# Clarence River Estuary

## Coastal Management Program
## Stage 1: Scoping Study




**Volume 1: Scoping Study**

**Final Report**

**September 2022**

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Clarence Valley Council and Hydrosphere Consulting acknowledge the Yaegl, Bundjalung and Gumbaynggirr peoples, Traditional Custodians of the lands discussed in this report and pay tribute and respect to the Elders both past and present and emerging of these nations.

Cover photos: Clockwise from top left – yachts in River at Maclean (source: CVC), McFarlane bridge at Maclean, Woodford Island, Chatsworth.

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



**22-008 CLARENCE RIVER ESTUARY CMP SCOPING STUDY**
**CLARENCE RIVER ESTUARY COASTAL MANAGEMENT PROGRAM STAGE 1: SCOPING STUDY**

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# EXECUTIVE SUMMARY

Clarence Valley Council (CVC), with assistance from the NSW Department of Planning and Environment (DPE), is preparing a Coastal Management Program (CMP) for the Clarence River Estuary in accordance with the NSW Coastal Management Framework. Stage 1 of the CMP development is a Scoping Study (this document) which sets out the remainder of the coastal planning process for the Clarence River Estuary:

- Stage 2 – determine risks, vulnerabilities and opportunities.
- Stage 3 – identify and evaluate options.
- Stage 4 – prepare, exhibit, finalise, certify and adopt the CMP.
- Stage 5 – implement, monitor, evaluate and report.

This Scoping Study has been compiled from existing studies and data sets, stakeholder consultation activities and site inspections. The development of the Scoping Study involved collaboration with a range of stakeholders involved in the management of the catchment, floodplain and waterways of the Clarence River. This Scoping Study presents the scope of the CMP and the forward program and costs to implement Stages 2 to 4 of the CMP. The CMP for the Clarence River Estuary will update and consolidate the *Pathways to a Living Estuary Clarence Estuary Management Plan* (Clarence River EMP, Umwelt, 2003) and the *Coastal Zone Management Plan for Wooloweyah Lagoon* (CZMP for Wooloweyah Lagoon, White, 2009a) and related estuary management plans.

The study area is defined by the catchment boundary of the Clarence River to the boundary of the study area for Clarence Valley Coastline and Estuaries CMP, which is being developed separately by CVC for the areas near the coast. Although the focus of the CMP is on the Clarence River estuary (coastal zone), consideration is given to issues in the wider catchment that may significantly impact the estuary. The Clarence River estuary has high cultural and spiritual significance to local First Nations people. Traditional custodians of the Clarence River estuary include three nations - Yaegl, Bundjalung and Gumbaynggirr. Their original occupation and custodianship of the lands and waters of the study area dates back many thousands of years. First Nations heritage and connection to land and water country are inseparable aspects. Healthy waterways and “sea country” are essential for First Nations people for health, wellbeing and culture as they allow kinship, connection, stories, song lines and healing. The ongoing use and relationship to Country by First Nations people is recognised with successful Native Title determinations over lands and waterways within the catchment.

The Clarence River is the largest coastal catchment in NSW, with a catchment area of more than 2.2 million hectares characterised into three landscapes - the coastal plains, midland hills and escarpment ranges. The tidal influence within the Clarence River currently extends approximately 100 km to Copmanhurst. The region experiences high rainfall and flooding is a regular event throughout the Clarence River catchment and is often associated with cyclonic rain depressions that bring intense rainfall to the region.

The study area occurs in the McPherson-Macleay Overlap area, where the temperate and tropical zones intersect, creating an area of extremely high biodiversity from the wide range of soil types, climate and topography across the region. The dominant land use within the Clarence River catchment is parks and reserves, mostly in the middle and upper freshwater catchment. Grazing and forestry plantations are also found in the upper ranges of the catchment. Cropping dominates the floodplains of the lower catchment.

Agriculture is a major driver of the local economy and much of the catchment has been cleared or modified for this purpose. The Clarence River estuary has regionally important commercial and recreational fisheries and supports the largest estuary-based fishery in NSW. Fishing activities and practices also have spiritual, social and customary significance for First Nations people. 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.

The Clarence River floodplain has been extensively modified by a network of constructed drains, artificial levee banks and floodgates. The development of the floodplain has resulted in significant consequences for the hydrology of the adjacent land and estuary health. Key issues are the exposure and oxidation of acid sulfate soils (ASS) and the formation of monosulfidic black ooze (MBO) and blackwater which impact water quality and ecosystem health. CVC manages public floodplain infrastructure, some of which was originally built by drainage unions or individual landowners and there are often no easements over infrastructure on private land. The *Clarence Floodplain Project* (CFP) was initiated in the late 1990s under the former Clarence River County Council and continued under CVC to improve outcomes of floodplain management across the Clarence River floodplain until the mid-2010s. Many initiatives, projects and improvements were undertaken as part of the CFP across the floodplain. Many improvements have been made to improve non-flood environmental outcomes whilst still retaining flood mitigation benefits.

Stakeholders regard the health of the Clarence River estuary as the central most important aspect that influences other factors such as cultural connection, on-going commercial use and social enjoyment of the estuary. The key ecosystem health challenges facing the Clarence River estuary are linked to its physical characteristics including the large catchment area (2.2 million ha) and floodplain (22,475 ha) coupled with areas of erosion and ASS and the significant catchment modifications that have occurred since European settlement. With this substantial catchment area and land use modifications, the management of the Clarence River catchment has a significant impact on the health of the estuary and coastal zone. An integrated management approach is required for the management of this river system with its diverse interests and influences.

The key threats to the Clarence River estuary have been prioritised in this Scoping Study. Due to the large geographical area and the range of environmental and social values of the study area, there are several key management threats to be considered in the CMP:

- The most significant threats to biodiversity in the Clarence River catchment are habitat degradation through native vegetation clearing, competition and predation by invasive species and increased sediment and nutrient loads to the estuary.
- 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.
- Sediment and nutrient runoff within the catchment (including from agricultural land, unsealed roads and urban development), ASS discharge, low oxygen ‘blackwater’ runoff from coastal floodplains and stormwater runoff contribute to poor estuarine water quality and can lead to exacerbating processes (e.g. eutrophication and potentially toxic blooms of blue green algae).

- The Clarence River estuary and catchment will experience broadscale climate change impacts as well as localised impacts into the future. It is expected that sea level rise will result in changes to the Clarence coastal zone including increased tidal propagation, increased salinity in the upper estuary reaches, impacts on coastal gravity drainage, stormwater infrastructure, sewerage systems and some roads. Other impacts of climate change may include increases in extreme rainfall events and more intense storms, more severe droughts and impacts on biodiversity from rising temperatures, rising sea levels, altered fire regimes, degraded water quality and altered ocean chemistry.

At the time of development of the Clarence River EMP in the early 2000s, estuary management was a responsibility of the former Department of Land and Water Conservation, in association with local councils. The plan acknowledged that there were major challenges to achieving sustainable management of the Clarence River estuary with many of those challenges deriving from human interactions with sensitive natural estuarine processes. The greatest challenge was to achieve sufficient integration of community aspirations, state and local government policy, quality technical information, best practice solutions and adequate resources, for real and recognisable progress to be made. The task of improving the health of the Clarence River estuary continues to be substantial, complex and multi-faceted and the difficulties in implementing the EMP actions reflect these complexities. The key challenge for the CMP will be to identify and implement targeted on-ground works that will result in improvements in estuary health. While CVC is working with agencies, community groups such as Landcare and some private landholders to implement restoration works, these projects rely on limited internal and external funding, are generally small scale, do not necessarily target priority areas and are limited to areas where landowners are engaged and are willing to complete works on their land. In addition, while some studies identify priority actions, there is a lack of detail on the steps required for successful implementation including funding.

There is a growing community sentiment towards actively addressing environmental issues and improving the health of the Clarence River Estuary and this has been reflected in state, regional and local planning policy as well as some local industry guidelines. 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 Clarence River.

The majority (54%) of the Clarence River catchment is freehold land under private ownership and effective change in catchment and waterway health will require active engagement and participation of landholders. 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 changes to land use and management practices, 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 estuary health improvements are related to the difficulties in regulating diffuse water pollution, the long-term acceptance of current land uses, the lack of positive environmental outcomes required by some industries and the expectation that restoration of private land will be funded by governments.

Accurate and detailed information about risk and consequence is necessary to assist decision makers generate effective management strategies which identify and prioritise future actions and investment.

Stakeholder consultation undertaken as part of this Scoping Study has identified significant support for on-ground works and less support for further studies. However, some strategic planning is recommended to focus efforts and ensure cost-effectiveness. Other related programs (e.g. the Marine Estate Management Strategy, Regional Water Strategy, NSW government regulation) are currently being undertaken in parallel with the CMP process and these are expected to address many knowledge gaps associated with priority threats to river health. Additional detailed studies are required in Stage 2 of the CMP development including strategic planning for on-ground works, assessment of coastal inundation risks, development of cultural recognition/ awareness projects, identification of funding options and review of planning controls.

The CMP process represents an opportunity to focus on strategic on-ground actions that are rationalised and prioritised. The CMP will set a long-term strategy for the coordinated management of the Clarence River catchment and estuary and seek to improve the values of the study area for current and future generations. CVC will coordinate the development of the CMP and will collaborate with land managers, state government agencies, industry and community representatives to provide effective coastal management outcomes. The CMP development will continue over the next three years with the estimated costs and timing to deliver stages 2 to 4 of the CMP development as follows:

- Stage 2: between $605,000 and $1,010,000 (21 months: July 2023 – March 2026).
- Stage 3: between $80,000 and $110,000 (4 months: April 2026 – July 2026).
- Stage 4: between $50,000 and $80,000 (6 months: August 2026 – July 2027).

CVC will seek funding from the DPE Coastal and Estuaries Grants Program and other external funding to ensure affordability of the CMP development. Ongoing stakeholder liaison will be a key component of the CMP development.

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# 1. INTRODUCTION

Clarence Valley Council (CVC), with assistance from the NSW Department of Planning and Environment (DPE), is preparing a Coastal Management Program (CMP) for the Clarence River estuary in accordance with the NSW Coastal Management Framework. Stage 1is a Scoping Study (this document) which sets the scene for the remainder of the coastal planning process for the Clarence River estuary.

The Scoping Study:

- Sets out the strategic, environmental, social, cultural and management context for the CMP.
- Identifies issues and opportunities affecting the coastal zone now, and those that are considered likely in the future.
- Includes review of existing plans and documents to identify actions and strategies which have been completed, and outstanding actions that will be considered for inclusion in the CMP.
- Assesses the adequacy of existing management arrangements including current and planned actions.
- Includes a first-pass risk assessment and an analysis of knowledge gaps to inform decisions specified in a preliminary business case addressing the need for, and scope of detailed studies to be undertaken.
- Includes a forward program for subsequent stages of the CMP.

This Scoping Study has been compiled from existing studies and data sets, stakeholder consultation activities and site inspections. The development of the Scoping Study involved collaboration with a range of stakeholders involved in the management of the catchment, floodplain and waterways of the Clarence River. This Scoping Study presents the scope of the CMP and the forward program and costs to implement Stages 2 to 4 of the CMP.

# 2. COASTAL MANAGEMENT STRATEGY

## 2.1 Coastal Management within the Clarence Valley

The coastal zone of the Clarence Valley local government area (LGA) includes the Clarence River estuary, many smaller estuaries, lagoons and freshwater bodies and the open coastline extending from Ten Mile Beach in the north to Jones Beach in the south. Due to the large geographical extent of the coastal zone (approximately 86 km of coastline) and the large estuary and catchment of the Clarence River, CVC, with advice from DPE, determined to separate the coastline from the Clarence River estuary for the preparation of CMPs. The coastal management strategy for the LGA includes the development of the following CMPs:

- CMP for the Clarence Valley Coastline and Estuaries. The Stage 1 Scoping Study has been completed (Hydrosphere Consulting, 2021). Stages 2 - 4 of the Clarence Valley Coastline and Estuaries CMP commenced in 2021 and focusses on the coastline and small coastal estuaries.
- The National Parks and Nature Reserves within the coastal zone will be addressed in separate coastal management planning documents to be prepared by NPWS, although there may be opportunities to collaborate with CVC on some components of CMP development. The coastline and small estuaries in the National Parks and Nature Reserves are addressed in the Clarence Valley Coastline and Estuaries CMP Scoping Study.
- CMP for the Clarence River Estuary. The CMP will update and consolidate the *Pathways to a Living Estuary Clarence Estuary Management Plan* (Clarence River EMP, Umwelt, 2003) and the *Coastal Zone Management Plan for Wooloweyah Lagoon* (CZMP for Wooloweyah Lagoon, White, 2009a) and related plans (refer Appendix 1, Volume 2).

## 2.2 Study Area for the Clarence River Estuary CMP

The study area is defined by the catchment boundary of the Clarence River to the boundary of the Clarence Valley Coastline and Estuaries CMP study area near the coast (refer Figure 1). Section 13(2) of the *Coastal Management Act 2016* specifies that “a CMP may be made in relation to the whole, or any part of the area included within the coastal zone”. Although the focus of the CMP is on the Clarence River estuary (coastal zone), consideration is given to issues in the wider catchment that may significantly impact the estuary.

The Clarence River estuary is situated entirely within the Clarence Valley LGA. The estuary includes the tidal waters and foreshore and adjacent lands of the following waterways:

- Clarence River to Copmanhurst.
- Esk River.
- Mangrove Creek.
- Wooloweyah Lagoon.
- The Broadwater.
- Shark Creek to Tyndale Swamp.
- Sportsmans Creek to Dilkoon.
- Coldstream River to upstream of Tucabia (Colletts Island).

- Whiteman Creek to the Clarence Way.
- Orara River to just downstream of Old Glen Innes Road.
- Other minor tributaries.

a. Wooloweyah Lagoon

b. Clarence River near Chatsworth

c. Clarence River at Harwood bridge

d. Clarence River at Iluka

**Plate 1: Waterways of the Clarence River estuary**

The Clarence River catchment extends into the Richmond Valley, Kyogle, Tenterfield, Glen Innes Severn, Armidale Regional, Bellingen and Coffs Harbour LGAs.

The study area for this CMP Scoping Study includes coastal management areas mapped in Chapter 2 (Coastal Management) of the *State Environmental Planning Policy (Resilience and Hazards) 2021* (Resilience and Hazards SEPP) as coastal wetland and littoral rainforest areas (CWLRA), coastal environment area (CEA) and coastal use area (CUA) (Figure 2). These mapped SEPP areas make up the Clarence River estuary coastal zone (refer Section 9.2). This Scoping Study also considers the coastal hazards for areas affected by coastal inundation and foreshore erosion (not yet mapped in the Resilience and Hazards SEPP). Other coastal hazards will be addressed in the Clarence Valley Coastline and Estuaries CMP.

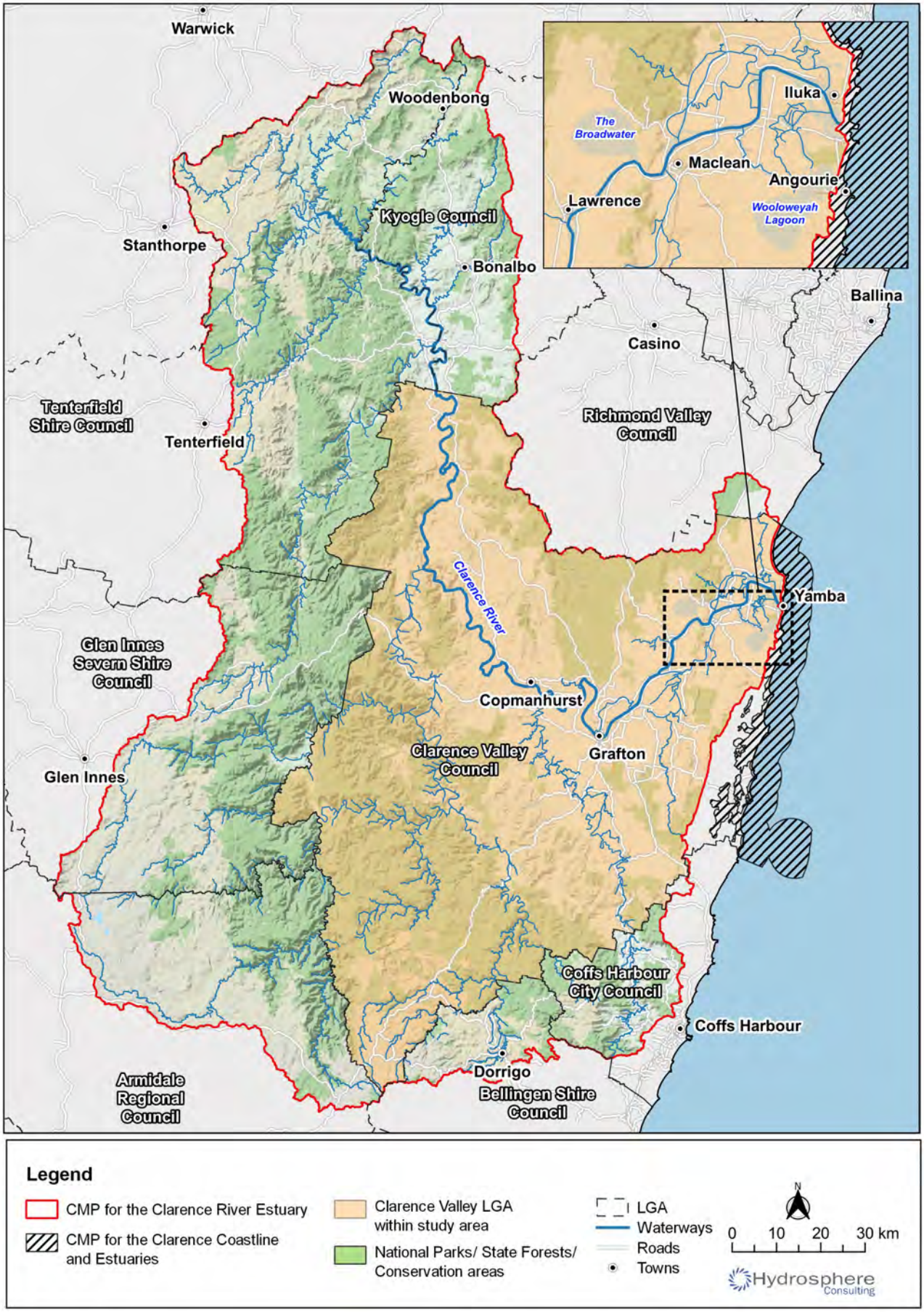



**Figure 1: Study area for the Clarence River Estuary CMP Scoping Study**

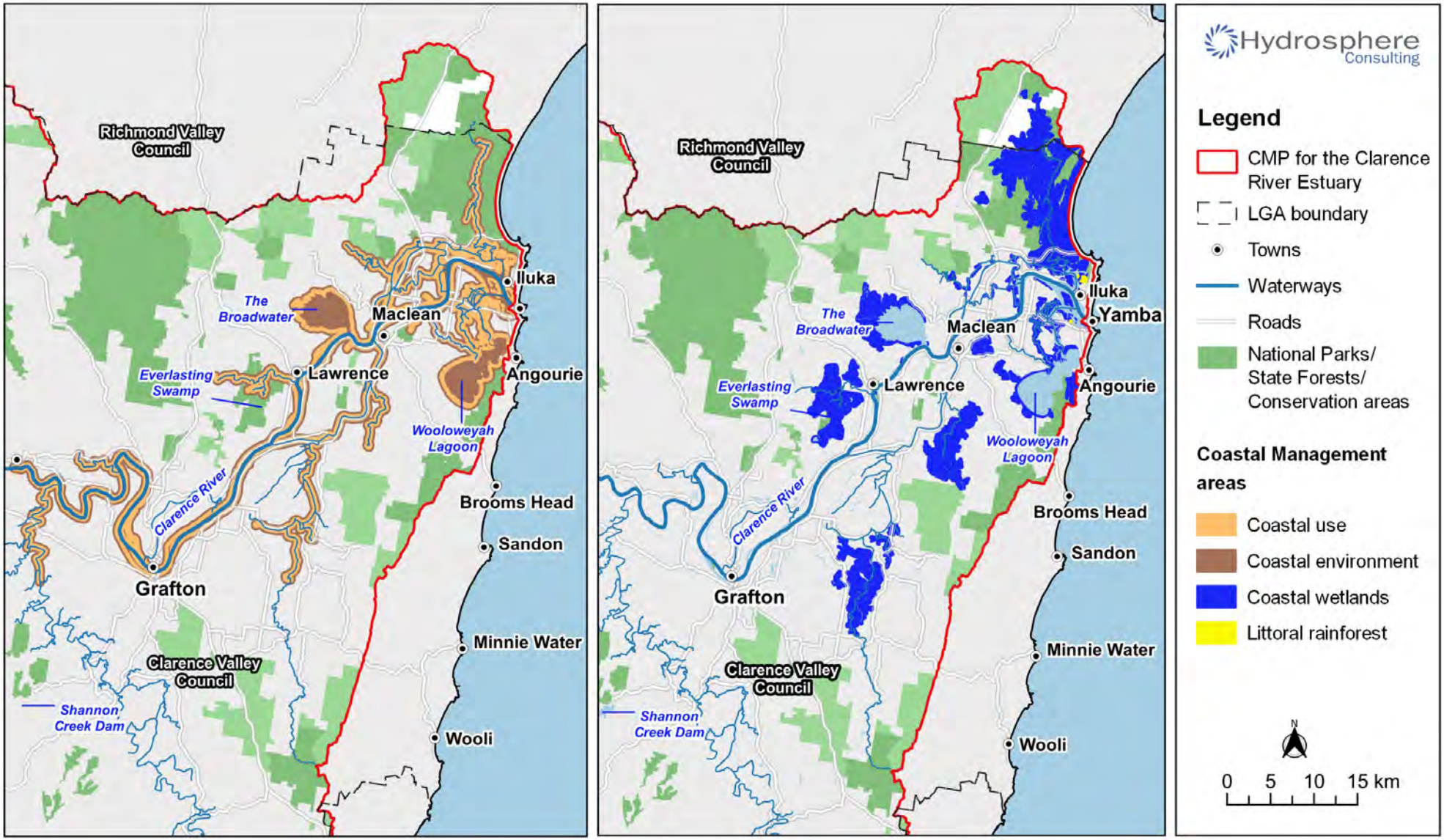



**Figure 2: Coastal management areas**

The Clarence River 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 cultural 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 & Kelly, 2020; 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”.

Recreational uses constitute the dominant use of the estuary waterways. Commercial boats also utilise the estuary waterways for fishing and tourism activities which are also important in the region although activities are concentrated in the lower estuary. Boating forms a vital component of the tourism sector of the Clarence 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. Agriculture, fishing and aquaculture are key industries relying on the health of the Clarence River estuary. While forestry, sugarcane, beef, dairy and aquaculture have long been established, emerging industries such as berries, macadamia nuts, as well as specialist food and vegetables are also developing (Localé Consulting, 2022a). In 2020, there were approximately 1,000 registered agricultural, forestry and fishing businesses, accounting for nearly 25% of the total number of businesses in the CVC LGA (.id Consulting, 2022).

**Figure 3: Motor boats moored at Grafton (left); Recreational fishing (right)**

Image source: CVC

# 3. STATUTORY AND PLANNING CONTEXT

## 3.1 The Coastal Management Framework in NSW

The *Coastal Management Act 2016* establishes the framework and overarching objectives for coastal management in NSW and supports the aims of the *Marine Estate Management Act 2014* to provide for strategic and integrated management of the whole marine estate – marine waters, coasts and estuaries. The *Coastal Management Act 2016* communicates the NSW Government's vision for coastal management and 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 legislative and policy framework (Figure 4 and Appendix 2, Volume 2) recognises natural coastal processes and the local and regional dynamic character of the coast and promotes land use planning decisions that accommodate them. The framework promotes coordinated planning and management of the coast and supports public participation in these activities.

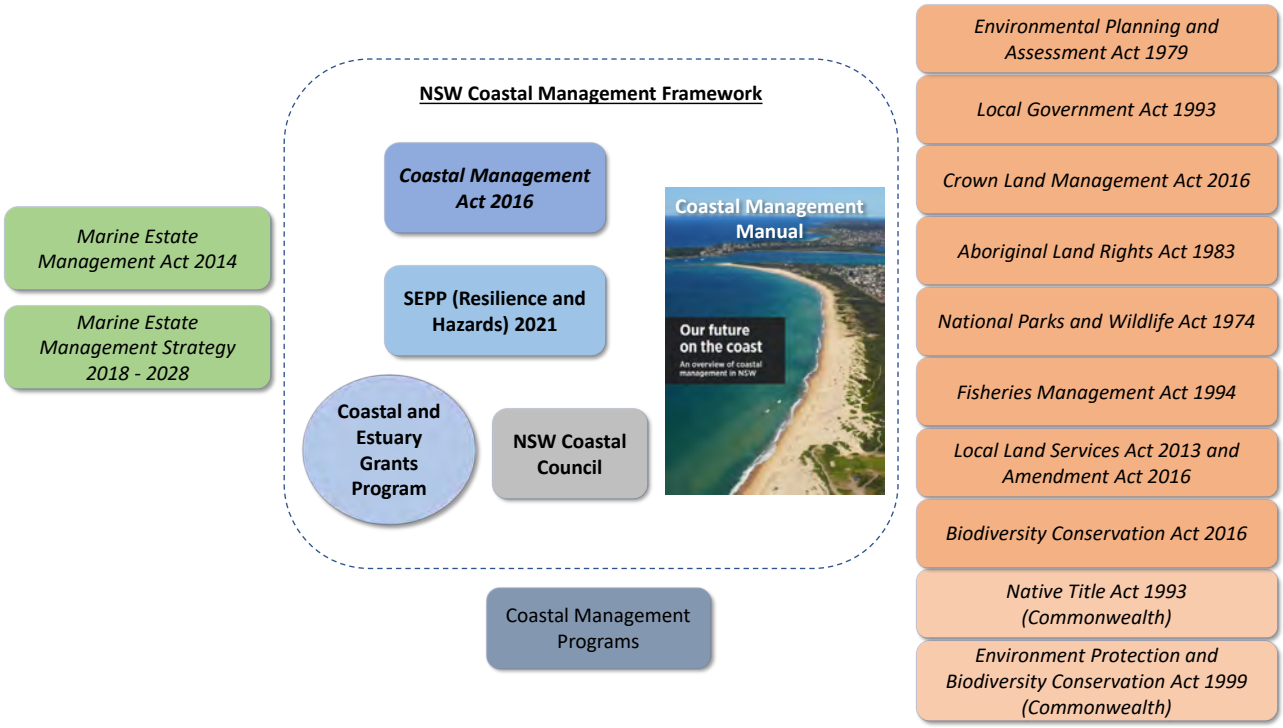



**Figure 4: NSW coastal management framework**

The *Coastal Management Act 2016* provides guidance on the integrated management of the coastal zone to support ecologically sustainable development to enhance the cultural, social and economic wellbeing of the community. The *Resilience and Hazards SEPP* is a broader land-use planning framework in NSW which delivers the statutory management objectives of the four coastal management areas which makes up the coastal zone. Chapter 2 (Coastal Management) of the SEPP specifies how development proposals in the coastal zone should be assessed.

The study area is managed in accordance with the *Marine Estate Management Act 2014* as marine waters, estuaries and coastal areas are classified as marine estate. This Act is supported by the *Coastal Management Act 2016* to provide strategic and integrated management of the whole marine estate.

Land within the study area that is classified as Crown land will be managed in accordance with the *Crown Land Management Act 2016*. This act requires environmental, social, cultural heritage and economic issues to be considered as part of the management of Crown land. Native title claims and determinations existing within the study area and the rights and interests that First Nations people hold in land and waters under their traditional laws and customers are recognised in the *Native Title Act 1993* and *Aboriginal Native Land Rights Act 1983*.

Management and protection of all threatened fish, their habitat and threatened marine vegetation in NSW is regulated under the *Fisheries Management Act 1994.* The Department of Primary Industries – Fisheries (DPI - Fisheries) manages this act to ensure ecologically sustainable development occurs.

The study area lies within the area covered by the *Water Sharing Plan for the Clarence Unregulated and Alluvial Water Sources 2016* and is managed in accordance with the *Water Management Act 2000*. The purpose of the act is to ensure sustainable and integrated management of water sources for present and future generations.

The *NSW Coastal Management Manual* (OEH, 2018a, the Manual) provides guidance for developing a CMP and assists councils in addressing the requirements of the *Coastal Management Act, 2016*. The Manual outlines the mandatory requirements and provides guidance on the preparation, development, adoption and content of a CMP. It includes a process for councils to follow when identifying and assessing coastal environmental, social and economic values and evaluating management actions. It also contains guidance on the integration of a CMP into Council's Integrated Planning and Reporting (IP&R) framework and land use planning. The Manual outlines a five-stage process for developing and implementing a CMP (Figure 5). This report addresses Stage 1 of the CMP process for the Clarence River.

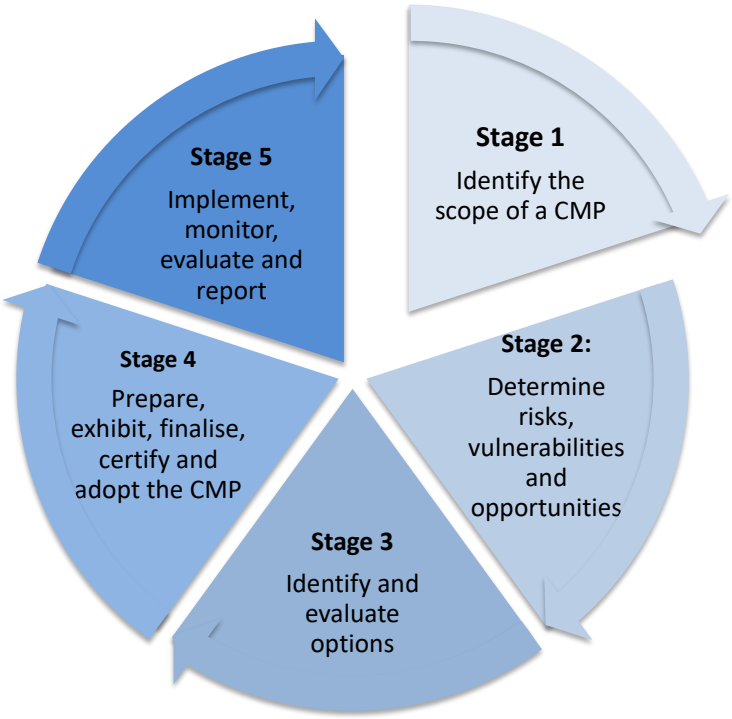



**Figure 5: The five-stage process for developing a coastal management program**

Source: Adapted from OEH (2018b)

## 3.2 Regional and Local Plans

The study area is currently managed in accordance with several regional and local level planning instruments, strategies and management plans implemented by CVC, former councils and other stakeholders (Figure 6). Other relevant plans include National Parks and Crown reserves plans of management, floodplain risk management plans and development control plans. Previous management plans include the *Coastal Zone Management Plan for Wooloweyah Lagoon* (White, 2009a), certified under the *Coastal Protection Act 1979* and the *Clarence River Estuary Management Plan* (Umwelt, 2003).

A detailed summary of all relevant coastal and estuary management plans, National Park plans of management and Crown Reserves plans of management are provided in Appendix 1 (Volume 2). The status of the current recommended actions in the coastal and estuary management plans is detailed in Appendix 3 (Volume 2).

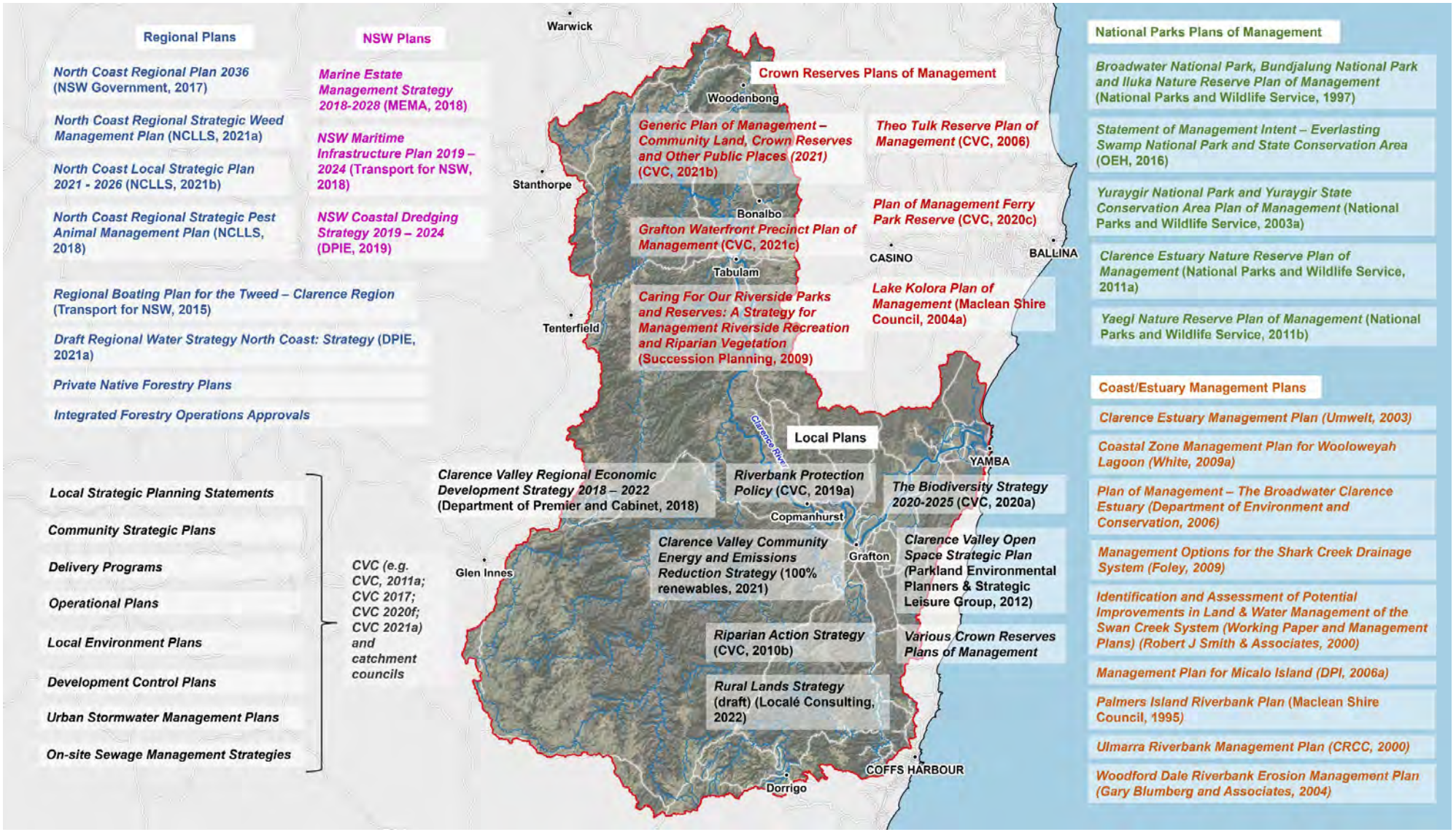



**Figure 6: Regional and local strategies and management plans for the Clarence River catchment**

# 4. STAKEHOLDER AND COMMUNITY ENGAGEMENT

Stakeholder engagement is a vital component which spans all stages in the production of a CMP. A key role of the Scoping Study is to involve stakeholders and ensure ongoing commitment for the CMP development and implementation.

Development of this Scoping Study included stakeholder engagement activities undertaken in accordance with the *Quality Assurance Standard for Community and Stakeholder Engagement* (IAP2, 2015), *CVC Community Engagement Policy* (CVC, 2020a) the *Guidelines for Community and Stakeholder Engagement in Coastal Management* (OEH, 2018a) and *Aboriginal Cultural Heritage Consultation Requirements for Proponent*s (OEH, 2010).

The aims of the engagement activities were to inform and involve stakeholders by bringing all interested parties on board early to share information and ideas, identify stakeholders and prepare a stakeholder profile. Feedback from the community and other stakeholders has been used to identify catchment usage and values, areas of interest/ responsibility and coastal management issues to be addressed in the CMP. Engagement activities are detailed in Appendix 4 and included:

- Meetings with the CVC Coast and Estuaries Management Committee (CEMC).
- An online community survey.
- Submissions were invited from government agencies, community, industry and business groups and the First Nations community.
- Engagement (meetings, phone calls and arrangement of on-Country cultural heritage assessment) with Native Title holders.
- The Clarence Conversations website included project information, a link to the community survey, information links, downloads, a discussion forum, questions page and pin map.
- Site meetings including field trip along the River with DPE, North Coast Local Land Services (NCLLS) and CVC representatives.

The key attributes of the Clarence River valued by the survey respondents were focused on the environment and waterway health. Feedback from industry and community groups highlighted key values including sustainable land management, environmental protection and the desire to be included in environmental management actions. The productive and sustainable management of agriculture, fisheries and biodiversity, as well as floodplain health and the economic wellbeing of the community were key aspirations highlighted by the stakeholders.

Results from the community survey showed the most common concerns were poor water quality, marine vegetation loss/ degradation and future land use. Key issues focused on bank erosion, weeds in public land (riparian zone) impacting surrounding private land, the complexity of floodplain mitigation infrastructure / drain maintenance, water quality and environmental degradation (marine vegetation and riparian zones). The majority of respondents preferred funding to focus on improving water quality and floodplain management, protecting biodiversity and improving riparian vegetation.

# 5. CULTURE AND HERITAGE

## 5.1 First Nations

The original occupation and custodianship of the lands and waters comprising the Clarence River estuary by First Nations people dates back many thousands of years. Traditional custodians of the Clarence River estuary include three nations:

- Yaegl – the lower estuary from Iluka/Yamba to Swan Creek.
- Bundjalung – mid to upper estuary and northern upper catchment, north and inland from Southgate.
- Gumbaynggirr – mid to upper estuary and southern upper catchment, south side of the Clarence River from Swan Creek.

Across the three nations the river is referred to differently (with various spellings) as Biirrinba (Yaegl), Boorimbah (Bundjalung) and Barrway/Bindarray (Gumbaynggirr). The Clarence River is significant to the culture of all three nations.

### 5.1.1 Yaegl

The Yaegl People, whose country centres around the lower Clarence River, skilfully managed the lower estuarine reaches of the river and its resources for thousands of years. The coastal zone is a resource-rich area and a reliable source of food for Yaegl people (Australian Museum Consulting, 2015). The Yaegl people have an ongoing and continuing relationship and connection to the lower Clarence River estuary. Many significant cultural sites exist along the river including the Dirrangun reef in the lower estuary.

### 5.1.2 Bundjalung

The Clarence River runs through the country of several Bundjalung (also known as Bunjalung, Bandjalang, Banjalang) dialects including Wehlubal, Birihn, Wahlubal, Dinggabal, Wudjehbal and Gidhabal. The southern end of the Bundjalung nation extends into the far upper estuary with the Clarence River marking the boundary with Gumbaynggirr (Australian Museum Consulting, 2015). There were rich resources available for the Bundjalung people throughout their areas, sustaining them for thousands of years prior to European colonisation. Historically, there were an estimated 20 dialects among the Bundjalung people (Australian Museum Consulting, 2015). Following European colonisation in the area, there are reports of amicable relationships between the cedar cutters and Bundjalung people. Cedar cutters would team up with local men who assisted in navigating thick forest and the felling and transportation of the logs (Australian Museum Consulting, 2015). Bundjalung dialects were still spoken widely until the 1950s, when English became more widely spoken.

### 5.1.3 Gumbaynggir

Ancestral stories of the Yuludara ancestor helped define the extents of Gumbaynggir territory. Yuludara turned two women into rocks which delineated the northern and southern boundaries (Australian Museum Consulting, 2015). Gumbaynggir people have physically and spiritually cared for the land, with knowledge of sacred paths and Dreaming stories for many thousands of years. There were abundant food resources throughout the whole Gumbaynggir territory, and it is believed that they travelled extensively between the coast, Clarence River and hinterland all year round (DECC, 2009a). Other Aboriginal groups travelled to the

area for ceremonies, feasts and other special events. The Gumbaynggir had a matrilineal system (clans descended from the mother's family), contrasting to other neighbouring coastal groups. Having this availability of food resources and a relatively low number of settlers in the area, allowed cultural continuity for the Gumbaynggir people from prior to colonisation until the early 1900s.

### 5.1.4 Culture and land management

First Nations people 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, 2020a). 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 9.5.

Known and recorded heritage sites in NSW are recorded in the Aboriginal Heritage Information Management System (AHIMS). Places of local heritage significance and conservation areas are also identified in the LEPs and a Yaegl cultural mapping project (in preparation). 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 NSW Government has developed an Aboriginal sites decision support tool, extending the AHIMS by illustrating the potential distribution of site features recorded in AHIMS. The maps of site feature predictions made by the tool are based on the application of site predictive modelling to correlate site information in AHIMS with landscape patterns such as proximity to water, vegetation, terrain, soils etc. The maps provide a regional overview about site feature distribution and related issues about the level of accumulated impacts they have experienced, where data gaps in the AHIMS data base remain, and where these gaps can be addressed through further survey (NSW Government, 2022).

## 5.2 Early Colonisation

The first European settlers in the Clarence River district were cedar cutters rather than pastoralists. The cedar cutters arrived around 1835 and worked and lived in small mobile groups (MHL, 2000). The low lying, forested wetlands of the Clarence River were the most easily accessible and the first to be cleared of their stands of red cedar. As the cedar cutters began to open up the forests, pastoralists followed with livestock. Squatting licences were taken up at Ramornie and Copmanhurst in 1839, at Yulgilbar, Tabulam, Nymboida, Eatonsville and Glenugie in 1840, at Southgate in 1841, at Buccarumbi in 1844 and at Coldstream near Grafton in 1845. This soon had an impact on Aboriginal land use and procurement of food resources, as riverine floodplains and forested wetlands were taken up for pasture, bringing the European and Aboriginal populations into conflict (Australian Museum Consulting, 2015).

Grafton was gazetted in 1851 and following the large-scale vegetation clearance and 'land grab' more Europeans arrived in the area. Settlers were allowed to select parcels of land between 40-320 acres under the *Sir John Roberts Free Select Land Act 1861.* After this colonisation, maize and sugar became the dominate industries (MHL, 2000). By the end of the 1890s, there were 80 privately owned sugar mills in the

area. The Clarence River was integral to the success of all industry in the area as it was the main mode of transport until a rail bridge connected Grafton in 1932. Widespread modifications to the Clarence River catchment and floodplain were undertaken to facilitate broadscale agriculture and settlement in the region. This included native vegetation clearing and drainage of floodplains and wetland areas. These historical modifications and ongoing environmental consequences are discussed further in Section 6.3 and 6.7.

# 6. ENVIRONMENTAL CONTEXT

## 6.1 Climate

The Clarence River catchment is characterised by a sub-tropical climate along the coast and a more temperate climate inland in the higher tablelands (DPIE - Water, 2016). The whole catchment generally experiences warm humid summers and mild winters, typical of a subtropical climate. However, the ocean influences the climate of the coastal towns, with more inland centres such as Grafton and towns within the upper catchment experiencing higher maximums and lower minimum temperatures. Average annual rainfall is dictated by the topography and varies between less than 1,000 mm in some floodplain regions, up to 1,400 mm along the coast and over 2,000 mm in the elevated tablelands (DPIE - Water, 2016). There is a high degree of seasonal variation in rainfall with a clear wet/dry seasonal pattern. The highest rainfall typically occurs during summer and in early autumn 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.

## 6.2 Topography

The Clarence River is the largest coastal catchment in NSW, with a catchment area of more than 2.2 million hectares extending in the north from the Queensland border north-east of Stanthorpe to Dorrigo in the south and near Glen Innes in the west. Most of the catchment lies between 0 - 800 mAHD (m above sea level) (Figure 7). The catchment has varied elevations, from wetlands below sea level on the coastal floodplain, up to 1,370 m above sea level in the upper reaches of the Nymboida National Park in the south-west. The catchment can be characterised into three landscapes - the coastal plains, midland hills and escarpment ranges. The coastal plains cover approximately 15% of the catchment and include the floodplain and associated low hills between the ocean and midland hills. The midland hills make up 43% of the catchment and include the foothills of the low ranges between the escarpment ranges and floodplain. The escarpment ranges make up 42% of the catchment, bordering the New England Tablelands to the west (CVC, 2010a). The eastern part of the catchment is defined by a very large coastal floodplain, which covers an area of over 1,500 km$^2$. Elevations on the floodplain range from 0 mAHD to approximately 8 mAHD, depending on the magnitude of the flood (Bader *et al.,* 2018). Backswamps on the floodplain are typically below 1 mAHD. Figure 8 highlights low-lying floodplain from 0 – 1 mAHD within the study area, which includes large areas of Wooloweyah Lagoon, The Broadwater, Everlasting Swamp, Tyndale Swamp and other floodplain areas surrounding the estuary.

**Plate 2: Clarence River floodplain (view from Maclean lookout)**


**Figure 7: Study area elevation**

Source: Mapping data from Geoscience Australia (2015b)

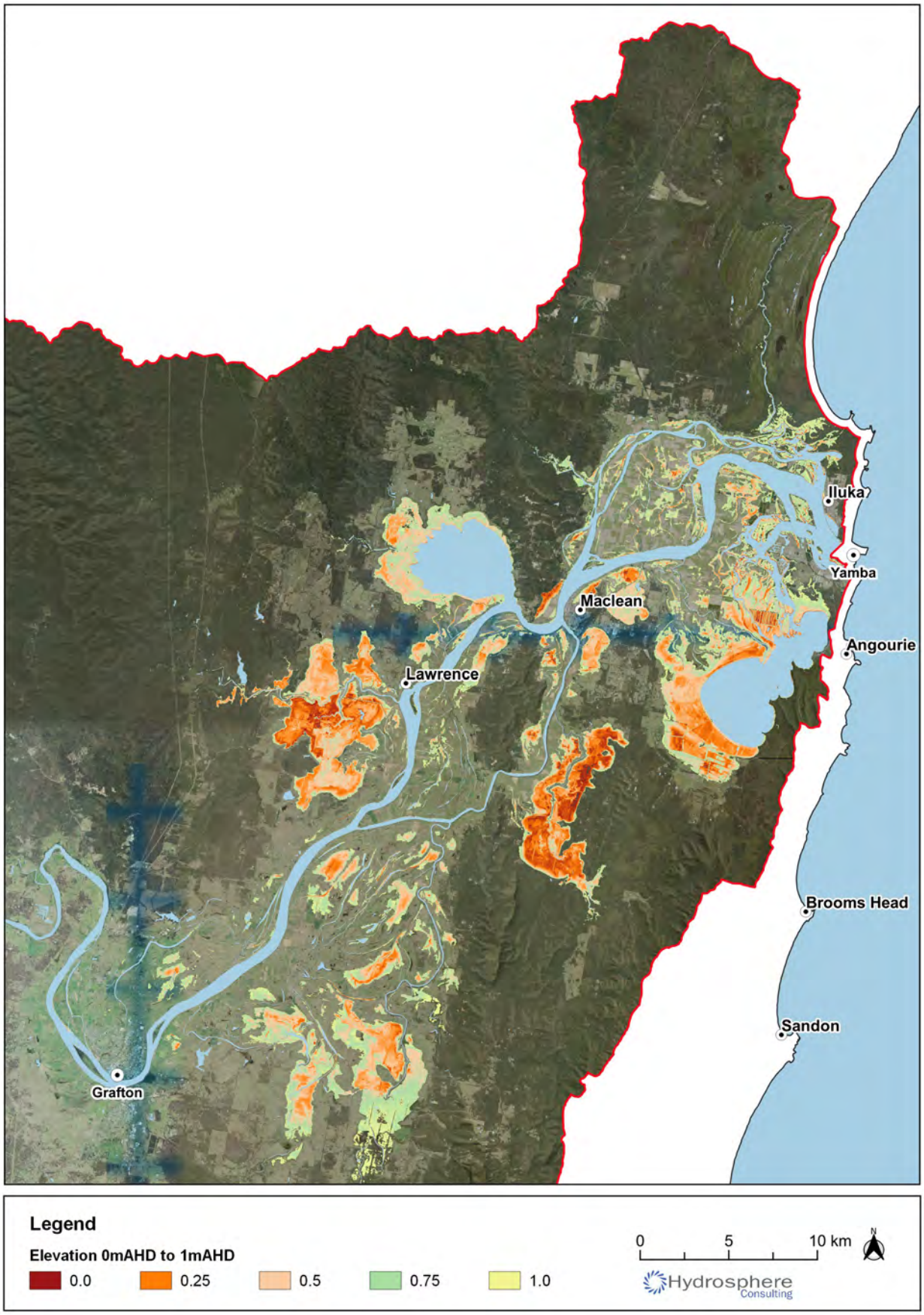



**Figure 8: Low-lying floodplain areas, below 1 mAHD excluding waterways**

Source: Mapping data from Geoscience Australia (2015b)

## 6.3 Hydrology and Catchment Modifications

### 6.3.1 Hydrology

The Clarence River is approximately 324 km in length with headwaters at the convergence of the Maryland River and Koreelah Creek at Rivertree and entering the ocean at Yamba/Iluka. The *Clarence Catchment Ecohealth Project* (Ryder *et. al,* 2014) divided the catchment into five sub-catchments - Clarence main stem, Coastal systems, Coastal tributaries, Mann-Nymboida-Boyd and Northern tributaries (Figure 9). Significant northern tributaries include the Maryland River, Koreelah, Tooloom and Duck Creeks, Boonoo Boonoo, Cataract and Timbarra/Rocky Rivers. In the south major tributaries include the Mann, Nymboida, Guy Fawkes and Boyd Rivers. The Orara and Coldstream Rivers from the south and the Esk River from the north discharge into the estuary.

Flows fluctuate from year to year, between seasons and across the catchment. In the wetter months (summer to early autumn) mean discharge can be almost ten times greater than the dryer months (late winter to spring). Peak daily flows during large floods can exceed 400,000 ML/d at Nymboida. The streams located in the southern part of the catchment where rainfall is typically higher exhibit markedly higher flows per catchment area than those in the western and northern parts of the catchment which experience lower rainfall.

Despite the large catchment size and significant rainfall and runoff the Clarence River catchment has few instream dams. Drinking water storages in the upper catchment include Shannon Creek Dam, Karangi Dam and Nymboida Weir. Smaller private storages also exist on properties within the catchment (Section 6.3.5).

### 6.3.2 Flooding

Flooding is a regular event throughout the Clarence River catchment and is often associated with East Coast Low events that bring intense rainfall to the region. 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, such as the Everlasting Swamp, and are responsible for the highly productive soils of the floodplains. Floods also flush rivers and floodplains of organic matter and provide important reproductive cues for many fish and invertebrates. However, floods can also have detrimental impacts on the environment (e.g. poor water quality and increased bank erosion), built infrastructure (e.g. damage to buildings, roads, water and sewer etc.) and can pose a threat to human life (DPIE, 2021a).

Floods typically occur in the summer and autumn months (although can occur during other times of the year) and are typically associated with one of the following severe weather events (DPIE, 2021a):

- East coast low pressure systems.
- Rain depressions originating as tropical cyclones.
- Monsoonal low-pressure systems.
- Sequence of fronts (phenomenon most likely during winter months).
- High intensity, short duration, convective thunderstorms (particularly in the summer months).

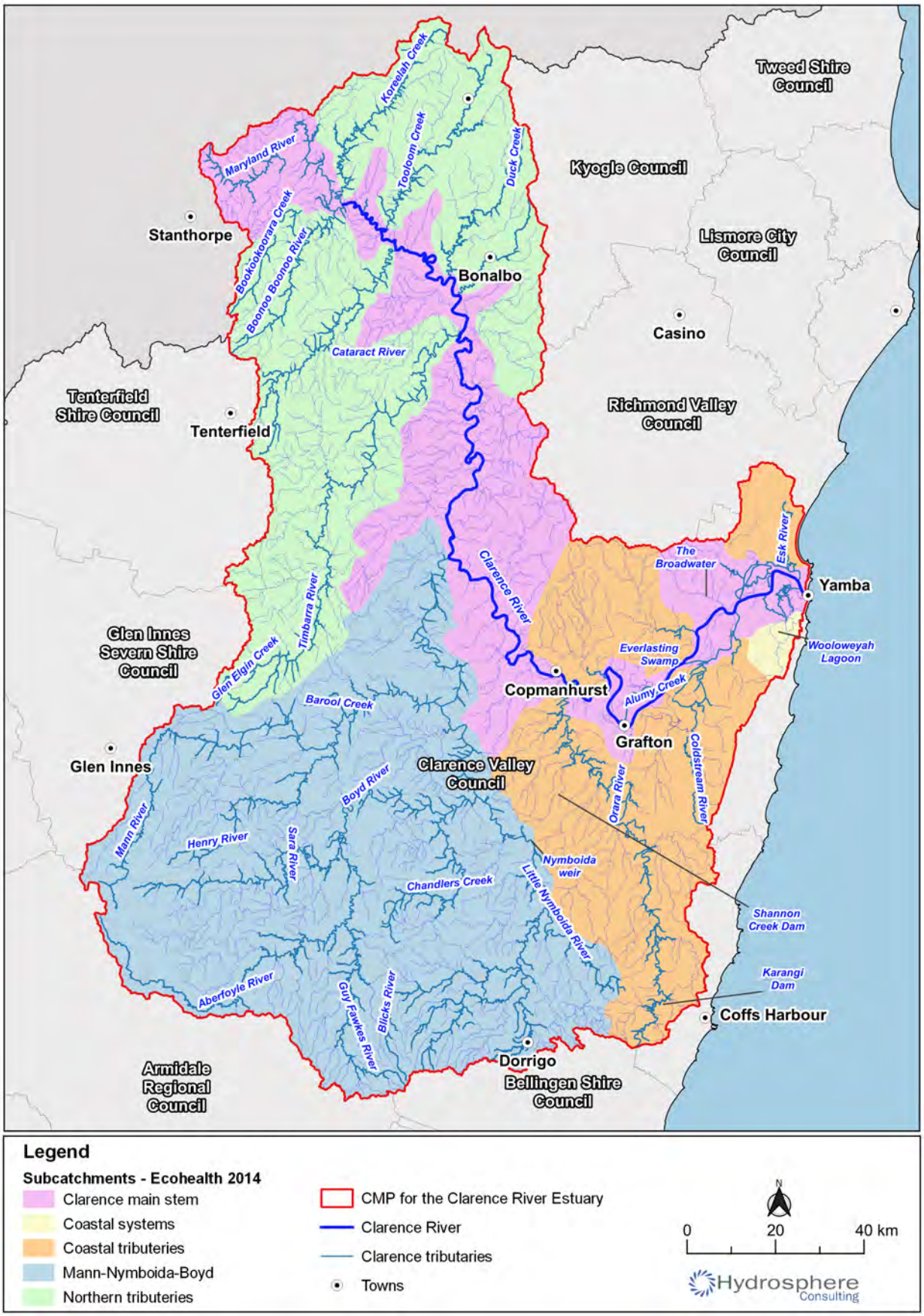



**Figure 9: Major waterways and sub-catchments**

Sub-catchments reproduced from Ryder *et al.* (2014)

There are three main sources of flooding in the Clarence River catchment:

1. River flooding caused by a widespread storm system (with precipitation typically occurring over a few days) over the broader catchment.
2. Local catchment caused by smaller storm systems occurring in local creek and urban stormwater catchments with intense rainfall bursts typically lasting less than 12 hours. Flood waters rise and fall quickly. This form of flooding presents a high hazard due to short warning times and fast flowing water.
3. Ocean storm surge flooding caused by low pressure systems, strong onshore winds and storm wave conditions, which lead to higher than usual ocean levels. This form of flooding is influenced by tides and will typically occur in combination with one or two high tides.

Localised flooding is usually exacerbated by constriction of drainage points, where the discharge capacity is limited, and a build-up of water behind the constriction point can encroach on urban areas. Localised flooding of this nature is often related to design and maintenance of drainage infrastructure and has the potential to lead to property damage, public safety risk, transport interruption and loss of amenity. The tidal inflows of estuarine water through stormwater pipes during high tides can also exacerbate flooding issues. Periodic flooding of roadways in parts of Yamba and Iluka is experienced during some high tides.

**Plate 3: Flooding on the Clarence River floodplain**

Image source: EPA

Until 2021 there were 120 river floods recorded in the Clarence since records began in 1839 however flooding patterns are often sporadic (DPIE, 2021a). By April 2022 another two floods occurred, the first being a major flood in February 2022. Into the future, climate change will change flood patterns and behaviour.

Flooding across the Clarence Valley LGA is strategically managed through various flood/floodplain studies and risk management plans to help protect rural and urban communities including Glenreagh, Grafton, Brushgrove, Ulmarra, Maclean, Yamba and Iluka. Council is required to manage the floodplain in accordance the *Floodplain Development Manual (DIPNR, 2005)*. Floodplain Management Australia (the peak national body for flood risk practitioners in Australia) has also provided guidance on the considerations for climate change flood risk in land use planning (Floodplain Management Australia, 2022).

### 6.3.3 Floodplain modifications

#### History and purpose

The Clarence River floodplain has been extensively modified by a network of constructed drains, artificial levee banks and floodgates. The two main objectives of floodplain modifications are to minimise/mitigate flood impacts during flood events and to minimise inundation on low-lying land generally (i.e. during normal flow conditions outside of flood events). The first is primarily achieved through flood levees which prevent river flood water from entering the floodplain. The second objective is typically achieved through the construction of drains to reduce water levels on the land and floodgates which prevent back-flooding of drains, creeks and tributaries and the subsequent inundation of agricultural land on the floodplain during minor flood events or by salt water from high tides.

Floodplain drainage was initially a government backed and funded initiative introduced to mitigate the impacts of floods and enhance the agricultural capacity of the land. Agricultural enterprises reliant on this drainage were established and have been in place for decades. Installation of floodplain drainage channels and flood mitigation works began in the late 1800s and accelerated in the mid-1900s with the majority of major works completed by the 1980s. The continued existence of much of the agricultural industry on the lower floodplain, in its current form, is dependent on the functioning of these flood mitigation works.

**Plate 4: Floodplain modifications: left – agricultural drainage, right – floodgate**

#### Impacts

The historical and on-going floodplain drainage works are known to have significant environmental impacts on the estuary. These include the exposure and oxidation of acid sulfate soils (ASS) and the formation of monosulfidic black ooze (MBO) and blackwater. Additionally, the artificial drainage provides a conduit to convey water and pollutants more effectively to the estuary resulting in changes in flood behaviour, tidal patterns and disruption of tidal flushing regimes affecting water quality and ecological processes including vegetation and fish passage. By the late 1990s there was a shift in floodplain management direction with the primary emphasis on urban flooding. There was also an acknowledgement of the negative impacts associated with historical floodplain management works and the beginning of the development of solutions to address and mitigate these impacts (MHL, 2000).

### Management responsibility

The history of floodplain modification and management in the Clarence is well documented (Smith *et al*., 2011; MHL, 2000; White, 2009a; Seabord Consultants, 2014; BMT, 2021). In the early 1800s - 1900s, floodplain works were the responsibility of drainage unions and trusts. In 1959 the Clarence River County Council (CRCC) was formed to undertake the majority of floodplain management works for the local councils across the floodplain.

Public floodplain infrastructure is now managed by CVC who became responsible for the assets when council amalgamations occurred in 2004. CVC has inherited many of the assets that were originally built by drainage unions and individual landowners or constructed by the councils on private land with no formal agreements. There is some uncertainty whether operation and maintenance of some of these assets serve the purpose of flood mitigation or farm protection/ improvement works (BMT, 2021). Today CVC is responsible for operating and maintaining approximately 110 km of levees consisting of more than 280 separate sections, more than 500 floodgates consisting of over 700 components, over 290 km of drainage channels and 18 flood pumps (BMT, 2021; Figure 10). The majority of levees are designed to protect primarily agricultural land however some levees are also in place to protect urban areas including Iluka, Maclean, Ulmarra, Grafton and South Grafton. There are also many other private floodplain management structures that are not CVC's responsibility, for example the Sportsmans Creek barrage is managed by the Sportsmans Creek Drainage Union.

Floodplain assets are managed by CVC under the State Government's Flood Prone Land Policy. Council's approach to flood damage reduction has moved from the priority based structural program of previous decades to a broader strategic merits-based approach (BMT, 2021). CVC aims to provide a sustainable flood risk management regime which makes best use of available resources recognising that CVC does not have sufficient financial resources to fund ongoing maintenance of all structural flood mitigation works within its ownership.

The *Clarence Valley Structural Mitigation Works Review* (BMT, 2021) provides a broad overview of the relative flood mitigation benefits provided by Council's assets across 33 floodplain areas and prioritises floodplain infrastructure management resources. Key conclusions from the multi-criteria assessment are summarised as follows:

- Schemes including the urban levees provide the highest flood risk benefit.
- The predominantly rural schemes typically provide protection to large areas but only during relatively small flood events, with larger floods overtopping levee assets. Many are recognised as protecting rural land and providing evacuation areas.
- Assets within some schemes (such as floodgates and drains) may assist with drainage following inundation events but they do not typically have a direct flood protection benefit.
- Some of the assets in all schemes are unlikely to play a significant role in assisting with flood risk mitigation but may serve another function such as keeping saltwater out of agricultural areas or other drainage functions.

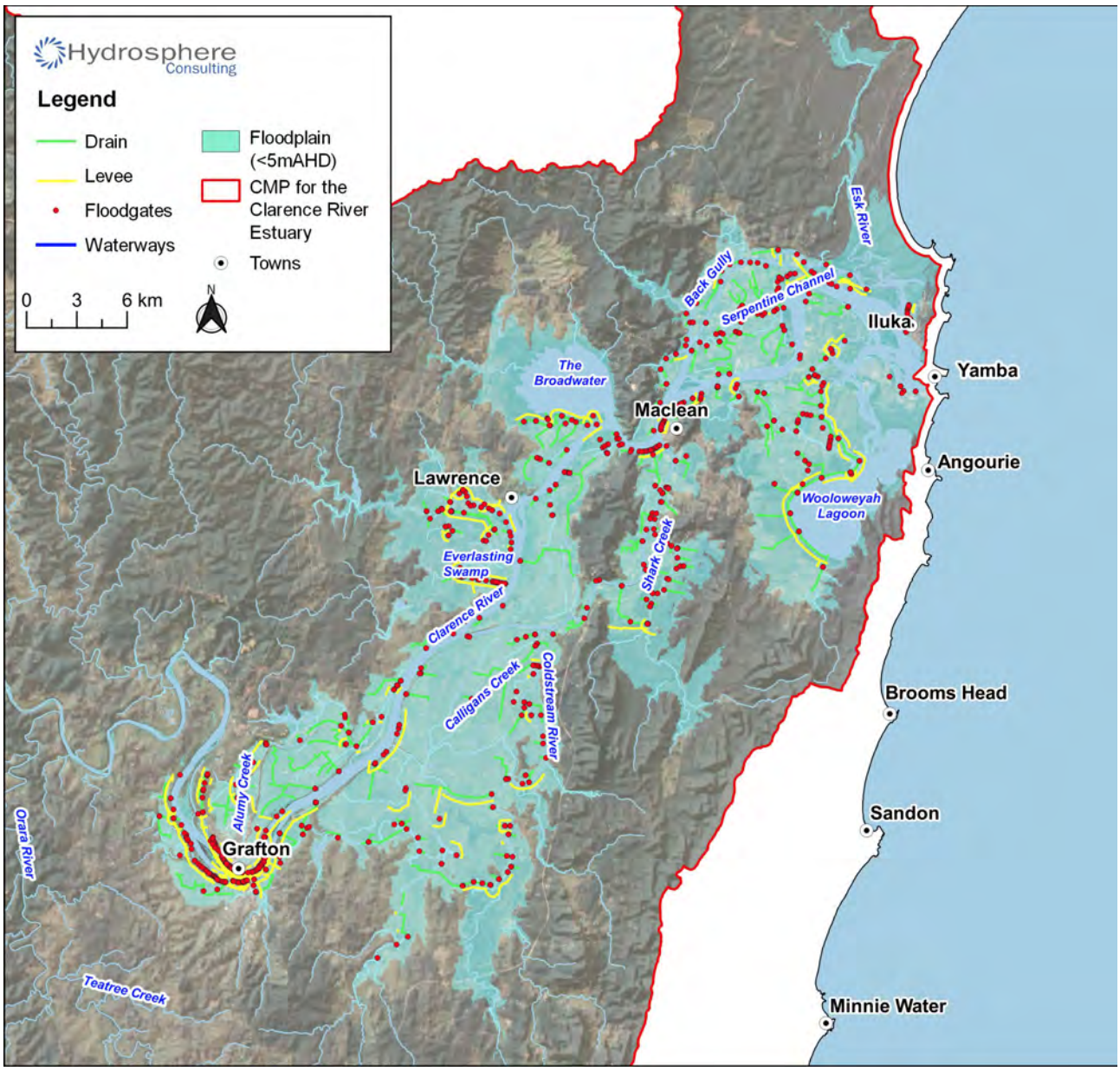



**Figure 10: Clarence floodplain infrastructure**

Source: Mapping data from Geoscience Australia (2015b) and CVC

Floodgate outlets can accumulate silt over time which prevents the proper function of the gates and can encourage mangroves and other vegetation to establish which further reduces the function of the outlet and drain. Landowners have observed that mangroves have colonised in previously clear floodgate outlets across the estuary, potentially affecting the operation of the floodgate and hydraulic performance of the drain. Some farmers across the floodplain 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/inundation reducing the productivity of affected land. Historically these floodgate outlets were maintained by mechanical cleaning. Many landowners have expressed frustration at the lack of maintenance of drains and floodgates by CVC and other agencies. Several landowners have expressed the desire to undertake the works themselves, however this activity is highly regulated and can require a large number of permits from NSW government agencies.

The draft *Rural Lands Strategy* (Localé Consulting, 2022b) includes a recommendation to lobby government to seek options to reduce delays and costs associated with drainage, floodplain maintenance and approval requirements. There are other strategic planning initiatives underway that are relevant to this issue (e.g. coastal management programs, the MEMS and other state government projects). DPE - 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 Clarence) as well as potential solutions. The consultation outcomes have not yet been published. Proposed reforms will be developed during 2022/23.

### Previous management actions

The *Clarence Floodplain Project* (CFP) was initiated in the late 1990s under the former CRCC and continued under CVC to improve outcomes of floodplain management across the Clarence River floodplain until the mid-2010s. The project was largely funded under various State and Federal Government programs however there was a significant reduction in floodplain environmental management funding which led to the cessation of the CFP Many initiatives, projects and improvements were undertaken as part of the CFP across the floodplain. Management plans were prepared for more than 100 drains across the floodplain. Common improvements made to improve non-flood environmental outcomes whilst still retaining flood mitigation benefits include installation of tidal gates, floodgate lifting devices, fish flaps and retention structures on drains. Positive outcomes from these improvements included (Oceanwatch, 2016):

- Increased tidal exchange and improved water quality.
- Improved aquatic fauna passage.
- Reduced risk of fish kills.
- Better control of aquatic weeds and lower incidence of algal blooms.
- Buffering of acidic water in drains with saltwater.
- Higher water tables in acid sulfate soil areas.
- Improved drainage following floods.
- Better water retention and water level management in wetland areas.
- Increased grazing productivity in drier times.
- Improved waterbird habitat.
- Stabilised bank erosion.
- Stabilised stock access points and stock exclusion.

Included in the CFP was a project to improve fish passage on the floodplain via improvements to floodgates. This project resulted in the opening up of more than 55 km of fish habitat (Walsh *et al*., 2012).

OEH (2015) provided a review of drain management plans and identified further potential improvement measures for many of the drain systems including the installation of water retention structures and bank

revegetation. A lack of maintenance and lack of active management of existing structures and mechanisms were common issues identified. Recommendations from this report have not been implemented.

Various studies and investigations into floodplain wetland/backswamp/ASS processes and management have been undertaken across the floodplain over the last 20 years (White, 2009b; Johns, 2008; WetlandCare, 2003; Makings, 2011; Johnston *et al*., 2003a; Johnston *et al*., 2003b; Johnston *et al*., 2004). Outcomes have contributed to the overall understanding of floodplain processes and informed management decisions.

### 6.3.4 Groundwater

Groundwater in the region is found in fractured rocks, porous 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 (Section 6.5), base flow to rivers and creeks. The groundwater sources within the catchment include (Figure 11) the Clarence Moreton Basin (porous rock), Floodplain Alluvial, Clarence Coastal Sands and North Coast Volcanics (fractured rock).

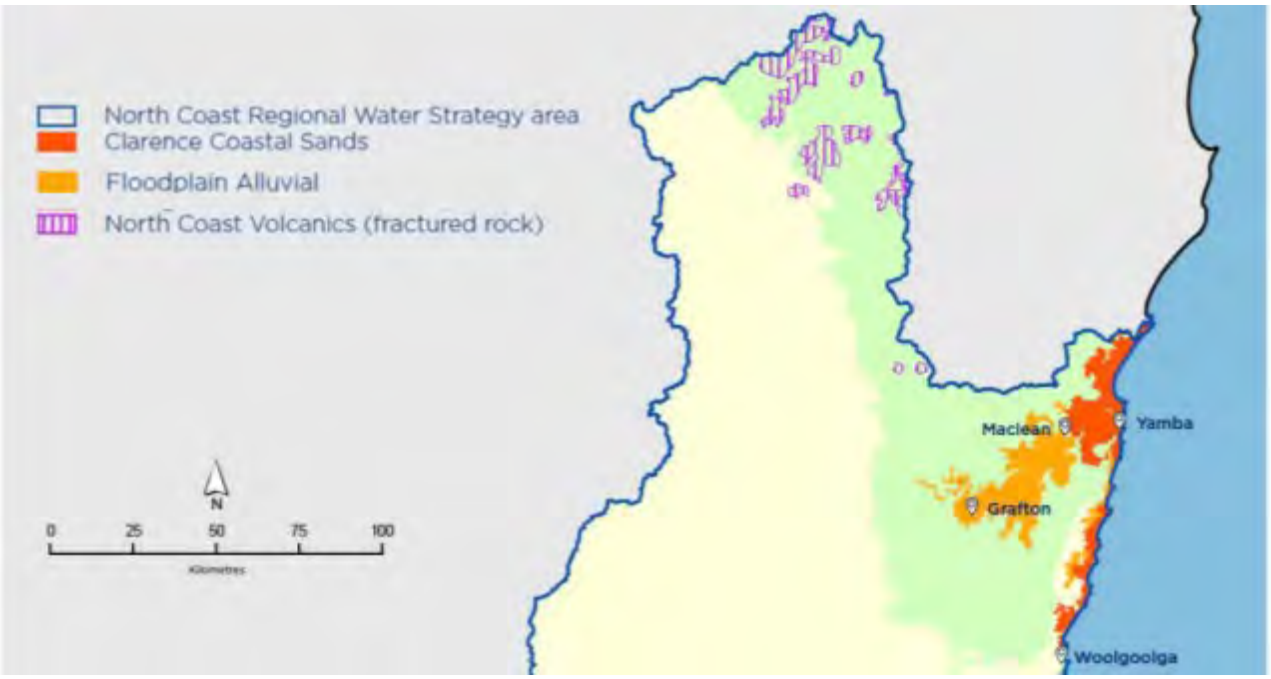



**Figure 11: Groundwater sources of the North Coast region**

Source: Adapted from DPIE (2021a)

**Case study - Taloumbi ring drain (Wooloweyah Lagoon)**

The Taloumbi ring drain is a major perimeter drain constructed along the south-western shore of Wooloweyah Lagoon. The drain is approximately 8.5 km long running just landward and parallel to the south-western shoreline of the lagoon. A levee (constructed with excavated material from the ring drain) is situated between the drain and the lagoon shoreline. The ring drain receives runoff from four major radial drains (11.5 km) and discharges into Palmers Channel at its northern end and into the lagoon at the intersection with each radial drain (White, 2009). Many kilometres of private drains and levee systems have been constructed that link to the drain (Engeny, 2019). It has been estimated that more than 70% of runoff enters the lagoon through the Taloumbi ring and radial drainage system due to the extensive drainage network on the western flats (Foley & White, 2007). One radial drain (drain 5) is not linked to the ring drain and discharges directly into the lagoon (White, 2009).

The management of the drain system has a long history. Minor flood mitigation works have been carried out in the Taloumbi area since the early 1900s. However, the majority of drainage works were carried out by CRCC in 1966. The purpose of the works was to protect agricultural lands from flooding, improve drainage and to improve the grazing productivity of lands around the western margins of Wooloweyah Lagoon (Engeny, 2019). Despite a long history of works, flooding appears to still be an issue in the area.

Engeny (2019) assessed the impact and efficiency of various drainage options for the system using modelling and notes that there are a number of impediments to the drainage of the land connected to the ring drain, including:

- Low elevation of surrounding land (approximately 0 mAHD).
- Attenuated tidal range caused by the lagoon.
- Blocked floodgates due to sedimentation at the mouth of the inlets (requiring regular removal by Council).
- General shallowing of Wooloweyah Lagoon (estimated to be 4 mm – 30 mm per year, depending on the location).
- Sea level rise.
- Condition of assets and floodgate leakage.

### 6.3.5 Water extraction

Water extraction in the Clarence River catchment occurs for a variety of purposes including town water supply, irrigation of agricultural crops and for stock and domestic use. Water sharing plans (prepared under the *Water Management Act, 2000*) set the limits on the amount of water that can be extracted from surface water and groundwater sources. Water use within the Clarence River catchment is regulated by the *Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources 2016.* The annual sharing of water is managed through long-term average annual extraction limits and daily sharing is managed through

cease-to-take rules, which can vary for different categories of licence. The majority (51%) of water entitlements within the water sharing plan area is for town water supply with 47% for irrigation and the remainder for stock, domestic and farming purposes. Town water supply is concentrated in the Mid Nymboida water source with 99% of the volume being allocated for local town water supplies. Shannon Creek Dam (18 km south of Grafton) and Karangi Dam (15 km west of Coffs Harbour) form part of the Clarence-Coffs Harbour regional water supply scheme. Shannon Creek Dam is supplied with water from the Nymboida River and Karangi Dam is supplied with water from either the Orara River or the Nymboida River. Coffs Harbour City Council sources town water from the Orara River for the town of Nana Glen. In the northern upper catchment Kyogle Council sources water from Peacock Creek (and groundwater) to supply Bonalbo. Water from Tooloom Creek supplies Urbenville, Muli Muli and Woodenbong.

Farm dams provide an important on farm source of water, particularly during dry periods, for many properties across the region. Farm dams require a licence unless they are defined as a basic right (harvestable right). Harvestable rights dams allow landholders to collect 30% of the average annual runoff from their properties and store it in farm dams. The Clarence River catchment contains the greatest number of licensed dams on the North Coast with storage capacity of the dams comprising approximately 30% of the total entitlement for the catchment (DPIE, 2021a). The number of harvestable rights dams is increasing, particularly in association with increased intensive horticulture occurring within the catchment.

There have been several proposals to dam the Clarence River, or a tributary, and pump the water west/north over the Great Dividing Range to drier regions. The State Government has previously eliminated options to divert water from the Clarence River catchment due to excessive costs, marginal benefits and significant environmental implications, including impacts on threatened species and biosecurity in the Clarence Valley (DPIE, 2021a). However, the option of an 'inland diversion from the east' was listed in the State Government's *20 Year Infrastructure Options Study Rural Valleys* (WaterNSW, 2018) and was incorporated into the *Draft Border Rivers Regional Water Strategy* (DPIE, 2020a). A cost benefit analysis of the inland diversion option (DPE, 2022c) was undertaken for the *Draft Border Rivers Regional Water Strategy*. The analysis found that the significant costs of the option outweighed the benefits. As a result, the inland diversion did not progress to a shortlisted action for the *Border Rivers Regional Water Strategy* due to the very low benefit to cost ratio (DPE, 2022c).

### 6.3.6 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 12 illustrates the important ecological functions of different flow types from cease to flow conditions to flood flows.

In the Clarence 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. Clarence River waterways also naturally experience periods of very low or no flow and at other times there are floods.

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 which require clean hard surfaces on which to deposit strongly adhesive eggs (DPI - Fisheries, 2012).

The extraction licence for the Clarence and Coffs Harbour regional water supply (for water diversion from Nymboida weir/ storage in Shannon Creek Dam) include restrictions on extraction during low flows (below 95$^{th}$ percentile flows) and monitoring of low flow aquatic habitat condition. To manage the water quality and environmental flow requirements, water is selectively sourced from either the Nymboida River or Shannon Creek Dam depending on the Nymboida River's flowrate and turbidity level.

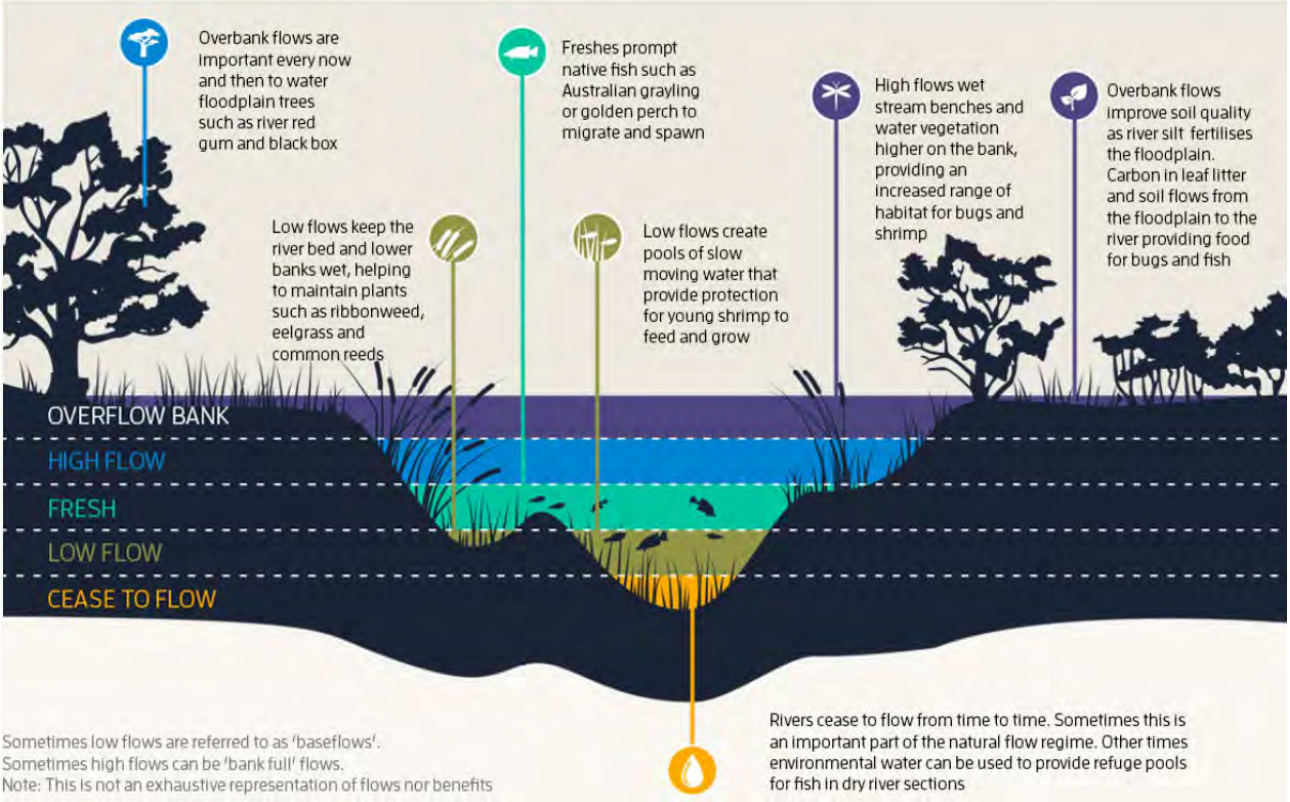



**Figure 12: The importance of different flow types**

Source: VEWH (2019)

## 6.4 Geology, Soils and Geomorphology

### 6.4.1 Geology and soils

The geology and soil types of the Clarence River catchment are shown on Figure 13 and Figure 14 respectively. A summary of the dominant geology and soils within the catchment is presented in Table 1. The two major underlying soil characteristics present in the catchment which contribute to waterway health are highly erodible soils in the mid and upper catchment and ASS on the floodplain/tidal flats.

The fault line (structural discontinuity) shown in Figure 13 and Figure 14 is part of the Demon fault system and is known as Demon Fault 4, a first order fault. The regional tectonic subdivision between the Coffs Harbour Block and Tablelands Complex are sub-regions of the Southern New England Orogen.

**Table 1: Summary of geology and soils of the catchment**

| Area description | Dominant geology[1] | Notes on soil type[2] | Erosion hazard[3] |
|---|---|---|---|
| Eastern side of Clarence River to catchment boundary | Jurassic sedimentary rocks - sedimentary sequences dominated by sandstone with minor conglomerate units and claystone. | Kurosols are strongly acid soils with an abrupt increase in clay. | Kurosols are highly erodible once cleared. |
| Lower reaches coastal | Quaternary Coastal dune deposits - the sand is deposited by both wind (aeolian) and ocean currents. Older (Pleistocene) dunes are vegetated and stable. Younger (Holocene) dunes are not vegetated and may be highly mobile depending on wind and wave action. | Podosols - accumulated organic matter, iron and aluminium. Highly sandy and acidic.<br>Hydrosols - seasonally or permanently wet. | Highly permeable soils without structure. Highly erodible when dried out.<br>Given their location and high clay content, Hydrosols have a low erosion hazard. However, acid scalds may be subject to wind erosion. |
| Tidal flat areas | Quaternary Alluvial deposits - current and recent mud, silt, sand and gravel deposited by river (alluvial) systems. | Tenosols (alluvial) - weakly developed soils with poor water retention.<br>Kandosols - low fertility and poor water holding-capacity. | Both Kandosols and Tenosols are highly erodible. |

| Area description | Dominant geology[1] | Notes on soil type[2] | Erosion hazard[3] |
|---|---|---|---|
| Western side of Clarence River to fault line (top) | Permian I-Type volcanics - volcanic eruptive rocks such as lava flows, and pyroclastic deposits such as ignimbrites. Typically, rhyolitic (quartz>feldspar) to rhyodacitic (quartz feldspar).<br>Permian-Triassic I-Type Granites - form by melting of igneous source rocks. Common minerals are quartz, feldspar, and biotite. The presence of amphibole is characteristic.<br>Silurian-Devonian sedimentary rocks - sedimentary rocks including sandstone, siltstone, mudstone and basal conglomerate units. May be fossiliferous. | Dermasols - moderately deep and well-drained soils.<br>Kandosols - low fertility and poor water holding-capacity. | Dermosols have moderate to high erosion hazard depending on slope and groundcover.<br>Kandosols are known to have high erodibility, depending on slope amount of ground cover. |
| Western side of Clarence River to fault line (bottom) | Carboniferous sedimentary rocks - a wide range of sedimentary rocks, including feldspar-rich sandstone, siltstone, mudstone and conglomerate units. | Kandosols - low fertility and poor water holding-capacity. | Kandosols are known to have high erodibility, depending on slope amount of ground cover. |
| West of fault line | Triassic I-type granites - form by melting of igneous source rocks. Common minerals are quartz, feldspar, and biotite. The presence of amphibole is characteristic.<br>Permian-Triassic I-type granite - form by melting of igneous source rocks. Common minerals are quartz, feldspar, and biotite. The presence of amphibole is characteristic<br>Permian sedimentary rocks - sandstone, siltstone and mudstone. Deposited in fluvial and floodplain systems, or in shallow marine environments. Also includes coal seams in some areas | Kandosols - low fertility and poor water holding-capacity.<br>Kurosols - strongly acid soils with an abrupt increase in clay. | Kandosols are known to have high erodibility, depending on slope amount of ground cover.<br>Kurosols are highly erodible once cleared. |

Sources: Adapted from 1. Ryder *et al.* (2014), 2. CSIRO (2021), 3. Alt *et al.* (2009)

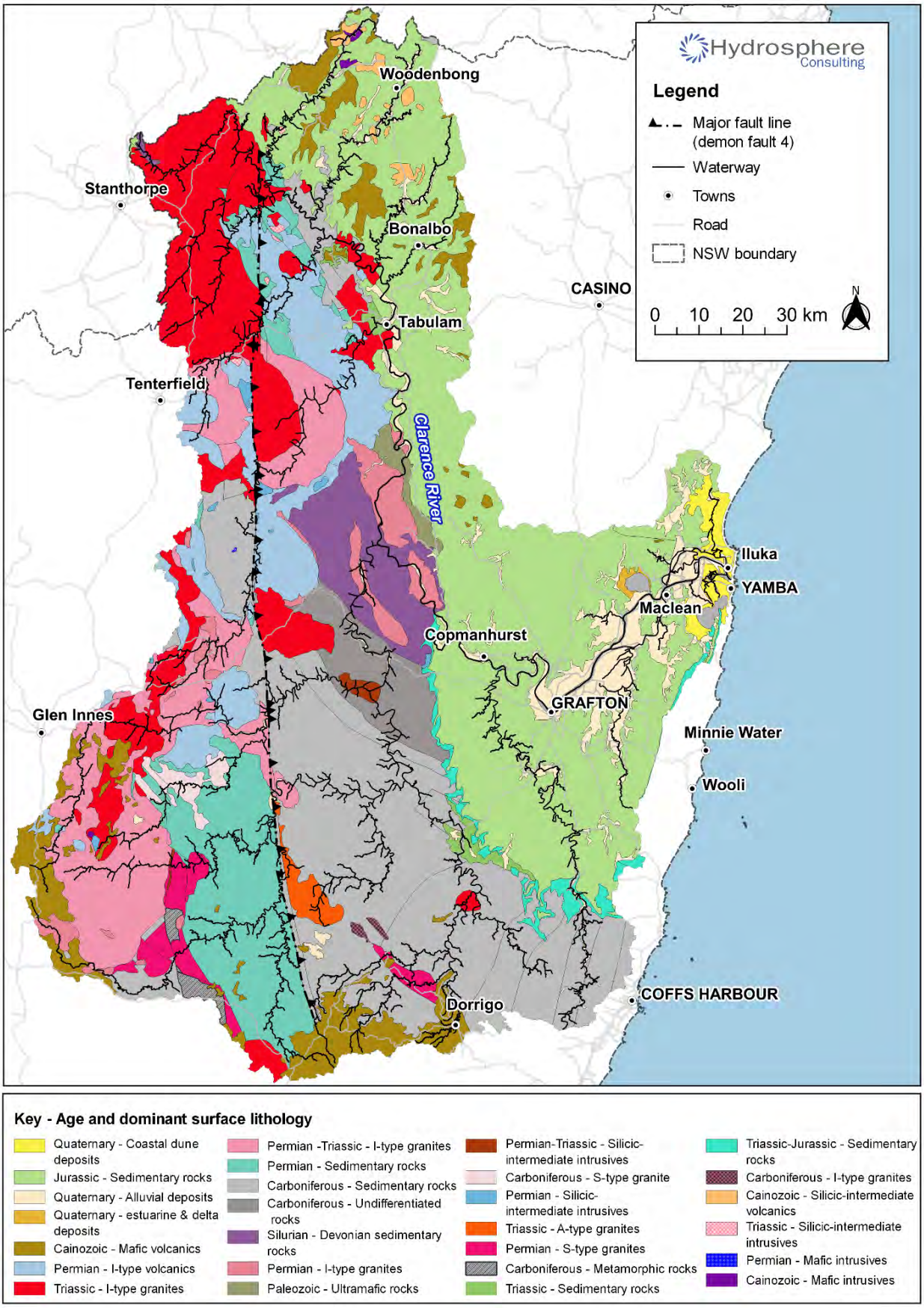



**Figure 13: Catchment geology**

Source: Mapping data sourced from Data NSW (2021a)

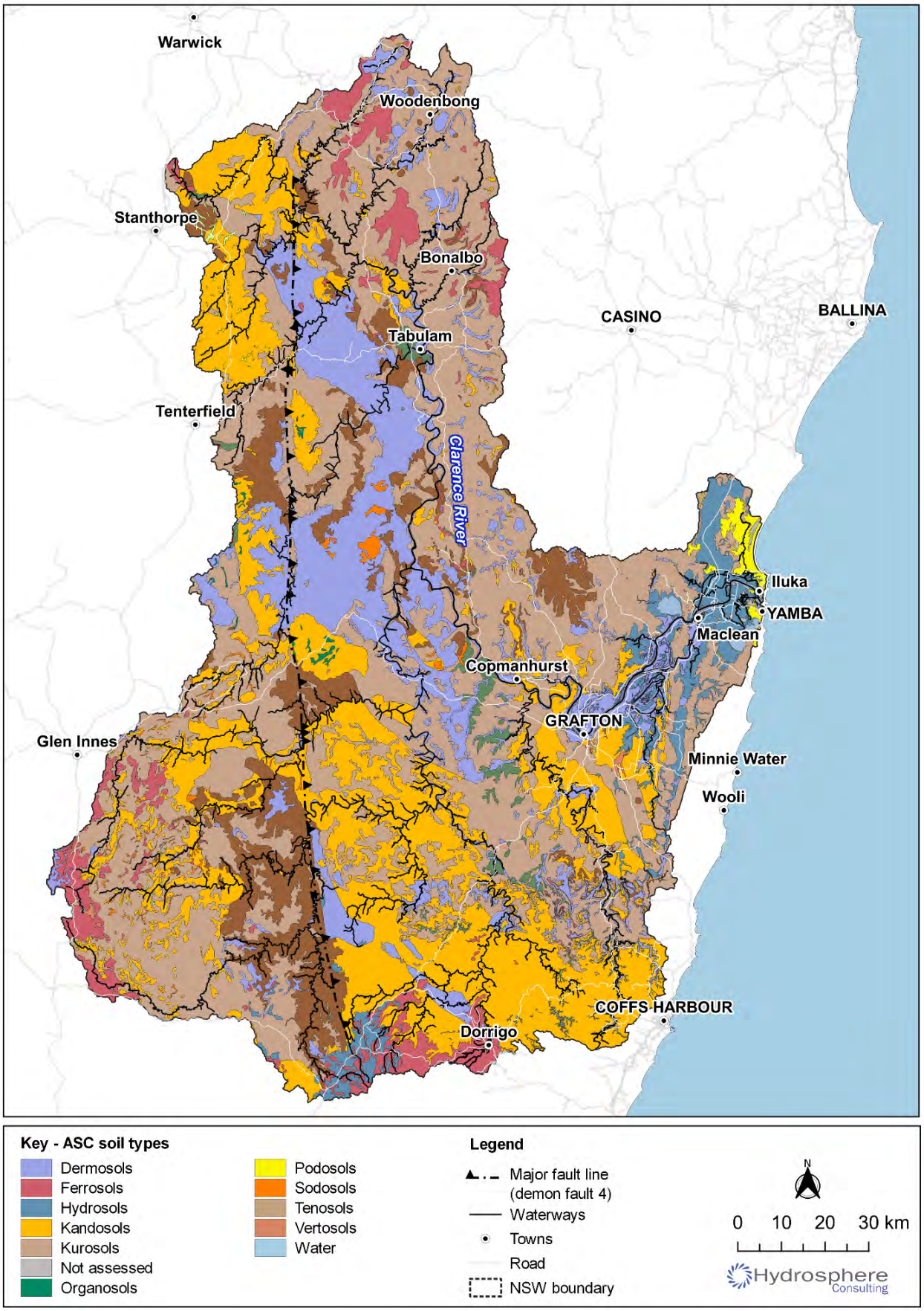



**Figure 14: Soil types**

Source: Mapping data sourced from Data NSW (2021a)

### 6.4.2 Geomorphology

The Estuary Processes Study (MHL, 2000) provides information about the physical evolution of the estuary, the major changes that have occurred to the channel and sedimentary patterns that form the fluvio deltaic complex infilling the coastal section of the Clarence Valley. The main implications of the geomorphic history of the Clarence estuary and floodplain include (Umwelt, 2002):

- A clear sedimentary process relationship between the estuary and the coastal floodplain, in terms of ongoing sediment source and sinks.
- Significant differences in the types of sediment and the nature of erosion and deposition processes between the inner basin (meandering channels) and outer basin (multiple channel system) of the estuary.
- Different risks associated with sediment extraction in the inner and outer basins associated with different sediment accretion and erosion processes, different sediment sources and sediment budgets.

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. The *NSW River Styles Framework* classifies waterways based on geomorphic qualities, that include river type, fragility, sensitivity to disturbance, condition and recovery potential. The NSW River Styles Database (DPIE - Water, 2021c) is a publicly available online mapping tool providing the River Styles classifications for NSW. The River Styles show how the geomorphological characteristics of waterways vary across the Clarence River catchment. The lower reaches of the estuary are classified as continuous tidal channels with sand/ fine grained beds. The middle catchment is characteristic as mostly gorge, partly confined meandering sand bed and planform controlled fine grained beds. The upper catchment is characterised mostly as gorge, but also some meandering sandy bed reaches.

Table 2 provides a summary of geomorphic condition scores for the Clarence River catchment assessed in 2012. The River Styles mapping for the Clarence River was completed 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 catchment management works.

Stream condition is assessed relative to the natural range of variability considered to be appropriate for the river style and the reach setting, given the present-day controls (Brierley *et al*., 2002). Recovery potential is the capacity for improvements in geomorphic condition. The recovery potential of a river uses data based on the future trajectory of changes and geomorphic recovery potential to predict the potential future river adjustment and can be used to prioritise rehabilitation works. The success of rehabilitation programs is maximised by starting with reaches that have a high recovery potential, then working out into more degraded parts of the catchment (Brierley *et al*., 2002).

The recovery potential mapping and statistics (Figure 15 and Table 2) shows that 23% of the Clarence River waterways within the coastal zone were classified as “Conservation” recovery potential, most of which are already protected within conservation reserves. The majority of the coastal zone waterways (56%) are assessed as having “Moderate” recovery potential.

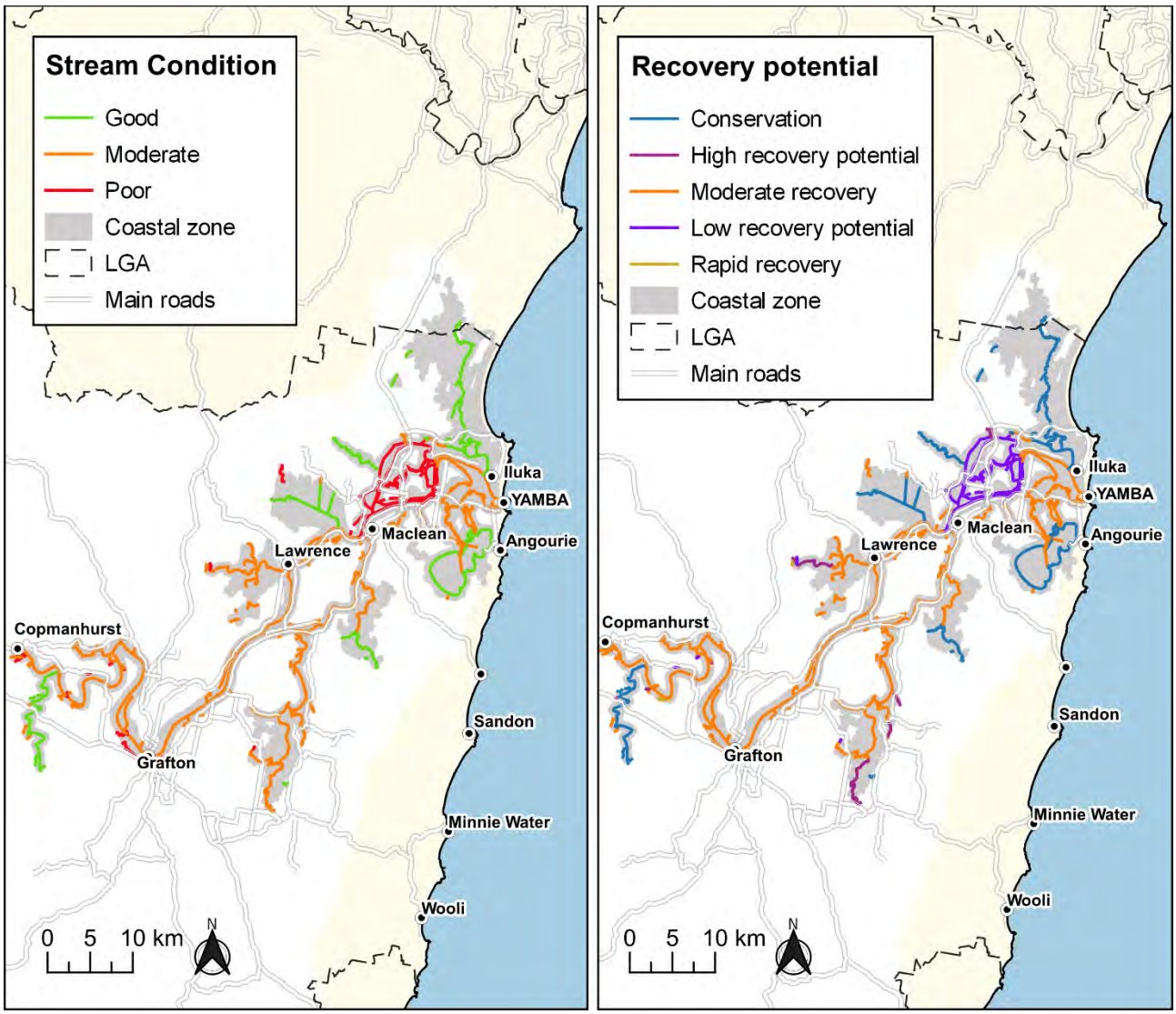



**Figure 15: River Styles attributes (coastal zone) - stream condition (left) and recovery potential (right)**

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

**Table 2: River Styles attribute classes**

| Attribute | Total length (km) | % of Clarence River waterways | Total length within coastal zone (km) | % of coastal zone waterways |
|---|---|---|---|---|
| **Stream condition** | | | | |
| Good | 6,312 | 50% | 133 | 23% |
| Moderate | 5,181 | 41% | 340 | 58% |
| Poor | 1,104 | 9% | 109 | 19% |
| **Recovery Potential** | | | | |
| Conservation | 6,313 | 50% | 133 | 23% |
| High Recovery Potential | 1,411 | 11% | 23 | 4% |
| Moderate Recovery Potential | 3,429 | 27% | 330 | 56% |

| Attribute | Total length (km) | % of Clarence River waterways | Total length within coastal zone (km) | % of coastal zone waterways |
|---|---|---|---|---|
| Low Recovery Potential | 344 | 3% | 92 | 16% |
| Strategic | 68 | 1% | 0 | 0% |
| Rapid | 1,035 | 8% | 4 | 1% |

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

### 6.4.3 Bank erosion

#### Locations

The *Estuary Processes Study* (MHL, 2000) reported areas of bank erosion and accretion throughout the estuary at South Grafton – Brushgrove, Woodford Island (Woodford Dale, Woodford Leigh and South Arm), Maclean (downstream towards Harwood), Ashby (upstream), Palmers Channel, Harwood (downstream), Serpentine Channel (east of highway), Palmers Island (adjacent to Palmers village), Goodwood Island and Iluka (Marandowie Drive). Areas of bank erosion appeared to be predominantly associated with point-bar formation and mid-channel bar growth however has been exacerbated by anthropogenic impacts such as riparian clearing, cattle access, boat wake and in the lower estuary canal developments and channel/floodplain modifications (MHL, 2000). Erosion at most locations appeared to be episodic occurring during or soon after flooding.

The *Clarence Catchment Ecohealth Project* (Ryder *et al.* 2014) found that all sites in the upper Clarence were highly disturbed and contained evidence of bank erosion. Bank condition in the reaches of the lower catchment tributaries was generally low. The lack of streambank vegetation was attributed to the poor bank condition and localised erosion throughout the catchment.

#### Impacts

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.

**Plate 5: Examples of bank erosion in the mid estuary (November 2021)**

Many erosional areas in the mid-lower estuary potentially threaten public infrastructure. Much of CVC's road infrastructure in this area is located on the floodplain levee, which is typically the highest point on the floodplain, but is also the location most vulnerable to bank erosion. Significant public infrastructure such as roads, water mains and floodplain management assets such as floodgates, headwalls and levees are under potential threat of bank erosion in various locations including:

- Woodford Island – Woodford Dale Road and water main upstream of Munro Island. Lawrence Road downstream of ferry crossing.
- Palmers Island – River Road and Palmers Village.
- Goodwood Island – Goodwood Island Road and water main.
- Navigation infrastructure has also been identified as under threat from bank erosion at the southern end of Goodwood Island adjacent to the upstream end of Collis Wall (Jayewardene *et al.,* 2016). The shoreline along a section of southern Goodwood Island is receding due to bank erosion which has caused the detaching of Collis Wall from Goodwood Island which further exacerbates the erosion. The recession has put navigation infrastructure under threat.

During consultation for this project members of the community identified bank erosion as a significant issue throughout the estuary, particularly on the floodplain. Much of the concern was around the loss of prime alluvial farm land to bank erosion and the associated instream impacts of such erosion. This is a key issue for landowners throughout the estuary however specific areas of bank erosion that were identified by the

community during consultation include (Plate 6) left bank at Southgate, left bank North Arm, Ashby Island, Martins Point, Harwood Island, Southern tip of Warregah Island, left bank (Main channel) and right bank (Middle Channel) Goodwood Island and left bank Oyster Channel, Micalo Island.

a. Bank erosion and slumping at Southgate

b. Bank erosion and failing rock protection, Goodwood Island

c. Bank erosion at Martins Point

d. Bank erosion at Warregah Island

**Plate 6: Examples of bank erosion throughout the estuary as supplied by the community**

Source: a. J.Kirby/W.Doust; b. D. Moss; c. T. McMahon/J. McMahon; d. S. Causley

### Management approach

To address areas of severe erosion threat within the estuary various studies and riverbank management plans were developed by the former councils in the late 1990s to early 2000s for high-risk locations including:

- Ulmarra – various detailed investigations (CRCC, 1993; CRCC, 1994; CRCC, 1997a; CRCC, 1997b; CRCC, 1998) identified the highest risk bank erosion reach (Butter Factory to Ferry Crossing) within the vicinity of the Ulmarra village. Following these investigations, a riverbank management plan (CRCC, 2000) was developed which adopted four key measures, rock placement, riverbank buffer zone, voluntary purchase and monitoring and review.
- Woodford Dale – riverbank erosion has been an issue in the Woodford Dale area for at least 70 years. An investigation by Gary Blumberg and Associates (2003) found that significant public assets (road, water main, services) were subject to unacceptable risk of being involved in riverbank failure. Subsequently a management plan (Gary Blumberg and Associates, 2004) for the Woodford Dale reach was developed. The plan identified measures including relocation of services (or contingency to do so), planning and development control, management of vegetation, management of road, existing rock protection maintenance, community education and monitoring.
- Palmers Island - The *Palmers Island Riverbank Plan* (Maclean Shire Council, 1995) covers all land between the intersection of River Road and Yamba to the south and Gillies Lane to the north. The plan addresses the threat posed by the erosion of the riverbank adjacent to Palmers Island village through non-structural measures. The plan outlines impact zones and appropriate development controls for each zone with no maintenance of riverbank protection.

No recent broadscale assessments of bank erosion, particularly within the lower estuary, have been undertaken. However, many of the erosion zones identified within previous studies are still in poor condition.

CVC has undertaken many bank protection projects throughout the estuary (Figure 16). However, over time the understanding, policies, priorities, funding and resources have changed. Currently, CVC manages bank erosion on a relatively *ad-hoc* basis. The *Riverbank Protection Policy* (CVC, 2019a) outlines Council's responsibilities related to river bank erosion, erosion stabilisation and river bank protection. The policy states that CVC may undertake erosion management works where erosion threatens public land, infrastructure or environmental assets or access to these. Under this policy CVC undertakes rock protection works for the purpose of protecting public assets such as roads, watermains and levees. Typically, works are only undertaken when suitable funds are available and/or works are determined as urgent. An example is rock revetment riverbank remediation work undertaken by CVC in 2021 when a section of riverbank slumped during a flood, damaging a section of Lawrence Road, Woodford Island (Plate 7).

**Plate 7: Recent riverbank remediation project, Woodford Island (May 2021)**

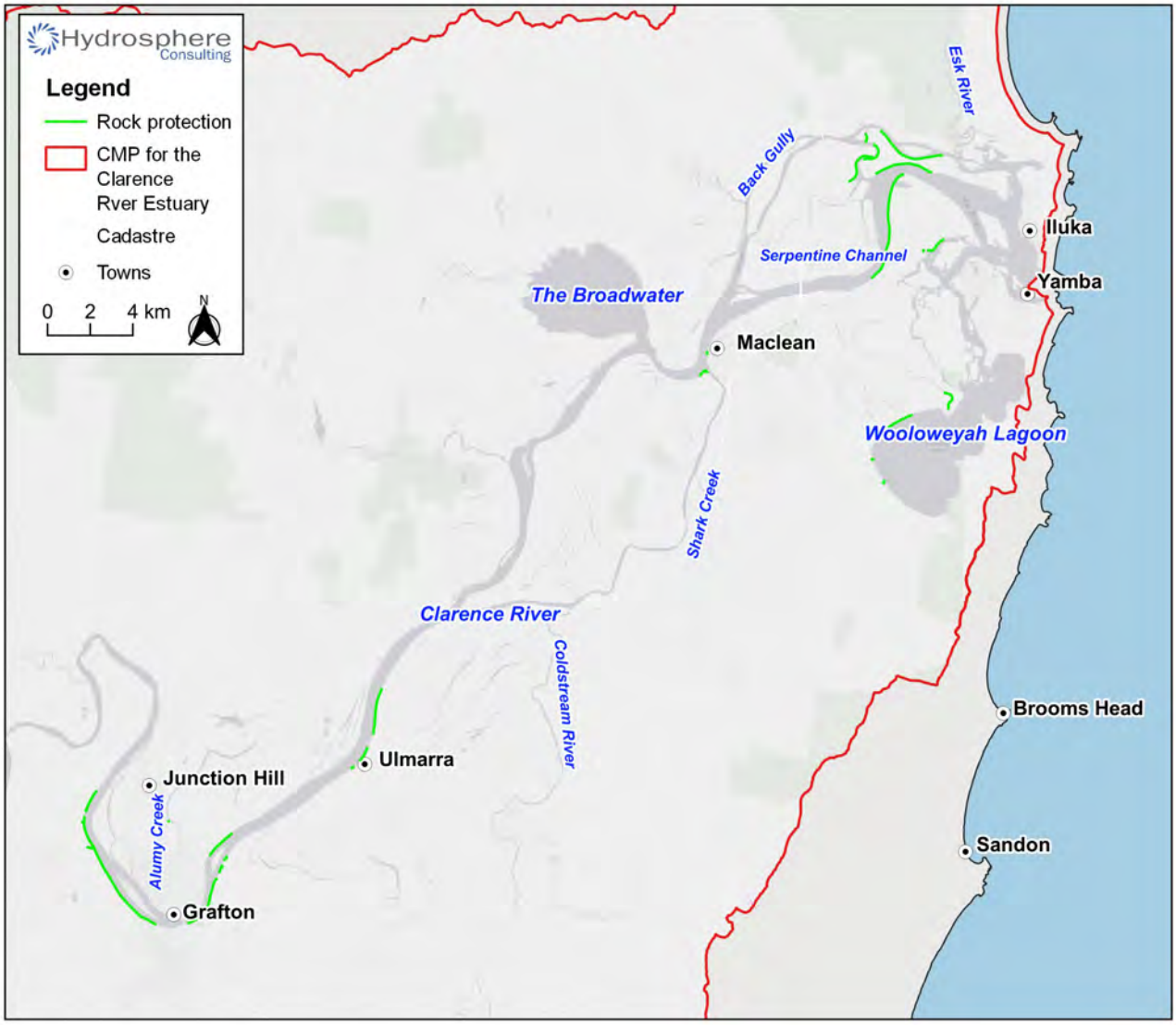



**Figure 16: CVC rock protection structures in Clarence River estuary**

Source: Mapping data provided by CVC

Many landowners expressed the desire to undertake bank protection works however cited excessive ‘red tape’ as a key barrier. Many also cited a lack of agency support/guidance and funds. This is not an issue unique to the Clarence River but is a universal challenge cited by those intending to undertake bank protection works all along the NSW coast, including landowners, councils, agencies and environmental groups. In response to this issue, 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. The project is being undertaken through the MEMS and the tool should be available for use in later stages of the CMP for the Clarence River Estuary.

The severe storms and floods in February and March 2021 (and also in 2022) caused extensive damage to riverbanks in the Clarence River. In response the NSW Government will fund a Targeted Riverbank Rehabilitation project, to be delivered by NCLLS commencing in June 2022. The project will identify, prioritise and undertake riverbank rehabilitation works on high priority, high-risk erosion sites aimed at future proofing environmental, cultural, agricultural and recreational assets on major impacted waterways. NCLLS technical officers will also assist landowners with approvals and on-ground works. An Interagency Working Group will be formed to develop a framework that will support consistent approaches to rehabilitation works and consider applications in a timely manner. The project will also provide ongoing resources and education that will allow landholders to make informed decisions when undertaking rehabilitation work through an Erosion Support Package (LLS, 2022).

### Case study – Rogans Bridge to Ulmarra

To address concerns from various stakeholders that human activities, in particular boat wake, was causing bank erosion within the upper estuary, a riverbank vulnerability assessment was undertaken by Glamore *et al.* (2014). The study assessed and ranked the susceptibility to riverbank erosion based on a variety of factors from Rogans Bridge downstream to Ulmarra. It was found that the majority of sites were considered to be 'mildly resistant' to erosion throughout the tidal range. At mid-low tide 9% of sites were classified as 'highly erosive'. The assessment also recommended management actions including on-water actions such as watercraft restrictions and riverbank actions such as rock revetment, large woody debris, stock exclusion fencing, alternate stock watering and revegetation. Following this assessment, the *Clarence River Erosion Management Plan* (Maritime Management Centre, 2015) was developed and commenced in September 2015. By April 2021 boating restrictions had been implemented, more than four kilometres of riverbank had been reinforced at specifically identified trouble spots. The reinforcement was accomplished through rock revetments and placement of tree stumps and root balls, salvaged from the Pacific Highway upgrade and other development sites. More than 3 ha of revegetation including 50,000 plants and approximately 4 km of fencing were also undertaken. Infill and follow-up planting, weed control, fencing and structure maintenance and monitoring is being undertaken across the sites. (NCLLS, 2020; Transport for NSW, 2021). The sites will be actively managed until 2022/23.

a. stock exclusion fencing and revegetation

b. large woody debris and rock bank stabilisation structure

c. rock toe protection

d. large woody debris and rock revetment bank stabilisation

**Plate 8: Clarence River erosion management project works (2015 – 2021)**

Source: All photos Soil Conservation Services

### 6.4.4 Sedimentation

Erosion and accretion (sedimentation) are natural processes that occur in meandering river systems. MHL (2000) note the dominant form of accretion (and erosion) in the mid-upper estuary (upstream of Woodford Island) is point bar formation. In the mid-lower estuary the dominant form of accretion was mid-channel bar growth. Many of the islands in this section of the estuary have progressively grown through accretion and eventual coalescence of mid-channel bars. The formation of such bars and shoals is seen as an impediment to navigation and a restriction of flow. However, the intertidal sand/mud flats provide important habitat for a range of fauna particularly threatened shorebird species. During the first half of the 20$^{th}$ century, until as late as 1965, there was a significant active maintenance dredging program in the estuary upstream to Grafton. The growth of many of the islands in the estuary due to accretion has occurred since the cessation of dredging (e.g. Munro Island).

**Plate 9: Shoaling in lower estuary**

There are two sources of sediment to the estuary, fluvial (catchment and river source) and marine sediments (from the ocean/coastline). Fluvial sediment is delivered to the estuary from the catchment by runoff processes which has increased significantly since European settlement. During large flood events the finer sediments are deposited on the floodplain or offshore. Following floods, the fine material remains in suspension or is deposited in backwater areas. The coarser sediments are deposited in the estuary and existing material in the estuary is scoured from banks, bars and the bed and transported downstream with some deposition on the floodplain. The fluvial bed material is then reworked down through the estuary leading to the accretion of point and mid-channel bars. Fluvial sediment dominance appears to occur downstream to approximately Palmers Island. Marine sediments (sand) are delivered to the lower estuary by littoral processes. During dry periods there is a net infeed of marine sands to the lower estuary by flood tide currents. Marine sands are re-worked upstream to approximately Palmers Island. During flood events some of the marine sand is scoured from the lower estuary and returned to the ocean (MHL, 2000).

The *Clarence River Estuary Management Plan* (Umwelt, 2003) included actions for the former Department of Land and Water Conservation (DLWC) to coordinate studies of sedimentation in the estuary. To date those assessments have not been completed and hence there is limited understanding of sedimentation processes and related impacts affecting bank condition and sediment movement.

Due to concerns about bank erosion impacting public infrastructure, CVC recently commissioned a bathymetric survey of the river bed within the vicinity of Ulgundahi Island. Survey results indicate that

shoaling within the vicinity of Ulgundahi is occurring and pushing the channel thalweg (lowest section of the river) against the southern bank.

Sedimentation of the main river channel of the lower estuary was raised as an issue by several stakeholders, particularly those within the marine industry. Concerns include siltation of the navigation channels impacting the safety, navigability and serviceability of the channel in the lower estuary.

### 6.4.5 Dredging

Dredging includes extraction of materials such as sand/gravel and maintenance dredging of navigation channels and harbours to maintain safe/navigable water depths. Sand/gravel extraction is undertaken for the commercial sale or use of the material whereas maintenance dredging is undertaken to remove the material to benefit the waterway users and the broader community.

Commercial sand/gravel extraction has historically been undertaken throughout the estuary, from the lower reaches to the upper estuary. Typically, gravel is extracted from the upper estuary and sand is extracted from the lower estuary. Between 1987 and 1998 there were ten active sand and gravel extraction locations within the estuary. There are currently three extractive industries licences in the upper estuary across five sites between Susan Island and Rogans Bridge which permit an extraction amount up to 500,000 $m^3$ of sand per annum. In 2018/19, 78,900 tonnes of material was extracted under three Department of Planning and Environment – Crown Lands (DPE - Crown Lands) licences for commercial dredging. Operations exceeding extraction of 30,000 tonnes per year of material are also licensed under the *Protection of the Environment Operations Act 1997*.

In 2021, under Initiative 2 of the MEMS, DPE – Crown Lands prepared a draft *Audit of Commercial Dredging on Crown Land*. This audit reviewed the licensed commercial operations within the Clarence River at Susan Island, Crowther Island and Seelands. The audit identifies opportunities to improve the management and administration of DPE - Crown Lands licences to achieve better outcomes for the marine estate. Consultation with CVC and the licence holder is being undertaken to discuss the draft findings of the audit.

**Plate 10: Commercial sand/gravel extraction**

To facilitate navigation of vessels, initial channel dredging or ‘clearance’ operations were undertaken throughout the estuary from the entrance to Copmanhurst between 1890 and 1970 (MHL, 2000). Since the

initial clearance operations maintenance dredging has been undertaken periodically to maintain safe depths for navigation and access, mostly in the lower estuary. In the 1990s maintenance dredging was undertaken in Yamba Bay, Oyster Channel, Wooloweyah Lagoon and around the Ashby Dry Dock and Ulmarra Ferry crossing (MHL, 2000). More recently, maintenance dredging has been undertaken in the lower estuary at the entrance bar (2004), Yamba approach channel (2004, 2008), Pelican Island (2007), main channel (Goodwood Island 2009), Palmers Channel (2011), Iluka Boat Harbour and Channel (2015) and Yamba Boat Harbour Approach (2016/17).

The Lower Clarence River, including the entrance channels to Iluka and Yamba boat harbours, is identified as a 'key investment location' in the *NSW Coastal Dredging Strategy* (DPIE, 2019a), implemented by Transport for NSW Maritime Infrastructure Delivery Office (MIDO).

### 6.4.6 Acid sulfate soils

Acid sulfate soils (ASS) is the common name given to naturally occurring sediments and soils containing iron sulfides. ASS are benign when undisturbed or found in inundated swamp lands. 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 waters (Naylor *et al*., 1998). Resulting conditions severely degrade terrestrial and aquatic vegetation, fauna, invertebrate and soil productivity and health (North Coast Regional State of the Environment Report Working Group, 2016). State-wide ASS risk mapping was originally prepared by Naylor *et al.* (1998) which mapped approximately 636 $km^2$ of high-risk ASS on the Clarence River floodplain (Figure 17). Several subsequent studies and investigations have confirmed the extent and severity of ASS on the Clarence River floodplain (Tulau, 1998; Sullivan & Lin, 1999; Johnston *et al.*, 2003; Harrison *et al.*, 2021a). Water quality issues associated with ASS are discussed in Section 6.7.2.

Backswamps, small tributaries and their floodplains typically have high-risk ASS as the damaging soils occur at shallower levels with a higher concentration (Sullivan & Lin, 1999). Due to the topography and historic floodplain mitigation works, the following areas within the catchment are at high risk of ASS (JEEPC, 1999):

- Everlasting Swamp - an infilled lagoon of formerly tidal and intermittent wetlands near Sportsman Creek. Large amount of acid soils within 20 cm of the surface. Largely attributed to historical artificial drainage activities. Fish kills have been attributed to strong acid discharge in the area.
- Shark Creek - historically drained with strong acid discharges and resultant fish kills recorded.
- Lower estuary floodplain and islands - low elevation islands (<1.5 mAHD) which are typically supratidal flats and extratidal saltmarshes have been historically cleared and (some partially) drained for agriculture. These areas have had acid discharges with resultant fish kills.
- Alumy Creek - the catchment around the creek has been subject to historic floodplain mitigation works since the 1960s, leading to lower water quality and extreme acid sulfate conditions and events occurring.

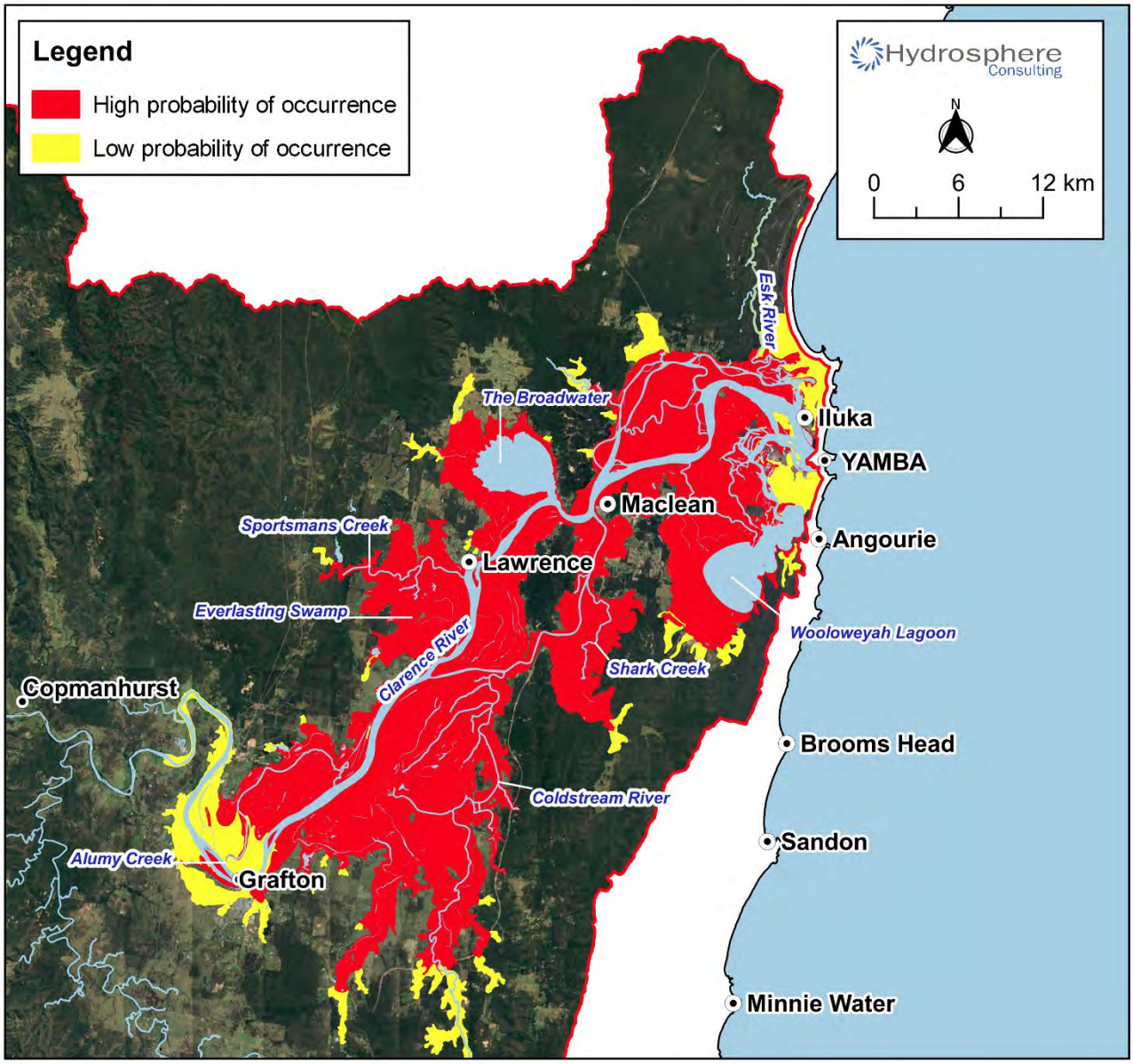



**Figure 17: ASS risk map of the Clarence River floodplain**

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

### 6.4.7 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 lower floodplain extent of the study area lies within the Bundjalung secondary sediment compartment which extends from Evans Head to Yamba Point, described in Table 3 and illustrated on Figure 18.

**Table 3: Secondary sediment compartment**

| Compartment | Bundjalung |
|---|---|
| Extent | Evans Head to Yamba Point |
| LGA | CVC |
| Geomorphology | Sandstone and conglomerate headlands, zeta-form bays, large and small embayed beaches, extensive Pleistocene prograded beach ridge plain, dunes, Holocene prograded barriers. |
| Sensitivity rating[1] | Sensitivity rating is 4, with several sections already 5. |
| Confidence rating[2] | Medium to high. |

1. Relevant sensitivity rating from 1 (low) to 5 (high): 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 (2017).

## 6.5 Biodiversity

State and federal databases provide listings of the flora and fauna of the study area (e.g. BioNet – NSW Government, 2022; Protected Matters Search Tool - Department of Agriculture, Water and the Environment, 2022). The Clarence River catchment supports 173 threatened species of fauna, 170 threatened species of flora and 18 threatened ecological communities (CVC, 2021d).

### 6.5.1 Terrestrial

The Clarence River catchment occurs within the NSW North Coast Bioregion, which has the second highest biodiversity in Australia (CVC, 2010a). The study area occurs in the McPherson-Macleay Overlap area, where the temperate and tropical zones intersect, creating an area of extremely high biodiversity from the wide range of soil types, climate and topography across the region (DECCW, 2010a). The overlap area extends from the McPherson Range in the north to the Macleay River in the south and 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 Iluka Nature Reserve which is part of the Gondwana Rainforests of Australia World Heritage Area is located in the study area for the CMP for the Clarence Coastline and Estuaries.

Much of the upper catchment around the escarpment ranges is covered with native vegetation of mostly dry sclerophyll forest, wet sclerophyll forests and rainforests (CVC, 2010a). There are some areas of grassy woodlands and heath, freshwater wetlands, forested wetland and rocky outcrops. The upper catchment has large, still pools with gravel races, known to support significant habitat and aquatic biodiversity. The vegetation occurring in the mid catchment is wet and dry sclerophyll forest, rainforest and grassy woodlands, which creates contiguous corridors which link escarpment ranges and the coastal flood plains (CVC, 2010a).

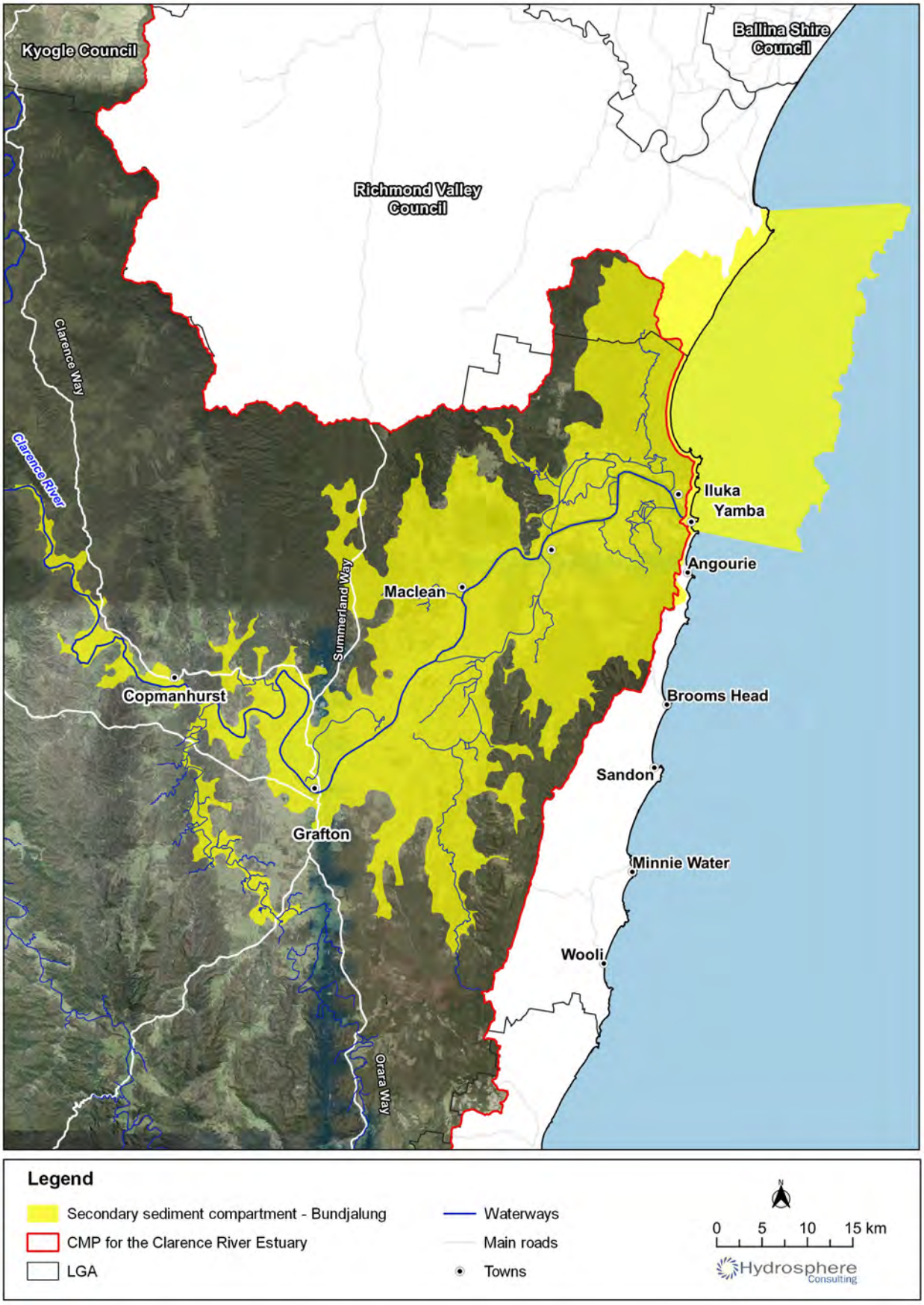



**Figure 18: Coastal sediment compartments**

Source: Mapping data provided by Geoscience Australia (2015a)

**Plate 11: Littoral rainforest**

Photo source: CVC

### 6.5.2 Aquatic

The aquatic habitat in the Clarence River catchment comprises freshwater, estuarine and marine environments. The lower estuary supports important areas of mangroves, saltmarshes, seagrasses, inter-tidal mud flats, wetlands, floodplains, riparian vegetation, dry and wet sclerophyll forests, grassy woodlands, heathlands and rainforests. This diversity of vegetation provides key habitats for many species of commercial fish, crustaceans and other aquatic invertebrates and is a significant resource for migratory birds, particularly in a drought. This part of the estuary supports the second highest population density of wading birds in NSW, many of which are migratory and spend the Australian summer in the area to feed, rest and nest (Mousley, 2011).

The catchment contains wetlands and estuarine habitats with significant biodiversity values, including 290 ha of coastal saltmarsh and the largest area of mangroves in the Northern NSW Coast (DPIE – Water, 2016; WetlandCare, 2010; DPIE, 2021a). The estuarine wetlands host important species (mangroves, saltmarsh and seagrass), promote nutrient cycling and provide habitat for fish nurseries and breeding grounds. The intricate network of permanent and ephemeral waterways supports important assemblages of aquatic and terrestrial species and provides suitable habitat and resources for many threatened and endangered fauna. 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.

**Plate 12: The Broadwater and Broadwater Creek (left), Everlasting Swamp (right)**

Photo source: NPWS

Within the study area, Little Llangothlin Nature Reserve is mapped as a Ramsar Wetland and many areas are listed in the Directory of Important Wetlands in Australia (Figure 19). These areas provide significant wetland habitat for many migratory waders including threatened and vulnerable species (Department of Agriculture, Water and the Environment, 2021; WRL, 2018). The broader estuary also provides important habitat for shorebird species, both endemic and migratory species.

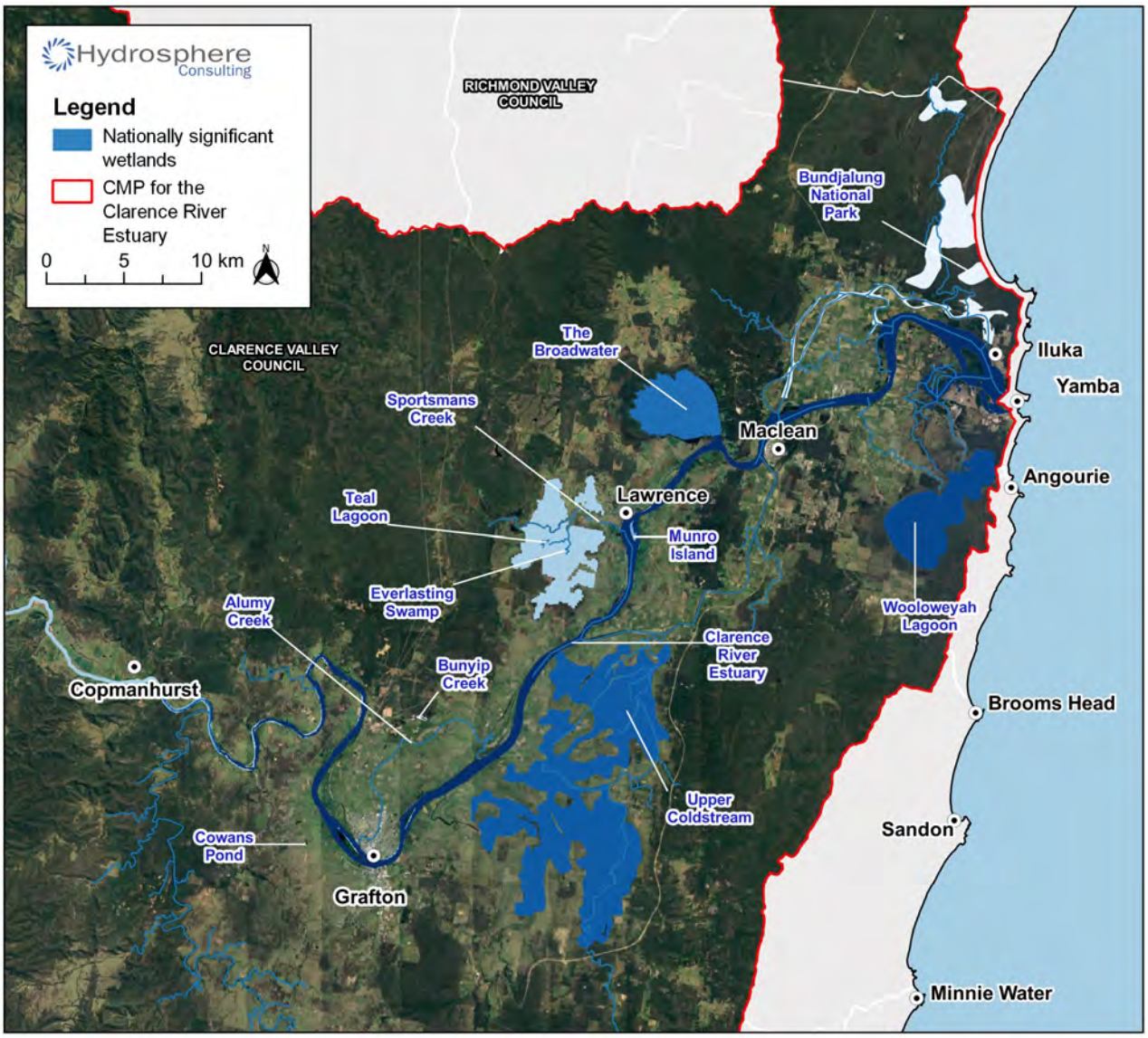



**Figure 19: Nationally Significant Wetlands in the Clarence River**

Ramsar Listed Wetland (Little Llangothlin Nature Reserve) in south-west of catchment is not shown.
Source: Mapping data sourced from Department of Agriculture, Water and the Environment (2021)

Key fish species include Dusky flathead, Yellowfin bream, Sand whiting, Luderick, mullets (numerous species, particularly Bully mullet), Mulloway, Mangrove jack, Trevally, Garfish, Fork-tailed catfishes, many smaller fish such as Gobies, Bennies, Mudskippers, Herrings, Glassfish, Pipefish, Toadfish and Fortescues. 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 Clarence 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.

Within the freshwater reaches the key recreational fish species is Australian bass with other species including Eel-tailed catfish and a range of smaller species such as the gudgeons, rainbow fish, freshwater herring and smelt. Some freshwater reaches also provide habitat for the threatened Southern purple spotted gudgeon and the endangered Eastern freshwater cod, particularly in the southern upper catchment. The presence of the Eastern freshwater cod in the Clarence River system is significant as it is considered extinct in other large river systems such as the Richmond River (DPIE – Water, 2016; Mousley, 2011). The threatened Oxleyan Pygmy Perch (*Nannoperca oxleyana*) also occurs within the coastal dunal freshwater tributaries.

The platypus is an iconic Australian species, endemic to the east coast of Australia and Tasmania. Platypus are found in the freshwater reaches of the Clarence River 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).

Numerous threatened frog species are known to occur across the catchment including the Fleay's Barred Frog, Giant Barred Frog, Glandular Frog, Green and Golden Bell Frog, Green-thighed Frog, Loveridge's Frog, Olongburra Frog, Pouched Frog, Sphagnum Frog, Stuttering Frog, Tusked Frog and the Wallum Frog (DPIE – Water, 2016). Three chelonians (Eastern snake-necked turtle, Saw-shelled turtle and Macquarie turtle) are found across the catchment as well as rakali.

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 Clarence River estuary which has been estimated to be 71 residents by Fury (2008). Although, the species occurs all year around, distinct seasonal fluctuations occur, with peak numbers typically occurring in Spring (Fury, 2008). Fury (2008) 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. Marine wildlife, including dolphins, are managed by NPWS under *the National Parks and Wildlife Act 1974* and the *Biodiversity Conservation Act 2016* with guidance from the *Marine Wildlife Management Manual 2021* (National Parks and Wildlife Service, 2022).

The Clarence River estuary is considered one of the two most important estuaries for shorebird locations in northern NSW with the highest shorebird population of any estuary on the North Coast with 36 different species being recorded within the estuary over a 23-year period (DECCW, 2010b). The Clarence River estuary is a priority site for a number of threatened migratory shorebird species (Lesser Sand Plover, Great Knot, Black-tailed Godwit, Terek Sandpiper and Greater Sand Plover) and threatened local shorebird species (Beach Stone-curlew, Sooty Oystercatcher and Pied Oystercatcher). Priority nesting sites for Pied Oystercatchers are also found in the estuary (DECCW, 2010b).

**Plate 13: Eastern Freshwater Cod (*Maccullochella ikei*, left), Pied Oystercatcher (*Haematopus longirostris*, right)**

Photo source: NSW DPIE (2021b), ebird.org

### 6.5.3 Estuarine

Estuarine vegetation (seagrass, mangroves and saltmarsh) provides habitat and performs a range of essential ecosystem functions and is an important part of a healthy estuarine environment. The most recent mapping of estuarine vegetation (2010) within the Clarence River is presented in Figure 20. Changes in areas of vegetation are presented in Figure 21 and Figure 22 and discussed below.

### 6.5.4 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. Groundwater dependant wetland ecosystems are typically areas where the water table is at the surface, or periodically at the surface (DPIE - Water, 2016). 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, 2021c). 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.

The NSW Government has adopted the Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE) framework developed by the Commonwealth Government (Dabovic *et al.,* 2018). In the current assessment for NSW, the HEVAE framework consists of four key criteria which include diversity, distinctiveness, naturalness and vital habitat. HEVAE score was determined for plant community types by adding together the final scores for each of the four criteria to categorise the ecological value of each groundwater dependent vegetation community from very high to very low.  Very high and high value GDEs were identified in the Bundjalung National Park (Esk River) and many small areas located along tributaries of the Clarence River.

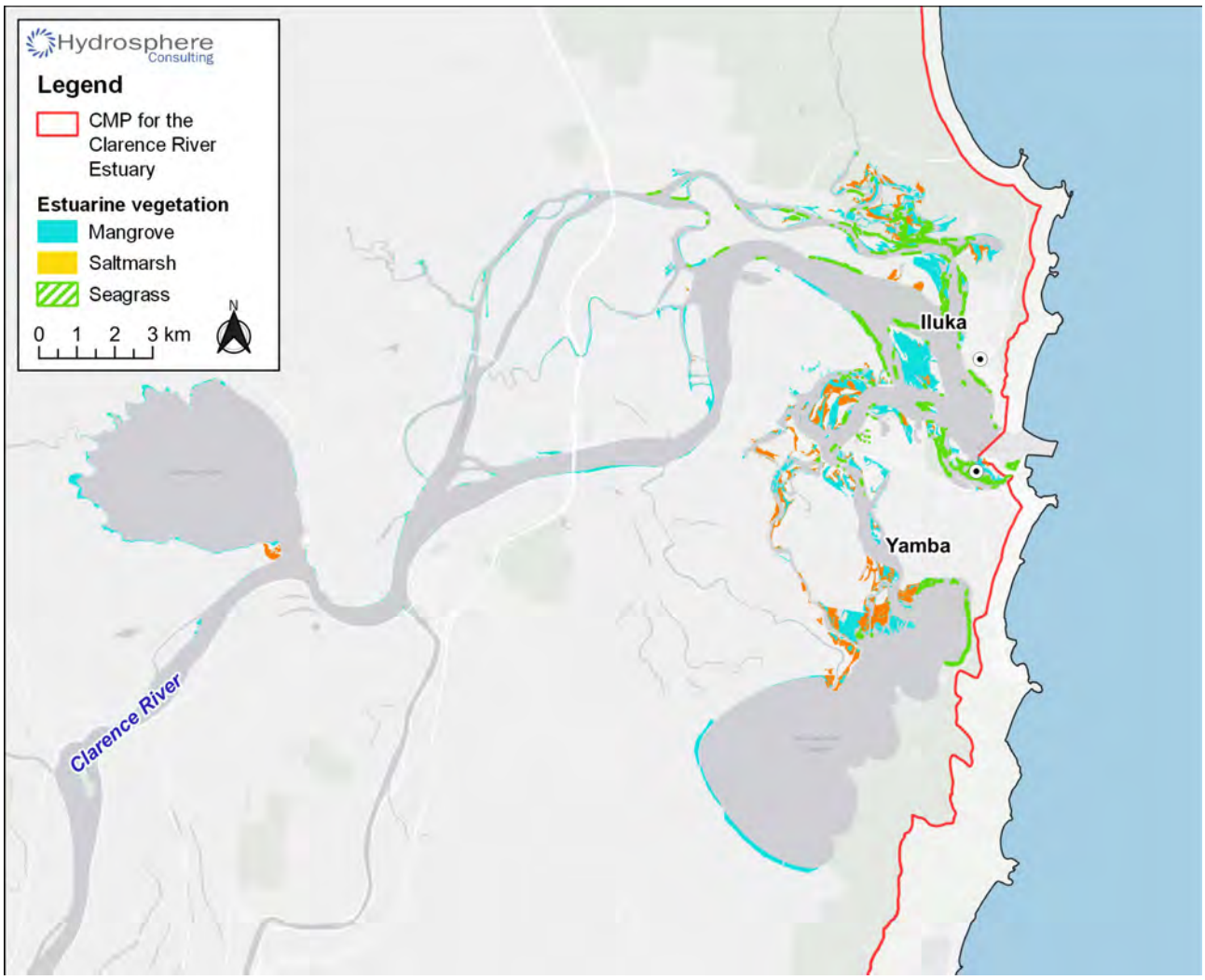



**Figure 20: Estuarine vegetation within Clarence River estuary (2010)**

### Case study – Seagrass in Wooloweyah Lagoon

Although estuarine vegetation within the wider estuary has increased over time, an apparent decline in seagrass, particularly within Wooloweyah Lagoon, has been raised as an issue by the community with stakeholders expressing concern during consultation for both the Clarence Valley Coastline and Estuaries CMP and this Scoping Study. The issue has a long history. Woodhouse (2001) reports that West *et al*. (1985) and Creighton (1985) both documented reported loss of seagrasses, with the Oyster Channel supporting one of the largest belts of seagrass in the Clarence at the time. Parker (1999) reported a 60% loss of seagrass beds since the 1940s (when aerial photography was first available) from the main Clarence River channel and from Oyster Channel. Seagrass decline within the lagoon was again raised by the community in local media in 2017 with further concerns in 2018 (Hourigan, 2018).

A brief review of historic seagrass distribution within Wooloweyah Lagoon indicates that seagrass was widely distributed in the lagoon in 1999 with four species recorded within the lagoon and associated channels (*Z. capricorni*, *Ruppia spiralis*, *Halophila ovalis* and *Halodule uninervis*, Woodhouse, 2001). Howland (1998) reported that the north-eastern end of the lagoon contains large areas of continuous seagrass. Mapping by DPI (2006b) indicates that seagrass distribution in the lagoon was restricted to the far north-east portion of the lagoon in 2004. Seagrass areas within the lagoon appear to increase between 2004 and 2010, however are still restricted to the north-east portion of the lake (Figure 20). No other mapping or studies of seagrass in the lagoon have been undertaken since this time however anecdotal reports suggest that seagrass has been at very low levels/non-existent in the lagoon over recent years.

Several theories on the loss of seagrass within Wooloweyah Lagoon have been documented. Woodhouse (2001) reported that the operation of trawlers and nets in the shallow depths of the lagoon causes high mixing and disturbance to the bottom habitats such as seagrass beds and sediments, resulting in increased turbidity. The Healthy River Commission of NSW (1999) suggested that seagrass changes in Wooloweyah Lagoon could be the result of episodic prawn trawling in the lake, natural growth cycle of some seagrass species or increased water turbidity and is most likely to be a combination of these and other factors. Woodhouse (2001) noted that fishers had identified that flood mitigation within the catchment had increased sedimentation and associated turbidity problems within the lagoon leading to a loss of seagrass. White (2009a) reported that any decrease in seagrass within the lagoon could potentially be due to reduced flushing of the lagoon and the associated nutrient increase. White (2009b) undertook water quality monitoring within the lagoon which investigated the impact of trawlers on turbidity in the lagoon. It was concluded that monitoring of turbidity did not show any evidence of trawling significantly increasing long-term turbidity within the lagoon. White (2009b) also noted that whilst trawling may have some impact on turbidity within the lagoon, results indicated that that it was not significant in comparison to the effect of wind-induced waves. Average turbidity in the lagoon was highest when the wind was from the south and south-east which was also when the average wind speed was highest. The lake also has a large southerly fetch. Researchers at Southern Cross University proposed studies to assess seagrass changes in Wooloweyah Lagoon however due to COVID-19 and other staffing issues within the University, this project did not eventuate.

### 6.5.5 Threats to biodiversity

The most significant threats to biodiversity in the Clarence River catchment are habitat degradation through native vegetation clearing, competition and predation by invasive species, increased sediment and nutrient loads to the estuary and fragmentation. Feral and invasive fauna impact vulnerable species, viable habitats and threatened ecological communities through predation and competition (EPA, 2018; CVC, 2010a; North Coast Regional State of the Environment Report Working Group, 2016; Smith *et al.*, 2011; DPIE, 2021a; MHL, 2000). Ongoing threats to the biodiversity of the estuary include:

- Loss of vegetation in riparian areas and wetlands. Riparian areas are the most contiguous environmental areas across the catchment and degradation in these areas reduces biodiversity by altering ecosystem productivity, available habitat and waterway health.
- Floodplain mitigation works. The modification of natural flows of wetlands (e.g. construction of drains and flood gates), pollution and acid sulfate soil exposure reduce water quality which can displace many species, particularly waterbirds.
- Water quality issues. Degraded riparian vegetation and floodplain mitigation increases pollution, sediment and nutrient runoff into waterways, reducing water quality (DPIE, 2021a). Fine sediments disturbed from the estuary bed can smother aquatic plant communities, impact aquatic habitat values and damage water quality.

Pressures on fish stocks include:

- 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.
- 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.
- 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 Clarence River estuary which have typically been attributed to blackwater events (Section 6.7.2). Red Spot Disease 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 in productivity and influences on the food chain.
- 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, restrictions on the size range of fish taken and the establishment of no fishing zones.

Stream connectivity and habitat diversity are critical components of healthy rivers. 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. Instream 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. Instream structures can also trap sediments which are critical for maintaining physical processes and habitats downstream. Fish passage barriers within the Clarence Valley LGA include natural and artificial structures such as floodgates, culverts, bridges, causeways, dams, weirs and waterfalls.

Within Clarence River estuary an 80% decline in seagrass areas between 1940 and 1986 was recorded by Umwelt (2003) with a further decline of 46 - 52% between 1983 and 2004 (Williams *et al*., 2006). However, between 2004 and 2010 there appeared to be an increase in seagrass area, particularly *Halophila* (Figure 21). Mangrove and saltmarsh areas have both gradually increased in the 1980 - 2010 period (Figure 22). There are no data available since 2010.

Seagrass growth and distribution is influenced by a multitude of factors. In the Northern Rivers region, the major factor affecting seagrass growth is typically weather events which exhibit a range of growth-limiting mechanisms. Wet season events bring increased turbidity (reduction in light), scouring through strong currents and sedimentation (smothering of seagrass beds). These high rainfall events generally occur in the summer months reducing seagrass growth and distribution. In winter, low water temperatures are common which can lead to a reduction in productivity causing winter die back of seagrass. Anthropogenic impacts such as reduced water quality, dredging, boat activity, land reclamation, built structures and smaller scale impacts such as trampling also influence seagrass growth.

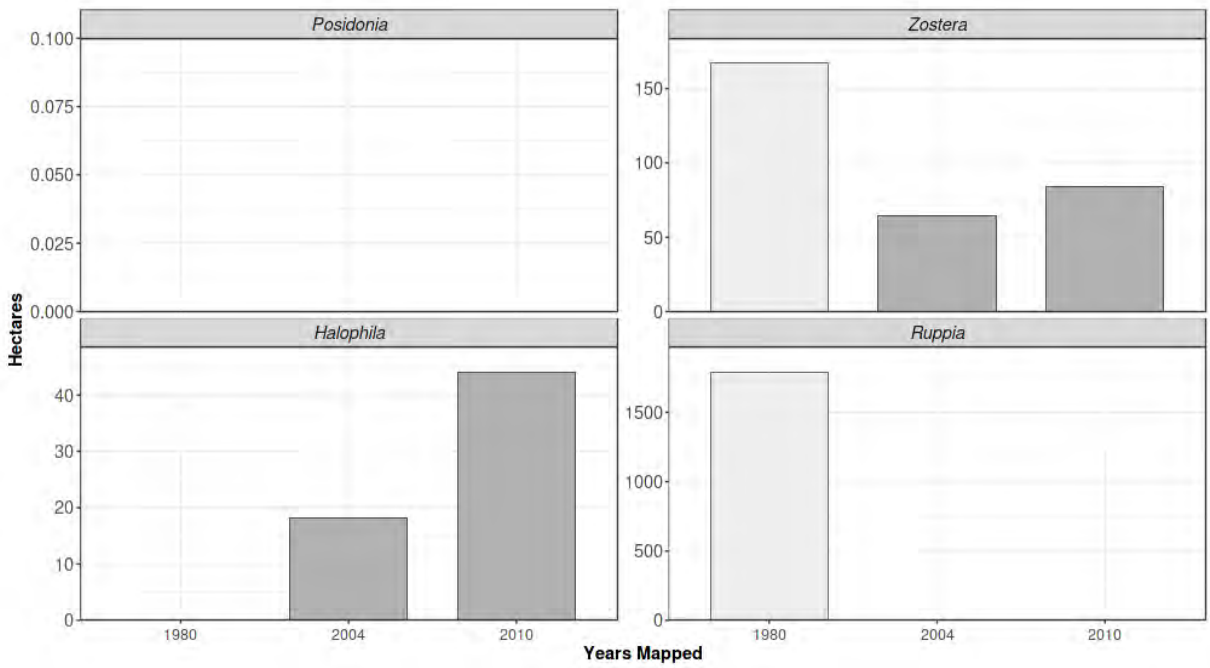



**Figure 21: Change in mapped area of seagrass within the Clarence River estuary 1980 - 2010**

Source: DPI (2021). Note: Due to differences in mapping techniques, comparison of areas from 1980 should be used as an indication of the direction of change rather than a magnitude of area change.

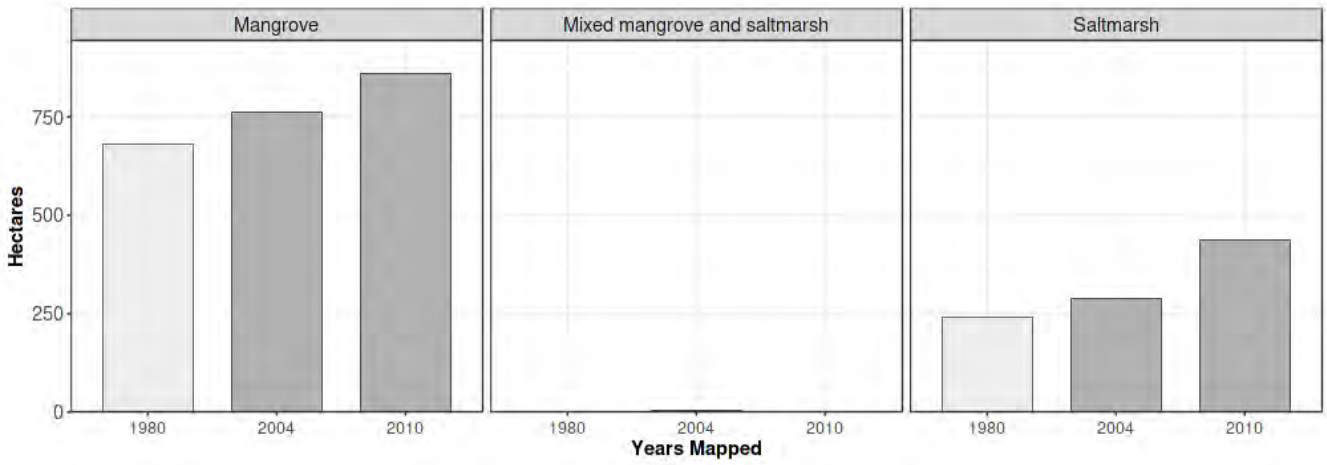



**Figure 22: Change in mapped areas of mangroves and saltmarsh within the Clarence River estuary 1980 - 2010**

Source: DPI (2021). Note: Due to differences in mapping techniques, comparison of areas from 1980 should be used as an indication of the direction of change rather than a magnitude of area change.

Concerns have been expressed amongst community members about the potential impacts of trawling on the health of the estuary. The *Environmental Impact Statement (EIS) on the Estuary Prawn Trawl Fishery* (NSW Fisheries, 2002) identifies the following likely consequences of estuary prawn trawling on estuarine habitats:

- Disturbance of seafloor sediments and any associated benthic infauna.
- Inputs of nutrients such as sedimentary nitrogen and silica into the water column.
- Damage to and/or removal of any epibenthos and associated macroalgae.
- Damage to seagrasses.

However, the EIS concedes that little is known about the impact trawling has on biodiversity in the estuary prawn trawl fishery. The EIS identifies a range of measures to be implemented to mitigate environmental impacts. Measures specifically for habitat damage included:

- Time and area closures.
- Mapping of habitats within trawl area.
- Prohibit trawling over seagrasses.
- Impact study on biodiversity.
- Continue to prohibit wilful damage of marine vegetation.
- Gear changes and restrictions.

With the inclusion of these measures the EIS assesses the level of risk to habitat damage from estuary prawn trawling to be low to high depending on key habitat type (e.g. medium for seagrass, high for unvegetated sediments). The EIS also assessed a range of other impacts including impact of the fishery on fish resources, biophysical components, economic impacts and social impacts. The assessment identified measures to minimise impacts to all of to these components.

In response to community concerns around the perceived ecological impacts of trawling on the Clarence River, a study was undertaken by Underwood (2007) to assess the impacts of estuarine prawn trawling. The specific aims were to understand the impacts on the invertebrate benthic fauna. The study focused on areas of the mid estuary, Ulmarra, Brushgrove and The Broadwater, comparing trawled and untrawled zones. The study failed to find any evidence for impacts on benthic fauna due to trawling. Although the study did not assess the impacts of trawling on seagrass or water quality, commentary was made on the difficulty in assessing the long-term impacts of trawling due to a lack of data on ecological diversity before trawling, lack of undisturbed areas and difficulty in differentiating impacts from other factors.

The estuary prawn trawl fishery was identified in the TARA (BMT, 2017) as a moderate-high priority threat to estuaries state-wide and a priority threat to estuaries in the North region (Table 4).

**Table 4: MEMS TARA estuary prawn trawl fishery risk levels**

| Category | Risk | Key stressors |
|---|---|---|
| Estuarine waters | Low | Water pollution – due to sediment resuspension, with impacts minor at a local scale. |
| Seagrass | Low | Physical disturbance, water pollution – minor impacts from physical disturbance and sediment re-suspension were considered likely to occur from this activity at a local scale under current management arrangements, and only at a local scale. |
| Shallow soft sediments | Low | Physical disturbance – minor impacts were considered likely due to physical disturbance, including sediment resuspension and the moderate resilience of the habitat, and the level of this activity. |
| Fish assemblages | Moderate | Reduction in abundances of species and trophic levels, bycatch – approx. 40% of recent state-wide landings are taken from the northern region, and approx. 60% from the central region, dominated by school prawns, and this was considered to result in a moderate consequence arising from harvest that is likely to occur. In addition, impacts from bycatch of fish assemblages associated with the fishery is considered to be moderate. |
| Threatened and protected species (macrophytes, fish and shark) | Low | Incidental catch of species of conservation concern – only minor impacts considered likely related to impacts on protected species (e.g. sygnathids). |
| Threatened and protected marine mammals, reptiles and birds | Low | Wildlife disturbance, catch of species of conservation concern, physical disturbance, marine debris, ghost fishing - moderate consequence considered possible due to known impacts from gear types used in this fishery on marine fauna, reports of turtle and seal entanglements and overlap between threatened species at risk and fishing activity. Wildlife is further impacted by disturbance and marine debris. |

Source: Data source BMT WBM (2017)

The TARA (BMT WBM, 2017) also identified the estuary general fishery as a state-wide priority (moderate-high) threat and a priority threat in the North region.

### 6.5.6 Management approach

Many aspects of biodiversity management are the responsibility of state government agencies (e.g. DPI – Fisheries, DPE) rather than Council. The CVC *Biodiversity Management Strategy* (CVC, 2010a) outlines CVC's responsibilities and supports actions outlined in the *Northern Rivers Regional Biodiversity Management Plan* (DECCW, 2010a) to reduce decline in biodiversity values. Opportunities to maintain, restore and/or establish new habitat corridors, establish and implement rehabilitation programs, manage natural areas, manage pests and weeds effectively and control of vegetation clearing have been identified as key actions to protect riparian value and condition. The *Biodiversity Strategy 2020 – 2025 Priorities and Actions* (CVC, 2020c) will guide CVC actions for biodiversity conservation management. Actions are outlined to obtain an overall net gain in vegetation, with an emphasis on connectivity and provision for the protection of remnant vegetation, endangered ecological communities and vegetated corridors. Improving riparian buffers and revegetation actions are outlined within agricultural areas and the whole catchment to improve habitat, water quality and connectivity.

## 6.6 Land Use

The dominant land use within the Clarence River catchment is parks and reserves, comprising approximately 43% of the catchment (Figure 23 and Table 5) occurring mostly in the middle and upper catchment. Grazing (25%) and forestry plantations (17%) are also found in the upper ranges of the north and south of the catchment. Cropping dominates the floodplains of the lower catchment. There has been a recent increase in horticulture, particularly blueberries, in the upper catchment around Tabulam and Orara and an increase in other 'hothouse' operations in the upper Orara River which has contributed to the total cropping area in the catchment. Sugarcane is the predominant crop cultivated on the floodplain, however, there has been some recent conversion of sugarcane to macadamia farms.

Table 5 also provides a breakdown of the land uses on land <1 mAHD (refer Figure 8). Dominant land uses on low-lying areas are grazing occupying 29%, followed by parks and reserves comprising 17% and cropping occupying approximately 14% of low-lying land.

**Table 5: Land use within the study area**

| Land use | Catchment | | Low-lying floodplain land (< 1 mAHD) | |
|---|---|---|---|---|
| | Area (ha) | Area (% of total) | Area (ha) | Area (% of total) |
| Parks and Reserves | 949,911 | 42.8% | 3,857 | 17% |
| Grazing | 769,128 | 34.7% | 6,479 | 29% |
| Forestry | 374,697 | 16.9% | 56 | 0.25% |
| River and drainage | 68,688 | 3.1% | 8,702 | 38.7% |
| Cropping | 28,704 | 1.3% | 3,098 | 13.78% |
| Non-urban residential | 13,715 | 0.6% | 34 | 0.15% |
| Urban residential | 5,292 | 0.2% | 18 | 0.08% |
| Infrastructure | 5,283 | 0.2% | 79 | 0.35% |

| Land use | Catchment | | Low-lying floodplain land (< 1 mAHD) | |
|---|---|---|---|---|
| | Area (ha) | Area (% of total) | Area (ha) | Area (% of total) |
| Horticulture | 3,164 | 0.1% | 13 | 0.06% |
| Quarrying and mining | 742 | 0.03% | 1 | 0.005% |
| Animal production | 620 | 0.03% | 137 | 0.6% |
| *Total* | *2,219,945* | *100%* | *22,475* | *100%* |

Source: DPIE (2020b)

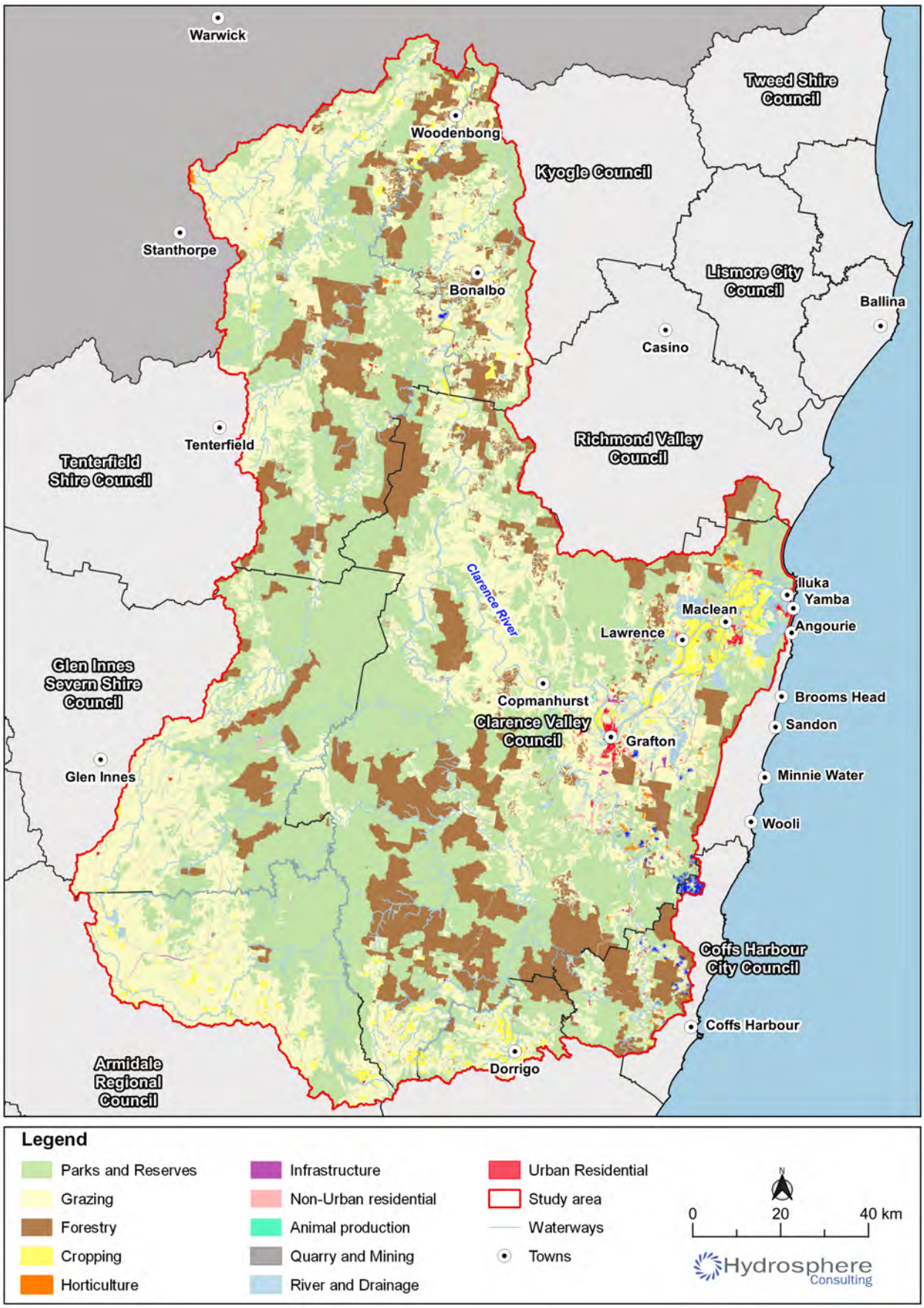



**Figure 23: Land use within study area**

Source: Mapping data sourced from DPIE (2020b)

## 6.7 Catchment Health

The key ecosystem health challenges facing the Clarence River estuary are linked to its physical characteristics including the large catchment area (2.2 million ha) and floodplain (22,475 ha) coupled with areas of erosion and ASS and the significant catchment modifications that have occurred since European settlement. With this substantial catchment area and land use modifications, the management of the Clarence River catchment has a significant impact on the health of the estuary and coastal zone.

### 6.7.1 Ecohealth project

The *Clarence Catchment Ecohealth Project* (Ryder, *et al.* 2014) was conducted over an 18-month period between 2012 and 2013, covering 81 sites (60 freshwater and 21 estuarine) across 32 river systems and seven sites in five coastal river catchments. The project objective was to provide a snapshot of ecosystem health across the catchment. The project assessed the health of waterways using standardised indicators including hydrology, water quality, riparian vegetation and habitat quality and macroinvertebrate assemblages across the five sub-catchments (Appendix 5, Volume 2). A report card was generated for each sub-catchment (with primary ratings ranging from a high of 'A', through 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). A total of 88 sites in 37 individual river systems in the Clarence catchment were used to calculate an overall score of 70.5 (C+) for the catchment. Average scores for water quality, aquatic macroinvertebrates and riparian systems consistently ranged from 60 - 66. A much higher average score of 91.5 for fish improved the overall catchment score, suggesting that lower scores for other attributes in freshwater reaches are not adversely impacting native fish populations (Ryder *et al.,* 2014).

Ryder *et al.* (2014) highlighted management priorities based on the findings of the study including:

- Identify point sources of high phosphorous concentrations and monitoring of total and available nitrogen. High phosphorus and nitrogen concentrations reduce aquatic productivity and support algal blooms. Locating diffuse pollution sources will guide future management recommendations.
- Improve riparian vegetation and bank condition in the tablelands and coastal reaches. Riparian restoration will reduce bank erosion and improve all indicators (e.g. enhance macroinvertebrate habitat, reduce sediment deposition and increase water quality). This will require a holistic approach to remove stressors (e.g. invasive weeds, clearing, stock access to banks etc.) and undertake assisted regeneration and/or revegetation of riparian zones.
- The poorest water quality was recorded from the sites closest to the tidal limit, highlighting their role as depositional environments for both freshwater and estuarine contaminants and the importance of this zone as a focal point for future monitoring programs.

The samples from 2012 were undertaken during a lower-than-average rainfall period and the samples collected in 2013 were subjected to unprecedented flooding events. After the flooding, sampling was completed prior and post flood peaks to allow for comparison of the impacts of flooding. Repeat survey following a standardised approach and adequately controlled for seasonal and climatic variables would allow for tracking of the health status of the Clarence catchment. Ryder *et al.* (2014) emphasises 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 conducted during similar flow conditions using 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.

### 6.7.2 Water quality monitoring

#### State-wide monitoring

DPE 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, 2021c). The program has not been applied in the Clarence River catchment as it was considered to be too large to provide a valid assessment with the adopted methodology.

The *NSW Estuary and River Water Quality Annual Summary 2018 - 2019* (MHL, 2019) presents data collected from water quality measured by automatic recording stations along many NSW coastal estuaries and rivers, including the Clarence River and estuary. There are two stations along the Clarence at Rogans Bridge and Grafton logging water level, temperature, conductivity and salinity since March 1999.

#### Ecohealth project

The *Clarence River Ecohealth Project* (Ryder *et al.,* 2014) summarised water quality throughout the catchment as follows:

- Total and available nitrogen was high throughout the catchment, notably after flood events which indicate impacts by diffuse sources.
- High nitrogen concentrations were recorded around the catchment, occurring without any spatial patterns. Pre-flood low flows in freshwater reaches and post-flood flows in estuarine reaches had high algal concentrations.
- Low dissolved oxygen (DO) concentrations and low pH were common in post-flood estuarine reaches.

Overall, the poorest water quality was recorded at sites nearest to the tidal limit. These results emphasise the importance of these areas as depositional environments for both freshwater and estuarine contaminants. Future monitoring recommendations included identifying phosphorous sources, monitoring chlorophyll *a* (algal biomass) in pre-flood in freshwater reaches and post-flood in estuarine reaches and DO monitoring between Copmanhurst and Maclean.

Results for each sub-catchment are reported as follows (Ryder *et al.,* 2014):

- Clarence Main Stem - the overall score of the main stem was a C+. The scores for the estuarine site was a C- with low water quality while the freshwater sites scored at C+, bolstered by better water quality and fish abundance. The lowest condition score was at the tidal limit, however there was no trend of increasing nutrients along the river, which indicates that local pollutant sources influence river condition. Nitrogen and phosphorous concentrations exceeded the guideline values throughout the area. The highest phosphorous readings taking during prolonged low flows in freshwater reaches and the highest nitrogen was recorded in estuarine reaches post flood. Estuary tributaries

(particularly Swan Creek, Mangrove Creek, Shark Creek) contributed very low oxygen and acidic water to the Clarence River post flood.

- Northern Tributaries - overall, this region scored a C, bolstered by high scores for fish communities. Water quality scores varied greatly, however there was no trend of reduce water quality or increased nutrients up the waterways, which indicates that local pollutant sources influence the variability in water quality. The highest nitrogen concentrations occurred after high flows, indicating catchment runoff is the main source. The highest phosphorous concentrations were documented during long period of low flow, suggesting instream sources contributing to the concentrations.
- Nymboida-Boyd-Mann - these river systems were graded a C+, which was the equal top score in the whole catchment with Clarence Main Stem. Across all sites, nitrogen levels were consistently high and phosphorous concentrations exceed guidelines vales in the table land rivers and tributary streams. No trends were identified along the rivers, which indicated that the conditions are influenced by local sources. The dissolved oxygen and pH levels across the area were consistently good, contributing high quality water to the Clarence.
- Coastal Tributaries - this region covered seven major river systems which drain into the Clarence River. This region scored an overall grade of C-. Condition and water quality was variable between the systems, indicating how local conditions influence the health of the waterways. Phosphorous and nitrogen concentrations were consistently high through the area and were scored the highest in the Clarence catchment. Highest nitrogen was recorded post high flows, which indicated that a main source of pollution is from catchment runoff. The highest phosphorous was recorded during prolonged low flow periods, which suggest the pollution comes from instream sources. Many of the estuary tributaries (mainly Swan, Mangrove and Shark Creeks) contributed very low water quality (acid water and low oxygen) to the main estuary, particularly after flooding.

### Beachwatch

CVC participated in the Beachwatch Partnership Program between 2002 and 2011 with many locations monitored within the LGA and a portion of these within the estuary. Monitoring associated with the Beachwatch Partnership Program began with Beachwatch Partnership Pilot Program in 2002/03 and 2003/04 summer swimming seasons. Nine sampling sites were part of the program, with a tenth being added in 2006/2007. Beachwatch Partnership Program sampling sites included estuarine beaches of Iluka Bay and Whiting Beach, Kolora Lake and estuarine swimming sites of Maclean Jetty, Ulmarra Jetty, Corcoran Park, Grafton Sailing Club, Prince Street and a site in Lawrence added in 2006/2007. Typically, swimming sites with consistently better quality included Lawrence, Ulmarra Jetty and Iluka Bay. Prince Street (Grafton), Grafton Sailing Clun and Corcoran Park had the most consistently low compliance levels, which were sometimes influenced by higher rainfall but also runoff (agricultural, stormwater or urban).

### Water quality objectives

The 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.). A review is currently being undertaken as part of the MEMS to update community and environmental values, assess land use

changes and the suitability of indicators used in the WQOs. A public consultation survey on WQOs for the north coast was undertaken as part of the MEMS (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 June 2022 (Section 9.7).

### Other monitoring

There has been event-based or project-based water monitoring undertaken across the estuary including:

- CVC monitors water quality at Corcoran Park jetty as part of the EPA licence conditions for North Grafton STP.
- Harrison (2009) undertook an analysis of water, sediment and biological samples from the Clarence River to identify potential causes for poor growth of school prawns. Samples were taken from the mouth upstream to Ulmarra. The study found:
    - The presence of MBO in The Broadwater and Wooloweyah Lagoon.
    - Elevated levels of nitrogen and phosphorous (both consistently exceeding guideline values) in association with elevated turbidity.
    - Aluminium and iron were found to be present in high concentrations upstream, likely due to acid sulfate runoff from lands around Coldstream River and Shark Creek.
- White (2009b) undertook water quality sampling along three coastal floodplain wetlands (Wooloweyah, Colletts Swamp and Little Broadwater):
    - Little Broadwater – the worst water quality was at the southern end of the wetland and was very acidic and often very saline. Dissolved aluminium concentrations were four orders of magnitude above guidelines and soluble iron was more than two orders of magnitude above guidelines in this area.
    - Wooloweyah (drainage network to west of Wooloweyah Lagoon) – samples taken near Palmers Channel and the lagoon had the highest salinity, however the Ring Drain, Little Reedy Creek and Reedy Creek were also saline. Rainfall during the study period decreased salinity considerably in the area. Total nitrogen concentrations were higher upstream, where agricultural lands surround the drain, and the drain water is often stagnant.
    - Colletts Swamp (southern region) - the north-arm and backswamp areas were acidic with high concentrations of aluminium, manganese and iron. The backswamp area had the highest salinity in Colletts Swamp, with high concentrations of calcium, potassium, magnesium and sodium.
- DPE surveyed the Clarence River from Iluka to upstream of Lawrence following the March 2022 flood and associated fish kill (Ferguson, 2022):
    - A large slug of anoxic water in the main channel extended from about 1 km upstream of Iluka to approximately Maclean. There was slightly better water in the north arm and back channel reaches.

  - The south arm was completely anoxic and highly sulfidic.
  - The Broadwater had reasonable water quality.
  - Sportsmans Creek was completely anoxic.
  - Ocean water was starting to penetrate to about Iluka on the high tide and there was a sharp salt wedge.
  - Dead fish were observed around Iluka, and a few locals advised that there have been large numbers of large fish washed up on the ocean beaches.
- The NSW Oyster Industry undertakes regular water quality monitoring, however the data are generally not provided to other government agencies.

### 6.7.3 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 (DPIE, 2021c; BMT WBM, 2017). Sediment and nutrient runoff within the catchment (including agriculture, unsealed roads and urban development), ASS discharge, low oxygen 'blackwater' runoff from coastal floodplains and stormwater runoff contribute to poor estuarine water quality and can lead to exacerbating processes (eutrophication and potentially toxic blooms of cyanobacteria i.e. blue green algae. Although only a small proportion of the catchment is used for intensive horticulture (e.g. blueberry farms), clear links have been established between management practices and elevated nitrogen in waters in the upper catchment and other nearby catchments (White & Santos, 2018; White *et al.*, 2018; Wadnerkar *et al.,* 2020). Pollution of waterways, river banks and habitat areas results from litter, marine debris and microplastics.

Much of the catchment has been cleared or modified and approximately 53% of land in the catchment is used for agriculture and forestry (Section 6.6). Poor water quality, specifically from diffuse agricultural runoff, has been recognised as one of the highest priority threats within NSW estuaries (Harrison *et al.*, 2021a). Diffuse agricultural runoff is identified to impact social, cultural and economic benefits derived from the marine estate. The threat and risk assessment (TARA) prepared for the MEMA (BMT WBM, 2017) emphasises the significance of risks associated with acid discharges and blackwater runoff associated with modified floodplain uses and drainage (Harrison *et al.*, 2021b).

Water quality management was identified by MHL (2000) as a significant issue in the catchment, with agricultural land uses, urban development, flood mitigation works, ASS and riparian zone degradation all contributing to significant sediment, chemical (e.g. pesticide and herbicide) and nutrient loads to the estuary during rain events. Unrestricted stock access to intertidal areas 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 (Parker, 1999). Agricultural fertilisers are reported as a major source of nutrients. Contaminant inputs and increased turbidity have flow-on effects to estuarine ecosystems and productivity in the immediate vicinity and downstream in the estuary.

The *NSW Diffuse Source Water Pollution Strategy* (DECC, 2009b) 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 MEMS including review of the current governance arrangements and approaches to managing diffuse source water pollution (Section 9.7). 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, 2020).

**Plate 14: Diffuse pollution sources – blackwater (left) and soil runoff (right)**

Photo source: CVC and Clarence Landcare

### NSW Estuary Health Risk Dataset – modelling nutrient and sediment export

DPE 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 risk of impacts based on sub-catchment scale 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. 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 Clarence River dataset is based on 2008 climate and land use data and DPE – Environment and Heritage Group (E&H) has indicated it plans to update the model with more recent data. The current estuary health risk results are mapped for the catchment on Figure 24. The results for the Clarence River catchment are broadly summarised as follows:

- There were no areas mapped as very high risk (equating to a score of 16 out of 16) in the catchment.
- High risk (scores of 9 – 12) were assigned to approximately 58% of the catchment, including the majority of the southern arm of the Clarence River main stem, and upper and lower catchment areas.

- Moderate risk (scores 6 – 8) were assigned to large areas (29%), including Wooloweyah Lagoon and The Broadwater, the Esk River and sub-catchments in the upper, middle and lower catchment.
- Low risk (scores 3 – 4) were assigned to 8% of the catchment, including some of the Clarence River main stem, the western boundary of the catchment, upper Timbarra River and small sub-catchments in the upper and mid catchment.
- Minimal risk (scores 1 – 2) were assigned to 4% of the catchment, including a portion of the floodplain (Harwood Island, Goodwood Island, Micalo Island), a small sub-catchment upstream of Grafton and in the upper catchment.

There are some differences between the modelled risk provided in the estuary health risk dataset results and the *Clarence River Ecohealth Project* (Ryder *et al*., 2014) 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.

### Acid sulfate soil runoff

ASS naturally occurs on the Clarence 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. Acid discharges along with blackwater events from the Clarence River floodplain have been identified as the key causative factors for fish kill events occurring in 2001, 2020 and 2022 (DPI, 2004; DPI, 2020; DPIE, 2021a; MHL, 2000; Wong *et al.,* 2010).

MBO accumulates in ASS environments and typically occurs at the base of drains. When disturbed and transported during flow events, MBO has the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways. MBO is known to occur in the Clarence River estuary and has also been identified as a factor in fish kills (Johnston *et al.,* 2003b).

The draft *Clarence River Floodplain Prioritisation Study* (Harrison *et al.,* 2021a) identifies priority locations across the Clarence 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 (Figure 25) as Sportsman Creek (1), Swan Creek (2), Gulmarrad/ East Woodford Island (3), Taloumbi/ Palmers Channel (4) and Coldstream River (5). These sub-catchments were estimated to contribute over 80% 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 (Section 6.4.6) which indicates 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.).

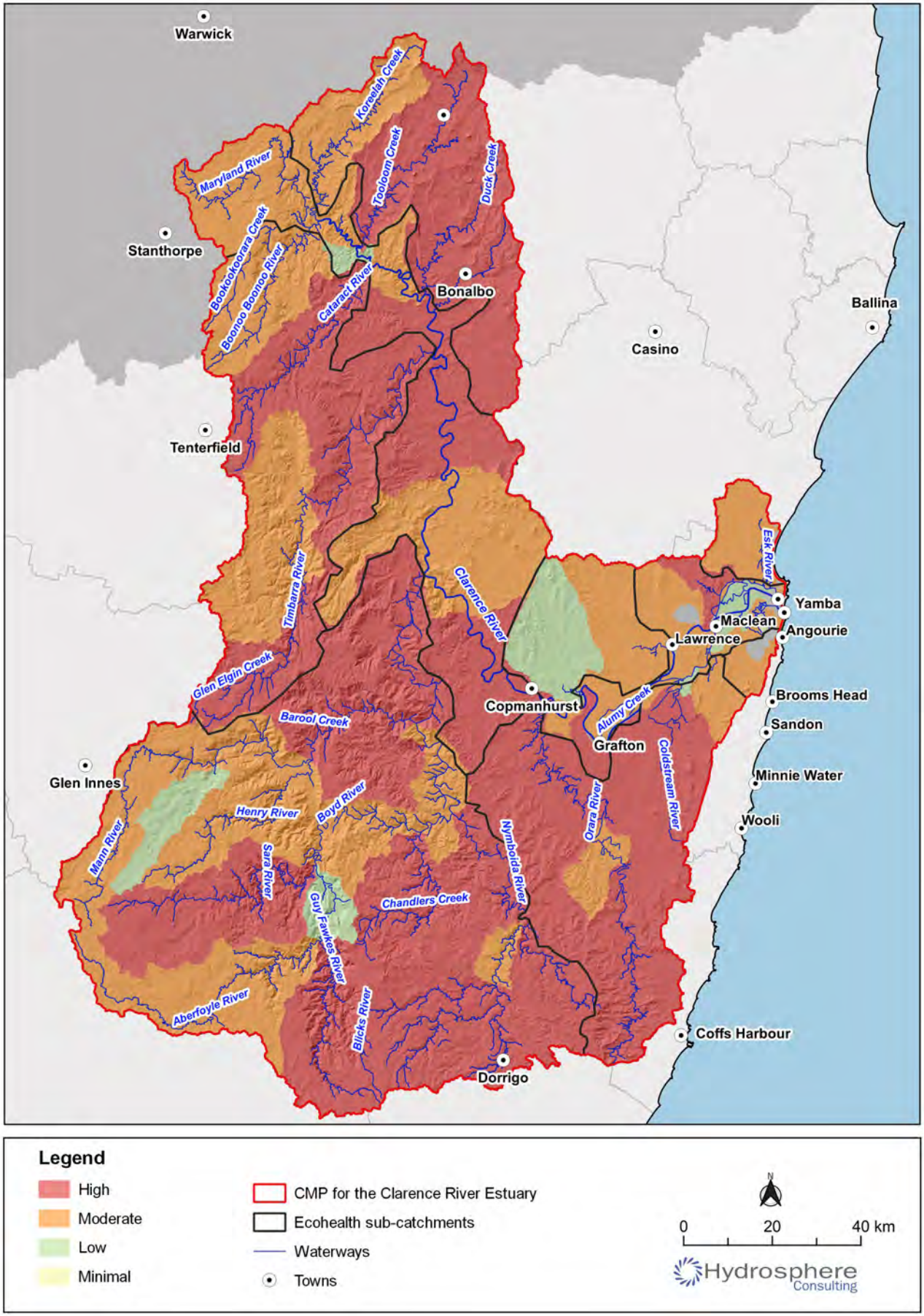
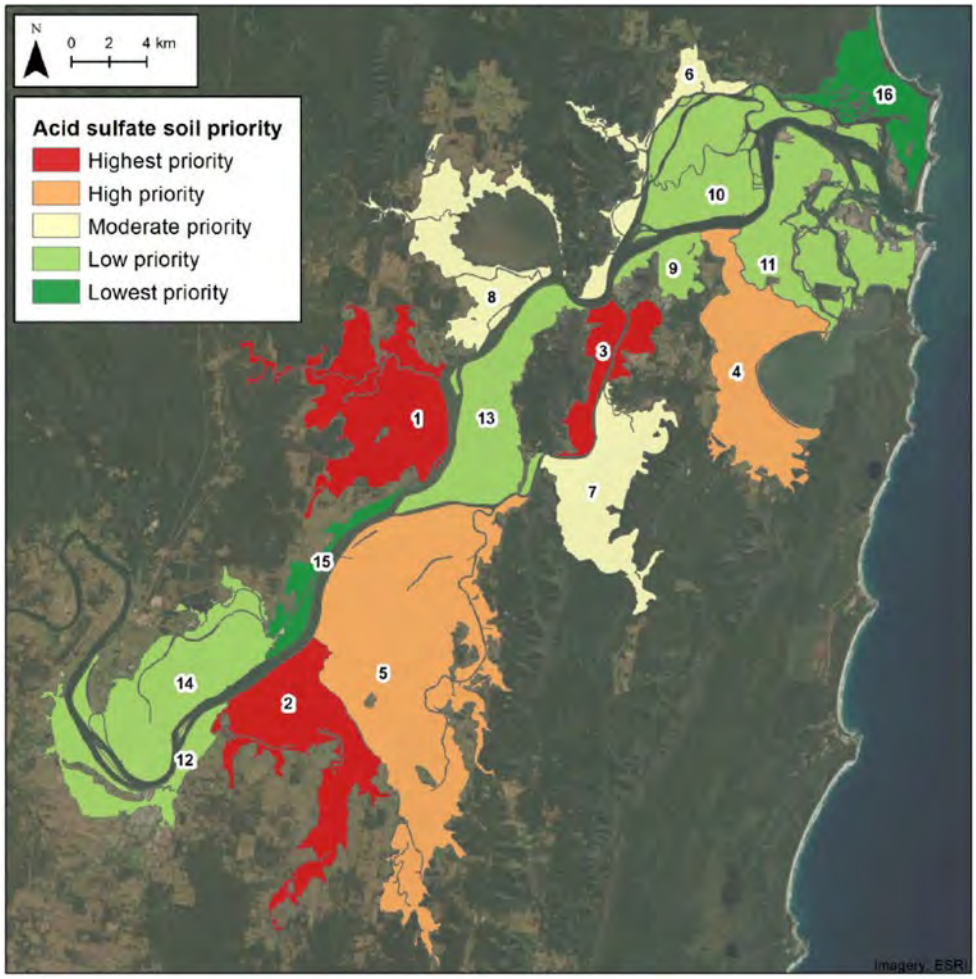



**Figure 24: Clarence River estuary health risk assessment results**




| | |
|---|---|
| 1 | Sportsmans Creek |
| 2 | Swan Creek |
| 3 | Gulmarrad/ East Woodford Island |
| 4 | Taloumbi/ Palmers Channel |
| 5 | Coldstream River |
| 6 | Mororo/ Ashby |
| 7 | Shark Creek |
| 8 | The Broadwater |
| 9 | Maclean |
| 10 | Harwood/ Chatsworth/ Goodwood/ Warregah Islands |
| 11 | Palmers Island/ Micalo Island/ Yamba |
| 12 | South Grafton |
| 13 | West Woodford Island |
| 14 | Alumy Creek |
| 15 | Southgate |
| 16 | The Freshwater |

**Figure 25: Clarence River floodplain sub-catchment ASS prioritisation**

Source: Harrison *et al*. (2021a)

The management options recommended by Harrison *et al.* (2021a) 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 Sportsman Creek, Swan Creek and Coldstream River. Harrison *et al*. (2021a) concluded that the lowest areas of the Sportsman Creek sub catchment should be prioritised for full remediation to achieve the most significant improvements in estuarine health, compared to any other single-sub catchment on the Clarence River floodplain.

The potential remediation options include:

- Decommissioning of Sportsman Creek weir.
- Restoring natural flow paths by removing flow impediments (including internal floodgates) and artificial levees.
- Short term options with minimal impacts to existing land uses including:
    - Improved flushing and aquatic connectivity by active management of existing floodplain infrastructure.
    - Consider active management of internal floodplains and opening of Sportsman Creek weir floodgates.

- 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 freshwater/ brackish wetlands.

Harrison *et al*. (2021a) recommend that further detailed on-ground investigations are completed prior to the implementation of actions.

The *Everlasting Swamp Hydrodynamic Modelling Study* (WRL, 2018) examined management options for the Everlasting Swamp wetland complex to mitigate issues associated with ASS in this high priority sub-catchment. The study provided scientific analysis and risk assessments to provide remediation strategies which consider the hydrological impacts of the surrounding environment through field data collection and calibrated computer modelling. The study provided six management options to address ASS issues. WRL (2018) highlighted correlating implications and risks for each option including displacement of landholders, impacts on terrestrial fauna and unwanted inundation on adjacent properties.

The study proposed changes to the physical status of the floodplain land (removal of the weir, land reshaping) to addresses identified ASS and water quality issues and improve the health of the Clarence River estuary. These changes will have a considerable impact on the current land uses, land capability and status of floodplain vegetation communities. Some of the proposed management options may require acquisition of many properties and discontinuation of current land management practices on affected properties (WRL, 2018). Detailed consideration of specific impacts on the Everlasting Swamp Nature Reserve has not been undertaken which would need to consider potential environmental impacts including changes to freshwater endangered ecological communities (i.e. Freshwater Wetlands on Coastal Floodplains, Swamp Oak Floodplain Forest and Swamp Sclerophyll Forest on Coastal Floodplains) as a result of proposed works.

Both the *Clarence River Floodplain Prioritisation Study* and the *Everlasting Swamp Hydrodynamic Modelling 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 Clarence River estuary. WRL (2018) highlight that some of the management options may require the discontinuation of current land management practices on the affected properties and 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. These factors currently present significant knowledge gaps and barriers to implementation of the recommended potential management options.

### Blackwater

Blackwater is formed from the decomposition of plants and organic matter in water during prolonged inundation during floods and is usually dark in colour and contains little or no oxygen (Harrison *et al.,* 2021a). The organic matter in blackwater can consume large amounts of dissolved oxygen and if mixed into rivers and creeks can deoxygenate waterways and cause fish kills. 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.

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 26).

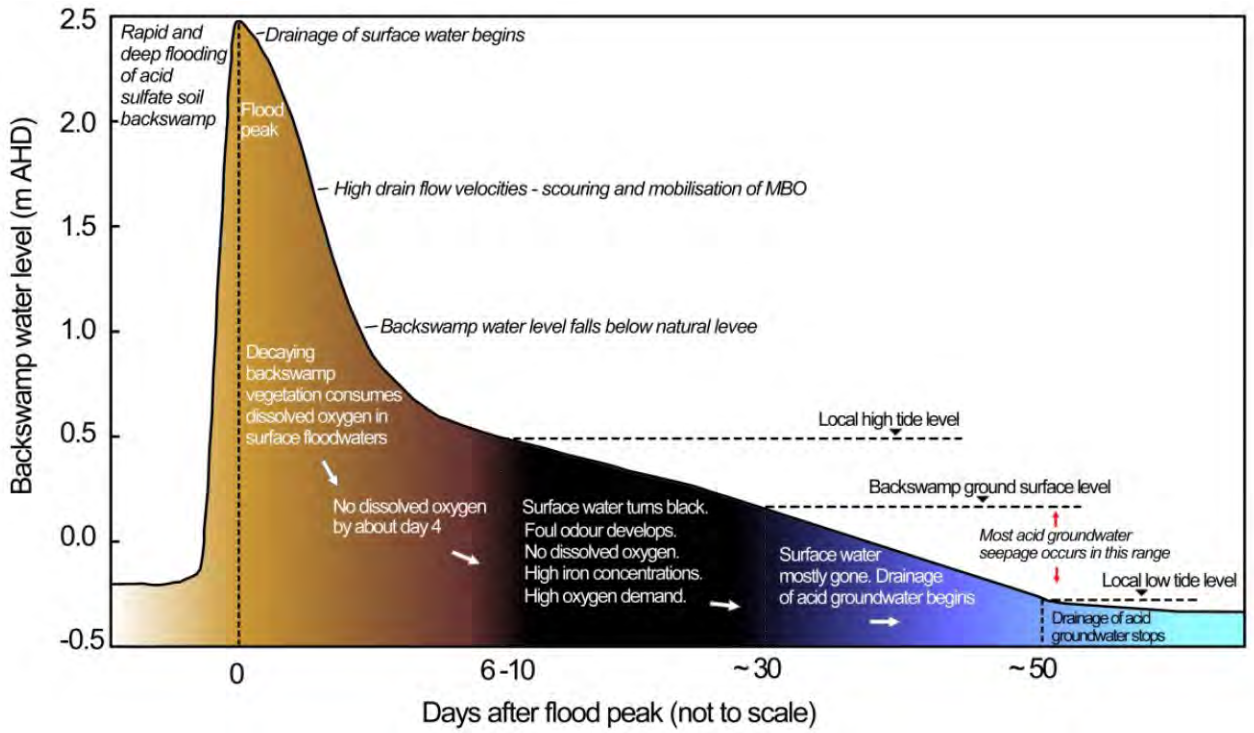


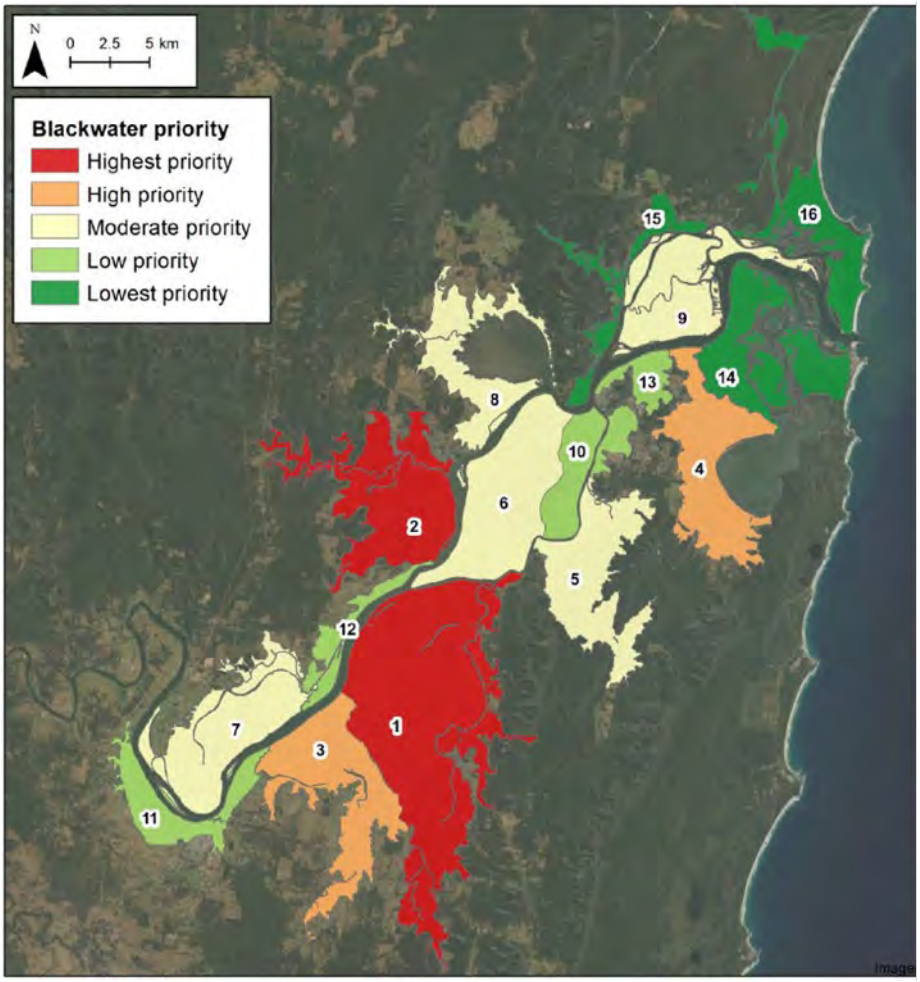

**Figure 26: General water quality processes after flooding**

Source: Johnston *et al*. (2003b)

Generally, blackwater retained on floodplains for four to eight weeks or more will lose most of its capacity to cause deoxygenation of river waters even though it retains the black colour (Clay *et al*., 2020). 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.

Wong *et al.* (2016) 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 *Clarence River Floodplain Prioritisation Study* (Harrison *et al.,* 2021) identified priority locations across the Clarence 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 (Figure 27) as Coldstream River (1), Sportsman Creek (2), Swan Creek (3), Taloumbi/Palmers Channel (4) and Shark Creek (5). The top three sub-catchments are located in the mid-to-upper estuary sub-catchments and are estimated to contribute over 50% 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.




| | |
|---|---|
| 1 | Coldstream River |
| 2 | Sportsmans Creek |
| 3 | Swan Creek |
| 4 | Taloumbi/ Palmers Channel |
| 5 | Shark Creek |
| 6 | West Woodford Island |
| 7 | Alumy Creek |
| 8 | The Broadwater |
| 9 | Harwood/ Chatsworth/ Goodwood/ Warregah Islands |
| 10 | Gulmarrad/ East Woodford Island |
| 11 | South Grafton |
| 12 | Southgate |
| 13 | Maclean |
| 14 | Palmers Island/ Micalo Island/ Yamba |
| 15 | Mororo/ Ashby |
| 16 | The Freshwater |

**Figure 27: Clarence River floodplain sub-catchment blackwater prioritisation**

Source: Harrison *et al*. (2021a)

### Urban stormwater

Stormwater runoff is generated from rainfall that flows over land and can collect pollutants, including sediments, organic materials, oils/greases from roads and dissolved chemicals from various sources. Stormwater is discharged into waterways predominantly from urban areas via pipes, drains, paved areas or overland runoff and has the potential to cause environmental impacts due to introduced pollutants and altered flow regimes if not managed appropriately. Grafton, Junction Hill, Ulmarra, Maclean, Yamba and Iluka all have stormwater infrastructure which discharges into the estuary.

Prior to amalgamation of the council areas, stormwater management plans were prepared for some urban areas and stormwater mitigation design principles were developed (Maclean Shire Council, 2004a; Grafton City Council, 2001). Stormwater management proposals for new developments are assessed against the requirements of CVC's *Residential Zones Development Control Plan 2011* (DCP, CVC, 2011a). The DCP includes procedures for development within residential zones in Clarence Valley LGA for the management of stormwater runoff and refers to the *Clarence Valley Sustainable Water Requirements: Information for Applicants* which were most recently updated by Council in May 2022.

Some of the Urban Release Areas in the Clarence Valley are in close proximity to waterways (Section 8.1) and have the potential to significantly increase stormwater runoff and associated impacts on the estuary, particularly West Yamba Urban Release Area and Junction Hill. Both of these areas are and/or will be managed under the DCP.

### 6.7.4 Point source pollution

#### Sewerage systems

The Environment Protection Authority (EPA) issues environment protection licences (EPL) to the owners or operators of various industrial premises under the *Protection of the Environment Operations Act 1997*. Licence conditions relate to pollution prevention and monitoring and cleaner production through recycling and reuse and the implementation of best practice. Within the Clarence River catchment, local councils operate centralised sewerage collection and treatment systems at urban centres with STPs discharging treated effluent to Clarence River waterways and managed in line with licences issued by the EPA. These include:

- Clarence Valley LGA – Clarenza, Coutts Crossing, North Grafton, Woodford Island. STPs at Yamba (servicing Yamba, Angourie, Wooloweyah and Oyster Channel) and Iluka discharge treated effluent at an ebb-tide release in the Clarence River entrance (all water clears the entrance on the outgoing tide). The Iluka release has never been used, until the March 2022 floods, except for monthly testing with treated effluent re-used for irrigation of open space areas. The ebb-tide release allowed CVC to cease discharge of treated effluent to Wooloweyah Lagoon. The EPLs for Clarenza, Iluka, Woodford Island and Yamba STPs require treatment of environmental release to "Accepted Modern Technology" (AMT) standard and that the EPL for North Grafton requires this STP to be upgraded to AMT by the end of 2027.
- Kyogle Council – Bonalbo, Woodenbong/ Muli Muli.
- Tenterfield Shire Council – Urbenville.
- Bellingen Shire Council – Dorrigo.

CVC manages sewerage systems at Baryugil, Malabugilmah and Clarence Correctional Centre that do not operate under an EPL, however are monitored by Council Environmental Health Officers.

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 as a result of diffuse loads from the catchment.

### On-site sewerage systems

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. Council's *On-site Wastewater Management Strategy* (CVC, 2019b) includes risk assessment and monitoring activities.

Kyogle Council is planning to construct sewerage systems at Mallanganee and Tabulam due to the significant environmental and health risks associated with the current wastewater management systems in these villages. There is also anecdotal evidence of potential health and environmental risks due to poor performance of on-site sewerage systems in the villages of Liston and Drake in Tenterfield Shire (Hydrosphere Consulting, 2015).

### Contaminated sites

There are various contaminated sites within the study area associated with petroleum storage, gasworks and other industry. A comprehensive list of these sites and their location is available from the EPA website (EPA, 2021a). Significant sites within the catchment include:

- Harwood Mill and Refinery, located on Harwood Island.
- Quarries located in Mororo, Grafton and Ashby.
- Concrete works in South Grafton, Lawrence, Yamba, Maclean.
- Sawmills located around Grafton, Dorrigo.
- Marinas in Yamba (including a dry dock and slipway) and Harwood.

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.

### 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 listed on the register within the study area, 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, 2017a) making them less bioavailable.

Cattle dip 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 remediated by DPI. Groundwater testing undertaken by DPI indicates no major concerns regarding groundwater transportation of contaminants from dip sites. A 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.

#### Other licensed activities

Other operations that may discharge to or potentially impact waterways managed in line with environmental protection licences include:

- Quarries at Ashby, Central Bucca, Nymboida, Jackadgery, Mororo, Hernani, Mountainview.
- Slipways at Harwood and Ashby.
- Harwood sugar mill.
- Multiple aquaculture premises at Palmers Island,
- Sawmills/timber processing at Koolkhan, Glenreagh, Grafton, South Grafton, Nana Glen.
- Waste management centres at Dorrigo, Coffs Harbour, Grafton, South Grafton, Tenterfield.
- Instream gravel extraction at Grafton.
- A piggery at Tabulam.
- Concrete works at Koolkhan.
- Yamba marina.

### 6.7.5 Weeds

Weeds are one of the most significant and costly environmental threats in Australia as once established, they place ongoing pressure on biodiversity (Natural Resource Management Ministerial Council, 2007). The current fragmentation of native vegetation in the Clarence River catchment makes it susceptible to invasion by weeds. Weeds can impact the environment and community by (CVC, 2010a):

- Causing bank destabilisation and eroding the creekbank.
- Outcompeting and smothering native species (e.g. *Dolichandra unguis-cati* (Cats claw creeper), Plate 15).
- Degrading riparian vegetation.
- Reducing aquatic and terrestrial ecosystem function and structure.
- Impacting the landscape amenity which can impact the community's enjoyment of natural areas.
- Impacting First Nations communities' connection to Country and the ability to undertake cultural activities.

The *North Coast Regional Strategic Weed Management Plan 2017-2022* (NCLLS, 2021a) outlines the primary objectives and strategies for managing priority weeds for the NSW North Coast and the responsibilities of the various stakeholders. CVC is the local control authority responsible for administering

the *Biosecurity Act 2015* for weeds in the LGA. A regional risk-based approach in the *NSW Weeds Action Program* (funded by the NSW Government) aims to control new problem weeds before they become a bigger problem in the region (i.e. exclude and eradicate) (CVC, 2021e). The most common weeds managed by CVC (identified over more than 10 km) include:

- Lantana (*Lantana camara*).
- Tropical soda apple (*Solanum viarum*).
- Blackberry (*Rubus fruticosus* species aggregate).
- Tobacco bush (*Solanum mauritianum*).
- Mother-of-millions (*Bryophyllum species*).
- Groundsel bush (*Baccharis halimifolia*).
- Cats claw creeper (*Dolichandra unguis-cati*).
- Water hyacinth (*Eichhornia crassipes*).
- Narrow-leaf Privet (*Ligustrum sinense*).

Ryder *et al.* (2014) reported the dominant weeds in the Ecohealth sub-catchments. Dominant weeds along the main Clarence Stem include Spear Thistle (*Cirsium vulgare*), Fireweed (*Senecio madagascariensis*), Mexican Poppy (*Argemone ochroleuca subsp. ochroleuca*), Small-leaved Privet (*Ligustrum sinense*), Prairie Grass (*Bromus catharticus*), Moth Vine (*Araujia hortorum*), Black Jack (*Bidens pilosa*) and Lantana (*Lantana camara*). Most sites along the Main Stem in the Ecohealth report were observed to be highly disturbed, with evidence of tree clearing and stock accessing the river. Many of these weed species specialise in establishing in a disturbed environment.

Some reoccurring weeds along the northern tributaries included Lantana, Small-leaved Privet, Wild Tobacco Bush (*Solanum mauriteanum*), Cat's Claw Creeper, Fireweed *(Senecio madagascariensis*), Mexican Poppy (*Argemone ochroleuca subsp. ochroleuca*), Spear Thistle (*Cirsium* vulgare) and exotic grasses such as Whisky Grass (*Andropogon virginicus*). Less weeds occurred along Bookooroorara Creek and Boonoo Boonoo River and Koreelah Creek on the Timbarra River. Some of these sites were relatively undisturbed by stock access (had appropriate fencing) or tree clearing which has preserved the native vegetation structure (Ryder, *et al*. 2014).

Ryder, *et al* (2014) reported that the Mann-Nymboida-Boyd sub-catchment had overall good native vegetation cover, with sites within conservation reserves having low disturbances. The most common weed species included Spear Thistle, Mexican Poppy, Small-leaved Privet, Prairie Grass and Lantana.

The most dominant weed species along the coastal tributaries of the Clarence River included Camphor Laurel (*Cinnamomum camphora*) as the dominant large tree layer, Small-leaved Privet, Broad-leaved Paspalum (*Paspalum mandiocanum*) and Wandering Trad (*Tradescantia fluminensis*) (Ryder, *et al*, 2014). Low diversity of native vegetation was observed in most lower tributaries, with many sites having little or no river-bank vegetation. Many of these species grow easily from seed or reproductive shoots which can be transported from further upstream and often form a dense monoculture which outcompetes native species.

Many of the major environmental weeds associated with the Clarence River are listed as priority weeds or Weeds of National Significance. A number of Landcare networks across the North Coast deploy on ground teams to carry out weed control, however, the number and extent of priority weed species in the region continues to increase (NCLLS, 2021a). Weed management resources are not adequate to address weed management priorities and favourable climatic conditions allow rapid establishment and reproduction of weeds.

Outbreaks of aquatic weeds are known to occur in several locations across the floodplain e.g. Alumy Creek. Problematic aquatic weeds include water hyacinth (*Eichhornia spp*.), Salvinia (*Salvinia molesta*), Parrots feather (*Myriophyllum aquaticum*). 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 MBO. Aquatic weeds can also cause damage to infrastructure such as fencing and pump assets and restrict the efficiency of floodplain drains.

**Plate 15: Cats claw creeper (*Dolichandra unguis-cati*) smothering riparian vegetation in the upper estuary (left) and aquatic weeds in Alumy Creek (right)**

Photo source: CRCC

### 6.7.6 Pest animal species

Pest animals can have a significant impact on threatened species and ecological communities, primary production and rural communities (NCLLS, 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.

Cane toads (*Rhinella marina*) are an invasive, poisonous, predatory, adaptive and competitive species that have contributed to the decline of a number of native species and are identified as a key threatening process under the *Biodiversity Conservation Act 201*6 and *Environment Protection and Biodiversity Conservation Act 1999*. The Clarence Valley is located at the southern 'frontline' of the cane toad invasion from the north. NCLLS, in association with NPWS, has engaged a number of Landcare networks, including Clarence Landcare, to deploy on ground teams to carry out cane toad control, data collection and education programs. Landcare also work with DPI to respond to reports of cane toads in areas where toads have not previously been detected. CVC does not have a formal role in cane toad management however some *ad hoc* voluntary collection occurs around STPs in the lower Clarence. Cane toads are a biosecurity priority for NPWS within

the lower Clarence. As such, NPWS engages contractors to actively control cane toads in and around NPWS estate in the lower Clarence including Everlasting Swamp and Yuraygir National Park

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. Carp, *Cyprinis carpio*). The introduced Mosquitofish (*Gambusia holbooki*) favours brackish waters found in the Clarence and Orara Rivers and is known to impact on ecosystem health through direct predation and competition with small native fish (National Parks and Wildlife Service, 2003b).

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

### 6.7.7 Riparian condition

A riparian zone is land alongside waterways and wetlands. These areas support diverse vegetation, protect against bank stability, support cleaner water, provide better habitat for wildlife and help to retain important nutrients and soil.

Rose *et al.* (2012) researched likely riparian vegetation on the floodplain prior to European colonisation using remote sensing, ground surveys and conceptual models to determine vegetation structure. The study reported the predicted extent of pre-European riparian forests (from the mouth of the Clarence River to beyond Grafton), floodplain vegetation structure and species composition and documented how the riparian zone is influenced by the natural meandering tendencies of the estuary.

The *Clarence Catchment Ecohealth Report* (Ryder *et al.* 2014) included a rapid assessment of riparian condition at selected sites throughout the catchment. Riparian condition scores were poor throughout the Clarence River catchment, with five of the seven major river systems scoring a “D+” (Appendix 5, Volume 2). The scores from the coastal tributaries downstream, adjacent to the estuary were very low, with Shark Creek and Swan Creek scoring an “F”. The main stresses were lack of riparian vegetation which contributes to poor bank condition, erosion, sediment deposition and benthic habitat smothering. The most significant impacts which reduce native vegetation recruitment and contribute to poor riparian condition are dominance of invasive weeds, disturbances for clearing and agriculture and livestock access (trampling and grazing).

The best riparian condition was recorded at the coastal tributaries, including Esk River (A) due to its location within Bundjalung National Park, Mangrove Creek (C+) and the Orara River (C). Previous studies and management plans (Ryder *et al.,* 2014; Umwelt, 2003; MHL, 2000) recommended that the active restoration of riparian revegetation be a priority in the Clarence River catchment to improve geomorphic condition, water quality and overall ecosystem health.

CVC’s *Riparian Action Strategy* (CVC, 2010b) was created to provide guidance around riparian management within the LGA. The strategy provides a descriptive site assessment template, which includes a Riparian Recovery Potential Table and a site assessment and condition index to be used to assess the condition of riparian zones and develop appropriate management strategies. The strategy has not yet been implemented.

### 6.7.8 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 28.

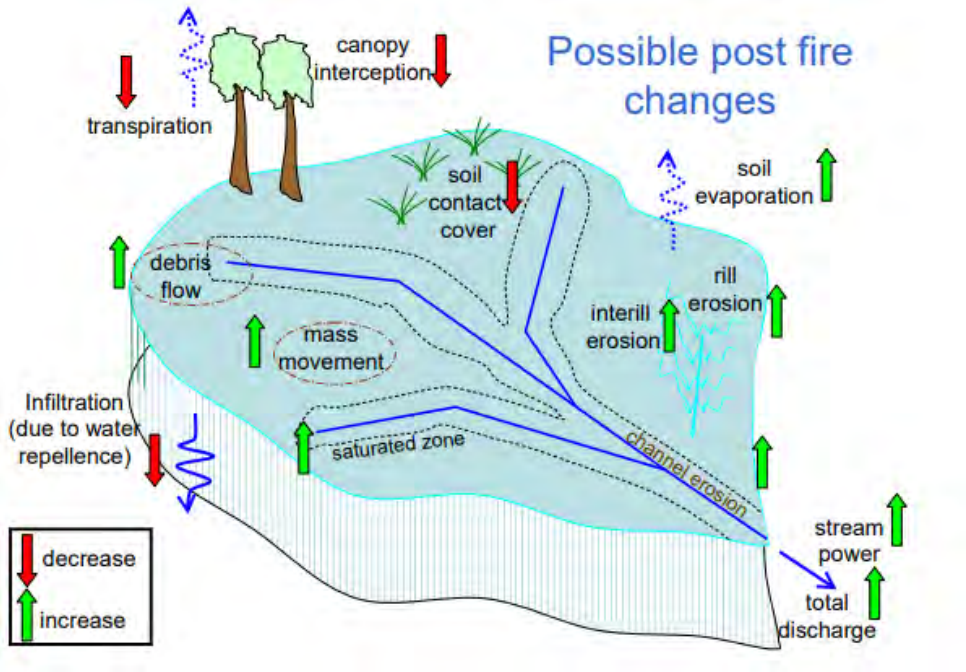



**Figure 28: Potential impacts resulting from changes in the landscape post-fire**

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 as dissolved oxygen levels drop (Lyon *et al*., 2008; DPI - Fisheries, 2021). Fire related fish kills were recorded in the Clarence following the 2019 bushfires (Smyth, 2020). 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 - Fisheries, 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 - Fisheries, 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 al*., 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.

Peat fires, which burn organic material underground for often long periods, are a particular risk to the estuary reach as they can occur in low lying swamp areas of the floodplain. A recent example is the Shark Creek peat fire of 2019 which caused the lower Clarence bushfire and was not fully extinguished until the March 2021 flood.

Cultural burning is used by First Nations people to improve the health of Country and its people. It has been used for over 60,000 years to manage land, plants and animals. There is increasing awareness of the important role it can play in the mitigating the effects of extreme bush fires caused by climate change.

Bushfire events in NSW are predicted to increase in frequency in the future while drought and rainfall events are forecast to become more extreme (Section 8.2) hence, the impacts of bushfires on aquatic ecosystems will become increasingly serious and responding to these threats is becoming more urgent.

## 6.8 Tidal inundation

The tidal influence within the Clarence River currently extends approximately 100 km to Copmanhurst. Inundation due to oceanic influences is concentrated in coastal regions. Astronomical tides are predictable, with spring tides occurring on a fortnightly basis and king tides over a few days during summer and a few nights in winter each year. Spring tides alone do not pose an existing issue, however during extreme king tides, the urban stormwater network allows penetration of tidal waters into the low-lying parts of Yamba leading to partial inundation of some roads by salt water. This relatively rare event is projected to become commonplace as sea level rise increases average tidal levels.

Storm surge is another phenomenon that threatens coastal urban areas. Storm surge is typically caused by a combination of factors which occur during adverse weather conditions where wind and wave setup combined with low atmospheric pressure results in temporarily increased local sea levels. This effect is most pronounced in coasts directly influenced by cyclones, however can also occur during intense East Coast Low events, which occur off the Northern NSW coast. Storm surge often occurs in combination with significant rainfall and associated local and catchment scale flooding. This combination of high tailwater levels and intense rainfall events can lead to significant stormwater inundation of low-lying land. Peak water levels can build over a sequence of high tides, where storm surge or flood water backed up by the first high tide is not cleared before the next high tide, thereby leading to an escalating sequence of flood peaks. The added influence of high tides and continued threat of sea level rise mean that tidal and storm surge inundation is a key consideration in the management of the Clarence River estuary. Whilst the configuration of the urban stormwater system does not cause high ocean water levels, the stormwater system in Yamba directly contributes to tidal inundation issues by allowing the intrusion of high water into low-lying areas.

The Federal government's online tidal inundation model, Coastal Risk Australia (2021) provides a visual indication of the places at risk from tidal inundation in the present day and at 2100 (example shown on

Figure 29). The mapping indicates that large areas of the study area may be at risk of tidal inundation, including the Clarence River floodplain and adjacent lands. This mapping is a coarse assessment that was completed across Australia to provide a broad overview of predicted tidal inundation risk and 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.

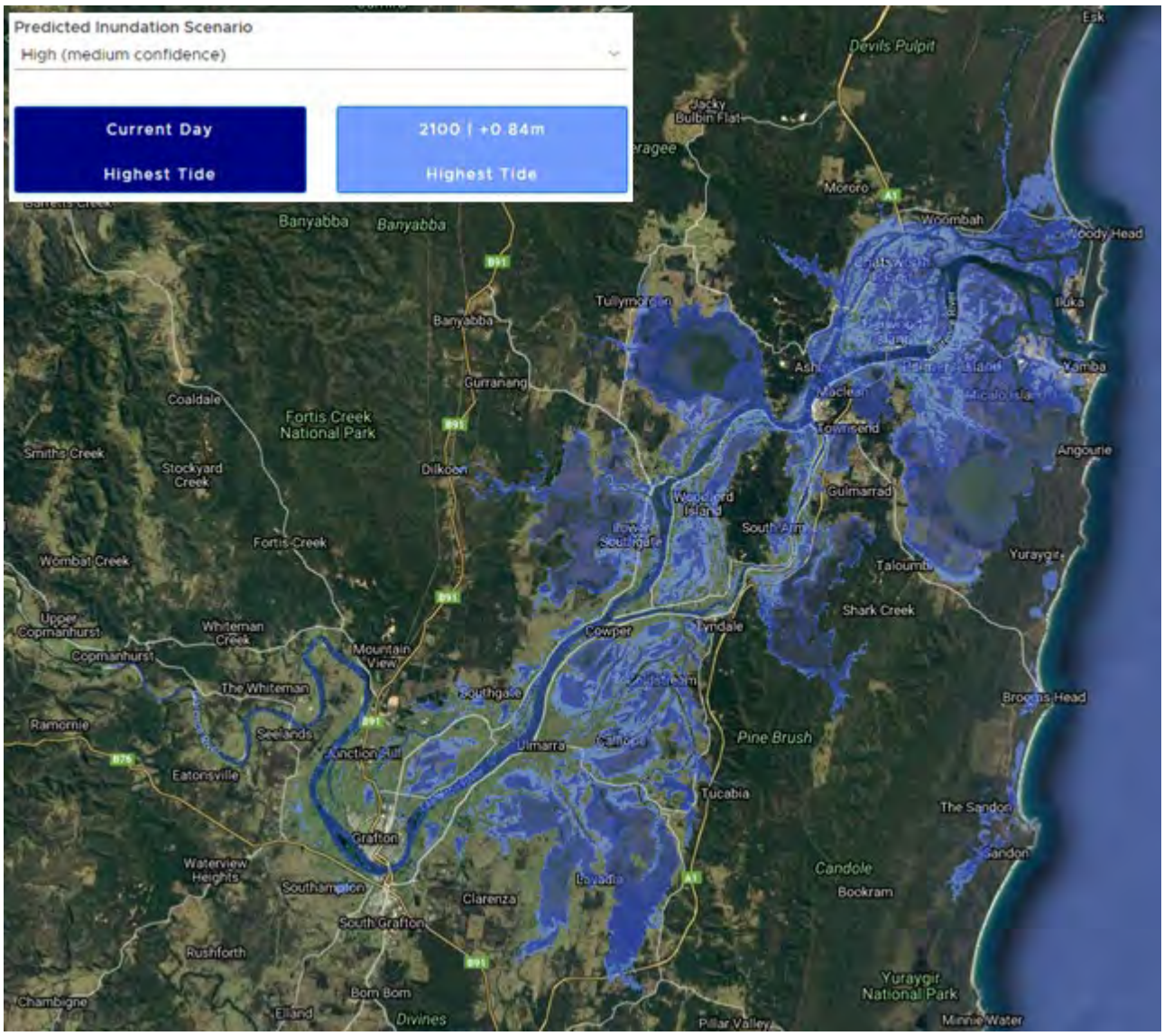



**Figure 29: First pass mapping of present-day and 2100 risk from tidal inundation**

Source: Coastal Risk Australia (2021)

# 7. SOCIO-ECONOMIC CONTEXT

## 7.1 Population and Demographics

Grafton is the main strategic centre of the Clarence Valley LGA and was a founding commercial centre on the North Coast. Other main population centres include Yamba and Maclean. Information on the communities making up the Clarence LGA has been analysed and reported from Census data by .id Consulting (2022). The estimated resident population of the LGA was 51,630 in 2016. The resident population is estimated to have increased by 1,480 people (0.57% p.a.) in the five years since the 2016 Census.

A summary of .id Consulting (2022) demographic information for the LGA is provided in Table 6. Aboriginal and Torres Strait Islanders made up 6.3% of the LGA population (3,217 people) in 2016. The most common ancestry is Australian and English. The LGA population is generally older than other regional areas with 33% 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.

**Table 6: Demographic data for Clarence LGA (2016 Census)**

| Indicator | CVC LGA | Regional NSW | NSW | Australia |
|---|---|---|---|---|
| Median age | 49 | 43 | 38 | 38 |
| Aboriginal and Torres Strait Islander population | 6.3% | 5.5% | 2.9% | 2.8% |
| Overseas born residents | 8% | 11% | 28% | 26% |
| Medium and high-density housing | 12% | 17% | 33% | 27% |
| Median weekly household income | $915 | $1,166 | $1,481 | $1,431 |
| Median weekly rent | $265 | $278 | $384 | $339 |
| Unemployment rate | 9.0% | 6.6% | 6.3% | 6.9% |
| Language at home other than English | 2% | 6% | 25% | 21% |
| SEIFA index of disadvantage[1] | 926 | 971 | 1,001 | 1,002 |

Source: Data sourced from .id Consulting (2022)

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.

## 7.2 Agriculture

Agriculture is a major driver of the local economy, employing approximately 6.1% of the working population within the Clarence Valley LGA, contributing over $119 million to the economy in 2016. Local forms of agriculture include cattle and livestock grazing, sugar cane cropping and dairy (Section 6.6). Blueberries, avocados and bananas are grown throughout the catchment and contribute nearly 5% of the Clarence Valley agricultural production (.id Consulting, 2022).

**Plate 16: Cattle and sugar cane farming**

The *Clarence Valley Regional Economic Development Strategy 2018 – 2022* (CVC, 2018) identified agriculture as an 'engine of growth'. Agricultural is highly valued by the community, with significant support for CVC to encourage and promote and regulate sustainable and innovative agricultural practices (CVC, 2017). The economy in the valley is closely associated with agricultural production activity, supported by arable soils and suitable climate. The *Clarence 2027 Community Strategic Plan* (CVC, 2017) identified that the agricultural industry had the fastest growth of any other comparable industry between 2011 – 2016, with more need for significant expansion. CVC's *Local Strategic Planning Statement* (CVC, 2020f) has a clear intent to "Protect agricultural land and increase opportunities for access to locally produced fresh food and economic growth" (Priority 13). CVC has planned expansions of strategic agricultural areas upstream from Grafton, with more interest in blueberries, fruit trees, tree nuts and beef. This would require increased water supply and supportive partnerships with other industries to meet these needs (CVC, 2018).

## 7.3 Fishing and Aquaculture

The Clarence River estuary has regionally important commercial and recreational fisheries and supports the largest estuary-based fishery in NSW (Creighton, 2013). 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, 2017a; DPI - Fisheries, 2017b).

a. Maclean boat ramp

b. Trawlers at Yamba marina

c. Fishing at Iluka

**Plate 17: Boating and fishing are popular activities in the Clarence River estuary**

Photo source: c. CVC

Recreational fishing is a popular lifestyle choice for residents and visitors which contributes to the tourism economy of the Clarence Valley (Umwelt, 2003). 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.,* 1985).

Commercial fishers target a wide range of species in particular mullet, whiting, luderick, yellowfin bream, blue swimmer crab, mud crab and dusky flathead (Harrison, 2010) and there has been an increase in fishing for octopus, lobster, cuttlefish, squid and bugs. Commercial fishing is an important economic activity in the lower reaches of the estuary and ocean (outside the study area) and fishery sustainability is influenced by catchment health. Management of commercial fisheries is discussed in Section 9.7.

DPI - Fisheries advised that as of March 2022 there were 116 commercial fishing businesses that hold one or more endorsements authorising the taking of fish for sale from the Clarence River. The total number of endorsements of each kind held by these 116 fishing businesses is shown in Table 7. An endorsement authorises the holder (a licensed fisher) to undertake particular fishing activities (in specified waters and subject to relevant laws etc.). The average number of days fishing per year over the last three years (2018/19 to 2020/21) by all fishers in each of these sectors is also shown in Table 7.

**Table 7: Commercial fishing endorsements and effort**

| Sector | Number of endorsements | Fishing effort (number of days) |
|---|---|---|
| Clarence River estuary prawn trawl | 48 | 2,660 |
| Handlining | 29 | 67 |
| Meshing | 61 | 2,140 |
| Prawning | 47 | 331 |
| Category 1 hauling | 21 | 218 |
| Category 2 hauling | 13 | 3 |
| Mud crab trapping | 19 | 1,091 |
| Trapping | 10 | 142 |
| Eel trapping | 17 | 26 |
| Hand gathering | 1 | 93 |

Some species are now subject to quota including the periodic setting of a total allowable catch (TAC) for the species concerned and allocation of the TAC amongst relevant shareholders as quota. Similarly, some fishing activities are now subject to effort quota. This includes the periodic setting of a total allowable effort (TAE) for relevant activities and allocation of the TAE amongst relevant shareholders as quota. Where these types of quota apply, the number of fishers undertaking the activity is largely irrelevant for stock-sustainability purposes.

The estuary prawn trawl fishery uses trawl nets to target school prawns and eastern king prawns in three estuaries in NSW (the Clarence, Hawkesbury and Hunter Rivers) with school prawns comprising the majority of the total fishery catch (DPI, undated). Estuary prawn trawling occurs throughout much of the lower to mid Clarence River estuary however is only permitted to occur between October and May in Wooloweyah Lagoon and December to May in the remainder of the Clarence River fishery. Trawlers may work all waters of Wooloweyah Lagoon (i.e. there are no legislated spatial restrictions), however there are many areas of the Lagoon that cannot be accessed due to the shallow depth of the Lake (pers. comm, Darren Hayle, DPI - Fisheries). Estuary prawn trawling is prohibited upstream of Ulmarra, Sportsmans Creek, the Broadwater, Esk River, Yamba Bay, Crystal Bay and most of Oyster Channel.

There are currently 48 endorsements for prawn trawling in the Clarence River (Table 7). Prior to recent industry reforms (known as the Commercial Fisheries Business Adjustment Program) there were approximately 110 fishing businesses endorsed to trawl for prawns in the Clarence River estuary. Anecdotally, approximately 20 years ago it was not unusual to see up to 50 - 60 trawlers on the lagoon on the first day of the season. Of those authorised to operate in the lagoon, 29 reported trawling for prawns in Wooloweyah Lagoon during the 2019/2020 season.

The estuary general fishery targets a wide range of species including fish and crab species. On average across NSW, the 10 species that make up over 80% of landings by weight are Sea mullet (*Mugil cephalus*) 40%, Luderick (*Girella tricuspidata*) 8%, Yellowfin bream (*Acanthopagrus australis*) 8%, School prawn (*Metapenaeus macleayi*) 5%, Blue swimmer crab (*Portunus pelagicus*) 4%, Dusky flathead (*Platycephalus*

*fuscus*) 4%, Sand whiting (*Sillago ciliata*) 3%, Pipi (*Donax deltoides*) 3%, Mud crab (*Scylla serrata*) 3% and Silver biddy (*Gerres subfasciatus*) 2% (DPI, 2017b). Methods include handlining, meshing, various prawning methods, fish trapping, crab and eel trapping, hauling and hand gathering (cuttlefish and mussels).

Estuary general fishery activities occur in the Clarence River estuary, Broadwater, Sportsman Creek, Shark Creek, Coldstream River, Orara River and Wooloweyah Lagoon. In Wooloweyah Lagoon, during 2019/2020, 24 commercial fishing businesses reported using fishing methods other than estuary prawn trawling.

DPI – Fisheries also provided information on recent commercial fishing catches within the Clarence River estuary. The average weight and value of the top 15 species caught per year over the last three years (2018/19 to 2020/21) from the Clarence River are shown in Table 8. These values are at the first point of sale and determined using average monthly sale prices supplied by the Sydney Fish Market, however, local sales may yield higher or lower sale prices.

**Table 8: Clarence River commercial fishing catches (2019/19 - 2020/21)**

| Species | Average weight (tonnes) | Average value ($) |
|---|---|---|
| Sea Mullet | 438.3 | 1,753,160 |
| School Prawn | 301.1 | 3,381,982 |
| Yellowfin Bream | 33.3 | 440,547 |
| Forktail Catfishes | 26.7 | 89,566 |
| Mud Crab | 19.0 | 729,202 |
| Luderick | 9.2 | 20,185 |
| Sand Whiting | 8.3 | 136,035 |
| Mulloway | 7.4 | 82,737 |
| Dusky Flathead | 7.3 | 82,416 |
| Common Pike Eel | 5.7 | 62,129 |
| Bull Shark | 2.6 | 5,727 |
| King Prawn | 1.8 | 47,685 |
| Longfin Eel | 1.7 | 7,537 |
| Sand Mullet | 1.5 | 3,369 |
| Black Bream | 0.9 | 1,1379 |
| Total | 864.8 | 6,853,656 |

The NSW oyster industry is the largest aquaculture industry in NSW worth $59 million in 2018/2019 (NSW DPI, 2020b). The *NSW Oyster Industry Sustainable Aquaculture Strategy* (DPI, 2016) identifies areas within NSW estuaries where oyster aquaculture is a suitable and priority outcome, known as Priority Oyster Aquaculture Areas (POAA). Within the study area, POAAs are located south of Hickey Island, at the mouth of the Clarence River estuary (2.74ha) (DPI, 2016).

Land-based aquaculture activities within the study area are around the lower and upper estuary and Wooloweyah Lagoon catchment. Several areas of land-based saline pond aquaculture are situated on

Palmers Island, Goodwood Island and the Whiteman. The dominant species farmed is Black Tiger Prawns (*Penaeus monodon*). In total, aquaculture added $8.52 million dollars to the local economy in 2019/2020 (.id Consulting, 2022).

## 7.4 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. There are many national parks with campgrounds throughout the whole study area, with popular locations in Nymboida National Park, Gibraltar Range National Park and Bundjalung National Park. Tourism and recreation are also major economic drivers for the North Coast Region. Tourism has been identified as an 'engine of growth' in the LGA, with flow on revenue contributing to 13 - 16% of wages, jobs and output (CVC, 2018). Annual tourism statistics show there were 1.2 million tourists visiting the LGA in 2019, adding $353 million dollars of revenue (Tourism Research Australia, 2019).

## 7.5 Other Industry

The forestry industry which includes logging activities, sawmilling and production of wood products has also been identified as one of CVC's 'engines of growth' (CVC, 2018). Forestry is one of the primary land uses in the upper catchment and occurs on both State forests and private lands (CVC, 2010a; Ryder *et al.,* 2014). The forestry industry employs approximately 11% of the local workforce, adding approximately $37 million in revenue during 2019/2020 (.id Consulting, 2022).

The mouth of the Clarence supports a marine industry which services the Northern Rivers and New England regions. The marine industry has been identified as an 'engine of growth' as it supports fishing, aquaculture, seafood, sugar cane, passenger and port transport services (CVC, 2018). The Port of Yamba has import and export facilities and hosts the second-largest fishing fleet in NSW. A wide range of marine facilities are located around the lower estuary, including shipbuilding and ship repair facilities, marinas, slipways, hardstands and boat storage facilities. There have been significant proposals to enhance the marine industry in the Clarence, namely the Harwood Marine Precinct and the Yamba Cruise Terminal.

Currently, there are eight companies which hold licences to carry out mining exploration in the Clarence Valley, however only three of those companies are currently active. Previously gold, copper, coal, sand, asbestos and stone has been mined throughout the Clarence Valley. During recent mining explorations, copper and cobalt were recorded at Gordonbrook Hill northwest of Grafton. All prospecting and mining activities in NSW must be carried out under an approved title granted under the *Mining Act 1992*. A 'Title' refers to all exploration and mining authorities, authorisations, tenements, licenses, leases, and claims. An approved title gives the holder the right to conduct exploration or mining activities within that area according to the conditions defined in the Act for each title type. Community groups have raised concern over current mining activities and Exploratory Mining Licences in the catchment. The community groups have a strong social media presence and petitions have reached over 10,000 signatures indicating significant community opposition to mining activities. The community is predominately concerned with protecting environmental, cultural and economic values of the area. There is concern around the potential for water pollution from mine tailings which would impact agricultural water users, tourism and the greater environment. The draft Rural Lands Strategy (Localé Consulting, 2022b) also recognises the impacts of mining on agricultural activities and includes a recommendation to lobby government to remove existing, and prohibit new, mining or exploratory licences.

# 8. FUTURE CONTEXT

## 8.1 Population Growth and Land Development

The LGA population is forecast to increase to 60,735 people by 2041 an increase of 9,105 people since the 2016 census (0.7% p.a., .id Consulting, 2022). Urban development and population growth is concentrated around existing larger centres, particularly in areas known to be safe from natural hazards and which contribute to the character of the LGA (CVC, 2020f). Clarenza, Junction Hill, James Creek, and West Yamba have been identified as 'urban growth areas' in the *North Coast Regional Plan 2036* (NSW Government, 2017) and have been rezoned in preparation for future development. If all available zoned land is developed in CVC, this could accommodate an additional 16,000 people (CVC, 2020e):

- The Clarenza Urban Release Area includes 130 ha of rezoned land located 4 km east of Grafton and approximately 860 m to the south-east of the Clarence River. The development has the potential to support approximately 750 lots and 2,000 new residents (CVC, 2011b).
- West Yamba Urban Release Area is 127 ha, with the capacity for 1,140 lots to be developed. The proposed development would accommodate 2,600 people. The area is located 4 km west from Yamba town centre, 260 m east of Oyster Channel and 410 m south of the Clarence River (GHD, 2020a).
- Junction Hill is a satellite village 6 km north of Grafton. Approximately 170 ha of land was rezoned to accommodate 500 new lots, which could support up to 1,200 people (Newplan, 2011). The proposed development footprint is approximately 100 m to the east of the Clarence River.
- 102 ha of land was identified as the James Creek Urban Growth Area and rezoned to accommodate expansion in the area. The area is 15 km west of Yamba and has the potential to support between 800 - 1,500 dwellings or 2,000 - 3,900 people (GHD, 2020b). The proposed development footprint is approximately 1.5 km south of the Clarence River.

Gulmarrad Urban Release Area is a 44 ha site identified in the Clarence Valley LEP 2011 which is zoned as General Residential. The site is the subject of a development application for a manufactured home estate.

The remaining growth is expected to largely occur in the existing urban growth centres and rural areas of the shire.

Concerns have been expressed amongst community members about the impacts of urban development including stormwater runoff, traffic and the increased risk of flooding.

## 8.2 Climate Change

The Clarence River estuary and catchment will experience broadscale climate change impacts as well as 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 have been specified in many sources (CVC, 2021f; DPIE, 2021a; MEMA, 2017; Risk Frontiers, 2021a). The *Draft Regional Water Strategy - North Coast Strategy* (DPIE, 2021a) outlines actions which have considered implications of climate change around water resilience. Modelling summarised in the strategy predicts climate change may increase the average number of days per year that cease-to-take conditions on town water licences are activated. Risks to water quality may result from changes to climatic influences by creating favourable environments for algal blooms or reducing effectiveness of floodgates and drains. Unregulated water systems may experience impacts on water habitats, water quality and reduced connectivity throughout the river system. Pressure from irrigation demand would also likely compound these impacts, which can lead to detrimental risks to broader floodplain health (DPIE, 2021a).

*The CVC Community Energy and Emissions Reduction Strategy* (100% Renewables, 2021) was developed following the targets set by CVC of:

- Reducing greenhouse gas emissions (excluding landfill) by 40% by 2030 compared with 2016/17 levels, with the long-term goal to reach zero net emissions by 2050.
- Supplying 50% of CVC's electricity demand from renewable energy by 2030, with the long-term goal to source all electricity from renewable energy.

CVC is implementing actions in the strategy to begin reducing emissions in nine identified abatement areas within the LGA.

The draft *Rural Lands Strategy* (Localé Consulting, 2022b) also recognises the impacts of climate change on rural land management and includes recommendations relating to planning for impacts of climate change.

## 8.3 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, 2020a). Based on these changes it is expected that sea level rise will result in changes to the Clarence coastal zone including:

- Increased tidal propagation 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 Shark Creek (and potentially others) and increase in the short-term release of acidity and trace metals (aluminium, iron, nickel and zinc) (Wong *et al*., 2010). This is likely to result in rapid, substantial, short-term declines in water quality in backswamp basins containing CLASS following seawater inundation. However, prolonged seawater inundation will eventually lead to reductive processes causing acidity to decrease and pH to increase, resulting in precipitation of Fe and Al hydroxides. 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*., 2010). High hydraulic conductivity in the sulfuric horizons is found in some of the CLASS floodplains within the Clarence River catchment including near Shark Creek (Johnston *et al.*, 2003a) 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.

**Plate 18: Many parts of the estuary are vulnerable to tidal inundation, particularly with sea level rise**

Risk Frontiers (2021b) analysed coastal flood and sea level rise data and highlighted the number of properties likely to be impacted by sea level rise and coastal floods within the Clarence Valley. The most concentrated impacts occur between Yamba to Angourie for present day risk and Iluka to Woody Head having the largest number of properties at high risk with increased coastal flood and sea levels. CVC (2019c) adopted sea level rise benchmarks for 2050 (40 cm rise) and 2100 (90 cm rise) and have committed to introducing strategies to mitigate impacts and develop resilience to the effects of climate change.

The Harrison *et al.* (2021a) floodplain prioritisation study assessed the sensitivity of the estuary to sea level rise conditions. Hydrodynamic modelling used historical (1960s), near future (2050) and far future (2100) sea level rise as well as floodgate infrastructure geometry and floodplain topography to determine floodplain vulnerability with sea level rise (Figure 30). Based on the modelling, the sub-catchments likely to be impacted the most significantly were Sportsman Creek sub catchment, Taloumbi/Palmers Channel sub-catchment and Shark Creek sub-catchment.

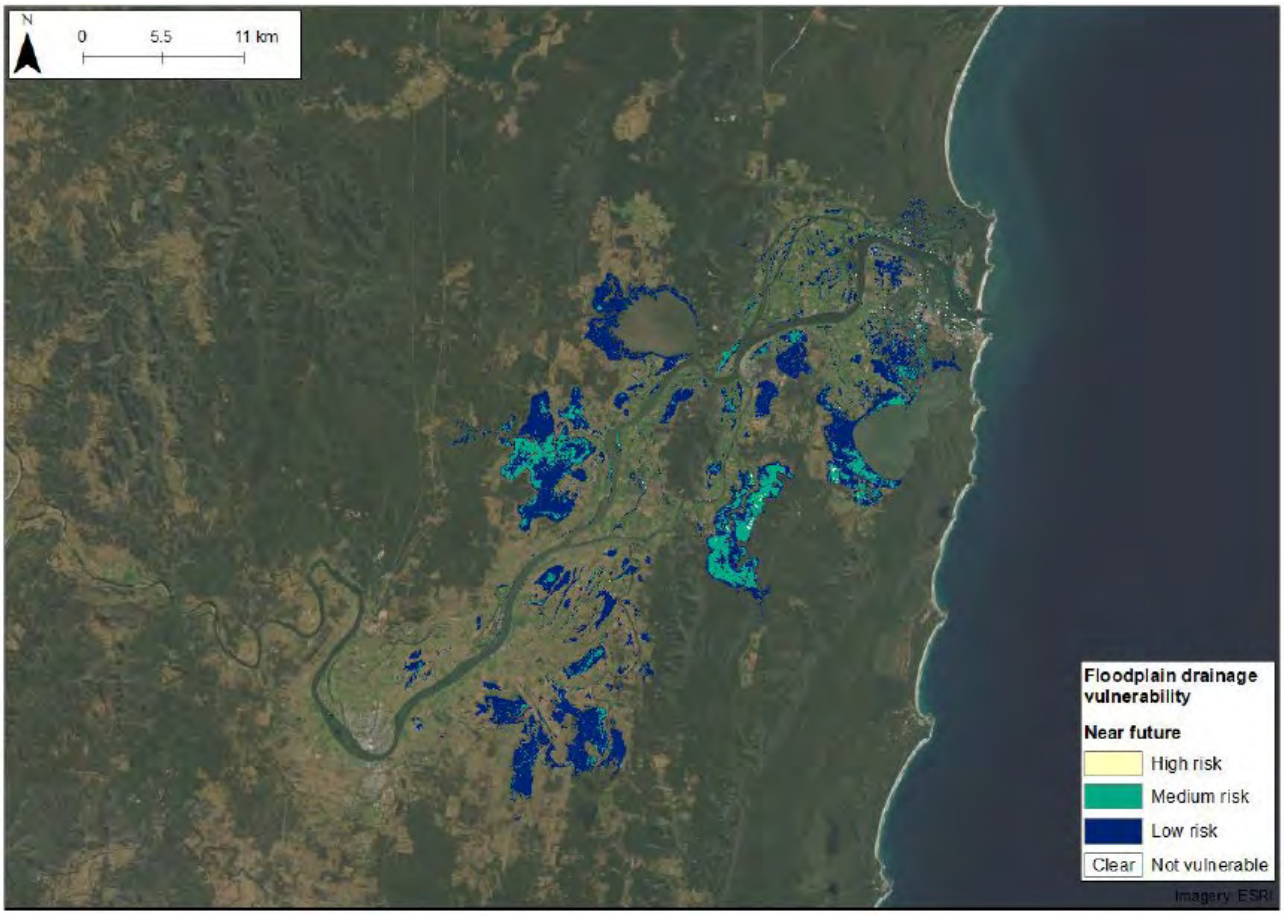



**Figure 30: Clarence River floodplain vulnerability with sea level rise (near future ~ 2050)**

Source: Harrison *et al*., (2021a)

Waddington *et al.* (2021) introduces the concept of the drainage window to quantify how much drainage time is available to different catchments within an estuary and to identify the potential impact of sea level rise on the drainage of estuarine floodplains. The drainage window was analysed for the Clarence River estuary with the results indicating that sea level rise may substantially reduce the available drainage time (Figure 31).

Areas with less time to drain are more susceptible to chronic problems associated with prolonged inundation and waterlogging that may necessitate changes to existing land uses.

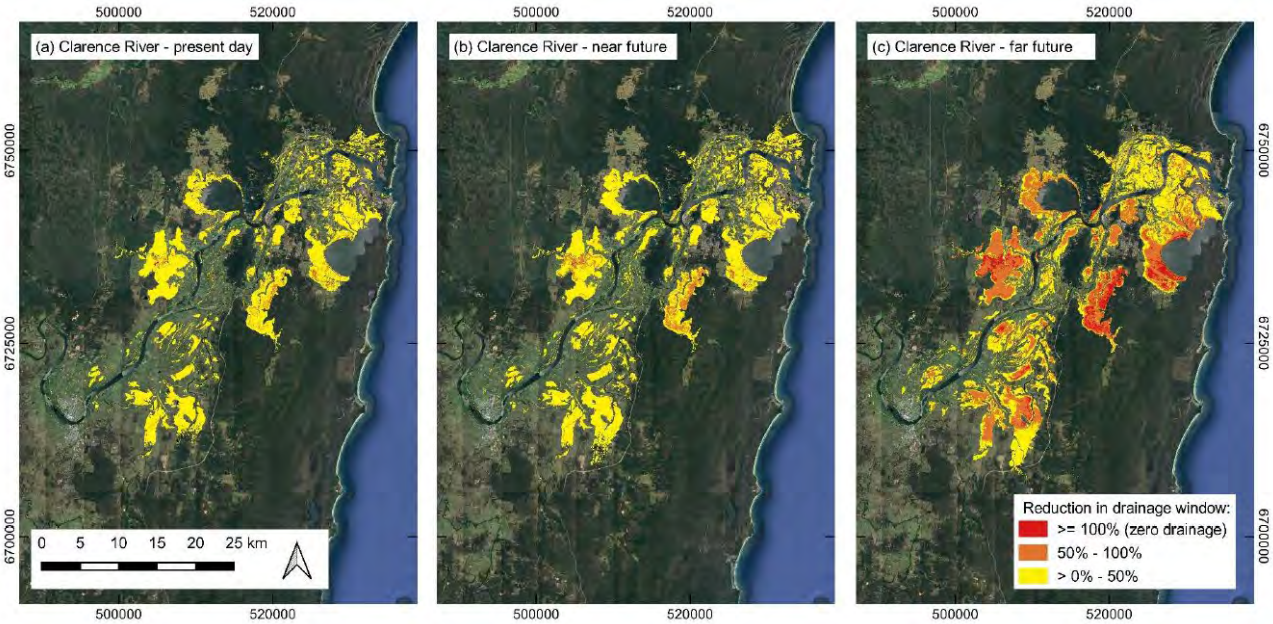



**Figure 31: Extent of estuarine floodplain impacted by limited drainage in the Clarence River**

Near future +0.16m at 2050. Far future +0.67m at 2100 relative to 2020 present day.
Source: Waddington *et al.* (2021)

## 8.4 Rainfall Patterns

Extreme rainfall events are associated with storms and flooding. Rainfall extremes in NSW are projected to increase in future (AdaptNSW, 2019a). 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. Climate modelling undertaken for the development of regional water strategies (DPIE, 2021a) has found that droughts may be more severe in 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 in the cool season with little change in these storms during the warm season. However extreme east coast lows in the warmer months may increase in number but extreme lows in cool seasons may not change (AdaptNSW, 2019b). The severity and frequency of flood-producing rainfall events, such as east coast lows 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.

## 8.5 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. Agricultural activities 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, 2021a).

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

The reduced rainfall will result in lower stream flows, particularly in winter months for most of the catchment. This might reduce the number of events which trigger fish movement and spawning, and also may reduce the larger tributary flows that stimulated riverine productivity for 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, 2021a).

## 8.6 Migration of Estuarine Vegetation

Sea level rise will lead to increased water levels and tidal propagation in estuaries. 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 saltmarsh 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. Coastal squeeze occurs when ecosystems are unable to migrate due to physical barriers (i.e. floodgates and levees) in response to sea level rise. 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 upper 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*. (2011) 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 DPI – Fisheries Marine Vegetation Strategy is a state-wide program currently underway as part of the MEMS to develop estuary specific plans to manage estuarine vegetation. The strategies aim to provide scientific evidence to support and guide the protection of existing and potential future coastal wetlands. The strategy for the Clarence 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 Marine Vegetation Strategies 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 to direct rehabilitation projects to the most meaningful locations given the biophysical conditions, anthropogenic exposure and the future wetland trajectory with sea level rise.

As part of the strategy a new method and dataset has been developed by Hughes *et al* (undated). The method is used to predict the future spatial distribution of mangroves and saltmarsh in NSW estuaries for three sea level rise scenarios. The method uses machine learning to develop a statistical model of the present-day landscape using a combination of response and predictor variables. The response variables were defined by using the mapping of intertidal mangroves and saltmarsh wetlands, high resolution imagery and object-based image analysis and field validation to model the present-day distribution of these variables and provide a guide to where saltmarsh and mangroves might occur in future landscapes. Three sets of predictions were prepared for each of the three sea level rise scenarios based on potential land use constraints. An example for the Clarence River estuary is presented in Figure 32.

The study used a measure of the error in the predictions to determine accuracy similar to the Pearson correlation co-efficient called the Matthews Correlation Co-efficient (MCC). For the Clarence River catchment mangrove prediction had an MCC of 0.41 whilst saltmarsh had an MCC of 0.29, representing moderate correlation and weak correlation respectively. The study offers several caveats regarding the various errors in the datasets and recommends a moderate level of caution when using the dataset to inform decision making for future sea-level rise impacts. It is intended as a regional scale guide where more detailed higher resolution datasets would improve the predictions.

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 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 the western areas of Yamba, creates risks for the estuary in terms of managing urban drainage and sewerage infrastructure.

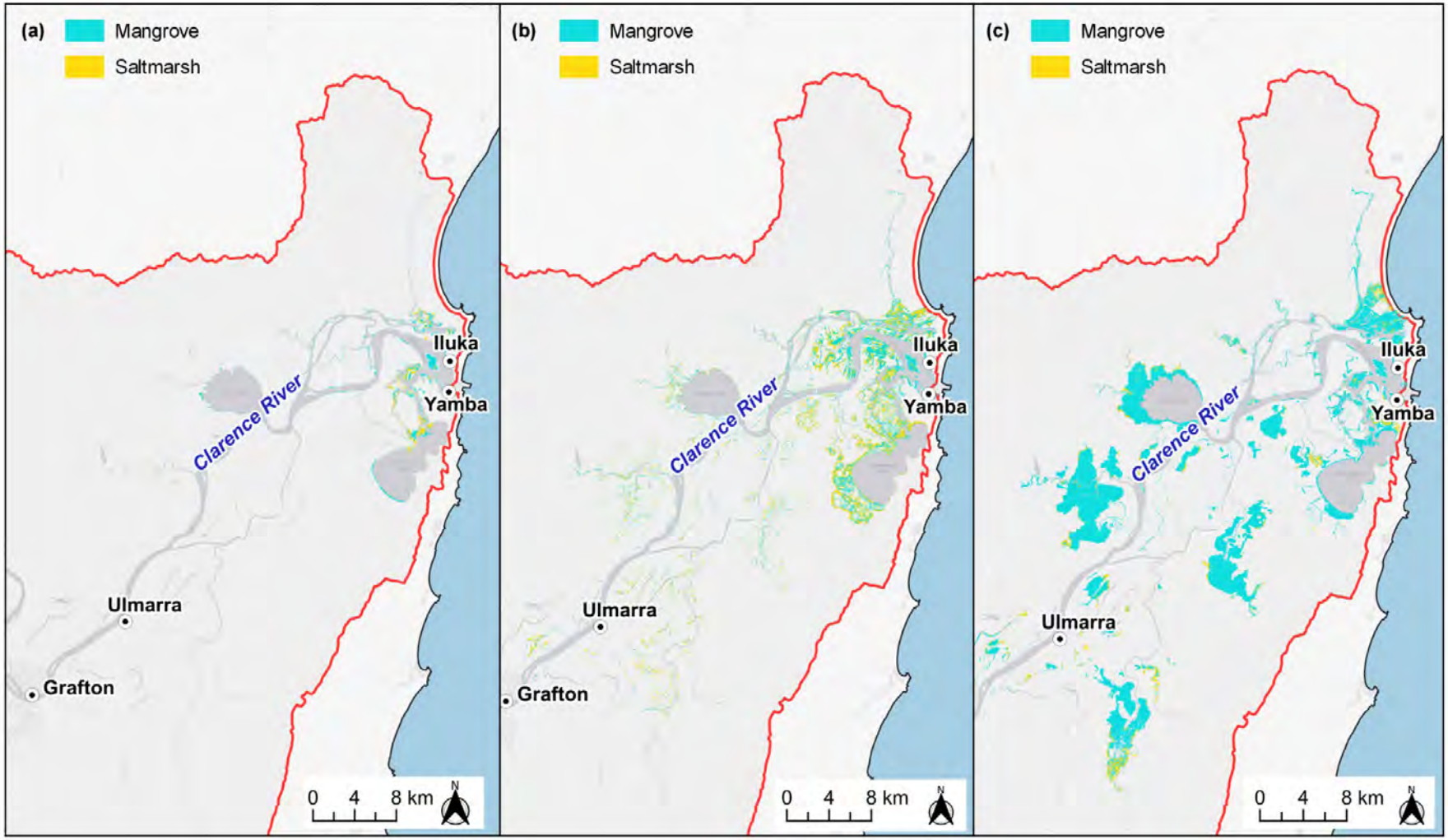



**Figure 32: Current and predicted mangrove and saltmarsh distribution**

(a) mangroves and saltmarsh mapped in the DPI - Fisheries layer 'Estuarine macrophytes of NSW (2010)' which was used as a surrogate for calculating the modelled present-day extent; (b) predicted present-day extent with no land use constraints other than exclusion from urban areas; (c) prediction with +1.0m sea level rise constrained by natural landcover and low intensity land uses.
Source: Mapping data sourced from Hughes *et al.* (undated)

## 8.7 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, 2010b). 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 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, mainly in summer and spring, with the largest increases by 2070 to occur in spring (Adapt NSW, 2019c).

## 8.8 Potential Land Use Adaptation

*The North Coast Regional Plan 2036* (NSW Government, 2017) outlines directions for councils to follow for sustainable management of natural resources, environmental conservation, urban growth and protection and enhancement of agricultural lands. As discussed in Section 7.2, some agricultural lands (particularly sugar cane and cattle grazing) are converting to emerging industries, including tree nuts and fruit trees throughout the catchment but the relative impact of these land uses on floodplain health have not been determined. A solar farm has also been proposed within the catchment, which would change 340 ha of agricultural and grazing land into a 280 ha solar farm. The *Rural Lands Strategy* (Localé Consulting, 2022b) builds on from the state-wide plan to provide guidance on a balanced approach to management of agricultural land, growing the rural land economy, implementing a sustainable long-term approach, strengthening existing networks and supporting structures and providing a consistent planning framework.

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. A multi-criteria approach was used to assess the environmental outcomes associated with land use transition and 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. 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.

Gaston *et al.* (2021) defines habitat-fishery linkages and provides strategic priorities for repair of habitat in combination with enhancement of tidal flows and resulting increases in tidal habitat in Wooloweyah Lagoon and associated tidal channels and wetlands. Hydrodynamic modelling and eco-hydrological outcome assessment identified a very large potential for intertidal wetland creation via modification of drainage works

around Wooloweyah Lagoon. Gaston *et al.* (2021) noted that the extensive network of drains and agricultural land uses throughout former freshwater wetland areas and Clarence River entrance training works along with sea level rise have contributed to a modified baseline condition for wetland establishment. The eco-hydrological assessment revealed that tidal introduction into currently drained low-lying land areas could achieve large gains in the current combined extent of saltmarsh and mangrove ecosystems. However, any on-ground restoration works need to consider freshwater inflows as well as future sea level rise. The study found that the Wooloweyah Lagoon and Clarence River prawn fishery would gain value through increased landings by rehabilitating saltmarsh, mangrove and seagrass communities but notes that seagrass rehabilitation is complex and often costly, therefore recommends that any rehabilitation efforts focus on saltmarshes in the area. Cost-benefit analyses of rehabilitation projects are required to quantify the future benefit of these projects to commercial fisheries and the broader economy including formal compensation for the purchase/ loss of any farmland that would result from hydrological modifications. The study also recommends follow-on projects for the broader Clarence River estuary that also account for additional co-benefits such as biodiversity, blue carbon (Section 8.9) and water quality improvement to value these habitats more comprehensively to provide further incentives to rehabilitate these environments.

Industry groups, councils and state government agencies provide assistance through education, advice and grants around changes to agricultural land uses to improve environmental outcomes. 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. DPE – E&H is currently investigating private landholder incentives for restoration of former freshwater wetlands and exploring possible funding for restoration outcomes and subsequent ongoing conservation.

## 8.9 Blue Carbon

Blue carbon is the term used to describe the carbon which is captured by oceans and coastal ecosystems, such as intertidal wetlands and supratidal forests (saltmarsh, seagrass meadows, mangrove forests) (Rayner *et al.,* 2021). Sequestration of blue carbon in mangrove forests, salt marshes and seagrass meadows is an important benefit of coastal wetlands. Seagrass, mangroves and salt marsh are known to sequester more carbon than other vegetation types. These ecosystems sequester carbon from the atmosphere at extremely high rates, in certain instances nearly four times that of terrestrial ecosystems (WRL, 2021). Restoring the coastal wetlands of the region poses a potentially substantial role in CVC achieving net zero emissions in accordance with the *CVC Community Energy and Emissions Reduction Strategy* (100% Renewables, 2021).

Since European colonisation there has been a reduction in available blue carbon ecosystems around Australia, mostly attributed to the conversion of coastal wetlands into arable land via floodplain drainage networks. The resultant environmental impacts include acidic water and black water generation and 'coastal squeeze' (Section 8.6). Saltmarshes are particularly vulnerable to the impacts of coastal squeeze. Australia, and in particular NSW, is considered highly favourable for large-scale blue carbon ecosystem restoration due to legislative and geographic conditions. Introducing or re-establishing tidal flushing and inundation in suitable low-lying coastal areas would reduce impacts of sea level rise (Sadat-Noori *et al.* 2021). Blue carbon initiatives create socio-economic benefits, enhance biological and ecological productivity of the marine estate

and create economic incentives for landholders to change land management practices or land use to cater for climate change and sea level rise. Australia's Emission Reduction Fund developed a *Blue Carbon Method* which supports projects which introduce or re-establish tidal flows back onto modified floodplains. The *Blue Carbon Method* also supports the removal or modification of infrastructure which restricts tidal flow, subsequently supporting re-establishment of coastal wetland ecosystems (Clean Energy Regulator, 2022). The aim of these projects is to increase the blue carbon being stored. When a landholder implements a Blue Carbon Method project, they will be eligible to receive Australian Carbon Credit Units which can then be sold or traded to the Australian Government or private companies for a profit (WRL, 2021).

# 9. MANAGEMENT CONTEXT

## 9.1 Coast and Estuary Management Plans

CVC prepared the Clarence River EMP (Umwelt, 2003) and the CZMP for Wooloweyah Lagoon (White, 2009a) in accordance with the NSW Government's former coast and estuary management framework. Both plans were adopted by Council. The CZMP for Wooloweyah Lagoon was certified by the NSW Government. These plans will be replaced by the CMP for the Clarence River Estuary. Various other management plans were prepared for parts of the Clarence River estuary by NSW Government agencies (refer Appendix 1, Volume 2).

The management actions recommended within the current plans are summarised in Appendix 3 (Volume 2) with the current status of each action. Not all management actions have been completed since the adoption of the plans. Some additional actions have been implemented under related programs, which although were not explicit actions within the CZMPs, contribute to overall catchment and waterway health. In addition, MEMA has undertaken studies relating to the Clarence River and its catchment.

The task of improving the health of the Clarence River continues to be substantial, complex and multi-faceted and the difficulties in implementing the actions reflect these complexities. The key challenge for the CMP will be to identify and implement targeted on-ground works that will result in improvements in estuary health. While CVC is working with agencies, community groups such as Landcare and some private landholders to implement restoration works, these projects rely on limited internal and external funding, are generally small scale, do not necessarily target priority areas and are limited to areas where landowners are engaged and are willing to complete works on their land. In addition, while some studies identify priority actions, there is a lack of detail on the steps required for successful implementation including funding.

A key gap in the existing investment and studies to date appears to be consultation with affected landholders and the development of mechanisms to ensure acceptance and successful implementation of identified priority actions. A significant challenge in implementing any on-ground change in rural farmland is landowner willingness. Actions within the CMP relating to native vegetation, riparian zones and backswamps may have a negative impact on the agriculture that occurs there or may be too costly for landowners to implement or maintain. There is currently no regulatory mechanism to require landowners to undertake any of these actions although many agencies are working with landowners including providing funding incentives.

The current CMP process represents an opportunity to develop a more manageable suite of coastal management actions across the catchment with a focus on strategic on-ground actions that are rationalised and prioritised. The CMP represents an opportunity to improve the funding and resources available for coastal management through the NSW Coastal and Estuary Grants Program, the IP&R Framework and other available funding and grant programs. The draft *Rural Lands Strategy* (Localé Consulting, 2022b) includes a recommendation to establish a Sustainable Agricultural Officer within CVC which will assist with delivery of sustainable agriculture programs.

## 9.2 Coastal Management Areas

The CUA, CEA and CWLRA within the study area have been mapped as part of Chapter 2 (Coastal Management) of the *Resilience and Hazards SEPP* and are presented in Figure 2. Mapping is currently not available for the CVA. 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.

The Coastal *Management Act 2016* definitions and objectives of the coastal management areas are discussed in Appendix 2 (Volume 2). The management of these areas is discussed in the following sections.

### 9.2.1 Coastal wetlands and littoral rainforests

The CWLRA supports high value biodiversity that is particularly sensitive to development. This management area is defined in the *Coastal Management Act 2016* 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.

Littoral rainforest areas are confined to four locations located within the lower estuary. All locations are within NPWS reserves. The largest area is within the Iluka Nature Reserve (within the Clarence Valley Coastline and Estuaries CMP study area). Another two patches are located adjacent to the 'old ferry approach' at Iluka within Bundjalung National Park and a small patch is located off Shores Drive, Yamba within the Clarence Estuary Nature Reserve.

Coastal wetlands are mapped across the lower Clarence River estuary with a total area of approximately 25,626 ha as follows:

- Significant areas within the lower Esk River and catchment within Bundjalung National Park and managed by NPWS.
- Lower estuary islands including parts of Goodwood, Yargai, Turkey, Harwood, Chatsworth, Warregah, Rabbit, Dart, Hickey, Freeburn, Micalo, Thorny, Romiaka Islands. The majority of these areas are private freehold or Crown Land and zoned as Conservation (C1, C2 or C3) with only small areas under Rural (RU1 or RU2) zoning.
- Around the perimeter of Wooloweyah Lagoon including the islands at the northern end of the lagoon, national park areas to the east, the western and south-western perimeter and area to the west towards Gulmarrad. The majority is under Conservation zoning, large areas within Yuraygir National Park and Clarence Estuary Nature Reserve, with only a small area under RU2 zoning.
- Significant areas to the west of The Broadwater. The majority is under conservation zoning with large areas under rural zoning.
- The Everlasting Swamp and Little Broadwater to the west and south-west of Lawrence. The majority of the Everlasting Swamp is now NPWS estate with other areas under Conservation and rural zoning. The majority of the Little Broadwater area is under Conservation zoning.
- Shark Creek and Tyndale Swamp. Freehold land under predominantly Conservation zoning.
- Coldstream River, to the south of Tucabia including Morans, Colletts, Ellis and Crows Nest Swamps and freehold land under rural zoning.

### 9.2.2 Coastal environment area

The CEA is characterised by natural coastal features such as coastal lakes, wetlands and estuarine waters. Within the study area the CEA is mapped over 45,440 ha from the downstream extent of the study area at Yamba/Iluka upstream to one km beyond the highest astronomical tide in all tidal waterways.

The majority of the CEA mapped within the study area is on private land mapped as RU1 Primary Production (15,136 ha) and RU2 Rural Landscape (7,698 ha) under the LEP. These areas are typically managed for agricultural production which is often inconsistent with the objectives of the CEA within the *Coastal Management Act 2016* which aim to protect and enhance coastal environmental values and enhance natural character, scenic value, biological diversity and ecosystem integrity.

Recreational waterways comprise 6,000 ha and a smaller proportion of the mapped CEA area is located on private land or Crown land mapped as W1 Natural Waterways (5,000 ha). Approximately 224 hectares are zoned E2 Environmental Conservation. Some areas are located within National Parks or Reserves (2,500 ha) and managed by NPWS under various Plans of Management which are generally consistent with the CEA objectives.

### 9.2.3 Coastal use area

The CUA is defined as land adjacent to coastal waters, estuaries and coastal lakes and lagoons where impacts of development on the use and enjoyment of these areas need to be considered. The CUA has a similar longitudinal extent to the CEA described above covering all tidal waterways to one km beyond the highest astronomical tide. However, the CUA area does not include the waterway itself, typically starting at the low water mark of tidal waters and extending to 250 m landward on either side of the waterway. There is approximately 30,000 ha of CUA mapped within the study area. Management of land within the CUA is similar to that described for the CEA above.

### 9.2.4 Coastal vulnerability area

The CVA is land which is subject to current and future coastal hazards. The CVA with the Clarence River is not yet mapped in the *Resilience and Hazards SEPP*.

Coastal hazards within the Clarence River to be addressed in the CMP include the following (OEH, 2018b):

- Tidal inundation - inundation of land by tidal action under average meteorological conditions. Tidal inundation may include shorter-term incursion of seawater onto low-lying land during an elevated water level event such as a king tide or more permanent inundation due to land subsidence, changes in tidal range or sea level rise.
- Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters.

## 9.3 Management Roles and Responsibilities

The study area is managed by local councils, various state government agencies, First Nations groups and private landholders (Table 9).

**Table 9: Management roles and responsibilities**

| Agency | Role |
|---|---|
| Local councils | Local councils have a central role in managing the waterways, foreshores and catchments of the study area (Section 9.6). The Clarence River estuary lies entirely within the CVC LGA. In addition to the above roles and responsibilities, CVC has the responsibility of estuary and floodplain management and coastal hazard management. CVC is responsible for preparing the CMP for the Clarence River Estuary. |
| Native title holders and claimants | Native title exists over many areas of the catchment and several claims remain active (Section 9.5). 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. The following LALCs operate within the Clarence River catchment: Birrigan Gargle LALC, Yaegl LALC, Grafton-Ngerrie LALC, Baryugil Square LALC, Jubullum LALC, Jana Ngalee LALC, Muli Muli LALC, Bogal LALC, Glen Innes LALC, Dorrigo Plateau LALC, Guyra LALC, Armidale LALC, Moombahlene LALC. |
| CEMC | The role of the CEMC is to advise CVC on developing and implementing management plans related to coasts and estuaries and initiating and overseeing coastline and estuary management processes. |
| 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 9.9). |
| DPE – E&H | DPE – E&H 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. DPE – E&H also works with local councils and communities to maintain or improve the health of estuaries/ lakes and enhance the recreational experience. DPE - E&H provides funding to councils for the development and implementation of CMPs through the Coast and Estuaries Grant Program. DPE - E&H has provided funding to CVC for the development and preparation of this CMP Scoping Study. |
| DPE – Crown Lands | DPE - Crown Lands is responsible for the administration and/or management of Crown land under *the Crown Land Management Act 2016*. Crown land includes submerged Crown land, seabed and subsoil to three nautical miles from the coastline of NSW that is within the limits of the coastal waters of the State. Crown land includes much of the submerged land within the estuary and associated intertidal areas (below MHWM). |

| Agency | Role |
|---|---|
| DPE - Water | DPE – Water is responsible for surface and groundwater management including:<br>• Ensuring equitable sharing of surface and groundwater resources and that water entitlements and allocations are secure and tradeable through water sharing plans.<br>• Ensuring water security for NSW.<br>• Managing water resources through planning, policy and regulation. |
| 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 (DPI, DPE (E&H and Planning and Assessment) and Transport for NSW.<br>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 highest astronomical tide (HAT) in the estuaries and extending up to three nautical miles offshore.<br>Under the *Fisheries Management Act 1994*, DPI - Fisheries:<br>• 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.<br>• Mitigates and manages risks from use of land and water.<br>Under the *Marine Estate Management Act 2014*, DPI - Fisheries is responsible for:<br>• Ensuring strategic and integrated management of the whole marine estate – marine waters, coasts and estuaries.<br>• 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 | Transport for NSW is the key agency with statutory and policy responsibilities related to the safety and accessibility of NSW waterways for recreational and commercial vessels.<br>The Maritime Infrastructure Delivery Office (MIDO) is a joint initiative between DPE – Crown Lands and Transport for NSW. A number of relevant DPE – Crown Lands programs are currently managed through MIDO including:<br>• Coastal Infrastructure Program (i.e. management of estuary break walls and training walls).<br>• Coastal Dredging Strategy.<br>• NSW Boating Access Dredging Program. |

| Agency | Role |
|---|---|
| Landcare/ community environmental 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 industry 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. |
| State Emergency Service (SES) | The SES is responsible for provision of emergency and rescue services during times of natural hazard emergencies and disasters, including bushfires, flooding, storms (including storm tide and severe erosion events) and tsunami events. |
| North Coast Local Land Services (NCLLS) | The NCLLS region extends from Tweed Shire Council in the north to Port Macquarie-Hastings Council in the south. 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 DPE – E&H 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.<br>NCLLS also provides a service to the Federal Government as a vehicle through which federal funding can be distributed to regional and rural landholders. |
| Forestry Corporation of NSW (FCNSW) | FCNSW manages the commercial native and plantation forests in the Clarence Valley with 196,000 ha of land under within the defined forest area, the majority with native hardwood and cypress forests (Forestry Corporation of NSW, 2022). |

## 9.4 Land Tenure

Land tenure within the Clarence Valley LGA within the study area is illustrated in Figure 33 and Table 10. Most of the area is freehold land under private ownership (54%). The Clarence River is a Crown waterway with submerged Crown land below the mean high-water mark (MHWM). With Council owned land and Council managed Crown land amounting to less than 2%, this places more importance on the need for an integrated approach to the management of the coastal zone.

**Table 10: Land tenure within the Clarence Valley LGA**

| Land Tenure/ LGA (ha) | Clarence Valley LGA | % of total LGA |
|---|---|---|
| Total | 1,042,939 | 100% |
| Freehold land | 558,874 | 54% |
| National Parks Estate | 195,854 | 19% |
| State forest | 189,834 | 18% |
| Crown Land | 36,486 | 3% |
| Roads/rail and water feature corridors | 60,715 | 5% |
| Council owned land | 887 | <1% |
| Crown Land managed by Council | 289 | <1% |

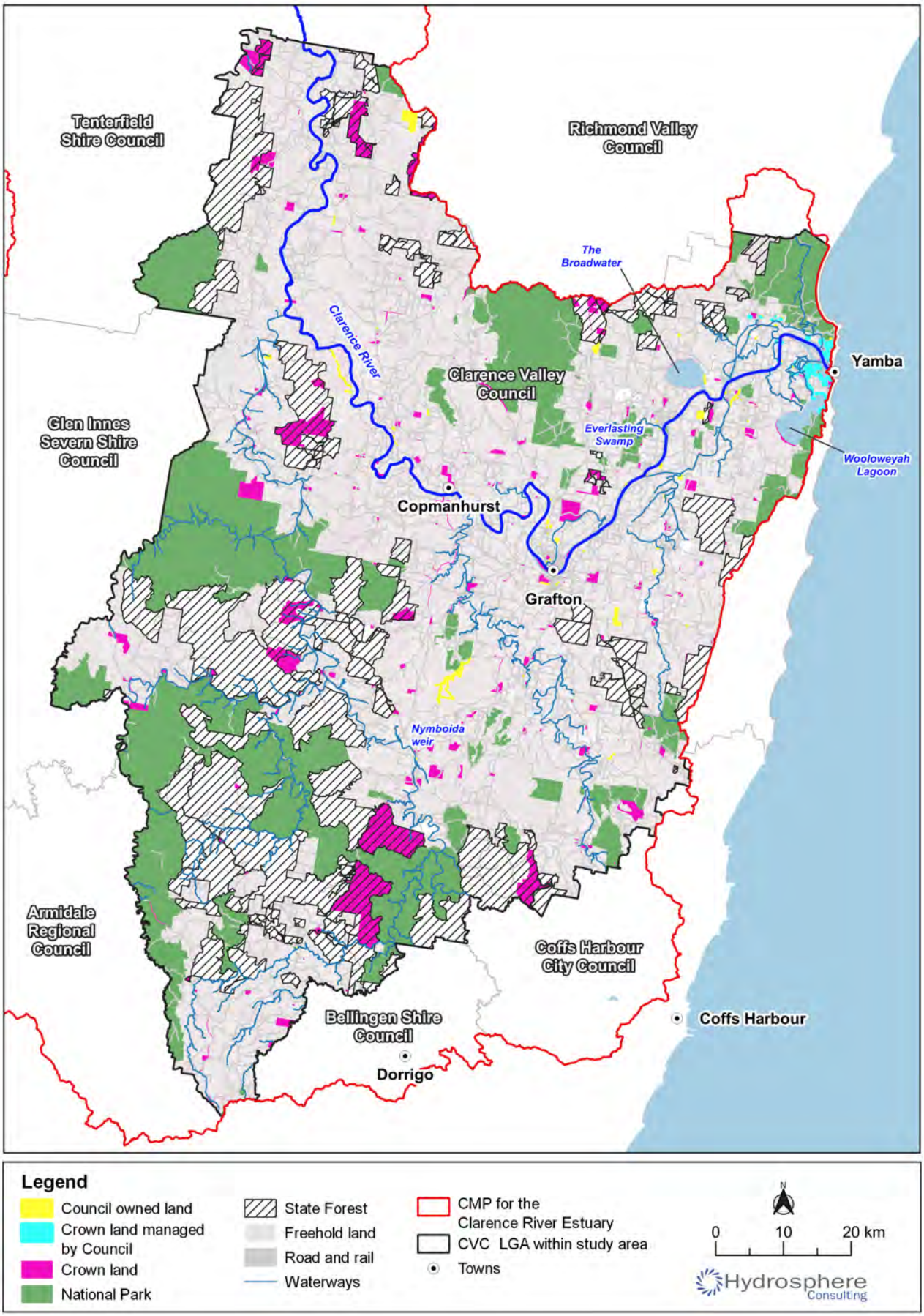



**Figure 33: Land tenure within the study area**

## 9.5 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 rights depend on each determination, but some typical activities native holders can undertake on native title areas are:

- Access to, remain on or traverse an area.
- Access resources to take, use, share, offer and exchange for non-commercial purposes.
- Maintain and protect places, objects and areas of importance or significance under traditional laws and customs in the area.

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, 2020a).

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, construction of public infrastructure prior to 1996, mining leases etc.) (DPIE, 2019b). 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*. Future act activities require a notice to be forwarded to the native title claimants' representative body for consultation and feedback.

**Table 11: Native title determinations**

| Application name | Tribunal file no. | Application status/ Registered Native Title Body Corporate |
|---|---|---|
| Yaegl People #1 | NCD2015/002 | Yaegl Traditional Owners Aboriginal Corporation RNTBC |
| Yaegl People # 2 | NCD2015/003 | |
| Bandjalang People #1 | NCD2013/001 | Bandjalang Aboriginal Corporation Prescribed Body Corporate RNTBC |
| Bandjalang People #2 | NCD2013/002 | |
| Bandjalang People #3 | NCD2021/001 | |
| Western Bundjalung People Part A | NCD2017/002 | Ngullingah Jugun (Our Country) Aboriginal Corporation RNTBC |
| Western Bundjalung People Part B | NCD2018/001 | |
| The Githabul People | NCD2007/001 | Githabul Nation Aboriginal Corporation RNTBC |

Source: Data sourced from National Native Title Tribunal (2022)

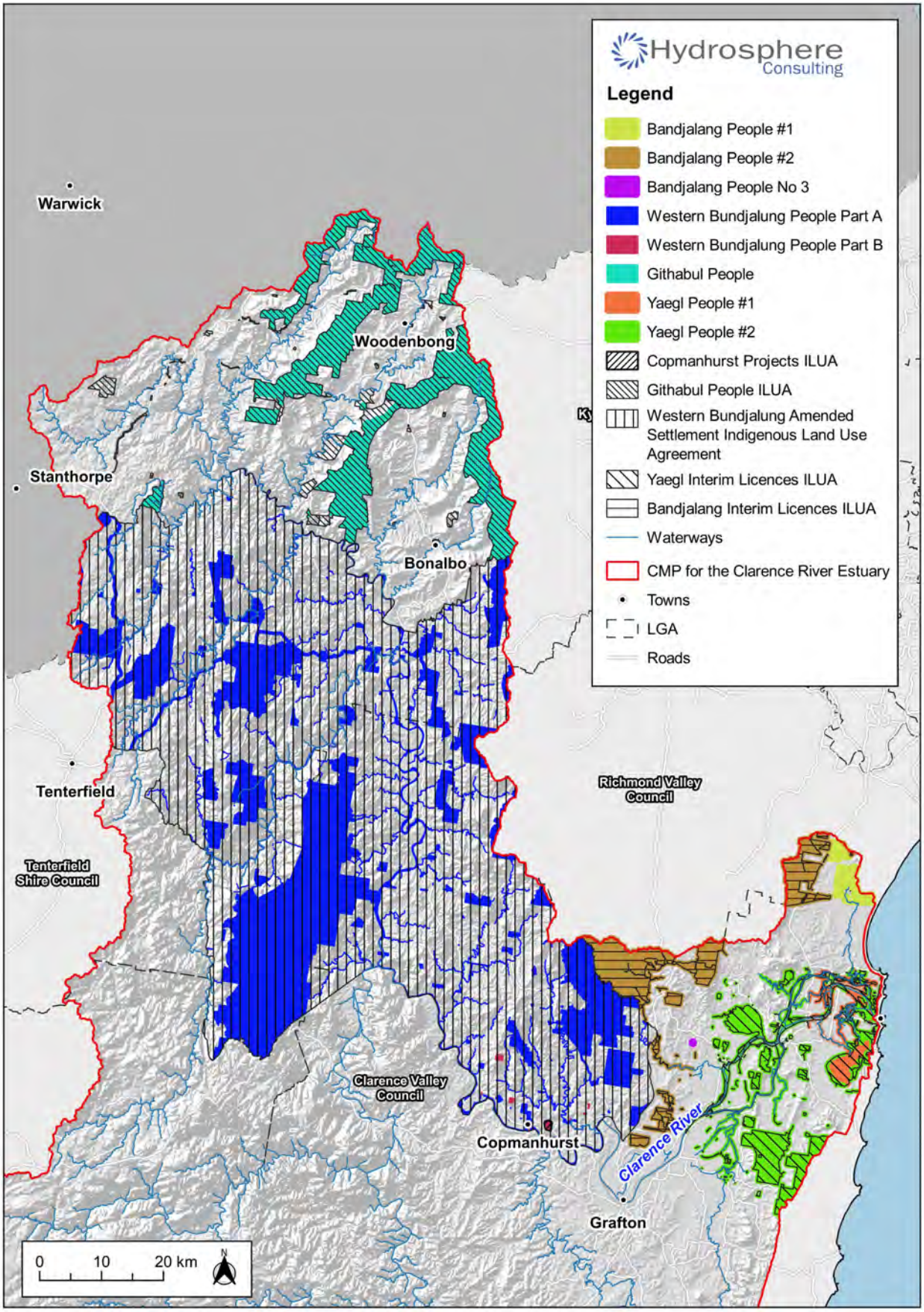



**Figure 34: Native title determinations and Indigenous Land use Agreements**

Source: Mapping data sourced from National Native Title Tribunal (2022)

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, 2022). The ILUAs in place within the study area 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 | Not specified |
| Western Bundjalung Settlement ILUA | Area Agreement | NI2018/001 | Government | Consultation protocol, tenure resolution |
| Yaegl Interim Licences ILUA | Body Corporate | NI2018/006 | Native Title Settlement | Not specified |
| Copmanhurst Projects ILUA | Area Agreement | NI2019/001 | Mining | Infrastructure |

Source: Data sourced from National Native Title Tribunal (2022)

Native title rights and interests need to be considered throughout the CMP process, starting with early engagement with relevant native title bodies. Native title and future acts will also need to be considered when considering future CMP actions. Some actions may be considered future acts and trigger notifications, consultation and negotiation with relevant native title bodies and potentially compensation.

## 9.6 Local Government

CVC is leading the CMP process and is collaborating with other local councils, land managers, state government agencies, industry and community representatives to provide effective coastal management outcomes. The Clarence Valley LGA makes up the greatest proportion of the catchment (Figure 1) comprising 45% of the study area (997,000 ha), followed by Tenterfield (20%, 442,000 ha), Glen Innes (13%, 292,000 ha), Armidale (9%, 204,000 ha), Kyogle (7%, 156,000 ha), Coffs Harbour (3%, 68,000 ha), Bellingen (2.5%, 51,000 ha) and Richmond Valley (0.5%, 10,000 ha).

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 IP&R Framework (Appendix 1, Volume 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 relating to 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 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 Clarence River. Due to the large size of the Clarence 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 Clarence River LGAs have relatively small rate payer bases to fund improvement actions. 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 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. CVC has established working relationships with other agencies, particularly NPWS, DPE - E&H, NCLLS, DPE - Crown Land and DPI - Fisheries through the CEMC and ongoing management. CVC has also established working relationships with industry and community groups with the joint funding and implementation of a range of actions within the catchment.

## 9.7 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 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 Clarence River is within the North Region (from Tweed Heads to Stockton). The state-wide TARA identified water pollution from diffuse sources and stormwater discharge as the number one threat to the marine estate.

Table 13 sets out the relevant priority threats to environmental assets and social and economic benefits identified by the TARA at a state-wide level (listed in descending order of significance). Commercial Fishing – Estuary Prawn Trawl (in estuaries) was also identified as a priority threat for the North Coast region.

**Table 13: State-wide priority threats identified in the MEMA TARA and relevant to the study area**

| Priority threats |
|---|
| *Threats to environmental assets* |
| • Urban stormwater discharge.<br>• Agricultural diffuse source runoff (in estuaries).<br>• Clearing riparian and adjacent habitat including wetland drainage.<br>• Climate change stressors 20-year timeframe (sea level rise, altered storm/cyclone activity, flooding, climate and sea temperature rise, altered ocean currents and nutrient inputs).<br>• Modified freshwater flows (in estuaries).<br>• Foreshore development.<br>• Recreation - boating and boating infrastructure (in estuaries).<br>• Navigation & entrance management and modification, harbour maintenance etc.<br>• Sewage effluent and septic runoff.<br>• Stock grazing of riparian and marine vegetation (in estuaries).<br>• Four-wheel driving.<br>• Recreational fishing - boat-based line and trap fishing.<br>• Passive recreational use.<br>• Recreational fishing - shore-based line and trap fishing.<br>• Commercial fishing - estuary general (in estuaries).<br>• Deliberate introduction of plants and animals (e.g. foxes, Bitou bush).<br>• Oyster aquaculture (in estuaries).<br>• Recreational fishing- hand gathering.<br>• Commercial Fishing – Estuary Prawn Trawl (in estuaries) – North Coast region priority threat |

| Priority threats |
| --- |
| *Threats to social, cultural and economic benefits* |
| • Water pollution on environmental values - urban stormwater discharge.<br>• Water pollution on environmental values - agricultural diffuse source runoff.<br>• Water pollution on environmental values - litter, solid waste, marine debris and microplastics.<br>• Inadequate social and economic information.<br>• Lack of compliance with regulations (by users) or lack of compliance effort (by agencies).<br>• Limited or lack of access infrastructure to the marine estate.<br>• Reductions in abundances of species and. trophic levels.<br>• Anti-social behaviour and unsafe practices.<br>• Climate change stressors 20-year time frame (sea level rise, altered storm/cyclone activity, flooding, climate and sea temperature rise, altered ocean currents and nutrient inputs).<br>• Loss of public access (either by private development or Government area closures).<br>• Inadequate, inefficient regulation, overregulation (agencies).<br>• Pests and diseases.<br>• Sediment contamination.<br>• Conflict over resource access and use.<br>• Habitat (physical) disturbance (e.g. from foreshore development, commercial and recreational fishing methods, four-wheel driving, and extractive industries (mining).<br>• Loss or decline of marine industries.<br>• Seafood contamination.<br>• Modified hydrology/hydraulics and flow regime.<br>• Water pollution on environmental values - septic runoff, point source pollution and sewage overflows (such as outfalls, STPs, etc.).<br>• Lack of community awareness of the marine estate, associated threats and benefits, regulations and opportunities for participation.<br>• Lack of or ineffective community engagement or participation in governance.<br>• Other water pollution/contamination affecting human health and safety.<br>• Excessive or illegal extraction. |

Source: adapted from BMT WBM (2017).

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 projects in Stage 1 and Stage 2 (current stage to June 2022) in the Clarence Valley LGA 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. The implementation of the MEMS since 2018 aims to address many of the key issues impacting on the health of the Clarence 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. 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. A summary of the status of the projects relevant to the study area is provided below (MEMA, 2021b; MEMA, 2021c):

- Initiative 1: Improving water quality and reducing litter:
    - Improved management of diffuse source water pollution (state-wide) - review of the NSW Diffuse Source Water Pollution Strategy (DECC, 2009b) is complete and recommendations provided to Government to effectively manage diffuse source water pollution.
    - Review of the NSW Water Quality Objectives (state-wide) - updated community values and uses obtained through consultation with the general public and local government. A state-wide database will be developed for water quality data collation to generate either regional or site specific (trigger) guideline values for coastal waterways. These are intended to replace the old generic trigger values in the ANZECC guidelines. The outcomes are expected to be available in June 2022.
    - Coastal floodplain study – audit of existing floodplain infrastructure such as drains and flood gates and prioritisation of remediation opportunities. The study has been completed for the Clarence floodplain (Harrison *et al.,* 2021).
    - Marine litter campaign (state-wide) - development of an integrated strategy and new animated works to support the “Don't be a Tosser” marine litter campaign.
    - Construction sediment management (state-wide) - this project aims to reduce run-off from construction sites into waterways. Project partners are developing standard planning conditions for controlling run-off. Coastal councils can use these conditions in development approvals and then ensure development complies with these conditions.
- Initiative 2: Delivering healthy coastal habitats with sustainable use and development:
    - An update to the 2003 *Coastal Design Guidelines for NSW* to illustrate how an urban design approach can inform development designs and layouts that are more sensitive to the unique

natural and urban characteristics of coastal places in NSW and to guide decision-making about legacy infrastructure in coastal areas.

  - Develop and implement a state-wide policy for the management of coastal Crown lands (including submerged lands) in collaboration with CMPs in priority areas. A draft policy and guidelines have been developed in consultation with marine estate agencies. This policy aligns the management of Crown land with the NSW coastal management framework.
  - Development of estuary-wide Domestic Waterfront Structures Strategies to guide and streamline future applications for domestic developments along foreshores (such as pontoons and boat ramps) within estuaries throughout NSW.
  - Marine vegetation management strategies (state-wide) - display of estuarine vegetation, combining future inundation areas, historic distribution and constraints into a management tool for natural resource managers.
  - Bank management strategies that reduce red tape for proposals and prioritise environmentally friendly approaches. The development of Bank Management Strategies will be undertaken by DPI - Fisheries in partnership with an Interagency Working Group consisting of DPE - Crown Lands, EES, NRAR, Transport for NSW, and DPE Planning and Assessment. Development of Bank Management Strategies will incorporate an investigation into causes and types of estuarine bank erosion and a review of existing best management practice bank treatment options. It will then match common types of erosion with preferred best management practice treatment methodologies, with the outcome of this step being the creation of a decision support tool. The resulting Bank Management Strategy, which will consist of online mapping and an explanatory companion document, will provide a strategic, upfront guide that specifies the best practice erosion control treatment method for a particular segment of foreshore within the estuary. This Bank Management Strategy can be used by land owners proposing erosion control treatment works and assessing agencies to determine the most environmentally friendly erosion control treatment approach.

- Initiative 3: Planning for climate change:
  - Enhanced mapping of estuarine communities (such as saltmarsh and mangroves) to identify those communities most at threat from sea level rise expected under climate change scenarios and use this information to model areas of land suitable for retreat and those that should be prioritised for protection (Section 8.6).
- Initiative 4: Protecting the Aboriginal cultural values of the marine estate.
  - Cultural interpretations - collaborating with Aboriginal communities on additional signage and artwork depicting their cultural connection to Sea Country. Discussions with Yaegl on cultural interpretation projects commenced but was postponed due to COVID-19.
  - Reviving culture - working with Aboriginal communities to revive cultural knowledge and practices of Sea Country.
  - Cultural economic development - increasing the number of people engaged in Aboriginal businesses in the marine estate.

- Initiative 5: Reducing impacts on threatened and protected species and Initiative 6: Ensuring sustainable fishing and aquaculture:
    - None focus on Clarence River however many state-wide programs provide information and assist in improving strategic planning and management to ensure sustainable fishing and aquaculture.
- Initiative 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. Projects funded include Yamba boating access improvements (2018), Spenser Street boat ramp jetty upgrade (2018), canoe and kayak trail access improvements (investigation, 2017), McLachlan Park boating facility improvements (2017), upper Clarence sewage pump-out facility (investigation, 2017), Brushgrove boat ramp and car park upgrade (2018), Corcoran Park Pontoon/jetty and access improvements (2022).

## 9.8 Commercial Fishery Management

The estuary prawn trawl fishery is managed by NSW DPI - Fisheries under the *Fishery Management Strategy for the Estuary Prawn Trawl Fishery* (NSW Fisheries, 2003a) and relevant legislation including *Fisheries Management (Estuary Prawn Trawl Share Management Plan) Regulation 2006, Fisheries Management Act 1994*, the *Fisheries Management (General) Regulation 2010* and *Fisheries Management (Supporting Plan) Regulation 2006*. An Environment Impact Statement (NSW Fisheries, 2002) has also been prepared for the fishery.

The Estuary Prawn Trawl Fishery is a share management fishery which means that commercial fishers must hold sufficient shares to be eligible for an endorsement to operate in the fishery. Each estuary in the fishery has its own specific share class and endorsement. The fishery is managed predominantly through restrictions on the numbers of fishers endorsed to operate in each estuary, a range of seasonal, time and area fishing closures, restrictions on the number and size of vessels permitted and the size and dimensions of the fishing gear used (DPI, undated).

The *Assessment of the New South Wales Prawn Trawl Fishery* (Department of Sustainability, Environment, Water, Population and Communities, 2011) was undertaken to assess the fishery against Australian Government guidelines. The assessment found that considering management measures for the fishery and the mandatory requirement for all other trawl operators to use bycatch reduction devices, the management regime for the estuary prawn trawl fishery provides for fishing operations to be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.

The estuary general fishery includes all forms of estuarine commercial fishing except for estuary prawn trawling. The estuary general fishery is managed under the *Fishery Management Strategy for Estuary General Fishery* (NSW Fisheries, 2003b) and relevant legislation including *Fisheries Management (Estuary General Share Management Plan) Regulation 2006*, *Fisheries Management Act 1994*, the *Fisheries Management (General) Regulation 2010* and *Fisheries Management (Supporting Plan) Regulation 2006*. An EIS (NSW Fisheries, 2001) has also been prepared for the fishery. The primary management controls used to assist in the long-term sustainability of the fishery include a limit on the number of fishers authorised to

operate in the fishery, temporal and spatial closures, gear restrictions (i.e. mesh sizes and net lengths) and minimum size limits (DPI, 2017b).

DPI - Fisheries is partnering with commercial, recreational and Aboriginal cultural fisheries across NSW to develop tailored harvest strategies for priority NSW species (trawl whiting, Lobster, Spanner crab and Mulloway). DPI - Fisheries has not scheduled a review of the Estuary Prawn Trawl Fishery or Estuary General Fishery.

## 9.9 National Parks and Reserves

NPWS manages significant areas of National Parks estate across the Clarence River catchment including over 40 national parks, nature reserves and state conservation area (Figure 1). Reserves within the coastal zone include Bundjalung National Park, Yuraygir National Park, Iluka Nature Reserve, Clarence Estuary Nature Reserve, Yaegl Nature Reserve, Everlasting Swamp National Park and State Conservation Area, Munro Island Nature Reserve and Susan Island Nature Reserve. Significant NPWS estate within the broader catchment includes Nymboi-Binderay National Park, Guy Fawkes River National Park, Nymboida National Park, Washpool National Park and Gibraltar Range National Park (refer Appendix 1, Volume 2).

## 9.10 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.

DPE – Crown Lands is responsible for the following activities on Crown land:

- 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 structures (e.g. jetties and pontoons), non-domestic waterfront structures (e.g. commercial fisheries, marinas and public jetties), boat ramps, pipelines for water extraction, retaining walls, grazing, seawalls, sliprails and boat hoists and easements and ongoing administration, management and regulation of these structures.
- Direct Crown land management responsibilities including activities such as access management, pest plant and animal management.

*Crown Land 2031* (DPIE - Crown Land, 2021) 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*". 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 reserves are owned by the State Government and are either managed by DPE – Crown Lands, local government or under Trust. Local councils manage Crown lands as 'community land' in accordance with the *Local Government Act 1993*. Crown land management strategies target unique values of the area which protect and enhance its social, cultural and/or natural attributes as well as identifying 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 (refer Appendix 1, Volume 2).

# 10. SCOPE OF THE CMP

## 10.1 CMP Purpose

The CMP will provide the long-term coordinated strategy for managing the Clarence River estuary. An integrated whole-of-government and community approach is required to implement the strategy, with CVC, the catchment Councils, NPWS, DPE and other state government agencies, stakeholders and local communities working together to achieve the CMP objectives.

The CMP will incorporate management actions and strategies to address key threats and support a diversity of natural values and human uses into the future. The CMP will consider the range of timeframes (immediate, 20 years, 50 years, 100 years) where appropriate as required by the *Coastal Management Act 2016*. Recommended management actions will be developed in the CMP to balance and manage uses so that they are compatible with the environmental, social and economic values of the study area and the issues and threats in the longer term. The actions will be developed with reference to a ten-year management timeframe reflecting the implementation phase of the CMP. Longer-term pressures such as climate change and sea level rise will be considered in the formulation of management actions to ensure resilience against future threats and the conservation of the values for future generations.

## 10.2 CMP Vision

The Clarence River estuary and catchment is highly valued by the community for its natural ecosystems, rich biodiversity and a range of human land uses and activities. The study area is the traditional home of First Nations people and has spiritual and cultural significance. Although the catchment and estuary have been substantially modified for agriculture, urban and rural settlements, many parts of the Clarence River system are in good condition and there remains a diversity of vegetation types and wildlife habitats, with many areas protected in national parks and reserves. Despite this, the catchment activities, rapid development and land use changes have had and continue to have adverse impacts on parts of the river system. There is a strong and growing community sentiment towards actively protecting the areas that are in good condition while addressing environmental issues and improving the health of the Clarence River.

The CMP vision statement has been developed from stakeholder feedback and is consistent with the objects of the *Coastal Management Act 2016*, the management objectives for the coastal management areas and Council's vision and objectives as identified in its Community Strategic Plan.

> ***The natural values of the Clarence River estuary will be conserved and enhanced. Sustainable management of the estuary will include adequate resourcing and funding to preserve the environmental, cultural, recreational, commercial and tourism values with consideration of existing and emerging threats to improve resilience to current and future pressures.***

## 10.3 CMP Objectives

Section 12 of the *Coastal Management Act 2016* states that: "*The purpose of a coastal management program is to set the long-term strategy for the coordinated management of land within the coastal zone with a focus on achieving the objects of this Act*." The objects of the *Coastal Management Act 2016* (Section 3) are to manage the coastal environment of NSW 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 (refer Appendix 2, Volume 2).

The CMP will also ensure that the following objectives for the four coastal management areas (CWLRA, CEA, CUA and CVA) are achieved:

(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

(i) 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

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

(k) 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

(l) to support the objects of the *Marine Estate Management Act 2014*.

The CMP objectives may be refined as the CMP is developed to reflect local issues and values and remain consistent with state government objectives. The CMP will include the development of performance indicators where relevant, for inclusion in the CMP Monitoring, Evaluation and Reporting (MER) framework.

## 10.4 CMP Area

CVC will prepare a CMP for the Clarence River. The spatial extent of the CMP is shown on Figure 1. The key ecosystem health challenges facing the Clarence River estuary are linked to its physical characteristics including the large catchment area (2.2 million ha), large floodplain (> 1,500 km$^2$) and the significant catchment modifications that have occurred since European settlement. With this substantial catchment area

and land use modifications, the management of the Clarence River catchment has a significant impact on the health of the estuary and coastal zone. However, there is no 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. The CMP for the Clarence River Estuary will therefore 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. While it is recognised that improving the health of the catchment and coastal zone will require substantial resources and commitment, the next stages of the CMP development will identify the priority actions and sustainable funding sources. Given the large study area, CVC may choose to focus on actions within the coastal zone (the mapped coastal management areas (CUA, CEA and CWLRA) shown on Figure 2 in Section 2.2), consistent with the NSW coastal management framework.

The CMP development will consider the suitability of the mapped coastal management areas (Figure 2) as follows:

- Recognising the influence of the catchment on the health of the coastal zone, CVC will consider the need to extend the mapping of the CEA to include some or all of the Clarence River catchment within the LGA if no other suitable catchment management process is available.
- The Resilience and Hazards SEPP defines the requirements for approval of development and clearing of native vegetation within the CWLRA. CVC will ensure that the mapping provides adequate protection for coastal wetlands and littoral rainforests as well as identifying any areas devoid of native vegetation that are included in the mapping. Detailed contemporary vegetation mapping is expected to be released by the NSW Government in 2022. Once this revised mapping is available, the adequacy of CWLRA mapping will be reviewed.
- There is currently insufficient information available on coastal hazards to map the CVA (bank erosion and coastal/tidal inundation) as part of the *Resilience and Hazards SEPP* or Council's LEP. Coastal inundation studies will be undertaken during Stage 2 and CVC will consider whether the inundation hazard should be mapped and included in the SEPP or LEP (via a planning proposal). Similarly, areas at risk of erosion will be identified through Stage 2 CMP studies and may be included in any planning proposal.

## 10.5 First Pass Risk Assessment and Gap Analysis

Following the identification of the current threats and issues within the study area, a first pass (or preliminary) risk assessment and gap analysis were completed to prioritise risks and identify those that should be further investigated in subsequent stages of the CMP. The objectives, methodology and outcomes are discussed in Appendix 6 (Volume 2).

### 10.5.1 Risk assessment

The risk assessment identifies the key threats to be addressed in the CMP for the Clarence River Estuary. Due to the large geographical area, extensive land use modifications and environmental and social values of the study area, there are several key management threats. Not all of the threats are within Council's management responsibility and the CMP may identify risk treatments that are the responsibility of other government agencies. The CMP will highlight the many significant issues that impact the values of the

coastal zone to direct future effort in the most appropriate areas. Based on the existing information, the threats with an extreme or high risk in the current timeframe are listed in Table 14 for each category of threat.

**Table 14: Key management issues (current timeframe) – extreme or high risk**

| Key threats (PT = priority threat, MEMA TARA) | Locations |
|---|---|
| *Water quality* | |
| T1: Acid sulfate soil (ASS) runoff | Clarence River Floodplain. Highest priority ASS areas – Sportsmans Creek, Swan Creek, Gulmarrad/ East Woodford Island, Taloumbi/ Palmers Channel, Coldstream River (Harrison *et al*., 2021). |
| T2: Blackwater events | Lowest lying areas of Clarence River Floodplain. Highest priority areas: Coldstream River, Sportsmans Creek, Swan Creek (Harrison *et al*., 2021). |
| T3: Agricultural diffuse source runoff (PT) | All rural areas |
| T4: Bank erosion | All areas (exacerbated by floods) |
| T5: Urban stormwater discharges (PT) | Urban areas (particularly Grafton, Yamba, Maclean, Iluka) |
| T9: Sediment runoff from unsealed roads (PT) | All non-urban areas |
| T11: Sand/ gravel extraction | Estuary – various locations |
| T16: Bushfire (impacts on water quality) | All – particularly bushland areas |
| T18: Litter, solid waste and microplastics (PT) | All areas |
| T19: Estuary prawn trawling (PT) | Wooloweyah Lagoon and other areas open to estuary prawn trawling (from Yamba/Iluka to Ulmarra) |
| T20: Long fetch and strong winds increasing turbidity | Wooloweyah Lagoon, likely other locations |
| T21: Future development, urban growth | Yamba, Gulmarrad, James Creek, Clarenza, Junction Hill – potential impact to all of estuary. |
| *Hydrology, connectivity and water extraction* | |
| T22: Modified freshwater flows (PT) | All areas with artificial barriers or water extraction |
| T23: Proposal to dam the Clarence River | Upper catchment |
| T24: Hydrological modification of wetlands and floodplain drainage works (PT) | Clarence River Main Stem and floodplain, including Wooloweyah Lagoon and channels |
| T25: Floodgate design, operation and maintenance (PT) | Clarence River Main Stem and floodplain, including Wooloweyah Lagoon and channels |
| T26: Catchment flooding (from River) | All areas |
| T27: Stormwater inundation | All urban areas |

| Key threats (PT = priority threat, MEMA TARA) | Locations |
|---|---|
| *Riparian condition* | |
| T28: Clearing of riparian and adjacent habitat (PT) | All areas |
| T29: Lack of suitable buffer zones between land use and waterways | All areas |
| T30: Dominance of invasive weeds | All areas |
| T31: Uncontrolled stock access to and grazing within the riparian zone (PT) | All rural areas |
| *Estuarine bank erosion* | |
| T32: Catchment flooding | All areas |
| T33: Powered vessels and towing (PT) | All navigable waterways |
| T34: Wind waves | All areas |
| T35: Historic clearing of riparian vegetation and adjacent habitat (PT) | All areas |
| T36: Stock grazing of riparian and marine vegetation (PT) | All rural areas |
| T37: Gully erosion and bed lowering | All - particularly in areas of highly dispersible soils and steep erodible country (e.g. north and north-west portion of catchment) |
| *Sea level rise* | |
| T38: Increasing tide/ sea levels | Tidal extent – Clarence Main Stem, Wooloweyah Lagoon and coastal tributaries |
| T39: Anthropogenic barriers (i.e. physical barriers, land use and planning constraints) to migration of vegetation communities with sea level rise | Tidal extent – Clarence Main Stem, Wooloweyah Lagoon and coastal tributaries |
| *Climate change* | |
| T41: Average warming and extreme temperatures (PT) | All areas |
| T42: Increase in extreme weather events (e.g. prolonged dry periods and increased frequency and magnitude of storms/ flood events (PT) | All areas |
| *Cultural heritage* | |
| T44: Lack of recognition of cultural values and connection to Country and specifically to water. | All areas |
| T46: Damage to Aboriginal cultural heritage items/ sites | All areas – various locations |

| Key threats (PT = priority threat, MEMA TARA) | Locations |
|---|---|
| *Biodiversity* | |
| T47: Clearing of riparian and adjacent habitat (PT) | All areas |
| T48: Terrestrial weeds | All areas |
| T49: Predation and invasion by feral animals/ pest species (PT) | All areas |
| T50: Habitat disturbance from sand/ gravel extraction (PT) | Estuary – various locations |
| T51: Habitat disturbance from mining (PT) | All areas – particularly upper catchment |
| T52: Aquatic weeds | e.g., Water hyacinth (*Eichhornia crassipes*) and Parrots feather (*Myriophyllum aquarium*) in smaller tributaries, modified waterways and floodplain drains e.g. Alumy Creek |
| T53: Foreshore development and land clearing for agriculture or urban development (PT) | All areas |
| T54: Loss of estuarine vegetation (mangroves, saltmarsh, seagrass) | Tidal extent, particularly Wooloweyah Lagoon |
| T55: Barriers to fish passage | All – various locations |
| T56: Bushfire | All – particularly bushland areas |
| T57: Forestry activities | Forestry operational areas and private native forestry (upper catchment areas). |
| T59: Commercial fishing (estuary trawling) (PT) | Mainly lower and mid estuary. |
| T61: Insufficient public land available to establish stewardship sites to offset loss of native vegetation through land development | All areas |
| *Public use and access* | |
| T63: Pathogens present in water | All – particularly high recreational use areas. |
| T68: Shoaling or siltation affecting navigation | Various locations within estuary |
| *Governance, regulation and funding* | |
| T70: Lack of comprehensive, integrated ecosystem monitoring strategy and reporting system | All areas |
| T71: Inadequate, inefficient regulation (agencies) (PT) | All areas |
| T72: Lack of collaboration in existing studies, programs and on-ground works | All areas |

| Key threats (PT = priority threat, MEMA TARA) | Locations |
|---|---|
| T73: Lack of funding and resourcing for catchment, coastal and floodplain management | All areas |
| T74: Limited understanding of existing management actions including their effectiveness | All – particularly areas with investment/ management works |
| T75: Barriers to implementation of drainage works | Clarence River Floodplain |
| T76: Lack of community awareness of the marine estate, associated threats and benefits, regulations and opportunities for participation (PT) | All areas |
| T79: Lack of compliance with regulations (by users) (PT) | All areas |
| *Planning Controls* | |
| T81: Inaccurate or incomplete mapping of Resilience and Hazards SEPP Coastal Wetland and Littoral Rainforest area | Coastal zone |
| T83: Limited mapping of Resilience and Hazards Management SEPP Coastal Environment Area | Coastal zone |
| T84: Inappropriate development within coastal hazard areas | Coastal zone |

### 10.5.2 Gap analysis

Accurate and detailed information about risk and consequence is necessary to assist decision makers generate effective management strategies which identify and prioritise future actions and investment or justify a business-as-usual approach. The risk assessment also identifies knowledge gaps related to each issue and the importance of resolving each knowledge gap to allow for effective future management of the issue. The gap analysis undertaken for this Scoping Study considered the level of existing information, the current studies underway or planned to address key knowledge gaps as well as stakeholder feedback.

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 affecting the health of the Clarence River. Many strategies have been implemented over the past 25 years by landowners, industry and Council. However, these actions have been small scale and have not resulted in appreciable improvements to the health of the river. If further improvements to river health are desired, further changes are required on a larger scale. Information gaps exist for implementing further large-scale strategies in specific areas. These include the environmental, social and economic impacts of different strategies, detailed costing and community perspectives and landholder interests in contributing to change. Support from landholders/ land managers and the community has not been established for further large-scale changes in priority areas. Existing studies do not currently provide the level of detail and mechanisms required to implement on-ground actions.

Stakeholder consultation undertaken as part of this Scoping Study has identified significant support for on-ground works and less support for further studies. However, some strategic planning is recommended to focus efforts and ensure cost-effectiveness. The gap analysis identified several further studies required to fill gaps in current understanding and to inform the optimum approaches to address key threats. Resolving immediate priority knowledge gaps in Stage 2 allows for the identification of appropriate management options/actions that address identified issues. All proposed studies have clearly defined aims and objectives and are directly linked to on-ground actions that result in improved river health and community values.

Further details of recommended Stage 2 studies including desired outcomes required to progress the CMP are provided in the Forward Plan (Table 15, Section 11.5).

### 10.5.3 Knowledge gaps to be addressed separately to Stage 2 of the CMP

The gap analysis identified a number of studies currently being undertaken in parallel with the CMP development that will address some knowledge gaps associated with priority threats to river health. Further investigation of these threats as part of Stage 2 of the CMP is not recommended. Some information gaps have been identified as detailed in Appendix 6, Volume 2 but are considered to require investigation outside of the CMP process as they require consideration of state government policy or direction across NSW or are currently being addressed through Council, MEMS or other state government programs. These include:

- ASS, blackwater, hydrological modifications, floodplain drainage/ private floodgate design, operation, and maintenance – existing MEMS and NPWS (Everlasting Swamp) studies.
- Point source pollution – EPA licensing.
- Marine vegetation and foreshore structure strategies – MEMS studies.
- Sustainable fishing and aquaculture – DPI - Fisheries, MEMS studies.
- Sand/ gravel extraction – DPE – Crown Lands licence audit.
- Catchment flooding – CVC flood management strategies.
- Estuarine vegetation protection - DPI - Fisheries, MEMS.

Results of the current and proposed studies are expected to be available for Stage 3 of the CMP Clarence River estuary to enable stakeholders to assess the available options for inclusion in the CMP. Stage 3 of the CMP will consider results of ongoing studies to determine and assess appropriate management options for implementation in the CMP.

The second draft *Regional Water Strategy for the North Coast* (DPE, 2022a) released for consultation in May 2022 identifies regional priorities and shortlisted actions that are consistent with the CMP priorities including collaboration with First Nations people, improved governance, riparian rehabilitation, river recovery, landholder support and sea level rise vulnerability assessment. It is not clear how overlaps between the CMP and Regional Water Strategy implementation, timing, funding and responsibilities will be managed.

# 11. PRELIMINARY BUSINESS CASE AND FORWARD PLAN

## 11.1 Benefits of CMP Development

The Clarence River provides a high level of ecosystem services (e.g. provision of food, carbon sequestration, habitat provision and aesthetic value) integral to the region's continuing ecosystem health, social and economic value. These values are threatened by increasing pressure from land uses, extreme weather events, climate change, sea level rise and urban development.

There are many organisations from the federal, state, regional and local level that are involved and have responsibilities in governing and managing the study area. Collaboration, cooperation and resource support amongst the landowners and managers is required to provide effective coastal management outcomes.

There is significant knowledge of catchment processes and estuarine dynamics and threats to the Clarence River. Engagement and consultation with the local community and key stakeholders conducted as part of this Scoping Study has highlighted the expectations of the community to progress with catchment and estuary management. In addition, the community, key stakeholders and public authorities are willing to participate in a coordinated and collaborative approach to management of the study area. This collaboration will provide additional benefits to all stakeholders.

The challenges of limited resources, significant threats to coastal values and multiple land managers have been documented in this Scoping Study. The CMP process provides a mechanism for effective management of short-term risks and development of adaptation pathways for longer-term or increasing risks. Continuing with the development of the CMP will assist with:

- Strengthening stakeholder relationships responsible for management in the coastal zone and the shared understanding of the values, risks and management priorities for each of those stakeholders.
- Obtaining funding for coastal management actions through the NSW Coastal and Estuary Grants Program (refer Section 11.2).
- Protecting, conserving and promoting the sustainable integrated management of ecosystem services and other social, cultural, environmental and economic values of the study area, now and for future generations.
- Collaboration with relevant First Nations representatives i.e. Traditional Owners and LALCs as well as other community organisations.
- Early identification of opportunities to reduce and adapt to future risks and to reduce associated future financial costs (e.g. disaster management costs), particularly in a climate of emerging coastal, climate and political risks.
- Limiting liability of CVC under Section 733 of the *Local Government Act 1993* with respect to land in the coastal zone through acting in "good faith", i.e. by preparation of a CMP "*substantially in accordance with the principles and mandatory requirements set out in the current coastal management manual under the Coastal Management Act 2016*".

The CMP will set the long-term strategy for the coordinated management of the Clarence River estuary and ensure that the values and benefits of the study area are enhanced and maintained for future generations. In continuing with the preparation and implementation of a CMP, CVC should consider:

- The obligation to implement a certified CMP under the *Coastal Management Act 2016*.
- The immediate financial cost of CMP preparation (though these are considered negligible in comparison to the future financial risk of not preparing a CMP as discussed below).
- Competing needs for internal council resources (funding, staff and equipment etc.).
- Competing needs for external stakeholder resources (funding, staff and equipment etc.). Early engagement with stakeholders required to collaborate on the CMP will ensure these risks are minimised.
- External agency priorities and responsibilities.
- Community expectations regarding expected actions. Transparency in the CMP and community engagement process may help to minimise unrealistic expectations from the community.

There are a number of risks associated with not developing a CMP. These include:

- A lack of understanding of key threats to estuary values and areas exposed to coastal hazards can result in inadequate or ineffective management practices and development controls.
- The lack of an adequate risk management process can result in a diminished ability to effectively evaluate and prioritise management actions which reduces the cost-effectiveness of government efforts and resources.
- Timely intervention is required before estuary health issues become more intractable.
- A lack of engagement with the local community can result in a lack of support or even opposition amongst the community and key user groups. This can result in a deficit of credibility and trust between the councils and the community and can derail the implementation of future management actions. A lack of engagement can also result in an incomplete understanding of local community values and therefore a misdirection of management effort and resources. Despite this, the level of community support can vary based on the issues experienced by individual community members in different areas, regardless of the level of engagement.
- No contemporary plan to guide management actions and investment of resources to effect sustainable coastal management.

It is evident that the benefits of continuing with the development and implementation of this CMP significantly outweigh the alternative financial costs as well as the costs to coastal and estuary values.

## 11.2 Funding

The development of the CMP and subsequent actions are expected to be funded through CVC and state government contributions, monetary grants and volunteer works by community members and organisations. Some actions are funded under normal council operating budgets or through existing programs and grants. CVC operates an annual budget primarily through rates and charges as well as fees, investment revenues, loans, property management and operating grants. It will not be possible for CVC to implement all actions without additional sources of funding. As such, identification of grants and the submission of successful funding applications will be an important component of the CMP and the development stages.

The NSW Government's Coastal and Estuary Grants Program provides technical and financial support to local government to help manage the coastal zone. The program supports coastal and estuary planning projects and the implementation of works identified in certified CZMPs or CMPs. Grant offers are subject to state-wide priorities and availability of funds each financial year.

Funding is currently available under five funding streams for a planning stream and four implementation streams. CVC will be ineligible for funding under the Coast and Estuary Grant Program (implementation stream) if it does not have a certified CMP by 31 December 2023. Schedule 3 (Part 2) (4) of the *Coastal Management Act 2016* enables a certified CZMP/EMP to remain valid until the 31 December 2021 and the Minister for Local Government has recently introduced legislation (October 2021) to extend this timeline by two years to 31 December 2023. While planning work is underway for a new CMP, on-ground implementation of the CZMP actions will continue in accordance with the certified CZMP for Wooloweyah Lagoon and other management plans.

Other funding opportunities include the NSW Environment Trust, DPIE - Crown Lands funding, DPI – Fisheries grants, other NSW Government programs (e.g. Riverbank Rehabilitation Project) partnerships with local community groups, research institutions and universities. The MEMS also includes targeted projects which may provide useful information for the CMP.

## 11.3 Forward Plan

CVC will coordinate the development of the CMP and will collaborate with land managers, state government agencies, industry and community representatives to provide effective coastal management outcomes.

The forward plan outlines the next four stages of the CMP process. The requirements for Stages 2 - 5 of the CMP process are detailed in the *NSW Coastal Management Manual* and summarised in the following sections. The CMP will be developed over the next three years.

### 11.3.1 Stage 2 – determine risks, vulnerabilities and opportunities

Stage 2 involves undertaking detailed studies that will help to identify, analyse and evaluate risks, vulnerabilities and opportunities. Studies prepared in Stage 2 provide information to support decision-making in later stages of the planning process. The additional information assists communities to better understand coastal management issues and to analyse and evaluate coastal risks and opportunities.

Stage 2 of the CMP for the Clarence River will include:

- Continuing engagement with the community and other stakeholders.
- Refining understanding of key management issues (where there are knowledge gaps) as described in Section 10.5.
- Analysing and evaluating current and future risks (detailed risk assessment) building on the first-pass risk assessment (Section 10.5) and outcomes of the Stage 2 studies.
- Identification of opportunities to reduce risks and enhance the environmental, social and economic values.

Concurrent with Stage 2, CVC will consider whether planning controls should be updated with any new information available.

### 11.3.2 Stage 3 – response identification and evaluation

Stage 3 involves the identification and evaluation of management options:

- Development of a strategic approach to risk management: alert, avoid risks, active intervention, planning for change, emergency response.
- Identifying and collating information on management options.
- Evaluating management actions, considering:
    - Feasibility (is it an effective and sustainable way to treat the risks?).
    - Viability (economic assessment).
    - Acceptability to stakeholders.
- Engaging public authorities about implications for their assets and responsibilities.
- Preparing a business plan for implementation - capital and operational costs, distribution of costs and benefits, funding and delivery.

Stage 3 will consider all findings from Stage 1, Stage 2 and stakeholder engagement activities. It is envisaged that a large component of this stage will involve prioritising actions to address key issues and threats as identified during Stages 1 and 2.

Formal consultation will take place with each agency with either a responsible or supporting role for each action. A cost-benefit analysis will be undertaken for any options requiring detailed analysis to determine socio-economic viability (potentially required for very high-cost options).

### 11.3.3 Stage 4 – finalise, exhibit and certify the CMP

Stage 4 will involve the preparation of the draft CMP document, review by CVC and Government agencies, placement of the draft CMP on public exhibition and consideration of feedback from all stakeholders. CVC and DPE - E&H will then review and approve the final CMP for certification and implementation. The CMP for the Clarence River will include:

- Coastal management actions (10 years) for CVC and other public authorities where applicable.
- Links to the IP&R framework and land use planning system.

### 11.3.4 Stage 5 – implementation, monitoring and reporting

The CMP will be implemented by CVC and other responsible stakeholders following certification, in accordance with the IP&R framework, land use planning system and partnerships. The implementation of the CMP will include a monitoring and reporting framework for the review and assessment of CMP outcomes.

## 11.4 CMP Engagement Strategy

A shared understanding of the risks and opportunities and stakeholder and community support for resulting actions included in the CMP will be beneficial during implementation phases. A stakeholder engagement strategy for the preparation of the CMP has been developed from the previous stakeholder consultation outcomes and the outcomes/ findings of consultation activities undertaken for this Scoping Study. Coastal management planning will include community engagement, including with First Nations people, from the

outset and will continue to occur throughout the process from development to implementation. The aim of the strategy is to inform all key stakeholders of the project and provide them with the opportunity to contribute to the development of the CMP through a variety of methods. The strategy lists each activity to be undertaken as well as the aim/ objective of the activity, content to be delivered, target stakeholders, delivery method, timing, frequency and who is responsible for delivering the activity.

## 11.5 CMP Development

CVC will rely on funding from the Coastal and Estuaries Grants Program or other external sources to ensure affordability of the CMP development. The Forward Plan (including responsibilities, costs and timing) for Stages 2 – 4 of the CMP for the Clarence River Estuary is provided in Table 15 and Table 16. The tasks listed in the Forward Plan have been developed using the information available during the preparation of this Scoping Study. Outcomes from the Stage 2 tasks and other information that becomes available during Stages 2 – 3 may identify further tasks which may also be required to better inform the CMP development. The Stage 2 tasks have been prioritised as follows:

- Critical – tasks that are required for the development of the CMP and particularly the identification and evaluation of potential responses in Stage 3.
- Recommended – tasks that are recommended for completion as soon as possible as they would assist in the identification and evaluation of potential responses in Stage 3 of the CMP development.
- Desirable – tasks that address data gaps identified through the risk assessment process but may be undertaken during CMP implementation (Stage 5) if funding/ resources are not available during Stage 2. These would be considered for inclusion in the CMP during Stage 3 and 4 if not undertaken during Stage 2.

Table 15 includes a reference to the recommendations from the risk assessment and gap analysis (refer Appendix 6, Volume 2).

Preliminary cost estimates have been developed for each stage of the CMP development. In-kind costs across the life of the CMP (e.g. liaison with internal CVC departments and councillors, compilation and synthesis of relevant data, fulfilling data requests, coordination with stakeholders and consultants) have not been included. CVC will ensure that staff resources are adequate to deliver this project. CMP implementation costs will be identified in the CMP.

It is noted that the *Regional Water Strategy for the North Coast* (DPE, 2022a) released for consultation in May 2022 identifies overlaps with the CMP priorities and development. The CMP process may need to adapt to any further detail on the Regional Water Strategy implementation, timing, funding and responsibilities once this is available. This may include revision of the forward plan considering any commitments made by the NSW Government relating to actions that are consistent with the CMP.

**Table 15: Forward Plan for the CMP for Clarence River estuary – Stage 2: determine risks, vulnerabilities and opportunities**

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Critical tasks* | | | | | | | | | | |
| 2.1 - Strategic planning for on-ground works | Implement a risk-based methodology to prioritise investment in future on-ground restoration works (i.e. riparian zone restoration, stock exclusion fencing and off-stream watering, bank management, on-farm erosion control, road sealing etc.). Consider factors contributing to priority threats such as climate change, flooding, geomorphological processes, land use practices and related rehabilitation programs. Undertake ground-truthing of priority areas within the Clarence LGA to assess condition and confirm priority. Identify potential showcase sites (e.g. on Council-managed land).<br>Outcomes: A high-resolution catchment model (based on the Risk-Based Framework) presenting the spatial risk of nutrients and sediment on the coastal zone. Include consideration of practical factors (e.g. landholder willingness, relationship to other on-ground works and objectives, funding opportunities, regulatory requirements etc.) to identify priority areas and plan for on-ground works within the coastal zone. Project descriptions to include priority, responsibility, partnerships, costs, approval requirements, funding and ongoing maintenance requirements. | S1: Identification of priority diffuse pollution sources/ locations of on-ground works.<br>S4: Identification of priority riparian restoration projects/ locations of on-ground works. | $150,000 | $180,000 | DPE – E&H, NCLLS, DPE – Crown Lands, DPI – Fisheries, industry, community groups, First Nations. | | 6 months | 6 months | | |

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.2 – Identify options for protection of priority CVC infrastructure and assets from bank erosion | Consider tools, data and guidance from MEMS work underway and outcomes of other CMP studies and related programs to develop a strategy for the protection of priority infrastructure and assets from bank erosion.<br>Outcomes: Risk assessment, analysis, prioritisation of works and preliminary concepts, costing and identification of approval pathway for priority sites. | S5: Strategy for protection of priority Council infrastructure and assets from bank erosion. | $40,000 | $50,000 | DPE – E&H, DPE – Crown Lands, DPI – Fisheries, First Nations | | | 6 months | | |
| 2.3 – Assessment of coastal inundation hazard | Detailed inundation assessment for a variety of future sea level rise scenarios and floodplain management scenarios. CVC's updated flood model will be used to assess the coastal inundation hazard (tides and storm surge) considering various floodplain management scenarios.<br>Outcomes: Detailed mapping of coastal inundation risk areas, assessment of risk to CVC assets, public land and infrastructure considering management scenarios. | S6: Assessment of coastal inundation risk. | $50,000 | $60,000 | DPE – E&H, DPE – Crown Lands | | 6 months | 6 months | | |

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.4a – Develop a method of assessing and reporting waterway health | Develop a waterway health monitoring program based on successful and cost-effective programs applied in other NSW estuaries.<br>Outcomes: A program that is cost-effective and targeted and capitalises on existing and ongoing monitoring (e.g. Ecohealth, CVC monitoring, MEMS monitoring) that informs the assessment of priority threats, provides information to the community and other stakeholders on ongoing ecosystem health and assists in the identification of management approaches and required investment in restoration actions. Develop resource requirements and opportunities including citizen science as well as methods of presenting monitoring outcomes to the community. | S10: Develop a method of assessing and reporting estuary health. | $20,000 | $30,000 | DPE – E&H | | 6 months | | | |
| 2.4b – Implementation of monitoring program | Implement the estuary health monitoring program and community engagement activities (Task 2.4a). | | $150,000 ($50,000 p.a.) | $300,000 ($100,000 p.a.) | DPE – E&H | | | Ongoing | Ongoing | Ongoing |
| 2.5 – Identify mechanisms for protection of Native Title rights in CMP development and implementation | Liaison with Native Title holders to understand impact on Native Title rights. Council to seek advice from DPE on overlap between CMP requirements and protection of Native Title rights to support decision-making.<br>Outcomes: Identification of appropriate protection mechanisms required during CMP development and implementation in accordance with relevant legislation. | S7: Identify mechanisms for protection of Native Title rights in CMP development and implementation. | $30,000 | $40,000 | DPE – E&H, DPE – Crown Lands, First Nations. | | | 6 months | | |

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.6 – Cultural recognition/ awareness project(s) communicating cultural values of the river and connection to Country | Consultation and co-design/ development of projects in collaboration with First Nations groups to increase involvement in waterway management and increase understanding of cultural values and traditional management practices.<br>Outcomes: Identification of groups and organisations with capacity and interest to be involved in CMP actions. Potential project descriptions to include priority, responsibility, partnerships, costs, approval requirements, funding and ongoing maintenance requirements. | S8: Cultural recognition/ awareness projects(s) communicating cultural values of the river and connection to Country. | $30,000 | $40,000 | DPE – E&H, NCLLS, DPE – Crown Lands, First Nations. | | 6 months | 6 months | | |
| 2.7 – Establish community priorities for waterway health, willingness to pay and potential funding options | Identification of potential community funding models. Community consultation to gauge level of support for CVC to direct funds and resources into waterway health projects and identify Council, landholder and other stakeholder responsibilities.<br>Outcomes: Potential community funding options and investment priorities. | S12: Establish community priorities for waterway health, willingness to pay and potential funding options. | $20,000 | $30,000 | DPE – E&H | | | 12 months | | |

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.8 – Confirm accuracy of Coastal Wetland and Littoral Rainforest Area mapping | Desktop comparison of CWLRA mapping and contemporary vegetation type mapping to identify potential inconsistencies to improve ecological protection mechanisms and ensure appropriateness of planning requirements for routine works such as asset maintenance (outside Conservation areas). On-ground vegetation assessments of identified priority sites to ground truth vegetation type and determine vegetation boundaries.<br>Outcomes: Potential modifications to CWLRA mapping. | S13: Confirm accuracy of SEPP Coastal Wetland and Littoral Rainforest Area with detailed vegetation type mapping and ground-truthing. | $25,000 | $30,000 | DPE – E&H, DPE – Biodiversity Conservation Division | | | 6 months | | |
| 2.9 – Review of planning controls | Review the adequacy of planning controls, regulation and policy including the Resilience and Hazards SEPP CWLRA, CEA and CVA and Council's LEP and DCP to prevent further threats and mitigate known risks.<br>Outcomes: Required modifications, planning pathway, data and consultation requirements. | - | $20,000 | $25,000 | DPE – E&H, DPE – Biodiversity Conservation Division | | | 2 months | | |
| 2.10 – Detailed risk assessment | Analysis and evaluation of current and future risks (updated preliminary risk assessment). | - | $10,000 | $15,000 | DPE – E&H | | | | 2 months | |
| 2.11 – Stage 2 documentation | Documentation, feedback and concurrence. | - | $10,000 | $20,000 | DPE – E&H | | | | 3 months | |
| 2.12 – Stakeholder engagement | Refer Community and Stakeholder Engagement Strategy. Stakeholder engagement will also be required as part of other Stage 2 studies. | - | $50,000 | $60,000 | DPE – E&H | | Ongoing | Ongoing | Ongoing | |
| *Stage 2 total – critical tasks* | | | *$605,000* | *$880,000* | | *21 months (July 2023 – March 2026)* | | | | |

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Recommended tasks* | | | | | | | | | | |
| 2.13 – Develop a database of on-ground works/ resource tool kit | Collaboration with stakeholders to collate details and map locations of completed and proposed on-ground works.<br>Outcomes: Live, publicly accessible online database including resources (e.g. restoration guidelines, past lessons learnt, study findings, species lists etc.) and long-term database maintenance arrangements. | S11: Develop a database of on-ground works. | $30,000 | $60,000 | DPE – E&H, NCLLS, DPE – Crown Lands, DPI – Fisheries, industry, community groups, First Nations. | | 6 months | | | |
| 2.14 – Cultural mapping to promote protection of cultural heritage | Consultation and co-design/development of cultural mapping project in collaboration with Aboriginal groups. Determine who will be involved, how it will work and how the information will be used. Linked to cultural recognition/ awareness projects – consultation could be carried out for both projects simultaneously. Consult with Bundjalung and Gumbaynggirr traditional custodians to co-design/develop a cultural mapping project potentially based on the process undertaken with Yaegl traditional owners. Work with Yaegl to finalise their mapping project.<br>Outcomes: Review and update of cultural mapping projects across the catchment to locate and conserve sites and items and provide input into planning and development controls. | S9: Cultural mapping | Included in CVC Operational Plan | | DPE – E&H, First Nations, catchment councils, Heritage NSW. | | 12 months | | | |

| CMP task | Scope and Expected Outcome | Data gap[1] | Cost (low)[2] | Cost (high)[2] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Desirable tasks* | | | | | | | | | | |
| 2.15 – Development of urban stormwater management plans | Review and update existing urban stormwater management plans and identify priority water quality improvement actions. | S2: Development/ review of urban stormwater management strategies | $30,000 | $60,000 | DPE - E&H, DPI – Fisheries | | | 6 months | | |
| 2.16 – Assess scale of litter and microplastics issues | Undertake and assessment of the scale of litter and microplastics issues across the coastal zone using available tools such as the EPA Litter Prevention Kit and Local Litter Check. | S3: Investigate scale of litter and microplastics issues | $5,000 | $10,000 | EPA, DPE - E&H | | 3 months | | | |
| *Stage 2 total – recommended and desirable tasks* | | | *$65,000* | *$130,000* | | - | | | | |

1. Refer Risk Assessment and Gap Analysis, Appendix 6, Volume 2.
2. Not including CVC or other agency staff costs.

**Table 16: Forward Plan for the CMP for Clarence River estuary – Stage 3 and Stage 4**

| CMP task | Scope and Expected Outcome | Cost (low)[1] | Cost (high)[1] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|
| *Stage 3 – response identification and evaluation* | | | | | | | | | |
| Options assessment[2] | Development of strategic response to risks, identification and evaluation of management options | $30,000 | $40,000 | DPE - E&H, NCLLS, DPE – Crown Lands, DPI – Fisheries, industry, community groups, First Nations. | | | | 4 months | |
| Business Plan | Development of business plan for implementation - capital and operational costs, distribution of costs and benefits, funding and delivery | $10,000 | $20,000 | DPE - E&H | | | | 1 month | |
| Stakeholder engagement | Refer Community and Stakeholder Engagement Strategy. | $40,000 | $50,000 | DPE - E&H | | | | 4 months | |
| *Stage 3 total* | | *$80,000* | *$110,000* | | *4 months (April 2026 – July 2026)* | | | | |

| CMP task | Scope and Expected Outcome | Cost (low)[1] | Cost (high)[1] | Stakeholders | 2022/23 | 2023/24 | 2024/25 | 2025/26 | 2026/27 |
|---|---|---|---|---|---|---|---|---|---|
| *Stage 4 – finalise, exhibit and certify the CMP* | | | | | | | | | |
| CMP documentation | Documentation, feedback and concurrence | $20,000 | $30,000 | DPE - E&H | | | | 3 months | |
| CMP exhibition | Public comment | $5,000 | $10,000 | - | | | | 2 months | |
| CMP finalisation | Final CMP document | $5,000 | $10,000 | DPE - E&H | | | | | 1 month |
| Stakeholder engagement | Refer Community and Stakeholder Engagement Strategy. | $20,000 | $30,000 | DPE - E&H | | | | | 6 months |
| *Stage 4 total* | | *$50,000* | *$80,000* | | *6 months (August 2026 – July 2027)* | | | | |

1. Not including CVC or other agency staff costs.
2. Not including detailed assessment of costs and benefits of high risk and complex options (if required).

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# GLOSSARY AND ABBREVIATIONS

| | |
|---|---|
| ASC | Australian soil classification |
| 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. |
| 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 |
| CEMC | (CVC) Coast and Estuary Management Committee |
| CFP | Clarence Floodplain Partnership |
| 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. |
| CRCC | (former) Clarence River County Council (now CVC) |
| CSP | Community Strategic Plan |
| CVC | Clarence Valley Council |
| CZMP | Coastal Zone Management Plan |
| DDT | Dichlorodiphenyltrichloroethane |
| DECCW | Former (NSW) Department of Environment, Climate Change and Water (now DPIE) |
| DCP | Development Control Plan |
| DLWC | (former) Department of Land and Water Conservation |
| DO | Dissolved Oxygen - oxygen dissolved in the water (oxygen saturation). |
| DPE | (NSW) Department of Planning and Environment |
| DPI | (NSW) Department of Primary Industries |
| DPIE | (NSW) Department of Planning, Industry & Environment (now DPE) |
| 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. |
| E&H | Environment and Heritage Group (a group of DPE) |
| El Niño | A global climate driver which affects extreme rainfall and flooding, hail and storm frequency |
| EPA | (NSW) Environmental Protection Agency |
| EPL | Environment Protection Licence |
| Estuarine | Part of the river channel with a mix of fresh water and salt (tidal) water |

| | |
|---|---|
| FCNSW | Forestry Commission of NSW |
| 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 |
| Holocene | The current geological epoch which began approximately 11,700 years ago. |
| Hydrology | The study of water and its properties, including precipitation onto land and returning to oceans |
| ICOLL | Intermittently Closed and Open Lake or Lagoon |
| IFOA | Integrated Forestry Operations Agreement |
| ILUA | Indigenous Land Use Agreement |
| Inundation | Rising and spreading of water over land |
| IP&R | Integrated Planning and Reporting |
| LALC | Local Aboriginal Land Council |
| La Niña | A global climate driver which affects extreme rainfall and flooding, hail and storm frequency |
| 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 |
| mAHD | metres above mean sea level |
| MBO | Monosulfidic black ooze |
| MEMA | Marine Estate Management Authority |
| MEMS | Marine Estate Management Strategy |
| MER | Monitoring, evaluation and reporting |
| MHWM | Mean high water mark |
| NCLLS | North Coast Local Land Services |
| North Coast Water | now Clarence Valley Council |
| NPWS | (NSW) National Parks and Wildlife Service |
| NRAR | Natural Resources Access Regulator |
| OEH | (former) Office of Environment and Heritage (now DPE) |
| Pleistocene | the geological epoch that lasted from about 2,580,000 to 11,700 years ago. The last ice age. |
| Quaternary | The current geologic period which began 2.58 million years ago |
| Riparian | Of, on or relating to the banks of a watercourse |
| Salinity | The level of salt dissolved in the water |
| Sedimentation | The deposition or accumulation of sediment |
| SEPP | State Environmental Planning Policy |
| SES | State Emergency Service |

| | |
|---|---|
| STP | Sewage Treatment Plant |
| TARA | Threat and Risk Assessment |
| Terrestrial | Living or growing on land (not aquatic) |
| UNCCMB | (former) Upper North Coast Catchment Management Board |