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Catchment Management Plan

REPORT

Prepared for

Bega Valley Shire Council

15 July 2016

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bega valley shire council

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Kyran Crane (BVSC)

Danny Wiecek (OEH)

Stuart Cameron (Local Resident)

Manly Hydraulics Laboratory

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 Cuttagee Lake.

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 Cuttagee Lake, 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 July 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 Cuttagee Lake.

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 Cuttagee Lake 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, seven (7) priority management areas have been identified; all situated in the lower Cuttagee catchment close to the estuary. Within each management area, at least one or more of the following issues is currently occurring - road erosion, weed incursion, 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 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
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
SELLS	South East Local Land Services

INTRODUCTION

1 BACKGROUND AND PROJECT OBJECTIVES

Cuttagee Lake 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. Water quality impacts may also be further exacerbated when the estuary entrance is closed.

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 Cuttagee Lake.

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

1.1 SCOPE OF WORK AND PROJECT TIMELINE OVERVIEW

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, Bermagui Library
6	March-May 2016	• Draft report review
7	July 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 in a series of 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 Bermagui Library 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 Cuttagee Lake catchment.

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

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

1.2 STUDY AREA

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

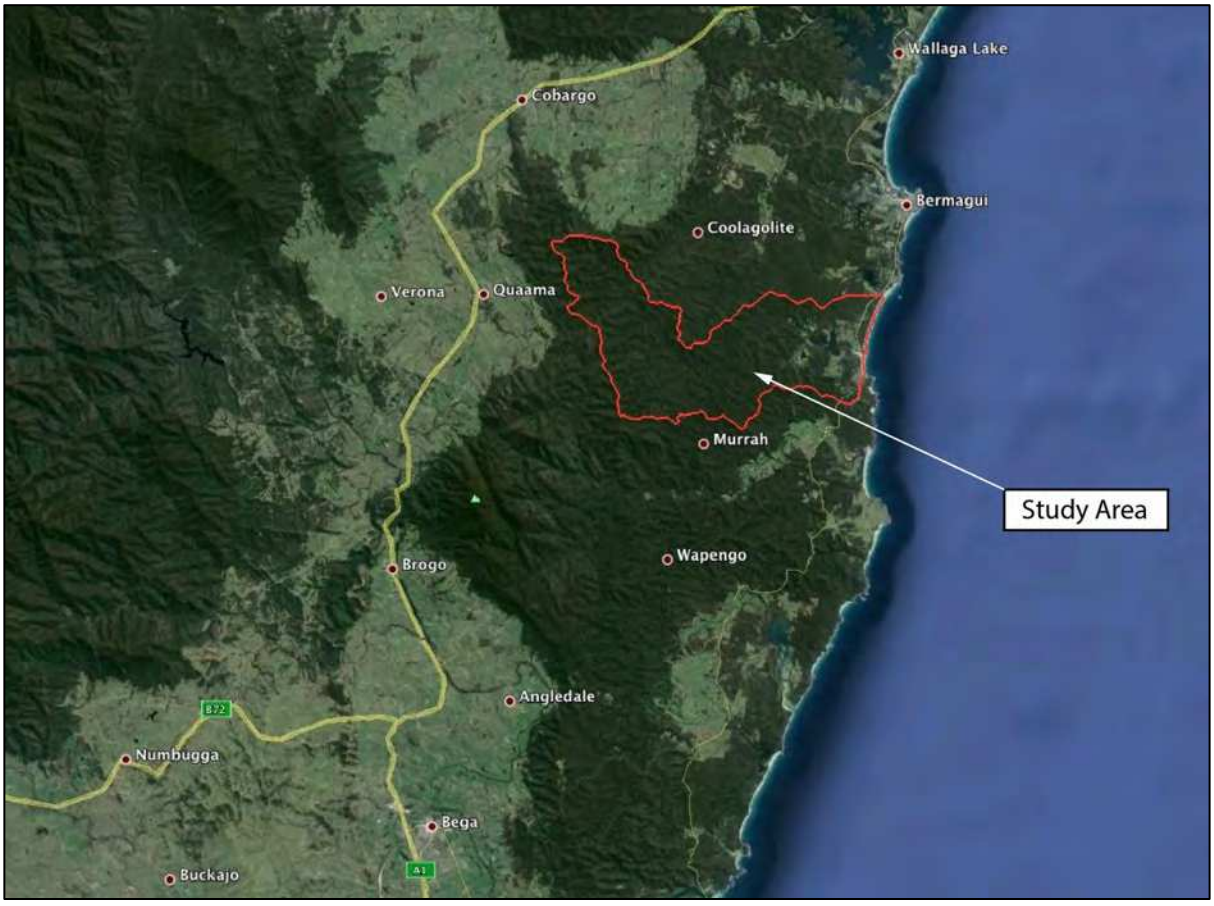


Figure 1. Catchment Area of Cuttagee Lake.

INTRODUCTION

2 CATCHMENT AND ESTUARY PROFILE

The Cuttagee catchment is 53.25 km^2 in area bounded by the ridgelines of Head of Cuttagee Road to the north, Bandicoot Road to west, and Murrah Forest Road to south. Cuttagee Creek is the primary catchment stream whose headwaters originate on the slopes of Cadjangarry Mountain in Biamanga National Park at an elevation of 370m 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 eventually discharging to the estuary on its southwestern shoreline.

The estuary, referred to as Cuttagee Lake, has a waterway size (including saltmarsh areas) of 1.23 km^2 (OEH 2016a). The estuary is a shallow, saline coastal lagoon classified as a semi-mature, wave-dominated, intermittent estuary (Roy *et al.* 2001). Estuary maturity refers to its stage of sediment infilling. Cuttagee Creek is the primary source of fluvial sediment supply with its propagating fluvial delta encroaching across the middle of the lake and that over time, is effectively dividing the estuary into three separate basins as shown in **Figure 2**.

Figure 2. Simplified geomorphological model of Cuttagee Lake (from Elgin 2014).

Wave action is a dominant force influencing the geomorphology of the estuary, which is characterised by a sand barrier at its mouth enclosing the central basin (Roy *et al.* 2001). The sand barrier creates a constricted ocean entrance that becomes intermittently closed to the ocean for prolonged time periods. In NSW these types of estuaries are commonly referred to as ICOLLs – *intermittently closed or open lakes or lagoons*.

ICOLLs are characterised by a broad range of ecological conditions that include tidal flows when open to ocean, a variable salinity regime, and variable water levels that has had significant

implications for the estuarine communities they support. Historically Cuttagee Lake has been permitted to open and close naturally. In more recent times, the estuary has been opened artificially, both by BVSC and illegally by members of the public. Further discussion regarding the intermittent nature of the estuary entrance is provided in Section 2.5 below.

A brief summary of Cuttagee Lake and Catchment characteristics is provided in **Table 1** below.

Table 1. Summary of Cuttagee Lake and Catchment Characteristics

Estuary waterway size: 1.23 km^2	**Catchment Area:** 53.25 km^2 <5% cleared, 45% Biamanga National Park (23.8 km^2), 47% Murrah State Forest (25.2 km^2)
Primary Inflow: Cuttagee Creek	
Estuary type: Semi-mature, Saline coastal lagoon (Roy *et al.* 2001)	
Estuarine vegetation: Saltmarsh 0.113 km^2, Seagrasses (*Zostera, Halophila* and *Ruppia*) 0.385 km^2 Estimated that 10-40% decline in seagrass extent over 20-year period from 1985 to 2006 (Creese *et.al.* 2009). Observations from 2010 to 2013 suggest a large loss of seagrass has occurred since the last assessment of seagrass extent in 2006 (Elgin 2014). Decline in seagrass extent is thought to be attributed to ongoing sedimentation of the central basin.	
Catchment land-uses: forestry, agricultural grazing, rural residential, recreation.	
Commercial activities: The estuary is available to commercial fishing as part of NSW Region 7 - Estuary General Fishery.	
Endangered Ecological Community (EEC) types: The catchment contains six (6) vegetation types listed as EECs under the *NSW Threatened Species Conservation Act 1995* (TSC Act) including - *Coastal Saltmarsh, Freshwater Wetlands, Bangalay Sand Forest, River-Flat Eucalyptus Forest, Swamp Schlerophyll Fores*t and *Littoral Rainforest.*	

Estuary opening-closure regime: (based on 10 years of observations)	Average	Minimum	Maximum
Entrance open duration (days):	219	14	541
Entrance closed duration (days):	224	12	544

Entrance Opening Policy: Draft policy currently in preparation by BVSC.

Water Quality:

- Low levels of nutrients. Mean levels of nitrogen and phosphorous typically below guideline limits.
- High levels of dissolved oxygen during open and closed periods. Water column is well-mixed either by tidal flows and/or wind advection during open and closed periods.
- Seasonal algal blooms occur occasionally though not currently a serious issue for ecosystem health.

INTRODUCTION

2.1 CATCHMENT GEOLOGY AND LANDFORMS

Majority of the catchment (90%) is underlain by Ordovician metasediments that can be observed outcropping around the shores of Cuttagee lake, in streambeds and occasionally on ridges. Late Devonian sediments of the Merimbula Group cap ridges at the southwestern extremity of the catchment and the lower catchment and estuary foreshore is characterised by Quaternary alluvial deposits. Granite does not occur in the catchment.

The Ordovician metasediments, often reinforced by quartz veins, 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 Late Devonian sediments produce shallow soils of even lower fertility. The geological characteristics of the catchment accounts for the limited efforts that have been made to clear land for farming.

2.2 LAND TENURE AND LAND-USES

The upper catchment is divided between State Forest and National Park tenure. Cuttagee Creek forms the boundary between Biamanga National Park on its northern bank and Murrah State Forest on the southern bank. Majority of the catchment (>90%) remains forested although large areas have been disturbed by historical forestry operations. Private land tenure is restricted to lands in the lower catchment close to the estuary as shown in **Figure 3** and represents approximately 8% of the total catchment area. It is estimated that 5% of the catchment has been cleared for agricultural grazing/rural residential uses.

Summary of catchment land tenure:

- Biamanga National Park (23.8 km^2) - 45% of catchment area
- Murrah State Forest (25.2 km^2) - 47% of catchment area
- Private Land tenure – approx. 8% of catchment area

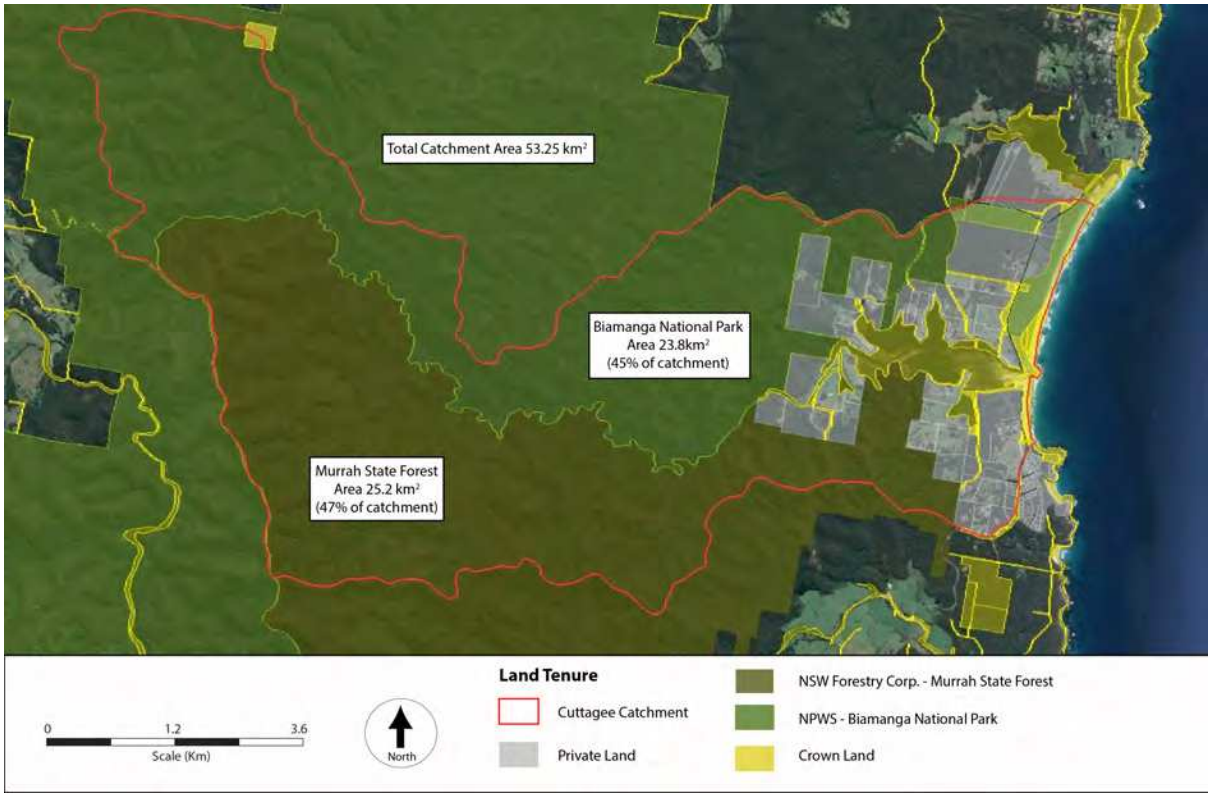


Figure 3. Cuttagee Catchment Land Tenure

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 Cuttagee catchment includes large areas of the upper catchment that have been subject to forestry operations since early 1900s and the associated network of unsealed road and snig-tracks, the majority (95%) of which was constructed between 1971 and 1976 (NSW State Forests EIS, 1994). There are approximately 75 km of unsealed roads within the catchment representing <1% of the catchment area. It is acknowledged that unsealed roads and their associated runoff controls (*i.e.* mitre drains) is a significant contributor of sediment to catchment streams (Croke *et al* 2006).

Land areas in the lower catchment were cleared for agriculture that probably commenced by early 1900s including small-scale dairying and some cropping. Commercial farming in the catchment was effectively abandoned from the late 1970s. The concomitant destocking and a relaxation of efforts to keep land clear of woody vegetation, has permitted substantial natural re-colonisation by local native species, especially on the immediate foreshore zone.

Discussion with a number of landholders during the study provide the following accounts of observed sedimentation impacts to the estuary that may be due to a combination of past and present natural and man-made disturbances in the catchment. A description of these accounts is provided below:

Landholder #1 – *Rapid sedimentation of the un-named creek that enters the estuary at its western margin was observed in the time since 1970s. The creek was once characterised by many wide swimming holes up to 8ft deep and upstream fish passage was common. However, the impact of rapid sedimentation of the creek since the 1970s has infilled the once deep creek, the creek is now a shallow and narrow watercourse. The impacts of sedimentation to the creek can be seen at the fluvial delta at the western margin of the lake where catchment sediments are continually being exported to the estuary.*

Landholder #2 – *Two large flood events occurred in 2010 and as a result significant amounts of new sediment were deposited at the fluvial delta of Cuttagee Creek. Large areas of seagrass community occurring in the immediate vicinity were subsequently buried. This area was casually monitored over the following years for signs of seagrass recovery by one of the authors of this report. Seagrass remained absent for at least a 2-year period before signs of recovery were observed in 2012.*

2.3 CATCHMENT VEGETATION

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

1) a diverse mosaic of communities occupying the lower catchment (within 1km of 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.

2.3.1 UPPER CATCHMENT VEGETATION

The upper catchment comprises dry, relatively steep ridges, and narrow, deeply incised gullies and the riparian zone along Cuttagee creek. The dry ridges support dry shrub forest communities, particularly *Far South Coast Foothills Dry Shrub Forest,* dominated by *Eucalyptus tricarpa* (red ironbark), *Eucalyptus bosistoana* (coast grey box) and *Eucalyptus longifolia* (woolybutt). Towards the western end of the catchment *Eucalyptus sieberi* (silvertop ash) tends to dominate and there are extensive *Allocasuarina littoralis* (black sheoak) stands. The dominance of these two latter species may result from past logging and burning practices.

Downslope towards the margins of the moist gullies *Eucalyptus cypellocarpa* (monkey gum) is the dominant *Eucalyptus* species above a predominantly fern groundcover. *Southeast Warm Temperate Rainforest* grows on the floors of the moist, relatively fire-protected gullies tributary to Cuttagee creek. Prominent taxa 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*, *Livistona australis* (cabbage palm).

The vegetation community in the narrow riparian zone of Cuttagee creek above the tidal limit (a community not described by Tozer *et al.* 2010) has significant rainforest elements but also a number of species restricted to alluvial sites subject to recurrent flood disturbance, such as *Tristaniopsis laurina* (kanooka), *Hedycarya angustifolia* (native mulberry), *Lomatia myricoides*, *Polyscias murrayi* (pencil cedar), *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 mosaic of diverse vegetation communities occurs in the lower catchment and close to the shores of Cuttagee Lake. These include *Far South Coast Foothills Dry Shrub Forest,* sometimes in the variant dominated by *Corymbia maculata* (spotted gum), and *Southeast Warm Temperate Rainforest.* These vegetation communities would have occupied most of the lower catchment areas that have been cleared.

More significantly, six endangered ecological communities (EEC) have been mapped in the lower catchment (OEH 2013), all on the foreshore of, or in close proximity to the estuary as shown in **Figure 4**. These include *Coastal Saltmarsh, Bangalay Sand Forest, Littoral Rainforest, Freshwater*

Wetlands on Coastal Floodplains, River-flat Eucalypt Forest on Coastal Floodplain, and Swamp Sclerophyll Forest on Coastal Floodplains. Some of these are of very restricted extent or have been extensively cleared. Verifying the distribution and extent of EECs was outside the scope of this study however some notes regarding the EECs were recorded during field inspections. Comments regarding the occurrence and/or significant floristic components within of each of the six EECs is provided in **Table 2.**

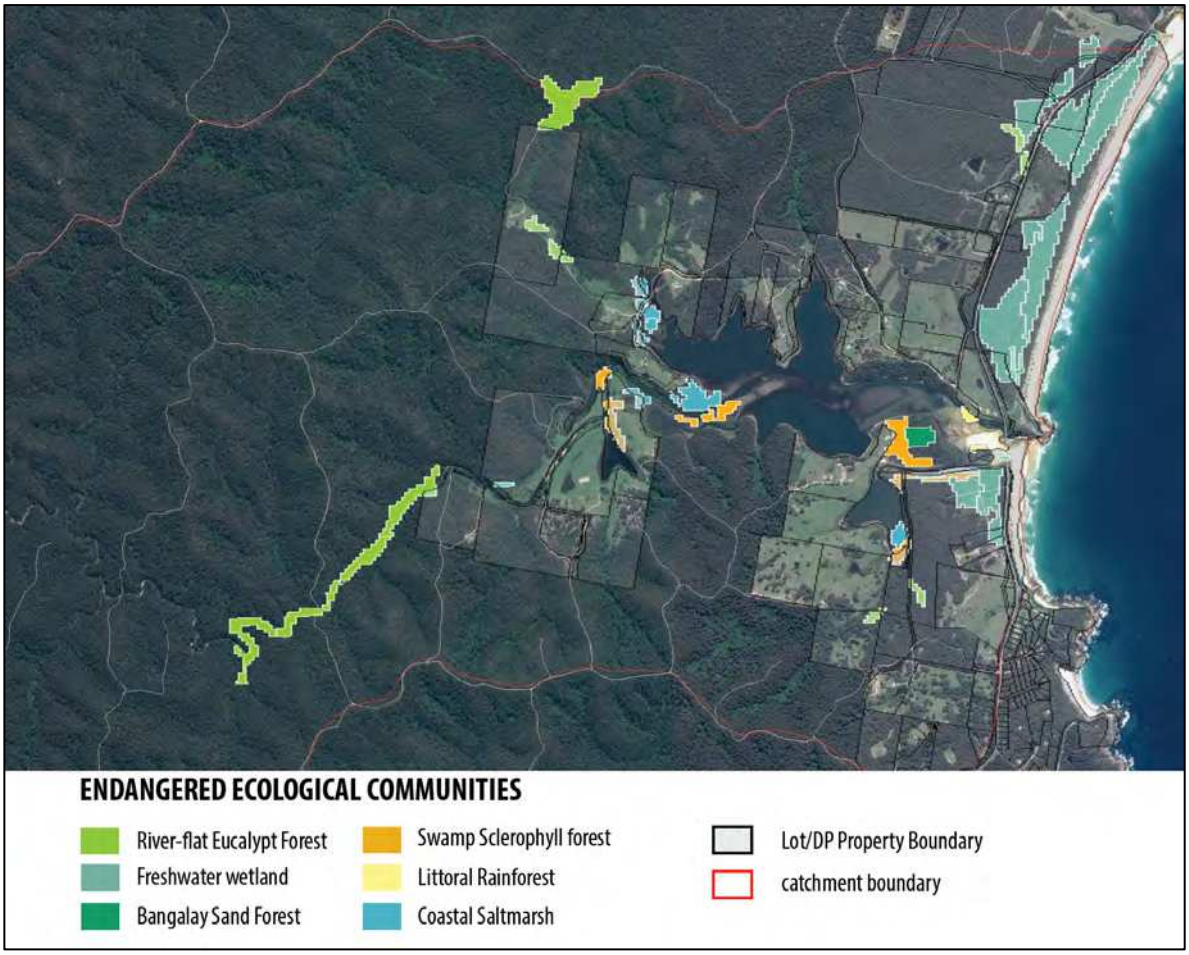


Figure 4. Distribution and extent of endangered ecological communities in Cuttagee catchment. (*Note* - mapping from OEH 2013 and has not been verified in this study).

2.3.3 OTHER RARE AND SIGNIFICANT FLORA

In addition to the six EECs listed in Cuttagee 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*, occurrence recorded at least four sites around the lake shore, with quite large populations at some sites.
- *Haloragis exalata subsp. exalata* (square raspwort), listed as *vulnerable* occurs at several sites around the lakeshore, exclusively within the high-stand inundation zone. This species is further discussed in Section 3.5.1 below.

- *Pomaderris bodalla*, another vulnerable species with a restricted distribution, occurs in a rainforest gully at the head of the lake.
- *Pultenaea pedunculata* (matted bush pea) an inconspicuous low-growing plant, listed as endangered in NSW, may occur in the catchment proper since it is present on roadsides at Cuttagee beach and Baragoot in very close proximity to the catchment.
- *Calocephalum lacteus* (cream beautyheads), a small daisy much more common in Victoria and Tasmania, had not been recorded in NSW until the discovery of small populations round the shores of Cuttagee and Baragoot lakes. Known populations grow in rough pasture on private land.
- *Acacia pedina* is a species with a very restricted distribution between Bermagui and Tathra. It is quite common round the Cuttagee shore, predominantly occurring just above the high stand level.
- *Myoporum bateae*, described as *rare in nature, although not endangered at present* is quite widespread around the Cuttagee shoreline. *Correa baeuerlenii* (Chef's cap correa), similarly rare and of restricted distribution grows in the gravel bars of Cuttagee creek.

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

EEC Name	Comments
Coastal Saltmarsh	Occurs at the inland extremities of Cuttagee and Little Cuttagee lake, at the mouth of Cuttagee lake and as a narrow fringe adjacent to where minor gullies enter the lake. Saltmarsh is estimated to cover 0.113 km^2 in area (Creese *et al.* 2009). It is in good condition in Cuttagee catchment and has a large population of the threatened species *Wilsonia backhousiae* (listed as *Vulnerable*). Those saltmarsh species dependent upon an uninterrupted tidal regime are not present in Cuttagee (refer to Section 2.5.1)
Freshwater Wetlands on Coastal Floodplains	Occurs on private land on the alluvial flats at the head of the lake. Patches are small and are subject to stock grazing.
Bangalay Sand Forest	*Bangalay Sand Forest* is restricted to the chenier formation on the peninsula between Cuttagee and Little Cuttagee Lakes. Dominated by large old *Eucalyptus botryoides* (bangalay) trees this small patch of forest is in excellent condition.
River-flat Eucalypt Forest on coastal floodplain	Mapped as extending some distance along Cuttagee creek above the tidal (and high stand) limit. The identification is debatable however, since few of the key indicator species described in the Scientific Committee determination are present there. The vegetation of this riparian zone is described in Section 2.3.1 above.
Swamp sclerophyll forest on coastal floodplains	Mapped as occurring as several small patches around the lake. At Cuttagee few of the indicative species 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 Cuttagee examples are in good condition.
Littoral Rainforest	*Littoral Rainforest* occurs as two tiny patches, one on the south side of Cuttagee headland, the other just west of the bridge. Both are dominated by *Szygium smithii* (lillipilli) and have been invaded by blackberry, which is now being controlled.

2.3.4 EXISTING CONDITION AND FUTURE TRAJECTORY OF ESTUARY FORESHORE VEGETATION COMMUNITY

The existing condition of estuary foreshore vegetation includes a number of good examples of remnant dry *Eucalyptus* forest on the exposed slopes and warm temperate rainforest in gullies, interspersed by previously cleared areas currently undergoing varying levels of successional change.

Substantial natural re-colonisation by local native species has occurred on the immediate estuary foreshore. Once-clear stretches of lake shore have been re-colonised initially by a fringe of *Melaleuca* and *Acacia* species. *Melaleuca armillaris* is dominant closest to the lake, except where freshwater seepage favours *Melaleuca ericifolia,* and *Acacia* species, especially *A. mearnsii (*black wattle*), A. pedina, A. longifolia* somewhat further upslope.

Currently the species succession that is occurring around the foreshore includes a substantial breakdown of the now senescent *Melaleuca* and *Acacia* regrowth with a somewhat more diverse suite of species gradually replacing them. Particularly prominent among these are *Myoporum acuminatum* (boobialla) and rainforest species such as *Pittosporum undulatum* (sweet pittosporum)*, Myrsine howitteana* (muttonwood)*,* as well as various *Eucalyptus* sp. seedlings. A good example of this succession process may be seen on the banks of Boggy creek on the northern shore of the lake.

The long term trajectory of the foreshore vegetation, in the absence of further significant disturbance, such as by renewed clearing or a major bushfire, will be to reconstitute the pattern still apparent in such places as the north side of the entrance channel or around the bay on the southern shore within the Murrah State Forest, which have never been wholly cleared. These sites are characterised by a very narrow fringe of *Melaleuca* sp. on the immediate shore (the zone commonly inundated during high stands) with warm temperate rainforest upslope in the moist gullies and *Eucalyptus* spp. dominated forest elsewhere.

The natural re-colonisation process of previously disturbed land at Cuttagee has been impressive and extensive over the past three decades (*pers. obs.* S. Cameron, Cuttagee Landholder), indicating the resilience of native vegetation when released from such inhibitors as grazing by livestock. 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 Cuttagee catchment is in very good condition with regards to weeds and could be considered relatively weed free in comparison to adjacent catchments such as Murrah, Bermagui and Wallaga

where upstream farmland provides a reservoir of weed propagules that can readily move down the catchment during floods.

Such ubiquitous weeds of disturbed sites as *Conyza* spp. (fleabane), *Cirsium vulgare* (sword thistle) *Senecio madagascariensis* (fireweed) are widespread in the cleared areas near the lake but have minimal impact on well established native vegetation.

Cuttagee headland at the mouth of the lake has been a weed hotspot with well-established populations of *Coprosma repens* (NZ mirror bush), *Rubus fruticosus* sp agg (blackberry) and *Araujia sericifera* (moth vine). The ongoing collaborative project to revegetate the headland, involving Bermagui Dunecare and BVSC, has greatly reduced these infestations and the risk they pose to the rest of the catchment. The effort will need to be maintained over the long term.

A small incursion of *Juncus acutus* (spiny rush) has been encountered on a property at the head of the lake during this study. This species poses a major threat to coastal saltmarsh and is a very high priority for eradication. This is one of only two populations known in the Shire and should be addressed as soon as possible. This is further discussed in Section 8 below.

Blackberry is widely scattered but not abundant around the lakeshore and on the banks of Cuttagee creek for a considerable distance inland. It is the most significant weed threat currently present in the catchment.

2.4 COASTAL GEOMORPHOLOGY

Cuttagee Lake is characterised as 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 river valley with a well-developed floodplain. This river 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; fluvial delta; central lake basin; lower estuary; and the entrance.

- 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 and back swamps.
- The fluvial delta propagates across the central lake basin, and the bulk of sediment eroded from the catchment is deposited at the fluvial delta. Rather than infilling the whole central lake basin evenly, sediment is deposited on the fluvial delta lobe, which is extending downstream towards the lower estuary. The ongoing migration of the fluvial delta is effectively dividing the estuary into three separate sub-basins with limited connectivity at low tide.

- The central lake basin was formed when the river valley was drowned approximately 7,000 year ago. Estuary basins gradual infill with fluvial sediment.
- 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, which adjoins the Tathra-Bermagui Road bridge 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.

The evolution of Cuttagee Lake from semi-mature to mature continues as catchment sediments infill the estuary.

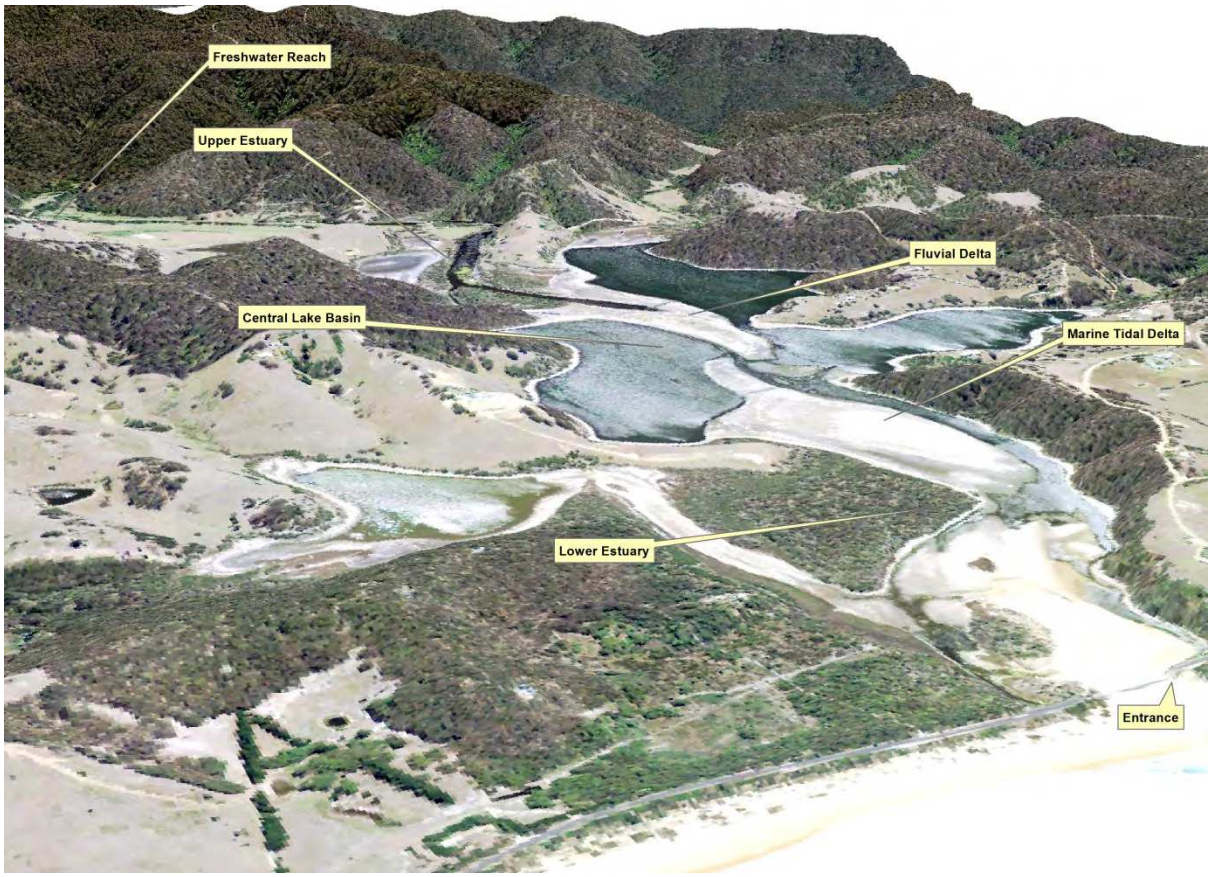


Figure 5. Distinct geomorphological zones of Cuttagee Lake.

2.5 ESTUARY ENTRANCE – OPEN AND CLOSED REGIME

The entrance of Cuttagee Lake intermittently opens and closes to the ocean. Factors contributing to the intermittent nature of the estuary entrance include coastal sediment transport processes (waves and currents), climatic factors such as rainfall (among others), catchment size and limited freshwater inflows to maintain a permanently open ocean entrance, which becomes blocked by beach sands.

Water levels and salinity of the estuary were monitored over a two-year period (June 2013 to March 2015) by OEH and Bega Valley Shire Council to better understand the maximum height attained by the entrance berm during closed periods and the duration of entrance open periods.

In addition, observations of entrance open-closed periods collected over a 10-year period (2004 to 2015) were provided by local Cuttagee resident S. Cameron. Analysis of the time series data and observations suggest the following characteristics about the behavior of the estuary entrance:

- Entrance opening periods are on average approximately 219 days duration. Over the past decade entrance open periods have ranged from 14 to 541 days.
- The estuary is subject to tidal flows during open periods, however the tidal prism can vary significantly depending on the capacity and tidal efficiency of the entrance. Tidal gauging data collected between June 2013 and March 2015 show the greatest tidal range of 0.48m between high tide (1.049m) and succeeding low tide (0.568m) occurred on 3 January 2014. Tidal data was collected over a limited time period and tidal range may exceed 0.48m after significant scouring of the entrance followed by a large spring tide.
- Sand is supplied to the entrance from nearshore coastal sand transport and overtime becomes progressively cut-off off from tidal flows when the berm reaches approximately 1.0m AHD. Once blocked by beach sands the entrance closures are on average approximately 224 days duration. Over the past decade closed periods have ranged from 12 to 544 days.
- During closed periods, lake standing water levels may exceed 2.0m AHD and historically the entrance has required artificial opening (Aug 2006, Sept 2014, June 2015) when high water levels persist above 1.8m AHD to alleviate inundation of low lying roads to permit access to private properties.
- In the period between June 2013 and March 2015 the maximum height attained by the entrance berm was 2.126m AHD. However, an entrance management policy for Cuttagee Lake is currently being developed by BVSC. A trigger level for artificially opening the lake is being proposed at 1.8m AHD so as to maintain road access for majority of landholders at the back of the estuary.
- The entrance opens naturally when water levels in the estuary exceed the height of the berm. This generally occurs after a large rainfall event.

A summary of Cuttagee Lake entrance open and closed periods observed since 2004 and entrance berm heights where known is provided in **Tables 3** and **4**.

Table 3. Summary of Cuttagee Lake entrance open – closed periods and water levels.

Entrance Open/Closed	Date[1]	Days Duration	Weeks Duration	Comment	Water Level (m AHD) at Opening[2]
open	16/05/03	397	56.7	Approx duration	
closed	16/06/2004	391	55.9		
open	12/07/2005	24	3.4		
closed	5/08/2005	379	54.1		
open	19/08/2006	91	13.0	Opened artificially	
closed	18/11/2006	210	30.0		
open	16/06/2007	421	60.1		
closed	10/08/2008	544	77.7	Approx date of closure	
open	5/02/2010	541	77.3		
closed	31/07/2011	215	30.7		
open	2/03/2012	415	59.3		
closed	21/04/2013	218	31.1		
open	25/11/2013	138	19.7		1.895
closed	12/04/2014	153	21.9		
open	12/09/2014	18	2.6	Opened artificially by BVSC	1.8
closed	30/09/2014	68	9.7		
open	7/12/2014	128	18.3		2.126
closed	14/04/2015	12	1.7		
open	26/04/2015	14	2.0		1.27
closed	10/05/2015	45	6.4		
open	24/06/2015			Opened artificially by BVSC	2.02

[1] Dates of open and closed periods recorded by S. Cameron (Cuttagee Resident)

[2] Water level data from OEH and MHL.

Table 4. Statistical summary of Cuttagee Lake entrance open – closed periods

	Average duration (days)	Min duration (days)	Max duration (days)	Total Days	% Time
Entrance Openings	218.7	14	541	2187	49.46
Entrance Closures	223.5	12	544	2235	50.54

2.5.1 ECOLOGICAL SIGNIFICANCE OF OPEN-CLOSED REGIME

The intermittent open and closed entrance of Cuttagee Lake (*i.e.* not permanently open to the ocean with a constant tidal regime) has been, and continues to be a significant and important influence on the distribution and variety of vegetation communities it supports around it shores and in its waters. Cuttagee Lake supports a suite of plant species that are adapted to prolonged entrance closures and a variable salinity regime and it is vital for these plant communities that the lake continue to alternate between open and closed conditions. For example, there is strong evidence to suggest the threatened shrub species *Haloragis exalata* subs *exalata* benefits from the disturbance caused by episodic high stands when the entrance is closed (Miles and Cameron 2007). This species is locally

rare being only known to occur at Cuttagee Lake within the Bega Valley region with other isolated populations recorded in the Eurobodalla and Shoalhaven regions.

Species that require a constant tidal regime and that are present in nearby permanently open estuaries such as Bermagui River estuary and the Murrah estuary are absent from Cuttagee. These include mangroves (*Avicennia marina* and *Aegiceras corniculatum*) and the saltmarsh species *Limonium australe* (sea lavender)*, Austrostipa stipoides* and *Gahnia filum.* However, the rare and threatened saltmarsh species *Wilsonia backhousiae* that occurs at Bermagui river estuary also occurs quite extensively at Cuttagee Lake, and evidently able to withstand months of total immersion without any damage.

In terms of estuarine vegetation, the natural intermittent closures make the estuary suitable for *Halophila* (paddleweed*)* and *Zostera* (eel grass) seagrass but not *Posidonia australis* (strapweed) that require marine conditions provided by a permanently open estuary. In contrast, the variable salinity regime and at times brackish waters of Cuttagee Lake provides suitable conditions for *Ruppia megacarpa* (sea tassel) that relies upon periods of low salinity in order for seeds to germinate.

During closed periods, the estuary water levels may increase to high stands exceeding 2.0m AHD and substantially higher than mean high water springs (MHWS) tide level of 0.556m AHD. If high water stand conditions persist for long enough, almost all the inundated foreshore vegetation drowns, even including seedlings of such inundation-tolerant species as *Melaleuca* spp. and *Myoporum acuminatum.* These high stand events also exclude eucalypts from colonising the immediate foreshore (low-lying seedlings are commonly drowned) and when the lake finally opens a shoreline strip devoid of vegetation is available for re-colonisation by opportunistic species.

One plant species that benefits from the episodic high stands is the rare plant *Haloragis exalata* subs *exalata* listed as *vulnerable* under TSC Act 1994. *Haloragis exalata* subs *exalata* occurs at several sites around Cuttagee Lake, exclusively within the high-stand inundation zone (Miles and Cameron 2007). The species also drowns during prolonged high stands but evidently benefits from the concomitant 'clearance' of competing lakeshore vegetation and has, over several high-stand cycles through the past decade, been observed to re-establish readily on the sites where parent plants had drowned. Were the opening regime of Cuttagee Lake to change significantly, for example by being artificially kept permanently open, the implications for disturbance-dependent *Haloragis* could be dire, as it has not been observed to occur on nearby permanently open waterways (Miles and Cameron 2007).

2.6 ESTUARINE VEGETATION

Cuttagee Lake supports a variety of estuarine macrophytes with seagrasses estimated to cover 0.385 km^2 (31%) of the estuary area including *Zostera muelleri* (eel grass), *Halophila ovalis* (paddle-weed) and *Ruppia megacarpa* (tassel-weed). 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 estimated losses of between 10-40% of seagrass community in the lake over the 20-year period from 1985 to 2006. A decline in available seagrass habitat appears to

be an ongoing trend for the estuary as observations recorded during 2010-12 indicate further losses of seagrass have occurred since the 2006 assessment (Elgin 2014).

Seagrass was observed to be sparse to absent in basin areas and it was noted that seagrass was absent from the central area of the lake where seagrass was previously mapped in 2006 by NSW DPI (Creese *et. al.* 2009). The estuary experienced several large flood events in the period since January 2010 and sedimentation associated with these floods is thought to have buried much of the seagrass habitat in the vicinity of Cuttagee Creek fluvial delta. However, the first signs of seagrass recovery in the central area were noted in late spring 2012 with patches of the small seagrass *Halophila ovalis* observed emerging from the muddy substrate after an approximate two-year absence.

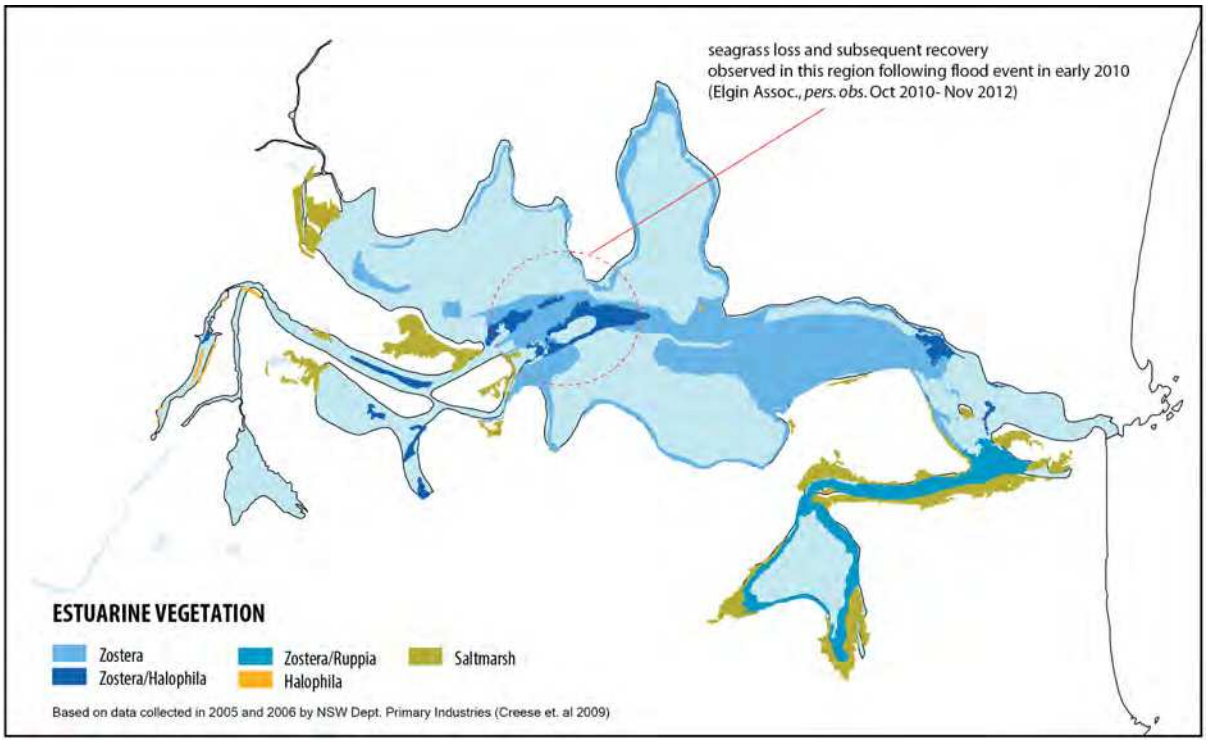


Figure 6. Estimated spatial extent of estuarine habitats of Cuttagee Lake (from Creese *et al.* 2009 - based on aerial imagery from March 2005 and field survey March 2006).

2.7 WATER QUALITY AND ESTUARINE ECOSYSTEM HEALTH

2.7.1 WATER QUALITY

Council in conjunction with OEH assessed Cuttagee Lake water quality over the three-year period 2010 to 2013 (Elgin 2014) to gain better understanding of the variable water quality conditions of the estuary with data collected during periods when the estuary entrance was open and closed, and following significant rainfall events. Estuary health was assessed in terms of eutrophication indicators including microalgal abundance (as chlorophyll a), water clarity (as turbidity) and water column nutrients.

The water quality conditions of Cuttagee Lake can be summarised as having:

- Typically high levels of dissolved oxygen (DO);
- High to moderate water clarity (*i.e.* low turbidity);

- Generally low levels of nutrients with mean levels of Total Nitrogen (TN) and Total Phosphorous (TN) below recommended guideline limits for the protection of estuarine aquatic ecosystems; and
- Typically low abundance of algae, with occasional algal blooms not a serious threat to ecosystem health.

These water quality trends are generally evident irrespective of the entrance being closed or open. Water clarity and surface water salinity do decline during closed periods although water clarity was not strongly influenced by entrance open-closed status due to the shallow nature of the estuary and sensitivity to wind-induced re-suspension of sediments.

Depth profiling indicated that tidal flushing and wind advection were effective mixing processes in the estuary with water quality parameters generally uniform throughout the water column. The estuary is affected by salinity density gradients following increased freshwater inflows generated by large rainfall events. These may occur during both open and closed periods, although density gradients do not persist for long periods due to effective vertical mixing processes. Overall, water quality of Cuttagee Lake is rated as very good based on data collected from 2010 to 2013 (Elgin 2014).

2.7.2 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 (Roper *et al.* 2011). Indicators represent elements of the structure, function and composition of estuarine ecosystems and are summarised in **Table 5** below. 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 5. 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, a comprehensive assessment of estuarine ecosystem health for Cuttagee Lake and the pressures acting upon it was completed as part of statewide estuary health reporting (DECCW 2011). The assessment provided Cuttagee Lake with an overall condition index of 4.0 (out of 5), rated as

being *'good'* based on the estuarine health indicators - chlorophyll *a*, turbidity, extent of seagrass, extent of saltmarsh and fish.

Turbidity and chlorophyll *a* were rated as '*good'*, while saltmarsh was rated '*very good'*. No rating was provided for fish assemblages as data was not available. The assessment also rated seagrass as '*fair'* based on an estimated 10-40% decline in seagrass extent over a 20-year period from 1985 to 2006. The assessment also provided Cuttagee Lake 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, disturbed habitat and tidal flows. Extractive fishing was rated as a moderate pressure.

In 2014, a subsequent assessment of ecosystem health commissioned by council and OEH was undertaken based upon eutrophication indicators only (microalgal abundance, turbidity and nutrients). In terms of eutrophication indicators, Cuttagee Lake was provided a condition index of 5.0 (out of 5.0), rated as being in very good condition (Elgin 2014) with results summarised in Ecosystem Health Report Card (see **Figure 7**).

CUTTAGEE LAKE ESTUARY

ECOSYSTEM HEALTH REPORT CARD 2010-13

Ecosystem health was assessed using indicators of eutrophication including microalgal abundance (as chlorophyll *a*), water clarity (as turbidity) and water column nutrients. The assessment is based on data collected from the central basin (Zones 1-3) that is dividing into three sub-basin areas due to sediment deposition at the fluvial delta in the central area of the estuary. Sampling was conducted on a seasonal basis over the 3-year period, spring 2010 to winter 2013.

Estuary Information (OEH 2014, NLWRA 2001)
Catchment area: 53.25 km² (<30% cleared)
Estuary area: 1.23 km²
Estuary type: semi-mature, saline coastal lagoon
Entrance: intermittently open or closed, closes approximately once every 12-18 months.
Major tributaries: Cuttagee Creek
Central basin average depth: 0.9 m (up to 3 m deep)

Water quality conditions were characterised by typically high levels of dissolved oxygen, high to moderate water clarity, low levels of nutrients and low abundance of microalgae irrespective of the entrance being open or closed. The entrance closes on an intermittment basis approximately once every 12-18 months, and is allowed to re-open naturally. The duration of closed periods is dependent on catchment inflows and may persist for longer than 6 months. Water clarity and suface water salinity decline during closed periods though water clarity appears to not be strongly influenced by the entrance status.

Water column nutrient levels exceeded guideline limits some of the time when the estuary was open and closed to the ocean. Mean Total Nitrogen concentration of 260 ug/L and mean Total Phosphorous concentration of 8 µg/L.

Information regarding the distribution, extent and condition of estuarine vegetation is based on data collected in 2005 and 2006 by NSW Department of Primary Industries (DECCW 2011, Creese *et al.* 2009).

The ecosystem health assessment for the 2010-2013 period provided the estuary with an overall score of 5.0, the lagoon rated as being in very good condition (Grade A+) based on the eutrophication indicators chlorophyll *a* and water clarity.

For further detailed information about Cuttagee Lake and Council's estuary health monitoring program, please refer to Estuary Health Monitoring Report Series Number 3 (Elgin 2014c).

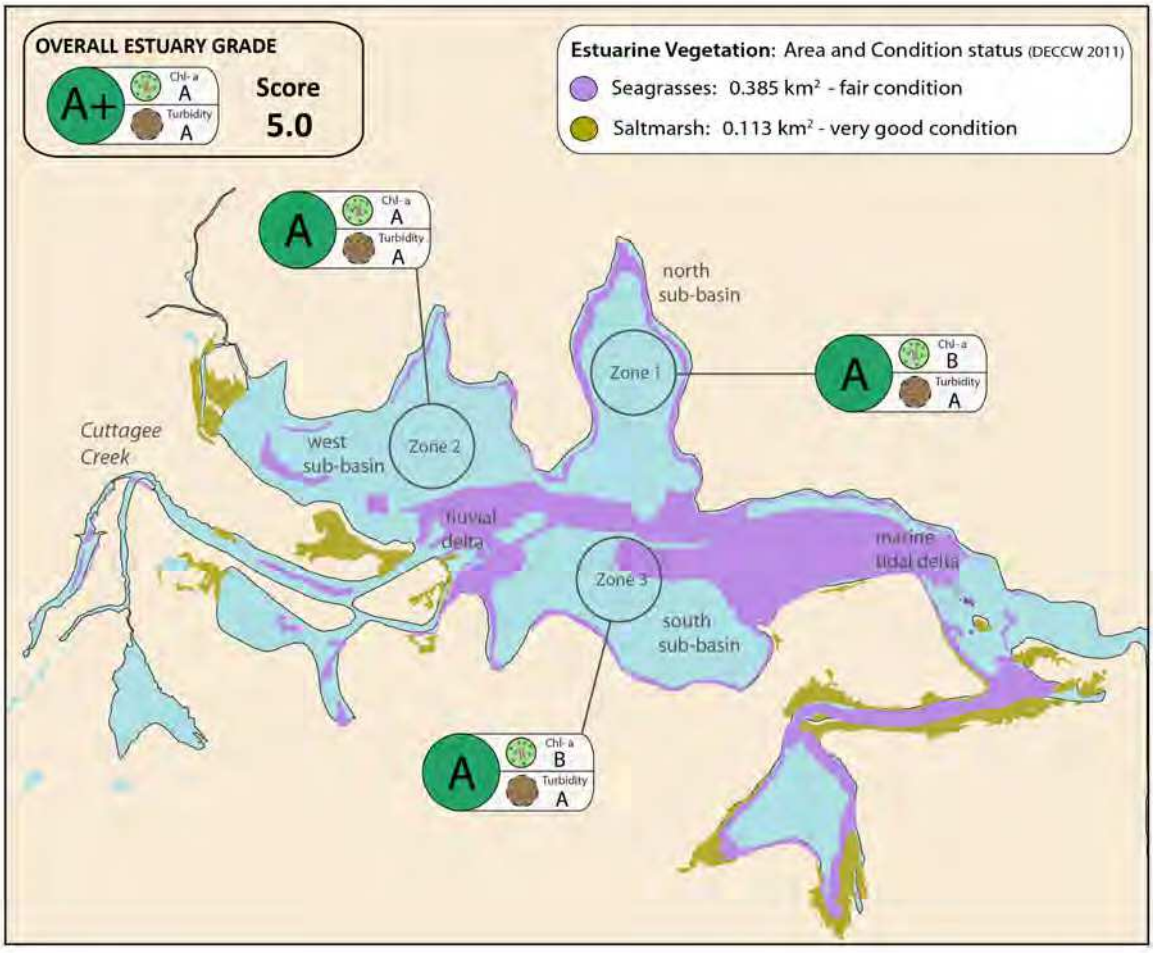


Figure 7. Ecosystem Health Report Card for Cuttagee Lake (based on 2010-2013 WQ data)

3 CULTURAL HERITAGE

There are approximately two Aboriginal sites recorded within the study area as reported by the Aboriginal Heritage Information Management System (AHIMS – OEH 2016). These sites are located in the lower catchment but distant from the estuary foreshore. However, the area is recognised as being significant to local Aboriginal people and it is acknowledged that there is high probability that other unrecorded Aboriginal sites also likely exist within the catchment.

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 Merrimans 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 the built environment and low-lying private and public assets. In particular, some access roads will likely become inundated more often.

Existing sea-level (based on Mean High Water Springs - MHWS) and predicted SLR (OZCoasts 2016b) for year 2100 are shown in **Figure 8** (attached). The 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:

Existing Tidal Elevation (AHD)
Mean High Water Springs (MHWS) for Cuttagee Lake were based on the nearest tidal monitoring station of Port of Bermagui (OEH 2012).

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

= 0.556 m AHD

MHWS only applies when the entrance to Cuttagee Lake is open and subject to large tidal flows.

Predicted Sea-Level Rise
CSIRO has developed a model for maximum sea level rise (SLR) for years 2030, 2050 and 2100 relative to 1990 levels (OzCoasts 2016b). Mapping presented in **Figure 8** (attached) uses the high-end scenario of a 1.1m increase in sea level relative to 1990 levels by 2100. The corresponding increase in MHWS relative to the Australian Height Datum (AHD) for years 2030, 2050 and 2100 are provided in **Table 6.**

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 **Figure 8** 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 6. Predicted MHWS for Cuttagee Lake based on maximum projected Sea-Level Rise (Ozcoasts 2016b)

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

2100 Sea-level Rise and Increase in MHWS

A Digital Elevation Model (DEM) for Cuttagee Lake 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 year 2100 compared to present day MHWS. The predicted increase in MHWS to 1.656m AHD would result in an increased additional tidal area of 0.6 km^2, equivalent to a 45% increase in tidal area compared to present day MHWS.

2100 Sea-level Rise and Increase in Berm Height

As sea-level rises it is anticipated there will be a concomitant increase in sand supply to the shoreline effectively resulting in a corresponding increase in berm height at the estuary entrance. Hence, the maximum height of the berm will increase by the corresponding increase in sea level. A present-day maximum berm height for Cuttagee Lake has been modelled at 2.36m AHD (DLWC 2000). Therefore, the maximum berm height for year 2100 is as follows:

Maximum Berm $_{2100}$ height =

2.36m AHD (DLWC 2000) + 1.1 m = 3.46 m AHD

Based on analysis of the DEM, an increase in the maximum berm height to 3.46m AHD would result in the periodic inundation of an additional area of 0.5 km^2 (see attached **Figure 8**) during entrance closed periods. This is equivalent to a 25% increase in brackish water area compared to present-day.

4.1 LIKELY AND POTENTIAL EFFECTS OF SEA-LEVEL RISE ON CUTTAGEE LAKE

Likely effects of a 1.1m sea-level rise on Cuttagee Lake include:

- Tidal waters will extend further upstream;
- Tidal area will increase by an estimated 45%;

- There will be a reduction in sediment transport from the catchment to the fluvial delta, due to an anticipated reduction in stream power; and
- Existing low-lying roads and crossings will become inundated.

An increased sea-level may result in variable behaviour of the estuary entrance due to associated climatic changes. Two scenarios are possible:

1) the berm may be permanently breached and estuary may become tidally dominated;

2) or 2) an increase in sea-level may translate to a corresponding increase in the berm height such that the entrance will behave in much the same way that it does today with an open-closed regime. The potential effects of each scenario are discussed below.

Under scenario 1, the estuary will become dominated by marine conditions similar to Nelson Lagoon and Merimbula estuary. Mangrove communities may establish in shallow tidal areas that are currently occupied by fringing stands of *Melaleuca armillaris*. The current extent of coastal saltmarsh will become permanently inundated and may be replaced over time with seagrass. Saltmarsh communities will retreat where suitable opportunities for retreat exist. It is noted that much of the Cuttagee foreshore are steeper slopes and opportunities for saltmarsh retreat appear limited. Seagrass meadows are likely to become more prevalent in the estuary assisted by an increase in marine tidal-delta. The total tidal part of the estuary will increase by 45 %.

Under scenario 2, the entrance will behave in the same way that it does today where the estuary will experience open and closed periods and the berm will be subject to breaching during flood events. The estuary will still experience a broad range of ecological conditions (i.e variable salinity regime and periods of inundation) similar to present day levels. There is likely to be a shift in the distribution of vegetation communities relative to elevation requirements. Under this scenario, the total brackish area of the estuary is estimated to increase by approximately 25% when the entrance closes.

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.

The terms of reference for this project were specifically focused to addressing erosion and sedimentation issues for the protection and improvement of estuarine water quality values. However a number of other issues such as limited boating access and estuary entrance management were identified through consultation and are also documented.

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 drop-in 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 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 7**.

- Merrimans Local Aboriginal Land Council
- National Parks and Wildlife Service (NPWS)
- Bega Valley Shire Council and members of Coastal Committee
- Forestry Corporation of NSW
- 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 7. Summary of Stakeholder, Responsibility and Key contact representative

Stakeholder Agency	Contact
Merrimans Local Aboriginal Land Council (Merrimans 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 Merrimans 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 Merrimans land area that includes the catchment area of Cuttagee Lake.	Anne Greenaway Chief Executive Officer ceo@merrimanslalc.org.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
Biamanga National Park Board of Management (Biamanga Trust) The Biamanga National Park was handed back to traditional owners in 2006, and leased backed to the National Parks and Wildlife Service in perpetuity. Title deeds are held in trust by the Merrimans and Bega LALCs and rent is paid by the NSW government into a trust fund. A Board of Management (13 members) is responsible for the strategic management of the Park; this is articulated in the Plan of Management which is available on the website of the Office of the Environment and Heritage. Day to day operations of the Park are carried out by the NPWS. Board representatives include 7 registered Aboriginal Owners and a representative from the Merrimans and Bega LALCs. Trust funds are used for the operations of the Board, Park management and community development, which includes a training and employment strategy.	Paul Stewart Chairperson paulantstewart@hotmail.com Roslyn Field Joint Management Coordinator Far South Coast Region NPWS Roslyn.Field@environment.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	Grant Merinuk grant.merinuk@crownlands.nsw.gov.au

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.	
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.	Paul Frank District Fisheries Officer Narooma 02 4476 0100 paul.frank@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.	Paul Brown Ranger Biamanga paul.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	Andrew Taylor Senior Lands Services Officer andrew.taylor@lls.nsw.gov.au

on-ground works to help protect and restore natural resources across the landscape.	
Forestry Corporation of NSW Forestry Corporation of NSW is the largest manager of commercial native and plantation forests in NSW. Managing more than two million hectares of forests for the economic, environmental and social benefit of the people of NSW and Australia. This includes approximately 25.2 km^2 area of the Murrah State Forest that represents 47% of the total catchment area of Cuttagee Lake.	Brendan Grimson brendan.grimson@fcnsw.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, catchment condition and the periodic closure of the estuary entrance.

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

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

5.2 Community Values and Concerns for Cuttagee Lake and Catchment

The online survey received a total of 22 respondents (9 resident landholders in the catchment, 11 community members located outside the catchment, and 2 stakeholders) who expressed their values and concerns for Cuttagee Lake.

5.2.1 Values

The consensus among survey respondents was that Cuttagee Lake 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 8.**

Table 8. Community Values of Cuttagee Lake

Ecological	Flora and fauna communities, birdlife, rare species, tidal flows when open, prawns, seagrass meadows, fish species, water quality, clear waters
Social	Kayaking, fishing, swimming, paddle boarding, bushwalking, indigenous cultural heritage
Economic	Tourism benefits from recreational opportunities that attract visitors to area, productive commercial fishery for fish, prawns, crabs and eels
Other	Environmental aesthetic, sustainable uses

5.2.2 CONCERNS AND ISSUES

Survey respondents were asked to rank their level of concern for the current condition of the catchment and estuary foreshore, water quality of Cuttagee Lake and whether the periodic closure of the entrance was a concern. 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 9.**

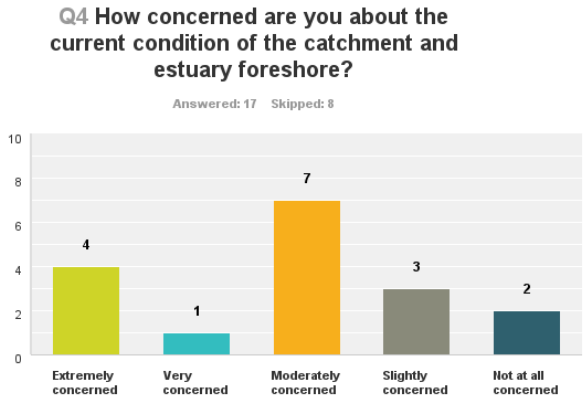
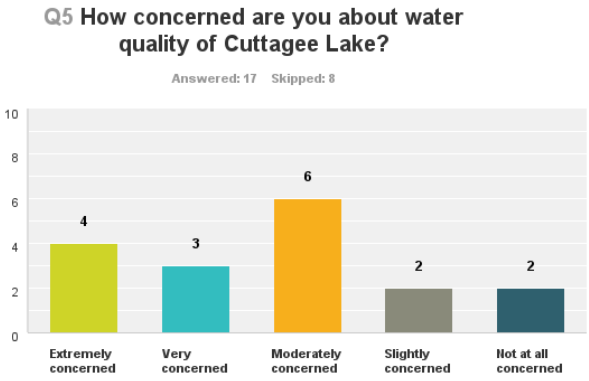
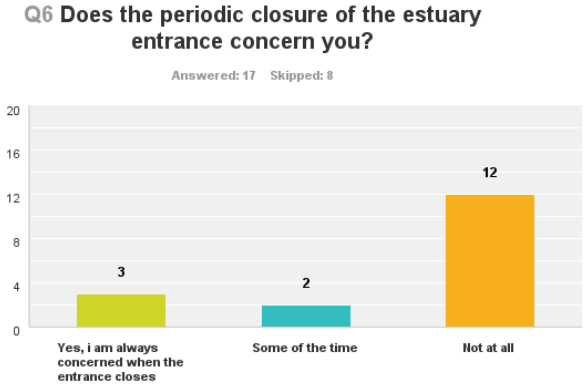
	Majority of survey respondents have some level of concern for current condition of the catchment and estuary foreshore
	Majority of survey respondents are concerned about water quality
	The periodic closure of the estuary entrance is not a concern for most survey respondents. Reasons of concern include: • Perceived decline in water quality; • Potential impact of commercial fishing on fish stocks during closed periods; and • Inundation of private and public access roads

Figure 9. Community concerns for catchment condition, water quality and periodic closure of the estuary entrance.

APPROACH AND OUTCOMES

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

1) Poorly maintained unsealed roads; and

2) Forestry practices.

The rank order of all ten issues is provided in **Table 9** based on the score averaging from all survey respondents. For instance, the closure of the estuary entrance was considered to be having a moderately high negative impact by survey respondents. Overall, however, the issue is considered to be having the least negative impact on catchment and estuary condition when compared to other issues.

Table 9. Ten general catchment issues ranked in order of greatest to least impact on catchment condition by survey respondents

Greatest Impact	1. Poorly maintained unsealed roads
	2. Forestry practices
	3. Unfenced creeklines and stock impacts
	4. Bank erosion
	5. Lack of riparian vegetation due to historical clearing
	6. Wetland degradation
	7. Illegal drains or weirs
	8. Ad-hoc foreshore access
	9. Weed infestation
Least Impact	10. Estuary entrance closure

Note – Rankings based on score averages of all responses

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 using GIS processing. The assessment was undertaken using a digital elevation model (DEM) for the Cuttagee Catchment (see **Figure 10**). 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.

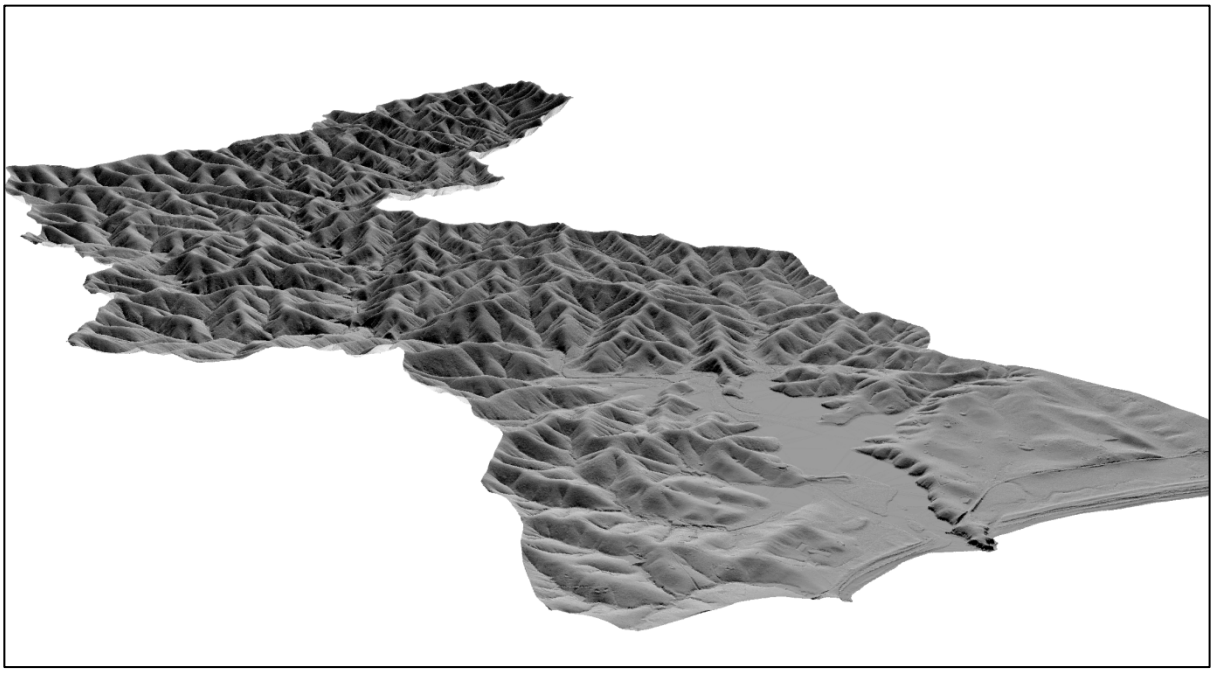


Figure 10. An enhanced Digital Elevation Model (DEM) and Hillshade model of Cuttagee Catchment.

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 catchment erosion sites identified in the assessment are shown in **Figure 11** (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 10**) 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 10. 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 were located in the upper catchment areas administered by State Forests or 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 Cuttagee Creek and these were subject to field inspections (see Section 6.3).
- The assessment did not identify un-natural erosion of estuary foreshore based on 2010 LiDAR information. All foreshore areas were inspected with some issues observed that have likely occurred since 2010 (see Section 6.3).

6.2 ASSESSMENT OF EROSION FROM LOGGED CATCHMENTS

The potential erosion assessment identified the many logging roads and snig tracks constructed in the catchment from historical forestry operations, particularly in the upper catchment with example image shown in **Figure 12**. Soils in the Cuttagee 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. 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 may be a dominant source of sediment supply to the estuary. Certainly there is evidence of excessive and recent sediment deposition on the fluvial delta of Cuttagee Creek, which may be from identified potential erosion sites in the upper catchment. However, further assessment would need to be undertaken to estimate the amount of sediment sourced from the upper catchment that is supplied to the estuary.

Most of the potential erosion sites identified in the upper 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. Also, major unsealed roads and trails may need to be regularly maintained and inspected by the relevant authority, particular adjacent watercourse crossings.

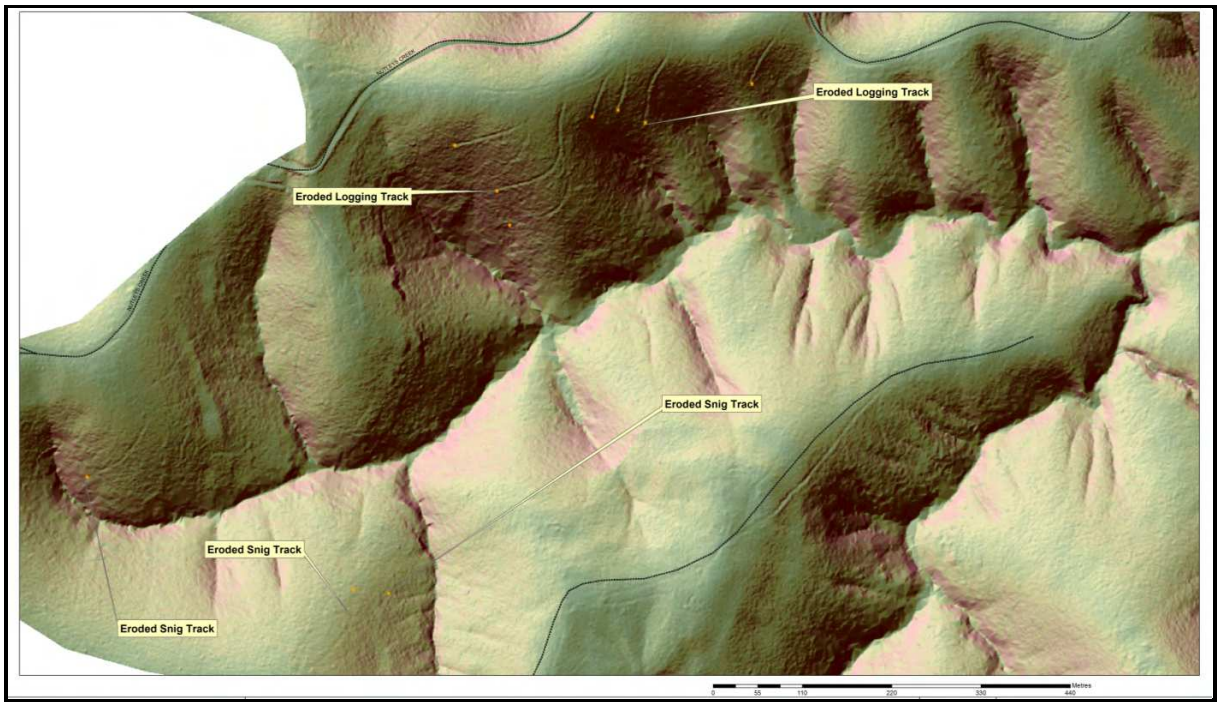


Figure 12. Example of forestry logging roads and snig tracks identified on the enhanced DEM and slope analysis.

6.3 FIELD INSPECTIONS OF POTENTIAL EROSION ISSUES

Field inspections to assess potential erosion issues in the Cuttagee catchment were undertaken on 5 July 2015, 30 July 2015, 23 September 2015 and 5 February 2016.

Stream banks of the lower freshwater reaches of Cuttagee 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 is provided in sections below.

6.4 STREAM BANK EROSION OF LOWER FRESHWATER REACHES

Minor stream bank erosion was observed along the northern banks of a 700m long reach of Cuttagee Creek. The bank erosion is due in part to two processes – 1) natural scouring of the banks during flood flows, as well as 2) collapse of large trees perched near the top of banks further exacerbating erosion in some areas. 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 4 - **Appendix B**.

Channel bedforms (pools & riffles) found in Cuttagee Creek were stable and there was no evidence of un-natural bed erosion. No hydraulic obstructions, natural (*ie.* log jams) or un-natural (*i.e.* illegal weirs), were observed across the lower creek and or floodplain that would have potential to concentrate flow velocities to cause accelerated bank erosion.

6.5 FORESHORE BANK EROSION

In general, foreshore banks of Cuttagee Lake 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. Also, majority of the foreshores in the estuary are underlain by bedrock and are highly stable.

However, one incidence of foreshore beach erosion recommended for action exists near the estuary entrance. The southern embankment foundations of the Cuttagee Bridge are exposed to foreshore beach erosion. The existing rock revetments appeared to not be constructed deep enough to prevent sand from being scoured from underneath the revetment, leading to movement and partial

failure of the rock revetment. This issue is further addressed in Priority Management Area 6 – **Appendix B**.

6.6 ASSESSMENT OF UN-SEALED ROAD NETWORK

Cuttagee catchment includes approximately 75km of unsealed road network (excluding logging extraction tracks) representing <1% of total catchment area (Croke *et al.* 2006). However these road surfaces contribute a significant amount of 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).

6.6.1 LOWER CATCHMENT

In the lower catchment, two high priority sites were identified where road and runoff control maintenance is urgently required to protect estuary values from erosion and sedimentation impacts. These include:

- Severe erosion of foreshore access road off Geall Road with erosion impacting estuary and nearby seagrass community (Refer **Appendix B** - Priority Management Area 1)
- Erosion of a roadside embankment and insufficient road runoff controls along a section of Head of Cuttagee Road with road erosion impacts affecting coastal saltmarsh (Refer **Appendix B** - Priority Management Area 2)

Other road areas in the lower catchment are generally in good condition and not causing direct impact to the estuary. A number of mitre drains along the first 2km stretch of Head of Cuttagee Road from Tathra-Bermagui Road have reached capacity and consequently redirect surface runoff either back across the road or further along the road. These drains require maintenance in order to perform their intended function.

6.6.2 UPPER CATCHMENT

The network of unsealed roads in the upper catchment crosses Cuttagee Creek at four locations as shown in **Figure 13.** Potential erosion issues were identified at these locations during desktop analysis of LiDAR aerial imagery. A total of five locations of the unsealed road network in the upper catchment were inspected to assess potential erosion issues including the four creek crossings and a location on the Nutleys Ck Road ridge.

Stream bank condition and riparian vegetation condition was very good at all creek crossing locations inspected. Some of the approach roads to Cuttagee Creek are steep gradients (4WD only) yet erosion was not observed to be a major problem. Good examples of large woody debris (LWD) and bank stabilising vegetation such as *Lomandra* were observed at all sites as shown in **Figure 14**.

A low to medium issue exists to implement road surface drainage maintenance to a 200m long section of Nutleys Creek Road as it approaches Cuttagee Creek from the north. Surface drainage is currently poor, with road runoff controls inadequate resulting in excessive sedimentation at entry

and exit points of a single culvert. The culvert has <30% capacity before it is full of sediment and fails. This issue is located in Biamanga National Park and is responsibility for NPWS.

A summary of the assessment of upper catchment locations is provided in **Table 11.**

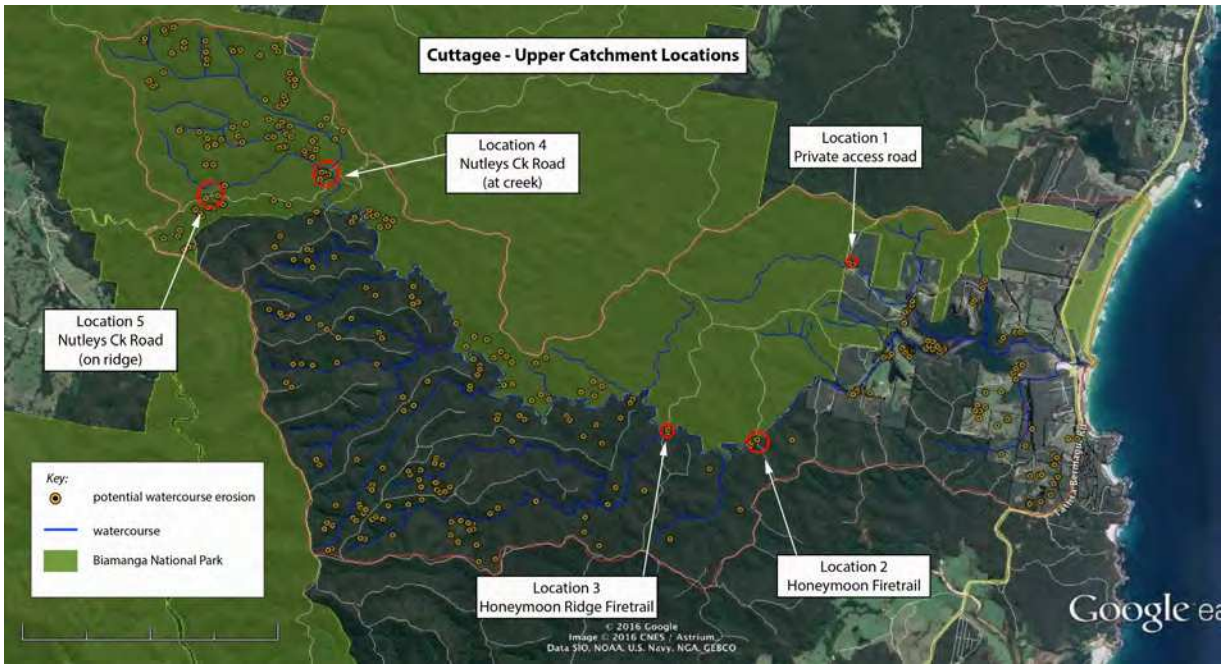


Figure 13. Upper Catchment locations and unsealed road areas inspected for erosion issues.

Figure 14. Examples of typical stream banks of upper catchment locations. Banks were in very good condition characterised by healthy riparian vegetation comprising canopy and understory strata with large woody debris providing protection to the bank toe.

Table 11. Summary of Upper Catchment locations inspected for potential road erosion issues

Location	Road/Track	Tenure	Comments	Issue	Priority	Action
1	Unamed road	Private Lot 1, DP707990	Access off Head of Cuttagee Road. Elevation 22m, potential erosion points identified in LiDAR imagery	None. Ford well maintained and stream-bed and riparian vegetation in very good condition.	-	None required. Monitor.
2	Honeymoon Firetrail	NPWS/State Forests	Access off Murrah River Road, drive north to Siltsone Firetrail, Cuttagee Ck, elevation 37m.	None. Road in good condition, stream banks and riparian condition appear very good condition. Weeds not evident.	-	None required. Monitor.
3	Honeymoon Ridge Road	NPWS/State Forests	Access off Murrah River Road, Cuttagee Ck, elevation 45m	None. Junction of tributary. Higher energy environment. No immediate issues.	-	None required. Monitor.
4	Nutleys Creek Road	NPWS	Ford Crossing Cuttagee Creek. Access from Cadjangarry Road. Cuttagee Ck, mutiple potential erosion points identified in LiDAR imagery. Elevation 130m.	None at the ford. Northen approach of Nutleys Ck road to the ford has poor surface drainage, is loosing sediment with sheet flow leading to and excessive sedimentation at entry and exit of a single culvert.	Low to Med	Implement road surface drainage management. Road length of approx. 200m above culvert to be addressed. Treatment to include mitre drain maintenance, culvert to be cleaned out (<30% capacity) before failure, sediment dispersion barrier install on the downslope from culvert exit point. Investigate potential for additional mitre drains and culvert to remove excess water from road.
5	Nutleys Creek Road	NPWS	Access off Murrah River/ Bandicoot Road. Elevation 165m, potential road/gully erosion points identified in LiDAR imagery, 207m.	None. Inpsected the drainage lines for potential head cuts.	-	None required.
	Head of Cuttagee Road	Crown Road	Road generally in good condition.	Mitre drains full of sediment and leaf litter forcing water flows back over and along road surface.	-	Mitre drain maintenance required
	Murrah River Road	Crown Road	Road generally in good condition.	No immediate issues.	-	None required.

Note - Field inspection undertaken on 5 February 2016

MANAGEMENT ACTIONS

7 CATCHMENT MANAGEMENT ISSUES

7.1 PRIORITY MANAGEMENT AREAS AND ISSUES

Seven (7) priority management areas have been identified, all situated around the lower Cuttagee catchment as shown in **Figure 15**. Within each management area, at least one or more of the following issues is currently occurring - road erosion, weed incursion, 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 12** below.

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

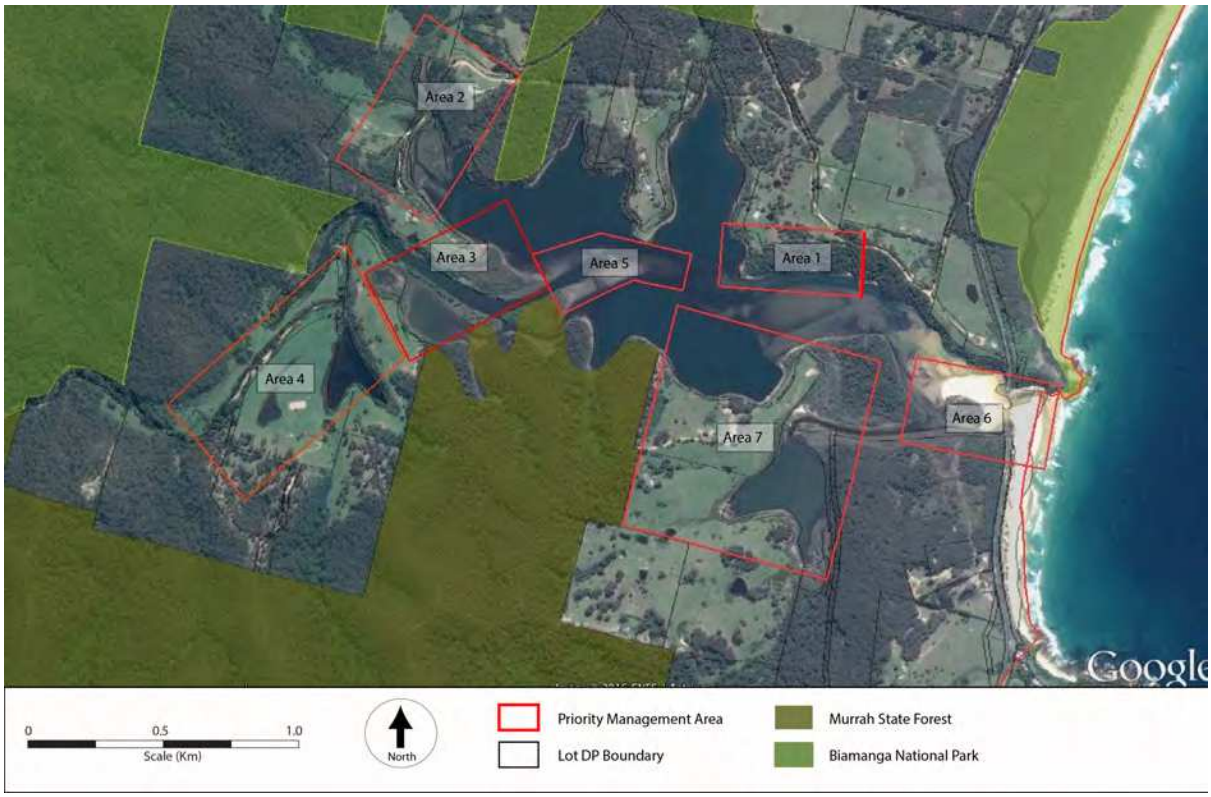


Figure 15. Overview of priority management area locations for Cuttagee catchment.

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.

8 OTHER GENERAL ISSUES

8.1 LIMITED BOATING ACCESS

Limited access to the foreshore for launching small vessels for recreational and commercial fishing was raised as an issue during the consultation period. Some community members question the suitability of the estuary for use by motored vessels. However, the estuary is currently available to commercial fishing under Region 7 of the NSW Estuary General Fishery and commercial fishers must be able access the estuary. Currently, boating access is limited to a poorly maintained unsealed road that continues to degrade over time. This issue is further addressed in Priority Management Area 1 – **Appendix B**.

8.2 ESTUARY ENTRANCE MANAGEMENT

Estuary entrance management is an issue of concern that has been raised during this study because prolonged closures of the entrance and rising water levels inundate roads causing access issues for some landholders, and the perceived impact that closures may be having on estuarine water quality, and sustainable commercial fishing.

Historically the entrance of Cuttagee Lake has been allowed to open naturally. Although in recent times, the entrance has been artificially opened by Council to mitigate and reduce impact of flooding. Members of the public have also opened the entrance on occasion. Opening the entrance of an estuary requires a permit from DPI Fisheries and it is an offence for a member of the public to carry out this activity. To do so attracts heavy penalties of up to $220,000 per offence.

Artificial opening an estuary can have many ecological implications including –

- Rapid lowering of water levels exposing sediments and estuarine vegetation. This exposure can cause release of offensive odours (hydrogen sulfide gas);
- Depending on level of dissolved oxygen in the water, fish kills may occur; and
- Altered salinity regime and water inundation level. While estuaries that have periodic closures naturally experience a broad range of salinity and water levels, more frequent opening of an estuary can lead to shifts in the structure and distribution of riparian vegetation communities.

MANAGEMENT ACTIONS

Council is currently preparing an entrance management policy for Cuttagee Lake to address some of the concerns raised by community members. With regards to the issue of road access for some landholders – this is further addressed in Priority Management Area 4 – **Appendix B,** with issue of illegal openings of the entrance further addressed in Priority Management Area 6 – **Appendix B.**

With regards to water quality and sustainable fishing concerns during closed periods, the following recommendations are made –

- That Council provide to the community available relevant water quality monitoring information and/or consider implementing a regular water quality monitoring program for Cuttagee Lake.
- That DPI Fisheries provide some educational materials and/or catch data regarding the Cuttagee Lake fishery to demonstrate the sustainability of the fishery and address community concerns.

Table 12. Summary of Cuttagee Lake 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	Foreshore access road highly eroded, in poor condition and contributing sediment to estuary	WQ and seagrass	High	DPI Lands, BVSC adjacent Private Land Lot 1503 DP749945	Road repair, regrading and stormwater drainage/runoff controls required
1	1.2	Vehicle damage to potential cultural heritage site	Cultural Heritage	High	DPI Lands/ Fisheries	Consult with Merrimans LALC to investigate the cultural heritage values of site. Develop signage to limit vehicle damage to foreshore vegetation.
2	2.1	Embankment and road erosion, sedimentation impact to coastal saltmarsh community	WQ and SEPP14 wetland coastal saltmarsh	High	DPI Lands, BVSC adjacent to Private Land Lot 183 DP752130	• Implement measures to stabilise roadside embankment adjacent to Lot 183 DP752130 to mitigate further erosion i.e. batter blanket or re-establish vegetation buffer on the upslope of embankment (as per Group A control measures in DECC 2008). • Implement road maintenance and establish effective drainage/runoff controls. Treatment may need to include installation of an additional culvert and or rollover drains. • At the stormwater pipe outlet, install new siltation curtain to retain excess sediments. • Address the process of sediment deposition into coastal saltmarsh by construction of a small log berm to contain excess sediments flowing down hillslope. • Monitor road condition and culvert capacity following heavy rainfall events. • Address the process of sediment deposition into coastal saltmarsh by construction of a small log berm to contain excess sediments flowing down hillslope. use logs to trap sediment and prevent from reaching saltmarsh
2	2.2	Small incursion of highly invasive Juncus acutus (Spiny rush). Serious weed that co-occurs and can be confused with native Juncus krausii.	WQ and Saltmarsh, native vegetation	High	Private Land Lot 97 DP752130 and Lot 183 DP752130	• Work with landholder to eradicate population and follow-up with subsequent monitoring of the creek line. • Notify other landholders to keep a look-out for this weed. • Work with landholder to establish new plantings of native sedges Juncus spp. along the creek line. Refer to recommended plant species list (Appendix D) for upper estuary zone.
2	2.3	Head of Cuttagee Road erosion and runoff on northern approach to causeway impacting saltmarsh	WQ and SEPP14 saltmarsh	Medium to High	DPI Lands, BVSC	• Implement road maintenance and effective drainage/runoff controls. Control measures to include mitre drain maintenance and construction of sediment trap before the causeway (as per Group D control measures in DECC 2008). • Monitor road condition following heavy rainfall events.
2	2.4	Bare banks with little or no riparian vegetation. Evidence of stock access to saltmarsh - horses.	WQ and Saltmarsh, native vegetation	Low	Private Land Lot 183 DP752130	Work with landholder to fence-off remaining area of saltmarsh from stock, allow natural regeneration of riparian vegetation. Could address issue 2.2 and 2.4 simultaneously
2	2.5	Localised erosion of unsealed road embankment south of causeway	SEPP14 Saltmarsh	Low	Private Land Lot 6 DP707990, DPI Lands	Stabilise embankment erosion points by planting salt tolerant species (eg. Juncus spp. and Lomandra sp.) Refer to recommended species list. Monitor condition.
2	2.6	Foreshore vegetation missing canopy strata and habitat trees	Visual aesthetic	Low	Private Land Lot 6 DP707990, DPI Lands	Work with stakeholder and landholder to implement a program of assisted natural regeneration along the western foreshore.

Table 12. Summary of Cuttagee Lake 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	2.7	Excessive sediment deposition on propagating fluvial delta	Saltmarsh and estuary health	Low	DPI Fisheries	Consider using strategic placement of LWD to enhance sediment deposition areas and protect saltmarsh
3	3.1	Livestock access and grazing impacts to coastal saltmarsh on crown land	WQ and saltmarsh	Medium to High	Private Land Lot 183 DP752130, DPI Lands/Fisheries	Work with landholder of Lot 183 DP752130 to fence off the coastal saltmarsh to exclude sheep from saltmarsh community and saline wetland.
3	3.2	Livestock access and grazing impacts to coastal saltmarsh on crown land	WQ and saltmarsh	Medium to High	Private Land Lot 43 DP752153, DPI Lands/Fisheries	Work with landholder of Lot 43 DP752153 to fence off the coastal saltmarsh to exclude stock from saltmarsh community and saline wetland. Fencing needs to take into consideration long periods of inundation and flood events.
3	3.3	Livestock access to riparian zone with understorey strata absent and general lack of riparian vegetation	WQ and bank stability	Medium to High	Private Land Lot 43 DP752153	Work with landholder of Lot 43 DP752153 to fence off and exclude stock from riparian zone and top of bank. A strategy of assisted natural regeneration using nodal plantings of tree and understorey species is recommended. Fencing requirements need to take into consideration long periods of inundation and flood events.
4	4.1	Localised areas of minor bank erosion with potential for top of bank collapse	Bank stability and WQ	Medium to High	Private Land Lot 1 DP604529	Work with landholder to expand riparian vegetation buffer where current vegetation exists, and assist natural regeneration of foreshore areas where there is little riparian vegetation. Opportunities for softer erosion control techniques such as hardwood logs and brush matting to be explored when funding and resources permit. Revegetate steeper banks with salt tolerant riparian sedges. Use strategically placed LWD to stabilise bank toes and improve channel hydraulics.
4	4.2	Creek crossing for access to private property becomes flooded when estuary entrance closed and water levels rise.	Landholder access to Private Land Lot 1 DP604529	Low	DPI Lands/Fisheries	Recommend landholder investigate alternative access to the property when water levels in the estuary exceed 1.2m AHD and during flood events. The creek-bed is the responsibility of DPI Fisheries and they would need to be consulted in addition to council should the landholder wish to apply for planning approval to construct an appropriately engineered crossing that would permit continued access during high water stands.
4	4.3	Cattle Crossing constructed across watercourse and potential barrier to fish passage	Fish passage, natural hydrodynamic regime	Low	DPI Lands/Fisheries, affects Private Land Lot 127 DP752153, Lot 43 DP752153	No intervention to cattle crossing is currently recommended. The backwater has become a freshwater refuge in an otherwise saline environment. The value of removing the weir structure would have to be considered in context of likely short-term impacts such as increasing turbidity and risk of disturbing acid sulphate soils associated with its removal. Work with landholder to ensure future stock management uses alternative routes between grazing areas. Work with landholder to eradicate exotic weed species to reduce risk to nearby EEC Swamp sclerophyll forest.

Table 12. Summary of Cuttagee Lake catchment priority management issues and recommended actions for treatment

Management Area	Issue #	Issue Description	Threat To	Priority (H/M/L)	Responsibility	Action/Recommended Treatment
4	4.4	Limited riparian vegetation buffer along eastern bank of Cuttagee Creek and surrounding freshwater wetland	Visual aesthetic	Low	Private Land Lot 127 DP752153	Work with landholder to increase the width of riparian buffer and re-establish vegetation around foreshore of freshwater wetland using strategy of assisted natural regeneration. Exotic weed species to be removed and replaced by local indgenous species. Any fencing requirements needs to take into consideration long periods of inundation and flood events.
5	5.1	Excessive sediment deposition on propagating fluvial delta.	Seagrass community and estuary	Low	DPI Fisheries	Consider using strategic placement of LWD to enhance sediment deposition areas, protect seasgrass community from being buried and create fish habitat opportunities. Update seagrass mapping and implement program to monitor condition of seagrass community.
6	6.1	Community foreshore access point degraded	Community access	Low to Medium	BVSC, DPI Lands/Fisheries	Undertake minor landscaping works to formalise access to the estuary foreshore from western side of Tathra-Bermagui Road.
6	6.2	Erosion around Tathra-Bermagui Road bridge foundations	Bridge structural integrity	Medium	BVSC, RMS	Following the artificial opening of Cuttagee Lake in mid-2015, substantial bed erosion occurred around the bridge foundations at its southern end. Geomorphic and engineering inspection recommended to determine threat to structural integrity of bridge.
6	6.3	Illegal opening of estuary entrance	Ecological values of estuary	Medium	BVSC, RMS	Development of educational signage to be erected near the entrance that explains the unique ecology of Cuttagee Lake as an ICOLL
7	7.1	Limited riparian vegetation surrounding estuary foreshore	Visual aesthetic	Medium	Private Land Lot 123 DP752153, Lot 122 DP752153	Work with landholder to expand riparian vegetation buffer where current vegetation exists, and assist natural regeneration of foreshore areas where there is little riparian vegetation.

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

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9 REFERENCES

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LIMITATIONS

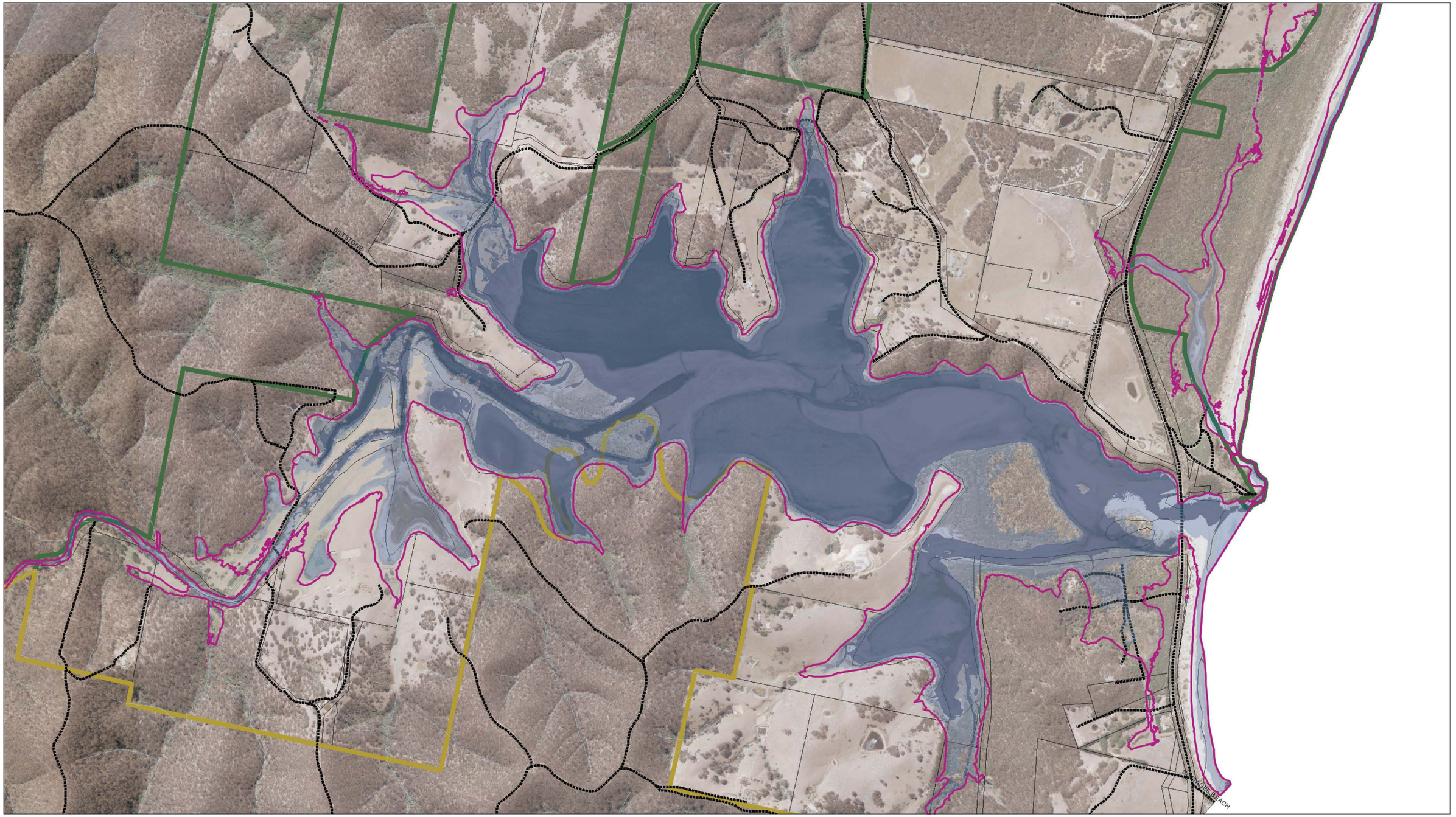
10 LIMITATIONS

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 July 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.



0 190 380 760 1,140 1,520 Metres

CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

ESTUARY AREA 2100 SEA LEVEL RISE MHWS & MAXIMUM BERM HEIGHT

Legend

- 2100 Sea Level Rise (Berm Height 3.46 m AHD)
- Tidal Area (MHWS = 0.556 m AHD)
- 2100 Sea Level Rise [Tidal Area (MHWS = 1.656 m)]
- Road
- Rivers and Creeks
- Murrah Flora Reserve
- Biamanga National Park
- Lot/DP Boundary

MHWS MEAN HIGH WATER SPRINGS

Riparian engineering

GDA
GDA 94 Zone 55

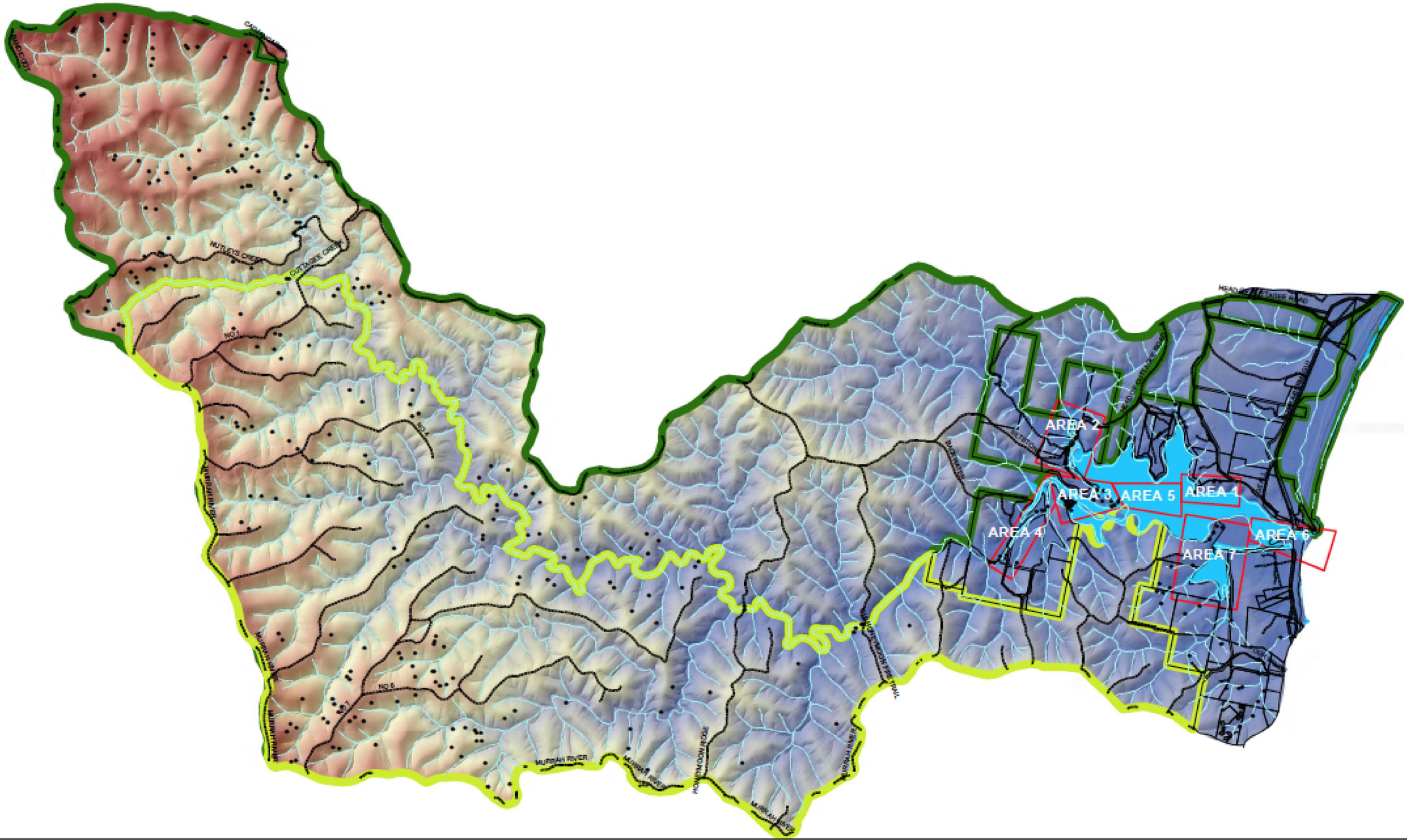
Sheet No.
Sheet 3 of 10

FIGURE 8

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

Checked by: Nicholas Yee

Date: 18 February 2016



CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

- Potential Watercourse Erosion Area
- Mapped Road
- Rivers and Creeks
- Property Boundaries
- Priority Areas
- Tidal Area
- Flora Reserve
- NPWS

DEM Value
High : 369.933
Low : -0.292

Assessment of Potential Erosion Sites
Priority Management Areas 1-7

Riparian engineering

GDA
GDA 94 Zone 55

Sheet No.
Sheet 1 of 10

Figure 11

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

Checked by: Nick Yee

Date: 18 February 2018

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]
[applicant address3]

CONSULTATION PLAN – Cuttagee Lake 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 Cuttagee Lake.

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 Cuttagee Lake.

Cuttagee Lake 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 Cuttagee Lake 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/resident, or stakeholder with an interest in Cuttagee Lake and its 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/Cuttagee_Lake

Or by contacting project manager Nicholas Yee directly on mobile 0400365234 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.

Background – Cuttagee Lake Catchment

Cuttagee Lake has a waterway size (including saltmarsh areas) of 1.23 km^2 and a catchment area of 53.25 km^2. Majority of the catchment is forested with 45% located within the Biamanga National Park and 47% in Murrah State Forest. While large areas of the catchment have been subjected to forestry operations, less than 5% of the catchment has been cleared for agricultural grazing/rural residential uses. The estuary is primarily used for recreation with fishing, swimming and canoeing the main activities although the estuary is available to commercial fishing.

Cuttagee Lake is a shallow, saline coastal lagoon whose entrance intermittently opens and closes to the ocean. Openings and closures are on average approximately 220 days duration, although over the past decade openings have ranged from 18 to 541 days and closed periods have ranged from 7 to 544 days. During closed periods, lake standing water levels may increase to 2.3 mAHD and occasionally the entrance requires artificial opening to alleviate inundation of low lying roads. An entrance management policy for Cuttagee Lake is currently being developed by BVSC.

Cuttagee Lake has moderately high vulnerability to catchment development and land-use disturbance and was classified for significant protection by the Healthy Rivers Commission (2002). This assessment 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.

<table>
<tr><th colspan="2">Snapshot Summary of Cuttagee Lake and Catchment Characteristics</th></tr>
<tr><td>Estuary waterway size: 1.23 km^2</td><td>Catchment Area: 53.25 km^2
<5% cleared, 45% Biamanga National Park (23.8 km^2), 47% Murrah State Forest (25.2 km^2)</td></tr>
<tr><td colspan="2">Primary Inflow: Cuttagee Creek</td></tr>
<tr><td colspan="2">Estuary type: Semi- mature, Saline coastal lagoon</td></tr>
<tr><td colspan="2">Estuarine vegetation: Saltmarsh 0.113 km^2, Seagrasses (Zostera, Halophila and Ruppia) 0.385 km^2

Estimated that 10-40% decline in seagrass extent over 20-year period from 1985 to 2006. Observations from 2010 to 2013 suggest a large loss of seagrass has occurred since the last</td></tr>
</table>

<table>
<tr><td colspan="4">assessment of seagrass extent in 2006. Decline in seagrass extent is thought to be attributed to ongoing sedimentation of the central basin.</td></tr>
<tr><td colspan="4">Catchment land-uses: Rural residential, agricultural grazing, recreation.</td></tr>
<tr><td colspan="4">Commercial activities: The estuary is available to commercial fishing as part of Estuary General Fishery.</td></tr>
<tr><td colspan="4">Endangered Ecological Community (EEC) types: The catchment contains six (6) vegetation types listed as EEC types under the NSW Threatened Species Conservation Act 1995 (TSC Act) including - Coastal Saltmarsh, Freshwater Wetlands, Bangalay Sand Forest, River-Flat Eucalyptus Forest, Swamp Schlerophyll Forest and Littoral Rainforest.</td></tr>
<tr><td>Estuary opening-closure regime:
(based on 10 years of observations)</td><td>Average</td><td>Minimum</td><td>Maximum</td></tr>
<tr><td>Entrance open duration (days):</td><td>220.6</td><td>18</td><td>541</td></tr>
<tr><td>Entrance closed duration (days):</td><td>221.6</td><td>7</td><td>544</td></tr>
<tr><td colspan="4">Entrance Opening Policy: Draft policy in preparation</td></tr>
<tr><td>Water Quality:</td><td colspan="3">• Low levels of nutrients. Mean nitrogen and phosphorous levels typically below guideline limits.
• High levels of dissolved oxygen. Water column well-mixed.
• Seasonal algal blooms occur though not a serious issue.</td></tr>
</table>

Regards

Kyran Crane
Coastal Management Officer

Rapid Catchment Assessment - Cuttagee Lake

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

Cuttagee Lake 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 Cuttagee Lake 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.

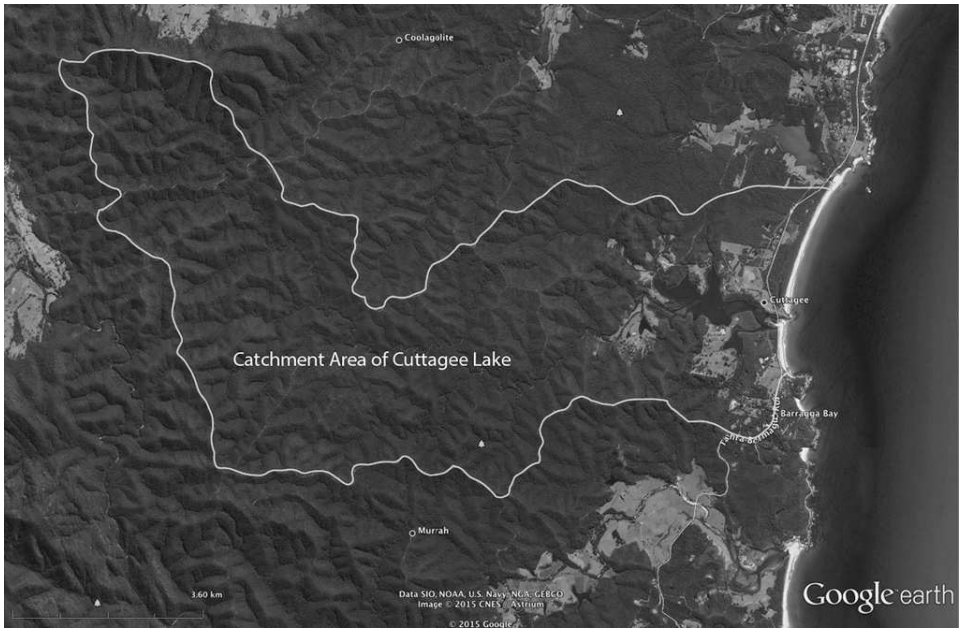
Local consultancy Elgin Associates has been engaged by BVSC to conduct the project.

This survey is designed to seek your initial input regarding catchment management and estuary foreshore issues you feel are important for Cuttagee Lake. As a landholder, stakeholder or community member who values Cuttagee Lake, 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 - Cuttagee Lake

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



* 2. Which stakeholder group do you represent?

- [ ] Merrimans 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
- [ ] Other (please specify)

Cuttagee Lake 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 Cuttagee Lake 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 Cuttagee Lake?

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

* 6. Does the periodic closure of the estuary entrance concern you?

- ◯ Yes, i am always concerned when the entrance closes
- ◯ Some of the time
- ◯ Not at all

7. Please describe why the periodic closure of the estuary entrance concerns you?

8.

What issues do you feel are negatively affecting the condition of the catchment and water quality of Cuttagee Lake?
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)
	Estuary entrance closure
	Forestry practices

9. Please provide other information regarding Cuttagee Lake catchment management issues that you feel are important.

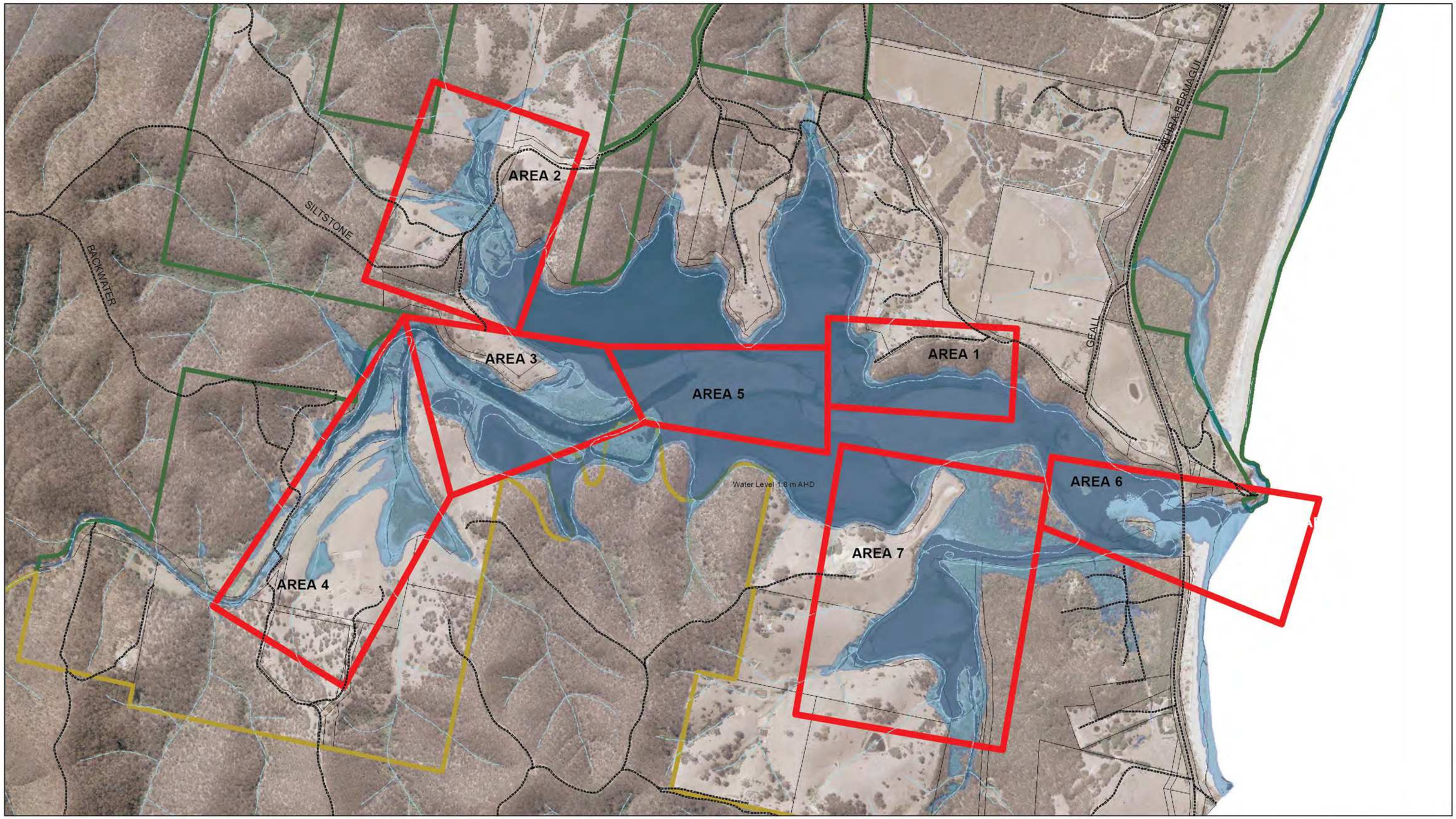
Please register your interest in this project by leaving your contact details. Your contact details and input will be kept private and will not be disclosed to any third party. All information will be deleted at the conclusion of the project.

10. Address

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

APPENDIX B

Cuttagee Catchment – Priority Management Areas



Metres
0 190 380 760 1,140 1,520

CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

- Mapped Road
- Rivers and Creeks
- Priority Management Areas
- Tidal Area (MHWS = 0.556 m AHD)
- Water Level 1.8 m AHD
- Murrah Flora Reserve
- Biamanga National Park
- Lot/DP Boundary

PRIORITY MANAGEMENT AREAS 1 to 7

MHWS MEAN HIGH WATER SPRINGS

Riparian engineering

GDA
GDA 94 Zone 55

Sheet No.
Sheet 2 of 10

OVERVIEW MAP

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

Checked by: Nicholas Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 1

Area Description and Issue Synopsis

This area includes an unsealed crown road off Geall Road that descends a moderate slope and provides access to the northern foreshore of Cuttagee Lake. The road is in poor condition with serious erosion, deep rutting and is not useable during wet conditions. The erosion of the road is also contributing sediment to the estuary during rainfall events.

The road is important as it represents the only public access point to the estuary foreshore for launching small vessels. Primarily both commercial and recreational fishermen utilise the road and commercial fisherman have no other access point to the lake and would like road access improved and maintained. Vehicle access to the foreshore is currently uncontrolled with low-level impacts to riparian vegetation. The boat launching area may also be a potential cultural heritage site of local significance.

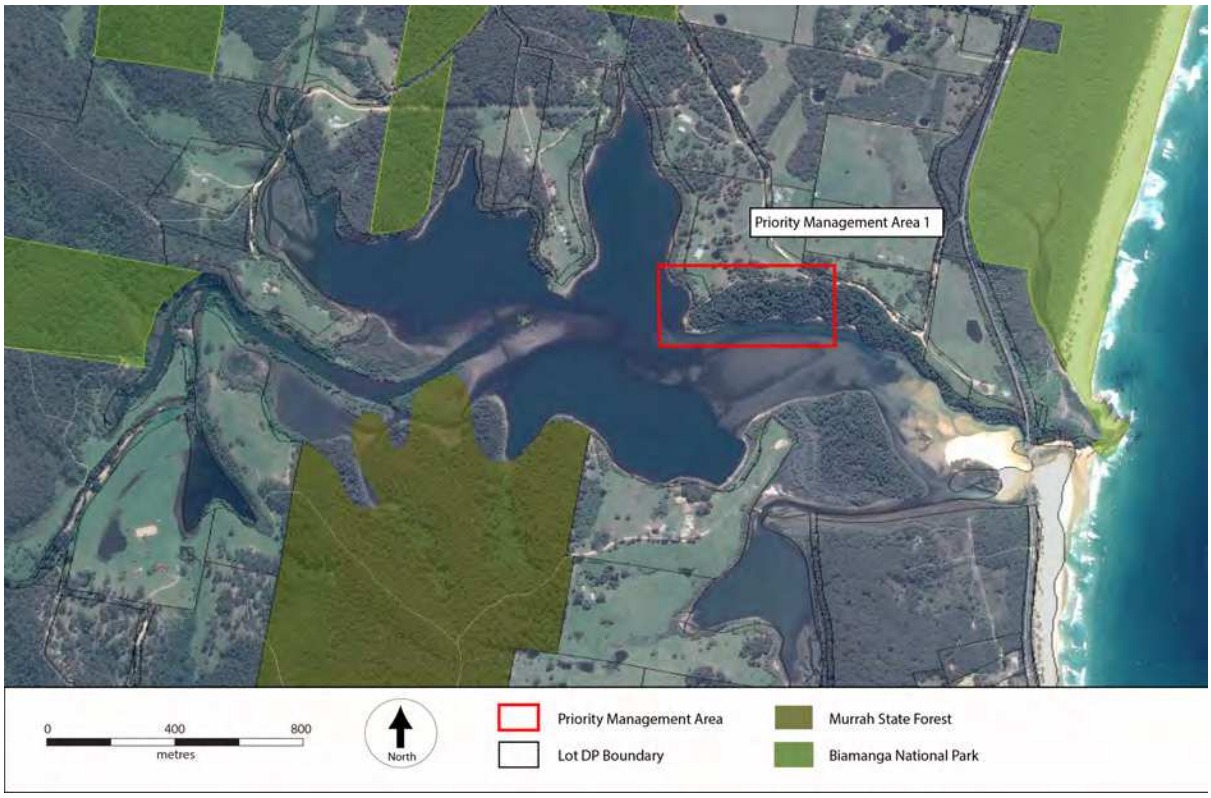


Figure B1 Location of priority management area 1.

High priority issues that require attention include:

- **Issue 1.1** Foreshore access road highly eroded, in poor condition and contributing sediment to estuary
- **Issue 1.2** Vehicle damage to potential cultural heritage site

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

APPENDIX B

Issue 1.1: Foreshore access road highly eroded, in poor condition and contributing sediment to estuary

HIGH PRIORITY

Site Address [Responsibility]: Crown Road [DPI Lands/BVSC] off Geall Road and adjacent to Private Land [Lot 1503 DP749945] and Crown Land reserve (Refer **Map B1**).

Lat/Long Coordinates: Road section between points **-** 36°28'59.07"S, 150° 2'45.37"E and 36°29'2.29"S, 150° 2'30.68"E

Issue Description: The road is in poor condition having become incised with deep ruts and is not useable during wet conditions. It is estimated that erosion of the road has already contributed approximately 300m^3 of sediment to the estuary with the sediment deposition zone apparent at edge of the estuary and ongoing sediment deposition a threat to estuary water quality and the health of the adjacent seagrass community.

Recommended Treatment Action/s:

- Implement road repair that may involve regrading, use of aggregate to stabilise the road surface and improve stormwater drainage/runoff controls. Stormwater and engineering designs are required. Soft engineering approaches will not succeed in treating this serious erosion issue.

Figure B2 Crown access road with example of section with deep rutting due to inadequate stormwater runoff controls (*left image*). Ongoing road erosion is contributing sediment fines to the estuary foreshore with potential impacts to adjacent nearby seagrass community (*right image*).

Issue 1.2: Vehicle damage to potential cultural heritage site of significance

HIGH PRIORITY

Site Address [Responsibility]: Estuary foreshore [DPI Lands/Fisheries] (Refer **Map B1**).

Lat/Long Coordinates: 36°29'2.29"S, 150° 2'30.68"E

Issue Description: This area of foreshore is the only public access point to the estuary for launching small vessels, which is primarily used by both commercial and recreational fishermen. In addition to

lack of a formal boat-launching ramp, there is no parking and vehicles are required to manoeuvre on the foreshore. Consequently, foreshore vegetation is being impacted to permit vehicle access and manoeuvring at this location. Low-level impacts to riparian vegetation are evident and are an increasing issue when the estuary entrance closes and water levels rise, subsequently limiting the foreshore area for vehicle access. The area is also a potential cultural heritage site of local significance and steps should be taken to identify the cultural values of the site prior to undertaking further works.

Recommended Treatment Action/s:

- Consult with Merrimans LALC to investigate the cultural heritage values of site.
- Develop signage to limit vehicle damage to foreshore vegetation.

Figure B3 Foreshore access areas were coincidentally often important estuary access sites for aboriginal community. Shell midden suggests the site may have local cultural heritage values (*left image*). Vehicle impacts to foreshore (*right image*).

Issue 1.1 Foreshore access road highly erded, in poor condition and contributing sediment to estuary.

Road repair, regrading and stormwater drainage/runoff controls required.

Estimated 300m3 sediment deposition in this zone due to historical road erosion. Ongoing sediment erosion is a threat to seagrass communiity immediately adjacent to deposition zone.

GEALL

Issue 1.2 Vehicle damage to potential cultural heritage site
Action: Further investigate the cultural heritage values of site in consultation with Merrimans LALC. Limit vehicle access area.

Consult with Merrimans LALC to investigate the cultural heritage values of site. Develop signage to limit vehicle damage to foreshore vegetation.

0 30 60 120 180 240 Metres

CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Sediment Deposition
- Road Erosion
- Potential Cultural Heritage Site
- Crown Road Reserve
- Fluvial Depositon
- Mapped Road
- Rivers and Creeks_MGA94
- Water Level 1.8 m AHD
- MHWS 0.556m AHD

Estuaries Macrophytes

HABITAT

- Zostera
- Saltmarsh

PRIORITY MANAGEMENT AREA 1

Riparian engineering

—

Sheet No.
Sheet 4 of 10

Map B1

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

Checked by: Nicholas Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 2

Area Description and Issues Synopsis

This area includes private and crown lands located at the western foreshore of estuary. The area features a large extent of *Coastal saltmarsh* community and a fluvial delta sediment deposition zone associated with freshwater inflows from two unnamed creeks that drain a small sub-catchment area of approximately 5.6km^2 (representing ~10% of the total estuary catchment). Anecdotal information from a local landholder suggests much of the sedimentation in the lower reaches of the creeks and fluvial delta has occurred and accumulated since the 1970s. Prior to this time, the creeks were characterised by many deep swimming holes and fish passage to reaches further upstream was common.

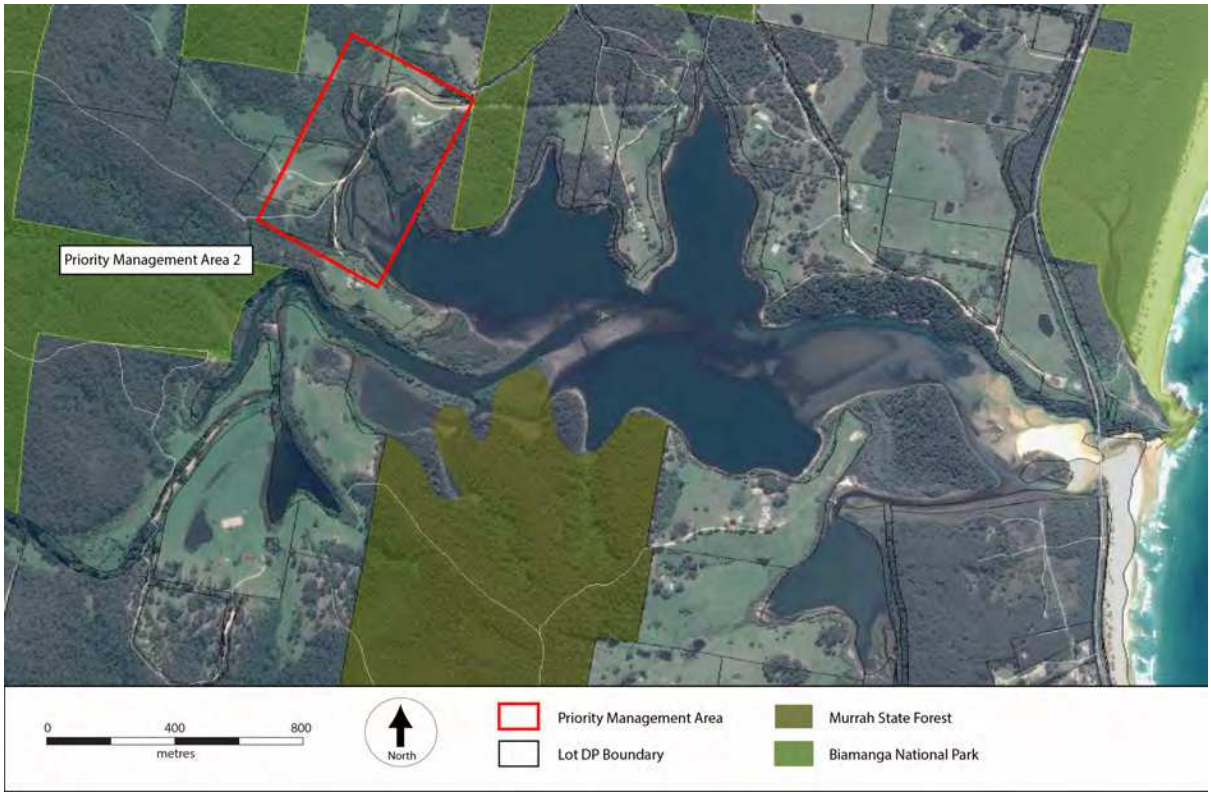


Figure B4 Location of priority management area 2.

High priority issues that require attention include:

- **Issue 2.1** Embankment and road erosion, sedimentation impact to coastal saltmarsh community
- **Issue 2.2** Incursion of exotic Spiny Rush (*Juncus acutus)*

Medium to High priority issues include:

- **Issue 2.3** Road erosion runoff impact to coastal saltmarsh community

Low priority issues include:

- **Issue 2.4** Sections of creek bank with little to no riparian vegetation and stock impact to saltmarsh
- **Issue 2.5** Localised erosion of the unsealed road embankment south of causeway

- **Issue 2.6** Foreshore vegetation missing canopy strata and habitat trees
- **Issue 2.7** Excessive sediment deposition on propagating fluvial delta

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

Issue 2.1: Embankment and road erosion causing sedimentation impacts to SEPP14 wetland

HIGH PRIORITY

Site Address [Responsibility]: Head of Cuttagee Road [DPI Lands/BVSC] including roadside embankment adjacent to private land [Lot 183 DP752130] (Refer **Map B2**).

Lat/Long Coordinates: 36°28'40.25"S, 150° 1'45.31"E (roadside embankment), 36°28'40.53"S, 150° 1'43.02"E (stormwater outlet), 36°28'40.68"S, 150° 1'40.86"E (sedimentation to SEPP 14 wetland)

Issue Description: Approximately 150m length of Head of Cuttagee Road with insufficient surface drainage runoff controls. Currently erosion from roadside embankment (estimated sediment volume of 220m^3) and from road surface (estimated sediment volume of 235m^3) has been lost with some of the yellow clay sediment impacting on SEPP14 wetland and EEC *Coastal saltmarsh* community. Currently a single stormwater pipe takes all stormwater runoff from this section of road and discharges to a hill-slope on private land (Lot 183 DP752130). The siltation guard below stormwater outlet has failed with sedimentation and erosion occurring below the outlet. Recent sedimentation and erosion impacts were observed following the significant rainfall event on 31 January 2016

Recommended Treatment Action/s:

- Implement measures to stabilise roadside embankment adjacent to Lot 183 DP752130 to mitigate further erosion *i.e.* batter blanket or re-establish vegetation buffer on the upslope of embankment (as per Group A control measures in DECC 2008).
- Implement road maintenance and establish effective drainage/runoff controls. Treatment may need to include installation of an additional culvert and or rollover drains.
- At the stormwater pipe outlet, install new siltation curtain to retain excess sediments.
- Address the process of sediment deposition into coastal saltmarsh by construction of a small log berm to contain excess sediments flowing down hillslope.
- Monitor road condition and culvert capacity following heavy rainfall events.

Figure B5 Erosion of roadside embankment on Head of Cuttagee Road adjacent to Lot 183

DP752130 *(left image*), stormwater pipe on Head of Cuttagee Road *(right image)*.

Figure B6 Failing siltation curtain at the stormwater pipe outlet *(left image*), new slug of roadside sediments that has intruded into the coastal saltmarsh community at bottom of hillslope following heavy rainfall event *(right image)*.

Issue 2.2: Incursion of invasive Spiny Rush (*Juncus acutus*)

HIGH PRIORITY

Site Address [Responsibility]: Private land [Lot 97 DP752130] (Refer **Map B2**).

Lat/Long Coordinates: 36°28'36.51"S, 150° 1'41.37"E

Issue Description: A small incursion of highly invasive Spiny Rush (*Juncus acutus)* has established along a section of the creek with an estimated population of <20-30 individuals. Spiny rush is a serious environmental weed that co-occurs with and can be confused with native sedge *Juncus krausii.* Left uncontrolled, infestations of spiny rush are a threat to coastal saltmarsh. Large seed bank reserves in the soil mean control and eradication may take more than 3 years. Further information regarding spiny rush can be found at http://www.weeds.org.au/ .

Recommended Treatment Action/s:

- Work with landholder to eradicate population and follow-up with subsequent monitoring of the creek line.
- Notify other landholders to keep a look-out for this weed.
- Work with landholder to establish new plantings of native sedges *Juncus* spp. along the creek line. Refer to recommended plant species list (**Appendix D**) for upper estuary zone.

APPENDIX B

Figure B7 Example of Spiny Rush individual with large terminal seed heads

Issue 2.3 Road erosion runoff impacting watercourse and coastal saltmarsh

MEDIUM to HIGH PRIORITY

Site Address [Responsibility]: Head of Cuttagee Road [DPI Lands/ BVSC] (Refer **Map B2**).

Lat/Long Coordinates: 36°28'45.72"S, 150° 1'41.03"E

Issue Description: Erosion and stormwater runoff along an approximate 140m long section of Head of Cuttagee Road, the northern approach to causeway, impacting the watercourse and saltmarsh.

Recommended Treatment Action/s:

- Implement road maintenance and effective drainage/runoff controls. Control measures to include mitre drain maintenance and construction of sediment trap before the causeway (as per Group D control measures in DECC 2008).
- Monitor road condition following heavy rainfall events.

Figure B8 Inadequate road runoff controls has resulted in moderate erosion to Head of Cuttagee Road with some sediment depositing to estuary on western side (*left image*), and sediment also depositing to estuary on eastern side (*right image*).

Issue 2.4: Sections of creek-banks with little or no riparian vegetation and evidence of stock impacts to coastal saltmarsh

LOW PRIORITY

Site Address [Responsibility]: Private land [Lot 183 DP752130] (Refer **Map B2**).

Lat/Long Coordinates: 36°28'34.29"S, 150° 1'44.82"E

Issue Description: Sections of creek running through private property with bare banks and little or no riparian vegetation. Visual evidence of stock impacts to coastal saltmarsh community in form of soil pugging although erosion not a serious issue. Consult landholder if stock other than horses still present on property.

Recommended Treatment Action/s:

- Work with landholder to fence off the remaining areas of coastal saltmarsh and creek line to exclude stock and permit natural regeneration of riparian vegetation.

Figure B9 Small ford constructed across watercourse that permits stock access to coastal saltmarsh (*left image*), and horse paddock above the coastal saltmarsh (*right image*).

Issue 2.5: Localised erosion of unsealed road embankment south of causeway

LOW PRIORITY

Site Address [Responsibility]: Head of Cuttagee Road [DPI Lands/BVSC] adjacent to Private land [Lot 6 DP707990] (Refer **Map B2**).

Lat/Long Coordinates: 36°28'47.65"S, 150° 1'39.56"E

Issue Description: The Head of Cuttagee Road has been constructed on a raised embankment across the saltmarsh. The eastern side of the roadside embankment is eroding in several localised areas. Erosion may be occurring during flood events or during high stands when the estuary entrance has closed.

Recommended Treatment Action/s:

- Stabilise embankment erosion points by planting salt tolerant species (eg. *Juncus* spp. and *Lomandra* sp.). Refer to recommended plant species list (**Appendix D**) for upper estuary

zone.

- Monitor condition of road embankment following flood events.

Figure B10 Examples of localised minor erosion points on the eastern side of roadside embankment.

Issue 2.6: Foreshore vegetation missing canopy strata and habitat trees

LOW PRIORITY

Site Address [Responsibility]: Western foreshore [DPI Lands] and Private land [Lot 6 DP707990] (Refer **Map B2**).

Lat/Long Coordinates: Foreshore between points 36°28'50.06"S, 150° 1'37.16"E and 36°29'2.27"S, 150° 1'48.19"E

Issue Description: The western foreshore of estuary is missing canopy vegetation and habitat trees such as *Eucalyptus* spp. that would have previously be present but have been historically cleared. The foreshore vegetation is this area is in a transitional stage of regrowth and senescence with black wattle (*Acacia mearnsii*) currently the dominant canopy forming species. An improved foreshore aesthetic where habitat trees are re-established along this foreshore could be achieved over shorter time frame by employing a strategy of assisted natural regeneration.

Recommended Treatment Action/s:

- Work with stakeholder and landholder to implement a program of assisted natural regeneration along the western foreshore. The action would involve mulching areas and establishing nodal plantings of canopy forming tree species. Over time the tree species would be expected to naturally regenerate the gaps between planted nodes. Refer to recommended plant species list for upper estuary zone (**Appendix D**).

APPENDIX B

Figure B11 Area of western foreshore (outlined in yellow) proposed for re-establishing habitat trees and canopy vegetation strata (*left image*). Example of northern foreshore where natural regeneration of canopy trees has been encouraged (*right image – courtesy of S. Cameron*)

Issue 2.7: Excessive sediment deposition on propagating fluvial delta

LOW PRIORITY

Site Address [Responsibility]: DPI Fisheries (Refer **Map B2**).

Lat/Long Coordinates: 36°28'53.23"S, 150° 1'43.06"E

Issue Description: Excessive deposition of fluvial sediments characterised by sands with gravel and cobble sized rocks has occurred at the propagating fluvial delta. Anecdotal landholder reports suggest much of this sediment deposition has occurred since the 1970s when the nearby ridges were being actively logged. It is estimated that approximately 17,600m^3 of fluvial sediments has been deposited in this zone but over what timescale is not known. Comparison of aerial imagery from 1944 and 2016 shows the fluvial delta has had a similar morphology over the 70-year period with channel location virtually unchanged and the delta approximately the same size. While increased rates of sediment deposition may have occurred since the 1970s, the imagery does not provide strong support for the anecdotal reports that the fluvial delta has undergone significant change in recent decades. Nonetheless, rapid, excessive and uncontrolled deposition over short time-scales can threaten estuary health in terms of smothering seagrass communities and loss of channel structure causing restriction to fish passage to upper brackish waters vital breeding areas for fish species such as bream.

Recommended Treatment Action/s:

- Monitor the health of coastal saltmarsh community and estuarine vegetation in this area that will enhance future sediment deposition on developing levee banks.
- Consider use of strategically placed LWD to enhance deposition of sediments in particular areas, protect channel structure and indirectly improve fish habitat opportunities.

APPENDIX B

Figure B12a Fluvial supply of gravels and cobble-sized rocks present across the propagating delta with channel structure impacted by excessive deposition over short time-scale (*left image*). View of the propagating fluvial delta looking upstream towards the causeway where the channel structure is in good condition (*right image*).

Figure B12b Comparison of aerial imagery showing the fluvial delta at the western margin of Cuttagee Lake from years 1944 (*left image courtesy of OEH*) and 2016 (*right image – Google Earth*). It is

Issue 2.2 Incursion of exotic Spiny Rush (Juncus acutus) and stock access to coastal saltmarsh.

- Work with landholder to eradicate population and follow-up with subsequent monitoring of the creek line.
- Notify other landholders to keep a look-out for this weed.
- Work with landholder to establish new plantings of native sedges Juncus spp. along the creek line. Refer to recommended plant species list (Appendix D) for upper estuary zone.

Issue 2.4 Sections of creek bank with little to no riparian vegetation and stock impact to saltmarsh.

Work with landholder to fence-off remaining area of saltmarsh from stock, allow natural regeneration of riparian vegetation. Could address issue 2.2 and 2.4 simultaneously.

Issue 2.1 cont. 235 m3 of sediment (orange CLAY) locally deposited on saltmarsh. See adjacent.

Issue 2.7 cont. Excessive sediment deposition in watercourse. See adjacent.

Issue 2.1 Embankment and road erosion, sedimentation impact to coastal saltmarsh community.

- Implement measures to stabilise roadside embankment adjacent to Lot 183 DP752130 to mitigate further erosion i.e. batter blanket or re-establish vegetation buffer on the upslope of embankment (as per Group A control measures in DECC 2008).
- Implement road maintenance and establish effective drainage/runoff controls. Treatment may need to include installation of an additional culvert and or rollover drains.
- At the stormwater pipe outlet, install new siltation curtain to retain excess sediments.
- Address the process of sediment deposition into coastal saltmarsh by construction of a small log berm to contain excess sediments flowing down hillslope.
- Monitor road condition and culvert capacity following heavy rainfall events.
- Address the process of sediment deposition into coastal saltmarsh by construction of a small log berm to contain excess sediments flowing down hillslope. Use logs to trap sediment and prevent from reaching saltmarsh.

Issue 2.5 Localised erosion of the unsealed road embankment south of causeway.

Stabilise embankment erosion points by planting salt tolerant species (eg. Juncus spp. and Lomandra sp.) Refer to recommended species list. Monitor condition.

HEAD OF CUTTAGEE ROAD

Issue 2.3 Road erosion runoff impact to coastal saltmarsh.

- Implement road maintenance and effective drainage/runoff controls. Control measures to include mitre drain maintenance and construction of sediment trap before the causeway (as per Group D control measures in DECC 2008).
- Monitor road condition following heavy rainfall events.

SILTSTONE

Issue 2.6 Foreshore vegetation missing canopy strata and habitat trees.

Work with stakeholder and landholder to implement a program of assisted natural regeneration along the western foreshore.

Issue 2.7 Excessive sediment deposition on propagating fluvial delta.

Consider using strategic placement of LWD to enhance sediment deposition areas and protect saltmarsh.

0 45 90 180 270 360 Metres

CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Proposed Regeneration Area
- Crown Road Reserve
- Road
- Environmental Weeds
- Road Stormwater Erosion
- Embankment Erosion
- Fluvial Depositon
- Sediment Deposition (Road)
- Road Erosion
- Rivers and Creeks_MGA94
- Water Level 1.8 m AHD
- MHWS 0.556 m AHD
- Biamanga National Park
- Lot/DP Boundary

PRIORITY MANAGEMENT AREA 2

Riparian engineering

—

Map B2

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

Sheet No.
Sheet 5 of 10

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 3

Area Description and Issues Synopsis

This area includes designated SEPP14 wetland and *coastal saltmarsh* community located on either side of lower Cuttagee Creek and the south-western foreshore of the estuary. Majority of saltmarsh community occurs on crown land adjacent to private property. Low level stock impacts are evident around margins of the saltmarsh and the area also includes the occurrence of *Swamp sclerophyll forest*.

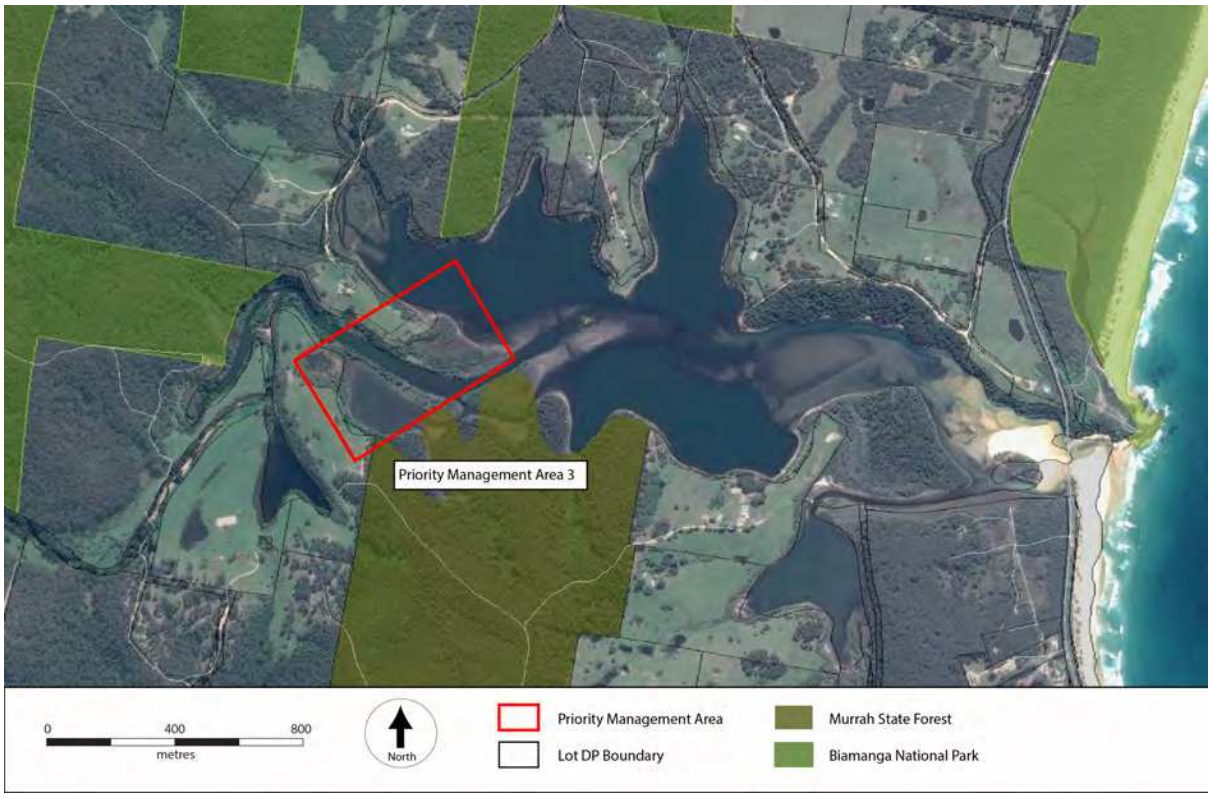


Figure B13. Location of priority management area 3.

Medium to High priority issues that require attention include:

- 3.1 Livestock access and grazing impacts to coastal saltmarsh on crown land
- 3.2 Livestock access and grazing impacts to coastal saltmarsh on crown land
- 3.3 Livestock access to riparian zone with understorey strata absent and general lack of riparian vegetation

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

APPENDIX B

Issue 3.1: Livestock access and grazing impacts to coastal saltmarsh on crown land

MED - HIGH PRIORITY

Site Address [Responsibility]: Estuary foreshore and coastal saltmarsh community [DPI Lands/Fisheries] adjacent to Private land [Lot 183 DP752130] (Refer **Map B3**).

Lat/Long Coordinates: 36°29'5.46"S, 150° 1'53.50"E

Issue Description: Evidence of low level sheep grazing in EEC *Coastal saltmarsh* community on northern side of Cuttagee Creek with impacts including trampling and track formation.

Recommended Treatment Action/s:

- Work with landholder of Lot 183 DP752130 to fence off the coastal saltmarsh to exclude sheep from saltmarsh community and saline wetland.
- Monitor saltmarsh condition.

Figure B14 Sheep can currently access coastal saltmarsh community located on northern side of Cuttagee Creek with evidence of low-level impacts such as track formation.

Issue 3.2: Livestock access and grazing impacts to coastal saltmarsh on crown land

MED - HIGH PRIORITY

Site Address [Responsibility]: Estuary foreshore and coastal saltmarsh community [DPI Lands/Fisheries] adjacent to Private land [Lot 43 DP752153] (Refer **Map B3**).

Lat/Long Coordinates: 36°29'7.15"S, 150° 1'38.34"E

Issue Description: Evidence of stock grazing in EEC *Coastal saltmarsh* community located on southern side of Cuttagee Creek with impacts including trampling and track formation. The EEC *Swamp sclerophyll forest* occurs along the peninsula adjacent to the saltmarsh community and at potential risk of weed introduction associated with stock access.

Recommended Treatment Action/s:

- Work with landholder of Lot 43 DP752153 and DPI Fisheries to fence off and exclude stock from saltmarsh community and saline wetland. Fencing requirements needs to take into consideration long periods of inundation and flood events.
- Monitor saltmarsh condition.

APPENDIX B

Figure B15 Coastal saltmarsh community located on southern side of Cuttagee Creek with evidence of stock impacts such as track formation (*left image*), tracks around margin of saltmarsh community with occurrence of EEC *Swamp sclerophyll forest* in background.

Issue 3.3: Livestock access to riparian zone with understorey strata absent and general lack of riparian vegetation

MED - HIGH PRIORITY

Site Address [Responsibility]: Private land [Lot 43 DP752153] (Refer **Map B3**).

Lat/Long Coordinates: Riparian zone along a 300m reach between points 36°29'1.42"S, 150° 1'31.04"E and 36°29'6.08"S, 150° 1'40.14"E

Issue Description: Large areas of floodplain located on private property where riparian vegetation is absent or lacking relative to other areas. It is not clear whether livestock are currently present although any attempts to re-establish riparian vegetation will require stock to be excluded with fencing. Opportunity exists to improve the riparian buffer along this reach to improve bank stability.

Recommended Treatment Action/s:

- Work with landholder of Lot 43 DP752153 to fence off and exclude stock from riparian zone and top of bank.
- A strategy of assisted natural regeneration using nodal plantings of tree and understorey species is recommended.
- Fencing requirements need to take into consideration long periods of inundation and flood events.

APPENDIX B

Figure B16 Large areas of the riparian zone on the floodplain of Cuttagee Creek are characterised by an absence of understorey strata (*left image*) and a general lack of riparian vegetation (*right image*).

Issue 3.1 Livestock access and grazing impacts to coastal saltmarsh on crown land.

Work with landholder of Lot 183 DP752130 to fence off the coastal saltmarsh to exclude sheep from saltmarsh community and saline wetland.

Issue 3.3 Livestock access to riparian zone with understorey strata absent and general lack of riparian vegetation

Work with landholder of Lot 43 DP752153 to fence off riparian zone (area within the red dashed line) to allow assisted natural regeneration of riparian vegetation. Fencing needs to take into consideration long periods of inundation and flood events.

Issue 3.2 Livestock access and grazing impacts to coastal saltmarsh on crown land.

Work with landholder of Lot 43 DP752153 to fence off the coastal saltmarsh to exclude stock from saltmarsh community and saline wetland. Fencing needs to take into consideration long periods of inundation and flood events.

0 30 60 120 180 240 Metres

CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Proposed Regeneration Area
- Road
- Water Level 1.8 m AHD
- MHWS 0.556 m AHD
- Rivers and Creeks_MGA94
- Proposed regeneration area

HABITAT

- Halophila
- Saltmarsh
- Zostera
- Lot/DP Boundary
- Biamanga National Park

PRIORITY MANAGEMENT AREA 3

Riparian engineering

–

Sheet No.
Sheet 6 of 10

Map B3

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

Checked by: Nicholas Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 4

Area Description and Issues Synopsis

This area includes alluvial flats and riparian zone located on private lands along an approximate 700m reach of lower Cuttagee creek as shown in **Figure B16**. Some revegetation works have already been undertaken along the western bank but many gaps in vegetation exist along this reach and localised areas of bank instability are an issue that requires attention. The area includes a creek crossing that becomes impassable when the estuary entrance closes and water levels exceed 1.2m AHD. This area also includes a large freshwater wetland that has been cut-off from the main riverine channel by historical construction of a cattle crossing. The endangered ecological community swamp sclerophyll forest has been mapped in this area.

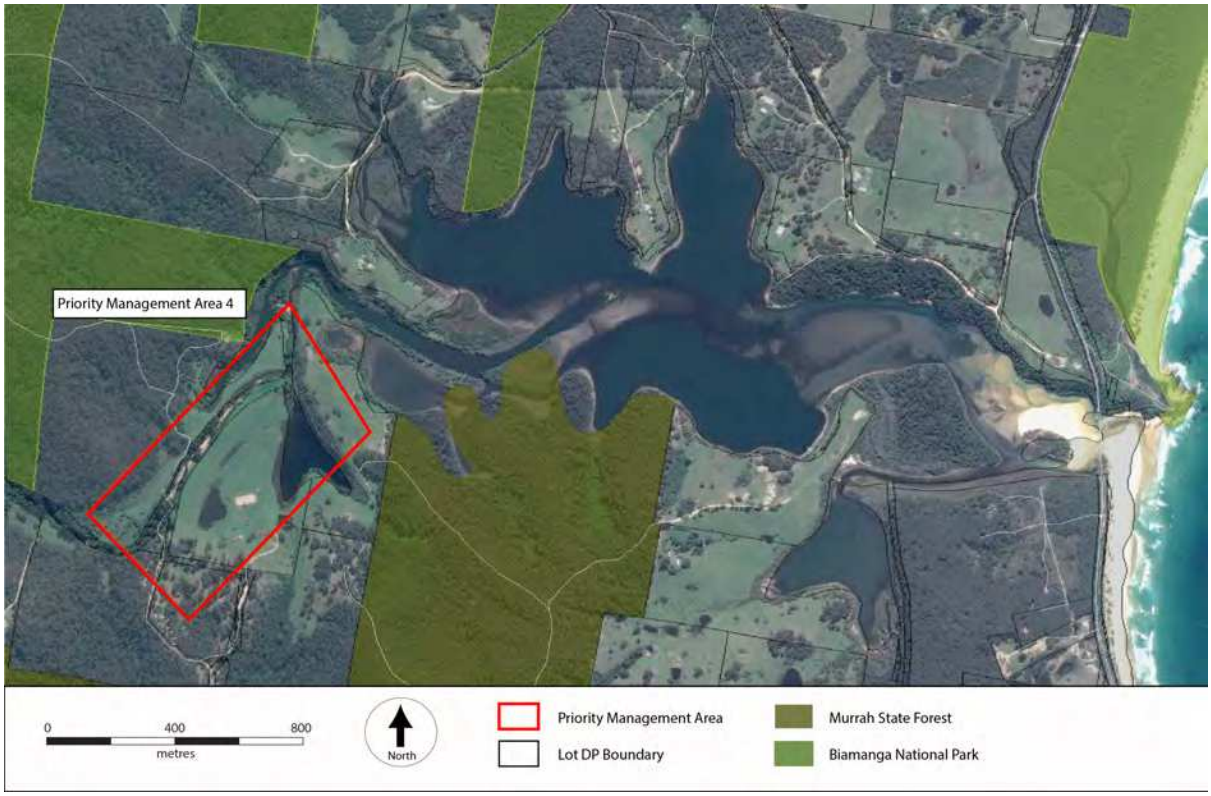


Figure B16 Location of priority management area 4.

Medium to High priority issues that require attention include:

- **Issue 4.1**

Low to Medium priority issues include:

- **Issue 4.2** Estuary crossing for access to private property becomes flooded when entrance closed and water levels rise
- **Issue 4.3** Cattle Crossing constructed across watercourse resulting in altered aquatic vegetation community
- **Issue 4.4** Limited riparian vegetation buffer along eastern bank of Cuttagee Creek and surrounding freshwater wetland

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

APPENDIX B

Issue 4.1: Localised bank erosion with potential for top of bank collapse

MED - HIGH PRIORITY

Site Address [Responsibility]: Riparian Zone on Private land [Lot 1 DP604529] (Refer **Map B4**).

Issue Description: Minor bank erosion is evident in multiple locations along a 700m reach of the western bank of Cuttagee Creek. Landholder has previously undertaken some revegetation of the riparian zone and natural regeneration of some species including black wattles has occurred along top of bank. Wind blow is affecting some of the trees close to the top of the bank with potential risk for top of bank collapse should trees fall over. 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 of Lot 1 DP604529 to expand existing riparian vegetation buffer with increased use of sedges and rushes at the top of the bank and tall trees planted further from top of bank. Refer to conceptual drawing for typical river restoration treatment (**Appendix C**) and recommended species list (**Appendix D**).
- Coppice / lop large woody vegetation at top of bank showing sign of potential failure
- Consider use of strategically placed LWD to stablise bank toe, improve channel hydraulics and indirectly improve fish habitat opportunities

Figure B17 Riparian vegetation on the alluvial flats of the western bank of Cuttagee Ck (*left image*), example of localised bank erosion on the western bank with woody debris providing some bank protection (*right image*).

Issue 4.2: Creek crossing for access to private property becomes flooded when estuary entrance closed and water levels rise

LOW PRIORITY

Site Address [Responsibility]: Cuttagee Creek [DPI Fisheries] crossing providing access to private Land [Lot 1 DP604529] (Refer **Map B4**).

Issue Description: Creek crossing provides access to a private property but becomes inundated and

impassable when the estuary entrance closes and estuary water levels rise. The crossing becomes inundated when estuary water levels reach 0.8 m AHD and impassable when water levels exceed 1.2m AHD. Access is also dangerous during flood events. This access issue affects one landholder who would like the estuary entrance managed to ensure continued access. However, Council is currently developing a policy of no entrance intervention below 1.8m AHD.

Recommended Treatment Action/s:

- Recommend landholder investigate alternative access to the property when water levels in the estuary exceed 1.2m AHD and during flood events.
- The creek-bed is the responsibility of DPI Fisheries and they would need to be consulted in addition to Council should the landholder wish to apply for planning approval to construct an appropriately engineered crossing that would permit continued access during high water stands.

Figure B18 Approach to Cuttagee Creek crossing from eastern bank (*left image*), the creek crossing during low tide conditions when the estuary was open to the ocean (*right image*).

Issue 4.3: Cattle Crossing constructed across watercourse

LOW to MED PRIORITY

Site Address [Responsibility]: Crown land [DPI Fisheries/DPI Lands] adjacent to private land [Lot 127 and Lot 43, DP752153] (Refer **Map B4**).

Issue Description: A cattle crossing weir structure has been constructed across the natural watercourse effectively cutting-off the estuarine wetland from the natural hydrodynamic regime of the estuary. The watercourse is a freshwater wetland as indicated by dominant macrophytes *Triglochin* sp and *Typha* sp, with overflows able to spill into Cuttagee Creek. The cattle crossing is a potential barrier to fish passage. Overgrown vegetation at the crossing comprising some weed species suggests the crossing is no longer used. Weeds including blackberry are a threat to nearby EEC *Swamp sclerophyll forest*.

Recommended Treatment Action/s:

- No intervention to the cattle crossing is currently recommended. The wetland is a freshwater refuge in an otherwise saline environment and may meet the EEC requirements

for *Freshwater wetlands on Coastal Floodplains.* The value of removing the weir structure would result in the partial drainage of the wetland and would have to be considered in context of likely short-term impacts such as increased turbidity, potential for altered vegetation community and potential risk of disturbing and exposing acid sulphate soils associated with its removal.

- Undertake further assessment of wetland flora to determine if the wetland community meets the EEC requirements for *Freshwater wetlands on Coastal Floodplains*
- Work with landholder to implement alternative stock management routes between grazing areas.
- Work with landholder to eradicate exotic weed species to reduce risk to nearby EEC Swamp sclerophyll forest.

Figure B19 Cattle crossing constructed over watercourse (*left image*), view over the freshwater wetland from near cattle crossing (*right image*).

Issue 4.4: Limited riparian vegetation along sections of Cuttagee Creek and surrounding freshwater wetland

LOW PRIORITY

Site Address [Responsibility]: Private land [Lot 127 DP752153] (Refer **Map B4**).

Issue Description: Stock grazing currently permitted to the top of bank along the eastern bank of Cuttagee Creek with a narrow buffer of riparian vegetation and woody weeds are present in localised patches. Little or no riparian vegetation exists around the western margin of the freshwater wetland. The wetland is a freshwater refuge and is receiving runoff from the surrounding slopes and is recharged by flood flows from Cuttagee Creek when the floodplain is inundated. Bank erosion on the eastern side of Cuttagee creek is a minor issue, however addressing the issue of limited riparian vegetation along open sections of Cuttagee Creek and removing the woody weeds would improve the condition of the riparian vegetation, improve bank stability and the overall visual aesthetic of the along the eastern bank and freshwater wetland.

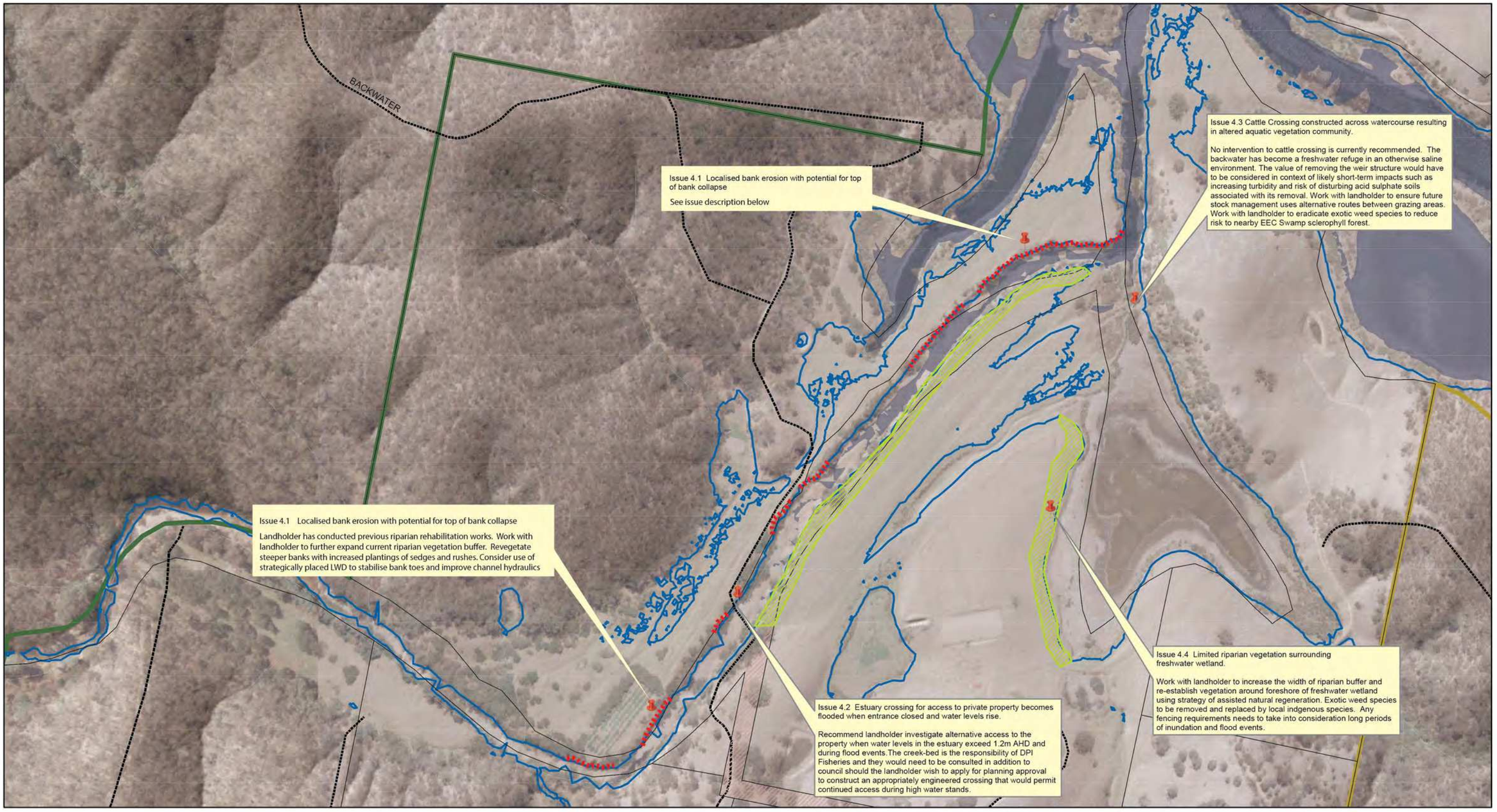
Recommended Treatment Action/s:

- Work with landholder of Lot 127 DP752153 to investigate opportunities to revegetate bare

banks and expand the riparian buffer along eastern side of Cuttagee creek and re-establish vegetation around the wetland foreshore using strategy of assisted natural regeneration. Refer to conceptual drawing for typical river restoration treatment (**Appendix C**) recommended species list (**Appendix D**)

- Any fencing requirement needs to take into consideration long periods of inundation and flood events.

Figure B20 Example of a reach of Cuttagee creek lacking riparian vegetation (*left image*). Example of the largely bare banks surrounding the freshwater wetland (*right image*).



CUTTAGEE LAKE CATACHMENT MANAGEMENT PLAN

Legend

- Issues
- Proposed Regeneration Area
- Bank Erosion
- Lot/DP Boundary
- Crown Road Reserve
- Road
- Murrah Flora Reserve
- Water Level 1.8 m AHD
- Biamanga National Park
- MHWS 0.556 m AHD
- Rivers and Creeks_MGA94
- crownland_region

PRIORITY MANAGEMENT AREA 4

Riparian engineering

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Sheet No.
Sheet 7 of 10

Map B4

Analysis By: Tim Dilworth
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

This area is the active sediment deposition zone of the Cuttagee Creek fluvial delta (**Figure B21**). The area is characterised by shallow estuarine waters, soft sediments that become exposed at lowtide when the estuary entrance is open and supports extensive seagrass community. Large logs have been deposited across the delta during flood events and these assist in the natural formation of levee banks of the propagating delta. The fluvial delta will over time effectively divide the estuary into three separate deeper basins with varying levels of connectivity to the main channel. In short term, actions could be implemented to enhance the sediment deposition area to confine sediments, improve channel morphology and protect the seagrass community. This would improve overall health outcomes for the estuary.

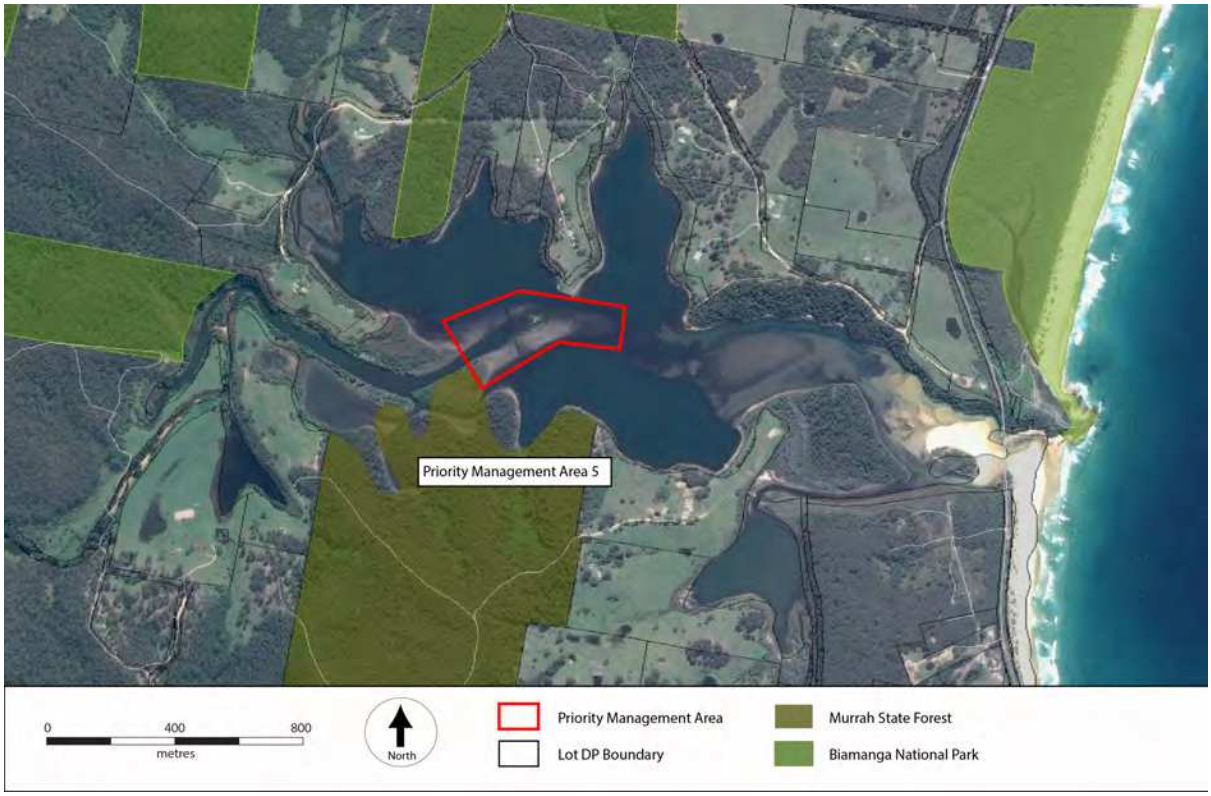


Figure B21 Location of priority management area 5.

Low priority issue that require attention includes:

- Issue 5.1 Excessive sediment deposition on the propagating fluvial delta of Cuttagee Creek

Issue 5.1: Excessive sediment deposition on the propagating fluvial delta of Cuttagee Creek

LOW PRIORITY

Site Address [Responsibility]: Estuary [DPI Fisheries] (Refer **Map B5**).

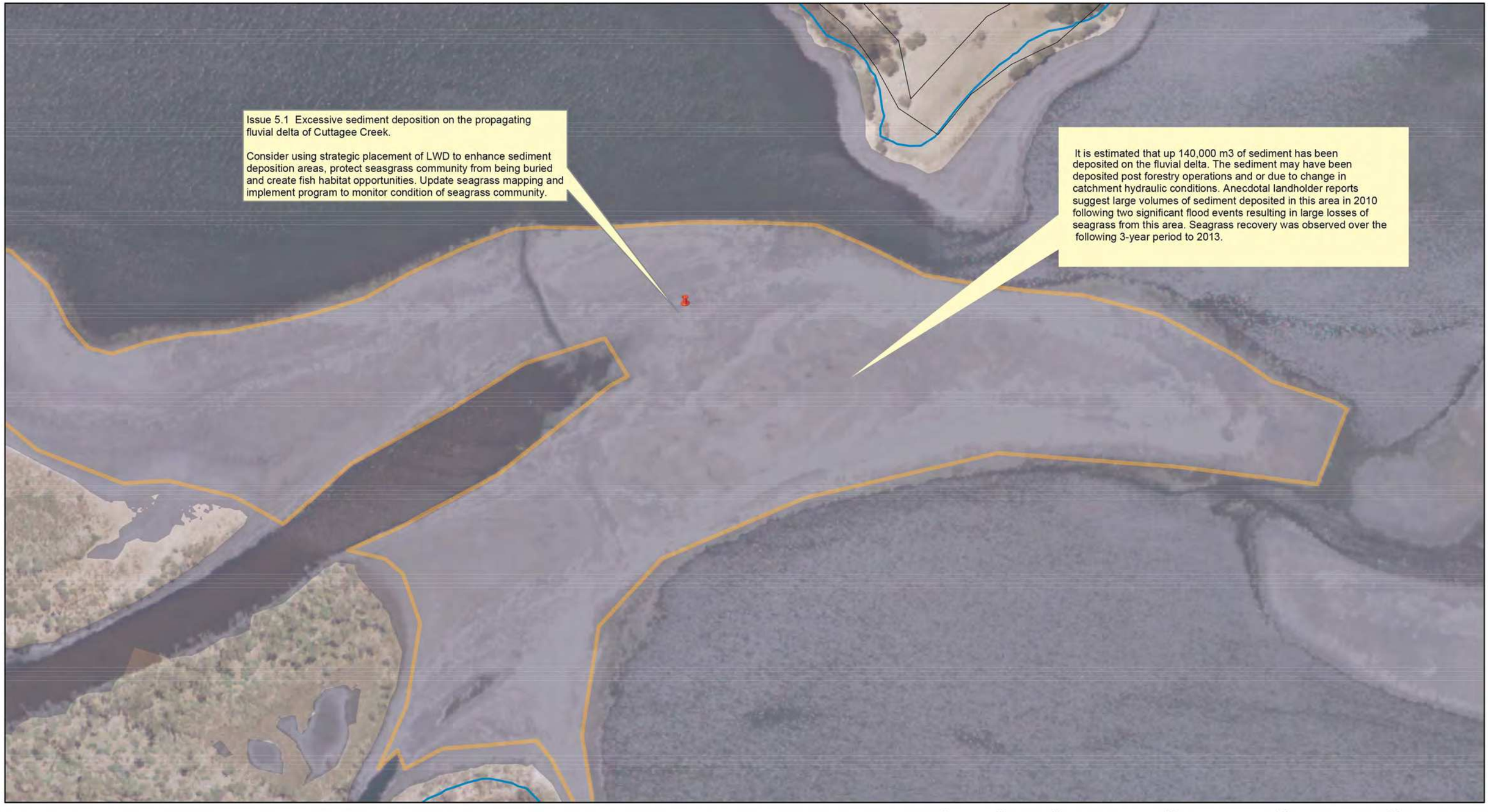
Issue Description: Excessive deposition of fluvial sediments has occurred at the propagating fluvial delta and it is thought that this has likely occurred over a shorter timescale than would be naturally expected. It is estimated that up 140,000 m^3 of sediment has been deposited on the fluvial delta. The sediment may have been deposited post forestry operations and or due to change in catchment

hydraulic conditions. Anecdotal landholder reports suggest large volumes of sediment deposited in this area in 2010 following two significant flood events resulting in burial of seagrass in this area (*pers. obs.* S. Cameron). Subsequent seagrass recovery was observed over the following 3-year period to 2013 (Elgin 2014).

Recommended Treatment Action/s:

- Consider the use of strategically placed LWD to enhance sediment deposition areas, improve channel morphology, protect seagrass community from being buried and indirectly create fish habitat opportunities.
- Update seagrass mapping and implement program to monitor condition of seagrass community. This recommendation may also consider monitoring sediment deposition rates.

Figure B22 Example of naturally deposited LWD at the mouth of Cuttagee creek assisting the formation of levee banks of the propagating delta (*left image*). Area of mapped *Zostera* and *Halophila* seagrass community (outlined in green) in vicinity of the fluvial delta (*right image*).



CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

Issues
Water Level 1.8 m AHD
MHWS 0.556 m AHD
Lot/DP Boundary
Fluvial Depositon

PRIORITY MANAGEMENT AREA 5

Riparian engineering

—

Map B5

Analysis By: Tim Dilworh
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Sheet No.
Sheet 8 of 10

Checked by: Nick Yee

Date: 18 February 2016

APPENDIX B

Priority Management Area 6

Area Description and Issues Synopsis

This area includes the entrance to Cuttagee Lake characterised by the flood-ebb tidal delta and the Tathra-Bermgaui road bridge (**Figure B23**). The area is popular for recreation providing a protected and safe swimming area with access to the foreshore provided via paths in the dunes on the eastern side or a degraded uneven path on the western side. The entrance to Cuttagee Lake intermittently opens and closes and the ecology of Cuttagee Lake is intrinsically linked to its open-closed regime. Frequent artificial openings of the entrance are a potential threat to the ecological values of Cuttagee Lake.

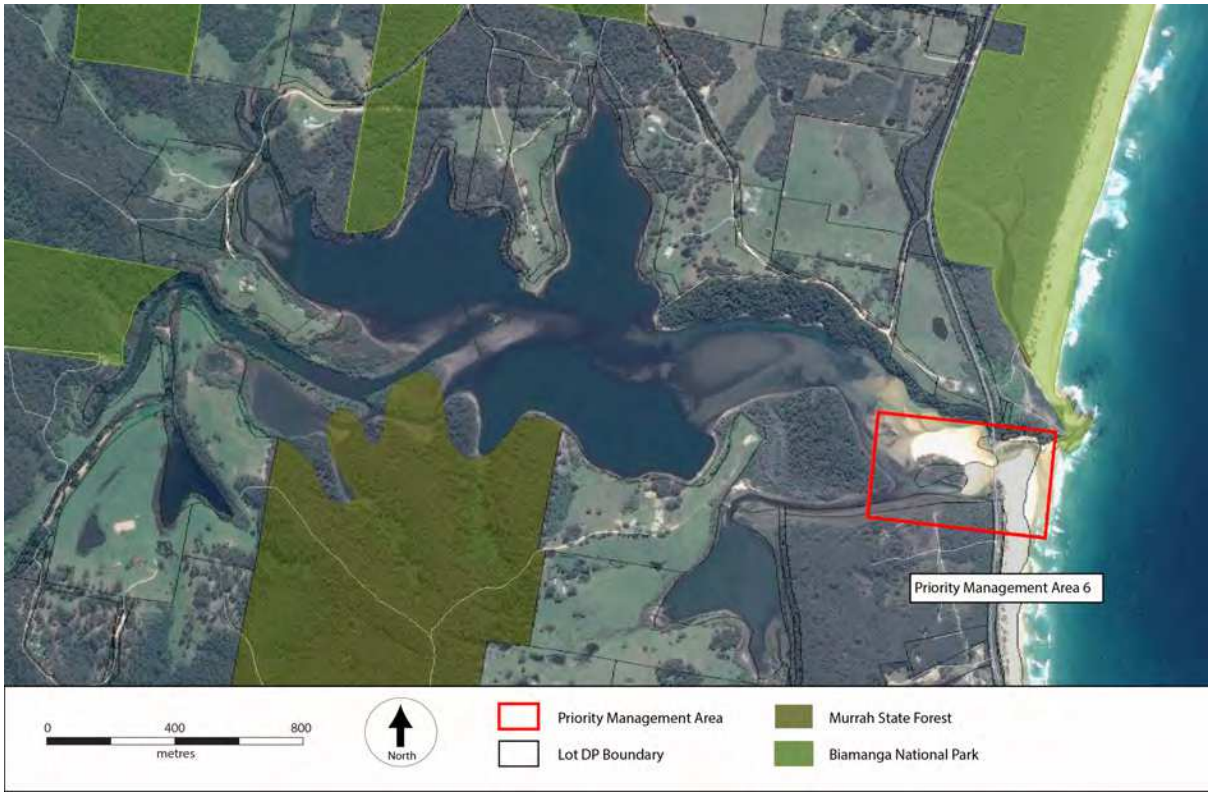


Figure B23 Location of priority management area 6.

Low to Medium priority issues that require attention include:

- **Issue 6.1** Community foreshore access point degraded
- **Issue 6.2** Erosion around foundations of bridge potential threat to structural integrity
- **Issue 6.3** Illegal openings of the estuary entrance

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

APPENDIX B

Issue 6.1: Community foreshore access point degraded

LOW - MED PRIORITY

Site Address [Responsibility]: Estuary foreshore [BVSC, DPI Lands] (Refer **Map B6**).

Issue Description: The entrance to Cuttagee Lake is a popular recreational area for the community. Foreshore access is currently provided via the dunes on the eastern side of Tathra-Bermagui road and via a narrow, uneven path off the western side of the Tathra-Bermagui road. The access path on the western side is degraded and access has become unsafe due to recent erosion.

Recommended Treatment Action/s:

- Consider undertaking minor landscaping works to formalise access to the estuary foreshore from western side of Tathra-Bermagui Road.

Figure B24 Community access to estuary foreshore degraded following recent erosion.

Issue 6.2: Erosion around foundations of Tathra-Bermagui road bridge potential threat to structural integrity

MEDIUM PRIORITY

Site Address [Responsibility]: Estuary foreshore [BVSC, DPI Lands] (Refer **Map B6**).

Issue Description: Following the artificial opening of Cuttagee Lake in mid-2015, substantial bed erosion occurred around the bridge foundations at its southern end. Further erosion may pose a potential threat to structural integrity of the bridge. Previous strengthening works have been undertaken.

Recommended Treatment Action/s:

- Geomorphic and engineering inspection recommended determining threat level to structural integrity of bridge.

- Monitor erosion around the bridge foundations.

Figure B25 Recent bed erosion around the foundations and support poles of the Tathra-Bermagui Road bridge with potential to threaten the structural integrity of bridge.

Issue 6.3: Illegal openings of the estuary entrance

MEDIUM PRIORITY

Site Address [Responsibility]: Estuary foreshore [BVSC, DPI Lands] (Refer **Map B6**).

Issue Description: The entrance to Cuttagee Lake intermittently opens and closes and the ecology of Cuttagee Lake is intrinsically linked to its open-closed regime. During open periods the lake is influenced by marine tidal flows. When the entrance closes, tidal flows cease and lake water levels gradually rise with continual riverine inputs.

Historically the entrance of Cuttagee Lake has been allowed to open naturally. Although in recent times, the entrance has been artificially opened by Council to mitigate and reduce impact of flooding of low-lying roads. Members of the public have also opened the entrance illegally on occasion.

Frequent artificial openings of the entrance are a potential threat to the ecological values of Cuttagee Lake. Opening the entrance of an estuary requires a permit from DPI Fisheries and it is an offence for a member of the public to carry out this activity. To do so attracts heavy penalties of up to $220,000 per offence.

Artificial opening an estuary can have many ecological implications including –

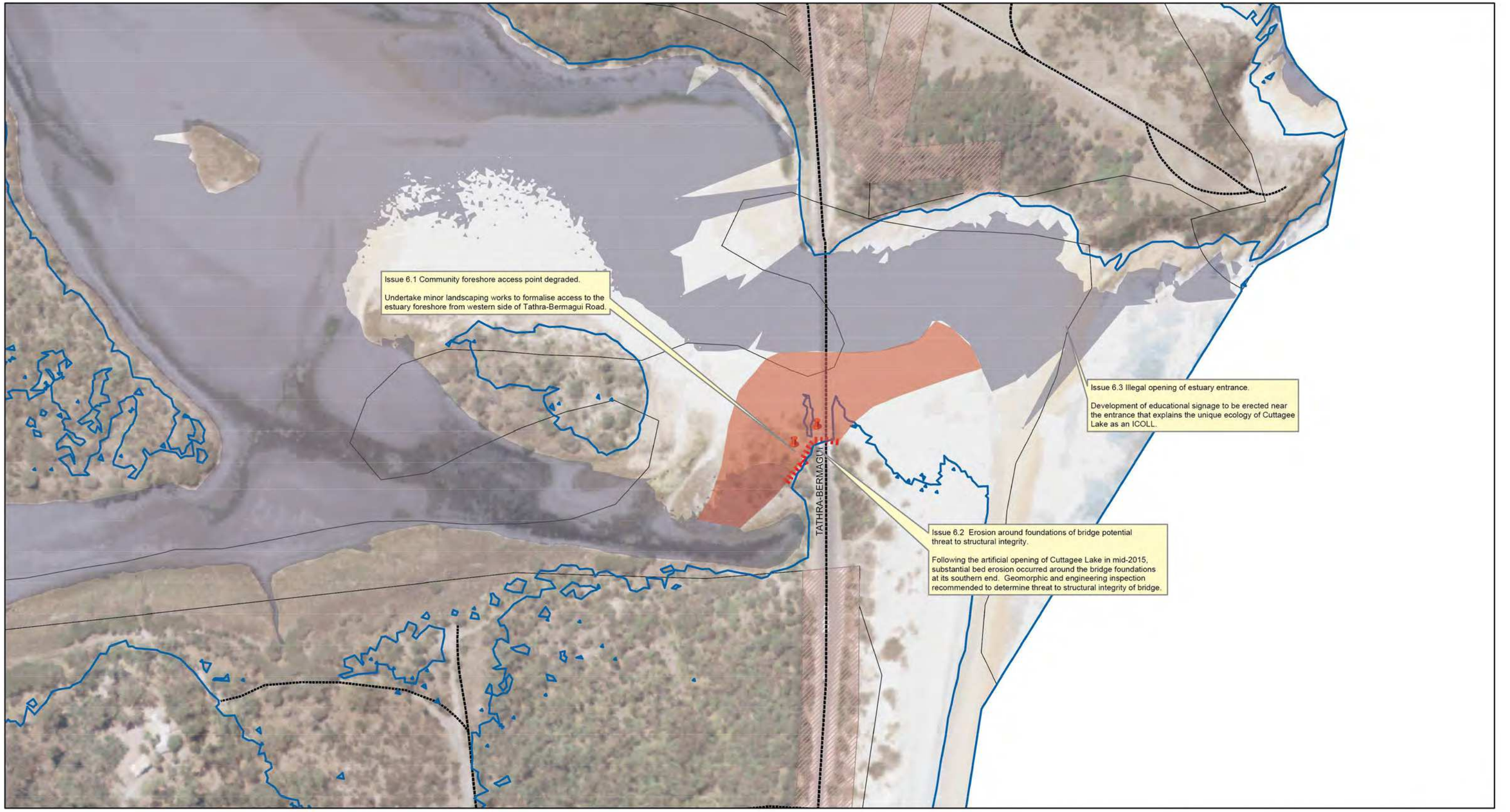
- Rapid lowering of water levels exposing sediments and estuarine vegetation. This exposure can cause release of offensive odours (hydrogen sulfide gas);
- Depending on level of dissolved oxygen in the water, fish kills may occur; and
- Altered salinity regime and water inundation level. While estuaries that have periodic closures naturally experience a broad range of salinity and water levels, more frequent opening of an estuary can lead to shifts in the structure and distribution of riparian

vegetation communities.

Council is currently preparing an entrance management policy for Cuttagee Lake.

Recommended Treatment Action/s:

- Development of educational signage to be erected near the entrance that explains the unique ecology of Cuttagee Lake as an ICOLL



CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

Legend

- Issues
- Beach Entrance Erosion Around Bridge
- Water Level 1.8 m AHD
- Bank Erosion
- Road
- Crown Road Reserve
- MHWS 0.556 m AHD
- Lot/DP Boundary

PRIORITY MANAGEMENT AREA 6

GDA 94 Zone 55

Riparian engineering

Map B6

Analysis By: Tim Dilworh
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Checked by: Nick Yee

Sheet No.
Sheet 9 of 10

Date: 18 February 2016

APPENDIX B

Priority Management Area 7

Area Description and Issues Synopsis

This area includes slopes on private lands surrounding the backwater of Little Cuttagee Lake and approximately 600m long section of estuary foreshore on southern side of Cuttagee Lake as shown in **Figure B26**. The area is bounded by the Murrah State forest on the west and includes good examples of a number of vegetation communities of conservation significance including EECs *Swamp Sclerophyll Forest*, *Bangalay Sand Forest*, and *Coastal Saltmarsh.* There is also a very good example of *Southeast Warm Temperate Rainforest* community that has regenerated naturally in a gully on private lands adjacent to the Murrah State forest. This provides some indication of how assisted restoration of some of the other cleared gullies would improve the overall natural aesthetic and biodiversity value of the estuary. Properties in this area have previously been used for agricultural grazing and thus large areas of vegetation have been historically cleared. Current landholders are not utilising these properties for grazing purposes and preliminary discussions indicate they would be open to the idea of re-establishing vegetation around estuary foreshore areas. Inspection of the area indicates erosion is not currently an issue of concern, with increasing the riparian buffer around the estuary foreshore an opportunity to improve visual aesthetic, biodiversity and water quality outcomes for the estuary.

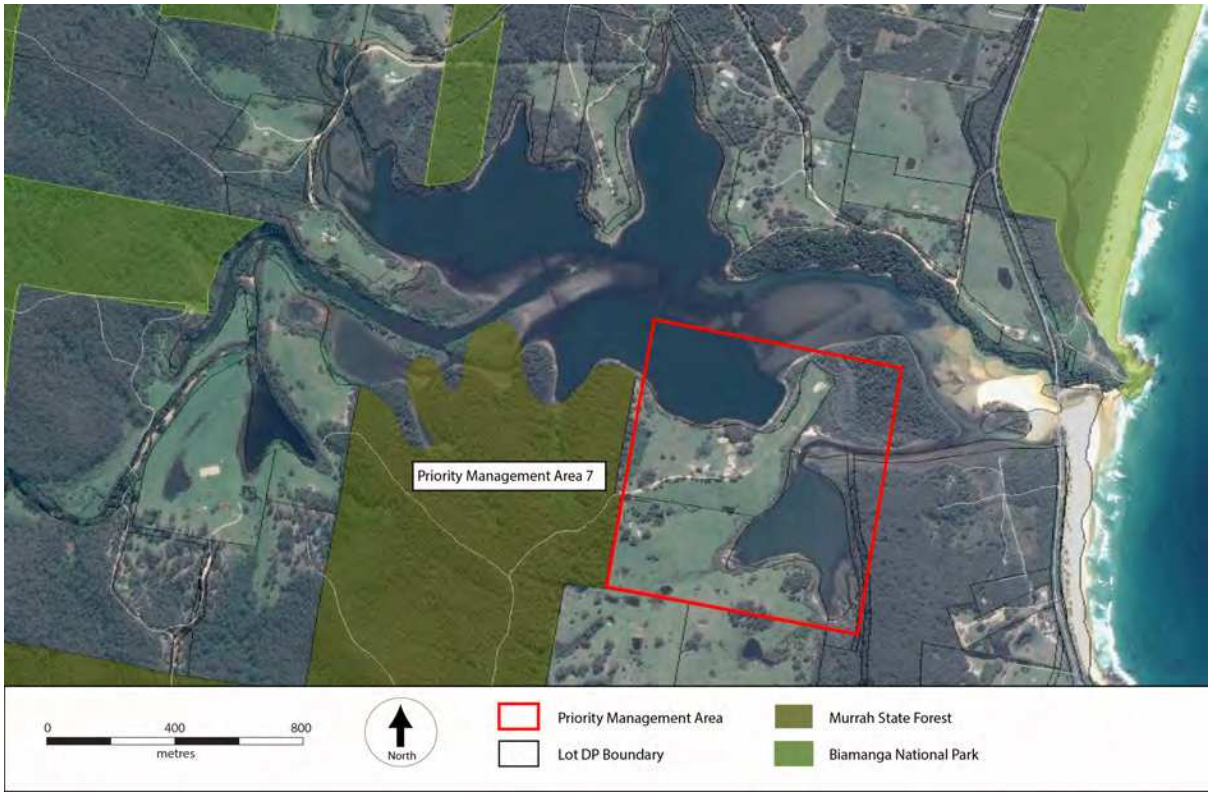


Figure B26 Location of priority management area 7.

Medium priority issue that require attention include:

- Issue 7.1 Limited riparian vegetation surrounding estuary foreshore

A description of this issue and recommended action for treatment is provided below.

APPENDIX B

Issue 7.1: Limited riparian vegetation surrounding estuary foreshore

MED PRIORITY

Site Address [Responsibility]: Riparian Zone on Private land [Lot 123 DP752153] [Lot 122 DP752153] (Refer **Map B7**).

Issue Description: The riparian buffer along the foreshore is narrow and currently comprised of transitional species *Melaleuca armillaris* and *M. ericifolia*. Behind this zone of *Melaleuca* are bare grassed slopes. Opportunities to improve the structure of the riparian vegetation exist employing a strategy of assisted natural regeneration. Re-vegetation of the foreshore and lower slopes would improve the visual aesthetic, biodiversity and water quality outcomes for the estuary.

Recommended Treatment Action/s:

- Work with landholders to expand riparian vegetation buffer where current vegetation exists, and assist natural regeneration of foreshore areas where there is little riparian vegetation.

Exotic weed species to be removed and replaced by local indigenous species. Refer to recommended species list (Appendix D).

Figure B27 Example of *South East Warm Temperate Rainforest* that has naturally regenerated in a gully adjacent to Murrah State forest (left image). Much of the foreshore has been fenced-off with a thin riparian buffer dominated by *Melaleuca* spp. (right image).

APPENDIX B

Figure B28 View of priority management area 7 from the northern side of the estuary showing relatively sparse riparian vegetation on southern foreshore and opportunities to improve the vegetation cover on some of the bare slopes (*left image*). Significant saltmarsh community comprising threatened species *Wilsonia backhousei* exists around Little Cuttagee Lake (right image).

0 62.5 125 250 375 500 Metres

CUTTAGEE LAKE CATCHMENT MANAGEMENT PLAN

PRIORITY MANAGEMENT AREA 7

Legend

- Issues
- South East Warm Temperate Rainforest
- Water Level 1.8 m AHD
- Proposed Regeneration Area
- Crown Road Reserve
- Murrah Flora Reserve
- Lot/DP Boundary
- MHWS 0.556 m AHD

Riparian engineering

GDA 94 Zone 55

Sheet No.
Sheet 10 of 10

Map B7

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 to brackish waters)

Substantial regeneration around Cuttagee Lake foreshores has occurred over past 30 years (since 1980s) by small tree/shrub species such as *Melaleuca armillaris, M. ericifolia, Pittosporum undulatum, Myoporum acuminatum*, with understorey graminoid *Lomandra longifolia*.

Large *Eucalyptus* trees are a notable absence in some lower foreshore areas where they were likely once present. Supplementary planting of species listed here is recommended to assist natural regeneration and re-establish a continuous fringe of tall trees around the estuary.

Vegetation Structure

Large Trees

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

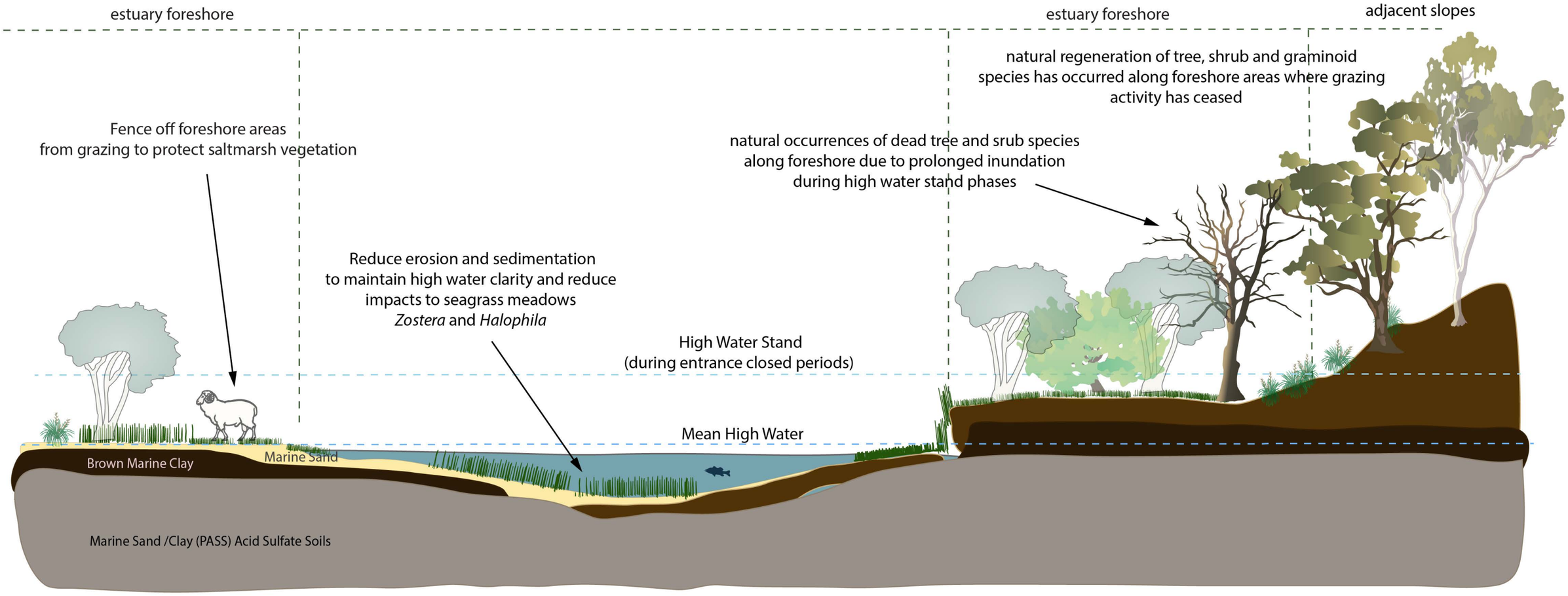
Shrubs/Mid-size trees

Melaleuca armillaris (Honey myrtle)
Melaleuca ericifolia (Swamp paperbark)
Pittosporum undulatum
Myoporum acuminatum (Boobialla)

Graminoids

Lomandra longifolia

Saltmarsh/ Saline wetland sp.



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

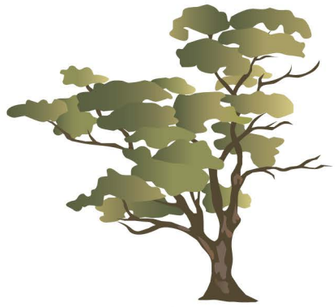
RIPARIAN ZONE OF UPPER ESTUARY

Below tidal limit and high water stand

Plants growing in this estuarine-riparian zone must contend with a degree of saline influence and periods of inundation of varying duration during high water stands when the estuary is closed to the ocean. These conditions preclude the use of several species that occupy the riparian zone further upstream, such as *Tristaniopsis laurina* (kanooka) and *Commersonia fraseri* (black fellows hemp).

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 occur in this zone.

Vegetation Structure



Large Trees

Eucalyptus botryoides (Mahogany)

Shrubs/Mid-size trees

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

Graminoids

Lomandra longifolia
Juncus krausii

Saltmarsh/ Saline wetland sp.

Tree collapse is a natural process that creates fish habitat but also disturbs the streambank causing sediment to enter the estuary. Trees growing at the top of banks showing signs of failure may be coppiced by arborist to reduce wind shear force. Expansion of riparian buffers also reduces wind shear on individual trees.

Fence off riparian buffers from grazing to protect vegetation and minimise damage to streambank

Retain large logs (LWD) for aquatic habitat

High Water Stand (during entrance closed periods)

Mean High Water

Brown Alluvium

Brown Marine Clay

Marine Sand /Clay (PASS) Acid Sulfate Soils

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

RIPARIAN ZONE OF LOWER CATCHMENT

Freshwater environment above tidal limit and high water stand

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 of Cuttagee Creek 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)

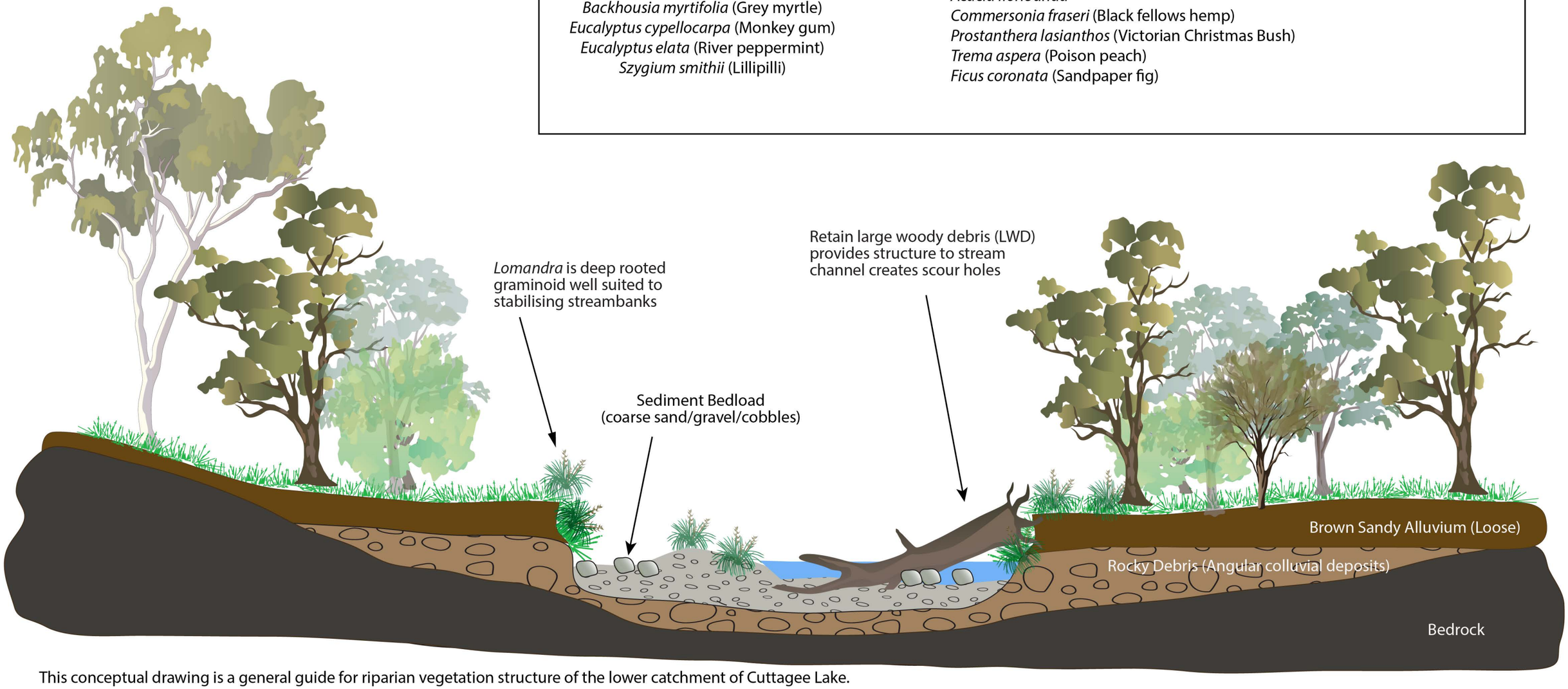
Vegetation Structure

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 Cuttagee Lake.
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 and high stand limit
- Riparian zone of upper estuary above tidal and high stand 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***. For example on parts of the Cuttagee lake shore line where it is recommended that *Eucalyptus* species be planted, use of *Corymbia maculata* (spotted gum) on some sites would be appropriate and in others it would not and alternatives such as *Eucalyptus bosistoana* (grey box) and *Eucalyptus tricarpa* (red ironbark) would be preferable. Similarly there are variations between catchments within otherwise comparable communities, for example *Hedycarya angustifolia* (native mulberry) and *Polyscias murrayi* (pencil cedar) are apparently restricted to Cuttagee stream banks, *Pimelea axillaris* (bootlace bush) to those in the two southern catchments.

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 recolonise 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

Substantial natural regeneration around Cuttagee Lake foreshores has occurred over the past 30 years by small tree/shrub species such as *Melaleuca armillaris, Melaleuca ericifolia, Pittosporum undulatum, Myoporum acuminatum,* with understory graminoid *Lomandra longifolia.*

Eucalypt trees are a notable absence in some lower estuary foreshore areas where they would have once been present. While seedlings have established in some places, some supplementary planting is desirable to reconstitute a continuous fringe of *Eucalyptus* around the shores. The list of *Eucalyptus* spp. recommended here occur along existing uncleared sections of the Cuttagee shoreline, close to the high stand level.

Corymbia maculata (spotted gum)	Large tree
Eucalyptus agglomerata (white stringybark)	Large tree
Eucalyptus bosistoana (grey box)	Large tree
Eucalyptus tricarpa (red ironbark)	Large tree

APPENDIX D

Riparian zone of Upper estuary below tidal and high stand limit	
Plants growing in this zone must contend with a degree of saline influence and periods of inundation of varying duration. These conditions preclude use of several species that occupy the banks further upstream, such as *Tristaniopsis laurina* (kanooka) and *Commersonia fraseri* (black fellow's hemp). Stream banks in this zone are composed of alluvial material whereas rock outcrops are common further upstream. 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 Upper estuary above tidal and high stand 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