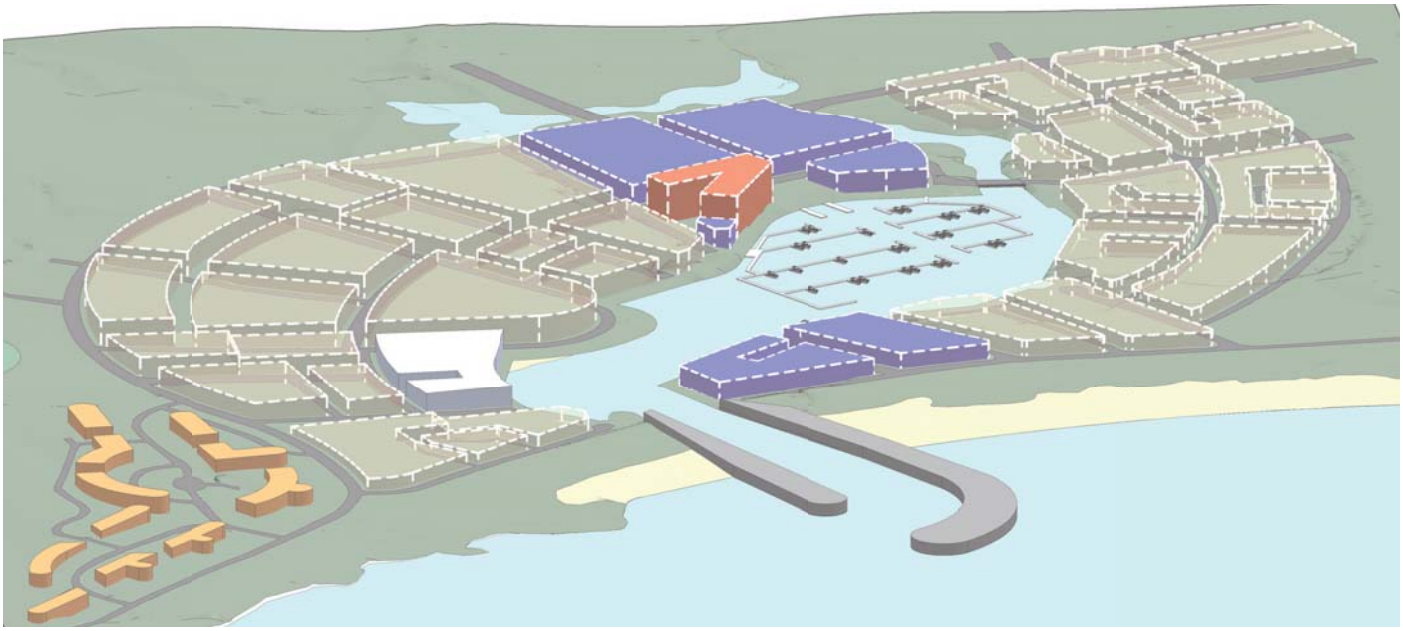

Shell Cove
Boat Harbour Precinct

Concept Plan Application and Environmental Assessment Appendix B - Coastal Processess and Water Cycle Management

prepared by LFA (Pacific) Pty Ltd

date February 2010

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AUSTRALAND HOLDINGS LIMITED
SHELLHARBOUR CITY COUNCIL

Shell Cove Boatharbour Precinct

Concept Application and Environmental Assessment

Support Information on Coastal Processes and Water Cycle Management

September 2009

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Telephone: (02) 8923 6866
Facsimile: (02) 8923 6877
www.worleyparsons.com
ABN 61 001 279 8 12

WorleyParsons

resources & energy

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AUSTRALAND HOLDINGS LIMITED
SHELLHARBOUR CITY COUNCIL
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REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	GWB		N/A	26/3/08	N/A	
B	Final	GWB	GWB		24/9/09	N/A	

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EXECUTIVE SUMMARY

General

This report addresses a number of key issues outlined in the Director General's Environmental Assessment Requirements for preparation of a Concept Plan Application for development of the Shell Cove Boatharbour Precinct. These key issues comprise:

- coastal processes:
  - coastal hazards and provisions of the Coastline Management Manual, including consideration of climate change;
  - consistency with relevant legislation and policy relating to the coast, wetlands, rivers and estuaries.
- water cycle management:
  - measures for integrated water cycle management based on water sensitive urban design principles;
  - impacts of the proposal on surface water hydrology and quality.

Coastal Processes

Coastline Hazards

The report addresses the eight coastline hazards referred to in the Coastline Management Manual; namely, beach erosion, shoreline recession, coastal entrance behaviour, sand drift, coastal inundation, slope and cliff instability, stormwater erosion and climate change.

Of these hazards, the most potentially significant for the Boatharbour Precinct are beach erosion and shoreline recession, and the effects of climate change. These hazards are interrelated as one component of shoreline recession is due to future sea level rise resulting from climate change. A further potentially significant hazard is sand drift, which has been an issue along Shellharbour South Beach in the past.

The development within the Boatharbour Precinct has been set sufficiently landward of Shellharbour South Beach that, even when a number of conservatisms are included in the assessment of the beach erosion and shoreline recession hazards, the development would not be threatened by coastal processes over a planning period of 100 years and beyond.

In addition, a Beach Nourishment / Rehabilitation Management Plan has been prepared and approved for Shellharbour South Beach that includes, among other things, monitoring of beach behaviour over time and the requirement for Shellharbour City Council to develop a strategy to deal with the impacts of climate change on the beach.

The above Beach Nourishment / Rehabilitation Management Plan also includes ongoing monitoring and maintenance of the dune system along Shellharbour South Beach, including planting of vegetation and restoration of storm damage to avoid the risk of sand drift. All of this work would be undertaken in accordance with the Coastal Dune Management Manual and would ensure sand drift does not emerge as a significant coastline hazard for the Boatharbour Precinct.

Consistency with Relevant Legislation and Policy

The proposed development has been considered for consistency with the *Water Management Act 2000*, NSW Coastal Policy, NSW Wetlands Management Policy, NSW State Rivers and Estuaries Policy, NSW Estuary Management Policy and NSW Draft Sea Level Rise Policy Statement.

The proposal is considered to be consistent with the above legislation and policy, in particular it is noted that:

- a stormwater water quality management strategy is proposed that will ensure protection of water quality within the sensitive nearshore coastal environment;
- water sensitive urban design practices have been adopted which include reduction in potable water use, inclusion of water saving devices, and internal and external reuse of non-potable water;
- the proposal involves the protection and rehabilitation of the dunal system along Shellharbour South Beach, embodied within a Beach Nourishment/Rehabilitation Management Plan;
- the proposal is set back a sufficient distance from Shellharbour South Beach to accommodate natural processes and climate change over a planning period of 100 years and beyond;
- the proposal provides public access to the beach, along the coastal structures (when safe to do so), and around the full perimeter of the boatharbour waterway;
- the proposal includes monitoring of beach behaviour to provide information that will allow effective management of natural coastal processes and the impacts of climate change;
- the project has successfully established a substantial fresh and estuarine wetland (Myimbarr Wetland) to offset the approved removal of the degraded Shellharbour Swamp;
- the proposal involves the creation of multiple freshwater wetlands as part of the stormwater quality management strategy;
- the proposal involves the creation of a new 20 ha estuarine system (the waterway of the Boatharbour), adding to the estuarine habitat and habitat complexity in the Shellharbour embayment.

Water Cycle Management

A range of measures have been adopted as part of the water management strategy, based on water sensitive urban design principles, to address the potential for the proposal to impact on the environment. These measures include rainwater tanks, grass swales, vegetated drainage corridors, bioretention swales and basins, gross pollutant taps and wetlands.

A MUSIC model was utilised to estimate the pollutant load exports and water volumes generated by the catchment for the pre-development and developed conditions. A conservative approach was adopted for selection of parameters in the model, in that EMCs (Event Mean Concentrations) adopted for pre-development conditions were low, EMCs adopted for developed conditions were high, and the performance of wetlands was understated compared to actual measured wetland data from the site.

Notwithstanding the conservatisms in the modelling, the predicted pollutant export in the developed condition is equal to or less than the pollutant export in the pre-development condition. This ensures the water quality in the Boatharbour would be satisfactory and there would be no adverse impact on sensitive nearshore coastal waters.

1. INTRODUCTION

The Shell Cove Boatharbour Precinct site is located 17 km south of Wollongong within the Illawarra region, immediately south of the existing Shellharbour Village. The site comprises approximately 100 ha of land that surrounds Shell Cove Boatharbour / Marina development and includes the foreshore of Shellharbour South Beach (refer **Figure 1.1**). The Boatharbour / Marina development received Ministerial consent in November 1996 and is not included within the Precinct site.

Development of the Shell Cove Boatharbour Precinct will involve residential, commercial, retail, hotel, marina facilities (on land), public parklands and technology park and subdivision. The development has been declared a project to which Part 3A of the *Environmental Planning and Assessment Act 1979* applies.

Accordingly, the Department of Planning has issued Director General's Environmental Assessment Requirements for preparation of a Concept Plan Application for the project. A copy of the Requirements are included in **Appendix A**. This report addresses a number of the key issues outlined in the requirements, as listed below[1]:

5. Hazard Management and Mitigation

Coastal Processes

5.1 Address coastal hazards and the provisions of the Coastline Management Manual. In particular consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms.

5.2 Address consistency with Rivers and Foreshore Improvement Act 1948, NSW Coastal Policy, NSW Wetlands Management Policy, NSW State Rivers and Estuaries Policy[2] and NSW Estuary Management Policy.

[1] The list provided is a direct extract from the Environmental Assessment requirements. Note that groundwater hydrology and quality under 6.2 is being addressed by others. Surface water hydrology and quality is included in this report.

[2] Since issue of the Director General's Environmental Assessment Requirements, the NSW Government has also released a Draft Sea Level Rise Policy Statement (NSW Government, 2009).

6. Water Cycle Management

6.1 Address and outline measures for Integrated Water Cycle Management (including stormwater) based on Water Sensitive Urban Design principles which addresses impacts on the surrounding environment, drainage and water quality controls for the catchment.

6.2 Assess the impacts of the proposal on surface and groundwater hydrology and quality.

2. HAZARD MANAGEMENT AND MITIGATION – COASTAL PROCESSES

2.1 Coastline Hazards

2.1.1 General

The Coastline Management Manual (NSW Government, 1990) identifies the following coastline hazards associated with the various coastal processes:

- beach erosion;
- shoreline recession;
- coastal entrance behaviour;
- sand drift;
- coastal inundation;
- slope and cliff instability;
- stormwater erosion;
- climate change.

In the case of the climate change, the most significant potential impacts are sea level rise and the possibility of more frequent and intense storms.

2.1.2 Beach Erosion

During storms, large waves, elevated water levels and strong winds can cause severe erosion to sandy beaches. The hazard of beach erosion relates to the limit of erosion that could be expected due to a severe storm or from a series of closely spaced storms (NSW Government, 1990). The amount of sand which can be removed from a beach during a storm event, and transported offshore, is referred to as the “storm demand”. This quantity is generally measured above 0 m AHD, and is usually expressed as a volume per metre length of beach (m^3/m).

Gordon (1987) estimated that the storm demand above 0 m AHD was about 220 m^3/m for the 100 year average recurrence interval (ARI) storm event, for exposed NSW beaches at rip heads. In practice, in any one storm, relatively large erosion may only occur at discrete locations corresponding to the location of major rips.

Shellharbour South Beach is protected from the predominantly southerly and south easterly storm waves by Bass Point. Coastal engineering studies conducted for the Environmental Impact Statement (EIS) for Shell Cove Boatharbour / Marina adopted a storm demand value of 140 m^3/m for the 100 year ARI storm event based on an assessment of the degree of shelter provided by Bass Point and having regard to actual measured beach erosion for moderate storms, which were between 65 and 80 m^3/m (LFA, 1995).

The value of the storm demand for Shellharbour South Beach was reconsidered by Patterson Britton as part of studies for the detailed design and documentation of the breakwater at the entrance to the Boatharbour. In particular, these studies involved extensive analysis of the wave climate along Shellharbour South Beach, which demonstrated quantitatively the degree of sheltering of the beach afforded by Bass Point. In addition, the results of an analysis of historical beach profiles using photogrammetric techniques was available from a foreshore hazard assessment study conducted for Shellharbour City Council (Patterson Britton & Partners, 2006). On the basis of these studies, a slightly higher, more conservative, storm demand of generally 160 m^3/m for a 100 year ARI event was adopted[3].

The sand volume typically available along Shellharbour South Beach seaward of the vegetated dune system is in the order of 60 to 80 m^3/m. During a severe storm at a rip head, erosion could be expected to occur back into the vegetated dune system by up to possibly 20 m. Following the storm, the beach would recover as the sand deposited in bars offshore during the storm reworked offshore.

The erosion described above would not affect any proposed building development within the Boatharbour Precinct and would be well seaward of Boollwaroo Parade / Bass Point Tourist Road, typically by some 60 to 80 m and greater. Some damage and temporary disruption to dune fences and accessways could occur but this is not unusual in severe storms along the NSW Coast. Maintenance of these structures would be undertaken as required by Shellharbour City Council.

Over time, the beach erosion hazard would increase (move further landward) due to the effects of shoreline recession. This is discussed in the following section.

It is also noted that the impact of the proposed entrance works to the Boatharbour on the stability of Shellharbour South Beach was reinvestigated as part of a Section 96 modification to the Development Consent to, among other things, delete the Southern Groyne that had been proposed in the EIS design. The investigation included detailed numerical (morphological) modelling and physical modelling[4].

[3] Storm demand would reduce further at the southern end of the beach due to the additional shelter.

[4] The numerical modelling investigation was carried out using the DELFT 3D model that simulates waves, wave and tide driven currents, sediment transport and seabed level change. The physical modelling involved use of a 3D model and assessment of beach planform changes (using a fine sand in the model) and tracking of nearshore currents.

The results from the numerical morphological modelling, supported by the current patterns and planform changes observed in the physical modelling, indicated very minor, almost negligible, differences in beach behaviour with and without the Southern Groyne. On this basis it was concluded that deletion of the Southern Groyne from the entrance configuration would be unlikely to have any detrimental effect on beach stability. As deletion of the groyne would have a number of aesthetic and environmental benefits a decision was taken to delete the groyne. The Section 96 modification was approved.

Full details of the above beach stability investigations can be found in the technical report prepared to support the proposed Section 96 modification (Patterson Britton, 2005).

2.1.3 Shoreline Recession Hazard

General

The hazard of shoreline recession is the progressive landward shift in the average long term position of the coastline (NSW Government, 1990). Two potential causes of shoreline recession are a continuing net sediment loss from the beach system due to coastal processes, and an increase in sea level.

Shoreline Recession due to Sediment Loss

According to the sediment budget concept, shoreline recession due to sediment loss occurs when more sand is leaving than entering the beach compartment. This recession tends to occur when:

- the outgoing longshore transport from a beach compartment is greater than the incoming longshore transport;
- offshore transport processes move sand to offshore “sinks”, from which it does not return to the beach; and/or
- there is a landward loss of sediment by windborne transport (NSW Government, 1990).

Shoreline recession due to net sediment loss should not be confused with beach erosion, which results in a short term exchange of sand between the subaerial and subaqueous portions of the beach, not a net loss from the active beach system. Shoreline recession is therefore a long term process which is overlaid by short term fluctuations due to storm activity.

Coastal engineering studies conducted for the Shell Cove Boatharbour / Marina EIS (LFA, 1995) concluded that there did not appear to be any significant sediment loss mechanisms for Shellharbour South Beach. Accordingly, a zero value for shoreline recession due to net sediment loss was adopted at that time.

Further assessment of potential mechanisms for sand supply and loss to Shellharbour South Beach was undertaken by Patterson Britton as part of the detailed design of the Shell Cove Boatharbour / Marina. This was assisted by the availability of additional photogrammetric analysis of historical vertical aerial photography (Patterson Britton, 2006).

This further work confirmed the findings contained in the EIS that there are no significant mechanisms for sand supply and loss and that, accordingly, shoreline recession due to net sediment loss is not a significant coastline hazard for Shellharbour South Beach. Rather than adopt a value of zero, a conservative allowance of 0.05 m/yr recession was adopted as the long term recession rate due to net sediment loss to account for uncertainties in future beach behaviour.

Adopting a planning period of 100 years, the estimated shoreline recession due to net sediment loss would be 5 m.

Shoreline Recession due to Sea Level Rise

A progressive rise in sea level may result in shoreline recession through two mechanisms: first, by drowning low lying coastal land, and second, by shoreline readjustment to the new coastal water levels. The second mechanism is probably the more important since deeper offshore waters expose the coast to attack by larger waves, the nearshore refraction and diffraction behaviour of waves may change, and a significant volume of sediment may move offshore as the beach seeks a new equilibrium profile (NSW Government, 1990).

Bruun (1962) proposed a methodology to estimate shoreline recession due to sea level rise, the so-called Bruun Rule. The Bruun Rule is based on the concept that sea level rise will lead to erosion of the upper shoreface, followed by re-establishment of the original equilibrium profile. This profile is re-established by shifting it landward. The concept is shown graphically in Bruun (1983), and can be described by the equation (Morang and Parson, 2002):

$$R = \frac{S \times B}{h + d_c}$$

where R is the recession (m), S is the long term sea level rise (m), h is the dune height above the initial mean sea level (m), d_c is the depth of closure[5] of the profile relative to the initial mean sea level (m), and B is the cross-shore width of the active beach profile, that is the cross-shore distance from the initial dune height to the depth of closure (m). This equation is a mathematical expression that the recession due to sea level rise is equal to the sea level rise multiplied by the inverse slope of the active beach profile.

[5] The depth of closure is the water depth beyond which repetitive profile surveys (collected over several years) do not detect vertical sea bed changes, generally considered to be the seaward limit of littoral transport. The depth can be determined from repeated cross-shore profile surveys, estimated using formulas based on wave statistics or established based on sedimentological factors (changes in seabed sediment types). Note that this does not imply the lack of sediment motion beyond this depth (Szuwalski and Morang, 2001).

Investigations undertaken as part of the EIS for the Shell Cove Boatharbour / Marina (LFA, 1995) and for the detailed design and documentation of the Boatharbour / Marina have established that a reasonable estimate of the closure depth for Shellharbour South Beach is about 8 m below Australian Height Datum (-8 m AHD).

Adopting the above formula it can be shown that the predicted shoreline recession R would be about 25 times the long term sea level rise S, ie:

$$R = 25 \times S$$

The NSW Department of Environment and Climate Change (DECC) has recently published a document *Practical Consideration of Climate Change – Floodplain Risk Management Guidelines* (DECC, 2007) that, while focussing mainly on flooding issues, outlines the latest global (IPCC, 2007) and local NSW coastline (McInnes et al, 2007) estimates for sea level rise by between the years 2090 and 2100 for purposes of impact assessment. The following 'Low', 'Mid' and 'High' values are recommended for the combination of global and local effects for sensitivity analyses.

- Low 0.18 m
- Mid 0.55 m
- High 0.91 m

Adopting a planning period of 100 years and the above equation, the estimated shoreline recession due to sea level rise would be as follows:

- Low 5 m
- Mid 14 m
- High 23 m

Total Shoreline Recession

The total estimated shoreline recession for a planning period of 100 years, combining the recession due to net sediment loss and recession due to sea level rise, is as follows:

- Low 5 m + 5 m = 10 m
- Mid 5 m + 14 m = 19 m
- High 5 m + 23 m = 28 m

Due to the large distances between the proposed development within the Boatharbour Precinct and the beach, eg typically greater than some 150 m measured to Mean High Water Mark (MHWM), the proposed development would not be affected by coastal processes even if the erosion due to the design storm described in **Section 2.1.2** occurred at the end of the 100 year planning period and following a 'High' shoreline recession outcome.

It is also noted that a Beach Nourishment / Rehabilitation Management Plan has been prepared and approved for Shellharbour South Beach as part of the conditions of development consent and conditions of concurrence under the *Coastal Protection Act 1979*. This Plan includes, among other things, monitoring of beach behaviour over time and the requirement for Shellharbour City Council to develop a strategy to deal with the impacts of climate change on Shellharbour South Beach and other beaches in the Local Government Area.

2.1.4 Coastal Entrance Behaviour Hazard

Both natural and trained coastal entrances can create a variety of hazards. Natural entrances tend to migrate along the beach in response to freshwater flooding and coastal storm effects, so potentially threatening any adjacent developments and the amenity of affected beaches. Training works will stabilise the location of an entrance, but may engender significant changes to the estuary and nearby beaches (NSW Government, 1990).

In the case of the Shell Cove Boatharbour / Marina development, the existing natural entrance to Shellharbour Swamp, which is mostly closed to the sea but breaks out across the beach berm in heavy rainfall, is to be replaced by a permanent (trained) entrance to provide safe boating access.

The impact of the proposed entrance works to the Boatharbour on the adjacent beaches was the subject of detailed investigation during preparation of the EIS (LFA, 1995) and again in studies carried out as part of a Section 96 modification to the Development Consent (Patterson Britton, 2005).

The investigations and studies included use of detailed three dimensional (3D) numerical (morphological) and physical models and demonstrated that the proposed entrance works would be unlikely to have any detrimental effect on beach stability. The Section 96 modification was approved.

It is also noted that a Beach Nourishment / Rehabilitation Management Plan has been prepared and approved for Shellharbour South Beach as part of the conditions of development consent and conditions of concurrence under the *Coastal Protection Act 1979.*

This Plan includes, among other things, monitoring of beach behaviour over time, preparation of an annual report of the monitoring, and, if necessary, sand nourishment of the beach to correct any unforeseen impacts of the entrance works and maintain recreational amenity.

2.1.5 Sand Drift Hazard

Sand drift is a result of wind blown (aeolian) movement of sediment and can create a number of hazards. At best drifting sand is a nuisance, at worst it represents a permanent loss of sand from the coastal system leading to shoreline recession or may completely overwhelm coastal developments (NSW Government, 1990). A stable vegetation cover on dune systems is essential to prevent sand drift.

The existing dune system along Shellharbour South Beach is currently reasonably well vegetated and stable with the exception of the entrance area to Shellharbour Swamp which is subject to the natural

breakout and migration of the breakout channel. Dune stability along Shellharbour South Beach has, however, been a concern in the past; historical vertical aerial photography shows evidence of instability and sand drift problems up until the mid 1980s when dune stabilisation works were undertaken.

A Beach Nourishment / Rehabilitation Management Plan has been prepared for both the construction phase and ongoing operational phase of the Boatharbour / Marina development. An important element of the Plan is the post-construction rehabilitation and ongoing maintenance and monitoring of the dune system along Shellharbour South Beach, including planting of vegetation and restoration of storm damage to avoid the risk of sand drift. All of this work would be undertaken in accordance with the Coastal Dune Management Manual (DLWC, 2001).

Adoption of the Beach Nourishment / Rehabilitation Management Plan will ensure that sand drift does not become a significant coastline hazard for the Boatharbour Precinct.

2.1.6 Coastal Inundation Hazard

Coastal inundation is the flooding of coastal lands by ocean waters. It is generally caused by large waves and elevated water levels associated with severe storms. Severe inundation is an infrequent event and is normally of short duration, but it can result in significant damage to both public and private property (NSW Government, 1990).

The components which give rise to elevated nearshore still water levels at times of storms comprise astronomical tide, wind setup and barometric setup (the combined effect is termed storm surge), and wave setup. Individual waves cause further temporary water level increases above the still water level due to the process of wave runup or uprush.

Two forms of possible inundation of the Boatharbour Precinct that are influenced by coastal water levels can be considered:

- inundation due to overtopping of the dune system along Shellharbour South Beach; and
- inundation due to the combination of rainfall from the catchment and the coastal water level (or 'tailwater' level).

Only the first form of possible inundation is considered in this report. The second form of possible inundation is considered as part of a flood study being undertaken by others.

The estimated 100 year ARI nearshore still water level along Shellharbour South Beach at the current time, ie no allowance for future sea level rise, is about 2.4 to 2.8 m AHD (LFA, 1995; Patterson Britton, 2006). Runup levels for individual waves are estimated to be typically approximately 5 m AHD[6].

[6] Wave runup levels at the southern end of the beach would be lower due to the additional shelter.

The existing dune crest level along Shellharbour South Beach is typically about 4.5 m AHD. In the vicinity of the existing entrance to Shellharbour Swamp, where dune levels are lower due to the breakout behaviour of the swamp, the dune crest level will be increased as part of the entrance works to match the adjacent levels, ie increased to about 4.5 m AHD.

Given the dune crest level of about 4.5 m AHD, and the estimated wave runup level during severe storms of approximately 5 m AHD, some overtopping of the dune crest level could be expected during severe storms at high tide. This likelihood of overtopping would increase over time due to sea level rise. As noted in **Section 2.1.3**, current 'Low', 'Mid' and 'High' estimates for sea level rise by between the years 2090 and 2100 are 0.18 m, 0.55m and 0.91 m respectively.

The inundation hazard to the Boatharbour Precinct due to wave overtopping of the dune crest level along Shellharbour South Beach is not considered significant however, for a number of reasons:

- wave runup levels equivalent to the estimated current value of 5 m AHD plus allowance for future sea level rise would only be realised if the foreshore physically extended to the runup level or higher. In reality waves that overtop the dune crest would tend to 'fold over' the crest and travel as a sheet flow at shallow depth, spreading out and infiltrating over the typically sandy dune system landward of the crest;
- north of the Boatharbour entrance a swale is to be maintained behind the dune system (seaward of Boollwaroo Parade / Bass Point Tourist Road). This swale would collect any overtopping flows from individual waves and allow drainage back to the Boatharbour entrance channel and / or natural infiltration;
- the drainage system in the Boollwaroo Parade / Bass Point Tourist Road would serve to collect any overtopping flows, although it is considered unlikely waves would ever reach this far landward within a planning period of 100 years.

2.1.7 Slope and Cliff Instability Hazard

Slope and cliff instability hazards refer to the possible structural incompetence of these features and associated potential problems with the foundations of buildings, seawalls or other coastal works (NSW Government, 1990).

In the case of the Boatharbour Precinct, it has been established in **Sections 2.1.2** and **2.1.3** that beach erosion along Shellharbour South Beach in a severe storm event, occurring at the end of a planning period of 100 years, even after allowance for the 'High' sea level rise scenario, would still be well seaward of proposed development and in fact well seaward of Boollwaroo Parade / Bass Point Tourist Road. In addition there are no cliffs or bluffs along the Boatharbour Precinct.

Accordingly, slope and cliff instability is not a significant or relevant hazard for the Boatharbour Precinct.

2.1.8 Stormwater Erosion Hazard

During major stormwater runoff events, stormwater collected from back beach areas and discharging into coastal waters can cause significant erosion to the beach berm. This in turn can allow larger waves to attack the beach and can cause migration of the stormwater discharge entrance (NSW Government, 1990).

The majority of the stormwater that flows from the Boatharbour Precinct (and upstream catchments), will enter the Boatharbour and flow to sea through the trained entrance channel. There is no potential for these flows to cause migration of the entrance channel, which is rock lined, or to cause significant beach erosion as the discharge point is well offshore in water depths greater than 5 m below mean sea level.

The minor exception to the above is the stormwater from the south eastern corner of the site termed the 'Commercial East Catchment', comprising an area of approximately 7.6 ha. Due to the topography of the land, stormwater from this catchment will be directed to the foreshore south of the Boatharbour entrance through an existing stormwater culvert under the Bass Point Tourist Road and a swale at the back of the beach.

Detention storage would be provided within the Boatharbour Precinct site so that post development stormwater flows did not exceed the predevelopment design flows for the culvert under the Bass Point Tourist Road. Accordingly, no additional periodic erosion of the beach berm beyond that which has occurred historically would be expected following development of the Precinct.

In view of the above, stormwater erosion on Shellharbour South Beach associated with development within the Boatharbour Precinct is not considered a significant hazard.

Discussion of other aspects of stormwater management for the Boatharbour Precinct is included in **Section 3**.

2.1.9 The Hazards of Climate Change

In coastal areas the most significant potential consequences of climate change are sea level rise, more frequent and intense ocean storms, and increased rainfall intensities. The issue of increased rainfall intensities is not discussed in this report but is considered by others as part of an assessment of flooding impacts.

Sea level rise may cause shoreline recession and increase the hazard of oceanic inundation. These hazards have already been taken into account in the assessment of the shoreline recession hazard and oceanic inundation hazard in **Sections 2.1.3** and **2.1.6** respectively.

The likelihood and extent of more frequent and intense storms is very difficult to quantify in the present state of knowledge on climate change. Given the uncertainty, the appropriate strategy is to take a conservative and precautionary approach in coastal planning, that also includes monitoring of coastline behaviour and the ability to readily adapt to changed circumstances if required.

In the case of the Shell Cove Boatharbour Precinct, such an approach has been adopted, as demonstrated by the following:

- a conservative value has been adopted for the storm erosion demand (**Section 2.1.2**);
- a conservative value has been adopted for the shoreline recession due to net sediment loss (**Section 2.1.3**);
- an assessment of shoreline recession due to sea level rise has included, as part of a sensitivity analysis, consideration of the 'High' value for possible future sea level rise[7] (**Section 2.1.3**);
- the proposed development within the Boatharbour Precinct has been sited sufficiently landward of Shellharbour South Beach that, even when the above conservatisms are included, the development would not be threatened by coastal processes over a planning period of 100 years and beyond (**Section 2.1.3**);
- a Beach Nourishment/Rehabilitation Management Plan has been prepared and approved for Shellharbour South Beach that includes, among other things, monitoring of beach behaviour over time and the requirement for Shellharbour City Council to develop a strategy to deal with the impacts of climate change on the beach.

In view of the above, it is considered that a sound management strategy is in place to deal with the hazards of climate change.

2.2 Consistency with Legislation and Policy

2.2.1 General

The Environmental Assessment Requirements lists the following legislation and policy for purposes of addressing the consistency of the proposal:

- *Rivers and Foreshores Improvement Act 1948;*
- NSW Coastal Policy;
- NSW Wetlands Management Policy;
- NSW State Rivers and Estuaries Policy;
- NSW Estuary Management Policy.

[7] This 'High' value is also consistent with the sea level rise planning benchmark in the recently released NSW Government Draft Sea Level Rise Policy Statement, refer **Section 2.2.7**.

The *Rivers and Foreshores Improvement Act 1948* has been repealed since preparation of the Environmental Assessment Requirements and the 'controlled activity' provisions in the *Water Management Act 2000* (WMA) have now commenced (4 February 2008). Accordingly, reference is made in the discussion below to the *Water Management Act 2000* rather than the *Rivers and Foreshores Improvement Act 1948*.

In addition, the NSW Government has also recently released (2009) a Draft Sea Level Rise Policy Statement.

An assessment of the consistency of the proposed Boatharbour Precinct development with the above legislation and policy is set out in the following sections, with emphasis on the issue of 'coastal processes' being the key issue under which reference to legislation and policy is made in the Director General's Environmental Assessment Requirements.

2.2.2 Water Management Act

General

The objects of this Act are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations and, in particular:

(a) to apply the principles of ecologically sustainable development;

(b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality;

(c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:

  (i) benefits to the environment;

  (ii) benefits to urban communities, agriculture, fisheries, industry and recreation;

  (iii) benefits to culture and heritage; and

  (iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water;

(d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources;

(e) to provide for the orderly, efficient and equitable sharing of water from water sources;

(f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna;

(g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users; and

(h) to encourage best practice in the management and use of water.

Assessment of Consistency

The proposed development of the Boatharbour Precinct is considered to be consistent with the *Water Management Act 2000* since:

- a stormwater water quality management strategy is proposed (refer **Section 3**) that will ensure protection of water quality within the sensitive nearshore coastal environment;
- water sensitive urban design practices have been adopted which include reduction in potable water use, inclusion of water saving devices, and internal and external reuse of non-potable water.

2.2.3 NSW Coastal Policy

General

The 1997 Coastal Policy has as its central focus the ecologically sustainable development (ESD) of the NSW Coastline. The policy is divided into nine goals. Flowing on from the goals are objectives and under each objective are strategic actions.

The nine goals are:

- to protect, rehabilitate and improve the natural environment;
- to recognise and accommodate natural processes and climate change;
- to protect and enhance the aesthetic qualities of the coastal zone;
- to protect and conserve cultural heritage;
- to promote ecologically sustainable development and use of resources;
- to provide for ecologically sustainable human settlement;
- to provide for appropriate public access and use;
- to provide information to enable effective management; and
- to provide for integrated planning and management.

Assessment of Consistency

The proposed development of the Boatharbour Precinct is considered to be consistent with the NSW Coastal Policy since:

- the proposal involves the protection and rehabilitation of the dunal system along Shellharbour South Beach, embodied within a Beach Nourishment/Rehabilitation Management Plan;
- the proposal is set back a sufficient distance from Shellharbour South Beach to accommodate natural processes and climate change over a planning period of 100 years and beyond;
- the proposal provides public access to the beach, along the coastal structures (when safe to do so), and around the full perimeter of the boatharbour waterway;
- the proposal includes monitoring of beach behaviour to provide information that will allow effective management of natural coastal processes and the impacts of climate change.

2.2.4 NSW Wetlands Management Policy

General

It is the policy of the NSW Government to:

- encourage the management of the wetlands of the State so as to halt and where possible reverse:
  - loss of wetland vegetation;
  - declining water quality;
  - declining natural productivity;
  - loss of biological diversity; and
  - declining natural flood mitigation.
- encourage projects and activities which will restore the quality of the State's wetlands, such as:
  - rehabilitating wetlands;
  - re-establishing areas of buffer vegetation around wetlands, and
  - ensuring adequate water to restore wetland habitats.

The Government's common goal to guide decision-making for wetlands is:

The ecologically sustainable use, management and conservation of wetlands in NSW for the benefit of present and future generations.

Assessment of Consistency

The proposed development of the Boatharbour Precinct is considered to be consistent with the NSW Wetlands Management Policy since:

- the project has successfully established a substantial fresh and estuarine wetland (Myimbarr Wetland) to offset the approved removal of the degraded Shellharbour Swamp. The Myimbarr Wetland includes 1.5 ha of saltmarsh, a tidal lagoon connected to the sea via Tongarra Creek and 11.5 ha of freshwater wetlands containing nine deep ponds and a series of shallow wetland areas;
- the proposal involves the creation of multiple freshwater wetlands as part of the stormwater quality management strategy.

2.2.5 NSW State Rivers and Estuaries Policy

General

It is the policy of the NSW Government to encourage the sustainable management of the natural resources of the State's rivers, estuaries and wetlands on the adjacent riverine plains, so as to reduce, and where possible halt:

- declining water quality;
- loss of riparian vegetation;
- damage to river banks and channels;
- declining natural productivity;
- loss of biological diversity; and
- declining natural flood mitigation;

and to encourage projects and activities which will restore the quality of river and estuarine systems such as:

- rehabilitating remnant habitats;
- re-establishing vegetation buffer zones adjacent to streams and wetlands;
- restoring wetland areas;
- rehabilitating of estuary foreshores; and
- ensuring adequate streamflows to maintain aquatic and wetland habitats.

The objectives of the State Rivers and Estuaries Policy is to manage the rivers and estuaries of NSW in ways which:

- slow, halt or reverse the overall rate of degradation in their systems;
- ensure the long term sustainability of their essential biophysical functions; and
- maintain the beneficial use of these resources.

Assessment of Consistency

The proposed development of the Boatharbour Precinct does not affect the natural resources of any of the State's rivers or estuaries. The impact of the proposed development on wetlands is considered to be beneficial as noted in **Section 2.2.4**.

The proposal does involve the creation of a new 20 ha estuarine system comprising the waterway of the Boatharbour. The waterway is already the subject of an approval from the Minister and is predicted to create more estuarine habitat and increase habitat complexity in the Shellharbour embayment.

2.2.6 NSW Estuary Management Policy

General

The NSW Government developed an Estuary Management Policy in recognition of the ecological, social and economic importance of the State's estuaries and concern regarding the long term consequences of their accelerating degradation.

The general goal of the Estuary Management Policy is to achieve an integrated, balanced, responsible and ecologically sustainable use of the State's estuaries. Specific objectives of the policy are:

- protection of estuarine habitat and ecosystems in the long term, including maintenance in each estuary of the necessary hydraulic regime;
- preparation and implementation of a balanced long term management plan for the sustainable use of each estuary and its catchment, in which all values and uses are considered, and which defines management strategies for:
  - conservation of aquatic and other wildlife habitats;
  - conservation of the aesthetic values of estuaries and wetlands;
  - preservation of further estuary degradation;
  - repair of damage to the estuarine environment; and
  - sustainable use of estuarine resources, including commercial uses and recreational uses as appropriate.

Assessment of Consistency

The proposed development of the Boatharbour Precinct is considered to be consistent with the NSW Estuary Management Policy for similar reasons stated in **Section 2.2.4** and **2.2.5**, namely:

- the project has successfully established the Myimbarr Wetland, which includes 1.5 ha of saltmarsh and a tidal lagoon connected to the sea via Tongarra Creek;
- the proposal involves the creation of a new 20 ha estuarine system (the waterway of the Boatharbour) thus adding to the estuarine habitat and habitat complexity in the Shellharbour embayment.

2.2.7 Draft Sea Level Rise Policy Statement

General

In 2009 the NSW Government released a policy statement to outline the Government's objectives and commitments to sea level rise. It outlines the support that the Government will provide to coastal communities and local councils to prepare and adapt to rising sea levels.

To support this adaptive risk-based approach, the NSW Government has adopted a sea level rise planning benchmark. This benchmark will enable consistent consideration of sea level rise within this adaptive risk-based management approach. There is no regulatory or statutory requirement for development to comply with this benchmark. The benchmark's primary purpose is to provide guidance to support consistent consideration of sea level rise impacts, within applicable decision-making frameworks. This will include strategic planning and development assessment under the *Environmental Planning and Assessment Act 1979* and infrastructure planning and renewal.

The NSW sea level rise planning benchmark is an increase above 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100. This was established by considering the most credible national and international projections of sea level rise[2] and takes into consideration the uncertainty associated with sea level rise projections. The Government will periodically review this planning benchmark, based on updated information, such as the release of future Intergovernmental Panel on Climate Change assessment reports.

Assessment of Consistency

The proposed development of the Boatharbour Precinct is considered to be consistent with the NSW Draft Sea Level Rise Policy Statement since a sea level rise value consistent with the planning benchmark (0.9 m) has been adopted for consideration of the future hazard due to sea level rise.

3. WATER CYCLE MANAGEMENT

3.1 General

WorleyParsons has prepared a 'Stormwater Quality Management Strategy' for the proposed Shell Cove development, including development within the Boatharbour Precinct, on behalf of Australand Holdings Ltd, September 2009.

The requirements of the stormwater water quality management strategy have been established based on the outcome of the Commission of Inquiry (COI) for the Shell Cove Boatharbour / Marina development in the mid 1990s. In addition to guidelines presented in 'Managing Urban Stormwater : Council Handbook' (Environment Protection Authority, 1996), specifically:

- the annual pollutant load export from the catchment to the proposed Boatharbour waterway under developed conditions must not exceed the pollutant load export from the catchment under existing (pre-development) conditions, including allowance for the treatment provided by Shellharbour Swamp;
- the annual pollutant load export from the catchment in the south-east of the Precinct that drains directly to the Tasman Sea, under developed conditions, must not exceed the pollutant load export under existing (pre-development) conditions;
- the following EPA (1996) guidelines have also been considered between developed (no treatment measures) and pre-development conditions:
  - Suspended Solids 80% reduction
  - Total Phosphorus 45% reduction
  - Total Nitrogen 45% reduction

Water quality modelling was undertaken using MUSIC, a continual run conceptual water quality assessment model developed by the Co-operative Research Centre for Catchment Hydrology. MUSIC can estimate the expected pollutant loads and also the long term annual average stormwater volume generated by a catchment.

A full copy of WorleyParsons' report is included in **Appendix B**. Information from this report is summarised in the following two sections in response to the Director General's Environmental Assessment Requirements to address and outline measures adopted for integrated water cycle management, and to assess the impacts of the proposal on surface water hydrology and quality.

3.2 Measures Adopted for Integrated Water Cycle Management

The following measures have been adopted as part of the water management strategy, based on water sensitive urban design principles, to address the potential for the proposed development to impact on the environment:

- rainwater tanks;
- grass swales;
- vegetated drainage corridors;
- bio-retention swales and basins;
- gross pollutant traps; and
- wetlands

Rainwater tank sizes have been estimated based on the minimum BASIX requirement of total potable water reduction of 40% and assuming water saving devices are implemented on taps, shower heads and toilets. It was assumed that the tanks would be used for internal and external non-potable water reuse (toilet flushing, washing machines and garden irrigation).

A description of proposed stormwater treatment strategy and the various measures are included in **Appendix B**.

3.3 Impacts of Proposal on Surface Water Hydrology and Quality

As noted in **Section 3.1**, the MUSIC model was utilised to estimate the pollutant load exports and water volumes generated by the catchment for the pre-development and developed conditions.

The various parameters adopted for use in the model, including rainfall and evaporation, soil data, and event mean concentration (EMC) values for each land use type, are discussed in **Appendix B**. A conservative approach was taken for selection of parameters in that EMCs adopted for pre-development conditions were low, EMCs adopted for developed conditions were high, and the performance of wetlands was understated compared to actual measured wetland data from the site.

Table 3.1 summarises the estimated annual exports of pollutant from the developed catchment (with the proposed treatment measures in place) and from the pre-development catchment for a mean rainfall year.

The results show that:

- the pollutant export to the Boatharbour waterway from the developed catchment does not exceed the pollutant export from the catchment under pre-development conditions including allowance for treatment provided by Shellharbour Swamp, ie pollutant export as measured at Shellharbour South Beach;
- the overall pollutant export to Shellharbour South Beach from the developed catchment (including catchments that do not drain to the Boatharbour waterway) does not exceed the pre-development export.

Accordingly, the impacts of the proposed development on surface water quality are acceptable.

Table 3.1 Performance of Proposed Water Quality Management Strategy

Node / Location	Pollutant Load (kg/yr)					
	Suspended Solids		Total Phosphorous		Total Nitrogen	
	Pre	Proposed Treated	Pre	Proposed Treated	Pre	Proposed Treated
Boatharbour	-	43,500	-	176	-	1,650
Shellharbour South Beach	70,700	46,700	202	185	1,840	1,750

Table 3.2 summarises the reductions in pollutant export achieved relative to the pre-development conditions and relative to the developed scenario (with no treatment measures incorporated), the latter to allow comparison to the EPA (1996) guidelines.

The results show that the EPA guidelines of 80% reduction in suspended solids export, 45% reduction in total phosphorus export, and 45% reduction in total nitrogen export have been achieved.

Table 3.2 Reductions in Pollutant Export (%)

Parameter	Reductions in Pollutant Export Relative to (%)	
	Developed conditions with no treatment	Predevelopment conditions
Suspended Solids	82	24
Total Phosphorus	57	6
Total Nitrogen	47	-

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FIGURES

FIGURE 1.1

boatharbour precinct

2360 - 02
July 2006

0 200 500m

1:8,000 @ A1

Shell Cove - Shellharbour

Preliminary masterplan

AUSTRALAND

APPENDIX A DIRECTOR GENERAL'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

NSW GOVERNMENT
Department of Planning

Contact: Tom Mithen
Phone: 9228 6489
Fax: 9228 6540
Email: thomas.mithen@planning.nsw.gov.au
Our ref: MP 07_0027

Mr Glenn Colquhoun
Australand Corporation Pty Limited
PO Box A148
SHELLHARBOUR
NSW 2529

Dear Mr Colquhoun,

Subject: Updated Director-General's Environmental Assessment Requirements for Construction of Residential, Commercial, Retail, Hotel, Marina Facilities, Public Parklands and Technology Park and Subdivision at Lot 8032 DP 8072187, Lot Part 8100 DP 1082981, Lot Part 206 DP 857030, Lot 1168 DP 1076113, Lot 8031 DP 1072187 and Lot 30 DP 229374 Boollwarroo Parade, Shell Cove, Shellharbour (MP 07_0027)

I have reviewed the Director General's Environmental Assessment Requirements (DGRs), dated 1 June 2007, in response to your concerns regarding the level of detail required for the Concept Plan Application. Some of the changes you requested have been incorporated and highlighted in the updated DGRs.

The proposal involves a significant new development in a sensitive coastal location which includes Shellharbour South Beach and its associated dunal system. Therefore all environmental studies need to represent the parameters imposed by the new development to enable proper consideration of the potential environmental impacts on the boat harbour and the coastal zone. You can make reference to the environmental studies undertaken as part of previous approvals for the boat harbour however, you will need to demonstrate in the environmental assessment how those studies satisfactorily address the impacts arising from the new development on land surrounding the boat harbour.

The updated Director General's Environmental Assessment Requirements (DGRs) for the environmental assessment of the project are attached to this correspondence at **Attachment 1**. These requirements have been prepared in consultation with the relevant government agencies including council. **Attachment 2** lists the relevant plans and documents which are required to be submitted with the Environmental Assessment (EA).

It should be noted that the DGRs have been prepared based on the information provided to date. Under section 75F(3) of the Act, the Director-General may alter or supplement these requirements if necessary and in light of any additional information that may be provided prior to the proponent seeking approval for the project.

It would be appreciated if you would contact the Department at least two weeks before you propose to submit the EA for the project to determine:

- the fees applicable to the application;
- whether the proposal requires an approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) and any assessment obligations under that Act;

- consultation and public exhibition arrangements that will apply; and
- number and format (hard-copy or CD-ROM) of the EA that will be required.

A list of some relevant technical and policy guidelines which may assist in the preparation of this EA is attached at **Attachment 3**.

Prior to exhibiting the EA, the Department will review the document to determine if it adequately addresses the DGRs. The Department may consult with other relevant government agencies in making this decision. If the Director-General considers that the EA does not adequately address the DGRs, the Director-General may require the proponent to revise the EA to address the matters notified to the proponent.

Following this review period the EA will be made publicly available for a minimum period of 30 days. The DGRs will be placed on the Department's website along with other relevant information which becomes available during the assessment of the project. As a result, the Department would appreciate if all documents that are subsequently submitted to the Department are in a suitable format for the web, and if you would arrange for an electronic version of the EA to be hosted on a suitable website with a link to the Departments website.

If your proposal includes any actions that could have a significant impact on matters of National Environmental Significance (NES), it will require an additional approval under the Commonwealth EPBC Act. This approval is in addition to any approvals required under NSW legislation. It is your responsibility to contact the Commonwealth Department of Environment and Water Resources in Canberra (6274 1111 or http://www.environment.gov.au) to determine if the proposal is likely to have a significant impact on matters of NES and would require an approval under the EPBC Act. The Commonwealth Government has accredited the NSW environmental assessment process for assessing any impacts on matters of NES. As a result, if it is determined that an approval is required under the EPBC Act, please contact the Department immediately as supplementary DGRs will need to be issued.

Copies of responses from government agencies to the Department's request for key issues and assessment requirements are enclosed at **Attachment 4**. Please note that these responses have been provided to you for information only and do not form part of the DGRs for the EA.

If you have any queries regarding these requirements, please contact Tom Mithen at 9228 6489 or email at thomas.mithen@planning.nsw.gov.au

Yours sincerely

9.11.07

Chris Wilson
Executive Director
as delegate for the Director General

Attachment 1
Director-General's Environmental Assessment Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application number
MP 07_0027
Project
Concept Plan Application: A concept plan approval is sought for Construction of Residential, Commercial, Retail, Hotel, Marina Facilities, Public Parklands and Technology Park and Subdivision. The application will involve approval of conceptual key design parameters including land use, accommodation types (residential and tourist), density, floor space ratio, site coverage, built form, setbacks, indicative building heights, roads and vehicle access, car parking, public and community private open space and pedestrian and bicycle connectivity, public access to foreshore, public domain works and infrastructure requirements, stormwater management and landscaping.
Location
Lot 8032 DP 8072187, Lot Part 8100 DP 1082981, Lot Part 206 DP 857030, Lot 1168 DP 1076113, Lot 8031 DP 1072187 and Lot 30 DP 229374 Boollwarroo Parade, Shell Cove, Shellharbour
Proponent
Australand Corporation Pty Limited
Date issued
October 2007
Expiry date
2 years from date of issue
General requirements
The Environmental Assessment (EA) for the **Concept Plan Application** must include: 1. An executive summary; 2. An outline of the scope of the project including: • any development options; • justification for the project taking into consideration any environmental impacts of the project, the suitability of the site and whether the project is in the public interest; • outline of the staged implementation of the project if applicable; 3. A thorough site analysis including constraints mapping and description of the existing environment; 4. Consideration of relevant statutory and non-statutory provisions, in particular relevant provisions arising from environmental planning instruments, Regional Strategies (including draft Regional Strategies) and Development Control Plans. Identify non-compliances and provide justification of departures. 5. Consideration of impacts, if any, on matters of national environmental significance under

the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*;

6. An assessment of the potential impacts of the project and a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures to be implemented to minimise any potential impacts of the project;
7. The plans and documents outlined in **Attachment 2**;
8. A signed statement from the author of the Environmental Assessment certifying that the information contained in the report is neither false nor misleading;
9. A Quantity Surveyor's Certificate of Cost to verify the capital investment value of the project; and
10. An assessment of the key issues specified below and a table outlining how these key issues have been addressed.

Key Issues

The EA must address the following key issues:

1. Strategic Planning

1.1 Justify the proposal with reference to relevant local, regional and State planning strategies. Provide justification for any inconsistencies with these planning strategies.

1.2 Consider the recommendations of the Shellharbour Local Government Area Retail/Commercial Study and Employment Study.

1.3 Demonstrate consistency with the Sustainability Criteria set out in the relevant Regional Strategy (including draft Regional Strategies).

2. Urban Design, Visual Impact and Sustainability

2.1 Demonstrate suitability of the proposal with the surrounding area in relation to bulk, scale, amenity (including noise) and visual amenity having regard to the *Coastal Design Guidelines of NSW* (2003) and the *NSW Coastal Policy 1997*.

2.2 Address the visual impact of the proposal in the context of surrounding development and relevant mitigation measures. In particular address impacts on the amenity of the foreshore, overshadowing of public reserves, loss of views from public places and cumulative impacts.

2.3 Use visual aids such as scale model and photomontage to demonstrate visual impacts. Amelioration of visual impacts through design, use of appropriate colours and building materials, landscaping and buffer areas must be addressed.

2.4 Demonstrate intended compliance with the primary development controls under SEPP 65.

3. Infrastructure Provision

3.1 Address existing capacity and requirements of the development for sewerage, water, electricity, waste disposal, telecommunications and gas in consultation with relevant agencies. Identify and describe staging, if any, of infrastructure works.

3.2 Address developer contributions, and provide the likely scope of any planning agreement with Council/ Government agencies.

4. Traffic and Access

4.1 Prepare a traffic impact study in accordance with Table 2.1 of the RTA's Guide to Traffic Generating Developments which addresses, but is not limited to the following matters:

- The capacity of the road network to safely and efficiently cater for the additional traffic generated;
- Access to and within the site;

- Indicative servicing and parking arrangements;
- Intersection site distances;
- Connectivity to existing developments;
- Impact on public transport (including school bus routes);
- Provision of access for pedestrians and cyclists to, through and within the site; and
- Identify suitable mitigation measures, if required to ensure the efficient and safe functioning of the road network. This should include identification of pedestrian movements and appropriate provisions for shared path/cycleway/public transport to existing and proposed road network.

4.2 Undertake intersection modelling using aaSIDRA for all key junctions of the development with the existing road network. The modelling should consider AM and PM peak volumes and holiday peak volumes. Electronic copies of the input and output files, movement summaries and queue lengths must be submitted for evaluation.

4.3 Protect existing public access to and along the beach and coastal foreshore and provide, where appropriate, new opportunities for controlled public access. Consider access for the disabled, where appropriate.

5. Hazard Management and Mitigation

Coastal Processes

5.1 Address coastal hazards and the provisions of the Coastline Management Manual. In particular consider impacts associated with wave and wind action, coastal erosion, climate change, sea level rise and more frequent and intense storms.

5.2 Address consistency with Rivers and Foreshores Improvements Act 1948, NSW Coastal Policy, NSW Wetlands Management Policy, NSW State Rivers and Estuaries Policy and NSW Estuary Management Policy

Contamination

5.3 Identify any contamination on site and appropriate mitigation measures in accordance with the provisions of SEPP 55 – Remediation of Land.

Acid Sulfate Soils

5.4 Identify the presence and extent of acid sulfate soils on the site and, where relevant, appropriate mitigation measures in accordance with the Acid Sulfate Soil Manual (NSW Acid Sulfate Soil Management Advisory Committee 1998).

Bushfire

5.5 Address the requirements of Planning for Bush Fire Protection 2006 (RFS).

Geotechnical

5.6 Provide an assessment of any geotechnical limitations that may occur on the site and if necessary, appropriate design considerations that address these limitations.

Flooding

5.7 Provide an assessment of any flood risk on site in consideration of any relevant provisions of the NSW Floodplain Development Manual (2005) and Flood Policy of Shellharbour City Council.

5.8 Address the impact of flooding on the proposed development, the impact of the development on flood behaviour and the impact of flooding on the safety of people/users of the development, factors that may affect flooding on the site and flood planning levels. Implications of climate change and sea level on flooding and a range of

flood events (up to and including the probable maximum flood) should be considered.

5.9 Include an assessment of the sensitivity of flood model parameters (hydrologic and hydraulic)

5.10 Consider the potential impacts of any filling on the flood regime of the site and adjacent lands.

6. Water Cycle Management

6.1 Address and outline measures for Integrated Water Cycle Management (including stormwater) based on Water Sensitive Urban Design principles which addresses impacts on the surrounding environment, drainage and water quality controls for the catchment.

6.2 Assess the impacts of the proposal on surface and groundwater hydrology and quality.

7. Heritage and Archaeology

7.1 Address the draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC, July 2005).

7.2 Identify whether the site has significance to Aboriginal cultural heritage and identify appropriate measures to preserve any significance (Aboriginal community consultation should be undertaken in accordance with DEC's *Interim Community Consultation Requirements for Applicants*).

7.3 Identify any items of European heritage significance and, where relevant, provide measures for the conservation of such items.

8. Flora and Fauna

8.1 Outline potential impacts on aquatic and terrestrial flora and fauna and their habitats (within the meaning of the Threatened Species Conservation Act 1995 and the Fisheries Management Act 1994). Provide measures for their conservation, where relevant.

8.2 Provide predictions of any impacts on aquatic environments on or adjacent to the site, in particular on offshore rocky reef areas and measures for mitigation.

8.3 Address measures to protect and manage the riparian corridor and adjacent aquatic habitats.

9. Noise, Odour and Air Quality

9.1 Address potential noise impacts, in particular noise from the adjacent quarry and road traffic noise, for future residents and appropriate mitigation measures.

9.2 Address odour impact from existing or proposed new sewage system in accordance with DEC's Technical Framework for Assessment and Management of Odour from Stationary Sources in NSW 2006.

9.3 Address NSW Action for Air and Action for Transport Plans.

10. Socioeconomic Impacts

10.1 Address the potential social and economic impacts of the development particularly with regard to any increased need for facilities such as schools, hospitals and community facilities.

Consultation

You should undertake an appropriate and justified level of consultation with the following agencies during the preparation of the environmental assessment:

(a) *Agencies or other authorities:*

- Commonwealth Department of Environment and Water Resources
- Shellharbour City Council;
- Department of Environment and Climate Change;

- Department of Primary Industries;
- Department of Natural Resources;
- Roads and Traffic Authority;
- NSW Police;
- NSW Department of Education and Training;
- NSW Department of Health;
- Department of Planning Regional Office, Wollongong; and
- Local Aboriginal Land Council/s and other Aboriginal community groups

(b) *Public:*
Document all community consultation undertaken to date or discuss the proposed strategy for undertaking community consultation. This should include any contingencies for addressing any issues arising from the community consultation and an effective communications strategy.

The consultation process and the issues raised should be described in the Environmental Assessment.

Deemed Refusal Period
60 days

Attachment 2
Plans and Documents to accompany the Application

Plans and Documents of the development	The following plans, architectural drawings and diagrams of your proposal as well as the relevant documents will be required to be submitted for your application: 1. The **existing site survey plan** is to be drawn to 1:500 scale (or other appropriate scale) and show: • the location of the land, the measurements of the boundaries of the land, the size of the land and north point; • the existing levels of the land in relation to buildings and roads; • location and height of existing structures on the site; and • location and height of adjacent buildings and private open space. 2. An **aerial photograph** of the subject site with the site boundary superimposed. 3. A **Site Analysis Plan** must be provided which identifies existing natural elements of the site (including all hazards and constraints), existing vegetation, property dimensions, footpath crossing levels and alignments, existing pedestrian and vehicular access points and other facilities, slope and topography, natural features such as watercourses, rock outcrops, utility services, boundaries, orientation, view corridors and all structures on neighbouring properties where relevant to the application (including windows, driveways etc.). 4. A **locality/context plan** drawn to 1:500 scale (or other appropriate scale) should be submitted indicating: • significant local features such as parks, community facilities and open space, water courses and heritage items; • the location and uses of existing buildings, shopping and employment areas; • traffic and road patterns, pedestrian routes and public transport nodes; and • The existing site plan and locality plan should be supported by a written explanation of the local and site constraints and opportunities revealed through the above documentation. 5. The **Environmental Assessment** in accordance with the Director-General's Environmental Assessment Requirements as outlined in Attachment 1. 6. **Indicative subdivision plans** are to show the following:- • The location, boundary dimensions, site area and north point of the land; • Proposed subdivision pattern and location of all proposed roads and footpaths; • Location of all structures proposed and retained on site; • Finished levels in relation to roads, footpaths and structures; • Location of access points to the subdivision; • Type of subdivision proposed (Torrens, strata and/or community title). 7. The **Conceptual Architectural drawings** are to illustrate the following general features: • location of any existing building envelopes or structures on the land;

	• proposed communal facilities and servicing points; • height shown as building envelopes in elevation and the length and built form of proposed buildings in relation to the land; • significant level changes; • parking and vehicular access arrangements; and • pedestrian access to, through and within the site. 8. **Stormwater Concept Plan** - illustrating the concept for stormwater management from the site and must include details of any major overland flow paths through the site and any discharge points to the street drainage system. Where an on-site detention system is required, the type and location must be shown and must be integrated with the proposed landscape design. Site discharge calculations should be provided. 9. **Landscape Concept Plan** – plan or drawing that shows the indicative planting design and plant species to be used, listing botanical and common names 10. **View analysis** – artist's impression, photomontages, etc of the proposed development in the context of the surrounding development
Specialist advice	Specialist advice, where required to support your Environmental Assessment, must be prepared by suitably qualified and practising consultants in relation to issues including, but not limited to, the following: • Flora and Fauna; • Bushfire; • Landscaping; • Aboriginal archaeology; • Geotechnical and/or hydro geological (groundwater); • Stormwater/drainage; • Urban Design/Architectural; • Contamination in accordance with the requirements of SEPP 55; and • Acid Sulphate Soil Management Plan.
Documents to be submitted	• 20 hard copies of the Environmental Assessment; • 20 sets of architectural and landscape plans to scale, including one (1) set at A3 size (to scale); • 1 copy of the Environmental Assessment and plans on CD-ROM (PDF format), not exceeding 5Mb in size (see below); and • If the Environmental Assessment is bulky and lengthy in volume, you will be required to package up each Environmental Assessment ready for distribution by the Department to key agencies.
Electronic Documents	Electronic documents presented to the NSW Department of Planning for publication via the Internet must satisfy the following criteria:- • Adobe Acrobat PDF files and Microsoft Word documents must be no bigger that 1.5 Mb. Large files of more than 1.5 Mb will need to be broken down and supplied as different files. • File names will need to be logical so that the Department can publish them in the correct order. Avoid sending documents that are broken down in more than 10 files. • Image files should not be bigger than 2Mb. The file names will need to be clear and logical so the Department can publish them in the correct order. • Graphic images will need to be provided as [.gif] files.

	• Photographic images should be provided as [.jpg] files. • Large maps will need to be presented as individual files and will need to be calibrated to be no more than 2Mb each. • Images inserted into the document will need to be calibrated to produce files smaller than 1.5Mb. Large images will need to be presented as individual files and will need to be calibrated to be no more than 2Mb each. The file names will need to be clear and logical so the Department can publish them in the correct order. Alternatively, these electronic documents may be placed on your own web site with a link to the Department of Planning's website.

Attachment 3
State Government technical and policy guidelines

The following list provides relevant technical and Policy Guidelines which may assist in the preparation of the Environmental Assessment. It should be noted, however, that this list is not exhaustive as other documents and policies may need to be reviewed. It is also important to note that not of all of these guidelines may be relevant to your proposal.

The majority of these documents can be found on the relevant Departmental Websites, on the NSW Government's on-line bookshop at http://www.bookshop.nsw.gov.au or on the Commonwealth Government's publications website at http://www.publications.gov.au.

Aspect	Policy /Methodology
Biodiversity	
Flora and Fauna	Draft Guideline for assessment of impacts on Threatened Species under Part 3A (Department of Planning 2005)
Fish and Aquatic Ecosystems	Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (NSW Fisheries, 2003)
	Threatened Species Management Manual (NPWS, 1998)
Coastal Planning	
	NSW Coastal Policy 1997 - A sustainable Future for the New South Wales Coast, NSW Government, 1997
	Coastal Design Guidelines for NSW, PlanningNSW, February 2003
	NSW Wetlands Management Policy (DLWC, March 1996)
Bushfire	
	Planning for Bushfire Protection 2006 (NSW Rural Fire Service)
Contamination of Land	
	Best Practice in Contaminated Sites (Commonwealth DEH, 1999, ISBN 0 642 546460)
Environmental Management Systems	
	NSW Government Interim Water Quality and River Flow Environmental Objectives (DEC)
	Guidelines for the preparation of Environmental Management Plans (DIPNR, 2004)
Heritage	
Aboriginal	Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC July 2005)
	Draft Guideline for assessment of impacts on Aboriginal Heritage under Part 3A (Planning 2005)
	Interim Community Consultation Requirements for Applicants (DEC, 2004)
Non-Indigenous	Assessing Heritage Significance Update for Heritage Manual (Heritage Office, 2000)
	NSW Heritage Manual (NSW Heritage Office, 1996)
Noise	

Aspect	Policy /Methodology
	Environmental Criteria for Road Traffic Noise (EPA, 1999)
	Acoustics - Road traffic noise intrusion - Building siting and construction (Standards Australia, 1989, AS 3671-1989)
Rehabilitation	
	Managing Urban Stormwater: Soils & Construction (NSW Landcom, March 2004) - "The Blue Book"
Safety and Hazards	
	Electrical Safety Guidelines (Integral Energy)
Soils	
	Acid Sulfate Soil Manual (ASSMAC)
	Contaminated Sites: Sampling Design Guidelines (EPA, 1999)
Traffic & Transport	
	Guide to Traffic Engineering and Guide to Geometric Design of Rural Roads (Austroads, 2003, AP-G1/03)
	Guide to Traffic Generating Developments (RTA, 2002)
Urban Design: Cycleway/Pathway Design	
	Guidelines for the Design and Construction of Paths and Cycleways along Watercourses and Riparian Areas (Version 2) (DIPNR/DNR)
Water	
	Water quality guidelines for the protection of aquatic ecosystems for upland rivers. (ANZECC, 2000)
Floodplain	NSW Government Floodplain Development Manual - the Management of Flood Liable Land (DIPNR, 2005)
Groundwater	NSW State Groundwater Quality Protection Policy (DLWC, 1998, 0 7313 0379 2)
Stormwater	Managing Urban Stormwater: Soils & Construction (NSW Landcom, March 2004) - "The Blue Book"
Waterways	Waterways Crossing Design & Construction (Version 4 – DIPNR/DNR Draft Guidelines)
EPBC Act	
FOR A CONTROLLED ACTION	Commonwealth Environment Protection and Biodiversity Conservation Act 1999: Guide to implementation in NSW: March 2007

Attachment 4
Agency Responses to Request for Key Issues - For Information Only

- Shellharbour City Council
- NSW Department of Primary Industries
- NSW Department of Natural Resources
- NSW Department of Environment and Climate Change (formerly DEC)
- NSW Roads and Traffic Authority

APPENDIX B STORMWATER QUALITY MANAGEMENT STRATEGY, SEPTEMBER 2009

WorleyParsons

resources & energy

EcoNomics

AUSTRALAND HOLDINGS LTD

Shell Cove Boat Harbour Precinct

Stormwater Quality Management Strategy

301015-01089

25 September 2009

Telephone: 8456 7200
Facsimile: 8923 6877
www.worleyparsons.com
ABN 61 001 279 812

Disclaimer

PROJECT 301015-01089 - SHELL COVE BOAT HARBOUR

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
1	Final	O Roborgh	N/A	N/A	14-10-05	N/A	
2	Refined	CJ Moon	MT	MT	05-02-08		
3	For Approval	CJ Moon	MT	MT	10-07-09		
4	Final Rev B	AE Williams	CJ Moon	MT	13-08-09		
5	Final Rev C	AE Williams	CJ Moon	MT	23-09-09		

CONTENTS

1. INTRODUCTION

WorleyParsons have been commissioned by Australand Holdings Ltd to prepare a stormwater quality management strategy for the proposed Shell Cove Development in Shellharbour. This strategy has been prepared for inclusion in a Part 3A application for the Boat Harbour precinct.

WorleyParsons (Incorporating Patterson Britton & Partners) have previously prepared two revisions of this strategy: 'Stormwater Quality Management Strategy', Issue No 1, October 2005; and 'Refined Stormwater Quality Management', Issue No. 2, February 2008. The predevelopment catchments are presented on **Figure 1.**

The Issue 1 report was prepared in support of a Section 96 application that included minor amendments to the approved Boat Harbour. The Issue 2 report was prepared to refine the Stormwater Quality Management Strategy in accordance with additional site details and updates to modelling software as they became available.

This report incorporates the findings of the above reports and further refines and updates the strategy in support of the Part 3A application for the Boat Harbour precinct.

The proposed catchments and extent of development and runoff water quality treatment measures are presented on **Figure 2.**

2. STORMWATER QUALITY MANAGEMENT STRATEGY

2.1 Background

2.1.1 Environmental Impact Assessment (June 1995)

GHD prepared the document *'Environmental Impact Statement Shell Cove Boat Harbour / Marina Shadforth Wetland Haul Road Landfill'* in June 1995. Appendix 13 of the above document relates to the hydrology, hydraulics and water quality of the Shell Cove development.

With regards to stormwater quality, the target adopted was that the post development pollutant loads match those for the pre-development or existing conditions. The preliminary sizing of the proposed stormwater treatment measures (*STMs*) was undertaken.

The investigations using water quality modelling in AQUALM indicated that the predicted post development average annual loads of the pollutants suspended solids (*SS*), total phosphorus (*TP*) and total nitrogen (*TN*) could be reduced to below the predicted existing condition loads following the installation of STMs.

2.1.2 Shell Cove Commission of Inquiry (January 1996)

A Commission of Inquiry (COI) was established to review the project and the EIS and provide recommendations as to whether it should be approved.

The predevelopment catchment runoff discharged to the Shellharbour Swamp before flowing into the ocean across Shellharbour South Beach. The Boat Harbour was to be constructed over the Shellharbour Swamp.

As part of the Inquiry (*1996*) the Commissioners sought not just to achieve a runoff water quality matching the existing load discharged to the Shellharbour Swamp but to match the load discharged from the swamp to the ocean. It appears this target was adopted as a precautionary principle to ensure there was an improvement in runoff water quality. The relative performance for the swamp as adopted in the COI was applied to establish the target pollutant load for the development.

Ministerial consent was granted for the Boat Harbour in 1996.

2.1.3 Section 96 Application (October 2005)

A Section 96 application was submitted for minor variations and amendments. As part of the application Patterson Britton prepared a stormwater quality management strategy. The Section 96 strategy meets the COI objectives and incorporated the most up to date data and methodology. Ministerial consent was granted for the Section 96 application with the Director General issuing conditions dated 1st June 2007.

2.2 Refined Strategy (February 2008)

As the masterplan has evolved during the design process additional detail regarding the physical constraints of the site has become available. This additional detail was worked into the refined Stormwater Quality Management Strategy.

With the inclusion of the additional detail into the MUSIC model, a refined set of pollutant targets were set and the achievement of these targets demonstrated.

The proposed development has two separate outlets each with individual targets, these are:

1. The proposed Shell Cove Boat Harbour will match the existing discharge conditions from the swamp to the ocean, as per the COI; and
2. The proposed business park which follows the existing drainage line for the area to the Tasman Sea will have to match the existing conditions for that corresponding catchment, in line with the COI requirements.

3. PRE-DEVELOPMENT CONDITIONS

3.1 Landuse Description

Aboriginal occupation of the area dates back at least 17,000 years, with the Wadi Wadi tribe being the first inhabitants of the Shellharbour district. This tribe occupied a large area of land along the Illawarra coastline, extending inland as far as Picton and Moss Vale. They hunted and collected food as they passed through the district in small groups, and had a relatively minor impact on the natural environment.

Settlement by Europeans began in 1803 when the government gave free grazing rights to James Badgery. At this stage, grazing was practiced in natural grassy clearings. In this era, Europeans also came to the district to cut Red Cedar.

The government subdivided the Shellharbour district in 1817 and issued free land grants between 1817 and 1831 and the land continued to be used to graze cattle.

The clearing of land accelerated in 1843 when Caroline Chisholm arranged for immigrant families to settle in the area. The families settled the land under a new system of clearing leases. Various agricultural activities were then undertaken including, vegetable growing, grain crops, pork, beef and dairy products. Dairying soon became the dominant activity and remained so for more than 100 years.

From the 1950s until recently, the site contained a golf course that periodically irrigated and fertilised the fairways and greens. During this period commercial farming ceased on the site, while farming on the adjacent Dunmore area has been active up to the recent construction of the new golf course.

3.2 Stormwater Water Quality Monitoring

Detailed monitoring has been undertaken of the rainfall and runoff characteristics within the existing Shell Cove catchment draining to Shellharbour Swamp (*the proposed Boat Harbour*) and also within the adjacent Dunmore catchment.

3.2.1 Boat Harbour Catchment (Rural)

The sampling site for the Boat Harbour catchment was located near the old Haul Road culvert crossing of the main creek. This was upstream of the old Shellharbour golf course and contained remnant riparian vegetation. This catchment is not considered representative of the historical land use pattern of grazing and more recently as a golf course.

3.2.2 Dunmore Wetland (Rural)

The Dunmore Wetland catchment is located immediately south of the subject site on the other side of the ridge. The sampling site for the Dunmore Wetland catchment was located approximately 80m

upstream of a dam on the watercourse immediately east of Shellharbour Road and draining south from the Haul Road to Dunmore Wetland. The catchment contained grazing and remnant riparian vegetation. This site is considered to contain landuse more representative of the historical landuse contained in the proposed Boat Harbour catchment.

During runoff monitoring of the catchment, an automatic water sampler was installed at each of the monitoring locations detailed in **Sections 3.2.1** and **3.2.2**. The water level at the samplers was used to trigger automatic sample collection. Samples were collected during individual rainfall runoff events and the samples were sent to a laboratory for analysis. Event Mean Concentrations (EMCs) were determined for each runoff event.

From 1996, a number of discrete monitoring results have been reported as outlined in **Table 3.1**. For the purpose of this stormwater quality management plan, average values have been calculated from all the results at each of the locations.

A statistical overview of urban stormwater quality has been carried out by Duncan in 1999. Duncan considered data from analysis of over 500 Australian and overseas studies. This has been updated with further work in 2004 by Duncan. The EMC values presented by Duncan for rural conditions have been included in **Table 3.1**.

Table 3.1 Monitoring Results – Existing Conditions

Monitoring Location	**EMC** (*mg/L*)		
	SS	**TP**	**TN**
Rural (*Proposed Boat Harbour Catchment*)			
from 2/95 *GHD,1996*	73	0.17	1.51
till 8/96 *GHD, Feb 1997*	70	0.18	1.43
till 1997 *GHD, Oct 1997*	106	0.2	1.73
till 1998 *GHD, 1999*	105	0.16	1.3
Average Rural (*Boat Harbour*)	**89**	**0.18**	**1.49**
Rural (*Dunmore Catchment*)			
till 1997 *GHD, Oct 1997*	146	0.28	2.3
till 1998 *GHD 1999*	139	0.27	2
Average Rural (*Dunmore*)	**143**	**0.28**	**2.15**
Rural (*Duncan*)	**90**	**0.22**	**2**

3.2.3 Adoption of Pre-development EMC Values

For the purpose of the stormwater quality modelling outlined in **Section 5**, EMC values need to be selected that are representative of the historical landuse for the Boat Harbour catchment.

The location of the proposed Boat Harbour catchment sampling point did not account for the golf course draining to the existing Shellharbour Swamp. Also a riparian corridor of remnant vegetation that had not undergone any grazing for at least a decade was the main landuse draining to the sampling point. The data collected by this monitoring was not considered representative of the historical landuse patterns and would have under predicted the actual pollutant loads in runoff discharged to the Shellharbour Swamp.

The catchment for the creek upstream of the Dunmore sampling site contained grazing land and remnant riparian vegetation. This landuse is considered to be more representative of the historical landuse patterns that have been applied to the proposed Boat Harbour catchment even though it does not take account of the golf course landuse. While an accurate representation of the actual pollutant export from the site would be estimated utilising the local Dunmore monitoring data, a more conservative approach has been taken by adopting the Duncan rural values.

The Duncan EMC values are lower than those for the Dunmore catchment thereby predicting lower pollutant generation for historical or pre Shell Cove development. As such, use of the Duncan rural values provides a more stringent water quality target for the development to meet.

3.3 Pre-developed catchment refinement

To more accurately model the pre-developed conditions the catchment area for the existing Shellharbour Township, Parklands, Graveyard and the Shell Cove site have been further broken down. The catchment boundaries for the pre-development state are shown in **Figure 1**.

4. PROPOSED DEVELOPMENT

4.1 Description

The proposed development consists largely of low to medium density residential lots surrounding a small commercial area that sits on the edge of the proposed man made Boat Harbour. Numerous wetlands, riparian corridors, pockets of remnant vegetation and recreational land will be incorporated into the proposed stormwater management strategy and development.

The proposed development on completion will include the construction of the following landuses which will drain to the Boat Harbour;

- Boat Harbour;
- 2,400 residential allotments;
- district retail centre;
- business park
- community facilities; and
- open space.

The extent of development is shown on **Figure 2**.

The drainage characteristics of the proposed development will mirror that of pre-developed conditions with all runoff draining centrally towards the proposed Boat Harbour, formally Shellharbour Swamp. Stormwater runoff would travel to the Boat Harbour via the drainage corridors before being discharged into the Boat Harbour and ultimately the Tasman Sea. The proposed layout and sub-catchments are shown in **Figure 2**.

4.2 Urban Runoff Concentrations

Detailed monitoring has been undertaken of the rainfall and runoff characteristics from the existing Shellharbour commercial/retail strip catchment. Monitoring has also been undertaken in the Shell Cove site for an existing developed residential catchment and constructed wetland (*Wetland 1*) on site.

4.2.1 Monitoring Shellharbour Commercial/Retail Strip (*Urban*)

Stormwater draining from the existing Shellharbour Township has been monitored at the stormwater pipe at the lower end of Addison Street Shellharbour, located approximately at the southern boundary of the car park. The catchment does not drain to the site and is not considered representative of the broader uses expected under a heading of urban development.

4.2.2 Monitoring Wetland 1 (*Urban*)

Constructed Wetland 1 located within a completed portion of the Shell Cove development has been the subject of a monitoring program. The stormwater inflow to Wetland 1 has been monitored over a period from 2003 to 2004. Over this period, 12 rainfall events and 11 dry weather samples taken. Samples have been collected from rainfall events with rainfall greater than 10mm in depth. Construction of the residences and Wetland 1 has been complete since 1999 and 2002 respectively; the catchment can be considered to be representative of a typical residential catchment.

4.2.3 Monitoring Results Wetland 1 (*Urban*)

During the monitoring of Wetland 1 an automatic water sampler was installed. The water level at the recorder was used to trigger automatic sample collection. Samples were collected during individual rainfall runoff events, the samples were sent to a laboratory for analysis and the EMCs for each runoff event were determined.

For the purpose of this report, average values have been calculated from all the results and are presented in **Table 4.1**.

A statistical overview of urban stormwater quality has been carried out by Duncan in 1999. Duncan considered data from analysis of over 500 Australian and overseas studies. This was updated by Duncan with further work in 2004. The EMC values presented by Duncan for residential conditions have been included in **Table 4.1** for comparison.

Table 4.1 Monitoring Results Wetland 1 (*URBAN*)

Monitoring Location	**EMC** (*mg/L*)		
	SS	**TP**	**TN**
Wetland 1 (till 2004 *BMD, 2004)*	38	0.168	1.5
Duncan (*Residential*)	140	0.25	2.0

4.2.4 Adoption of Urban EMC Values

For the purpose of the stormwater quality modelling outlined in **Section 5,** EMC values representative of the developed conditions need to be selected.

The EMC values calculated from the Wetland 1 sampling are derived from a catchment that is considered to be representative of the proposed development on the site. However in comparison with the Duncan values for a residential catchment, the monitoring results have significantly lower pollutant loads. This could be due to the fact that the catchments contained in the Duncan study may have been older and built with less stringent sewer requirements resulting in leakage of nutrients to the stormwater runoff. If this is the case, the use of Duncan residential values for new development with better sewerage infrastructure would over predict the pollutant export rates.

However, it is considered appropriate to adopt the widely accepted industry standard Duncan EMC values for residential land use. This approach applies a degree of conservatism as the Duncan EMC values are significantly higher than the Wetland 1 EMC values, resulting in over prediction of pollutant loads.

5. STORMWATER QUALITY IMPACT ASSESSMENT

5.1 Requirements

It is considered that the target runoff water quality for the Shell Cove development is as established in the COI approval and confirmed in the Section 96 application. The target being to ensure that the annual pollutant load export to the proposed Boat Harbour in the developed state does not exceed that of the existing state export from the existing (pre-development) conditions, including the treatment provided by Shellharbour Swamp.

In addition Department of Environment and Conservation (*DEC*) guidelines as presented in Managing Urban Stormwater: Council Handbook EPA (1996), recommend reductions in the post development pollutant loads for runoff from a site. The following DEC guidelines have been considered as additional pollutant attenuation objectives:

- Suspended solids 80% reduction;
- Total Phosphorus 45% reduction; and
- Total Nitrogen 45% reduction.

Water quality modelling was used to estimate the annual pollutant load discharging from the site in both the existing *(pre Shell Cove development)* and developed conditions.

5.2 Water Quality Modelling

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads.

MUSIC is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

To undertake the water quality assessment a long-term MUSIC model was established for the Shell Cove site. The model was used to estimate the annual pollutant load generated from the site under the existing state and developed conditions for a mean rainfall year. The MUSIC model developed layout is attached in **Appendix A**.

MUSIC was chosen for this investigation because it has the following attributes:

- it can account for the temporal variation in storm rainfall throughout the year;
- modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- it can model a range of treatment devices;
- it can be used to estimate pollutant loads at any location within the catchment; and

- it is based on logical and accepted algorithms.

5.3 Rainfall and Evaporation

The following rainfall and evaporation records in the vicinity of Shell Cove were adopted for use in the MUSIC model of the site.

5.3.1 Rainfall

The 1995 EIS adopted rainfall data from Albion Park to determine the stormwater pollutant export to the Boat Harbour. The Albion Park data is available only as a daily time step. In order to develop a MUSIC model that comprehensively assesses the performance of water quality treatment devices such as bioretention basins and wetlands, 6 minute pluviograph data is necessary.

The Bureau of Meteorology weather station at Port Kembla (*68131*) near the site contains a pluviograph. Data from this station for 1996-2002 with a mean annual rainfall of 1014mm has been adopted. This rainfall data set is considered a reasonable reflection of the rainfall data presented in the 1995 EIS.

5.3.2 Evaporation

Monthly areal potential evapotranspiration values were obtained for the site from 'Climate Atlas of Australia, Evapotranspiration' (*Bureau of Meteorology, 2001*) and are shown in **Table 5.1**.

Table 5.1 Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	170
February	130
March	115
April	80
May	55
June	40
July	40
August	55
September	85
October	125
November	145
December	160

5.4 Soil Data and Model Calibration

A rainfall-runoff calibration was undertaken prior to modelling being undertaken. The model was calibrated to achieve a volumetric coefficient of 0.28 from a 100% pervious catchment. This value was determined from Table F.2 of the EPA document 'Managing Urban Stormwater: Council Handbook'. The following soil parameters have been adopted for the MUSIC model:

Impervious Area

- rainfall threshold 3.5mm

Pervious Area

- soil capacity 60mm
- initial storage 50mm
- field capacity 40mm
- infiltration coefficient '*a*' 50
- infiltration exponential '*b*' 0.20

Groundwater Properties

- initial depth 50mm
- daily recharge 25%
- daily base flow 5%

The adopted objective of the water quality management strategy is to achieve a no net increase in the annual pollutant load. Therefore, the pre-development pollutant export from the site was estimated to establish the base case against which to formulate the water management strategy for the proposed development.

5.5 Pollutant Concentrations

The pre-developed and developed site catchment conditions and characteristics are discussed in **Section 3** and **4** respectively. The pollutant EMC values adopted for each land use type for the purpose of the MUSIC model are presented in **Table 5.2**.

Table 5.2 Adopted Pollutant Concentrations (*EMC mg/L*)

Land Use	Suspended Solids	Total Phosphorous	Total Nitrogen
Urban (Duncan Residential)	140	0.25	2.0
Roofs (Duncan)	20	0.13	2.0
Pre-developed Site (Duncan Rural)	90	0.22	2.0

5.6 Pre-developed State

5.6.1 Existing Shellharbour Swamp

The 1996 Shell Cove Commission of Inquiry determined that pollutant retention from the existing Shellharbour Swamp was to be included in the estimation of the existing state pollutant export to Shellharbour Beach. It was estimated in 1996 for the COI that the pollutant retention of the existing Shellharbour Swamp was approximately:

- SS – 36%;
- TP – 7%; and
- TN – 4%.

A generic treatment node has been included in the existing state MUSIC model that adopts the above pollutant retention percentages.

5.6.2 Pre-development Catchment Characteristics

The catchment areas defined in **Table 5.3** have been adopted to create a MUSIC model for the pre Shell Cove development conditions.

Table 5.3 Catchment Parameters – Predevelopment State

Subcatchment	Area (*ha*)	Impervious (%)
Pre-developed Site	261.01	10
Pre-developed Commercial*	9.12	10
Graveyard	3.75	15
Shellharbour Parkland	1.18	20
Shellharbour Township	52.56	60
External Catchment M	1.40	30
Total	**329.02**	

*Pre-developed commercial refers to the proposed technology park draining directly to the Tasman Sea.

5.6.3 Pre-development Conditions Pollutant Export

The MUSIC model was used to simulate the pollutant export generated during a mean rainfall and evaporation year using the typical pollutant concentrations contained in **Table 5.2**.

The estimated annual export of pollutants discharging out of Shellharbour Swamp from the predevelopment state catchment for a mean year is shown in **Table 5.4**.

The pre-developed volumetric run-off co-efficient is 0.32 for the Shell Cove site and surrounding catchments.

Table 5.4 Annual Pollutant Export Loads – Pre-development

Node / Location	Pollutant Load (*kg/yr*)		
	Suspended Solids	Total Phosphorous	Total Nitrogen
Shellharbour South Beach	70,500	202	1,840
Commercial Area	1,740	4.34	42.5

5.7 Developed State

5.7.1 Developed Catchment Characteristics

To determine the requirements of the water quality management strategy, the pre-development model was modified to reflect the proposed developed catchment. The model was modified to reflect the impervious proportions defined in **Table 5.5** and pollutant concentrations of the developed catchment as defined in **Table 5.2**.

Table 5.5 Catchment Parameters - Developed State

Sub Catchment	Total Area (ha)	Impervious %	Land Use
Sub-Catch A Rural 1	7.41	5%	Rural
Sub-Catch A Rural 2	7.12	5%	Rural
Sub-Catch A Rural 3	5.69	5%	Rural
Sub-Catch A (commercial east)	7.56	70%	Urban
Sub-Catch A (commercial west)	2.04	70%	Urban
Sub-Catch A1	10.51	41%	Urban
Sub-Catch A1 roof	2.09	100%	Urban
Sub-Catch A2	9.27	39%	Urban
Sub-Catch A2 roof	1.87	100%	Urban
Swale A2	0.16	0%	Forested
Sub-Catch A3	3.24	40%	Urban
Sub-Catch A3 roof	0.65	100%	Urban
Sub-Catch A4	3.74	41%	Urban
Sub-Catch A4 roof	0.74	100%	Urban
Sub-Catch B	2.76	41%	Urban
Sub-Catch B roof	0.55	100%	Urban
Sub-Catch C	2.85	40%	Urban
Sub-Catch C roof	0.57	100%	Urban
Sub-Catch D	6.59	54%	Urban
Sub-Catch D roof	1.01	100%	Urban
Riparian Zone D	0.50	5%	Forested
Wetland 6a and 6b (D)	0.71	100%	Forested
Sub-Catch E1	10.69	60%	Urban
Bio-retention (E1 east)	0.08	0%	Urban
Bioretention E1 (west)	0.08	0%	Urban
Sub-Catch E2	10.91	54%	Urban
Sub-Catch E2 roof	1.67	100%	Urban
Sub-Catch E3	3.96	54%	Urban

Sub Catchment	Total Area (ha)	Impervious %	Land Use
Sub-Catch E3 roof	0.61	100%	Urban
Wetland 7A (E3)	0.50	0%	Forested
Sub-Catch E4	9.87	54%	Urban
Sub-Catch E4 roof	1.59	100%	Urban
Sub-Catch E5	2.61	54%	Urban
Sub-Catch E5 roof	0.40	100%	Urban
Sub-Catch E6	2.57	40%	Urban
Sub-Catch E6 roof	0.51	100%	Urban
Sub-Catch F1	9.75	60%	Urban
Sub-Catch F2	7.42	60%	Urban
Bio-retention F (F2)	0.15	0%	Forested
Bio-retention F2	0.24	0%	Forested
Recreation A (F2)	7.33	15%	Forested
Sub-Catch G1	1.05	41%	Urban
Sub-Catch G1 roof	0.21	100%	Forested
Bioretention G1	0.11	0%	Urban
Sub-Catch G2	0.87	40%	Urban
Sub-Catch G-2 roof	0.17	100%	Forested
Bio-retention G2	0.20	0%	Urban
Sub-Catch H	2.40	40%	Urban
Sub-Catch H roof	0.40	100%	Urban
Bio-retention H	0.22	0%	Forested
Sub-Catch I	1.16	39%	Urban
Sub-Catch I roof	0.24	100%	Urban
Sub-Catch J1	4.87	39%	Urban
Sub-Catch J1 roof	0.99	100%	Urban
Sub-Catch J2	1.38	41%	Urban
Sub-Catch J2 roof	0.27	100%	Urban
Sub-Catch K1	21.03	50%	Urban
Sub-Catch K2	10.60	50%	Urban
Riparian Zone K2	2.30	5%	Forested
Wetland Area 1 and 5 (K2)	1.40	100%	Forested
Sub-Catch L	28.17	50%	Urban
Sub-Catch M	18.68	50%	Urban
Wetland 1a (M)	0.33	100%	Forested
Sub-Catch N	30.87	50%	Urban
Riparian Zone N	4.85	15%	Forested
MDB1pond 1 and 2 (N)	0.61	100%	Forested
Sub-Catch O	6.21	50%	Urban
Sub-Catch P	5.27	50%	Urban
Riparian Zone P	4.57	5%	Forested

Sub Catchment	Total Area (ha)	Impervious %	Land Use
Remaining Vegetation P	3.52	0%	Forested
Sub-Catch Q	13.90	50%	Urban
Riparian Zone Q	1.98	5%	Forested
Wetland 3a and 3b Area (Q)	1.00	100%	Forested

5.8 Refined Proposed Treatment Strategy

The proposed Stormwater Quality Management strategy has been simulated in MUSIC to estimate the treatment efficiencies in a mean rainfall year. The strategy is described in the following sections.

5.8.1 Wetlands

Wetlands can support a range of water quality management objectives. The processes influencing water quality in wetlands resemble those operating in better-known aquatic environments. The wetland's inflow, organic matter and nutrient loads, and hydrologic regime determine the dominance of particular processes in the wetland and their relative importance. The three significant types of processes are:

- biological and chemical processes involving soluble materials (e.g. uptake of nutrients by epiphytes, adsorption and desorption of phosphorus onto and from particles, nitrification and denitrification);
- coagulation and filtration of small, colloidal particles (e.g. adhesion of colloids and particles on the surface of aquatic vegetation. These particles are in a size-density range that makes them too small to settle under all but the most quiescent conditions);
- physical sedimentation of particles (e.g. sedimentation in wetlands due to decreased water velocity. Large plants (macrophytes) such as reeds and rushes enhance this process by further reducing turbulence and water velocity).

5.8.1.1 Wetland Performance

A stormwater monitoring program has been carried out by BMD on the inflow and outflow of a constructed wetland (*Wetland 1*) located within the Shell Cove development. Wetland 1 has been constructed to provide water quality treatment to the stormwater runoff from the local urban catchment. The *Water Quality Sampling Program* was prepared by GHD in June 2004.

It is reported that Wetland 1 has been established since early 2003 and the monitoring period extended between December 2003 and September 2004. Over this period, 12 rainfall events have been sampled and 11 dry weather samples taken. Samples have been collected from rainfall events

with rainfall greater than 10mm in depth. The catchment draining to the wetland has been developed prior to the wetland. At the time of the wetland being monitored the catchment could be considered representative of a typical urban catchment.

The collected samples have been analysed for a range of pollutants. The results have been used to calculate the EMC values for SS, TP and TN and estimate the stormwater pollutant removal capabilities of the wetland.

5.8.1.2 RESULTS OF MONITORING

The EMC values at the inlet and outlet of Wetland 1 as determined by BMD from the monitoring results are presented in **Table 5.6**. The percentage reduction in EMC values (*as calculated by PBP*) are also outlined in **Table 5.6**.

Table 5.6 Wetland 1 Average EMC Concentrations (*mg/L*)

Parameter	**Average EMC** (*mg/L*)		
	Inlet	Outlet	Reduction in EMC (%)
Total Suspended Solids (*mg/l*)	38	4	89
Phosphorous (*total reactive*) (*mg/l)*	0.094	0.017	82
Total Nitrogen (*mg/l*)	1.5	0.4	73

5.8.1.3 DISCUSSION OF MONITORING RESULTS

The Environment Protection Authority (*EPA*) has produced a document titled *Managing Urban Stormwater: Treatment Techniques,* 1996. This document contains pollution retention curves that calculate the estimated percentage of pollutant retention in wetlands based on a hydraulic residence time. The hydraulic residence time of constructed Wetland 1 can be estimated as the permanent wetland water volume divided by the average annual runoff volume. This method gives an effective hydraulic residence time of 19 days.

The EPA curves suggest that optimal retention of pollutant in wetlands occurs after approximately 10 days hydraulic residence time as there is little additional removal provided beyond 10 days. Removal rates for 5, 19 and 50 days hydraulic residence time have been estimated from the EPA curves and compared in **Table 5.7** with those calculated from the monitoring results.

Table 5.7 Comparison of Monitored and EPA Pollution Retention (*% removal*)

	Pollutant Removal (%)			
	Monitoring EMC reduction	EPA, 5 days (1996)	EPA, 19 days (1996)	EPA, 50 days (1996)
SS	89	50-80	60-90	95 max
TP	82	20-50	48-72	90 max
TN	73	10-40	38-54	60 max

The reduction in TP and TN EMC values as calculated from the samples collected from Wetland 1 in the monitoring program are significantly greater than those estimated for a similar retention time from the EPA curves *(19 days)*.

Analysis of constructed wetland performance in Australia has been undertaken by the Cooperative Research Centres (*CRCs*) for Catchment Hydrology (*CRCCH*) and Freshwater Ecology (*CRCFE*) and has been presented in an industry report titled *Managing Urban Stormwater Using Constructed Wetlands*, 1999. This document outlines that the effectiveness of a wetland system appears to be most influenced by the catchment runoff characteristics of the respective site (*i.e. the combined effects of climate, catchment size and land use*), as well as the design and surface area of the wetland (*the theoretical hydraulic residence time achieved in the wetland*). The relevant catchment and wetland characteristics for Wetland 1 are outlined below.

Rainfall

The monitoring period extended between December 2003 and September 2004. **Table 5.8** compares the historical average monthly rainfall at the nearby Port Kembla rain gauge (*period of rainfall 1963 to 2004*) with the monthly rainfall recorded at the same gauge over the monitoring period. The majority of the monthly totals are relatively similar with the exception of April, June and October. The variations in the monthly totals cancel out to give very similar total annual rainfalls. Therefore the rainfall conditions that occurred over the monitoring period could be considered typical of those events that would occur in an average year.

Table 5.8 Comparison of Historical Monthly Rainfall Data with Data Recorded Over the Monitoring Period (*mm*)

Month	Port Kembla, historical (*mm*)	Port Kembla, 2003-2004 (*mm*)
January	98	60
February	123	74
March	147	105
April	110	315
May	90	21
June	106	27
July	52	45
August	74	37
September	57	42
October	93	238
November	-	-
December	69	42
Annual	**1,019**	**1,006**

Relative Catchment Size

The surface area of Wetland 1 is approximately 5,950m^2. The area of catchment draining to Wetland 1 including the wetland surface area is approximately 218,955m^2. Hence the surface area of the wetland is approximately equivalent to 3% of the contributing catchment which is within the industry standard. It would therefore be expected to achieve typical pollutant removal rates.

5.8.1.4 APPLICATION OF MONITORING RESULTS TO MUSIC

The catchment, climate and physical properties of Wetland 1 suggest that the MUSIC model should predict pollutant removal rates in wetlands similar to those predicted by the monitoring results.

Wetland Background Concentrations

The concentration of inflow contaminants into a wetland tend to move towards an equilibrium or background concentration within that wetland.

MUSIC simulates this change using an algorithm that has an exponential decay towards the background concentration C*. The rate at which the wetland returns to the equilibrium values is determined by the hydraulic loading and the decay constant K. Stormwater entering a wetland could have a lower pollutant concentration than the assumed background concentration of the wetland. In

this case, due to the background concentrations, the outlet of the wetland would have a higher pollutant concentration than at the inlet.

The monitoring data indicates a wet and dry weather TN concentration at the outlet of 0.4 mg/L. Therefore the proposed Shell Cove development MUSIC model adopts a wetland background TN concentration of 0.4mg/L. The monitoring results suggest that it should not be any lower. The pollutant removal efficiencies in all the proposed wetlands as predicted by the MUSIC model are presented in **Table 5.9** along with the predicted EPA curve efficiencies based on the effective hydraulic residence time.

Table 5.9 Pollutant Removal Efficiencies

Pollutant Reduction (%)							
	MUSIC Predictions				EPA Curves		
Wetland	Hydraulic Residence (days)	TSS	TP	TN	TSS	TP	TN
Wetland 1a	6	64	42	44	47-75	20-60	20-40
Wetland 1	19	64	41	53	67-95	35-75	33-58
Wetland 2a	1	10	6	8	15-45	0-35	0-20
Wetland 2b	2	10	6	8	30-58	5-45	10-30
Wetland 3a	2	13	16	10	30-58	5-45	10-30
Wetland 3b	3	6	6	5	37-65	12-53	13-35
Wetland 5	5	15	13	10	45-72	18-59	20-40
Wetland 6a	1	4	3	3	15-45	0-35	0-20
Wetland 6b	2	5	3	3	30-58	5-45	10-30
Wetland 7	12	43	30	37	60-88	30-68	27-50

This illustrates that the MUSIC model is estimating wetland performance comparable to the EPA curve estimates. There is a degree of conservatism included as the reductions estimated in MUSIC are significantly less than those estimated by the site monitoring results for Wetland 1.

5.8.1.5 PHYSICAL PROPERTIES OF PROPOSED WETLANDS

The physical properties presented in **Table 5.10** have been adopted in the MUSIC model for the proposed wetlands

Table 5.10 Wetland Properties

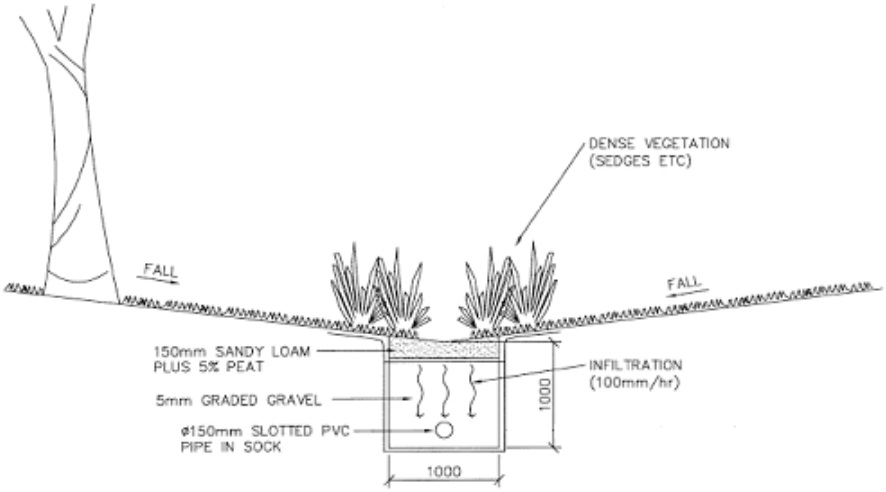
Wetland	Upstream Catchment	Surface Area	Permanent Pool Volume	Extended Detention Depth	Seepage Loss
Wetland no.1	K1	5955 m^2	5955 m^3	1.00 m	0.00 mm/hr
Wetland no.1a	M	3310 m^2	1655 m^3	0.50 m	0.00 mm/hr
Wetland no.2 (pond 1)	O	608 m^2	514 m^3	0.40 m	0.00 mm/hr
Wetland no.2 (pond 2)	O	1001 m^2	925 m^3	1.00 m	0.00 mm/hr
Wetland no.3a	L, Q	4900 m^2	3430 m^3	0.40 m	0.00 mm/hr
Wetland no.3b	L, Q	5100 m^2	3570 m^3	0.40 m	0.00 mm/hr
Wetland no.5	K2	8000 m^2	8000 m^3	0.40 m	0.00 mm/hr
Wetland no.6a	D	2500 m^2	1750 m^3	0.40 m	0.00 mm/hr
Wetland no.6b	D	4600 m^2	3220 m^3	0.40 m	0.00 mm/hr
Wetland no.7a	E3	5000 m^2	3500 m^3	0.30 m	0.00 mm/hr

5.8.2 Bio-retention Swales and Basins

Bio-retention systems are designed to promote the filtration of stormwater through a prescribed filter medium. Swales and basins would be depressed areas planted with native grasses and fringe vegetation on a layer of coarse sand and soil. The area below the swale or basin would be filled with gravel wrapped in geofabric membrane with perforated pipes at the base.

The purpose of bioretention is to provide a filtering effect to remove pollutants in the runoff when the runoff flows across the surfaces and through the vegetation. Further treatment would be achieved by filtering through the gravel trench and biological action due to growth on the gravel. Low flows are maintained as much as possible on the surface exposed to sunlight and with turbulence introducing oxygen to the flows.

The role of the bioretention systems is not to promote infiltration into the subsoils, although the swale would have check dams at regular intervals to promote infiltration into the drainage media. The proposed locations of the bioretention basins and swales are shown in the **Figure 2** and a typical cross section through a bioretention swale is shown below.



TYPICAL CROSS SECTION
OF A BIORETENTION SWALE
NTS

5.8.3 Gross Pollutant Trap

Gross Pollutant Traps (*GPT's*) would capture litter, debris, coarse sediment, oils and greases. While the pollutant capture efficiency of various traps may vary, the paper "*Removal of Suspended Solids and Associated Pollutants by a Gross Pollutant Trap*" (*Cooperative Research Centre for Catchment Hydrology, 1999*) suggests the following efficiencies. These efficiencies have been adopted for GPTs that do not have treatment in the Catchment above;

- gross pollutants majority;
- total suspended sediments up to 70%;
- total phosphorous up to 30%; and
- total nitrogen up to 13%.

Due to the level of treatment the stormwater from some catchments will have already undergone prior to the GPT's, the capture rates for GPT's downstream of treatment devices have been reduced to more conservative values. The following treated capture rates have been adopted:-

- gross pollutants majority;
- sediments up to 48%;
- total phosphorous up to 18%; and
- total nitrogen up to 8%.

GPT's would be placed in the locations as shown on **Figure 2**.

5.8.4 Seepage

Piezometers have been placed across the eastern side of the development as part of tests conducted by Coffey Geoscience Pty Ltd. The results from the permeability tests can be found in the "*Stage 2 Geotechnical and Acid Sulfate Assessment and Groundwater Study*" report by Coffey Geoscience Pty Ltd, 27th of October 2004.

The piezometers across the test site returned seepage rates ranging from between 2-9 mm/hr within the pre-developed swamp region. The test also yielded a small number of high seepage rates of up to 45 mm/hr. These rates were considered to be outlying results and have not been considered. Low range permeability results of less than 2 mm/hr were also achieved in some locations within the test area.

From the permeability tests, an average seepage rate of 4 mm/hr was adopted across all the swales within the site. This seepage rate is conservatively at the low end of the accepted range for sandy clay in MUSIC of between 3.6-36 mm/hr.

5.8.5 Rainwater Tanks

Rainwater tanks help reduce pollutant export into the harbour by collecting and storing rainwater for reuse.

Rainwater tanks will be required on all residential lots as part of the BASIX requirements. BASIX compliance is a requirement for DA approval for all new residential developments in New South Wales. A 40% reduction in potable water use is required to issue a certificate for BASIX compliance.

To estimate the size of the rainwater tanks on the development, it was assumed that the tanks were sized to meet the minimum BASIX requirement of total potable water reduction of 40% and water saving devices are implemented on taps, shower heads and toilets.

The WorleyParsons in house water balance model was used to determine an appropriate size for the rainwater tank. It was determined that each lot would have a 4kL rainwater tank.

The same rainfall and evaporation data used for the MUSIC model was adopted for the water balance model. The rainwater tanks will be located above ground collecting runoff from the roofs in residential lots. It is assumed that the average roof catchment area across the development is approximately 200m^2. Roof catchments have separated out in the MUSIC model and EMC values have been applied as per **Table 5.2**.

It is assumed that the rainwater tank will be used for internal and external non-potable water reuse (toilet flushing, washing machines and garden irrigation). The demand for non-potable water was collected from the Department of Planning NSW, 2005-2008 BASIX data.

With the water balance model, the appropriate size tanks were found for each catchment.

A breakdown of the rainwater tank volume, internal and external demand for each catchment is shown in **Table 5.11**.

Table 5.11 Rainwater Tank Properties

Catchment	Tank Volume (m^3)	Internal reuse (kL/day)	External Reuse (kL/yr)
Sub-Catch B	109	3	800
Sub-Catch C	114	4	835
Sub-Catch D	202	6	1477
Sub-Catch H	80	2	586
Sub-Catch G1	42	1	306
Sub-Catch J2	54	2	399
Sub-Catch I	47	1	348
Sub-Catch E2	334	10	2445
Sub-Catch A2	375	12	2745
Sub-Catch G2	35	1	255
Sub-Catch J1	197	6	1444
Sub-Catch A3	130	4	949
Sub-Catch A4	148	5	1086
Sub-Catch A1	418	13	3060
Sub-Catch E3	121	4	887
Sub-Catch E4	319	10	2336
Sub-Catch E5	80	2	585
Sub-Catch E6	103	3	752
Sub-Catch B	109	3	800
Sub-Catch C	114	4	835
Sub-Catch D	202	6	1477
Sub-Catch H	80	2	586

5.9 Developed Treated Pollutant Export

The water quality controls outlined in **Section 5.8** were incorporated into the MUSIC model for the developed scenario. The estimated annual exports of pollutant from the developed site (with treatment) for a mean rainfall year are shown in **Table 5.12**.

Table 5.12 Performance of Proposed Water Quality Management Strategy

Node / Location	Pollutant Load (kg/yr)					
	Suspended Solids		Total Phosphorous		Total Nitrogen	
	Pre	Proposed Treated	Pre	Proposed Treated	Pre	Proposed Treated
Boat Harbour	-	43,500	-	176	-	1,650
Shellharbour South Beach	70,500	46,700	202	185	1,840	1,750

Table 5.12 shows that the water quality objective of maintaining developed pollutant export rates at levels equivalent to the pre Shell Cove development condition has been achieved.

The reductions in pollutant export achieved relative to the predevelopment conditions and relative to the developed scenario with no stormwater treatments incorporated are presented in **Table 5.13.**

Table 5.13 Reductions in Pollutant Export

Parameter	Reductions in Pollutant Export Relative to (%)	
	Developed conditions with no treatment	Predevelopment conditions
Suspended Solids	82	24
Total Phosphorus	57	6
Total Nitrogen	47	-

The developed scenario produces a volumetric run off coefficient of approximately 0.38. The increase in runoff from 0.32 in the existing state is due to the increase in impervious area and is considered appropriate for the developed catchment incorporating rainwater tanks and some seepage loss in the bioretention swales.

From **Table 5.13** it can be seen that the DEC guidelines of 80% reduction in suspended solids export, 45% reduction in total phosphorous export and 45% reduction in total nitrogen export have been achieved for runoff discharging from the site. More importantly, the pollutant loads following development are less than or equivalent to those exiting the Shellharbour Swamp for the pre Shell Cove development conditions. This is significantly better than the load exiting the site in pre Shell Cove conditions because of the following conservative assumptions in our assessment:

- EMCs adopted for predevelopment conditions are low;
- EMCs adopted for developed conditions are high; and
- Wetland performance is under predicted.

5.10 Copper Export to the Boat Harbour

In order to assess the Boat Harbour water quality it was required to estimate the quantity of copper exported from the surrounding urban area via stormwater runoff.

Water quality monitoring (*BMD, November 2004*) has been carried out on the inflows and outflows of Wetland 1 in Shell Cove. One of the parameters tested for as part of the monitoring program was copper. The EMC values at the inlet and outlet of Wetland 1 as calculated by BMD are outlined in **Table 5.14**.

Table 5.14 Water Quality Monitoring Results

Location	**Wet EMC** (mg/L total copper)	**Dry EMC** (mg/L total copper)
Inlet	0.014	0.007
Outlet	0.005	0.007

This information is provided for completeness. The proposed Boat Harbour water quality was previously analysed during the CO1 and subsequent Sector 96 amendment to the approved Boat Harbour.

6. CONCLUSION

The pollutant loads discharged to the Boat Harbour in catchment runoff from the ultimate development have been estimated for the purposes of predicting Boat Harbour water quality.

The management of runoff in the catchment represents industry best practice with emphasis on water sensitive urban design and a treatment train approach.

The proposed stormwater management strategy for the development will ensure the runoff water quality discharged to the ocean is maintained compared to pre-development conditions. The stormwater controls would include:

- rainwater tanks;
- grass swales;
- vegetated drainage corridors;
- bio-retention swales and basins;
- gross pollutant traps; and
- wetlands.

The prediction of runoff pollutant loads has been conservative in that it over predicts the loads, under predicts the treatment performance and has a target performance level considerably below the actual pre Shell Cove development conditions. Even with this conservatism, the predicted post-development pollutant loads are equal to or less than the adopted pre Shell Cove development conditions.

In addition, the predicted post-development pollutant loads meet DEC guidelines.

The proposed commercial precinct '*A Commercial East"* draining directly to the Tasman Sea will need to implement a water sensitive urban design stormwater strategy. The strategy will need to achieve sufficient treatment to ensure that there is no increase in pollutant export compared to the pre-developed conditions.

7. REFERENCES

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FIGURES

FIGURE 1

NORTH

SUB – CATCHMENT	TOTAL AREA
EXISTING SHELLHARBOUR TOWNSHIP	52.56 ha
EXTERNAL CATCHMENT M	1.40 ha
TOWNSHIP PARKLAND	1.18 ha
GRAVEYARD	3.75 ha
PRE–DEVELOPED SITE	261.01 ha
PRE–DEVELOPED COMMERCIAL AREA	9.12 ha
TOTAL	329.02 ha

LEGEND

- SUB CATCHMENT BOUNDARY
- DIRECTION OF RUNOFF
- EXISTING URBAN AREA

TOWNSHIP PARKLAND *(1.18 ha)*

EXISTING SHELLHARBOUR TOWNSHIP *(52.56 ha)*

GRAVEYARD *(3.75 ha)*

EXTERNAL CATCHMENT M *(1.40 ha)*

PRE-DEVELOPED SITE *(261.01 ha)*

SHELLHARBOUR SOUTH BEACH

TASMAN SEA

TO BASS POINT

PRE-DEVELOPED COMMERCIAL AREA *(9.12 ha)*

0 100 200 300 400 500m

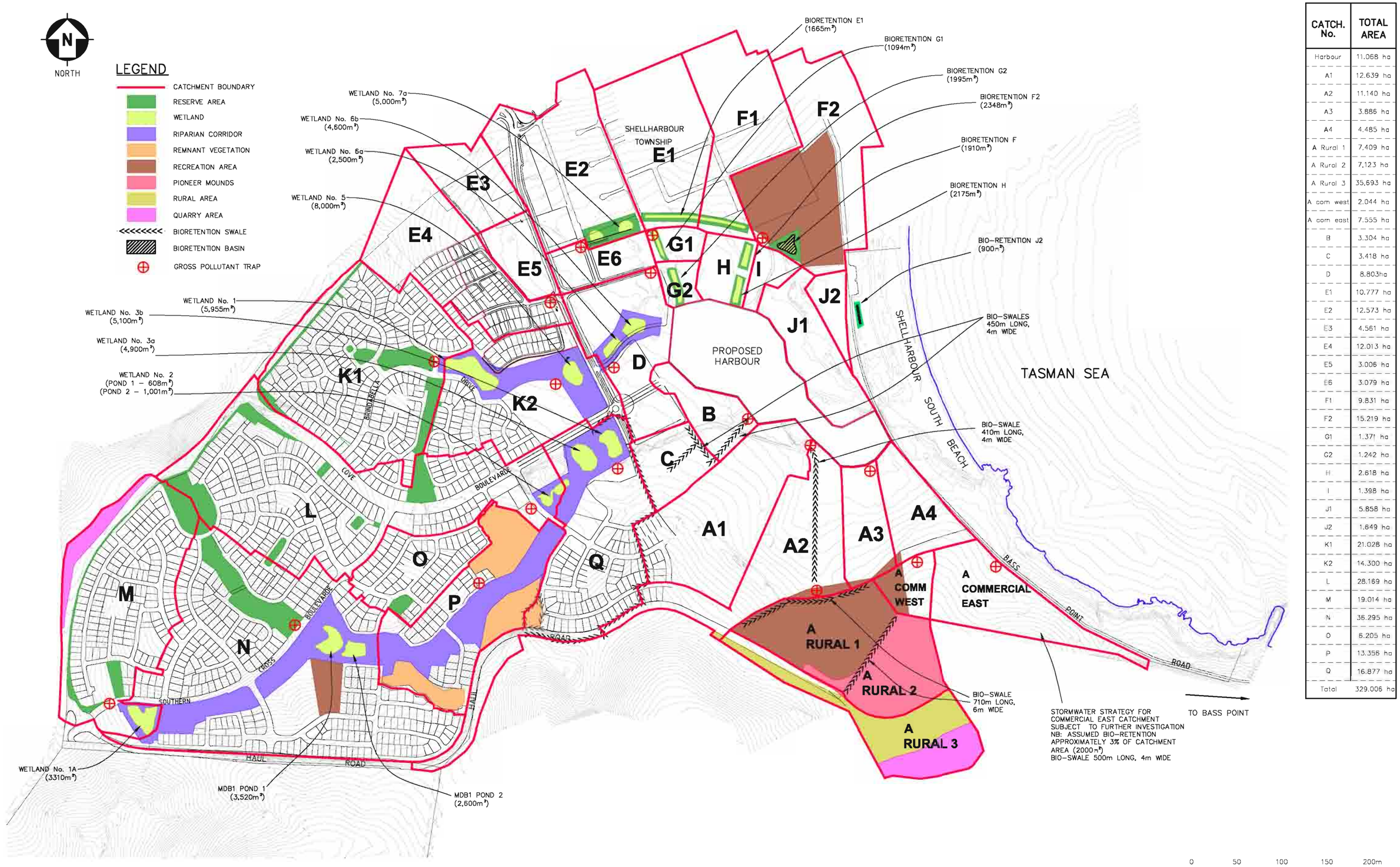
1 : 5000 (A1) 1:10000 (A3)

WorleyParsons
resources & energy

EXISTING SHELLCOVE CATCHMENT PLAN

W:_Infrastructure\Projects\301015101089_Shellcove Stage 8\1.0 Drawings\Dngs\CIVIL\Figure 1 - Existing Site.mh07.1.15.dwg, Layout1, 25/09/2009 9:27:15 AM

FIGURE 2



CATCH. No.	TOTAL AREA
Harbour	11.068 ha
A1	12.639 ha
A2	11.140 ha
A3	3.886 ha
A4	4.485 ha
A Rural 1	7.409 ha
A Rural 2	7.123 ha
A Rural 3	35.693 ha
A comm west	2.044 ha
A comm east	7.555 ha
B	3.304 ha
C	3.418 ha
D	8.803ha
E1	10.777 ha
E2	12.573 ha
E3	4.561 ha
E4	12.013 ha
E5	3.006 ha
E6	3.079 ha
F1	9.831 ha
F2	15.219 ha
G1	1.371 ha
G2	1.242 ha
H	2.618 ha
I	1.398 ha
J1	5.858 ha
J2	1.649 ha
K1	21.028 ha
K2	14.300 ha
L	28.169 ha
M	19.014 ha
N	36.295 ha
O	6.205 ha
P	13.356 ha
Q	16.877 ha
Total	329.006 ha

0 50 100 150 200m

1 : 2000 (A1) 1:4000 (A3)

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PROPOSED MASTERPLAN STORMWATER QUALITY TREATMENT STRATEGY

APPENDIX A - MUSIC MODEL NETWORK