Coastal Zone Management Plan for Shaws Bay, Ballina

Volume 2: Supporting Information

Final Draft

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Prepared on behalf of Ballina Shire Council by Hydrosphere Consulting.

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PROJECT 14-019 – SHAWS BAY CZMP - VOLUME 2: SUPPORTING INFORMATION

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1. INTRODUCTION

This document provides a consolidated report on the available information which will inform and support the Coastal Zone Management Plan (CZMP) for Shaws Bay, Ballina. The review includes:

- A summary of community and stakeholder consultation activities undertaken in previous studies and as part of the current study;
- A summary of the relevant information from the 2000 Estuary Management Plan and Estuary Processes Study;
- A summary of other relevant information and its relevance to the CZMP development;
- A discussion of the management issues, supporting data and historical context; and
- A discussion of the quality and reliability of the data and identification of any knowledge gaps.

This information is presented within the categories of coastal hazards, coastal ecosystem health and community uses of the coastal zone. Management issues drawn from this review will form the basis for management actions to be implemented in the CZMP.

1.1 The Study Area

The study area for the Shaws Bay CZMP is located near the mouth of the Richmond River in East Ballina on the NSW north coast (Figure 1). It lies within the Ballina Shire Council (BSC) local government area. The boundary of the study area follows the topographical catchment for Shaws Bay as shown in Figure 2.

Figure 1: Shaws Bay and the Richmond River

This management plan focuses on issues with direct impact on Shaws Bay. Areas of the broader topographical catchment as indicated in Figure 2 are only considered where activities or processes occurring in the catchment have been shown to affect the coastal hazards, ecosystem health, cultural heritage and/or community use of Shaws Bay. The land surrounding the Bay includes a mix of residential and tourist accommodation and recreational areas. The study area includes:

- Part of the Shaws Bay Caravan Park;
- The Shaws Bay Hotel and Fenwick House;
- Residential developments;
- The Ballina Lakeside Holiday Park;
- The off-leash dog exercise area along Compton Drive;

- Pop Denison Park;
- The Ballina Beach Resort;
- The reserve west of the Lighthouse Beach sand dunes and along Fenwick Drive;
- The Marine Rescue Tower; and
- The northern training wall of the Richmond River.

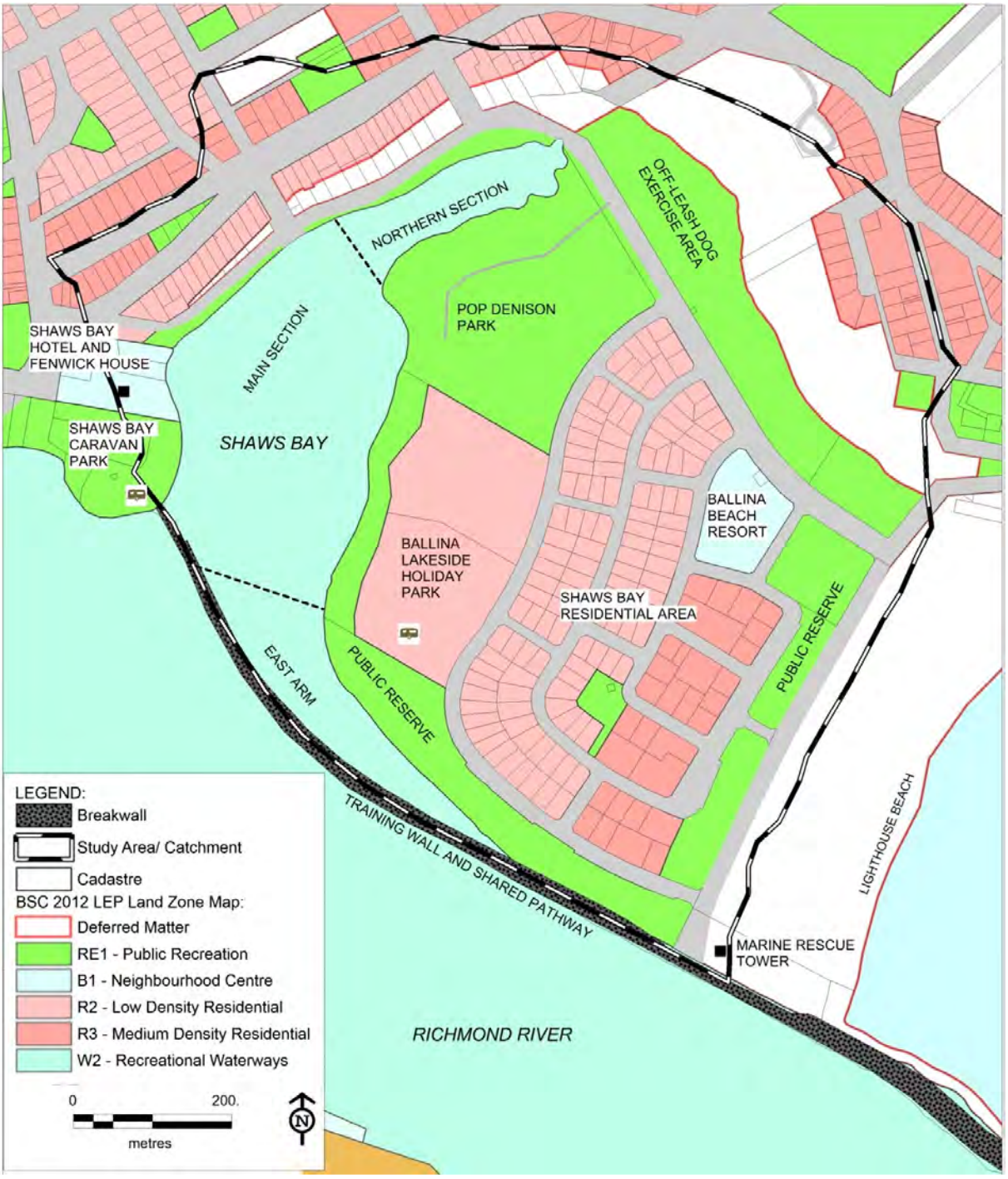


Figure 2: Shaws Bay study area showing Ballina LEP Zoning

Figure 2 also shows the Local Environmental Plan zoning for the study area. The Shaws Bay catchment includes land zoned RE1 Public Recreation, R2 Low Density Residential, R3 Medium Density Residential and B1 Neighbourhood Centre under the 2012 LEP as well as land identified as “deferred matter” which is still subject to the 1987 LEP. The land identified as “deferred matter” is under review by the Minister for Planning and Infrastructure and includes 7(d) Scenic Escarpment along the western side of Compton Drive, 2(a) Living Area along Bayview Street, 6(a) Open Space west of Compton Drive.

For the purposes of this study, the waterway has been divided into three distinct areas (as in the 2000 EMP) shown on Figure 2:

- Northern Section (right);
- Main Section (bottom left); and
- East Arm (right).

Figure 3: Shaws Bay waterway areas

The foreshore features include sandy shorelines, a retaining wall supporting Compton Drive and the Shaws Bay Caravan Park, concrete steps providing access to the Bay adjacent to Shaws Bay Caravan Park, rock revetment along the Main Section of the East Arm and the northern training wall of the Richmond River. Community infrastructure and amenities include public toilets, picnic shelters and tables, a playground and boules area, outdoor showers and benches. Urban stormwater from the surrounding areas drains into Shaws Bay (refer Section 6.1.3).

The Shaws Bay area retains a cultural connection for Aboriginal people because of historic events known to have taken place there, and because for countless generations, ancestors were known to have maintained and managed the food resources available in the area. The Bay is also a popular recreational area of great importance to the local community. Community uses of Shaws Bay including a description of public access, recreational uses, amenity and cultural heritage are discussed in Section 7.

Shaws Bay has evolved into a diversity of habitats for a wide variety of flora and fauna. Important estuarine habitats include areas of seagrass, saltmarsh and mangroves. Terrestrial vegetation in the immediate vicinity of the Bay and surrounding catchment also provides habitat for a range of species and includes protected vegetation communities. A number of threatened fauna species are known to utilise Shaws Bay including shorebirds, raptors and fish species. The estuary health status is discussed in Section 6.

2. EXISTING MANAGEMENT PLANS

2.1 Shaws Bay Estuary Management Plan (2000)

The Shaws Bay Estuary Management Plan (EMP) (PBP, 2000b) was prepared to address the management needs of Shaws Bay and propose activities to address those needs. The issues addressed in the 2000 EMP were identified by the Shaws Bay Estuary Management Committee (which is no longer active) and through community consultation activities. The EMP included an Estuary Processes Study (EPS; PBP, 2000a) to provide an understanding of physical, chemical and biological processes within the Bay and enable prioritisation of the management issues based on their actual impact on the environmental and recreational values of the Bay.

The overall goal for management of Shaws Bay in the 2000 EMP was:

> *"to improve the recreational amenity of Shaws Bay and to ensure that the habitat and ecological values of the Bay are maintained within an acceptable range."*

Management objectives were also developed to address the primary areas of concern:

- Pollution Objectives:
    - To reduce the amount of organic litter entering Shaws Bay.
    - To minimise the amount of nutrients and bacteria entering Shaws Bay.
    - To reduce the amount of rubbish around the foreshores of Shaws Bay and generally improve aesthetics.
- Siltation Objectives:
    - To monitor the amount of siltation occurring in Shaws Bay.
    - To stop erosion of the foreshores of Shaws Bay.
- Recreation Objectives:
    - Maintain seagrass-free access into and out of Shaws Bay.
    - To enhance public access (including disabled access) around the foreshores of Shaws Bay.
    - To enhance public facilities around Shaws Bay.
- Ecology Objectives:
    - To reduce the amount of weed growth around Shaws Bay.
    - Protection of aquatic life and habitats within and around Shaws Bay.
    - Protection of terrestrial flora and fauna around Shaws Bay.
    - To gain a better appreciation for the biodiversity and ecology of Shaws Bay.

A variety of options (structural and non-structural measures) were developed as part of the EMP to address the above management objectives. Management tasks were then proposed to address the primary management issues of pollution, siltation, recreation and ecology.

To assist in the development of this CZMP, an assessment of the status of actions from the 2000 EMP was undertaken. This audit of actions will assist in determining what management issues have been addressed, what requires further management and any lessons learned from previous implementation actions. Where residual issues are still apparent, further action that may be required is discussed in Table 1.

Table 1: Status of tasks from 2000 EMP

Task	Actions undertaken since EMP and current status (April 2014)	Potential Considerations for 2014 CZMP
Pollution Related Tasks		
A. Install litter/organic debris collection devices	Approximately 100 stormwater pollution baskets ('Enviropod' baskets) have been installed in the inlet pits of Shaws Bay and two end-of-line pollution control units have also been installed.	Effectiveness of installed pollution controls and current impacts on water quality in Shaws Bay from urban stormwater drainage.
B. Encouragement of native gardens	This has been addressed Shire-wide via the publication of the *Urban Garden Guide* and *Protecting Reserves from Dumping* brochure. Illegal dumping is pursued wherever possible but has not been a serious issue in Shaws Bay.	Any revegetation actions to consider the use of native evergreen species to minimise organic litter in the stormwater drainage system. Monitoring of the content of stormwater pits (refer Task A) will assist in identifying the magnitude of this issue.
C. Garden refuse collection service	This issue is addressed in the Council's shire-wide Waste Management Plan which commenced in July 2011. Organic waste bins have been provided to all Shire residents with weekly kerbside collection.	This task is considered to be complete.
D. Placement of gravel aprons at stormwater outlets	Works to control scour at outlets from the stormwater drains were completed in 2010/11. This included scour protection works at seven stormwater outlets. The placement of gravel aprons at the stormwater outlets is also expected to assist with the prevention of anaerobic pools and sedimentation.	Effectiveness of scour control works on water quality in Shaws Bay.
E. Community education on pollution	This is a continuing process shire-wide with advice in news letters on topical issues, publications issued with grant funding when available such as the *Sustainable Urban Business Program* and regular messages from all levels of Government. Rangers or Environmental Health Officers deal with offenders when evidence is available.	Ongoing community education to be considered.
F. Regular water quality monitoring	Shaws Bay is monitored throughout the swimming season through the Beachwatch program run by Council in conjunction with the Office of Environment and Heritage. This includes bacterial indicators and physico-chemical parameters. The program is focussed on bathing water quality.	Estuary health monitoring program consistent with the NSW Monitoring, Evaluation and Reporting (MER) Program and locally relevant to Shaws Bay. The NSW MER Program provides a system for monitoring, evaluation and reporting on estuary condition against the state-wide natural resource targets. The target specific to estuaries is: By 2015 there is an improvement in the condition of estuaries and coastal lake ecosystems.

Task	Actions undertaken since EMP and current status (April 2014)	Potential Considerations for 2014 CZMP
G. Install more rubbish bins	Complete. Adequacy is being monitored.	General status of foreshore facilities to be considered.
H. Improve aesthetics of Bay foreshores	Broken stormwater pipes and mangrove debris have been removed. Limited landscaping works has been undertaken around the Compton Drive car parking area.	General status of foreshore facilities and water way access to be considered.
Siltation Related Tasks		
I. Routine hydro surveys of Shaws Bay	Hydrographic surveys were undertaken in 2000 and more recently in 2013.	Extent of infilling and required management measures to be considered.
J. Remove accumulated sediment, as required	Dredging of the Bay was undertaken in the mid-1970s, early 1980s, mid to late 1980s and 1990s.	Sediment removal to be considered.
K. Create stable sandy beach in East Arm	Council commissioned a study to investigate options to address erosion of the East Arm shoreline in 2001 (WBM, 2001). Methods considered involved dissipation of the wave energy and interruption of sand transport. The study recommended a combined beach reshaping and single primary groyne constructed from sand bags. The option was then developed in consultation with Fisheries NSW and an environmental assessment was prepared in 2009 (GeoLINK, 2009). An application was made under the NSW Estuary Management Program for implementation funding but was unsuccessful.	Erosion control options to be considered.
L. Remediate gully erosion	Gully erosion controls works were completed at five sites around the Bay in 2010/11.	Effectiveness of gully erosion control works on water quality and bank erosion in Shaws Bay. Some gully erosion still present (e.g. north of Lakeside Holiday Park). Sediment fences installed during the works (near Pop Denison Park) to be removed.

Task	Actions undertaken since EMP and current status (April 2014)	Potential Considerations for 2014 CZMP
Recreation Related Tasks		
M. Maintain seagrass-free access into water	Council sought a permit from Fisheries NSW in 2004 to undertake dredge and reclamation works in the Bay (to remove seagrass). At that time, areas in the eastern side of the Bay and two middle access points on the western side were found to be clear of seagrass. The northern and southern most access points had a minor amount of seagrass recovery in the "seagrass free zones". Due to the recreational values relying on seagrass (fishing, snorkelling etc.) and the water quality benefits provided by the seagrass beds, Fisheries NSW did not support the harming and removing of marine vegetation to maintain infrequently used access points and Council was unable to secure an approval to undertake this work.	The locations and extent of seagrass to be reviewed. Options for waterway access to be considered in consultation with Fisheries NSW.
N. Cycleway/pedestrian way along western foreshore	Not commenced. Identified issues include access across private land, various approvals, possible reclamation and cost implications.	General status of foreshore facilities to be considered.
O. Disabled access to foreshore	Disabled access ramp to the waterway was installed on the north-western shore during the early phase of EMP implementation.	General status of foreshore access arrangements to be considered.
P. Install more picnic facilities in Pop Denison Park	Existing facilities have been enhanced and maintained. A new barbecue and picnic shelter was approved by Council in March 2014. Funding of $53,000 has been approved for 2013/14. Funding for rebuilding of existing amenities into a modular amenities block ($100,000) has been allocated for 2016/17.	General status of foreshore facilities to be considered.
Q. Plant more shade trees in Pop Denison Park and around foreshores	Some new tree planting has taken place since the plan was adopted. Vandalism, maintenance and funding constraints have prevented further progress.	General status of foreshore facilities to be considered.
R. Install washdown shower on western foreshore	A shower was installed during the early phase of EMP implementation.	General status of foreshore facilities to be considered.
S. Install bench seating around Bay	Seats were added along the training wall. A memorial bench seat was installed along the East Arm foreshore. Further seating has not been installed to date.	General status of foreshore facilities to be considered.
Ecology Related Tasks		
T. Remove weeds from around foreshore	Some effort has been made in this regard including ongoing maintenance. Further work may be considered as part of a landscaping master-plan not currently funded.	Condition of foreshore vegetation to be considered.

Task	Actions undertaken since EMP and current status (April 2014)	Potential Considerations for 2014 CZMP
U. Selective removal of mangrove seedlings	Approval from Fisheries NSW has been obtained for mangrove exclusion in specific areas (along the training wall between the Bay and the river and access areas identified in the 2000 EMP) and this occurs on an annual basis. This will continue as necessary.	General status of foreshore access arrangements to be considered.
V. Monitor the spread of *Ulva* in Shaws Bay	*Ulva* appears to have receded to the point where this is not currently a priority.	Condition of aquatic habitat to be considered.
W. Plant vegetation corridor between Bay and rainforest	Not commenced. Priority being given to escarpment regeneration and restoration (see Task Y).	Condition of terrestrial vegetation to be considered.
X. Erect Osprey pole	Not commenced. This has been discussed with appropriate authorities and is not recommended at this time.	Avifauna habitat requirements to be considered.
Y. Remove weeds from rainforest	Council has been in receipt of several grants that have allowed significant progress on this very challenging task. This work is continuing under a current grant in association with Coastcare. Council is also preparing a Vegetation Management Plan which will direct future efforts in this regard.	Condition of terrestrial vegetation to be considered.
Z. Mangrove boardwalk and rainforest hiking trails	Not commenced.	General status of foreshore facilities to be considered.
AA. Interpretive eco-educational signage	Not commenced.	General status of community facilities to be considered.
BB. Development of school project kits and tours	Council understands that Ballina High School Marine Studies include Shaws Bay in their educational program. The school has special lifters to enable students to view the contents of the 'Enviropod' units that are installed in the stormwater pits.	Consultation with Ballina High School Marine Studies Unit
CC. Community participation in management works	Whilst not extensive there has been involvement of the community through Landcare groups and on Clean-up Australia Day.	Ongoing community participation to be considered.

2.2 Related Initiatives

In addition to the EPS and EMP produced in 2000, a range of other initiatives are directly relevant to the management of Shaws Bay.

2.2.1 Coastal Zone Management Plan for the Richmond River Estuary

The *Coastal Zone Management Plan for the Richmond River Estuary* (Hydrosphere Consulting, 2011) contains a suite of broad catchment actions aimed at improving estuarine ecosystem health. The Plan includes the Shaws Bay catchment as a management zone within the plan area and therefore many of the management strategies are directly applicable to Shaws Bay. The Richmond River CZMP is much broader in its approach to management across a large catchment encompassing several local government areas. The Richmond River CZMP includes actions to assess and prioritise key areas to direct management effort such as riparian restoration at key sites to provide maximum overall benefit. It also promotes catchment-wide initiatives, such as farm management planning, assessment of alternative land uses for backswamp farms, education programs, and Ecohealth monitoring. The Richmond River CZMP was adopted by Council in 2011 and gazetted by the Minister in February 2012.

2.2.2 Ballina Urban Stormwater Management Plan

The *Ballina Shire Urban Stormwater Management Plan* (USMP) (Hydrosphere Consulting, 2012) has been prepared to improve the sustainability and amenity value of the Ballina Shire urban stormwater management systems. This Plan builds on Council's 2002 *Urban Stormwater Management Strategy* and focuses on providing an effective framework for stormwater management and providing a clear implementation path to address priority issues. This Plan seeks to review and improve Council's management and planning processes to ensure that stormwater systems are designed, constructed and maintained to best practice standards and in locations that will maximise their environmental, social and economic benefits to the community. The USMP focuses on delivering enhanced urban stormwater management components of an integrated urban water management approach through improved administration and governance and increased emphasis on water sensitive urban design.

2.2.3 CZMP for Ballina Shire Coastline

The draft *CZMP for the Ballina Shire Coastline* (GeoLINK, 2013) provides the strategic framework for BSC to protect coastal values in a manner that has the support of its government partners and the community. The geographical area covered by the CZMP includes the coastline of the Ballina Shire inland to the landward limit of coastal hazards over the 2100 planning period, which for Lighthouse Beach is defined as the erosion extent due to shoreline recession of up to 55m at 2100 including the effects of sea level rise based on the previous NSW government sea level rise policy. Note that this policy has been withdrawn by the NSW Government but is currently still used by Council for planning purposes. The limit of coastal hazard at Lighthouse Beach addressed by the CZMP does not extend into the Shaws Bay CZMP study area.

Lighthouse Beach is expected to remain stable into the future, with some beach rotation, and is likely to be subject to sea level rise induced shoreline recession. As there is no major development under coastal erosion threat and the beach exhibits general stability and low recession distances, the primary coastline management objective is to allow coastal erosion to proceed under monitoring. In addition to the monitoring, localised dune management works are also recommended in the CZMP.

2.2.4 Flood Management Planning

The New South Wales government's *Flood Prone Land Policy* is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard, and does not create additional flooding problems in other areas. For Ballina Shire, the Data

Collection and the Flood Study phases were completed in 2008 and the *Ballina Floodplain Risk Management Study* (BFRMS) was adopted in 2012. The *Floodplain Risk Management Plan* (BFRMP, BMT WBM, 2013) is expected to be publicly exhibited and adopted in 2014/15. The BFRMP provides practical information with regard to the recommended floodplain management measures such as timing, priority, expense and responsibility or recommendations for further investigation.

As part of the BFRMS, a computer-based flood model was used to simulate hypothetical design floods. The flood model simulates how the design floods spread through the catchment, thereby facilitating an assessment of flood risk. The model has been used to assess current flood risk to both rural and urban areas in the Plan's study area. This flood risk may be exacerbated by future climate change and the BFRMP simulates predicted increases in sea levels and rainfall intensity based on the *NSW Government Sea Level Rise Policy* (now withdrawn but used by Council for planning purposes) of:

- An increase above 1990 mean sea levels of 40 cm by 2050;
- An increase above 1990 mean sea levels of 90 cm by 2100; and
- A 10% increase in rainfall intensity for both the 2050 and 2100 climate change horizons.

The BFRMS identifies the extent of flooding predicted for a 100 year ARI flood event for current, 2050 and 2100 (the 100 year flood event is a flood that can be expected to be equalled or exceeded every 100 years on average over a long period of time. A 100 year ARI flood has a 1% probability of being exceeded in any year, which leads to a 50% probability of occurring within a 70 year period).

The BFRMP considers three types of management measures:

- Property modification measures seek to reduce flood risk through careful planning of future developments. Property modification measures can also be applied to existing developments to either reduce the flood risk by raising the house, or by removing the property from the flood prone location altogether. Property modification measures include development controls;
- Flood modification measures are designed to modify the behaviour of floodwaters by either reducing flood depths or velocities, or by excluding floodwater from certain areas; and
- Response modification measures change the way we respond to flood risk, through measures such as evacuation planning and education. In general, response modification measures are the simplest and most cost effective measures to install, alongside planning controls. These measures primarily mitigate the residential flood risk.

The recommended flood mitigation measures relevant to Shaws Bay CZMP study area are:

- Update of development controls – Council has prepared a draft floodplain management development control plan (DCP) which is expected to be adopted in 2014/15. Each of the flood prone areas within the local government area are classified based on different levels of potential flood risk. The DCP identifies parts of the Shaws Bay CZMP study area as extreme flood risk precinct (the waterway and parts of Pop Denison Park and Fenwick Drive Reserve), high flood risk precinct (parts of the western foreshore, Shaws Bay Caravan Park, Pop Denison Park and Ballina Lakeside Holiday Park), medium flood risk precinct (the remainder of Pop Denison Park, much of Ballina Lakeside Holiday Park and parts of the residential area) and low flood risk precinct (the remainder of the residential area). Controls for filling or development in the flood risk precincts are based on the level of risk identified in the DCP and the proposed land use;
- Flood warning and evacuation planning and management; and
- Development of community engagement strategy.

2.2.5 Ballina Coastal Reserve Plan of Management

The primary objective of the *Ballina Coastal Reserve Plan of Management* (PoM) (Ballina Shire Council, 2011) is the rationalisation of all vacant Crown lands and existing Crown reserves into a single coastal Crown reserve for the notified purpose of Public Recreation and Coastal Environmental Protection with the appointment of Ballina Shire Council as Reserve Trust Manager. Management issues for Shaws Bay were identified as:

- Desire to maintain recreational amenity value of the area;
- Potential for improved amenity in some areas to cater for future demands;
- Protection and promotion of heritage values of the area;
- Potential for additional light commercial activity to supplement funding requirements for implementation of the Plan of Management; and
- Integration with Shaw's Bay Caravan Park and Pop Denison Park Plans of Management (when completed).

Prioritised management options were identified as:

- Water quality and recreational amenity in Shaw's Bay Lagoon – Seagrass control, maintenance of tidal flushing and management of stormwater discharge into the Shaw's Bay water body;
- Environmental management – habitat and native vegetation – completing and implementing native vegetation management plans. Rationalising and formalising pedestrian beach access paths;
- Locality planning – developing and implementing detailed operational plans for Shaws Bay, Pop Denison Park, south-east Finger Shaw's Bay;
- Traffic management and parking;
- Cultural heritage - identifying and promoting the cultural heritage of Precinct 5; and
- Amenity improvements.

2.2.6 Vegetation Management Plan

The *Vegetation Management Plan for East Ballina Reserves* (VMP) (Blackwood Ecological Services, 2014) provides an up to date assessment for vegetation along the western and northern fringes of Shaws Bay and the Shaws Bay Escarpment area. The VMP does not include areas to the immediate east of the Bay including Pop Denison Park, Lakeside Holiday Park or Shaws Bay residential area. The VMP sets out a detailed set of management actions including prescribed methods of bush regeneration and weed management strategies for 'subzones' within the study area.

2.2.7 Shaws Bay Holiday Park Plan of Management

NSW Trade and Investment (Crown Lands) has prepared a draft Plan of Management for Shaws Bay Holiday Park. The Holiday Park is situated on Crown land on the Richmond River estuary foreshores (western foreshore of Shaws Bay) and provides holiday accommodation and recreational opportunities. The plan provides the blueprint for management and improvements to the Holiday Park and the surrounding reserve area over the next 5 -10 years. The plan aims to maximise the values of the unique setting and improve Holiday Park facilities and recreational values in an environmentally sensitive manner. It also addresses the conservation and appropriate management of items of heritage significance. Proposed improvements to the Holiday Park include upgraded facilities, layout and presentation.

The North Coast Accommodation Trust was appointed to manage the land in April 2010 and was replaced in May 2013 by the NSW Crown Holiday Parks Trust. The land identified in the original gazettal of the

appointment of the North Coast Accommodation Trust did not accurately represent the operational boundaries of the Holiday Park. The Plan includes proposed adjustment to the park boundary to reflect the operational areas as shown in Figure 4.

Figure 4: Land covered by the Draft Plan of Management for Shaws Bay Holiday Park and proposed boundary adjustment

Source: Crown Lands (2014)

Other aspects of the draft Plan of Management include:

- Improving amenity and safety of the Holiday Park for users;
- Providing more car parking within the park and less reliance on street parking;
- Modifications to the entry precinct to provide a more efficient check in area and reduce congestion in the car parking area at the front of the park;
- Alteration to the layout of roads and sites in the hilltop precinct to resolve compliance concerns, improve traffic flow and provide more generous sites;
- Modification of the two storey amenities overlooking Shaws Bay to provide a new guest lounge on the upper level;
- Creation of a new recreation area on the lower foreshore precinct including a pool;
- Adaptive re-use of the heritage listed former ambulance station as a guest lounge;
- Adaptive re-use of the laundry to provide a riverfront café;
- Provision of high quality modern guest facilities and amenities;
- Provision of additional wheelchair accessible accommodation and facilities; and
- Amenities that facilitate equity of access.

3. STUDY AREA CHARACTERISTICS

3.1 Formation of Shaws Bay

Shaws Bay was formerly part of the Richmond River entrance and is now a coastal embayment formed by the construction of the Richmond River training walls and the subsequent residential development. The formation of the Bay is discussed in the EPS (PBP, 2000a) and summarised below.

Prior to the construction of the training walls at the turn of the century, the river entrance was very dynamic, capable of moving by up to two kilometres depending on prevailing ocean conditions and flood discharges from North Creek and the Richmond River. After construction of the training walls, marine sand was able to move into the area and form extensive sand deposits behind the beach foredunes. During large seas, ocean water was able to penetrate into the remnant lagoon (now known as Shaws Bay) behind the Lighthouse Beach sand dunes via the East Arm. Wind-blown sand would also have been slowly filling in Shaws Bay (PBP, 2000a).

In about 1962, the low-lying sand flats between the lagoon and high beach dunes were filled to their present elevation with material from the lagoon (and possibly North Creek) in preparation for urban development. Compton Drive was constructed by infilling of the western foreshore and gazetted a public road in 1965. The retaining wall was constructed along the waterway edge and sand was placed to form a new sand foreshore along Compton Drive. The northern training wall was extended in the mid-1960s and Lighthouse Parade was constructed, effectively closing the East Arm to the ocean and preventing further ingress of marine sands into the Bay. The Shaws Bay residential development was constructed in the early to mid-1970s, preventing further transport of wind-blown sand from the area (PBP, 2000a).

Dredging of the Bay was undertaken in the mid-1970s to form sandy beaches along the western side of the Bay. Dredging was again carried out twice in the 1980s. Wind generated waves transported this sand back into the deeper sections of the Bay in a northerly direction. A long-reach excavator was used in the early 1990s to again pull sand back onto the beach areas. Since then, the shoreline has become relatively stable (PBP, 2000a).

Figure 5: Camping and other recreational facilities at Shaws Bay (c. 1920s)
Source: BSC (2008)

3.2 Climate

The Ballina region experiences a mild subtropical coastal climate with moderate maximum and mild minimum temperatures and high intensity rainfall. The majority of rain falls in the summer and autumn months. Average annual rainfall is 1,782 mm measured at the Ballina Airport AWS (since 1992). Average daily temperatures vary from 18°C to 28°C in summer and from 9°C to 20°C in winter. Mean wind speed is 21.4 km/h at 3pm, predominantly from the south, tending to the north-east in summer months (BOM, 2014).

3.2.1 Climate Change

Natural variations in temperature and rainfall in NSW are influenced by the naturally variable climate systems. Although there is natural variability in the climate, there is consensus among climate scientists that the rate and magnitude of climate change is outside the expected range of this natural variability. Climate change is an important consideration for strategic planning, particularly in coastal areas where the combined effects of sea level rise and increased storminess are considered key threats.

Sea level rise is anticipated to result in management issues including increased inundation of low lying lands, infrastructure and development and implications for drainage and flooding in urban areas. The issue of potential increased storminess is less well understood. It is generally anticipated that rainfall events will become more intense, even if average rainfall reduces, in response to climate change. This may result in effects such as more floods as well as greater capacity for erosion and runoff and pollution of waterways within the catchment.

Climate change is inevitable and planning benchmarks already exist in terms of future sea level rise as discussed in Section 5.1. Locally, there will be impacts from climate change that are unavoidable such as sea level rise and changes to rainfall patterns and therefore long-term management planning needs to consider the likely changes to Shaws Bay and the factors constraining adaptation to such change.

3.3 Topography, Geology and Soils

Current topography of the Shaws Bay catchment includes a steep heavily vegetated escarpment to the west and north and flat delta shoals, back barrier beach and washover deposits which have been compacted for urban development in the main part of the study area. The escarpment represents former sea cliffs of basalt rock with a thin sand cover, remnant from former transgressive dune development and Aeolian sand accumulation. The urban development area has a natural substrate of marine sand with imported marine sand and loamy material used as fill (PBP, 2000a).

3.4 Bathymetry

Prior to the construction of the Richmond River training walls, historic survey charts show Shaws Bay as a lagoon enclosed by the shifting sand shoals and variable channel of the Richmond River as discussed in Section 3.1. The construction of the training walls and infilling works for residential development establishing the present day plan shape of Shaws Bay, with dredging activity further defining the bathymetric characteristics of the Bay. Dredging was restricted to depths of around 3-4m with the majority of material being extracted from the north-western section of the Bay with much of the Bay already below the 3 to 4m dredging threshold (PBP, 2000a).

Shaws Bay consists of three main bathymetric sections (refer to Figure 2 and Figure 6). The central Main Section of the Bay, which is also the deepest makes up the main proportion of the waterway and currently has a maximum depth of around 6.6m (at mid-tide). The Northern Section of Shaws Bay is narrower (50-80m wide) with a central channel of around 4m depth. At the south-eastern end of the Bay, a narrow shallow area known as the East Arm extends along the training wall. This area is typically less than 1m deep at mid-tide, with extensive sandy shoals toward the east at low tide.

Although some anecdotal records exist of historical bathymetry, the only contemporary hydrographic surveys of Shaws Bay were undertaken in 1999 and again in 2013 (Figure 6). Changes in the bathymetry between these surveys and rates of infilling is discussed in Section 3.6.1.

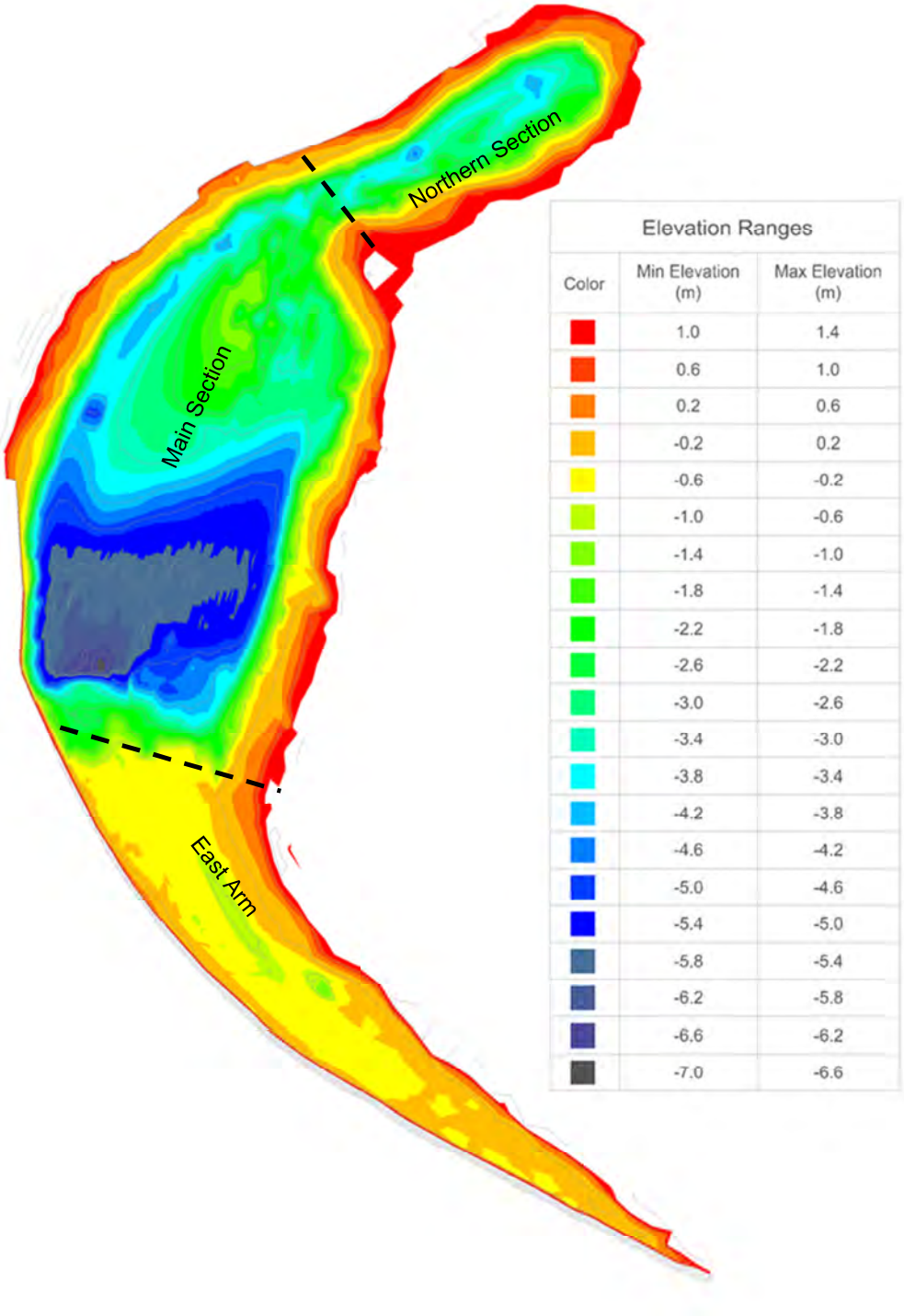


Figure 6: Shaws Bay bathymetry based on 2013 hydrographic survey

3.5 Tidal and Freshwater Hydrodynamics

Shaws Bay is dominated by tidal hydrodynamic processes but occasionally receives significant freshwater inputs from the natural catchment as well as stormwater infrastructure that discharges to the Bay. The influence of these factors is discussed below.

3.5.1 Tidal Hydraulics

The oceanic tidal influence on Shaws Bay is due to the open (porous) structure of the training wall separating Shaws Bay from the Richmond River estuary. The influence of the tide is visually apparent, particularly in the East Arm, where tidal flows can be observed, depending on the tide state, to be entering or exiting through the rockwork of the training wall.

Although few long-term data exist on the tidal behaviour of Shaws Bay, studies carried out in support of the EPS (PBP, 2000a) provide some understanding based on data collected in 1999. In comparison to the adjoining Richmond River, the levels of high tides within Shaws Bay were found to be very similar, indicating that there is no significant impediment to the propagation of high water levels through the matrix of the wall.

Conversely, during spring low tides, it was found that the level of Shaws Bay did not drain to the same low-tide level as the Richmond River, indicating that there is sufficient obstruction in the lower strata of the training wall to impound tidal waters and prevent the full ebb of the tide in the Bay. This phenomenon was only exhibited during spring tides, with neap low tides being fully transmitted through the wall. It is concluded that the level of the main obstruction to flow through the wall is therefore between spring and neap low tide levels. The EPS notes that this is most likely due to the build-up of sediment within the wall, although many community members believe that the mangroves and associated sediments fringing the Shaws Bay side of the wall is the main cause of reduced circulation.

During incoming tides, the main tidal flow, particularly in the early stages of the rise, originates along the eastern half of the training wall, where water freely flows from distinct locations, often creating small scour holes and channels. The flow is not constant but tends to arrive in pulses, corresponding to changing water levels due to wave action in the Richmond River propagating through the wall. The transmission of these long-period waves through the wall contributes to bank erosion issues in the East Arm as discussed in Section 5.2.

The large tidal exchange (see Section 3.5.2) and concentration of much of this flow in the East Arm, means that tidal flows are highly directional in this part of Shaws Bay, with velocities up to 0.3m/s in the sandy channel of the East Arm (PBP, 2000a). Within the Main Section of the Bay, tidal circulation is less observable but can be inferred from patterns in scour and sedimentation as well as the bathymetry of the Bay.

Figure 7: Shaws Bay bathymetry East Arm at low tide (left) and king tide (right, January 2014)

The main circulation patterns during inflowing and ebbing tides are shown in Figure 8. This is discussed further in Section 3.5.2.

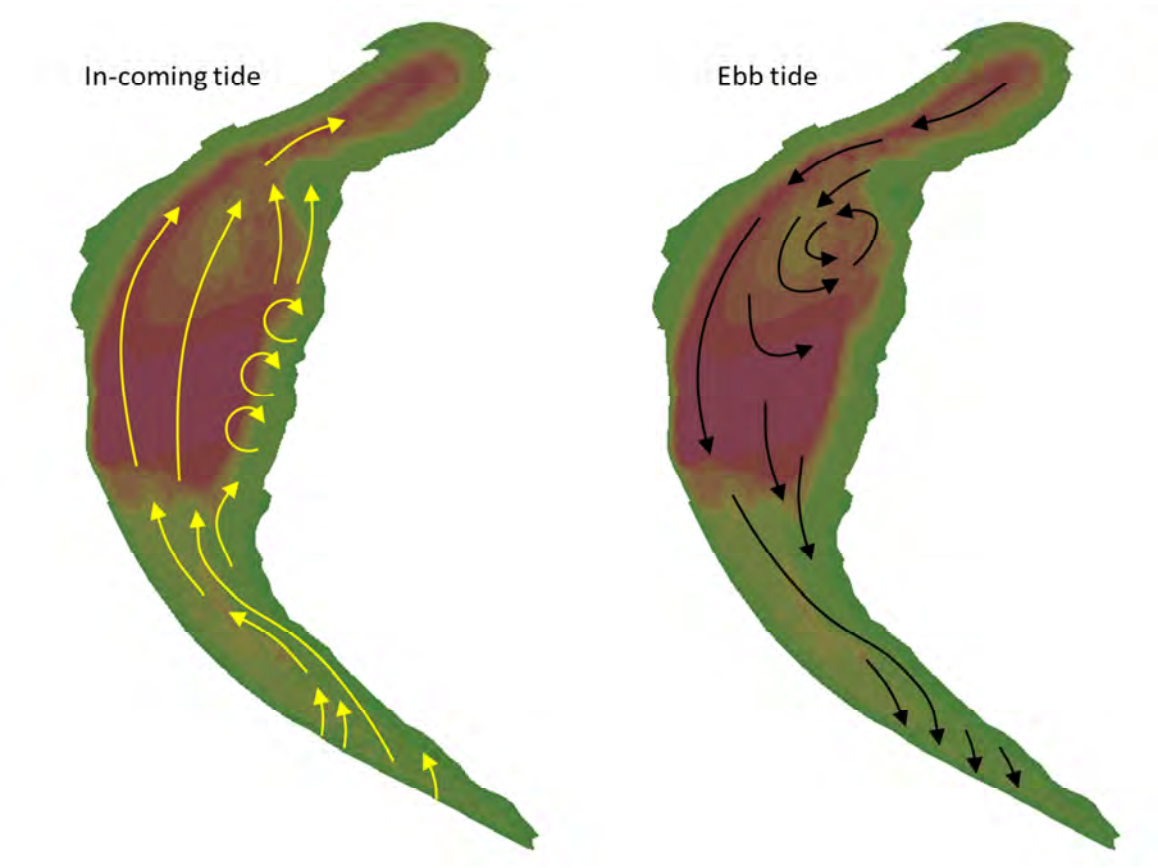


Figure 8: Conceptual diagram of tidal flow patterns in Shaws Bay

3.5.2 Tidal Exchange and Flushing

The EPS demonstrated that the level of high tides within Shaws Bay were approximately equal (<0.1m difference) and lagged only slightly (<45 minutes) in comparison to the corresponding tides in the Richmond River, whereas the low-tides were truncated at around -0.3m AHD. Given these levels, and the bathymetry of the Bay, it was estimated that the volume of water (tidal prism) that is exchanged between the Richmond River and Shaws Bay is approximately 130,000m^3 for spring tides and 90,000m^3 for neap tides, which is approximately 30% and 23% respectively of the total Shaws Bay tidal prism (PBP, 2000a).

Tidal exchange is maximised within the East Arm, with the entire volume of this section virtually drained (Figure 9) during ebb and refilled during incoming tides twice daily, whereas the Northern Section, furthest from the tidal inflow/outflow through the training wall, is least flushed. Circulation patterns due to wind as well as the mixing/dispersal characteristics modelled for the EPS showed that the flushing time for the Northern Section is around 5-8 days, and for deeper sections of the Main Section of Shaws Bay in the order of 4-7 days.

It is anticipated that continued sea level rise will lead to greater rates of tidal exchange in the future as the training wall currently appears to allow free exchange of higher water levels. This effect may be offset by increased sedimentation within and against the training wall and/or expansion of mangrove and seagrass growth along the wall within Shaws Bay which will further restrict exchange at low tide levels. Tidal exchange of the waters within the Bay may also change not only in response to rising average tide levels, but also due to sedimentation/dredging within the Bay which will alter the tidal prism and flushing characteristics.

Figure 9: Low tide draining of the East Arm, Shaws Bay

3.5.3 Freshwater Inflows

Groundwater

Shaws Bay lies within a catchment of approximately 87ha. The northern part of this catchment is in the form of an encircling bedrock escarpment which generates a number of freshwater springs. These springs emerge at the foothills of the escarpment and are collected in a catch drain which is then directed under Compton Drive before discharging into the Bay (PBP, 2000a).

A number of residents in the housing estate to the east of Shaws Bay utilise groundwater for garden irrigation and report bore levels 'close' to the surface. This water resource would also be fed from subterranean flows from the escarpment as well as local rainfall infiltration within the catchment.

It is likely freshwater enters Shaws Bay through diffuse ground water seepage as well as channelised drainage. The EPS estimated the combined channelised drainage and determined a flow rate of 1-2 L/s during a moderate wet weather period and concluded that dry weather flows were likely to be less than this.

Stormwater Runoff

Shaws Bay receives stormwater runoff via 17 stormwater drains, with 3 main systems draining the Shaws Bay residential area to various locations within the Bay. The EPS estimated stormwater discharge for a 1 in 100 year average return interval storm to be 76,000m^3, for a 1 in 10 year event to be 44,000m^3 and a 1 in 1 year event to be 20,000m^3. These volumes equate to approximately 16%, 9% and 4% respectively of the high tide volume of Shaws Bay (475,560m^3 at 1m AHD). Clearly stormwater can be a significant input to the Bay during such extreme events, however the overall contribution of stormwater to the hydrodynamics of Shaws Bay is generally minor (EPS; PBP 2000a). Stormwater runoff and water quality is discussed in Section 6.1.3.

3.6 Sediments and Geomorphological Processes

The EPS provides a discussion of sediment composition and dynamics. Limited core samples were taken at that time and it was concluded that that there were no significant pollutants within Shaws Bay and that the sediment grain size composition within the Bay was variable. No additional sedimentological studies were undertaken as part of this CZMP however the general findings of the EPS are still considered valid. The following sections discuss sediment characteristics, sources and the rate of infilling of the Bay.

3.6.1 Infilling and Source of Sediments

Prior to the construction of the river training walls, the Shaws Bay area was dominated by marine sands, with coarser sand contained in historical deposits and shifting shoals transported by tidal currents, wave action and the scouring effect of river flood events. Finer sand distributed by aeolian (wind) processes made up sand dunes in the area and would also have been deposited in parts of what is now Shaws Bay. Although historically protected at most times from high wave energies and scouring flows, the Shaws Bay area would have been geomorphologically dynamic, resulting in an environment dominated by well sorted, clean marine sands.

With the construction of the training walls, Shaws Bay became a highly sheltered environment and the effects of wave energy, tidal currents and flood scouring was greatly reduced. Historical dredging during the 1970s, 1980s and 1990s maintained deep water in the centre of the Bay and the dredged sand was placed around the foreshores to create sandy beaches (PBP, 2000a). Since the cessation of dredging, Shaws Bay has gradually infilled with sediment. Comparison of the 1999 and 2013 bathymetric surveys (Figure 10) indicates that the Bay had infilled by a calculated 12,265m^3 over those 14 years (876m^3/year). No recent sedimentary analysis or modelling has been undertaken for Shaws Bay and therefore the sediment composition in areas of infill has not been determined and the relative contribution of sediment sources cannot be quantified. Despite this, the sources of sediment and processes leading to distribution of this material in the Bay are readily identifiable:

- Silt-laden flood waters in the Richmond River are likely to contribute a significant amount of fine sediment to Shaws Bay. During floods, high turbidity water would enter the sheltered environment of Shaws Bay through the normal tidal processes and would subsequently deposit much of the suspended silt within the Bay. The EPS estimated that an average of 400m^3/year of fine sediment would enter the Bay via this mechanism;
- Fine sediment entrained in local catchment runoff would enter the Bay via the stormwater system and through direct runoff. The EPS estimated this contribution to be in the order of 75m^3/year, although the contemporary figure may be significantly less than this due to modification of the stormwater system to capture debris as well as sediment;
- The sandy channel within the East Arm is subject to significant tidal currents and resulting scour and bed transport. This channel is gradually broadening through the erosion of the bank on the northern side. The banks are composed of clean marine sands overlain by approximately 0.3m of loam material which was likely placed there during the levelling and establishment of the adjoining park to encourage grass growth or during erosion control works. Although this is the most visible area of erosion and a perceived large source of sediment, the actual contribution was estimated in the EPS as being only around 12m^3/year; and
- Redistribution of sediment within the Bay and minor erosion of some banks in areas other than the East Arm.

Although, the above estimates do not fully account for the observed rate of infill, the relative proportion of these inputs is considered to be appropriate for the purposes of understanding the main source of sediments to the Bay.

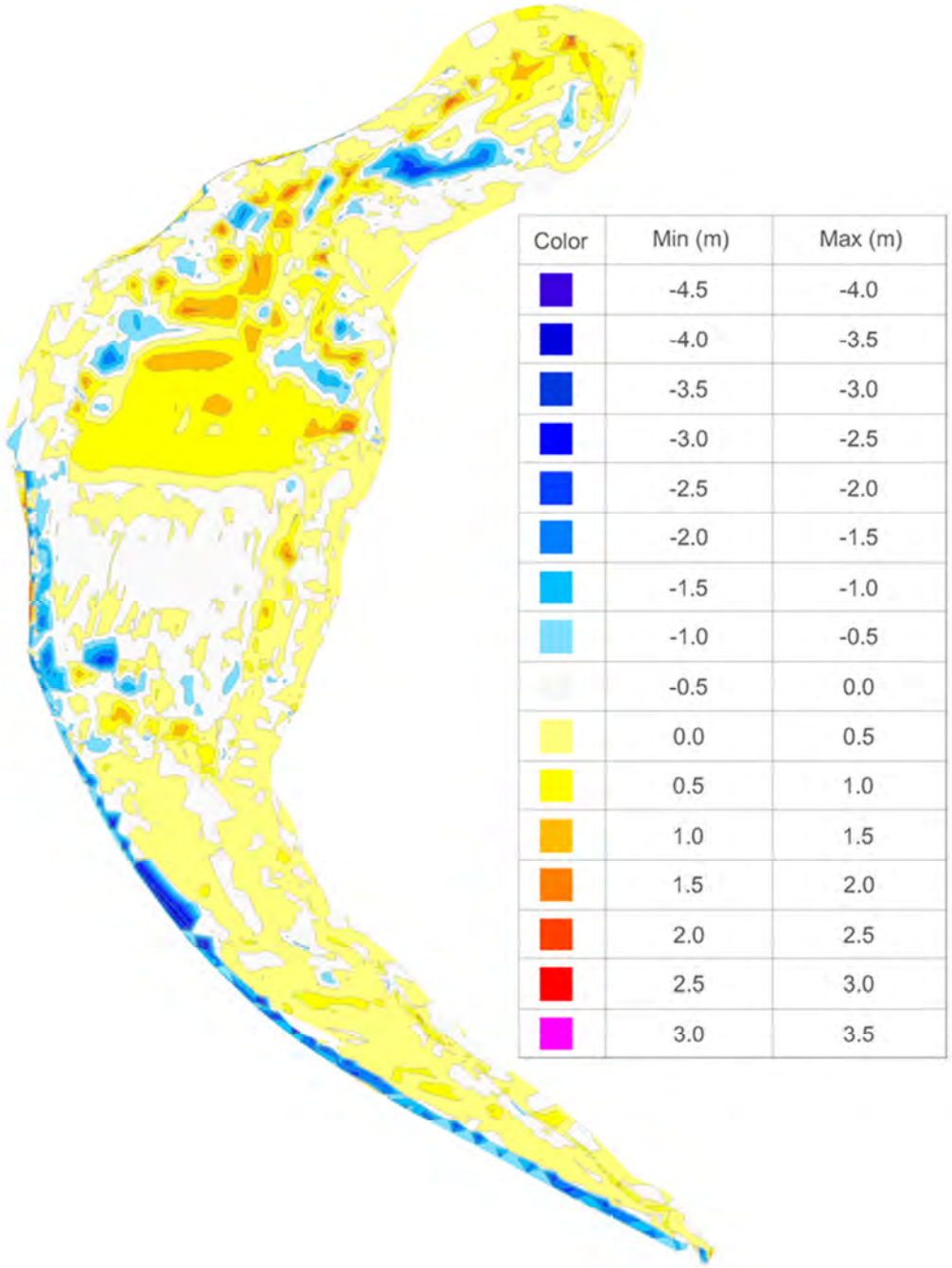


Figure 10: Bathymetric changes in Shaws Bay based on 1999 and 2013 hydrographic surveys

There were some changes in the hydrographic survey methodology between 1999 and 2013, the principal difference being the latter survey was at a higher resolution and therefore more likely to pick up smaller bathymetric features, but also slight differences in the surveyed area. These differences account for some of the mapped changes in bathymetry, particularly next to the training wall, but overall the bathymetric comparison is indicative of the rates and patterns of infilling.

Figure 10 shows that the rate of infill is not uniformly distributed, with the key areas of infill being on the eastern margin of the Bay adjacent to the Ballina Lakeside Holiday Park and the northern half of the Main Section. Some areas have also appreciably deepened along the western margin of the Bay, indicating that the scour from tidal exchange with the Northern Section is concentrated along this margin. A summary of the geomorphic (erosion, sedimentation/infilling) trends within the Bay is presented in Figure 11.

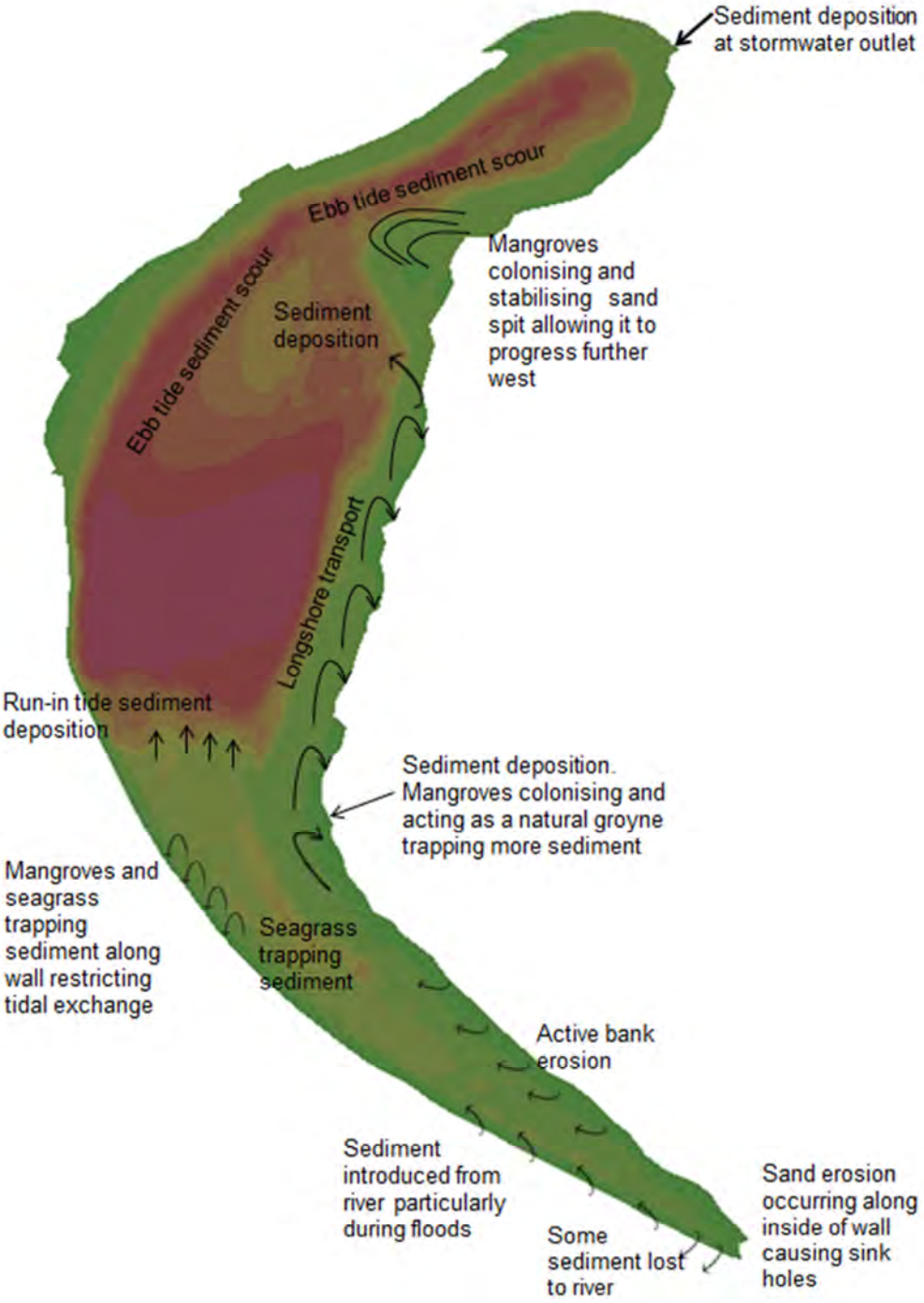


Figure 11: Summary of geomorphic trends in Shaws Bay

3.6.2 Sediment Distribution

In conjunction with the broadening of the East Arm, comparison of the 1999 and 2013 bathymetric surveys also shows that this reach is becoming slightly shallower. It was observed during the seagrass surveys in 2014 (refer Section 6.2.1) that, apart from localised scour at points where the tide flowed through the training wall, the sediment composition along the southern side of the East Arm was generally finer. The deposition of this finer material encourages establishment of marine vegetation (seagrass and mangroves) which in turn reduces tidal scour and allows greater deposition. Unchecked, it is likely that this process will continue, with the sandy channel gradually meandering northward through erosion of the bank, with deposition of finer

material and growth of marine vegetation along the edge of the training wall in areas not directly scoured by tidal flows through the wall.

Sand generated within the East Arm is transported along the sandy channel by the incoming tide and deposited at the confluence of the East Arm and the Main Section of Shaws Bay. Historical aerial photography has shown that the delta that has formed at this location has been formed through individual lobes of sand being deposited at the outflow of the sandy channel (Figure 12). As the channel shifts a new sand lobe is deposited and seagrass colonises the shallow areas previously scoured by the tidal flow.

The beach adjoining the Ballina Lakeside Holiday Park is likely to also receive some of the sand discharged from the East Arm due to the prevailing southerly winds (PBP, 2000a). Sand lobes deposited along the beach, particularly at the neck leading to the Northern Section, indicate significant movement of sand in a northerly direction. The balance between the northerly transport of sand along this beach and the scour due to tidal flows into the Northern Section is leading to accelerated deposition of sediment within the Main Section of the main part of Shaws Bay. This area of deposition has been identified by numerous stakeholders as an area of concern as the shallowing of the Bay in this location may be accelerated by seagrass colonisation and increased deposition of finer (muddier) material.

The Northern Section is dominated by silty material, although areas of sand remain exposed, most notably adjacent to Pop Denison Park, where frequent swimmer access and disturbance tends to maintain relatively silt-free areas. This area is also likely to receive some of the northward borne sand transported along the eastern shore of the Bay.

The sediment composition of the deeper sections of the waterway is unknown but is assumed to consist of fine silt underlain by marine sands.

Figure 12: The sand delta formed at the confluence of East Arm and the Main Section of Shaws Bay and seagrass colonisation.

4. COMMUNITY AND STAKEHOLDER CONSULTATION

Consultation activities undertaken by Council in relation to Shaws Bay are discussed in the following sections.

4.1 Estuary Management Study and Plan (PBP, 2000a and 2000b)

The 2000 EMP recognised the importance of Shaws Bay to the community. The development of the 2000 EMP included an extensive program of consultation to fully appreciate the issues associated with the Bay and give the community an opportunity to provide input into management approaches.

The community consultation consisted of a detailed questionnaire, a formal drop-in session, follow-up personal interviews, meetings with government authorities and a presentation of preliminary results.

Where relevant, the results of the questionnaire undertaken in 2000 are compared to the survey results from 2014 in Appendix 1.

4.2 Consultation Conducted For Current CZMP

A similar detailed program of consultation was undertaken for the current study. Consultation activities included:

- Community survey – To engage the community and obtain input into the CZMP development, a survey was developed. Some questions were designed to mimic the 2000 questionnaire to provide comparable data and identify any changes in community opinions. New questions were also included to provide data required for the CZMP. The survey was available on-line and hard copy with 105 on-line and 18 hard copy surveys (123 total surveys) completed. A copy of the survey and a summary of the results are provided in Appendix 1;
- Project webpage – A project webpage was used to introduce the project, provide a link to the on-line community survey, project updates and contact details for further information. The webpage address was communicated to community and stakeholders in media and other correspondence and a link was provided on the Ballina Shire Council website;
- Community drop-in session 1 – Wednesday 9 April 2014 (during community survey period). The aim of the session was to encourage community involvement and completion of the survey and facilitate ideas for the CZMP development;
- Media and advertising – various forms of media were utilised to advertise the project and encourage community involvement in the survey and drop-in sessions. This included:
    - Media release - 24 March 2014 distributed to print, TV, radio and web-based media (Appendix 1);
    - Council notices in the Advocate newspaper – 26 March 2014 and 2 April 2014; and
    - Article in Community Connect – distributed to Ballina Shire residents 7 April 2014.
- Targeted stakeholder consultation with key stakeholder groups. This included a phone call, email or letter informing stakeholders of the survey, webpage and inviting input. Follow-up meetings were held with the major stakeholders where necessary to discuss and clarify comments (refer Appendix 1);
- Meetings with the Project Reference Panel (relevant Council staff and representatives from Fisheries NSW and the Office of Environment and Heritage, OEH) and ongoing liaison as required;
- Follow-up discussions with the relevant stakeholders as necessary on issues as they arise;

- Councillor workshop – The development of the draft CZMP was presented to Ballina Shire Councillors on 11 August 2014;
- Public Display - The Final Draft CZMP was placed on public exhibition for 21 days (as per legislative requirement) during September 2014. Formal (written) submissions on the Draft CZMP were sought from the community and stakeholder groups. Submissions were considered in the development of the Final CZMP; and
- Community drop-in session 2 – Thursday 11 September 2014 (during the public exhibition stage). This was an opportunity for informal discussions between the community, stakeholders and the project team to discuss issues and obtain feedback prior to formal submissions.

4.3 Summary of Stakeholder Feedback

Shaws Bay and the development of the CZMP generated a significant amount of community interest with many articles appearing in the local newspapers as well as direct correspondence to Ballina Shire Councillors.

The key outcomes of the consultation are listed below and discussed further in later sections and in Appendix 1:

- Shaws Bay is primarily a recreational asset with the most popular activity being swimming, followed by walking/exercise, picnicking and fishing;
- There is considerable community interest in maintaining the health and amenity of the Bay as well as enhancing the recreational experience of the area;
- The recreational experience at Shaws Bay creates strong links to the need to protect ecological values through water quality, vegetation management and protection of fish stocks;
- The overlap between recreational activities and ecological values creates some management conflict. For example, there was concern among many stakeholders regarding a perceived decline in amenity resulting from seagrasses and mangroves at waterway access points, whereas some respondents noted the value of the marine vegetation for habitat and water quality;

Figure 13: Seagrass and recreational activities along east arm (left) and seagrass and waterway access points (right)

- Other key amenity issues also related to access to the waterway for primary contact recreation including erosion of banks in the East Arm, shallowing of the Bay and occasional poor water quality particularly following wet weather;
- Community stakeholders also expressed concern about the condition of facilities in the area including barbecues, parking, amenities and waterway access points;
- There was also significant concern about illegal fishing activities within the Bay. While the majority of respondents who mentioned fishing in the Bay valued the ability to fish (within the rules), a small minority wanted fishing to be banned to protect the fish living in the Bay, particularly the Estuary cod; and
- A few respondents identified biting insects and skin irritations thought to be derived from swimming in the Bay.

The management issues ranked as most important in the survey were:

- Litter (88% of respondents ranked this as very important or important);
- Siltation/shoaling (78% of respondents ranked this as very important or important);
- Poor water quality (for water-based activities) (77% of respondents ranked this as very important or important);
- Slicks on the water surface (74% of respondents ranked this as very important or important);
- Shoreline erosion (72% of respondents ranked this as very important or important); and
- Changes to foreshore vegetation (71% of respondents ranked this as very important or important).

Feedback from key government agencies involved in the CZMP development included:

- Fisheries NSW provided guidance on fishery and habitat management. The CZMP will need to detail any potential impacts on marine vegetation resulting from proposed management measures and approvals under the *Fisheries Management Act* are likely to be required; and
- OEH provided guidance on assessment of coastal hazards including current state government requirements.

5. COASTAL HAZARDS

The coastal zone is exposed to many hazards of differing severity that may threaten coastal ecosystems, built assets, human activities and coastal amenity. While the hazards are part of the natural coastal processes, they can affect the human uses of the coastal zone, and responses need to be planned and managed. An understanding of coastal hazards and their potential effects on development, safety and amenity is essential if the coastal zone is to be effectively managed.

This section provides an overview of the coastal processes, hazards and associated risks relevant to Shaws Bay including a description of:

- Coastal processes within the study area, to a level of detail sufficient to inform decision-making;
- The nature and extent of risks to public safety and built assets from coastal hazards; and
- Projected climate change impacts on risks from coastal hazards based on Council's adopted sea level rise projections.

Relevant background information has been summarised where necessary and relevant documents referred to for further details.

The following coastal hazards are relevant to Shaws Bay:

- Shoreline recession;
- Tidal inundation; and
- Erosion within estuaries caused by tidal waters, including interaction of those waters with catchment floodwaters.

The hazards of beach erosion and coastal inundation (overtopping of dunes) are addressed in the *CZMP for the Ballina Shire Coastline* (GeoLINK, 2013).

Current knowledge of coastal hazards in Shaws Bay is discussed below.

5.1 Sea Level Rise

Average sea levels are projected to continue to rise throughout the 21st century. In 2009 the NSW Government released the *NSW Sea Level Policy Statement* and associated guidelines to assist coastal councils in their planning for sea level rise impacts. These guidelines indicated that a mean sea level rise, relative to 1990 levels. of 0.4m should be expected by 2050 and 0.9m by the year 2100 and this was used as the basis for coastal planning. This broad policy was withdrawn in 2013, recognising that a single set of predictions may not satisfactorily reflect local conditions and that councils should adopt locally relevant projections as appropriate.

In the absence of detailed localised studies, many NSW councils, including Ballina Shire Council continue to use the 2050 (+0.4m) and 2100 (+0.9m) projections provided in the rescinded *NSW Sea Level Policy Statement*, as the most appropriate basis for coastal planning and risk assessment.

Sea level rise has implications for shoreline recession, inundation risk, estuarine ecosystem health as well as public access and amenity as discussed throughout this document.

5.2 Shoreline Erosion and Recession

The hazard of shoreline recession is the progressive landward shift in the average long-term position of the coastline. Two potential causes of shoreline recession are net long-term sediment loss from banks/beaches and an increase in sea level leading to water level extension up the shoreline. For Shaws Bay, both of these factors are relevant.

5.2.1 Bank Erosion and Sediment Loss

Bank erosion is most pronounced on the northern shore of the East Arm and has been occurring for several decades. The best visual indicator of the distance of bank retreat is the location of the stormwater outlet in this section of the Bay, which would originally have been constructed to coincide with the position of the bank but now the bank is around 13m behind the outlet location.

Figure 14: Shoreline recession indicated by location of stormwater outlet in the East Arm

Erosion in this reach is caused by the surging of water levels associated with long period waves propagating through the wall and into the East Arm. The oscillating water levels winnow out the fine sand from the base of the bank, leading to undercutting and eventual slumping of the bank face into the water. The loam material within the top 0.3m of the bank profile is fine grained and once this falls in the water, high tidal current velocities in this section have sufficient energy to transport this material away from the toe of the bank, thereby leading to ongoing erosion.

Rock protection of the bank within this reach has only been partially successful, with the bank in many places receding behind the location of the original rock work (Figure 15), which has subsequently collapsed and is partially buried by the mobile sand at this location. In the more easterly sections of the East Arm, the rock protection still affords some protection (along with fallen trees and intact tree trunks) but may eventually be defeated. It was noted in the EPS that the rock protection works were poorly designed with no mechanism (e.g. geofabric) for retaining the fine material behind the wall.

As recommended in the EMP, a design for a new rock revetment was developed (WBM, 2001; GeoLINK, 2009) for the eastern end of this reach, with a concept for a re-contoured beach and retaining groyne to be installed further to the west. The funds required to implement this design were estimated to be approximately $200,000 (in 2009). These funds were not secured and approval for the project was not pursued.

The winnowing effect of long period waves can be seen further east towards the Marine Rescue Tower and extending towards Lighthouse Beach where sandy fill against the base of the training wall is being lost to voids in the wall (and presumably to the Richmond River) through the action of the surging water levels. The resulting sink holes were observed to be up to 2m deep. Some residents have attempted to fill these holes through the dumping of garden clippings, which creates a potential public safety hazard as the openings can become concealed without being filled and can contribute to weed propagation (Figure 16).

This same process is leading to the eastward extension of the East Arm despite extensive rock placement (Figure 17).

Figure 15: Bank erosion beyond the rock revetment in the East Arm

Figure 16: Sink holes along the training wall partially covered by garden clippings

Figure 17: Continued erosion at the eastern extremity of the East Arm

Other areas of bank erosion are relatively minor and localised. The EPS discusses gully erosion at various locations around Pop Denison Park. Some of these locations have been remediated or have naturally stabilised and are considered to represent minimal erosion risk.

Along the western margins of the Bay, the banks are protected from erosion by the concrete steps adjoining the training wall which then transition to a long rock/concrete wall which extends for much of the western shoreline, apart from the foreshore in front of Shaws Bay Hotel. In the vicinity of the disabled access ramp adjacent to Compton Drive, the beach face appears relatively stable, probably as a result of marine vegetation growth although bathymetric surveys indicate continued scour along this western margin (Section 3.6).

5.2.2 Bank Recession due to Sea Level Rise

The highest astronomical tide (HAT) for the Richmond River entrance is 1.11m AHD (WBM, 2008) which is 0.5m higher than mean high water spring (MHWS) tides. Based on the tidal monitoring in the EPS (2000) spring high tides are almost fully transmitted into Shaws Bay with levels around 0.1m less than the adjoining Richmond River as discussed in Section 3.5.1 (say 1m AHD for the HAT). It is estimated that the corresponding HAT levels with future sea level rise will be 1.4m AHD for 2050 (+0.4m) and 1.9m AHD for 2100 (+0.9m) respectively based on Council's adopted sea level rise projections.

Sea level rise has the potential to cause bank recession through two different mechanisms. For sloping shores, the vertical component of sea level rise leads to a horizontal landward translation of the shoreline such that high tides will extend further inland than present. The second factor is that increased average sea levels will expose more of the waterway banks to erosive forces, thereby potentially exacerbating the erosion of susceptible banks resulting in shoreline retreat.

The southern and majority of the western margins of Shaws Bay are protected by steep to near-vertical rock and concrete wall. The main retaining wall is variable, but the crest is at around 1.8m elevation. It is conceivable therefore that this wall would be overtopped during extreme astronomical tides in the distant future but typically will define the shoreward extent of Shaws Bay along these margins for the foreseeable future.

Using the MHWS tide levels for present (0.5m AHD), 2050 (0.9m) and 2100 (1.4m) as an indicator of the potential future eastern shoreline for Shaws Bay, Figure 18 shows that although higher sea levels will cause landward contraction of the shoreline, this will be minor for 2050 and only result in significant changes in the second half of this century, where some of the flat areas of Pop Denison Park start to become regularly inundated and a marked change from terrestrial to marine vegetation would be expected.

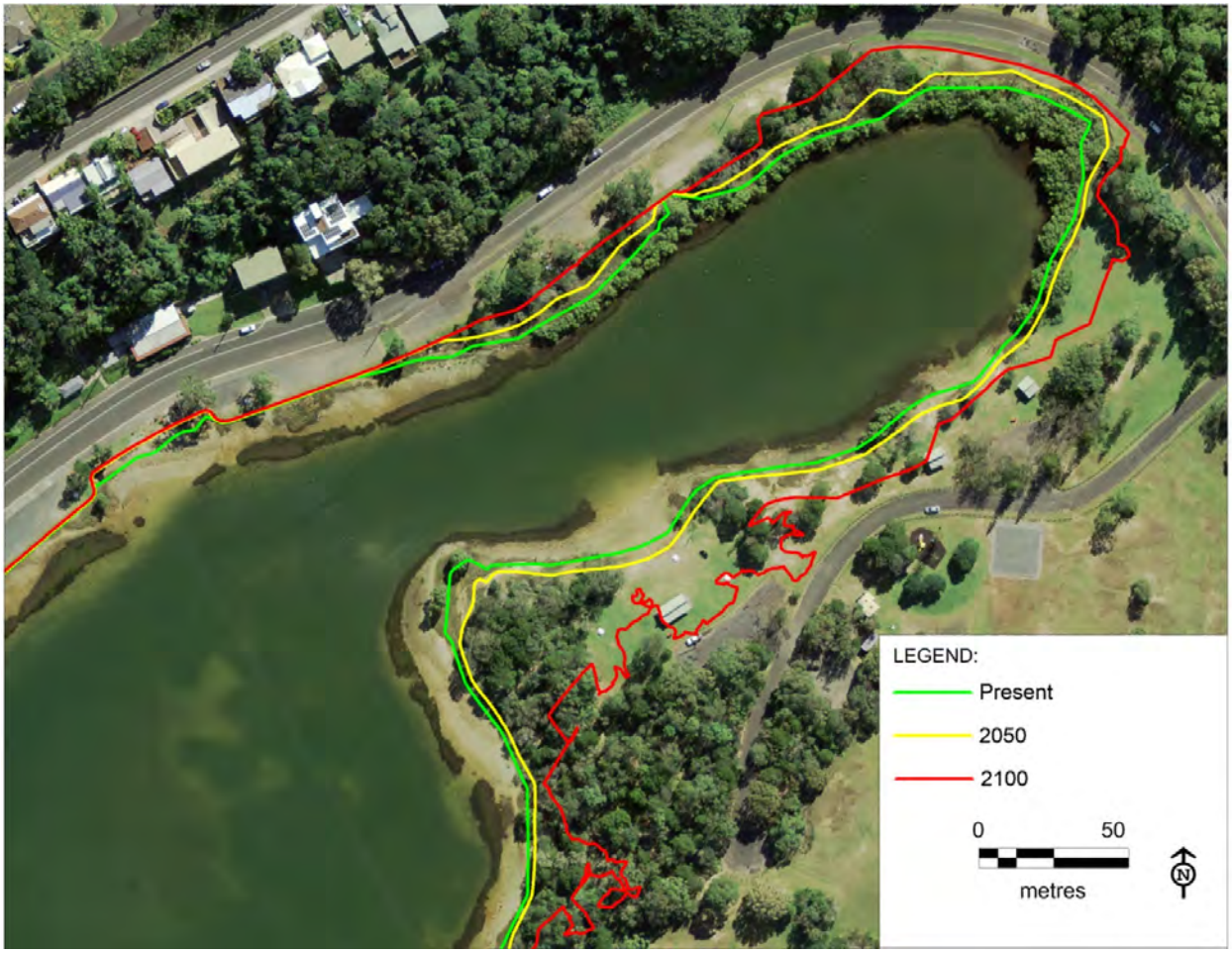


Figure 18: MHWS tide levels as an indicator of future shoreline position for Pop Denison Park

The susceptibility of the Shaws Bay shoreline to erosion was assessed to determine the potential for future erosion and bank retreat. As discussed previously, the southern and western margins of the Bay are largely protected by rock walls which adequately protect these areas from bank erosion. A small sandy beach in front of the Shaws Bay Hotel remains stable, although some scour of sand from the low tide margin is evident. The Main Section of the Bay is heavily vegetated with mangroves, and given the sheltered nature of this reach, is unlikely to be susceptible to erosion. The heavily trafficked and un-vegetated banks of Pop Denison Park are susceptible to erosive forces, both from overland flow during heavy rain as well as physical disturbance from pedestrian traffic as noted in the EPS. Despite this, the level of current erosion in this area is low and risk of potential shoreline retreat due to bank erosion in this area is considered minor.

As discussed previously, the northern bank of the East Arm is currently eroding and will remain susceptible to erosive processes at current sea levels and this will be exacerbated with sea level rise. The bank in this reach will continue to respond to scour of the bank toe by the meandering of concentrated tidal flows in this area and will naturally retreat in order to achieve a stable beach slope of around 1 in 10 (PBP, 2000a). The elevation of the park area north of this eroding bank is at around 1.5 to 1.7m AHD, whilst the toe of the bank escarpment is, on average, around 1m below this. At a slope of 1 in 10, it is expected that the bank would need to retreat in the order of 10m to achieve a stable configuration. Further erosion of the toe of the bank, which is likely, although gradual, will further displace the position of the shoreline in this location.

5.3 Inundation Risks

Coastal inundation is the flooding of coastal lands by ocean waters, which is generally caused by large waves and elevated water levels associated with severe storms. Coastal inundation, for the purpose of hazard definition as advocated in the guidelines for preparing CZMPs (OEH 2013), includes the effects of wave run up and dune overtopping for ocean beaches. Whilst wave run up and dune overtopping are not relevant for Shaws Bay, the tidal inundation components (excluding wave setup and overtopping) do pose a significant hazard. The BFRMS (BMT WBM 2012) notes that the flood risk at Shaws Bay is dominated by the influence of the ocean and highlights the importance of considering this form of flooding for much of the urban area of Ballina.

The key components of the tidal inundation risk for the Shaws Bay area are:

- Astronomical high tides;
- Storm surge (the combination of increased water levels due to low atmospheric pressure plus a provision for wind setup), and;
- Wave setup (the 'piling up' effect of large waves increasing water levels on the coastline).

Figure 19: Tidal inundation of stormwater drain (January 2014)

In addition to the present day inundation risks, the CZMP guidelines require the assessment of the effects of sea level rise on coastal hazards including inundation risks (for future ocean levels corresponding to 2050 and 2100 as well as present day risks).

A review of other studies relevant to northern NSW incorporating ocean level events was undertaken to evaluate the most appropriate future ocean level scenarios to be included within this CZMP. Although numerous scenarios and combinations of contributing factors have been included in previous studies, the levels provided in *Flood Risk Management Guide: incorporating sea level rise benchmarks in flood risk assessments* (DECCW (2010a) are considered most appropriate for this study. The estimates for present day levels are based on figures generated for 2010. To avoid confusion with other documentation, these same figures have been utilised without any additional correction for the current year (i.e. 2010 versus 2014) and represents a negligible underestimation of the present day levels (approx. 2.6 cm).

The effect of wave setup on estuarine water levels is the subject of some variation, with some practitioners advocating the inclusion of large wave setup allowances, whilst others consider deep, trained river entrances to pose little risk of increased estuary water levels due to wave setup. The Richmond River entrance is fully trained, however the bar depth is not maintained by dredging and therefore the bar varies in both geometry and depth. Hydrographic surveys of the Richmond River bar undertaken on behalf of NSW Trade &

Investment, Crown Lands indicate that the shallowest section of the bar outer is typically between -4 and -5 m AHD, with the narrowest point between the training walls typically falling in the -6 to -7 m AHD range.

New guidelines being developed by OEH advocate the use of wave setup for estuarine water level modelling based on the category of entrance type. These new guidelines had not been released at the time of preparation of this CZMP, but OEH have advised that it would be appropriate to consider the potential for wave setup and suggest 6% of offshore wave heights, in line with the draft OEH guidelines, would be appropriate for Shaws Bay. Shand *et al*. (2011) report 1-hour exceedance significant wave heights (H_{sig}) for the Byron Bay wave rider buoy as being 5.2 m, 7.2 m and 7.6 m for 1, 50 and 100 year ARI events respectively. The ocean level scenarios considered in this CZMP are provided in Table 2 with, and without, the additional 6% of H_{sig} wave setup component.

The water level scenarios presented in Table 2 provide the effects of sea level rise (Present, 2050 and 2100) and the influence of wave setup, including the average return interval (ARI). The sea level rise scenarios reflect Ballina Shire Council's adopted position which recognises that sea level is likely to rise 40 cm by 2050 and 90 cm by 2100 relative to 1990 levels. As the baseline for these levels is set 20 years before the 2010 levels used in this CZMP, discounted sea level increases of 34 cm (2050) and 84 cm (2100) have been used to provide the correct estimates. The ARI is an indication of the probability of the event occurring. An event that occurs on average once a year (i.e. 1 year ARI) is less extreme than a rarer event (e.g. one that averages only once in 50 years: a 50 year ARI).

Table 2: Ocean levels (m AHD) utilised for tidal inundation risk assessment

	Present (2010)			2050			2100		
Average recurrence interval (years)	1	50	100	1	50	100	1	50	100
Estuary level without wave setup (m AHD)	1.24	1.41	1.44	1.58	1.75	1.78	2.08	2.25	2.28
Estuary level with wave setup (m AHD)	1.55	1.84	1.89	1.89	2.18	2.23	2.39	2.68	2.73

A subset of the inundation scenarios is provided below in Figure 20 and Figure 22.

Figure 20: Predicted present day inundation due to 1, 50 and 100 year ARI ocean level events (not including wave setup)

Ocean levels influence Shaws Bay by flowing through the training wall as discussed in Section 3.5 and can subsequently penetrate the low lying areas around Shaws Bay, particularly to the east, either by overland flow or intrusion through the stormwater network.

Figure 21: High tide level at Pop Denison Park (left) and Ballina Lakeside Holiday Park (right) January 2014

No numerical modelling of ocean water levels, wave behaviour or propagation of water levels through the training wall into the Shaws Bay basin was undertaken for this study. More detailed work is intended to be undertaken as part of Council's flood risk management planning, however, to give an indication of the potential ocean inundation issues, the predicted ocean levels described above were adopted as inundation levels within the study area. Comparison of these water levels with ground surface elevation data derived from aerial laser survey provided water depth estimates for the various scenarios.

The influence of sea level rise (without wave setup) is mapped in Figure 22 for 2050. Water depths of up to 0.3m could be expected to occur within some parts of the Ballina Lakeside Holiday Park on an annual basis by 2050. By 2100, annual inundation of virtually all land between Fenwick Drive and the Bay would be expected, with lower probability ocean levels (e.g. 50 and 100 year ARI) causing significant inundation depths and likelihood of property damage.

The worst case considered for the current study is the combination of a 1 in 100 year ocean level event with wave setup at a future sea level corresponding with the projections for 2100. In this scenario, virtually the entire Shaws Bay residential area is affected by significant inundation.

Figure 22: Predicted 2050 inundation due to 1, 50 and 100 year ARI ocean level events (not including wave setup)

The extent of inundation is consistent with previous large scale work undertaken as part to the BFRMP (BMT WBM 2013 - see Section 2.2.4), although slightly different assumptions were utilised in the inundation scenarios. It should be noted that no hydraulic studies have been undertaken to determine the extent to which flow through the wall, overland and via the stormwater network would occur. However, tidal studies undertaken as part of the EPS would indicate that there is little impediment to high water levels entering the Shaws Bay area and therefore ocean levels at the mouth of the Richmond River estuary have been assumed to fully extend to the study area. As described in DECCW (2010a), flooding in the lower reaches of coastal waterways may occur due to a combination of ocean and catchment flooding driven by the same storm cell. The probability or the magnitude of flood levels combining localised (stormwater system) flooding, catchment (Richmond River) flooding as well as extreme ocean level events has not been determined. It considered that further investigation of extreme ocean level events, in conjunction with catchment flooding should be undertaken for Shaws Bay as part of Council's floodplain risk management planning.

5.4 Infrastructure and Property Risk and Response

The number and type of buildings (e.g. residential, tourism, community) and significant infrastructure affected by tidal inundation within Shaws Bay are provided in Table 4 (as mapped in Figure 18 with inundation depths given in Table 3).

Table 3: Inundation depths at 2100 for 100 year ARI events

	Without wave setup		With wave setup	
Area	**Minimum Depth (m)**	**Maximum Depth (m)**	**Minimum Depth (m)**	**Maximum Depth (m)**
Ballina Lakeside Holiday Park	0	0.8	0.1	1.25
Compton Drive road infrastructure and shared path	0	1.0	0	1.45
Pop Denison Park infrastructure	0.4	1.0	0.85	1.45
Shaws Bay residential area – public infrastructure	0	0.6	0	1.05
Shaws Bay residential area – private properties	0	0.3	0	0.75
Shaws Bay Caravan Park	0	0.4	0	0.85

The risk category assigned to each area follows the vulnerability categories from the CZMP guidelines (OEH, 2013a) which are based on the timeframes of expected impacts as follows:

- Risk category 1: Current Hazard Area (i.e. likely to be affected by erosion, recession or inundation during severe weather events occurring at present);
- Risk category 2: 2050 Hazard Area (i.e. likely to be affected by erosion, recession or inundation in the next 40 years); and
- Risk category 3: 2100 Hazard Area (i.e. likely to be affected by erosion, recession or inundation in the next 40-90 years).

The preliminary public authority response to manage risks to property is provided in Table 4. Table 5 provides response category descriptions from the CZMP guidelines. The intended public response will be confirmed through further investigation of inundation scenarios as part of floodplain risk management in the Shire. The BFRMP (BMT WBM 2013) recommends a number of property and flood modification measures to be employed as part of flood risk management that may be applicable to the Shaws Bay area and it is recommended that strategies that minimise risk to infrastructure and property due to tidal inundation continue to be investigated as part of this process.

No properties or infrastructure are expected to be affected by shoreline erosion and recession.

The risks associated with inundation at 2100 are presented in Table 3 for the 100 year ARI (the likelihood) and the predicted depth of inundation (the consequence) assuming no wave setup.

Table 4: Property and infrastructure risk and preliminary hazard response categories for Shaws Bay

Risk category	Hazard Area for property	Hazard type	Specific Location	Type of building or infrastructure	No. of buildings/ length of infrastructure		Intended BSC response (refer Table 5)
					Without wave setup	With wave setup	
1	Current hazard area (100 year ARI)	Tidal inundation	Pop Denison Park Infrastructure	Roads and parking	~30m	~350m	A
				Picnic shelters	2	3	
				BBQ	1	1	
				Playground	-	1	
				Amenities	-	1	
				Boules Court	-	1	
			Compton Drive and shared path	Pathway	~100m	~600m	A
			Ballina Lakeside Holiday Park	Roads	~200m	~1700m	B
				Buildings	-	~125	B
			Shaws Bay Residential Area- Public	Roads	-	~1100m	A
			Shaws Bay Residential Area- Private	Private properties	-	~12	B
2	2050 hazard area (100 year ARI)	Tidal inundation	Pop Denison Park Infrastructure	Roads and parking	~350m	~350m	A
				Picnic shelters	3	3	
				BBQ	1	1	
				Playground	1	1	
				Amenities	1	1	
				Boules Court	1	1	

Risk category	Hazard Area for property	Hazard type	Specific Location	Type of building or infrastructure	No. of buildings/ length of infrastructure		Intended BSC response (refer Table 5)
					Without wave setup	With wave setup	
			Compton Drive and shared path	Pathway	~500m	~700m	A
				Road	~500m	~800m	
			Ballina Lakeside Holiday Park	Roads	~1,250m	~1700m	B
				Buildings	~75	~139	
			Shaws Bay Residential Area- Public	Roads	~700m	~2600	A
			Shaws Bay Residential Area- Private	Private properties	-	~100	B
3	2100 hazard area (100 year ARI)	Tidal inundation	Pop Denison Park Infrastructure	Roads and parking	~350m	~350m	A
				Picnic shelters	3	3	
				BBQ	1	1	
				Playground	1	1	
				Amenities	1	1	
				Boules Court	1	1	
			Compton Drive and shared path	Pathway	~700m	~700m	A
				Road	~900m	~950m	
			Ballina Lakeside Holiday Park	Roads	~1,350m	~1700m	B
				Buildings	~139	~139	
			Shaws Bay Residential Area- Public	Roads	~ 2,500m	~2900	A
			Shaws Bay Residential Area- Private	Private properties	~114	~135	B

Table 5: Coastal hazard response category

Response Category	Intended BSC Response *
A	Coastal protection works are considered technically feasible and cost-effective. Funding will be sought for implementation*.
B	Coastal protection works are considered technically feasible but not cost-effective for public funding – unlikely to be implemented by Council
C	Coastal protection works are not considered technically feasible – no intended public authority works

Source: OEH (2013a)

* Note: Further assessment of the hazard and appropriate response is recommended to be undertaken as part of Ballina Shire Council's floodplain risk management planning process.

5.5 Inundation Risks to Public Safety

To address the risk to public safety, the draft BFRMP (BMT WBM 2013) recommends a number of flood response modification procedures including:

- Finalise selection of evacuation centres;
- Update evacuation planning;
- Development of a community engagement strategy;
- Extension of the flood monitoring gauge network to provide better hydrological information during floods;
- Development of flood intelligence cards that identify on-ground implications of reported gauge levels and flood heights;
- Assess alternative (more timely and efficient) methods for issuing evacuation orders;
- Investigate flood warning and prediction system options; and
- Raise low points on evacuation routes to prevent the premature inundation of safe passage areas;

It is noted in the BFRMS (BMT WBM, 2012) that there is high ground directly adjacent to the flood-prone areas of Shaws Bay. As such an evacuation capability assessment was not carried out for that area as people will be able to use minor roads to access the high ground. The study recommends that in the event of flooding, residents drive to the East Ballina Evacuation Centre via Suvla Street.

It is recommended that the Shaws Bay area continues to be specifically considered in all catchment flooding and ocean level event scenarios as part of Council's floodplain risk management process.

6. COASTAL ECOSYSTEM HEALTH

This section provides an assessment of the ecological health of Shaws Bay including:

- The health status of Shaws Bay comprising a discussion of water quality, terrestrial and estuarine vegetation, aquatic fauna, and birdlife (avifauna); and
- The pressures affecting estuary health and their relative magnitude including: projected climate change impacts; flow conditions and siltation/infilling; water quality; urban stormwater; terrestrial weeds etc.

An understanding of coastal ecosystem health and the vulnerability of the system to pressures is required to provide a sound basis for designing management actions and understanding the effects of management practices.

The *Estuary Processes Study* (PBP, 2000a) provided a comprehensive assessment of ecosystem health based on a review of background and historical information as well as ecological surveys, mapping and modelling completed in 2000. The following section provides a summary of the key findings of the *Estuary Processes Study* that are considered to be relevant to the current state of Shaws Bay and provides updated information available since 2000.

The key physical characteristics of Shaws Bay are outlined in Table 6.

Table 6: Shaws Bay physical characteristics and available data

Characteristic	Data	Notes
Catchment area	87 ha (0.87 km^2)	Calculated from approximate catchment boundary (Figure 2)
Estuary area	15.5 ha (0.155 km^2)	Based on areas at 0.6 m AHD (as per MER methodology utilised in Roper *et al.,* 2011).
Estuary volume (ML)	413	Based on areas at 0.6 m AHD (as per MER methodology utilised in Roper *et al.,* 2011).
Average depth (m)	2.67	Estimated by dividing the total volume (in m^3) at 0.6 m AHD by the total surface area (in m^2) of the estuary at 0.6m AHD. Refer to Section 3.4 for detailed bathymetric information.
Hydrographic Survey	June and July 1999	Ballina Council carried out hydrographic survey for Shaws Bay (Department of Land and Water Conservation, 2000).
	July 2013	Ballina Council carried out hydrographic survey for Shaws Bay including an assessment of infilling since 2000 survey (Ballina Shire Council, 2013).
Estuarine Macrophytes	Seagrass extent: 3.1 ha (0.031km^2) Saltmarsh extent: 0.9 ha (0.009km^2) Mangrove extent: 0.5 ha (0.005km^2)	2013/2014 macrophyte areas estimated using aerial photography interpretation and verified during field inspections (2013 aerial photography supplied by Ballina Shire Council). Refer to estuarine vegetation mapping (Figure 30)

The NSW Monitoring Evaluation and Reporting (MER) Strategy is a state-wide program providing information on natural resource condition and trends within catchments and includes assessment of estuary health. Findings are reported in the State of Catchments reports. The MER Strategy assesses the Richmond River but does not include a separate assessment of Shaws Bay. The 2010 State of Catchment Report (DECCW,

2010d) reported the overall condition as “Very Good” for the Richmond River. This was essentially an average of all scores which ranged from “Very Good” ratings for seagrass and saltmarsh and “Good” ratings for Fish and Chlorophyll a indicators. While the assessment did not specifically target Shaws Bay, the Richmond River is closely associated with the system and it is likely that similar conditions existed within Shaws Bay.

6.1 Water Quality

6.1.1 Existing Information

A list of the water quality information available for Shaws Bay is provided in Table 7 including details of the data collected, timeframes, modelling undertaken and key conclusions drawn from reporting of results.

Table 7: Water quality information available for Shaws Bay

Data type	Reporting	Key Conclusions
BSC bacteriological data collected since the late 1960s	A summary of Faecal Coliform data collected by BSC from 1991 to 1999 was reported in the *Estuary Processes Study (*PBP, 2000a)	Majority of samples were within the ANZECC and NSW Health Guidelines for safe primary contact recreation (e.g. swimming). However, there were a number of occasions when guidelines were exceeded. Further wet weather sampling was recommended to determine cause and extent of problem. Computer modelling showed that expected bacterial levels in the Main Section of Shaws Bay, where the majority of the public utilise the waterway, would be considerably less than the Northern Section where monitoring occurs.
Wet weather sampling October 2002 – April 2003	*Beachwatch Partnership Pilot Program and Wet Weather Monitoring Program* (BSC, 2003)	Rainfall events greater than 10mm in 24 hours generally result in elevated enterococci levels and may pose a health risk for swimming.
Computer model developed to assess flushing potential and dilution and dispersion in Shaws Bay	*Estuary Processes Study and Management Plan* (PBP (2000a, 2000b)	Catchment pollutant loads to Shaws Bay are considered small in comparison to the oceanic flushing potential. Flushing varies from 1 day in the East Arm to approximately 5 days in the northern bay. Good flushing times are assisted by constant input of groundwater seepage, circulation within the Bay due to wind driven currents and tidal exchange with the river/ocean. The Bay returns to background conditions within about 12 hours after a significant catchment runoff event (i.e. a 1 in 10 year ARI event). Note that this scenario does not consider poor water quality inputs from the Richmond River, which could extend recovery times.

Data type	Reporting	Key Conclusions
Conceptual model of water quality processes	*Estuary Processes Study and Management Plan* (PBP (2000a, 2000b)	The largest sources of pollutants to the Bay were three stormwater outlets draining the urban area. However, modelling indicates that pollutants are likely to be diluted and dispersed relatively quickly and any impacts are expected to be short-lived. The Northern Section of the Bay has reduced dilution capacity due to smaller resident volume and pollutants discharged to this section have a greater relative impact on water quality in the short-term. The Main Section of the Bay has a large dilution capacity and pollutants discharged to this section of the Bay have a relatively minor effect on overall water quality. The water quality in the East Arm generally reflects the water quality of the adjacent river as water in this section is completely exchanged with the river each tide.
Time series water quality and water level data recorded by data logger from March 1999 to April 2000.	*DLWC Water Quality Monitoring at Shaws Bay* (DPWS, 2001)	In general water quality was considered to be typical of a healthy estuarine environment. Water level data indicated that while Shaws Bay is tidal, it does not experience the full tidal range experienced by the Richmond River due to the restriction of the tidal cycle by the training wall. Stratification of the water column was observed following rainfall due to freshwater inputs overlying seawater. Diurnal fluctuations in dissolved oxygen (4-12mg/L) are mostly controlled by the photosynthesis and respiration of large seagrass beds in the East Arm.
Additional physico-chemical water quality data collected during the estuary processes study to give a better understanding of spatial variation in water quality.	*Estuary Processes Study* (PBP, 2000a)	In general water quality was considered to be typical of a healthy estuarine environment. Stratification of the water column was observed with salinity, temperature and dissolved oxygen all varying with depth consistent with what would be expected in an estuarine embayment (i.e. fresher, warmer, and more oxygenated water exists in surface layers, whereas saltier, cooler and more deoxygenated water exists in bottom layers). The Main Section of the Bay has more fresh water at the surface reflecting constant groundwater seepage and rainfall runoff. Dissolved oxygen was slightly depressed near the bottom of the Bay, which is likely due to the decay of organic matter on the bed surface. This did not affect healthy dissolved oxygen levels in the main water column.
Water quality data collected as part of seagrass study in November 2013 and January 2014.	*Seagrass growth and dynamics in semi isolated sub-tropical estuary* (Veness, 2014)	High level of water clarity and relatively low levels of nutrients present in the water column. Salinity was slightly elevated at all sites. Turbidity increased (water became less clear) with distance from the training wall. All other parameters were within healthy ranges for estuarine water.
Beachwatch Partnership Program microbial water quality data collected since 2002. Physico-chemical data collected at one site.	Data provided by BSC and downloaded from OEH Beachwatch webpage (OEH, 2014b)	A summary of results is presented in Section 6.1.2 (see below).

6.1.2 Beachwatch Partnership Program: data collected from 2002-present

Ballina Shire Council has been a part of the Beachwatch Partnership Program since its inception in 2002. The water quality of beaches and other swimming locations is monitored to provide the community with accurate information on the cleanliness of the water. To inform the community of water quality results during the summer swimming season, Council provides links to weekly 'star ratings' on their website, publishes results in the local paper *The Advocate* and also issues a newsletter. This communication is designed to enable individuals to make informed decisions about where and when to swim. Beachwatch Reports are produced annually providing detailed information on beach suitability for each site during the swimming season. Routine assessment can also be used to assess general trends in water quality over the monitored period and help to identify and assess risk factors including:

- The relationship between rainfall and enterococci (bacterial contamination indicator) results, and identifying expected 'at risk' periods such as after rainfall events;
- Providing an indication of the impact of pollution sources; and
- Where management has been undertaken (such as stormwater improvements), it may enable the effectiveness of management practices to be assessed, and highlights areas where further work is required (OEH, 2012).

Water Quality Guidelines

Water quality guidelines are developed to assist water quality planning and management. The guidelines help to define the water quality needed to protect the environmental values of a waterway. Environmental values are those values or uses of water that the community believes are important for a healthy ecosystem - for public benefit, welfare, safety or health (OEH, 2014b). The key environmental values to be protected in Shaws Bay include primary and secondary contact recreation, aquatic ecosystems, and visual amenity.

For each environmental value, the guidelines identify particular water quality characteristics or 'indicators' that are used to assess whether the condition of the water supports that value. For example, if the objective is to protect primary contact recreation (environmental value), we need to keep the bacteria levels in the water (the indicator) below a specified number or trigger value (OEH, 2014c).

Recreational guidelines

The National Health and Medical Research Council's (NHMRC) *Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008) are the current adopted guidelines for monitoring and reporting recreational water quality in New South Wales. The Beachwatch Partnership Program uses the NHMRC guidelines to assess and manage hazards to minimise health risks. There are two main types of assessment carried out:

- Weekly 'Star Ratings' based on a single enterococci data point. The star rating categories are derived from the microbial assessment categories used in the NHMRC (2008) guidelines and vary between one and four stars depending on performance that week (refer to Table 9 for description of the weekly star ratings); and
- Annual Beachwatch Reporting reports on combined results for the swimming season and assigns Beach Suitability Grades for each site. The Beach Suitability Grades are based on microbial assessment and sanitary inspection and have five-levels ranging from Very Good to Very Poor.

Guidelines for the protection of aquatic ecosystems and visual amenity

The applicable aquatic ecosystems guidelines for Shaws Bay are provided by the estuaries section of the *Richmond River Water Quality and River Flow Objectives* (OEH, 2014b). The water quality objectives are long-term goals for consideration when assessing and managing the likely impact of activities on waterways. Where the water quality objectives are being achieved in a waterway, they should be protected, and where

the water quality objectives are not being achieved in a waterway, all activities should work towards their achievement over time (OEH, 2014b). Table 8 provides a summary of applicable indicators and trigger values.

Table 8: *Richmond River Water Quality and River Flow Objectives* applicable to Shaws Bay (OEH, 2014b)

Environmental Value	Indicator	Numerical criteria (trigger values)
Aquatic Ecosystem (Estuaries)	Dissolved oxygen	80-110% saturation >6mg/L is generally considered suitable for most species
	pH	7-8.5
	Turbidity	0.5-10 NTU
	Salinity	-
	Total Nitrogen	<0.3 mg/L
	Total Phosphorus	<0.03 mg/L
	Chlorophyll-a	<4 µg/L

Data Collection and Quality Assurance

There are three Beachwatch monitoring sites within Shaws Bay: Shaws Bay East, Shaws Bay North, and Shaws Bay West (Figure 23). Sites are generally sampled five times per month during the four busiest months of the swimming season (November, December, January and February) except when more frequent sampling is conducted during significant events such as major flooding of the Richmond River.

Water quality samples are collected from each site and transported for laboratory analysis of enterococci. Physico-chemical parameters (pH, temperature, dissolved oxygen, conductivity/salinity and turbidity) are also measured using a hand-held Horiba water quality meter at the Shaws Bay East site. These measurements provide an insight into the general health and condition of Shaws Bay at this site in the Main Section.

Beachwatch staff (external to BSC) conduct regular quality assurance audits of Council's field sampling, laboratory analysis, data management and community reporting to ensure data is accurate and reliable.

Summary of Results

Recreational Water Quality Assessment

Table 9 presents all available enterococci data collected over summer swimming months (November - February) from 2002 to 2014 and subsequent star ratings (shown as coloured cells) assigned using the current Beachwatch rating criteria. It is noted that the Shaws Bay North and West sites were not sampled for enterococci from 2009/2010 to 2011/2012 summer seasons. Sampling of these sites began again in the 2012/2013 summer period.

Figure 23: Beachwatch sampling site locations in Shaws Bay

Table 9: Beachwatch star ratings based on enterococci data collected at three sites in Shaws Bay (Shaws Bay East – top; Shaws Bay North – middle; and Shaws Bay West – bottom) over summer swimming months (November to February) from 2002-2014

	November					December					January								February				
Shaws Bay East																							
2002/03	1	0	0	12	5	1	27	5	6		33	0	8	4	8				32	2	10	50	
2003/04						2	60	6	1	1	62	2	0	10	0				78	0	0	3	5
2004/05						6	67	11	0	2	0	110	3	50	2				4	20	15	60	0
2005/06	5	10	17	770	5	1	4				30	1	0	110					7	4	5	5	125
2006/07	4	4	10	2	0	13	42	10	2	29	61	6	2	11	48				25	0	235	6	4
2007/08	15	154	1	11	33	3	4	59	4	4	385	202	980	85	14	4	15	21	102	12	58	22	
2008/09	7	19	31	61	80	0	6	2	0	7	0	0	4	11	3				106	6	6	6	7
2009/10	4	7	2	44		43	4	28	9		13	2	13	3	2				2	64	2	4	75
2010/11	4	194	3	52		13	29	42			60	16	36	18	2				15	16	194	60	2
2011/12	2	47	32	19	4	12	3	190	25	35	13	115	13	4					382	54	113	34	113
2012/13	1	1	360	16	28	3	53	8	24	1	13	6	2	1	324				146	5	6	98	116
2013/14	61		16	4	150	170	3	85	12	12	9	3	8	100	86				6	14	32	12	2
Shaws Bay North																							
2002/03	0	0	0	0	24	0	9	6	13		6	1	7	30	1				5	0	20	10	
2003/04						2	4	0	0	1	74	4	0	20	0				18	0	4	1	30
2004/05						0	58	60	0	3	0	8	15	13	8				1	16	2	0	8
2005/06	3	45	3	540	5	2	6				25	0	1	116					14	203	36	15	165
2006/07	43	110	16	2	9	7	8	25	5	68	50	2	85	23	258				42	1	440	8	32
2007/08	0	160	4	18	2	3	9	15	5	4	80	240	320	36	93	5	34	70	72	2	19	44	
2008/09	3	57	160	25	45	29	175	385	80	41	2	16	8	61	7				450	10	11	19	31
2009/10																							
2010/11																							
2011/12																							
2012/13	4	2	1	7	5	3	10	150	164	23	1	54	3	11	280				58	12	24	220	176
2013/14	9	14	332	7	333	1800	7	100	6	0	6	2	2	360	113				0	10	18	12	1
Shaws Bay West																							
2002/03	1	0	1	0	2	3	5	24	18		20	8	9	10	3				11	22	80	56	
2003/04						1	9	4	3	1	7	5	0	8	2				138	1	25	32	16
2004/05						17	295	36	9	0	1	26	4	10	9				25	1	15	5	7
2005/06	120	46	42	640	144	1	8				15	11	2	130					80	37	12	5	61
2006/07	129	15	8	15		7	6	3	52	268	21	3	2	3	9				110	1	181	8	20
2007/08	1	100	3	32	0	4	1	75	2	9	178	198	278	25	6	11	11	51	434	24	101	7	
2008/09	0	72	14	19	15	28	15	24	2	10	0	14	3	12	9				633	42	0	12	11
2009/10																							
2010/11																							
2011/12																							
2012/13	32	0	23	1	49	0	235	320	30	19	0	720	5	8	224				96	6	332	340	220
2013/14	14	33	55	60		19	42	156	140	13	85	43	6	41	215				1	8	12	13	8

Rating		Colour	Enterococci (cfu/100mL) category	Description
**** (4 stars)	Good		<41	bacterial levels are safe for bathing according to NHMRC guidelines
*** (3 stars)	Fair		41-200	bacterial levels indicate an increased risk of illness to bathers, particularly those with lower immune function such as the elderly and young children
** (2 stars)	Poor		201-500	bacterial levels indicate a substantially increased risk of illness to bathers
* (1 star)	Bad		>500	bacterial levels indicate a significant risk of illness to bathers
			No data	data not collected

Sources: data and star rating descriptions soured from OEH Beachwatch webpage (OEH, 2014a).

Over the 12 year period of monitoring, there were a total of 549 samples collected from three sites during summer swimming months. Figure 24 shows the percentage of Beachwatch ratings based on combined enterococci results from Shaws Bay East, North and West sites from 2002 to 2014. The majority of samples have resulted in either a 'Good' or 'Fair' rating with a low level of risk of illness to bathers. However, there were a number of occasions when water quality indicated increased risk of illness to bathers (i.e. rating of

'Poor' or 'Bad'). The results are fairly similar across all three sites with the East site recording a marginally greater number of "Good" and "Fair" ratings than North or West.

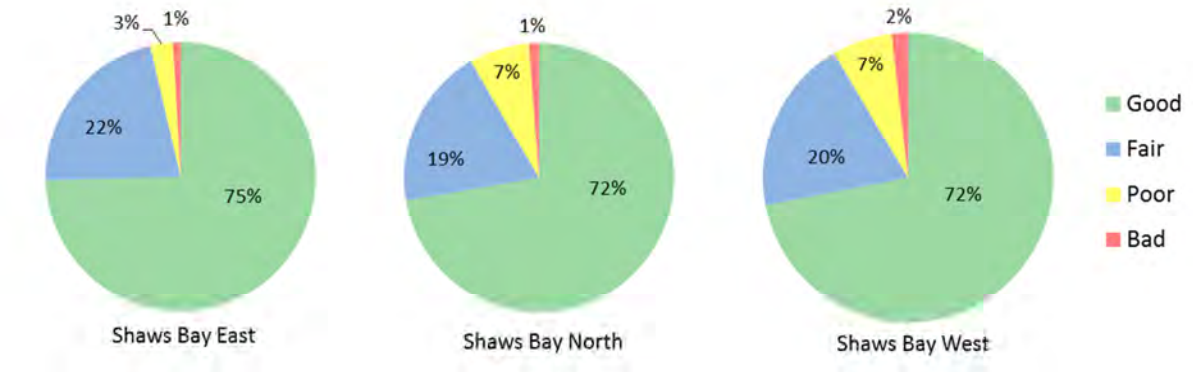


Figure 24: Beachwatch ratings based on combined *entero*cocci results from Shaws Bay East, North and West sites 2002-2014

There are many potential sources of bacterial contamination in Shaws Bay including stormwater, river discharge, animals, bathers and toilet facilities (OEH, 2013b). A previous study (BSC, 2003) has linked rainfall with increased enterococci levels and nominated daily rainfall of >10mm as a trigger for elevated swimming risk. Wet weather monitoring indicated that elevated bacterial levels are present in the Bay for up to two days following heavy rainfall (DEC, 2004). The Beachwatch program currently recommend that swimming in Shaws Bay be avoided during and for up to three days following rainfall, or if there are signs of stormwater pollution such as discoloured water or floating debris (OEH, 2013b).

Analysis of Beachwatch data from 2002 to 2014 provides further support for the link between rainfall and swimming risk. All of the 'Poor' or 'Bad' ratings given in Table 9 correspond to samples collected following at least some rainfall in the three days preceding sampling. In a small number of cases, the three day rainfall did not exceed 10mm which could indicate either direct sources of contamination to the Bay such as animals and bathers, or that rainfall recorded at the Ballina Airport (where the BOM weather station is located) did not capture isolated coastal storms affecting the Shaws Bay catchment. There were also many cases where significant rainfall resulted in elevated enterococci at only one site, while the others were assessed as low risk. There was no particular pattern to which site had elevated levels, with all sites showing elevated levels some of the time. This highlights the variation in bacterial levels between sites at any one time.

The current Beachwatch recommendation of avoiding swimming in Shaws Bay for up to three days following rainfall is considered to be consistent with monitoring results and a good rule of thumb to minimise risk to public health. Communicating this recommendation effectively to the public will be important in implementing a preventative approach recommended by NHMRC (2008).

The influence of river discharge is also evident in the sampling results. Of particular note is major flooding in the Richmond River in January 2008, which was accompanied by widespread water quality degradation throughout the estuary and major fish kills. Beachwatch sampling in Shaws Bay during January 2008 shows that most sites were unsuitable for primary contact recreation for a number of weeks following flooding (refer Table 9).

While there are no sample sites located in the Main Section or East Arm of Shaws Bay, we know from the *Estuary Processes Study* (PBP, 2000a) that these areas are better flushed than the Northern Section and as such are expected to have better water quality than the northern sample sites during most conditions. One exception may be during times of major flood in the Richmond River, where river water exchange through the wall is a source of poor quality water affecting the Bay. As the East Arm is a popular recreational swimming area, particularly during high tides in summer, it is recommended that Beachwatch sampling be amended to cover this location. It is expected that recreational use of the East Arm will increase as elements of the CZMP are implemented to improve foreshore facilities and amenity. The addition of a site in the East Arm will also allow for better characterisation of the ecological health parameters (DO, pH, Conductivity etc.)

in hydrologically different areas of Shaws Bay, and assist in identifying sources of contamination and overall interpretation of results.

Aquatic Ecosystem Water Quality Assessment

Physico-chemical water quality data was collected over seven years at the Shaws Bay East site during summer Beachwatch sampling from 2005/06 - 2013/14, excluding the 2009/10 season. Parameters measured included conductivity, pH, dissolved oxygen and turbidity. While the available water quality data provides some insight into the general health of Shaws Bay, it is difficult to draw conclusions about the overall health of the system without measurement of trophic status (i.e. nutrients and/or chlorophyll a) and without representation of the full range of locations in Shaws Bay. The following assessment provides an overview of water quality data available for the Shaws Bay East site during summer. Given that this site is located in the Northern Section of the Bay, which is more susceptible to poor water quality episodes due to reduced flushing, and summer is the time when the system experiences higher pollutant inflows from stormwater and catchment inputs, it is likely that this site represents the 'worst case scenario' for Shaws Bay.

Figure 25 shows box and whisker plots for the combined data set since 2005 showing the range of values measured over time. The central line in the box represents the median, the lower and upper box limits represent the 25th and 75th percentiles respectively. The *Richmond River Water Quality and River Flow Objectives* (OEH, 2014b) for estuaries are shown as horizontal lines. Comparison with water quality objectives has been undertaken by first comparing the median values of water quality data with the relevant guideline to assess whether trigger levels have been exceeded (as per ANZECC, 2000). The 25th and 75th percentiles have also been examined with reference to the guidelines (box and whisker plots) and finally the temporal trend of water quality relative to rainfall has also been examined for occasional exceedances to assist in interpretation of results.

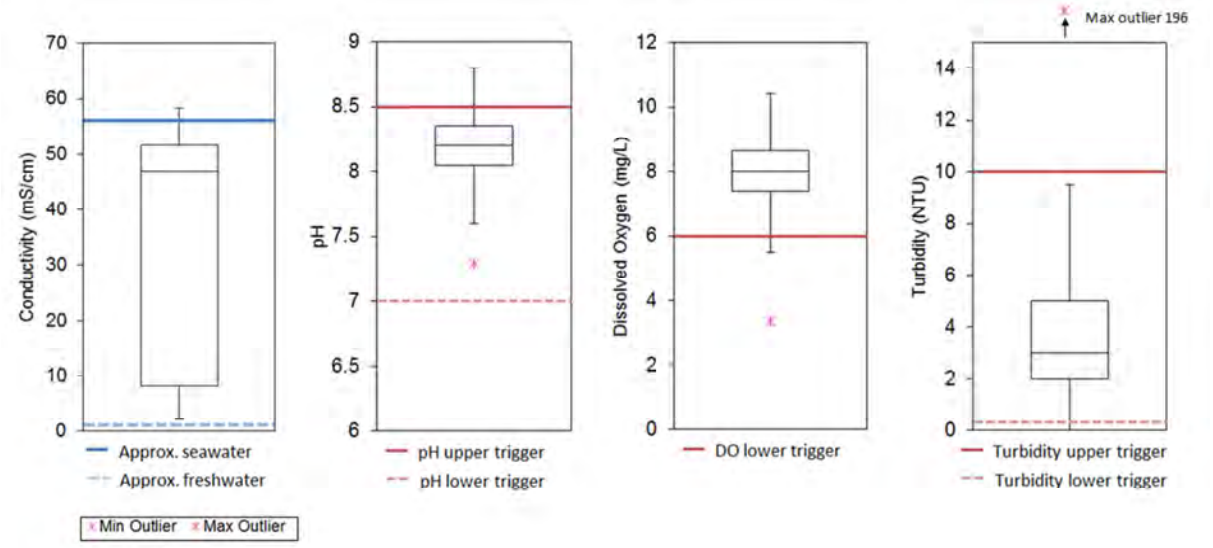


Figure 25: Shaws Bay water quality at east site: box and whisker plots for conductivity, pH, dissolved oxygen and turbidity for combined data collected in 2005/06, 2008/09 and 2010/11-2013/14 summer samples

The median values for all parameters (central line in box in Figure 25) were within the guideline (trigger) values for estuaries in the Richmond River catchment. The median values assessed for each year were also within guideline values for all parameters (Table 10). This result indicates that for the water quality indicators measured at this site, the results are consistent with what would be expected from a healthy, functioning estuarine ecosystem.

Table 10: Median values for physio-chemical parameters measured across each swimming season

Sample Year	pH	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temperature (°C)	No. samples
Guideline values:	**7.5-8.5**	**-**	**<10 NTU**	**>6mg/L**	-	
2005/06	8.30	51.90	2	7.29	26.10	18
2007/08	8.05	49.90	4	8.40	25.60	17
2008/09	8.31	51.75	2	8.25	24.90	20
2010/11	8.17	49.50	4	8.65	24.30	17
2011/12	8.18	46.00	3	7.85	23.95	14
2012/13	7.97	52.10	3	8.25	24.35	18
2013/14	8.19	48.90	4	7.63	25.10	17

Conductivity ranged from levels consistent with freshwater to seawater as expected in a tidal system with freshwater catchment inputs. With a median value of 47 mS/cm, the Northern Section of the Bay (at East site) was only slightly less salty than seawater during most samples. The box plot also shows that there were a small number of occasions when the water at this site was slightly saltier than seawater, which could be attributed to evaporation and concentration of salt in the Bay during low rainfall periods.

Levels for pH were within guideline trigger values for estuaries for most of the time (median pH 8.2). A small number of samples had pH levels slightly higher than the trigger values, although this appears to be limited to a few samples taken in 2006 and 2007 and is not considered to be of concern. There were no results where pH was below 7, indicating there are no issues with acidity at any of the sample occasions at this site.

The median value of 8 mg/L dissolved oxygen is considered to be suitable for healthy ecosystem function. A few samples measured DO below 6 mg/L with a number of low DO readings taken in January 2008 including the lowest value in the dataset of 3.37 mg/L (Figure 26). These readings coincided with major flooding and widespread deoxygenation in the Richmond River and highlighted the influence of river discharge on Shaws Bay water quality during flooding.

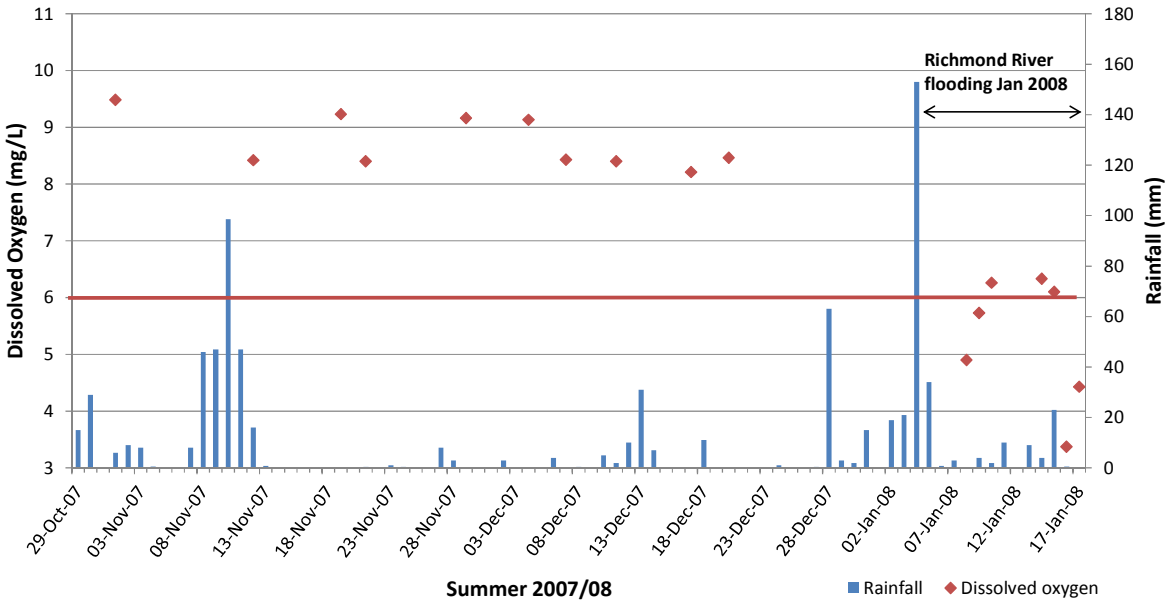


Figure 26: Dissolved oxygen concentrations at Shaws Bay East and rainfall for the 2007/08 summer

Turbidity at Shaws Bay East is low during most conditions with a median value of 3 NTU across all years of data which is well below the upper trigger of 10 NTU. A small number of occurrences of elevated turbidity are directly associated with rainfall events including the highest recorded value of 196 NTU, measured during the January 2008 floods (Figure 25).

6.1.3 Urban Stormwater Runoff

The majority of the Shaws Bay catchment is serviced by stormwater drains including the Shaws Bay residential area, as well as developed and undeveloped areas to the west of Shaws Bay, including sections of Hill Street. Other areas such as the Shaws Bay escarpment, the public reserve on the north side of Compton Drive, Pop Denison Park and the east corner are not directly serviced by stormwater drains and drainage occurs primarily via infiltration through the soil into groundwater or overland runoff. There are 17 stormwater drains discharging directly into Shaws Bay (Figure 28).

PBP (2000a) developed a computer model to predict both the annual load of pollutants to the Bay and the likely pollutant concentrations in the Bay following a major stormwater runoff event (1in 10 year ARI event). The model demonstrated that the annual pollutant loads are considered to be small compared to the oceanic flushing potential of the Bay, and are unlikely to have a major impact on overall water quality. The model showed an increase in pollutant concentrations in the Bay shortly after a major rainfall event, however the concentrations were within the recommended guideline limits for estuarine systems (ANZECC Guidelines) with the exception of *E. Coli*. Based on result of modelling, PBP (2000a) estimated that elevated *E. Coli* levels were likely to persist for less than 12 hours following the event and reported that this was consistent with results of bacteriological sampling carried out in Shaws Bay following rainfall events.

The model also found that the Northern Section of Shaws Bay receives a large amount of stormwater runoff relative to its volume and is therefore more susceptible to poorer water quality than other parts of the Bay. However, good tidal flushing means that any impacts are short-lived with pollutants being dispersed and advected out of the northern bay relatively quickly (PBP, 2000a). Results of the modelling are consistent with water quality monitoring undertaken to date which show there are poor water quality episodes following rain events, but the average water quality condition is suitable for healthy ecosystem function and recreational use.

Since the 2000 EMP, several improvements have been made in the Shaws Bay catchment that are expected to have a positive impact of stormwater quality including the installation and regular maintenance of filter bag pit inserts into all stormwater drains in the Shaws Bay residential area (Figure 28), installation of two Gross Pollutant Traps (GPTs) and the introduction of organic waste recycling which assists in diverting garden waste to council composting operations.

Figure 27: Stormwater GPT installed on western foreshore

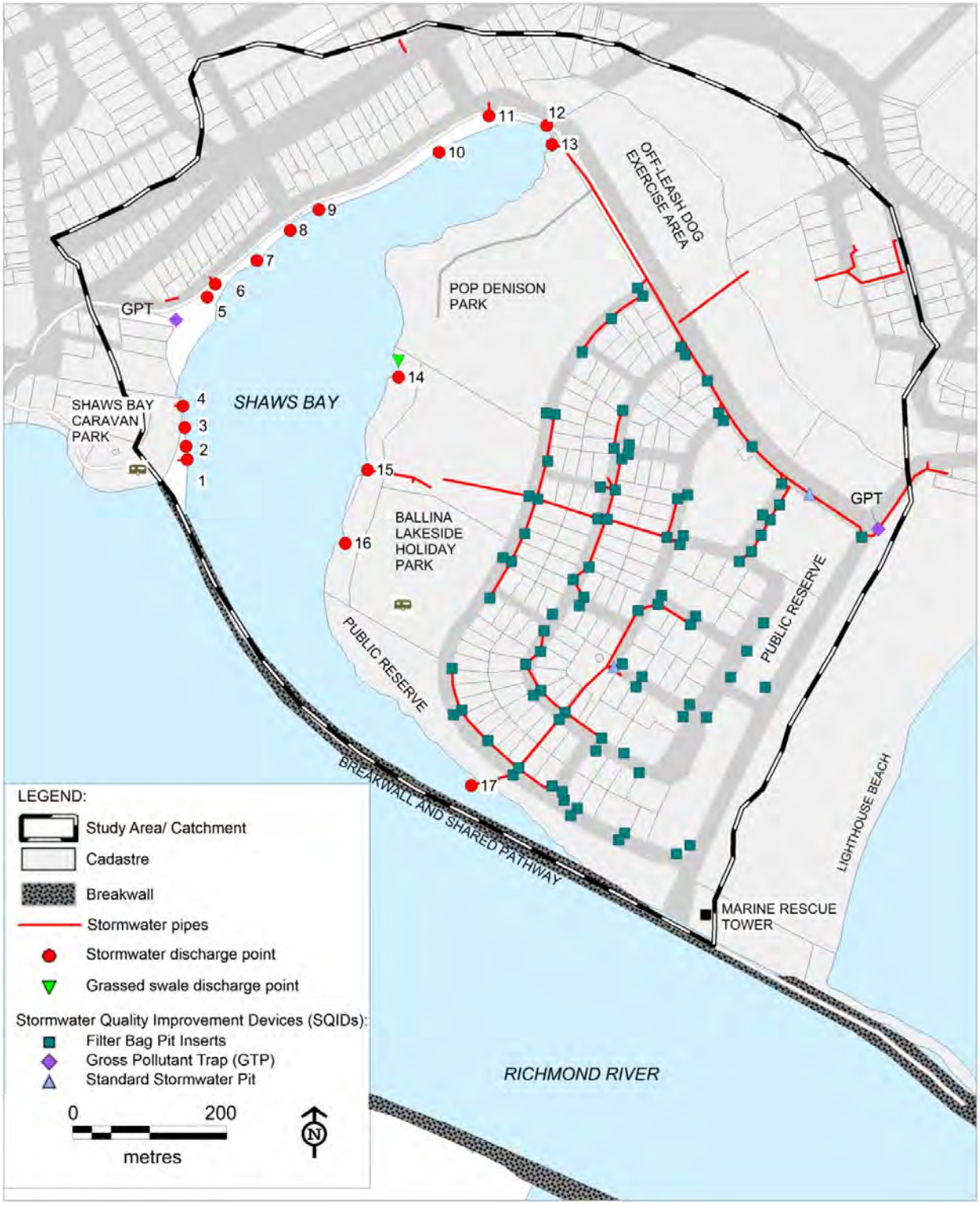


Figure 28: Stormwater infrastructure in the Shaws Bay catchment

Stormwater asset mapping provided by BSC. Note that mapping of some infrastructure is not complete.

6.2 Estuarine Vegetation

Estuarine vegetation refers to seagrass, mangrove and saltmarsh plant communities within the Shaws Bay study area. Seagrass occurs in the intertidal or sub-tidal (marine) zone and is generally covered with water except during very low tides, mangroves occur in the intertidal zone between low and high tide and saltmarsh communities occur mostly behind mangroves in the upper limits of the intertidal zone and are only inundated briefly on high tides (Figure 29). In an estuary, riparian vegetation is vegetation above the high tide level and generally does not include estuarine vegetation.

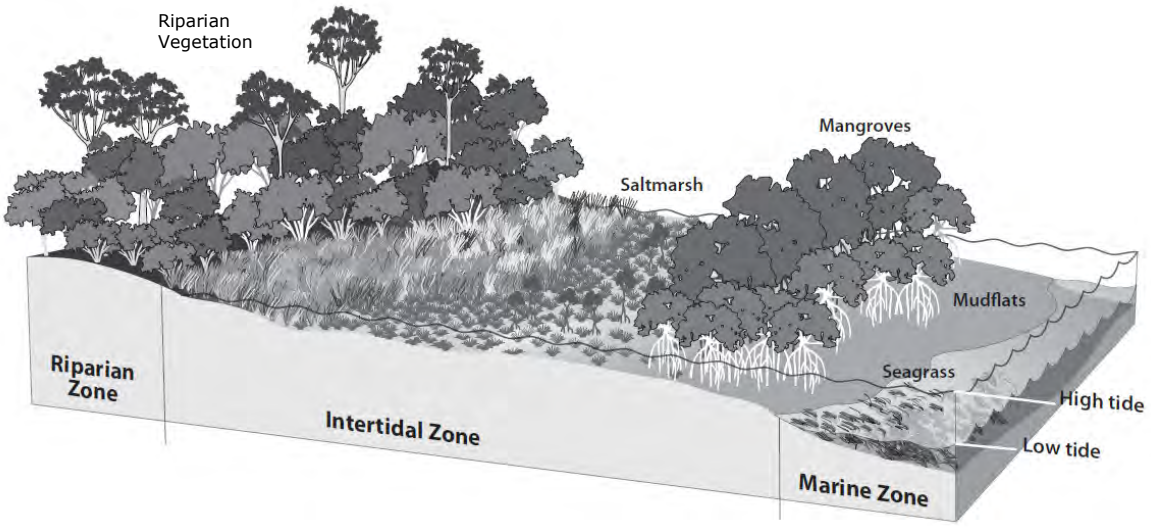


Figure 29: Zonation of estuarine vegetation

Source: OEH (2014d)

Estuarine habitat mapping has been completed as part of this CZMP and is shown in Figure 30.

Estuarine vegetation performs a number of important ecosystem functions. Saltmarsh, mangrove and seagrass habitats are essential nursery areas for many species of commercially and recreationally important fish and crustaceans and the food they eat, contributing large amounts of organic material to the ecosystem (Hannan & Williams, 1998). Depending on their type and location, estuarine vegetation reduces the effects of erosion due to waves or currents and helps trap sediments. Saltmarsh and mangroves also act as a buffer from urban areas and a filtration system for sediment and nutrients entering the waterway from the terrestrial environment (Russel, 2005).

Natural events such as floods and storms have impacted on seagrass, mangrove and saltmarsh in the Northern Rivers region. Human actions such as construction of infrastructure (e.g. roads, walkways, buildings etc.), actions to exacerbate bank erosion, poor water quality and direct disturbance from vehicles, watercraft and humans can also influence the distribution, abundance and condition of estuarine vegetation.

Figure 30: Shaws Bay estuarine habitat 2014

6.2.1 Seagrass

Seagrass forms a critical part of estuarine and marine ecosystems playing a major role in fishery production and sediment accumulation and stabilisation (Short *et al*., 2007). Highly productive seagrass ecosystems have a relatively complex physical structure, providing a combination of food and shelter that enables high biomass and productivity of commercially important fish species (Beck *et al*., 2001).

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

Historic Seagrass Distribution

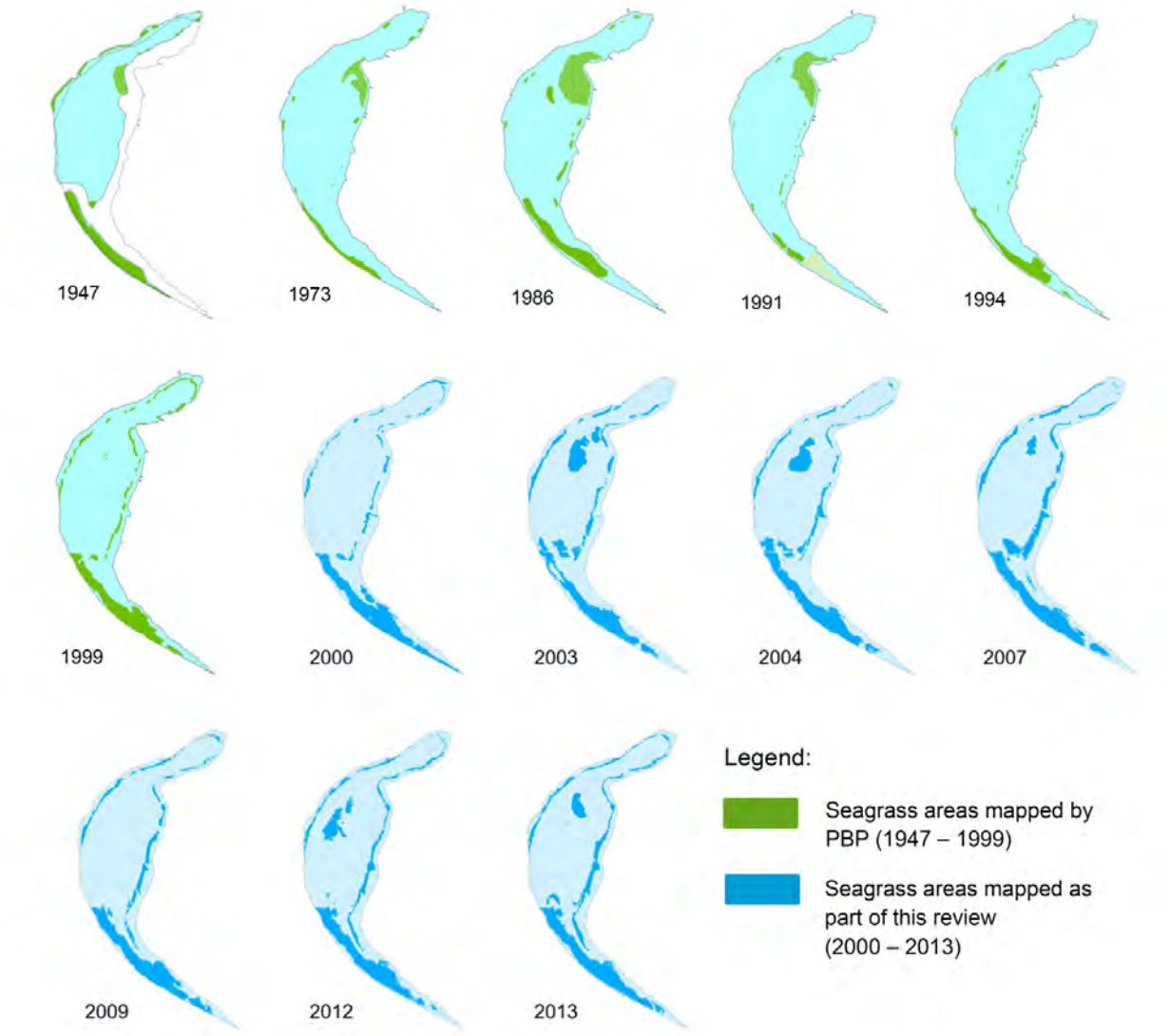
Mapping of historic seagrass distribution was conducted by PBP (2000a) from 1947 to 1999 illustrating changes in seagrass distribution in the Bay over time. As a part of this CZMP more recent aerial photographs from 2000 to 2013 have been analysed and seagrass distribution mapped. Figure 31 shows the combined sets of historical seagrass mapping from PBP (2000a) and the present review providing an overview of the changes in seagrass area over time. Note that there are limitations to aerial photo interpretation of seagrass extent (e.g. scale or quality of photographs and/or poor water quality conditions can make it difficult to discern exact seagrass extents) and these maps should therefore be viewed as general indications of change over time.

Seagrass distribution in Shaws Bay has fluctuated in the last 60 years. Overall, the largest seagrass meadows have occurred in East Arm of Shaws Bay with fringing communities around the remaining perimeter since 1999. A large area of seagrass was mapped in the central section of the Bay for eight out of the thirteen years mapped.

PBP (2000a) reported that historically, seagrass growth in Shaws Bay was most likely governed by larger scale anthropogenic impacts such as dredging, land reclamation and deliberate clearing. Loss of seagrass in the central section of the Bay between 1986 and 1994 may be attributable to dredging that occurred in this area over this time period. PBP (2000a) also noted that clearing/removal of seagrass in the East Arm was evident in the 1991 aerial photo.

More recently (at least since 2000) these larger scale human induced impacts have not occurred and potential impacts have been restricted to natural events such as flooding, siltation, tidal scour and smaller scale human impacts such as trampling.

Since 2000, there has been a general increase in the total area of seagrass in Shaws Bay with a 10% increase in area recorded between 2012 and 2013 (Figure 31). One exception was mapping results for 2009, which showed a reduction of 16% in seagrass area compared to the previous 2007 mapping. This decline may be attributable to poor water quality conditions following the 2008 floods. During January 2008, particularly high turbidity was recorded in Shaws Bay (196 NTU recorded in Beachwatch sampling) indicating a high level of suspended solids in the water column. This suspended matter (murky water) would have restricted light penetration to seagrass beds and therefore the ability of plants to photosynthesise. Low dissolved oxygen and high nutrient status in the water would also have been detrimental to seagrass at this time, inhibiting seagrass growth and encouraging excessive epiphytic algae growth. Recovery of seagrass area in 2012 and 2013 is apparent in the mapping, reflecting better overall health of the system in subsequent years.



Year	Total Area m^2	% change from previous map
2000	23253	-
2003	26829	15%
2004	29549	10%
2007	30626	4%
2009	25598	-16%
2012	28213	10%
2013	31129	10%

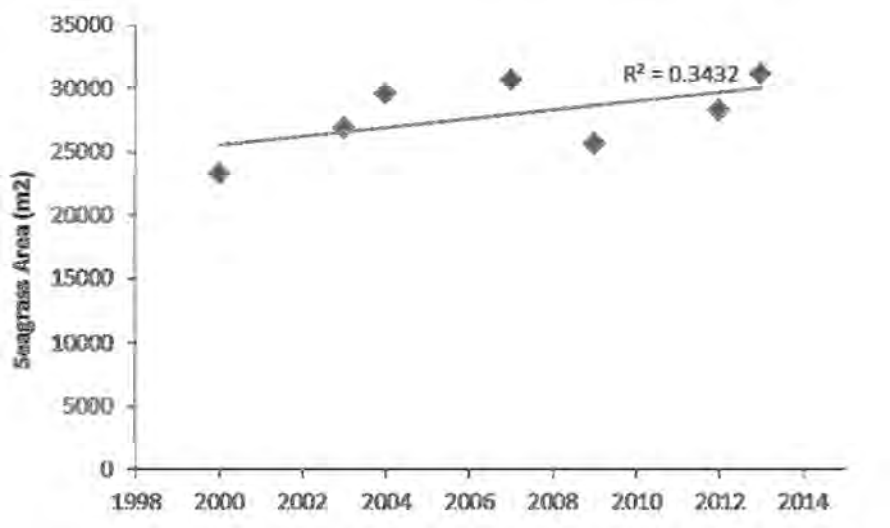


Figure 31: Historical seagrass distribution in Shaws Bay (1947-2013)

Current Distribution and Health

During late March a seagrass survey was conducted at several sites throughout the Bay. The aim of the survey was two-fold:

1. To establish a 'snapshot' of the current health of seagrass meadows in Shaws Bay; and
2. To substantiate the presence and broad distribution of *Ulva* spp. (Sea lettuce) within Shaws Bay.

Seagrass beds were assessed by snorkelling survey at high tide. The health of seagrass was described including a relative description of blade length, density, algal growth and presence of *Ulva* spp. Evidence of disturbance such as tidal scouring and undercutting or deposition and siltation of seagrass beds was also noted. Photos of representative sections were taken. Poor vision in the Main Section of the Bay restricted the extent of the survey. Figure 30 provides an overview of the current distribution and general health of seagrass in Shaws Bay, based on the field assessment.

Seagrass communities within Shaws Bay consist of two species *Zostera capricorni* (Figure 32) and *Halophila ovalis*. The communities are overwhelmingly dominated by *Z. capricorni* which appears as long grass like strands of seagrass (up to 50 cm long). *H. ovalis* is a much smaller and delicate species which has small ovate leaves which grow very close to the bottom substrate, appearing generally around the margins of *Z. capricorni* meadows. Both species will collectively be referred to as seagrass.

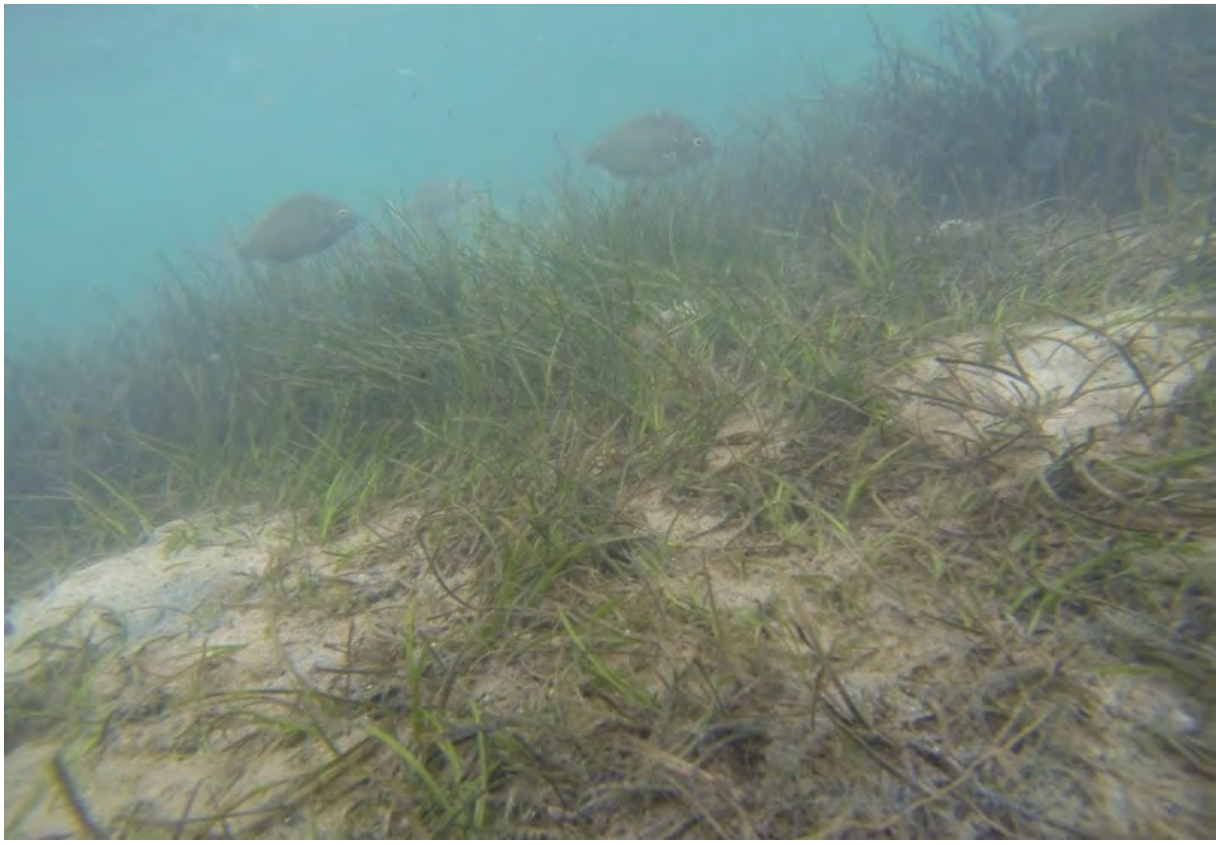


Figure 32: Typical Shaws Bay seagrass community dominated by *Zostera capricorni*

Shaws Bay seagrass is in generally healthy condition with no *Ulva* spp. observed during the survey. A summary of seagrass health and condition is provided below based on the field assessment:

- In the southern section of the Bay there appears to be several general zones of seagrass health;

- In the far south eastern corner, seagrass appears to be mature but density is very patchy. Evidence of scouring and undercutting of the seagrass in this area along with the close proximity to the primary tidal exchange section of the wall suggest that this patchy distribution is possibly a result of higher current velocities in the area;
- Moving further north into the Bay (mid-East Arm) there is a large dense meadow where seagrass is mature with long blades and is in a generally healthy condition. There is evidence of scouring along the northern margin of this meadow where it meets the main flow channel;
- Unlike in the far southern corner, the environment around the base of the training wall appears to become depositional (with siltation and no visual evidence of scouring) and epiphytic algal growth appears to slightly increase. This pattern continues north to where the mangroves are growing along the training wall; and
- The health of the seagrass growing along the eastern bank of the Main Section (in front of the Lakeside Holiday Park) appears to have a very distinct cross sectional pattern. The shallow margins of the meadow are dominated by dense, short, very young *Z. capricorni* shoots and become longer and more mature further towards the middle of the meadows. In the middle of the meadows the seagrass is older, sparser and covered in a medium-heavy layer of epiphytic algae. On the deeper margins the pattern follows that of the shallow margin except the young *Z. capricorni* is bordered by *H. ovalis*. The *H. ovalis* extends a considerable distance into deeper water (approximately 2m deep).

6.2.2 Mangroves

Mangrove communities can comprise several species that inhabit the intertidal shores of sheltered sub-tropical and tropical waterways. Mangroves are adapted to saltwater, anoxic and sulfidic environments exhibiting several adaptations which allow them to thrive in such environments. They provide many ecosystem services to the estuarine system including:

- Trapping sediments both reducing turbidity and buffering the shoreline against erosion;
- Providing habitat for both terrestrial and aquatic species;
- Providing nursery areas for juvenile aquatic species;
- Providing food and habitat for terrestrial birds and important roosting sites for migrating shorebirds; and
- Filtering surface runoff of nutrients and pollutants.

Mangrove distribution can be influenced locally by a range of factors including:

- Clearing for development;
- Trampling of pneumatophores and seedlings;
- Restriction of extent due to hard structures such as retaining walls and roads;
- Major storms;
- Pollution, in particular heavy metals and petrochemicals, causing dieback; and
- Changes in sediment dynamics (i.e. a newly formed sand/mud bank maybe colonised by mangroves).

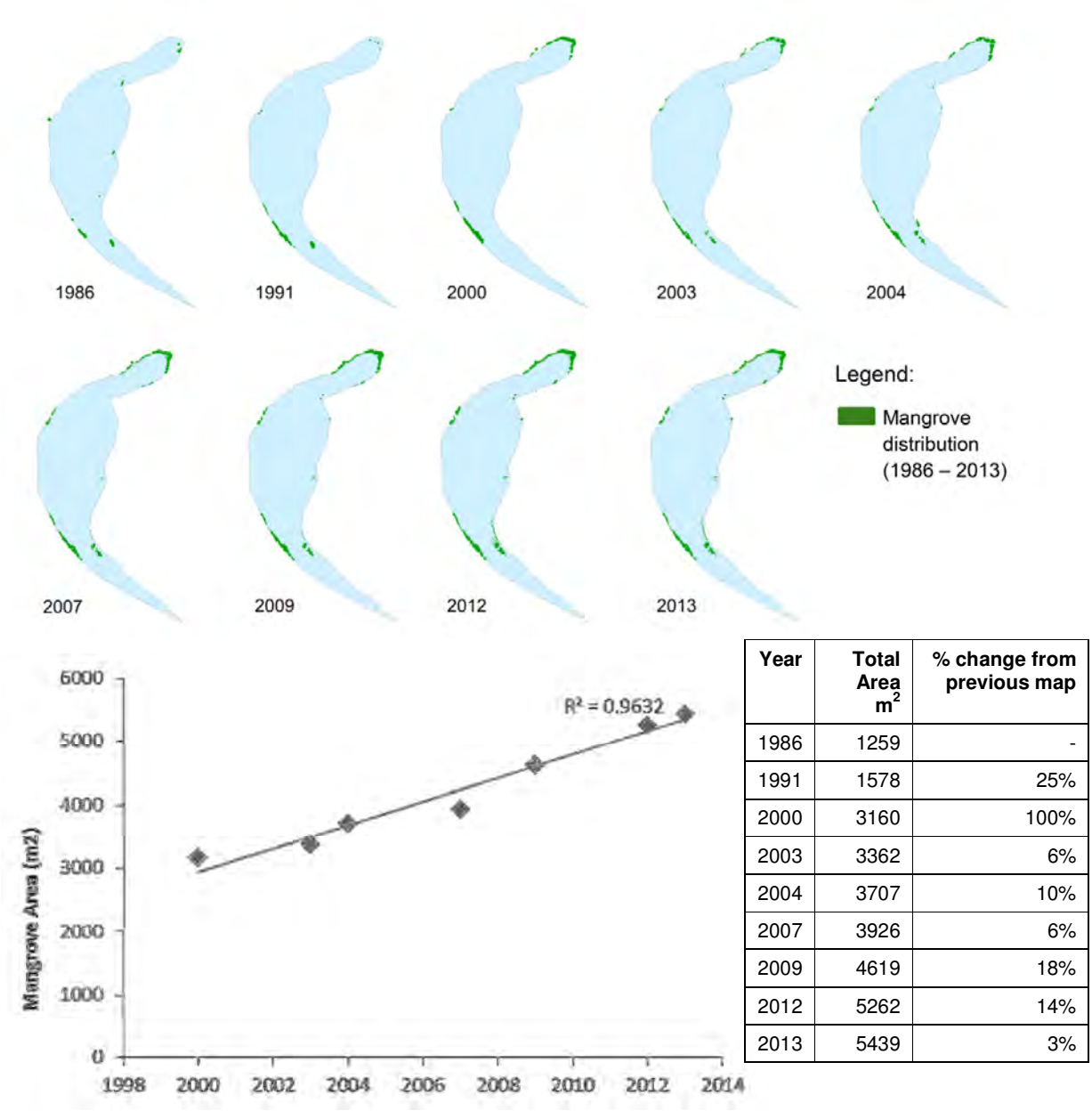
Figure 33: Mangrove seedlings establishing in Shaws Bay (mangrove pneumatophores are also visible)

Historic Mangrove Distribution

Mapping of historic mangrove distribution was conducted by Fisheries NSW in 1986 and 1991. As a part of this CZMP, more recent aerial photographs from 2000 to 2013 have been analysed to map mangrove distribution. Figure 34 shows the combined sets of historical mangrove mapping providing an overview of the changes in mangrove area over time. Note that while mangrove areas are more easily discernable than seagrass from aerial photographs, these maps should also be viewed as general indications of change over time.

In the last 28 years mangrove distribution in Shaws Bay has fluctuated, however the general trend shows an increase in area of mangroves over time. There are four main areas of mangroves that have been present since 1986 and have increased in size during most map updates. These include a stand along the training wall, an area opposite the training wall south of the Lakeside Holiday Park, a stand along the western foreshore between the Shaws Bay Hotel and disabled access ramp and the largest section in the northern tip of the Bay. PBP (2000a) noted that prior to construction of Compton Drive, it is likely that mangroves would have extended further north into the area the road currently occupies and beyond. Since 2003, additional small stands of mangroves (sometimes only two or three individuals) have appeared along the eastern and western foreshores.

PBP (2000a) reported that historically, mangrove growth and distribution was largely restricted by shoreline disturbance from dredging and excavation. PBP also noted a high number of mangrove seedlings around much of the Bay in 2000 and the potential for significant increases in mangrove area considering that main sources of disturbance were no longer occurring. It is apparent from the subsequent mapping (Figure 34) that there has been an increase in the total area of mangroves in Shaws Bay over time.



Year	Total Area m^2	% change from previous map
1986	1259	-
1991	1578	25%
2000	3160	100%
2003	3362	6%
2004	3707	10%
2007	3926	6%
2009	4619	18%
2012	5262	14%
2013	5439	3%

Figure 34: Historical mangrove distribution in Shaws Bay (1986 - 2013)

Current Mangrove Distribution and Health

Figure 30 provides an overview of the current distribution and general health of mangrove communities in Shaws Bay. The total mapped area of mangroves in Shaws Bay was approximately 5,439 m^2 using the latest aerial photography (2013). This is over four times the area mapped by Fisheries NSW using 1986 photography. The majority of area was divided between the main mangrove areas as follows:

- The stand along the training wall (approximately 1,483 m^2);
- The area opposite the training wall, south of the Lakeside Holiday Park (approximately 800 m^2);
- A stand along the western foreshore (approximately 434 m^2); and
- The largest section in the northern tip of the Bay (approximately 2,340 m^2).

- The remaining area (381 m^2) comprises small stands of a few individual trees each scattered around the Bay perimeter.

Mangroves occurring in Shaws Bay consist of two species: River mangrove (*Aegiceras corniculatum*); and Grey mangrove (*Avicennia marina*). Mangroves appear to be relatively good condition in Shaws Bay and are successfully colonising new areas along the foreshore where they are not being actively removed.

The two key factors that will restrict mangrove growth into the future are:

- Active removal of mangroves in accordance with the current Fisheries Permit to maintain access areas and remove mangroves along the river training wall; and
- Barriers to upslope migration of mangroves expected with sea level rise. One of the main restrictions to future mangrove growth is the presence of hard barriers such as the river training wall, retaining walls along the western foreshore and Compton drive. These barriers will restrict the natural upslope migration of mangroves and may eventually result in the loss of mangroves in some areas (refer to Section 6.2.4 for further details).

6.2.3 Saltmarsh

Coastal saltmarsh is an inter-tidal community of plants such as sedges, rushes, reeds, grasses, succulent herbs and low shrubs that can tolerate high soil salinity and occasional inundation with saltwater (DPI, 2013). Saltmarsh communities inhabit sheltered, soft substrate foreshores of coastal lakes and estuaries. They often occur behind mangroves in the upper limits of the inter-tidal zone and are only inundated briefly on high tides often to the extent of the highest astronomical tide (DECC, 2007b). Distribution of coastal saltmarsh is influenced by the combination of elevation, salinity and frequency of inundation (DPI, 2013).

Saltmarsh communities are comprised of low growing hyper-saline adapted plant species and are often zoned within the community according to tide levels and frequency of inundation and subsequently salinity levels. Dominant species that are indicative of a saltmarsh community in NSW include Samphire (*Sarcocornia quinqueflora*) at the lower more frequently inundated levels, Saltwater Couch (*Sporobolus virginicus*) dominating the mid-level saltmarsh and Sea Rush (*Juncus kraussii*) which is usually dominating the drier plant communities at higher elevations (DPI, 2013). However, with over 200 plant species known to occur in Coastal Saltmarsh environments there are a number of possible combinations of plant species.

Saltmarsh communities provide important ecosystem services, including:

- Providing food and habitat for not only aquatic animals (when inundated at high tide) but also for terrestrial animals such as shorebirds when exposed at low tide;
- Providing basic inputs of carbon to estuaries in the form of dead leaves and branches which becomes part of the food chain when broken down and dispersed by tidal currents. Material can be taken in by filter feeders such as mussels and oysters and surface feeders such as crabs and mullet (Valiela et al., 1978);
- Filtering surface runoff water of nutrients and sediments before it enters coastal waters; and
- Providing vegetative cover along estuary banks which traps sediment and helps minimise erosion.

Saltmarsh distribution and condition can be influenced locally by a range of factors including:

- Clearing for development;
- Physical disturbance (e.g. trampling, vehicle access etc.);
- Reclamation and drainage activities;
- Stormwater runoff;

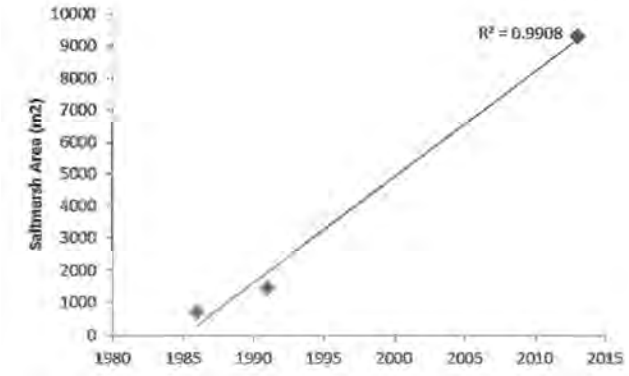
- Weed invasion;
- Encroachment by other vegetation such as mangroves; and
- The combination of sea level rise and barriers to upslope migration restricting suitable habitat areas for saltmarsh (refer Section 6.2.4).

Coastal Saltmarsh is currently recognised as being at very high risk of extinction in NSW and is classified as an Endangered Ecological Community (EEC) under the NSW *Threatened Species Conservation Act 1995.*

Historical Saltmarsh distribution

Mapping of saltmarsh communities in Shaws Bay has shown a great variation in Saltmarsh abundance and distribution in Shaws Bay over time (Figure 35). Mapping from 1986 and 1991 was supplied by Fisheries NSW and was part of a state-wide initiative mapping estuarine habitat based on aerial photography interpretation. Mapping completed during this CZMP was based on high resolution 2013 aerial photography confirmed with ground-truthing in 2014, and it is of much greater detail than previous mapping. The differences in methods may account somewhat for the vast discrepancy in results.

In 1986 the only saltmarsh area mapped was a small patch along the northern tip of the Bay. In 1991 this patch increased to more than double its original size, but again there was no saltmarsh mapped in any other areas. In 2000 ground surveys undertaken by PBP as part of the *Estuary Processes Study* (PBP, 2000a), mapped indicative lines representing the location of saltmarsh communities occurring along the majority of the eastern bank foreshore as well as the northern and northwest foreshores (refer to Figure 7.1, PBP, 2000a). While PBPs mapping did not assess the total area of saltmarsh, it is clear that the distribution of saltmarsh in 2000 had increased significantly from what was mapped in 1991. Mapping conducted as part of this CZMP shows saltmarsh extending in fringing communities along much of the eastern foreshore of Shaws Bay as well as the western foreshore to a point approximately level with the Shaws Bay Hotel. Figure 35 shows the mapped Saltmarsh distribution in 1986, 1991 and current distribution in 2013.



Year	Total Area m^2	% change from previous map
1986	693	-
1991	1446	109%
2013	9302	543%

Figure 35: Historical saltmarsh distribution (1986 - 2013)

Current Saltmarsh Distribution and Health

Saltmarsh communities were mapped using 2013 aerial photography with the presence and composition of communities verified through on-ground survey in May 2014. Figure 30 provides an overview of the current distribution and general health of saltmarsh communities in Shaws Bay.

The total mapped area of saltmarsh in Shaws Bay was approximately 9,302 m^2 based on latest aerial photography (2013). This is over thirteen times the area mapped by Fisheries NSW using 1986 photography. However, as discussed, differences in the scale and methods of mapping may explain the large discrepancy in results. The main area of mapped saltmarsh in 1986 and 1991 in the northern tip of the Bay is noticeably absent from the 2013 mapping. Currently, saltmarsh in this area consists of a thin band (approx. 0.5 – 1.0 m in width) squeezed between mangroves and the mown verges of the footpath.

The saltmarsh communities in Shaws Bay are dominated by Saltwater couch (*Sporobolus virginicus*) and the succulent Shoreline purslane (*Sesuvium portulacastrum*). Other commonly occurring succulent species were Samphire (*Sarcocornia quinqueflora*) and Astral Seabite (*Suaeda australis*). Small patches of sedge and rush species including Club Sedge (*Schoenoplectus* spp) and Sea Rush (*Juncus kraussii*) were observed sporadically around the perimeter, with one large sedge area just north of the beach area in front of the Shaws Bay Hotel. In general, saltmarsh communities were in good condition although weed invasion and encroachment by 'garden escapees' were degrading factors at some locations. Common weed species included Coastal morning glory (*Ipomoea cairica*), Siratro (*Macroptilium atropurpureum*), Asparagus fern (*Asparagus aethiopicus*), and Bitou bush (*Chrysanthemoides monilifera*). It is also evident that Saltmarsh is restricted along its landward edge in many locations by hard structures (e.g. retaining walls, footpaths etc.), mown areas, or elevated topography. Over-time and in the presence of sea level rise it is likely that saltmarsh will be squeezed against these obstacles and landward-shifting mangroves and will eventually be replaced by them (refer to Section 6.2.4 further details).

Figure 36: Shaws Bay saltmarsh community occurring behind mangroves. Dominant saltmarsh species are Saltwater couch (*Sporobolus virginicus*) and Shoreline purslane (*Sesuvium portulacastrum*)

6.2.4 Impacts on Estuarine Vegetation due to Sea level rise

Sea level rise (refer Section 5.1) is expected to increase the average water depth and extend tidal propagation in Shaws Bay with associated changes in salinity regime. It is anticipated that sea level rise will result in the landward recession of fringing estuarine wetland systems. The location of estuarine habitats such as mangrove stands and saltmarsh are controlled principally by tidal range and salinity influence and will gradually respond to changes in increases in average water levels and salinity. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, rock walls, retaining walls and urban development on the landward side (DECC, 2009). This impact has been named "Coastal Squeeze" by the Department of Climate Change (now OEH, DECC, 2009) (refer Figure 37 below). Under these conditions the landward side of these important habitats will be fixed but the lower margin will gradually be pared away, leading to a loss of habitat area.

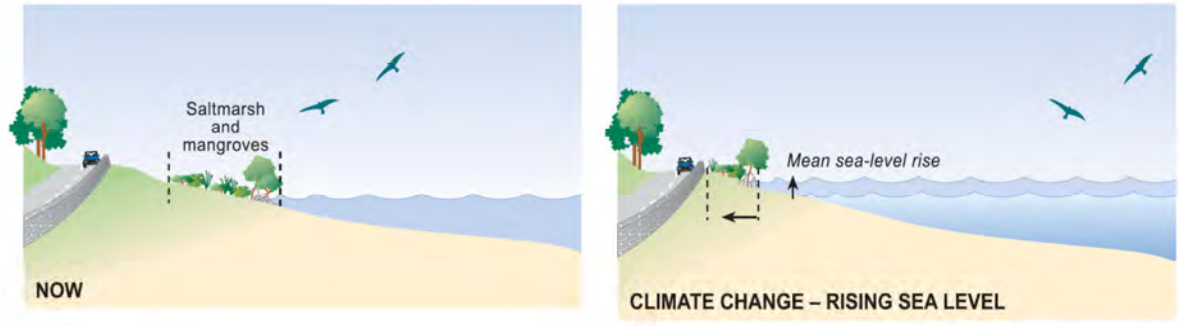


Figure 37: 'Coastal squeeze' under sea level rise: impact of development
Source: DECC, 2009

To examine the likely migration of estuarine vegetation in Shaws Bay with sea level rise, and the impact of barriers to migration, an assessment was undertaken based on the tidal ranges of different vegetation types. The potential areas were then compared to the existing barriers to migration such as the river training wall, retaining walls along the western foreshore, footpaths, roads, property boundaries and residential areas. This allowed for an estimate of the impact of sea level rise on future estuarine habitats in the study area.

The assessment contained a number of assumptions as follows:

- Constraints to migration were assumed to be hard barriers (e.g. retaining walls, roads etc.) and private property boundaries (extent of building and maintenance);
- There was no consideration of management actions such as mowing of public park areas or active removal of vegetation. It has been assumed that estuarine vegetation would be allowed to colonise unconstrained areas such as Pop Denison Park and the East Arm public reserve;
- There was no allowance for sedimentation or infilling of the Bay over time; and
- The estimation of suitable tidal ranges for vegetation types was made by considering approximate known ranges for each vegetation community and adjusting these ranges to fit what is currently present in Shaws Bay. Vegetation communities may have greater or lesser tolerance ranges than those assumed in this assessment.

Figure 38 shows the estimated potential areas for estuarine vegetation migration considering existing barriers and sea level rise scenarios for 2010 (current), 2050 and 2010 as well as these areas without the barriers (unconstrained). Seagrass (black); mangroves (green) and saltmarsh (purple) communities are depicted for each of the scenarios. Table 11 provides an estimate of the change in total area of seagrass, mangroves and saltmarsh for each of the scenarios and this is shown graphically in Figure 39.

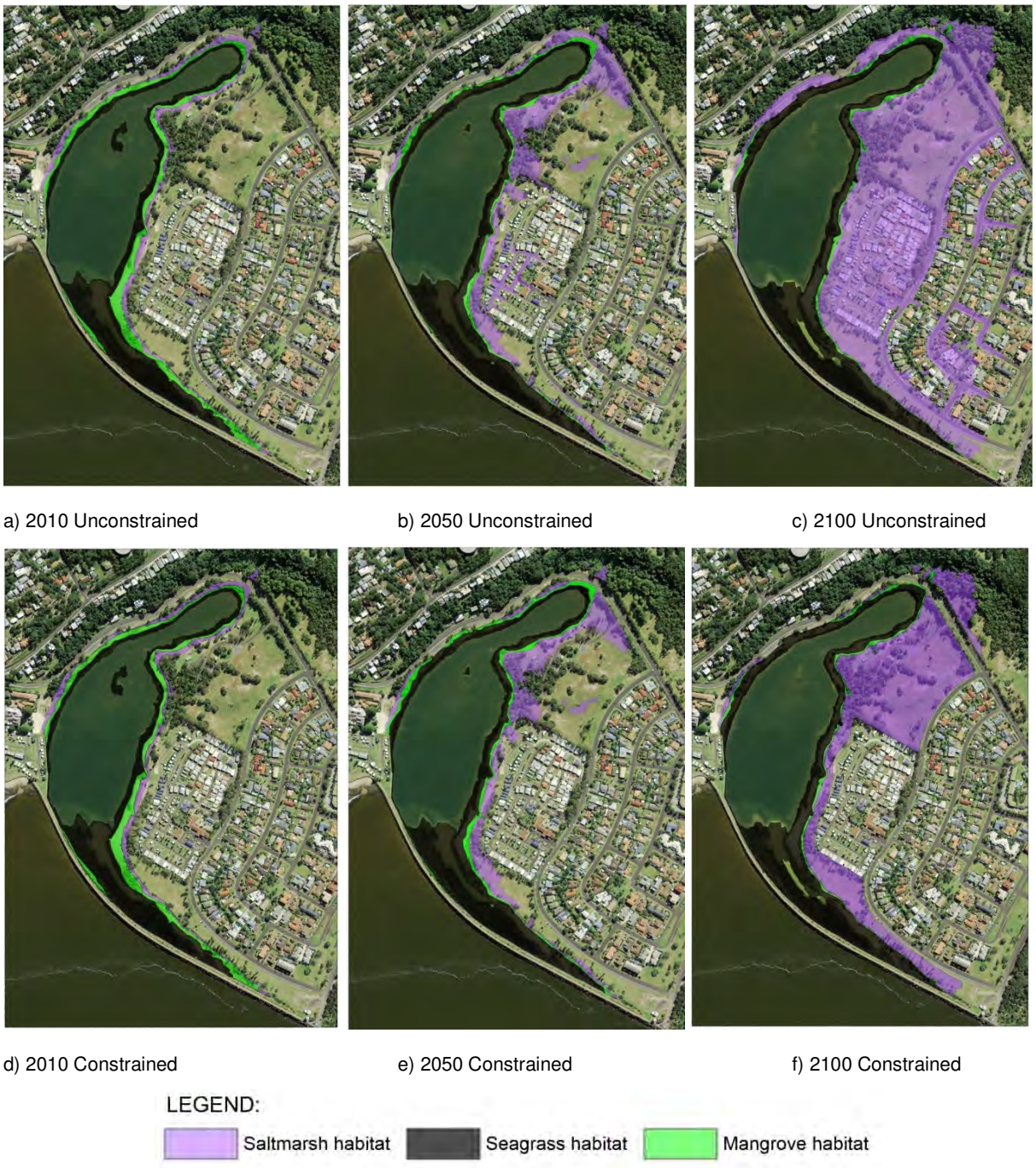


Figure 38: Potential areas for migration of estuarine vegetation types with sea level rise

Table 11: Predicted change in area of seagrass, mangrove and saltmarsh habitats with sea level rise for 2010, 2050 and 2100

UC – unconstrained, C – constrained

	2010 Area (ha)		2050 Area (ha)				2100 Area (ha)			
	UC	C	UC	% UC change from 2010	C	% C change from 2010	UC	% UC change from 2010	C	% C change from 2010
Seagrass	4.5	4.5	5.7	28%	5.7	27%	6.2	37%	6.1	37%
Mangrove	2.1	2.1	1.0	-50%	1.0	-50%	0.8	-64%	0.7	-65%
Saltmarsh	1.5	1.5	4.8	219%	3.8	154%	21.8	1360%	10.1	577%

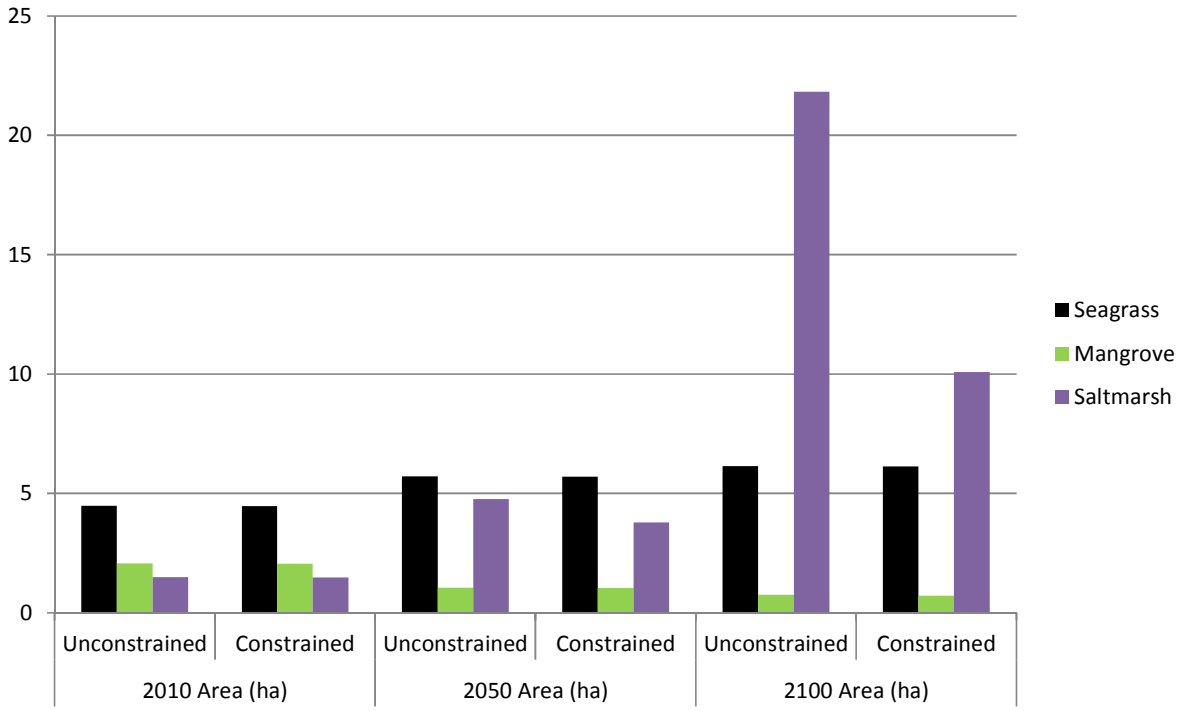


Figure 39: Predicted change in area of seagrass, mangrove and saltmarsh habitats with sea level rise for 2010, 2050 and 2100 (showing constrained and unconstrained scenarios)

Based on this assessment, the following changes in estuarine vegetation distribution are expected:

- Seagrass beds in the middle of the Main Section of the Bay will decrease in size and eventually be lost as water depth increases beyond the acceptable limit for seagrass growth;
- Total seagrass area however, will expand greatly as current foreshore areas around the perimeter of the Bay become sub-tidal zones with increasing water levels and provide areas suitable for seagrass proliferation. The total area suitable for seagrass growth will expand by 37% with projected sea level rise at 2100;
- The suitable tidal range for mangroves will reduce over time as this community is 'squeezed' between seagrass and saltmarsh zones and reduced to a thin band along foreshore areas or lost

completely from some areas. This is primarily due to either hard barriers along the southern and western edges of the Bay, or the small but steep step in the bank along most of the eastern shoreline;

- It is noted that there may be suitable areas of mangrove proliferation north of Compton Drive, assuming that a hydrologic connection is maintained under the road;
- The area of mangroves and saltmarsh will be reduced (and eventually lost) along the western foreshore as sea levels rise and these communities are 'squeezed out' against the retaining wall; and
- Saltmarsh communities have the greatest potential for expansion as sea levels rise due to the large flat areas on the eastern side of the Bay that would become subject to intermittent tidal inundation (i.e. suitable habitat for saltmarsh). In an unconstrained scenario, areas suitable for saltmarsh would increase by approximately 1,360% by 2100. In the constrained scenario this equated to approximately 577% in 2100. Without management intervention, this habitat would extend over Pop Denison Park, the East Arm public reserve, and areas north of Compton Drive.

6.3 Terrestrial Vegetation

Terrestrial vegetation refers to all non-aquatic and non-estuarine plant species occurring within the Shaws Bay study area (refer Figure 29). This includes riparian vegetation which is located adjacent to the Bay, above the high tide level. Healthy terrestrial vegetation communities in the catchment are important for maintaining general biodiversity, aesthetic value and improving runoff water quality to Shaws Bay.

The *Vegetation Management Plan for East Ballina Reserves* (VMP, Blackwood Ecological Services, 2014) includes assessment and management planning for vegetation within public reserves in the study area. This includes the Shaws Bay Escarpment, Pop Denison Park and the foreshore areas of Shaws Bay (excluding the training wall). Figure 40 and Figure 41 provide vegetation community mapping and management zones for the area sourced from the VMP. The study area contains a number of terrestrial vegetation communities including large areas of littoral rainforest along the Shaws Bay Escarpment to the west and north of Shaws Bay. Patches of coastal forest, woodland, shrubland and open grassland interspersed with stands of casuarina, acacia, banksia and eucalypts characterise the remaining study area. Reference can be made to the VMP for detailed descriptions of communities and recommended vegetation management for each subzone.

6.3.1 Ecological Values

A total of three terrestrial Endangered Ecological Communities (EECs) listed under the *Threatened Species Conservation Act 1995* (TSC Act 1995) occur within the Shaws Bay study area. Littoral Rainforest EEC, patches of Coastal Cypress Pine Forest EEC and Swamp Sclerophyll Forest EEC are all mapped within the study area in the VMP. Small patches of Coastal Cypress Pine Forest EEC are present at various locations around the perimeter of Shaws Bay and adjacent to the Ballina Lakeside Holiday Park (Figure 40).

A search of the Atlas of NSW Wildlife was conducted to obtain a list of all records of flora sightings held for the Shaws Bay study area. The VMP was also examined for any additional threatened species detected in the study area. Scented Acronychia (*Acronychia littoralis)* is the only listed threatened species identified within the study area. It is classified as endangered under the TSC Act 1995 and known to occur within the Shaws Bay Escarpment area (Blackwood Ecological Services, 2014). While individual plants of Coastal Cypress Pine (*Callitris columellaris)* are not classified as a threatened species, they make up the dominant species of the EEC (Coastal Cypress Pine Forest in the NSW North Coast Bioregion) which is protected in NSW. All other records of terrestrial vegetation contained in the Atlas of NSW Wildlife database are common species that are not listed as protected in NSW.

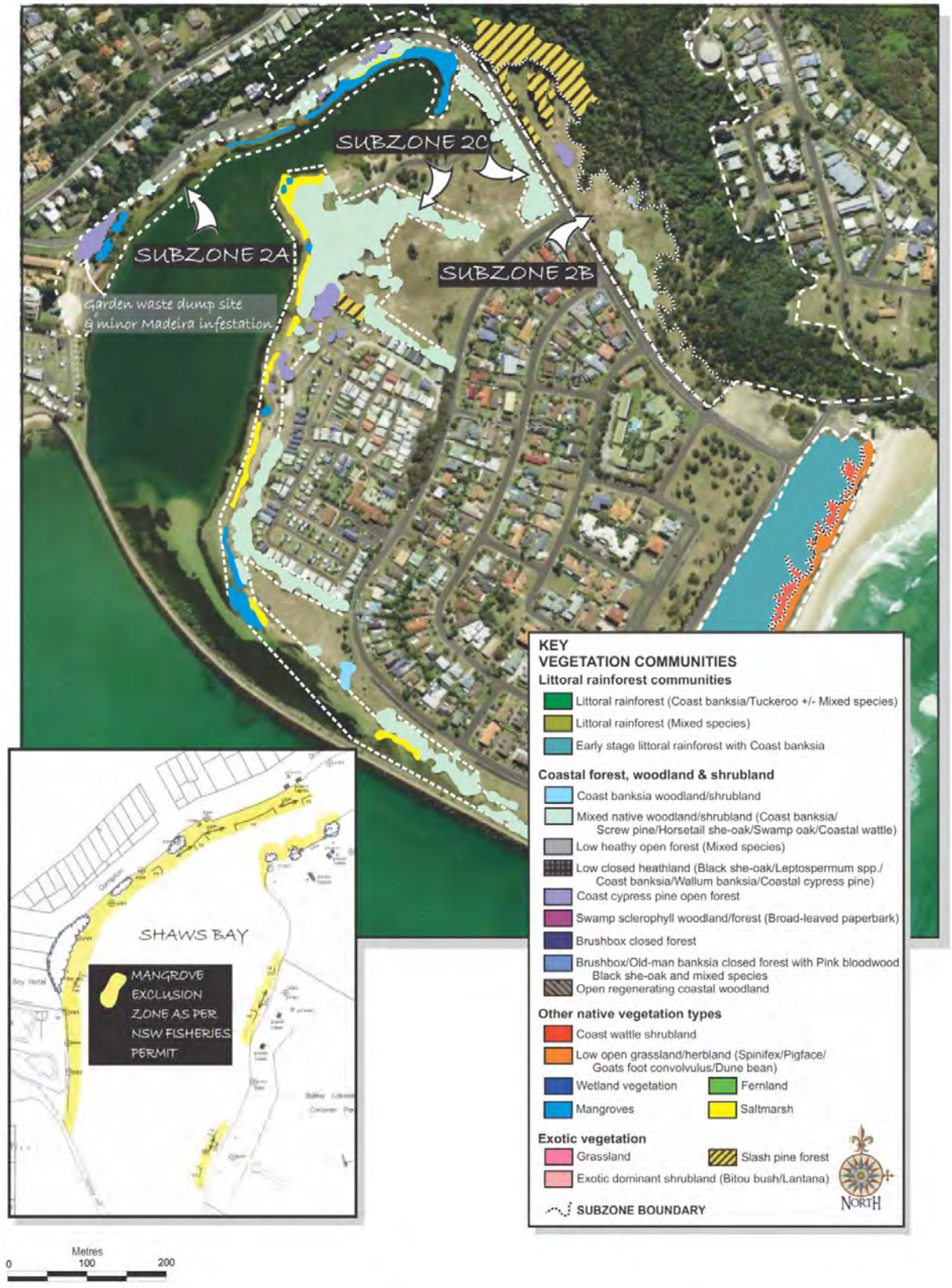


Figure 40: Vegetation communities and subzone boundaries for Shaws Bay

Source: Blackwood Ecological Services (2014)

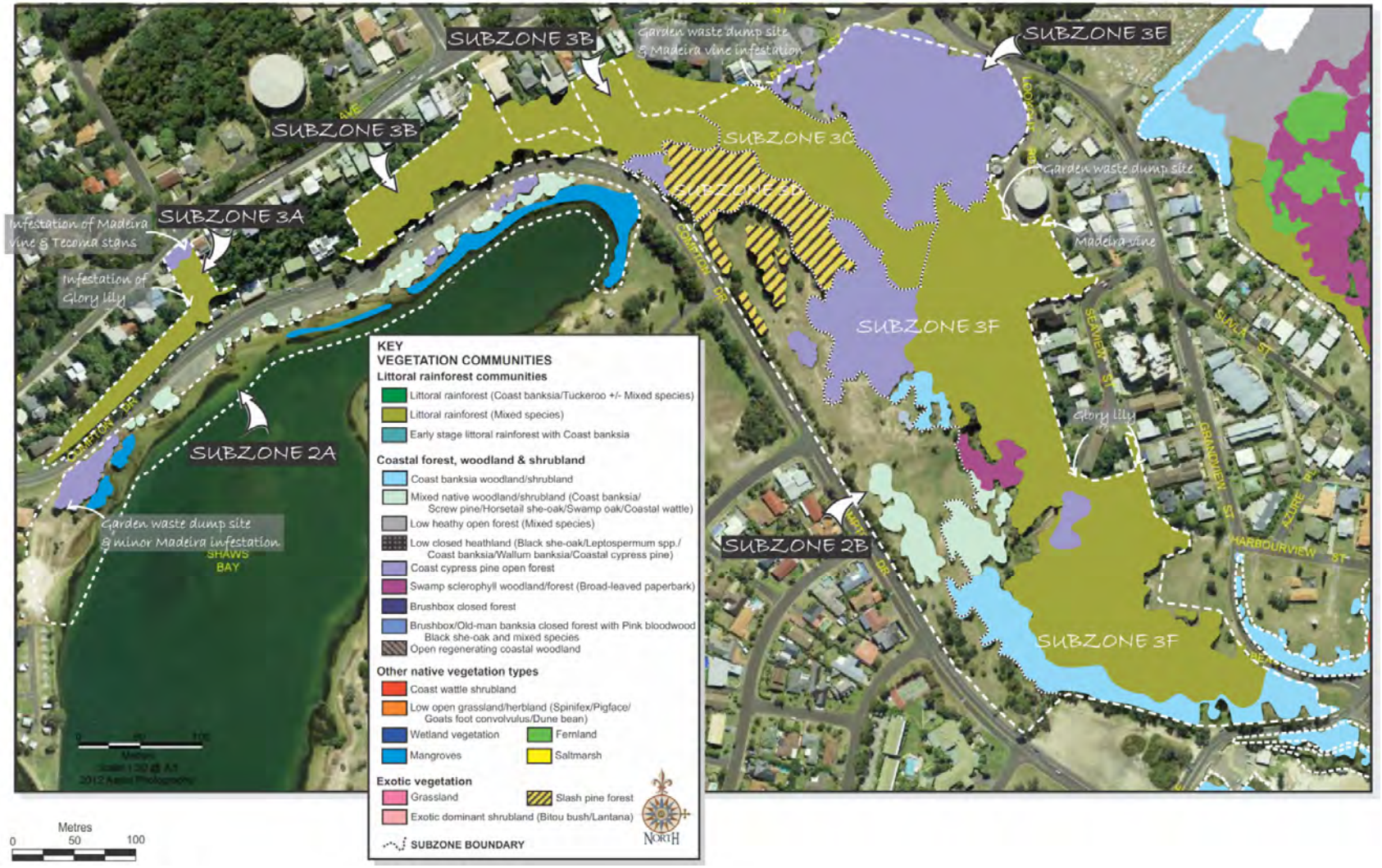


Figure 41: Vegetation communities and subzone boundaries for Shaws Bay Escarpment

Source: Blackwood Ecological Services (2014)

6.3.2 Vegetation Condition

Much of the vegetation displays varying levels of disturbance and weed infestation due to past clearing and disturbance, garden escapees and illegal dumping of garden waste. Common weeds within the escarpment littoral rainforest areas include Madeira vine, Glory lily, Coastal morning glory, Ground asparagus, Lantana, Umbrella Tree and Air potato. Areas of Coastal Cypress Forest are co-dominant with exotic Slash-pine and contain several other weed species including Umbrella tree, Winter senna, Ground asparagus fern, Fishbone fern, Ochna and Coastal morning glory (Blackwood Ecological Services, 2014). Along the steep slopes along the northern side of the training wall a number of weed species are present including Lantana, Bitou Bush, Prickly pear, Umbrella Tree, Siratro, Coastal morning glory and a number of herbaceous weeds and grasses. In some sections these weeds restrict the view of Shaws Bay and decrease amenity values of the area.

6.3.3 Vegetation Management

Extensive works have been undertaken throughout areas of the Shaws Bay escarpment since the previous Vegetation Management Plan was prepared in 2004 (Greening Australia, 2004). Works included the control of Bitou Bush and other woody weeds through the eastern end of the zone. Regeneration of littoral rainforest species was noted in this area by Blackwood Ecological Services (2014). Weed control has also occurred around the reservoir along the top of the escarpment and accessible mid-slopes which have greatly reduced ground asparagus fern amongst Coastal Cypress Pine Forest communities and other weeds in this area.

The VMP contains a suite of detailed management actions for the various vegetation communities in the study area including engaging adjoining landholders to minimise weed propagation from urban gardens, measures to reduce illegal dumping, weed control works, native species planting where needed and ongoing maintenance (Blackwood Ecological Services, 2014).

6.4 Aquatic Fauna

The Estuary Processes Study (PBP, 2000a) included an aquatic fauna assessment of Shaws Bay which recorded a variety of aquatic fauna including Sea mullet, Flathead, School prawns, Snapping prawns, Sea cucumbers, Mud crabs, Moray eels and numerous gastropods including Sydney whelks and Moon snails. Intertidal crustaceans such as Soldier crabs were also observed. Fish species anecdotally caught by recreational anglers and observed in the Bay include Bream, Tarwhine, Whiting, Flathead, Giant trevally, Moses perch, Garfish, Mullet, Estuary cod and a range of smaller fish species.

The training wall prevents the passage of large fish to the main Richmond River estuary. The number of predatory fish is also restricted to those that have grown within the Bay itself. This allows for an abundance of fish species of potentially large size. There are anecdotal reports of exceptionally large fish being caught in Shaws Bay such as Giant trevally.

Estuary cod (*Epinephelus coioides*) is listed as a protected fish in NSW under the *Fisheries Management Act 1994*. They are a typically brownish fish shading to a dull white underbelly with many brownish-orange spots covering its head and body and five dark brown blotchy vertical bars along its body (Figure 42). Colouration may vary and be less distinct in juveniles.

Estuary Cod are a tropical/warm temperate marine species that is prevalent throughout many tropical regions of the world. In Australia they are most common in Queensland, Northern Territory and Western Australia, with NSW being at the southern extent of their Australian distribution. Estuary cod are commonly found in lower reaches of estuaries within close proximity to structure such as rock, reef and bridge pylons. In Shaws Bay they are often easily observed swimming along the base of the training wall. They are protected in NSW due to (DPI, 2006):

- NSW being the southern extent of their Australian distribution;

- Susceptibility to depletion due to their lifecycle, longevity and territorial nature; and
- Vulnerability to spearfishing, recreational line fishing and commercial fishing.

Taking or possessing estuary cod is an offence under the Fisheries Management Act 1994 and heavy penalties apply.

Figure 42: Estuary cod (*Epinephelus coioides*)
Source: Australian Museum, 2010

Fish kills have historically been a major issue in the wider Richmond River estuary and catchment where deoxygenated floodwaters draining into the river have caused fish kill events. No respondents during the consultation phase of either the 2000 Estuary Management Plan (PBP, 2000b) or the current CZMP noted observing fish kills in Shaws Bay. This lack of response suggests that fish kills are not a significant issue within Shaws Bay.

6.5 Birdlife

Shaws Bay is home to a wide range of bird species utilising the area for both food and shelter. Land-based birds inhabit native vegetation along the escarpment, surrounding the Bay and throughout the caravan parks and residential areas. Seabirds such as Silver gulls, Pelicans and Cormorants feed on fish and other aquatic animals in Shaws Bay and roost on its shoreline. Shorebirds including a number of listed threatened species forage along the sandbanks, mangroves and seagrass areas at low tide. Threatened shorebird species observed in Shaws Bay include: Pied Oystercatcher (*Haematopus longirostris*) - Endangered (in NSW) under the TSC Act 1995; Sooty oystercatcher (*Haematopus fuliginosus*) - Vulnerable under the TSC Act 1995; Black-necked stork (*Ephippiorhynchus asiatus*) - Endangered under the TSC Act 1995; Curlew sandpiper (*Calidris ferrugenea)* - Endangered under the TSC Act 1995. Larger predatory species (raptors) including the Eastern Osprey (*Pandion cristatus)* - Vulnerable under the TSC Act 1995 and Brahminy Kite *(Haliastur indus).* These species can be regularly seen perched on tall trees or street lights around the Bay and actively hunting small animals and fish.

The Richmond River estuary (including Shaws Bay) is a priority location for threatened resident and migratory shorebirds (DECCW, 2010b). The estuary provides important nesting, feeding and roosting habitat for up to 29 species of migratory shorebirds and nine resident species including the Critically Endangered (in NSW) Beach Stone-curlew (*Esacus magnirostris*) and Endangered (in NSW) Pied Oystercatcher (*Haematopus longirostris*) (DECCW, 2010b).

Figure 43: Shaws Bay birdlife

Appendix 2 provides the results of a search of the Atlas of NSW Wildlife conducted as part of this CZMP, a list of birds observed in Shaws Bay during the field work phase of the EPS as well as incidental observations noted during site inspections as part of this CZMP. A total of 33 species were noted in these data sources including several raptors, shorebirds, sea birds and land birds. It is likely that there is a number of other bird species not recorded here that utilise the site and surrounding areas throughout the year.

6.6 Acid Sulphate Soils

Acid Sulfate Soils (ASS) are acidic and sulfur rich soils found within the floodplain of coastal areas generally below RL 5m AHD. Potential Acid Sulfate Soils (PASS) is the common name given to soil and sediment containing iron sulfide (usually pyrite). They can become Actual Acid Sulfate Soils (AASS) and produce sulfuric acid if they become exposed to air through excavation or lowering of the water table.

ASS runoff impacts on the estuarine environment include low pH, high concentrations of dissolved iron, aluminium and other metals (ABER, 2008). Exposure to ASS runoff can impair gill function and increase susceptibility to disease in fish. Major negative implications of ASS impacts include fish kills and major aquatic habitat changes, reduced plant growth (acid scalds), and corrosion of concrete, iron and steel structures.

ASS have been classified and mapped as part of the Ballina Local Environment Plan (LEP) 2012.

Figure 44 shows that Shaws Bay bottom sediments are Class 1 ASS. Areas to the immediate east of Shaws Bay including Pop Denison Park and Shaws Bay residential area are Class 3 ASS. West of Shaws Bay along the escarpment, Class 5 ASS exists. Table 12 provides the development consent requirements for each class of ASS.

The majority of the Shaws Bay residential area has been filled to raise ground levels for development. The sources of fill are believed to be mostly marine/estuarine sand trucked in (possibly from North Creek), some dredged from Shaws Bay lagoon, marine sand and a top layer of loamy material to an approximate thickness of 0.5 m (PBP, 2000a).

From the available information, there are not currently any ASS issues in the Shaws Bay catchment. Water quality information collected from Shaws Bay to date does not indicate there are any issues with acidity in the water body itself. However, any works involving disturbance of soils, dredging of estuarine sediments or lowering of the water table has potential to expose ASS and will need to be fully assessed to gain development consent.

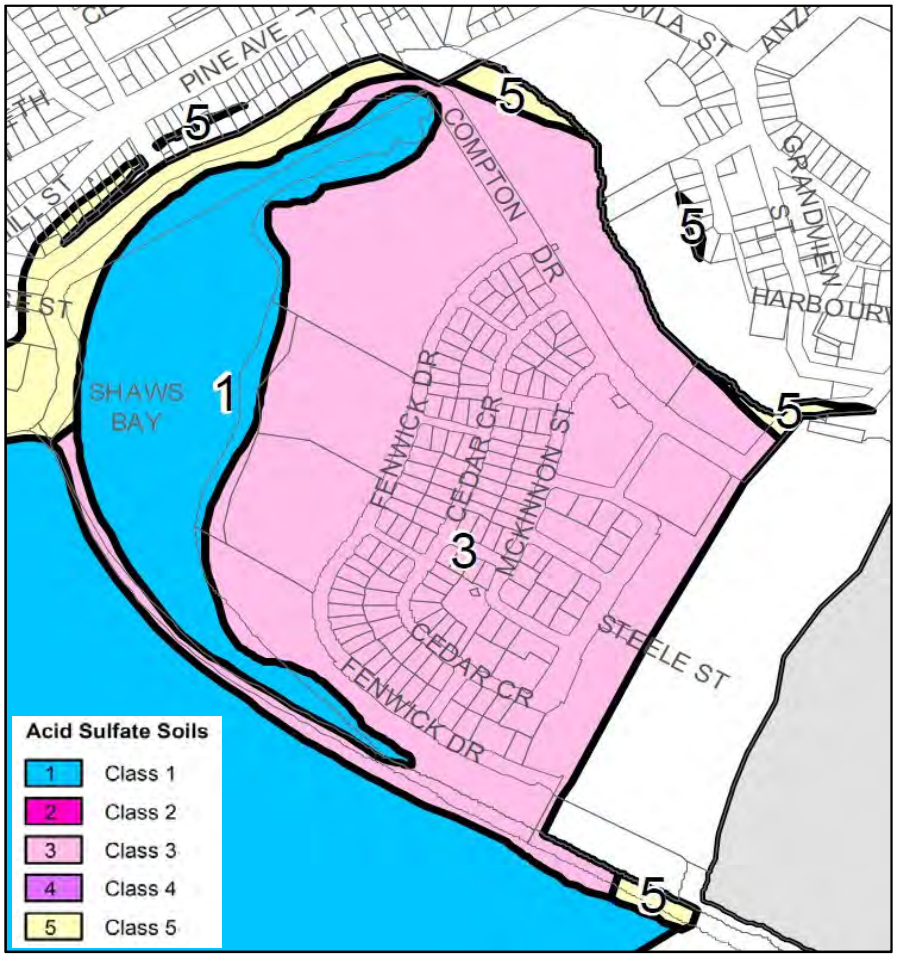


Figure 44: Acid sulfate soil mapping

Source: extracted from Acid Sulfate Soils Map Sheet ASS_06, Ballina LEP (2012)

Table 12: Development consent required for the carrying out of works on land shown in ASS map

Class of land	Works
1	Any works.
2	Works below the natural ground surface. Works by which the watertable is likely to be lowered.
3	Works more than 1 metre below the natural ground surface. Works by which the watertable is likely to be lowered more than 1 metre below the natural ground surface.
4	Works more than 2 metres below the natural ground surface. Works by which the watertable is likely to be lowered more than 2 metres below the natural ground surface.
5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 metres Australian Height Datum and by which the watertable is likely to be lowered below 1 metre Australian Height Datum on adjacent Class 1, 2, 3 or 4 land.

Source: Part 7 of Ballina LEP (2012)

7. COMMUNITY USES OF THE COASTAL ZONE

BSC recognises the importance of community uses of the coastal zone. In this CZMP, public access refers to the ability of the general public to gain appropriate access to public lands surrounding Shaws Bay as well as the waterway. Figure 45 provides an overview of community access points, facilities and recreational uses of Shaws Bay which are discussed in this section.

Shaws Bay and the adjoining foreshore areas have a long association with the leisure time pursuits of the residents of Ballina and visitors to the area. The natural assets have attracted visitors to the area and a variety of man-made changes have occurred and features and facilities developed in response. In the early 1900s the areas around Shaws Bay were popular for walking and 'promenading'. The need for access for the construction of the training wall resulted in the development of the first bridge across North Creek and this improved accessibility from the town. Quarrying to win basalt for the training wall created a "pool" and its use for swimming was officially recognised by the Department of Lands in 1912 (Crown Lands, 2014).

Records held by Council show camping at Shaws Bay occurred from as early as 1917. Council and private interests responded to the increase in visitor numbers by steadily adding facilities to support and enhance the community's enjoyment. Over the years these facilities included a kiosk, dressing sheds, public toilets, a giant slippery slide, a dance hall known as The Waterfront and in 1958 a skating rink. The dance hall had become a popular tourist draw card, particularly in the 1930s and 1940s but was demolished in 1966. In later years the kiosk was expanded and housed a restaurant known as the Luana Room. The building was demolished by Council in 2001 after it suffered severe storm damage (Crown Lands, 2014).

The following sections provide an assessment of current community uses in Shaws Bay:

- The current access arrangements to beaches and waterways in the study area, their adequacy and any associated environmental impacts;
- Any potential impacts (e.g. erosion, accretion or inundation) on these access arrangements; and
- The cultural and heritage significance of the area.

7.1 Access

Whilst providing and maintaining access to public lands in coastal environments is important, access and use must be balanced with protection of the environment and the maintenance of public safety. BSC recognises that:

- Access to and sympathetic use of publicly owned lands is desirable where it does not conflict with environmental management objectives;
- Uncontrolled public access has the potential to irreparably damage fragile environments; and
- Human safety is a prime consideration when planning access to estuaries.

There are many sandy/silty intertidal and supra-tidal beaches around the Bay as shown on Figure 45. These are easily accessible from Fenwick Drive (East Arm), Shaws Bay Hotel, Compton Drive, Pop Denison Park and Lakeside Holiday Park (Main Section) and from Pop Denison Park (Main Section). These beaches are utilised for water-based recreational activities such as swimming, canoeing/paddle-boarding and fishing as well as picnicking on the foreshore. Other informal access tracks have also been established along the foreshore.

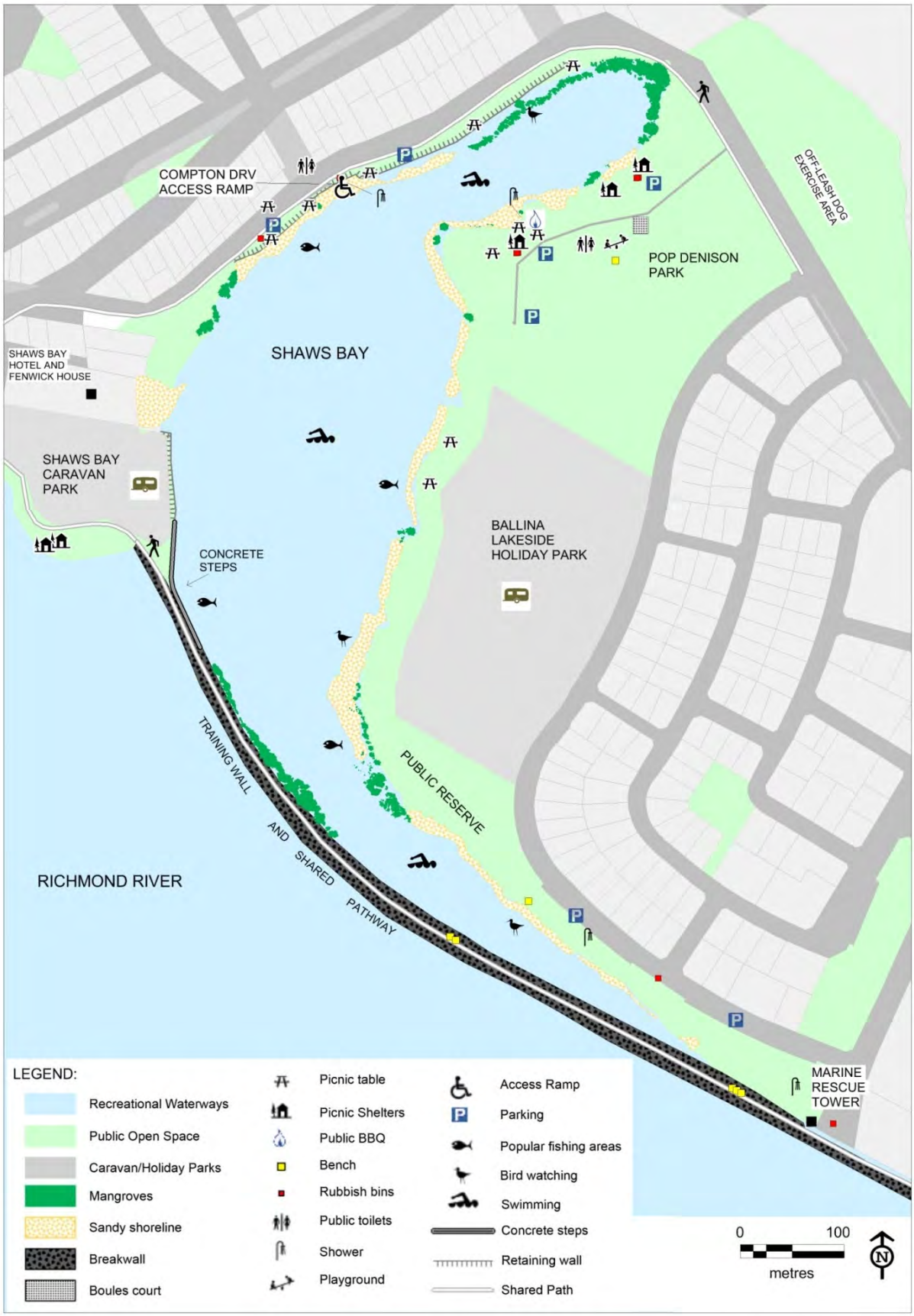


Figure 45: Shaws Bay amenities and community uses

There are also constructed access points along the foreshore:

- Concrete steps near the training wall, mainly used for fishing; and
- Concrete access ramp from Compton Drive which is one of the main access points for swimmers and provides disabled access to the waterway.

Footpaths and shared pathways have been constructed around the foreshore on Compton Drive, Pop Denison Park and along the training wall. Constructed pathways are available around the majority of the foreshore excluding the foreshore areas in front of Lakeside Holiday Park and Shaws Bay Hotel.

Public car parking is available along Compton Drive (Main Section) and Pop Denison Park (Northern Section) and Fenwick Drive (East Arm).

The results of the community survey (refer Section 4) indicate that all access points are popular but the most common access points (with more than half the respondents very likely or likely to use them) for Shaws Bay are:

- Pop Denison Park (79% of respondents are very likely or likely to use this access point);
- The training wall and shared path (78% of respondents are very likely or likely to use this access point);
- Compton Drive access ramp (70% of respondents are very likely or likely to use this access point);
- Fenwick Drive (68% of respondents are very likely or likely to use this access point); and
- Training wall concrete steps (61% of respondents are very likely or likely to use this access point).

The survey highlighted some issues with access to the Bay:

- Seagrass along the water's edge - some community members expressed concern that seagrass growing along the water's edge made access to the water difficult and decreased enjoyment of the near-shore environment;
- Mangrove encroachment in swimming and access areas – mangrove seedlings will quickly germinate along the inter-tidal zone if not physically removed. Some community members are concerned that mangrove seedlings are not being removed quickly enough from some designated access areas and this is decreasing accessibility to the water;
- Poor parking along Compton Drive - parking is informal and requires crossing of the shared pathway;
- Poor condition of training wall (concrete) steps - the steps are uneven, cracked and potentially slippery in places with sharp edges and oyster shells; and
- Erosion of banks in East Arm – compromising safety and access to this section of the Bay (refer Section 5.2).

7.2 Recreational Uses

Shaws Bay and its surrounding lands are frequently utilised by the local community as well as visitors to the area. Two caravan parks on the immediate foreshore as well as other holiday accommodation facilities nearby provide easy access for tourists. The relative safety of the Bay compared to the local beaches and Richmond River allows for many water-based activities. The Shaws Bay foreshores also include significant areas for land-based recreational activities, particularly at Pop Denison Park. There is also an off-leash dog exercise area along Compton Drive.

The results of the community survey identified the following recreational uses of the Bay:

- Swimming (24% of respondents);

- Walking/exercise (18% of respondents);
- Picnicking (14% of respondents);
- Fishing (13% of respondents);
- Canoeing/kayaking/boarding (10% of respondents);
- Snorkelling (10% of respondents);
- Bird watching/nature appreciation (7% of respondents);
- Education (1% of respondents); and
- Other activities (triathlons, board/ski training, camping, playing on equipment and fish watching).

The following community groups utilise the Bay for recreational activities:

- Ballina Lighthouse and Lismore Surf Lifesaving Club – swimming and board/ski training;
- Scouts/girl guides;
- Boules club;
- Dragon Boat club;
- Triathlon club;
- Swimming clubs; and

Commercial paddle-boating and canoe-hire operations have previously used the Bay but are not currently operational.

Community concerns (related to recreational activities) raised in the survey and other community input included:

- Concerns about water quality, particularly at low tide and after heavy rain – refer Section 7.2.1 below;
- Seagrass along the water's edge and lack of clean sandy beach areas – refer Sections 6.2.1 and 7.1;
- Mangrove encroachment in swimming and access areas – refer Sections 6.2.2 and 7.1;
- Lack of quality barbecue facilities – the public barbecue in the Shaws Bay study area was an ageing wood-fired barbecue which was rarely used due to its dilapidated state, the amount of time and effort required to establish a cooking fire, and lack of wood. There is also a risk that members of the public will take wood from nearby vegetation (potentially damaging habitat values). This is currently being upgraded to a gas fired barbecue;
- Concerns about contact with large fish while swimming – some swimmers expressed concern about the dangers of coming into contact with large fish while swimming. There is a perception that there are too many large fish in the Bay and this is decreasing the enjoyment of swimmers and also posing a potential risk of injury;
- Illegal fishing activities (crab pots, spear fishing) and lack of signage – refer Section 7.2.4 below;
- Siltation, shoaling and shallowing of water body – there is concern that Shaws Bay is getting shallower due to infilling and eventually it will be unsuitable for recreational activities (refer Section 3.6.1);
- Ageing, damaged or poor quality public amenities including public toilets, seating, and picnic facilities along Compton Drive. The public toilets require crossing the road. There is limited seating along the

western foreshore and some of the picnic tables are damaged. There is also a lack of shade along this section;

- Ageing amenities block in Pop Denison Park;
- Inadequate outdoor shower facilities in Pop Denison Park;
- Biting insects (identified as sand flies, larval blood flukes, water midges, sea lice, discussed in Section 7.2.3);
- Skin irritations (refer Section 7.2.2); and
- Lack of refuse bins.

7.2.1 Recreational Water Quality

The results of the Beachwatch water quality monitoring program are discussed in Section 6.1.2. These confirm that the majority of samples have resulted in either a 'Good' or 'Fair' rating with a low level of risk of illness to bathers during dry conditions. However, there is increased risk of illness to bathers following rainfall and the current Beachwatch recommendation of avoiding swimming in Shaws Bay for up to three days following rainfall is considered to be a good rule of thumb to minimise risk to public health. Communicating this recommendation effectively to the public will be important in implementing a successful preventative approach.

7.2.2 Bacterial Infections

There have been unconfirmed anecdotal reports of bacterial wound infections that are suspected to have been contracted from Shaws Bay.

Infectious pathogenic bacteria are a part of most coastal and estuarine ecosystems. The *Vibrio spp.* of bacteria is a human pathogen that occurs naturally in estuarine and coastal waters throughout the world (Lewis *et al.* 2005). Vibrio species are most commonly associated with gastrointestinal illness, although they can also cause skin infections, with the most common species implicated being *V. alginolyticus*, *V. cholerae* , *V. damsela*, *V. parahaemolyticus* and *V. vulnificus* (Hudson, 2012). Infections from these bacteria can be contracted by ingesting infected seafood or through open wounds exposed to infected waters. Infections generally occur more prolifically during the warmer months (Lewis *et al.* 2005).

V. vulnificus thrives in warm waters (especially warmer than 18 $^{\circ}$C) and it is therefore common in tropical and subtropical estuarine and sea waters (Queensland Health, 2013). Queensland Health (2013) state that for the majority of people, the bacterium is harmless, however, people who wade or swim in estuarine or sea water with wounds or breaks in their skin, or who ingest raw or undercooked shellfish, may be at risk of infection. People who are particularly at risk include those with chronic liver diseases including hepatitis, cirrhosis, haemochromatosis (iron storage disease); liver cancer; diabetes; chronic kidney disease or conditions that impair the immune system. Infections are uncommon and are usually mild, however, on rare occasions *V. vulnificus* may cause life-threatening infections (Queensland Health, 2013).

Discussions with NSW Pubic Health staff regarding Shaws Bay have indicated that there are no records of elevated occurrences of bacterial infections at this location and the risk of contracting a bacterial infection from swimming in the Bay is similar to other estuarine locations in the region (pers. comm. Tony Kohlenberg, NSW Public Health).

7.2.3 Biological Irritants

Community concerns relating to the nuisance of biological irritants within the Bay have been raised. The two main biological irritants of concern include biting midges (sand flies) and swimmers itch with other isolated

reports of suspected wound infections. There is often confusion and misinformation about the sources, causes and symptoms of biological irritants, resulting from a lack of accurate public information.

Biting Midges

Biting midges (often referred to as sand flies) are a small insect generally 1-4 mm in length. They are often associated with coastal habitats such as coastal lagoons and swamps, mangroves and estuarine areas. The female biting midge feeds on blood and is what often causes nuisance bites on humans. The midges are a concern to users of the Bay as the bites are uncomfortable and often become very itchy leading to scratching and sores. Biting midges appear to be at their worst during the warmer months of the year.

An investigation into biting midges in Shaws Bay was undertaken as a part of the Shaws Bay EMP (PBP, 2000). The study found that the main species of biting midge in the Bay was *Culicoides molestus* which breed on most sandy tidal river foreshores and suitable sand bars. Within Shaws Bay they were found to be breeding intensively within the intertidal zone along the foreshore near the Lakeside Holiday Park although suitable habitat exists in other regions of the Bay. *C. molestus* emerge as adults just prior to the new and full moon periods and biting mostly occurs during the week following these periods (PBP, 2000).

Swimmers Itch

Swimmers itch is often a type of non-infectious dermatitis contracted from within the marine environment. A local study determined that the most likely cause of swimmers itch in Shaws Bay was Schistosome dermatitis (Stace, 2008). This determination was supported by the following evidence:

- Infected *Batillaria australis* (a snail also known as Small whelk) were found in Shaws Bay;
- The summer timeframe of infections corresponds to the life-cycle of avian blood-flukes (Avian schistosome);
- The dermatitis described by the public matches the bite-like itchy inflammatory elevations of the skin that characterises Schistosome dermatitis; and
- Stace (2008) did not find any evidence of water quality or bio-chemistry triggers for swimmers itch in Shaws Bay.

Schistosome dermatitis is triggered when avian blood-flukes find and penetrate an unsuitable host like a human and die within the skin producing a dermatitis characterised by itchy inflammatory elevations of the skin known as pruritus papular eruptions. Avian blood-flukes have a two host lifecycles, a definitive host (generally birds) and an intermediate host (marine snail). The mature blood-flukes live in the definitive host where it lays eggs in its intestines. The eggs are then excreted into the water in the host's faeces where they hatch and seek an intermediate host (snail). Once inside the snail, the blood-flukes develop before leaving the snail and seek a definitive host to repeat the cycle. It is at this stage that they become a nuisance to humans and cause dermatitis. When a person is in the water (where the blood-fluke is actively seeking a new definitive host) the blood-fluke attaches itself to the person and when the person leaves the water it penetrates into the person's skin. This creates an itching sensation (triggering scratching) so the blood-fluke buries deeper into the epidermis only to find that humans are not a suitable host and inevitably die. This causes a papule under the skin which is commonly known as an 'itchy bite'. Symptoms are usually inconsequential and usually only require treatment according to the symptoms developed by the victim which can include rashes, blisters, allergic reactions and bite eruption (Burke 2002; Stace 2008).

Sea Lice

Sea Lice are actually marine parasites that attach themselves to fish and feed on their mucus, skin tissue and blood. However, the term 'sea lice' is often used to describe bites occurring on humans after swimming (or undertaking other activities) in coastal waters. The creatures causing these bites are often small immature larval forms of jellyfish. These larva have the same stinging cells (nematocysts) as adult jelly fish,

and when they become trapped on the human body (often under swimming costumes or the like) activate the stinging cells which release toxins. The toxins cause a reaction resulting in itchy red bumps ('sea lice bites') on the skin which is referred to as sea bathers eruption and is often confused with 'swimmers itch'. Some people appear to be more sensitive to the toxins than others.

Such organisms are a natural part of coastal marine ecosystems and are widely distributed throughout the world. Anecdotally they are more abundant in warmer waters which in this region generally occur in summer and autumn.

7.2.4 Recreational Fishing

Fish species known to occur in Shaws Bay are discussed in Section 6.4.

Recreational fishing has been raised during the community consultation phase as an issue potentially affecting ecosystem health in Shaws Bay. There are anecdotal reports of people spearfishing, keeping protected species and setting crab pots within Shaws Bay.

Fisheries NSW is responsible for the control and regulation of recreational fishing in NSW. The current recreational fishing rules applicable to Shaws Bay are published in *Primefact 868: Richmond Recreational Fishing Guide* (I&I NSW, 2009) which is available on the Fisheries NSW website. There are a number of rules and regulations for recreational fishers including bag and size limits, protected species and prohibited methods. Commercial fishing, spear-fishing and the use of traps (other than bait traps) or nets (other than dip or scoop nets) are prohibited in the Bay.

Currently, the signage at Shaws Bay contains a 'no spearfishing' icon as part of a number of general warnings. There is no other signage at Shaws Bay notifying the public of the other applicable fishing rules and restrictions or providing information on protected fish species or species size and bag limits.

7.3 Amenity

Scenic amenity is valued highly by the local community and visitors. Shaws Bay is a beautiful place enjoyed by locals and tourists alike. Specific characteristics identified in the community survey include:

- It's beauty;
- It is safe from most marine hazards (e.g. sharks, stingers, rips, waves etc.);
- The diverse range of activities that can be undertaken in the Bay;
- The facilities for families (picnic areas, safe swimming, fishing etc.)
- It is an ideal place to swim, fish, snorkel and paddle, especially for children;
- No cost for use of facilities;
- The diversity of wildlife (fish and birds);
- Usually clean water;
- The location of the caravan parks and easy access to water;
- Opportunities for exercise (cycling, walking, swimming etc.);
- Lack of crowds, plenty of space;

The maintenance and enhancement of the amenity of Shaws Bay is important to maintain community enjoyment and tourism in Ballina. The community survey also identified the following issues associated with amenity value:

- Concerns about water quality, particularly at low tide and after heavy rain (refer Section 6.1.2);

- Lack of clean sandy beach areas - there is community concern that the sandy beach areas that existed in the past are no longer present and this has decreased the amenity value of Shaws Bay. Most beach areas (expect for the area in front of the Shaws Bay Hotel) have exposed sand only on the lowest tide and even when exposed the sand is mixed with silty material and is often wet and not suitable for sitting or laying on;
- Mangrove encroachment in swimming and access areas (refer Section 7.1);
- Lack of quality barbecue facilities (refer Section 7.2);
- Illegal fishing activities (crab pots, spear fishing) and lack of signage (refer Section 7.2.4);
- Siltation, shoaling and shallowing of water body (refer Section 3.6.1);
- Ageing, damaged and/or poor quality public amenities including public toilets, seating, and picnic facilities along Compton Drive (refer Section 7.2).
- Ageing amenities block in Pop Denison Park (refer Section 7.2);
- Inadequate outdoor shower facilities in Pop Denison Park (refer Section 7.2);
- Poor parking along Compton Drive (refer Section 7.1);
- Poor condition of training wall (concrete) steps (refer Section 7.1);
- Weeds and green waste dumped along foreshore – garden waste is dumped at several locations along the Bay foreshore and creates issues for weed encroachment into estuarine vegetation areas and is unsightly;
- Biting insects (identified as sand flies, larval blood flukes, water midges, sea lice) and skin irritations (refer Sections 7.2.2 and 7.2.3);
- Stormwater discharging into the Bay (refer Section 6.1.3);
- Litter in the water, particularly near mangroves and seagrass and lack of refuse bins;
- Erosion of banks in East Arm (refer Section 5.2.1); and
- Lack of pelican perches.

The most important issues (identified by more than half the respondents as very important or important) were:

- Litter (88% of respondents ranked this as very important or important);
- Siltation/shoaling (78% of respondents ranked this as very important or important);
- Poor water quality (for water-based activities) (77% of respondents ranked this as very important or important);
- Slicks on the water surface (74% of respondents ranked this as very important or important);
- Shoreline erosion (72% of respondents ranked this as very important or important);
- Changes to foreshore vegetation (71% of respondents ranked this as very important or important);
- Algal blooms (68% of respondents ranked this as very important or important); and
- Difficulties with access to waterway (51% of respondents ranked this as very important or important)

The community survey also identified some conflicting opinions on the best way to manage the Bay:

- The seagrass growing along the water's edge was seen by many respondents as unsightly, unclean and restricting their access to the water whereas some respondents noted the value of the marine vegetation for habitat and water quality.
- Similarly, the majority of respondents who mentioned fishing in the Bay valued the ability to fish (within the rules), particularly for children. A small minority wanted fishing to be banned to protect the fish living in the Bay, particularly the estuary cod. Some respondents had also experienced bumping from large fish while swimming and suggested larger fish should be removed;
- The majority of the respondents identified a desire for improved recreational facilities (picnic tables, toilets, showers, playground equipment, parking etc.) while a small minority wanted to maintain the natural facilities of the Bay without built infrastructure; and
- Siltation and shallowing of the Bay is seen by most respondents as a hindrance to water-based activities and detrimental to water quality while some valued the shallow areas for safe swimming for young children.

In March 2012, OceanWatch Australia and the Northern Rivers CMA coordinated a clean-up day at Shaws Bay, collecting over half a tonne of rubbish consisting of 218 beer stubbies, 34 foam cups, 270 cigarette butts, 125 plastic bottles, 70 aluminium cans, a chair and a pushbike tyre.

Green waste dumping was identified as a significant issue in the 2000 EMP. Council has since introduced a weekly green waste collection service for all residential areas in the shire. While this is expected to reduce the amount of green waste being dumped around Shaws Bay, there is still evidence of this occurring. In particular, there appears to be a deliberate attempt to fill the sink holes in the East Arm of the Bay with palm fronds. This is detrimental to the amenity and water quality of the Bay as well as creating a hazard for users of the Bay.

7.4 Cultural and Heritage Environment

BSC recognises that cultural heritage is an important coastal zone management issue due to the long association of Aboriginal communities with the coastal zone over many tens of thousands of years. More recently, European settlement has also made extensive use of the coastal zone, resulting in a multi-layered pattern of cultural usage of coastal sites and resources.

The Richmond River estuary has spiritual and cultural significance for local communities. Both European and Aboriginal heritage sites and items exist in and around the estuary and their recognition and protection are important to the local community.

7.4.1 Aboriginal Cultural Heritage

Descendants of the study areas traditional Aboriginal custodians recognise features and places of significance within a cultural landscape. Shaws Bay was an important source for gathering shellfish on the shallow sand flats and for traditional fishing practices in river channels. Despite the surrounding density of urban settlement, evidence for these traditions remains on the adjacent ridges of East Ballina, where numerous registered sites of camping places and middens are recorded.

All of East Ballina and the Richmond River estuary retain a cultural connection for Aboriginal people because of historic events known to have taken place there, and because for countless generations ancestors were known to have maintained and managed the food resources available in the area.

Historic sources (such as Ainsworth (undated), *Reminiscences, Ballina in the Early Days 1847-1922*) record observations of traditional Aboriginal people from the greater Richmond Valley region gathering at East Ballina on a seasonal basis to participate in ceremonies and feasting on shellfish obtained from the estuary and North Creek areas. Several hundred people were observed during these times and it was evident that

the local Nyabul people hosted groups from other Bundjalung language speaking areas. Nyabul is a recognised dialect of the Bundjalung-Yugambeh language chain (Livingstone 1892). However, some people prefer a local "clan" identity to express their cultural connections, rather than a broad "tribal" identity. Cultural identity is a complex issue and some descendants may choose different names to express their beliefs and cultural associations (Steele 1984, Keats 1988).

In 2012, the NSW Government gazetted the East Ballina Aboriginal Place under section 84 of the *National Parks and Wildlife Service Act, 1974*. The East Ballina Aboriginal Place recognises the cultural connections of the area and the fact that a massacre of Aboriginal people was known to have occurred at East Ballina around 1853/54. The attack was carried out by a visiting contingent of Native Police Officers and is believed to have resulted in the deaths of more than 40 Aboriginal people (Ainsworth, J., undated).

East Ballina Aboriginal Place extends from the Main Section of the Shaws Bay study area (Figure 46) to Flat Rock and includes East Ballina Cemetery, Chickiba wetlands and Angels Beach. It remains today a place of special significance to Aboriginal culture and people. Aboriginal families of the area who have a traditional connection to East Ballina continue to use the cemetery to be buried close to their immediate predecessors in ancestral lands. The place contains a landscape of extensive cultural features, story places and natural resources, including former wetlands and coastal ecosystems, which provide a continuing teaching resource for current and future generations (NSW Government, 2012).

The declaration of an 'Aboriginal Place' is one way of recognising and protecting Aboriginal heritage under legislation and does not change the status of the land or affect ownership rights. However, under section 90 of the *National Parks and Wildlife Service Act, 1974*, it is an offence to harm or desecrate any Aboriginal object or Aboriginal place without appropriate approvals as defined within the Act. Exemptions apply, but there are strict liability provisions and it is necessary for any activity within an Aboriginal place to be authorised in accordance with the Act.

Figure 46: East Ballina Aboriginal Place within the vicinity of the study area

Maintenance and management of Aboriginal heritage interests within Ballina Shire is, in the first instance, overseen by Jali Local Aboriginal Land Council and is supported by the *National Parks and Wildlife Act, 1974* and the *NSW Heritage Act, 1977,* which provide legal protection for Aboriginal sites and relics in NSW, including sites yet to be recorded.

A search of the NPWS Aboriginal Heritage Information Management System (AHIMS) was conducted for the CZMP study area. The AHIMS search identified the East Ballina Aboriginal Place (discussed above), but it is known that specific sites and Aboriginal cultural objects are both within and outside the boundaries of the declared area and therefore may still be present within the CZMP study area.

The protection of Aboriginal cultural heritage at Shaws Bay was not raised as an issue in broader stakeholder consultation undertaken for this CZMP, and this may potentially be due to the perceived modified environment of Shaws Bay.

7.4.2 Other Cultural Heritage

The Ballina Local Environmental Plan 2012 identifies the following heritage items in the study area (refer Figure 47):

I57 – Pioneer Cemetery

I52 – Victorian manor house known as “Fenwick House”

I59 – Former East Ballina (Shaws Bay) Ambulance Station

I58 – Former Shaws Bay camp site laundry building

I53 – Monument to HMAS Lismore,

I54 – Shaws Bay ship wreck sites

I56 – Ballina Lighthouse

I60 – East Ballina cemetery (and heath surrounds)

The Ballina Local Environmental Plan 2012 also identifies the historic Shaws Bay precinct as an archaeological site (item A3 on Figure 47: Heritage items identified in Ballina LEP 2012Figure 47).

A search of the NSW Heritage Act revealed no items of significance in the study area.

Figure 47: Heritage items identified in Ballina LEP 2012

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GLOSSARY AND ABBREVIATIONS

Acid sulfate soils (ASS)	Acid sulfate soils are the common name given to soils containing iron sulfides. In Australia, the acid sulfate soils of most concern are those which formed within the past 10,000 years, after the last major sea level rise. When the iron sulfides are exposed to air and produce sulfuric acid, they are known as actual acid sulfate soils. The soil itself can neutralise some of the sulfuric acid. The remaining acid moves through the soil, acidifying soil water, groundwater and, eventually, surface waters.
Anaerobic	Living without air
Aquatic	Living or growing in water, not on land.
Amenity	A desirable or useful feature or facility of a building or place
Bacteriological	Related to bacteria (microorganisms involved with infectious diseases and nitrogen fixation)
Bathymetry	Measurement of water depth in lakes, oceans and seas. In other words, bathymetry is the underwater equivalent to topography.
Blackwater	A collective term used to describe low oxygen water emanating from backswamp areas, drains and floodplains. The term usually refers to low oxygen flood waters receding from floodplain after extended periods of backswamp flooding.
Causal factors	Contributing causes
Chlorophyll a	The green pigment in plants used to capture and use energy from sunlight to form organic matter (see photosynthesis). Concentrations of chlorophyll-a in the water column are used as an indicator for phytoplankton and benthic algae biomass. It provides a useful proxy indicator of the amount of nutrients incorporated into phytoplankton biomass, because phytoplankton have predictable nutrient-to-chlorophyll ratios
CZMP	Coastal Zone Management Plan
DECCW	Former (NSW) Department of Environment, Climate Change and Water (now OEH)
Dilapidated	In a state of disrepair or deterioration
Dissolved oxygen	Oxygen dissolved in the water (oxygen saturation). Often abbreviated to DO
DPI	(NSW) Department of Primary Industries
Ecology	The interactions between organisms and their environment
Ecosystem	Refers to all the biological and physical parts of a biological unit (e.g. an estuary, forest, or planet) and their interconnections.
Embayment	A shape resembling a bay
Estuarine	Part of the river channel with a mix of fresh water and salt (tidal) water
EMP	Estuary Management Plan
EPS	Shaws Bay Estuary Management Plan, Volume 1 - Estuary Processes Study
Foreshore	That part of the shore that lies between the mean high tide mark and the mean low tide mark
Hydrodynamics	The motion of a fluid and interactions with its boundaries
Hydrographic	Refers to topographic/bathymetric features of a water body (depth and morphology)
Hydrology	The study of water and its properties, including precipitation onto land and returning to oceans
LEP	Local Environmental Plan
LLS	Local Land Services
Long period waves	Surging of water levels in response to wave action at the estuary entrance
Macroinvertebrate	Animal lacking a backbone
MER	NSW Natural Resources Monitoring, Evaluation and Reporting Strategy
OEH	Office of Environment and Heritage

Pathogen	An agent that causes disease
Physico-chemical	Physical properties dependent on and influencing chemical structure, properties and reactions
POM	Plan of Management
Porosity	Measure of the void spaces in a material
Riparian	Of, on or relating to the banks of a watercourse
RRCC	Richmond River County Council
Salinity	The level of salt dissolved in the water
Sand shoal	A shallow sand bank or sand bar
Sedimentation	The deposition or accumulation of sediment
SEPP	State Environmental Planning Policy
SLSC	Surf Life Saving Club
SOE	State of Environment
SQIDs	Stormwater Quality Improvement Devices
Terrestrial	Living or growing on land (not aquatic)
Tidal prism	The difference between the mean high water volume and mean low water volume of an estuary
Turbid	Cloudy or dirty (not clear)
Turbidity	A measure of the amount of light-attenuating particles in a water body.
VMP	Vegetation Management Plan for East Ballina Reserves
Zooplankton	Animal plankton inhabiting the surface layer of water bodies that serve as food for fish and other animals

APPENDIX 1: COMMUNITY CONSULTATION

APPENDIX 2: LIST OF BIRD SPECIES IN SHAWS BAY

Table 13: Bird species records within the Shaws Bay study area extracted from the Atlas of NSW Wildlife and the Estuary Processes Study (PBP, 2000a) and incidental observations as part of this CZMP

Common Name	Species name	Conservation status
Raptors:		
Eastern Osprey	*Pandion cristatus*	Vulnerable (TSC Act 1995)
Brahminy Kite	*Haliastur indus*	Marine Species (EPBC Act 1999)
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Migratory Species (EPBC Act 1999); Marine Species (EPBC Act 1999)
Seabirds:		
Silver Gull	*Larus novaehollandiae*	Marine Species (EPBC Act 1999)
Common Tern	*Sterna hirando*	Marine Species (EPBC Act 1999)
Australian Pelican	*Pelecanus conspicillatus*	Marine Species (EPBC Act 1999)
Little Black Cormorant	*Phalacrocorax sulcirostris*	not listed
Pied Cormorant	*Phalacrocorax varius*	not listed
Shorebirds:		
Pied Oyster Catcher	*Haematopus longirostris*	Endangered (in NSW) (TSC Act 1995)
Sooty Oystercatcher	*Haematopus fuliginosus*	Vulnerable (TSC Act 1995)
Black-necked Stork	*Ephippiorhynchus asiatus*	Endangered (TSC Act 1995)
Curlew Sandpiper	*Calidris ferruginea*	Endangered (TSC Act 1995); Migratory Species (EPBC Act 1999); Marine Species (EPBC Act 1999)
White Faced Heron	*Egretta novaehollandiae*	not listed
Australian White Ibis	*Threskiornis molucca*	Marine Species (EPBC Act 1999)
Great Egret	*Ardea alba*	Marine Species (EPBC Act 1999)
Bar-tailed Godwit	*Limosa lapponica*	Migratory Species (EPBC Act 1999); Marine Species (EPBC Act 1999)
Royal Spoonbill	*Platalea regia*	not listed
Land-based birds:		
Mangrove Honeyeater	*Lichenostomus fasciogularis*	Vulnerable (TSC Act 1995)

Common Name	Species name	Conservation status
Sacred Kingfisher	*Todiramphus chloris*	Marine Species (EPBC Act 1999)
Masked Lapwing	*Vanellus miles*	not listed
Willy Wagtail	*Rhipidura leucophrys*	not listed
Crested Pigeon	*Ocyphaps lophotes*	not listed
Galah	*Eolophus roseicapilla*	not listed
Kookaburra	*Dacelo novaeguineae*	not listed
Rainbow Lorikeet	*Trichoglossus haematodus*	not listed
Little Wattlebird	*Anthochaera chrysoptera*	not listed
White-cheeked Honeyeater	*Phylidonyris nigra*	not listed
Grey Fantail	*Rhipidura albiscapa*	not listed
Horsfields Bronze Cuckoo	*Chalcites basalis*	not listed
Superb Fairy Wren	*Malurus cyaneus*	not listed
Australian Magpie	*Gymnorhina tibicen*	not listed
Pied Currawong	*Strepera graculina*	not listed
Pied Butcherbird	*Cracticus nigrogularis*	not listed