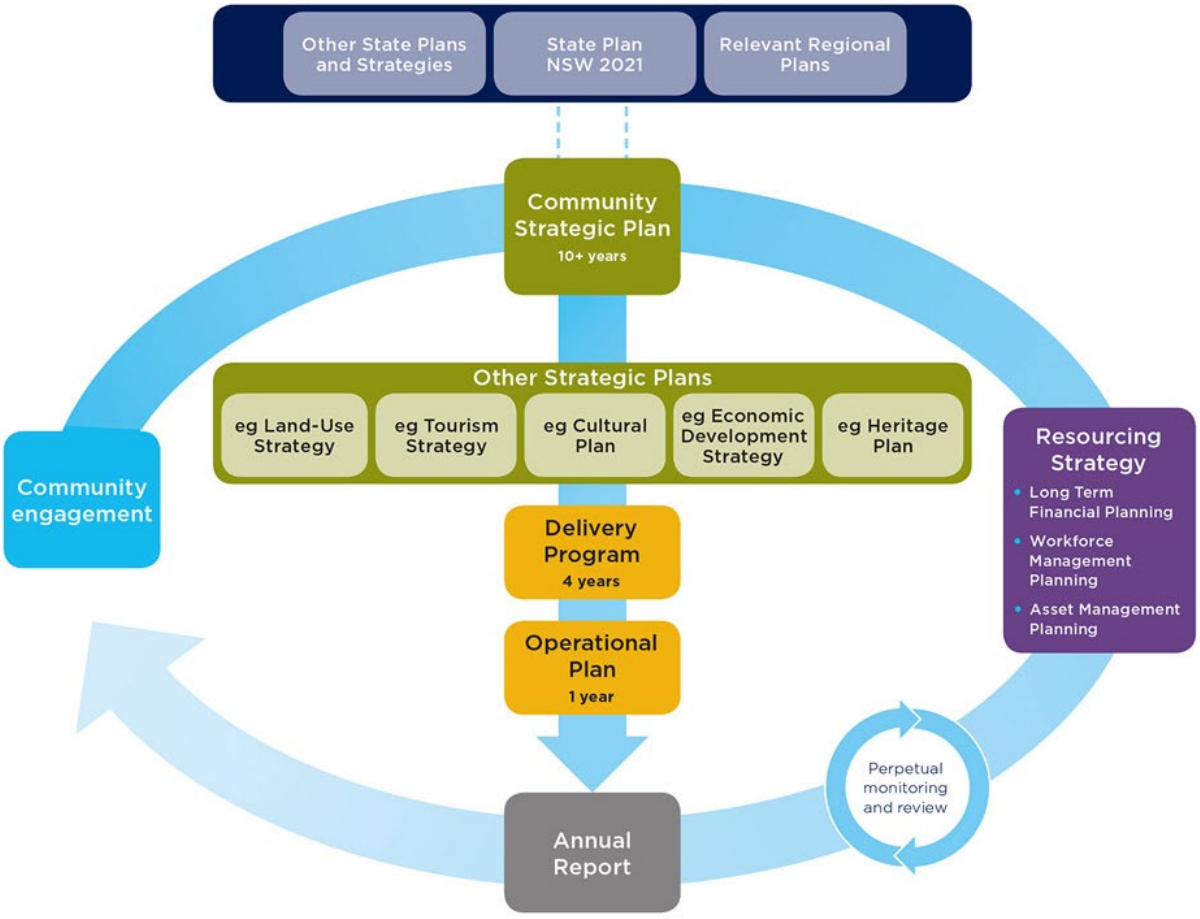

Figure 37: The NSW Government IP&R Framework

Source: Office of Local Government (2021)

Protection of the natural environment was consistently flagged as a key opportunity for attention in the community consultation undertaken during development of the CSPs.

The CSPs will assist in guiding the development of the CMP for the Richmond River. The council objectives from the CSPs are:

- BaSC: Vision: The Ballina Shire is safe, with a connected community, a healthy environment and a thriving economy
- BySC: Vision(s):
    - Our community is empowered to be creative, innovative and listened to as we shape the future way of living that we want.
    - While we strongly protect our Shire, its natural environment, lifestyle, diversity and community spirit, we welcome visitors and the contribution they make to our culture
    - Our future is sustainable, we have the services and infrastructure we need to thrive, and we encourage and support local business and industry.
    - We foster the arts and cultural activities, respect and acknowledge our first peoples and celebrate and embrace diverse thinking and being.
- LCC aspirations and objectives (five categories): An inclusive and healthy community, A prosperous and vibrant city, the natural environment, the built environment and leadership and participation.
- RVC: Vision: A great community with a relaxed lifestyle, beautiful environment and vibrant economy.
- KC: Vision: Working together to balance environment, lifestyle and opportunity. Mission: To meet the challenges of our unique and diverse region.

The council objectives, strategies and actions relating to the natural environmental and catchment management are summarised in Table 17

Table 17: CSP, Delivery Program and Operational Plan objectives, strategies and actions

Strategies	Actions	KPI/ Milestone/ Statistic
Ballina Shire Council		
Healthy Environment		
H.E1 We understand the environment.	H.E1.2 Undertake and promote initiatives that improve our waterways.	Health and use of our waterways is improving.
H.E3 Our built environment blends with the natural environment.	H.E3.2 Minimise negative impacts on the natural environment.	Retention of our natural environment.

Strategies	Actions	KPI/ Milestone/ Statistic
Byron Shire Council		
3. We Protect and Enhance our Natural Environment		
3.1 Partner to protect and enhance our biodiversity, ecosystems and ecology.	-	-
3.3 Partner to protect and enhance the health of the Shire's coastlines, estuaries, waterways and catchments.	-	-
Lismore City Council		
Our Natural Environment		
C1 Our waterways and catchments are healthy.	C1.1 Enhance riparian vegetation and manage off-stream impacts to improve water quality.	• Gross pollutants diverted from river – Wilsons River and Tucki Creek urban catchments. • Sediment diverted from river – Wilsons River and Tucki Creek urban catchments.
	C1.2 Provide a safe and serviceable stormwater drainage system.	
C4 Our diverse natural environment is protected and enhanced.	C4.1 Protect and improve biodiversity on public and private land in Lismore's urban and rural landscapes.	• Amount of restored and revegetated native vegetation. • Amount of restored and revegetated koala habitat. • Amount of restored riparian area. • Amount of riparian area excluded from livestock. • Community satisfaction with the protection of the natural environment.
	C4.2 Protect and improve Lismore's koala population.	
	C4.3 Report on the condition of our environment.	

Strategies	Actions	KPI/ Milestone/ Statistic
Richmond Valley Council		
Looking After our Environment		
Environmental Management: Advocate for and support initiatives to improve the health of the Richmond River	Facilitate the upgrade to the Jabiru Geneebeinga Wetlands in Casino.	-
Kyogle Council		
Agriculture Strategies and Actions		
Strategy C: Encourage and support land management practices that will ensure the long-term sustainability of agriculture and the environment.	3. Kyogle Council to positively support weed management efforts by actively managing weeds within the road reserve and on other council-maintained land.	Medium-term
	4. Promote excellence in land management practices through media campaigns, awards, etc.	Long-term
	5. Work closely with North Coast Weeds to deliver training and eradication services.	Medium-term
Visitor Attraction Strategies and Actions		
Strategy C: Enable and Promote access to our world class heritage areas, National Parks, visitor facilities and services.	2. Collaborate with and develop partnerships with National Parks, State Forests NSW, Aboriginal Groups and other stakeholders.	Short-term and ongoing
	4. Encourage the control and eradication of pests and weeds in high priority areas.	Medium-term
Strategy D: Range of recreational, heritage, cultural activities and places of interest.	2. Engage local Aboriginal groups with a view to developing Cultural Tourism Opportunities.	Medium-term

Source: Byron Shire Council (2018), Ballina Shire Council (2017), Lismore Shire Council (2017b), Richmond Valley Council (2017), Kyogle Council (2016)

Local Environmental Plans and Development Control Plans

Each local council has a Local Environmental Plan (LEP) and a Development Control Plan (DCP) which are the principal planning instruments for each area. The LEPs make local environmental planning provisions for land within each LGA in accordance with the relevant standard environmental planning instrument under section 3.20 of the *Environmental Planning and Assessment Act 1979*. The plans use a standard format set by the NSW Government's Standard Instrument for LEPs which provides a consistent format including standard land use zones, definitions and clauses. Each council may also include additional local provisions for their area.

A DCP is a non-statutory document that supports the LEP by providing development guidelines for development that requires council approval. The councils are required under Section 79C of the *Environmental Planning and Assessment Act 1979* to take into consideration the relevant provisions of its DCP in determining development applications on land to which the DCP applies. These planning instruments aid in protecting waterways and the environment at large through development controls. Table 18 gives examples of some of the controls within each plan which function to contribute to the protection of waterways and environmental values within the study area.

Table 18: Examples of planning controls relevant to the CMP

Council	Plans	Examples of relevant controls
BaSC	Ballina LEP 2012	• Additional local provision for acid sulfate soils. Clause (7.1). • Additional local provision for drinking water catchments. Clause (7.4).
	DCP	• Chapter 2 - General and Environmental Considerations. • Chapter 2A - Vegetation Management. • Chapter 2B - Floodplain Management.
BySC	Byron LEP 2014	• Additional local provision for acid sulfate soils. Clause (6.1). • Additional local provision for drinking water catchments. Clause (6.5).
	Byron DCP 2014	• Chapter B1: Biodiversity • Chapter B2: Tree and Vegetation Management • Chapter C4: Development in a drinking water catchment
RVC	Richmond Valley LEP 2012	• Additional local provision for acid sulfate soils - refer clause (6.1). • Additional local provision for terrestrial biodiversity - refer clause (6.6). • Additional local provision for riparian land and watercourses - refer clause (6.8). • Additional local provision for drinking water catchments - refer clause (6.9). • Additional local provision for wetlands - refer clause (6.9)
	Draft Richmond Valley DCP	• Part H-2 Acid sulfate soils.
LCC	Lismore LEP 2012	• Additional local provision for acid sulfate soils. Clause (6.1). • Additional local provision for drinking water catchments. Clause (6.4).
	Lismore DCP	• Chapter 14 Vegetation protection. • Chapter 17 Acid sulfate soils.
KC	Kyogle LEP 2012	Standard provisions
	Kyogle DCP 2014	• Includes development guidelines for protection of watercourses and ecological features.

Local Strategic Planning Statements

Each council has a Local Strategic Planning Statement (LSPS) which plan for their communities' needs through immediate, short, medium and long-term actions to deliver strategic land use planning priorities. The LSPSs align local planning priorities for each council with the regional strategic priorities set out in the *North Coast Regional Plan 2036*. Each LSPS sets out priorities under various themes with each of the councils including an environmental/sustainability theme. Examples of environmental priorities outlined in the LSPSs which aid in protecting waterways and the environment are listed in Table 19.

Table 19: LSPS priorities

Council and Theme	Planning Priority	
KC - Theme: Sustainability	D2	Protect and enhance the health of the Richmond and Clarence catchments.
	D3	Protect communities from the risks associated with natural hazards.
	D4	Plan for adaptation to, and mitigation of, the effects of climate change.
RVC – Theme 2: Our Environment	4	Look after our environment.
	6	Celebrate our heritage.
LCC – Theme 4: Sustainable Environment	10	Areas of high biodiversity value and connectivity are protected and enhanced.
	11	Waterways, riparian areas and water catchments are protected and enhanced.
	12	Protect and improve productive agricultural land and other natural resources.
BaSC – Theme: Healthy Environment	12	Protect and enhance productive agricultural lands through the development of a Ballina Shire Agricultural Land Use Strategy.
	14	Focus development to areas of least biodiversity sensitivity and least exposure to natural hazards such as flooding and bush fire risk.
BySC – Theme: Sustainable Shire	1	Protect and enhance our biodiversity, ecosystems and ecology
	2	Strive to become a sustainable community.
	3	Adapt to climate change and build resilience.

Source: Ballina Shire Council (2020), Byron Shire Council (2020b), Lismore City Council (2020c), Richmond Valley Council (2020), Kyogle Council (2020c).

National Parks Plans of Management

The *National Parks and Wildlife Act 1974* requires that a plan of management be prepared for each National Park and Nature Reserve (Section 26). A plan of management (PoM) is a legal document that outlines how an area will be managed in the years ahead. Once a plan has been adopted by the Minister no operations may be undertaken within the Reserve except in accordance with the plan. However, if after adequate investigation, operations not included in this plan are found to be justified, a PoM may be amended in accordance with Section 75 of the Act.

The PoMs include policies and framework for management relating to:

- Natural and cultural values of the planning area:
    - Landforms, geology, soil and hydrology.
    - Native plants and animals.
    - Cultural heritage.
    - Introduced plants and animals.
    - Fire management.
- Promotion and public use of the planning area:
    - Promotion of the planning area.
    - Recreation opportunities.
    - Scientific use.
    - Management operations.
    - Non-park management activities.

Each PoM also has specific management objectives relevant to the management area.

Drinking Water Catchment Management Plans

RCC has prepared a combined drinking water Catchment Management Plan for all of the RCC's current and potential future drinking water catchments: Rocky Creek Dam, Wilsons River Source, Emigrant Creek Dam and Dunoon Dam (potential future source). The Catchment Management Plan (Hydrosphere Consulting, 2020b) fulfils the requirements of the *Australian Drinking Water Guidelines* (ADWG, NHMRC, NRMMC, 2011) from catchments to the offtake points for water supplies as a critical part of the overall *RCC Drinking Water Management System* (Rous County Council, 2018). It followed a risk-based approach to assess catchment water quality, identify catchment hazards, and specify control measures to reduce risk to water quality.

Many of the hazards to drinking water also pose a significant risk to the health and function of waterways both within the drinking water catchments and the downstream Richmond River estuary. Similarly the actions proposed to reduce risks to drinking water quality within the Catchment Management Plan also reduce threats to ecosystem health.

A key component of RCC's catchment management is the implementation of River Reach Plans for the Wilsons River (Sleeman, 2011) and Emigrant Creek (Rous County Council, 2017b) to assist groups of landholders to undertake river rehabilitation projects with the aim of identifying and mitigating threats to water quality. The plans include property-scale recommended activities to rehabilitate waterways including weed control, planting and erosion control works. All of the actions were informed by the reach-scale assessments, with property-specific plans developed in consultation with participating landholders.

BySC manages the water supply for the township of Mullumbimby. This water is sourced from Wilsons Creek at the Laverty's Gap Weir which draws its water from the upper reaches of the Wilsons River. Management of the Laverty's Gap water resource is guided by The *Catchment Management Plan for the Laverty's Gap Weir Catchment* (Byron Shire Council, 2007).

Urban Stormwater Management Plans

Councils are responsible to manage the quality of stormwater within urban centres. Each council has previously prepared an Urban Stormwater Management Plan or Strategy to guide stormwater quality improvements. DCPs provide controls on stormwater management including requirements and benchmarks for the design and/or performance of urban stormwater infrastructure for new developments.

On-site Sewage Management Strategies

Each council implements an On-site Sewage Management Strategy that guides the design, installation and maintenance of on-site sewage and wastewater systems. Councils have inspection programs for monitoring all on-site sewage management systems to ensure they meet standards protecting public health, the environment and community living. Each council has its own process for prioritisation of systems and inspection requirements. Generally, improvement notices or other orders may be issued for immediate rectification works or other action to be undertaken if problem are detected as part of the strategy implementation.

Biodiversity Management Strategies

LCC and BySC have prepared Biodiversity Management Strategies for their respective LGAs. The Strategies aim to build partnerships with the community to protect and enhance biodiversity on public and private land in both urban and rural landscapes. They Strategies were developed in consultation with the community, environment groups and industry to ensure they are practical and in the interests of the community.

Lismore

The *Biodiversity Management Strategy for the Lismore Local Government Area 2015-2035* (Lismore City Council, 2015) sets out actions to be achieved based on prioritisation over the next 20 years, with a review every 4 years. Actions are broadly divided into three categories: Internal (within Council), Rural (working with the rural community) and Urban (working within the urban environment). Within these three categories there are six components:

1. Council's environmental management.
2. Development Assessment
3. Funding opportunities.
4. Rural Landholder Initiative (RLI).
5. Urban Green Corridors Plan.
6. Education.

The RLI is a key action relevant to the health of the Richmond River through improvements in land management and reduction of diffuse pollution export to waterways. The RLI was designed by LCC in partnership with Southern Cross University and works with landholders to restore and enhance biodiversity assets on private land. It involves incentives such as an annual small grants program for on-ground works and educational opportunities such as field days and free educational resources.

The RLI has had a high take-up rate and is currently oversubscribed with more applications than available funding can support. In 2019/20, the RLI has achieved the following (Lismore City Council, 2020b):

- 44 projects have been completed and a further 24 continue to a second stage.
- 81.92 ha of native vegetation has been regenerated.
- 8,463 trees have been planted.
- 3.6 km of fencing has been installed for habitat protection.
- 8.68 km of riparian areas have been restored.
- 7.63 km of riparian areas have been excluded from stock.
- Seven off-stream watering units have been installed.

Round 7 of the initiative started in October 2020 with 31 new RLI Projects funded through the LCC Biodiversity Management Strategy (Lismore City Council, 2020b). The projects represent an investment of $203,000 of public funds over two years with at least $260,000 of in-kind investment from landholders. Individual project funds range between $3,000-$10,000 depending on need and location (Lismore City Council, 2020b). Education resources include online mapping tools and a range of booklets on the major environmental issues for five land use types in our region: beef graziers, dairy farmers, orchardists, floodplain croppers and rural 'lifestyle' landholders.

The *Urban Green Corridor Plan* (Lismore City Council, 2017a) is an action of LCC's Biodiversity Management Strategy which identifies a network of wildlife corridors through Lismore's urban area and priority areas for bush regeneration and revegetation programs. The areas included in the plan cover a range of vegetation and habitat types including rainforest remnants, a variety of rivers, creeks and wetlands and koala habitat which supports a resident population of koalas. Riparian corridors have also been identified in the plan including a 20m buffer along the Wilson River and Leycester Creek and upper Tucki Tucki Creek (Figure 38) with particular significance for Richmond River health. The identified corridor included areas with a range of elevations and aspects, incorporating links between the coastal floodplain and ridgelines. The plan includes a five year works program which outlines the budget for bush regeneration works in 20 council reserves between 2017–2022.

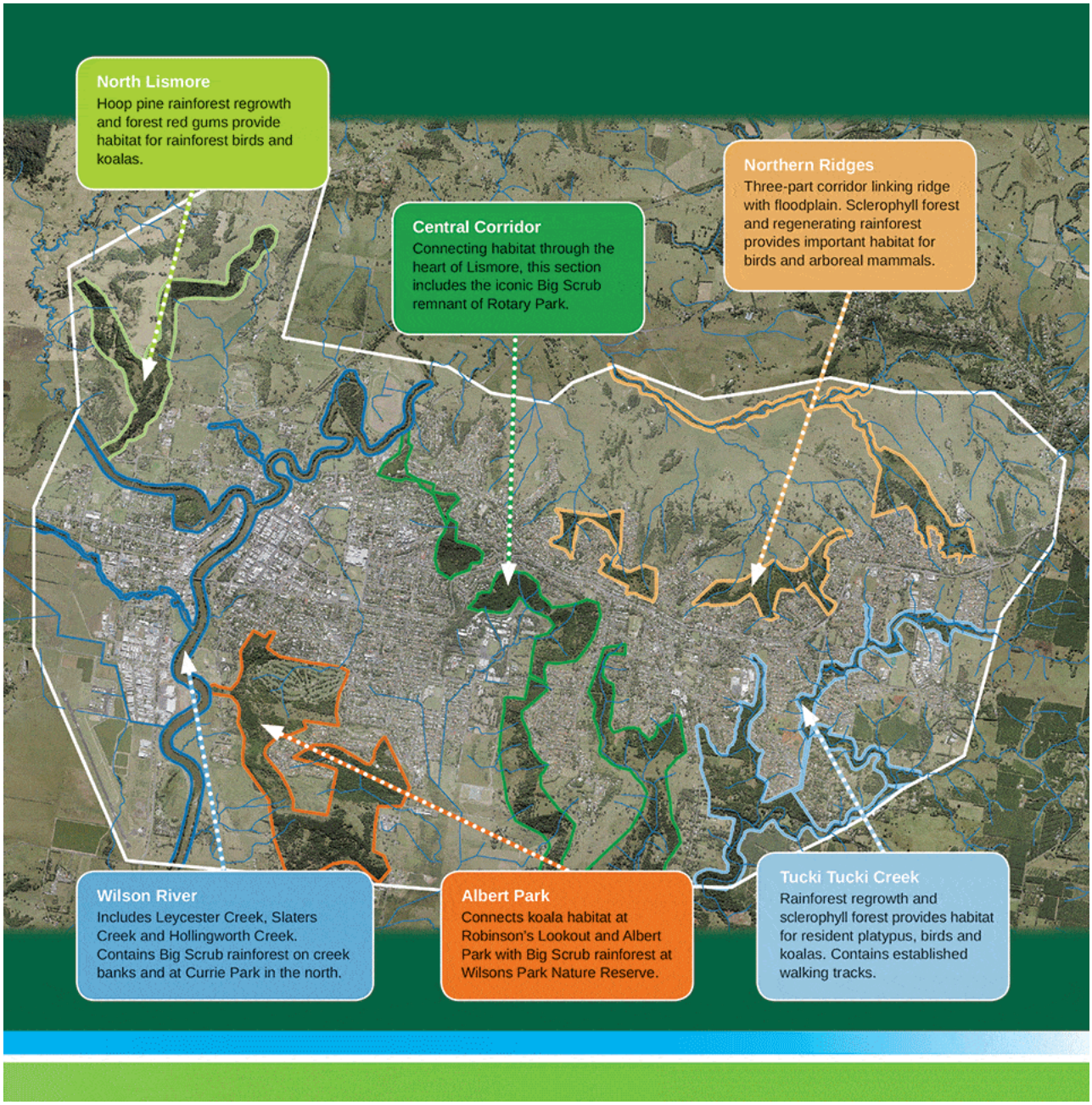

Figure 38: Urban Green Corridors Plan mapping for Lismore

Source: LCC (2021)

Byron Shire

The *Byron Shire Council Biodiversity Conservation Strategy 2020 – 2030* (Byron Shire Council, 2020a) outlines 90 actions to be undertaken over the next 10 years to help improve biodiversity conservation in the Byron Shire. The actions are spread across four biodiversity aims:

- Aim 1: Lead – We are an organisation that provides clear direction, guidance and resources to conserve and enhance our biodiversity.
- Aim 2: Inform – Our community is well informed about biodiversity and what they can do to protect it.

- Aim 3: Support – Our land managers are well supported to conserve biodiversity across the landscape.
- Aim 4: Manage – We use best practice land management to improve ecological resilience and reduce threats to biodiversity.

Objectives and actions that are most relevant to improving waterway health within the Richmond River catchment are given in Table 20.

Table 20: Biodiversity actions relevant to estuary and catchment management – Byron Shire

Objective	Action	Performance indicator
1.3 Council uses current best practice desktop tools to support and facilitate HEV landscape and habitat protection.	1.10 Develop a priority restoration investment map that identifies key sites on private and public land requiring either protection or restoration, to assist in directing future Council and community restoration activities.	Priority investment map available on Council GIS, and accessible to community conservation groups.
1.4 Biodiversity conservation and management principles are better integrated into Council's day-to-day operations.	1.30 Continue development of Coastal Management Programs for the Shire's coastline and estuaries, ensuring CMPs are consistent with the intent of this Biodiversity Strategy.	Refer Council Coastal Management Plans.
1.5 Additional funding is secured to support biodiversity projects.	1.33 Incorporate relevant elements of this strategy (e.g. relating to coastal wetlands, littoral rainforest) into Council's Coastal Management Programs, to increase potential for funding support through the State Government Coastal and Estuary Grants Program.	Refer Council Coastal Management Programs.
2.4 Information on our local indigenous heritage is integrated into education and information materials developed for residents and visitors.	2.17 In consultation with Bundjalung of Byron Bay Aboriginal Corporation (Arakwal), increase inclusion of known Bundjalung language for place, plants and animals in Council biodiversity documents and outputs.	Interpretive signs incorporate Bundjalung language. Environmental messaging for visitors and tourism providers incorporates Bundjalung language where relevant.

Objective	Action	Performance indicator
3.2 Council works positively and proactively with rural landholders to facilitate biodiversity restoration and conservation on private land.	3.4 Develop a web page that connects rural landholders to biodiversity management resources for rural properties.	Rural landholders' biodiversity web page developed.
	3.6 Compile a database of: landholders interested in or participating in active restoration and landholders of sites identified as high priority for conservation/ restoration.	Landholder database created.
	3.7 Engage with landholders identified in Action 3.6 to: a) advise of available land management resources, training, and incentives. b) advise of funding opportunities available for restoration, including grants and Biodiversity Stewardship Agreements.	Information regarding: a) available resources and b) funding opportunities provided to identified landholders.
	3.8 Work with neighbouring Councils and Friends of the Koala to Implement NE Hinterland Koala Conservation Project to increase planted koala habitat and secure conservation agreements for koala habitat on private land in Byron Shire.	2.8 Ha koala habitat planted by 2022.
	3.9 Seek grant funding opportunities for combined Council-private landholder restoration and revegetation projects on private land.	Funding secured for restoration projects on private land.
	3.13 Investigate opportunities for Council to provide incentives for landholders to conduct restoration works that will assist with long term biodiversity conservation.	Landholder incentive options reviewed and reported to Biodiversity Advisory Committee.
	3.14 Seek grant funding for an extension officer to work with landholders to protect and enhance biodiversity values on private land.	Grant proposal submitted to relevant authority.
4.8 Encourage and provide direct and in principle support to Landcare, Primary Industry groups and individual landholders to implement best practice natural resource management along the waterways of the Brunswick and Wilsons River catchments.	4.30 Seek funding to develop and implement projects addressing improvements in riparian and instream habitat, water quality, fish passage and habitat connectivity on Council and private land along waterways of the Wilson River catchment.	Funding secured for rehabilitation of 5km of riparian habitat along Wilson's River.

Source: Byron Shire Council (2020)

Healthy Waterways Program

The Ballina Shire Health Waterways Program funds projects that focus on improving the health of the Richmond River, its tributaries and other waterways in the shire. Projects include riparian revegetation, work with the local oyster industry, and community and industry educational programs including the “Love it or Lose it” campaign. Funds have been instrumental in leveraging further State Government contributions and grants which require co-contributions from Council.

NSW Landcare Program

NSW Landcare is a non-profit community organisation which encourages and supports sustainable natural resource management. The organisation undertakes a range of projects with landholders, volunteer groups, and government agencies including river restoration, farm planning and bush regeneration. Landcare NSW is the peak representative body for the community Landcare movement in NSW. The Landcare movement is a community-based approach to managing and protecting natural resources, creating more productive and sustainable farms, conserving the environment and building more cohesive and resilient communities (Landcare NSW, 2021).

A number of Landcare Groups are active in the Richmond River catchment working in collaboration with local councils and state agencies to deliver restoration of natural environments. Richmond Landcare Incorporated is a non-profit community led Landcare network formed in 1998 to support Landcare in the Richmond River catchment (Richmond Landcare Incorporated, 2020). Richmond Landcare Incorporated is managed by a committee of volunteers drawn from representatives of its member groups and is a participating member of the regional Landcare network, North Coast Regional Landcare Network, and the state group Landcare NSW. There are over 100 member Landcare Groups located throughout the Richmond River Catchment.

The NSW Landcare Program is a collaborative initiative of Local Land Services and Landcare NSW empowering landholders to take action on local problems and deliver outcomes that address local and regional issues. The *NSW Landcare Program – Strategic Plan 2019 – 2023* (LLS and Landcare NSW, 2020) has been published by the NSW Landcare Program as a collaborative initiative of LLS to provide an outline of the program over 4 years from July 2019 to June 2023. The Plan acknowledges the importance of social capital of Landcare organisations and broadening the impact of government and other services; designed to support whole of community, landscape and industry outcomes. Landcare on-ground works typically focus on community-based weed management and biodiversity enhancement on both public and private land. Some of the delivery metrics referenced in the Plan that are directly relevant to Richmond River health are:

- Stream length (M) river/estuary enhanced, rehabilitated or protected.
- Area (Ha) of wetlands enhanced, rehabilitated or protected.
- Area (Ha) land managed for improved soil condition.
- Number of projects undertaken to protect Aboriginal.
- Cultural Heritage or Traditional Ecological Knowledge.
- Area (Ha) weed management.

Cultural Mapping Projects

The *Shire Wide Aboriginal Cultural Mapping Project* (Converge Heritage + Community, 2012) documents the location of sites, objects and landscape features in the Kyogle LGA which are associated with First Nations people's use of those features in the everyday lives and for traditional cultural activities. Included in the mapping are sites where there is a high probability of the existence of a cultural site and sites identified by community oral advice or knowledge although the maps do not give any detailed or sensitive information about the sites. The intention is for these maps to be updated if additional sites are identified.

The Bundjalung Cultural Mapping Project (SCU, 2021) aimed to give Indigenous communities greater input into how their traditional lands are managed and to preserve the wisdom of Elders in the Northern Rivers region. The Project was undertaken between Southern Cross University, the Bundjalung Nation Aboriginal Cultural Heritage Natural Resource Management Committee, Northern Rivers Catchment Management Authority (now LLS), and the NSW National Parks and Wildlife Division.

The Project resulted in a digital record-keeping system through which communities can record and thus own their cultural knowledge. The system was designed so that it could be administered and controlled by Indigenous communities, with important or sensitive information only able to be accessed by those persons delegated by the local Aboriginal community. Communities can record oral, visual and written histories, photographs, films and any other kind of digital media about their cultural places and landscapes and file them on the database for the benefit of future generations.

Integrated Forestry Operations Approvals

Integrated Forestry Operations Approvals (IFOAs) under the *Forestry Act 2012* set environmental rules for how forestry operations can be carried out in State Forests and Crown Timber Lands in NSW. The Coastal IFOA (combing the previous plan for the Upper North East (refer Figure 17) with other coastal NSW regions) includes new rules to protect plants, animals, ecosystems, soils and waterways during native forestry operations on State Forests. These include minimum standards to preserve important wildlife habitat, which will be complemented by existing protected areas such as habitat corridors, old growth forest, rainforests, streams and wetlands. The EPA regulates Forestry Corporation of NSW's compliance with the IFOAs.

Private Native Forestry Plans

Private native forestry (PNF) is the management of native vegetation on private property for sustainable logging and timber production. Harvesting timber for the purposes of PNF requires approval through a private native forestry plan (PNF Plan). A PNF Plan is a legally binding agreement between a landholder and LLS. Once a PNF Plan is entered into landholders must conduct PNF operations in accordance with the minimum operating standards set out in the PNF Codes of Practice. The EPA is responsible for monitoring compliance with the PNF Plan and relevant PNF Code of Practice and undertaking associated enforcement activities.

APPENDIX 3 GUIDELINES AND RESOURCES

This Appendix provides a summary of guidelines and resources relevant to catchment, estuary and coastal management in the study area prepared by local and state government, community and industry groups.

Local and State Government Guidelines and Resources

Local councils and state government agencies implement a range of community awareness projects across the Richmond River catchment aimed at enhancing community understanding of the value of water and providing guidelines and direction on how to protect waterway health. Some of the key engagement activities are summarised below:

- *Landholders' Guide to Looking after waterways in Richmond Catchment* (Rous County Council, 2017a).
- *Healthy Catchments, Healthy Water - Managing land within drinking water catchments: A practical guide for NSW landholders* (The Water Directorate, 2016).
- RCC fact sheets and materials:
    - *Protect and Restore Vegetation to look after our drinking water catchments*
    - *Manage Macadamia Farms to look after our drinking water catchment*
    - *Manage Livestock in and around waterways to protect drinking water quality*
    - Health catchments, quality water - screen saver, postcard or fridge magnet for rural landholders
    - Health catchments, quality water - screen saver, postcard or fridge magnet for urban landholders.
- Native Planting Guides:
    - *My Local Native Garden Guide - a planting guide to promote biodiversity in the Lismore region* (Rous County Council and Lismore City Council, 2016).
    - My Local *Native Garden Guide - a planting guide to promote biodiversity in Byron Shire* (Brunswick Valley Landcare, 2014).
    - *Ballina Shire Urban Garden Guide* (Ballina Shire Council, 2006).
- Rural Landholder Initiative booklets (co-operative between LCC, SCU and RCC):
    - Book 1: Healthy landscapes and waterways (Lismore City Council, 2016a).
    - Book 2: Beef grazing and dairying (Lismore City Council, 2016b).
    - Book 3: Macadamias and other orchards (Lismore City Council, 2016c).
    - Book 4: Floodplain cropping (Lismore City Council, 2016d).
- Coastal Management Toolkit - contains information and guidance to help councils to manage the NSW coast and prepare coastal management programs.
- *RCC Reconnecting to Country* projects at several sites (e.g. Wilsons Creek Rainforest and Bush Tucker Garden, Byron Creek and Bangalow Park Wetland). Open days, interpretative signage, cross cultural training etc.

- *RCC Reconciliation Action* Plan (RAP) (RCC, 2016).
- *LCC Reconciliation Action* Plan (RAP) (LCC, 2016).
- Welcome to Widjabul Country info sheets; Widjabul posters; and The Watering Hole Cartoons created by RCC, Widjabul descendants and Sustainable Futures. The language used is Wiabul, the traditional language of the Widjabul people. Messaging relates to healthy land practices = healthy water.
- *Love it or Lose it* Education Campaign.
- Primary and secondary school education programs in partnership with Dorroughby Environmental Education Centre through a joint regional education initiative to deliver water education programs throughout the Northern Rivers.
- Byron Writer's Festival 2017 book launch – Big Scrub Rainforest: A Journey Through Time, presented by RCC and Big Scrub Landcare.
- World Environment Day (annual events).
- Council tree plantings.
- Clean up Australia Day (annual events).
- World Water Day (annual events).
- RCC Primex stall and display (annual event) incorporating the Catchment Trailer display, and staff on-hand to discuss and provide information on land management practices to improve water quality in a relaxed setting.
- Mapping/ Database Resources:
    - Koala Habitat Restoration Archive - an Atlas of Living Australia BioCollect project which aims to provide a free, online, open access and enduring archive of current and past work restoring habitat for koalas in the Northern Rivers region and to document that work using standard criteria and in standard format. The information base created by the archive will assist with coordination and planning of large-scale restoration programs and provide data for summarising and analysing restoration work conducted within the Northern Rivers at different spatial and temporal scales (pers. comm. S. Hernandez, 2021).
    - Coastal Risk Australia Mapping - Predicted Coastal Flooding Resulting from Climate Change - IPCC Sixth Assessment Report Update (2021).
    - SEED Mapping - the NSW Government's central resource for Sharing and Enabling Environmental Data. It was developed for the NSW community in a collaborative effort between government agencies to provide an accessible and reliable platform for environmental data.

Industry Guidelines

Several Richmond River Industry Groups produce management guidelines to assist industry to self-regulate and implement best-practice with direct relevance to Richmond River health. Table 21 lists industry guidelines of relevance to the Richmond River.

Table 21: Industry guidelines and policy documents

Industry	Industry Group	Document	Description
Sugar Cane	Sunshine Sugar	*NSW Sugar Industry Farming Code of Practice* (Sunshine Sugar, 2014)	Provides practical measures to assist in keeping farms profitable and to minimise environmental impacts.
		The NSW Sugar Industry Best Practice Guidelines for Acid Sulfate Soils (Sunshine Sugar, 2020).	Sugar cane farms in the Richmond River floodplain that operate through Sunshine Sugar agree to comply with the guidelines. Sunshine Sugar, through its Agricultural Services division, undertakes studies to support latest research and to enhance the adoption of recommended farming practices based on that research. The overall objective is to support the sustainability of the industry and to improve and enhance the quality of water leaving sugarcane farms.
Macadamia	Australian Macadamia Society	*Macadamia Industry Integrated Orchard Management Practice Guide* (AMS, 2016)	A guide for growers focusing on implementing best practice methods to reduce erosion and the level of sediment and nutrients entering waterways.
		Macadamia Integrated Orchard Management Drainage (AMS, 2017)	Provides a step-by-step process for growers to manage drainage in their orchards. The document provides clear guidelines around three main principles: stopping water entering orchard initially; stabilising existing watercourses within the orchard; and slope specific groundcover providing different options to provide as much groundcover as possible.
Meat Processing	The Casino Food Co-op	*Environmental Policy*	Policy stating commitment to "*the long-term care of the land and environment from which our members and our industry derive our existence, raw material and viability*"
		Livestock Water Infrastructure Project	A proposed project focussed on providing on-ground infrastructure to landholders to facilitate off-stream stock watering (e.g. tanks, troughs, fencing etc.). Once stock are excluded from riverbanks, riparian revegetation can occur. The project is an industry-led model focussed on solutions rather than problems.

Industry	Industry Group	Document	Description
Forestry	Forestry Commission NSW	*Integrated Forestry Operations Approval for the Coastal Region* (EPA, 2018)	The approval authorises the carrying out of forestry operations in accordance with conditions, terms and requirements of the approval. Relevant conditions relate to riparian buffer widths, pollution of waters and biodiversity protection.