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Brunswick River Estuary NEAP Bank Erosion and Riparian Condition Assessment Report

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Acknowledgement of Country
Fruition Environmental acknowledges the traditional custodians of the Bundjalung lands upon which this assessment was undertaken. We recognise the continuing connection to lands, waters and communities. We pay our respect to Aboriginal and Torres Strait Islander cultures; and to Elders past and present.

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Executive Summary

This report presents the findings of the Brunswick River Estuary NEAP Bank and Riparian Condition Assessment. The assessment is a product of the NSW Estuary Asset Protection Program (NEAP), part of the Riparian Stabilisation Package, co-funded by the Australian and NSW Governments under Disaster Recovery Funding Arrangements and managed by NSW Department of Primary Industries and Regional Development – Fisheries.

The data and analyses from this assessment are to be used to inform future management actions to improve flood resilience, estuary asset protection, and estuary health including water quality, bank stability and riparian vegetation condition.

Bank erosion, riparian management, and water quality issues have in the past been of concern to the local community, as evidenced by the development of the Brunswick River Estuary Coastal Zone Management Plan (CZMP, Byron Shire Council, 2005-2018) supported by the NSW Governments Estuary Planning Process. Sedimentary processes, hydrodynamic processes and to a lesser extent bank erosion processes were documented during the estuary planning process. Unfortunately, this plan was never certified. Nevertheless, the CZMP identifies a number of actions to improve the management of the Brunswick River Estuary, many of which are used by Byron Shire Council and other groups such as Brunswick Valley Landcare to guide the implementation of strategies to improve estuary health and resilience.

Bank erosion and riparian vegetation condition have been mapped previously using a variety of methodologies. The most detailed recent published mapping was in 2017 by Byron Shire Council staff to audit previously identified erosion sites to update the draft CZMP. Mapping of bank erosion was also undertaken in 2020 to field trial the draft version of the DPIRD Fisheries Decision Support Tool for Bank Erosion Management in NSW Estuaries (the "DST"), and by the community organisation "Positive Change For Marine Life" under a citizens science project in 2021 and 2022.

This project updates the existing mapping dataset using the DPIRD Fisheries DST tool as the basis of the assessment with additional criteria related to erosion processes and riparian vegetation attributes. In total approximately 56.7km of estuary bank were surveyed, including 357 individual reaches. This covered the navigable sections of the Brunswick River estuary to Mullumbimby, lower Kings Creek, Simpsons Creek and Marshalls Creek. Data was collected using a field mapping application developed by Fruition Environmental Pty Ltd. The data is stored online through an ESRI ArcGIS web portal and is able to be viewed and analysed using a simple web-based interface or exported to desktop GIS for further, more detailed analyses.

The field investigations showed that just over 3% of surveyed estuary banks were considered to have high severity erosion, meaning that the rate and scale of erosion was considered significantly accelerated. No extreme severity erosion was recorded. A further 16.4% were considered to be eroding at a rate beyond what could be considered a natural rate of channel change (i.e. moderate erosion severity). More than 80% of banks showed no or low erosion severity reinforcing that erosion is not currently a major issue from a whole of estuary perspective when compared to other more developed North Coast estuaries. Some areas recorded as having negligible erosion are stable because of bank protection works, particularly in the lower estuary around public foreshores, parks and infrastructure.

As is typically the case, reaches of high erosion severity are concentrated in the fluvial dominated reaches of the river, predominantly in the upper estuary of the Brunswick River, and on outside bends. Many of these areas have been recorded as eroding in previous assessments indicating that the issues are persistent at many

of these locations. Other areas recorded with high erosion included:

- The northern bank of the lower Brunswick River estuary opposite Mangrove Island where shoaling at the upstream end of the island forces the navigable channel close to the bank, meaning that these banks are exposed to persistent boat wave wash impacts.
- The upper reaches of Marshalls Creek where bank undercutting from wash and current scour is threatening Casons Road at New Brighton and public access foreshore.
- On an outside meander bend in Kings Creek in an agricultural setting.

Riparian Vegetation Condition was assessed using a multi-metric index of riparian condition which considered vegetation width, continuity, structure, diversity and weed presence/cover. Over half of the banks surveyed had riparian vegetation in very good condition (59.7%), with a further 23.7% recording riparian vegetation in good condition. This is unusually high for the region and in part explains the results of the erosion assessment. The high proportion of good to very good riparian reaches is related to the extensive areas of foreshore contained with National Park, Marine Park Estate, Crown Reserve and Council owned land.

Poor and Very Poor condition riparian vegetation is concentrated in the lower reaches of the Brunswick River, Marshalls Creek and Simpson Creek estuaries and is mostly associated with the extensive areas of foreshore protection works adjacent to the urban settlement of Brunswick Heads and the entrance. Poor condition riparian vegetation reaches are more concentrated in the mid to upper Brunswick River estuary where agricultural development has been more intensive and past vegetation clearing has occurred.

The most major impacts on riparian vegetation condition which were observed during the field assessment were:

- Clearing, associated with infrastructure and urban development.
- loss due to erosion processes including undermining of mangroves due to persistent wind or boat wave effects and post flood bank slumping particularly where only a narrow fringe of vegetation exists on the bank.
- stock access which suppresses vegetation regeneration including mangroves, although evidence of stock impacts were not observed to be extensive in this system.
- weed incursion, which although in most reaches is not significant, has resulted some reaches of the upper estuary around Mullumbimby becoming dominated by camphor laurel and many reaches of the lower estuary having ground asparagus, particularly in areas of coastal Swamp Oak vegetation communities.

The most common invasive and exotic weeds recorded were ground asparagus and coastal morning glory in the lower estuary, and camphor laurel in the upper estuary. A single occurrence of cats claw creeper was observed in the upper Brunswick River estuary with the location record forwarded to Council and Brunswick Valley Landcare for further investigation. Records of observation within the surveyed reaches are available and searchable through the online mapping database.

The presence, method and observed effectiveness of existing bank protection works was also recorded. Of the total length of individual bank field surveyed in the Brunswick River estuary study area (56.7km), 7.5km or 13.2% of bank had some form of existing bank protection. Only just over half of existing works (55.3%) were considered effective at controlling erosion at the location. Just over 28.4% (~2km) were considered only partially effective due to poor condition or poor design, with many of these sites occurring adjacent to public access locations. Over 11% of works were considered ineffective or redundant (i.e. not performing any

function with regard erosion control and/or using inappropriate materials).

The most prevalent form of bank protection observed was rock revetment with over three quarters of all works recorded utilising this method (78.5%: 6.15km), representing 3.7% of the total surveyed length of estuary bank in the study area. The next most prevalent were revegetation works (often in association with toe stabilisation methods), building rubble including broken concrete, and timber walls. Some novel works were recorded including pile fields in the upper Brunswick River estuary which were recorded as trial works.

Of note, a number of high priority sites listed in the CZMP (BSC, 2018) have been addressed in the period between the site audit (January 2017) and the NEAP field assessment in 2024. These sites include sites B5 Marshalls Creek River Street), B6 (Marshalls Creek, North Head Road in the Nature Reserve), and B8 (the site of the pile fields on the Upper Brunswick River).

On the basis of the field collected data, a number of recommendations for works have been made by the DPI Fisheries DST. These includes recommendations for cobble beaching works, sandbag installation, large woody debris works, rock fillets, and maintenance of existing works depending upon the estuary location. Approximately 1.5km of works attracted a DST primary recommendation for works, with about 2.9km of existing works identified as requiring maintenance. In many cases the maintenance required is minimal and may involve simple steps to increase the bank/works resilience of the works at that location. More than 92% of estuary length attracted no primary recommendations but may have a final DST recommendation to improve riparian width or introduce management controls such as boating restrictions or formalising public access. The online web portal data can be reviewed and filtered to see the full range of DST recommendations over the full Brunswick River estuary study area.

Importantly, whilst the recommendations are considered a best practice starting point for consideration there may be reasons why the DST recommendation may not be the most suitable option for the bank segment and these reasons may not be captured by the input data. Hydrosphere, in its documentation on the tool explicitly states that "*It is crucial that the DST recommendations are further investigated…to assess whether they are indeed applicable or if other techniques could be more suitable*" (Hydrosphere, 2020, p.18). Additionally, the fact that a surveyed reach attracts a recommendation for works or maintenance within the DST does not infer that the reach is a priority for management action. This is because the DST does not include any consideration of overall objectives for estuary management beyond bank erosion control using best practice. However, where a reach is separately assessed to be a priority for intervention, the DST provides a reasonably objective and standardised approach to determining which treatment options should be first considered.

In terms of where activities may be directed to improve estuary bank and riparian vegetation condition in the Brunswick River estuary, the report outlines a priority system for determining future action and investment. A set of criteria, drawn from the objectives of a number of foundational documents relevant the management of the estuary (including the NSW Coastal Management Act 2016, the Marine Estate Management Strategy 2018-2028 and the Brunswick River Coastal Zone Management Plan 2018) were used to create a "pool" of priority reaches drawn from the 2024 field data which could then be ranked using multicriteria analyses.

Of the 357 reaches field surveyed, 44 were included in the pool of priority reaches for action and management using the above system. These are presented in the report along with a breakdown of reaches which are considered a priority for defined sets of typical estuary management objectives (lower ranked reaches for ongoing monitoring are included in *Appendix B*). These include a subset of priorities that address public asset protection and/or maintenance, water quality improvement, and riparian vegetation protection and enhancement.

The high priority reaches for management intervention are heavily weighted towards the protection of estuary assets and increasing flood resilience by directing works towards vulnerable areas of the estuary. This is a key objective of the NEAP program. The term “Estuary assets” has been interpreted broadly and includes both infrastructure (such as roads and public foreshore) and natural assets such high conservation vegetation types, important estuarine habitats, and water quality. The 12 highest priority reaches are listed in *Table 10* in Part 5 of the Report and shown in *Figure 20* on page 75. Addressing the issues identified at these locations will lead to lasting improvements in estuarine health, flood resilience and public amenity. The proposed timeframe for implementation is the next 10 years to 2034.

Introduction

This report has been commissioned under the NSW Estuary Asset Protection Program (NEAP Program), part of the Riparian Stabilisation Package, co-funded by the Australian and NSW Governments under Disaster Recovery Funding Arrangements, managed by the NSW Department of Primary Industries and Regional Development – Fisheries. The aims of the NSW Estuary Asset Protection program are to:

- Assess the severity of flood impacts on estuarine and floodplain assets
- Identify priority areas for asset protection and increased resilience
- Implement actions that will provide increased resilience for estuarine and floodplain assets from flooding events.

This Report presents the findings of the Brunswick River Estuary Bank and Riparian Condition Assessment undertaken by Fruition Environmental Pty Ltd. The assessment commenced in July 2024.

The study area encompasses the navigable tidal reaches of the Brunswick River estuary including Kings Creek, Simpsons Creek and Marshalls Creek estuaries (*Figure 1*). Approximately 66.2km of estuary bank was delineated through digitising of the estuary bank from 2024 Nearmap® imagery. Approximately 56.7km of this bank length was field surveyed recording more than 357 individual reaches. Areas not surveyed were not accessible by powered watercraft. Further detail of the estuary characteristics including climate, geology, land use, and broader management context are available in the Brunsick River Estuary Study (MHL, 2002b).

The mapping from this assessment is to be used to inform future management actions to improve the stability, resilience, and ecological condition of the estuary. In addition to an updated and comprehensive understanding of the distribution of estuary bank erosion and riparian vegetation condition, the report:

- Reviews the existing knowledge and data relating to estuary bank erosion, erosion processes, riparian vegetation distribution and condition, sediment sources and loads, existing bank protection works, and bank and riparian management priorities.
- Describes the process zones existing in the estuary in terms of the estuary character and behaviour.
- Map bank condition and riparian vegetation condition as at the time of field assessment (July 2024).
- Maps existing bank protection works as at the time of field assessment (July 2024) including methods used and current effectiveness.
- Reports the recommendations of the NSW *Decision Support Tool for Bank Erosion Management*, developed by DPIRD Fisheries as part of the Marine Estate Management Strategy Initiative 2, for each surveyed segment.
- Presents a prioritisation system based on the objectives of the Coastal Management Act, NSW Marine Estate Management Strategy and other relevant plans covering the study area.
- Lists management priorities for improving bank and riparian condition in the estuary framed around the main objectives of increasing resilience to flooding, improving asset protection, water quality improvement, and riparian vegetation protection and enhancement.

The report draws on existing information and data provided by Byron Shire Council staff including local knowledge of bank erosion and vegetation management issues affecting the Brunswick. The Council has also played a valuable role in reviewing the field dataset, review and feedback on the data portal, and review and

feedback on the drafts of this report, all of which is gratefully acknowledged.

This report summarises the findings of the field and desktop assessments of bank and riparian condition.

Requests for access to the full online mapping dataset, which includes up to 106 individual attributes per reach, should be addressed to NSW Department of Primary Industries and Regional Development - Fisheries.

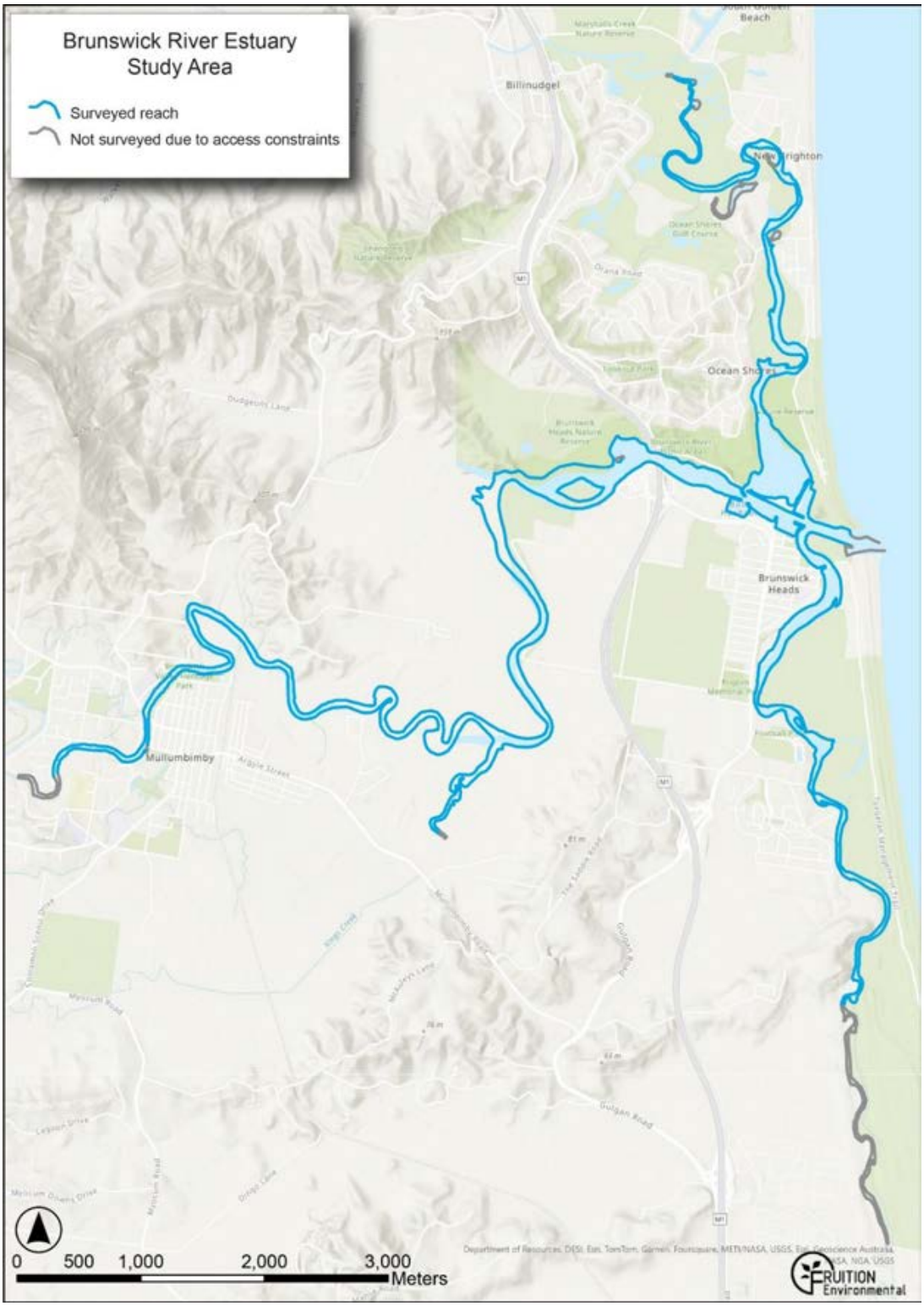

Figure 1 Brunswick River Estuary Bank and Riparian Condition Assessment Study Area, July 2024

PART 1 - Existing Knowledge and Data

Literature Review

This section reviews the existing information and data that relate to the Brunswick River estuary physical processes and condition. There have been a number of studies and reports that have assessed to varying levels of detail the estuary processes, bank erosion distribution, estuarine vegetation, and potential estuary management strategies covering the study area. These include:

- Coastal Zone Management Plan (CZMP) for the Brunswick River Estuary: Issue No 5.1, April 2018 (BSC, 2018)
- Brunswick River Report 2022 by the grass roots community organisation Positive Change for Marine Life (PCFML, 2022)
- Validation of the Decision Support Tool for Bank Erosion Management in NSW Estuaries: Brunswick River estuary GIS validation dataset only (Hydrosphere, 2020 unpublished)
- Brunswick River Estuary Process Study presented as Appendix E of the Brunswick River Estuary Study 2002 (MHL, 2002a)

A number of additional documents were identified that provide useful background and overview information for the Brunswick River Estuary study area. Most of these sources do not provide specific information or datasets of relevance to the NEAP Bank and Riparian Condition assessments but are nevertheless identified here for completeness. These include:

- River Styles® assessment and mapping in the Northern Rivers CMA area (Alluvium, 2012)
- Ecological Health – A contributory report to the Brunswick River Estuary Study – June 2011 (Nelson, 2001)
- Byron Shire Council Biodiversity Conservation Strategy 2020-2030 (BSC, 2020)
- NSW Coastal Quaternary Geological Mapping dataset (Troedson et al., 2016)

Much of the background information presented in these documents are still relevant to managing the estuary in 2024 including information pertaining to the prevailing climate (rainfall, temperature, wind environments), historical river flow records, estuary sedimentation and erosion processes, bed sediment distribution, and estuary hydrodynamics. It is not intended to repeat the information presented in the documents here, except to summarise some of the information that is specifically relevant to the current 2024-2025 assessment of bank and riparian condition.

In this context, the focus of the review will be on identifying existing information relevant to the determination of estuary geomorphic process zones, estuary erosion processes, historic bank erosion mapping, historic riparian vegetation mapping, sediment sources and processes, existing bank protection works, and bank erosion and riparian vegetation management priorities in the Brunswick River estuary.

Where relevant and appropriate, the information presented in this review will be compared to the contemporary bank and riparian condition assessment results in later sections of this report.

Estuary Process Zones

Estuary process zones are a useful way to describe estuarine geomorphic attributes, estuarine character, estuarine sedimentary and erosion processes and to some extent riparian and estuarine vegetation associations occurring in a specific estuary system.

Whilst estuary process zones are not directly identified in any of the reviewed documents, the Brunswick River Estuary Study (MHL, 2002b) and specifically Appendix E – Physical Processes (MHL, 2002a) do provide details on the estuary's recent geomorphological evolution, sediment characteristics, hydrodynamics and processes. Additionally, NSW costal Quaternary geological mapping (Troedson et al, 2016) illustrates the geomorphological history of the estuary including the physical controls on the estuary's form and processes. These datasets can be used to classify the estuary into broad process zones that can assist in explaining the typical processes occurring in the zones, the relative influence of fluvial and tidal processes, within channel sedimentation patterns, relative susceptibility and resilience to erosion, and riparian vegetation associations.

Brunswick River Estuary Processes Study – Physical Processes Appendix E 2002

The Processes Study provides an overview of the recent geomorphological history of the estuary.

In the lower reaches of the estuary, the modern-day estuary channel runs predominantly through Holocene sands and muds, which mix in the lower reaches of the Brunswick and in Marshalls and Simpsons Creeks with older Pleistocene sands (up to 140k years before present) which once formed the coastal barrier systems and shorelines (see *Figure 2*). An active tidal delta occurs in the main arm of the river and in Simpson Creek, with marine derived sands delivered to the estuary via coastal processes. The tidal delta in Marshalls Creek is no longer active having been cut off by the network of training walls (*Figure 3*).

Reworked Pleistocene sands are generally found in the upstream reaches of the tidal delta and on the west bank of Simpsons Creek as these deposits were laid down when sea levels were 5-6m higher than present (see *Figures 2* and *4*). Banks composed of older Pleistocene materials generally demonstrate greater resistance to erosion as they are often high in clay content if estuarine muds are present or indurated if sand is present. Outcrops of coffee rock and other indurated sand deposits are found in several areas, particularly on the southern bank of the mid lower Brunswick and in Simpsons Creek (*Plate 1*).

Holocene sands, deposited in the last 6000 years during a period of sea level relatively similar to present day, occur in the lower reaches of the estuary. Further upstream towards the upstream extent of the tidal delta, quartz sands reworked from the Pleistocene and Holocene deposits mix and heavy shoaling can occur in these locations as tidal currents and ocean conditions fluctuate.

Bedrock outcropping also occurs, most notably around the M1 motorway and Pacific Highway bridge location, but also in Marshalls and Simpsons Creek where ridges intersect the back barrier depression, and also in the upper Brunswick where the channel abuts the valley margin.

Sediment sampling identified the reach just above the island downstream of Midjimbil Creek as the upstream extent of the active tidal delta in the main arm (*Figure 3*). The extent of the tidal delta on Simpsons Creek is less than 1km upstream of the confluence. Accordingly, most of Simpson Creek is dominated by fluvial processes albeit in a relatively low energy environment. The tidal delta on Marshalls Creek has been reduced considerably by the construction of the northern training walls and as a consequence Marshalls Creek is also mostly dominated by fluvial processes.

Plate 1 *Indurated sands or coffee rock outcrops in both Simpsons Creek (top image) and in the main arm of the Brunswick River (lower image).*

Bed sediments in the main arm of the Brunswick River estuary upstream of Kings Creek confluence are dominated by fluvial inputs with coarse sands to fine gravels dominant in sediment samples (*Figures 2* and *5*). The extent of the fluvial delta was determined to be just downstream of the Kings Creek confluence (*Figures 3* and *4*). Kings Creek contains finer sediments with higher organic content, generally reflecting the smaller catchment area of this system and lower stream power and sediment transport capacity than the main arm.

From Kings Creek down to approximately Midjimbil Creek, the estuary channel meanders within what is thought to be a relict back barrier depression. Bank profiles exhibit a distinct lower horizon of at times mottled clays overlain by more recent alluvial deposits.

Peak tidal velocities in the mid sections of the river are estimated at 0.5-0.6m/s, compared to 1.8m/s at the entrance. Velocities decrease rapidly up Marshalls and Simpsons Creeks. During flood events flow velocities can exceed 2m/s in the mid section of the estuary and exceed 3m/s at the entrance. Floods therefore are capable of transporting large volumes of bedload sediments and creating significant scour throughout the estuary although differing channel configurations in different parts of the estuary means that erosion is not uniform. Fine sediment is transported through the lower estuary offshore by flood flows or deposited preferentially on the channel margins on low flood benches and channel levees.

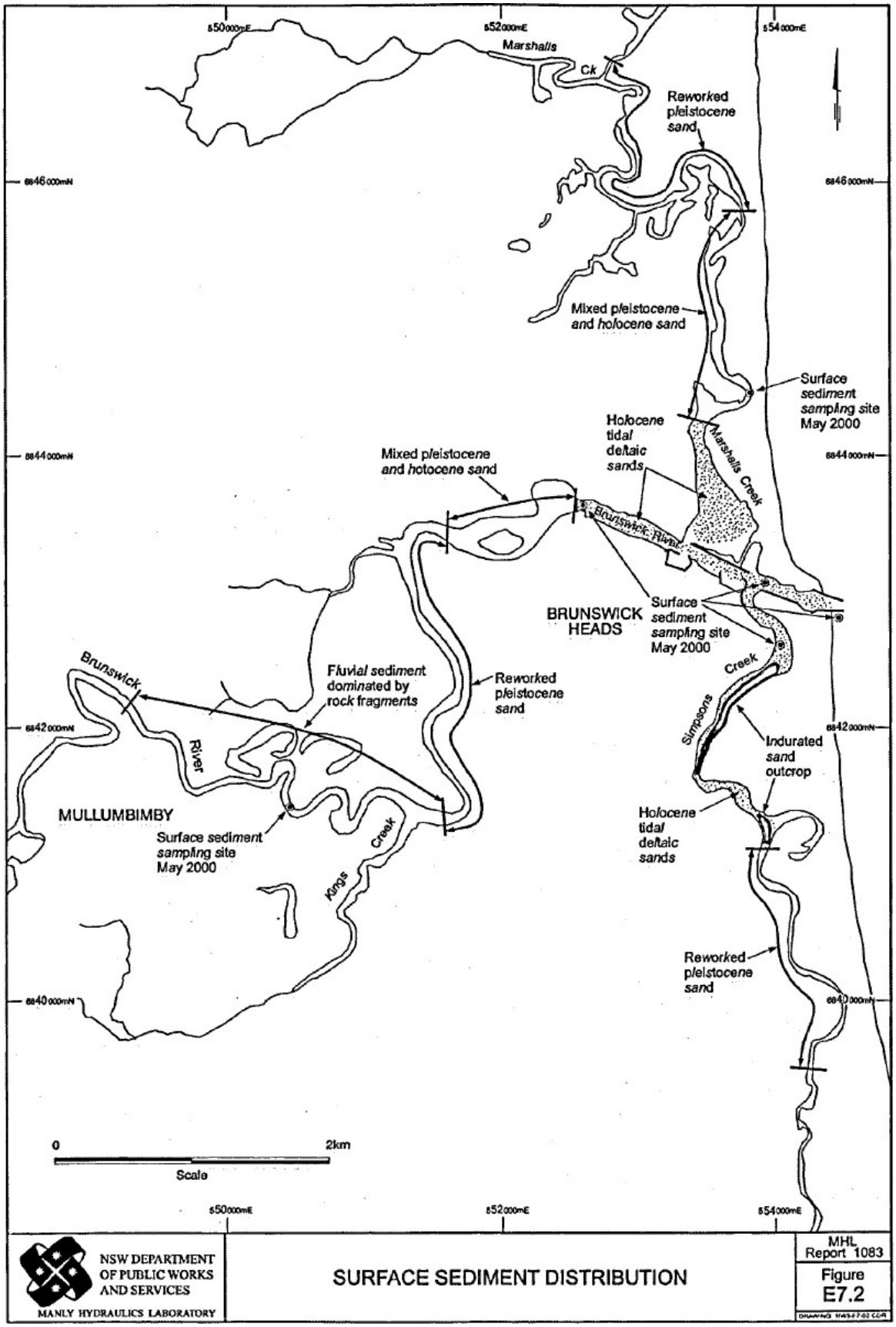

Figure 2 Figure E7.2 from the Estuary Process Study showing sediment distribution within the Brunswick River estuary (Source: MHL, 2002a).

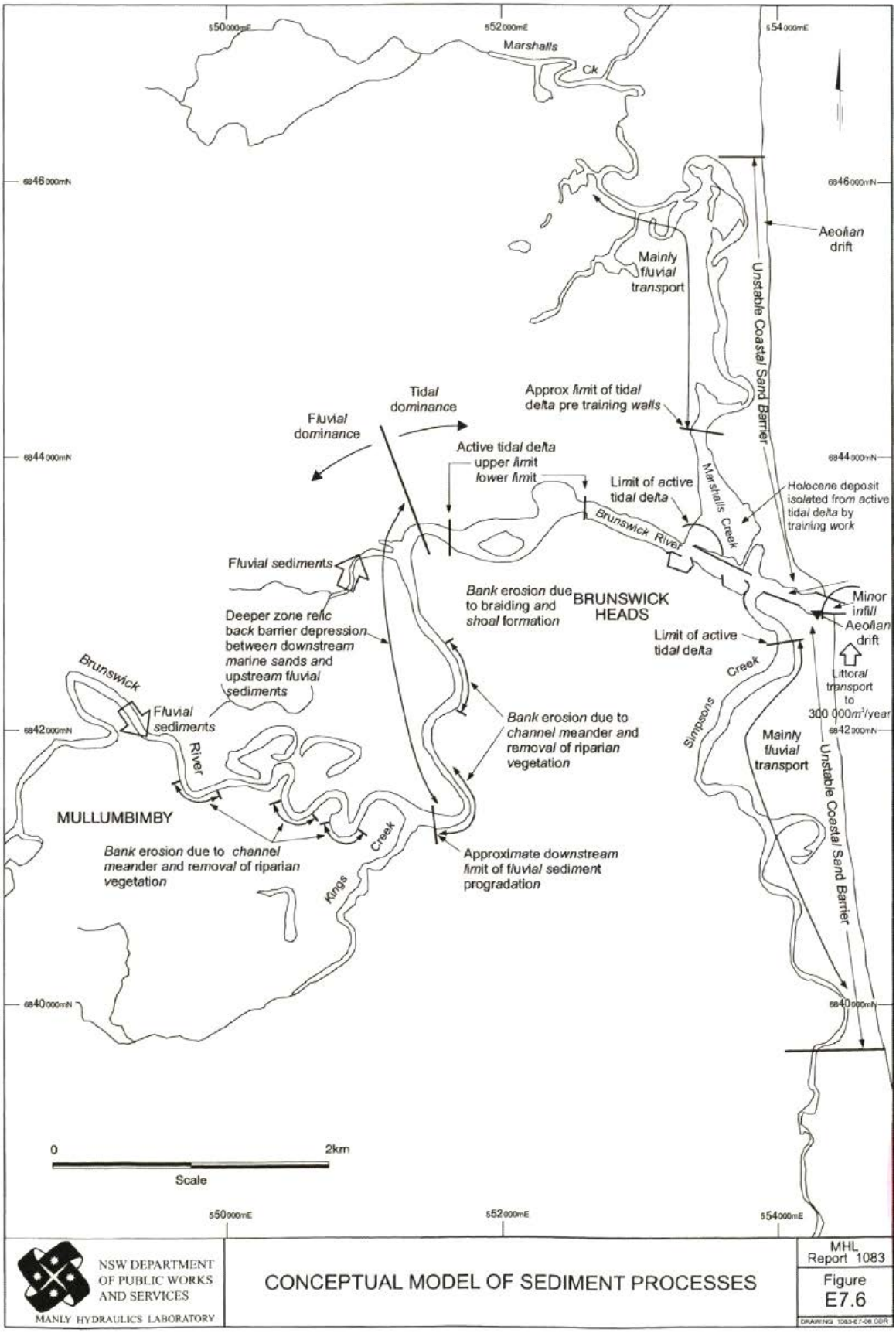

Figure 3 Figure E7.6 from the Estuary Process Study showing a conceptual model of sediment processes in the Brunswick River estuary in 1999 (Source: MHL, 2002b).

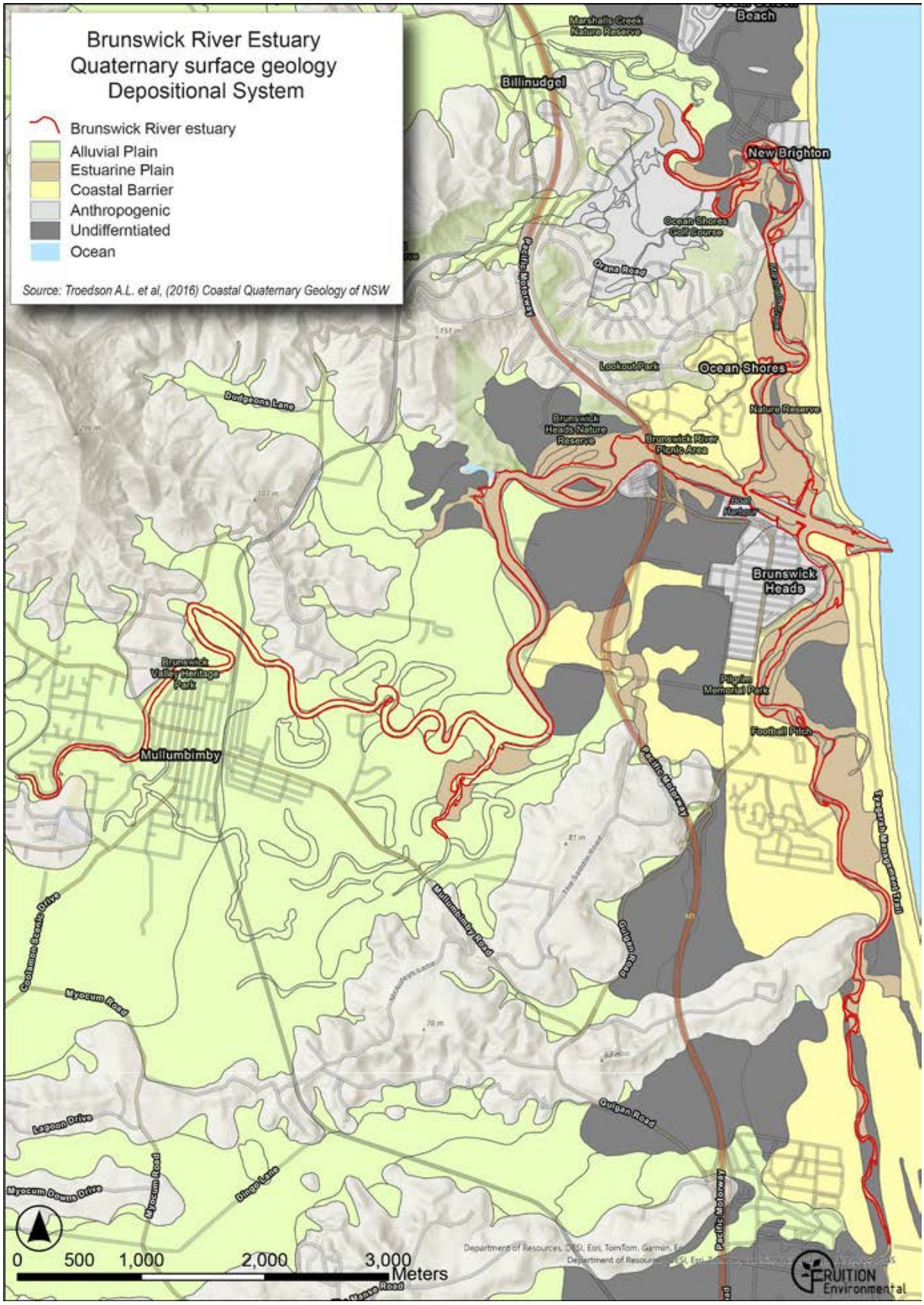

Figure 4 Coastal Quaternary geology mapping indicating the deposition system for the study area (Data source: Troedson et al., Geological Survey of NSW, 2016).

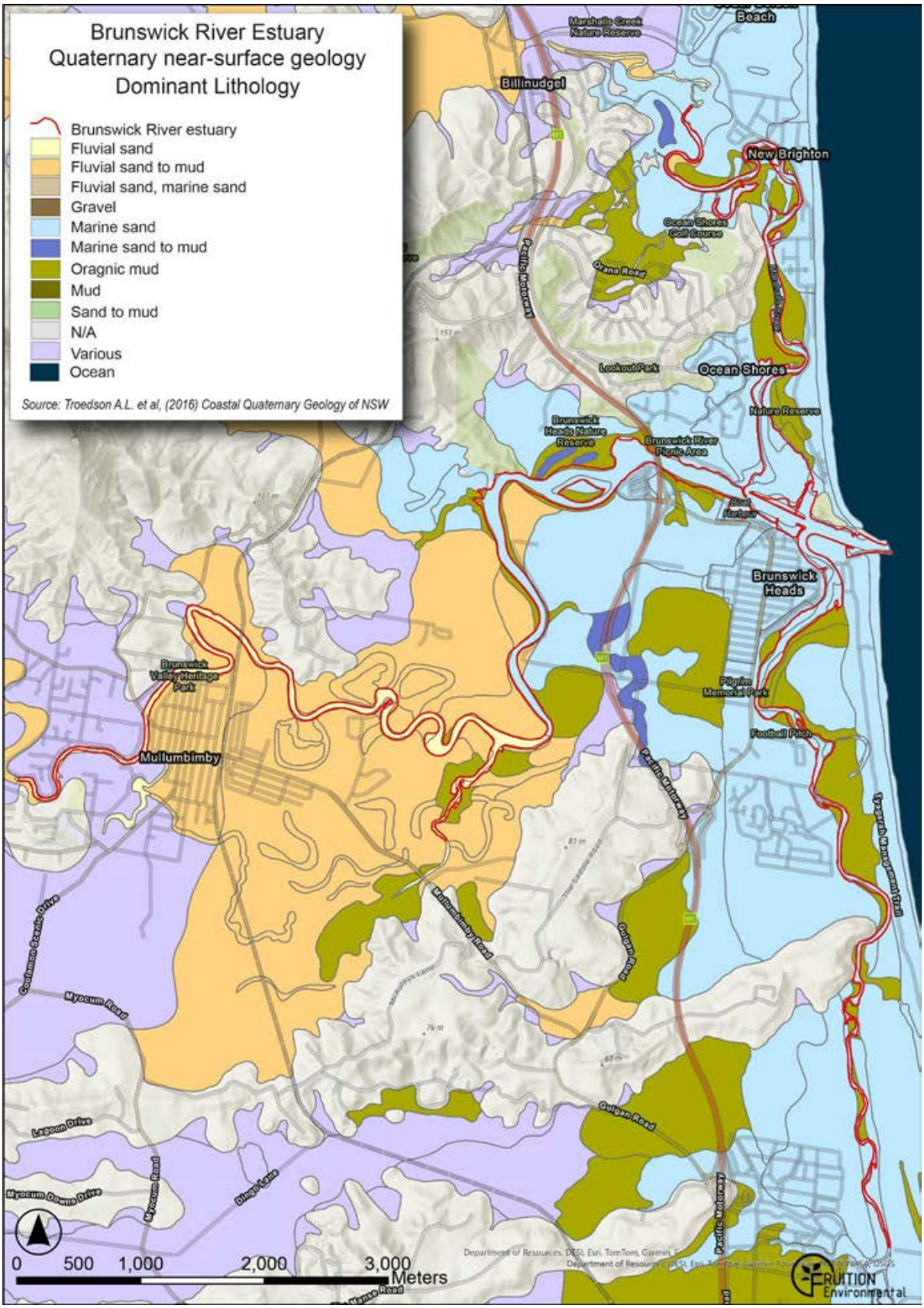

Figure 5 Coastal Quaternary geology mapping indicating the near-surface dominant lithology for the study area (Data source: Troedson et al., Geological Survey of NSW, 2016).

Estuary Bank Erosion Mapping and Estuary Bank Erosion Processes

Several studies of erosion in the Brunswick River Estuary have been undertaken over the last 30 years that have incorporated estuary bank erosion mapping and discussion of processes. The most recent and relevant of these studies are the "citizen science" bank erosion surveys undertaken by the Positive Change for Marine Life (PCFML) organisation under their Brunswick River Warriors program, which included simple assessments of bank stability both pre and post the major flooding events which occurred in March-April 2022.

Other studies that have focussed on bank erosion distribution and to a limited extent the bank erosion processes occurring in the estuary are the 2020 validation of the MEMS funded Decision Support Tool for Bank Erosion Management in NSW Estuaries undertaken by Hydrosphere Consulting, the 2017 site survey and audit for the Coastal Zone Management Plan for the Brunswick estuary (BSC, 2018), the Northern Rivers Riverstyles® Assessment (2012), and the 2002 bank erosion assessments which formed part of the Estuary Processes Study (MHL, 2002a). Where mapping of bank erosion has been presented, it has been undertaken for a range of reasons and different methods for assessing and describing bank erosion have been used.

Positive Change for Marine Life – bank erosion surveys 2021 and 2022

PCFML conducted kayak-based surveys to map bank erosion in the Brunswick River estuary main arm from Mullumbimby to Brunswick Heads in 2021 and 2022. The 2022 survey was conducted post the major flooding which occurred in the Northern Rivers area in March/April 2022.

The survey classified estuary banks into three categories of stability with data compiled into an ArcGIS database and StoryMap:

- Stable: well vegetated or stable with gentle slopes and intact banks.
- Unstable: some signs of erosion and lack of stability
- High risk: slumping or undercut banks, trees collapsing into water, minimal vegetation or very steep banks.

The report identifies boat wash, increased catchment inflows, riparian vegetation clearing, livestock access and the impacts of invasive weeds such as camphor laurel as contributing to bank instability generally. The relative effect of these impacts at any specific site is not reported although cattle access was mapped at two locations within the study area (Figure 14 in the PCFML report).

The data is viewable through the Brunswick River Warriors StoryMap at https://storymaps.arcgis.com/stories/659fe5585635418b9e9e76e54a353326 and is reproduced in *Figure 6* (2021 data) and *Figure 7* (2022 data).

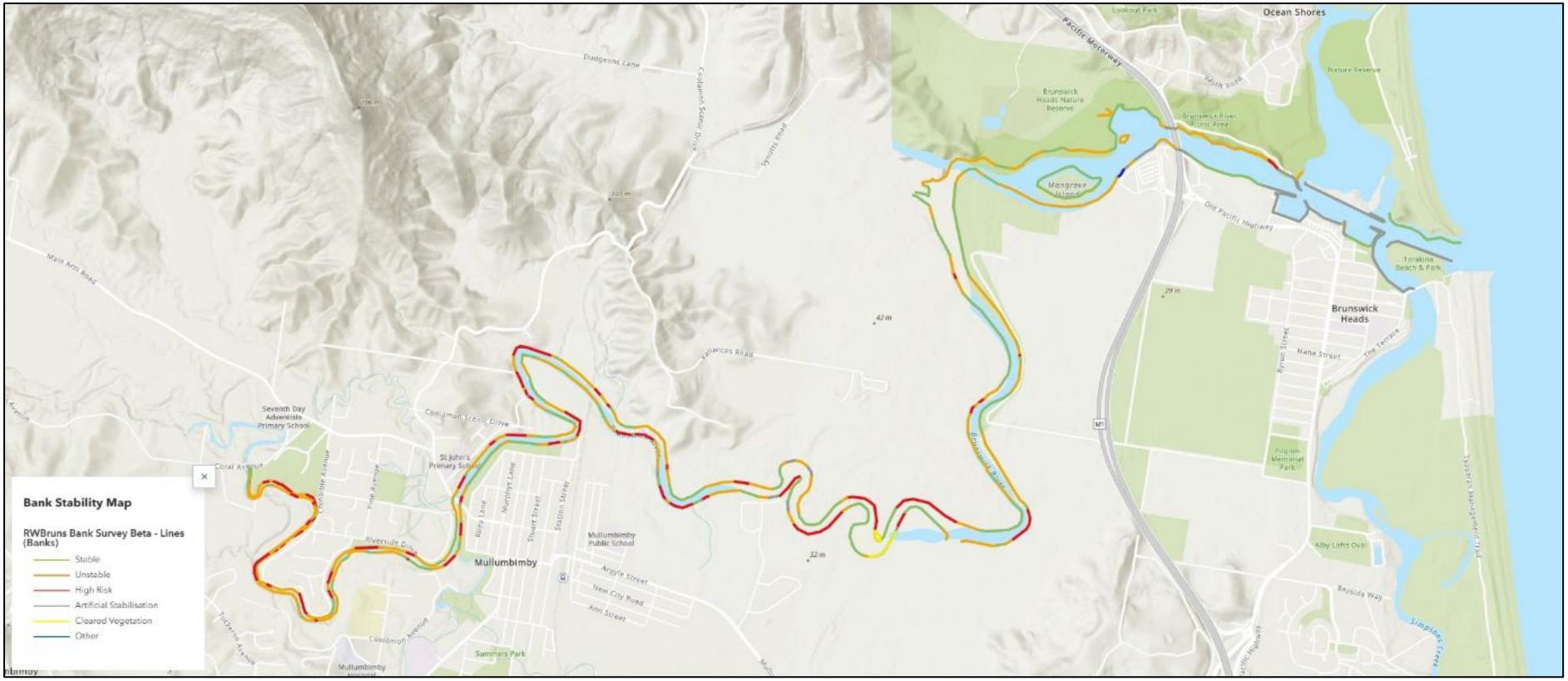

Figure 6 *Bank stability mapping undertaken by Positive Change for Marine Life's Brunswick River Warrior program in 2021 (Source: Positive Change for Marine Life: https://storymaps.arcgis.com/stories/659fe5585635418b9e9e76e54a353326M accessed 14 August 2024).*

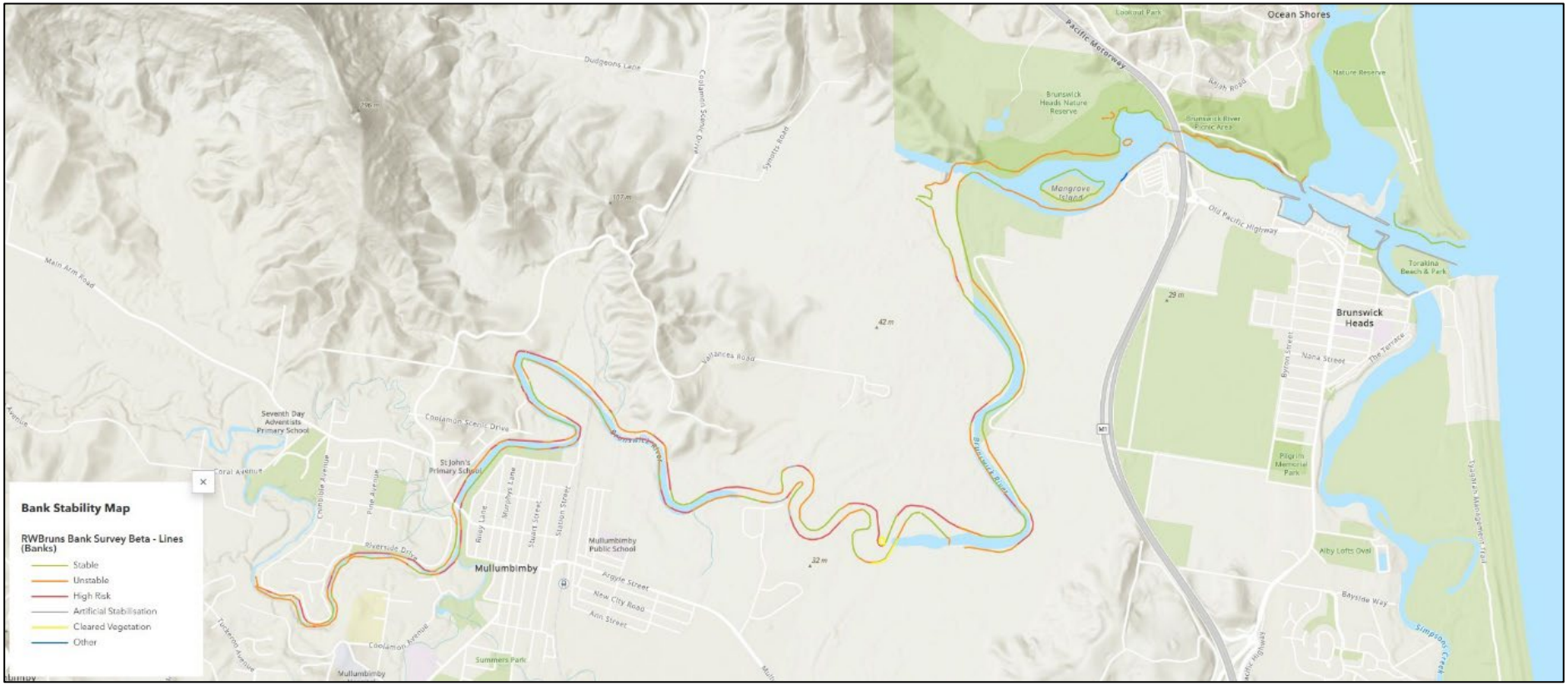

Figure 7 *Bank stability mapping undertaken by Positive Change for Marine Life's Brunswick River Warrior program in 2022 (Source: Positive Change for Marine Life: https://storymaps.arcgis.com/stories/659fe5585635418b9e9e76e54a353326M accessed 14 August 2024).*

DRAFT DST for Bank Erosion Management field testing – Hydrosphere 2020

The Decision Support Tool (DST) for Bank Erosion Management in NSW estuaries (Hydrosphere, 2020) was field tested for validation purposes in the Brunswick River estuary in 2020.

The Brunswick River from the entrance to Mullumbimby, Marshalls Creek and Simpsons Creek were all surveyed using the draft methodology.

The field data was transferred into an ArcGIS database and a series of maps produced showing Environmental Impact Ratings and Primary DST recommendations for each reach surveyed. The GIS dataset included all the DST criteria used in the draft methodology including erosion severity, estimated future trajectory, impact ratings, and likely causal factors of erosion. Reach photography was also collected during the DST survey but was not available to review at the time of writing this report.

Figure 8 shows the erosion severity attributed to each survey segment in 2020.

The data provides a useful baseline for the pre 2022 floods which impacted much of the Northern Rivers area including the Brunswick River estuary. The data uses a different collection methodology to that used by the PCFML survey, which also included post 2022 flood surveys, but used a much simpler assessment method and different erosion categories and only assessed the Brunswick River main arm. For this reason, the Hydrosphere DST data is considered a more analogous dataset to the data collected under the NEAP 2024 assessment as the NEAP project was required to be DST compatible and therefore has collected many of the same criteria.

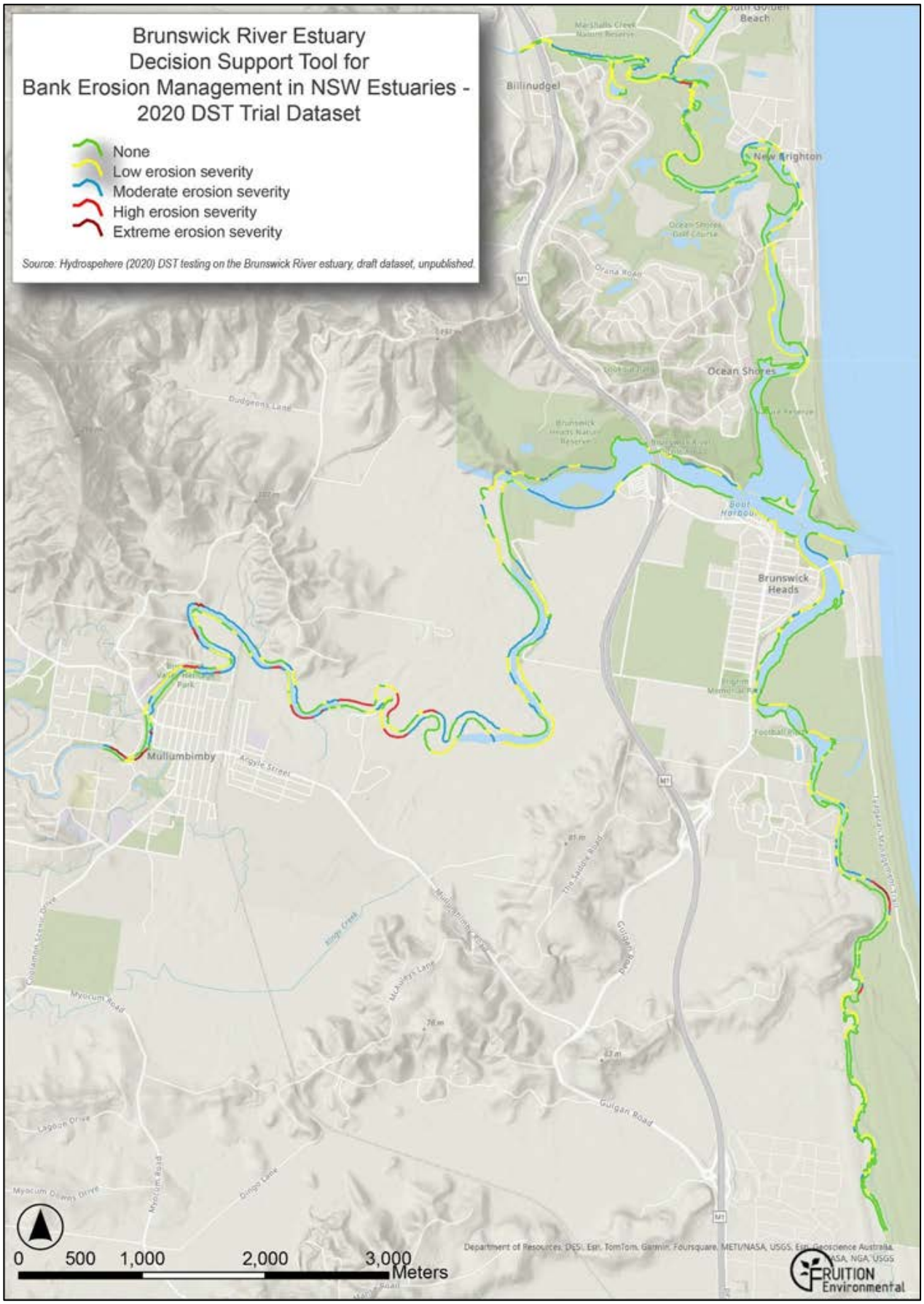

Figure 8 *Draft mapping of bank erosion severity in 2020 undertaken by Hydrosphere Consulting during field validation of the MEMS funded DST for estuary bank erosion management project (Data source: Hydrosphere, 2020, unpublished data provided by NSW DPIRD Fisheries).*

Site Survey and Audit update for the Coastal Zone Management Plan for the Brunswick Estuary 2017

A field survey of erosion sites on the Brunswick River, Simpsons Creek, and Marshalls Creek estuaries was undertaken by Byron Shire Council and then Office of Environment and Heritage in January 2017.

The purpose of the survey was to update the CZMP which due to delays in certification was considered potentially to be based on outdated datasets (C.Dowsett, pers.comm. 14 August, 2024). Unfortunately, the CZMP has never been certified and hence does not carry any statutory weight. It does however provide useful background information and a thorough overview of sites flagged for remediation/retoration.

Sites previously identified in the Estuary Processes Study (MHL, 2002a: see below) were reviewed and several new sites were identified. Sites of erosion were recorded and given a Site ID reference. A bank erosion and stability rating was attributed based on a 1- 5 scale where:

> ***1*** - Extensive or almost continuous erosion. Over 50% banks have some form of erosion; very unstable with little vegetation cover.
>
> ***2*** - Significant active erosion evident especially during high flows. Unstable excessive areas of bare banks, little vegetation cover.
>
> ***3*** - Localised erosion. Relatively good vegetation cover. No continuous damages to bank structure or vegetation.
>
> ***4*** - Only spot erosion, little undercutting of bank, good vegetation cover, usually gentle bank slopes, no significant change to bank structure.
>
> ***5*** - Stable: no erosion or sedimentation evident. No undercutting of banks, usually gentle bank slopes, and lower banks covered with root mat, grasses, reeds or shrubs.

Observations of the scale and likely processes and contributing factors at each site were also noted.

The results of the survey are presented in Appendix B of the CZMP (Byron Shire Council, 2018). *Figure 9* (overleaf) shows the distribution of the identified erosion sites as presented in that document. Table B4 in the report provides the ratings and additional information including management actions and priorities.

Riverstyles® Assessment 2011

Alluvium Consulting was engaged by Northern Rivers Local Land Services to undertake a Riverstyles® assessment and mapping in the Northern Rivers CMA region (reported in Alluvium, 2012). The Alluvium assessment describes the entire Brunswick River estuary study reach as a Tidal Laterally Unconfined Continuous Channel. The entire estuary is described as being in either Poor or Moderate geomorphic condition, with moderate recovery potential. There are no reasons for the classification or specific management implications provided and so the ratings have limited practical management application.

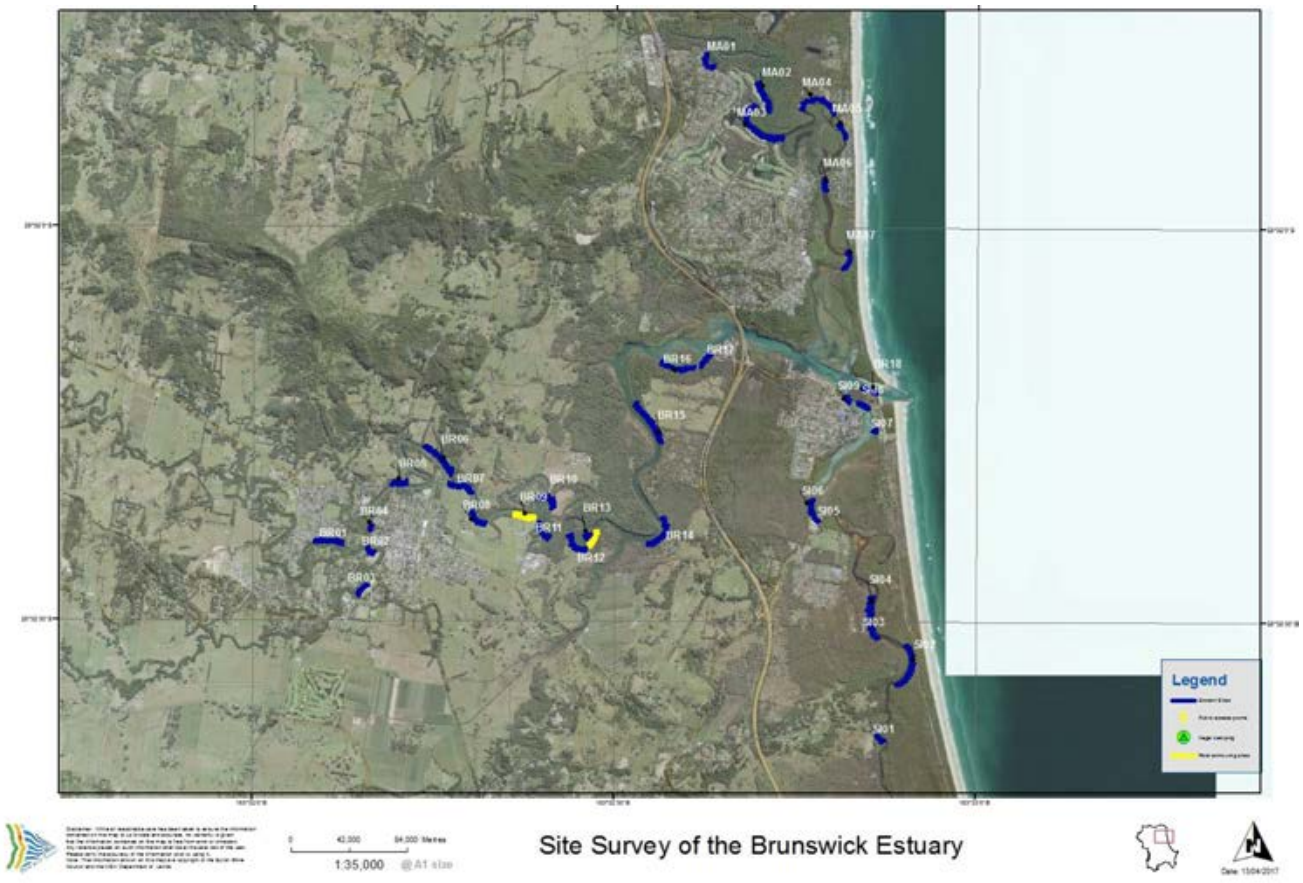

Figure 9 *Locations of bank erosion (blue) and rock revetment (yellow) identified in the CZMP site survey and audit update in February 2017 (Source: BSC, 2018).*

Brunswick Estuary Processes Study Appendix E – Sedimentation and bank erosion MHL 2002a

Estuary bank stability was assessed in May 2000 as part of investigations undertaken in the Brunswick River Estuary Process study (MHL, 2002a). The area of survey was the Brunswick River from the entrance to Mullumbimby, and Marshalls Creek to approximately 1km south of Ocean Shores, with limited spot checks of Simpsons Creek. Earlier records of bank erosion from an inspection undertaken in 1992 by Public Works were incorporated into the assessment.

There was no categorisation of the scale or severity of the bank erosion undertaken, only the presence/absence of erosion was noted with some site photographs provided. Similarly, site specific processes were generally not identified. However, the assessment identified that bank erosion was concentrated between the then Pacific Highway bridge and Mullumbimby occurring mostly on the south bank at bends, suggesting meander migration as the primary erosion process. Clearing of bank vegetation was also identified as a contributing factor, particularly where the bank toe was undermined.

Erosion in the Brunswick adjacent to the prominent islands upstream of the highway bridge was attributed to “channel braiding and island development” with the undercutting of mature growth trees provided as evidence.

Figure 10 shows the locations of erosion mapped during the processes study (MHL, 2002a).

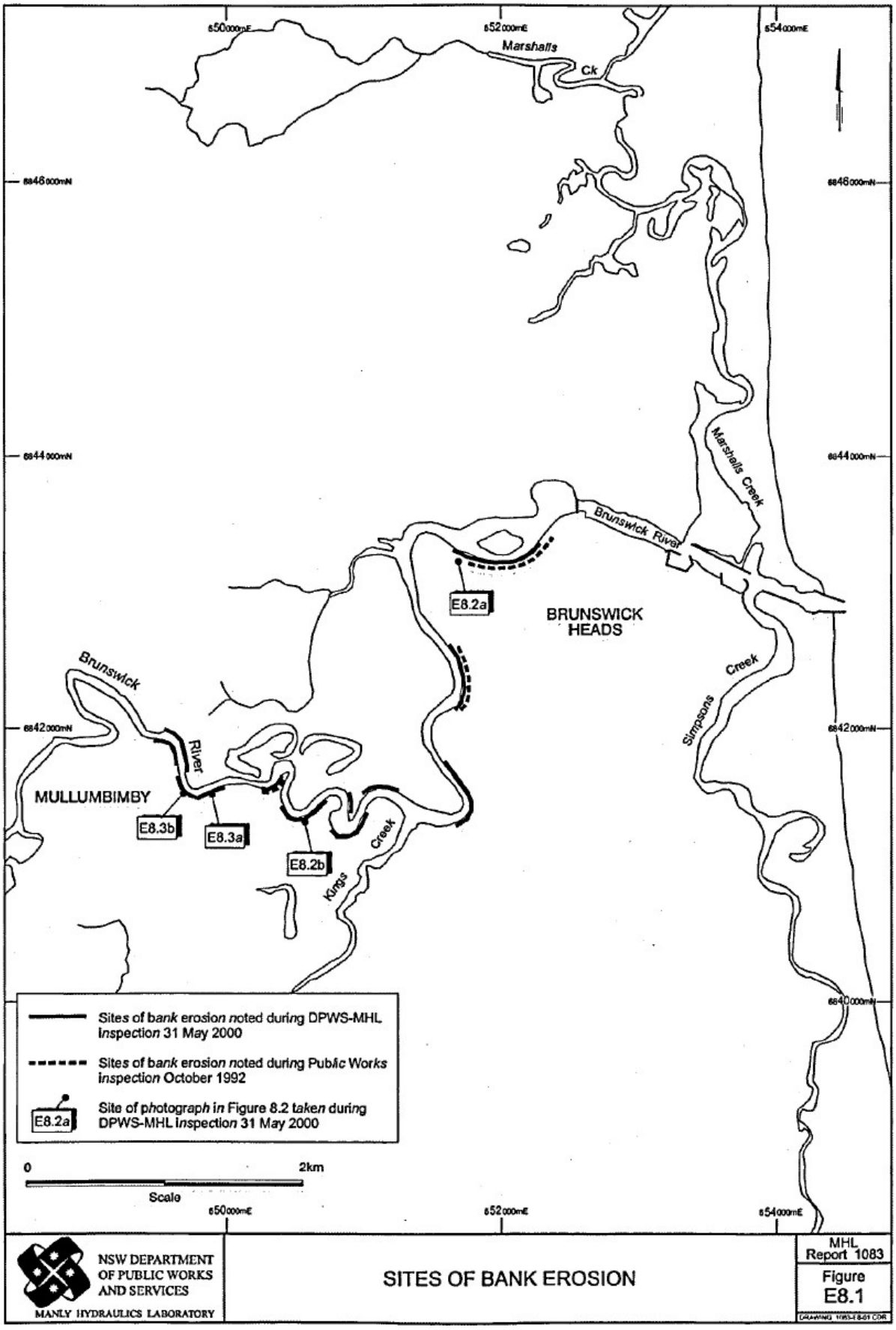

Figure 10 Sites of bank erosion recorded during the MHL bank erosion assessment (2000) and previous Public Works (1992) assessments (Source: MHL, 2002a).

Riparian Vegetation Condition Mapping

There has been no comprehensive mapping of riparian vegetation condition undertaken for the Brunswick River Estuary study area. Nevertheless, the following documents contain some information on the distribution, composition and condition of riparian vegetation within the study area.

Byron LGA Vegetation 2023

This GIS dataset contains the most comprehensive vegetation mapping for the Byron Shire Council Area, current as of 2023. The dataset does not directly differentiate vegetation communities into riparian vegetation types but shows vegetation occurring adjacent to waterways and in some cases estuarine macrophytes also. Additionally, Endangered Ecological Communities have been derived from the dataset and so candidate EEC vegetation can be displayed. The dataset does not contain explicit vegetation condition criteria.

DRAFT DST for Bank Erosion Management field testing – Hydrosphere 2000

Data collected during the field validation of the DST methodology in the Brunswick estuary in 2020 included limited riparian vegetation criteria. These criteria include average riparian width for each reach surveyed and the degree of continuity of vegetated cover in the riparian zone. The data were determined using both desktop and field assessment. The data covers the entire Brunswick River, Simpsons Creek and Marshalls Creek estuaries.

The primary purpose of collecting the riparian vegetation width and continuity data in the DST is to determine whether management actions are required to improve riparian vegetation as a method of improving estuary bank stability and resilience. Where average riparian width for any reach is recorded as less than 10m, the DST will automatically recommend riparian vegetation management.

Whilst not a riparian vegetation condition dataset, the data does provide some limited information on riparian characteristics that may infer riparian condition. For example, areas of estuary bank that record vegetation widths less than 2m and low to negligible continuity are likely to be in very poor to poor overall condition.

Site Survey and Audit update for the Coastal Zone Management Plan for the Brunswick Estuary 2017

In combination with the field survey of bank erosion and stability undertaken to update the draft CZMP for the Brunswick Estuary, riparian vegetation condition was also recorded wherever bank erosion was recorded. The sites where these assessments occurred are those shown in *Figure 9* above.

The dataset can broadly be described as being locations where riparian vegetation condition has been recorded due to the presence of bank erosion and as such it is not a comprehensive assessment of riparian vegetation condition as it is necessarily directed towards already impacted or degraded sites.

The riparian vegetation condition categories used were:

> ***Very Poor*** - Introduced ground cover with lots of bare ground, occasional tree. Also includes sites with concrete-lined channels.
>
> ***Poor*** - Introduced ground cover, little native under- or over- storey. Mainly introduced vegetation.
>
> ***Fair*** - Medium cover, mixed native and introduced or one side cleared and one side undisturbed.

Good - Mainly native vegetation. Little disturbance or no signs of recent disturbance.

Very Good - Mainly undisturbed native vegetation. Little signs of alteration.

Again, the results of the survey are presented in Appendix B of the CZMP (BSC, 2018) with Table B4 in that report documenting the riparian vegetation condition rating for each site.

Positive Change for Marine Life – Invasive weed mapping 2022

PCFML mapped invasive weed species during the 2021 survey of the main arm of the Brunswick River and combined this information with existing weed mapping to produce a map of locations of invasive species along the Brunswick River estuary. Additionally, a citizen science project which allows community members to log sitings of weeds on the river through a mobile phone accessible collector application was created. The data is viewable through the Brunswick River Warriors StoryMap at https://storymaps.arcgis.com/stories/659fe5585635418b9e9e76e54a353326

Brunswick Estuary Processes Study Appendix F – Ecological Processes MHL 2002a

"Appendix F2 – Flora and Fauna", undertaken by Peter Parker Environmental Consultants Pty Ltd in June 2001, and "Appendix F4 – Ecological Health" by Peter Nelson, are included in the Brunswick Estuary Processes Study (MHL, 2002a). Neither report includes any specific mapping of riparian vegetation and only broadly characterises the vegetation types in the catchment with some general observations on localised areas of mangrove recruitment, the importance of riparian vegetation generally, and weed invasion in specific vegetation communities.

The flora and fauna report noted that significant proportions of the original floodplain forest have been cleared with remnants now confined to narrow strips along waterways. These strips generally contain large proportions of exotic weeds including Camphor laurel (*Cinnamomum camphora*), Large leaved privet (Ligustrum lucidum), Small-leaved privet (*Ligustrum sinense*) Lantana (*Lantana camara*), ground asparagus fern (Protasparagus aethiopicus), climbing asparagus fern (*Protasparagus africanus*), Glory lily (*Lilium formosanum*), coastal morning glory (*Ipomea cairica*), and common morning glory (*Ipomea purpurea*). This study recommended increasing riparian buffer widths but notes that liaison between landowners and Council or community groups will be required as most riparian land is privately owned.

The ecological health report (Nelson, 2001) generally describes the available habitats in the estuary including riparian zone vegetation making similar observations to the flora and fauna report. Further monitoring is recommended although no specific recommendations are made with respect to riparian vegetation.

Existing Bank Protection Works

There is some limited information in the existing literature detailing the extent and range of bank protection works within the estuary.

The most extensive dataset is included in the 2020 DST validation dataset (Hydrosphere, unpublished, 2020) which provides the location of reaches that include bank protection works in the Brunswick River, Simpsons Creek, and Marshalls Creek estuaries. Data includes the types of works and their assessed effectiveness in controlling site erosion. *Figure 11* shows the location and types of works mapped.

Additionally, the Brunswick River Estuary CZMP (BSC, 2018) contains some limited mapping of the location of rock protection works at sites surveyed during the CZMP audit in 2017 (see *Figure 9* earlier in this report). More detail is provided in the individual descriptions of the sites identified during the site survey and audit, which may provide a benchmark for comparison to the 2024 NEAP assessment of existing works.

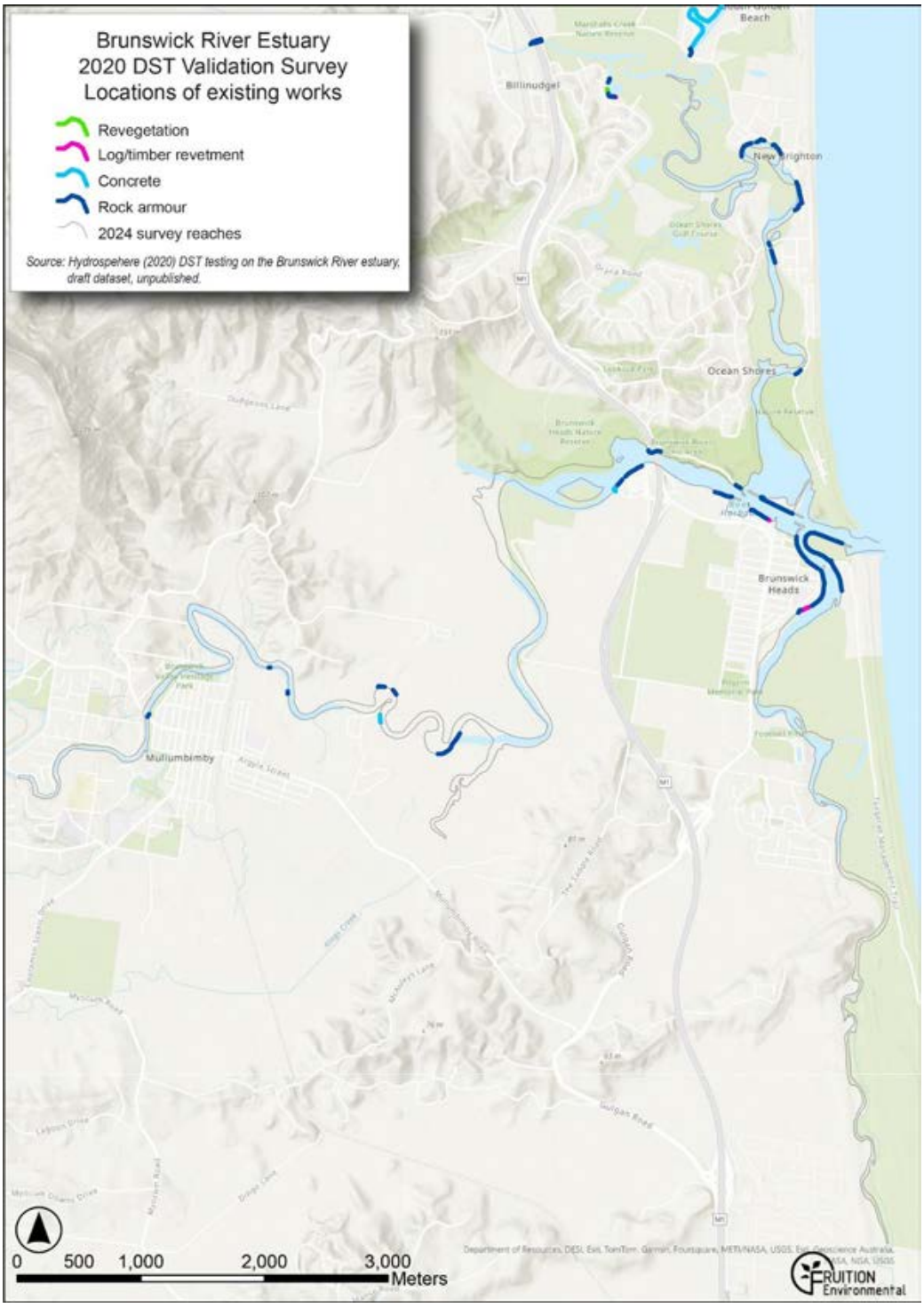

Figure 11 *Sites of existing bank protection works recorded during the mapping of bank erosion severity in 2020 undertaken by Hydrosphere Consulting during field validation of the MEMS funded DST for estuary bank erosion management project (Data source: Hydrosphere, 2020, unpublished data provided by NSW DPIRD Fisheries).*

Bank Erosion and Riparian Vegetation Management Priorities

The main document which contains recommendations and priorities for the future management and protection of estuary banks and estuary bank vegetation in the study area is the Brunswick River Estuary CZMP (BSC, 2018). The CZMP was never formally certified due to changes in legislative requirements for coastal management plans and delays in approvals by the State Government (C.Dowsett, pers comm., 14 August 2024). Nevertheless, the document has continued to be used by Council and others to prioritise management actions in the estuary and many of the recommendations and actions are still relevant. These include:

- Various specific on-ground works actions including Priority 1 Strategies such as repairing reaches of failing rock wall on Simpsons Creek; bank stabilisation and revegetation adjacent to Casons Road on Marshalls Creek; repairing a number of existing works sites on Marshalls Creek; monitoring a number of erosion sites on the Brunswick River.
- Strategy R1: Lobby for a review of vessel speed limits within the Brunswick River and Marshalls Creek
- Strategy R2: Addressing illegal rock armouring in the estuary
- Strategy R4: Address encroachment of built structures and clearing of riparian vegetation at areas adjacent to the estuary
- Strategy G4: Map and eradicate weed infestations by survey. Education and weed management programs
- Strategy E4: Educate the community on the impacts of human activities on estuary processes

In addition to the CZMP, the Byron Shire Council Biodiversity Conservation Strategy 2020-2030 (BSC, 2020) also contains objectives and actions relevant to the Brunswick River estuary, particularly in relation to riparian vegetation and habitats. These include:

- **Objective 1.3** which aims to have Council using current best practice desktop tools to support and facilitate High Ecological Value (HEV) landscape and habitat protection including by:
    - *Action 1.10* Developing a priority restoration investment map that identifies key sites on private and public land requiring either protection or restoration, to assist in directing future Council and community restoration activities.
- **Objective 1.4** which aims to ensure biodiversity conservation and management principles are better integrated into Council's day-to-day operations including by:
    - *Action 1.30* Continuing development of Coastal Management Programs for the Shire's coastline and estuaries, ensuring CMPs are consistent with the intent of this Biodiversity Strategy.
- **Objective 1.5** which aims to secure additional funding to support biodiversity projects including by
    - Action 1.33 Incorporating relevant elements of this strategy (e.g. relating to coastal wetlands, littoral rainforest) into Council's Coastal Management Programs, to increase potential for funding support through the State Government Coastal and Estuary Grants Program.

- **Objective 4.8** which aims to encourage and provide direct and in principle support to Landcare, Primary Industry groups and individual landholders to implement best practice natural resource management along the waterways of the Brunswick and Wilsons River catchments including through:
    - Action 4.29 Continuing to develop and implement 'Bringing back the Bruns' branded projects to address improvements in riparian and instream habitat, water quality, fish passage and habitat connectivity on Council and private land along the Brunswick River and its tributaries.

The strategies and actions contained within these two documents will be used later in Part 5 of this report to assist in the ranking and prioritising sites.

Existing and Derived GIS Datasets used in this Assessment

Existing spatial datasets

The following existing spatial datasets have been used in this assessment:

- *NSW Crown Lands Parcels* accessed via the NSW Spatial Data portal at https://www.spatial.nsw.gov.au/products_and_services/spatial_data which allowed for the identification of Crown owned land during the field survey and later during the priority setting process
- *NSW State Forest Parcels*, *NSW National Parks Estate Parcels, and Local Government Authority areas* accessed via the NSW Spatial Data portal at https://www.spatial.nsw.gov.au/products_and_services/spatial_data which was used during the field survey and later during the priority setting process
- *Council Owned Land Parcels* and Council Managed Land Parcels accessed under licence from Byron Shire Council which allowed for the identification of Council owned land during the field survey and later during the priority setting process
- *SEPP (Resilience and Hazards) 2021 Coastal Wetland Area, Coastal Wetland Proximity Area, Littoral Rainforest Area, and Littoral Rainforest Proximity Area* mapping accessed via the Seed Portal at https://www.seed.nsw.gov.au which was used as one of a variety of criteria which informed the determination of priorities for action relevant to the Coastal Management Act 2016
- *Estuarine Macrophytes* accessed via the Seed Portal at https://www.seed.nsw.gov.au which was used during the priority setting process
- *Aquaculture Lease Areas, Priority Oyster Aquaculture Area* and *NSW Oyster Reefs* datasets accessed via the NSW DPIRD Fisheries portal at https://www.dpi.nsw.gov.au/fishing/fisheries-research/spatial-data-portal which was utilised during the field survey and later during the priority setting process
- *Byron Shire Council 2023 Vegetation* mapping dataset including candidate NSW Endangered Ecological Communities mapping accessed under licence from Byron Shire Council which allowed for the identification of areas of high ecological value (HEV) vegetation during the field survey and also informed the priority setting process for riparian management actions.
- *Draft 2020 DST Validation survey dataset for the Brunswick River* created by Hydrosphere Consulting, provided by NSW Department of Primary Industries and Regional Development – Fisheries which was utilised in the literature review section of this report

Spatial datasets derived from existing sources for the field survey

The following spatial datasets were created to facilitate the field survey component of this assessment:

- *Brunswick River Estuary Bank Reference Layer* was onscreen digitised at 1:2000 scale off June 2024 Nearmap® imagery accessed via subscription. This line feature allowed for increased accuracy of the mapping with field surveyed reaches “snapped” to the current 2024 bank location.

Community, Industry and Stakeholder Consultation

A targeted community consultation process was undertaken to assist in identifying bank and riparian issues affecting the estuary from an industry and recreational use viewpoint. The consultation was undertaken by telephone interview, targeting estuary users and land managers identified by early-stage consultation with local and state government stakeholders, during the interviews themselves and through online research. The consultation was supplemented by conversations with estuary users during the field mapping exercise.

The early-stage consultations with Byron Shire Council identified a number of community groups that were operating in partnership with Council under the Bringing back the Bruns initiative, including Brunswick Valley Landcare and Positive Change for Marine Life. These groups were interviewed during the targeted stakeholder consultation but also were subsequently involved in reviewing the field dataset and the prioritisation system used in Part 5 of this Report.

Interviews were undertaken with the following individuals/organisations with summaries of the comments made in the interviews provided below:

- Noah Baggaley of Brunswick Seed Oysters.
- Jonathon Wilcock of Marine Rescue.
- Alison Ratcliffe of Brunswick Valley Landcare.
- Dane Marx of Positive Change for Marine Life

Some other members of the community were contacted but either did not wish to comment or were not able to respond to calls or emails.

Department of Transport Maritime was also contacted for comment but declined to participate in the consultation process or comment on issues surrounding recreational boating in the estuary.

Oyster Industry Comments

Noah Baggaley from Brunswick Seed Oysters was interviewed by telephone to gain an appreciation of the oyster industry's views of bank erosion and riparian management issues in the Brunswick River estuary area. Brunswick Seed Oysters have active oyster leases and an oyster shed in Readings Bay near the upstream confluence of Marshall's Creek and the Brunswick River and has been operating in the estuary for over 40 years. They also have leases in the main channel of the Brunswick River but these are currently not active. Their use of the Brunswick River is mostly for spat collection and as a nursery area for oysters.

Noah doesn't feel that riverbank erosion or riparian condition is currently impacting oyster farming on the estuary. He says he doesn't often travel far upstream. He did identify the National Parks Road that runs along the northern bank of the Brunswick River upstream of Marshall's Creek as having partially collapsed during recent flooding.

Figure 12 shows the area identified by Noah Baggaley. It was assessed during the filed survey to determine the severity of any bank erosion present and likely processes operating.

Marine Rescue Comments

Unit Commander Jonathon Wilcock from Marine Rescue was interviewed via telephone to record his perspective on bank erosion issues in the Brunswick River estuary. Marine Rescue have a wharf and pontoon in the harbour and are on the river doing safety and rescues regularly.

Jonathon felt that tidal movements are a major safety issue for unpowered craft (and powered craft broken down). He feels that riverbank erosion is not contributing significantly to boating safety on the Brunswick. With respect to erosion and riverbank condition, Jonathon mentioned:

- The rock wall collapse (worsening since 2022) between Torakina Beach and Simpsons Ck is a big boating safety issue because it is on the channel side of the river and is an area with heavy boating use but also lots of swimming and snorkelling use.
- Other areas of notable erosion include downstream of the Rugby Club, Downstream of Federation Bridge (left/northern bank) and around grassy areas where the river enters the series of tight bends downstream of Mullumbimby (including the 'Mills Property').
- Boating use contributes to erosion in the lower reach from Ferry Reserve downstream, especially on the beaches around Macy Green Reserve where lots of users pull up to the banks.

Jonathon also identified that riverbank condition and shoaling is constantly changing and mentioned that there is a lot of sand buildup in the lower reach of the estuary between the entrance and highway bridge currently.

Figure 12 shows the areas identified by Jonathon. They were all assessed during the filed survey to determine the severity of any bank erosion present and likely processes operating.

Brunswick Valley Landcare

Alison Ratcliffe from the Brunswick Valley Landcare (BVL) was interviewed to gain an appreciation of BVL's activities around the Brunswick River Estuary and their understanding of current bank erosion and riparian vegetation management issues.

Alison feels like most of the erosion and riparian veg issues on the Brunswick system are in the freshwater reaches. Simpsons and Marshalls Creeks are in pretty good condition along most of the estuarine reaches. The main arm has some issues with erosion and riparian vegetation condition. These are mostly associated with 3 properties, 2 large grazing properties and one cane farm located between the rugby club the Kings Creek confluence on the southern shoreline. These potentially contribute to water quality issues downstream.

She identified another property but it has had recent works undertaken by LLS to repair the bank. Council have done extensive rehabilitation around the STP, which now has an adequate riparian buffer. Some of these works were reportedly damaged during recent flooding.

On Marshalls Creek, the reach opposite the New Brighton shop and around to Casons Road has been identified as a problem area. Previous attempts have been made to control erosion in this area including installation of coir logs, revegetation and rock armouring. Waves from boats are reportedly a contributing factor in this area despite the shallow channel. This Council is currently looking to acquire a portion of the area to protect the foreshore and assist ongoing management.

The areas identified by Alison have also been included in *Figure 12*.

Positive Change for Marine Life

Positive Change for Marine Life (PCFML) has undertaken community-based surveys of estuary stability and health and has been running the Brunswick River Warriors program and a community hub for a number of years. Dane Marx from PCFML attended part of the field survey undertaken under this project and provided some information on future prospective remediation sites that PCFML was interested in pursuing. One of these sites, a prospective revegetation area, falls within the study area and is indicated in *Figure 12*.

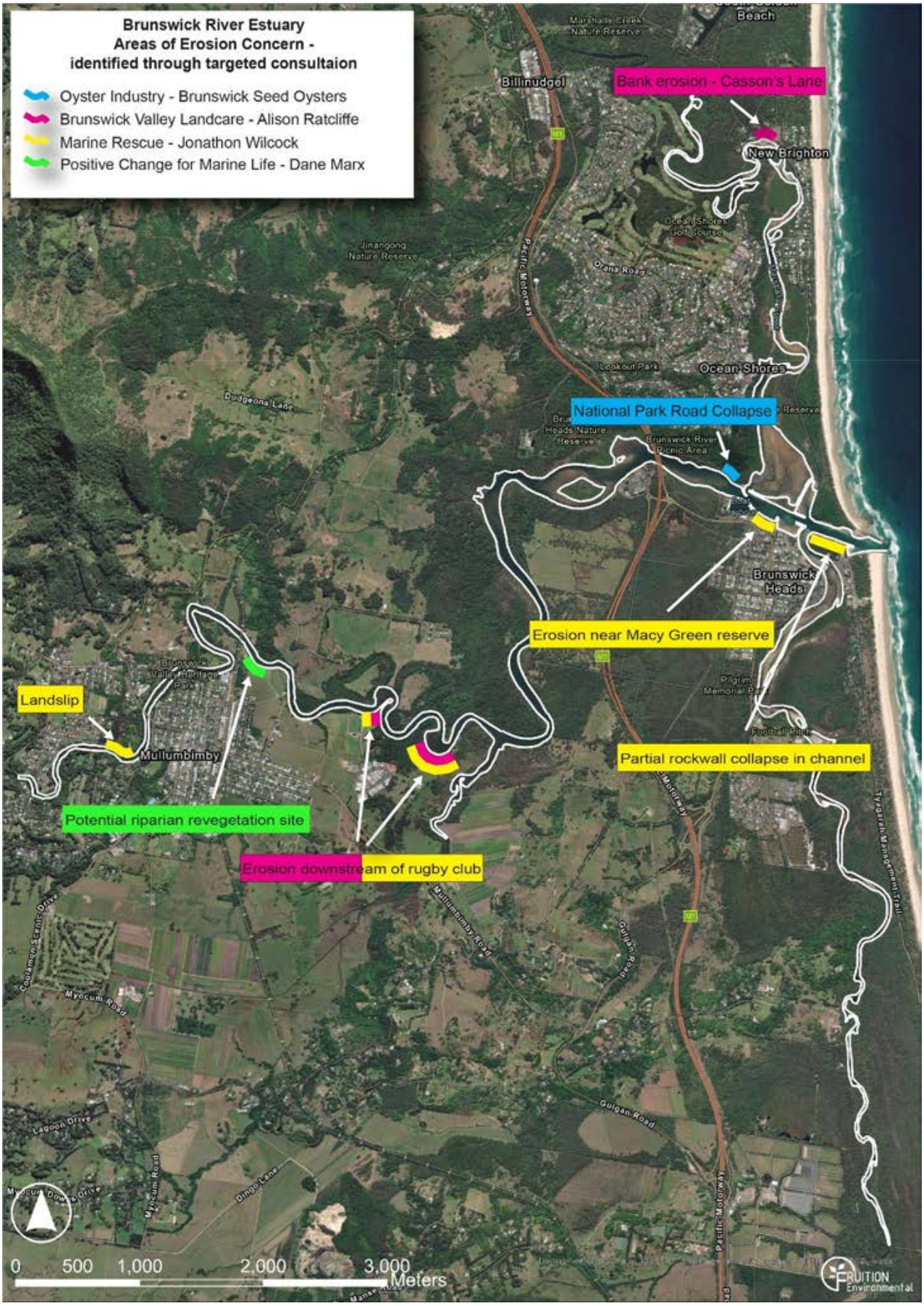

Figure 12 Areas of perceived bank erosion concern as identified by targeted consultation.

PART 2 – Brunswick River Estuary Process Zones

The distribution of sedimentation within the estuary as well as the bank, channel and floodplain morphology characteristics allow for the identification of geomorphic process zones within the estuary.

The distribution of marine and fluvial sediment has been previously assessed in the Brunswick Estuary Processes Study Appendix E (MHL, 2002a) and it is primarily upon this basis (supplemented by the geomorphic implications of the NSW Coastal Quaternary Geology mapping provided in Troedson et al., 2016) that the broad geomorphic process zones have been proposed.

The process zones have been adopted to assist in understanding the primary factors influencing erosion processes within the estuary.

The distribution of the estuary process zones adopted for this study are shown in *Figure 13*.

Process Zone Descriptions

Fluvial-Dominated Process Zone

This process zone occurs in the upper Brunswick River, Kings Creek, upper Marshalls Creek, and upper Simpsons Creek estuaries (*Figure 13*).

In the Brunswick River, this zone is characterised by a single thread meandering channel. The floodplains are mostly continuous in that they occur on both banks. However, bedrock does outcrop at several locations along the channel, mostly on the northern bank where the channel abuts the valley margin approximately 500m above and 500m below the railway bridge at Mullumbimby. Downstream from the lower instance of bedrock control there are several locations of meander cutoffs which demonstrate that the downstream progression of meander bends is a natural process within this zone, and that there is sufficient energy during floods to force avulsions where the meander radius reaches a critical threshold.

In the Brunswick River the channel sediments are a mix of catchment-derived silts, sands and fine to small angular gravels. Mid channel shoals and submerged bank attached gravel bars are common from the upstream extent of the estuary at Mullumbimby through to about 200m below the railway bridge. These features are likely mobile during flood events and would have some impact on flow dynamics and scour within the channel. In the more active channel zone where the prominent meander cutoffs can be observed in aerial imagery, the development point bars (composed of fine to coarse sands and fine gravels) drive meander development and several of these locations exhibit ongoing erosion related to flood scour on outside bends. A number of these locations have had bank protection works installed with varying degrees of success.

Where the orientation of the channel is such that flood flows are directed perpendicularly at downstream banks, backwaters occur as a result of eddy currents. In these locations the bed sediments and more fine-grained sands and organic rich muds and estuarine macrophytes including seagrasses and mangroves proliferate.

Figure 13 Distribution of geomorphic process zones in the Brunswick River estuary.

In Simpsons Creek, a single thread, low sinuosity channel flows in the back barrier depression formed between the current Holocene barrier to the east and the Pleistocene barrier to the west. The fluvial reaches of Simpson Creek extend to approximately 2km upstream of the confluence, with the upper half of that reach forming the Fluvial Transition zone (discussed below). Again, there are intermittent bedrock controls on the west bank where a basalt ridge intersects the channel zone (*Plate 2*), however the channel mostly intersects estuarine plains composed of reworked marine derived sands and organic rich muds/silts. The reaches downstream of the Fluvial-Dominated Process Zone in Simpsons Creek are relatively choked with sands which are thought to be relic deposits from tidal deltas associated with previous entrances of Simpsons Creek to the Brunsick River entrance (MHL, 2002a). Accordingly, most of Simpson Creek is dominated by fluvial processes albeit in a relatively low energy environment.

Plate 2 *Bedrock outcropping is common in the Fluvial Dominated Process Zone in both Simpsons Creek (left) and the Brunswick River estuaries (right).*

Marshalls Creek is similar to Simpsons Creek in that it is nested in a back barrier depression although its planform is more controlled by the prominent ridge running east to northeast towards New Brighton. Again the predominant sediments are reworked marine derived sands and organic rich muds/silts. The fluvial dominated zones of Marshalls Creek have expanded downstream since the construction of the northern entrance training walls as the walls have limited tidal influences into Readings Bay. As a result, sands that were once part of the tidal delta prior to the construction of the training walls have now been progressively shifted to the northern side of the training wall by fluvial processes (MHL, 2002a).

Kings Creek contains finer sediments with higher organic content, generally reflecting the smaller catchment area of this system and lower stream power and sediment transport capacity compared to the main arm of the Brunswick River.

Reaches in the Fluvial Dominated Process Zone are high-energy reaches in comparison to the rest of the estuary. As inferred by the name, fluvial processes dominate erosion processes in this zone including bank scour during flooding and bank slumping/mass failure post flood (*Plate 3*). Boat and wind waves related erosion are less significant issues in this process zone as boat traffic is limited and wind fetches are generally not sufficient to generate significant waves.

Riparian vegetation in this zone becomes less tolerant of saline conditions towards the upstream extent of the estuary and there is an increased dominance of native freshwater riparian vegetation species including

Weeping Lilly Pilly (*Waterhousea floribunda*), common reed (*Phragmites australis*), river lilies (*Crinum pedunculatum*), and Matt rush (*Lomandra hystrix*). In this system mangroves are recorded almost to the upstream extent of the estuary. Mangrove fern (Acrostichum speciosum) was observed in several reaches. However, the predominant vegetation type of the riparian zone in this process zone was historically lowland rainforest which once dominated the floodplain of the Brunswick, mixed with subtropical coastal floodplain forest and swamp sclerophyll forests on coastal floodplains depending on underlying soils, elevation and microclimate. Much of the original extent of these vegetation types as been reduced as a result of clearing and agricultural and urban development. Remaining remnants are often heavily invaded by exotic weeds such as camphor laurel, small-leaved privet, lantana and ground asparagus.

Plate 3 *Bank scour and slumping post flood are the dominant erosional processes in the Fluvial Dominated Process Zone in the Brunswick River estuary. Scour is generally concentrated on the outside meander bends, for example clockwise from top left: the Brunswick River Reach 310, Brunswick River Reach 227, Marshalls Creek Reach 318, and Kings Creek Reach 56.*

Fluvial Transition Process Zone

The fluvial transition process zone reflects a section of the estuary study area which exhibits a pronounced marine influence whilst still exhibiting a fluvial form. On the Brunswick River this zone starts just below the Kings Creek confluence and continues to just upstream of Mangrove Island downstream of Midjimbil Creek (*Figure 13*).

On Simpsons and Marshalls Creek estuaries this zone is somewhat truncated by the extensive shoaling at their downstream extent which reduces the tidal/marine influence. As discussed previously, these two creek systems dissect fluvial and estuarine sediments laid down over successive periods of sedimentation related to changing sea levels over the past 150,000 years. There are areas of coffee rock outcropping in the estuary banks, particularly on the southern bank of the Brunswick River and western bank of Simpsons Creek (*Plate 4*), which represent indurated Pleistocene sand deposits.

Plate 4 *Coffee rock (cemented indurated sands) occurs at isolated locations in the Fluvial Transition Process Zone in both the Brunswick River (left) and the Simpsons Creek estuaries (right).*

In many NSW coastal estuary systems, this process zone occurs in areas of infilled mud basins with wide low-relief floodplains often extensively developed for agriculture. However, agricultural development is not extensive in this zone in the Brunswick estuary as the soils adjacent to the channels are generally strongly acid and often waterlogged with low fertility and localised salinity (Morand, 1994).

In this zone, the stream gradient is less than the upstream fluvial-dominated zone, and resultant stream energy is also less, resulting in finer bed sediment than in the fluvial-dominated reaches upstream. Bed and bank sediments are predominantly silts and fine sands. The silts depositing in this zone are derived from the upstream catchment and fluvial dominated process zones and accumulate on intertidal benches and in backwaters. These deposits can be stabilised by estuarine macrophytes such as mangroves, may be eroded during episodic flood events by scour, or eroded by persistent wave attack between low and mid tide. Wave attack may be via wind waves where fetch and channel orientation are conducive, or by boat wash where the navigation channel is in close proximity to susceptible banks (*Plate 5*). Boat wash is more prevalent in the Brunswick River, with boat wash erosion considered minimal in Simpsons Creek and Marshalls Creek due to poor navigability.

The lack of agricultural development in this zone means that there are large areas of relatively intact riparian vegetation. The species present are typical mid estuary vegetation communities on the North

Coast NSW with fringing grey and river mangroves (*Avicennia marina*, *Aegiceras corniculatum*), swamp sheoak (*Casuarina glauca*) on intertidal flats and lower banks, and mid to upper banks commonly containing brushbox (*Lophestemon confertus*), blood wood (*Corymbia intermedia*) and other eucalypt species (*Eucalyptus spp.*), tuckeroo (*Cupaniopsis anacardioides*), wattle (*Acacia spp.*) pittosporum (*Pittosporum undulatum*), cheese tree (*Glochidion fernandii*), silkpod (*Parsonsia sp.*), blue flax lily (*Dianella caerulea*), and saw sedge (*Ghania clarkei*).

Plate 5 *Wave wash erosion in the Fluvial Transition Process Zone in the Brunswick River Reach 12 (left) and Brunswick River Reach 19 (right).*

Marine Tidal Delta Process Zone

The marine-tidal process zone reflects the component of the estuary dominated by marine processes (e.g. flood and ebb-tide sediment transport). It extends from the estuary mouth at Brunswick Heads upstream above the highway bridge to just above Mangrove Island, a short distance into Marshalls Creek, and approximately 600m upstream of the footbridge on Simpsons Creek (*Figure 13*).

As explained in the Estuary Processes Study (MHL, 2002a), there is an imbalance between the faster and shorter duration inflowing tide and the slower outflowing tide which brings some of the beach and nearshore sand into the lower estuary each tidal cycle. These sands produce the prominent shoals located within this process zone. As a consequence, bedload is predominantly reworked coastal sands. The banks are composed of silts, clays and fine sands over old estuarine clays and barrier sands although bedrock outcrops occur on the northern bank at the entrance and around the Pacific Highway bridge on the Brunswick River (*Plate 6*).

Contemporary erosion processes are predominantly current scour associated with tidal flows, scour associated with episodic floods, and wind and boat wave erosion which are somewhat tempered by the extensive bank protection works and entrance training works found throughout this zone (*Plate 6*).

Extensive areas of estuarine vegetation are found in the Marine Tidal Delta process zone including areas of intact saltmarsh, seagrass, and mangroves. Riparian vegetation on low intertidal benches consists of Swamp Oaks (*Casuarina glauca*), River mangrove (*Aegiceras corniculatum*), grey mangrove (*Avicennia marina*), and prickly-leaved paperbark (*Melaleuca styphelioides*) with Swamp sclerophyll Forest on Coastal Floodplains EEC on higher ground. In the lower reaches, coastal wattle (*Acacia longifolia*), white sally wattle (*Acacia floribunda*), Cheese tree (*Glochidion ferdinandii*), tuckeroo (*Cupaniopsis anacardioides*) and coastal banksia

(*Banksia integrifolia*) are common. Littoral rainforest (identified in the SEPP (Resilience and Hazards) 2021 dataset, previously the SEPP26 mapping) occurs on the western side of Marshalls Creek. The main exotic weeds present in this zone are ground asparagus, coastal morning glory and bitou bush.

Plate 6 *Bedrock outcropping and extensive bank protection works, entrance training walls and seawalls occur in the Marine Tidal Delta Process Zone. For example, clockwise from top left: bedrock on the northern bank of the lower Brunswick River adjacent to the Brunswick River Nature Reserve; entrance training walls on lower Marshalls Creek, the lower Brunswick River, and lower Simpsons Creek.*

PART 3 – 2024 Bank and Riparian Condition Survey

Brunswick Estuary NEAP Online Estuary Condition Mapping Database

Approximately 56.7km of the Brunswick River Estuary was surveyed via boat in July 2024. The survey area included the navigable reaches of Simpsons Creek to an upstream limit approximately adjacent to Tandys Lane, Marshalls Creek to just upstream of the Ocean Shores Golf Club at New Brighton, Kings Creek to approximately 380m downstream of Mullumbimby Road, and the Brunswick River from the entrance to approximately 900m upstream of Federation Bridge in Mullumbimby. In Simpsons Creek, where conditions were not suitable for access via small motorised craft in some reaches, drone footage was used to capture further survey detail.

Data was entered directly into the field maps app, which allowed for survey segments (reaches) to be drawn as a line feature along the bank based on current location in the field. Reaches were defined based on a change in either erosion severity, riparian vegetation condition, or existing controls. Each new reach segment was snapped onto the previous line segment and the survey was repeated.

Except where survey bank length was very small, a minimum of two photos were taken of each segment: one downstream looking upstream, and one upstream looking downstream. Any features of interest within the section were also photographed (i.e., existing controls, erosion, etc.).

Three hundred and fifty-seven (357) reaches were surveyed. Each reach had up to one hundred and six (106) attributes recorded. The recorded attributes primarily focussed upon:

- Bank erosion severity
- Riparian vegetation continuity, width, structure, diversity and weed presence (used to generate the riparian vegetation condition ratings)
- Presence of existing erosion control works, proportion of segment with works, style of works and works effectiveness.
- Criteria relevant to the NSW Fisheries Decision Support Tool for Bank Erosion Management, 2024 version (the "DST"; developed by Hydrosphere Consulting for DPIRD Fisheries under the Marine Estate Management Strategy Initiative 2, see Hydrosphere Consulting, 2020 and 2020b).

Appendix A and the methodology descriptions in the following section provide further detail on the criteria assessed.

The Fruition Environmental Web App

The Fruition Environmental Web App holds the full database of survey records including all attributes for each segment surveyed and any photographs taken of the reach. The records are current as of 21 August 2024 but are able to be updated in the field using ESRI Field Maps and an appropriate login if required.

How to access the online bank and riparian condition database

The custodian for the estuary condition survey database is Department of Primary Industries and Regional Development - Fisheries. Requests to use the database should be made directly to the Senior Fisheries Manager - NEAP.

Brunswick River Estuary Bank Condition

Method

Attributes related to bank condition were mapped directly into ESRI Field Maps via the Fruition Environmental online mapping tool. This ensured a standardised collection methodology across all areas of the estuary surveyed and also between survey personnel.

A component of the project scope was to allow for the bank condition dataset to be compatible with the 2024 version of the DPIRD Fisheries DST for bank erosion management in NSW estuaries. Accordingly, the methodology for recording bank condition incorporated the data attributes and definitions used in the DST manual (Hydrosphere Consulting, 2020b) in addition to other project attributes specific to this project.

Bank erosion severity was the primary attribute for the differentiation of bank segments for the bank condition assessment. The bank segments represent relatively homogenous reaches of similar attributes so where bank erosion severity was homogenous but riparian vegetation condition changed the segment was broken to allow the different vegetation condition to be represented despite the erosion severity being recorded as the same. The degree of bank erosion present in the segment was recorded as either Negligible, Low, Moderate, High or Extreme.

The definition for each erosion severity category were adopted from the DPIRD Fisheries DST (see Hydrosphere, 2020b) and as follows:

- NEGLIGIBLE: currently aggrading or stable – no erosion
- LOW: some erosion occurring but considered within natural parameters
- MODERATE: rate or scale of erosion is considered more than natural
- HIGH: rate and scale of erosion is significant
- EXTREME: erosion occurring with significantly accelerated rate and scale

No “Extreme” erosion was recorded within the Brunswick River estuary study area.

Examples of reaches with High to Low erosion severity are shown in *Plates 7* to *9*.

In addition to the severity of erosion, a number of other attributes were recorded to maintain compatibility with the DST and provide additional factors relevant to bank condition at the site.

The following additional information were recorded for all segments surveyed (see *Appendix A* for category definitions):

- Presence or absence of **bedrock** in the segment (Yes/No).
- The **estimated future trajectory** of erosion being either *not occurring not likely*, *not occurring but likely*, *occurring and continuing,* or *occurring and accelerating* (only one selected).
- **Water depth** (measured by a staff at 5m from the mean high tide mark on the bank), being a surrogate measurement for the question of what types of erosion control works could potentially be practical at the site if required: *shallow* (less than 0.8m), *moderate* (0.8 to 1.5m), *deep* (>1.5m).
- A subjective assessment of the **impact of erosion** upon perceived environmental, infrastructure/commercial, and amenity/safety values of the segment or broader estuary (see Hydrosphere Consulting, 2020b for more detail). Ratings of *negligible*, *low*, *medium*, or *high* could

be assigned (one to be selected for each of the three values category). To assist this assessment, a number of existing datasets were available within the Field Maps app to help inform the surveyor of known issues in the reach. These included NSW Endangered Ecological Vegetation Community mapping, aquatic vegetation mapping, and crown/council/NPWS land parcels.

- The **location** of any erosion occurring was recorded as either one or a combination of: *top of bank*, *upper bank*, and/or *lower bank*.
- The c**ontributing causes** of erosion for each segment were documented with one or more causes selected from: *ocean waves*, *public access*, *river flood or tidal flows*, *sediment extraction*, *stock access*, *vessel waves*, and/or *wind waves* (Yes/No required for each cause for DST compatibility).

Plate 7 *Examples of high erosion severity: clockwise from top left, Brunswick River Reach 134; Kings Creek Reach 56; Marshalls Creek Reach 318; Brunswick River Reach 59.*

Plate 8 *Examples of moderate erosion severity: Clockwise from upper left, Brunswick River Reach 229; Marshalls Creek Reach 333; Brunswick River Reach 94; and Simpsons Creek Reach 195.*

Plate 9 *Examples of low erosion severity: Clockwise from left, Brunswick River Reach 229; Marshalls Creek Reach 333.*

Overview of Results

Figure 14 shows the distribution of bank erosion severity within the Brunswick River estuary.

Table 1 summarises the proportions of estuary bank which were mapped against each category of erosion severity for the whole estuary study area. This table shows that the majority of estuary banks in the study area have either low or negligible erosion severity (80.5%). There were no extreme erosion severity reaches recorded, and only 3.1% of banks surveyed (1750 m of bank) were identified with high erosion severity. Effectively, bank erosion is not a major issue within this system despite there being isolated occurrences of high severity erosion recorded.

Table 1 Bank erosion severity in the Brunswick River Estuary study area

Bank erosion severity	Length of bank (m)	% of overall estuary bank mapped
Extreme erosion	nil	-
High erosion	1750	3.1%
Moderate erosion	9279	16.4%
Low erosion	11,578	20.4%
Negligible erosion	34,114	60.1%

Table 2 presents the proportions of estuary bank erosion severity across each river system and process zone, graphically presented in *Figure 15*. The Brunswick River consistently experiences higher levels of moderate and high erosion across all process zones compared to the other creeks, relating to differences in hydrological regimes and pressures between the systems. Marshalls Creek is the most stable, with negligible erosion dominating across all process zones, suggesting effective natural and artificial erosion controls.

Table 2 Distribution of bank erosion severity by estuary process zone and location: summary statistics

	Total length (m)	Negligible	Low erosion	Moderate erosion	High erosion	Extreme erosion
Fluvial Dominated Process Zone Reaches						
Brunswick River	14,503	26.7%	36.1%	30.8%	6.3%	-
Kings Creek	2468	73.5%	15.4%	6.4%	4.7%	-
Marshalls Creek	11,444	75.1%	17.1%	7.2%	0.5%	-
Simpsons Creek	5441	72.2%	15.5%	12.3%	-	-
Fluvial Transition Process Zone Reaches						
Brunswick River	5770	48.6%	23.1%	25.7%	2.6%	-
Marshalls Creek	2005	100%	-	-	-	-
Simpsons Creek	3348	78.3%	19.4%	2.3%	-	-
Marine Tidal Delta Process Zone Reaches						
Brunswick River	8296	71.6%	7.4%	14.9%	6.1%	-
Marshalls Creek	760	93.8%	-	6.2%	-	-
Simpsons Creek	2686	67.4%	20.7%	11.9%	-	-

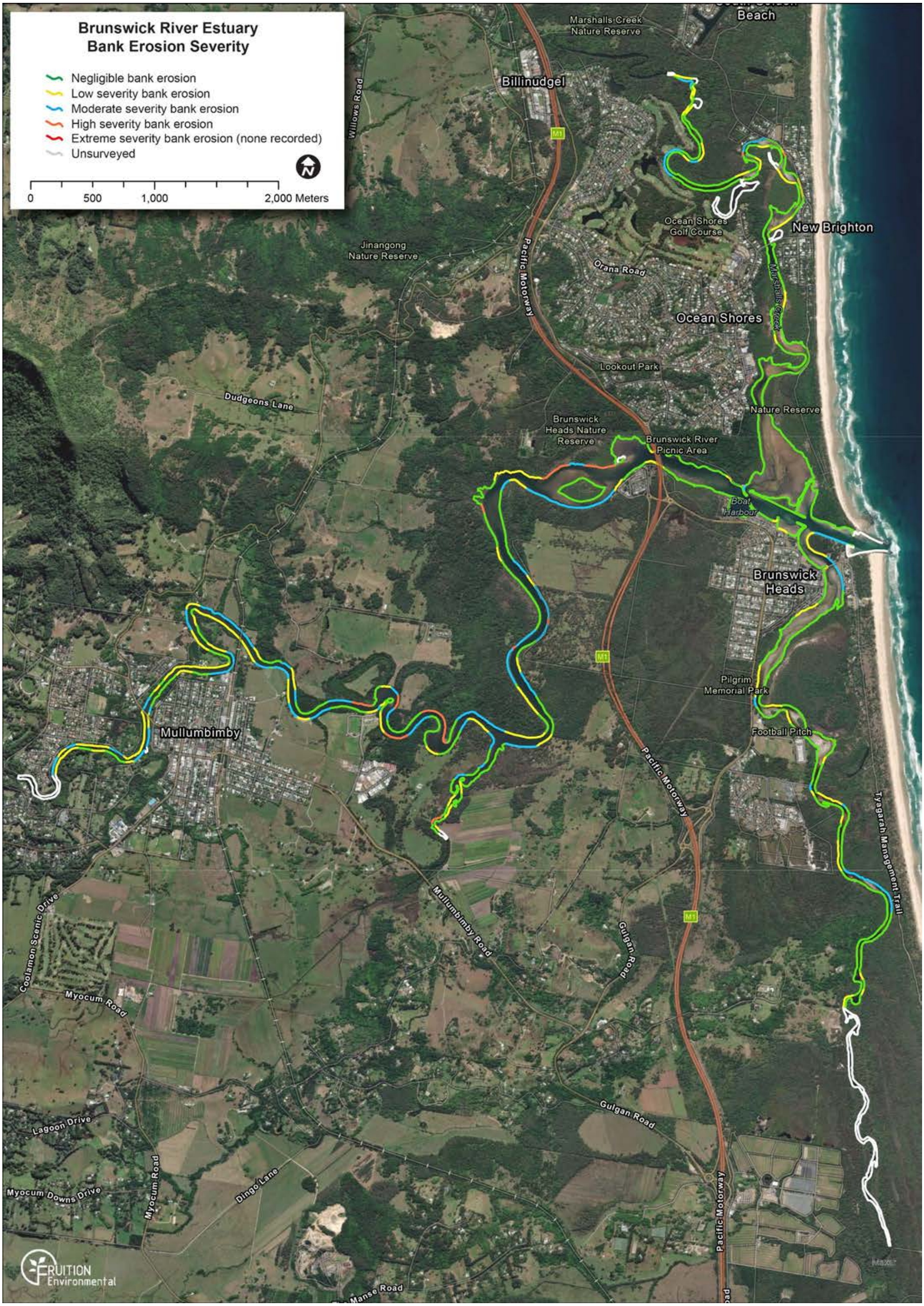

Figure 14 Distribution of mapped bank erosion severity across the Brunswick River Estuary Study Area

The Fluvial Dominated process zone of the Brunswick River disproportionately features the highest concentrations of moderate and high severity erosion. While this zone represents 26% of the surveyed estuary area, it features 48% of all the surveyed *moderate* erosion, and 48% of all surveyed *high* erosion. Higher concentrations of erosion in the fluvial dominated process zone are commonly the case in NSW estuaries as they are typically, but not exclusively, areas where agricultural development is concentrated, bank materials are susceptible to erosion, and the effects of recent flooding are most evident. Compared to the smaller tributary creeks of the Brunswick, the hydrodynamics and flow regime of the Brunswick River also increase its relative susceptibility to erosion compared with the other surveyed estuaries. High erosion reaches occur predominantly on outside bends, reflecting the fluvial processes occurring in this zone. It is likely that the extent of bank erosion in this zone has been influenced by the significant flood events of March-April 2022, although it is noted that several areas of erosion have been identified over successive surveys since 1992 (*Figures 6 - 8*). Bank protection works have successfully mitigated erosion in some reaches of the Brunswick River estuary.

In contrast, the fluvial dominated process zones of Kings Creek, Marshalls Creek, and Simpsons Creek do not display the same erosion distributions as the Brunswick River, although the majority of *moderate* or *high* erosion in these creeks is focused in this process zone. They have significantly lower percentages of high erosion, likely due to their smaller size and catchments, locations within the landscape and relatively intact margins. These three systems feature high percentages of negligible erosion (ranging from 72.2% to 75.1%). Erosion along Kings Creek appeared to be mostly related to historic agricultural development and only one reach displayed high erosion, along an outside bend of the upper estuary. Low and moderate erosion in both the Fluvial zones of Marshall Creek and Simpsons Creek also relates to the channels having formed adjacent to coastal barrier systems (*Figure 4*). The unconsolidated nature of the marine sands that comprise these systems make them prone to natural erosion processes as the streams rework sediments and adjust their boundaries.

In the Fluvial Transition process zone of the main arm of the Brunswick River Estuary there is a fairly balanced distribution of erosion severity. Moderate erosion was generally related to toe scour but importantly a number of locations demonstrated stripping of fine sediments from intertidal benches that supported mangrove habitat (*Plate 10*). Although it was beyond the scope of this project to assess the rate of erosion at these sites, the mechanisms of erosion and volume of tree fall in many of these reaches indicate that erosion rates are accelerated beyond natural.

Plate 10 *Mangrove stilting occurs when the drape of peaty/muddy soils overlaying the basal sands are winnowed by persistent wave attack and to a lesser extent tidal or flood flows.*

In the Marine Tidal Delta process zone, the Brunswick River shows that 71.6% of areas are experiencing negligible erosion, with only 14.9% of bank length mapped with moderate erosion and 6.1% with high erosion. Much of this erosion is focused on both branches of the Brunswick River around Mangrove Island, which reflects the dynamic nature of tidal and fluvial influences coupled with disturbance pressures from wave attack. Along both outside banks, flows are pushed against the banks as the thalweg creates the deepest area of the channel, while extensive sand shoals protect the island. This has had the effect of focussing boat activity close to the outer banks where navigation is easier and indeed the NSW Maritime marker buoys direct boating traffic in this way (with minimal signage to direct boat users to reduce wave wash). Wind waves are also a factor in some locations where wind fetch and bank orientation is conducive.

Simpsons Creek generally is very stable with 67.4% negligible, 20.7% low, and 11.9% moderate erosion. This reflects the relatively low energy environment but also the predominance of bank protection structures in the lower reaches. Where moderate erosion does occur it is generally reflective of partial failure of rock walls, where slumping of rock wall toe has occurred and erosion is affecting the upper bank only. Similar erosion processes were observed along the rock walls of the Brunswick River adjacent to Torakina Park. Marshalls Creek exhibits a negligible Marine Tidal Delta process zone with mostly no erosion present in this zone (93.8%).

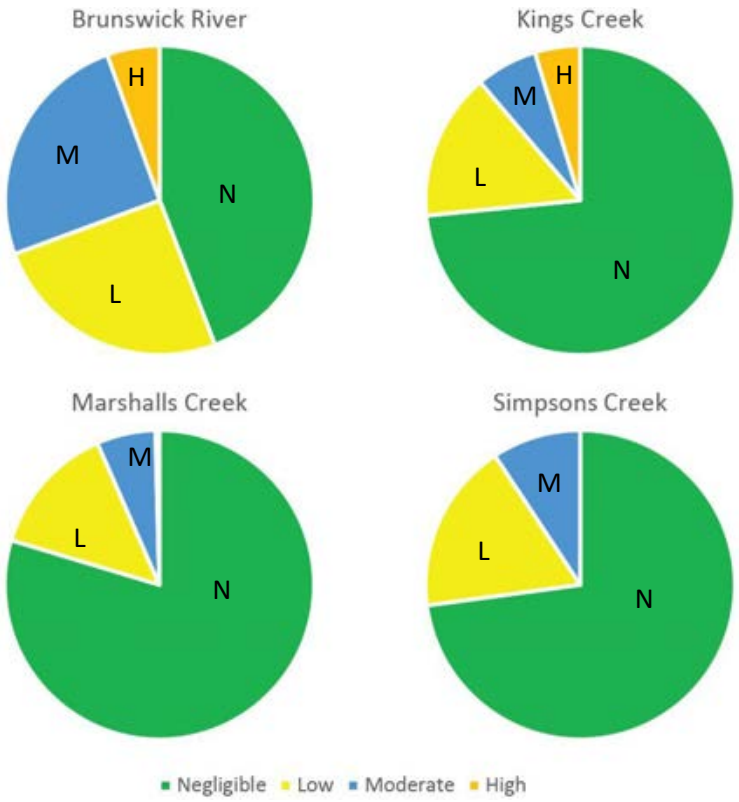

Figure 15 Proportional distribution of bank erosion severity within each estuary of the Brunswick River study area.

Comparison to Previous Erosion Assessments

A comparison of sites identified as eroding in 1992 and 2000 (MHL, 2002a) with survey data from this study highlights that there have been some reaches with persistent bank erosion issues for the last 20 – 30 years, although erosion severity and processes were generally not recorded in these earlier assessments. For example, the reach downstream of the Mullumbimby Rugby League Football Club is identified in the MHL process study documents (MHL, 2002a) and in all the recent studies from 2018 to 2022, including being recorded with high erosion severity in 2020 (Hydrosphere, 2020), "High Risk" by PCFML in 2021 and 2022, and in this study. However, in most instances the reaches identified in the 1992 and 2000 reports have been classified in this study as having moderate erosion severity.

It is difficult to reconcile changes in erosion severity between studies as they are often based upon different assessment criteria that lack description to allow comparison (eg. PCFML assessments). In other cases, the processes that may result in an estuary bank being described as having high or severe erosion are episodic, for example post-flood drawdown and mass failure/slumping of banks. In the period between surveys these areas can stabilise and vegetation can regenerate resulting in a less severe erosion rate being recorded in subsequent surveys. Subsequent flooding can reverse this result.

Further, the assessment criteria applied in this study will at times result in lower severity ratings as the reaches are considered in a different context to most snap-shot surveys of erosion. The focus of the DST assessments is to describe erosion in terms of both its "severity", its likely trajectory, and impacts to environmental, infrastructure/commercial and amenity/safety. This combination of attributes tends to differentiate to some extent erosion which looks bad from erosion which is problematic from an estuary management context.

For example, in some upper reaches near Mullumbimby, some previously "high-risk" rated banks had the general appearance of severe erosion from prior slumping (PCFML, 2024). However, much of the material appears to be indurated, with a well-developed bench at the bank toe and establishing vegetation suggesting erosion is currently less active than in the past, despite the influence of recent floods. An additional example is found in a reach along Simpsons Creek which was mapped with high to extreme erosion in 2020 during the DST field test (Hydrosphere, 2020) and which has been subsequently assessed in this study as only of moderate erosion severity. While the actual severity of erosion is likely unchanged since the 2020 assessment, as the site is eroding into an unconsolidated coastal barrier, the reach has an initial appearance of problematic erosion. In the NEAP assessment, the erosion has been considered a largely naturally occurring process related to the geomorphic context of the reach.

This added layer of geomorphic context is helpful in terms of assessing erosion consequence and the potential need for management intervention, but it is important to qualify that rates of erosion analyses and reach scale geomorphic processes are generally not considered in the NEAP assessments. This means that the assessments of erosion trajectory and erosion impact are subjective and rely on the experience of the field assessor which in practice can result in difference between assessments when follow-up surveys are undertaken.

Of note, a number of high priority sites listed in the CZMP (BSC, 2018) have been addressed in the period between the site audit (January 2017) and the NEAP field assessment in 2024. These sites include sites B5 Marshalls Creek River Street), B6 (Marshalls Creek, North Head Road in the Nature Reserve), and B8 (the site of the pile fields on the Upper Brunswick River). Of the remaining high priority sites listed in the CZMP, B2-B4 and B9 remaining outstanding and are identified as erosion hotspots in the 2024 assessment.

Brunswick River Estuary Riparian Vegetation Condition

Method

Riparian Vegetation Condition was assessed using a multi-metric index of riparian condition. The index has been modified from previous methodologies utilised by Fruition Environmental in other estuarine assessments and studies (e.g. The Bellinger Kalang estuary study undertaken by Cohen and Telfer in 2010). The method has proved suitable for whole of estuary studies where each segment needs assessment (i.e. where the length of bank being assessed precludes more detailed assessments such as those undertaken under the Ecohealth Monitoring Project by Ryder et al, 2017).

Again, the attributes collected included those required to ensure compatibility with the DPIRD Fisheries DST methodologies. To this end the DST attributes of riparian vegetation continuity and width have been adopted with the criteria for assessment for these two attributes adopted from the DST assessment method (Hydrosphere Consulting, 2020b). Specifically:

- **Riparian Vegetation Continuity** was recorded as either *negligible*, *low*, *medium*, or *high*
- **Riparian Vegetation Average Width** was recorded as *<2m*, *<5m*, *<10m*, *<20m* and *>20m*.

In addition to the DST compatible attributes, three additional attributes were adopted to assist in determining riparian condition. The additional attributes adopted were:

- **Riparian Vegetation Structure** which was recorded as either *very poor*, *poor*, *medium*, *good* or *very good* (see Appendix A for descriptions of each category for this attribute). Again, a number of existing datasets were available within the Field Maps app to help inform field staff of what vegetation communities could be expected in the segment. These included NSW Endangered Ecological Vegetation Community mapping (derived from Byron Shire Council HEC vegetation mapping, 2023) and aquatic vegetation mapping (mangrove, saltmarsh and seagrass communities, as per the NSW DPIRD Estuarine Macrophyte data layer). For instance, where the riparian vegetation was a coastal saltmarsh community then the riparian vegetation structure value reflected what would be expected for a vegetation community of that type.
- **Riparian Vegetation Diversity** which was recorded as either *very poor*, *poor*, *medium*, *good* or *very good* (see *Appendix A* for detail). Again the value recorded was measured against the level of diversity expected for a vegetation community of the type that would naturally occur in that segment, informed by vegetation mapping layers loaded into field maps.
- **Exotic Weed Presence** which was recorded as either *nil observed*, *low* (<10% Foliage Projective Cover or FPC), *moderate* (10-25% FPC), *high* (25-50% FPC), or *very high* (>50% FPC).

Upon completion of the field mapping exercise, the results of each segment's survey against the five sub-indices were used to compute a riparian condition index score using a simple algorithm (sum of attribute scores). The attribute scores used to convert the field records into the riparian vegetation condition score are shown in *Table 3*.

Table 3 Riparian Condition Index attributes and values used in calculation the Riparian Vegetation Condition Score for each field surveyed bank segment in the Brunswick River Estuary.

Attribute	Value	Score
Riparian Vegetation Continuity	Negligible	0
	Low	1
	Moderate	5
	High	9
Riparian Vegetation Average Width	Less than 2m	0
	Less than 5m	2
	Less than 10m	5
	Less than 20m	9
	Greater than 20m	12
Riparian Vegetation Structure	Very poor	0
	Poor	2
	Moderate	5
	Good	9
	Very Good	12
Riparian Vegetation Diversity	Very poor	0
	Poor	2
	Moderate	5
	Good	9
	Very Good	12
Weed Presence	Nil observed	5[1]
	Low (<10% FPC)	3
	Moderate (10-25% FPC)	1
	High (25-50% FPC)	0
	Very High (>50% FPC)	0
	Maximum Score	**50**

The condition score was then converted to a **Riparian Vegetation Condition** Rating which represents 5 condition bands ranging from *very poor*, *poor*, *moderate condition*, *good condition* through to *very good condition*. The bands used to convert the condition score to the Riparian Condition Ratings are shown in *Table 4* with the definition for each category as follows:

- VERY POOR CONDITION: no to very little riparian vegetation.
- POOR CONDITION: discontinuous riparian vegetation of narrow width with poor diversity and structure, exotic weeds may be present.
- MODERATE CONDITION: medium to high vegetation continuity, width greater than 2m and with variable structure and diversity, weeds may be present.

[1] Note: if Riparian Vegetation Continuity <3 then weed presence score was set at 0 regardless of the weed presence entry. This was because if there was "no" to "low" vegetation continuity then there was likely also no weeds present so without this adjustment the condition score would be artificially high due to the 5 scored against "nil observed".

- GOOD CONDITION: medium to high vegetation continuity, width greater than 5m and with structure and diversity generally medium to good, weeds may be present but not dominant.
- VERY GOOD CONDITION: high vegetation continuity with width greater than 10m, very good vegetation structure and diversity, and low to no weed presence.

Table 4 Riparian Vegetation Condition Ratings derived from the Condition Index Scores used in the Brunswick River Estuary assessment.

Riparian Vegetation Condition Rating	***Riparian Condition Index Score***
Very Poor Condition	*0-5*
Poor Condition	*6-10*
Moderate Condition	*11-25*
Good Condition	*26-40*
Very Good Condition	*41-50*

In addition to the five attributes which combine to form the Riparian Vegetation Condition rating, more detailed presence/absence of important individual **environmental weed species** were recorded. These included presence/absence within the segment of *Bitou bush*, *Broad-leaved privet*, *Camphor laurel*, *Coastal morning glory*, *Ground asparagus*, *Lantana*, and *Small-leaved privet*. The records of observations are available through the online mapping database.

Examples of reaches with Very Good Condition to Very Poor Condition riparian vegetation are shown in *Plates 11* to *15*.

Plate 11 Examples of very good condition riparian vegetation: From left to right, Brunswick River Reach 5; Marshalls Creek Reach 344.

Plate 12 Examples of good condition riparian vegetation: Left to right, Marshalls Creek Reach 299, Brunswick River Reach 199.

Plate 13 Examples of moderate condition riparian vegetation: Clockwise from top left, Brunswick River Reach 90; Kings Creek Reach 62; Simpsons Creek Reach 195; and Marshalls Creek Reach 294.

Plate 14 *Examples of poor condition riparian vegetation: Clockwise from top left, Brunswick River Reach 146, Brunswick River Reach 191, Brunswick River Reach 94, Kings Creek Reach 56.*

Plate 15 *Examples of very poor condition riparian vegetation: Left to right, Brunswick River Reach 145, Simpsons Creek Reach 259.*

Overview of Results

Figure 16 shows the proportional distribution of riparian vegetation condition within each stream, while *Figure 17* shows the spatial distribution within the Brunswick River estuary study area. Table 5 highlights the proportions of surveyed estuary bank which were mapped against each category of riparian vegetation condition. The survey data shows that the majority of the banks are in a healthy state, with 83% of banks surveyed (approximately 47 km) classified as having riparian vegetation in good to very good condition. Only a small proportion of the riparian vegetation are in less favourable states, with just over 4% in "Very Poor" condition and 3.4% in "Poor" condition. The vast majority of these areas were in close proximity to developed areas, particularly around Brunswick Heads, reflecting the interface between urban areas, public access and training walls (Figure 10).

Table 5 Riparian Vegetation Condition in the Brunswick River Estuary study area.

Riparian Vegetation Condition	Length of bank (m)	% of overall estuary bank mapped
Very Poor Condition	2303	4.1%
Poor Condition	1928	3.4%
Moderate Condition	5172	9.1%
Good Condition	13,453	23.7%
Very Good Condition	33,865	59.7%

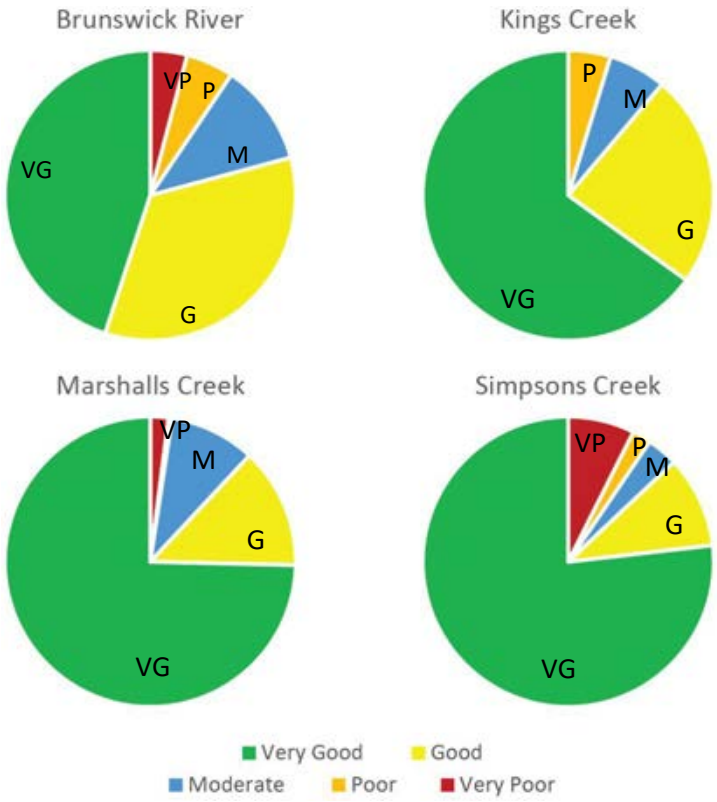

Figure 16 Proportional distribution of riparian vegetation condition within each estuary of the Brunswick River study area.

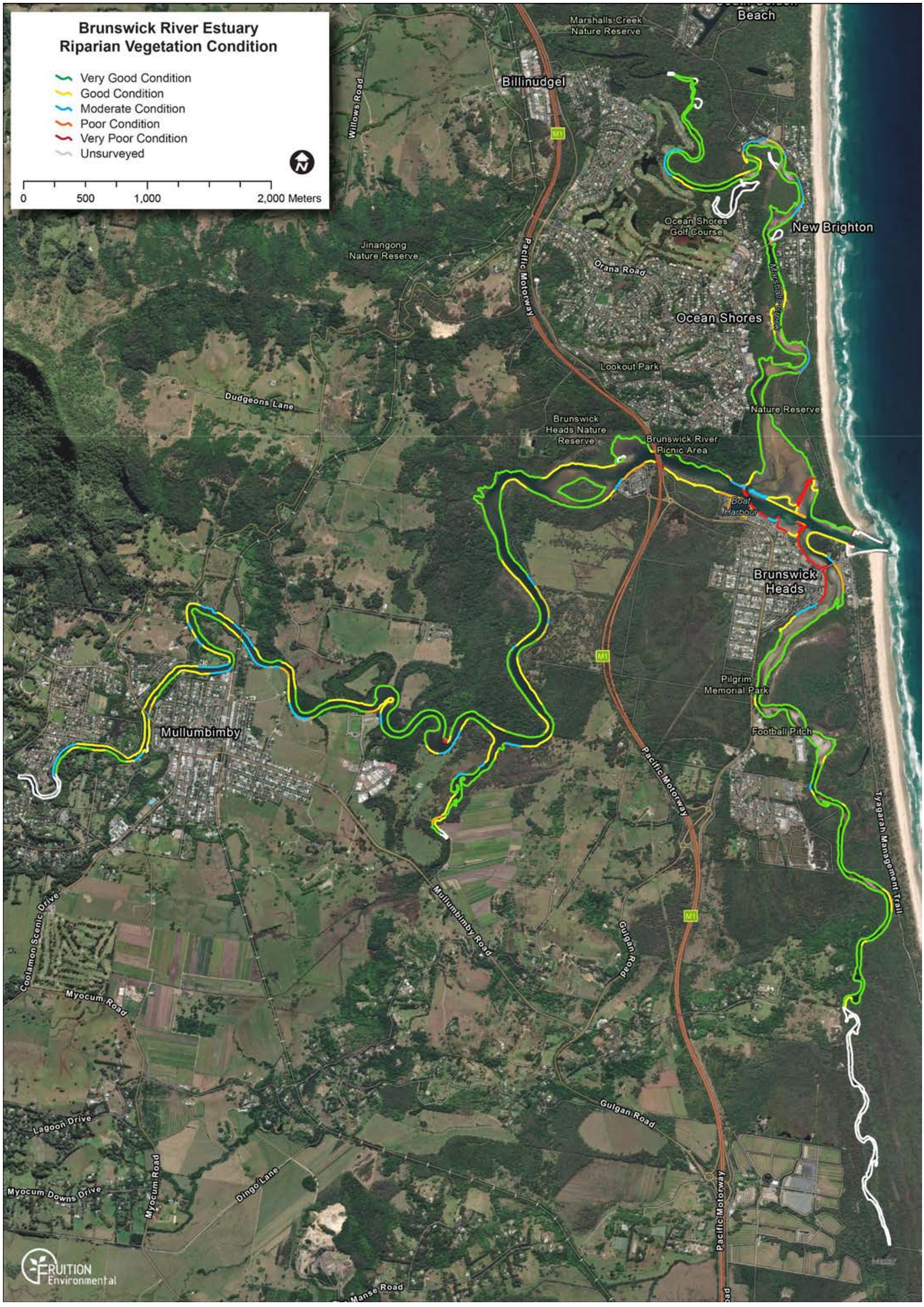

Figure 17 Distribution of riparian vegetation condition across the Brunswick River Estuary Study Area

Table 6 provides the distribution of riparian vegetation condition by process zone and estuary location. This table reinforces that the overall riparian vegetation condition of the estuary is quite healthy, with the two fluvial zones having between 79% and 99% "Good" and "Very Good" conditions across all streams. Simpsons Creek has the healthiest vegetation, with >90% in "Very Good" condition in both the Fluvial Dominated and Fluvial Transition process zones. The Brunswick River shows a more even distribution across "Good" and "Very Good" conditions but also has the highest percentage of "Moderate" condition (18%) in the Fluvial Dominated process zone which appears related to both agricultural and urban development. Although Marshalls Creek has a notable 14% in "Very Poor" condition, this is associated with a seawall constructed in the lower estuary delta which would not have formerly supported vegetation. There is only one reach in the study area (Reach Id 59) where high erosion is associated with very poor riparian vegetation and two (Reach Id 56 and 311) associated with poor riparian vegetation.

In the Marine Tidal Delta process zone, there is more evidence of vegetation degradation, with both the Brunswick River and Simpsons Creek displaying considerable portions in "Very Poor" and "Poor" conditions (28% and 40.5% respectively). These ratings are related to urban development in the lower estuary and often correlate with areas of rock revetment, entrance training walls, or public access infrastructure such as boat ramps, wharves or roads. In such situations the opportunities for improvement in vegetation cover, width and structure/diversity are limited by the lack of available space for active revegetation or for practical reasons related to estuary access. Nevertheless, some opportunities for improvement exist especially where these limitations do not exist.

The major impacts on riparian vegetation condition observed during the field assessment included:

- Clearing, associated with infrastructure and urban development in the lower estuary and in proximity to Mullumbimby, as well as for agriculture in some mid reaches of the Brunswick River.
- Loss due to erosion processes including stripping of intertidal benches under mangrove habitat due to persistent wind or boat wave effects and post flood bank slumping particularly where only a narrow fringe of vegetation exists on the bank.
- Weed incursion in the upper reaches of the Brunswick River estuary becoming dominated by camphor laurel.

Table 6 *Distribution of riparian vegetation condition ratings in the Brunswick River estuary by estuary process zone and location: summary statistics.*

	Very Poor Condition	Poor Condition	Moderate Condition	Good Condition	Very Good Condition
Fluvial Dominated Process Zone Reaches					
Brunswick River	0.4%	2.2%	18%	37.7%	41.7%
Kings Creek	-	4.7%	6.4%	23.8%	65.1%
Marshalls Creek	-	0.5%	10%	11.2%	78.2%
Simpsons Creek	-	-	1.1%	8.8%	90.1%
Fluvial Transition Process Zone Reaches					
Brunswick River	-	-	3.3%	36.8%	59.8%
Marshalls Creek	14.2%	-	-	14.1%	71.7%
Simpsons Creek	-	-	1.9%	5.7%	92.5%
Marine Tidal Delta Process Zone Reaches					
Brunswick River	13.4%	14.5%	5.4%	26.3%	40.3%
Marshalls Creek	-	-	27.1%	44.9%	28%
Simpsons Creek	**31.6%**	8.9%	10.4%	18.8%	30.3%

Existing Estuary Erosion Control Works

Method

The presence or absence of existing erosion controls on the bank was recorded for each surveyed section. The methodology broadly followed the DPIRD Fisheries Draft Decision Support Tool methodology (Hydrosphere Consulting, 2020b) with some modification. Compatibility with the DST was maintained although extra information was recorded to assist in the more accurate determination of existing control statistics (percentage of bank treated with control) and a number of additional control types were added (eg. gabion baskets).

If existing erosion control works were present the following information were recorded:

- The type of control/s (i.e., rock revetment, revegetation, building rubble, etc.) were recorded using a yes/no data field against each potential control listed (multiple selections possible).
- the percentage of segment with an existing control/s was recorded to allow more accurate determination of length of works as the control length does not always correlate with the segment length as it is not the primary determinant of the segment. The options for this field were *nil existing*, *less than 10%*, *10-25%*, *25-50%*, *50-75%*, and *75-100%* of the segment length (only one selected).
- Finally, the effectiveness of the existing control/s was recorded. The options for this field were *Ineffective*, *Partial (Condition)*, *Partial (Design)*, *Completely*, *Under Construction*, *Trial works/untested*, or *Redundant*. The DST descriptions of the works effectiveness categories were adopted for this assessment (see Hydrosphere Consulting, 2020b; also *Appendix B*).

Types of works present

Of the total length of individual bank field surveyed in the Brunswick River estuary (56.7km), 7.49km or 13.2% of estuary bank had some form of existing bank protection (*Table 7*).

The most prevalent form of bank protection observed was rock revetment with over half (57.7%: 4.53km) of all works recorded utilising this method, representing 8% of the total surveyed length of estuary bank in the study area (*Table 7*). The next most prevalent works types were:

- entrance training walls/sea walls in the lower estuary (~1.62km);
- revegetation works in the mid-upper Brunswick River, predominantly at two Byron Shire Council remediation sites and a Positive Change for Marine Life site (~470m); and
- building rubble including broken concrete (~387m) in the mid Brunswick River, particularly around the Mullumbimby Rugby League Football Club, and lower estuary upstream of the Reflections Ferry Reserve Holiday Park. Concrete and building rubble works were generally located adjacent to private property even where crown land or reserve foreshore occurs.

Interestingly, rock fillet and large woody debris works placed on intertidal benches have not been utilised in estuary bank remediation in the Brunswick to date. These styles of works are specifically designed to address wave erosion (wind or vessel generated) in reaches where there is an existing shallow intertidal bench and have been proven effective in many north coast estuaries. Variations of these works types are canvassed in the Brunswick Estuary CZMP (Appendix F: BSC, 2018).

Table 7 *Total length of each existing bank protection works style, the percentage of each style of the overall total length of bank protection measures, and the percentage of each style of the total length of estuary bank surveyed in the Brunswick River estuary*

Control Type	Total length of bank (m)*	% of overall works	% of surveyed bank
Rock armouring	4525	57.7%	8%
Entrance training walls / seawalls	1627	20.8%	2.9%
Revegetation	470	6%	0.8%
Building rubble	387	4.9%	0.7%
Timber wall	201	2.6%	0.4%
Other	160	2%	0.3%
Concrete	159	2%	0.3%
Rock groynes	116	1.5%	0.2%
Pile Fields	108	1.4%	0.2%
Tyres	46	0.6%	0.1%
Cobble beaching	19	0.2%	0.03%
Natural log wall	13	0.2%	0.02%
Geotextile sand bags	6	0.1%	0.01%
Rock fillets	None recorded	-	-
Natural logs on bench	None recorded	-	-
Oyster shells	None recorded	-	-
Gabion baskets	None recorded	-	-
Total bank treated	**7492**	**100%**	**13.2%**

* *Note: the total length of works may exceed the length of bank treated where works types overlap, such as rock armouring of the bank toe and revegetation of the mid and upper bank.*

Condition of works

Over half (55.3%; 4.1 km) of the existing bank protection measures observed were recorded as completely effective (*Table 8*). Just under a third (28.4%: 2.1 km) of all works were described as only partially effective either because of poor condition (resulting in some erosion continuing) or poor design (resulting in the works being compromised or only partially suitable). Maintenance or retrofitting of the partially effective works in the Marine Tidal zone of the Brunswick River and Simpsons Creek would likely improve the erosion control effectiveness.

Few areas of ineffective works were recorded. Only 0.9% of works (64 m) were described as ineffective and ~780 m (~10%) described as redundant. Ineffective works were primarily located in the fluvial dominated process zone where fluvial scour has resulted in failure of works and bank erosion has persisted, particularly works undertaken along the bank opposite the Mullumbimby Rugby League Football Club. In both cases the net result is that the works do not address erosion at the site and maintenance would not improve the works effectiveness. The main differentiation is that redundant works are generally an inappropriate form of erosion control as well as being ineffective.

Pile fields with coir logs and revegetation located on the upper Brunswick River estuary at Reach 88 were recorded as “Trial works”. The use of hardwood piles in this context is novel. Pile fields are generally used to address fluvial erosion by increasing channel roughness and thus decreasing stream power and erosion, and encouraging deposition. Whilst fluvial processes are certainly operating at this site (evidenced by toe scour undermining the downstream area of rock armouring), wave action is also an issue and this process is continuing. The effects of persistent wave attack were obvious during the field survey and despite their

being considerable mangrove establishment on the lower bank there was also undermining of the propagules particularly where the coir logs had decomposed. It is understood that the coir logs have been replaced since the field survey and this may allow the mangroves to establish. The revegetation works are generally well established.

Examples of the types of erosion protection works present in the Brunswick River Estuary study area and their condition/effectiveness status are shown in *Plates 16* to *20*.

Table 7 *Total length of each category of works effectiveness for bank erosion protection measures surveyed and percentage of each category of the total length of surveyed bank protection measures in the Brunswick River estuary.*

Works Effectiveness	Total length of bank (m)	% of overall works
Ineffective	64	0.9%
Partially Effective (Condition)	1029	13.7%
Partially Effective (Design)	1100	14.7%
Completely Effective	**4145**	**55.3%**
Under Construction	-	-
Trial works/untested	375	5%
Redundant	780	10.4%
TOTAL	**7492**	**100%**

Plate 16 *Examples of trial/untested bank protection works in the Brunswick River estuary. These pile field and coir log bank protection works were installed in 2022. Mangroves have recruited in the embayments behind the coir logs but are at risk of undermining as the coir logs have quickly disintegrated below the high tide level. The coir logs were replaced in July/August 2024.*

Plate 17 *Examples of effective bank protection works in the Brunswick River estuary, clockwise from top left: rock revetment in the lower Brunswick; Rock armouring in lower Simpsons Creek; rock armouring and sandstone blocks on the lower Brunswick River at Reach 118; rock armouring on Marshalls Creek Reach 355.*

Plate 18 *Examples of partially effective bank protection (design) in the Brunswick River estuary: From left to right, insufficient rock blanket thickness and armour toe failure on the Brunswick River Reach 85; failure of the bank toe and subsequent subsidence on the Brunswick River Reach 71.*

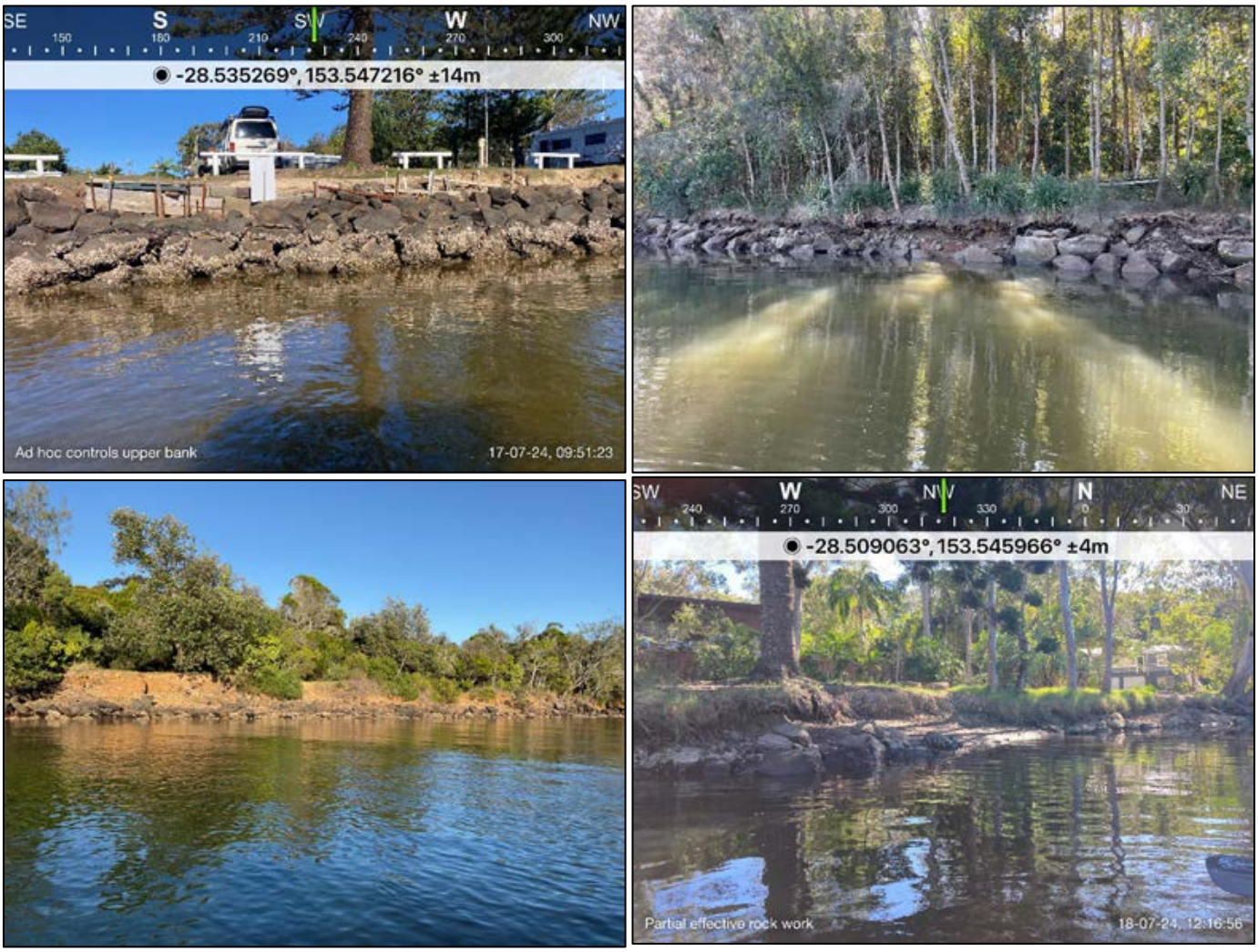

Plate 19 *Examples of partially effective bank protection works (condition) in the Brunswick River estuary, From left to right: ad hoc controls above slumped rock revetment in the lower Brunswick estuary Reach 145; subsiding rock works on the Brunswick River exposing upper bank to erosion, Reach 73; partial failure of rock revetment in Marshalls Creek at Reach 311 adjacent to Casons Road, New Brighton; partial failure of rock armouring on the southern entrance wall, Brunswick River Reach 255.*

Plate 20 *Examples of inappropriate bank protection works in the Brunswick River estuary, from left to right: building rubble dumped over the bank at Reach 61; building rubble as bank protection on the Brunswick River below the rugby club bend, Reach 78.*

DST For Bank Erosion Management in NSW Estuaries – Summary of Recommendations

Method

The Decision Support Tool for Bank Erosion Management in NSW Estuaries (the "DST") is an excel-based tool developed by Hydrosphere Consulting for NSW Department of Primary Industries and Regional Development – Fisheries under the NSW Marine Estate Management Strategy. The tool is designed to contribute to the development of estuary bank management strategies which are consistent with best management practices.

The main output of the tool is the DST Recommendation. This recommendation is made up of the primary recommendation determined by the DST macros plus any additional recommendations related to riparian management, fencing, or other management actions (eg. boating controls). The primary recommendation may be a recommended treatment type where bank erosion and erosion impact thresholds are exceeded or may be a recommendation to undertake maintenance on existing controls. Shortlisted treatment types are also provided.

The method by which the DST determines bank erosion treatments and riparian/estuary management actions are detailed in the DST's supporting documentation (see Hydrosphere, 2020 and 2020b). It is important to review these documents before using the DST outputs as they provide important context and explanatory notes on the outputs. As examples:

- Fencing will be recommended where stock access or public access is identified as contributing to erosion in a specific reach
- Riparian vegetation management will be recommended where the average width of riparian vegetation in a surveyed reach is less than 10m, or where the vegetation is patchy (ie. "continuity" is negligible or low), unless there is a landward constraint such as a road or other infrastructure that would prevent improvement.
- Other management controls are recommended where vessel wave wash is identified as a contributing factor or public access is a consideration.

It is explicitly acknowledged in the DST documentation that social and economic impacts of the recommendations have not been considered at this stage and that consultation with relevant stakeholders would be required before implementation.

Importantly also, the primary recommendation and shortlisted options provided by the DST are based on the data collected during the field survey which due to the scale of assessment are not necessarily of the detail that would normally be required for developing site specific remediation recommendations. As such there may be reasons why the DST recommendation may not be the most suitable option for the bank segment and these reasons may not be captured by the input data. Hydrosphere, in its documentation on the tool explicitly states that "*It is crucial that the DST recommendations are further investigated…to assess whether they are indeed applicable or if other techniques could be more suitable*" (Hydrosphere, 2020, p.18).

Overview of Results

Figure 18 shows the distribution of DST Primary Works Recommendations within the Brunswick River estuary study area.

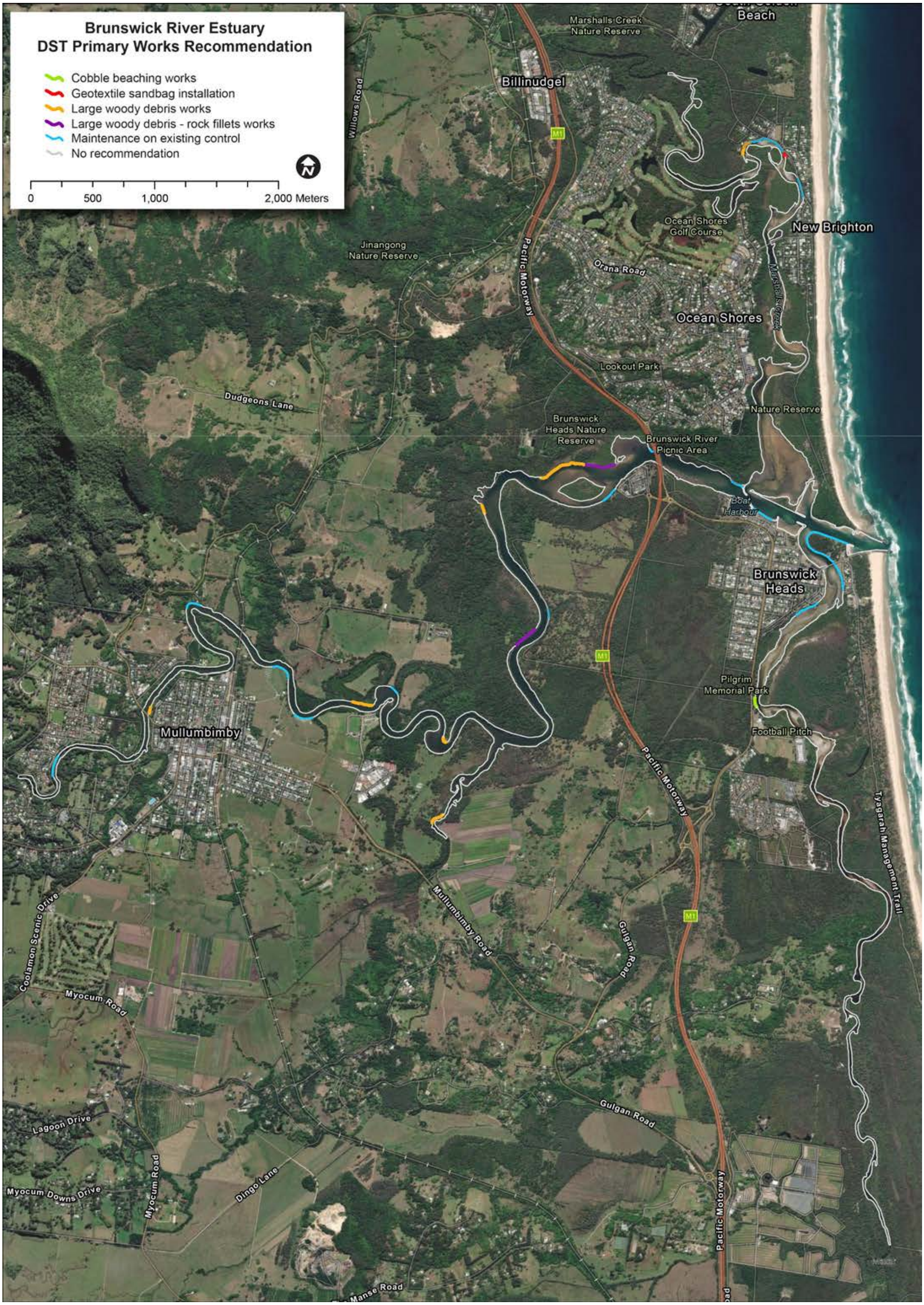

Figure 18 Distribution of DST Recommendations across the Brunswick River Estuary Study Area

As mentioned previously, the DST recommendations are made on the basis of the field data in accordance with the tool's macros and are designed to give a first cut assessment of best practice works types suitable for the estuary location and the processes and impacts recorded during the field survey. The DST primary recommendation is either a main works type or a recommendation to maintain the existing controls present where appropriate. A summary of the range of Primary DST Recommendations made for the Brunswick River estuary study area is included in *Table 9*.

Table 9 Summary of primary recommendations from the DPIRD Fisheries Decision Support Tool for Bank Erosion Management in NSW for the Brunswick River estuary.

Control Type	Total length of works recommended (m)	% of total surveyed bank
Cobble beaching works	77	0.13%
Geotextile sandbag installation	32	0.06%
Large woody debris works	972	1.71%
Large woody debris/rock fillet works	459	0.81%
Maintenance on existing controls	2925	5.16%
Total works	**4555**	**7.87%**
No recommendation	52256	92.13%

The fact that a surveyed reach attracts a recommendation for works or maintenance within the DST does not infer that the reach is a priority for management action. This is because the DST does not include any consideration of overall objectives for estuary management beyond bank erosion control using best practice[2]. However, where a reach is separately assessed to be a priority for intervention, the DST provides a reasonably objective and standardised approach to determining which treatment options should be first considered.

Where a reach is indicated to require "Maintenance on existing controls", the primary factors considered by the DST are whether an appropriate treatment/control exists at the site that is not either completely effective or a trial/untested form of works, not ineffective, and not redundant (in terms of having no effect on bank stability). Maintenance on an existing control will generally not be recommended where the works type is inappropriate, such as utilising tyres or building rubble for erosion control, but may be recommended where part of the works implemented includes inappropriate works. In this case, maintenance on the existing controls should include removing inappropriate materials and implementing current best practice methodologies.

Lastly, it should be noted that the DST Final recommendation may also include management actions such as fencing, riparian vegetation management or other management controls (managing public access or implementing boating speed restrictions, etc). The complete NEAP Brunswick River Estuary Condition Survey dataset should be reviewed to understand Final DST Recommendations within the study area.

[2] The prioritisation of reaches for management intervention is covered separately in Part 5 of this assessment report.

Future Works

It is clear from the existing works statistics that, when entrance training walls are excluded, the predominant form of bank erosion protection used in the estuary to date is direct protection using rock armouring (greater than half of all works). This is a common occurrence in NSW estuaries which generally have a history of public works programs targeting urban foreshores and protection of public foreshore. The preference for hard engineering solutions probably reflects the setting, that is, rock revetment is often used in high public use areas or where public infrastructure is to be protected. However, there are many examples of ad hoc works adjacent to private properties, some of which appear to occur on Crown foreshore.

The NEAP field survey reveals that in the Brunswick River estuary and its tributaries, erosion is generally not as great an issue as in some north Coast and Mid North Coast estuary systems that have more extensive floodplain development and less extensive riparian vegetation. However, as discussed in the previous sections there are isolated areas of high erosion and associated impacts to public assets and infrastructure, estuarine health, water quality and high conservation value vegetation types.

The question then is, are there more appropriate works types to use in the Brunswick River estuary system than direct rock armouring? This was a question partly canvassed in the Brunswick CZMP which provided examples of “soft engineering” approaches in an appendix to the Plan.

The field survey revealed that riparian vegetation condition is also generally quite good throughout the Brunswick River estuary, particularly in the tributary systems such as Simpsons and Marshalls Creek. Several of the reaches assessed with high erosion severity occurred adjacent to reaches also mapped with very good vegetation condition and there was generally little correlation between erosion severity and riparian condition. Further, the need for widespread revegetation and stock management is probably less than in some larger estuary systems where floodplain development is more extensive and grazing is more intensive.

Additionally, natural recovery processes are occurring in the Brunswick and its estuarine tributaries. For example, the Site Audit undertaken to support the 2018 CZMP (Byron Shire Council, 2018: Appendix B) identified several sites that were recorded as eroding in previous investigations as having stabilised as a result of tree fall providing some subsequent degree of natural protection.

Despite natural recovery at some sites, there are clearly several areas where riparian vegetation programs and weed control programs could improve riparian vegetation condition along the estuary and the existing works programs of Byron Shire Council, Brunswick Valley Landcare, Positive Change for Marine Life should be commended and supported. Part 5 of this reports recommends a number of areas where the focus of management intervention is on protecting high conservation value riparian vegetation in the estuary.

In areas where erosion processes are such that natural recovery processes are unlikely to alleviate ongoing bank erosion and associated impacts, the approach adopted must reflect the underlying geomorphic processes and the site constraints. Where near-bank deep water channel profiles exist then rock revetment may be the only practical solution. However, where this is not the case there are a range of alternatives available, many involving hybrid approaches that seek to provide estuary appropriate remediation works that target improved bank stability and restore estuarine habitat and bank and mangrove vegetation.

An example of this approach is where wave wash erosion is impacting bank stability and important estuarine habitat types such as mangroves and saltmarsh communities. The fundamental process at many of these sites is the persistent attack of wave wash on the peaty/organic rich muds of the intertidal bench which when unimpacted by waves generally supports dense mangrove forest. As fine sediments are removed by the wave wash, the peaty soils on the intertidal bench are winnowed away exposing the basal sands common in the lower Brunswick River estuary. The removal of these organic rich mud layer reduces the

ability of mangroves to persist and regenerate and mangrove stilting occurs. Senescence of the mangrove pneumatophores reduces the intertidal bench and wave action is able then to attack the intertidal zone of the bank leading to undercutting and subsequent slumping. This process can then only be reversed by structures that recreate the intertidal bench by dissipating wave action and encouraging deposition, allowing mangrove establishment.

Suitable works in these locations include rock fillets and hybrid log/rock fillets potentially with the addition of cobble beaching and/or oyster shell to restore intertidal bench height and encourage mangrove colonisation.

Interestingly, rock fillet works have not been utilised within the study area. Although not suitable to all locations, these structures have proved to be very effective in other estuary locations on the mid north and north coast in situations where a suitable intertidal bench is present and wave erosion is the dominant cause of erosion (either wind generated or boat wake). However, care is required in their construction. Important considerations are ensuring the site has a suitable bench for construction that resists subsidence or settlement of the structure, that the finished level of the fillet crest equates to the Mean High Water Spring (MHWS) level (see *Figure 19*), and that some protection is provided on the bank face adjacent to the fillet opening that ensures wave erosion doesn't "funnel" into the bank at that location. Importantly, where deep water occurs adjacent to the eroding bank toe, rock fillets are difficult to construct and not usually cost effective and therefore are not an appropriate technique to use in this setting.

As has been noted in various previous assessments (e.g. Stockard et al., 1999; Taylor, 2017), in areas where bank erosion is caused by wave action (boat or wind) and an intertidal bench is available, an alternative and cheaper option to rock fillets which may be available depending on site condition is the use of cobble beaching or low rock revetments. These styles of works are less intrusive in the estuary, are a more commonly observed natural estuarine habitat type, do not impede bank to channel access in the same way as fillets, absorb rather than reflect wave energy, can suffer minor resettlement without losing structural integrity, can be repaired easily, and encourage both oyster and mangrove colonisation within the structure.

Lastly, there is increasing interest in hybrid works models that seek to tailor specific works styles to address erosion processes at a reach scale and which combine the objectives of improving bank stability with maintaining estuarine character and other objectives such as the provision of diverse estuarine habitats, maintenance of foreshore access, encouraging oyster reef, or encouraging mangrove re-establishment. These are often referred to as soft engineering approaches and there are many sites where such approaches are suitable, constructable, and likely to be cost-effective. A number of examples of these approaches are provided in the CZMP but there are few examples of such works implemented in the Brunswick River.

Of course, management controls are also important, particularly where boat wave impacts are identified, such as the reaches on the northern bank of the Brunswick River estuary adjacent to Mangrove Island within the Brunswick River Nature Reserve. Unfortunately, NSW Transport Maritime Branch was not responsive to attempts to seek their view on recreational boating needs and management in the Brunswick.

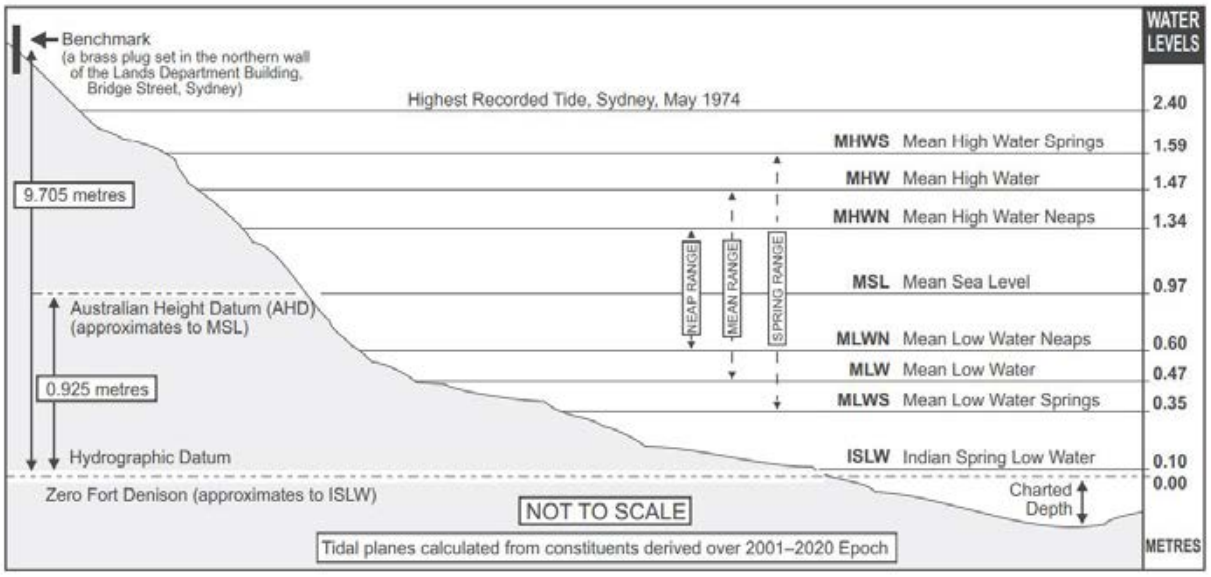

Figure 19 Tidal height definitions (Source: Manly Hydraulics Laboratory, NSW Tide Chart).

PART 5 – Priorities for Action and Investment

This part of the bank and riparian condition assessment report outlines a priority system designed to identify and rank priority reaches for management, remediation, protection and investment. The multicriteria analyses used to determine the priority reaches draws the criteria from the objectives of a number of foundational documents relevant the management of the estuary. These include the NSW Coastal Management Act 2016, the Marine Estate Management Strategy 2018-2028, the Coastal Crown Lands Guidelines 2023, the existing Brunswick River Estuary Coastal Zone Management Plan (BSC, 2018), and to a lesser extent the Byron Shire Council Biodiversity Conservation Strategy 2020-2030 (BSC, 2020).

The Management Context

Coastal Management Act No 20 2016 (NSW)

The *Coastal Management Act 2016 No 20* NSW (CMA 2016) identifies the management objectives for coastal management areas in New South Wales. The objects of the CMA 2016 include (s3):

> *to manage the coastal environment of New South Wales in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of the State*, and of particular relevance to this assessment:
>
> *(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*
>
> *(f) to mitigate current and future risks from coastal hazards, taking into account the effects of climate change, 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*
>
> *(m) to support the objects of the Marine Estate Management Act 2014.*

The CMA 2016 breaks the coastal zone into management areas with identified management objectives. Under Part 2 Section 8 the management areas include *wetlands and littoral rainforest areas* and *coastal environment areas*. These areas are defined within the State Environmental Planning Policy (Resilience and Hazards) 2021 (SEPP(R&H) 2021) and associated mapping (SEPP(R&H) 2021, s2.4). Coastal environment areas are defined in the CMA 2016 as the coastal waters of the State, estuaries, coastal lakes, coastal lagoons and land adjoining those features, including headlands and

rock platforms. Wetlands and littoral rainforest areas are defined as land which displays the hydrological and floristic characteristics of coastal wetlands or littoral rainforests and land adjoining those features.

The entire area of this assessment constitutes *coastal environment area*, however only a small proportion of the assessment area constitutes *wetland and littoral rainforest* areas. The CMA 2016 proscribes a hierarchy that operates where a parcel of land is mapped as more than one management area (s10(3)). In the context of this assessment that hierarchy operates to ensure that the management objectives for the wetland and littoral rainforest areas are given priority over the management objectives for coastal environment areas wherever an inconsistency arises. The management objectives for the two management areas are generally consistent. However, one practical outcome of this hierarchy is that in areas of the Brunswick River estuary where wetlands or littoral rainforests occur, management efforts should include promoting the rehabilitation and restoration of degraded wetlands and littoral rainforests (CMA 2016 s6(b)).

In all other areas assessed in this study, the management objectives for *coastal environment areas* can be reasonably adopted and include (CMA 2016 s8(2)):

(a) to protect and enhance the coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes and coastal lagoons, and enhance natural character, scenic value, biological diversity and ecosystem integrity,

(b) to reduce threats to and improve the resilience of coastal waters, estuaries, coastal lakes and coastal lagoons, including in response to climate change,

(c) to maintain and improve water quality and estuary health,

(d) to support the social and cultural values of coastal waters, estuaries, coastal lakes and coastal lagoons,

(e) to maintain the presence of beaches, dunes and the natural features of foreshores, taking into account the beach system operating at the relevant place,

(f) to maintain and, where practicable, improve public access, amenity and use of beaches, foreshores, headlands and rock platforms.

NSW Marine Estate Management Strategy 2018-2028

In terms of the State-wide perspective, the NSW Marine Estate Management Strategy 2018-2028 identifies a number of Management Initiatives relevant to this assessment including:

- Under *Management Action 1.3*: Facilitate and deliver on-ground activities that reduce diffuse source water pollution through investigation and provision of funding programs and financial incentives.
- Under *Management Action 2.3*: Develop marine vegetation management plans that maximise resilience…address key threats…facilitate rehabilitation opportunities. Also, to investigate estuary-wide bank protection options to inform the assessment of bank protection work proposals and facilitate rehabilitation opportunities.
- Under *Management Initiative 3*: Note that on-ground activities and habitat protection and rehabilitation that will help mitigate the impacts of climate change are to occur via actions under Initiative 1 and 2 and will include rehabilitating coastal wetlands, revegetating riparian areas, and protecting river banks.

Coastal Crown Lands Guidelines 2023

The Coastal Crown Lands Guidelines were released by the NSW Department of Planning and Environment in October 2023. The Guidelines apply generally to the administration of Crown land where that land occurs within the "coastal zone" within the meaning of section 5 of the Coastal Management Act 2016. This includes lands mapped under the SEPP (Resilience and Hazards) 2021 as coastal wetlands and littoral rainforest area, coastal vulnerability area, coastal environment area, and/or coastal use area.

The Guidelines focus on aligning decisions made under the Crown Land Management Act with the objects and principles of the Coastal Management Act and promote the integration of Crown land management with CMPs.

Of particular relevance to this report and its future use, where the preparation of a CMP is envisaged and actions stemming from this report are proposed to occur upon Crown Lands, it is a requirement that those actions are referred to Crown Lands before the CMP is adopted. If this process is followed and the CMP is then certified, then applications for dealings or authorisations under the Crown Land Management Act will be streamlined.

Brunswick River Estuary Coastal Zone Management Plan 2018

The CZMP contains a number of strategies relevant to the prioritisation of actions to improve flood resilience, bank stability, riparian vegetation, and estuarine health in the Brunswick River estuary. These strategies have been briefly outlined in the literature review section of this report. Unfortunately, the CZMP has never been certified and hence does not carry any statutory weight. It does however identify sites where high priority on-ground works actions such as bank stabilisation works, targeted revegetation, and maintenance of existing protection works have been recommended.

Byron Shire Council Biodiversity Strategy 2020-2030

The Byron Shire Council Biodiversity Conservation Strategy 2020-2030 (BSC, 2020) contains objectives and actions relevant to the Brunswick River estuary, particularly in relation to riparian vegetation and habitats. These include:

- **Objective 1.3** To use current best practice desktop tools to support and facilitate High Ecological Value (HEV) landscape and habitat protection
- **Objective 1.5** To secure additional funding to support biodiversity projects including by incorporating relevant elements of this strategy (e.g. relating to coastal wetlands, littoral rainforest) into Council's Coastal Management Programs, to increase potential for funding support through the State Government Coastal and Estuary Grants Program (*Action 1.33*).
- **Objective 4.8** To encourage and provide direct and in principle support to Landcare, Primary Industry groups and individual landholders to implement best practice natural resource management along the waterways of the Brunswick and Wilsons River catchments including through continuing to develop and implement 'Bringing back the Bruns' branded projects to address improvements in riparian and instream habitat, water quality, fish passage and habitat connectivity on Council and private land along the Brunswick River and its tributaries (*Action 4.29*).

Bringing Back the Bruns Initiative

Whilst not a strategy per se, the Byron Shire Council's *Bringing Back the Bruns* program is a significant environmental objective to holistically rehabilitate the Brunswick River and catchment through various Council projects and collaborative partnerships with key stakeholders. A number of projects exist under the initiative including bush regeneration activities on the Brunswick River, Mullumbimby riverbank restoration activities, and causeway upgrade projects to improve fish passage between the freshwater and estuarine reaches of the river.

Priorities for Intervention

The priorities for intervention outlined below reflect the management objectives in the *Coastal Management Act 2016*, the management initiatives under the MEMS 2018-2028, the bank and riparian management strategies identified in the Brunswick CZMP (BSC, 2018), and the estuary related objectives of the Byron Shire Council Biodiversity Strategy 2020-2030 (BSC, 2020).

Priority reaches and priority focus areas

As part of the Brunswick River Estuary NEAP Bank Condition and Riparian Condition Assessment, a ranked list of priority reaches for protection, enhancement and/or remedial intervention is to be produced.

In this context, an estuary "reach" refers to an individually mapped segment of bank which has been assessed during the field survey as being relatively homogenous in terms of either bank erosion severity and/or riparian vegetation condition.

Three hundred and fifty-seven (357) individual reaches were mapped during the field survey. However, where appropriate, a number of adjacent reaches may be grouped and targeted as a priority on the basis that the same or similar strategies would be applied to address issues common to all the reaches in that grouping. To avoid confusion, where several reaches are combined to strategically address an identified issue, the combined reaches will be referred to as a "priority focus area".

The bank erosion severity and riparian vegetation condition are the primary fields upon which the estuary banks have been segmented into reaches. However, each reach also has a number of additional data fields recorded. This allows reaches to be identified on the basis of other attributes besides erosion severity or riparian condition. These additional attributes may include for example physical features (e.g. Presence of bedrock), vegetation characteristics (e.g. Presence of priority weed species), and/or man-made influences (e.g. the presence of existing control works and their effectiveness/condition at the time of survey).

The recording of field data in this way allows the interrogation of the field data sets using multicriteria analyses which in turn allows reaches with certain sets of attributes to be extracted from the field dataset and supplemented with other existing datasets to produce subsets which form either potential priority reaches or potential priority focus areas for further assessment.

Table A describes the draft analyses adopted for this assessment to develop the subset of reaches where further investigation as to whether protection, enhancement, or remediation is warranted. The analyses have been separated into the four primary areas of interest to this assessment: bank condition, riparian vegetation condition, estuarine habitat and existing works condition.

Table A *Reach analyses outcomes based on the field data collected and multi-criteria analyses, supported by existing GIS datasets as described. These reaches form the pool of mapped estuary reaches to which the priority ranking criteria are to be applied to determine priorities for estuary bank and riparian vegetation remediation/protection actions.*

ID	Analyses	Description	Notes
Bank Condition			
BC1	Reach mapped as "high" erosion severity and associated with "good" or "very good" riparian vegetation condition.	These are reaches where bank remediation measures would protect existing riparian vegetation that has been mapped as being in good to very good condition.	MEMS Action 2.3. 11 reaches identified. (Reaches 12, 61, 70, 129, 131, 134, 136, 138, 158, 159, 310)
BC2	Reach mapped as "high" erosion severity and also containing existing bank protection works which have been identified as partially effective, ineffective, or redundant.	These are reaches where erosion severity was classified as "high" based on field assessment and the DST criteria, but which landholder interest can be inferred by the presence of existing erosion protection works (which were not mapped as effective).	MEMS Action 1.3. 2 reaches identified. (Reaches 21 and 70)
BC3	Reaches mapped with "moderate" or "high" erosion severity but also mapped as having "medium" to "high" infrastructure/commercial or Amenity/safety impact rating	These are reaches where high erosion severity is causing medium to high level impacts to infrastructure, commercial, amenity or safety values as defined in the DPIRD Fisheries Decision Support Tool for bank erosion management.	CMA 2016 s3(b). 5 reaches identified. (Reach 164, 191, 312, 315, 318)
BC4	Reaches mapped with "moderate" or "high" erosion severity and also important for public access	These are reaches where public access is established but where bank erosion is potentially compromising public safety	CMA 2016 s8(2)(f). 5 reaches identified. (Reaches 164, 191, 255, 266, 318, 352)
BC5	Reaches mapped with high erosion severity and also containing riparian vegetation in moderate condition	These are reaches where bank remediation measures would protect existing riparian vegetation that has been mapped in moderate condition.	MEMS Action 2.3. 3 reaches identified. (Reaches 21 ,27, 318)

ID	Analyses	Description	Notes
Riparian Vegetation Condition			
RC1	Reach containing or immediately adjacent to a mapped littoral rainforest community and threatened by at least "high" erosion severity.	These are reaches that correspond to the SEPP (Resilience and Hazards) 2021 Littoral Rainforest area mapping and are threatened by high severity erosion.	CMA 2016 s6(b) promotion of rehabilitation and restoration of degraded littoral rainforests. Also BSC Biodiversity Strategy Action 1.33. No reaches identified. Littoral rainforest occurs adjacent to Marshalls Creek but erosion severity is generally negligible in these areas.
RC2	Reach containing or immediately adjacent to a mapped coastal wetland and threatened by at least "high" erosion severity.	These are reaches that correspond to the SEPP (Resilience and Hazards) 2021 Coastal Wetlands Area mapping and are threatened by high severity erosion.	CMA 2016 s6(b) promotion of rehabilitation and restoration of degraded coastal wetlands. Also BSC Biodiversity Strategy Action 1.33. 12 reaches identified (Reaches 12, 56, 59, 61, 129, 131, 134, 136, 138, 310, 311, 318)
RC3	Reach immediately adjacent to a candidate High Ecological Value riparian vegetation community (excluding estuarine macrophyte communities) and threatened by Moderate or High erosion (e.g. BSC mapped EEC), with at least "Good" riparian vegetation condition.	These are reaches where the estuary bank vegetation forms part of a mapped candidate NSW Endangered Ecological Community which is threatened by erosion processes which are considered above natural rates. NOTE: The riparian vegetation condition rating of at least "Good" filters out reaches with very poor to moderate condition vegetation condition.	BSC Biodiversity Strategy Objective 1.3 16 reaches identified. (Reaches 24, 28, 30, 37, 68, 71, 76, 106, 107, 108, 156, 164, 232, 255, 261, 273, 302)

ID	Analyses	Description	Notes
Estuarine Habitat			
EH1	Reach containing or immediately adjacent to a mapped coastal saltmarsh community and threatened by at least moderate erosion severity.	These reaches are where coastal saltmarsh is threatened by erosion processes which are considered above natural rates.	MEMS Action 1.3. 6 reaches identified. (Reaches 12, 62, 131, 132, 134, 136)
EH2	Reach containing significant mapped mangrove habitat (at least half of reach containing mapped mangrove habitat) and threatened by at least moderate erosion severity	These reaches are where mangrove habitat is threatened by erosion processes which are considered above natural rates.	MEMS Action 1.3. 10 reaches identified. (Reaches 6, 12, 37, 65, 79, 129, 131, 132, 136, 138)
Existing Works Condition			
EC1	Reach identified as having "medium" to "high infrastructure/commercial impacts or amenity/safety impacts and also have existing works in ineffective or partially effective condition.	Identifies reaches where failing works are contributing to impacts to infrastructure, commercial, amenity or safety values.	CMA 2016 s3(b). 2 reaches identified (Reaches 191, 312)
EC2	Reach mapped as at least "moderate" erosion severity and also containing existing bank protection works adjacent to public land.	Public land is defined as Council owned land, crown reserves, or crown land parcels. This criterion identifies reaches that have existing works but where erosion is continuing and is affecting a public land asset/public foreshore area	CMA 2016 s3(b). 10 reaches identified. (Reaches 19, 21, 68, 70, 71 108, 191, 255, 261, 266)

Rankings

A simple weighted scoring system has been adopted to rank the priority reaches and focus areas identified using the above analyses. Higher rankings are allocated to higher scoring reaches. Higher ranking indicates greater justification for investment to meet the objectives outlined under the Coastal Management Act, the MEMS 2018-2028, the Byron Shire Council CZMP for the Brunswick River estuary, and the Byron Shire Council's Biodiversity Conservation Strategy 2020-2030.

Table B outlines the criteria used.

Table B Criteria and associated weightings used to rank the list of priority reaches and focal areas for potential investment in remediation/enhancement/protection.

ID	Criteria	Description	Weighting	Notes
A	Public assets or infrastructure at high risk	Primarily proximity to road, boating, or other public infrastructure.	+5	CMA 2016 Object 3(b) and (d). Reaches where works are currently being implemented will be excluded.
B	Intervention likely able to address suite of estuarine natural values including bank stability, estuarine and riparian vegetation, estuarine habitat, and water quality	Reaches which intervention is likely to address a suite of estuary values are ranked more highly than those which address only a single value (such as bank stability).	+5	CMA 2016 Object 3(a). MEMS Management Initiative 1,2 and 3.
C	Reach is an important public access location	Proximity to a public access location and requiring considerations of safe access	+5	CMA 2016 s8(2)(f).
D	Intervention likely to Improve future flood resilience of built assets	Interventions likely to improve the resilience of coastal built assets to the impacts of extreme events (e.g. Storm or flooding events) are given more weight.	+5	CMA 2016 Object 3(f) and (i). This criterion is primarily focussed on built assets as criteria B focusses on natural assets although the two are not mutually exclusive.
E	Reach is listed within the Brunswick Estuary CZMP as a Priority 1 action area and has not yet been addressed through an appropriate management action	Reaches in the priority pool which are also identified in the Brunswick CZMP as Priority 1 on-ground actions have already gone through an estuary planning process and audit so, if not already addressed, are ranked more highly in the priority system.	+5	CMA 2016 s3(a), (h) and (i) Brunswick Estuary CZMP (2018) Strategies B1-B10

ID	Criteria	Description	Weighting	Notes
F	Aboriginal Cultural Heritage values at the site	It is acknowledged that a consultation process will be required with the Arakwal Native Title holders and the Tweed Byron LALC to identify reaches of significance in terms of Aboriginal cultural heritage and ongoing use. This process should identify the preferred pathway for identifying cultural appropriate approaches to estuary remediation and protection, noting that the whole of the Brunswick River is considered significant by the Arakwal peoples.	TBD	CMA 2016 Object 3(c) and s8(2)(d) and MEMS Management Action 4.2. Comment has been sought from both Arakwal representatives and the TBLALC on ways to integrate cultural significance and culturally appropriate approaches to management of the issues raised in this assessment document. At this stage weightings for cultural value will not be applied until an agreed approach is adopted.
G	Landholder support known or likely	Landholder support is generally crucial to the successful implementation of most interventions on estuary banks or in the riparian zone. Where landholder support is known or can be inferred from previous works or communications then potential interventions in those reaches will be scored more highly.	+4	Byron Shire Council Biodiversity Conservation Strategy Objective 4.8: Action 4.29 In the Brunswick River study area, the likelihood of landholder support was assessed through consultation with Brunswick Valley Landcare and the Positive Change for Marine Life community organisation. Reaches adjacent to Crown Land, NPWS estate, Council owned or managed land, and road reserves are assumed to meet this criteria.
H	Intervention likely to have a high degree of success	Site factors, erosion processes, and recommended methods are considered to have a high probability of achieving and maintaining site stability over the medium term (~10 years).	+4	Based on expert opinion.
I	Access is straight forward and is via all-weather private road/track, Crown Land or Council owned land	Ease of access reduces intervention costs	+4	Straightforward access will reduce implementation costs.

ID	Criteria	Description	Weighting	Notes
J	Intervention likely to protect/enhance important natural or aesthetic values	Factors include proximity to good to very good riparian vegetation, style of likely intervention, and location within the estuary.	+3	CMA 2016 Object 3(a).
K	Reach corresponds with or located within close proximity of a biodiversity priority action area (based on Byron Shire Council Biodiversity Strategy)	Interventions that support the existing biodiversity strategy for the Byron Shire are scored more highly.	+3	CMA 2016 Object 3(a). The biodiversity strategy does not explicit identify priority action areas, consultation with Council officers has assisted in identify reaches of high priority for biodiversity conservation. Areas located within Nature Reserves meet this criterion automatically.
L	Reach adjacent to the oyster harvest zone or aquaculture lease	The Oyster Industry is an important commercial end user group that contributes to the local economy. The industry is highly dependent on good water quality and is often the first to be impacted from nutrient, sediment and ASS runoff.	+3	CMA 2016 Object 3(d).
M	Reach immediately adjacent to mapped estuarine vegetation – Seagrass	Determined from existing mapping, seagrass must be on the same side of the channel as the segment to receive the additional weighting.	+3	CMA 2016 Object 3(a). Seagrass has been allocated a high rating due to its limited distribution in the estuary.
N	Reach contains mapped estuarine vegetation – Coastal Saltmarsh	Based on the Byron Shire Council HEV mapping dataset and the NSW Estuarine Macrophytes mapping	+3	CMA 2016 Object 3(a) and (f). Coastal saltmarsh has been allocated a high rating due to its susceptibility to sea level rise and the limited opportunities for landward expansion of the community.

ID	Criteria	Description	Weighting	Notes
O	Site factors facilitate lower cost interventions	Some site factors such as severity of erosion, scale of required works, type of intervention, and materials requirements can significantly influence the costs of interventions. Lower cost interventions are scored more highly as cheaper interventions can free resources up for other interventions elsewhere.	+2	Cost of intervention is relative to the value of the asset or issue being addressed.
P	Intervention likely to protect/enhance existing estuary remediation works	Interventions that protect existing investments in estuary health or stability are considered to add additional value.	+2	Recognises the importance of maintaining existing assets which are contributing to estuary stability and health.
Q	Reach contains estuarine vegetation - Mangroves	Determined from existing mapping and aerial or other imagery	+2	CMA 2016 Object 3(a).
R	Reach located within a high use boating area	There is existing commercial boating use in the estuary (oyster growers, boat hire, etc.). Additionally, recreation boating is a very popular activity in some sections of the estuary, particularly the lower to mid Brunswick River. High use boating areas have been identified by the NSW Maritime BSO.	+2	CMA 2016 Object 3(b). Likely to increase costs of remediation due to specific issues related to boat wave wash management but consistent with addressing multiple objectives protecting the social values of estuarine waterways.
S	Reach complimentary to existing other NRM program	Interventions that support existing NRM programs in the estuary are scored more highly.	+1	CMA 2016 Object 3(h). E.g. Cultural heritage program, fish habitat program, etc.

ID	Criteria	Description	Weighting	Notes
T	Reach identified as a priority investment site in previous or ancillary studies	A small increase in weighting is given to any sites mapped as high or extreme erosion in the 2024 field survey and which are also identified as having high erosion or bank instability in other documents such as reports from/to Council, DCCEEW, Landcare or other community organisations.	+1	CMA 2016 Object 3(h).
U	Reach has a complicated approvals pathway due to proximity to coastal wetlands, littoral rainforest, or marine parks estate.	Reaches that are likely to involve significant costs and delays associated with approvals/permitting/licencing reasons are discounted slightly.	-2	

Priority Reaches

The priority system outlined above has been applied to the 357 estuary reaches assessed during the NEAP field survey. Reaches were first reviewed against the objective criteria in *Table A* and if the reach satisfied any of the criteria it was added to the "pool" of priority reaches. The criteria resulted in 44 reaches being added to the priority pool. Each of the reaches in the "priority pool" were then assessed against the ranking criteria in *Table B*.

Overall Priority list

After accumulating adjacent reaches with similar processes and management issues into priority focus areas (for example reaches 312 and 315 adjacent to Casons Road on Marshalls Creek; and 129, 131, and 132 at Brunswick Heads Nature Reserve), a ranked list of 32 priority reaches/focus areas remained.

Table 10 lists the top 12 ranked reaches/focus areas within the Brunswick River estuary. These locations are considered higher priority for management interventions to improve flood resilience, protect public assets and infrastructure, improve water quality, improve estuary health, and protect or enhance important riparian vegetation communities. The main issues identified as affecting the reach and the objectives of management intervention are listed. *Figure 20* shows the distribution of the identified priority reaches in the study area, categorised as either "Higher" or "Lower" priority.

Tables 11-13 identify the top ranked locations for targeted programs that aim to protect public assets and infrastructure, improve water quality, or protect or enhance riparian vegetation (specifically high conservation value vegetation types). These are subsets of the overall priority list and include locations outside of the high priority list.

For the Brunswick Estuary NEAP Assessment, reaches outside the top 12 should be pro-actively monitored for any change, for example after flood events. These reaches are listed in *Appendix B* and their locations are indicated by yellow in *Figure 20*.

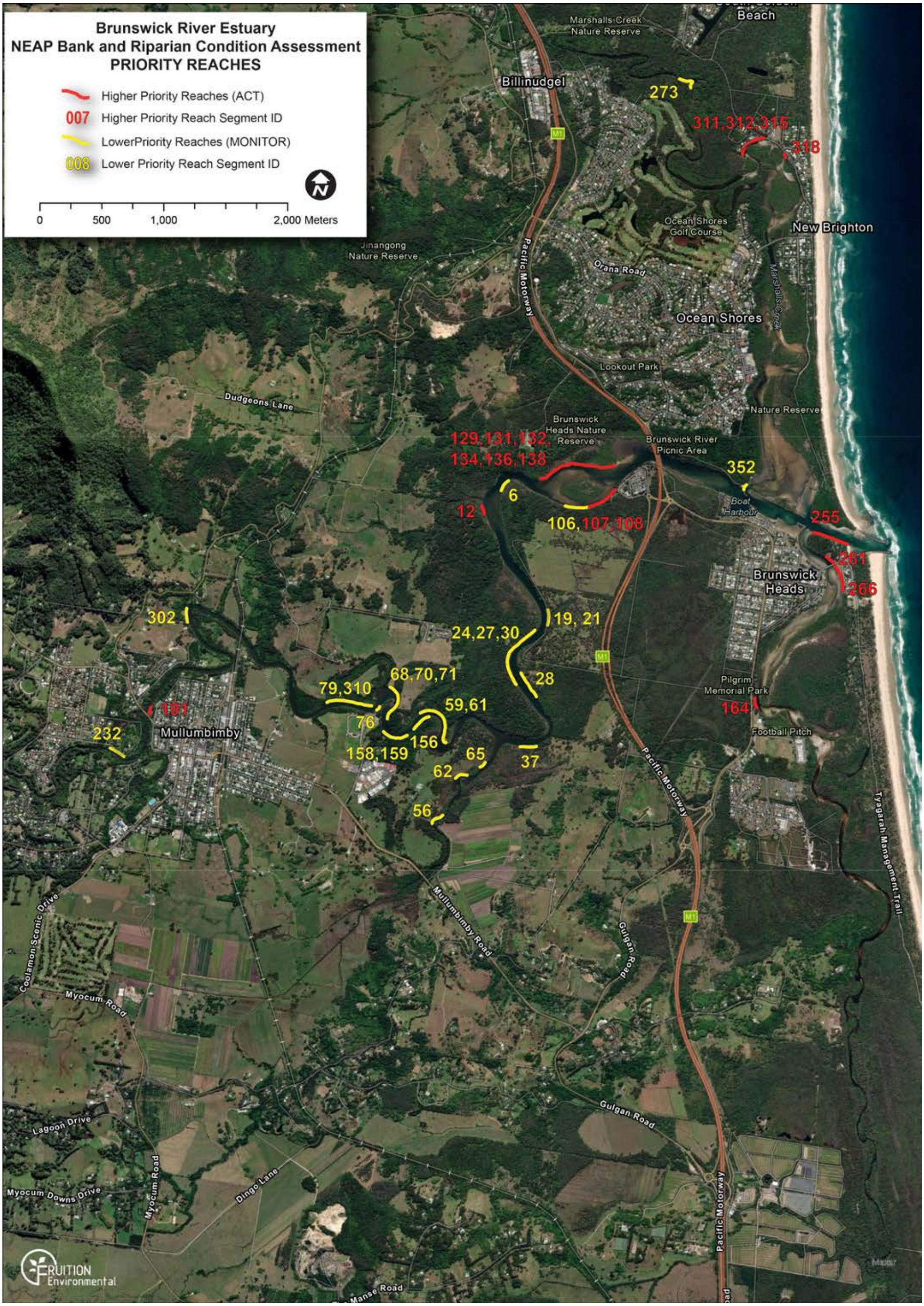

Figure 20 Locations and Reach reference IDs for priority reaches for management intervention in response to the Brunswick River Estuary NEAP Bank and Riparian Condition Assessment 2024

Table 10 Ranked list of the 12 highest priority reaches/priority focus areas for management interventions to improve overall bank and riparian condition in the Brunswick River estuary study area (Lower priority reaches which have been assessed as monitor only are included in Appendix B).

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
1	191	Upper Brunswick River, Mullumbimby	Public access location with poor riparian vegetation and moderate erosion, poor amenity, road reserve.	34	Improve estuary condition and maintaining safe access on public land
2	312,315	Marshalls Creek, New Brighton	Moderate erosion potentially impacting public infrastructure (Casons Road) with public access considerations.	34	Infrastructure protection and maintaining safe access on public land
3	318	Marshalls Creek, New Brighton	High severity erosion undermining narrow riparian vegetation adjacent to public access and road infrastructure, candidate Subtropical Coastal Floodplain Forest EEC, potentially Marshalls Creek Nature Reserve.	32	Infrastructure protection and maintaining safe access on public land
4	164	Simpsons Creek, Pilgram Memorial Park	Moderate erosion at area of informal public access (rope swing), Crown Land, potential cultural heritage site.	28	Maintaining safe access on public land
5	266	Simpsons Creek, Brunswick Heads	Existing rock armour works requiring maintenance in area of high public use, areas of moderate erosion recorded, Crown Land.	27	Maintenance of existing works on public land, flood resilience
6	12	Mid Brunswick River	High severity erosion from boat wave wash impacting Coastal Saltmarsh EEC.	27	Protection of Coastal Saltmarsh
7	255	Brunswick River, southern entrance wall	Existing rock armour works requiring maintenance in area of high public use, areas of moderate erosion recorded, Crown Land managed as Torakina Beach and Park.	26	Maintenance of existing works on public land, flood resilience
8	107,108	Lower Brunswick River, adjacent to Mangrove Island	Candidate Subtropical Coastal Floodplain Forest EEC with moderate erosion and public access, Crown Land.	25	Protect HCV vegetation in the estuary
9	261	Simpsons Creek, Brunswick Heads	Existing rock armour works requiring maintenance in area of high public use, areas of moderate erosion recorded, Crown Land managed as Torakina Beach and Park.	24	Maintenance of existing works on public land, flood resilience

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
10	129, 131, 132	Lower Brunswick River, Brunswick Heads Nature Reserve	High severity erosion from boat wave wash impacting Coastal Saltmarsh EEC and Mangrove communities.	22-24	Protect HCV vegetation in the estuary
11	134,136, 138	Lower Brunswick River, Brunswick Heads Nature Reserve	High severity erosion from boat wave wash impacting Coastal Saltmarsh EEC and Mangrove communities.	19-24	Protect HCV vegetation in the estuary
12	311	Marshalls Creek	High severity erosion, candidate Subtropical Coastal Floodplain Forest EEC, potentially Marshalls Creek Nature Reserve, potential public access location.	22	Maintaining safe access on public land, protect HCV vegetation in the estuary

Priorities for asset protection and/or maintenance

The ranked priority list presented in *Table 11* is a subset of reaches where the management objectives are related to infrastructure and public asset protection or maintenance and include reaches where:

- protecting public assets and infrastructure (e.g. roads) is the primary objective, or
- maintenance of existing bank protection works (i.e. existing investment protection) whilst maintaining safe public access are objectives.

Table 11 Ranked list of priority reaches for management intervention to improve or maintain public assets, infrastructure and public access in the Brunswick River estuary study area.

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
1	191	Upper Brunswick River, Mullumbimby	Public access location with poor riparian vegetation and moderate erosion, poor amenity, road reserve.	34	Improve estuary condition and maintaining safe access on public land
2	312,315	Marshalls Creek, New Brighton	Moderate erosion potentially impacting public infrastructure (public road) with public access considerations.	34	Infrastructure protection, maintenance of public access
3	318	Marshalls Creek, New Brighton	High severity erosion undermining narrow riparian vegetation adjacent to public access and road infrastructure, potentially Marshalls Creek Nature Reserve.	32	Infrastructure protection, maintenance of public access
5	266	Simpsons Creek, Brunswick Heads	Existing rock armour works requiring maintenance in area of high public use, areas of moderate erosion recorded, Crown Land managed as Torakina Beach and Park.	27	Maintenance of existing works on public land, flood resilience
7	255	Brunswick River, southern entrance wall	Existing rock armour works requiring maintenance in area of high public use, areas of moderate erosion recorded, Crown Land managed as Torakina Beach and Park.	26	Maintenance of existing works on public land, flood resilience
9	261	Simpsons Creek, Brunswick Heads	Existing rock armour works requiring maintenance in area of high public use, areas of moderate erosion recorded, Crown Land managed as Torakina Beach and Park.	24	Maintenance of existing works on public land, flood resilience

Priorities for water quality improvement

The field survey of bank erosion and riparian condition has demonstrated that estuarine bank erosion is not likely to be a major source of fine sediment and associated nutrients in the Brunswick River estuary when compared to catchment inputs. Nevertheless, a number of reaches were identified in the mid and upper Brunswick River estuary and Kings Creek where bank remediation works would reduce annual inputs of fine sediments. None of the sites identified for water quality improvement are in the high priority for intervention list in *Table 10.* Nevertheless, the sites listed in *Table 12* could be targeted if funding under programs specifically targeting fine sediment and associated nutrient reductions in estuarine waterways were to become available.

Table 12 Ranked list of priority reaches for management intervention to improve water quality and in particular suspended sediment and associated nutrient loads in the Brunswick River estuary study area.

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
13	6	Mid Brunswick River Estuary	Moderate erosion severity, possible Swamp Oak Floodplain Forest EEC although not mapped, likely source of fine sediment inputs into estuary, private land access required.	21	Protecting HCV vegetation, Improving estuarine water quality
16	24,27, 30	Mid Brunswick River Estuary	Moderate to high erosion impacting Candidate EEC vegetation communities, likely private land access.	16-17	Protecting HCV vegetation, Improving estuarine water quality
19	62	Lower Kings Creek Estuary	Moderate erosion severity, possible Swamp Oak Floodplain Forest EEC although not mapped, likely source of fine sediment inputs into estuary, private land access required.	15	Protecting HCV vegetation, Improving estuarine water quality
21	76	Upper Brunswick River Estuary	Moderate erosion impacting Candidate Subtropical Coastal Floodplain Forest EEC and also contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients).	15	Protecting HCV vegetation, Improving estuarine water quality
23	79	Upper Brunswick River Estuary	Moderate severity erosion contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients), Council owned land.	14	Improving estuarine water quality

Priorities for riparian vegetation protection and enhancement

Table 13 provides a ranked priority list of reaches where the management objectives are related to protecting or enhancing riparian vegetation, particularly High Conservation Value (HCV) vegetation communities (such as NSW Endangered Ecological Communities). Many of these sites have the additional objectives such as erosion protection, habitat protection or enhancement, and water quality improvement. Not all reaches contain riparian vegetation in good or very good condition and in some cases the actions required will include weed control, assisted natural regeneration, or active revegetation.

Table 13 Ranked list of priority reaches for management intervention to protect and/or enhance riparian vegetation in the Brunswick River Estuary study area.

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
6	12	Mid Brunswick River	High severity erosion from boat wave wash impacting Coastal Saltmarsh EEC.	27	Protection of Coastal Saltmarsh
8	107,108	Lower Brunswick River, adjacent to Mangrove Island	Candidate Subtropical Coastal Floodplain Forest EEC with moderate erosion and public access, Crown Land.	25	Protect HCV vegetation in the estuary
10	129, 131, 132	Lower Brunswick River, Brunswick Heads Nature Reserve	High severity erosion from boat wave wash impacting Coastal Saltmarsh EEC and Mangrove communities.	22-24	Protect HCV vegetation in the estuary
11	134,136, 138	Lower Brunswick River, Brunswick Heads Nature Reserve	High severity erosion from boat wave wash impacting Coastal Saltmarsh EEC and Mangrove communities.	19-24	Protect HCV vegetation in the estuary
13	6	Mid Brunswick River Estuary	Moderate erosion severity, possible Swamp Oak Floodplain Forest EEC although not mapped, likely source of fine sediment inputs into estuary, private land access required.	21	Protecting HCV vegetation, Improving estuarine water quality

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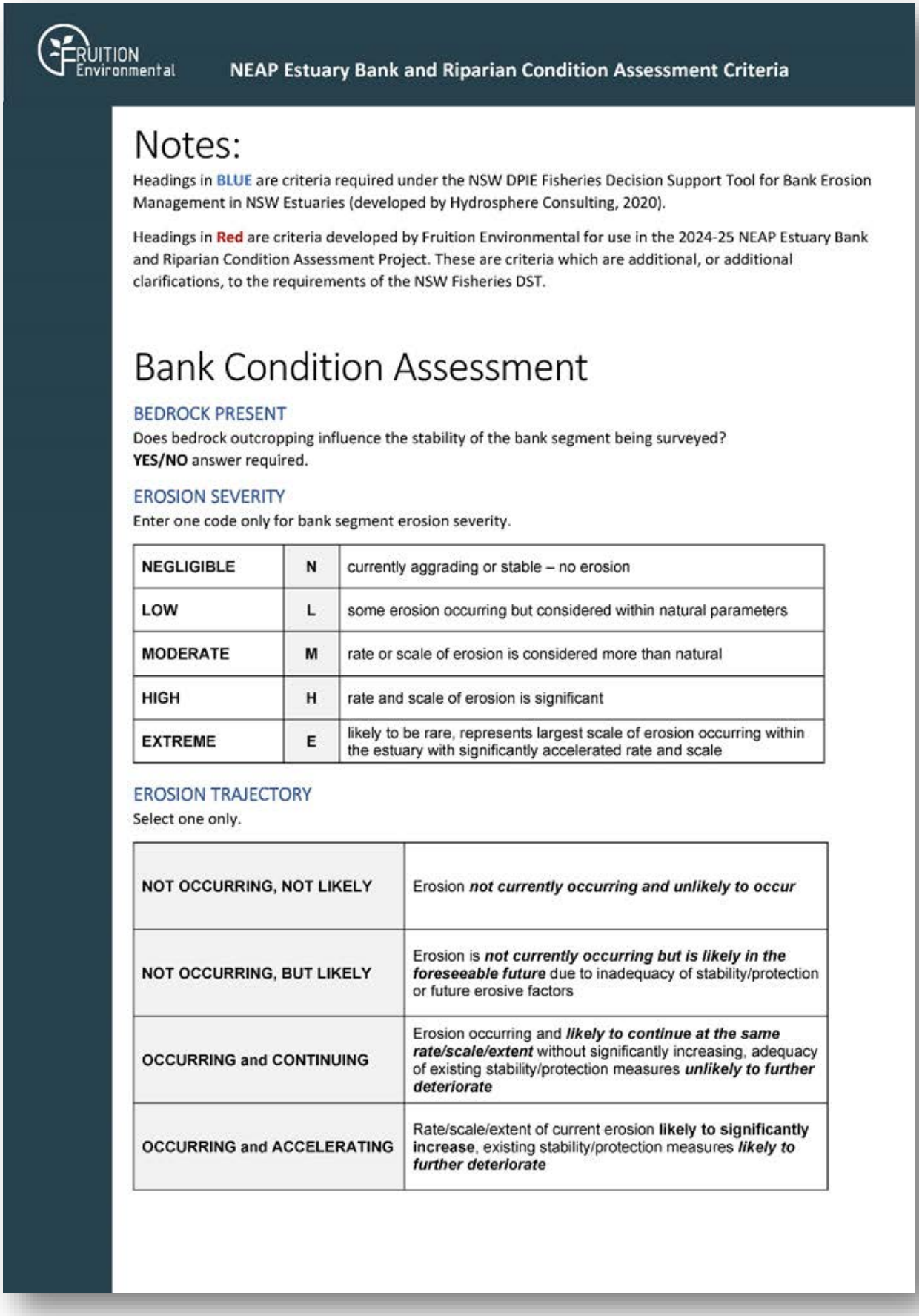
Appendix A – Bank and Riparian Condition Assessment Criteria



FRUITION Environmental

NEAP Estuary Bank and Riparian Condition Assessment Criteria

Notes:

Headings in **BLUE** are criteria required under the NSW DPIE Fisheries Decision Support Tool for Bank Erosion Management in NSW Estuaries (developed by Hydrosphere Consulting, 2020).

Headings in **Red** are criteria developed by Fruition Environmental for use in the 2024-25 NEAP Estuary Bank and Riparian Condition Assessment Project. These are criteria which are additional, or additional clarifications, to the requirements of the NSW Fisheries DST.

Bank Condition Assessment

BEDROCK PRESENT

Does bedrock outcropping influence the stability of the bank segment being surveyed?
YES/NO answer required.

EROSION SEVERITY

Enter one code only for bank segment erosion severity.

NEGLIGIBLE	**N**	currently aggrading or stable – no erosion
LOW	**L**	some erosion occurring but considered within natural parameters
MODERATE	**M**	rate or scale of erosion is considered more than natural
HIGH	**H**	rate and scale of erosion is significant
EXTREME	**E**	likely to be rare, represents largest scale of erosion occurring within the estuary with significantly accelerated rate and scale

EROSION TRAJECTORY

Select one only.

NOT OCCURRING, NOT LIKELY	Erosion ***not currently occurring and unlikely to occur***
NOT OCCURRING, BUT LIKELY	Erosion is ***not currently occurring but is likely in the foreseeable future*** due to inadequacy of stability/protection or future erosive factors
OCCURRING and CONTINUING	Erosion occurring and ***likely to continue at the same rate/scale/extent*** without significantly increasing, adequacy of existing stability/protection measures ***unlikely to further deteriorate***
OCCURRING and ACCELERATING	Rate/scale/extent of current erosion **likely to significantly increase**, existing stability/protection measures ***likely to further deteriorate***

NEAP Estuary Bank and Riparian Condition Assessment Criteria

WATER DEPTH

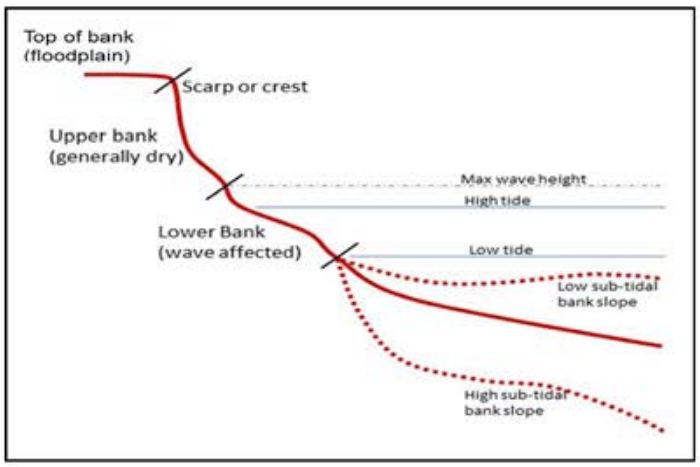
Select one only.

AS A GUIDE:

- select SHALLOW if there is an obvious intertidal bench extending out from the bank toe for at least 5m.
- Select DEEP if there is obvious deep water within 5m of the bank toe
- Select MODERATE if neither of the above apply.

SHALLOW	***Less the 0.8m deep*** on average at estimated mean high water, measured 5m from the bank toe
MODERATE	***Between 0.8m and 1.5m deep*** on average at estimated mean high water, measured 5m from the bank toe
DEEP	***More than 1.5m deep*** on average at estimated mean high water, measured 5m from the bank toe

LOCATION OF EROSION



NOTE:

Erosion on the top of the bank is rare.

Normally it will be Lower Bank or Upper Bank.

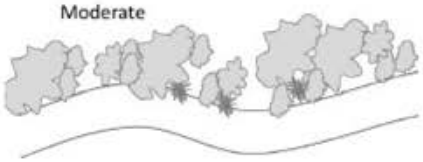
Toggle YES/NO for each location in the survey

NEAP Estuary Bank and Riparian Condition Assessment Criteria

Riparian Condition Assessment

RIPARIAN VEGETATION CONTINUITY

The longitudinal continuity along the bank of riparian vegetation (recorded for the maximum vegetation structure likely at the site (ie. usually woody vegetation but may be only sedges/rushes in saltmarsh areas)

NEGLIGIBLE	No vegetation, OR Isolated individual trees and shrubs	None 
LOW	Woody vegetation discontinuous with significant gaps. Gaps more dominant than vegetation.	Low 
MODERATE	Woody vegetation almost continuous. Occasional small gaps but vegetation is dominant	Moderate 
HIGH	Woody vegetation continuious. No significant gaps.	High 

RIPARAIN VEGETATION AVERAGE WIDTH

Enter one code only for ***average*** riparian vegetation width for the segment. ***Measured from the low bank***.

<2m	Less than 2m average width of riparian vegetation
<5m	Less than 5m average width of riparian vegetation
<10m	Less than 10m average width of riparian vegetation
<20m	Less than 20m average width of riparian vegetation
>20m	Greater than 20m average width of riparian vegetation

NEAP Estuary Bank and Riparian Condition Assessment Criteria

RIPARAIN VEGETATION STRUCTURE

Riparian Vegetation Structure refers to the existence or otherwise of expected vegetation sub-strata (eg. canopy, shrub layer, ground layer, etc). ***This is a relative measure of structure based on what vegetation community would be expected to naturally occur at that location given the estuary location and context***.

Enter one code only for riparian vegetation structure for the segment.

VERY POOR	No riparian vegetation present in the segment OR only grass present
POOR	Riparian vegetation is mostly grass with sporadic canopy trees/shrubs
MEDIUM	Riparian vegetation is missing one or more sub-strata through entire segment (ie. no shrubs present but groundcover and canopy present through whole segment)
GOOD	Riparian vegetation structure has all of the expected elements for that location but has some areas of patchiness within the segment
VERY GOOD	Riparian vegetation structure has all expected elements for that location for the whole segment (eg. Intact riparian forest or intact saltmarsh or mangrove forest)

RIPARAIN VEGETATION DIVERSITY

Riparian Vegetation Diversity refers to what would be expected in a natural situation at that location, focussing on native riparian vegetation species. ***It is a relative measure of diversity based on what vegetation community would be expected to naturally occur at that location given the estuary location and context***.

Enter one code only for riparian vegetation diversity for the segment.

VERY POOR	No riparian vegetation present in the segment OR only grass present
POOR	Sporadic native shrubs and/or trees (unless mapped as saltmarsh) with a uniform grass understorey (often grazed, parklands or private foreshore areas)
MEDIUM	Moderately diverse native vegetation species but impacted by land use or clearing. May be regenerating but lower diversity of shrubs and groundcovers than would otherwise occur without disturbance.
GOOD	Disturbed remnant vegetation BUT with diverse ground cover species (ie. some grazing or clearing impacts)
VERY GOOD	Remnant riparian vegetation (eg. intact riparian forest, mangrove forest or Saltmarsh)

WEED PRESENCE

Enter one code only for ***presence of woody weeds and exotic vines***. Measured as **Estimated Foliage Projective Cover** (FPC) for weed species observed.

NIL OBSERVED	No woody or vine weed species observed
LOW	Less than 10% FPC for woody and vine weeds observed
MODERATE	10%-25% FPC for woody and vine weeds observed
HIGH	25%-50% FPC for woody and vine weeds observed
VERY HIGH	Greater than 50% FPC for woody and vine weeds observed

WEED SPECIES

Do any of the listed priority weed species occur in the segment? **YES/NO** answer required for each possibility.

NEAP Estuary Bank and Riparian Condition Assessment Criteria

Existing Controls and Erosion Works

EXISTING CONTROLS PRESENT

Do any of the existing controls occur in the segment? Toggle **YES if any occur** and then select **PERCENTAGE of BANK** with any controls present then select **OVERALL EFFECTIVENESS** for all works present. Toggle **WORKS TYPES** present.

PERCENTAGE OF SEGMENT WITH EXISTING CONTROLS

Select one only.

<10%	Less than **1/10**th of the bank segment has existing works
10-25%	About **1/10**th to **1/4** of the bank segment has existing erosion works
25-50%	About **¼** to **½** of the bank segment has existing erosion works
50-75%	About **½** to **¾** of the bank segment has existing erosion works
75-100%	More than **¾** of the bank segment has existing erosion works

EFFECTIVENESS OF EXISTING CONTROLS

Select one only.

No Existing Control	DEFAULT OPTION, select another from list below
INEFFECTIVE	Existing control not effective and maintenance would not improve
PARTIALLY (CONDITION)	Existing acceptable controls that are only partially effective due to deterioration, maintenance may ameliorate.
PARTIALLY (DESIGN)	Existing acceptable controls that are only partially effectiveness due to a design flaw (ie.work doesn't address processes, etc)
COMPLETELY	Existing acceptable controls that are completely effective
REDUNDANT	Existing control unacceptable form or not contributing to bank stability
UNKNOWN / UNTESTED	The existing control is a demonstration or untested trial works type
UNDER CONSTRUCTION	Bank protection controls are currently under construction

NSW FISHERIES DST CRITERIA

IMPACT RATINGS

Select one only for each of the three IMPACT CATEGORIES.

ENVIRONMENTAL IMPACTS

Select one category only for environmental impact.

NEGLIGIBLE	**N**	**Erosion at "natural rate"** (NEGLIGIBLE to MODERATE) **AND** No features of biodiversity or conservation value threatened **AND** No impacts of erosion likely to effect downstream environments. Examples: • No erosion present (either naturally or because of erosion mitigation) • If Low Erosion Severity must be minimal water quality impacts and no vegetation being lost • If Moderate Erosion Severity then must be no water quality impacts and no biodiversity/conservation value impacts (eg. Sandy sediments)
LOW	**L**	Erosion rate/scale elevated above natural rate (ie. MODERATE to EXTREME) **AND** No features of biodiversity or conservation value **significantly** threatened **AND** Impacts of erosion likely to have local effects on water quality only (NOTE CONSIDER LENGTH OF SEGMENT). Examples: • Localised water quality impacts (ie. localised turbidity within the bank segment) • Erosion threatening or small loss of "low value" vegetation
MEDIUM	**M**	Erosion rate/scale significantly greater than natural rate (MODERATE to EXTREME severity) **AND** Features of biodiversity or conservation value **likely** to be affected **AND/OR** Impacts of erosion likely to have water quality impacts beyond the segment surveyed. Examples: • Water quality impacts extending beyond the segment surveyed • Erosion threatening vegetation of biodiversity or conservation value
HIGH	**H**	Erosion rate/scale significantly greater than natural rate (HIGH to EXTREME severity) **AND** Features of **listed** biodiversity or conservation value directly affected **AND/OR** A known cultural heritage site is directly affected **AND/OR** Impacts of erosion having water quality impacts beyond the segment surveyed. Examples: • Erosion significantly impacting water quality beyond the segment surveyed (ongoing sedimentation, turbidity) • Erosion actively damaging vegetation of biodiversity or conservation value (Listed EEC or HCV vegetation type eg Mangroves/saltmarsh) • Erosion impacting a midden.

NEAP Estuary Bank and Riparian Condition Assessment Criteria

INFRASTRUCTURE/COMMERCIAL IMPACTS

Select one category only for infrastructure/commercial impact.

"THREAT" defined as impacted, use impaired, damaged or lost as a result of erosion in the next 10 years.

NEGLIGIBLE	No built or land assets under threat
LOW	Minor assets of low value under threat, **AND** Loss of land relatively minor and likely to be of low concern to landholder
MEDIUM	Assets of intermediate value threatened Examples: boat ramps, foot paths, park benches, access stairs.
HIGH	High value or important infrastructure under threat. Examples: power lines, water and sewerage infrastructure, public utilities, houses, buildings, roads, carparks, etc.

AMENITY/SAFETY IMPACTS

Select one category only for amenity/safety impact.

NEGLIGIBLE	No impact on visual amenity, **AND** Very low risk of injury associated with erosion.
LOW	Minor impact on visual amenity to a small number of people, **AND** Low risk of injury associated with erosion.
MEDIUM	Significant visual impact, **OR** Public access to foreshore impeded, **OR** Greater risk of injury related to higher use area.
HIGH	Significant visual impact to high number of users, **OR** Foreshore access significantly impeded, **OR** Public safety risks associated with public areas.

NEAP Estuary Bank and Riparian Condition Assessment Criteria

CONSTRAINTS

Do any constraints effect the segment? Toggle **YES if any occur.**

Immediate Landward Constraint	Record YES if there is a feature located landward that may hinder or limit construction or effectiveness of an erosion treatment method. EXAMPLES • impossible access or roads, • footpaths • powerlines or other utilities or buildings
Offshore Constraint	Record YES if there is a sensitive estuarine habitat (seagrass, rocky reef, etc), a navigation channel, aquaculture lease or boat mooring immediately offshore an eroding bank.
Public Access	Record **YES if public access to the bank or foreshore is a major consideration** for the site. Select **NO** if the access is any of the following: • if it is private property • if it is likely UNAUTHORISED access example a private access point or an informal camping area • informal access areas and areas of unauthorised access. • If the access is only along the top of the bank, for example a public walkway above the foreshore.
High Value Asset at Risk	**High value assets** are generally built assets such as Public Roads, Public Buildings, Public Structures (such as boat ramps, jetties, car parks), Public Utilities, Flood mitigations structures (such as levees and floodgates), Cultural Heritage Sites. **Assets are considered at risk if within 5m of Moderate to Extreme erosion that is continuing and accelerating and not stabilised by some means.**

Appendix B – Lower priority reaches for ongoing monitoring

The table presented in this Appendix lists the reaches and focus areas from the priority pool which fall outside the highest 12 priorities after applying the ranking criteria. In general, these reaches should be monitored for any change that may affect the priority scores, for example after flooding.

Entries in **BOLD** are also listed in *Tables 12* and *13* above which target specific management objectives such as improving water quality or protecting and enhancing riparian vegetation in the Brunswick River Estuary.

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
13	6	Mid Brunswick River Estuary	Moderate erosion severity, possible Swamp Oak Floodplain Forest EEC although not mapped, likely source of fine sediment inputs into estuary, private land access required.	21	Protecting HCV vegetation, Improving estuarine water quality
14	**19,21**	**Mid Brunswick River Estuary**	**Moderate to High erosion of the foreshore within the Brunswick Heads Nature Reserve, private access tracks, private land access required.**	**19-21**	**Protection of public foreshore (monitor)**
15	70,71	Upper Brunswick River Estuary	Existing estuary remediation works failing due to scour of bank toe and rock armour subsidence, works requiring maintenance, difficult access for construction, Council owned land .	20	Maintenance of existing works on public land, improving flood resilience (monitor)
16	**24,27,30**	**Mid Brunswick River Estuary**	**Moderate to high erosion impacting Candidate EEC vegetation communities, likely private land access.**	**16-17**	**Protecting HCV vegetation, Improving estuarine water quality**
17	352	Lower Marshall Creek Estuary	Marshalls Creek Nature Reserve, subsided rock armour works with moderate erosion of the upper bank, public access area.	17	Infrastructure protection, Maintenance of existing works on public land, Protecting public access (monitor)
18	106	Lower Brunswick River Estuary	Adjacent to Mangrove Island, Subtropical Coastal Floodplain Forest EEC impacted by moderate erosion, Brunswick Heads Nature Reserve.	16	Protecting HCV vegetation, Protection of public foreshore (monitor)

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
19	62	Lower Kings Creek Estuary	Moderate erosion severity, possible Swamp Oak Floodplain Forest EEC although not mapped, likely source of fine sediment inputs into estuary, private land access required.	15	Protecting HCV vegetation, Improving estuarine water quality
20	65	Lower Kings Creek Estuary	Moderate erosion severity, mangrove and patchy Coastal Saltmarsh vegetation impacted, private land access required.	15	Protecting HCV vegetation (monitor)
21	76	Upper Brunswick River Estuary	Moderate erosion impacting Candidate Subtropical Coastal Floodplain Forest EEC and also contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients).	15	Protecting HCV vegetation, Improving estuarine water quality
22	37	Mid Brunswick River Estuary	Moderate erosion impacting mangrove habitat and Swamp Oak Floodplain Forest EEC and Subtropical Coastal Floodplain Forest EEC, overlaps Crown Land parcel and private land.	14	Protecting HCV vegetation (monitor)
23	79	Upper Brunswick River Estuary	Moderate severity erosion contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients), Council owned land.	14	Improving estuarine water quality
24	28	Mid Brunswick River Estuary	Moderate erosion impacting mapped Subtropical Coastal Floodplain Forest EEC, overlaps Crown Land parcel and private land.	12	Protecting HCV vegetation (monitor)
25	310	Upper Brunswick River Estuary	High severity erosion contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients), Council owned land.	12	Improving estuarine water quality (monitor)
26	68	Upper Brunswick River Estuary	Existing estuary remediation works failing due to scour of bank toe and rock armour subsidence, works requiring maintenance, difficult access for construction, Council owned land.	11	Protecting existing works, improving flood resilience (monitor)

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
27	56	Lower Kings Creek Estuary	High erosion severity, likely source of fine sediment inputs into estuary, private land access required.	10	Protecting agricultural lands, Improving estuarine water quality (monitor)
28	273	Upper Marshalls Creek Estuary	Moderate erosion impacting mapped Swamp Sclerophyll Forest on Coastal Floodplains, possibly NSW Marine Protected Area or Marshalls Creek Nature Reserve although tenure unclear, possible Council Community land.	10	Protecting HCV vegetation (monitor)
29	302	Upper Brunswick River Estuary	Moderate erosion impacting mapped Littoral Rainforest (vegetation community requires verification), private land access required.	10	Protecting HCV vegetation (monitor)
30	59	Upper Brunswick River Estuary	Moderate erosion impacting mapped Coastal Saltmarsh (vegetation community requires verification as likely incorrect), contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients), private land access required.	9	Improving estuarine water quality (monitor)
31	156	Upper Brunswick River Estuary	Moderate erosion impacting mapped Littoral Rainforest (vegetation community requires verification), contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients), Crown Land parcel.	9	Protecting HCV vegetation, Improving estuarine water quality (monitor)
32	158,159	Upper Brunswick River Estuary	High severity erosion impacting otherwise very good riparian vegetation condition (not mapped as High Ecological Value Community), erosion contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients).	9	Improving estuarine water quality (monitor)

Rank	Reach	Location	Management Issues	Priority Score	Management Objectives
33	61	Upper Brunswick River Estuary	High severity erosion impacting otherwise very good riparian vegetation condition (not mapped as High Ecological Value Community), erosion contributing to poor estuarine water quality (likely source of fine suspended sediment and associated nutrients), Council owned land.	8	Improving estuarine water quality (monitor)
34	232	Upper Brunswick River Estuary	Currently moderate erosion in a reach affected by significant slumping (most likely associated with post flood draw-down). Reach will require on-going monitoring as the bank will likely regrade to a natural angle of repose that may impact Riverside Drive in the mid to long term. Vegetation mapped as Lowland Rainforest on the Floodplain EEC.	8	Protecting HCV vegetation, Infrastructure protection (monitor)