Water Research Laboratory

Trial Groyne Design at Bambra Reef Roches Beach Tasmania

WRL Technical Report 2013/20
October 2013

by
C D Drummond, A Mariani and J T Carley

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Water Research Laboratory
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Contents

List of Tables

List of Figures

Executive Summary

Following the recommendations of the Tasmanian Coastal Adaptation Pathways Project (TCAP), the Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering, of The University of New South Wales was commissioned by the Clarence City Council (CCC) to prepare the preliminary design and costing of a rock trial groyne to be constructed as an extension of the Bambra Reef on Roches Beach, Tasmania. Potential ecological impacts of the structure were not considered in WRL's study but were considered by others separately.

Structure Design Life

The trial structure was considered a temporary structure with a design life of 5 to 10 years. Two alternative designs were developed based on two design events, the 1 in 10 and 1 in 100 year average recurrence interval (ARI) storm events.

Trial Groyne Design

The groyne would be constructed using several layers of quarried rocks, with a required median primary armour mass of 0.4 tonnes for the trunk and 1.0 tonnes for the head for 100 year ARI design conditions. For the 10 year ARI design conditions, the required median primary armour mass would be 0.3 tonnes for the trunk and 0.9 tonnes for the head. The groyne would be located at Bambra Street, extending offshore in a shore-normal direction over a length of approximately 160 m to 2 m water depth (i.e. –2 m AHD contour).

The groyne crest height was designed at 1 m above Mean Sea Level (i.e. 1 m AHD). This elevation should restrict sediment from bypassing over the top of the groyne without significantly hindering pedestrian access along Roches Beach. It is expected the groyne may be overtopped during high tides and moderate wave conditions. The crest width was designed at 3.5 m to allow construction operations.

Cost Estimate

Indicative costs for a rock groyne structure as described above were estimated as:

- $535,000 (ex GST) designed for a 100 year ARI event
- $470,000 (ex GST) designed for a 10 year ARI event

If Clarence City Council were to use internal resources to (i) undertake the placement of rocks, (ii) provide supervision and survey as well as (iii) provide contract documentation, the indicative costs could be reduced to:

- $300,000 (ex GST) for the 100 year ARI design
- $270,000 (ex GST) for the 10 year ARI design.

Conclusions

Based on previous studies (Shand and Carley, 2011), it is predicted that the proposed trial groyne would produce an increase in beach width up to approximately 44 m in the area south of the groyne. These accretionary effects would taper down to nil at a distance of 1200 m south of Bambra Reef. It was estimated that approximately 13,000 m^3 of sediment would be trapped by the groyne in the first year, with yearly trapped volumes generally reducing slightly over time as more bypassing occurs.

A similar volume would be expected to erode on the downdrift (northern) side. The trial groyne should be monitored closely to provide information on littoral drift and shoreline response rates. If significant erosion occurs on the downdrift side, some nourishment material may be required.

On this basis, WRL recommend that sediment equivalent to 1 to 2 years of accumulation volume is sourced and placed or made available for placement if required.

1. Introduction

Clarence City Council (CCC) is considering the option of a trial groyne structure located at Bambra Reef along the foreshore of Roches Beach on the south-east coast of Tasmania (Figure 1). The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at The University of New South Wales was engaged by CCC to undertake the preliminary design of the rock trial groyne at Bambra Reef.

Roches Beach is a section of the CCC coastline with built assets at immediate risk from coastal hazards. Erosion and recession in recent years has resulted in substantial loss of beach amenity and community land, in particular in the section of coastline south of the Bambra Reef.

Based on a series of feasibility assessment studies and consultations with stakeholders, the Tasmanian Coastal Adaptation Pathways Project (TCAP) recommended a series of actions for beach protection works at Roches Beach. The recommended action in the medium term (one to five years) was to "*Extend Bambra Reef both to the shore and as necessary seaward with a rock groyne to protect Bambra Reef from being buried in sediment from beach nourishment works and capture sand moving northward, assisting protection of properties just south of the reef*" (TCAP Lauderdale Recommended Action Report, July 2012). The trial groyne will be monitored closely to provide information on littoral drift and shoreline response rates for use in development of future management strategies and/or engineering works.

A number of documents addressing coastal processes, coastal protection works and coastal management within the CCC local government area (LGA) were consulted for this study including:

- Blacka *et al.* (2012) *"Investigation of Roches Beach Protection Works"* (WRL TR 2012/09);
- Shand and Carley (2011) *"Investigation of Trial Groyne Structures for Roches Beach"* (WRL TR 2011/06); and
- Carley *et al.* (2008) *"Coastal Processes, Coastal Hazards, Climate Change and Adaptive Responses for Preparation of a Coastal Management Strategy for Clarence City, Tasmania"* (WRL TR 2009/04).

In this report, the trial groyne main structural dimensions (elevation, length, width etc.) and principal construction materials are provided. The preliminary design is based on the concept design developed in Shand and Carley (2011) for a location further south along Roches Beach and no additional analysis and modelling was undertaken.

Preliminary costs based on consultation with local quarries are provided as estimates only and are subject to detailed design. It is understood that the structure will be conceived as a trial structure and that its performance should be monitored to inform future decisions and planning.

Potential ecological impacts of the structure were not considered in this study. It is understood that a preliminary assessment of the potential ecological impacts of the groyne on the Bambra Reef biota was undertaken in parallel to this study.

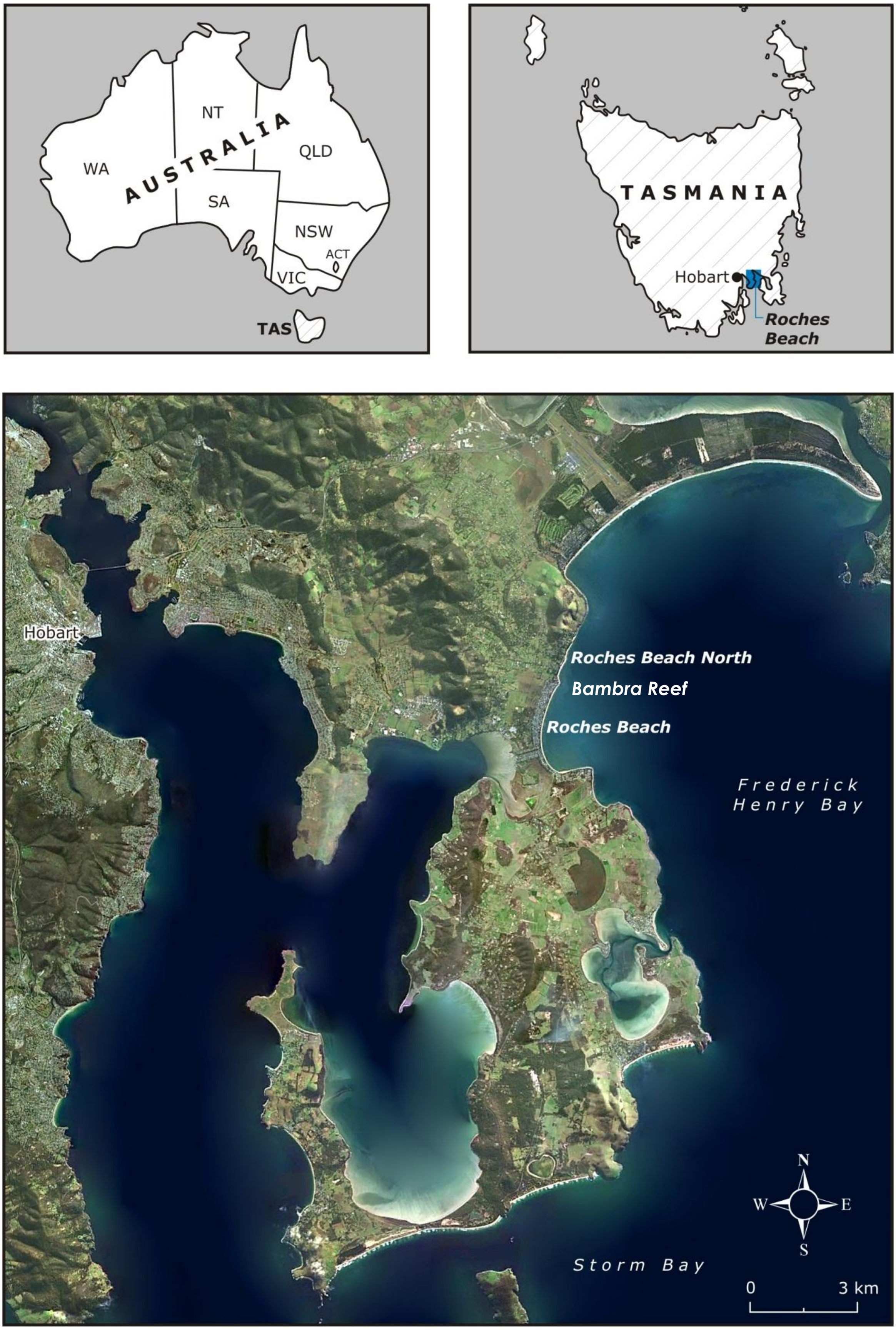

Figure 1: Study Location

2. Design Environmental Conditions

2.1 General

A groyne is a permeable or impermeable structure that extends from the shore into the active zone of longshore sediment transport (littoral drift), and that, by intercepting longshore currents, reduces littoral drift and promotes sediment accretion on the updrift side. The main parameters that influence the structural design and effective operation of a groyne are:

- Littoral drift;
- Ocean wave (height, period and angle) and water level conditions (tides and storm surges);
- Geotechnical conditions; and
- The expected seabed scour level at the toe of the groyne.

The trial groyne at Roches Beach was designed to be located on the rocky substrate of the Bambra Reef. No site specific geotechnical information was available for this study so it was considered reasonable for the purposes of design that the structure would be founded on reef. Based on this, seabed scour and settlement in the medium term (one to five years) would be minimal. It is suggested that the validity of this assumption be investigated prior to construction.

Design conditions presented in this section are based on the concept design of an impermeable trial groyne developed in Shand and Carley (2011) for further south along Roches Beach. Shand and Carley (2011) undertook extensive analysis and modelling of both littoral drift and wave climate. No further modelling was undertaken for the present study.

2.2 Design Life

Establishing the design working life of the proposed trial groyne is critical for determination of subsequent design parameters. The typical design life for a normal maritime structure is 50 years (AS 4997, 2005). A trial structure is considered a temporary structure with a design life of 5 to 10 years. The trial groyne preliminary design has been prepared for this working life and would require revision if this planning horizon were modified.

Having established the design life of the trial groyne, an appropriate level of design risk was selected in order to assign design waves and water levels. The average recurrence interval (ARI) for significant wave height and still water level forms the design "event" or design conditions. It is accepted engineering practice in Australia to adopt the 1 in 100 year ARI event in the design of permanent coastal structures such as rock seawalls and groynes. This event has a 39% probability of occurring during a 50 year design life (Table 1).

For the trial groyne, two alternative designs were developed based on two design events, i.e. the 1 in 10 and 1 in 100 year ARI events. The 1 in 10 year ARI event has a 39% and 63% probability of being exceeded during a 5 year and a 10 year design life respectively. The 1 in 100 year ARI design event has a 5% and 10% probability of occurring in the 5 year and 10 year design life respectively (Table 1).

Table 1: Encounter Probability for Given ARI and Project Design Life

Design life (years) ↓	Event probability (%) for various return periods (years)						
	5	10	20	30	50	100	200
1	18%	10%	5%	3%	2%	1%	0%
2	33%	18%	10%	6%	4%	2%	1%
3	45%	26%	14%	10%	6%	3%	1%
5	63%	**39%**	22%	15%	10%	**5%**	2%
7	75%	50%	30%	21%	13%	7%	3%
10	86%	**63%**	39%	28%	18%	**10%**	5%
20	98%	86%	63%	49%	33%	18%	10%
50	100%	99%	92%	81%	63%	**39%**	22%
70	100%	100%	97%	90%	75%	50%	30%
100	100%	100%	99%	96%	86%	63%	39%

2.3 Design Wave Conditions

Offshore wave conditions were analysed in Carley *et al.* (2008) and a summary of extreme offshore significant wave heights (H_s) as extrapolated from wave buoy datasets is presented in Table 2.

Wave transformation coefficients from offshore to nearshore at Bambra Reef were calculated by setting up a numerical wave model in Shand and Carley (2011). The wave modelling undertaken in Shand and Carley took into account the processes of refraction, diffraction, wave-wave interaction and dissipation by bed friction and wave breaking. Shand and Carley found a maximum nearshore wave coefficient (at the -5 m AHD contour level) of 0.19 corresponding to swell and wind waves from the south.

Waves were propagated from the -5 m AHD contour level to the -2 m AHD and -1 m AHD contours, i.e. the structure head and trunk locations respectively, using the Goda irregular wave method (Goda, 2007). Table 2 summarises the adopted offshore design wave conditions while Table 3 summarises those at the structure.

Table 2: Summary of Extreme Offshore Wave Heights Derived by Carley *et al.* (2008)

ARI (years)	Hs (m) as derived from offshore wave buoy datasets		
	Eden NSW	Cape Sorell	Wedge Island
1	5.3	9.0	5.5
5	5.8	10.5	6.0
10	6.4	11.0	6.8
20	7.4	11.5	7.9
50	8.1	12.3	8.5
100	8.5	13.0	9.0

Note: the wave buoy location closest to the study site is Wedge Island

Table 3: Summary of Adopted Wave Conditions

ARI (years)	Hs (m)				Tp (sec)
	Offshore (from the south)	Nearshore (-5 m AHD)	Head (-2 m AHD)	Trunk (-1 m AHD)	
1	5.5	1.0	1.8	1.2	13
10	6.8	1.3	1.9	1.3	13
100	9.0	1.7	2.0	1.5	15

2.4 Design Water Levels

Water levels in the Clarence region are discussed within Carley *et al.* (2008). Water levels consist of (predictable) tides which are forced by the sun, moon and planets (astronomical tides), and a tidal anomaly. The largest positive anomalies are associated with major storms and are driven by barometric setup (associated with low barometric pressure) and coastal wind setup, which are often combined as "storm surge". Water levels within the surf zone are also subject to wave setup and wave run-up.

2.4.1 Tides

The Australian National Tide Table values for the Port of Hobart are reproduced in Table 4. Australian Height Datum (AHD) is approximately mean sea level.

Table 4: Published Tidal Planes for Hobart

(Source: Royal Australian Navy Hydrographic Service 1999, 2006)

Tide	Tidal level (m AHD)	Tidal level (m CD)
Highest Astronomical Tide (HAT)	0.8	1.7
Mean Higher High Water (MHHW)	0.6	1.5
Mean Lower High Water (MLHW)	0.1	1.0
Mean Sea Level (MSL)	0.0	0.9
Mean Higher Low Water (MHLW)	-0.1	0.8
Mean Lower Low Water (MLLW)	-0.6	0.3
Lowest Astronomical Tide (LAT)	-0.9	0.0

Notes: AHD: Australian Height Datum (approximately present mean sea level)

2.4.2 Tidal Anomalies

Tidal anomalies result from factors such as wind setup or setdown, barometric effects, seasonal changes and coastally trapped waves. An extensive analysis of the Hobart tide gauge data was undertaken by Hunter (2007). This analysis did not separate tide from anomaly and thus implicitly includes both. Resultant extreme water levels for Hobart as presented within Carley *et al.* (2008) are shown within Table 5. The 10 year ARI water level was calculated using an interpolation of the available data.

Table 5: Extreme Water Levels at Hobart

ARI (years)	Water level (m AHD)
1	0.97
10	1.21
50	1.37
100	1.44

Note: excludes local effects such as local wind setup, wave setup and wave runup

2.4.3 Wave-induced Components

Wave setup occurs due to radiation stress by breaking waves balancing a gradient in the water surface, thus elevating the water level through the surf zone. To determine the wave setup at various points along the length of each proposed groyne, H_{RMS} (m) corresponding to the adopted 1 in 100 and 1 in 10 year ARI wave conditions was first calculated according to CIRIA (2007) in Equation 2.1.

$$H_{RMS} = 0.706 \times H_S \tag{2.1}$$

This wave height was applied as a boundary condition to the Dally, Dean and Dalrymple (1984) two-dimensional surf zone model, which also incorporated the corresponding peak spectral wave period and storm tide water level. Results indicated that no wave setup occurred at the -2 and -1 m AHD contours for the 10 and 100 year ARI events. Therefore, wave setup was not considered for the design conditions at the head or the trunk of the groyne at high tide.

Run-up occurs after a wave breaks, travels across the surf zone and then is carried by momentum above the still water level until momentum forces are exceeded by gravity. The wave run-up calculations implicitly include wave setup. Wave run-up is generally defined as a percentage exceedance elevation, i.e. the elevation exceeded by 10% of waves is referred to as $R_{10\%}$. For design wave run-up on beaches, the $R_{2\%}$ value is most commonly used, which is the run-up exceeded on average by two individual waves out of every 100 waves.

Based on Shand and Carley (2009), the adopted $R_{2\%}$ wave run-up elevation for the 100 year ARI event was 2.3 m AHD and 1.8 m AHD for the 10 year ARI event. A summary of wave-induced contributions to extreme water levels is presented in Table 6.

Table 6: Wave-induced Contributions to Extreme Water Levels

ARI (years)	10	100
Wave Setup (m)	0	0
Wave Runup $R_{2\%}$ (m AHD)	2.34	1.78

2.5 Summary of Adopted Design Wave and Water Level Conditions

Adopted design wave and water level conditions along the groyne are presented in Table 7 for the -1 and -2 m AHD contours at Bambra Reef. Additional wave statistics ($H_{1/10}$) were derived according to Battjes and Groenendijk (2000).

Table 7: Summary of Adopted Conditions Along the Groyne

Location along groyne	Bed Contour (m AHD)	100 year ARI				10 year ARI			
		Water Depth (m)	H_s (m)	$H_{1/10}$ (m)	T_p (s)	Water Depth (m)	H_s (m)	$H_{1/10}$ (m)	T_p (s)
Head	-2	3.4	2.0	2.5	15	3.2	1.9	2.3	13
Trunk	-1	2.4	1.5	1.8	15	2.2	1.3	1.6	13

2.6 Littoral Drift

Construction of any shore-normal structure on Roches Beach such as the proposed trial groyne will obstruct littoral transport of sediment and alter existing sediment transport regimes. The existing sediment transport regime along Roches Beach was assessed in Shand and Carley (2011) by:

- Estimating the gross and net potential littoral drift using the Queens/Kamphuis expression (Kamphuis, 2002) and the 13 year (1997 to 2010) nearshore wave climate;
- Investigating the shoreline evolution following the placement of a groyne structure using a calibrated GENESIS shoreline evolution model; and
- Deriving sand bypassing curves by investigating the cross-shore distribution of the littoral transport using the Bijker (1971) transport model.

The Kamphuis (2002) model predicted a net littoral drift towards the north at Bambra Reef of 13,000 m^3/year, with swell waves responsible for the majority of the sediment transport towards the north.

GENESIS model predictions for different groyne lengths near Bambra Reef are presented in Table 8. The maximum updrift accretion and downdrift recession extents and volumes which occurred after the 10 year simulation period are presented. These values do not consider the offset of any nourishment material. In the case of no nourishment material being placed on the updrift area, results show that while accretion volume and extent is increased on the updrift area, recession is also increased on the downdrift area.

Table 8: GENESIS Model Shoreline Predictions without Nourishment

Groyne Location	Offshore Toe Depth (m AHD)	Approx. Groyne Length (m)	Maximum Updrift Accretion Extent (m) [1]	Maximum Downdrift Recession Extent (m)[1]	Net Updrift Accretion (m^3) [2]	Net Downdrift Recession (m^3) [2]
Bambra Street	-0.5	35	4	-11	16,864	-51,038
Bambra Street	-1.0	60	25	-61	94,954	-125,574
Bambra Street	-1.5	80	38	-91	140,179	-169,304
Bambra Street	-2.0	95	44	-103	157,558	-186,428

Notes: [1] Accretion and erosion extents are shown in terms of predicted beach widths after 10 years of shoreline response; [2] Total volumes over 10 year simulation period.

Numerical modelling of the 10-year prediction of shoreline response south of Bambra Reef is shown in Figure 2. Beach widths were predicted to increase up to a maximum of approximately

40 m over a 10-year period with the beneficial effects of the groyne impacting over 1000 m of beach length south of the Bambra Reef.

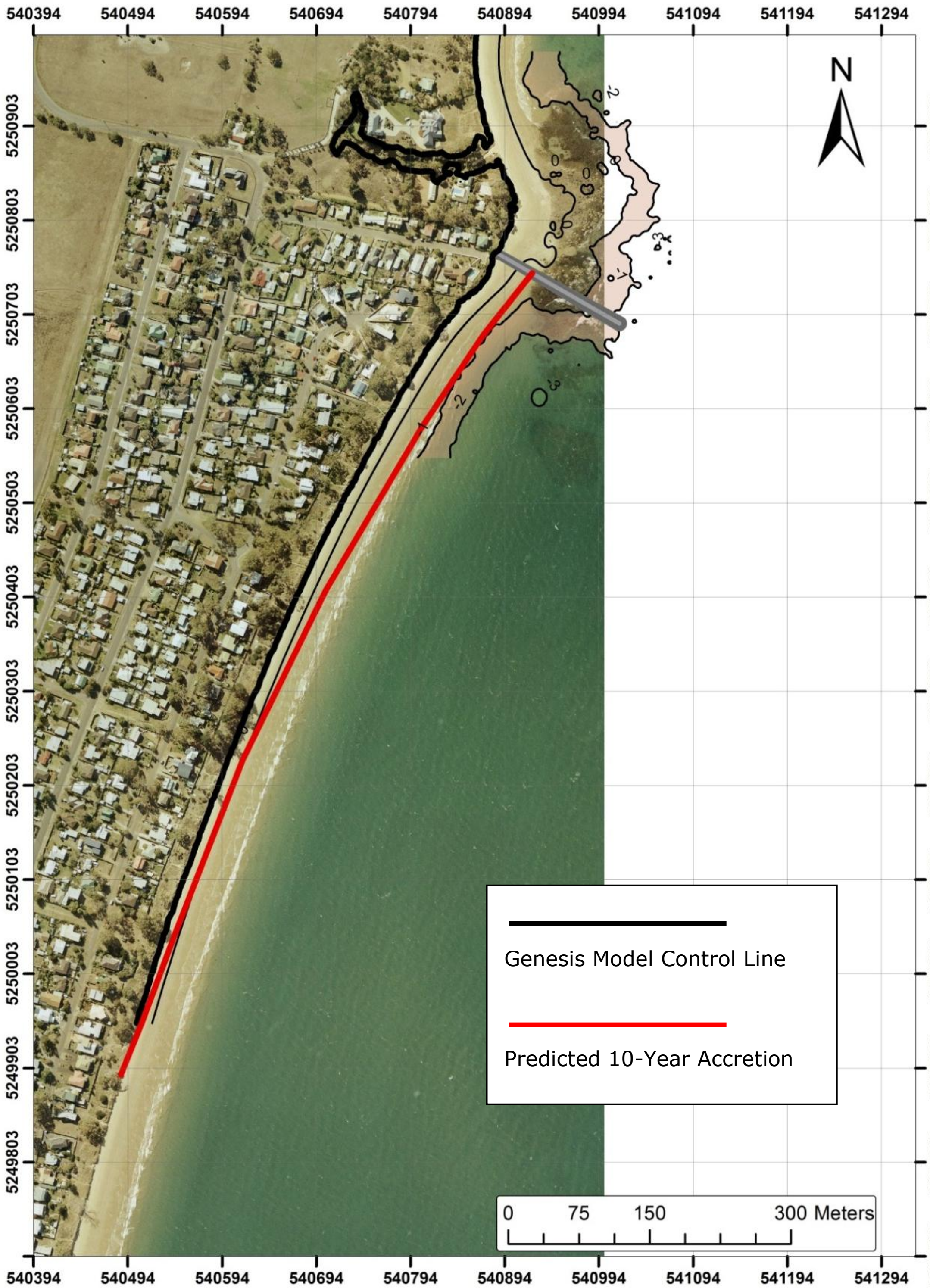

Figure 2: Numerical Modelling 10-Year Prediction of Shoreline Response South of Bambra Reef

The Kamphuis formula estimates the total sediment transport rate over the entire surfzone. However, the sediment transport rates are not constant across the surfzone and depend on the combined effect of wave breaking and longshore currents. Transport rates are the highest just inside the breakpoint where breaking generates high sediment concentrations and waves may not be fully refracted. The Bijker (1971) transport model allowed quantification of the cross-shore distribution of the sediment transport rate. Results from Shand and Carley (2011) show that longshore transport rapidly reduces with distance offshore due to the relatively steep offshore slopes. This indicates that any groyne extending past –1.0 m AHD is likely to reduce longshore sediment transport to less than 10% of initial values until the updrift profile builds sufficiently seaward to allow bypassing. Figure 3 shows bypass rates as calculated using the Bijker Sediment Transport Model implemented on a cross-shore profile at Hadlow Street (Shand and Carley, 2011).

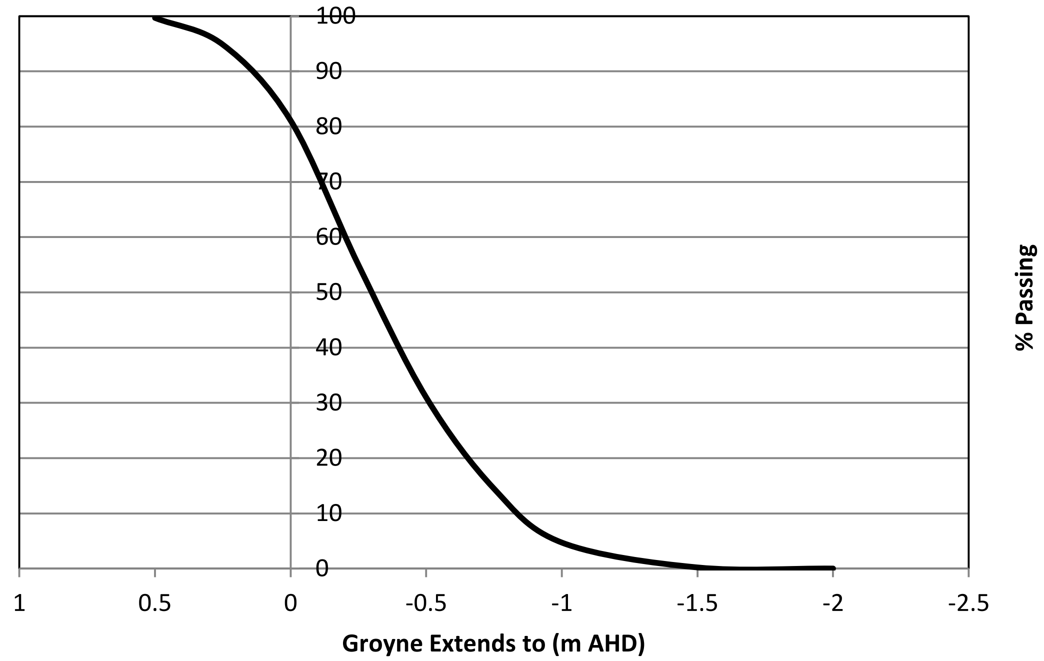

Figure 3: Bypass Rates at Cross-shore Locations Calculated using the Bijker Sediment Transport Model at Hadlow Street Cross-shore Profile (Shand and Carley, 2011)

3. Trial Groyne Design

3.1 Crest Level and Width

The crest level of the proposed groyne is influenced by several opposing factors including:

- Minimising the amount of construction materials used;
- Controlling sand movement over the top of the groyne; and
- Accommodating land-based construction equipment that might operate directly on the structure.

A groyne crest elevation of 1.0 m AHD has been adopted for preliminary design. This elevation is 0.4 m above the Mean Higher High Water level of 0.6 m AHD and should restrict sediment from bypassing over the top of the groyne without significantly hindering pedestrian access along Roches Beach. Following a monitoring period it may be necessary to increase the crest elevation if the structure is to be retained beyond the adopted design life. The seaward end of the groyne may be overtopped during high tides and moderate wave conditions. Note that signs warning pedestrians of the wave overtopping hazard should be displayed on the groyne as it would be occasionally overtopped by waves.

WRL adopted a groyne crest width of 3.5 m for the primary armour to enable access during construction i.e. to allow traffic of land-based equipment such as dump trucks or excavators with operating width in the range of 2.50 to 3.50 m (CIRIA, 2007).

3.2 Groyne Length

The length of the groyne is governed by the volume of littoral drift estimated to bypass the groyne head. Shand and Carley (2011) had modelled the cross-shore distribution of littoral drift transport at a cross-shore profile at the end of Hadlow Road (south of Bambra Reef). Results indicated that any groyne extending past –1.0 m AHD was likely to reduce littoral drift bypassing to less than 10% and that a groyne extending to -2.0 m AHD was likely to interrupt most littoral drift of sediment towards the north. On this basis, the preliminary design of the trial groyne was prepared for a groyne extending offshore to the -2 m AHD contour. The groyne should extend to the back of the beach and 2 to 3 m into the dune to prevent outflanking in the short to medium term.

Bed contours at Roches Beach between -3 m AHD and 0 m AHD in 1 m increments are shown in Figure 4 based on the bathymetric survey undertaken by Aquenal on 26 June 2013. Based on this bathymetric data, the groyne length would be approximately 160 metres. This is longer than the groyne designs for Hadlow Road in Shand and Carley (2011) as the bathymetry at Bambra Reef is of flatter gradient than at the Hadlow Road location.

Figure 4: Aquenal Bathymetry Survey of Bambra Reef, June 2013

3.3 Groyne Orientation and Location

For a groyne placed at Bambra Street, modelling showed the 100 year ARI extreme significant wave height approaching from 110-130 degrees North. A structure placed shore-normal at this location would extend offshore at an angle of approximately 120 degrees North meaning that waves would approach the structure normally or at a slightly oblique angle. Figure 5 shows the nominated preliminary location and orientation of the trial groyne.

Figure 5: Trial Groyne Location and Orientation

3.4 Construction Materials

Rock armour has been assessed as a suitable construction material for the trial groyne design. Preliminary enquiries with local quarries indicated an availability of dolerite rock with a median mass up to 5 t with a density of up to 2900 kg/m^3. In the absence of rock density testing at these quarries for confirmation, calculations have assumed a conservative density estimate of 2650 kg/m^3.

Conventional rock armoured coastal structures, commonly referred to as rubble mound structures, comprise two layers of graded primary armour stones overlying another two layers of graded secondary armour stones. For preliminary design, a structure slope of 1V:1.5H was adopted for the head and trunk of the structure.

The rock armour sizing was undertaken using several different empirical methods as detailed in CIRIA (2007):

- Van der Meer (shallow water, CEM, 2006);
- Hudson (CEM, 2006); and
- Hudson (SPM, 1984).

The results of this analysis present a range of values for the 100 year ARI design in Table 9 and in Table 10 for the 10 year ARI design. Uncertainty in the mass required for the armour units could be resolved through a physical modelling program, however due to the trial nature of the required design, this was not considered immediately necessary. With a crest of 1.0 m AHD the structure would be partially submerged during extreme water level events, which would provide additional protection to the structure.

Table 9: 100 year ARI Preliminary Sizing for Armour

	Head (-2 m AHD)		Trunk (-1 m AHD)	
Armour Sizing Method	Required Armour Mass M_{50} (t)	Equiv. Cube Side D_{n50} (m)	Required Armour Mass M_{50} (t)	Equiv. Cube Side D_{n50} (m)
Van der Meer (CEM, 2006)	0.81	0.67	0.24	0.45
Hudson (CEM, 2006)	1.06	0.74	0.39	0.53
Hudson (SPM, 1984)	3.31	1.08	1.21	0.77

Table 10: 10 year ARI Preliminary Sizing for Armour

	Head (-2 m AHD)		Trunk (-1 m AHD)	
Armour Sizing Method	Required Armour Mass M_{50} (t)	Equiv. Cube Side D_{n50} (m)	Required Armour Mass M_{50} (t)	Equiv. Cube Side D_{n50} (m)
Van der Meer (CEM, 2006)	0.65	0.63	0.20	0.42
Hudson (CEM, 2006)	0.85	0.68	0.28	0.47
Hudson (SPM, 1984)	2.63	1.00	0.89	0.70

The preliminary results using the Hudson method (CEM, 2006) indicate that the required median armour mass would be 0.4 t for the trunk and 1.0 t for the head for initiation of damage to the groyne for the 100 year ARI design conditions. For the 10 year ARI design conditions the required median armour mass would be 0.3 t for the trunk and 0.9 t for the head. Typical cross sections of the 100 year and 10 year ARI design are reproduced in Figure 6 and Figure 7 respectively. The location of these cross sections along the groyne cross section are shown in Figure 8.

Recommended rock gradings for coastal protection works from various sources are shown in Table 11.

Table 11: Rock Size Grading Ratios

Source	Grading Description	Parameter	Value
CIRIA (2007)	Narrow or single sized	M85/M15	1.7 to 2.7
CIRIA (2007)	Wide gradation	M85/M15	2.7 to 16.0
CIRIA (2007)	Very wide or quarry run gradation	M85/M15	16.0 to 125+
PIANC (1992)	Model testing required due to wide gradation	M85/M15	>16.0
SPM (1984)	Idealised grading for conventional breakwater primary armour	M100/M0	1.7
SPM (1984)	Idealised grading for conventional breakwater toe (below min water level)	M100/M0	1.9
SPM (1984)	Idealised grading for conventional breakwater core toe berm	M100/M0	5.7

Expected grading values for the 10 and 100 year ARI design using the Hudson (CEM, 2006) method are shown in Table 12.

Table 12: Rock Size Grading Ratios for 10 and 100 Year ARI Design

Source	Grading Description	Parameter (after Hudson (CEM, 2006))					
		100 Year ARI			10 Year ARI		
		M85 (kg)	M50 (kg)	M15 (kg)	M85 (kg)	M50 (kg)	M15 (kg)
CIRIA (2007)	Narrow or single sized	1330 to 1550	1060	570 to 790	1070 to 1240	850	460 to 630
CIRIA (2007)	Wide gradation	1550 to 2000	1060	570 to 120	1240 to 1600	850	100 to 460

These gradings can be varied to provide the most economical solution and/or to match available materials at a chosen quarry.

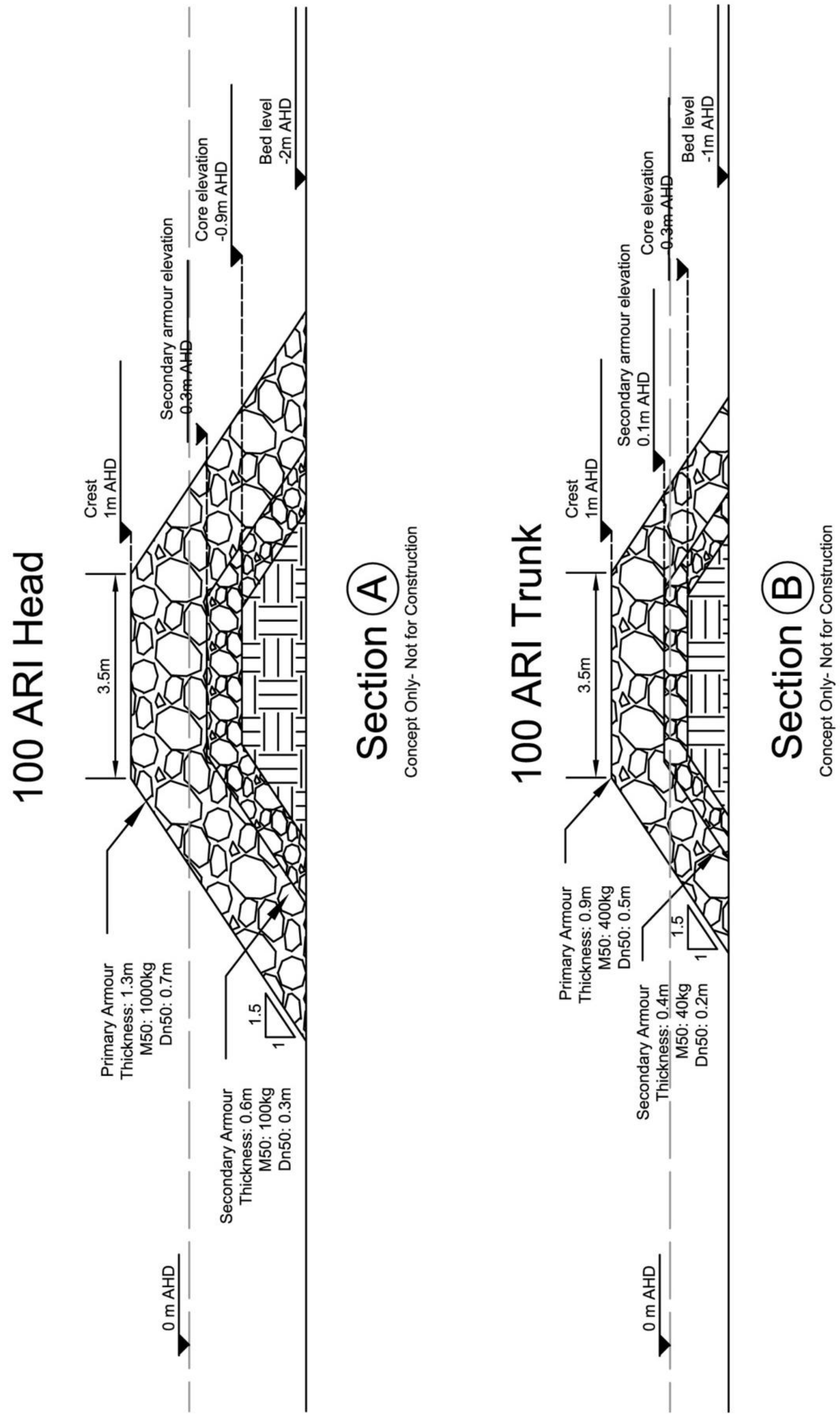

Figure 6: 100 Year ARI Groyne Head and Trunk Design

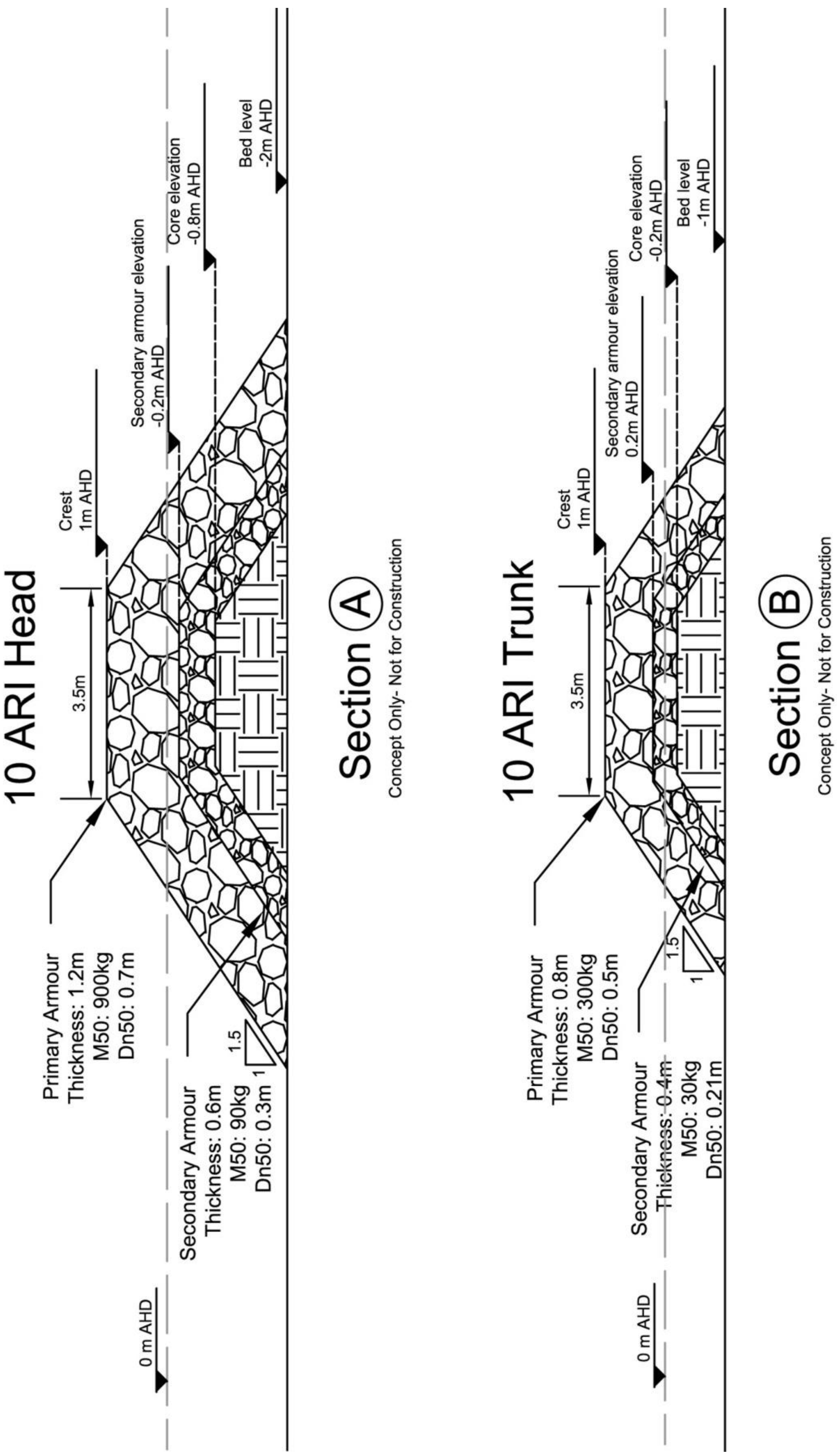

Figure 7: 10 Year ARI Groyne Head and Trunk Design

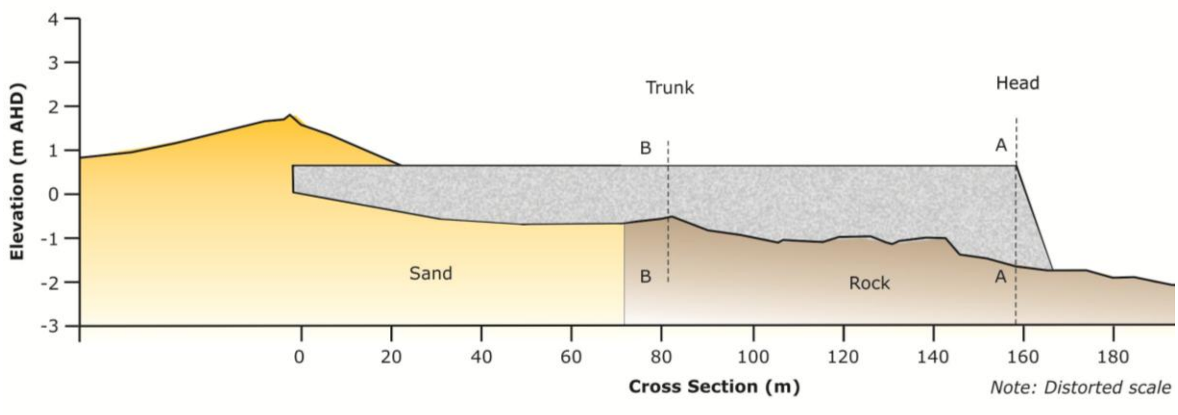

Figure 8: Trial Groyne Cross Section

3.5 Climate Change Considerations

Simplified engineering estimates of sea level rise as a result of climate change are presented in Table 13 and are based on upper projections in IPCC (2007) and NCCOE (2012). It is also estimated that sea levels are rising at a rate of 1 to 3 mm/year on the Australian coastline (NCCOE 2012).

Table 13: Sea Level Rise Projections (source: IPCC (2007) and NCCOE (2012))

Planning Period (year)	**Sea Level Rise(1)** (m)
2050	0.4
2100	0.9

Note: (1) increase above 1990 Mean Sea Level

For a 10 year design life, allowance for sea level rise is not needed and has not been included in this preliminary design. If the trial groyne structure was to be made permanent, additional armour, crest raising and/or increased maintenance may be required to allow for sea level rise.

3.6 Groyne Sand Filling

The placement of any structure interrupting the littoral drift will tend to initially accrete the beach on the updrift side as sediment becomes trapped against the structure and to erode the downdrift side as that part of the system is deprived of the trapped sediment. As the updrift beach accretes and bypassing around the structure increases, the downdrift erosion rate decreases until the initial littoral drift rate is restored. This downdrift erosion can be reduced, offset or avoided by initially ‘pre-filling’ the updrift accretion zone with nourishment material.

A structure extending to -2.0 m AHD would potentially trap up to around 13,000 m^3 of sediment in the first year, with yearly trapped volumes generally reducing slightly over time. A similar volume would be expected to erode on the downdrift side. The trial groyne will be monitored closely to provide information on littoral drift and shoreline response rates. If significant erosion occurs on the downdrift side, some nourishment material may be required. On this basis, WRL recommend that sediment equivalent to 1 to 2 years of accumulation volume is sourced and placed or made available for placement if required.

It is important to note that sand trapping of the groyne will be dominated by the ambient and frequent conditions which is in contrast to armour stability that is determined by extreme waves and water levels.

4. Cost Estimate

Preliminary cost estimates excluding GST have been prepared for the 10 year and 100 year ARI groyne designs. These estimates have been prepared for the purpose of comparing the alternatives and are not prepared to the level of detail of a tender submission.

Material quantities have been derived from the concept design drawings (Figure 6 and Figure 7) with unit and bulk rates determined from the following sources:

- Discussions with local quarries and material suppliers;
- Tender information from similar projects available to WRL; and
- Rawlinsons (2012) "Australian Construction Handbook – 2012".

A number of quarries were contacted regarding armour rock availability, characteristics and price. This included quarries such as the Hazel Bros Quarry at Leslie Vale producing dolerite rock with a density of 2900 kg/m^3 (Figure 9). Individual armour units up to 5 tonnes can easily be produced in sufficient quantities and the quarry has previously supplied armour units for coastal protection works in Hobart. Indicative supply costs (including delivery) for the primary armour units are up to $35 per tonne. Indicative supply costs (including delivery) for core material and small secondary armour are $24 per tonne. These are preliminary estimates only and are subject to detailed design. The adopted placement cost for larger primary armour is $25 per tonne, $15 per tonne for smaller secondary armour and $10 per tonne for the core.

Figure 9: Dolerite Formation at Hazel Bros Quarry, Leslie Vale

A supply cost of $7 per m^2 and a placement cost of $10 per m^2 have been used for a geotextile layer between the core and secondary armour.

A rate of $50,000 has been used for site establishment by the primary contractor. This item includes the cost of establishment, mobilisation and dis-establishment of plant and site amenities.

Rock structures are considered to be durable, however, all rock structures require periodic maintenance following large storm events. Typical maintenance costs for a rock rubble structure are 1% of the initial capital cost per year though this is usually undertaken following storms. This maintenance cost has not been included due to the trial nature of the structure.

Cost estimates for the 100 year ARI design groyne are shown in Table 14 indicating a cost of approximately $535,000 (ex GST). Table 15 indicates a cost of approximately $470,000 (ex GST) for the 10 year ARI design.

Potential savings are possible if CCC were to internally undertake the placement of armour units, provide supervision and survey as well as contract documentation. Incorporating these savings leads to an indicative cost of $300,000 (ex GST) for the 100 year ARI design and $270,000 (ex GST) for the 10 year ARI design.

Table 14: 100 Year ARI Design Costing

Item	**Unit** unit	**Quantity**	**Rate** $/unit	**Amount** $ (ex GST)
Site Establishment	item	1	50000	$ 50,000
Earthworks	m^3	735	15	$ 11,025
Primary Armour				
Supply	tonne	2797	35	$ 97,895
Place*	tonne	2797	25	$ 69,925
Secondary Armour				
Supply	tonne	843	30	$ 25,290
Place*	tonne	843	15	$ 12,645
Core				
Supply	tonne	1099	24	$ 26,376
Place*	tonne	1099	10	$ 10,990
Geotextile layer	m^2	1160	17	$ 19,720
Supervision and Survey*	Day	50	2000	$ 100,000
Contract Documentation*	item	1	40000	$ 40,000
SUB-TOTAL				**$ 463,866**
Contingency (15%)				$ 69,580
TOTAL				**$ 535,000**

* May be completed internally by Council

Table 15: 10 Year ARI Design Costing

Item	Unit unit	Quantity	Rate $/unit	Amount $ (ex GST)
Site Establishment	item	1	50000	$ 50,000
Earthworks	m^3	735	15	$ 11,025
Primary Armour				
Supply	tonne	2573	30	$ 77,190
Place*	tonne	2573	20	$ 51,460
Secondary Armour				
Supply	tonne	908	24	$ 21,792
Place*	tonne	908	15	$ 13,620
Core				
Supply	tonne	1324	24	$ 31,776
Place*	tonne	1324	10	$ 13,240
Geotextile layer	m^2	1200	17	$ 20,400
Supervision and Survey*	Day	40	2000	$ 80,000
Contract Documentation*	item	1	40000	$ 40,000
SUB-TOTAL				**$ 410,503**
Contingency (15%)				$ 61,575
TOTAL				**$ 470,000**

* May be completed internally by Council

5. Conclusions

The Water Research Laboratory (WRL) was commissioned by Clarence City Council (CCC) to undertake the preliminary design of the rock trial groyne at Bambra Reef. Roches Beach is a section of the CCC coastline with built assets at immediate risk from coastal hazards. Ongoing erosion/recession in the last few years has resulted in substantial loss of beach amenity and community land, in particular in the section of coastline south of the Bambra Reef.

The overall recommendations of this report are:

- That a single trial groyne structure is constructed at the end of Bambra Road;
- That the trial groyne structure extends 160 m from the back of the beach to an offshore depth of -2 m AHD at Bambra Reef;
- That a crest height of 1 m AHD is adopted for the structure though this may require raising following a monitoring period;
- Indicative costs for a rock groyne structure as described above are likely to be:
    - $535,000 (ex GST) designed for a 100 year ARI event
    - $470,000 (ex GST) designed for a 10 year ARI event
- If CCC were to use internal resources, the indicative costs could be reduced to:
    - $300,000 (ex GST) for the 100 year ARI design
    - $270,000 (ex GST) for the 10 year ARI design.

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