Supported by the

Catchment Management Plan

REPORT

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Author (s):	Nicholas Yee	
	Tim Dilworth	
	Stuart Cameron	
Project Manager:	Nicholas Yee	
Reviewed by:	Kyran Crane (BVSC) Daniel Wiecek (OEH)	**Date:** 11 August 2016 **Status:** FINAL
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Contact:	Elgin Associates Pty Ltd ABN 59123488639 Level 1, 45-47 Church Street, PO Box 829 Bega, New South Wales, 2550 Telephone: +61 400 365 234 Fax: +61 3 86486336 www.elgin.com.au	

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George and Barbara George

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EXECUTIVE SUMMARY

Bega Valley Shire Council (BVSC) received funding from the Office of Environment and Heritage (OEH) under the NSW Estuary Management Program to undertake a rapid catchment assessment (the 'Assessment') of Nelson Lagoon.

The objectives of the Assessment were to:

- Identify catchment and foreshore issues currently impacting, or with the potential to impact, water quality and estuary health;
- Identify and recommend priority areas within the catchment for protection and targeted rehabilitation that will improve catchment condition and water quality of Nelson Lagoon; and
- Preparation of this catchment management plan that highlights priority management areas and actions for protection and targeted rehabilitation that can be implemented as funding permits.

Elgin Associates in association with Riparian Engineering were engaged by BVSC to undertake the project, which involved multiple stages undertaken over a 16-month period from March 2015 to August 2016.

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This document is a preamble to the project and is structured to provide relevant background information and context to the project objectives and tasks undertaken. The document provides a summary of catchment and estuary physical characteristics including landforms and geology, vegetation communities (terrestrial and aquatic), current and historical land uses, and provides an overview of the current understanding of water quality and ecosystem health status of Nelson Lagoon.

Catchment residents, the broader community and stakeholders (*i.e.* government agencies and others) were consulted throughout the project regarding issues affecting catchment condition and estuary health. Opinions regarding values and concerns for Nelson Lagoon and the catchment were sought via an online questionnaire, email and phone. Subsequent information provided by the community and stakeholders was vital to undertaking field investigations where highlighted issues were examined and documented.

Field investigations of lower and upper catchment areas and the entire estuary foreshore were completed over a number of days and supplemented the preliminary assessment completed by Bega Valley Shire Council and Office of Environment and Heritage. In total, five (5) priority management areas have been identified; all situated in the lower Nelson catchment close to the estuary. Within each management area, at least one or more of the following issues is currently occurring - natural stream bank erosion, estuary foreshore erosion due to vehicle access, degradation to saltmarsh community, unsealed road erosion, erosion of dune foreshore and impacts to dune vegetation and potential loss of seagrass community. Each of these issues is the result of past and present disturbances and considered to be either currently or have the potential to affect catchment condition and estuary water quality if not addressed.

A detailed description of each priority management area and each issue is provided in Appendix B.

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LIST OF ABBREVIATIONS AND ACRONYMS

DPI	NSW Department of Primary Industries
AHD	Australian Height Datum
EEC	Endangered Ecological Community
HAT	Highest Astronomical Tide
LALC	Local Aboriginal Land Council
LiDAR	Light Detection And Ranging
m^2	Metres squared
MHWS	Mean High Water Springs
OEH	Office of Environment and Heritage
N/A	Not Applicable
RCA	Rapid Catchment Appraisal
RMS	Roads and Maritime Services
SE LLS	South East Local Land Services
SLR	Sea Level Rise
SRCMA	Southern Rivers Catchment Management Authority

INTRODUCTION

1 BACKGROUND AND PROJECT OBJECTIVES

Nelson Lagoon has significant ecological, recreational and socio-economic values all of which are reliant on good water quality. The water quality of the estuary is highly dependent on land-use practices and catchment disturbance, both past and present. Catchment management issues such as natural and man-made erosion, intensive land-use, and unsealed roads can all impact on water quality via increased sediment and nutrient inputs.

Bega Valley Shire Council (BVSC) received funding from the Office of Environment and Heritage (OEH) under the NSW Estuary Management Program to undertake a rapid catchment assessment (the 'Assessment') of Nelson Lagoon.

The objectives of the Assessment were to:

- Identify catchment and foreshore issues currently impacting, or with the potential to impact, water quality and estuary health;
- Identify and recommend priority areas within the catchment for protection and targeted rehabilitation that will improve catchment condition and water quality of Nelson Lagoon, and
- Preparation of this catchment management plan that highlights priority management areas and actions for protection and targeted rehabilitation that can be implemented as funding permits.

Elgin Associates in association with Riparian Engineering were engaged by BVSC to undertake the project.

1.1 SCOPE OF WORK

The project involved multiple stages undertaken over 16-month period from March 2015. A summary of the project stages and scope of work completed is provided below.

Project Stage	Date/s	Scope of Work
1	March – April 2015	• Preliminary analysis of lower catchment and foreshore issues completed by BVSC and OEH
2	July - August 2016	• Elgin Associates engaged to work on project • Data acquisition and desktop analysis • First round of Community and Stakeholder Consultation - Distribution of consultation plan and online questionnaire
3	August – February 2016	• Rapid catchment assessment – field site inspections
4	December 2015 – February 2016	• Preparation and submission of Draft catchment management plan
5	March 2016	• Second round of Community and Stakeholder

		Consultation – Drop-In Session, Tanja Hall
6	March-May 2016	• Draft report review
7	August 2016	• Submission of Final catchment management plan

Stage 1 [March-April 2015] - Preliminary analysis of lower catchment and foreshore issues was undertaken by BVSC and OEH following a series of comprehensive field inspections conducted in March 2015. These data including photographs were compiled and provided for project use.

Stage 2 [July-August 2015] - Elgin Associates engaged to deliver Stages 2-7 of the project. Stage 2 included data acquisition and desktop analysis including review of available spatial datasets (*i.e.* cadstre, land tenure and property, aerial imagery, LiDAR), previous reports and preliminary analysis completed during Stage 1. A GIS project database was developed to contain all the spatial and environmental information. The GIS was used to identify potential erosion areas throughout the catchment. Erosion types identified included head cuts on catchment streams, erosion on unsealed roads, bank and roadside embankments, and erosion from old logging snig tracks.

A consultation plan was prepared and distributed to catchment landholders and stakeholders for the purpose of raising awareness of the project objectives and seeking input to the project. Input from landholders, stakeholders and the wider community was received via phone, email with majority of feedback provided via an online questionnaire. Information gathered during this initial consultation period was used to prepare for field site inspections.

Stage 3 [August 2015 – February 2016] - Field site inspections of upper and lower catchment, and estuary foreshore areas were undertaken over multiple days during a 6-month period to assess erosion and other catchment issues (*i.e.* stock impacts, lack of riparian vegetation, *ad hoc* foreshore access, unsealed roads, wetland degradation, illegally constructed weirs). Inspections were undertaken on crown lands as well as private properties building upon preliminary work completed in Stage 1 by BVSC and OEH. All issues currently impacting or with the potential to impact on estuarine health were documented and photographed. Issues on private lands and potential remedial options were discussed with relevant landholders where possible at the time of inspection.

Stage 4 [December 2015 – February 2016] - A draft catchment management plan was prepared with findings of field site inspections compiled as a list of priority issues (High, Medium and Low), described and documented with management actions recommended to mitigate impacts on estuary health a key component of the report. The catchment was divided into a number of priority management areas with a map showing the location of each issue prepared for each area. The risk of high conservation areas (*i.e.* endangered ecological community, protected species) under threat from erosion processes or other issues was considered during the preparation of the catchment management plan. As well, the implications of predicted sea level rise with regard to high conservation areas located on estuarine foreshore and lower freshwater reaches was considered in the assessment. Draft report submitted to BVSC and OEH for review.

Stage 5 [March 2016] – A second round of community and stakeholder consultation was undertaken in March 2016 at Tanja Hall where community members and stakeholders were invited to attend a

drop-in session to review a series of maps showing the Priority Management Areas and issues affecting Nelson Lagoon catchment.

Stage 6 [March – May 2016] – Receipt of BVSC and OEH draft report review comments.

Stage 7 [August 2016] – Final version of Catchment Management Plan report submitted.

1.2 STUDY AREA

The study area included the catchment and estuary foreshore areas of Nelson Lagoon. The catchment of Nelson Lagoon and its proximity within the Bega Valley Shire is shown in **Figure 1**.

Figure 1. Catchment Area of Nelson Lagoon.

INTRODUCTION

2 CATCHMENT AND ESTUARY PROFILE

The Nelson catchment is 27.2 km^2 in area bounded by the ridgelines of Dr George Mountain Road to the north, Quarry Road to west and Goats Knob Road to the south. Nelson Creek is the primary catchment stream whose headwaters originate on the eastern slopes of Dr George Mountain at an approximate elevation of 295m above sea level. The creek meanders for majority of its flow through a forested catchment characterised by steep gullies before reaching the alluvial floodplain of the lower catchment at the Tathra-Bermagui Road where the it discharges to the upper estuary.

The estuary, referred to as Nelson Lagoon, has a waterway size (including saltmarsh areas) of 1.3 km^2 (OEH 2016a). The estuary is a shallow, saline coastal lagoon classified as a semi-mature (referring to its stage of sediment infilling), wave-dominated, barrier estuary (Roy *et al.* 2001). Nelson Creek is the primary source of fluvial sediment supply with a number of smaller streams draining the hill slopes to the north and south of the lagoon.

Wave action is the dominant force influencing the geomorphology of the estuary with a sand barrier at its mouth enclosing the ebb-flood tidal delta and central basin. The entrance is characterised by shifting, shallow sand shoals but remains permanently open to the ocean and tidally influenced due to the configuration of the rocky headland at its mouth. Consequently, Nelson Lagoon is dominated by marine conditions and as such is able to support extensive grey mangrove habitat that is absent from other estuaries that experience prolonged closed periods and brackish conditions. A brief summary of Nelson Lagoon and Catchment characteristics is provided in **Table 1**.

Table 1. Summary of Nelson Lagoon and Catchment Characteristics	
Estuary waterway size: 1.12 km^2	**Catchment Area:** 27.2 km^2 <1% cleared (0.23 km^2), 92% Mimosa National Park (25.1 km^2)
Primary Inflow: Nelson Creek	
Estuary type: Semi- mature, wave-dominated, barrier estuary	
Estuarine vegetation: Nelson Lagoon supports significant areas of mangrove and saltmarsh community. Mangrove 0.491 km^2, Saltmarsh 0.155 km^2, Seagrasses (*Zostera* and *Halophila*) 0.010 km^2.	
Catchment land-uses: Rural residential, recreation.	
Commercial activities: Oyster Aquaculture. The estuary is a recreational fishing haven and thus not available to commercial fishing as part of Estuary General Fishery.	
Endangered Ecological Community (EEC) types: Seven (7) vegetation types listed as EEC types under the *NSW Threatened Species Conservation Act 1995* (TSC Act) have been mapped in the catchment these include - *Coastal saltmarsh, Freshwater wetlands, Bangalay Sand Forest, Lowland Grassy Woodland*, *River-flat Eucalyptus Forest, Swamp Schlerophyll Forest* and *Swamp Oak Floodplain Forest*.	
Estuary entrance status: Permanently open	

INTRODUCTION

2.1 CATCHMENT GEOLOGY AND SOILS

The underlying geology of Nelson catchment is Ordovician metasediments. These are sedimentary rocks including slate, siltstone, shale and greywacke that have been altered by metamorphic processes of folding, faulting and later intruded by granite and gabbro by volcanic activity during the Devonian period. Dr George granite outcrops on the western margin of the Nelson catchment. The Ordovician metasediments are relatively resistant to erosion, compared, for example, to weathered granitic substrates, and give rise to shallow soils of fairly low fertility. They tend to produce a landscape of steep ridges and narrow, deeply incised and sheltered gullies. The lower catchment and estuary foreshore is characterised by extensive areas of Quaternary alluvial sand and gravel deposits.

2.2 LAND TENURE AND LAND-USES

Majority of the catchment (>92%) is National Park tenure forming the southern limit of, and a large proportion of the Mimosa Rocks National Park. Prior to becoming National Park, Crown lands of the Nelson Catchment were previously gazetted as Tanja West and Tanja State Forests. The catchment remains forested though large areas of catchment were previously disturbed by historical timber harvesting up until 1977 and localised gold mining activity in the late 1800s. The catchment boundary follows Dr George Mountain Road to north, and Goats Knob Road to the south. Private land tenure is restricted to lands on the alluvial floodplain in the lower catchment close to the estuary (**Figure 2**) and represents approximately <1% of the total catchment area. It is estimated that <1% of the catchment has been cleared for agricultural grazing/rural residential uses.

Summary of catchment land tenure:

- Mimosa Rocks National Park (25.1 km^2) - 92% of catchment area
- Private Land tenure – <1% of catchment area

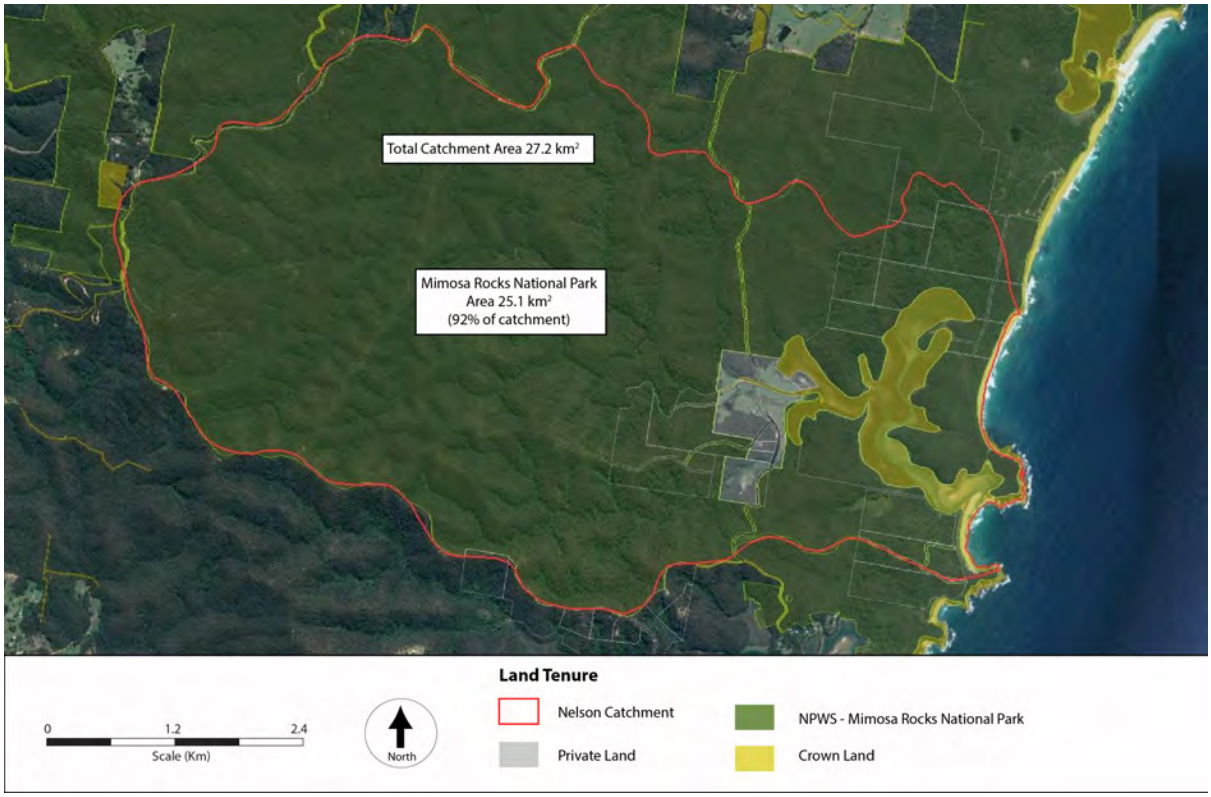


Figure 2. Nelson Catchment Land Tenure

2.2.1 HISTORICAL CATCHMENT DISTURBANCE AND EFFECTS OF DISTURBANCE

In general, European settlement of catchments has introduced substantial changes to the landscape including:

- Clearing of catchment vegetation for forestry, construction of road networks, and land for farming and housing; and
- Degradation of riparian vegetation by clearing for development, thinning for views, trampling by stock, and invasion by exotic pest species.

Cleared and disturbed catchments have less capacity to reduce the volume and rate of surface runoff under moderate to high rainfall events. Furthermore, the effects of human induced disturbance on catchment condition can be further exacerbated by natural stochastic events such as bushfire. Catchment disturbance typically results in increased rates of catchment and bank erosion and thus increased infilling of alluvial floodplains, fluvial deltas and shallow mud basins of estuaries via surface runoff.

Sediment supply and with it, nutrients and organic materials are important for the productivity of estuaries. However, excess supply of sediments and nutrients can be detrimental to the overall health of the estuary. Excess sediment and nutrient supply can lead to increased turbidity, and increased primary productivity by algae. Over long-term, persistent poor water clarity due to re-suspension of sediment fines and consistently high levels of nutrients can have a detrimental impacts on seagrass communities as algal flora outcompetes and becomes more dominant over seagrasses. Loss of seagrass community has negative flow-on effects for estuarine fish populations. In addition, persistent and prolific growth of algae can lead to episodes of low levels of dissolved

oxygen in the water column and this can be harmful to aquatic fauna and is often a cause of fish-kills.

The history of disturbance in the Nelson catchment includes large areas of the catchment that have been subject to selective timber harvesting operations since the early years of European settlement up until the late 1970s and the associated network of unsealed road and snig-tracks. There are approximately 36 km of unsealed roads within the catchment (excluding an estimated 20km of unmapped old forestry roads) and it is acknowledged that unsealed roads and their associated runoff controls (*i.e.* mitre drains) can be a significant contributor of dispersible sediment to catchment streams (Croke *et al* 2006). Other historical catchment disturbances include gold mining and episodic wildfire events, and these are briefly discussed below.

Discovery of Gold in Nelson Catchment

Alluvial gold was first discovered in the Nelson catchment in 1872 that triggered a local goldrush. At the headwaters of Nelson Creek (also known as Diggers Creek), miners excavated a race to divert the flow of the creek allowing them to excavate the streambed in search for gold (NPWS 2009). Subsequent mining activity included numerous shafts sunk in the Kings Ridge area of the catchment with old shafts, trenches and mullock heaps marking the remains of former mine workings.

Fire Disturbance

Wildfires in the catchment contribute to erosion of the hill slopes with fire resulting in a reduction of vegetation cover, leaf litter and loss of soil crust community that provide a protective layer to the surface soils during rainfall events. The history of fire disturbance in the Nelson catchment since 1978 includes three major fire events: 1) 1980/81 season where a proportion of catchment was burnt; 2) 1981/82 season where 1700 hectares of the catchment was burnt including ridge and slopes southwest of Dr George Mountain; and 3) approximately 1000 hectares of northern section of the catchment was burnt during the 1986/87 season (NPWS 2009).

2.3 CATCHMENT VEGETATION

The vegetation of Nelson catchment may be grouped into two major sections:

1) A diverse mosaic of communities occupying the lower catchment (within close proximity to estuary) and estuary foreshore itself; and

2) A much more extensive but less diverse expanse of vegetation of the upper catchment.

A brief description of both is provided below with recognised vegetation communities (as per Tozer *et al.* 2010) provided in italics. Further detailed description of the native vegetation is provided in the *Mimosa Rocks Plan of Management* (NPWS 2009).

2.3.1 UPPER CATCHMENT VEGETATION

The upper catchment comprises dry, relatively steep ridges, and narrow, deeply incised gullies and the riparian zone along Nelson creek. The dry ridges support dry shrub forest communities, particularly *Far South Coast Foothills Dry Shrub Forest,* dominated by *Corymbia maculata* (spotted gum), *Eucalyptus tricarpa* (red ironbark), *Eucalyptus bosistoana* (coast grey box) and *Eucalyptus longifolia* (woolybutt). Downslope towards the margins of the moist gullies *Eucalyptus cypellocarpa*

(monkey gum) is the dominant eucalypt species above a predominantly fern groundcover.

Southeast Warm Temperate Rainforest grows on the floors of the moist, relatively fire-protected gullies tributary to Nelson creek. Characteristic species in this species-rich community are *Szygium smithii* (lillipilli), *Backhousia myrtifolia* (grey myrtle), *Myrsine howitteana* (muttonwood), *Eupomatia laurina* (bolwarra), *Doryphora sassafras* (sassafras), *Ficus coronata* (sandpaper fig), *Pomaderris cinerea*, and *Livistona australis* (cabbage palm).

The vegetation community in the narrow riparian zone of Nelson creek above the tidal limit [a community not described by Tozer *et al.* (2010) and best described as 'gallery rainforest' as the formation is known in Victoria] has significant rainforest elements but also a number of species restricted to alluvial sites subject to recurrent flood disturbance, such as *Tristaniopsis laurina* (kanooka), *Lomatia myricoides*, and *Commersonia fraseri* (blackfellows hemp). *Eucalyptus botryoides* (bangalay) and *Eucalyptus elata* (river peppermint) occur as emergents. Clumps of *Lomandra longifolia* grow in the streambed proper and must have a substantial role in consolidating gravel bars.

2.3.2 LOWER CATCHMENT AND ESTUARY FORESHORE VEGETATION

A range of diverse vegetation communities occurs in the lower catchment and close to the shores of Nelson Lagoon. Two vegetation communities that occur close to the shore of Nelson Lagoon include *Far South Coast Foothills Dry Shrub Forest,* sometimes in the variant dominated by *Corymbia maculata* (spotted gum) and *Eucalyptus paniculata* (grey ironbark), and *Southeast Warm Temperate Rainforest.*

More significantly, seven endangered ecological communities (EEC) have been mapped in the lower catchment (OEH 2013), either on the foreshore of, or in close proximity to the estuary (**Figure 3)**. These include *Coastal Saltmarsh, Bangalay Sand Forest, Freshwater Wetlands on Coastal Floodplains, River-flat Eucalypt Forest on Coastal Floodplain, Swamp Sclerophyll Forest on Coastal Floodplains, Swamp Oak Floodplain Forest and Lowland Grassy Woodland.* Some of these communities are of very restricted extent, and some community identifications appear to have been made without the benefit of ground-truthing field surveys to confirm mapping. Verifying the distribution and extent of EECs was outside the scope of this study however some notes regarding the occurrence and/or significant floristic components within of each of the EECs were recorded during field inspections (**Table 2).**

In addition to coastal saltmarsh community, Nelson lagoon also supports extensive grey mangrove community (*Avicennia marina*) owing to the fact the estuary is permanently open to the sea, tidally influenced and dominated by marine conditions.

2.3.3 OTHER RARE AND SIGNIFICANT FLORA

In addition to the seven EECs listed in Nelson Lagoon catchment, a number of rare and threatened plant species listed under *NSW Threatened Species Conservation Act 1995* (TSC Act) or otherwise regionally significant plant species are also known from the catchment. These include:

- *Wilsonia backhousiae*, a low-growing saltmarsh herb, listed as *vulnerable*, has previously been reported from Nelson Lagoon (*pers. obs.* Jackie Miles) but was not observed during this assessment.
- Two species endemic to Dr George Mountain and that might be expected to occur at the western margins of the catchment include *Acacia georgensis* (Bega wattle), listed as vulnerable, and the rare *Eucalyptus specatatrix.* However, their presence was not confirmed in this assessment.
- The regionally significant *Acacia pedina* has a very restricted distribution, only known to occur between Bermagui and Tathra (Kodela and Tame 1999). It is present around the Nelson lagoon shore, predominantly occurring just above the high tide level.
- Other rare plants found in the vicinity of Dr George Mountain include the vulnerable *Leionema carruthersii, Leionema ralstonii* and *Haloragodendron* sp. Wet forests growing on fire-protected aspects of Dr George Mountain contain the vulnerable species upright pomaderris (*Pomaderris virgata*).

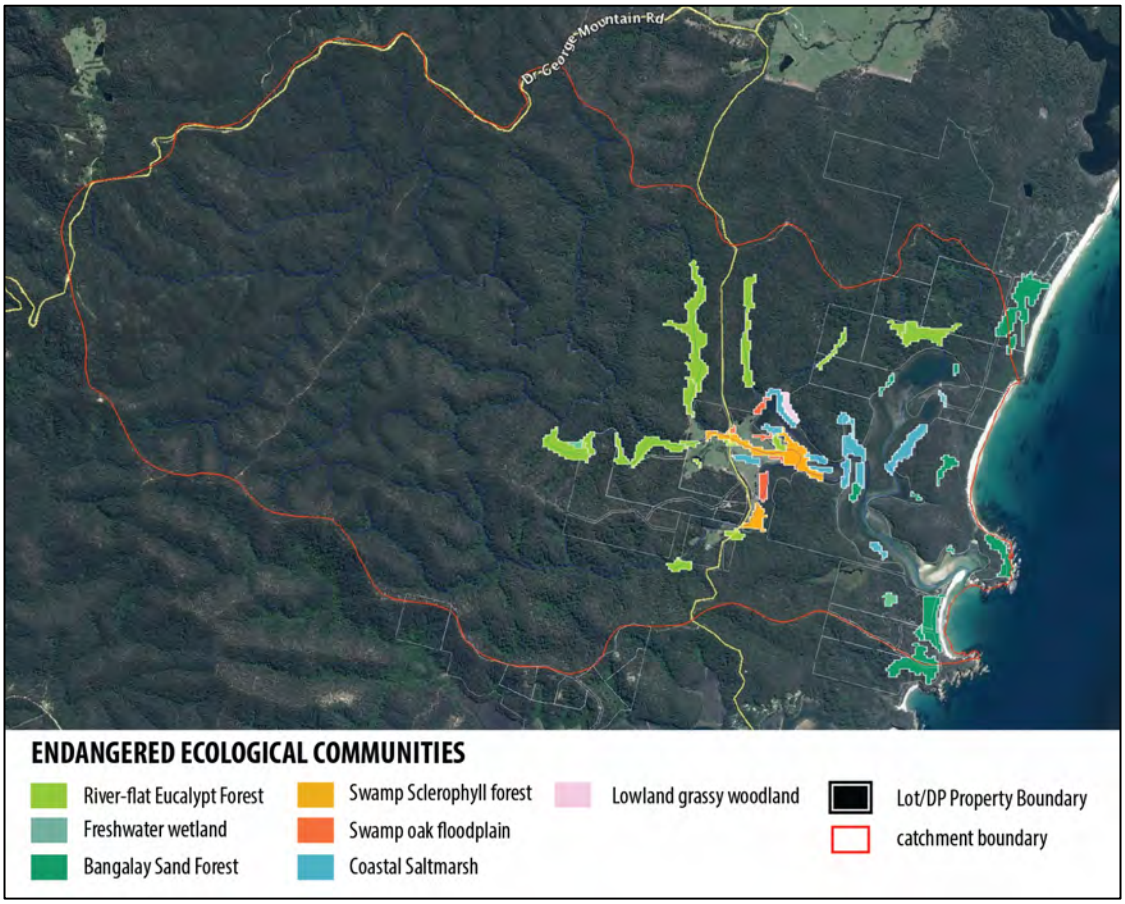


Figure 3. Distribution and extent of endangered ecological communities in Nelson Lagoon catchment. (*Note* - mapping from OEH 2013 and has not been verified in this study).

Table 2. Summary of Endangered Ecological Communities mapped in Nelson Lagoon catchment with notes regarding the occurrence of each ECC.

EEC Name	Comments
Coastal Saltmarsh	*Coastal saltmarsh* is very extensive around Nelson lagoon estimated to cover 0.155 km^2 in area (Creese *et al.* 2009). The saltmarsh is the variant characteristic of permanently tidal systems with such distinctive species as *Tecticornia arbuscula, Austrostipa stipoides, Gahnia filum.* The rare saltmarsh herb *Wilsonia backhousiae* has been reported at Nelson Lagoon but was not observed in this assessment.
Freshwater Wetlands on Coastal Floodplains	A small patch of *Freshwater Wetlands on Coastal Floodplains* occurs within the national park on the southern shore of the lagoon.
Bangalay Sand Forest	*Bangalay Sand Forest,* dominated by large old *Eucalyptus botryoides* (bangalay), is restricted to small areas on sandy substrate on southern side of the estuary adjacent to the main visitor carpark.
River-flat Eucalypt Forest on coastal floodplain	*River-flat Eucalypt Forest on coastal floodplain* is mapped as being quite extensive along creekbanks. The identification is questionable however, since uncleared river flats are of negligible extent in the catchment and the vegetation on the streambanks is best characterised as a form of gallery rainforest (Refer Section 2.3.1 above).
Swamp Sclerophyll Forest on Coastal Floodplains	*Swamp sclerophyll forest on coastal floodplains* is mapped as occurring as several small patches around the estuary. However few of the indicative species for this community are present. *Melaleuca armillaris* forms a fairly continuous canopy with scattered *Myoporum acuminatum* and an understorey of graminoids. This community is vulnerable to weed invasion but the Nelson Lagoon examples are in good condition.
Swamp Oak Floodplain Forest	Swamp Oak Floodplain Forest is mapped as occurring in multiple locations on the floodplain area of the upper estuary. However this is a doubtful identification since the key indicator species, *Casuarina glauca,* does not extend this far south.
Lowland Grassy Woodland	A small area of *Lowland Grassy Woodland* occurs on the northern side of the lagoon, though unverified.

2.3.4 EXISTING CONDITION AND FUTURE TRAJECTORY OF ESTUARY FORESHORE VEGETATION COMMUNITY

The existing condition of estuary foreshore vegetation is very good. With the exception of the alluvial flats of the upper estuary, very little of the Nelson Lagoon foreshore has been cleared and is generally in good condition. A number of projects and initiatives have been undertaken by NPWS, SRCMA and private landholders to improve the condition of degraded coastal saltmarsh community and protect mangrove community around the upper estuary. These projects have been successful at minimising the impacts of stock grazing and excluding vehicle access with saltmarsh regeneration slowly occurring and mangrove community flourishing as a result. However, the dune vegetation of the lower estuary foreshore is degraded in some areas and subject to the highest level of pressure

in terms of human disturbance due to trampling despite NPWS efforts to control access to the dune system.

The long term trajectory of the foreshore vegetation, in the absence of further significant disturbance, such as by renewed clearing on private land or a major wildfire, will be to ensure the natural pattern of vegetation is maintained through active management of potential threats by NPWS. These include controlling access to pedestrian, vehicle and motorbike. Improved catchment condition in terms of overall increased vegetation cover will contribute to ensuring the ecosystem health of the estuary is maintained in good condition for future generations to enjoy.

2.3.5 WEED ISSUE

The Nelson catchment is in excellent condition with regards to weeds. The only invasive species noted being a common weed of disturbance, *Phytolacca octandra* (inkweed). *Rubus fruticosus* sp agg. (blackberry) is likely to be present in the catchment but was not observed during the assessment.

2.4 COASTAL GEOMORPHOLOGY

Nelson Lagoon is a wave-dominated estuary (OzCoasts 2016, Roy *et al* 2001) and the geomorphic evolution of the estuary most likely follows that of other estuaries found on the south coast of NSW as described by Sloss *et al* (2007) and is briefly described below.

During the peak of the last ice age, approximately 12,500 years ago, the estuary was originally a creek valley with a well-developed floodplain. This creek valley was drowned by rising sea levels approximately 7,000 years ago, with beach sands pushed towards the coast leading to the formation of the barrier dune system that created the estuary.

Over the last 7,000 years the estuary has been subject to continuous deposition from both the catchment and coastal environment. This has led to the formation of distinct estuarine zones, which include the: upper estuary; lagoon areas; lower estuary; and the entrance (**Figure 4**).

- The upper estuary is dominated by sediments sourced from the catchment and deposited during flood events. Over the last 7,000 years these fluvial sediments have vertically accreted over the older floodplain (Pleistocene deposits), forming the current day floodplain downstream of the Tathra-Bermagui bridge.
- Six separate lagoon areas are found at the back of the estuary. These areas are isolated from each other and are relatively small compared to the rest of the estuary. Four of these lagoons are connected to the main estuary by a tidal channel. The other two lagoons are brackish and only subject to tidal inundation during very high tides.
- The lower estuary is dominated by the transgression of marine sands deposited by wave and tide action in the estuary entrance and was formed as early as 7,000 to 5,000 years ago. The tidal channel in the lower estuary has likely been in the same location for the last 2,500 years.
- The entrance of the estuary is a much younger deposit, and is subject to periodic erosion caused by waves, and flood flows during severe storm events. As such the boundary of this

area is ambulatory, being subject to continuous erosion and deposition and changes to its morphology.

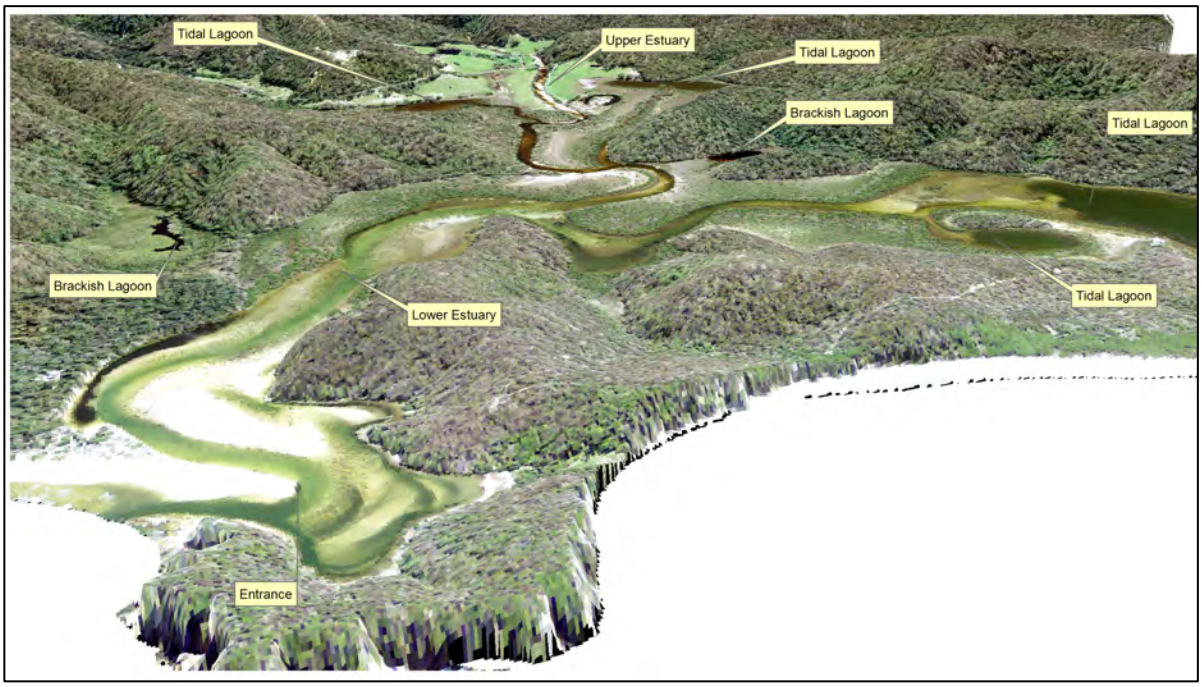


Figure 4. Geomorphological zones of Nelson Lagoon.

2.5 ESTUARINE VEGETATION

Nelson Lagoon supports a variety of estuarine macrophytes with seagrasses estimated to cover 0.01km^2 (<1%) of the estuary area including *Zostera muelleri* (eel grass) and *Halophila ovalis* (paddle-weed). The lagoon supports significant stands of grey mangrove habitat covering approximately 0.491 km^2 (43%) of the estuary area with saltmarsh community fringing areas of the upper estuary and covering a total of 0.155 km^2 (14% of the estuary area). The estimated spatial extent of these estuarine habitats is shown in **Figure 5** based on aerial imagery from 2005 and field ground-truthing surveys conducted by NSW DPI in 2006 (Creese *et al.* 2009).

The 2006 NSW DPI assessment of seagrass extent estimated that greater than 70% of seagrass community in Nelson Lagoon was lost over the 20-year period from 1985 to 2006. However, there is low confidence in this estimate of seagrass loss due to differences in the mapping techniques applied in the 1985 and 2006 assessments (*pers. comm.* D. Wiecek, OEH). It is currently not clear whether seagrass loss is an issue for Nelson Lagoon. The largest continuous patch of seagrass community mapped in Nelson Lagoon occurs in the lower estuary where recreational activity is most popular and rates of human disturbance perhaps also greatest. Disturbance factors contributing to historical seagrass loss may include sedimentation, scouring by boat propellers and anchors, and historical commercial fishing practices. Minimising potential loss of seagrass is an ongoing issue that will have broader implications for the ecological condition of the estuary. Efforts to improve the extent of the seagrass community will enhance recreational fishing opportunities for future generations.

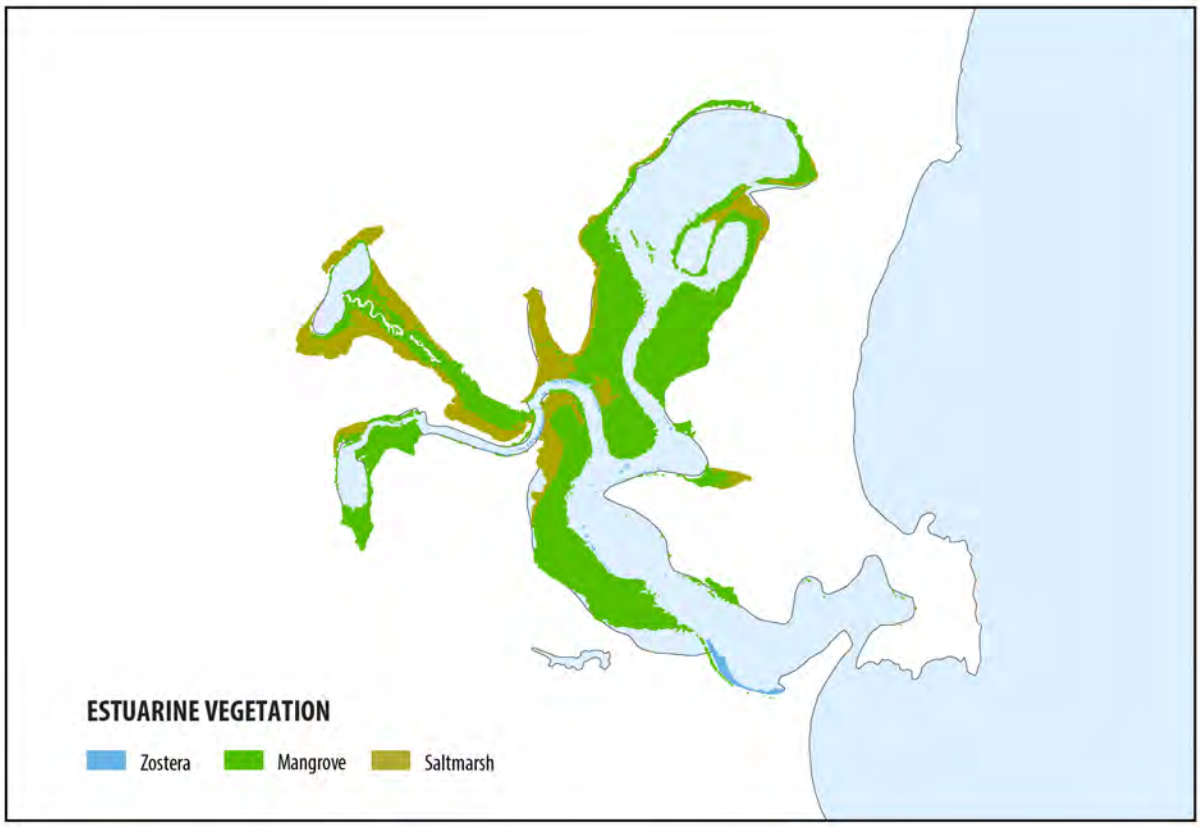


Figure 5. Estimated spatial extent of estuarine habitats of Nelson Lagoon (from Creese *et al.* 2009).

2.6 WATER QUALITY AND ESTUARINE ECOSYSTEM HEALTH

2.6.1 WATER QUALITY

Nelson Lagoon is widely regarded as being one of the most pristine estuaries in the Bega Valley Shire region, a reputation owing to its high water quality that is directly related to the low level of catchment development and disturbance compared to other estuaries. The estuary is often considered as the reference benchmark for other estuaries of similar geomorphic class - barrier river (OEH 2013), that include Bermagui River, Murrah River, Bega River, Pambula River, Towamba River and Wonboyn River estuaries.

Water quality of Nelson Lagoon has been the subject of intermittent monitoring programs that have included the collection of physico-chemical, nutrient and biological data in 1994 to 1995 (NSW EPA) and 2002 to 2003 (WBM 2005), as well as regular monthly monitoring of microbiological parameter faecal coliforms since 1998 as required by the Australian Shellfish Quality Assurance Program (ASQAP).

A summary of the available datasets is provided below.

NSW EPA 1994-1995

NSW EPA monitored water quality over a seven-month period between December 1994 and June 1995. A summary of mean data compared to relevant ANZECC and NSW estuary WQ guidelines where applicable is provided in **Table 3.** The data indicate Nelson Lagoon over the monitoring period was characterised by:

- Typically high levels of dissolved oxygen (DO).
- Typically high water clarity (*i.e.* low turbidity).
- Regularly elevated levels of nutrients with mean levels of Total Nitrogen (TN) and Total Phosphorous (TP) exceeding the recommended ANZECC and NSW MER guideline limits for the protection of estuarine aquatic ecosystems.
- Consistently low levels of inorganic species of nitrogen (NOx) and phosphorous in bioavailable forms indicating the risk of prolific growth of nuisance algae was low during this time period.
- Limited data regarding microalgal abundance (as chlorophyll *a*) to draw meaningful inference.

WBM 2002-2003 (WBM 2005)

WBM conducted a monthly baseline surface water quality-monitoring program between January 2002 and February 2003 to examine seasonal trends and assess whether water quality was impacted during peak tourist periods and following catchment run-off events. Sampling locations included two sites in the lower estuary (BEG_0032 and BEG_0031), and one in the basin (BEG_0030) as shown in **Figure 6**. The findings of the study (WBM 2005) included:

- Few parameters showed seasonal trends with exception of temperature and dissolved oxygen.
- Nitrogen parameters including total nitrogen, inorganic nitrogen (NOx), and ammonia regularly exceeded guideline limits.
- Total phosphorous was generally below guideline limits although bioavailable ortho-phosphate exceeded guideline limits on several occasions during the monitoring period.
- The design of the monitoring program and the data collected were not able to address the study objectives *i.e.* inferences regarding potential water quality impacts during the peak tourist period and following catchment run-off events could not be adequately addressed.

NSW Food Authority (data collected by oyster growers as part of the ASQAP)

Water quality of Nelson Lagoon is subject to regular monthly testing by NSW Food Authority for faecal coliforms as part of the NSW Shellfish Program that adopts the Australian Shellfish Quality Assurance Program (ASQAP). Data collected by oyster growers since 1998 shows that the median faecal coliform count is 1.99 cfu/100ml with a maximum count of 66 cfu/100ml reported over a 17-year period since 1998. Data show faecal coliforms to be consistently below the ANZECC guideline for primary contact recreation of 150 cfu/100ml.

INTRODUCTION

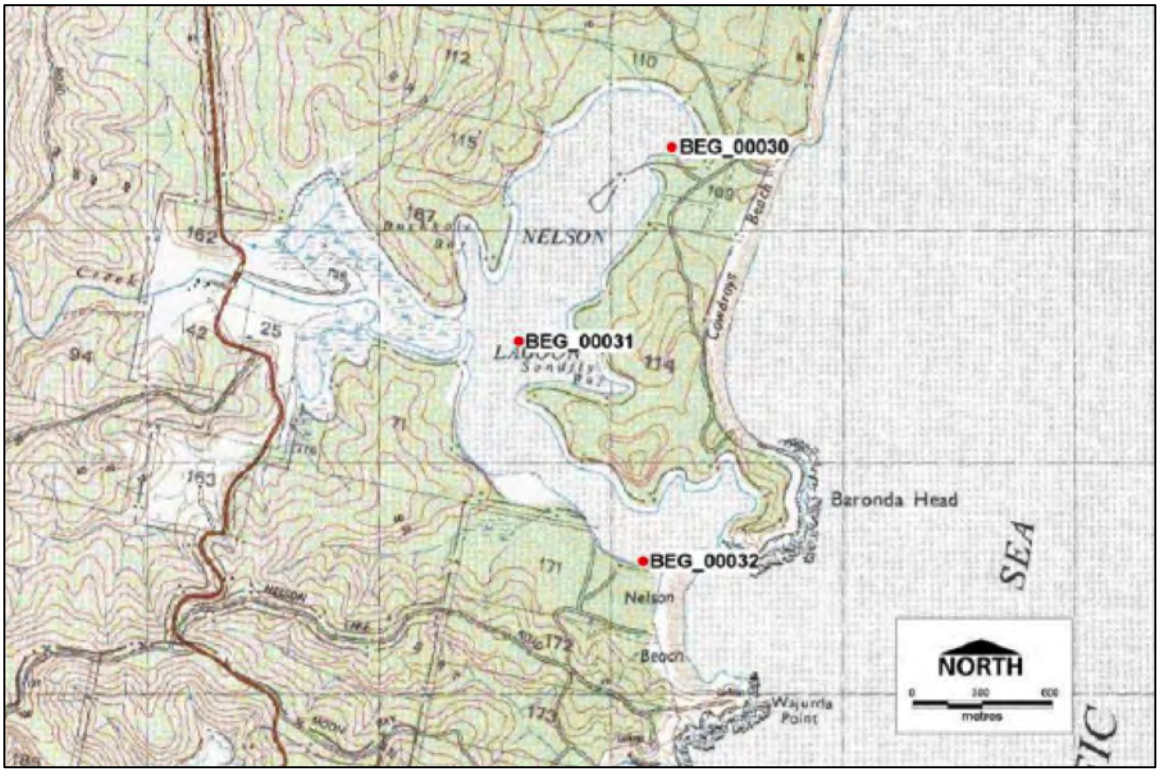


Figure 6. Water quality monitoring sites sampled by WBM (2005)

In summary, the limited available datasets indicate base-flow catchment inputs were not impacting the water quality of Nelson Lagoon in years 1994-1995, and 2002-2003. However, it has been more than a decade since water quality conditions of Nelson Lagoon were assessed and a contemporary assessment of water quality is recommended. Future monitoring should adopt sampling approaches and protocols used by the NSW estuary ecosystem health program (OEH 2013) and include sampling following high rainfall event to accurately assess the magnitude of episodic catchment inputs.

Table 3. Summary of mean water quality data collected by NSW EPA 1994-1995

	Nitrite and Nitrate (NOx)	Ammonia (NH3)	Ortho-phosphate (PO4)	Total Nitrogen	Total Phosphorous	Temperature	Salinity	pH	Dissolved Oxygen	Dissolved Oxygen	Turbidity	Chlorophyll a
Units	µg/L	µg/L	µg/L	µg/L	µg/L	°C	ppt	pH	% sat.	mg/L	ntu	µg/L
Aquatic Ecosystems[1]	15	-	5	300	30	-	-	-	80-110	-	-	-
NSW Estuary MER Trigger Values[2] Riverine Lower	5.1	8	2.8	205	10.3	-	-	-	-	-	2.8	2.3
Dec-94	<10	**26**	-	188	**30**	23.2	35.4	-	**111.1**	7.8	**4.5**	-
Jan-95	<10	**21**	-	147	**22**	22.7	35.1	-	103.9	7.3	**3.9**	-
Feb-95	<10	**18**	-	**211**	**18**	17.6	34.7	-	106.4	8.2	2.7	-
Mar-95	<10	**39**	-	**310**	**14**	20.2	34.9	-	110	8.1	1.9	-
Apr-95	<10	**30**	-	132	**14**	18.9	34.9	-	110	8.1	0	-
May-95	<10	**57**	-	**432**	**17**	17.9	35.6	-	105.7	8.1	**3.1**	-
Jun-95	<10	**10**	-	**330**	**24**	15.6	35.6	-	**114.4**	9.2	0.7	0.2

[1] WQOs for protection of Aquatic Ecosystems are for Bega River Catchment - based on ANZECC/ARMCANZ 2000

[2] NSW estuary MER trigger values for 'Riverine Lower' estuaries with low levels of catchment disturbance

2.6.2 ESTUARINE ECOSYSTEM HEALTH

In NSW, estuary ecosystem health is based on a suite of ten (10) indicators that address state-wide coastal issues including eutrophication, habitat availability and fish assemblages. Indicators represent elements of the structure, function and composition of estuarine ecosystems (see **Table 4)**. Detailed information regarding the adopted indicators is provided in *Assessing the condition of estuaries and coastal lake ecosystems in NSW* (Roper *et. al.* 2011).

Table 4. Environmental indicators used to assess estuarine ecosystem health in NSW

Issue	Indicator
Eutrophication	microalgal abundance as phytoplankton determined by chlorophyll *a*;
	macroalgal abundance;
	water clarity as turbidity
Habitat Availability	extent of seagrass
	extent of mangroves
	extent of saltmarsh
Fish Assemblages	species diversity and composition
	species abundance
	nursery function
	trophic integrity

In 2010, an assessment of estuarine ecosystem health for Nelson Lagoon and the pressures acting upon it was completed as part of state-wide estuary health reporting (DECCW 2011). The assessment provided Nelson Lagoon with an overall condition index of 3.0 (out of 5), rated as being *'fair'* based on the estuarine health indicators - extent of seagrass, extent of saltmarsh and mangrove (**Figure 7**).

Saltmarsh was rated '*very good'*, while seagrass was rated '*very poor'*. No rating was provided for mangrove as the assessment was baseline data only and no data was available to assess for chlorophyll a, macroalgae, turbidity or fish assemblages.

Seagrass was rated as '*very poor'* based on an estimated 70% decline in seagrass extent over a 20-year period from 1985 to 2006. As previously noted in Section 2.5, this estimate of seagrass loss may not be accurate due to differences in mapping techniques applied in the 1985 and 2006 assessments. The potential issue of seagrass loss in Nelson Lagoon is worthy of further investigation through additional seagrass mapping utilising methodology similar to that applied by NSW DPI in 2006.

The ecosystem health assessment also provided Nelson Lagoon with a pressure index of 4.5 (out of 5), rated as having low to very low pressure in terms of pressure indicators – cleared land, population, sediment and nutrient inputs, freshwater flows, tidal flows and fishing. However disturbed habitat was rated as being a very high pressure owing to the proportion of estuary area occupied by aquaculture leases.

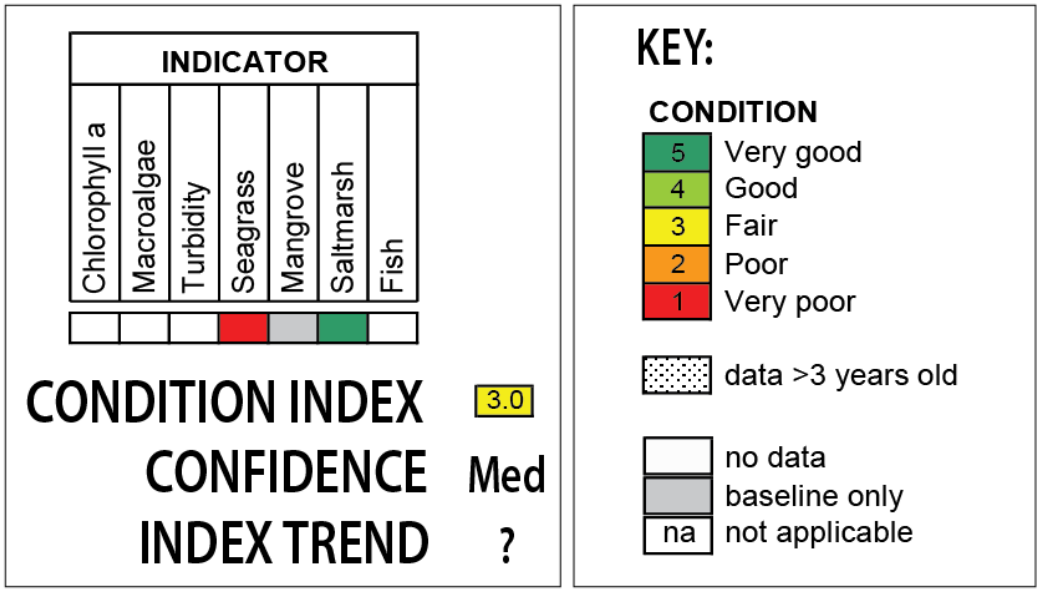


Figure 7. Ecosystem Health Assessment for Nelson Lagoon (from DECCW 2011)

3 CULTURAL HERITAGE

The Nelson catchment is part of country belonging to the Yuin people who have inhabited this region for at least 20,000 years (NPWS 2009). Oral tradition and physical evidence indicate the Yuin maintained a thriving society that incorporated sophisticated exchange patterns and rich social and ceremonial lives. Estuaries such as Nelson Lagoon provided bountiful seafood resources including fish, shellfish and eels.

Nelson Lagoon is recognised as being significant to local Aboriginal people and it is acknowledged that the beach and lagoon areas contain extensive archaeological values (BVSC 2010). In regards to this matter, it is recommended that an archaeological survey be completed prior to commencing any works disturbing ground particularly in relation to actions recommended in this report. Surveys should be conducted by a qualified archaeologist in consultation with the Bega Local Aboriginal Land Council.

4 SEA-LEVEL RISE

The effect of predicted sea-level rise (SLR) associated with climate change was considered during this study in context of potential change to the estuarine environment and in particular to areas of high conservation significance (*i.e.* EECs such as coastal saltmarsh community).

In discussing the potential effect of predicted SLR on the estuary, it is important to note the estuary was formed as a consequence of global SLR approximately 7,000 years ago. Since that time, small variations in sea level of +/-1.5m have occurred relative to present day sea-levels on the southeast coast of Australia (White *et al* 2014; Sloss *et al* 2007). Hence, the estuary has adjusted to changes in sea level in the past. Consequently the main impact of SLR will likely be on estuary macrophyte vegetation, and the built environment and low-lying private and public assets.

INTRODUCTION

Existing sea level based on Mean High Water Springs (MHWS) and Highest Astronomical Tide (HAT) were compared to the estimated extent of tidal inundation for MHWS and HAT for year 2100 under predicted SLR scenario of a 1.1m increase in sea-levels (Ozcoasts 2016b). Mapping was based on the following simplistic approach to provide an indication of potential inundation and is a useful preliminary assessment of SLR for this study:

4.1 EXISTING TIDAL CONDITIONS IN NELSON LAGOON

Nelson Lagoon tidal conditions are monitored by Manly Hydraulics Laboratory (MHL) who provided data for the period between November to December 2015. Data show that water levels in Nelson Lagoon slightly exceed water levels of the open ocean as shown for Eden in **Figure 8**. This difference is likely due to errors associated with not having good survey points in the Nelson Lagoon area and known issues with translation of Australian Height Datum (AHD) on far south coast of NSW (*per. comm.* D. Wiecek, OEH, 3 May 2016). Data show that tidal amplitude of Nelson Lagoon may be as much as 1.4m during spring tides as recorded in November 2015 (**Figure 9**). In comparison, the tidal amplitude of the open ocean at Eden for the corresponding time period is approximately 1.8m.

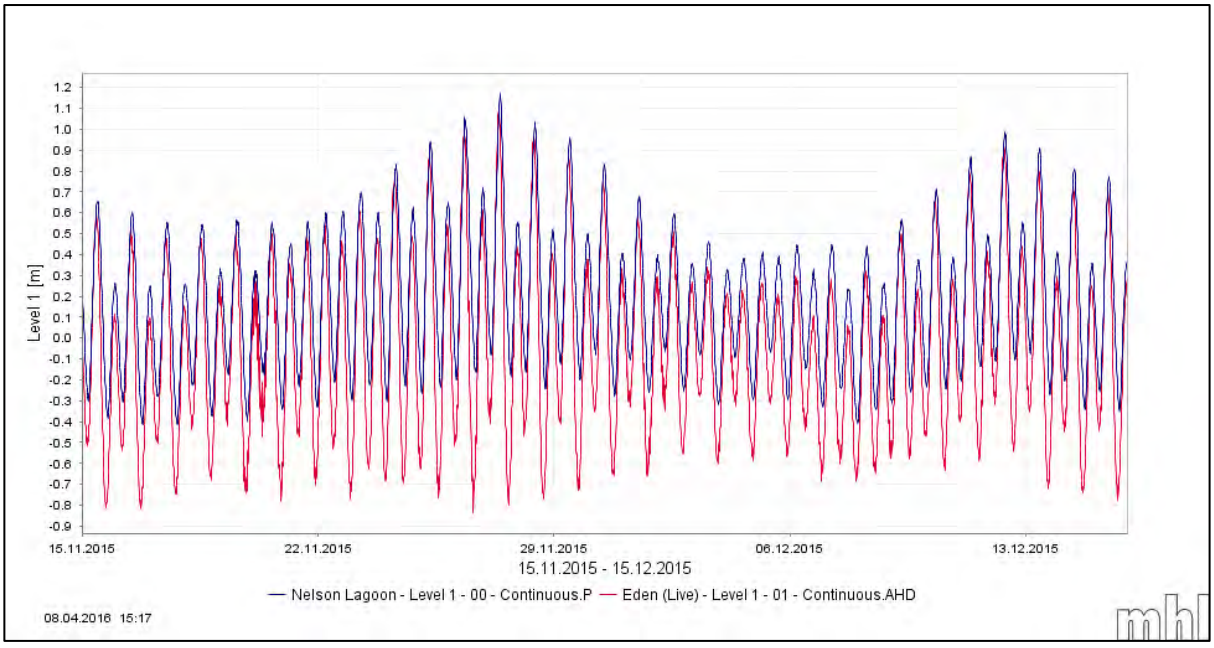


Figure 8. Comparison of tidal levels recorded at Nelson Lagoon and Eden offshore monitoring gauges – November to December 2015 (*Data courtesy of Manly Hydraulics Laboratory*).

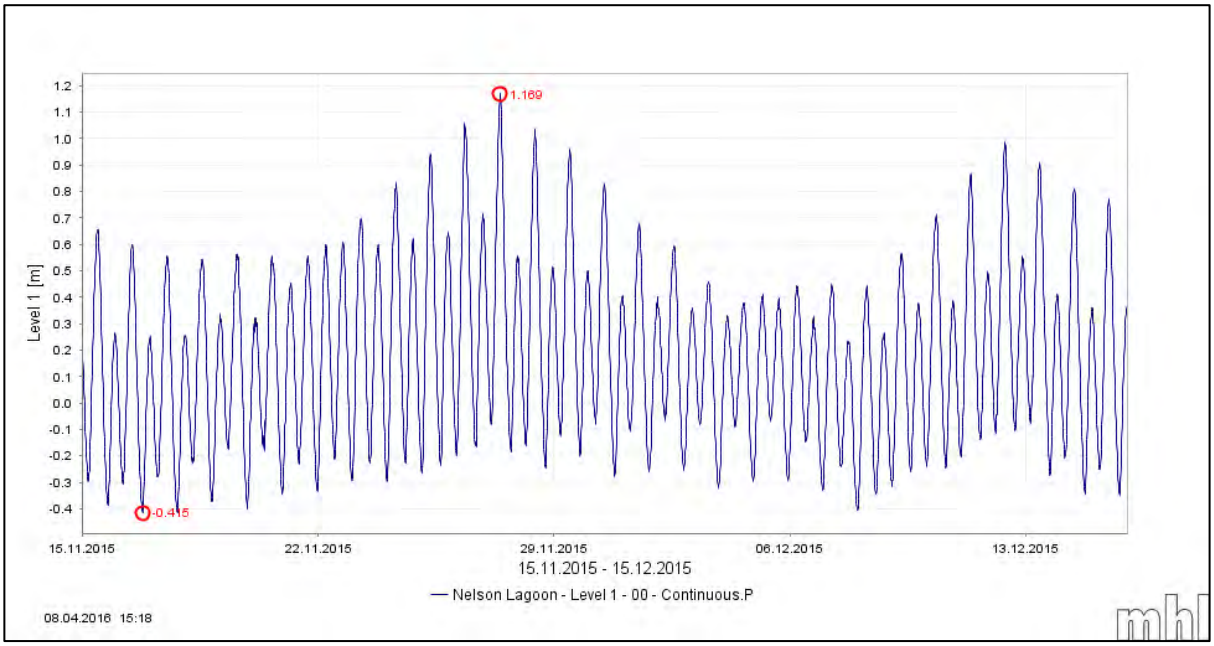


Figure 9. Tidal levels recorded at Nelson Lagoon monitoring gauge – November to December 2015 (*Data courtesy of Manly Hydraulics Laboratory*).

For purposes of investigating potential inundation under a SLR scenario for year 2100, Mean High Water Springs (MHWS) for Nelson Lagoon was based on the nearest tidal monitoring station of Port of Bermagui (OEH 2012).

Estimated Tidal Elevation Mean High Water Springs (MHWS)

MHWS (Bermagui) = 1.27 m (MHWS of Tidal Gauge) + (-0.714 m AHD [Elevation of Gauge])

= 0.556 m AHD

Estimated Tidal Elevation Highest Astronomical Tide (HAT)

HAT (Bermagui) = 2.0 m (Predicted HAT of tidal gauge) + (-0.714 m AHD elevation of gauge)

= 1.286 m AHD

Values for MHWS and HAT were converted to the Australian Height Datum (AHD) to model and map tidal areas of Nelson Lagoon. MHWS and HAT tidally inundated areas were modelled using a conditional decision rule applied to the DEM using the spatial analysis extension in ArcGIS 10. The estuary area likely inundated by MHWS and HAT is shown on **Figures 10** and **11** respectively.

4.2 PREDICTED SEA-LEVEL RISE

CSIRO has developed a model for sea level rise for years 2030, 2050 and 2100 relative to 1990 (OzCoasts 2016b). Mapping presented in **Figures 10 and 11** (attached) uses the high-end scenario of a 1.1m increase in sea level by 2100. The corresponding increase in MHWS and HAT relative to the Australian Height Datum (AHD) for years 2030, 2050 and 2100 are provided in **Table 5.**

It is important to note that BVSC has adopted a sea level rise policy for planning purposes that is consistent with the former NSW Government's SLR Policy and provides for an increase in mean sea level of 0.91m by 2100 above 1990 levels (BVSC 2013). There is still considerable uncertainty

surrounding estimates of future SLR. Therefore, mapping presented in **Figures 10** and **11** shows a greater potential inundation of areas than what would be expected under a SLR scenario of a 0.91m increase above 1990 levels, and in terms of planning purposes, presents a more conservative approach using a higher estimate of future SLR.

Table 5. Predicted MHWS and HAT for Nelson Lagoon based on maximum projected Sea-Level Rise

Year	Max. Sea-Level Rise (OzCoasts 2016b)	Predicted MHWS (AHD)	Predicted HAT (AHD)
2030	0.2 m	0.756 m	1.486 m
2050	0.7 m	1.256 m	1.986 m
2100	1.1 m	1.656 m	2.386 m

Sea-level Rise (Year 2100) and Increase in Tidal Inundation in Nelson Lagoon

A Digital Elevation Model (DEM) for Nelson Lagoon was created using Arc GIS 10. The DEM enabled calculation of the likely change in estuary tidal area due to a 1.1m increase in sea level by the year 2100. The predicted increase in MHWS to 1.656m AHD would result in an estimated additional tidal area of 0.78 km^2, equivalent to a 64% increase in tidal area compared to present day MHWS (**Figure 10**). The predicted increase in HAT to 2.386m AHD would result in an increased additional tidal area of 0.34 $km^{2,}$ equivalent to a 19 % increase in tidal area compared to present day HAT (**Figure 11**).

4.3 LIKELY AND POTENTIAL EFFECTS OF SEA-LEVEL RISE ON NELSON LAGOON

Likely effects of a 1.1m sea-level rise on Nelson lagoon include:

- Tidal waters will extend further upstream;
- MHWS tidal area will increase by an estimated 64.4%;
- HAT tidal areas will increase by an estimated 19% and,
- There will be a reduction in sediment transport from the catchment to the fluvial delta, due to an anticipated reduction in stream power, provided that there is no further land-clearing and or major fires in the catchment.

An increase in sea-level may result in variable behaviour of the estuary entrance due to associated climatic and near shore sediment transport changes. Two scenarios are possible:

1) Estuary will remain tidally dominated; or
2) An increase in sea-level may translate to a corresponding increase in the berm height at the entrance of the estuary, such that tidal processes are altered and tidal influences are reduced.

The potential effects of each scenario are discussed below.

Nelson Lagoon Remains Tidally dominated

Under scenario 1, the estuary will remain dominated by marine conditions similar to current day conditions, albeit with higher elevation tides relative to the Australian Height Datum (AHD). Analysis

of MHWS (year 2100) modelling shows that seagrass communities may establish in shallow tidal areas that are currently occupied by mangrove and saltmarsh. The current extent of drier coastal saltmarsh may become permanently inundated and may be replaced over time with mangrove community. Seagrass meadows may become more prevalent in the estuary assisted by an increase in tidal inundation. Saltmarsh community will retreat to higher ground where suitable opportunities for retreat exist. However, the extent of tidal inundation area is controlled by the proximity of hillslope adjoining the estuary. Hence, opportunities for saltmarsh retreat appear limited and analysis of HAT (year 2100) modelling shows that the total area available for saltmarsh is approximately 0.34 km^2 if the estuary is subject to sea level rise of 1.1 m AHD.

Nelson Lagoon may experience Altered Tidal Processes

Under scenario 2, a concomitant increase in berm height with SLR may result in increased shoaling of the entrance channel such that tidal processes are altered. This may result in overall reduced tidal influences with estuarine waters becoming more brackish and remaining brackish for longer periods. However, exactly how the entrance berm will respond to SLR is uncertain and its effect on estuary processes unknown.

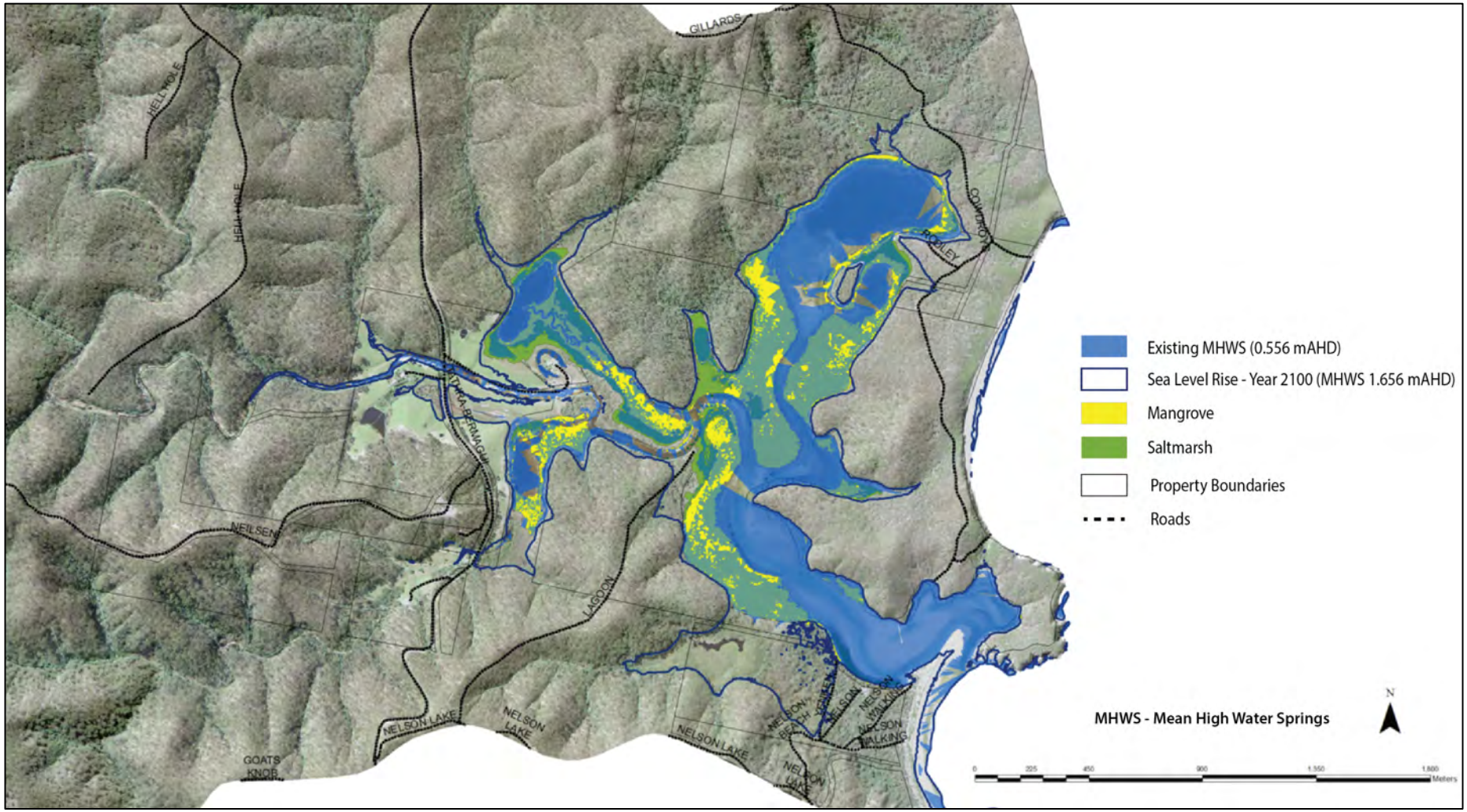


Figure 10. Nelson Lagoon existing tidal area for MHWS and estimated extent of tidal inundation for MHWS under sea level rise scenario for Year 2100 (Ozcoasts 2016b).

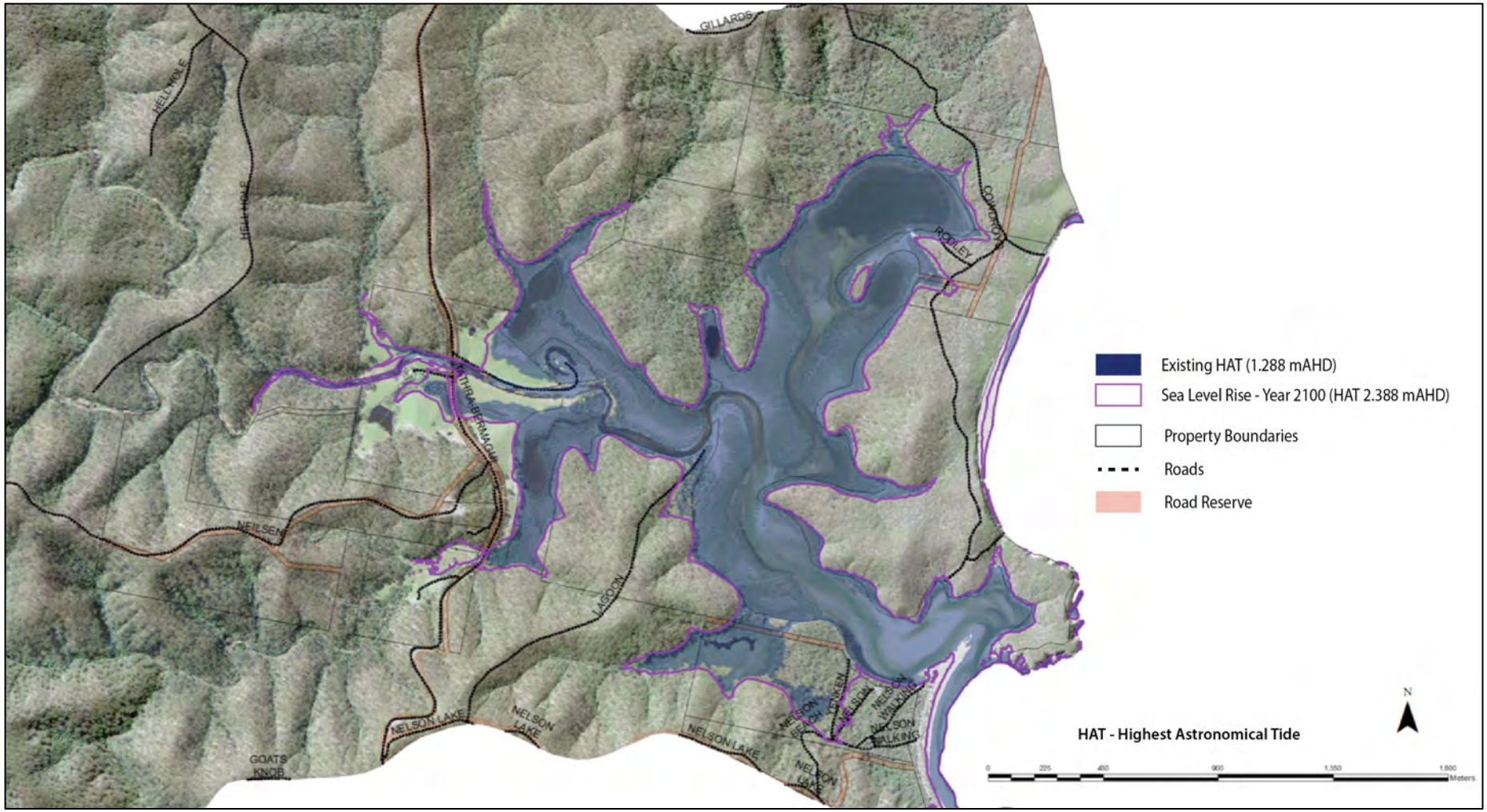


Figure 11. Nelson Lagoon existing tidal area for HAT and estimated inundation extent for HAT under sea level rise scenario for Year 2100 (Ozcoasts 2016b).

APPROACH AND OUTCOMES

5 COMMUNITY AND STAKEHOLDER CONSULTATION

Approach to Community and Stakeholder Engagement

The aim of consultation was to raise awareness and provide opportunity to community and stakeholders to input to the project regarding catchment and estuary values, management issues and concerns. Community and stakeholder consultation was important to prioritising erosion management areas for targeted rehabilitation, achieving a high level of understanding, involvement and overall acceptance of the proposed management recommendations.

Consultation was undertaken using a combination of the following methods:

- Distribution of letter and consultation plan to stakeholders and catchment residents;
- Online survey to gather input regarding catchment values and issues from community and stakeholders;
- Media release - BVSC website and ABC radio
- Meeting with stakeholder representatives and individual landholders;
- Monitoring and responding to email and telephone feedback; and
- Facilitation of community information session to present findings of catchment and estuary erosion issues and management recommendations.

Distribution of Letter and Consultation Plan

A hard-copy letter including consultation plan explaining project objectives and seeking input to the project was sent to landholder residents within the catchment at the commencement of the project in July 2015. The consultation plan provided a brief overview of catchment characteristics and ecological values including terrestrial vegetation communities of conservation significance, types and extent of estuarine vegetation, catchment land uses, commercial fishing rights and water quality. The consultation plan is provided in **Appendix A**.

A digital copy of the consultation plan was also distributed to key representatives of each of the following stakeholder agencies whose responsibilities are summarised in **Table 6**.

- Bega Local Aboriginal Land Council
- National Parks and Wildlife Service (NPWS)
- Bega Valley Shire Council and members of Coastal Committee
- Southeast Local Land Services (SELLS)
- Dept. of Primary Industries – Fisheries
- NSW Roads and Maritime Services (RMS)
- Dept. of Primary Industries – Lands (formerly Crown Lands)

Table 6. Summary of Stakeholder, Responsibility and Key contact representative

Stakeholder Agency	Contact
Bega Local Aboriginal Land Council (Bega LALC) As the State's peak representative body in Aboriginal Affairs, the NSW Aboriginal Land Council aims to protect the interests and further the aspirations of its members and the broader Aboriginal community. The Bega Local Aboriginal Land Council receives funding from this State body (from asset generated funds) to undertake projects and programs specific to the local community of the Bega land area that includes the catchment area of Nelson Lagoon.	Glenn Wilcox Chief Executive Officer ceo_begalalc@commander.net.au
Bega Valley Shire Council (BVSC) Council is a local statutory authority with powers and responsibilities conferred from State and Federal Parliament. The main piece of legislation that details the powers of local councils is the *Local Government Act 1993*. Council provides a range of day-to-day services for our community and Bega Valley Shire Council is committed to ensuring that the Council and the community work in partnership to achieve the best outcome for the Shire. Responsible for a broad range of programs the Environment Section of the BVSC is involved in estuary, storm water, waste, water, sewage, weed and road management programs.	Kyran Crane Coastal Management Officer K.crane@begavalley.nsw.gov.au Daniel Murphy Coordinator of Environmental Management D.murphy@begavalley.nsw.gov.au
Department of Primary Industries - Lands (Lands) DPI Lands is responsible for the sustainable and commercial management of Crown land. Lands manages the development, marketing and sales of crown lands not required for public purposes. Various land uses are authorised by Lands including: waterfront occupations, commercial, grazing and agriculture, residential, sporting; community purposes, tourism, and industrial. It manages these Crown lands through a variety of methods such as licensing, leasing, sale and disposal of surplus crown and other state-owned lands. Lands also provide land information/status and land accounts services as well as a map and products sale centre.	Grant Merinuk grant.merinuk@crownlands.nsw.gov.au
Office of Environment and Heritage (OEH) The Office of Environment and Heritage works to protect and conserve the NSW environment, including the natural environment, Aboriginal country, culture and heritage and our built heritage, and manages NSW national parks and reserves. OEH develops and leads policy, reform and education in sustainability, biodiversity and native vegetation, coastal protection and Aboriginal cultural heritage.	Daniel Wiecek Senior Natural Resource Officer – Coasts and Estuaries (Southeast Region) daniel.wiecek@environment.nsw.gov.au

Department of Primary Industries - Fisheries Responsible for the management of recreational fishing, commercial fishing, aquaculture, habitat management, species protection, disease and pest management, research and compliance in NSW in accordance with the *Fisheries Management Act 1994*. Responsibility and jurisdiction over waterway areas up to mean high water mark.	Matt Proctor District Fisheries Officer Eden 02 4476 0100 matt.proctor@dpi.nsw.gov.au
National Parks and Wildlife Service (part of OEH) NSW has 879 national parks and reserves that protect a diversity of landscapes and cultural heritage sites while providing for public access to camping sites, walking tracks and picnic/BBQ facilities. NPWS is responsible for management of lands protected under the *NPW Act 1974* to mean high water mark of estuaries and ocean.	Kathryn Brown Ranger Mimosa Rocks Kathryn.brown@environment.nsw.gov.au
NSW Roads and Maritime Services (RMS) RMS is responsible for management of network of state and national roads in NSW and associated infrastructure such as bridges, culverts and tunnels. RMS also manages navigable waterways, wharves and maritime safety aids for commercial and recreational boating.	Darren Hulm darren.hulm@rms.nsw.gov.au Graham Roche Environment Manager graham_roche@rta.nsw.gov.au
Southeast Local Land Services (SELLS) Locally based and managed organisation with a Board of local people, reporting directly to the NSW Minister for Office of Environment and Heritage. It is a statutory body established under the *Catchment Management Authorities Act 2003* to facilitate and coordinate the management of natural resources in the southeastern NSW. SELLS responsibilities include involving local communities, farmers and other land managers, Landcare, government agencies, Aboriginal people, local government and industry in addressing the natural resource management issues facing the region. Through SELLS and its partnerships and programs, the NSW and Australian Governments provide funding for strategic on-ground works to help protect and restore natural resources across the landscape.	Andrew Taylor Senior Lands Services Officer andrew.taylor@lls.nsw.gov.au

5.1 ONLINE SURVEY QUESTIONNAIRE

An online survey questionnaire was developed to gain an overview of the catchment and estuary values important to the community. Survey respondents were asked specific questions focused on level of concern for estuarine water quality and catchment condition.

Respondents were also asked to rank nine general catchment issues in order of greatest to least impact that they considered were negatively affecting catchment condition and water quality of Nelson Lagoon. A copy of the online survey is provided in **Appendix A**.

APPROACH AND OUTCOMES

The findings from the community survey are provided in the sections below.

5.2 COMMUNITY VALUES AND CONCERNS FOR NELSON LAGOON AND CATCHMENT

The online survey received a total of 20 respondents (5 resident landholders in the catchment, 14 community members located outside the catchment, and 1 stakeholder) who expressed their values and concerns for Nelson Lagoon.

5.2.1 VALUES

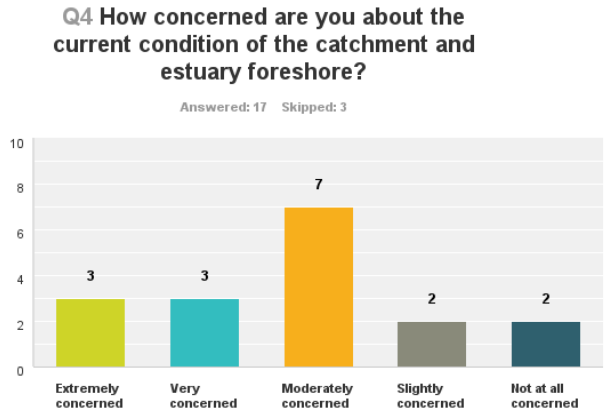
The consensus among survey respondents was that Nelson Lagoon is valued most for its ecological and social values, followed by economic values associated with tourism and commercial fishing. A summary of the ecological, social, economic and other values provided by survey respondents are provided in **Table 7.**

Table 7. Community Values of Nelson Lagoon

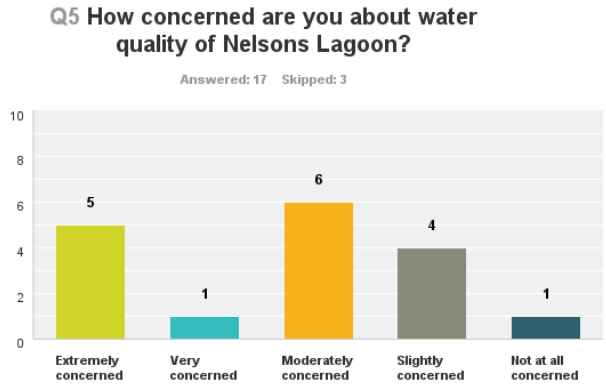
Ecological	Flora and fauna communities, birdlife, forested catchment, tidal flows, seagrass meadows, fish species, hydrology, high water quality, intertidal sand-flats and shorebirds
Social	Kayaking, fishing, swimming, wading sand-flats, paddle boarding, meeting place
Economic	Direct and indirect tourism benefits to local businesses that rely on the ecological and social values (*i.e.* recreational opportunities) of the lagoon that attract visitors to area. Productive and clean waters for oyster aquaculture.
Other	Environmental aesthetic, near pristine condition, isolation from human population and relatively low level of human interference.

5.3 CONCERNS AND ISSUES

Survey respondents were asked to rank their level of concern for the current condition of the catchment and estuary foreshore and water quality of Nelson Lagoon. While the questions were broad in nature, the responses provide a general indication of community sentiment regarding these matters with survey results provided in **Figure 12.**



Majority of survey respondents have some level of concern for current condition of the catchment and estuary foreshore



Majority of survey respondents are concerned about water quality

Figure 12. Community concerns for catchment condition and water quality.

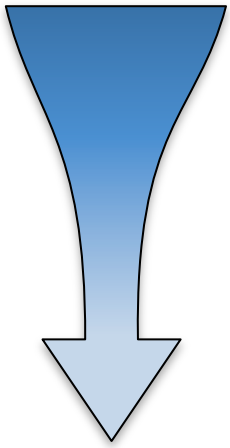
The two issues that were consistently ranked highest among survey respondents as having the greatest negative impact on catchment condition and water quality of the estuary were:

1) Unfenced creek lines and stock impacts; and

2) Lack of riparian vegetation due to historical clearing.

The rank order of all nine issues is provided in **Table 8** based on the score averaging from all survey respondents.

Table 8. Nine general catchment issues ranked in order of greatest to least impact on catchment condition by survey respondents (80% of respondents completed)

Greatest Impact	1. Unfenced creek lines and stock impacts
	2. Lack of riparian vegetation due to historical clearing
	3. Weed infestation
	4. Poorly maintained unsealed roads
	5. Wetland degradation (freshwater or saltmarsh)
	6. Ad-hoc foreshore access
	7. Bank erosion
	8. Forestry practices
Least Impact	9. Illegal drains or weirs

Note – Rankings based on score averages of 16 of 20 responses provided

APPROACH AND OUTCOMES

6 CATCHMENT AND FORESHORE EROSION ASSESSMENT

6.1 CATCHMENT TERRAIN AND POTENTIAL EROSION ASSESSMENT

A catchment terrain and potential erosion assessment was undertaken in Arc GIS 10 using the spatial analyst extension. The assessment was undertaken using a digital elevation model (DEM) for the Nelson Catchment (**Figure 13**). The DEM was created using 0.5m LiDAR (Light Detection and Ranging) elevation data captured in 2008 and provided by Council for project use. LiDAR is able to detect subtle topographic features such as river terraces and river channel banks, and measure the land-surface elevation beneath the vegetation canopy. It is able to resolve spatial derivatives of elevation, and useful for detecting elevation changes between repeat surveys that enables better understanding of physical processes that shape landscapes.

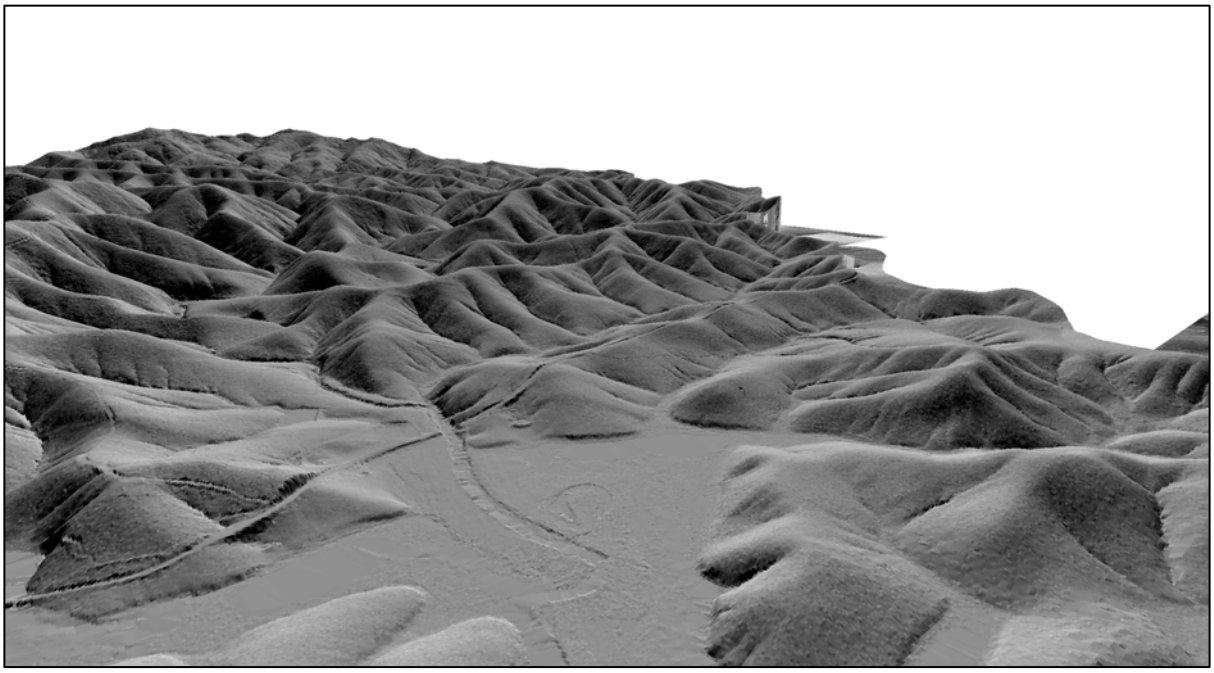


Figure 13. An enhanced Digital Elevation Model (DEM) and Hillshade model of the Nelson catchment.

Other GIS datasets including aerial images, soils, watercourses, roads, and land tenure were incorporated into the assessment. This data was then used to locate and estimate the extent of potential erosion for the following types:

- Road erosion
- Logging track erosion
- Embankment erosion
- Bank erosion
- Foreshore erosion
- Head cut and nick point erosion

Potential erosion sites identified in the assessment are shown in **Figure 14** and **15** (attached). The length width and depth of erosion for various erosion types was measured from the DEM, Hillshade,

and slope models inside Arc GIS 10. Analysis was also undertaken on soil types and proximity to a watercourse.

A catchment erosion assessment matrix (**Table 9**) was developed to characterise each potential erosion site. The assessment details the erosion type, sediment yield, threats caused by erosion, responsible landholder / agency, management priority (based on estimated sediment yield), and likely cause of erosion.

The results of the potential erosion assessment are contained in a GIS shapefile. Only selected sites were ground-truthed during field inspections as inspection of all areas was not achievable within the scope of this project. Majority of the potential erosion sites exist within the upper catchment and were not validated by visual assessment. Further field investigation would be required to validate the current status of majority of potential erosion sites.

Table 9. Sample output of Catchment Erosion Assessment (GIS Shapefile)

Site ID	Erosion Type	Estimated sediment yield	Treat to	Responsibility	Priority	Likely Cause
1	Head Cut	>1000 m^3	Watercourse & wetland destruction	NPWS	High	Natural Logging / Clearing
2	Road Erosion	>100 m^3	Road maintenance	Council	High	Design
3	Logging track erosion	>100 m^3	Hillslope drainage	State Forest	Low	Logging / Clearing
4	Embankment erosion	>100 m^3		Council	Medium	Soil
5	Bank erosion	>100 m^3	Loss of riparian land	Landholder	Medium	Non specific
6	Foreshore erosion	>10 m^3	Loss of riparian land	Council	Low	Non specific

Summary of Potential Erosion Assessment

- In general, majority of potential erosion sites in the catchment were located in the hillslope areas directly adjacent the estuary and lower freshwater reaches, which had been subject to historical logging operations. These areas are now administered by National Park. Many of these were located in vicinity of old logging roads and snig tracks.
- Potential bank erosion was identified in the lower freshwater reaches of Nelson Creek and these were subject to field inspections (see Section 6.3).

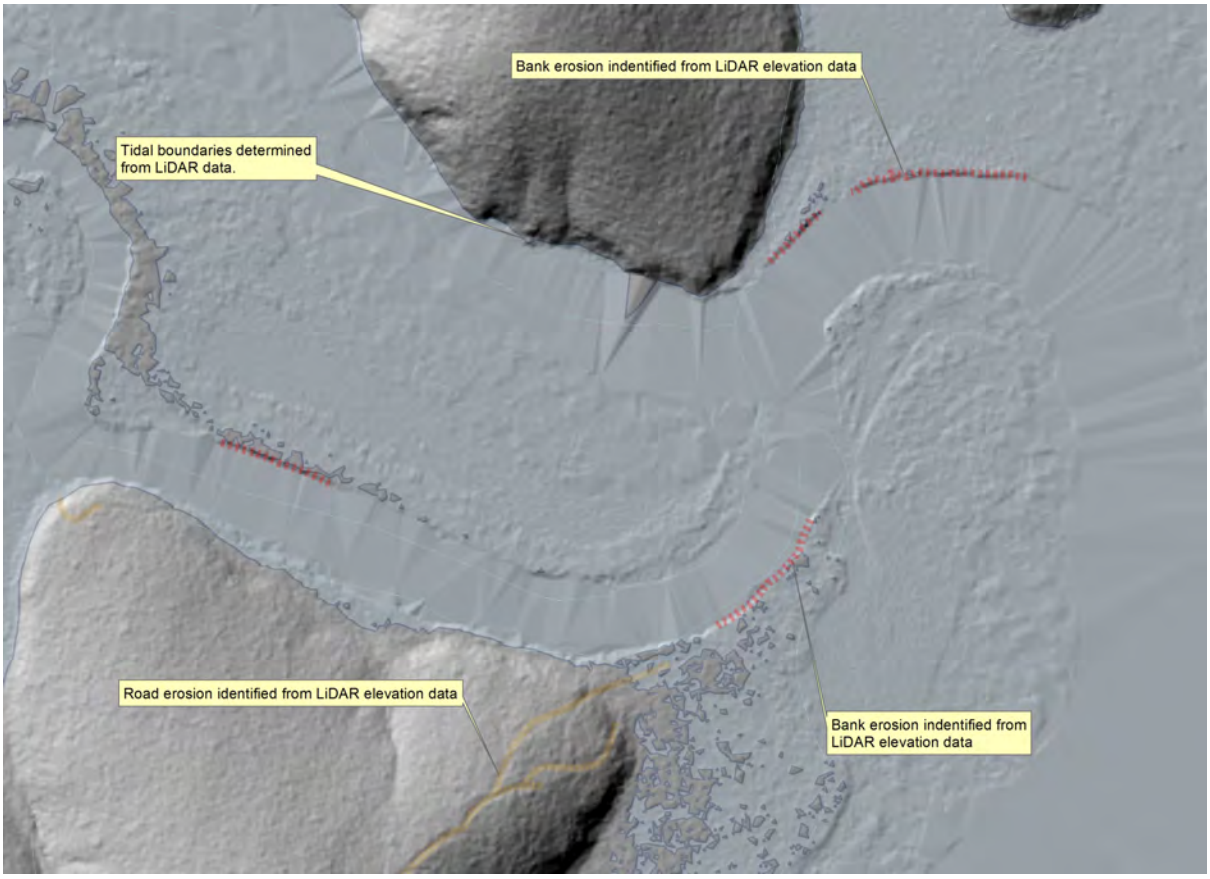


Figure 14. Potential erosion sites in the mid-estuary area identified from LiDAR elevation data and DEM.

6.2 ASSESSMENT OF EROSION FROM LOGGED CATCHMENTS

The potential erosion assessment identified the many logging roads and snig tracks that have been constructed in the catchment from historical forestry operations (**Figure 16)**. Soils in the Nelson Creek catchment are classified as erosional soil landscapes (DLWC 1999). This means that soils are extremely sensitive to disturbance and are particularly prone to erosion when they are disturbed and or burnt. Constructed logging roads, tracks, and snig tracks are vulnerable to erosion, especially when runoff concentrates in these depressions, and without appropriately functioning runoff controls, begin to behave like first order drainage lines. Sediments may be mobilised from the surfaces of unsealed roads in even low to moderate rainfall events. These areas are likely to continue to erode until they reach the underlying bedrock or dense clays.

Erosion of logging roads and snig tracks has likely supplied some sediment to the upper estuary, particularly the main channel of Nelson Creek. Although most of the sediment eroded from logged hillslopes was likely still trapped in deposition fans at the base of 1st order drainage lines. The dispersible fraction of sediment eroded from logged hillslopes has likely been transported to the lower estuary.

Most of the potential erosion sites identified in the catchment would be difficult to access and it may not be practical to implement remediation actions. It is important however, to have an overview of the distribution of potential erosion sites and where possible, inspect sites to assess erosion significance.

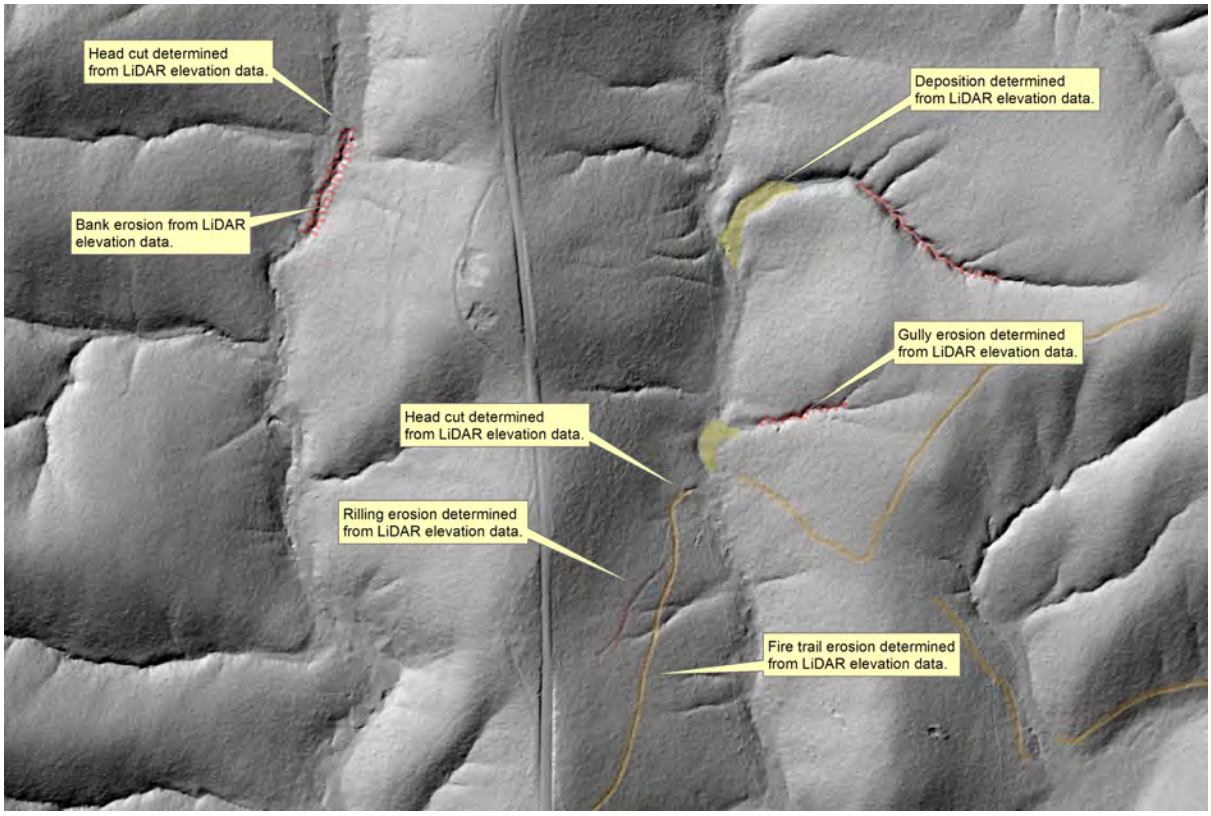


Figure 16. Example of forestry logging roads (now fire trails) and rilling of old snig tracks identified on the enhanced DEM and slope analysis.

6.3 FIELD INSPECTIONS OF POTENTIAL EROSION ISSUES

Field inspections to assess potential erosion issues in the Nelson Creek catchment were undertaken on 29-30 October 2015, and 8 March 2016.

Stream banks of the lower freshwater reaches of Nelson Creek and foreshore banks across the whole estuary were inspected for erosion. Where erosion is active, the assessment took into consideration fluvial geomorphology, hydraulic environment and geotechnical characteristics of the sediments at each site. Erosion of the banks was assessed in the context of the following criteria:

- stratigraphy of bank sediments
- geotechnical strength of banks sediment
- height of eroded banks
- proximity of large trees to eroding banks and potential for bank collapse
- stability of channel bedforms (pools and riffles)

A brief summary of the field inspections of is provided in sections below.

6.4 STREAM BANK EROSION OF UPPER ESTUARY AND LOWER FRESHWATER REACHES

Minor to moderate stream bank erosion was observed along Nelson Creek located in the upper estuary. The erosion is due in part to two processes – 1) collapse of trees perched near the top of banks further exacerbating erosion in some areas, as well as, 2) scouring of the bank toe. These are processes are discussed further.

Tree collapse most often occurs during high winds leading to shear forces acting on the bank. It should be noted that this is a natural process that indirectly creates fish habitat in form of instream woody debris. However, landholders whose properties include riparian environments are at risk of loosing riparian land through this process and have the right to implement management actions to address that include creating wider riparian buffers and planting an understorey strata. An alternative management action to this problem and utilised in other areas includes the practice of coppicing trees with the potential for failure, reducing the shear forces acting on the bank due to wind, whilst still retaining the root binding strength applied to bank sediments. This issue is further addressed in Priority Management Area 1 - **Appendix B**.

Bank erosion of Nelson Creek is also due to bank toe scour and undermining of the bank. This occurs when increased hydraulic forces scour the bed and bank toe leading the collapse of the upper bank. This is most likely to be occurring during flood flows. In affected areas, the bank toe and adjacent bed may need to be stabilised with rock and log structures to prevent further bank erosion. This issue is further addressed in Priority Management Area 1 - **Appendix B**.

Channel bedforms (pools & riffles) inspected in the freshwater reaches of Nelson Creek were stable and there was generally no evidence of un-natural bed erosion. However, the lower freshwater reach of Nelson Creek has been subject to excessive sediment deposition in the main channel (see Priority Management Area 1, Appendix B). This sediment may need to be stabilised with the strategic placement of LWD to improve structure of pool riffle units in the creek.

6.5 FORESHORE BANK EROSION

In general, foreshore banks of estuary are highly stable and not currently showing signs of un-natural erosion requiring intervention. This is because the sediment layers that comprise foreshore banks have high geotechnical strength and can withstand existing hydraulic forces that act on them. Vertical eroded banks found at outside of bend apexes observed in Priority Management Area 2 – **Appendix B**, are stable and do not reflect an ongoing or active bank erosion problem.

6.6 ASSESSMENT OF UN-SEALED ROAD NETWORK

Nelson catchment includes approximately 36km of unsealed road network (excluding logging extraction tracks) representing a small fraction of total catchment area. However these road surfaces contribute a significant amount of dispersible sediment to catchment watercourses and appropriate maintenance of the roads and their runoff controls are vital to protecting the water quality values of catchment streams.

A limited assessment of the unsealed road network was undertaken in accordance with the *Managing Urban Stormwater - Soils and Construction Volume 2C Unsealed Roads* (DECC 2008). Four sites identified in the potential erosion assessment that were accessible and adjacent to watercourses were inspected (**Figure 17**). A summary of the assessment of upper catchment locations is provided in **Table 10.**

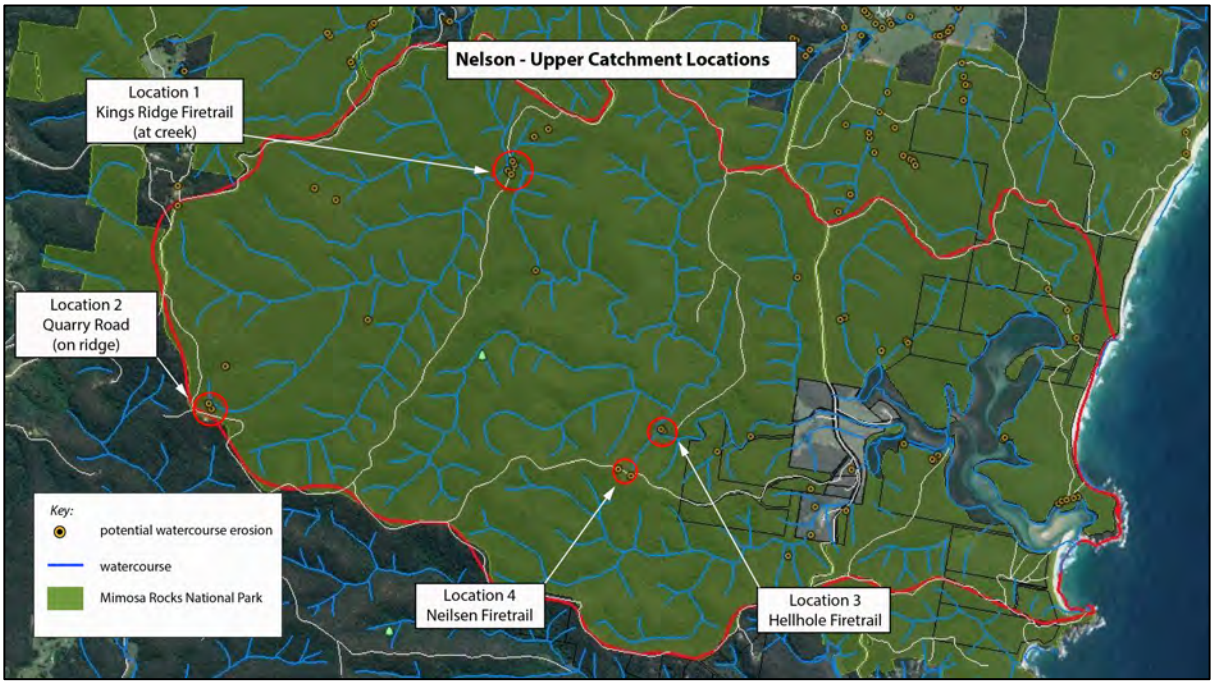


Figure 17. Upper Catchment locations and unsealed road areas inspected for erosion issues.

Table 10. Summary of Upper Catchment locations inspected for potential road erosion issues

Location	Road/Track	Tenure	Comments	Issue	Priority	Action
1	Kings Ridge Firetrail	NPWS	Access off Dr George Mtn Road. Elevation 100m, potential erosion points identified in LiDAR imagery	None. Ford in ok condition. Stream flows ephemeral. Riparian vegetation intact. Road blocked by fallen trees as of 8 March 2016.	High	Removal of fallen trees blocking access. Monitor road condition.
2	Quarry Road	NPWS	Access off Quarry Road, 1st order stream, potential erosion points identified in LiDAR imagery, elevation 218m.	None, road condition ok. Illegal dumping of rubbish along roadside primary issue.	-	Regular monitoring. Recommend use of surveillance cameras to capture illegal dumpers.
3	Hell Hole Firetrail	NPWS	Access at end of Hell Hole Firetrail, 1st order tributary of Nelson Ck, potential erosion points identified in LiDAR imagery, elevation 43m	None. Historical erosion points stabilised with regenerating vegetation. Evidence of illegal collection of firewood.	-	None required. Monitor
4	Neilsen Firetrail	NPWS	Potential road/gully erosion points identified in LiDAR imagery, Elevation 158m.	Could not locate erosion.	-	None.

Note - Field inspection undertaken on 8 March 2016

MANAGEMENT ACTIONS

7 CATCHMENT MANAGEMENT ISSUES

7.1 PRIORITY MANAGEMENT AREAS AND ISSUES

Five (5) priority management areas have been identified, all situated around the lower Nelson catchment as shown in **Figure 18**. Within each management area, at least one or more of the following issues is currently occurring - road erosion, natural stream bank erosion, degradation of riparian zone and/or sensitive coastal saltmarsh areas, estuary foreshore erosion, and excessive sedimentation.

Each of these issues is the result of past and present disturbances and considered to be either currently or have the potential to affect catchment condition and estuary water quality if not addressed.

A summary of the issues including brief description, the issue threat, responsible stakeholder/ landholder for addressing issue, and actions recommended for treatment of issue are provided in **Table 11** below.

Further detailed description of each priority management area and issues is provided in **Appendix B.**

Figure 18. Overview of priority management area locations for Nelson catchment.

MANAGEMENT ACTIONS

7.2 PRIORITIES

The recommendations have been assigned a priority, which represents the following indicative timeframe for implementation.

High Priority	Within 1 year
Medium Priority	Year 1 to 3
Low Priority	Year 4 to 6

These priorities are subject to availability of Council's or relevant stakeholder operational budgets to undertake recommended actions. For some recommendations, the availability of State and Commonwealth funding grants will affect implementation of priorities.

Table 11. Summary of Nelson Lagoon catchment priority management issues and recommended actions for treatment.

Management Area	Issue #	Issue Description	Threat To	Priority (H/M/L)	Responsibility	Action/Recommended Treatment
1	1.1	Moderate bank erosion of lower Nelson Creek, sections of creek with little riparian vegetation and cattle access to streamside zone	Bank stability, sedimentation of watercourse, WQ	Med-High	Private Land Lot 254 DP789402, DPI Lands	Work with landholder to limit stock access to streamside zone, implement rehabilitation and protection works for degraded bank sections. Landholder concerned that LWD deposited at edge of active channel contributing to erosion issue. Landholder prefers that LWD be removed. Recommend that LWD be retained, realigned and strategically secured to protect bank toes. Refer to conceptual drawing for typical river restoration treatment (Appendix C). Rock and log toe protection works may be required to prevent further bank erosion.
1	1.2	Moderate to serious bank erosion of lower Nelson Creek with potential for top of bank collapse and further erosion	Bank stability, sedimentation of watercourse, WQ	Med-High	Private Land Lot 254 DP789402, DPI Lands	Riparian zone is fenced though very narrow, <2m wide. Severity of bank erosion increases moving downstream towards NPWS estate. Work with landholder to expand the existing riparian buffer using strategy of assisted natural regeneration. Refer to conceptual drawing for typical river restoration treatment (Appendix C) and recommended species list (Appendix D). Existing LWD can be realigned and secured to stabilise bank toe and improve channel hydraulics. Senescent black wattles (*Acacia mearnsii)* growing close to top of bank may be coppiced to mitigate risk of top of bank collapse and further loss of land when tree is dead.
1	1.3	Moderate to serious bank erosion (slumping) due to hydraulic scour of the bank toe	Bank stability, sedimentation of watercourse, WQ	Med-High	Private Land Lot 254 DP789402, NPWS	Localised areas of bank slumping due to hydraulic scour of bed sediments and bank toe during flood events. Work with landholder and NPWS to 1) Implement bank toe protection works using strageically placed LWD and rock, 2) Expand the riparian vegetation buffer where vegetation currently exists, and 3) Re-establish vegetation along streamside zone where riparian vegetation is currently absent.
1	1.4	Minor erosion to bridge abutments of Tathra-Bermgaui Road bridge	Bridge integrity	Low	RMS, BVSC	Monitor condition, particularly after flood flows. Rock revetment works may be required to prevent further erosion around abutments.
1	1.5	Road embankment erosion and sediment delivery to creek	Sedimentation of watercourse, WQ	Low	RMS, BVSC	Erosion of the table drain and embankment on western-side of Tathra-Bermagui Road is contributing sediment to Nelson Creek. Recommend removal of excess loose sediment from affected area and construct a small sediment detention basin/trap to prevent excess sediments from entering watercourse. Batter eroding bank to a minimum slope as specified by geotechnical engineer.
1	1.6	Water quality of private canal a potential risk to estuarine WQ	Estuarine WQ	Low	Private Land Lot 184 DP752158, BVSC	Recommend working with landholder to test canal waters annually for signs of sewage contamination that may indicate a potential failure of OSM.
1	1.7	Stock access to saline wetland	Saline wetland flora	Low	Private Land Lot 254 DP789402, SE LLS	Work with landholder to repair fencing where required excluding stock from sensitive wetland area.

Table 11. Summary of Nelson Lagoon catchment priority management issues and recommended actions for treatment.

Management Area	Issue #	Issue Description	Threat To	Priority (H/M/L)	Responsibility	Action/Recommended Treatment
2	2.1	Foreshore access road in poor condition, localised areas of bare banks and degraded mangrove vegetation due to regular and uncontrolled disturbance	Mangrove community, bank stability, environmental aesthetic and site amenity	High	NPWS	Foreshore access road used primarily by recreational fisherman and kayakers to launch small vessels. Road is in poor condition in areas with deep rutting and mud tracks. Areas of the foreshore becoming degraded due to uncontrolled access with stretches of bare bank where regenerating mangrove is absent due to regular bank disturbance. Implement control fencing and or bollards to direct foreshore access to a single area.
2	2.2	Vehicle damage to potential cultural heritage site	Cultural Heritage	Low	NPWS	Vehicle access to foreshore to launch small vessels may be impacting on cultural heritage values of the site. Consult with Bega LALC to investigate the cultural heritage values of site. Develop signage to limit vehicle damage to foreshore vegetation.
2	2.3	Minor foreshore erosion to saltmarsh community	Foreshore access, WQ	Low	NPWS	Monitor condition of saltmarsh community. No other action required.
2	2.4	Erosion to foreshore access road and informal boat ramp	Sedimentation to estuary, WQ	Low	NPWS	Road and informal boat ramp off Cowdroys Road providing vehicle access to foreshore to launch small boats. Current usage of this foreshore access road is not known. The road is relatively stable with majority of dispersible sediment already delivered to estuary. Consult with NPWS to determine whether foreshore access at this location is to be maintained. Monitor road condition and implement repair if condition deteriorates.
3	3.1	Potential loss of seagrass community	Estuary health, habitat for fish and crustaceans	Med	NPWS, DPI Fisheries, BVSC	Estimated that >70% loss of seagrass from Nelson Lagoon may have occurred over 20-year period between 1985 to 2006 (Creese etal 2009), with the current condition of the seagrass community rated as being in very poor condition (DECCW 2011). This estimate of seagrass loss may not be accurate due to differences in mapping techniques applied in the 1985 and 2006 assessments. However, the potential issue of seagrass loss in Nelson Lagoon is worthy of further investigation through additional seagrass mapping utilising methodology similar to that applied by NSW DPI in 2006. Recommendations include using educational signage to illustrate the ecological importance of seagrass meadows and role they play in stabilising estuarine sediments. Erect signage at all boat launching areas. Update seagrass mapping to ascertain changes in seagrass community over the last 10-year period and implement program to monitor condition of seagrass community.
3	3.2	Erosion of dune foreshore and impacts to dune vegetation	Stability of foreshore	Low	NPWS	High vertical sand banks subject to increased erosion due to uncontrolled pedestrian access. Associated impacts include human disturbance to dune vegetation with many coastal *Banksia* dying in recent years. Recommend maintain existing management of the foreshore that includes controlling and restricting pedestrian access to dune vegetation. Additional signage may be erected to raise awareness of sensitivity of dune vegetation.

Table 11. Summary of Nelson Lagoon catchment priority management issues and recommended actions for treatment.

Management Area	Issue #	Issue Description	Threat To	Priority (H/M/L)	Responsibility	Action/Recommended Treatment
3	3.3	Erosion of foreshore access road off Cowdroys Road	Sedimentation to estuary, WQ	Low	NPWS	A steep road from the Cowdroys Road carpark provides access down to the northern side of the lagoon foreshore. Minor to moderate erosion of the road surface is occurring. Road surface runoff controls need to be improved incluing use of siltation curtains to minimise potential sediment inputs to the estuary.
4	4.1	Erosion of Cowdroys Road and sedimentation to tributary streams	Sedimentation of watercourse, estuary WQ	Low	NPWS, Gary Rodely	Road maintenance is the responsibility of NPWS. However, an unofficial agreement exists between NPWS and Gary Rodely (oyster grower) that permits Gary to personally take responsibility for managing the maintenance of Cowdroys Road from Gillards Road to his oyster lease area to mitigate the threat that sediment inputs pose to estuarine water quality and viability of his oyster business. This agreement was reached after Gary had noted instances of erosion and sediment deposition that followed grading of this steep road. Gary and his team use hand tools to build and maintain mitre drains and oyster shell to maintain and stabilise the road surface. Work with NPWS and Gary Rodely to continue to implement effective erosion controls to protect condition of Cowdroys Road. This may include installing siltation curtains at tributary streams to trap sediments and minimise further sedimentation impacts of tributary streams. Monitor road condition to ensure road erosion does not become an active threat to estuary WQ.
4	4.2	Uncontrolled vehicle access to foreshore and threat to saltmarsh community	Saltmarsh community	Med	NPWS, DPI Fisheries	A short track off Cowdroys Road provides access to an estuarine backswamp that is surrounded by significant areas of mangrove and saltmarsh community. There have been a number of incidents involving vehicles being driven beyond the track and onto saltmarsh community whereupon vehicles have subsequently become bogged. Retrieval of vehicles has also caused significant damage to the soft sediment substrates with long lasting impacts to saltmarsh. Work with NPWS to install bollards and or logs at the end of this track to prevent foreshore access by vehicles.

Table 11. Summary of Nelson Lagoon catchment priority management issues and recommended actions for treatment.

Management Area	Issue #	Issue Description	Threat To	Priority (H/M/L)	Responsibility	Action/Recommended Treatment
5	5.1	Erosion of old foreshore access track with sedimentation impacts to estuary back lgaoon	Sedimentation of estuary back lagoon, WQ.	High	NPWS	Old foreshore access track that may have been used to launch small boats. Consult with NPWS to determine whether foreshore access at this location is to be maintained. Address erosion issue using combination of siltaton curtain and several constructed log berms to trap and minimise potential sediment input to back lagoon.
5	5.2	Head cut and gully erosion	Sedimentation to tributary stream, proportion of dispersible sediment fines delivered to estuarine back lagoon, WQ.	Low	NPWS	Multiple examples of active head-cut that have formed deep incised gullies. Natural erosion process that shows examples of undercutting, lateral bank erosion and slumping due to highly erodible, sodic soils. These may have been exacerbated by historical logging operations and past fire events in the forest. Difficult to treat due to scale of problem and site access. Majority of the sediment fractions eroded from the head-cut and gullies have been re-deposited downstream and may not reach the estuary. However, a proportion of dispersible fraction of sediment fines has and will continue to be delivered to the estuary back lagoon under high flow events. Recommend a collaborative research project with a university to further investigate the significance of the process – spatially and temporally, and identify factors that may be exacerbating the process, and what potential actions could be undertaken to halt or slow down process.
5	5.3	Rill erosion associated with historical logging operations	Sedimentation to tributary stream, proportion of dispersible sediment fines delivered to estuarine back lagoon, WQ.	Low	NPWS	Rill erosion caused by soil disturbance (e.g. log snig track) which has eroded and incised over time. Sediment delivered to tributary stream but a portion of dispersible sediment delivered to estuary in high flow events. Construct a number of log-berms to trap sediment and encourage colonisation of vegetation.
5	5.4	Erosion of poorly maintained NPWS management track	Sedimentation to tributary stream, proportion of dispersible sediment fines delivered to estuarine back lagoon, WQ.	Low	NPWS	Firetrail currently restricted to NPWS management vehicles only. Road is rough and in poor condition with a fallen tree currently blocking vehicle access. Consult with NPWS to consider placing a locked gate on this management track to prevent public 4WD access and further deterioration of road condition.

Note - Refer to Appendix B for detailed description of Issues and Recommended Actions

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LIMITATIONS

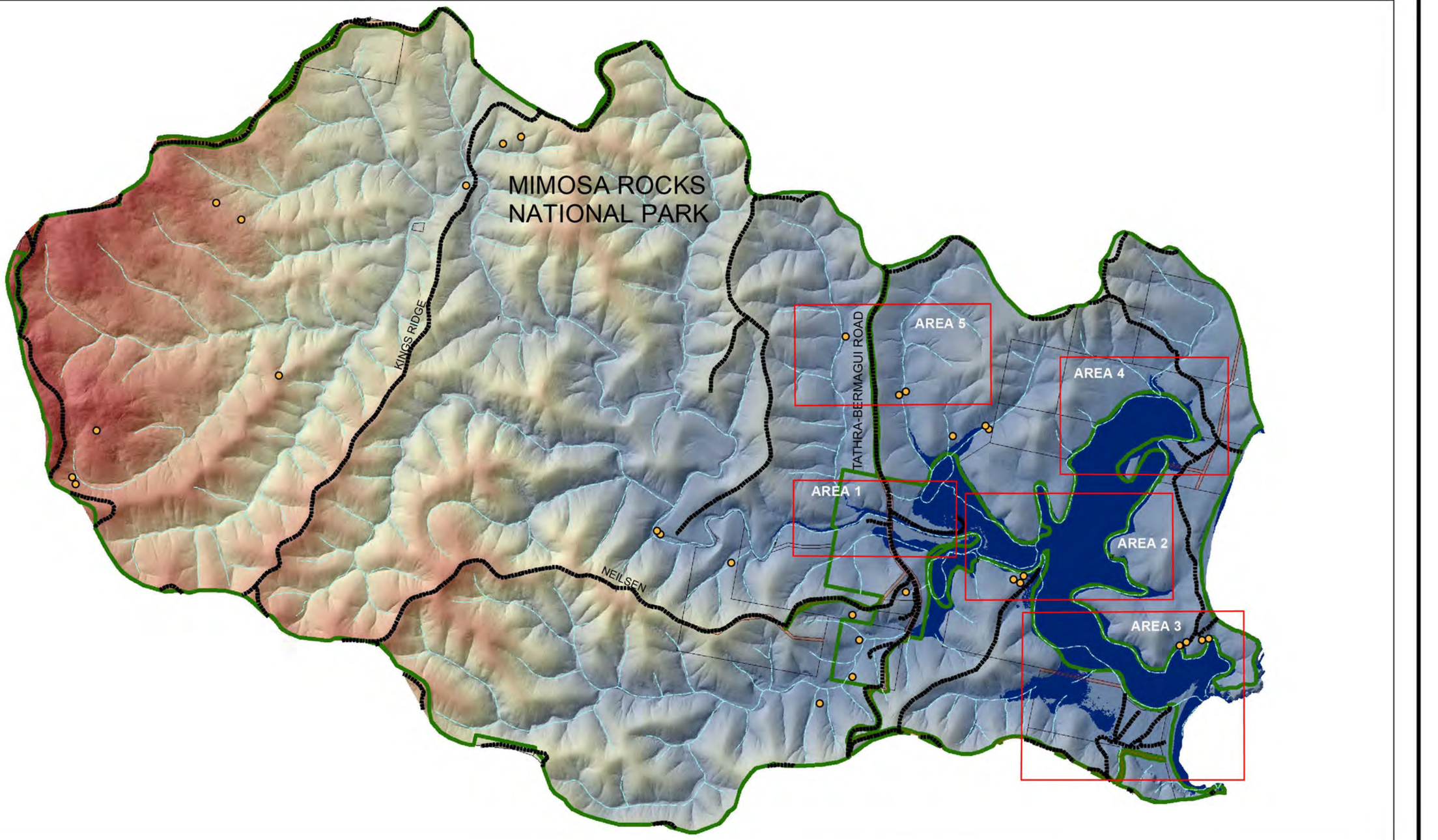
9 LIMITATIONS

Elgin Associates Pty Ltd has prepared this report for the sole use of BVSC in accordance with generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the original proposal dated 22 May 2015.

The methodology adopted and sources of information used by Elgin Associates are outlined in this report. Elgin Associates has made no independent verification of this information beyond the agreed scope of works and Elgin Associates assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to Elgin Associates was false.

This report was prepared between October 2015 and August 2016 and is based on the conditions encountered and information reviewed during that period up to the time of preparation. Elgin Associates disclaims responsibility for any changes that may have occurred after this time. Opinions and recommendations contained in this report are based upon information gained during desktop study and fieldwork and information provided from government authorities' records and other third parties. The information in this report is considered to be accurate at the date of issue and reflects at the site at the dates sampled. This document and the information contained herein should only be regarded as validly representing the site conditions at the time of the fieldwork unless otherwise explicitly stated in a preceding section of this report.

This report should be read in full together with all other reports referenced by this report. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.



0 440 880 1,760 2,640 3,520 Meters

NELSON LAGOON CATCHMENT MANAGEMENT PLAN

Legend

- Lot / DP Boundary
- Potential Erosion Area
- Rivers & Creeks
- Roads
- Priority Management Area
- Crown Road Reserve
- Mimosa Rocks National Park
- Tide HAT (1.286 m AHD)

Elevation Value

High : 295.687

Low : -0.259

POTENTIAL EROSION ASSESSMENT
PRIORITY MANAGEMENT AREAS 1 to 5

GDA
GDA 94 Zone 55

Riparian engineering

FIGURE 15

Analysis By: Tim Dilworth
River & Coastal Engineer MIE CPEng Aust, NER, RPEQ

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX A

Stakeholder and Community Consultation

- **Consultation Plan**
- **Online Questionnaire**

PO Box 492, Bega NSW 2550
P. (02) 6499 2222
F. (02) 6499 2200
E. council@begavalley.nsw.gov.au

ABN. 26 987 935 332
DX. 4904 Bega

12 August 2015

[applicant name]
[applicant address1]
[applicant address2]

CONSULTATION PLAN – Nelson Lagoon Catchment

Dear Landholder/Resident/Stakeholder

Bega Valley Shire Council (BVSC) has received funding from the Office of Environment and Heritage to conduct a rapid catchment assessment of Nelson Lagoon

The assessment has several objectives including:

- To identify catchment and foreshore issues currently impacting, or with the potential to impact, water quality and estuary health; and
- To identify priority areas within the catchment for protection and targeted rehabilitation that will improve catchment condition and water quality of Nelson Lagoon.

Nelson Lagoon has significant ecological, recreational and socio-economic values all of which are reliant on good water quality. The water quality of the estuary is highly dependent on land-use practices and catchment disturbance. Catchment management issues such as natural and man-made erosion, intensive land-use, and unsealed roads can all impact on water quality via increased sediment and nutrient inputs.

The assessment of Nelson Lagoon will utilise rapid visual assessment methodology to identify catchment and estuary foreshore issues that are currently, or have the potential to impact on water quality and estuary health. The primary outcome from the assessment will be actions documented in a catchment management plan that will highlight priority areas for protection and targeted rehabilitation that can be implemented as funding permits.

Local consultancy Elgin Associates has been engaged by BVSC to conduct the project.

As a landholder or resident living within the Nelson Lagoon catchment, we would like to hear your thoughts regarding how you value the lagoon but also your concerns about the current condition of the catchment and estuary foreshore. You can provide your input to this project via a number of ways – via online survey using the weblink: https://www.surveymonkey.com/s/Nelson_Lagoon

Or by contacting project manager Nicholas Yee directly on mobile 0400 365 234 or email nick.yee@elgin.com.au

Field inspections by Elgin Associates will commence in September 2015. Access to catchment areas via your property may be required. A further consultation period will be convened in late 2015 to present the information gathered during the field inspections.

Nelson Lagoon has a waterway size (including saltmarsh areas) of 1.12 km^2 and a catchment area of 27.2 km^2. Majority of the catchment is forested with 92% located within the Mimosa Rocks National Park with less than 1% of the catchment cleared for agricultural grazing/rural residential uses. The estuary is popular for recreation with fishing, swimming and canoeing the main activities. The estuary is used for the commercial production of oysters and is also available to commercial fishing.

Nelson Lagoon is a permanently open barrier estuary with good tidal flushing and high water clarity. The estuary supports significant areas of mangrove and saltmarsh community.

The Healthy Rivers Commission (2002) classified Nelson Lagoon for comprehensive protection according to its perceived conservation value and management orientation. This was based on the estuary's natural sensitivity, condition of the waterbody and catchment, as well as patterns of settlement, future opportunities for development, and potential for restoration and rehabilitation.

Snapshot Summary of Nelson Lagoon and Catchment Characteristics	
Estuary waterway size: 1.12 km^2	**Catchment Area:** 27.2 km^2 <1% cleared (0.23 km^2), 92% Mimosa National Park (25.1 km^2)
Primary Inflow: Nelson Creek	
Estuary type: Semi- mature, barrier estuary	
Estuarine vegetation: Mangrove 0.491 km^2, Saltmarsh 0.155 km^2, Seagrasses (*Zostera* and *Halophila*) 0.010 km^2. Nelson Lagoon supports significant areas of mangrove and saltmarsh community.	
Catchment land-uses: Rural residential, recreation.	
Commercial activities: Oyster Aquaculture. The estuary is a recreational fishing haven and thus not available to commercial fishing as part of Estuary General Fishery.	
Endangered Ecological Community (EEC) types: The catchment contains seven (7) vegetation types listed as EEC types under the *NSW Threatened Species Conservation Act 1995* (TSC Act) including - Coastal saltmarsh, Freshwater wetlands, Bangalay Sand Forest, Lowland Grassy Woodland, River-flat Eucalyptus Forest, Swamp Schlerophyll Forest and Swamp Oak Floodplain Forest.	
Estuary open – closed period (%): Open 100% of time.	

Regards

Kyran Crane

Kyran Crane
Coastal Management Officer

Rapid Catchment Assessment - Nelson Lagoon

Bega Valley Shire Council (BVSC) has received funding from the Office of Environment and Heritage to conduct an assessment of Nelson Lagoon and its catchment.

Nelson Lagoon has significant ecological, recreational and socio-economic values all of which are reliant on good water quality. The water quality of the estuary is highly dependent on land-use practices and catchment disturbance.

Catchment management issues such as natural and man-made erosion, intensive land-use, and unsealed roads can all impact on water quality via increased sediment and nutrient inputs. Water quality impacts can be further exacerbated when the estuary entrance is closed.

The assessment of Nelson Lagoon will utilise rapid visual assessment methodology to identify catchment and estuary foreshore issues that are currently or have the potential to impact on water quality and estuary health. Actions from the assessment will be documented in a catchment management plan that will highlight priority areas for targeted protection and rehabilitation.

Local consultancy Elgin Associates has been engaged by BVSC to conduct the project.

This survey is designed to seek your initial input regarding catchment management and estuary foreshore issues you feel are important for Nelson Lagoon. As a landholder, stakeholder or community member who values Nelson Lagoon, thank you for participating in our survey. Your input is vital.

Your responses will be used to help inform field inspections that will be conducted by Elgin Associates during late winter-early spring 2015.

Rapid Catchment Assessment - Nelson Lagoon

* 1. Are you a resident landholder, stakeholder or community member interested in Nelson Lagoon?

Rapid Catchment Assessment - Nelson Lagoon

* 2. Which stakeholder group do you represent?

- [ ] Bega Aboriginal Land Council
- [ ] Biamanga Trust
- [ ] Office of Environment and Heritage
- [ ] Bega Valley Shire Council
- [ ] Forestry Corporation of NSW
- [ ] South East Local Land Services
- [ ] Department of Primary Industries
- [ ] NSW Roads and Maritime
- [ ] NSW Crown Lands
- [ ] Oyster Farmer
- [ ] Other (please specify)

Nelsons Lagoon has significant ecological, social and economic values.

Ecological values include flora and fauna communities, hydrology and tidal flows, intermittent flood regime due to periodic closure of the entrance, water quality and variable salinity. Social values include all recreational activities (i.e swimming, kayaking, fishing, boating, hiking, 4wD, camping). Economic values may include rural water source for stock and domestic supply, oyster farming, forestry or tourism associated benefits.

3. What do you value most about Nelsons Lagoon and its catchment?

Ecological values	
Social values	
Economic values	
Other values	

* 4. How concerned are you about the current condition of the catchment and estuary foreshore?

- Extremely concerned
- Very concerned
- Moderately concerned
- Slightly concerned
- Not at all concerned

* 5. How concerned are you about water quality of Nelsons Lagoon?

- Extremely concerned
- Very concerned
- Moderately concerned
- Slightly concerned
- Not at all concerned

* 6.

What issues do you feel are negatively affecting the condition of the catchment and water quality of Nelsons Lagoon?
Rank in level of importance to you (*e.* #1 = has the greatest negative impact.....#8 = least negative impact)

- Unfenced creek lines and stock impacts
- Lack of riparian vegetation due to historical vegetation clearing
- Weed infestation
- Ad hoc foreshore access
- Poorly maintained unsealed roads
- Wetland degradation (i.e/ freshwater or saltmarsh)
- Bank erosion
- Illegal drains or weirs (i.e. barriers to fish passage)
- Forestry practices

7. Please provide other information regarding Nelsons Lagoon catchment management issues that you feel are important.

Rapid Catchment Assessment - Nelson Lagoon

Please register your interest in this project by leaving your contact details. Your contact details and input will be kept private and will not be disclosed to any third party. All information will be deleted at the conclusion of the project.

8. Address

Name	
Address	
City/Town	
State/Province	
ZIP/Postal Code	
Email Address	
Phone Number	

APPENDIX B

Nelson Lagoon Catchment – Priority Management Areas

APPENDIX B

Priority Management Area 1

Area Description and Issues Synopsis

The area includes the alluvial floodplain of Nelson Creek and the tidal limit of the upper estuary. A large proportion of the area is private land that is used for cattle grazing by the current resident landholder of approximately 40 years. The floodplain has been dissected by the construction of the Tathra-Bermagui Road, which acts as a barrier and interrupts the natural flow of floodwaters across the floodplain with flood flows confined to the active channel under the bridge. Minor erosion to the bridge abutments is evident with moderate to serious ongoing erosion of both sides of the stream bank immediately downstream of the bridge. Four endangered ecological communities (EECs) have been mapped as occurring in this area including *River-flat Eucalyptus Forest* along the riparian zone of freshwater reaches, *Swamp Sclerophyll Forest* along the riparian zone of the upper estuary, with *Swamp Oak Floodplain* and *Coastal Saltmarsh* in upper estuary areas. Although, the validity of some of the current EEC mapping is questionable due to the absence of key indicator species.

The landholder has been pro-active towards protection of high conservation value areas fencing off a large area of saltmarsh community and preventing cattle access to mangrove community. However, erosion issues affect the stability of the streamside zone along freshwater and upper estuary reaches of Nelson Creek and protective measures are required to mitigate further degradation and loss of land.

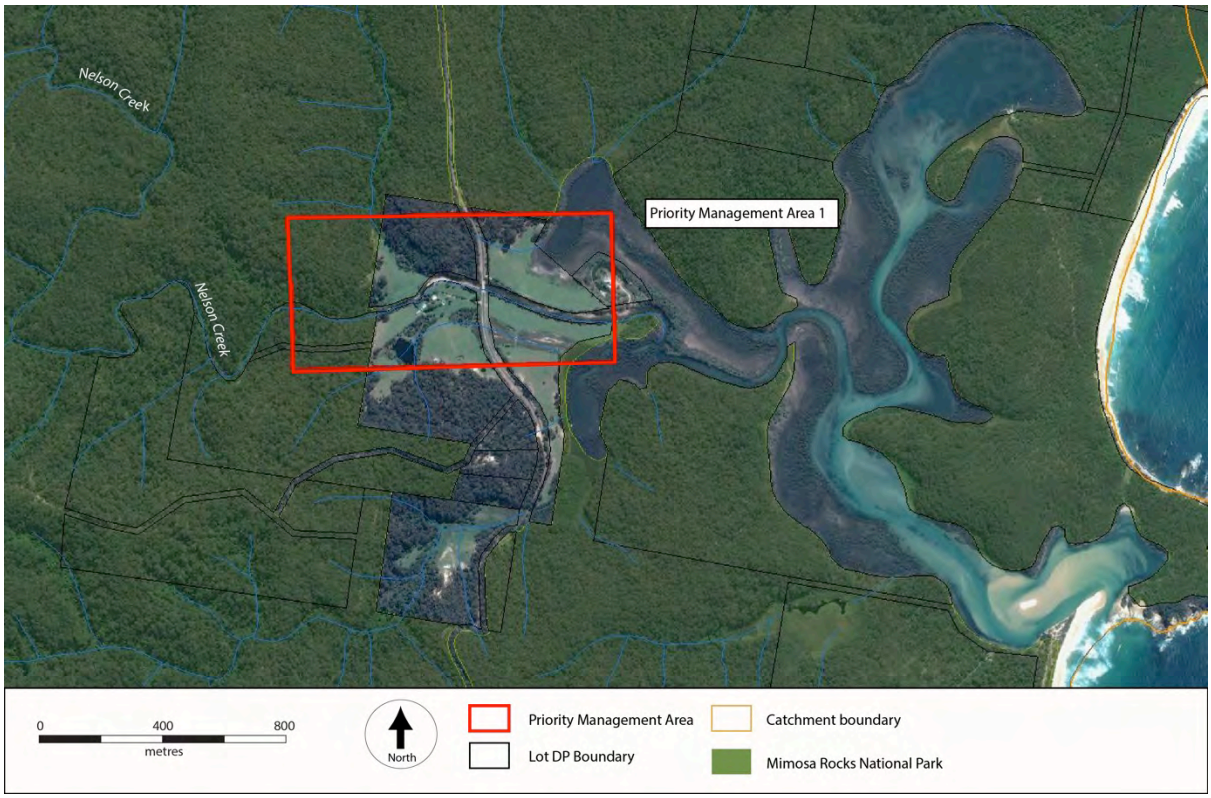


Figure B1 Location of priority management area 1.

APPENDIX B

Medium to High priority issues that require attention include:

- **Issue 1.1** Moderate bank erosion of lower Nelson Creek, sections of creek with little riparian vegetation and cattle access to streamside zone.
- **Issue 1.2** Moderate to serious bank erosion with potential for top of bank collapse.
- **Issue 1.3** Moderate to serious bank erosion (slumping) due to hydraulic scour of the bank toe.

Low priority issues that require attention include:

- **Issue 1.4** Minor erosion to bridge abutments of Tathra-Bermgaui Road bridge
- **Issue 1.5** Road embankment erosion and sedimentation to Nelson Creek
- **Issue 1.6** Water quality of private canal a potential risk to estuarine WQ
- **Issue 1.7** Stock access to saline wetland

Each issue is described with recommended actions for treatment provided in sections below.

Issue 1.1 Moderate bank erosion of lower Nelson Creek, sections of creek with little riparian vegetation and cattle access to streamside zone

MED-HIGH PRIORITY

Site Address [Responsibility]: Private Land [Lot 254 DP789402], DPI Lands (Refer **Map B1**).

Lat/Long Coordinates: 36°40'31.67"S, 149°58'8.39"E

Issue Description:

Localised areas of bank erosion are occurring along freshwater reach of lower Nelson Creek. The riparian zone on the right-bank is fenced with the left-bank currently unfenced. Stock can access the streamside zone when moved between grazing areas with banks characterised by isolated patches of vegetation interspersed by grassed banks currently devoid of natural shrub and groundcover vegetation. Current stocking rates are low and bank erosion is primarily due to episodic flood flows that also deposit LWD in the active channel. The LWD could be secured to help protect the bank toe from further erosion and improve channel hydraulics.

Recommended Treatment Action/s:

- Work with landholder to limit stock access to the streamside zone.
- Work with landholder to implement rehabilitation and bank toe protection works for sections of degraded creek bank using assisted natural regeneration. Refer to conceptual drawing for typical river restoration treatment (**Appendix C**) and recommended plant species list (**Appendix D**). Fencing requirements to consider flood flows and temporary periods of inundation.

APPENDIX B

Figure B2 Section of degraded bank where stock cross Nelson Creek to access grazing areas (*left imag*e). Stock are occasionally provided access the streamside zone and enter Nelson Creek upstream of the Tathra-Bermagui Road bridge (*right image*).

Issue 1.2 Moderate to serious bank erosion with potential for further erosion due to top of bank collapse

MED-HIGH PRIORITY

Site Address [Responsibility]: Private Land [Lot 254 DP789402] (Refer **Map B1**).

Lat/Long Coordinates: 36°40'33.68"S, 149°58'19.04"E

Issue Description: Moderate to serious ongoing erosion is affecting the bank stability of Nelson Creek along an approximate 450m long reach of the upper estuary, east of Tathra-Bermagui Road bridge. Erosion severity increases moving downstream towards NPWS estate and is contributing sediment to the channel representing a threat to water quality. The existing riparian buffer is fenced but narrow, generally 1 to 2m wide, dominated by *Acacia mearnsii* (black wattle) and *Melaleuca armillaris* trees. Wind blow affects the trees with senescent individuals providing high potential for top of bank collapse should trees fall over further exacerbating the erosion issue. While this is a natural process that results in creation of instream large woody debris (LWD), an important fish habitat, the landholder is also at risk of loosing riparian land. An increased riparian buffer width would minimise the effect of wind shear forces on trees growing closest to the top of bank.

Recommended Treatment Action/s:

- Work with landholder to expand the width of the riparian vegetation buffer where current vegetation exists. Refer to conceptual drawing for typical river restoration treatment (**Appendix C**) and recommended plant species for upper estuary floodplain areas (**Appendix D**).
- Existing LWD can be realigned and secured to stabilise bank toe and improve channel hydraulics.
- The risk of top of bank collapse and further erosion due to tree collapse can be minimised by coppicing / lopping the senescent black wattles (*Acacia mearnsii*) and woody vegetation showing sign of potential failure.

APPENDIX B

Figure B3 Example of steep bank and narrow strip of riparian vegetation with a large black wattle perched at the bank edge (*left image*). View downstream along left bank showing the narrow band of riparian vegetation (*right image*). It is recommended that the riparian buffer be expanded as much as possible to mitigate against further degradation of the stream bank and loss of alluvial flats.

Issue 1.3 Moderate to serious bank erosion (slumping) due to hydraulic scour of the bank toe

MED-HIGH PRIORITY

Site Address [Responsibility]: Private Land [Lot 254 DP789402], Mimosa Rocks National Park [NPWS] (Refer **Map B1**).

Lat/Long Coordinates: 36°40'36.16"S, 149°58'32.93"E

Issue Description: Localised areas of bank slumping due to hydraulic scour of the bed sediments and bank toe is occurring along the upper estuary east of Tathra-Bermagui Road bridge. This process is exacerbated during and after flood flows with most severe bank slumping apparent along a reach in Mimosa Rocks National Park where riparian vegetation is absent.

Recommended Treatment Action/s:

- Work with landholder and NPWS to implement bank toe protection works using strategically placed LWD and rock
- Work with landholder to expand the width of the current riparian vegetation buffer along whole bank. Refer to conceptual drawing for typical river restoration treatment (**Appendix C**) and recommended plant species for upper estuary floodplain areas (**Appendix D**). Fencing requirement will need to consider flood flows and temporary periods of inundation.
- Work with NPWS to implement rehabilitation of the streamside zone using strategy of assisted natural regeneration where there is currently no riparian vegetation. Fencing requirement need to consider flood flows and temporary periods of inundation.

APPENDIX B

Figure B4 Example of moderate to severe bank slumping of Nelson Creek in upper estuary reaches (*left imag*e). Recent severe bank slumping along an un-vegetated section of the stream bank (*right image*). It is recommended that bank toe protection works be undertaken and the riparian buffer be expanded as much as possible to mitigate against further degradation of the stream bank and loss of alluvial flats.

Issue 1.4 Minor erosion to bridge abutments of Tathra-Bermagui Road bridge

LOW PRIORITY

Site Address [Responsibility]: Tathra-Bermagui Road bridge at Nelson Creek [RMS, BVSC] (Refer **Map B1**).

Lat/Long Coordinates: 36°40'31.77"S, 149°58'15.88"E

Issue Description: Minor erosion is evident around the abutments of the Tathra-Bermagui Road bridge. Following construction of the Tathra-Bermagui Road across the floodplain, flood flows are concentrated and confined to the active channel flowing beneath the bridge rather than dispersing flow energy across the floodplain.

Recommended Treatment Action/s:

- Monitor condition particularly after flood flows.
- Rock revetment works may be required to prevent further erosion.

APPENDIX B

Figure B5 Minor erosion evident to the bridge abutments on the left bank (*left image*). View of erosion to left bank from above (*right image*).

Issue 1.5 Road embankment erosion and sedimentation to Nelson Creek

LOW PRIORITY

Site Address [Responsibility]: Tathra-Bermagui Road at Nelson Creek [RMS, BVSC] (Refer **Map B1**).

Lat/Long Coordinates: 36°40'30.39"S, 149°58'15.27"E

Issue Description: Erosion of the table drain and roadside embankment on western-side of Tathra-Bermagui Road is contributing sediment to Nelson Creek. Batter eroding bank to a minimum slope as specified by geotechnical engineer.

Recommended Treatment Action/s:

- Recommend removal of excess loose sediment from affected area and construct a small sediment detention basin/trap to prevent sediment from entering watercourse.
- Batter eroding bank to a minimum slope as specified by geotechnical engineer and treat as provided in guidance for Group A erosion control measures (DECCW 2008).

Figure B6 The western side of Tathra-Bermagui Road where surface road runoff drains to Nelson Creek (*left image*). Example of an area of eroding roadside embankment that could be improved through appropriate battering (*right image*).

APPENDIX B

Issue 1.6 Water quality of private canal potential risk to estuarine WQ

LOW PRIORITY

Site Address [Responsibility]: Private Land [Lot 184 DP752158], BVSC (Refer **Map B1**).

Lat/Long Coordinates: 36°40'33.40"S, 149°58'36.02"E

Issue Description: A former oxbow meander of Nelson Creek that has been cut-off from the main channel is now effectively a private canal surrounding property at Lot 184 DP752158. This waterbody is confined and water quality status is currently unknown. The onsite sewage management (OSM) system classification for the property is identified as critical risk requiring annual inspection. Waters from the canal overflow to the estuary after high rainfall events and may be a potential risk to estuarine water quality.

Recommended Treatment Action/s:

- Recommend working with landholder to test canal waters annually for signs of faecal contamination that may indicate a potential failure of OSM.

Figure B7 Unknown water quality of private canal waterbody in close proximity to residence and associated OSM system represents a potential risk to estuarine water quality.

APPENDIX B

Issue 1.7 Stock access to saline wetland

LOW PRIORITY

Site Address [Responsibility]: Private Land [Lot 254 DP789402], SE LLS (Refer **Map B1**).

Lat/Long Coordinates: 36°40'35.85"S, 149°58'13.36"E

Issue Description: Saline wetland that is part of private property with adjoining paddocks used for stock grazing. The wetland has been fenced-off and the landholder has undertaken some revegetation works. However, stock were observed inside the wetland area and access may be possible through a damaged section of fence line.

Recommended Treatment Action/s:

- Work with landholder to repair fencing where required excluding stock from sensitive wetland area.

Figure B7 Inspect integrity of fence line enclosing saline wetland and undertake repairs where required to exclude stock access.

Issue 1.1 Moderate bank erosion of lower Nelson Creek, sections of creek with little riparian vegetation and cattle access to streamside zone.

Work with landholder to limit stock access to streamside zone, implement rehabilitation and protection works for degraded bank sections. Landholder concerned that LWD deposited at edge of active channel contributing to erosion issue. Landholder prefers that LWD be removed. Recommend that LWD be retained, realigned and strategically secured to protect bank toes. Refer to conceptual drawing for typical river restoration treatment (Appendix C). Rock and log toe protection works may be required to prevent further bank erosion.

Issue 1.5 Road embankment erosion and sediment delivery to creek.

Erosion of the table drain and embankment on western-side of Tathra-Bermagui Road is contributing sediment to Nelson Creek. Recommend removal of excess loose sediment from affected area and construct a small sediment detention basin/trap to prevent excess sediments from entering watercourse. Batter eroding bank to a minimum slope as specified by geotechnical engineer.

Issue 1.6 Water quality of private canal potential risk to estuarine WQ

The water quality of the private canal is unknown. Waters from the canal overflow to the estuary after high rainfall events. Recommend working with landholder to test canal waters for pollutants to determine level of risk to estuary.

Issue 1.4 Minor erosion to bridge abutments of Tathra-Bermgaui Road bridge.

Monitor condition, particularly after flood flows. Rock revetment works may be required to prevent further erosion around abutments.

TATHRA-BERMAGUI

Issue 1.2 Moderate to serious bank erosion with potential for top of bank collapse

Riparian zone is fenced though very narrow, <2m wide. Severity of bank erosion increases moving downstream towards NPWS estate. Work with landholder to expand the existing riparian buffer using strategy of assisted natural regeneration. Refer to conceptual drawing for typical river restoration treatment (Appendix C) and recommended species list (Appendix D). Existing LWD can be realigned and secured to stabilise bank toe and improve channel hydraulics. Senescent black wattles (Acacia mearnsii) growing close to top of bank may be coppiced to mitigate risk of top of bank collapse and further loss of land.

increase riparian buffer width

Issue 1.2 Moderate to serious bank erosion of lower Nelson Creek with potential for top of bank collapse and further erosion. See adjacent for treatment.

increase riparian buffer width

Issue 1.7 Stock access to saline wetland

Saline wetland is fenced and landholder has undertaken some revegetation. However, stock observed to still access wetland area. Work with landholder to exclude stock from sensitive wetland area.

Issue 1.3 Moderate to serious bank erosion (slumping) due to hydraulic scour of bank toe

Localised areas of bank slumping due to hydraulic scour of bed sediments and bank toe during flood events. Work with landholder and NPWS to 1) Implement bank toe protection works using strageically placed LWD and rock, 2) Expand the riparian vegetation buffer where vegetation currently exists, and 3) Re-establish vegetation along streamside zone where riparian vegetation is currently absent.

0 30 60 120 180 240 Meters

NELSON LAGOON CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Sediment Delivery to Estuary
- Proposed expansion of riparian buffer
- Bank Erosion
- Roads
- Embankment Erosion
- Deposition
- HAT (1.286 m AHD)
- Rivers & Creeks
- Mimosa Rocks National Parks
- Lot / DP Boundaries

NELSON LAGOON PRIORITY MANAGEMENT AREA 1

Riparian engineering

GDA
GDA 94 Zone 55

Sheet No.

Map B1

Analysis By: Tim Dilworh
River & Coastal Engineer MIE CPEng Aust, NER, RPEQ

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 2

Area Description and Issues Synopsis

The area includes the middle estuary area located wholly within Mimosa Rocks National Park. This part of the estuary is characterised by tidal channels with significant areas of coastal saltmarsh and mangrove community fringing the estuary margins. A NPWS foreshore access road provides vehicle access to the estuary for launching kayaks, canoes and small boats. The road is in poor condition with road sections along the foreshore most degraded due to uncontrolled access with stretches of bare bank devoid of regenerating mangrove and other vegetation due to regular trampling disturbance associated with launching boats and other small vessels. While these issues do not pose a serious threat to water quality of the estuary addressing them will have environmental benefits such as improved aesthetic and foreshore amenity.

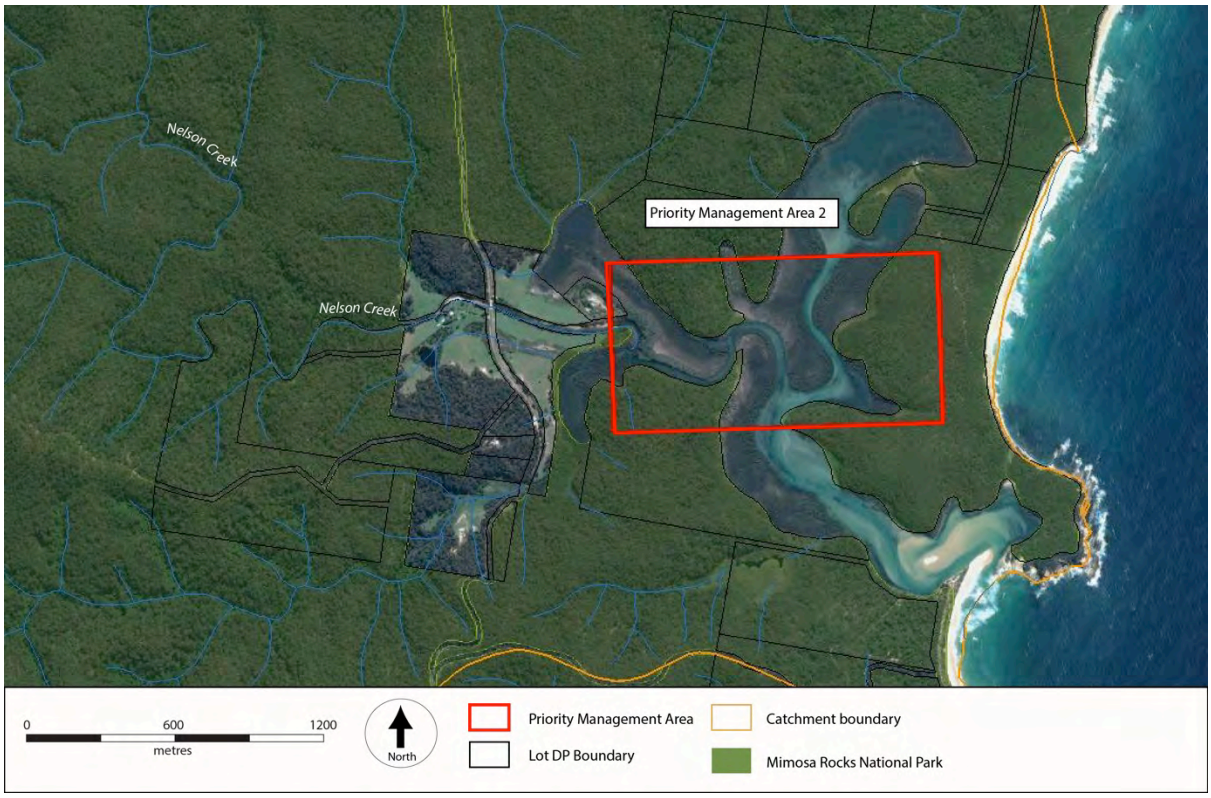


Figure B8 Location of priority management area 2.

High priority issue that require attention include:

- **Issue 2.1** Foreshore access road in poor condition, localised areas of bare banks and degraded mangrove vegetation due to regular and uncontrolled disturbance

Low priority issues that require attention include:

- **Issue 2.2** Vehicle damage to potential cultural heritage site
- **Issue 2.3** Minor foreshore erosion adjacent to saltmarsh community
- **Issue 2.4** Erosion to foreshore access road and informal boat ramp off Cowdroys Road

Each issue is described with recommended actions for treatment provided in sections below.

APPENDIX B

Issue 2.1 Foreshore access road in poor condition, localised areas of bare banks and degraded mangrove vegetation due to regular and uncontrolled disturbance

HIGH PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B2**).

Lat/Long Coordinates: 36°40'41.25"S, 149°58'42.95"E

Issue Description: Foreshore access road off Nelson Road providing vehicle access to the middle estuary area. The road is primarily used by recreational fishermen for launching kayaks, canoes and small boats. The road is in poor condition along the estuary foreshore, with deep rutting and mud tracks caused by vehicle usage in wet conditions. Areas of the foreshore are degraded due to uncontrolled access with stretches of bare bank devoid of regenerating mangroves and other vegetation due to regular trampling disturbance associated with launching boats and other small vessels.

Recommended Treatment Action/s:

- Implement control fencing and or bollards to direct foreshore access to a single area.
- Improve site amenity by addressing the poor road condition and consider closing access road during wet conditions.

Figure B9 Degraded bank currently devoid of any regenerating vegetation (*left image*). Parts of the foreshore access road are in poor condition with deep wheel ruts and mud tracks (*right image*).

Issue 2.2 Vehicle damage to potential cultural heritage site and foreshore vegetation

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B2**).

Lat/Long Coordinates: 36°40'40.63"S, 149°58'39.72"E

Issue Description: A shell bed was identified in the vicinity of the informal boat ramp and vehicle access to the foreshore to launch small vessels may be impacting on cultural values of the site.

Recommended Treatment Action/s:

- Consult with Bega LALC to investigate the potential cultural heritage values of site.
- Develop signage and install bollards to limit vehicle damage to foreshore vegetation and potential cultural heritage values.

Figure B10. Informal boat ramp located at the western end of the foreshore access road (*left image*). A shell bed layer with potential cultural heritage values is present at the site and warrants further assessment to determine its significance (*right image*).

Issue 2.3 Minor foreshore erosion adjacent to saltmarsh community

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B2**).

Lat/Long Coordinates: 36°40'39.37"S, 149°58'57.08"E

Issue Description: A significant area of saltmarsh has been fenced off to exclude vehicle access by a previous SR CMA funded project with educational signage used to raise awareness of the ecological importance of the community. Minor foreshore erosion is occurring in areas adjacent to the saltmarsh community.

Recommended Treatment Action/s:

- Monitor condition of saltmarsh community.
- No other action required.

APPENDIX B

Figure B11. Regenerating saltmarsh community following exclusion of vehicles to the area by a previous conservation project by SR CMA (*left image*). Minor erosion of foreshore adjacent to saltmarsh community (*right image*).

Issue 2.4 Erosion to foreshore access road and informal boat ramp off Cowdroys Road

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B2**).

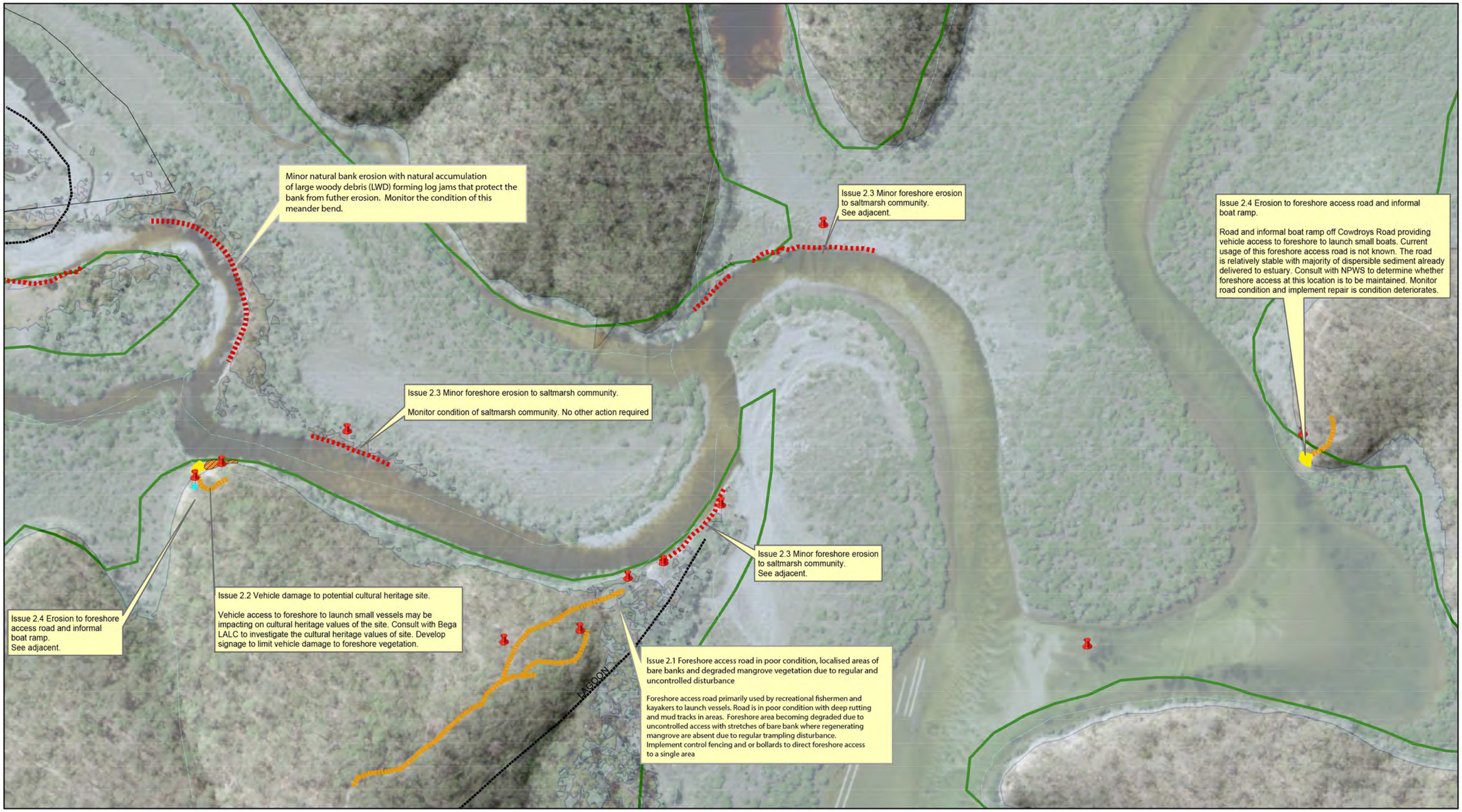
Lat/Long Coordinates: 36°40'39.50"S, 149°59'15.07"E

Issue Description: Road and informal boat ramp off Cowdroys Road providing vehicle access to estuary foreshore to launch small boats. Current usage of this foreshore access road is not known. Currently the road is relatively stable with majority of dispersible sediment having already been delivered to estuary.

Recommended Treatment Action/s:

- Consult with NPWS to determine whether foreshore access at this location is to be maintained.
- Monitor road condition and implement repair should road condition deteriorate further.

Figure B12. Vehicle access to the foreshore from Cowdroys road with moderate erosion and wheel rutting evident (*left image*). Current road condition is relatively stable with majority of dispersible sediment already eroded (*right image*).



NELSON LAGOON CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Sediment Delivery to Estuary
- Road Erosion
- Potential Cultural Heritage Site
- Bank Erosion
- Roads
- Deposition
- HAT (1.286 m AHD)
- Rivers & Creeks
- Mimosa Rocks National Park
- Lot / DP Boundaries

NELSON LAGOON PRIORITY MANAGEMENT AREA 2

Riparian engineering

GDA
GDA 94 Zone 55

MAP B2

Analysis By: Tim Dilworh
River & Coastal Engineer MIE CPEng Aust, NER, RPEQ

Sheet No.

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 3

Area Description and Issues Synopsis

This area includes the lower estuary and entrance to Nelson Lagoon characterised by the flood-ebb tidal delta and the main visitation areas used for recreation (**Figure B13**). Well-defined pathways from the carpark area provide access to the beach and lagoon foreshore through the endangered ecological community *Bangalay Sand Forest*. Pathways have been fenced in an effort to control pedestrian impacts to the dune system although impacts to the dune vegetation due to trampling and erosion continue to occur. The lagoon foreshore with north-west aspect is one of the most popular recreational areas of the estuary providing a protected and safe swimming area. However, intense use of this area of the foreshore has also resulted in the decline of dune vegetation on the adjacent sand banks with loss of several large *Banksia* trees in recent years due to trampling associated erosion. Mangroves make regular attempts to regenerate in this foreshore area but are kept clear due to regular disturbance. The seagrass community of Nelson Lagoon is patchy but the largest continuous extent of *Zostera muelleri* occurs in this area and its conservation significance warrants recognition. It is estimated that the seagrass community of Nelson Lagoon declined >70% over the 20-year period between 1985 and 2006 (Creese *et al.* 2009) but it is not clear whether the seagrass community has continued to decline or improve since 2006. The area also includes the carpark area terminating Cowdroys Road. A steep road from the carpark provides access down to the northern side of the lagoon foreshore and has primarily been used by oyster growers to access lease areas. Minor to moderate erosion of the road surface is occurring and improved surface runoff controls could be implemented to minimise potential sediment inputs to the estuary.

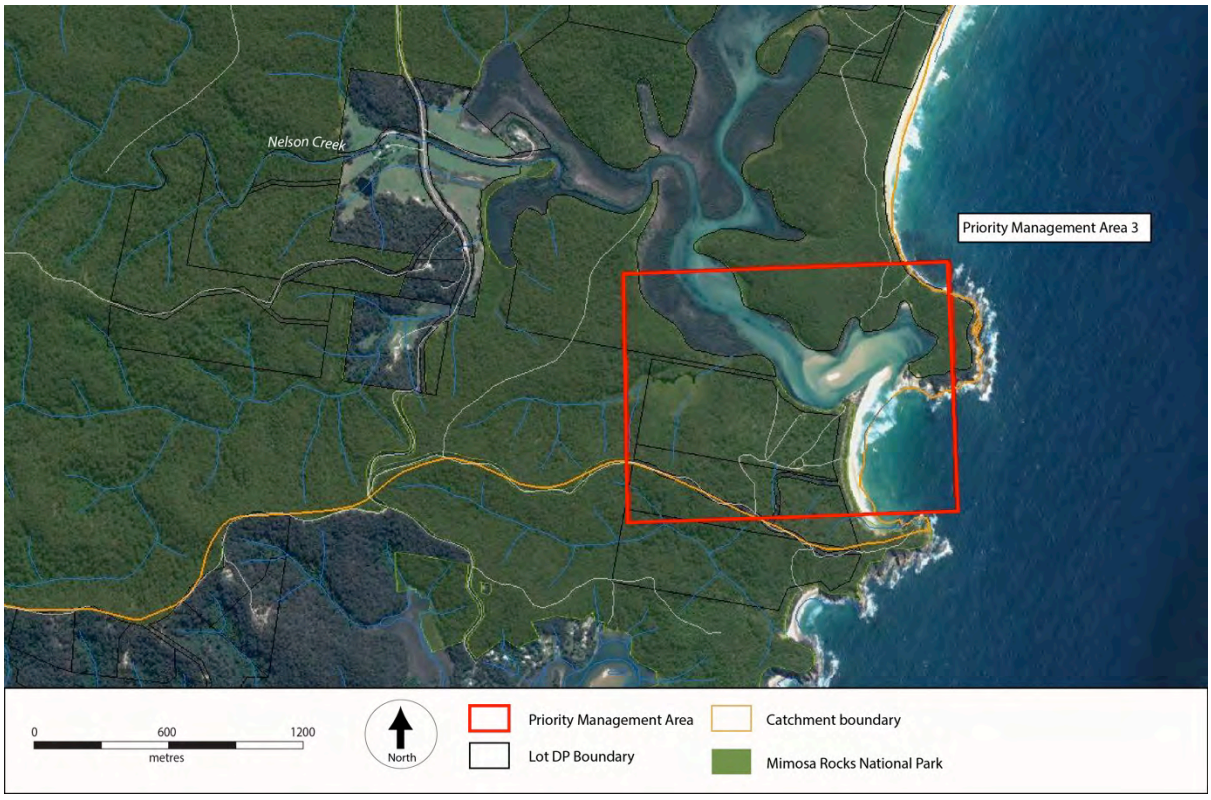


Figure B13 Location of priority management area 3.

APPENDIX B

Medium priority issue that require attention include:

- **Issue 3.1** Potential loss of seagrass community

Low priority issues that require attention include:

- **Issue 3.2** Erosion of dune foreshore and impacts to dune vegetation
- **Issue 3.3** Erosion of foreshore access road off Cowdroys Road

Each issue is described with recommended actions for treatment provided in sections below.

Issue 3.1 Potential loss of seagrass community

MEDIUM PRIORITY

Site Address [Responsibility]: Nelson Lagoon - Mimosa Rocks National Park [DPI Fisheries, NPWS], BVSC (Refer **Map B3**).

Lat/Long Coordinates: 36°41'10.03"S, 149°59'23.12"E

Issue Description: Estimated that >70% loss of seagrass has occurred from Nelson Lagoon over 20-year period between 1985 to 2006 (Creese et al. 2009) with the current condition of the seagrass community rated as being in very poor condition (DECCW 2011). This estimate of seagrass loss may not be accurate due to differences in mapping techniques applied in the 1985 and 2006 assessments. However, the potential issue of seagrass loss in Nelson Lagoon is worthy of further investigation through additional seagrass mapping utilising methodology similar to that applied by NSW DPI in 2006. The largest continuous patch of seagrass community mapped in Nelson Lagoon occurs in the lower estuary where recreational activity is most popular and rates of human disturbance perhaps also greatest. Minimising potential loss of seagrass is an ongoing issue that will have broader implications for the ecological condition of the estuary.

Recommended Treatment Action/s:

- Erect educational signage to illustrate the ecological importance of seagrass meadows and role they play in stabilising estuarine sediments. Recommend that signage be erected at all boat launching areas as outboard engines at low-tide represent a high potential threat of damage to seagrass community.
- Update seagrass mapping to ascertain changes in seagrass community over the last 10-year period and implement program to monitor condition of seagrass community.

APPENDIX B

Figure B14 Mapped distribution and extent of seagrass and mangrove community in the lower estuary area of Nelson Lagoon.

Issue 3.2 Erosion of dune foreshore and impacts to dune vegetation

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B3**).

Lat/Long Coordinates: 36°41'9.87"S, 149°59'31.22"E

Issue Description: The lagoon foreshore with north-west aspect is one of the most popular recreational areas of the estuary providing a protected and safe swimming area. However, intense use of this area of the foreshore has also resulted in the decline of dune vegetation on the adjacent high vertical sand banks with loss of several large *Banksia* trees in recent years due to trampling associated erosion. The erosion of these sand banks will continue to occur naturally via flow induced scour (particularly in floods) and is not impacting water quality but the condition of dune vegetation can be improved through ongoing controlled access of this foreshore area.

Recommended Treatment Action/s:

- Maintain existing management of the foreshore that includes restricting pedestrian access to dune vegetation.
- Consider erecting additional signage to raise awareness of sensitivity of dune vegetation.

APPENDIX B

Figure B15 Example of eroding sand banks and impacts to dune vegetation associated with uncontrolled pedestrian foot traffic and trampling.

Issue 3.3 Erosion of foreshore access road off Cowdroys Road

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B3**).

Lat/Long Coordinates: 36°40'57.69"S, 149°59'34.71"E

Issue Description: A steep unsealed road provides access down to the northern side of the lagoon foreshore from the carpark terminating Cowdroys Road. This road has primarily been used by oyster growers to access lease areas. Minor to moderate erosion of the road surface is occurring and maintenance of surface runoff controls could be implemented to minimise potential sediment inputs to the estuary.

Recommended Treatment Action/s:

- Improve road surface runoff controls including maintenance (*i.e.* removal of leaf litter and excess sediments), use siltation curtains to minimise potential sediment inputs to the estuary.

Figure B16 Foreshore access to northern side of Nelson lagoon from Cowdroys Road (*left image*). Existing surface runoff controls require maintenance and could be improved with addition of siltation fences to further minimise potential sediment inputs to estuary (*right image*).

Issue 3.1 Potential loss of seagrass comnunity
See adjacent.

Issue 3.3 Erosion of foreshore access road off Cowdroys Road.
See adjacent.

Issue 3.3 Erosion of foreshore access road off Cowdroys Road.

A steep road from the Cowdroys Road carpark provides access down to the northern side of the lagoon foreshore. Minor to moderate erosion of the road surface is occurring. Road surface runoff controls need to be improved incluing use of siltation curtains to minimise potential sediment inputs to the estuary.

Issue 3.1 Potential loss of seagrass comnunity
See adjacent.

Issue 3.1 Potential loss of seagrass community

Estimated that >70% loss of seagrass has occurred from Nelson Lagoon over 20-year period between 1985 to 2006 with the current condition of the seagrass community rated as being in very poor condition. This estimate of seagrass loss may not be accurate due to differences in mapping techniques applied in the 1985 and 2006 assessments. However, the potential issue of seagrass loss is worthy of further investigation.

Recommend using educational signage to illustrate the ecological importance of seagrass meadows and role they play in stabilising estuarine sediments. Erect signage at all boat launching areas. Update seagrass mapping to ascertain changes in seagrass community over the last 10-year period and implement program to monitor condition of seagrass community.

The largest continuous patch of seagrass community mapped in Nelson Lagoon occurs in the lower estuary where recreational activity is most popular and rates of human disturbance perhaps also greatest. Minimising potential loss of seagrass is an ongoing issue that will have broader implications for the ecological condition of the estuary.

Issue 3.2 Erosion of dune foreshore.
See adjacent.

Issue 3.2 Erosion of dune foreshore and impacts to dune vegetation

High vertical sand banks subject to increased erosion due to uncontrolled pedestrian access. Associated impacts include human disturbance to dune vegetation with many coastal Banksia dying in recent years. Recommend maintain existing management of the foreshore that includes controlling and restricting pedestrian access to dune vegetation. Additional signage may be erected to raise awareness of sensitivity of dune vegetation.

0 85 170 340 510 680 Meters

NELSON LAGOON CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Road Erosion
- Bank Erosion
- Roads
- Deposition
- HAT (1.286 m AHD)
- Rivers & Creeks
- Mimosa Rocks National Park

NELSON LAGOON PRIORITY MANAGEMENT AREA 3

Riparian engineering

GDA
GDA 94 Zone 55

Sheet No.

Map B3

Analysis By: Tim Dilworh
River & Coastal Engineer MIE CPEng Aust, NER, RPEQ

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 4

Area Description and Issues Synopsis

The area is located in Mimosa Rocks National Park and includes the main estuary basin that receives catchment inflows from a number of small streams draining a sub-catchment area of approximately 1.47 km^2 (5% of total catchment area). Gillards Road forms the boundary of the basin sub-catchment. The basin is the main oyster growing area of the lagoon with lease areas situated around the margins. This part of the estuary is also popular with recreational fishermen though shoaling of the main channel limits boat access to high tide conditions. The primary issue for this catchment area concerns the ongoing maintenance of Cowdroys Road with a number of erosion points identified along the road.

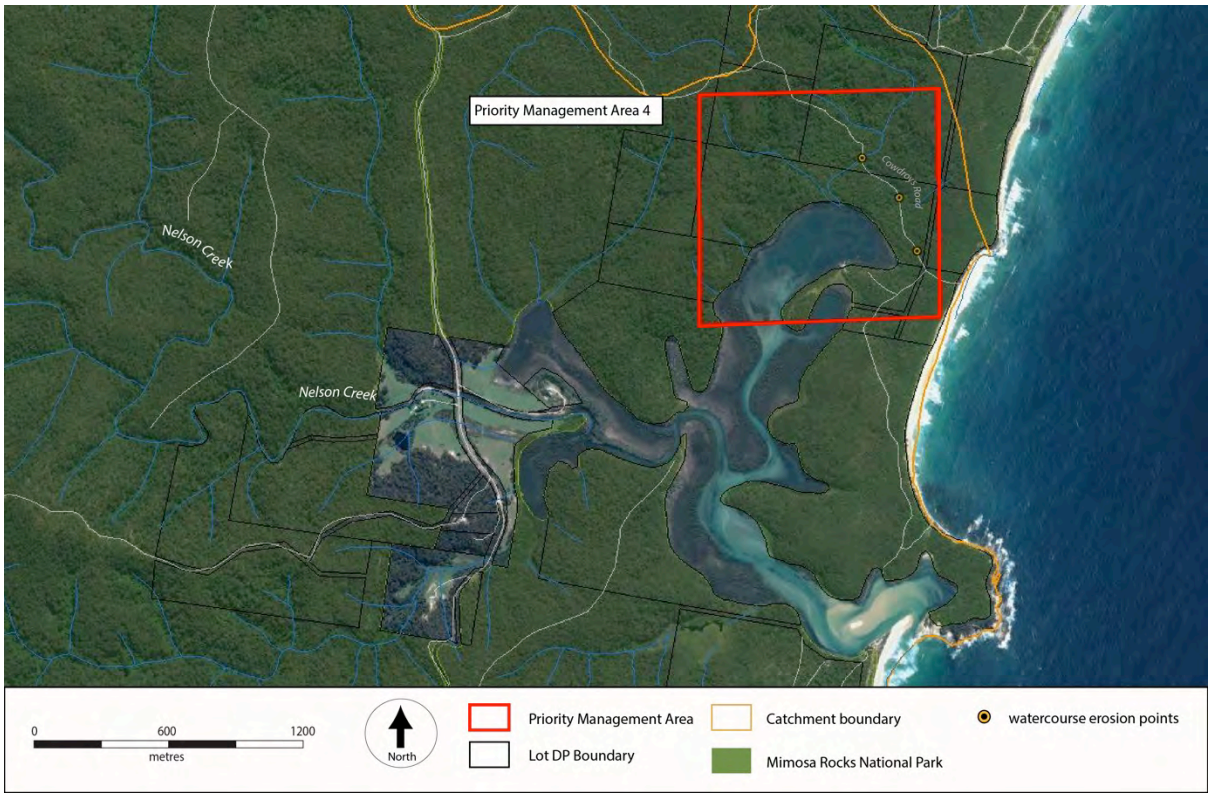


Figure B17 Location of priority management area 4.

Low priority issues that require attention include:

- **Issue 4.1** Erosion of Cowdroys Road and sedimentation to tributary streams
- **Issue 4.2** Uncontrolled vehicle access to foreshore and threat to saltmarsh community

The issue is further described with recommended actions for treatment provided below.

APPENDIX B

Issue 4.1 Erosion of Cowdroys Road and sedimentation to tributary streams

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B4**).

Lat/Long Coordinates: 36°39'56.41"S, 149°59'30.54"E

Issue Description: Cowdroys Road provides access to the northern side of Nelson Lagoon. Road condition is generally rough with access primarily limited to 4WD or 2WD during dry weather conditions. Significant erosion of the road surface has already occurred with historical sedimentation impacts to tributary streams evident. Road maintenance is the responsibility of NPWS. However, an unofficial agreement exists between NPWS and Gary Rodely (oyster grower) that permits Gary to personally take responsibility for managing the maintenance of Cowdroys Road from Gillards Road to his oyster lease area to mitigate the threat that sediment inputs pose to estuarine water quality and viability of his oyster business. This agreement was reached after Gary had noted instances of erosion and sediment deposition that followed grading of this steep road. Gary and his team use hand tools to build and maintain mitre drains and oyster shell to maintain and stabilise the road surface.

Cowdroys road is currently in serviceable condition with the numerous small mitre drains installed providing effective runoff control. While the road is rough in areas, road erosion does not currently pose a threat to WQ values of the estuary. However significant sedimentation to tributary streams has already occurred and a proportion of dispersible sediment will continue to enter the estuary under high flow events.

Recommended Treatment Action/s:

- Work with NPWS and Gary Rodely to continue to implement effective erosion controls to protect condition of Cowdroys Road. This may include installing siltation curtains at tributary streams to trap sediments and minimise further sedimentation impacts of tributary streams.
- Monitor condition to ensure road erosion does not become an active threat to estuary WQ.

Figure B18 Cowdroys Road showing the original road surface - orange clay, supplemented with three decades of crushed oyster shell - white color (*left image*). Example of a siltation barrier constructed by oyster grower to minimise sediment inputs to lagoon basin (*right image*).

APPENDIX B

Issue 4.2 Uncontrolled vehicle access to foreshore and threat to saltmarsh community

MEDIUM PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B4**).

Lat/Long Coordinates: 36°40'22.41"S, 149°59'27.25"E

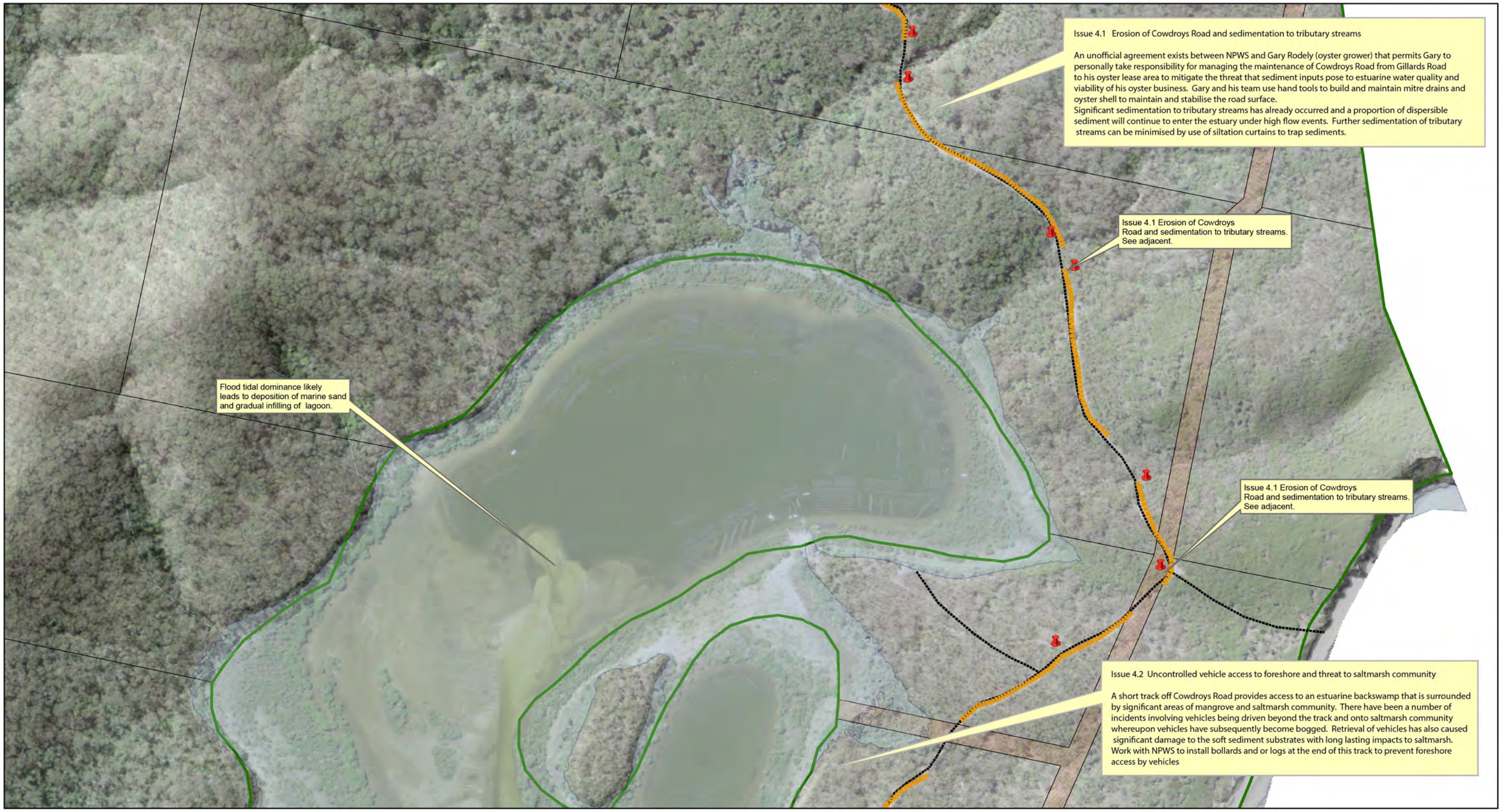
Issue Description: A number of informal tracks provide access to the foreshore of Nelson Lagoon from Cowdroys Road. These tracks are primarily used by recreational fishermen to access the waterway. While it is important to maintain foreshore access to permit the continuation of recreational user experience, vehicle access via some of these informal tracks needs to be restricted to protect the foreshore and saltmarsh community from degradation.

A short track off Cowdroys Road provides access to an estuarine backswamp that is surrounded by significant areas of mangrove and saltmarsh community. There have been a number of incidents involving vehicles being driven beyond the track and onto saltmarsh community whereupon vehicles have subsequently become bogged. Retrieval of vehicles has also caused significant damage to the soft sediment substrates with long lasting impacts to saltmarsh.

Recommended Treatment Action/s:

- Work with NPWS to install bollards and or logs at the end of this track to prevent foreshore access by vehicles.

Figure B19 Overview of issue 4.2 showing the foreshore location where bollards or logs could be installed to prevent vehicle access to foreshore.



0 65 130 260 390 520 Meters

NELSON LAGOON CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Road Erosion
- Roads
- HAT (1.286 m AHD)
- Rivers & Creeks
- Mimosa Rocks National Park
- Lot / DP Boundaries

NELSON LAGOON PRIORITY MANAGEMENT AREA 4

Riparian engineering

GDA
GDA 94 Zone 55

Sheet No.

MAP B4

Analysis By: Tim Dilworh
River & Coastal Engineer MIE CPEng Aust, NER, RPEQ

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 5

Area Description and Issues Synopsis

The area is located in Mimosa Rocks National Park to the north of Nelson Lagoon and includes a number of minor catchment streams in forested setting that drain either to Nelson Creek or to an estuarine back lagoon. Significant natural erosion has occurred along these drainage lines but may have also been exacerbated by historical catchment disturbance that has included past logging operations. Multiple examples of natural erosion processes include head-cuts, deeply incised gully formation, and rill erosion. Majority of the sediment from these eroded gullies has been deposited in tributary streams that are characterised by ephemeral flows. Streambeds are well vegetated with bracken fern and *Lomandra* stabilising sediments. However, a proportion of dispersible sediment fractions continue to be delivered to the estuary during high flow events. The main issue of concern is ongoing erosion of an old foreshore access track that continues to deliver sediment to the estuary back lagoon and needs addressing.

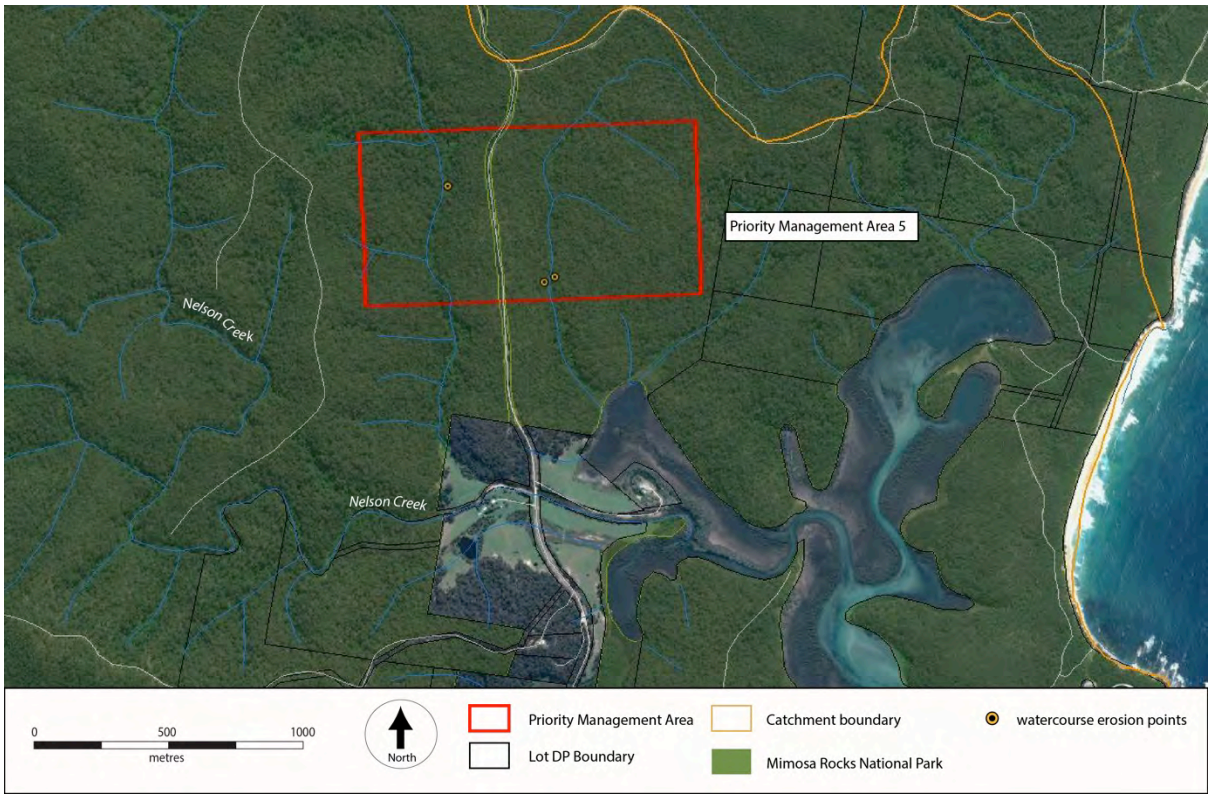


Figure B20 Location of priority management area 5.

High priority issue that requires attention include:

- **Issue 5.1** Erosion of old foreshore access track with sedimentation impacts to estuary back lagoon

Low priority issues that require attention include:

- **Issue 5.2** Head cut and gully erosion
- **Issue 5.3** Rill erosion associated with historical logging operations
- **Issue 5.4** Erosion of poorly maintained NPWS management track

Each issue is described with recommended actions for treatment provided in sections below.

APPENDIX B

Issue 5.1 Erosion of old foreshore access track with sedimentation impacts to estuary back lagoon

HIGH PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B5**).

Lat/Long Coordinates: 36°40'24.54"S, 149°58'25.99"E

Issue Description: Erosion of an old foreshore access track approximately 300m long has caused historical sedimentation impacts to the estuary back lagoon with deposition of coarse hill-slope sediments evident at the lagoon margin. Mangroves are absent from this localised deposition area and it may have previously been used to launch small boats. The track is covered in leaf litter and several logs already provide some erosion and sedimentation control. Ongoing erosion of the track will continue to deliver sediment to the estuary and this issue can be easily treated with the addition of several more log berms and use of siltation fence.

Recommended Treatment Action/s:

- Consult with NPWS to determine whether foreshore access at this location is to be maintained.
- Address erosion by using a combination of siltation fences and constructing several log berms to trap sediments and minimise further potential sediment input to the back lagoon.

Figure B21 Deposition of hill slope sediments at the margin of estuary back lagoon due to erosion of old foreshore access track (*left image*). Example of erosion affecting the foreshore access track (*right image*).

Issue 5.2 Head cut and gully erosion

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B5**).

Lat/Long Coordinates: 36°39'57.48"S, 149°58'27.11"E; 36°39'48.24"S, 149°58'30.39"E; 36°39'51.19"S, 149°58'1.13"E

Issue Description: Multiple examples of active head-cut that have formed deep incised gullies. Natural erosion process that shows examples of undercutting, lateral bank erosion and slumping due to highly erodible, sodic soils. These may have been exacerbated by historical logging operations and past fire events in the forest. Difficult to treat due to scale of problem and site access. Majority

of the sediment fractions eroded from the head-cut and gullies has been re-deposited downstream and may not reach the estuary. The stream channel is well vegetated with bracken fern (*Blechnum* sp.) and *Lomandra longifolia* providing stability to streambed sediments. However, a proportion of dispersible fraction of sediment fines has and will continue to be delivered to the estuary back lagoon during high flow events.

Recommended Treatment Action/s:

- This is a natural process and would be difficult to treat due to the scale of the problem. Potential options include undertaking a collaborative research project with a university to further investigate the significance of the process – spatially and temporally, and identify factors that may be exacerbating the process, and what potential actions could be undertaken to halt or slow down process.

Figure B22 Deeply incised gully formation along drainage line of a minor stream (*left image*). Example of downstream channel where majority of gully sediments have been deposited and colonised by vegetation that provides stability to the streambed (*right image*).

Issue 5.3 Rill erosion associated with historical logging operations

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B5**).

Lat/Long Coordinates: 36°40'6.37"S, 149°58'15.08"E

Issue Description: Rill erosion caused by soil disturbance (e.g. log snig track), which has eroded and incised over time. Sediment delivered to tributary stream but a portion of dispersible sediment may be delivered to estuary during high flow events.

Recommended Treatment Action/s:

- Address erosion by constructing several log berms to trap sediments and encourage colonisation of vegetation.

APPENDIX B

Figure B23 Example of rill erosion on the hill slope of management area 5 caused by disturbance of the soil surface likely due to historical logging operations. This issue can be treated by constructing several log berms to disperse surface runoff, trap sediments and encourage colonisation of vegetation.

Issue 5.4 Erosion of poorly maintained NPWS management track

LOW PRIORITY

Site Address [Responsibility]: Mimosa Rocks National Park [NPWS] (Refer **Map B5**).

Lat/Long Coordinates: 36°40'6.37"S, 149°58'15.08"E

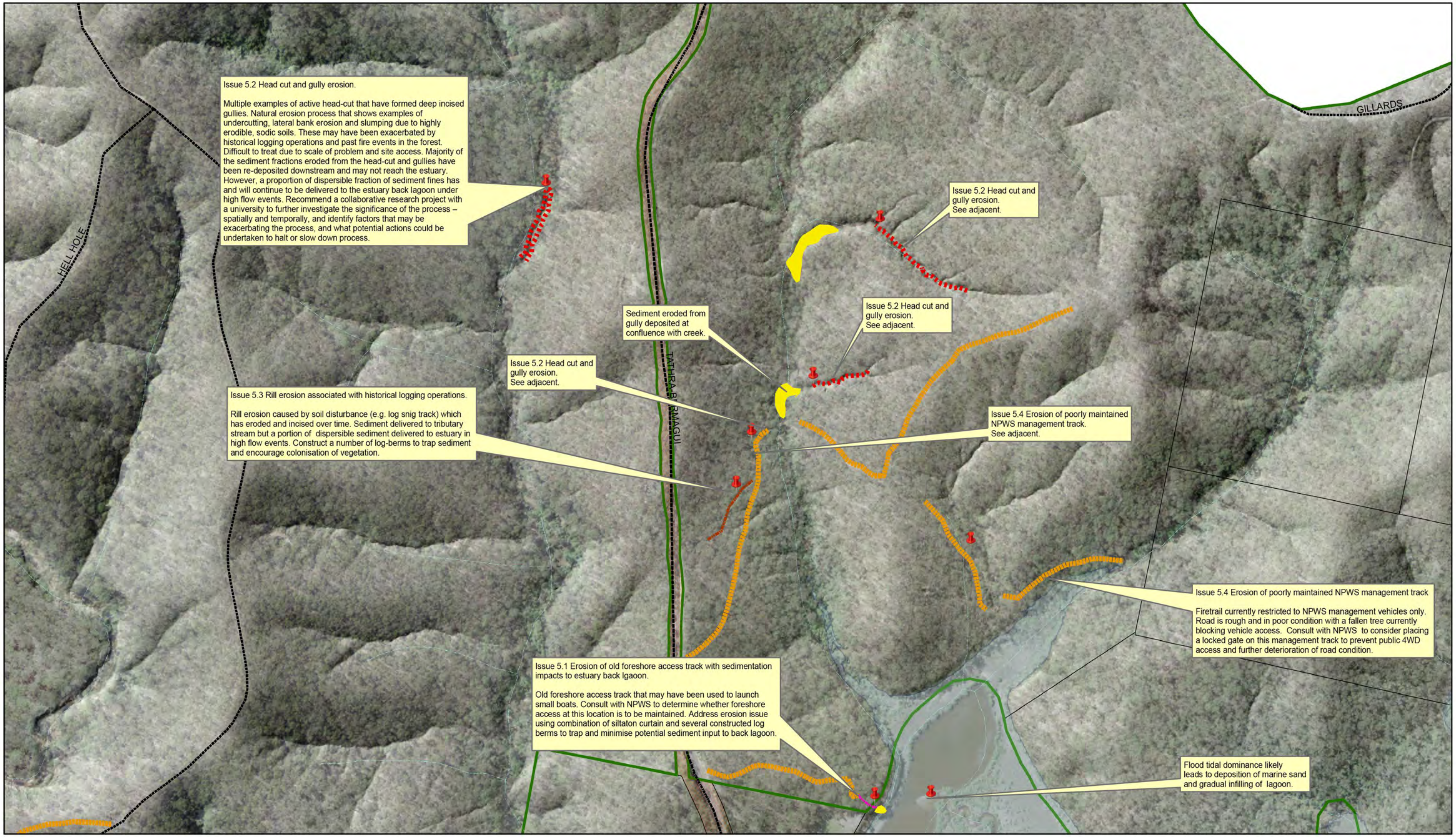
Issue Description: Firetrail currently restricted to NPWS management vehicles only. Road is rough and in poor condition with a fallen tree currently blocking vehicle access. Multiple examples of poor surface runoff controls with road erosion causing sedimentation impacts to tributary streams.

Recommended Treatment Action/s:

- Consult with NPWS to consider placing a locked gate on this management track to prevent public 4WD access and further deterioration of road condition.

APPENDIX B

Figure B24 Example of NPWS management track showing minor to moderate erosion (*left image*). Localised areas of road erosion include nick-points with potential to develop into gullies if left unaddressed (*right image*).



Issue 5.2 Head cut and gully erosion.
Multiple examples of active head-cut that have formed deep incised gullies. Natural erosion process that shows examples of undercutting, lateral bank erosion and slumping due to highly erodible, sodic soils. These may have been exacerbated by historical logging operations and past fire events in the forest. Difficult to treat due to scale of problem and site access. Majority of the sediment fractions eroded from the head-cut and gullies have been re-deposited downstream and may not reach the estuary. However, a proportion of dispersible fraction of sediment fines has and will continue to be delivered to the estuary back lagoon under high flow events. Recommend a collaborative research project with a university to further investigate the significance of the process – spatially and temporally, and identify factors that may be exacerbating the process, and what potential actions could be undertaken to halt or slow down process.
GILLARDS
HELL HOLE
Issue 5.2 Head cut and gully erosion. See adjacent.
Issue 5.2 Head cut and gully erosion. See adjacent.
Sediment eroded from gully deposited at confluence with creek.
Issue 5.2 Head cut and gully erosion. See adjacent.
Issue 5.3 Rill erosion associated with historical logging operations.
Rill erosion caused by soil disturbance (e.g. log snig track) which has eroded and incised over time. Sediment delivered to tributary stream but a portion of dispersible sediment delivered to estuary in high flow events. Construct a number of log-berms to trap sediment and encourage colonisation of vegetation.
TATHRA-BERMAGUI
Issue 5.4 Erosion of poorly maintained NPWS management track. See adjacent.
Issue 5.4 Erosion of poorly maintained NPWS management track
Firetrail currently restricted to NPWS management vehicles only. Road is rough and in poor condition with a fallen tree currently blocking vehicle access. Consult with NPWS to consider placing a locked gate on this management track to prevent public 4WD access and further deterioration of road condition.
Issue 5.1 Erosion of old foreshore access track with sedimentation impacts to estuary back lgaoon.
Old foreshore access track that may have been used to launch small boats. Consult with NPWS to determine whether foreshore access at this location is to be maintained. Address erosion issue using combination of siltaton curtain and several constructed log berms to trap and minimise potential sediment input to back lagoon.
Flood tidal dominance likely leads to deposition of marine sand and gradual infilling of lagoon.

0 105 210 420 630 840 Meters

Legend

- Issues
- Rilling
- Sediment Delivery to Estuary
- Road Erosion
- Bank Erosion
- Roads
- Deposition
- HAT (1.286 m AHD)
- Rivers & Creeks
- Crown Road Resrve
- Mimosa Rocks National Park
- Lot / DP Boundaries

NELSON LAGOON CATCHMENT MANAGEMENT PLAN

NELSON LAGOON PRIORITY MANAGEMENT AREA 5

Riparian engineering

GDA
GDA 94 Zone 55

Sheet No.

Map B5

Analysis By: Tim Dilworh
River & Coastal Engineer MIE CPEng Aust, NER, RPEQ

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX C

Conceptual Drawings of Typical Treatments

- **Lower Estuary**
- **Upper Estuary**
- **Lower Freshwater**

LOWER ESTUARY FORESHORE

Tidal Areas (saline waters)

A range of diverse vegetation communities occurs close to the shores of Nelson Lagoon. Two of these vegetation communities include *Far South Coast Foothills Dry Scrub Forest*, sometimes in the variant form dominated by *Corymbia maculata* (spotted gum) and *Eucalyptus paniculata* (grey ironbark), and *Southeast Warm Temperate Rainforest*.

Tree, shrub and graminoid species listed here already occur in this zone and are recommended for rehabilitation works.

Vegetation Structure

Large Trees

Corymbia maculata (Spotted gum)
Eucalyptus agglomerata (White stringybark)
Eucalyptus bosistoana (Grey box)
Eucalyptus tricarpa (Red ironbark)
Eucalyptus paniculata (Grey ironbark)

Shrubs/Mid-size trees

Melaleuca ericifolia (Swamp paperbark)
Pittosporum undulatum
Myoporum acuminatum (Boobialla)
Banksia serrata (Old man banksia)

Graminoids

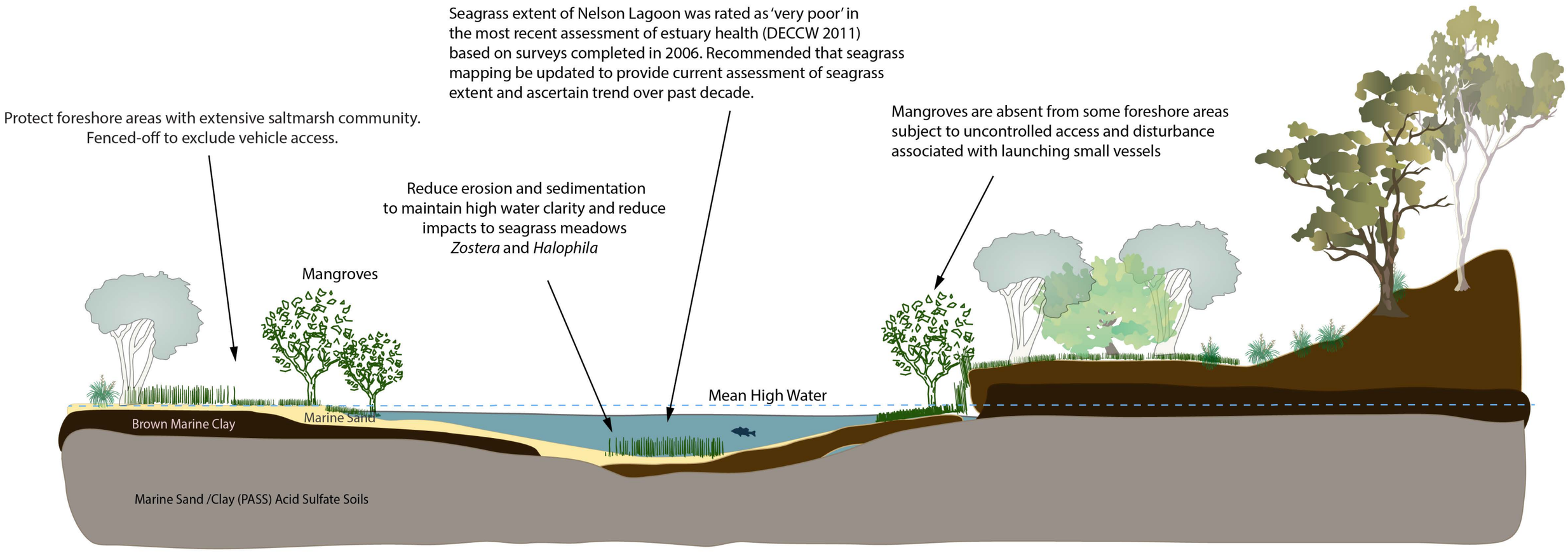
Lomandra longifolia
Austrostipa stipoides
Gahnia filum

Mangrove

Avicennia marina (Grey mangrove)

Saltmarsh/ Saline wetland sp.

Seagrass extent of Nelson Lagoon was rated as 'very poor' in the most recent assessment of estuary health (DECCW 2011) based on surveys completed in 2006. Recommended that seagrass mapping be updated to provide current assessment of seagrass extent and ascertain trend over past decade.



This conceptual drawing is a general guide for vegetation structure of lower estuarine foreshore of Nelson Lagoon.
Specific sites would require investigation and planning prior to undertaking works.

RIPARIAN ZONE OF UPPER ESTUARY

Below tidal limit

Plants growing in this estuarine-riparian zone must contend with a degree of saline influence.

Stream banks in this zone are composed of alluvial material and assisted natural regeneration of areas where erosion is or may become an issue is recommended. Tree, shrub and graminoid species listed here already occur in this zone and are recommended for rehabilitation works.

Vegetation Structure

Large Trees

Eucalyptus botryoides (Mahogany)

Shrubs/Mid-size trees

Melaleuca armillaris (Honey myrtle)
Acacia floribunda
Acacia mearnsii (Black wattle)
Myoporum acuminatum (Boobialla)

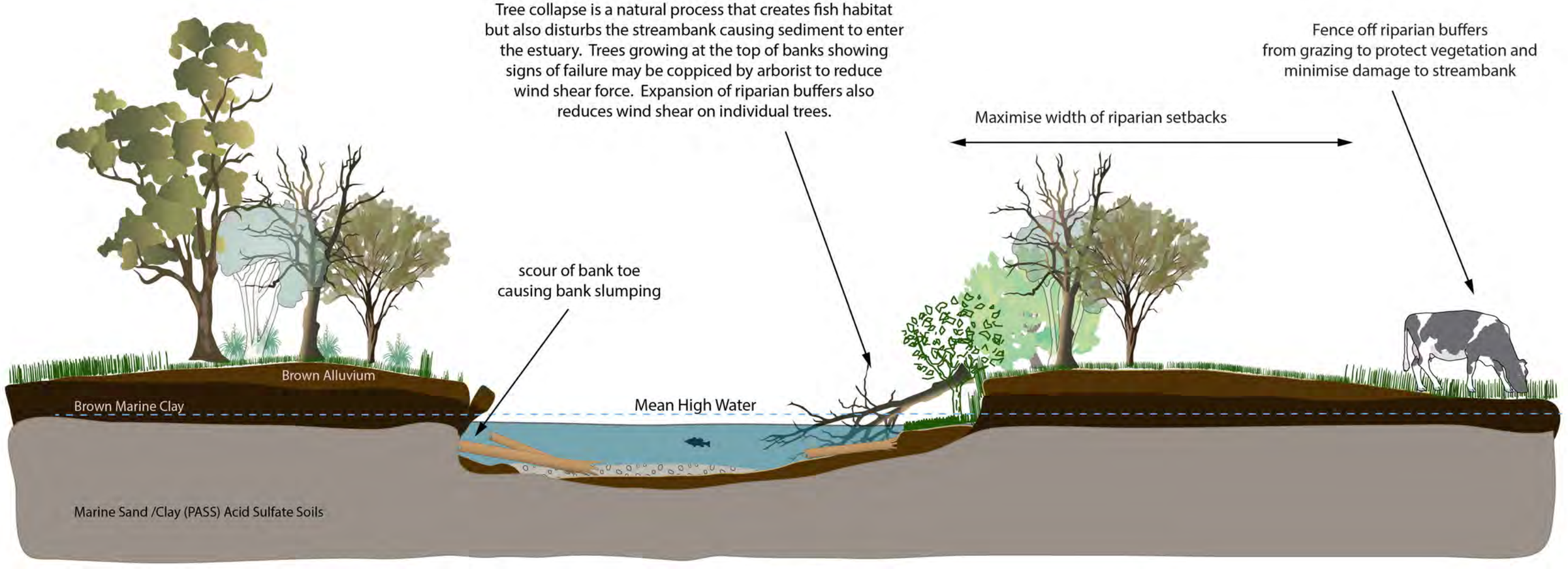
Mangrove

Avicennia marina (Grey mangrove)

Graminoids

Lomandra longifolia
Juncus krausii

Saltmarsh/ Saline wetland sp.



This conceptual drawing is a general guide for riparian vegetation structure of the upper estuary of Nelson Lagoon. Specific sites would require investigation and planning prior to undertaking works.

RIPARIAN ZONE OF LOWER CATCHMENT

Freshwater environment above tidal limit

A relatively wide range of species could be used for reahbilitating sites located in this zone. For high energy sites prone to erosion in flood events, recommend the planting of *Tristaniopsis laurina* (kanooka), *Commersonia fraseri* (black fellows hemp) and *Lomandra longifolia*.

Commersonia fraseri is a fast-growing post-disturbance coloniser that has been observed to form dense stands on banks in wake of major flood events. Both *Tristaniopsis* and *Lomandra* grow within the stream beds and play and major role in consolidating streambed sediments.

Large Trees

Eucalyptus botryoides (Mahogany)
Backhousia myrtifolia (Grey myrtle)
Eucalyptus cypellocarpa (Monkey gum)
Eucalyptus elata (River peppermint)
Szygium smithii (Lillipilli)

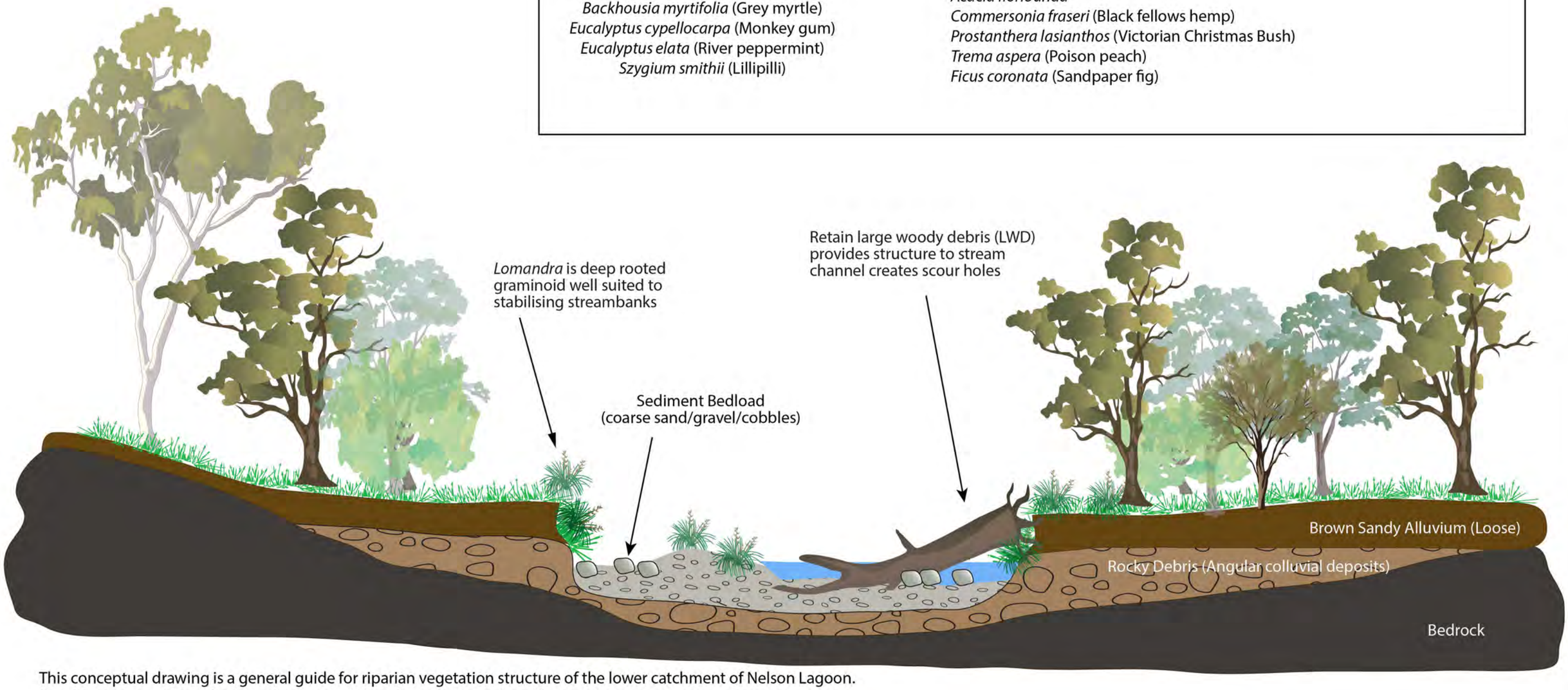
Vegetation Structure

Shrubs/Mid-size trees

Tristaniopsis laurina (Kanooka)
Acacia floribunda
Commersonia fraseri (Black fellows hemp)
Prostanthera lasianthos (Victorian Christmas Bush)
Trema aspera (Poison peach)
Ficus coronata (Sandpaper fig)

Graminoids

Lomandra longifolia



This conceptual drawing is a general guide for riparian vegetation structure of the lower catchment of Nelson Lagoon. Specific sites would require investigation and planning prior to undertaking works.

APPENDIX D

List of Plant Species recommended for Rehabilitation Works

A preliminary list of plant species is provided here grouped in accordance with the three types of management sites for which rehabilitation planting may be undertaken. The three sites include:

- Lower estuary foreshore
- Riparian zone of upper estuary below tidal limit
- Riparian zone of lower catchment above tidal limit

The species list provided is indicative only and ***no species should be selected for any specific site without a careful assessment of the species likely to have once been present there***.

Careful species selection is required so as to harmonize new plantings within existing distribution patterns. Seed of local provenance should always be used for propagation so as to preserve genetic integrity.

In general, a minimalist approach is desirable with only species being planted that are likely to be slow to re-colonise a site naturally. Local natural vegetation has great resilience and a strategy of assisted natural re-generation generally produce better, more aesthetically satisfying outcomes than deliberate interventions.

Lower estuary foreshore	
Corymbia maculata (spotted gum)	Large tree
Eucalyptus agglomerata (white stringybark)	Large tree
Eucalyptus bosistoana (grey box)	Large tree
Eucalyptus tricarpa (red ironbark)	Large tree
Eucalyptus paniculata (grey ironbark)	Large tree
Pittosporum undulatum	Medium tree
Melaleuca armillaris	Shrub
Myoporum acuminatum (boobialla)	Shrub
Lomandra longifolia	Graminoid

APPENDIX D

Riparian zone of Upper estuary below tidal limit	
Plants growing in this zone must contend with a degree of saline influence. Stream banks in this zone are composed of alluvial material. The following shrub, tree and graminoid species are recommended:	
Acacia floribunda	Shrub
Melaleuca armillaris	Shrub
Myoporum acuminatum (boobialla)	Shrub
Acacia mearnsii (black wattle)	Medium tree
Eucalyptus botryoides (mahogany)	Large tree
Lomandra longifolia	Graminoid
Juncus krausii	Graminoid

Riparian zone of lower catchment above tidal limit	
A relatively wide range of species could be used for sites in this zone. For high energy sites prone to erosion in flood events, recommend the planting of *Tristaniopsis laurina* (Kanooka), *Commersonia fraseri* and *Lomandra longifolia. Commersonia fraseri* is a fast-growing post-disturbance coloniser that has been observed to form dense stands on banks of Sandy Creek (Middle Catchment) and Cuttagee Creek in the wake of major flood events. Both *Tristaniopsis laurina* (Kanooka) and *Lomandra longifolia* grow within the stream beds. They have the capacity to survive major flood events and a play a major role in consolidating streambed sediments. The following shrub, tree and graminoid species are recommended:	
Acacia floribunda	Shrub
Prostanthera lasianthos (Victorian Christmas bush)	Shrub
Trema aspera (poison peach)	Shrub
Tristaniopsis laurina (Kanooka)	Medium tree
Backhousia myrtifolia (grey myrtle)	Large tree
Commersonia fraseri	Medium tree
Ficus coronata (sandpaper fig)	Medium tree
Eucalyptus elata (river peppermint)	Large tree
Eucalyptus botryoides (mahogany)	Large tree
Eucalyptus cypellocarpa (monkey gum)	Large tree
Szygium smithii (lillipilli)	Medium to Large tree
Lomandra longifolia	Graminoid