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Coal & Allied

Report for Lower Hunter Lands Project

Gwandalan: Marine Baseline Assessment of Lake Macquarie

October 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Project Background

GHD Pty Ltd (GHD) has undertaken a marine baseline condition assessment within Lake Macquarie at the site of the proposed Gwandalan Estate for Coal & Allied Industries Limited (Coal & Allied).

The objectives of this assessment were to provide:

- An outline of the existing baseline marine condition adjacent to the site;
- A summary of the listed species potentially associated with the site;
- An assessment of existing habitat condition with regard to potential to support listed species;
- An assessment of the benefits and constraints to development of the site relating to the marine environment;
- Outline of basic mitigation measures to reduce any potential impacts; and
- A guide to future monitoring of the marine environment associated with the site.

1.1 Site Context

The Minister for Planning released the Lower Hunter Regional Strategy (LHRS) on 4 November 2005. The LHRS defines the State Government's development strategy for the region designating major centres, employment and conservation areas along with land releases for an additional 115,000 new dwellings. It covers the local government areas of Lake Macquarie, Newcastle, Maitland, Cessnock and Port Stephens.

Coal & Allied has identified surplus landholdings that have development and conservation potential within the area covered by the LHRS. These lands total 4,078 hectares and are comprised of seven (7) sites, four (4) in the north and three (3) in the south.

This report is a focus study on the Gwandalan Estate. The proposed land use for Gwandalan is a residential development with 623 lots. The development is to be based on Water Sensitive Urban Design (WSUD), which encompasses all aspects of urban water cycle management. WSUD is a multi-disciplinary approach that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimise the impacts of development upon the water cycle.

1.2 Local Government Area

The Local Government Area (LGA) for Gwandalan is Wyong Shire Council (WSC).

1.3 Location and Site Description

1.3.1 Location

The land examined in this report is at Gwandalan in Crangan Bay, at the south western extent of Lake Macquarie, as indicated in Figure 1, Appendix A. It consists of a single parcel of land to the east of Kanangra Drive and south east of the village of Gwandalan. The parcel represents a total land area of 268 hectares, of which 205.75 hectares have been identified for conservation and 62.24 hectares for development.

1.3.2 Existing Conditions

Climate and Rainfall

Gwandalan experiences a sub-tropical climate with rainfall predominantly occurring in late summer and autumn. The nearest operational daily rainfall station is located at Norah Head lighthouse (BOM Stn 061273), which registered a mean annual rainfall of 1227 mm for the period of 1969 to 2006.

The high likelihood of rainfall occurring in any month throughout the year would support utilisation of WSUD. Furthermore, the mild seasonal variability would indicate that rainwater collection via rainwater tanks might be viable.

Topography and Slopes

Topography is an important consideration when assessing the potential influence of the development to the marine environment. The land parcel generally has steep gradients with an average grade in the order of 6%.

Soils and Erosion Risk

According to the Soil Landscapes maps of the Gosford-Lake Macquarie 1:100,000 Sheet (CALM : 1992), the Gwandalan site is underlain by two major soil landscape groupings. They are:

- *Wyong Landscape.* Underlies the low-lying area adjacent to Lake Macquarie. The limitations of this soil group include localised waterlogging, poorly drained, potential acid sulphate soils, saline subsoils, localised stream bank erosion and low fertility; and
- *Awaba Landscape.* Underlies the remainder of the site. The limitations of this soil group include steep slopes, high erosion hazard with localised mass movement, stoniness, shallow, acidic soils with low fertility.

The limitations of the soil groups and propensity to erosion would need to be considered when planning WSUD strategies.

Watercourses, Creeks and Receiving Waters

Within the estate there is one named watercourse, Strangers Gully, and several smaller gullies draining the development site. The land generally slopes east towards Lake Macquarie and runoff discharges to Crangan Creek, Lake Macquarie via dispersed overland flow.

Adjoining Land Uses

The existing residential area of Gwandalan adjoins the site to the north.

1.4 Relevant Legislation

Legislation that was considered in this report and may need to be considered with regard to the marine environment during development of the site is provided in this section.

1.4.1 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) aims to provide for the protection of the environment, especially those aspects of the environment of that are Matters of National Environmental Significance (NES).

Approval by Commonwealth Minister of Environment and Water Resources is required for actions that are likely to have a significant impact on Matters of NES or Commonwealth land.

The seven matters of NES include:

- World Heritage properties;
- National heritage places;
- Ramsar wetlands of international significance;
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine area; and
- Nuclear actions (including uranium mining).

1.4.2 State Legislation

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) forms the statutory framework for planning and environmental assessment in New South Wales.

The Proposal will be assessed under Part 3A of the EP&A Act with the Minister for Planning as the consent authority.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) provides for listing of threatened species, populations and ecological communities as well as critical habitat and key threatening processes. It also provides for preparation of Species Recovery Plans and Threat Abatement Plans.

Section 5A of the EP&A Act lists a number of factors, known as the Seven Part Test, to be taken into account in deciding whether there is likely to be a significant impact on threatened species, populations or their habitats or ecological communities listed under the TSC Act and *Fisheries Management Act 1994*.

Threatened species and ecological communities potentially affected by the proposed works have been discussed in the relevant sections of this report.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) includes provisions to list threatened species of fish and marine vegetation, including endangered populations, ecological communities and key threatening processes. The FM Act protects marine waters, which includes marine and estuarine habitats such as mangroves, seagrasses, seaweeds, saltmarshes, mudflats and rocky reefs.

Section 205 of the FM Act outlines the permit to cut, remove, damage or destroy marine vegetation on public water land or an aquaculture lease, or on the foreshore of any such land or lease. Pursuant to Section 75U of the EP&A Act, Section 205 of the FM Act does not apply as the Proposal is to be assessed under Part 3A. However potential impacts must be considered as applies under the FM Act.

National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act) intends to conserve nature, objects, places or features (including biological diversity) of cultural value within the landscape. The NPW Act also aims to foster public appreciation, understanding and enjoyment of nature and cultural heritage, and also provides for the preservation and management of national parks, historic sites and certain other areas identified under the Act.

Native Vegetation Act 2003

The *Native Vegetation Act 2003* (NV Act) encourages and promotes the management of native vegetation on a regional basis in the social, economic and environmental interests of the State and prevents broad scale clearing unless it improves or maintains environmental outcomes.

Under the provisions of the *Native Vegetation Act 2003* (NV Act), clearing carried out in accordance with an approval issued by a determining authority under Part 5 of the EP&A Act does not require approval under the NV Act.

Noxious Weeds Act 1993

The objectives of the *Noxious Weeds Act 1993* (NW Act) include:

- Identify noxious weeds in respect of which particular control measures need to be taken;
- Specify those control measures;
- Specify the duties of public and private landholders as to the control of those noxious weeds; and
- Provide a framework for the State-wide control of those noxious weeds by the Minister and local control authorities.

Under this Act, noxious weeds have been identified for Local Government Areas and assigned control categories (eg. W1, W2, W3 and W4). Part 3 provides that occupiers of land (this includes owners of land) have responsibility for controlling noxious weeds on the land they occupy.

The noxious weed *Caulerpa taxifolia* has previously been identified in Lake Macquarie.

Rivers and Foreshore Improvement Act 1948

The *Rivers and Foreshore Improvement Act 1948* (RFI Act) provides for the carrying out of works for the removal of obstructions and the improvement of rivers and foreshores; and to prevent the erosion of lands by tidal and non-tidal waters. Most of the RFI Act has been repealed by the *Water Management Act 2000* (WM Act).

Under the provisions of the RFI Act, if certain prescribed works are to be carried out within 40 m of a watercourse, a permit issued under Part 3A of the RFI Act is required to undertake the works.

2. Methods

2.1 Ecological Reviews

GHD undertook a desk based assessment to determine the listed and commonly occurring marine species with potential to occur within the vicinity of the Gwandalan Estate. Information on marine and flora and fauna species was derived from relevant published literature and knowledge of the area from previous aquatic surveys in the area. Previously recorded information for the site was obtained from:

- *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act*) by using the Database Search Tool;
- *NSW Threatened Species Conservation Act 1995 (TSC Act);*
- DEC Atlas of NSW Wildlife Database Search for threatened species recorded within the locality;
- NSW NPWS threatened species habitat mapping;
- *NSW Fisheries Management Act 1994 (FM Act);* and
- *JAMBA* and *CAMBA*.

The species identified during the desk-based assessment provided a background to the field based assessment, which particularly targeted the listed species.

Additional information was derived from the Australia Geological Survey geology and soils mapping database, and climatic information (where applicable) from the Australian Meteorological Bureau.

2.2 Field Assessment

2.2.1 Habitat Assessments

A visual habitat assessment was conducted concurrently with the measurement of water quality parameters and biotic surveys. This visual assessment outlined and summarised the important habitat features such as water depth, sediment type, water quality and health of the shore environment. This information was incorporated in the interpretation of the water quality and ecological data.

2.2.2 Water Quality

Insitu

General physico-chemical water quality parameters were measured at two locations within Crangan Bay adjacent to the site using GHD's insitu multi-parameter TPS-900 water quality meter. The variables measured were temperature (^{o}C), pH, turbidity (NTU), salinity (ppt) and dissolved oxygen (mg/L and % saturation).

Chemical/Biological

Water quality samples were taken at two sites within Crangan Bay adjacent to the proposed development site. Samples were measured for alkalinity, total nitrogen, total phosphorous, ammonia, nitrate and nitrite, filterable reactive phosphate, chlorophyll-a, total suspended solids and biological oxygen demand. The samples were kept chilled and delivered to ALS laboratory in Newcastle within holding times for analysis.

Analysis

The water quality results were compared against the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Guidelines (ANZECC/ARMCANZ (2000)) default trigger values for South-east Australia Estuaries.

2.2.3 Seagrasses

A spatial dataset was created through a combination of the captured information from the GPS, field investigation ground-truthing, and interpretation of aerial imagery. At the site four transects were run perpendicular from the shore to the extent of the seagrass bed. Following the methodology from Braun-Blanquett (1993) two ecologists ground truthed the seagrass areas by snorkelling and determined the boundaries, depth, species and abundance and density present of the beds present. The Braun-Blanquett method involves identifying a specific area (called a "plot" or "quadrat") along the transect, identifying all species represented in that area, then assigning each a code based on its contribution to the total area (Table 1). Each region of seagrass was attributed with the following information:

- Species;
- Density; and
- Cover.

The results were mapped using ArcView GIS to show presence/absence, density and abundance along the site coastline.

Table 1 Braun-Blanquett Coverage/Density Matrice

Coverage/Density		1	2	3
		Single individual plants	Moderate individuals	Continuous mat
A	Patchy	1A	2A	3A
B	Fairly continuous	1B	2B	3B
C	Established beds	1C	2C	3C

2.2.4 Mangroves

Surveys for presence and absence of mangroves were undertaken during the overall habitat assessment.

2.2.5 Macroalgae

Macroalgae from a variety of orders occur across the Lake and typically blooms smother seagrass beds. As such it was important to document the order and density of algae present during the baseline assessment to assist in future monitoring of impacts. Macroalgae presence and absence along the shoreline and transects was noted.

2.2.6 Benthic Invertebrates

Benthic invertebrates were sampled at four locations at Gwandalan Wharf using a hand held corer to 20cm. The invertebrate samples were sieved in the field and the resulting animals were retained for identification. The invertebrates were identified to family and reporting provided an assessment of marine health based on the abundance and diversity of the communities.

3. Results

3.1 Desktop Review

3.1.1 EPBC Act (1999) Protected Matters Report and TSC (1992) Summary

Database searches of the study area with regard to the marine environment largely identified migratory terrestrial, marine and marine fly over birds potentially associated with the site, though three terrestrial based bird and two frog species were also identified as potentially occurring. The listed marine species are presented in Table 2.

Table 2 EPBC Listed Species

	Scientific Name	Common Name	Status EPBC	NSW TSCA
Birds	*Ardea alba*	Great Egret, White Egret	Migratory, Listed fly over marine area	
	Ardea ibis	Cattle Egret	Migratory, Listed fly over marine area	
	Gallinago hardwickii	Latham's Snipe, Japanese Snipe	Migratory, Listed fly over marine area	
	Numenius madagascariensis	Eastern Curlew	Migratory, Listed	
	Pluvialis fulva	Pacific golden Plover	Migratory, Listed	
	Rostratula benghalensis s. lat.	Painted Snipe	Vulnerable, Migratory, Listed fly over marine area	Endangered
	Apus pacificus	Forktailed Swift	Migratory, Listed fly over marine area	
	Haliaeetus leucogaster	Whitebellied Sea Eagle	Listed	
	Hirundapus caudacutus	Whitethroated Needletail	Listed fly over marine area	
	Lathums discolor	Swift Parrot	Endangered, Listed fly over marine area	Endangered
	Merops ornatus	Rainbow Beeeater	Listed fly over marine area	

	Scientific Name	Common Name	Status EPBC	NSW TSCA
	Monarcha melanopsis	Blackfaced Monarch	Listed fly over marine area	
	Myiagra cyanoleuca	Satin Flycatcher	Listed fly over marine area	
	Rhipidura rufifrons	Rufous Fantail	Listed fly over marine area	

3.2 NSW Fisheries Listed Species

A search of the *NSW Fisheries Management Act 1994* identified the following listed marine fish as potentially occurring within the Lake Macquarie region.

Table 3 State Listed Species

Scientific Name	Common Name	Status FMA
Carcharias taurus Rafinesque	Grey nurse shark	Endangered
Nannoperca oxleyana Whitley	Oxleyan pygmy perch	Endangered
Pristis zijsron Bleeker (1851)	Green sawfish	Endangered
Bidyanus bidyanus (Mitchell, 1838)	Silver perch	Vulnerable
Branchinella buchananensis Geddes, 1981	Buchanans fairy shrimp	Vulnerable
Carcharodon carcharias (Linnaeus, 1758)	Great white shark	Vulnerable
Epinephelus daemelii (Günther, 1876)	Black cod	Vulnerable
Nereia lophocladia J. Agardh (1897)	Brown algae	Vulnerable

3.3 Habitat Assessment

The marine environment along the proposed development site at Gwandalan has a bank that slopes very steeply and is stabilised by high levels of vegetation cover. The banks of the shore exhibit very little erosion with any areas experiencing wave and tidal action largely stabilised by root balls, large woody debris and bank vegetation that reaches the bank margins. The benthic sediment is composed largely of gravel (55%) with good sand (30%) and pebble (cover (25%). The marine environment adjacent to the site close to the banks is a shallow shelf that slopes slowly at 15 metres from shore to 1.5 metres depth by 25 metres from shore. The very steep nature of the shoreline, stable bank structure and shallow inshore nature of the receiving environment characterise the marine environment at this site. Seagrass beds are well established close to shore and provide good benthic stability.

Figure 1 Gwandalan Site 1

3.4 Water Quality Results

3.4.1 Insitu

The insitu water quality results indicate that the sites fall within the specified ANZECC/ARMCANZ (2000) Guideline trigger values with the exception of:

- Conductivity which is high at both sites indicating hypersaline conditions; and
- Dissolved oxygen at both sites indicating saturated levels of oxygen in the system;

Table 4 Insitu Water Quality Results

Variable	Units	ANZECC Guideline Trigger Value	Chain Valley Bay 1	Chain Valley Bay 2
Temperature	oC		19.1	19.9
pH		7.0-8.5	7.39	7.37
Conductivity	mS/cm	20-30	55.3	54.5
Turbidity	NTU	0.5-10	3.1	1
DO	ppm		12.56	13.88
DO	% saturation	80-110	133	150

3.4.2 Chemical/Biological

The chemical water quality results for the sites indicate that all the sites fall within the specified ANZECC/ARMCANZ (2000) Guideline trigger values or the limits of reporting (LOR) are above the trigger values. For most of the variables there are no specified trigger values. Generally the results indicate:

- The sites have relatively high level of suspended solids in the water column;
- Alkalinity levels are typical to those experienced in estuarine conditions; and
- The sites are not experiencing disturbance for elevated nutrients or algal activity.

Table 5 Chemical/Biological Results

	Units	LOR	ANZECC Guideline Trigger Value	Gwandalan 1	Gwandalan 2
Suspended Solids (SS)	mg/L	1		40	123
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1		104	105
Total Alkalinity as CaCO3	mg/L	1		104	105
Ammonia as N	mg/L	0.01	0.015	<0.100	<0.100
Nitrite as N	mg/L	0.01		0.01	<0.010
Nitrate as N	mg/L	0.01		<0.010	<0.010
Nitrite + Nitrate as N	mg/L	0.01	0.015	<0.010	<0.010
Total Kjeldahl Nitrogen as N	mg/L	0.1		<1.0	<1.0
Total Nitrogen as N	mg/L	0.1	0.3	<1.0	<1.0
Total Phosphorus as P	mg/L	0.01	0.03	0.01	<0.01
Reactive Phosphorus as P	mg/L	0.01	0.005	<0.010	0.01
Chlorophyll a	mg/m3	1	0.004	<1	<1
Biochemical Oxygen Demand	mg/L	2		<2	<2

3.5 Seagrass

The seagrasses are of particular concern in Lake Macquarie. Seagrasses usually grow on sandy or muddy substrates, and their extensive rhizome systems help stabilise underlying sediment and prevent sediment movement. There have been significant losses of seagrass communities through both natural (cyclones, floods) and anthropogenic events (nutrient enrichment, coastal development). Most losses from these influences can be attributed to reduced light intensity. Once destroyed, seagrass systems do not readily recover. If an area does recover, the timeframes are long (years or decades) increasing the importance of seagrass bed conservation and preservation. The dominant seagrass species found in Lake Macquarie (as documented by the NSW Department of Natural Resources) are:

- Eelgrass, *Zostera capricornia* and *muelleri,*
- *Heterozostera tasmanica*;
- Strapweed, *Posidonia austalis*;
- Paddleweed, *Halophila ovalis* and *decipens*; and
- *Ruppia*.

Two taxa of seagrass *Zostera capricornia* and *Halophila* sp were observed at the site. Appendix B presents the density and abundance of the seagrass community adjacent to the site. Largely the seagrasses extend as continuous mats to approximately 50 meters from shore where the plants begin to thin to occasional single rhizomes before petering out towards the center of the bay. . The beds are mostly thick and continuous from between 10-40 meters from shore where the depth is 0.5-1.5 meters in depth.

3.6 Mangroves

Mangroves *Avicennia marina* were present along the northern shoreline and along the small creek near the park. The mangroves are not extensive with a limited band of trees along the shoreline widening to the north to a couple of metres in density. This species of mangrove has a very wide tolerance to ranges in temperature conditions, tidal inundation levels, moisture, salinity and substrates making this species extremely hardy and able to tolerate harsh conditions.

3.7 Macroalgae

The site supports a variety of macroalgae that were sparsely dispersed throughout the seagrass beds particularly in the shallow edge habitat. The species identified included:

- Cytoseira sp;
- Sargassum sp; and
- Gracillia multuipartita.

These macroalgae do not tend to blanket or smother seagrasses and are often sessile.

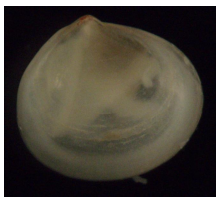
3.8 Benthic Invertebrates

The infauna communities at Gwandalan includes species of polychaetes, crustaceans, bivalves and gastropods. The invertebrates present at this site are indicative and common to marine and estuarine communities of the East Coast of Australia and the Indo West Pacific region. Table 6 summarises each species distribution and shows a represented photograph.

The Amphipod found at this site is of particular importance as this group make up a key part of the marine food web, by occupying niches as herbivores, detritivores, predators and scavenger. They are almost always an important component of marine and freshwater environmental surveys in the region. Table 6 summarises each species distribution and shows a represented photograph.

Table 6 Benthic Invertebrates

Species	Distribution	Habitat	Photo
Crustacea, Tanaidacea 1:	Found Australia wide	Mostly Marine Burrows into the sediment Filter feeders or carnivorous	
Amphipoda Melitidae 1	Australia Wide	Marine and Freshwater Lives on the surface of the sediment Scavenger	
Polychaete Nereididae 1	Australia wide	Only Marine Borrows into the Sediment Carnivores	
Echinodermata Ophiuroidea 1	Australia Wide	Only Marine Lives on the surface of the sediment Detritus feeder	N/A
Gastropoda Nassinidae 1	Queensland, and Indo-West Pacific	Only Marine Feeds on surface Scavenger	

Species	Distribution	Habitat	Photo
Bivalve Arcidae 1	Queensland Region	Only Marine Borrows into sediment Scavenger and detritus feeder	
Bivalve Tellinidae 2	Queensland	Only Marine Borrows into sediment detritus feeder	

3.8.1 Razor Clams

A large number of *Pinna bicolor* or Razor Clams were present along the shallow shoreline margins. These native clams bury themselves in the sediment with the top three centimeters of shell exposed. This species has recently become more prolific within Lake Macquarie recently due to an exceptional rate of survival of razor clam larvae three to four years ago. It seems that the population of razor clams is likely to fall again, unless favourable conditions return.

Figure 2 Razor Clams

4. Site Benefits and Constraints

Urban developments close to aquatic environments have potential to impact upon existing environmental values through a variety of ways including:

- Stormwater discharges,
- Overland water flow;
- Increased catchment imperviousness;
- Bank erosion; and
- Increased anthropogenic disturbance.

The site at Gwandalan currently has limited impacts on the estuarine receiving environment. The site has however been cleared along most of the banks but due to the shallow slope of the bank and stable nature of the foreshore the risk from erosion is considered low.

Development of the site does not have any particular constraints posed by the adjoining estuarine lake except overall issues that are relevant to any development on the foreshores of Lake Macquarie. Some of the benefits offered by the site and aspects for consideration during design, construction and operation and associated general mitigation measures are discussed in this section.

4.1 Benefits

The marine environmental values associated with the site are typical to Lake Macquarie and while part of a fragile estuarine lake ecosystem provides a variety of benefits to development of the site, including:

- Stable banks in the form of root balls and large woody debris;
- Stable and well established seagrass beds;
- Stable sand and pebble benthic substrate;

4.2 Constraints

The marine habitat adjacent to the site offers very little in the way of constraints to development but rather threatening processes and considerations typical to development of Lake Macquarie and near shore urban development requires consideration during design and construction.

4.2.1 Considerations

Studies undertaken for the LMCC indicate that the Southern Lake Margin of the Lake suffers from the following impacts and is considered in marginal condition. The report identified that the area is characterised by:

- Depressed light penetration;
- Excellent dissolved oxygen;
- Small periodic increases in nutrients; and
- High bacteria levels.

The report identified that more effort is required to further reduce sediment and nutrient loads in the Southern Lake Margin. To address these main considerations the following aspects will need to be considered.

Foreshore Erosion

Foreshore erosion, loss of foreshore vegetation, loss of wetlands and saltmarsh, and damage to seagrass can affect water quality and change the balance of the lake's ecology.

Bank erosion is a major issue affecting the Lake and can result in the loss of waterfront land and riparian vegetation that typically has conservation, recreational and economic values and can result in loss of seagrass beds. Increased runoff and changes in waterway morphology, as a result of urbanisation, contribute to erosion and increased sediment loads within waterways, and have a detrimental effect on water quality and aquatic habitat of the Lake (Lake Macquarie Estuary Management Plan (LMEMP) 1997).

Marine Flora

Seagrasses and mangroves are of particular concern in Lake Macquarie and are protected under the Fisheries Management Act 1994. Seagrasses usually grow on sandy or muddy substrates, and their extensive rhizome systems help stabilise underlying sediment and prevent sediment movement. There have been significant losses of seagrass communities through both natural and anthropogenic events (nutrient enrichment, coastal development). Most losses from these influences can be attributed to reduced light intensity. Once destroyed, seagrass systems do not readily recover. If an area does recover, the timeframes are long (years or decades) increasing the importance of seagrass bed conservation and preservation.

Mangroves play an important role in estuarine ecological processes in Lake Macquarie and management of these systems will require integration into the planning process.

Stormwater

Estimates show that sediment washing into the Lake has increased to about 57,000 tonnes a year since European settlement. Only 30% of the catchment is urbanised, but 80% of nutrients that enter the lake come from urban runoff.

Additional

Due to the shallow nature of the Lake there is potential to increase algal blooms during times of increased temperatures if nutrients are discharged and increase turbidity.

4.3 Mitigation Measures

Localised and short-term adverse environmental impacts may be generated during the development and operation of the urban development. The following identifies the mitigation measures that may be required to address these impacts.

Mangroves, seagrasses and seaweeds are listed as protected marine vegetation under the NSW *Fisheries Management Act 1994* (FM Act). No seagrasses will be impacted upon directly be the development however increased turbidity due to runoff will need to be managed.

A number of mitigation and management measures are recommended to prevent direct and indirect impacts on flora and fauna and their habitat. Proposed mitigation measures will be detailed in the

Construction Environmental Management Plan (CEMP) for the Development.

- Implementation of erosion and sediment control measures to mitigate impacts on the aquatic habitat;
- Implementation of erosion and sediment control measures;
- Avoidance of protected marine flora, including young and mature mangroves and associated pneumatophores. It is recommended that the contractor conducts an on-site identification of these species before work commences, ensuring machinery is not used in close proximity to protected flora, and identify work methods to minimise disturbance.
- Implementation of Acid Sulphate Soils Assessment and Management response;
- The containment of waste materials in designated waste storage areas and disposal to licensed waste management facilities;
- Installation of erosion and sediment control devices during construction and operation of the development to assist with sediment containment;
- Retention of foreshore vegetation to maintain bank integrity; and
- Discharge of stormwater from point sources that will not impact upon seagrass communities.

5. Monitoring

The following monitoring components may be suitable to provide an assessment of potential impacts during construction and operation of the development:

- Water quality assessments during various construction phases to monitor ESC activities the surveys will need to consider seasonal and rainfall events. The assessments will need to monitor changes in parameters such as nutrients, dissolved oxygen and turbidity.
- Seasonal seagrass surveys to determine the natural condition of the Bay over time.

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Appendix A

Site Photographs

Figure 1 Gwandalan Mangroves

Figure 2 Gwandalan North

Figure 3 Gwandalan – Bank 1

Figure 4 Gwandalan Bank 2

Figure 5 Gwandalan Bank 2

Figure 6 Gwandalan South

Figure 7 Gwandalan Bank 3

Appendix B

Seagrass Map

GHD
CLIENTS | PEOPLE | PERFORMANCE

Source: GIS data supplied by GoogleEarthPro
Projection: GDA94 Zone 56
Date Printed: 30/10/07
File: g\42\14995\GIS\Projects\Gwan.mxd
Size: A3

Legend

Type

- Z1A
- Z1B
- Z1C
- Z2A H1A
- Z2B
- Z2C

Coverage/Density	1	2	3
	Single indiv plants	Moderate indiv's	Continuos mat
A	Patchy		
B	Fairly continuous		
C	Established beds		

NOTE: *Z = Zostera capricornia; H = Halophila sp.;*
Widths are indicative only and not necessarily to scale.

N
W E
S

0 50 100 150 200
Meters

1:7,000

Gwandalan

Appendix B

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Number of DRAFT Versions	J Sargent	A number of internal reviews have taken place, on previous versions including a Client's review. Minor changes in all cases		R Berg		Jan, Feb. May Sep 2010
Review of Adequacy	Minor change	Client and Scott Fraser		R Berg		2010.10.11