Development of a Proposal and Environmental Assessment of Beach Scraping - New Brighton and South Golden Beach

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by

J T Carley, I R Coghlan, M J Blacka and R J Cox

Technical Report 2008/19
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1. INTRODUCTION

1.1 Description of Beach Scraping

This report examines the feasibility of beach scraping for the villages of New Brighton and South Golden Beach (Figure 1.1) in Byron Shire. Beach scraping is defined as the movement of small to medium quantities of sand from the lower part of the littoral beach system to the dune, using mechanical means. It mimics natural beach recovery processes, but increases the recovery rate. The process is illustrated in Figures 1.2 and 1.3.

1.2 History

The area north of the Brunswick River has a history of beach erosion. WBM (2000), Rendell (1975-76) and PWD (1978) reported on numerous breaches of the dunes between the Brunswick River and Crabbes Creek. This included a breakthrough of Marshalls Creek (Figure 1.4). It was reported that the sand dunes were levelled seaward of the South Golden Beach development in the 1970s. There was also extensive sand mining throughout the area.

The village of Sheltering Palms was abandoned in the 1970s. Rendell (1975-76) reported four extensive sand breakthroughs between New Brighton and the Brunswick River on 24 January 1976, and nine major "sand blows" between New Brighton and the Brunswick River on 28 June 1976, following Tropical Cyclones *David, Colin* and *Hope* earlier in the year. Rendell (1975-76) Drawing No 3006-019 indicates that dune crest levels at the worst breach just south of Sheltering Palms were in the range 2.0 to 2.8 m (state datum) in February and March 1976. Dune sand which had been washed landward towards Marshalls Creek (forming a breach) was bulldozed to reform dunes with a crest level of 5 to 6 m AHD (WBM, 2000, p59). WRL was advised that a construction report for this reconstruction was available from state government departments, however, enquiries with Sydney and North Coast regional offices could not locate this report.

Houses were damaged at the southern end of New Brighton village in the 1970s and sand was washed over North Head Road (Figure 1.4). Rendell (1975-76) reported that in the main part of New Brighton the higher dune was eroded, but had sufficient volume to protect houses and The Esplanade.

WBM (2000 p59) reported that dune rebuilding occurred in 1979 and that beach scraping continued regularly in New Brighton until the early 1990s. Erskine and Thompson (2003) reported that beach scraping was undertaken at New Brighton until 1996, and was discontinued because of possible negative impacts on “pipi” populations. They suggested that “pipis” are migratory and are absent some years, so that timing of beach scraping may be possible so as not to affect “pipis”. Additional discussion on environmental effects follows in this report.

2. LITERATURE REVIEW ON BEACH SCRAPING

2.1 Physical Effects

2.1.1 Overview

Beach scraping has been widely practised but there is relatively little published literature on its application. Most work has been done without detailed environmental approvals or studies.

Beach scaping has also been called:

- Beach skimming;
- Beach panning;
- Nature assisted beach enhancement (NABE);
- Assisted beach recovery.

2.1.2 NSW Department of Land and Water Conservation (2001)

The NSW Coastal Dune Management Manual provides management and rehabilitation techniques for coastal dunes in NSW. The manual provides some guidance on dune reforming including suggested dune profiles, materials and position geometries. The manual states that "*reconstructed dunes should vary in slope, size and shape just as natural dunes do. However unnatural protruding hummocks or steep-sided undulations that may interrupt or concentrate wind flow should be avoided*." The manual further states that "*the height and width of a reconstructed dune depends on a number of factors including*:

- *the height and width of existing dune*
- *remnants*
- *the availability of sand*
- *available space*
- *the degree of landward protection required.*

It may be desirable to reconstruct the dune to a height that will prevent wave overtopping during storms"

2.1.3 Smutz, Griffith and Wang (1980)

Smutz *et al.* (1980) reasoned that by removing a small amount of sand from the lower beach and placing it above the wave runup limit, accretion of the lower beach is accelerated because a flatter nearshore profile prevails. Flatter profiles promote accretion, whereas steeper profiles are more prone to erosion. Smutz *et al.* reported on physical model studies of this and also presented theoretical wave steepness calculations.

They acknowledged that their work was not based on field studies, but argued that beach scraping was more efficient than conventional nourishment because nature provides most of the energy (in accreting the lower beachface).

2.1.4 Bruun (1983)

Bruun (1983) commented on scraping practice in Denmark and the USA. He recommended "responsible scraping", with scraping depths of 0.2 to 0.5 m and that placing material into the dune provided the best coastal protection. "Responsible scraping" did not have adverse effects on neighbouring beaches. He argued from his extensive observations that if material is removed from a seaward berm during accretionary conditions, another berm will form. Bruun concluded:

1. "Beach scraping .... is not harmful, but rather is beneficial as coastal protection of eroding dunes...
2. Undertaken in a technically responsible way, it also has beneficial rather than adverse effects on adjacent beaches.
3. Beach scraping is a way of organizing available beach material in a more sensible way – on a short term basis. But it is a temporary measure only. It does not replace artificial nourishment,..."

2.1.5 Tye (1983)

Tye (1983) examined the seasonal effects, post storm recovery and the response of an eroded beach to scraping and artificial dune construction at Folly Beach, South Carolina, USA following a major hurricane. The analysis involved six beach profile transects at 1.6 km intervals along the beach. The scraping volumes averaged 28 m^3/m. Tye found that this scraping rate was excessive on profiles which did not recover naturally, and resulted in additional erosion in subsequent storms .

Tye stated that a “well organized and prudently monitored beach scraping program can prove beneficial to dune and beach restoration.” He concluded that “By working in conjunction with the natural beach recovery cycle, beach recovery can be accelerated with minimal environmental damage.” This was predicated on scraping rates not exceeding natural recovery rates.

2.1.6 McNinch and Wells (1992)

McNinch and Wells (1992) reported on a scraping project at Topsail Beach, North Carolina, USA. The scraping rates in their project were small, averaging 0.21 m^3/m per day over 3.5 weeks, scraping to a depth of 0.15 to 0.2 m, and using only a single piece of machinery. Their borrow area was below the high water mark. They cautioned that unsuccessful scraping projects involved scaping more sand than natural recovery rates, and that such excessive scraping may involve oversteepening of beaches and additional erosion. They quoted a project at Folly Beach, South Carolina, USA which used scraping rates of 5.2 m^3/m/day which was considered unsuccessful, in that the lower beach borrow area had not recovered 5 weeks after scraping.

McNinch and Wells (1992) concluded that “under certain conditions, beach scraping can be beneficial in preventing overwash and preventing damage to backshore features..... we recommend limited scraping, only on that part of the beach inundated daily by tides....”

2.1.7 Queensland BPA (2003)

The Queensland BPA (2003) suggested that dune heights on open coasts should be 5 to 7 m AHD. Dunes will ultimately develop their own profile, but they suggested a seaward design slope of 1V:5H for sand dune design.

2.1.8 Conaway and Wells (2005)

Conaway and Wells (2005) report on aeolian dynamics on scraped shorelines in North Carolina. Their study notes that as beach scraping increases the dry sediment volume above the high tide and increases the foredune surface area with loose, unconsolidated material, sand movement due to aeolian (wind-induced) processes is increased. This increased aeolian transport may result in *in-situ* dune growth but may also be lost from the active beach system completely if blown onshore. Mitigation of wind erosion was therefore suggested desirable, with wind fencing recommended as the most effective means.

2.2 Biological Studies

2.2.1 Overview

Numerous studies have been undertaken on the effects of beach nourishment (defined as importing sand into the littoral system), but few specifically address beach scraping.

2.2.2 Henry (1999)

Henry (1999) undertook a B.Sc. thesis on the biological effects of beach scraping at Wooli, northern NSW, where beach scraping has been used primarily to improve beach access. Nine species of macrofauna were identified from the following taxon, namely:

- Crustacea (crustaceans):
  - *Ocypode cordimana* (ghost crab);
  - *Gastrosaccus sp.;*
  - *Excirolana sp.*
- Polychaeta (beach worms):
  - *Polychaeta sp. A (cf. Lumbrinereis sp.);*
  - *Polychaeta sp. B (cf. Glycera sp.);*
  - *Nephtys sp.*
- Mollusca (molluscs):
  - *Donax deltoids* (pipi).
- Insecta (insects):
  - *Bledius sp.*(shore beetle);
  - *Coelopidae sp.* (kelp fly).

From a limited sampling scope and duration, Henry found that species abundance was less for the scraped sites than the unscraped, but there was no significant difference in species diversity between sites. Henry found highly significant differences in populations of *Donax deltoids* and significant differences in populations of *Ocypode cordimana.*

Though not mentioned by Henry, it is likely that the scraped sites were subject to increased pedestrian traffic (since the scraping was undertaken to improve pedestrian access). This may be an alternative explanation for the observed differences between scraped and unscraped sites.

3. DETAILED SURVEY

A survey of the beach was undertaken on 15 and 16 August 2007 by WRL utilising Real-Time Kinematic Global Positioning System (RTK-GPS). This was mounted on a 4WD quad bike to survey areas seaward of the vegetation line and carefully carried on foot to survey vegetated dune areas. The system can rapidly collect high accuracy (±2 cm vertical and horizontal) spatial data. To obtain its high accuracy, it requires two GPS receivers – a fixed receiver on a known point (a base station) and a roving unit that surveys points in real time.

This survey supplemented photogrammetric data provided by DECC for the dates shown in Table 2.1. Also shown in Table 2.1 is the estimated photogrammetry accuracy from Evans and Hanslow (1996), namely:

- Pre-1960: ±1 to 1.5 m horizontal and ±0.7 m vertical
- Post-1960: ±0.5 m horizontal ±0.2 m vertical.

Table 2.1
Photogrammetry and Survey Dates

Date	Survey	Accuracy
27/05/1947	Photogrammetry	±1 to 1.5 m horizontal and ±0.7 m vertical
22/09/1966	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
17/04/1973	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
30/07/1974	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
02/12/1976	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
31/08/1984	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
06/08/1987	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
26/07/1991	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
19/05/1994	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
04/09/1999	Photogrammetry	±0.5 m horizontal ±0.2 m vertical
16/08/2007	WRL	±0.02 to 0.05 m vertical

Illustrations of WRL's beach survey techniques are shown in Figures 2.1 and 2.2. In the top right of Figure 2.2 the dots show the sampling points for that particular survey. RTK-GPS data points are typically taken at horizontal spacings of 4 m.

A plot of the dune crest level is shown in Figure 2.3. It can be seen that for New Brighton the crest level is generally around 6.5 m AHD, but is as low as 4.2 m AHD to the south and north of the village. In South Golden Beach the crest level is typically around 6 m AHD, but is as low as 5 m AHD in places.

4. COASTAL PROCESSES AND HAZARDS IN THE STUDY AREA

4.1 Introduction

Major studies have been undertaken for the study area by PWD (1978) and WBM (2000), with useful information also provided in Rendell (1975-6) and PBP (2006). A detailed analysis of coastal processes and hazards is beyond the scope of this study, however, a summary of the current state of knowledge relevant to beach scraping is provided below.

4.2 Water Levels

Extreme water levels consist of the following components:

- Astronomical tide – the predicted tide forced by the sun, moon and planets; and
- The storm surge (or tidal anomaly), which is the actual water level minus the predicted tide, excluding wave setup and runup.

Storm surge results from low barometric pressure (barometric setup) and strong onshore winds (wind setup). Other oceanographic factors may also contribute to tidal anomalies.

Accepted present day extreme water levels for Sydney (Haradasa *et al.* 1992) are shown in Table 4.1. These levels exclude wave setup and wave runup. Also shown in Table 4.1 are CSIRO (2007) estimated extreme storm surges (actual water level minus predicted tide, excluding wave setup and runup) for Wooli. As stated above, the storm surge is the amount by which the water level exceeds the predicted (astronomical) tide.

Table 4.1
Design Water Levels and Storm Surges

Average Recurrence Interval (years)	Design Still Water Level for Sydney (m AHD) (Haradasa et al, 1991)	Design storm surge (tidal anomaly) for Wooli (m) (CSIRO, 2007)
1	1.28	
2	1.31	
5	1.36	
10	1.39	0.48
20	1.43	0.53
50	1.47	0.61
100	1.50	0.67

4.3 Sea Level Rise

A broad outline of the reasoning behind projections for sea level rise is as follows:

- The earth and atmosphere are warming due to emissions of greenhouse gases (eg carbon dioxide) into the atmosphere.
- Sea level is rising on a global scale due to the following major components:
    - Thermal expansion of ocean water;
    - Increased melting and discharge of glaciers and ice caps;
    - Melting of the Greenland ice sheet;
    - Melting of the Antarctic ice sheet.
- On a local scale, sea level may vary from the global average due to changes in ocean currents and local changes in land levels.

The Intergovernmental Panel on Climate Change (IPCC) have produced major reports in 1990, 1996, 2001 and 2007. Hence the 2007 report is known as the Fourth Assessment Report (AR4) and the 2001 report the Third Assessment Report (TAR). The latest IPCC Summary for Policymakers Report (IPCC SPM, 2007a) and Working Group 1 Report (IPCC, 2007b) provide numerous sea level rise scenarios for 2090 to 2100. Values for 2050 are not available in the Summary Report or Working Group 1 2007 reports. The IPCC (2007b) scenarios have been reproduced in Table 4.2.

Simplified “mid” and “high” sea level rise scenarios developed by WRL for engineering application are shown in Table 4.3. Similar engineering scenarios were developed in NCCOE (2004) (reproduced in Figure 4.1 of this report) based on the IPCC (2001) scenarios and are almost identical when ice melt is included and the end date is extended to 2100. As such, the NCCOE (2004) values for 2050 have been used (since no IPCC, 2007a, b values are available).

IPCC SPM (2007a) stated, “*TAR projections were made for 2100, whereas projections in this Report are for 2090-2099. The TAR would have had similar ranges to those in Table SPM-2 if it had treated the uncertainties in the same way*.”

The 2100 “mid” sea level scenario shown in Table 4.3 was estimated using the following assumptions detailed in Table 4.2 and IPCC (2007b, Table 10.7):

- Averaging the central values for the six emission scenarios: 0.34 m;
- Adding a central value for ice melt: 0.06 m;

- Extending to from 2095 to 2100 (by 5 years at 5.6 mm/year) 0.03 m;
- Which gives an actual total of 0.43 m, which was rounded to: 0.5 m.

The "high" sea level scenario shown in Table 4.3 was estimated using the following assumptions detailed in Table 4.2 and IPCC (2007b, Table 10.7) for the A1FI emission scenario:

- Sea level rise (excluding accelerated ice melt): 0.59 m;
- Upper value for ice melt: 0.17 m;
- Extending to from 2095 to 2100 (by 5 years at 13.6 mm/year) 0.07 m;
- Which gives an actual total of 0.83 m, which was rounded to: 0.9 m.

CSIRO (2007) estimated local sea level rise for the NSW coast to exceed global values for 2070 by between 0.0 and 0.12 m. DECC (2007) combined IPCC (2007a) and CSIRO (2007) to estimate upper limit local sea level rise for the NSW coast in 2100 of 0.91 m, which is virtually identical to the rounded value of 0.9 m derived by WRL, NCCOE (2004) and NSW Government (2009).

IPCC (2007a, page 17) addresses a doomsday scenario involving the total melting of the Greenland ice sheet (suggested timescale is millennia) which it estimates would elevate global sea levels by a further 7 m. Even more extreme postulations exist, including a rise of up to 70 m (GACGC, 2006) if all the world's ice sheets were to melt, however, the timescale is considered to be millennia. The IPCC represents an international consensus position for planning purposes.

During the course of this study the NSW Government (2009a) released its "Draft Sea Level Rise Policy Statement", which has since been finalised as "NSW Sea Level Rise Policy Statement" (NSW Government, 2009b). It recommends planning for the following sea level rise:

- 2050: up to 0.4 m;
- 2100: up to 0.9 m.

Table 4.2
IPCC (2007b) Global Sea Level Rise Scenarios

IPCC Scenario or Component	**Rise**			**Rate of Rise**		
	Lower (5%)	**Upper (95%)**	**Central (by WRL)**	**Lower (5%)**	**Upper (95%)**	**Central (by WRL)**
Starting year (1980 to 1999)			1990			
Final year (2090 to 2099)			2095			
Sea level rise excluding “scaled up dynamical ice sheet melt”	(m)	(m)	(m)	(mm/yr)	(mm/yr)	(mm/yr)
B1 scenario	0.18	0.38	0.28	1.5	3.9	2.7
B2 scenario	0.20	0.43	0.32	2.1	5.6	3.9
A1T scenario	0.20	0.45	0.33	2.1	6.0	4.1
A1B scenario	0.21	0.48	0.35	1.7	4.7	3.2
A2 scenario	0.23	0.51	0.37	3.0	8.5	5.8
A1FI scenario	0.26	0.59	0.43	3.0	9.7	6.4
Average of scenarios			0.34			4.3
Scaled up dynamical ice sheet melt component						
B1 scenario	0.00	0.09	0.05	0	1.7	0.9
B2 scenario	0.00	0.11	0.06	0	2.3	1.2
A1T scenario	-0.01	0.13	0.06	0	2.6	1.3
A1B scenario	-0.01	0.13	0.06	0	2.3	1.2
A2 scenario	-0.01	0.13	0.06	-0.1	3.2	1.6
A1FI scenario	-0.01	0.17	0.08	-0.1	3.9	1.9
Average of scenarios			0.06			1.3
Total (by WRL)						
B1 scenario	0.18	0.47	0.33	1.5	5.6	3.6
B2 scenario	0.20	0.54	0.37	2.1	7.9	5.0
A1T scenario	0.19	0.58	0.39	2.1	8.6	5.4
A1B scenario	0.20	0.61	0.41	1.7	7.0	4.4
A2 scenario	0.22	0.64	0.43	2.9	11.7	7.3
A1FI scenario	0.25	0.76	0.51	2.9	13.6	8.3
Average of scenarios			0.40			5.6

Table 4.3
Simplified Engineering Estimates of Global Sea Level Rise (by WRL) based on IPCC (2001, 2007), NCCOE (2004) and NSW Government (2009)

Sea Level Scenario	Year	
	2050	**2100**
Adopted "Mid" scenario	0.2	0.5
Adopted "High" scenario	0.3	0.9
NSW Government (2009)	0.4	0.9

4.4 Wave Climate

The following offshore median wave conditions prevail (Kulmar *et al.* 2005):

- Significant wave height is 1.6 m;
- Spectral peak period is 10 s;
- Most common direction is south to south-east.

Other wave height exceedances and period distributions are shown in Figure 4.2. Extreme wave heights are shown in Table 4.4 and Figure 4.3.

Table 4.4
1 Hour Duration Significant Wave Height Return Periods for Byron Bay (Kulmar, Lord & Sanderson, 2005)

ARI (Years)	H_S (m)
1	5.0
2	5.4
5	5.9
10	6.3
20	6.7
50	7.3
100	7.7

4.5 Wave Setup and Runup

4.5.1 Wave Setup

Wave setup is defined as the quasi-steady increase in water level inside a surf zone due to the conversion of part of the waves' kinetic energy into potential energy. Numerical models such as Dally, Dean and Dalrymple (1984) and SBEACH are available to calculate wave setup. For an initial engineering approximation on a sandy beach (but not a reflective rocky shore or seawall), wave setup at the shore is typically 15% of the significant wave height at the outer limit of the surf zone (breaker height). Wave setup levels are presented in Table 4.5. For locations not directly subject to wave impact, and where wave overtopping is not a critical factor, the wave setup level at the shore is the best indicator of an inundation level.

4.5.2 Wave Runup

Wave runup is defined as the rush of water up a beach due to a wave. The runup level is defined as the vertical height above the still water level. For runup calculations, the reference still water level used usually excludes wave setup, that is, the water level seaward of the surf zone is used as the basis of calculations and wave setup is implicitly included within the runup calculation. Wave runup is important in defining the landward limit of beach change due to waves, and the potential for dune breaching and inundation.

Mase (1989) presented predictive equations for irregular runup on plane, impermeable beaches (slopes 1V:5H to 1V:30H) based on laboratory data. Field measurements of runup (Holman, 1986; Nielsen and Hanslow, 1991) have found lower values than those predicted by Mase, however, this is partly because they have used the upper beach face slope to calculate runup, rather than the entire (average) surf zone slope (from break point to runup limit), and may also be related to differing permeability between laboratory and natural beaches. Nevertheless, WRL has successfully verified the Mase equations against recorded runup reported at numerous beaches in Higgs and Nittim (1988) if the entire (average) surf zone slope is used. This approach of the “whole of surf zone gradient” has also been used within the SBEACH erosion model which has successfully predicted the upper limit of profile change at numerous Australian beaches (Carley and Cox, 2003). It is applicable to natural beaches, but not where structures are present.

Wave runup is generally calculated on a two-dimensional cross sectional basis, which can change over short distances where structures (e.g. seawalls or road embankments) are present. Calibration or verification of runup calculations on beaches is best undertaken with either field measurements, a physical model, or surveys of debris lines (Higgs and Nittim, 1988) following major storm events. Prediction of wave runup on structures is best undertaken with a physical model. For wave runup on beaches, the $R_{2\%}$ value is the most commonly used, which is the runup exceeded by 2% of waves. That is, two waves out of 100 will exceed the runup limit quoted. As stated above, the wave runup calculations are relative to the still water level seaward of the surf zone.

Wave setup levels are shown in Table 4.5 together with the $R_{2\%}$ wave runup levels calculated from the methods of Mase (1989). These numbers are uncalibrated due to the absence of site measurement data. Nevertheless, it is noted that these levels suggest a design dune crest level of 6 m AHD (incorporating 0.5 m freeboard). Dune crests below this level are vulnerable to breaching through dune overwash as has occurred on numerous occasions around New Brighton and Sheltering Palms.

WBM (2000 p 108) estimated a present day design runup value of 5.1 m AHD. This was a "design" value for sandy beaches throughout Byron Shire. They cautioned that this level would increase where structures are present. It is noted that this value is consistent with the values estimated by WRL in Table 4.5 for the more extreme events.

Table 4.5
Design Water Level Conditions for New Brighton and South Golden Beaches
(For T_P = 15 s)

ARI (years)	Tide Level (m AHD)	Wave Setup (m)	Wave Setup Level (m AHD)	$R_{2\%}$ Wave Runup (m)	$R_{2\%}$ Runup Level (m AHD)	Max Wave Runup (m)	Max Runup Level (m AHD)
1	1.28	0.75	2.03	2.9	4.1	3.2	4.5
2	1.31	0.81	2.13	2.9	4.3	3.3	4.6
5	1.36	0.89	2.25	3.1	4.4	3.4	4.8
10	1.39	0.95	2.34	3.2	4.6	3.5	4.9
20	1.43	1.01	2.44	3.3	4.7	3.6	5.1
50	1.47	1.09	2.56	3.4	4.9	3.8	5.2
100	1.50	1.15	2.65	3.5	5.0	3.8	5.3

4.6 Littoral Drift

4.6.1 Net Littoral Drift

Littoral drift is defined as the movement of sand along the coast (as opposed to cross shore) due to waves travelling at an angle to the shore. It is generally measured in cubic metres per year (m^3/year) of sand, which includes the pore spaces of the sand matrix. That is 1 m^3 of sand, typically contains 60% actual sand grains and 40% pore spaces.

4.6.1.1 PWD (1978)

Annual average net littoral drift transport was estimated by PWD (1978) to be:

- 120,000 m^3/year northward bypassing the Brunswick Heads training walls;
- 170,000 m^3/year northward at New Brighton;
- 200,000 m^3/year northward around Hastings Point.

The difference between the littoral drift bypassing the Brunswick Heads training walls and that at Hastings Point was one of two main reasons attributed to the observed high recession rates north of Brunswick Heads in the 1970s – the other reason being high storminess.

4.6.1.2 WBM (2000)

Later estimates by WBM (2000) indicated average annual littoral drift transport (over the period 1989 to 1995) to be:

- 450,000 m^3/year northward at Cape Byron, New Brighton and Hastings Point;
- 520,000 m^3/year northward at the Gold Coast.

WBM argued that the projected recession rates from PWD (1978) did not eventuate, indicating a lower gradient, but that interannual variability is high, and the period of their (WBM's) estimate may not be representative of longer term conditions.

4.6.1.3 PBP (2006)

PBP (2006) considered the littoral drift estimates of PWD (1978), WBM (2000) and incorporated them with recession estimates published in WBM (2000) which were supplemented with additional 2004 photogrammetry near Byron Bay township.

PBP's estimates of littoral drift near New Brighton and South Golden Beach were:

- 174,000 to 224,000 m^3/year northward bypassing the Brunswick River training walls;
- 214,000 to 264,000 m^3/year northward at New Brighton;
- 250,000 to 450,000 m^3/year northward at Hastings Point.

4.6.1.4 Patterson (2007)

Estimates by Patterson (2007) using contemporary coastal engineering techniques, which included directional wave buoy data, SWAN wave modelling and the Queens formula for sediment transport, estimated annual littoral drift transport (over the period 2000 to 2004) to be:

- 422,000 m^3/year northward at Belongil North (presumably near the creek mouth);
- 472,000 m^3/year northward at Brunswick Heads;
- 483,000 m^3/year northward at Mooball, (north of South Golden Beach);
- 528,000 m^3/year northward at Burleigh on the Gold Coast.

4.6.1.5 Littoral Drift adopted for this Study

Even in highly monitored areas, littoral drift rates may differ by ±50% over well developed theoretical estimates. From the above studies, the following range of net littoral drift has been considered in developing a beach scraping proposal:

- 170,000 to 480,000 m^3/year northward at New Brighton.

4.6.2 Gross Littoral Drift

The accepted average annual littoral drift rate for the Gold Coast is approximately 500,000 m^3/year northward from numerous studies (eg, Delft, 1970; BPA, 1981; Pattearson and Patterson, 1983). The directional distribution for this is approximately:

- 80,000 m^3/year southward (16% of the net);
- 580,000 m^3/year northward (116% of the net), giving a net value of:
- 500,000 m^3/year northward (net).

No local studies for New Brighton and South Golden Beach are available, but in the absence of such studies, it is reasonable to assume a similar directional distribution to the Gold Coast, that is, approximately 16% of the net travels southward and 116% of the net travels northward.

4.7 Beach Erosion

Beach erosion is the loss of sand from above mean sea level due to an oceanic storm or sequence of storms. It is usually measured in cubic metres per (alongshore) metre of beach (m^3/m), which can be converted into an erosion volume (in m^3) for a given area or compartment by multiplying by the compartment length. WBM (2000) estimated a “design” erosion volume of 220 m^3/m for New Brighton and South Golden Beach, which was reduced to 200 m^3/m relative to the 1999 photogrammetry due to the eroded beach state prevailing at the time. These values appear to be based on the work of Gordon (1987).

Sand erosion volumes above AHD estimated from Gordon (1987) for a range of average recurrence intervals are shown in Table 4.6 and Figure 4.4. The total volume of sand potentially eroded above AHD from New Brighton (1800 m length) and South Golden Beach (500 m length), is also shown in Table 4.6, that is a total length of 2300 m. This indicates the potential quantity requirements for beach scraping.

Table 4.6
Storm Erosion Demand above AHD (from Gordon, 1987)

ARI (Years)	Storm Sediment Volume Demand (m^3/m)		Volume Lost from New Brighton (1800 m) and South Golden (500 m) Beaches (m^3)	
	V_L Low Demand (Open Beaches)	V_H High Demand (Rip Heads)	Low Demand (Open Beaches) = V_L * (1800 + 500)	High Demand (Rip Heads) = V_H * (1800 + 500)
1	5	40	11,500	92,000
2	26	68	59,300	155,800
5	53	104	122,600	240,100
10	74	132	170,400	303,800
20	95	160	218,200	367,600
50	122	197	281,400	451,900
100	143	224	329,300	515,700

4.8 Beach Recovery

Beach recovery does not invoke the sense of crisis that major beach erosion does, so studies of beach recovery rates are less common than those for beach erosion. While there is good photogrammetric data for Byron Shire, the aerial photos are more than 2 years apart, with numerous storm events in the intervening period, meaning that true rates of beach recovery cannot be deduced. The only known studies on beach recovery for eastern Australia were by Thom and Hall (1991) involving 15 years of monthly profile data from 1972 to 1986 for Moruya NSW, and Carley *et al* (1998) who analysed approximately 30 years of collected profile data from 1967 to 1996 for the Gold Coast. The work of Thom and Hall has been continued and extended by McLean and Shen (2006) to the end of 2004. Detailed recovery rates have not been analysed in Professor Andy Short’s studies at Narrabeen (eg Short *et al*, 2000), though the data for such an analysis exists. A summary of calculated natural beach recovery rates is shown in Tables 4.7 and 4.8. It should be noted that these rates are simply volumetric. Relatively rapid recovery occurs due to wave accretion, but this is limited to the wave runup limit and forms a berm on the beach (Figure 1.2). Accretion of the dunes above the runup limit is dependent on wind, which is a slower process (Section 4.10), which may be accelerated through beach scraping.

The above studies still relied on surveys conducted at intervals of weeks to approximately monthly, so may still not capture the true maximum rate of beach recovery. The recovery process is discontinuous as shown in plots in Thom and Hall (1991).

Thom and Hall (1991) analysed beach recovery from June 1978 to November 1981 and found a maximum accretion rate above ISLW (Indian Springs Low Water, approximately -0.9 m AHD) of 0.27 m^3/m per day. They did not attempt to parameterise intervening storm events in the recovery process, but rather analysed the period due to the net recovery trend.

Carley *et al.* (1998) identified nine recovery events around Surfers Paradise on the Gold Coast, seven of which occurred when wave buoy records indicated significant wave heights of generally less than 2 m for the duration between surveys. Two recovery events occurred in the 1960s for which wave buoy data did not exist. No parameterisation of wind in the intervening periods between surveys was made. They found an average recovery rate above AHD of 0.4 m^3/m per day, though this ranged from 0 to 1.0 m^3/m per day. The average rate of 0.4 m^3/m per day is close to the findings of Thom and Hall (0.27 m^3/m per day).

Without regular collection of profile data, it is not known if these rates can be directly applied to the study area. The times shown are a transfer of observed times on other east coast beaches to the study area, and express the time for the beach to evolve from an eroded state back to an average or accreted state.

Due to the reality of subsequent storms reversing beach recovery over any extended period, Thom and Hall (1991) found the actual recovery time observed following the major 1974 storms was of the order of 5 to 7 years. There can be no certainty that recovery will occur.

Table 4.7
Natural Recovery Time for New Brighton and South Golden Beaches
Low Storm Demand
(from Carley et al, 1998; Thom and Hall, 1991; Gordon, 1987)

ARI (years)	Erosion volume (m3/m above AHD)	Assumed Natural Recovery Rate (weeks)			
		0.1 m^3/m/day (low rate)	0.27 m^3/m/day Thom & Hall best estimate	0.4 m^3/m/day Carley et al best estimate	1.0 m^3/m/day (high rate)
1	5	7.1	2.6	1.8	0.7
2	26	36.8	13.6	9.2	3.7
5	53	76.1	28.2	19.0	7.6
10	74	105.8	39.2	26.5	10.6
20	95	135.5	50.2	33.9	13.6
50	122	174.8	64.7	43.7	17.5
100	143	204.5	75.7	51.1	20.5

Table 4.8
Natural Recovery Time for New Brighton and South Golden Beaches
High Storm Demand
(from Carley et al, 1998; Thom and Hall, 1991; Gordon, 1987)

ARI (years)	Erosion volume (m3/m above AHD)	Assumed Natural Recovery Rate (weeks)			
		0.1 m3/m/day (low rate)	0.27 m3/m/day Thom & Hall best estimate	0.4 m3/m/day Carley et al best estimate	0.7 m3/m/day (high rate)
1	40	57.1	21.2	14.3	5.7
2	68	96.8	35.8	24.2	9.7
5	104	149.1	55.2	37.3	14.9
10	132	188.7	69.9	47.2	18.9
20	160	228.3	84.6	57.1	22.8
50	197	280.7	104.0	70.2	28.1
100	224	320.3	118.6	80.1	32.0

4.9 Beach Recession

The long term difference between erosion and recovery, and longshore transport differentials, results in either recession, stability or accretion.

PWD (1978) estimated the following recession rates:

- Sheltering Palms: 0.5 m/year 1947 to 1962 (pre training walls);
- Sheltering Palms: 2.6 m/year 1962 to 1977 (post training walls);
- New Brighton: 1.1 m/year 1947 to 1977 (reported to be relatively constant);
- South Golden Beach: 0.6 m/year 1947 to 1977.

WBM (2000) estimated the following recession rates:

- 2 km north of Brunswick walls (Sheltering Palms to southern end of New Brighton):
  - Best estimate 0.3 m/year 1947 to 1999 (range 0.15 to 0.6 m/year);
- Remainder of New Brighton and South Golden Beach:
  - Best estimate 0.1 m/year 1947 to 1999 (range 0.05 to 0.2 m/year);

The WBM rates were lower than those estimated by PWD, and were attributed by WBM to a less stormy period and natural realignment (and bypassing) of the Brunswick River training walls. The WBM rates represent the most recent analysis.

4.10 Wind Blown Sand

The typical median sand grain size at New Brighton and South Golden Beach is 0.22 mm (PWD, 1978). The threshold of motion for 0.22 mm beach sand due to wind has been calculated from the methods of CEM (2002), which yield:

- Dry sand: 6.8 m/s (13 knots, 25 km/hour);
- Wet sand: 11.9 m/s (23 knots, 43 km/hour).

The large difference in motion threshold between wet and dry sand shows the sensitivity to location on the beach face and tidal water level, as well as changes in rainfall, which may be due to natural variability, seasonality, cyclic patterns (el niño-southern oscillation and inter-decadal Pacific oscillation) and climate change.

A wind rose for Cape Byron Lighthouse is shown in Figure 4.5, with the data shown in Tables 4.9 and 4.10. Natural dune building for the study area can occur when the winds are from the south-east to north-east and exceed the threshold of motion. The monthly distributions of suitable dune building winds at 9 AM, 3 PM and daily average are shown in Figures 4.6, 4.7 and 4.8 where it can be seen that the potential is lowest in May, June, July and August.

Table 4.9
Cape Byron 9 AM Annual Average Wind Frequency and Speed
(From BoM records 01 Jan 1957 to 31 Dec 2006)

Wind Direction	Degrees	Wind Speed(km/hr)					
		0-10	10-20	20-30	30-40	> 40	Sum
Calm	-						2
N	0	4	4	3	1	1	12
NE	45	2	1	1	0	0	4
E	90	3	2	2	1	1	8
SE	135	3	2	2	2	2	11
S	180	4	3	2	1	1	11
SW	225	9	10	7	1	0	26
W	270	4	4	3	0	0	11
NW	315	6	6	2	0	0	15

Table 4.10
Cape Byron 3 PM Annual Average Wind Frequency and Speed
(From BoM records 01 Jan 1957 to 31 Dec 2006)

Wind Direction	Degrees	Wind Speed(km/hr)					
		0-10	10-20	20-30	30-40	> 40	Sum
Calm	-						1
N	0	2	3	5	4	3	17
NE	45	3	4	4	1	1	13
E	90	4	6	5	2	1	17
SE	135	4	6	8	4	3	25
S	180	1	2	4	3	2	13
SW	225	2	1	2	1	0	6
W	270	1	1	1	0	0	4
NW	315	1	1	1	0	0	4

4.11 Beach Rotation

Beach rotation involves a cyclic or one way change in the alignment of a beach's planform due to changes in the wave direction over medium (weeks to months) to long (decades) term time scales. It is a well known seasonal phenomenon in Perth WA (Masselink and Pattiaratchi, 1998), where the beach planform alignment is influenced by north-west storms in winter and south-west seabreezes in summer. The work on beach rotation presented by Short *et al.*, (2000) involved more than 20 years of ongoing monthly surveys at Narrabeen NSW, which is approximately 3.6 km long. Short *et al.*, found that beach rotation accounted for about 30% of beach width variation (along the 3.6 km long Narrabeen Beach). Regular long term monitoring is the only method available to properly track beach changes, so that extremes, averages, cycles and rotation can be properly identified.

4.12 Seasonality

WRL has operated a coastal imaging system at Narrowneck on the Gold Coast since 1999, which maps beach width on a weekly basis with analysis undertaken on a six monthly basis (e.g. Blacka *et al*, 2007). Additionally, Carley *et al.* (1998) analysed approximately 30 years of beach profile surveys from the northern Gold Coast which were collected at intervals ranging from 1 week to 2 years.

A summary of beach width seasonality is shown in Figure 4.9. In summary, a cyclic pattern of beach variability is evident in this region: erosion is a characteristic of the first half of the calendar year, followed by accretion in the second half of the year. This general cyclic trend matches the prevailing wave climate of the south-east Queensland/Northern NSW coast, whereby larger storm wave events are more frequent in the later summer and autumn months.

5. PROPOSAL DEVELOPMENT AND DESIGN

5.1 Aim and Scope of Beach Scraping

There are several possible aims and scopes of beach scraping, which could be attained either singly or as a combination. These are:

1. Restore and maintain pedestrian beach access following storm erosion;
2. Build a dune to a design profile by:
   a. Raising low points of the dune to a design level;
   b. Increasing the dune volume over the long term to meet storm demand;
   c. Accelerating beach recovery following storm erosion.
3. Increase the dune volume to offset recession due to sea level rise (as a medium term measure).

5.2 Sand Borrow Area

A cross section of the proposed sand borrow area is shown in Figure 5.1. Spring and neap tidal ranges, and average wave setup and runup are shown in Table 5.1.

Table 5.1
Design Water Levels for Operational Scraping Conditions

Parameter	Low Tide	High Tide
Spring Tide (MLWS & MHWS)	-0.6 m AHD	+0.7 m AHD
Wave Setup for Hs = 1.6 m	0.2 m	0.2 m
2 % Wave Run-up for Hs = 1.6 m, Tp = 10 s	0.7 m	0.7 m
		0
Typical Nearshore Water Level	- 0.4 m AHD	+ 0.9 m AHD
Typical Nearshore Runup Level	+0.1 m AHD	+1.4 m AHD

The following reasoning has been applied to the sand borrow area, with some consideration from the work of Bruun (1983):

Borrow sand would not be substantially mechanically transported along the beach, but mostly transported cross shore (up the beach) only.

Lower beach work would be undertaken on spring tides, with consideration given to wave setup and wave runup. The seaward limit of the borrow area (Figure 5.1) is defined by:

- Mean low water spring tide (-0.6 m AHD) combined with:

- Median wave setup (15% of 1.6 m = 0.2 m);
- Median wave runup (0.7 m);
- Giving a practical seaward limit of -0.4 to +0.1 m AHD.

The upper limit for borrow area is defined by:

- Mean high water spring tide (+0.7 m AHD) combined with:
- Median wave setup (15% of 1.6 m = 0.2 m);
- Median wave runup (0.7 m);
- Giving a practical upper limit of +0.9 to +1.4 m AHD.

By limiting the borrow area to below the wave runup limit, the sand borrow area would be replenished naturally by littoral drift and onshore wave transport during mild wave conditions.

5.3 Design Sand Dune Profiles

5.3.1 Existing Representative Profiles

Representative existing profiles for New Brighton and South Golden Beach are shown in Figure 5.1. A suggested minimum dune crest level is 6 to 6.5 m AHD for the present day, which would have to be increased in line with measured future sea level rise (Section 4.3).

While the primary capability of beach scraping is to accelerate natural beach recovery to improve recreational amenity, some consideration is given to increasing dune volumes to reduce erosion effects on infrastructure and to prevent overtopping. The design sand volumes to remove the immediate erosion hazard from houses and roads were determined from WBM (2000) and the principles of Nielsen *et al.* (1993). The target sand volume seaward of houses or roads is 260 m^3/m, which comprises a storm demand of 220 m^3/m and an allowance for a *Stable Foundation Zone* of 40 m^3/m.

5.3.2 Preferred Profiles of Deposited Sand

A suggested profile for deposited sand for New Brighton is shown in Figure 5.2. This has the following features:

- A seaward gradient of 1V:4H (range 3H to 5H) for public safety and to promote wind assisted dune building;

- The crest of the deposited sand is 0.3 to 0.5 m above the abutting dune, so that onshore winds can distribute the sand into the dunes without excess smothering of existing vegetation.

The typical volume of material moved (where needed) would be 8 m^3/m per episode (see Section 4.7 for an explanation of m^3/m).

For present day South Golden Beach only dune raising is needed.

5.3.3 Required Sand Volume – Present Day

5.3.3.1 New Brighton

It is noted that the present day erosion hazard line (WBM, 2000) is seaward of houses in New Brighton, but does encroach onto private property and beachfront roads. Based on analysis of the survey data at 50 m transects, the sand volume required (relative to the August 2007 survey) to be added to the dune at New Brighton to remove the immediate erosion hazard to private land and roads is approximately:

- 90,000 m^3 (over 1800 m);
- 50 m^3/m on average.

This requirement for approximately 50 m^3/m is 2.5 to 12 times the suggested quantities gained per episode (Section 5.4). That is, multiple scraping episodes would be required to remove the immediate erosion hazard. Furthermore, there may not be sufficient dune width in some locations to remove the hazard to beachfront roads.

5.3.3.2 South Golden Beach

South Golden Beach requires only dune raising by an average height of 1 to 1.5 m, requiring:

- 2000 to 4000 m^3 (over 500 m);
- 4 to 8 m^3/m on average (over 500 m).

This requirement for approximately 4 to 8 m^3/m could be gained in a single scraping episode (Section 5.4).

5.4 Quantity of Sand Gained per Episode

The depth of scraping could be in the range 0.1 to 0.5 m. For the borrow area shown in Figure 5.1, the quantity of sand gained for a range of scraping depths is shown in Table 5.2. The required quantity is dependent on the following factors:

- The purpose and aim of the scraping (Section 5.1);
- Limiting scraping to a proportion of the net littoral drift.

The scraping depths and cross shore limits shown in Tables 5.1 and 5.2 would translate to the volumes shown in Table 5.2. Also shown in Table 5.2 is the proportion of annual average net littoral drift transport which would be removed from the system for a range of scraping depths.

Littoral drift estimates were discussed in Section 4.6. As stated in Section 4.6 annual average net littoral drift transport was estimated by PWD (1978) to be 170,000 m^3/year northward around New Brighton. Later estimates by WBM (2000) indicated that it could be as high as 450,000 m^3/year northward. The most recent published estimates (Patterson, 2007) using contemporary coastal engineering techniques were approximately 480,000 m^3/year northward (at Mooball).

Table 5.2
Proposed Total Scraping Volumes per Episode

Scrape depth (m)	Volume (m^3/m)	New Brighton volume (m^3) for 1800 m	South Golden Beach volume (m^3) for 500 m	Total volume (m^3)	Proportion of annual littoral drift transport (170,000 m^3/year)	Proportion of annual littoral drift transport (480,000 m^3/year)
0.1	4	7,200	2,000	9,200	5%	2%
0.2	8	14,400	4,000	18,400	11%	4%
0.3	12	21,600	6,000	27,600	16%	6%
0.5	20	36,000	10,000	46,000	27%	10%

5.5 Machinery to be used to Scrape and Transport Sand

If the project is tendered commercially, the choice of machinery would be determined by the contractor and would depend on local commercial factors such as, supply, demand and transportation distance.

For the method proposed, likely machinery would be a bulldozer such as a Caterpillar D6 or D9 (or equivalent), or tracked loader (Caterpillar 939, 953, 963 or equivalent) as shown in

Figure 5.3. For longer transport distances alongshore, and as was done historically at New Brighton, a skimmer (e.g. Caterpillar 621, 631 or equivalent), loader, dump truck and dozer could be used, however, for the short distance, cross shore scraping proposed, these may not be as economical. Intense scaping campaigns which make maximum advantage of low spring tides and calm waves could use multiple dozers simultaneously. There is a greater risk of wheeled machinery becoming bogged on the upper beach face.

While the proposed machinery is heavy, the ground contact pressures are not large, due to their tracked operation, with some models comparable to an adult on one foot (walking). Indicative contact pressures are:

- 80 kg adult walking (standing on one foot): 40 to 80 kPa;
- Caterpillar D6 class dozer 33 to 70 kPa;
- Caterpillar D9 class dozer 90 to 125 kPa;
- Four wheel drive vehicle (15 PSI tyres) 100 kPa.

5.6 Estimates of Machinery hours/days per Scraping Episode

Estimated machinery productivity rates are shown in Table 5.3. These were obtained from *The Caterpillar Handbook* (2008), *Rawlinsons Australian Construction Handbook* (2007) and discussions with contractors. On large civil engineering earthmoving contracts, comparable unit rates may be as low as \$2 per m^3. However, for beach scraping, based on discussions with contractors, unit rates would be increased due to the following factors:

- The aggressive, corrosive and abrasive marine environment which causes additional wear and maintenance requirements on machinery;
- The uphill push in soft sand which would cause higher fuel usage;
- The narrow time windows available around low tide and the fortnightly spring tidal cycle;
- The potential for down time due to storm waves;
- The low level of security for machinery left on or near the beach;
- The requirement for shaping and grading of placed sand;
- The high level of environmental controls on the project and likely high level of scrutiny.

A unit rate of \$7 per m^3 (ex GST) has been used for an average dozing distance of less than 100 m for large quantities, that is, in a cross shore direction directly up the beach, with minimal longshore redistribution. From discussions with contractors and earthworks calculations, subject to contractual requirements, this rate could range from $2 to 10 per m^3. A rate of $7 per m^3 (ex GST) has also been used for minor works such as beach accesses only. Estimated machinery hours and costs are shown in Table 5.4. Through judicious planning and management of the risks raised by contractors, BSC may be able to undertake scraping using internal resources at rates lower than $7 per m^3 (ex GST). For example, machinery and/or personnel may be deployed elsewhere at times unsuitable for beach scraping work, whereas contractors may incorporate this downtime into their price.

Table 5.3
Estimated Machinery Productivity Rates

Parameter	Dozer type	
	D9	D6
m^3/hr	188	94

Table 5.4
Estimated Machinery hours and Costs (ex GST) for New Brighton and South Golden Beaches

Scrape depth (m) over 1800 + 500 m	m^3/m	m^3 South Golden Beach (500 m)	m^3 New Brighton (1800 m)	m^3 total (2300 m)	$ total at $5/$m^3$ (ex GST)	$ total at $7/$m^3$ (ex GST)	$ total at $10/$m^3$ (ex GST)	Machine hours		Machine days (7 hour day)	
								D9	D6	D9	D6
0.1	4	2,000	7,200	9,200	46,000	64,400	92,000	49	98	7	14
0.2	8	4,000	14,400	18,400	92,000	128,800	184,000	98	196	14	28
0.3	12	6,000	21,600	27,600	138,000	193,200	276,000	147	294	21	42
0.5	20	10,000	36,000	46,000	230,000	322,000	460,000	245	491	35	70

5.7 Number of Scraping Episodes for Present Day Hazards

5.7.1 New Brighton

Based on the analysis above, to increase dune volumes sufficiently to remove the present day erosion hazard from private property (relative to the August 2007 survey) would require:

- **Six** scraping episodes of 8 m^3/m (0.2 m scraping depth);
- **Three** scraping episodes of 20 m^3/m (0.5 m scraping depth).

Note that the locations requiring dune raising would require placement of sand near the crest rather that just on the face of the erosion scarp.

5.7.2 South Golden Beach

Based on the analysis above, to raise dunes to 6.5 m AHD at South Golden Beach would require:

- **One** scraping episode of 8 m^3/m.

Note that dune raising would require placement of sand near the crest rather that just on the face of the erosion scarp.

5.8 Defined Accesses to and off Beach

5.8.1 Machinery

The choice of machinery may need to consider bridge loads. The required width for the largest machine proposed to be used (a Caterpillar D9 or equivalent) is 3.3 m. This would be transported on a low loader having a typical length of 15 m. It is proposed to access the beach at the existing access point off North Head Road at New Brighton (Figure 1.1) and probably along the beach to South Golden Beach. North Head Road is unsealed at this point, so a tracked vehicle would cause minimal surface damage. Careful access would be required at South Golden Beach to prevent damage to bitumen road surfaces, which would need to be defined in the contract documentation.

5.8.2 Pedestrian

There are approximately seven pedestrian access tracks to the beach at South Golden Beach. There are approximately 13 public access tracks to the beach at New Brighton, with numerous private access tracks. As discussed in the Draft Byron CZMP an excessive number of pedestrian beach accesses are present, including unauthorised private beach accesses. As part of beach scraping and implementation of the CZMP, excess beach accesses should be closed and rehabilitated. All beach accesses should be raised to a minimum crest level of 6 to 6.5 m AHD and to be compatible with the surrounding dunes.

Community preference (CZMP, 2008) is for rubber beach access surfaces with geobags as seaward toe protection. Design standards for boarded walkways are contained in the *NSW Dune Management Manual* (2001).

5.9 Dune and Upper Beach Stabilisation Methodology

The dune and upper beach stabilisation methodology would involve the design profiles described above, together with vegetation in accordance with the latest version of the NSW Government *Coastal Dune Management Manual* (currently 2001). Dune vegetation is not believed to reduce erosion volumes during major storms, but will trap wind blown sand to increase the available dune buffer. It is expected that ongoing dune revegetation and maintenance would be undertaken as part of the *Dunecare* program. The potential for dune building due to wind blown sand was discussed in Section 4.10.

5.10 How the Works will Integrate with Current Dunecare Activity

The proposed works would mimic natural dune building, with the quantities and profiles proposed not being large enough to smother existing vegetation. Some low points in the dune require additional raising (Figure 2.3) which will require a detailed revegetation plan.

The work of Erskine and Thompson (2003) indicated that large portions of the dunes are infested with weeds which should be revegetated in the medium term. These vegetation management plans for New Brighton and South Golden Beach are proposed to be reviewed in 2009-2010 and should provide appropriate dune revegetation strategies.

Should the scraping works proceed, ongoing monitoring and refinement of the techniques used should be undertaken (Section 7).

6. ANALYSIS OF LONG TERM VIABILITY IN LIGHT OF CLIMATE CHANGE

Sea level rise scenarios were presented in Section 4.3. The resulting coastal recession using the Bruun Rule (Bruun, 1962, 1988) is shown in Table 6.1. WBM (2000) estimated a Bruun factor of 55 for New Brighton. That is, the coastal recession is projected to be 55 times sea level rise. They suggested a seaward closure depth of 10 to 15 m. The typical dune crest level is 6 m AHD, giving a total active profile height of 16 to 21 m. The presence of reefs off New Brighton further complicates the application of the Bruun Rule, however, there are few alternative assessment tools within the scope of the WBM (2000) project and this report.

Beach scraping is unlikely to be able to counteract a sea level rise of 1 m, however, as can be seen in Tables 6.1 and 6.2, the required scraping volumes and number of episodes to counteract recession due to intermediate sea level rise scenarios are relatively small. Values are presented in Table 6.1 for 2100, however, in light of the high uncertainty regarding sea level rise and beach scraping behaviour, the use of this study for planning beyond 2050 is not recommended without additional monitoring and analysis. It can be seen in Table 6.1 that for a 2050 mid sea level rise scenario of 0.2 m, approximately eight scraping episodes (each of 8 m^3/m) would be needed, that is, approximately every 5 years (notwithstanding storm events which may alter the required frequency). Furthermore, it can be seen in Table 6.1 that for the NSW Government (2009) 2050 sea level rise scenario of 0.4 m, approximately 17 scraping episodes (each of 8 m^3/m) would be needed, that is, approximately every 2 to 3 years (notwithstanding storm events which may alter the required frequency).

It should be noted that (subject to placement location) ongoing scraping in conjunction with beach recession would likely result in steepening of the beach if the erosion scarp extended to the placed sand. As mentioned previously though, sustainable scraping of the beach can result in a flatter beach profile, which can promote additional accretion. It is unlikely that scraping alone could maintain a dune profile substantially seaward of receded dunes to the north and south, however, scraped sand placed at, or landward of, the erosion scarp would reduce the landward impacts of storm erosion, and reduce the potential for dune overtopping. If beach recession continues as projected, there may be insufficient space available between the erosion scarp and existing infrastructure (houses and roads) for a viable dune to be formed. Ongoing monitoring would be the only suitable method of assessing this, and if scraping is undertaken, the findings of this report should be reviewed at least every 10 years.

In the CSIRO (2007) modelling of climate change impacts for Wooli, the projected 100 year ARI storm surges were not predicted to increase by more than 0.03 m relative to 1980 levels (in addition to sea level rise). This increase in 100 year ARI storm surge over present day levels is minor relative to projections for sea level rise. Similarly, projections for increased storminess in CSIRO (2007) were inconclusive.

Table 6.1
Recession due to Sea Level Rise and Scraped Volumes required to Counteract it

	Sea level rise (m)		Recession (m)		Additional dune volume required to offset recession* (m^3/m)		Required number of scraping episodes (@ 8 m^3/m)	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Adopted “Low” SLR	0.05	0.1	3	6	18	36	2.3	4.5
Adopted “Mid” SLR	0.2	0.5	11	28	66	168	8.3	21
Adopted “High” SLR	0.3	0.9	17	50	102	300	13	38
NSW Government (2009)	0.4	0.9	22	50	132	300	16.5	38

*This is an equivalent scraped volume, which is not the same as full profile nourishment. High volumes would result in oversteepening of the beach and dune, and would not be sustainable. Full profile nourishment would require at least three times this volume and be over a greater length of beach.

Table 6.2
Required Scraping Volumes to Offset Recession (on subaerial beach only)

Scenario	Rate of rise (mm/year) at year			Recession rate (m/year)				Required scraping volume to offset ($m^3/m/year$)			
	2008	**2050**	**2100**	**Other**	**2008**	**2050**	**2100**	**Other**	**2008**	**2050**	**2100**
Recession due to SLR											
Adopted “Low” SLR	0.8	0.9	0.9		0.04	0.05	0.05		0.2	0.3	0.3
Adopted “Mid” SLR	1.7	4.2	8.3		0.09	0.23	0.46		0.5	1.4	2.8
Adopted “High” SLR	3.8	8.2	12.9		0.21	0.45	0.71		1.3	2.7	4.3
NSW Government (2009)*											
Underlying Recession											
PWD (1978) New Brighton				1.1				6.6			
PWD (1978) South Golden Beach				0.6				3.6			
WBM (2000) Best estimate south New Brighton				0.3				1.8			
WBM (2000) Best estimate remainder of New Brighton and South Golden Beach				0.1				0.6			

*The rate of rise is not given in NSW Government (2009), however, the projected values are similar to those adopted for the “High” scenario

7. MONITORING PROGRAM

7.1 Beach Profile Monitoring

It is recommended that the beach be surveyed at the following intervals:

- Before scraping;
- Immediately after scraping;
- 1 month after scraping;
- 3 monthly or following major storms if no additional scraping is undertaken.

Recommended beach profile monitoring could include:

- Manual surveys, $5,000 per episode;
- RTK-GPS surveys on foot and/or quad bike, $4,000 per episode;
- Aerial laser scanning ALS/LIDAR ($5,000 to $10,000 per episode);
- A coastal imaging system ($50,000 per year with weekly data).

A coastal imaging system may not be feasible due to the lack of high mounting points.

There may be positive or negative community opinion regarding the effects of beach scraping on surfing conditions and rip formation, however, the complexity of these phenomena (natural variability, multiple processes, antecedent wave climate, seasonality and human perception) means that objective assessment would be difficult.

7.2 Ecological Monitoring Program

The monitoring program (Appendix B) will also consider ecological recolonisation as part of the process. It will consider 'before and after' sampling of benthic invertebrates through the environmental impact assessment process.

8. APPROVAL PROCESS

The approval process is described in Parsons Brinckerhoff (2009) "Preliminary Environmental Impact Assessment - Beach Scraping New Brighton and South Golden Beach, Byron Shire, NSW, which is attached as Appendix A of this WRL report.

9. PRELIMINARY ENVIRONMENTAL ASSESSMENT

A preliminary environmental assessment is provided in Parsons Brinckerhoff (2009) "Preliminary Environmental Impact Assessment - Beach Scraping New Brighton and South Golden Beach, Byron Shire, NSW", which is attached as Appendix A of this WRL report. A brief summary is provided below.

9.1 Birds

Birds which may nest in the dunes include:

- Beach Stone-curlew *(Esacus neglectus)* which nests from September to November;
- Little Tern *(Sterna albifrons)* which nests in spring and summer.

The impacts of scraping on these nesting species could be avoided by undertaking the works outside of the nesting season. Other bird species are likely to use the impact areas only for feeding.

9.2 Turtles

Turtles which may nest in the dunes include:

- Green Turtle *(Chelonia mydas)* which nests from November to January;
- Loggerhead Turtle *(Caretta caretta)* which nests from November to January.

The impacts of scraping on these nesting species could be avoided by undertaking the works outside of the nesting season.

9.3 Vegetation

Some sand burial is a natural process for dune vegetation. Impacts can be minimised by not burying vegetation excessively and by integrating the works with vegetation management plans.

9.4 Intertidal Species

Pipis *(Donax deltoids)* live in both the intertidal and shallow sub tidal sediments. They are likely to be affected by scraping, however, scraping would only remove sand from the intertidal zone. Therefore, scraping would not affect those in the sub tidal zone, which would allow recolonisation. The effects can be minimised by maintaining shallow scraping depths of approximately 200 mm.

9.5 Additional Assessments Required

Before proceeding with the works the following actions would be required (Appendix A and B):

Significance assessment under the Threatened Species Act for the following:

- Dwarf Heath Casuarina (*Allocasuarina defungens);*
- Great Knot *(Calidris tenuiristris);*
- Beach Stone-curlew *(Esacus neglectus);*
- Pied Oystercatcher *(Haematipus longirostris);*
- Little Tern *(Sterna albifrons);*
- Green Turtle *(Chelonia mydas).*

Significance assessment under the Environment Protection and Biodiversity Conservation Act for the following:

- Dwarf Heath Casuarina (*Allocasuarina defungens);*
- Great Knot *(Calidris tenuiristris);*
- Little Tern *(Sterna albifrons);*
- Green Turtle *(Chelonia mydas).*

9.6 Timing of Scraping

Subject to the significance assessments required, the preliminary environmental assessment indicates that scraping could be undertaken in winter without affecting turtles or nesting birds.

10. COSTS AND COST-BENEFIT ANALYSIS

10.1 NSW Treasury Guidelines

NSW Treasury (2007) recommends a 20 year project life be used in economic appraisal, with a maximum allocated project life of 30 years. The 30 year life is used for durable assets such as dams. Costing for the Tweed River Sand Bypassing Project used a 25 year timeframe. A 20 to 30 year project life for economic modelling is somewhat at odds with the requirements of 50 to 100 year climate change planning timeframes. The WBM (2003) study which formed the basis of assessing benefits in this present WRL study, used timeframes of 25, 50 and 100 years. NSW Treasury (2007) suggests a real discount rate of 7% be used, with sensitivity analyses undertaken using rates of 4% and 10%. Costs presented in this report are exclusive of GST.

10.2 Property Values

WBM (2003, Table 2-8) estimated the present value of residential property forecast to be lost due to beach recession around Byron Shire. It is assumed that their recession calculations were based on mid sea level rise scenarios, but this is not clear. The WBM estimates for New Brighton and South Golden Beach using market values (indicated to be for 2001) are shown in Table 10.1 for 2001 dollars. It is noted that this analysis did not consider inundation. A detailed reanalysis of the WBM estimates is beyond this study, however, property market values have been adjusted upwards by 100% based on information presented by RPdata (www.realestate.com.au). This indicates the following change in median values between 2001 and 2007:

- New Brighton +100%;
- South Golden Beach +180%.

It is acknowledged that these increases are in the median price for the entire village, rather than the properties directly vulnerable to hazards. An assumed increase of +100% has been applied to both villages between 2001 and 2007. Clearly, ongoing changes in property values will alter this analysis. In undertaking the presented cost benefit analyses, the NSW Treasury (1997) recommendation of a 20 to 30 year project life (25 years adopted for non-climate change scenarios) with a discount rate of 7% and sensitivity analyses of 4% and 10% has been adopted.

The extent of benefit (in the form of an avoided loss) is the most difficult component to quantify. The substantial WBM (2003) study attributed a credible valuation to property and then attributed a proportion of the total property value (as a benefit in the form of an avoided loss) to a range of coastal management options for New Brighton and South Golden Beach. However, this proportion allocated in WBM appeared to be a subjective assumption. This proportion has been termed the *efficacy factor* by WRL. The proportions (efficacy factor) adopted by WBM were:

- Seawall: 50% of property losses avoided, plus 50% increase in property values (100% total);
- Groynes: 50% of property losses avoided, plus 50% increase in property values (100% total);
- Nourishment: 50% of property losses avoided, plus 50% increase in property values (100% total);
- Beach scraping: 0% of property losses avoided;
- Nourishment and groynes: 50% of property losses avoided, plus 50% increase in property values (100% total).

It is noted that WBM considered property losses in the south of New Brighton village (along North Head Road) which are south of the beach scraping study area (Figure 1.1). These properties comprise approximately 75% of the lots affected by the present day erosion hazard. Therefore, in Table 10.1, under the heading "Scraping Study Area Only" an item has been listed for the value of lots within the scraping study area which are affected by the present day erosion hazard. These lots within the beach scraping study area comprise only 25% of affected land identified within WBM (2003). Almost all the additional lots affected by the 50 year erosion hazard are within the study area. Note also that no houses are located in the present day study erosion hazard zone, but private residential land is. The cost (or avoided loss) for relocating beachfront roads (particularly The Esplanade at New Brighton) has not been costed, as a definitive plan is needed for realignment.

Tourism losses are discussed in the next section. Due to the higher uncertainty with beach scraping, WBM (2003) assumed that scraping did not provide any protection to avoid losses to property, nor would it provide any increase in property value.

As one of the aims of beach scraping is to reduce the erosion hazard to private property and infrastructure, this report has assumed that if scraping is undertaken with sufficient rigour and monitoring, sufficient scraping will protect property to a similar level as nourishment. It should be realised that compared with other management options, beach scraping has a lower initial cost, but higher uncertainty. Therefore, the recommended path if scraping is implemented, involves a rigorous monitoring program to test its efficacy.

Table 10.1
Present Value of Residential Property Forecast to be Lost due to Beach Erosion and Recession (WBM, 2003)

	New Brighton ($2001)	**South Golden Beach ($2001)**	**New Brighton ($2007, by WRL)**	**South Golden Beach ($2007, by WRL)**	**Combined ($2007, by WRL)**
Land value per 1000 m^2	400,000	400,000	800,000	800,000	
Land value per m^2	400	400	800	800	
Residential land with no utility (m^2)	13,114	0	13,114	0	
Additional in 50 years (m^2)	37,137	0	37,137	0	
Additional in 100 years (m^2)	27,732	10,466	27,732	10,466	
All of New Brighton and South Golden Beach					
Present Value (PV) @ 0%					
PV of losses now	5,245,600	0	10,491,200	0	10,491,200
PV of additional losses in 50 years	14,854,800	0	29,709,600	0	29,709,600
PV of additional losses in 100 years	10,870,944	4,102,672	21,741,888	8,205,344	29,947,232
Total of PV losses	**30,971,344**	**4,102,672**	**61,942,688**	**8,205,344**	**70,148,032**
Present Value (PV) @ 4%					
PV of losses now	5,043,846	0	10,087,692	0	10,087,692
PV of additional losses in 50 years	6,136,799	0	12,273,598	0	12,273,598
PV of additional losses in 100 years	640,612	241,7666	1,281,224	4,835,332	6,116,556
Total of PV losses	**11,821,258**	**241,766**	**23,642,516**	**483,532**	**24,126,048**
Present Value (PV) @ 7%					
PV of losses now	4,902,430		9,804,860	0	9,804,860
PV of additional losses in 50 years	3,831,913		7,663,826	0	7,663,826
PV of additional losses in 100 years	96,902	36,571	193,804	73,142	266,946
Total of PV losses	**8,831,244**	**36,571**	**17,662,488**	**73,142**	**17,735,630**
Present Value (PV) @ 10%					
PV of losses now	4,768,727		9,537,454	0	9,537,454
PV of additional losses in 50 years	2,677,865		5,355,730	0	5,355,730
PV of additional losses in 100 years	17,020	6,423	34,040	12,846	46,886
Total of PV losses	**7,463,612**	**6,423**	**14,927,224**	**12,846**	**14,940,070**
Scraping Study Area Only					
Residential land with no utility (m^2) (Scraping study area only)	3,280				
Residential land with no utility ($) (Scraping study area only)			2,624,000		2,624,000
Additional in 50 years (m^2)	37,137	0			
PV (0%) of additional in 50 years	14,854,800	0	29,709,600	0	29,709,600
PV (4%) of additional in 50 years	6,136,799	0	12,273,598	0	12,273,598
PV (7%) of additional in 50 years	3,831,913	0	7,663,826	0	7,663,826
PV (10%) of additional in 50 years	2,677,865	0	5,355,730	0	5,355,730

10.3 Tourism Effects

WBM (2003) estimated the cost of beach erosion on gross tourism receipts using limited data for Byron Shire. This was predominantly based on work undertaken by Raybould and Mules (1998) for the Gold Coast. The majority of WBM's analysis was undertaken only on a shire-wide basis, without separate values being derived for New Brighton and South Golden Beach. Some apportionment to New Brighton and South Golden Beach was undertaken by WBM which is discussed later in this WRL report. WBM (2003, p 2-98) cautioned that:

"*...the estimated losses described here assume that the Shire's beaches are repaired promptly after major erosion events..... If no repairs were conducted the long-term cumulative impacts would be far larger than even the worst case scenario developed...*"

It should be noted that the assumed revenue losses due to beach erosion are a small proportion of total tourism revenue. WBM (2003) presented four scenarios for tourism effects as shown in Table 10.2, namely:

Scenario 1: revenue grows at 2% per annum, revenue losses with major erosion are 2%.
Scenario 2: revenue grows at 2% per annum, revenue losses with major erosion are 10%.
Scenario 3: revenue grows at 4% per annum, revenue losses with major erosion are 2%.
Scenario 4: revenue grows at 4% per annum, revenue losses with major erosion are 10%.

Table 10.2
Present Value of Tourism Losses from Beach Erosion – Shire wide
($M 2003, WBM, 2003)

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Growth rate in visitor receipts (% pa)	2	2	4	4
Tourism lost (% of gross tourism receipts)	2	10	2	10
Present Values (PV) $M 2003				
PV of losses over 25 years @ 4%	39.5	197.6	40.3	201.5
PV of losses over 25 years @ 7%	29.5	147.4	30.1	150.3
PV of losses over 25 years @10%	23.0	114.8	23.4	117.1
PV of losses over 50 years @ 4%	54.3	271.7	55.4	277.0
PV of losses over 50 years @ 7%	34.9	174.6	35.6	178.0
PV of losses over 50 years @10%	25.1	125.4	25.6	127.9
PV of losses over 100 years @ 4%	62.0	309.9	63.2	316.0
PV of losses over 100 years @ 7%	36.1	180.5	36.8	184.0
PV of losses over 100 years @10%	25.3	126.5	25.8	129.0

Australian Bureau of Statistics population data from the 2006 census was as follows:

Byron Shire:	27,767;
New Brighton (NB):	274;
South Golden Beach (SGB):	1,474;
Ocean Shores (OS):	4,679;
Combined NB + SGB + OS:	6,427 (= 23% of Byron Shire).

In an effort to convert the WBM shire wide values to specific values for the combined area (the study area) of New Brighton and South Golden Beach, the values from WBM (2003) shown in Table 10.2 were converted to per capita values and allocated to the combined population of the study area (considered to be New Brighton, South Golden Beach and Ocean Shores) as shown in Table 10.3. Additional economic modelling would be needed to test this assumption. In the absence of such modelling, there is no other rational method to convert shire wide values to the study area other than per capita. WBM (2003, p2-101) did attempt to apportion potential tourism revenue losses by assuming "*a reasonable distribution of tourism values among the local beaches*" for a limited number of scenarios. The scenarios covered by WBM (2003) are shown with asterisks in Table 10.3. The notes below the table show that the values of WBM and WRL are comparable, but as noted above, a less subjective method was needed to consider additional scenarios to those presented in WBM (2003).

The consumer price index (all cities, all groups) increased by 12.1% between December 2003 and December 2007 (ABS, 2008), which formed the basis of an adjustment to 2007 dollars by WRL in Table 10.3. Also shown in Table 10.3 are average, and upper (Scenario 4 with 4% discount rate) and lower (Scenario 1 with 10% discount rate) limits for sensitivity costing.

The extent of benefit (in the form of an avoided loss) is the most difficult component to quantify. The substantial WBM (2003) study attributed a proportion of the total potential tourism revenue loss to a range of coastal management options for New Brighton and South Golden Beach, however, this proportion appeared to be a subjective assumption. As stated previously, this proportion has been termed the *efficacy factor* by WRL. The proportions (efficacy factor) adopted by WBM were:

- Seawall: 0% of tourism losses avoided;
- Groynes: 50% of tourism losses avoided;
- Nourishment: 100% of tourism losses avoided;
- Beach scraping: 10% of tourism losses avoided;
- Nourishment and groynes: 100% of tourism losses avoided.

These efficacy factors relate to a portion of a portion of total tourism revenue, for example groynes would avoid tourism losses of 50% of 2% for scenario 1, that is 1% of total tourism revenue.

As one of the aims of beach scraping is to avoid the loss of tourism revenue due to beach erosion in a manner comparable to nourishment, this report has assumed that sufficient scraping will achieve this aim to a similar extent as nourishment, that is, 100% of tourism losses avoided, however, ongoing monitoring would be required to test this assumption. Also shown in Table 10.3 are limited cases with an efficacy factor of 10% as originally assumed by WBM. It should be realised (as stated previously) that compared with other management options, beach scraping has a lower initial cost, but higher uncertainty. Therefore, the recommended path if scraping is implemented, involves a rigorous monitoring program to test its efficacy.

Table 10.3
Present Value of Tourism Losses from Beach Erosion adapted to New Brighton, South Golden Beach and Ocean Shores

	Scenario				**Av ($M 2003 by WRL)**	**Av ($M 2007 by WRL)**	**Av ($M 2007 by WRL)**	**Upper ($M 2007 by WRL)**	**Lower ($M 2007 by WRL)**
	1	**2**	**3**	**4**					
Growth in visitor receipts (% pa)	2	2	4	4	3				
Tourism lost (% gross receipts)	2	10	2	10	6				
Efficacy factor assumed (%)	100	100	100	100	100	100	10	100	100
Present Values (PV) $M 2003									
PV of losses over 25 years @ 4%	9.1	45.7	9.3	46.6	27.7	31.0		52.2	
PV of losses over 25 years @ 7%	6.8	34.1	7.0	34.8	20.7	23.2	2.3		
PV of losses over 25 years @10%	5.3	26.6	5.4	27.1	16.1	18.0			5.9
PV of losses over 50 years @ 4%	12.6	62.9	12.8	64.1	38.1	42.7		71.8	
PV of losses over 50 years @ 7%	8.1 *	40.4	8.2	41.2 **	24.5	27.4	2.7		
PV of losses over 50 years @10%	5.8	29.0	5.9	29.6	17.6	19.7			6.5
PV of losses over 100 years @ 4%	14.4	71.7	14.6	73.1	43.5	48.7		81.9	
PV of losses over 100 years @ 7%	8.4	41.8	8.5	42.6	25.3	28.4	2.8		
PV of losses over 100 years @10%	5.9	29.3	6.0	29.9	17.8	19.9			6.6

Notes for Table 10.3:

* The value from WBM (2003) for New Brighton and South Golden Beach for this scenario was based on assuming “a reasonable distribution of tourism values among the local beaches” was $7.0M. WRL’s estimate is based on per capita distribution. The two methods yield similar values. A comparable value for the other scenarios (not asterisked) was not available in WBM (2003).

** The value from WBM (2003) for New Brighton and South Golden Beach for this scenario based on assuming “a reasonable distribution of tourism values among the local beaches” was $35.6M. WRL’s estimate is based on per capita distribution. The two methods yield similar values.

10.4 Rate Revenue

WBM (2003) also considered loss of rate revenue to Council in its economic modelling, however, this amount was small relative to the values shown in Tables 10.1, 10.2 and 10.3.

10.5 Benefit to Cost Ratio

Rawlinsons (2007) provides the following quotation on Life Cycle Costing or Net Present Value Analysis:
"Life Cycle Costing is best used in a comparative situation to provide an approximate answer to a precise question *rather than a precise answer to an approximate question*."

10.5.1 Scenarios

This section considers only economic costs and benefits. Costs presented in this report are ex GST. Environmental impacts are described in PB (2009), but have not been costed. The overall justification for a project may extend beyond economic factors. The following beach scraping scenarios have been considered in this report:

- Scenario 1: Scrape to preserve/restore beach access points (25 years);
- Scenario 2: Scrape to build dunes to a design profile (25 years);
- Scenario 3: Scrape to build dunes to a design profile and offset recession due to sea level rise (0.2 m, 40 years);
- Scenario 4: Scrape to build dunes to a design profile and offset recession due to sea level rise (0.4 m, 40 years).

The assumptions used in developing costing are shown in Table 10.4.

Table 10.4
Assumptions used in Benefit to Cost Ratio Scenarios

	Scenario				
	All	**1**	**2**	**3**	**4**
Time		25 years	25 years	40 years	40 years
Alongshore length	2300 m				
Sea level rise		-	-	0.2 m	0.4 m
Scraping cost	$7/m^3				
Underlying recession		-	0.1 m/yr	0.1 m/yr	0.1 m/yr
Initial volume (in multiple episodes)		640 m^3	94,000 m^3	94,000 m^3	94,000 m^3
Annual maintenance volume		640 m^3	18,400 m^3	18,400 m^3	18,400 m^3
Volume to offset underlying recession per year			1,380 m^3	1,380 m^3	1,380 m^3
Volume to offset SLR per year		-	-	3,795 m^3	7,590 m^3

10.5.2 Scenario 1: Scrape to Preserve/Restore Access Points to 2035 (25 years)

This scenario involves the following assumptions:

- One episode per year of 8 m^3/m over 4 m width, giving 32 m^3 per access point;
- 20 access points (7 + 13);
- $7 per m^3 of material scraped;
- No monitoring program;
- Avoided tourism losses as per WBM (2003) adjusted by WRL as per Table 10.3;
- No reduction in property losses.

Costs and benefits are shown in Table 10.5. Benefit to cost ratios greater than one can economically justify a project, with the overall justification also subject to non-economic factors. For the 7% discount rate scenario, and 100% efficacy factor, the benefit to cost ratio is 444, which is highly favourable. Even with an efficacy factor of 10%, the benefit to cost ratio is 44, which is highly favourable. Other means besides beach scraping may be available to preserve/restore beach access. The high benefit to cost ratio shows the value of beach access for tourism.

10.5.3 Scenario 2: Scrape to Build Dunes to Design Profile to 2035 (25 years)

This scenario involves the following assumptions:

- Initial sand volume of 90,000 m^3 for New Brighton (about six episodes with 0.2 m scraping depth);

- Initial sand volume of 4,000 m^3 for South Golden Beach (one episode with 0.2 m scraping depth);
- Maintenance scraping of 8 m^3/m each year. Note that the future sequencing of storms and ongoing monitoring may vary this requirement;
- Additional scraping to offset underlying recession of 0.1 m/year (0.6 m^3/m each year);
- $7 per m^3 of material scraped;
- Physical monitoring program of $20,000 per year;
- Biological monitoring program of $10,000 per year;
- Property losses as per WBM (2003) adjusted by WRL as per Table 10.1;
- Tourism losses as per WBM (2003) adjusted by WRL as per Table 10.3.

Costs and benefits are shown in Table 10.6. Benefit to cost ratios greater than one can economically justify a project, with the overall justification also subject to non-economic factors. For the 7% discount rate scenario and 100% efficacy factor, the benefit to cost ratio is 9.6 for tourism revenue, which is very favourable, and 1.0 for property protection which is neutral. With an efficacy factor of 10%, the benefit to cost ratio for tourism revenue is 1.0, which is neutral.

10.5.4 Scenario 3: Scrape to Build Dunes to Design Profile and Offset Recession due to Sea Level Rise to 2050 (0.2 m, 40 years)

This scenario involves the following assumptions:

- Initial sand volume of 90,000 m^3 for New Brighton (about six episodes with 0.2 m scraping depth);
- Initial sand volume of 4,000 m^3 for South Golden Beach (one episode with 0.2 m scraping depth);
- Maintenance scraping of 8 m^3/m each year. Note that the future sequencing of storms and ongoing monitoring may vary this requirement.
- Additional scraping to offset underlying recession of 0.1 m/year (0.6 m^3/m each year);
- Mid sea level rise of 0.2 m by 2050, resulting in sea level rise scraping of 8 m^3/m every 5 years (Table 6.1). Note that the future sequencing of storms and ongoing monitoring may vary this requirement.
- $7 per m^3 of material scraped;

- Physical monitoring program of $20,000 per year (lower than above scenarios due to reduced scope);
- Biological monitoring program of $10,000 per year (lower than above scenarios due to reduced scope);
- Property losses as per WBM (2003) adjusted by WRL as per Table 10.1;
- As the timeframe substantially exceeds treasury guidelines, tourism losses have not been calculated for this scenario.

Costs and benefits are shown in Table 10.7. Benefit to cost ratios greater than one can economically justify a project, with the overall justification also subject to non-economic factors. For the 7% discount rate scenario with 100% efficacy, the benefit to cost ratio with 0.2 m sea level rise is 3.3 for property losses which is favourable.

10.5.5 Scenario 4: Scrape to Build Dunes to Design Profile and Offset Recession due to Sea Level Rise to 2050 (0.4 m, 40 years)

This scenario involves the same assumptions as Scenario 3, except for the following:

- Sea level rise of 0.4 m by 2050;
- Scraping of 8 m^3/m every 3 years (Table 6.1). Note that the future sequencing of storms and ongoing monitoring may vary this requirement.

The benefits from this scenario cannot be directly calculated from WBM (2003) because this sea level scenario was not considered by them. Therefore the same benefit attributed to 0.2 m sea level rise has been used – though this is likely to be an underestimate.

Costs and benefits are shown in Table 10.8. For the 7% discount rate scenario with 100% efficacy, the benefit to cost ratio with 0.2 m sea level rise is 3.0 for property losses which is favourable.

Table 10.5
Benefit to Cost Ratio for Scenario 1: Scraping to Preserve/Restore Beach Access Points to 2035 (25 years)

	Combined cost ($2007)	**Benefits ($2007)**	**Benefit to cost ratio**
Scrape to preserve beach access points			
Cost per episode	4,500		
Monitoring program – physical	minor		
Monitoring program – environmental	minor		
Net present cost 25 years @ 4%	70,000		
Net present cost 25 years @ 7%	52,000		
Net present cost 25 years @ 10%	41,000		
Benefits			
Preservation of property 25 years @ 4%		0	
Preservation of property 25 years @ 7%		0	
Preservation of property 25 years @ 10%		0	
100% efficacy factor			
Preservation of tourism revenue (high scenario, 4%)		52,200,000	
Preservation of tourism revenue (mid scenario, 7%)		23,200,000	
Preservation of tourism revenue (low scenario, 10%)		5,900,000	
Total benefits (high scenario 4%)		52,200,000	746
Total benefits (mid scenario 7%)		23,200,000	444
Total benefits (low scenario10%)		5,900,000	145
10% efficacy factor			
Total benefits (mid scenario 7%)		2.300,000	44

Notes: 1. Future sea level rise may reduce the feasibility of this option
2. Additional access structures may replace or compliment this option

Table 10.6
Benefit to Cost Ratio for Scenario 2: Scraping to Build Dunes to Design Profile to 2035 (25 years)

	Combined cost ($2007)	Benefits ($2007)	Benefit to cost ratio
Scrape to build dunes to design profile			
Cost for initial episode	660,000		
Annual maintenance per year	128,800		
Additional annual underlying recession of 0.1 m/year	9,660		
Monitoring program – physical per year	20,000		
Monitoring program – environmental per year	10,000		
Net present cost 25 years @ 0%	4,703,000		
Net present cost 25 years @ 4%	3,104,000		
Net present cost 25 years @ 7%	2,422,000		
Net present cost 25 years @ 10%	1,975,000		
Benefits (Property in study area only)			
100% efficacy factor for property and tourism			
Preservation of property 25 years @ 0%		2,622,800	
Preservation of property 25 years @ 4%		2,522,000	0.8
Preservation of property 25 years @ 7%		2,451,000	1.0
Preservation of property 25 years @ 10%		2,384,000	1.2
Preservation of tourism revenue (high scenario, 4%)		52,200,000	16.8
Preservation of tourism revenue (mid scenario, 7%)		23,200,000	9.6
Preservation of tourism revenue (mid scenario, 10%)		5,900,000	3.0
0% efficacy factor for property, 10% for tourism			
Preservation of tourism revenue (mid scenario, 7%)		2,320,000	1.0

Notes: 1. The same factors used for the efficacy of nourishment in WBM (2003) have been used for scraping

Table 10.7
Benefit to Cost Ratio for Scenario 3: Scraping to Build Dunes and Offset Sea Level Rise (0.2 m, 40 years)

	Combined cost ($2007)	Benefits ($2007)	Benefit to cost ratio
Build dune to design profile	660,000		
Annual maintenance per year	128,800		
Additional annual underlying recession of 0.1 m/year	9,660		
Scrape to offset recession due to SLR	26,565		
Monitoring program – physical per year	20,000		
Monitoring program – environmental per year	10,000		
Net present cost 40 years @ 0%	8,266,000		
Net present cost 40 years @ 4%	4,307,000		
Net present cost 40 years @ 7%	3,035,000		
Net present cost 40 years @ 10%	2,330,000		
Benefits (100% efficacy)			
Preservation of property 50 years @ 0%		32,332,000	3.9
Preservation of property 50 years @ 4%		14,796,000	3.4
Preservation of property 50 years @ 7%		10,115,000	3.3
Preservation of property 50 years @ 10%		7,739,730	3.3

Table 10.8
Benefit to Cost Ratio for Scenario 4: Scraping to Build Dunes and Offset Sea Level Rise (0.4 m, 40 years)

	Combined cost ($2007)	Benefits ($2007)	Benefit to cost ratio
Build dune to design profile	660,000		
Annual maintenance per year	128,800		
Additional annual underlying recession of 0.1 m/year	9,660		
Scrape to offset recession due to SLR	53,130		
Monitoring program – physical per year	20,000		
Monitoring program – environmental per year	10,000		
Net present cost 40 years @ 0%	9,302,000		
Net present cost 40 years @ 4%	4,807,000		
Net present cost 40 years @ 7%	3,364,000		
Net present cost 40 years @ 10%	2,565,000		
Benefits (100% efficacy)			
Preservation of property 50 years @ 0%		32,332,000	3.5
Preservation of property 50 years @ 4%		14,796,000	3.1
Preservation of property 50 years @ 7%		10,115,000	3.0
Preservation of property 50 years @ 10%		7,739,730	3.0

10.6 Summary of Benefit to Cost Ratios

For the discount rate of 7%, the following benefit to cost ratios were estimated above, assuming 100% efficacy for beach scraping:

Preserve/restore beach access following storm erosion (tourism only): 444

Build a dune to a design profile to reduce erosion hazard (property benefits): 1.0

Increase the dune volume and offset sea level rise (0.2 m) (property benefits): 3.3

Increase the dune volume and offset sea level rise (0.4 m) (property benefits): 3.0

These benefit to cost ratios are high and economically justify beach scraping, particularly for tourism benefits. This is predominantly because beach scraping is a potentially cheaper form of beach nourishment, whereby much of the work is performed by nature. WBM (2003) undertook a limited economic appraisal of beach scraping and estimated lower benefit to cost ratios – their costs were comparable to WRL's but they attributed a lower efficacy to the benefits of beach scraping relative to other management options, whereas, subject to ongoing monitoring, WRL has attributed the same efficacy to scraping as nourishment.

As discussed previously, beach scraping has higher uncertainty as a protection measure than other coastal management options, so should only be undertaken in conjunction with a comprehensive monitoring program (Appendix B).

11. STAKEHOLDER INVOLVEMENT

The following Community information sessions were held:

- Ocean Shores community centre on 4 September 2007 from 2 to 3 pm. 11 attendees;
- South Golden Beach hall on 4 September 2007 from 5 to 6 pm. 12 attendees.

Information on beach scraping was presented to attendees, the details of which are on Byron Shire Council's website at http://www.byron.nsw.gov.au/beach-scraping .

12. CONCLUSIONS

12.1 Description

Beach scraping is defined as the movement of small to medium quantities of sand from the lower part of the littoral beach system to the dune, using mechanical means. It mimics natural beach recovery processes, but increases the recovery rate. Beach scraping is not as well tested as a coastal engineering protection measure compared with full profile nourishment and coastal structures. Therefore it is more difficult to predict its performance. For beach scraping, as with all sandy beaches, future behaviour is dependent on storminess and sea level rise which cannot be predicted.

12.2 History

New Brighton suffered major damage to houses in the 1970s. Beach scraping and dune building was undertaken from the late 1970s until 1996. It was discontinued due to possible negative environmental impacts. It is noteworthy that no property damage has occurred at New Brighton for more than 30 years. This may be partly attributed to dune building through beach scraping, however, it may also be attributed to lower storminess and increased littoral bypassing of the Brunswick River training walls.

12.3 Scope and Costing

12.3.1 Scope

Several aims and four cost scenarios of beach scraping were considered, namely:

1. Restore and maintain pedestrian beach access;
2. Build dune to a design profile;
3. Build dune to a design profile and offset sea level rise (0.2 m);
4. Build dune to a design profile and offset sea level rise (0.4 m).

It is recommended that material be won from the intertidal area and that scraping depths be limited generally to 0.2 m, with an absolute maximum scaping depth of 0.5 m.

12.3.2 Restore and Maintain Pedestrian Beach Access

For a real discount rate of 7% over 25 years to 2035, the net present cost to restore and maintain pedestrian beach access for the assumptions used is $52,000. Based on the economic modelling undertaken by WBM (2003) with some updating and modification by WRL, the benefit to cost ratio with regard to tourism revenue for this with a mid scenario 7% discount rate is 444. This indicates the dependence of tourism on beach access, however, alternative beach access methodologies may be considered.

12.3.3 Build Dune to a Design Profile

It is estimated that as of the last survey (16/08/2007) New Brighton requires approximately 90,000 m^3 over 1800 m to build the dunes to a design profile sufficient to resist overtopping and reduce the present day erosion hazard to private and public property. South Golden Beach has sufficient sand volume but requires the dune crest to be raised by approximately 1 m in places to reduce the risk of inundation.

For a real discount rate of 7% over 25 years to 2035, the net present cost to build the dune to a design profile for the assumptions used is $2.4M. Based on the economic modelling undertaken by WBM (2003) with some updating and modification by WRL, the benefit to cost ratio for this with a mid scenario 7% discount rate is 1.0 for property protection.

12.3.4 Build Dune to a Design Profile and Offset Sea Level Rise

Beach scraping is unlikely to be able to counteract a sea level rise of 1 m, however, the required scraping volumes and number of episodes to counteract recession due to intermediate sea level rise scenarios are relatively small. In light of the uncertainty regarding future sea level rise and beach scraping behaviour, the use of this study for planning beyond 2050 is not recommended without additional monitoring and analysis. For a 2050 mid sea level rise scenario of 0.2 m, approximately eight scraping episodes would be needed, that is approximately one every 5 years (notwithstanding storm events) in addition to those for initial construction, maintenance and underlying recession. For a 2050 high sea level rise scenario of 0.4 m, approximately 17 additional scraping episodes would be needed, that is approximately one every 2 to 3 years (notwithstanding storm events).

For a real discount rate of 7% over 40 years to 2050, the net present cost to construct the dune and increase the dune volume to offset recession due to sea level rise (0.2 m) for the assumptions used, is $3.0M, and for 0.4 m sea level rise is $3.4M. Based on the economic modelling undertaken by WBM (2003) with some updating and modification by WRL, the benefit to cost ratio for property protection for this with a mid scenario 7% discount rate is 3.3 for 0.2 m sea level rise and at least 3.0 for 0.4 m sea level rise.

12.4 Monitoring

Physical and environmental monitoring programs (as detailed in the text and Appendix B) need to be undertaken if beach scraping is undertaken or planned.

It is recommended that the beach be surveyed at the following intervals:

- Before scraping;
- Immediately after scraping;
- 1 month after scraping;
- 3 monthly or following major storms if no additional scraping is undertaken.

12.5 Environmental factors

A preliminary environmental assessment is provided in Parsons Brinckerhoff (2009) "Preliminary Environmental Impact Assessment - Beach Scraping New Brighton and South Golden Beach, Byron Shire, NSW", which accompanies this WRL report. A brief summary is provided below.

With reference to Appendix A and B, birds which may nest in the dunes include:

- Beach Stone-curlew *(Esacus neglectus)* which nests from September to November;
- Little Tern *(Sterna albifrons)* which nests in spring and summer.

Turtles which may nest in the dunes include:

- Green Turtle *(Chelonia mydas)* which nests from November to January;
- Loggerhead Turtle *(Caretta caretta)* which nests from November to January.

The impacts of scraping on these nesting species could be avoided by undertaking the works outside of the nesting season. Other bird species are likely to use the impact areas only for feeding.

Some sand burial is a natural process for dune vegetation. Impacts can be minimised by not burying vegetation excessively and by integrating the works with vegetation management plans.

Pipis *(Donax deltoids)* live in both the intertidal and shallow sub tidal sediments. They are likely to be affected by scraping, however, scraping would only remove sand from the intertidal zone. Therefore, scraping would not affect those in the sub tidal zone, which would allow recolonisation. The effects can be minimised by maintaining shallow scraping depths of approximately 0.2 m.

12.6 Additional Environmental Assessments Required

Before proceeding with the works the following actions would be required (Appendix A and B):

Significance assessment under the Threatened Species Act for the following:

- Dwarf Heath Casuarina (*Allocasuarina defungens;)*
- Great Knot *(Calidris tenuiristris);*
- Beach Stone-curlew *(Esacus neglectus);*
- Pied Oystercatcher *(Haematipus longirostris);*
- Little Tern *(Sterna albifrons);*
- Green Turtle *(Chelonia mydas).*

Significance assessment under the Environment Protection and Biodiversity Conservation Act for the following:

- Dwarf Heath Casuarina (*Allocasuarina defungens);*
- Great Knot *(Calidris tenuiristris);*
- Little Tern *(Sterna albifrons);*
- Green Turtle *(Chelonia mydas).*

12.7 Timing of Scraping

Based on the analysis of wind data, wave climate and measured beach processes nearby on the Gold Coast, it is recommended that scraping work be undertaken in late winter or in spring. Subject to the significance assessments required (Appendix A and B), the preliminary environmental assessment indicates that scraping could be undertaken in winter without affecting turtles or nesting birds.

Therefore, August is considered to be the most suitable (but not ideal) month for major scraping works. Due to the high pedestrian traffic and limited alongshore extent, minor scraping to maintain pedestrian access could be undertaken at other times without major impacts.

12.8 Other Considerations

This study has focussed on the urban areas of New Brighton and South Golden Beach. If beach scraping is implemented there and considered successful after a monitoring period (of the order of 5 to 10 years) consideration also needs to be given to extending the scheme to the areas south and north of New Brighton which have low dunes.

12.9 Recommendation

Minor ongoing scraping to preserve or restore access at authorised points is recommended, as these points already carry frequent foot traffic.

Subject to the required physical and environmental monitoring programs being undertaken, it is recommended that a trial scraping episode be undertaken at New Brighton, with scraping undertaken in the intertidal zone for depths of up to 0.2 m, giving a scraping volume of approximately 8 m^3/m. The focus should be to raise low points in the dune, and to enhance beach access and amenity.

Ongoing physical and environmental monitoring should be undertaken with this trial episode, and community acceptance gauged before proceeding with further scraping episodes.

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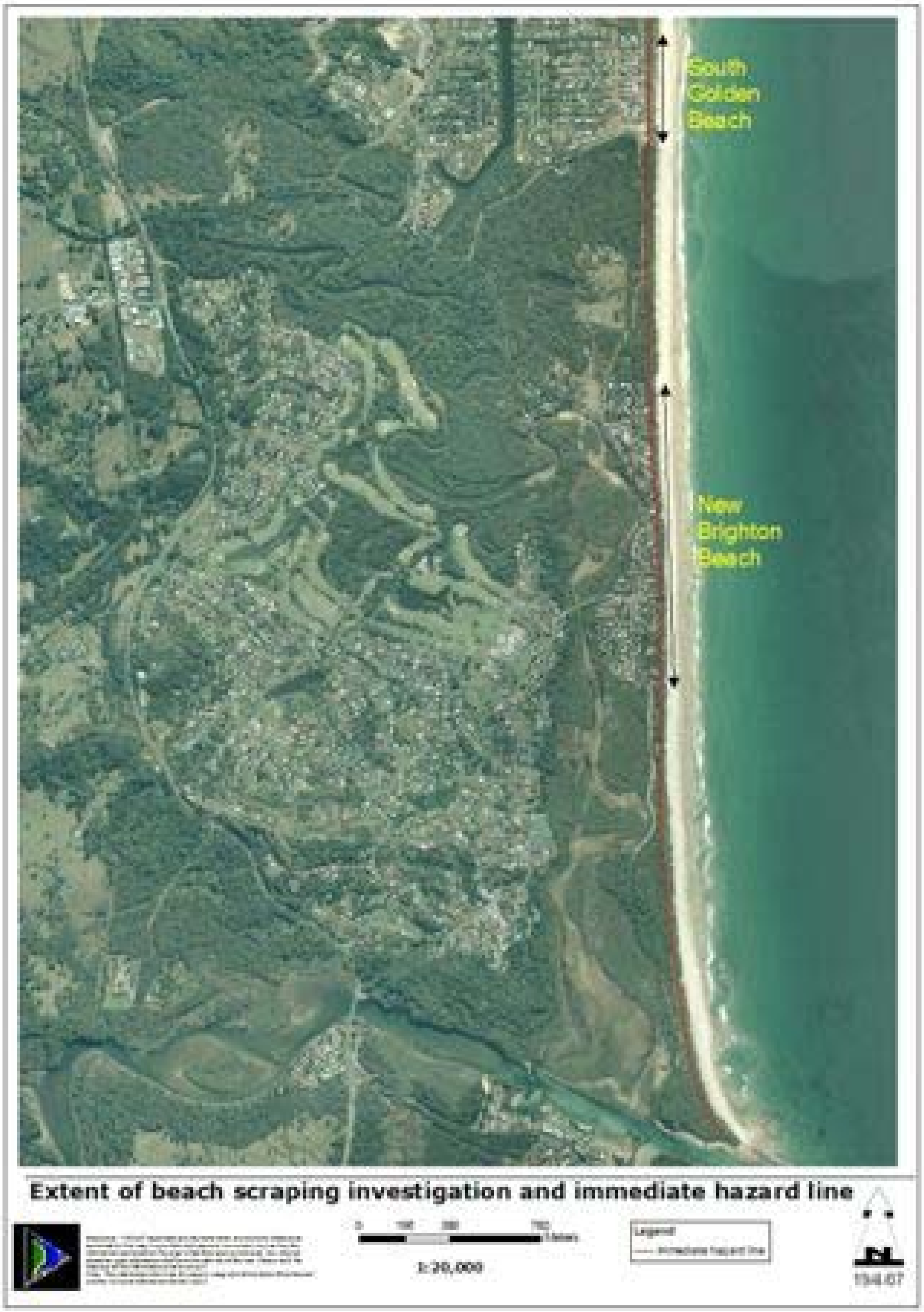
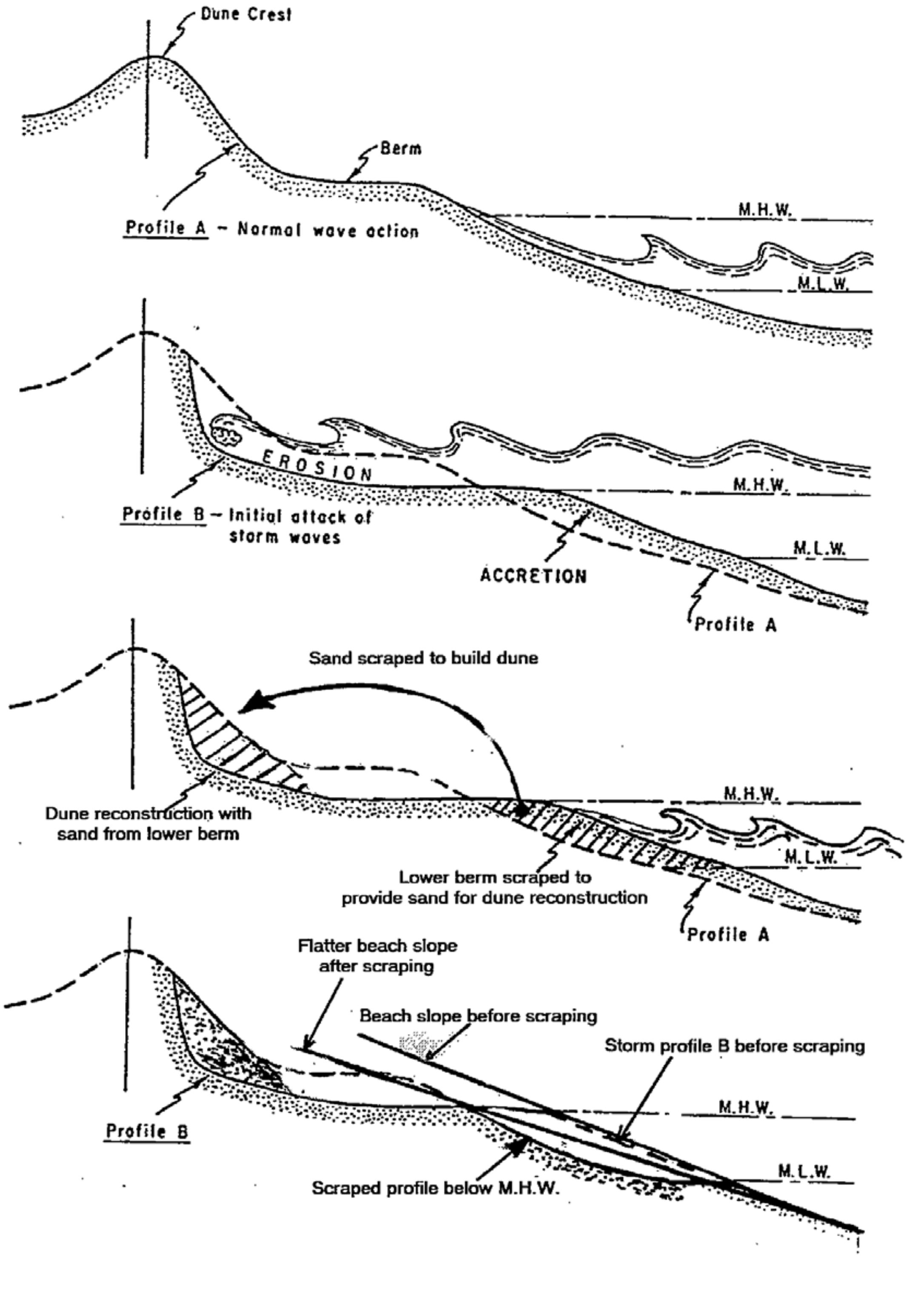


Source: Byron Shire Council



WRL Report No. 2008/19	CONCEPT OF BEACH SCRAPING	Figure 1.2

Gold Coast 1967

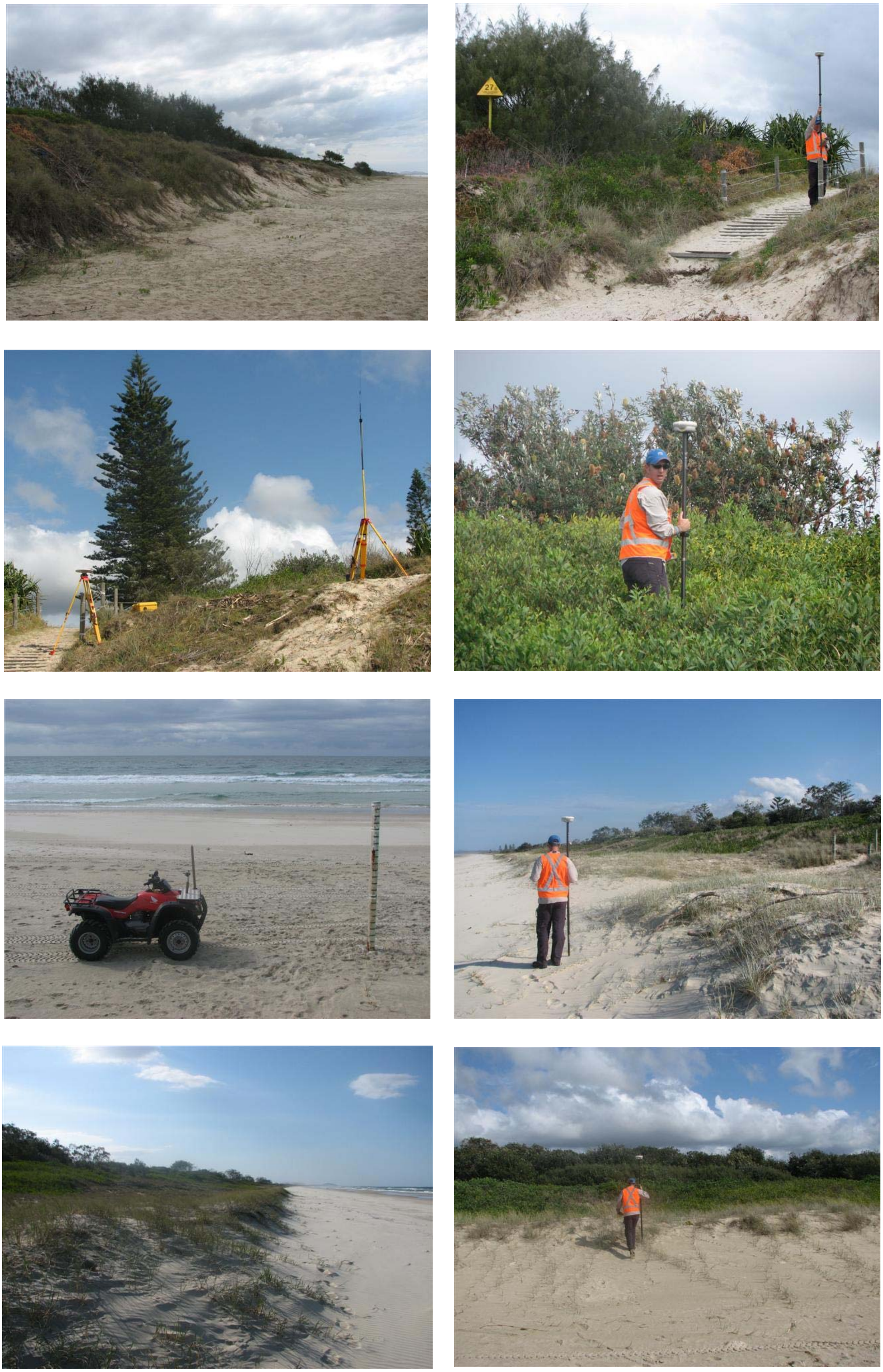
Sydney 2008

Sydney 2008

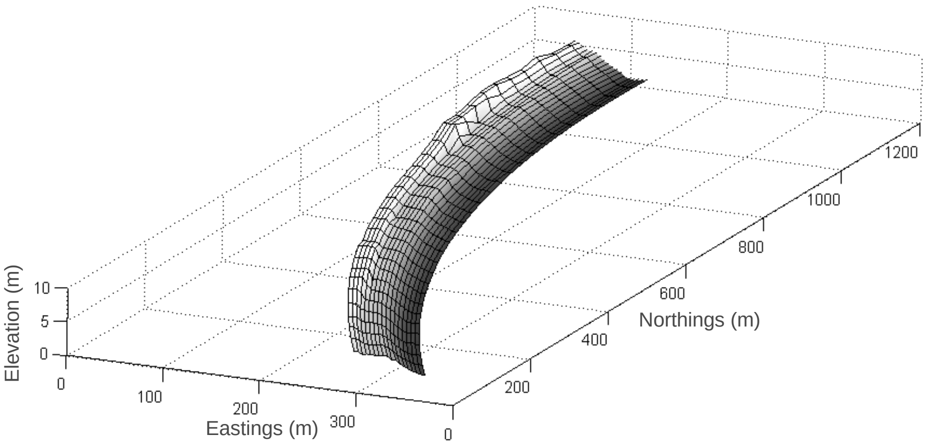
WRL Report No. 2008/19	PHOTOS OF BEACH SCRAPING	Figure 1.3

Esplanade looking north, March 1975. Source: Rendel (1975)

North Head Road looking south, 6 March 1976. Source: Rendel (1976)



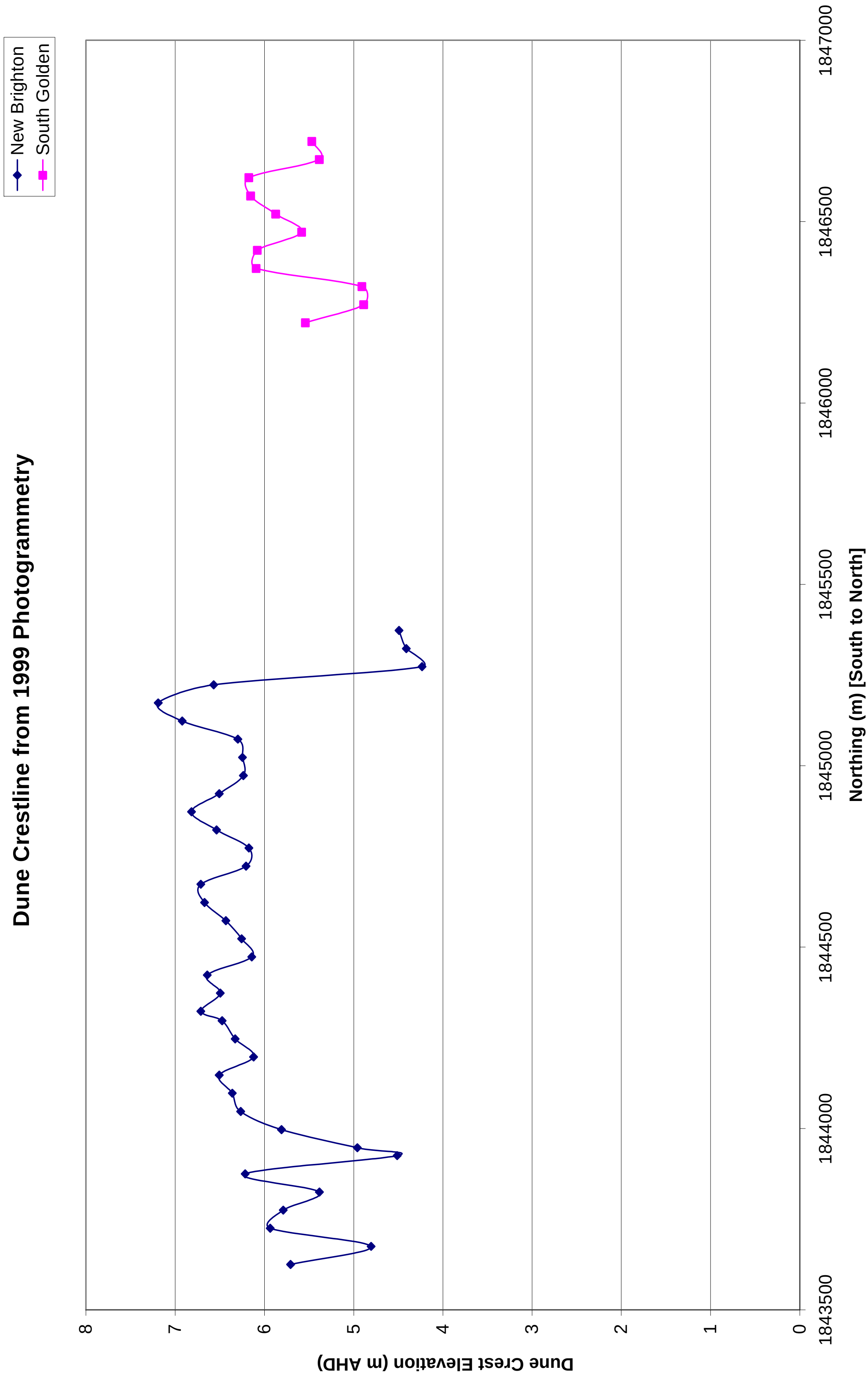
WRL Report No. 2008/19	WRL SURVEY OF NEW BRIGHTON AND SOUTH GOLDEN BEACHES: 15-16 AUGUST, 2007	Figure 2.1



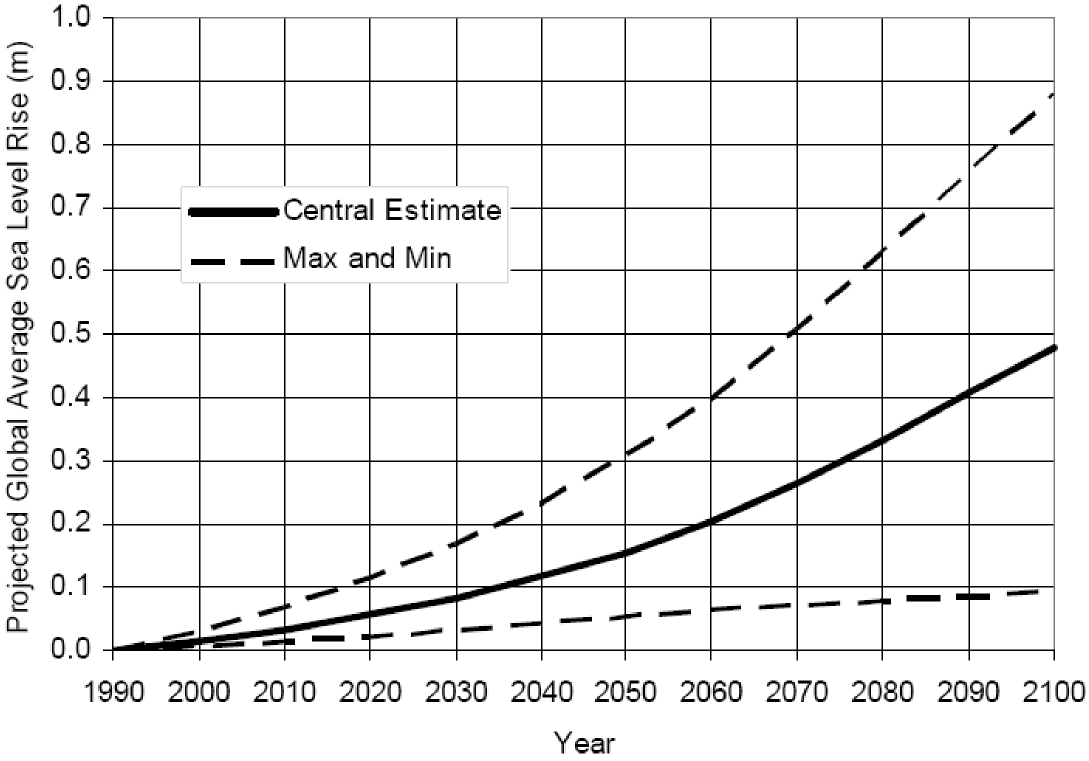
WRL
Report No. 2008/19

ILLUSTRATION OF WRL BEACH SURVEYING

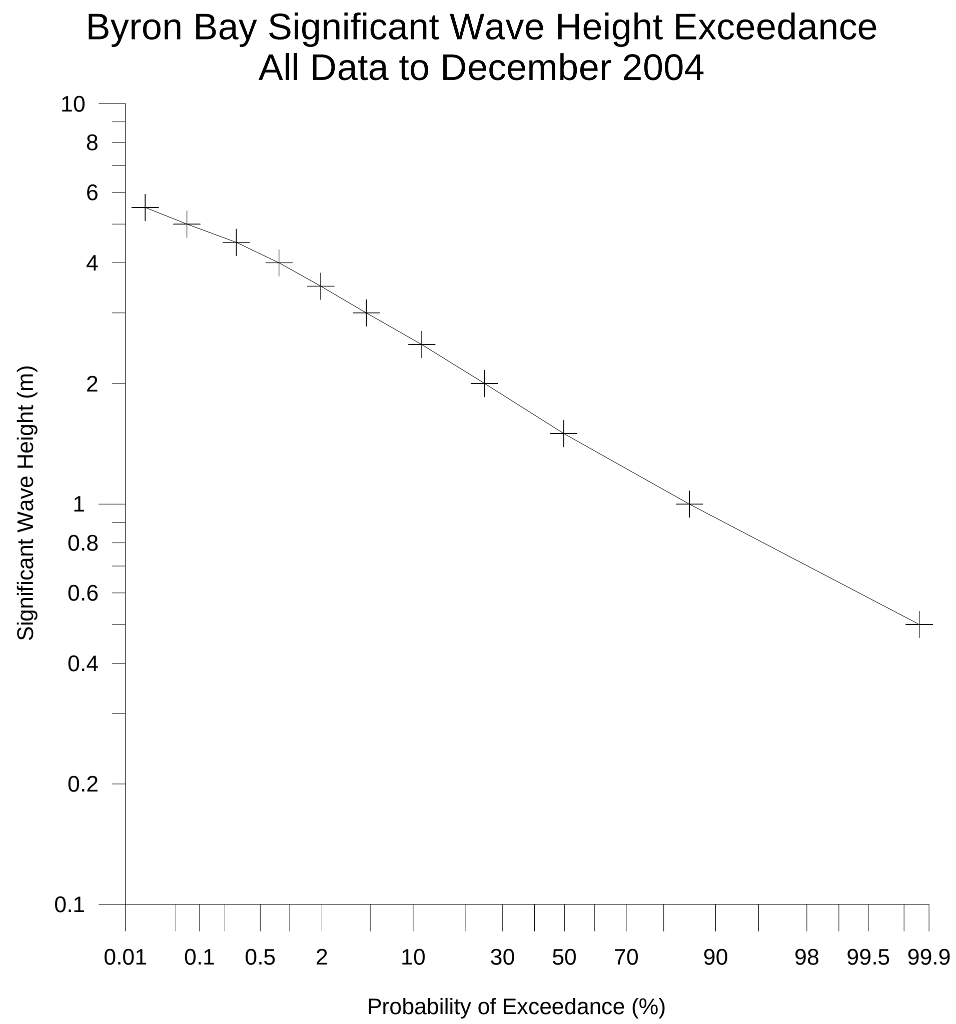
Figure 2.2

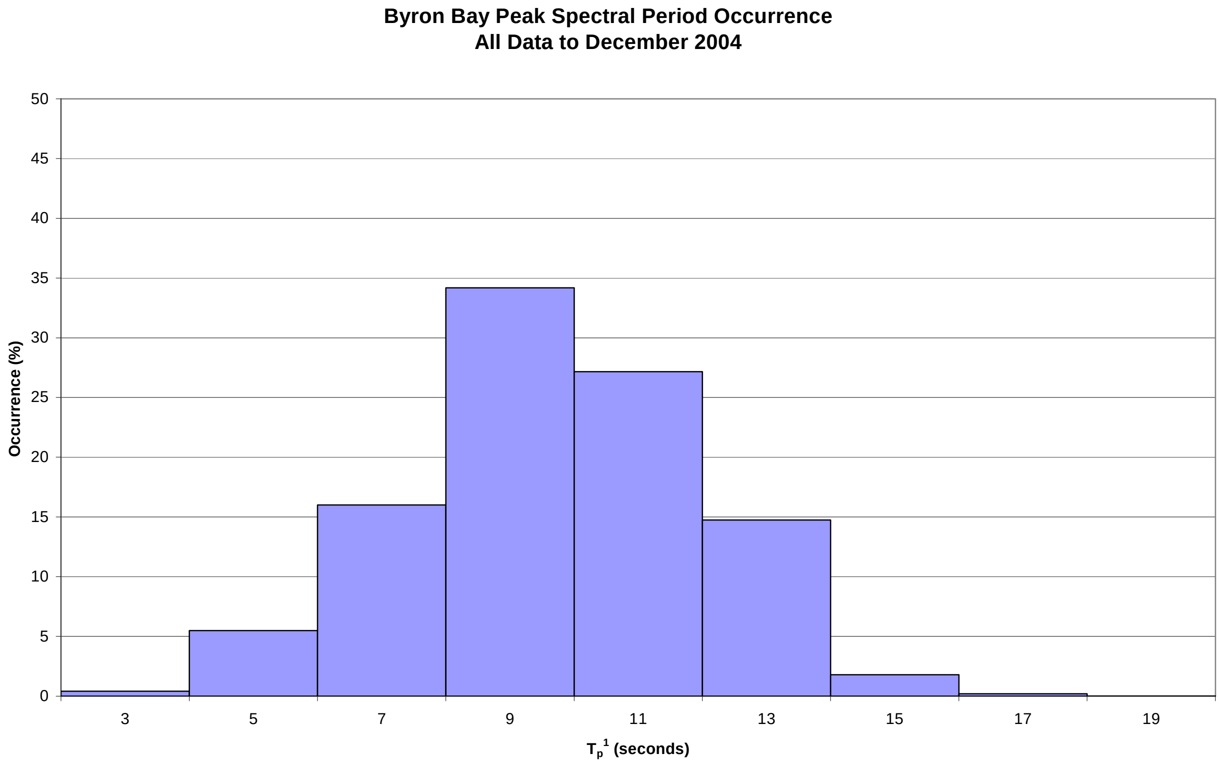


WRL Report No. 2008/19	DUNE CRESTLINE IN NORTH-SOUTH DIRECTION	Figure 2.3



Simplified sea level rise scenarios from NCCOE (2004)

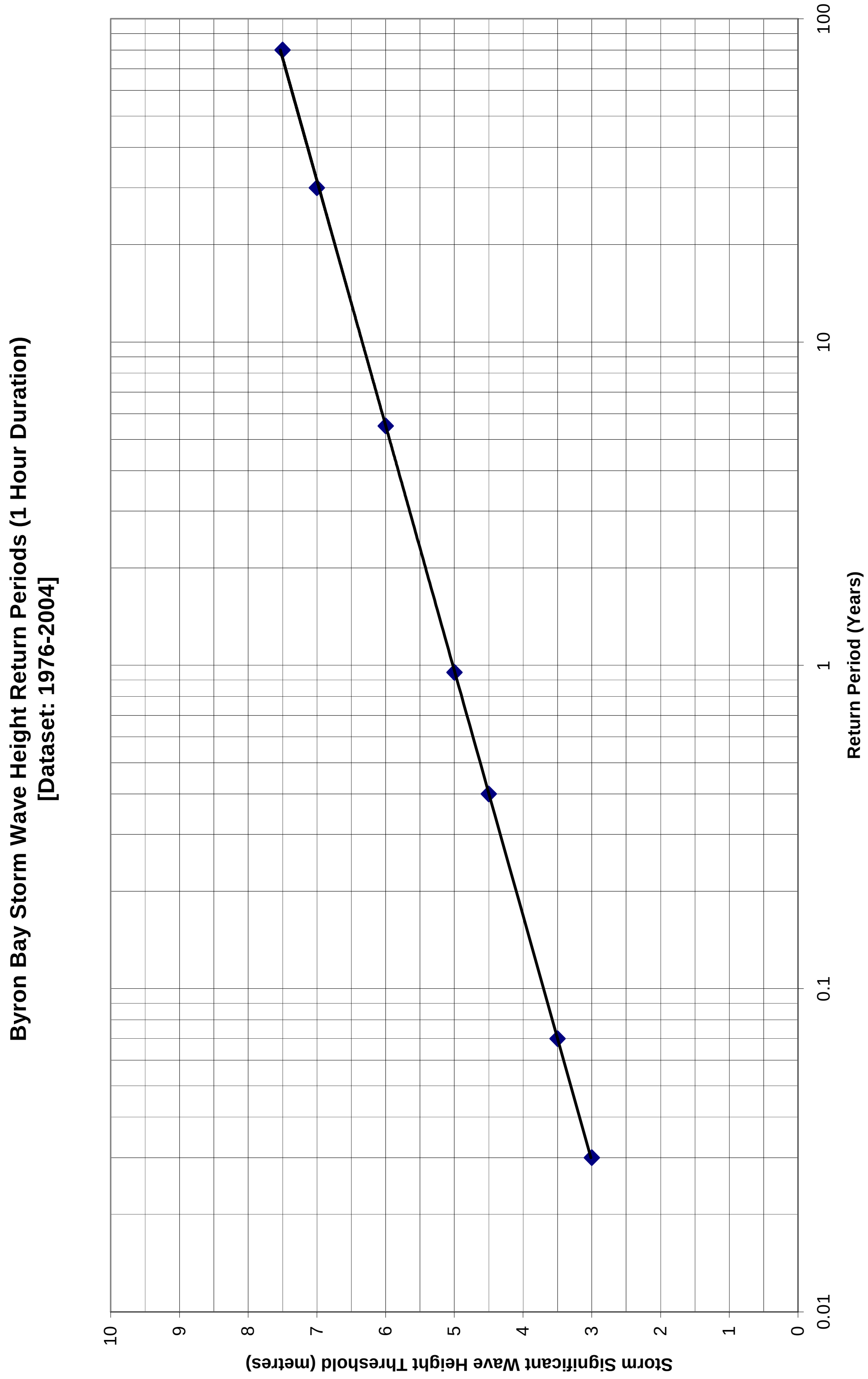




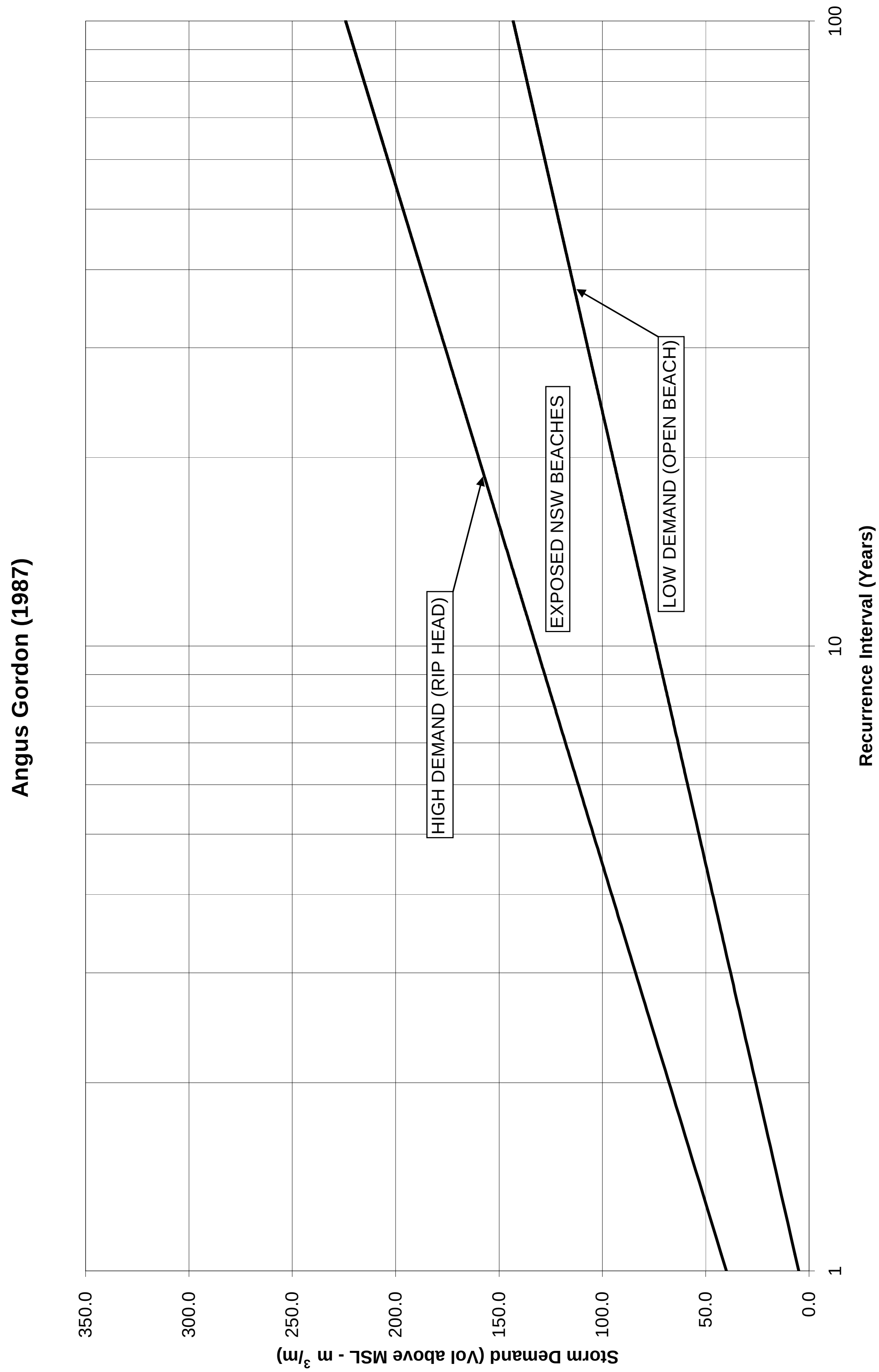
(Source: Manly Hydraulics Laboratory)

WRL Report No. 2008/19	BYRON BAY WAVE CLIMATE	Figure 4.2

(Source: Manly Hydraulics Laboratory)



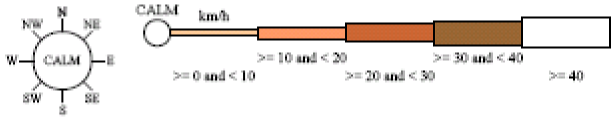
WRL Report No. 2008/19	BYRON BAY STORM WAVE HEIGHT RETURN PERIODS (1 HOUR DURATION)	Figure 4.3



WRL Report No. 2008/19	STORM DEMAND VERSUS RECURRENCE INTERVAL	Figure 4.4

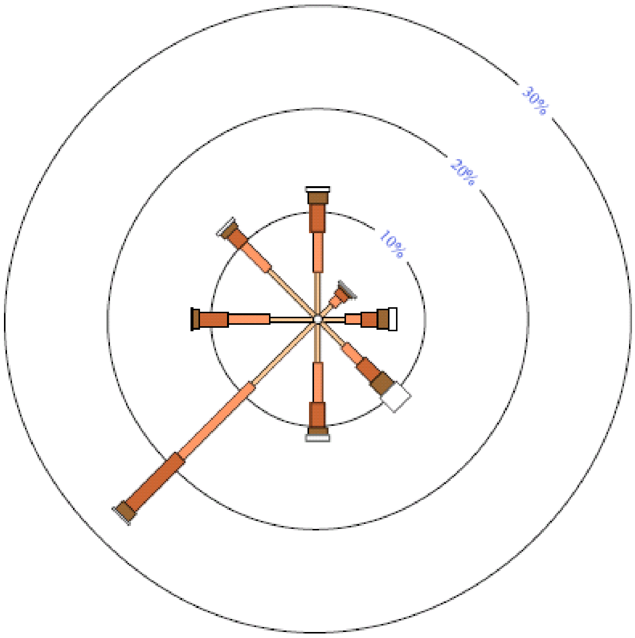
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 31 Dec 2006)
BYRON BAY (CAPE BYRON LIGHTHOUSE)
Site No: 058009 • Opened Jan 1948 • Still Open • Latitude: -28.6388° • Longitude: 153.6361° • Elevation 95m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



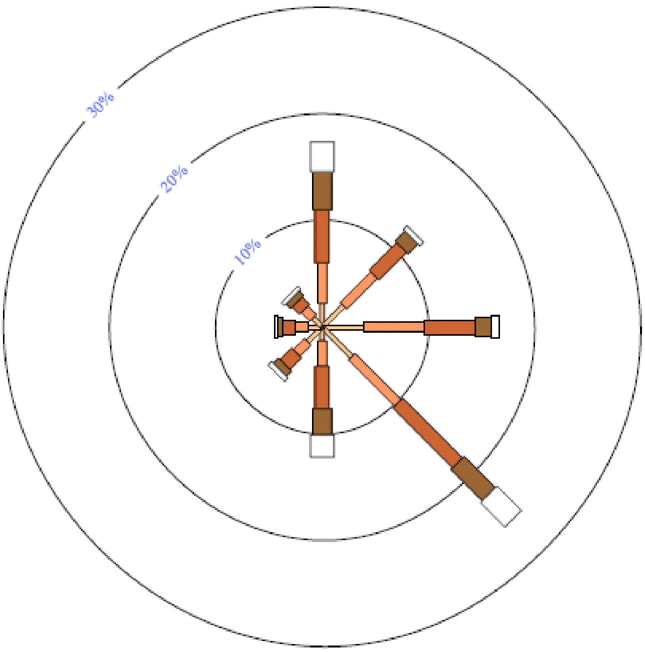
9 am
16461 Total Observations

Calm 2%



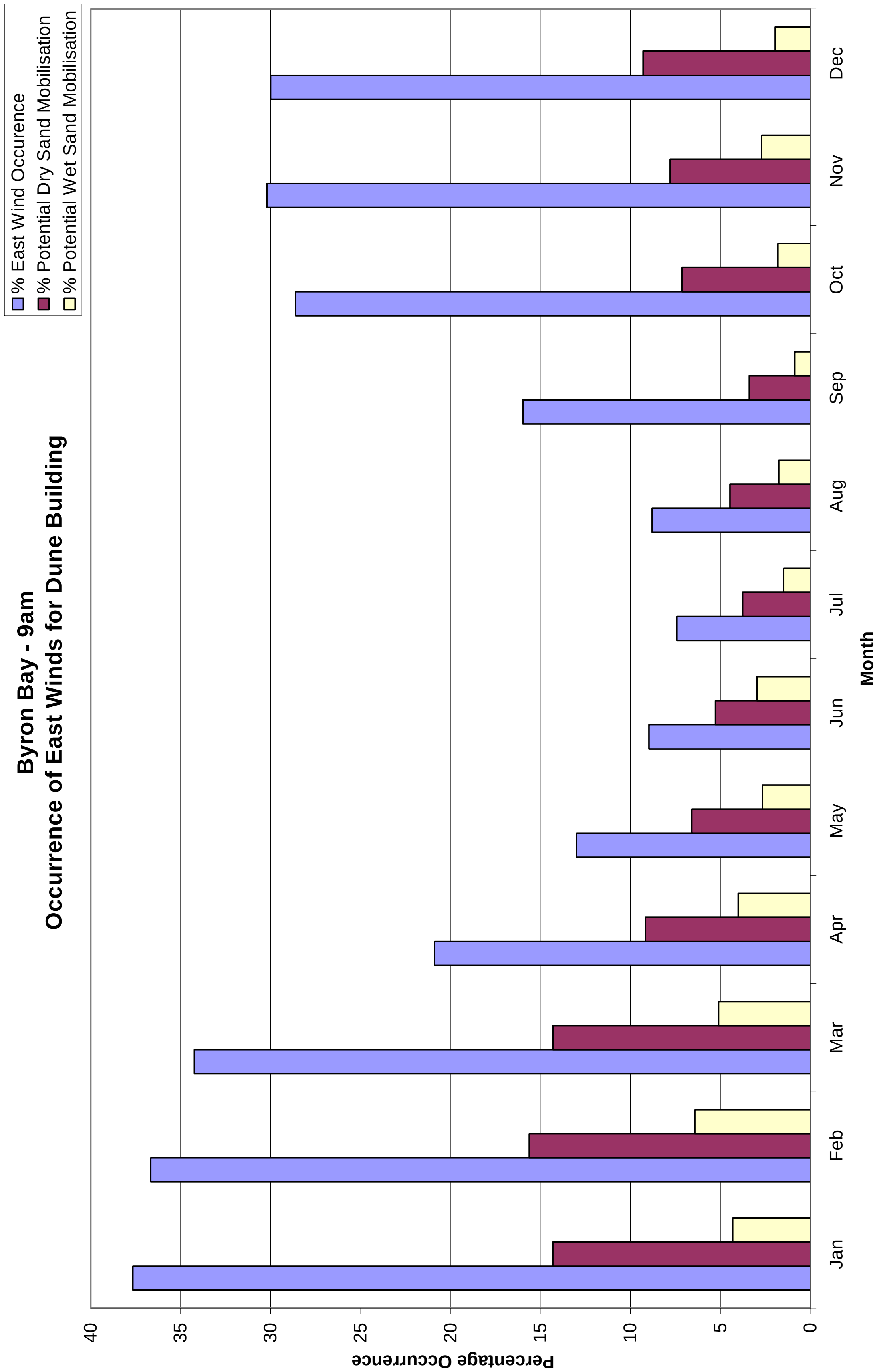
3 pm
16015 Total Observations

Calm 1%



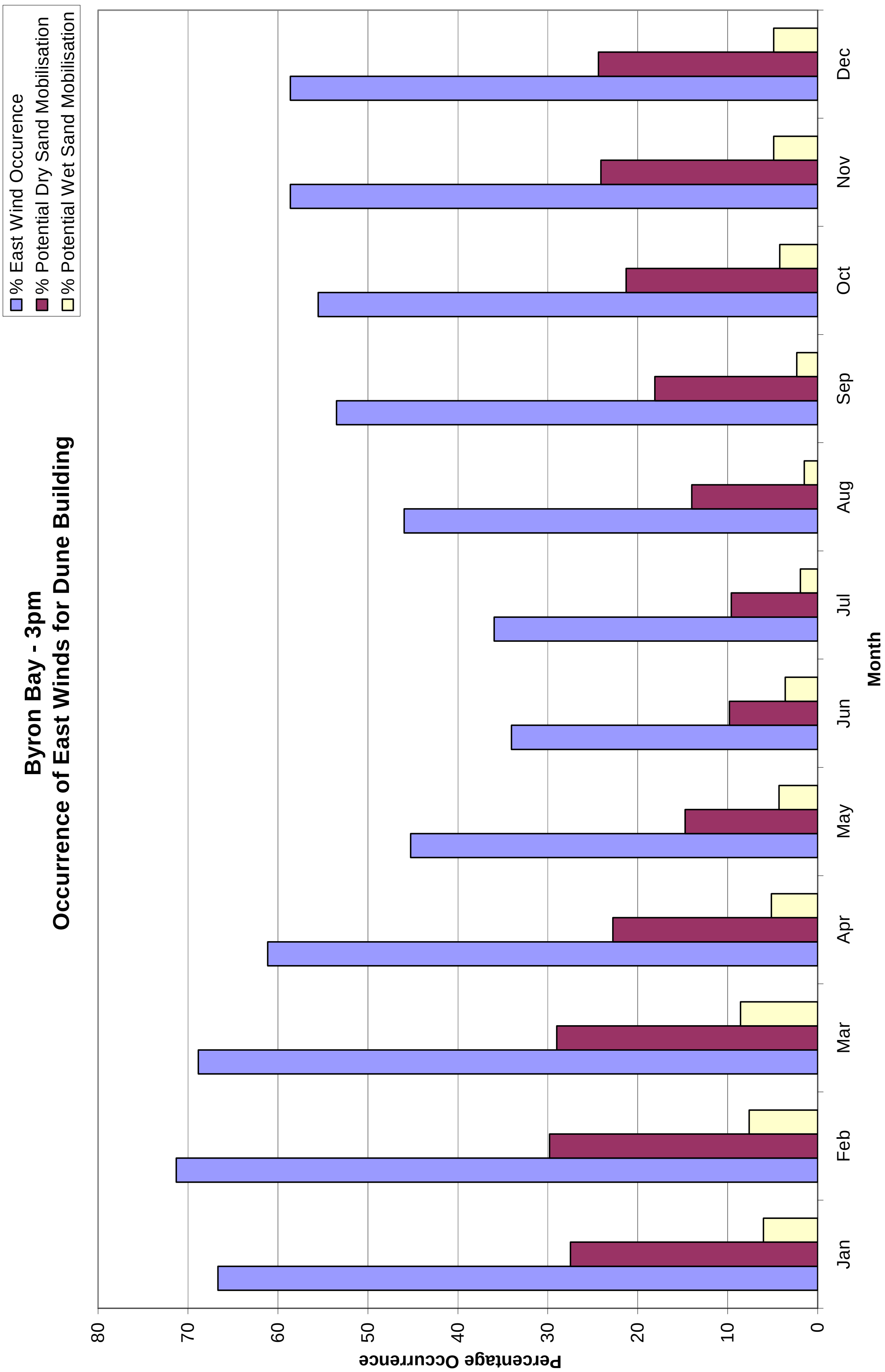
WRL Report No. 2008/19	WIND ROSE FOR CAPE BYRON (SOURCE: BOM)	Figure 4.5

(Note: includes NE, E and SE winds)



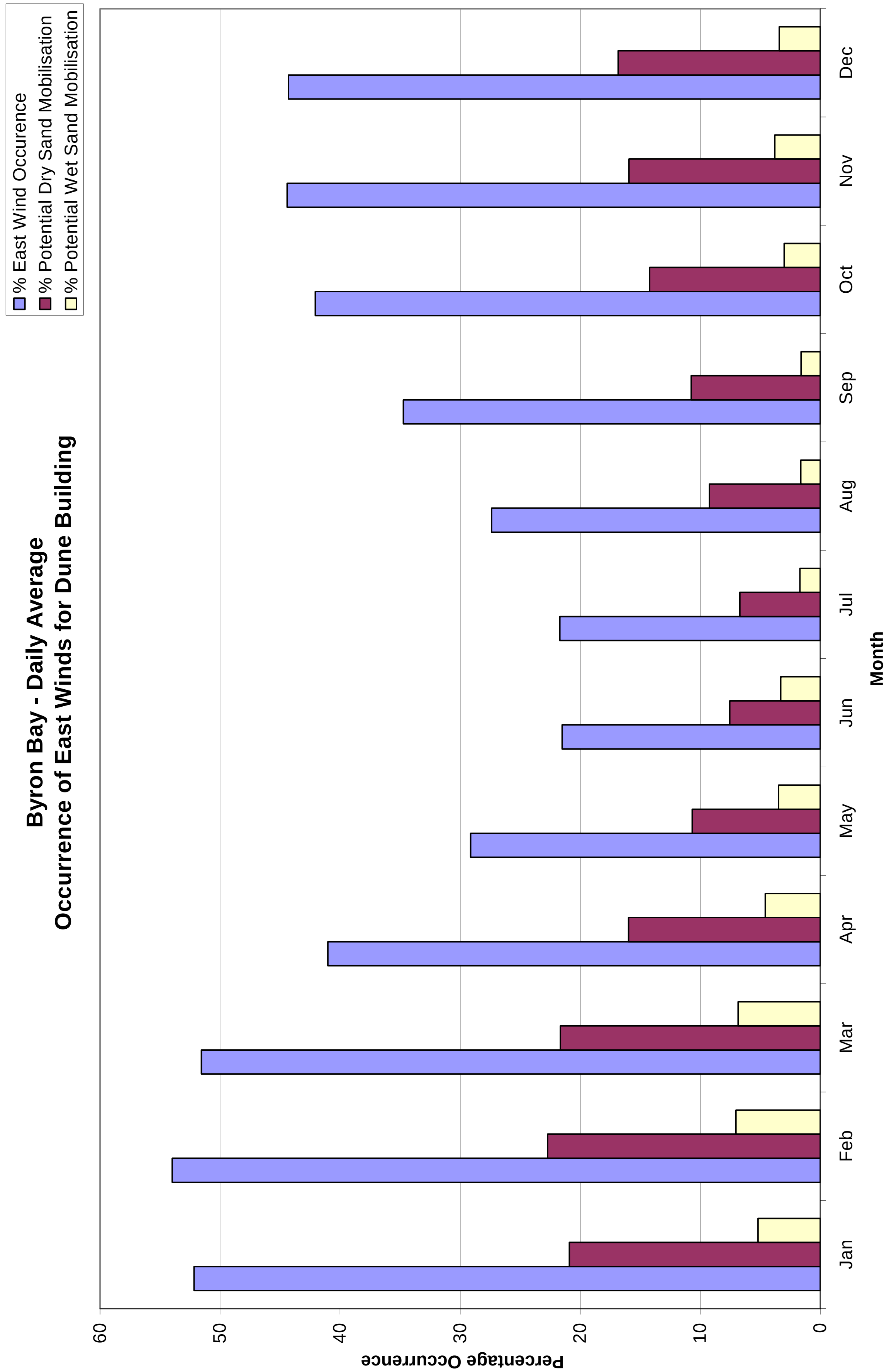
WRL Report No. 2008/19	BYRON BAY 9 AM OCCURRENCE OF EAST WINDS FOR DUNE BUILDING	Figure 4.6

(Note: includes NE, E and SE winds)

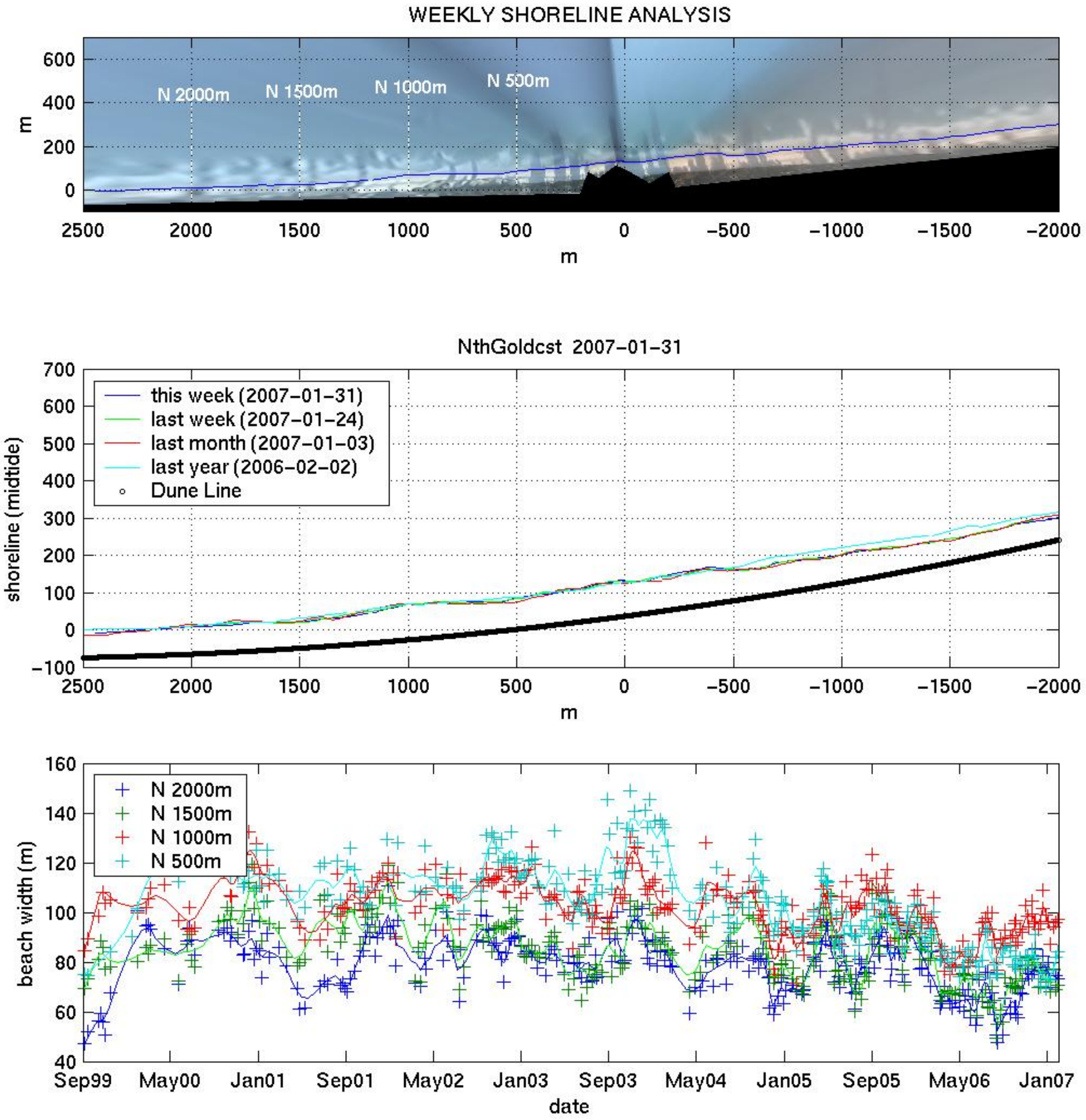


WRL Report No. 2008/19	BYRON BAY 3 PM OCCURRENCE OF EAST WINDS FOR DUNE BUILDING	Figure 4.7

(Note: includes NE, E and SE winds)



WRL Report No. 2008/19	BYRON BAY DAILY AVERAGE OCCURRENCE OF EAST WINDS FOR DUNE BUILDING	Figure 4.8



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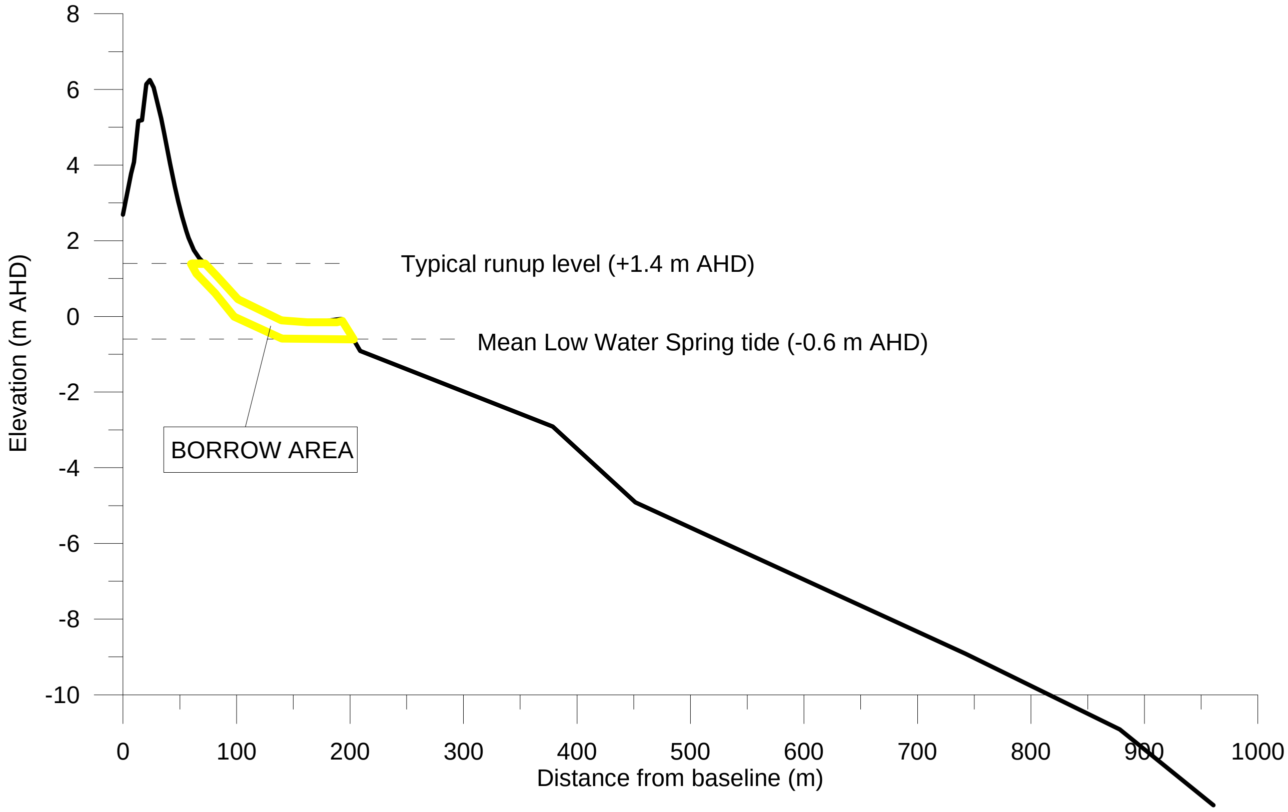
www.wrl.unsw.edu.au/coastalimaging

From WRL Technical Report 2007/08 Figure 7.5

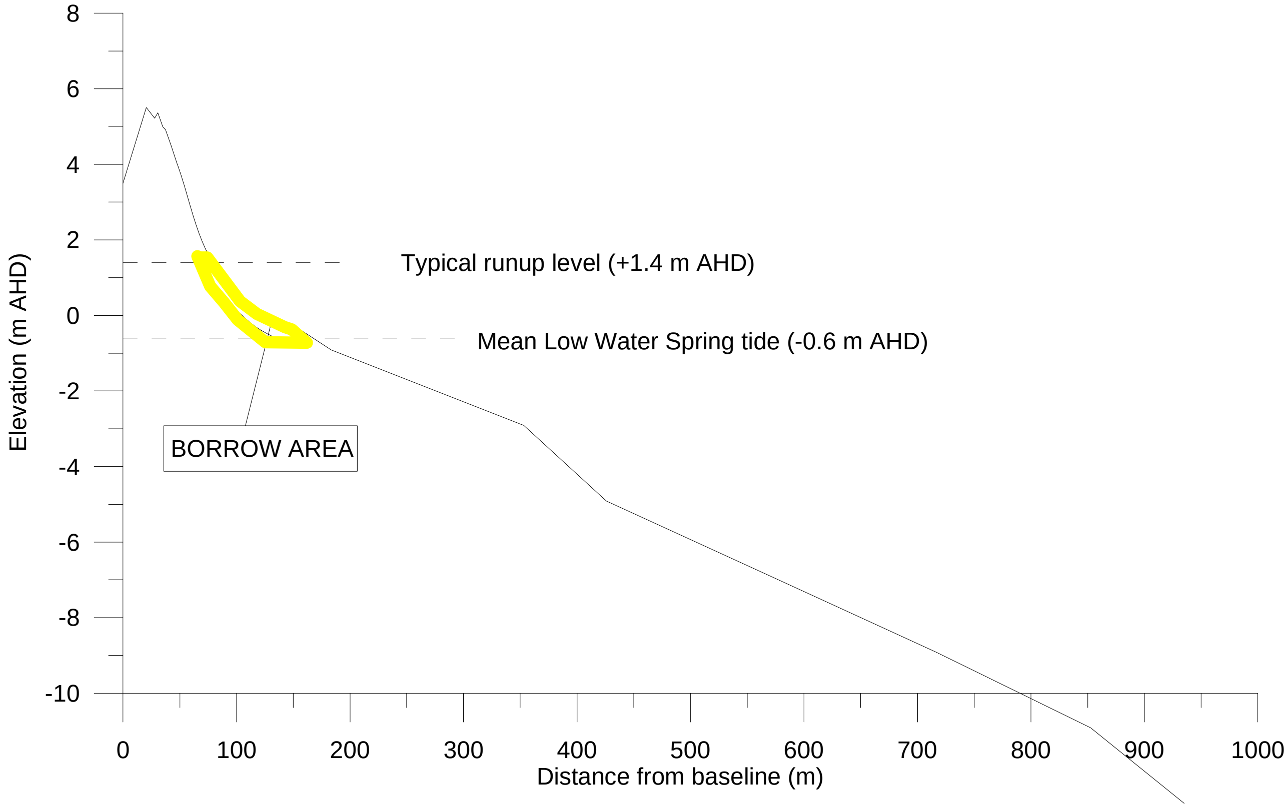
"Analysis of Shoreline Variability, Seasonality and Erosion/Accretion Trends: August 2006 – January 2007"

Report #15: Northern Gold Coast Coastal Imaging System

WRL Report No. 2008/19	SEASONAL BEACH WIDTH ANALYSIS: NORTHERN GOLD COAST	Figure 4.9

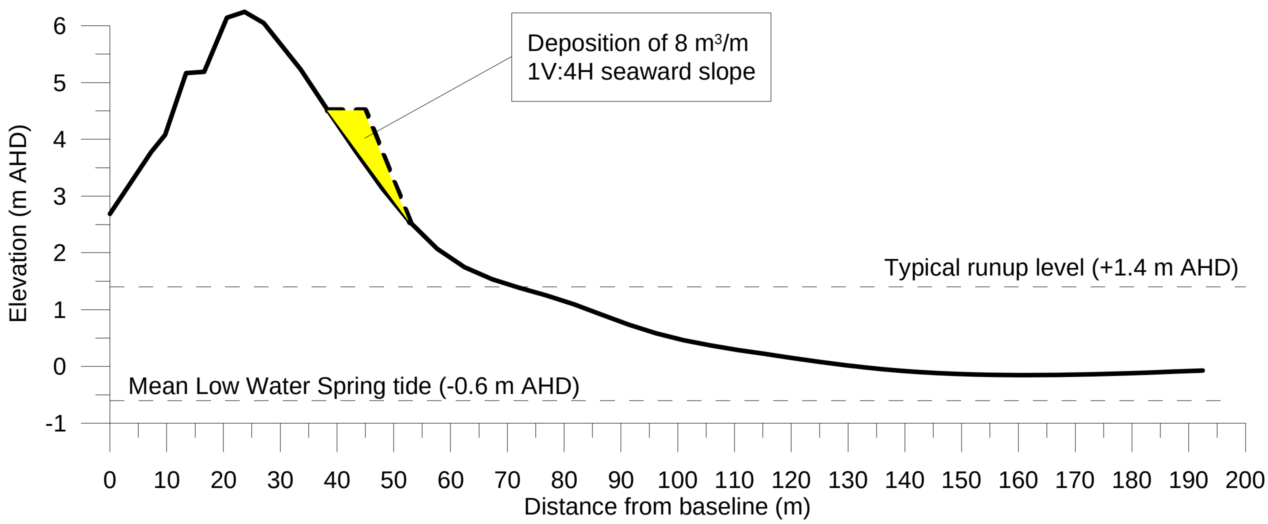


New Brighton (Block 7, Profile 15)

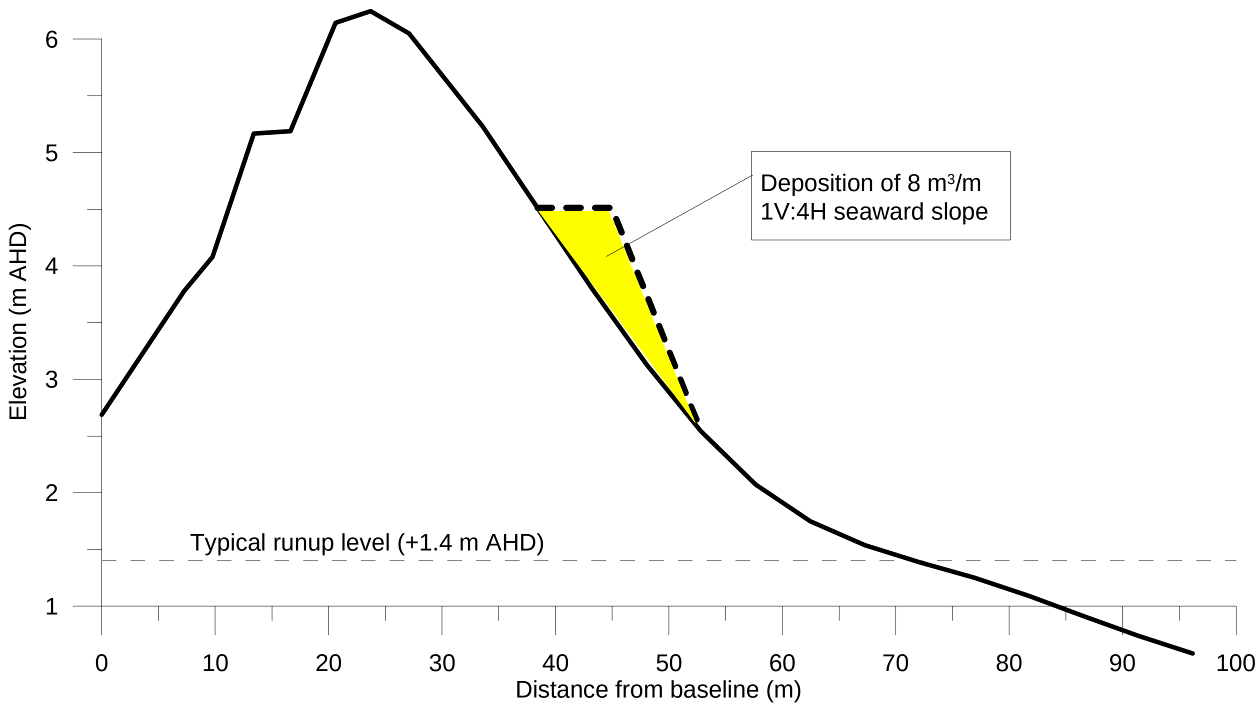


South Golden Beach (Block 8, Profile 17)

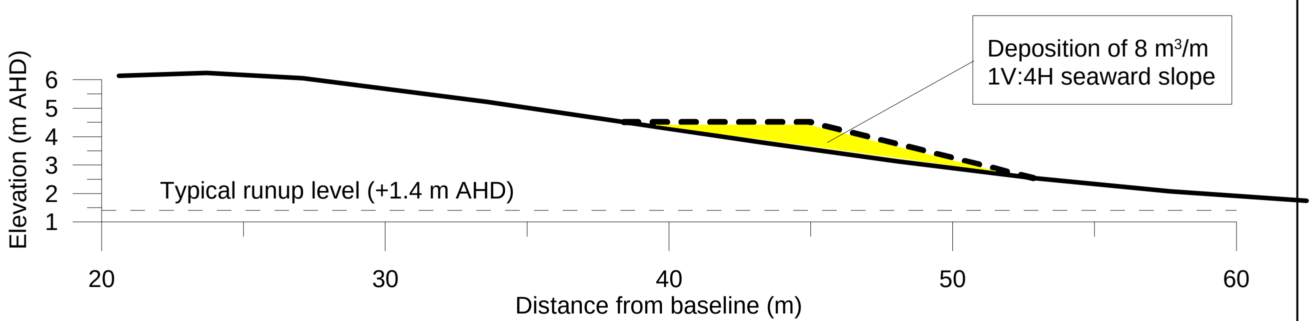
WRL Report No. 2008/19	REPRESENTATIVE BEACH PROFILES AND BORROW AREA	Figure 5.1



Distorted Scale



Distorted Scale, close up



Undistorted Scale

WRL Report No. 2008/19	TYPICAL PLACEMENT PROFILE	Figure 5.2

Caterpillar D6K dozer (source: Caterpillar Australia)

Caterpillar 953D Tracked Loader (source: Caterpillar Australia)

WRL Report No. 2008/19	PICTURES OF SUGGESTED MACHINERY	Figure 5.3

APPENDIX A
REVIEW OF ENVIRONMENTAL FACTORS

Preliminary Environmental Impact Assessment – Beach Scraping
New Brighton and South Golden Beach, Byron Shire, NSW

July, 2009

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1. Introduction

1.1 Background to the project

The Byron Shire coastline has endured a long history of coastal recession. Erosion and long-term shore-line recession has been occurring at New Brighton and South Golden Beach since long before the construction of the Brunswick River entrance training walls, completed in 1961. Following the completion of the training walls, a continuing and erosive stormy period saw re-alignment of the beach to the north of the estuary. The beach re-alignment and associated coastal erosion resulted in the loss of the small township 'Sheltering Palms' (also known as North Beach) in 1974 (BSC, 2007). Since the mid-1970s, a period of relative calm, combined with significant dune care works in the area, has enhanced the ability of the dune system to accommodate coastal processes to date. The planting and fencing of the dunes has aided the trapping of wind blown sand, building up a reservoir to better accommodate erosion during major storm events.

However, particular coastal areas are subject to natural coastal processes and resultant coastline hazards, including coastal erosion, oceanic inundation and shoreline recession. Major coastline hazards occur from Broken Head in the south to South Golden Beach in the north. The major two coastal erosion/oceanic inundation problems are:

- undercutting of dunes on their seaward sides threatening the Esplanade Road and collapse of dwellings and other infrastructure at New Brighton Beach
- potential breaking through of the dunes by sea water, causing flooding and isolation of property on the landward side of the dunes (South Golden Beach and New Brighton Beach).

The most severe problems of coastal erosion/inundation occur as a result of oceanic storm conditions associated with large meteorological events, which may cause temporary sea level rises with large associated waves. The worst erosion/inundation is likely when severe weather conditions occur in conjunction with high tides.

During storms, increased wave heights and elevated water levels cause sand to be eroded from the upper beach/dune system (the storm bite) and transported in an offshore direction, typically forming one or more sand bars parallel with the shore in the nearshore zone. As the bars build up, wave energy dissipation in the surfzone increases and wave attack at the beach face reduces. The severity of wave attack at the dune depends on wave height and elevated water level (combination of tide, storm surge and wave setup). During calmer weather, sand slowly moves back onshore from the bar to the beach forming a wave berm, and subsequently, a wind-formed incipient foredune (BSC, 2005).

At New Brighton there is an immediate erosion threat to the beach-front access road and a longer term threat to private residential development (BSC, 2005). At South Golden Beach there is an immediate coastal inundation threat and a medium to longer term erosion threat to private residential development landward of the dune system.

This Preliminary Environmental Impact Assessment (PEIA) has been prepared by Parsons Brinckerhoff (PB) on behalf of the Byron Shire Council. It describes the environmental impacts, benefits and recommendations associated with beach scraping as a potential management strategy to mitigate the effects of coastal hazards on New Brighton and South Golden Beach development and infrastructure.

1.2 Project objectives

There are three objectives for beach scraping:

- restore and maintain pedestrian beach access following storm erosion
- build a dune to a design profile by:
  - raising low points of the dune to a design level
  - increasing dune volume in the long term to meet storm demand
  - accelerating beach recovery following storm erosion
- increase the dune volume to offset recession due to sea level rise.

The first objective aims to maintain and restore pedestrian beach access on authorised paths. Beach access levels would be raised to surrounding dune levels and covered.

The second and third objectives may be achieved concurrently. At New Brighton, the second objective addresses an immediate erosion hazard threatening nearby houses and roads, while South Golden Beach requires an increase in the height of the dunes to reduce the threat from oceanic inundation.

The third objective addresses aims to increase sand reserves to offset coastal recession and erosion for medium-term protection of beachfront residences from coastal erosion and oceanic inundations. With future sea levels likely to rise, beach scraping may provide additional protection for residences and infrastructure in the short to medium term.

1.3 Planning, zoning and approvals

The planning and assessment process for the project is established by the requirements of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and other relevant planning instruments. The processes described below present PB's professional opinion at the time of writing, however, revisions to legislation and precedent may alter the process presented.

Clause 6 of the State Environmental Planning Policy (Major Projects) 2005 (Major Projects SEPP) identifies developments that, at the discretion of the Minister, could be considered Part 3A Projects. Developments that are considered Part 3A projects are listed in Schedules 1 to 3 of the Major Projects SEPP. Schedule 2 (specified sites) identifies development within the 'coastal zone' for an 'extractive industry' as a Part 3A project. An extractive industry is defined as 'the winning or removal of extractive materials (other than from a mine) by methods such as excavating, dredging, or quarrying including the storing, stockpiling or processing of extractive materials by methods such as recycling, washing, crushing, sawing or separating.'

Maps from the *New South Wales Coastal Policy 1997* identify New Brighton and South Golden Beaches as within the coastal zone. The project involves removal of sand from a lower section of the beach to a higher area of the beach, thus these works are within the definition of an 'extractive industry' under the Major Project SEPP. Therefore, in accordance with Schedule 2 of the Major Projects SEPP, the project would need to be assessed under Part 3A of the EP&A Act.

The Department of Planning (DoP) confirmed the above assessment (pers comm. Howard Reid - Manager of Mining and Extractive Industries, 10 November 2008) and advised that a Preliminary Project Application Report should be submitted to DoP to allow the Minister to decide whether the project would be assessed under Part 3A of the EP&A Act.

Council is required to undertake the above application to determine if the project would be assessed under Part 3A of the EP&A Act, or to seek further legal advice to ascertain whether the project is considered a Part 3A project under the Major Projects SEPP.

Further, Section 4 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Reg) identifies 'designated development' as development that is listed in Schedule 3. Schedule 3, of the EP&A Reg indicates that certain 'extractive industries' are considered designated development. Extractive industries are defined as 'being industries that obtain extractive materials by methods including excavating, dredging, tunnelling or quarrying or that store, stockpile or process extractive materials by methods including washing, crushing, sawing or separating'. Part 1(c) of Schedule 3 states extractive industries that are 'within 200 metres of a coastline' are considered designated development. In accordance with the EP&A Reg, the project is considered an extractive industry and is to be located within 200 metres of the coastline. The project is therefore considered designated development.

It should also be noted that the project would be considered designated development regardless of whether it was assessed under Part 3A or Part 4 of the EP&A Act. However should the project be assessed under Part 3A of the EP&A Act, due to it being classified as designated development, it has the potential to be subject to 'appeals by an objector'. Section 75L of the EP&A Act applies to designated development and allows an objector who is dissatisfied with the determination of the Minister to appeal to the Court within 28 days after the date of the determination. This means that, unlike other proposals assessed under Part 3A should this project be approved, a third party could challenge the Minister's decision in Court. Therefore, Council should consider this risk moving forward.

2. Project description

2.1 Location and setting

South Golden Beach and New Brighton are located in Byron Shire (refer Figure 2-1). The area is located approximately 12 kilometres north of Byron Bay and three kilometres north of Brunswick Heads town centres. The South Golden Beach site is approximately one kilometre north of New Brighton and is 500 metres in length. The New Brighton site is 1,800 metres in alongshore length.

At South Golden and New Brighton Beaches , extensive sand mining and urban development have caused damage to the frontal dunes and a reduction in the buffering capacity of the dunes to large storm events. Dune care works have since enhanced the capacity of the dunes to accommodate erosion.

Some of the easternmost roads at New Brighton and South Golden Beach are within the immediate hazard zone of coastal erosion. There is an identified oceanic inundation threat in an area of low dunes north of New Brighton village and at South Golden Beach. There is also a potential for breakthrough of Marshalls Creek south of New Brighton.

The area north of the Brunswick River training walls, particularly from the entrance to New Brighton, has undergone significant threats from the ocean in the late 1960s and early 1970s. This included the loss of the village of Sheltering Palms and loss of the foredune in front of New Brighton.

Subsequent to these losses, dune works were carried out in 1979. Sand at Sheltering Palms, which was carried landward by overtopping waves, was pushed back by bulldozer to the previous dune alignment and to a height of about RL 5-6 metres Australian height datum (AHD). This was carried out to prevent the breakthrough of Marshalls Creek, which would have resulted in a reduction in navigation depths at the Brunswick River entrance. Subsequent to this, sand was pushed up from the beach to form a low dune in front of New Brighton to accelerate the development of a frontal dune in this area. In both cases sand was not added to the active system, but merely relocated, along with beach scraping operations that continued regularly in the New Brighton area until the early 1990s. This, in combination with an active dune care campaign, has maintained the dune vegetation in this area and enhanced the natural rebuilding of the dune system (BSC, 2005).

There are several local community dune care groups in Byron Shire, in particular the groups at New Brighton/South Golden Beach and Suffolk Park, which have helped to stabilise the dunes in these areas (BSC, 2005).

The New Brighton area contains a diversity of vegetation associations including swamp sclerophyll forest and coastal heathland/shrubland. The vegetation to the north of New Brighton, including lands to the north of South Golden Beach, provides an important buffer to Billinudgel Nature Reserve and a tenuous link between the nature reserve and Byron Shire's coastal vegetation corridor (BSC, 2000).

The Billinudgel Nature Reserve extends northward from South Golden Beach to the Byron Shire boundary and remains undeveloped, with no specific beach erosion threats to infrastructure.

The dune at New Brighton is steep, which makes beach access tracks more difficult to maintain. Many informal accesses from private property have detrimental effects on the dunes, resulting in locally eroded low points that weaken the dune's ability to protect the township from inundation.

2.2 Description of the proposed works

Beach scraping, also known as 'skimming', is defined as the movement of sand from the intertidal zone of a beach (borrow area) to the dune above the ordinary wave runup limit (placement area) and is usually carried out using mechanical equipment (WRL, 2008).

Beach scraping is proposed for New Brighton and South Golden Beach. Where possible, the borrow sand would not be transported along the beach, but would be transported primarily cross shore (up the beach). The borrow area would be limited to below the wave runup limit to enable the borrow area to replenish naturally by littoral drift and onshore wave transport during mild wave conditions.

The likely machinery to be used for the proposed beach scraping would be a bulldozer such as a Caterpillar D6 or D9 (or equivalent) or tracked loader (Caterpillar 939, 953, 963 or equivalent). Multiple dozers may be used simultaneously for intense scraping campaigns that take maximum advantage of low spring tides and calm waves.

2.2.1 Access

There are approximately seven pedestrian access tracks to South Golden Beach and approximately 13 public and numerous private access tracks to New Brighton Beach, including a number of unauthorised private accesses. As part of the beach scraping and implementation of the Byron Shire Coastal Zone Management Plan (CZMP), excess beach accesses would be closed and rehabilitated.

Beach access would be controlled through fencing and raised to a minimum crest level of 6-6.5 metres AHD and to be compatible with the surrounding dunes.

Rubber beach access surfaces with geobags as seaward toe protection would be used where possible as suggested by the community (Draft CZMP, 2008). The boarded walkways would be designed in accordance with the *NSW Dune Management Manual* (2001).

2.2.2 Erosion hazard and sea level rise

At New Brighton, beach scraping works are proposed to construct sand reserves to increase the dune buffer for beachfront residences and roads from coastal erosion and oceanic inundation. Beach scraping would also supplement the normal barrier provided by sand dunes from natural processes.

The amount of sand needed to remove the immediate erosion hazard is approximately 90,000 cubic metres (m^3), which would be added to the dunes over the 1,800 metre site. Locations that require dune raising would require placement of the sand near the crest of the dune rather than just on the face of the erosion scarp. Multiple scraping episodes at New Brighton would be necessary to achieve this volume. The number of episodes for New Brighton would be:

- six scraping episodes of $8m^3/m$ (0.2 metre scraping depth)
- three scraping episodes of $20m^3/m$ (0.5 metre scraping depth).

At South Golden Beach, it would be necessary to increase the height of the dune to reduce the threat from oceanic inundation and potential sea level rise. To achieve this, between $2,000m^3$ and $4,000m^3$ of sand would be placed over the 500 metre site at the crest of the dune where the erosion scarp is apparent. The earth moving equipment would extract sand to approximately 0.2 metres in depth from the beach littoral zone and transport it up the beach and deposit it at the crest of the dune. To achieve this at South Golden Beach would require one scraping episode of $8m^3/m$ (0.2 metre scraping depth).

Figure 2-1 **Site location and access**

3. Need for the project and alternatives

3.1 Need for the project

Coastal regions of northern NSW are susceptible to storm surge and heavy swells, in particular developed areas at New Brighton and South Golden Beach, Belongil Spit, and Byron Bay. Residential developments at New Brighton and South Golden Beaches are located within 50 metres of the erosion escarpment (BSC, 2008).

A storm surge is a rise above the normal water level along a shore resulting from strong onshore winds, and/or reduced atmospheric pressure, and/or large waves. Storm surges accompany tropical depressions or cyclones as they come ashore. They may also be formed by intense low-pressure systems in non-tropical areas. The worst impacts occur when the storm surge arrives on top of a high tide, this can lead to significant flooding in what would normally be considered safe areas, and is further compounded by large waves generated by powerful winds. Storm surge results in coastal erosion and/or oceanic inundation. In the Byron local government area (LGA) (BSC, 2007), these coastline hazards may impact developed areas by:

- undercutting of dunes on their seaward side threatening the collapse of dwellings and other infrastructure
- potential break through of the dunes by sea water, causing flooding and isolation of property on the landward side of the dunes.

There are four recorded events of storm surge, associated with tropical cyclones (1954, 1967, 1972, 1974; BoM 2009; Specht 2008) that have directly impacted the Byron LGA causing significant coastal erosion, damage to established dune systems and beach access tracks, and threatened properties adjacent to the dune system.

The swells cause severe coastal erosion and this, in turn, can cause significant damage to property. Potential impacts include possible fatalities and/or injuries to people who become trapped in storm surge areas who are then displaced or need to be evacuated.

Damage may also occur to the environment, infrastructure (power, water, sewerage and communications), and disruption of transport routes through closure of road networks (BSC, 2007).

3.2 Alternatives considered

A number of alternatives were considered, including:

- Do nothing — this alternative would mean that Council continues to monitor natural processes.
- Retreat — in 1998 Council adopted a Development Control Plan for coastal erosion that identified planned retreat as the coastal hazard management option with relevance to coastal development and infrastructure. In 2004 Council adopted the Coastline Management Study and planned retreat position for Belongil/Cape Byron Beach and New Brighton compartments. (Res. 04-1056; 04-1057 #495033). Council also determined in 2006 that a Coastline Management Plan be developed as a document that identifies strategies and actions that are required to implement planned retreat (Res 06-721 #637507).
- In 2007 Council resolved to accept funding through the NSW Coastline Management Program for beach access improvement and for environmental assessment of beach scraping at New Brighton and South Golden Beach. It was also resolved that Council continue to seek funding for environmental assessment of beach scraping for Suffolk Park and South Golden Beach and any other required locations (Res. 07–164). (BSC, 2008a).

Beach scraping has been considered by Council for preliminary environmental assessment to inform Council of the likely benefits and the environmental, social and economic implications of implementing a beach scraping program.

4. Stakeholder consultation

An understanding of community coastline issues and values was needed to assist the design of solutions that successfully implement appropriate hazard management and also meet community expectations.

Community members were invited to attend site inspections of the Byron Shire coastline and participate in community workshops following each site inspection. The site inspections and workshops were run by Council's consultants in conjunction with Council staff.

The site inspections provided community members with the opportunity to observe the environmental, recreational, landscape, development and amenity issues of key areas of the Byron coastline. Information packages for the day were posted to those who responded to the registration requirement. The site inspections and workshops were held on the following dates:

- Ocean Shores Community Centre on 4 September 2007 from 2 pm to 3 pm, 11 people attended.
- South Golden Beach Hall on 4 September 2007 from 5 pm to 6 pm, 12 people attended.

Attendees of the site inspection were provided with feedback forms to assist in gathering written comments, in addition to those issues discussed during the site inspections. During the workshops, community members formed small groups to complete 'work sheets'. This provided the attendees with the opportunity to express their issues and expectations, identify perceived pressures on the coastline, and work together in developing solutions for consideration by the technical team.

The workshops were well attended by the broader community and representatives of the following groups, including (but not limited to):

- Council staff and Councillors
- State Government department representatives, particularly NSW Department of Environment and Climate Change representatives
- Byron Shire Council Coastline Management Committee members
- South Golden Beach Progress Association
- New Brighton Progress Association
- Belongil Progress Association
- Suffolk Park Progress Association
- individual beachfront property owners
- tourism operators.

The issues raised included impacts on existing dune vegetation and marine fauna, changes to the beach width and profile, the success of previous beach scraping activities, the frequency of beach scraping proposed and the required approvals for the proposed beach scraping.

5. Description of the affected environment

The environmental context of the proposed activity is outlined in Table 5-1.

Table 5-1 Existing environment

Issue	Description
Land use	
Coastal lands	The area adjacent to the urban areas of New Brighton and South Golden Beach abutting the Pacific Ocean.
Urban coastal lands	The coastal urban areas of New Brighton and South Golden Beach.
Natural environment	
Cape Byron Marine Park	The Cape Byron Marine Park is located approximately two kilometres south of the southern point of the proposed works on New Brighton Beach. The Marine Park extends about 30 kilometres south from the Brunswick River training wall to Lennox Head. Nearshore littoral currents in the ocean adjacent to the coastline at New Brighton and South Golden Beaches are wave driven and generally move northward away from the marine park. The tidal waters of Marshall Creek are also included in the marine park as the Marshalls Creek Sanctuary Zone excluding the waters of Capricornia Canal/Billinudgel Creek upstream of the New Brighton Road.
Biodiversity	A database review was carried out to determine if any threatened species were likely to occur in the area. The NSW government Bionet database was accessed and a threatened species report generated for Byron Bay LGA (Department of Environment and Climate Change, 2008). An *Environment Protection and Biodiversity Conservation Act 1999* Protected Matters search was completed to provide a list of Commonwealth protected flora and fauna in the locality of the sites. The results of the database searches were used to provide a list of threatened flora and fauna species that have been recorded from the locality. These results were used to assess the likelihood of occurrence of threatened species on the site. Other literature reviewed includes the following: ▪ aerial photographs (scale 1:25,000) and topographical maps (scale 1:25,000) ▪ lists of threatened species, populations and communities in the schedules of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Threatened Species Conservation Act 1995* (TSC Act) ▪ PlantNet database of Rare or Threatened Australian Plants (ROTAP) ▪ Byron Bay Council's vegetation mapping (BSC, 2005a) ▪ previous reports within the local area. The study area consists of two beaches — South Golden Beach in the north and New Brighton Beach to the south. Both beaches are situated along the same stretch of coastline and are separated by a distance of approximately one kilometre.

Issue	Description
	Vegetation The vegetation adjacent to South Golden and New Brighton Beaches has been mapped as Heathland/Shrubland in the Byron Shire Council vegetation mapping (BSC, 2005a). Vegetation Management Plans prepared by EnviTE in 2003 found that vegetation mapped by Byron Shire Council for this area was mostly accurate, however, there were small, highly degraded patches of rainforest vegetation consistent with the Littoral Rainforest Vegetation Management Plans prepared for South Golden and New Brighton Beaches (EnviTE 2003). ***Fauna and their habitats*** The area to be affected by the project is likely to contain grasses such as *Spinifex sericeus* and *Festuca littoralis* and herbaceous species. The foredune is mainly composed of semi-permanent populations of herbs, shrubs and trees, which stabilise the foredune sand mass. These areas may support nesting, roosting and resting birds such as the Beach-stone Curlew and the Little Tern and some terrestrial arthropods such as crabs and mites. A number of threatened fauna species have been recorded within the locality, primarily threatened bird species that are highly mobile. The habitat to be modified could support the following threatened and migratory species Great knot (*Calidris tenuirostris*), Beach Stone-curlew (*Esacus neglectus*), Pied Oystercatcher (*Haematopus longirostris*), Little Tern (*Sterna albifrons*) and the Green Turtle (*Chelonia mydas*). ***Corridors and connectivity*** The areas of South Golden and New Brighton Beaches that would be modified form part of a long beach with associated dune vegetation to the north and south.
Topography and soils	The South Golden and New Brighton Beaches are situated on Quaternary (Holocene) sands. Soils are deep siliceous sands and some calcareous sands on beaches. Disturbed hind dunes may consist of siliceous sands and very disturbed podzols. These soils are non-cohesive, highly permeable, of very low fertility, with low water-holding capacity (Morand, 1994). Inland sediment basins of mixed estuarine and aeolian origin forming level to gently undulating plains. Soils are deep, well drained podzols and acid peats. These soils are very strongly acid, permeable, often waterlogged soils of low fertility and low water-holding capacity. Permanently high water tables and moderate wind erosion hazard are features. The beaches and dune areas are in a process of dynamic change. Cycles of erosion and accretion of sands occur as a result of a complex interaction of factors including climate, wind, current and wave patterns, sediment transport, and dune vegetation. The dominant local influences on dune formation or erosion are storm intensity and recurrence intervals and longshore sediment transport rates in a northerly direction (James, 2000).
Landform and hydrology	The seaward side of the New Brighton and South Golden Beach sites consist of Quaternary (Holocene) sands. Soils are deep siliceous sands and some calcareous sands on beaches. Disturbed hind dunes may consist of siliceous sands and very disturbed podzols (Morand, 1994).
Vegetation	All native vegetation was removed from both beach sites during the period of sandmining in the 1970s. The present day vegetation is a mixture of weed species and some natives transferred by wind and fauna.

Issue	Description
Non-Indigenous heritage	The Byron Shire coastline has a considerable range of cultural heritage values including the Cape Byron Lighthouse and the many shipwrecks along the coast. Additionally, the Byron Shire coastline has exceptional contemporary cultural values, including its unique and diverse settings for recreation and its alternative lifestyles (BSC, 2000).
Indigenous heritage	A number of significant Aboriginal sites have been located in the district, including Bora rings (Tyagarah and Brunswick Heads), camp and work sites and substantial shell middens (Palm Valley). It is possible that dune carers may encounter artefacts of earlier habitation.
Air quality	There are few sources of air pollution in the vicinity of New Brighton and South Golden Beaches. The air pollution source with the greatest impact at the sites would be emissions from vehicles.
Noise and vibration	The nearest residential properties are located approximately 50 metres from the proposed work sites. Noise sources in the area are limited to existing road noise, general business noise, residential noise and agricultural activities. The sound of breaking waves usually reduces the perception of this noise.
Other	
Waste and hazardous materials	The area is considered to have little current waste or hazardous materials issues due to its natural environment qualities. Waste material deposits generally consist of litter from onshore wind, stormwater, fishing or beach visitation.
Traffic and access	Roads leading into South Golden and New Brighton Beaches provide access to numerous open entrance points to the beach accessible by car. These have developed over time by locals along with maintenance of existing pedestrian entrance points. A potential access route to New Brighton is shown in Figure 2-1 from Brunswick Valley Way following Orana Road crossing Marshall Creek via a local council bridge then onto North Head Road. The proposed access point to the project is via an existing entrance point on North Head Road at New Brighton. It is located at the southern end of the residential housing and is used as a local entrance point where cars can park on the unsurfaced open area before the dune. Unloading of the earth moving machine would take place at this local parking area whereby access to the beach would occur by manoeuvring over the dune system to the littoral section of New Brighton beach. Access to South Golden beach would be by driving the machine approximately 700 metres further north of the northern New Brighton scraping section along the littoral section of the beach.
Cultural values	The Byron Shire coastline has a considerable range of cultural heritage values ranging from the mythological sites, secular artefacts and stories of Aboriginal people, to items of non-Indigenous heritage, including the Cape Byron Lighthouse and the many shipwrecks along the coast. Additionally, the Byron Shire coastline has exceptional contemporary cultural values including its unique and diverse settings for recreation and its alternative lifestyles (BSC, 2000). Byron Shire exhibits a characteristic lifestyle that is cherished as an important element of contemporary Australia. Byron Shire has evolved into a ‘mecca’ for surfers and backpackers, and has achieved national recognition as a centre for people seeking an 'alternative' lifestyle (BSC, 2000). The adjacent areas to both work sites have residential properties on the western side of sealed (north of North Head Road) Council roads opposite the existing dune system before the open sandy section of New Brighton and South Golden Beaches. In particular Pacific Esplanade in South Golden Beach. In New Brighton, residential streets adjacent to the work sites are: Gaggin, Terrace, and River Streets, The Esplanade and North Head Road. The proposed access point is immediately south of 41 North Head

Issue	Description
	Road sharing the same access with 47 North Head Road. This access point is also used by local residents to park cars to access the beach.
Landscape values	The dynamic combination of the exposed coastal headlands and long sweeping beaches, set against spectacular volcanic ranges and the subtropical waters of the Pacific Ocean have made Byron Bay a national and international icon. Landscape and visual values associated with the coastline encompass the entire viewshed (i.e. visible scenery) as viewed from the coastline and includes features associated with the ocean, coastline, and coastal plain and inland ranges (BSC, 2000).

6. Preliminary environmental impact assessment

6.1 Biodiversity

The proposed beach scraping and nourishment would result in the removal of up to 90,000m^3 of sand to a depth of up to 0.5 metres from New Brighton Beach and deposition in or near the dunes. Approximately 4000m^3 of sand would be scraped from South Golden Beach from up to a depth of 0.2 metres and deposited in the dunes.

The area of habitat to be impacted is likely to provide either suitable optimal or sub-optimal habitat for threatened plant or animal species, such as:

- *Allocasuarina defungens* (Dwarf Heath Casuarina)
- Great knot (*Calidris tenuirostris)*
- Beach Stone-curlew (*Esacus neglectus*)
- Pied Oystercatcher (*Haematopus longirostris*)
- Little Tern (*Sterna albifrons*)
- Green Turtle (*Chelonia mydas*).

The area along the beach where sand is proposed to be borrowed contains intertidal benthic macrofauna. These species inhabit the beach littoral zone which is characterised by species with a high tolerance towards several forms of environmental stresses. Characteristic fauna includes; Crustaceans (such as crabs), Molluscs (such as Pipi's) and Polychaetes (worms). These also provide important food sources to some of the above threatened plant or animal species.

The proposed depositional area where beach sand will be placed supports dunal vegetation and fauna. During placement vegetation will be smothered by the scraped sand and/or trampled by machinery. The possible impacts are considered variable in their extent on the flora and faunal species. Smothering the dune vegetation has short to medium term implications for biodiversity and associated habitat value of the dune system in the proposed work area. Any wind blown sand migrating inland from the borrow pile will not have a significant impact on the intact dunal vegetation as this is considered a natural process.

Preliminary desktop assessment is provided in Table 6-1, which describes the species possibly affected, their vulnerability and listing under relevant legislation, the area of impact and the predicted level of impact. Generally, there is a predicted low to medium level impact, however, confirmation through field survey and significance assessment for some of the species is recommended.

Table 6-1 Preliminary environmental impact assessment of biodiversity

Species	Threatened species status	Area of impact	Predicted level of impact	Significance assessment required	Comment
Littoral Rainforest	Endangered ecological community (TSC Act) Critically endangered (EPBC Act)	Placement	Low	No	Occurs as small scattered patches to the west of both South Golden and New Brighton Beach, but not within the study area. Potential for impact would only likely occur as a result of accessing the beaches and this can be suitably avoided.
Emu (*Dromaius novaehollandiae*)	Endangered population within the North Coast Bioregion and Port Stephens LGA (TSC Act)	Placement	Low	No	The majority of recent recordings are concentrated between Coffs Harbour and Ballina, with occasional records inland of the coastal ranges (NSW Scientific Committee, 2002). The sites occur outside the main range of this population and are unlikely to support this species. An impact assessment is not considered necessary for this population.
Long-nosed Potoroo (*Potorous tridactylus*)	Vulnerable (TSC Act and EPBC)	Placement	Low	No	A population of the Long-nosed Potoroo occupies disjunct habitat in the Tweed LGA of north-eastern NSW, within the localities of Cudgen, Kingscliff, Duranbah and Bogangar (Geographical Names Board of NSW 2004, Map GNB 3810, 4780). Approximately 370 hectares of Wallum (coastal) habitat suitable for Potoroo exists in this area, surrounded by extensive unsuitable habitat (Milledge, 2001). The study site occurs outside the main range of this population and is unlikely to support this species. As such, an impact assessment is not considered necessary for this species.
Dwarf Heath Casuarina (*Allocasuarina defungens*)	Endangered (TSC Act and EPBC Act)	Placement	Low to medium	Yes	The species has a moderate likelihood of occurrence within the site, based on habitat that the dune areas would provide for this species. This species grows mainly in tall heath on sand with suitable habitat immediately west of the site. However, the site is highly prone to environmental fluctuations, such as high tides, that at times become inundated with salt water providing unsuitable conditions for this species to grow. A review of aerial photography and recent photographs of the sites has revealed that no small trees are currently present within the areas to be affected at South Golden and New Brighton Beaches. Therefore, it is unlikely that the project would impact this species despite the presence of sub-optimal habitat. Furthermore, the placement would mimic natural dune building and would not necessarily endanger any specimens present. Further assessment of the project on this species is necessary. Significance assessment required under the TSC Act and EPBC Act.

Species	Threatened species status	Area of impact	Predicted level of impact	Significance assessment required	Comment
Great Knot (*Calidris tenuirostris*):	Vulnerable (TSC Act) and Marine, Migratory (EPBC Act)	Placement	Low	Yes	Likely to use the habitat within the sites for feeding purposes only. Forages by thrusting bill deep into mud to search for invertebrates such as bivalve molluscs, polychaete worms and crustaceans. Significance assessment required under the TSC Act and EPBC Act.
Beach Stone-curlew (*Esacus neglectus*)	Vulnerable (TSC Act) and Marine Migratory (EPBC Act)	Placement	Low to medium	Yes	May use the habitat within South Golden and New Brighton Beaches for nesting. Nesting from September to November. May nest in sandbanks or in sand surrounded by short grasses and scattered Casuarinas. One egg is laid and both parents care for young until it reaches independence after 7 to 12 months. Nest disturbance is possible due to construction noise or sand and may lead to nest desertion. This may be prevented by undertaking works outside of the September to November nesting season. Significance assessment required under the TSC Act and EPBC Act.
Pied Oystercatcher (*Haematopus longirostris*)	Vulnerable (TSC Act)	Placement	Low to medium	Yes	Likely to use the habitat within the sites for feeding purposes only. Forages on exposed mud, sand and rock at low tide for molluscs, worms, crabs and small fish. Significance assessment required under the TSC Act.
Little Tern (*Sterna albifrons*)	Endangered (TSC Act) and Marine, migratory (EPBC Act)	Placement	Low to medium	Yes	Seabird that nests in small scattered colonies in low dunes or on sandy beaches just above high tide mark near estuary mouths or adjacent to coastal lakes and islands. May use the habitat within South Golden and New Brighton Beaches for nesting (spring and summer). Nest is a scrape in the sand with well camouflaged eggs, which may be difficult to locate or avoid. This may be prevented by undertaking works outside of the spring and summer nesting season. Significance assessment required under the TSC Act and EPBC Act.

Species	Threatened species status	Area of impact	Predicted level of impact	Significance assessment required	Comment
Green Turtle (*Chelonia mydas*)	Vulnerable (TSC Act and EPBC Act) also Marine, migratory (EPBC Act)	Placement	Low to medium	Yes	Turtles can grow up to one metre in length and spend most of the time out at sea. Scattered nesting records along the coasts of Australia. Temperature of the nest affects the sex ratio of hatchlings. Cooler, more shaded beaches produce more males, while warmer, sunny beaches produce more females. Beaches become heated when cleared of coastal forest, or when heat-absorbing sand is imported for 'beach nourishment', and potentially through global climate change. These changes result in female-biased populations. Human alteration to the temperature of nest sites can also increase in parasites and diseases in the eggs and make some beaches unsuitable for nesting (DEH 2005a; US Fish & Wildlife Service 1999). May use the habitat within South Golden and New Brighton Beaches for nesting (November to January), although nesting records along the NSW coast are scattered. Disturbance may be prevented by undertaking works outside of the November to January nesting season. All marine turtle species are experiencing threats to survival, including loss of and/or changes in nesting locations. Significance assessment is required under the TSC Act and EPBC Act.
Loggerhead Turtle (*Caretta caretta)*	Endangered (NSW TSCA and EPBC Act	Placement	Low to Medium	Yes	May use the habitat within South Golden and New Brighton Beaches for nesting (November to January), although nesting records along the NSW coast are scattered. Disturbance may be prevented by undertaking works outside of the November to January nesting season. All marine turtle species are experiencing threats to survival, including loss of and/or changes in nesting locations. Significance assessment is required under the TSC Act and EPBC Act.
Sand Spurge *Chamaesyce psammogeton*	Endangered (NSW TSCA)	Placement	Low	Yes	Considered to have a low likelihood of occurrence within the project site associated with coastal headland heaths and maritime grasslands nearby to marine environments. Significance assessment is required under the TSC Act.
Fore Dune Vegetation	Nil	Placement	High	No	All the dunal vegetation that will be flattened e.g. Spinifex, Coastal Banksia. Depending on the height of the placement area at the very least the Spinifex and shrub veg will be destroyeded/smothered. The foredune will be rehabilitated with fencing and vegetation in accordance with Councils dune

Species	Threatened species status	Area of impact	Predicted level of impact	Significance assessment required	Comment
					management plan for the area.
Pipis (*Donax deltoids*)	Nil	Borrow	Medium to high	No	Pipis are an important link in coastal food chains. They filter feed by extracting phytoplankton from the water, and in turn, are eaten by shorebirds, fish, crabs, snails, stingrays and humans. Pipis live a few centimetres below the surface in the intertidal and shallow sub-tidal sediments. Henry (1999) showed that pipi numbers were significantly affected by beach scraping in the Wooli Beach area, but did not consider whether this was due to increased foot traffic in the scraped areas. No significance assessment required.
Crustacea	Nil	Borrow and Placement	Medium	No	A large group of arthropods with the genus *Ocypode* including *Ocypode cordimana* (ghost crabs) common on the shores of temperate Australia. Henry 1999, found that vertical distribution of the ghost crabs was similar for scraped and un-scraped sands. This indicates that ghost crabs may be capable of rapid colonisation or are able to burrow out from under sand if buried. Overall density, however, was significantly less in scraped beaches (Henry, 1999). No significance assessment required.
Polychaeta	Nil	Borrow	Low to medium	No	Group of worms that inhabit intertidal to sub-tidal sands. Henry 1999, found that vertical density and mean density of *Polychaeta* was generally lower in scraped sands, however, no significant difference was noted (Henry, 1999). No significance assessment required.

The impact of nourishment is proposed to be undertaken at two different sites. The first site is the 'borrow site' where the nourishment material comes from undisturbed sites within the beach littoral zone. The second site is the 'placement site' that receives the borrowed material. Both sites can be impacted indirectly by sediment movement (by water or by wind) (Speybroeck, 2006).

In the short term, resident plant and animals may be inhibited or destroyed by the addition of a thick layer of nourishment sand; however, wind blown sand is a natural process on beach dunes. Changes in the beach habitat after nourishment, such as altered beach profile and sediment movement, will influence the rate of recovery of the ecosystem's natural equilibrium.

Owing to the highly dynamic nature of their environment (mainly determined by waves and tides but also winds), the benthic organisms inhabiting the littoral zone of sandy beaches are limited to species with a high tolerance towards several forms of environmental stress. Therefore, it is considered that nourishment is likely to have temporary short-term impacts, but is unlikely to significantly affect the local ecosystem in the longer term.

Management measures

As a result of potential impacts to some of the species identified in Table 6-1, an assessment of the significance of impacts is recommended to be undertaken in accordance with both the *EPBC Act Policy Statement 1.1 - Threatened species assessment guidelines* and the NSW TSC Act Significance assessments (s5A of the *Environmental Planning and Assessment Act 1979*). These assessments would need to be supported by a one day field reconnaissance of the site to confirm the vegetation and habitat, presence of threatened species and verify the impact footprint.

It is recommended that an inspection be performed by an ecologist prior to works commencing to ensure no threatened or non-threatened fauna are occurring within the areas of South Golden and New Brighton Beaches, which are subject to scraping and beach nourishment.

To reduce the impact on Threatened species, it is recommended that the scraping and beach nourishment on both beaches occur in winter to ensure that threatened species such as the Beach Stone-curlew (*Esacus neglectus*) and Little Tern (*Sterna albifrons*) are not nesting and that potential nest sites for the Green Turtle (*Chelonia mydas*) are identified prior to undertaking the works so as not to be disturbed through compaction or removal as a result of the project.

As suggested by Andrew Page (pers comm. Byron Marine Park Authority Park Manager, 30 November 2009) shallower scraping regimes (i.e. 200 millimetres below natural surface level) for longer distances may reduce potential impacts to food sources that reside within the borrow area. This depth is all that is required for the initial episode at South Golden Beach. For New Brighton, a scraping depth of 200 millimetres would necessitate six initial episodes.

Construction worksites would be rehabilitated progressively. They would be revegetated according to the Byron Shire Council Dune Vegetation Management Plans (soon to be reviewed at the time of writing) to aid in dune re-vegetation for habitat value and to stabilise the renourished dunes from wind blown sand losses.

If the scraping works are undertaken, the contractor should implement weed control measures to prevent spread of weed during construction. This should include cleaning vehicles, equipment and clothes of weed seeds and soil prior to entering or leaving the site.

6.2 Topology and soils

The proposed beach scraping would change the profile of the beach, increasing the height of the existing dunes and the profile of the dune system.

Existing dunes would be renourished by means of extracting unconsolidated sand borrow material from the mid-littoral beach profile above the mean low water spring tide mark and placed up to approximately 1,000 millimetre depth on the existing eroded dune profile.

Management measures

Further detailed investigation is required with respect to restoring the dunes in terms of impacts to existing native vegetation and habitat whilst meeting guidelines in the NSW Coastal Dune Management Manual 1991 and principles in the NSW Coastal Policy.

6.3 Water quality

Due to the nature of the project, there could be potential impacts on water quality through spillages and leaks from machinery. This could lead to a degraded aquatic environment or contamination of the receiving water environment.

Management measures

Prior to construction, all staff would be inducted in the incident emergency procedures and made aware of the location of the emergency aquatic spill kit, which is to be kept on site at all times.

6.4 Traffic, transport and access

There would be minimal local impact on traffic, transport and access associated with the proposed works. With respect to movement of beach scraping machinery one delivery and decommissioning trip to (and from) the beach is proposed via local roads.

The choice of machinery would be made considering local bridge loads. The required width for the largest machine proposed to be used (a Caterpillar D9 or equivalent) is 3.30 metres. This would be transported on a low loader of typical 15 metres length. It is proposed to access the beach at the existing access point off North Head Road at New Brighton and along the beach to South Golden Beach. North Head Road is unsealed, so a tracked vehicle would cause minimal surface damage.

Management measures

As part of beach scraping activities and implementation of the Byron Coastal Zone Management Plan, investigation and assessment of closure and rehabilitation of excess pedestrian beach access would be made. All beach accesses would be raised to be compatible with the surrounding dune system. Rehabilitation would occur as part of Council's dune vegetation management program.

Further detailed environmental assessment is required to assess the access point off North Head Road, including potential vegetation clearing and protection and integrity of the dune system.

6.5 Noise and vibration

For the method proposed, likely machinery would be a bulldozer, such as a Caterpillar D6 or D9 (or equivalent), or tracked loader (Caterpillar 939, 953, 963 or equivalent). Noise emissions associated with the operation of this equipment would be minimal and short-term in duration. Vibration emissions during the construction works would be minimal.

Management measures

Construction activities would be undertaken in accordance with AS 2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*. All equipment used on site would be required to demonstrate compliance with the noise levels recommended within AS 2436-1981. Limitation of compaction and vibration to the littoral and dune zones through selective track material for machinery at each work site would be implemented.

6.6 Air quality

Emissions from the plant and equipment would be associated with the use of diesel fuel and petroleum. Given the scale of proposed works, the emissions from the construction plant and equipment are unlikely to result in substantial impacts on the amenity of residential receptors.

Management measures

Residents potentially affected by the project would be consulted prior to commencement of works to advise of the nature and duration of the works. Contact details would be provided to those potentially affected so that information could be received, and complaints could be logged, maintained and addressed.

6.7 Waste and hazardous materials management

The likely effects from waste or hazardous materials from the project would be minimal due to limited operation of only a single earth moving dozer operating on the two beach sites for up to six weeks. The likely waste generated would be construction worker waste or waste material generated by obtaining access to the site and rehabilitation of the site. No materials are expected to trigger State Environmental Planning Policy No. 33 Hazardous or Offensive Development to impose conditions to reduce or minimise any adverse impact.

The project has limited potential to generate waste as the activity would be limited to movement of sand.

Management measures

The principles of waste management: minimise the amount of waste generated; recycle waste wherever possible; and dispose of the remainder in a responsible manner, would be followed where possible.

All wastes would be separated at the source and stored at the temporary construction depot, where necessary, until reuse or disposal options are arranged.

Specific sources, contamination levels and volumes of waste and fuel/chemicals to be stored would be confirmed prior to construction to determine the need for management and licensing under the Protection of the Environment Operations (Waste) Regulations 2005.

6.8 Visual

The proposed beach scraping activities would change the appearance of the beaches and the dune system.

For the initial scraping episode, for a short duration (six weeks) machinery would be operating on New Brighton (four weeks) then South Golden Beach (two weeks) and would cause temporary visual impact for each scraping event. Similar duration episodes at intervals of the order of 5 years would be required to offset the effects of sea level rise over the next 50 years. Lesser duration scraping episodes would be required to restore or maintain beach accesses.

Management measures

Construction worksites would be rehabilitated progressively. They would be revegetated according to the Byron Shire Council Dune Vegetation Management Plans (soon to be reviewed at the time of writing) to aid in ameliorating the visual impact and stabilise the renourished dunes at a local visual catchment scale.

6.9 Heritage

It is anticipated that no impacts on any listed heritage sites would occur due to the distance to the proposed works, refer to Figure 2-1.

Management measures

Further heritage assessment and ongoing consultation with registered Aboriginal groups is recommended in accordance with the Department of Environment and Climate Change's Part 6 Approval – Interim Community Consultation Requirements for Applicants.

6.10 Cultural values

Beach scraping would lead to disruption to local residents and local car parking amenity due to the loading and unloading of the bulldozer machinery and other ancillary equipment.

The expected traffic movements are one to two plant unloading movements for establishment over each scraping episode and one to two loadings at the conclusion of each scraping episode. A fuel tanker delivery and refuelling (approximately 1,000 litres) would need to be undertaken approximately every two to three days of scraping. The expected disruption to the residents and locals who use the access point would be minor.

Management measures

Traffic movements and loadings of plant would be limited to minimise impact to local residents. Residents would be given sufficient notice when loadings and scraping episodes are likely to take place.

7. Conclusion

Beach scraping is almost certain to bring about, as a minimum, short-term changes in the beach ecosystem. Whilst it is difficult to confirm the direct or indirect effects because of previous beach scraping in the area, and disruption due to recreation, large storm surges, and the onset of sea level rise; local natural values have already been affected. Furthermore, beach scraping has the potential to have a less significant impact on the previously disturbed South Golden and New Brighton Beaches than on previously undisturbed beaches.

Considering the following factors; proposed season (winter) to undertake the scraping, the limited extent of the scraping in relation to identified threatened species (refer to Table 6-1) compared to the regional beach environment, and the ability of the species to recolonise after storm events, this PEIA concludes that the project is likely to have temporary impacts, but is unlikely to significantly affect the local environment. However, further detailed investigation is recommended to test if beach scraping 'significantly affects the environment' and whether the project is likely to significantly impact any 'matters of national environmental significance' under the EPBC Act or any TSC Act listed species.

Furthermore, it is recommended the approval pathway be confirmed with the Department of Planning to determine whether beach scraping is defined as an extractive industry thus triggering a determination under Part 3A of the NSW EP&A Act.

While the environmental impacts cannot be comprehensively determined, the renourishing of the dune system to protect public and private infrastructure (in particular housing) would be a key benefit of the project. PB recommends Council undertake further assessment associated with construction and maintenance to ensure that the long-term project benefits outweigh the short-term project impacts.

8. Recommendations

Before beach scraping may commence, various actions must be performed. The actions required by Council and the desired outcomes from those actions are summarised in Table 8-1.

Table 8-1 Actions required by Council

Actions required	Desired outcomes
Legislative and regulatory	
Council must undertake an application to determine if the project would be assessed under Part 3A of the EP&A Act, or seek further legal advice to ascertain whether the project is considered a Part 3A project under the Major Projects SEPP.	Determine appropriate legislative and regulatory pathways for approval.
Biodiversity	
Council to undertake significance assessments under the TSC Act for the following species: ▪ *Allocasuarina defungens* (Dwarf Heath Casuarina) ▪ Great Knot (*Calidris tenuirostris*) ▪ Beach Stone-curlew (*Esacus neglectus*) ▪ Pied oystercatcher (*Haematopus longirostris*) ▪ Little Tern (*Sterna albifrons*) ▪ Green Turtle (*Chelonia mydas*)	Assessments under the TSC Act are prepared to determine the impact of beach scraping on species listed as threatened in NSW.
Council to undertake significance assessments under the EPBC Act for the following species: ▪ *Allocasuarina defungens* (Dwarf Heath Casuarina) ▪ Great Knot (*Calidris tenuirostris*) ▪ Little Tern (Sterna albifrons) ▪ Green Turtle (Chelonia mydas)	Assessments under the EPBC Act are prepared to determine the impact of beach scraping on species listed as threatened by the Commonwealth Government.
Council should ensure that scraping and beach nourishment on both beaches, if undertaken, occurs in winter.	Ensure that threatened species such as the Beach Stone-curlew (*Esacus neglectus*) and Little Tern (*Sterna albifrons*) are not nesting and that potential nest sites for the Green Turtle (*Chelonia mydas*) are not disturbed through compaction or removal as a result of the project.
Council should aim to use shallower scraping depths (200 mm), which will necessitate additional scraping episodes at New Brighton.	Reduce potential impacts to organisms that reside within the borrow area. Shallow scraping would provide sufficient sand for initial scraping at South Golden Beach.
Aboriginal heritage	
Council should undertake further consultation with the local Aboriginal groups.	Identify the presence of sites of special Aboriginal cultural value and to identify any contemporary Aboriginal issues relating to cultural heritage sites.
Community	
Council should undertake further consultation with community members.	Diverging views of the local community on the process and operation of the beach scraping must be considered.

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APPENDIX B
BIOLOGICAL MONITORING PROGRAM

BEACH SCRAPING PROPOSAL AT NEW BRIGHTON AND SOUTH GOLDEN BEACH, BYRON SHIRE, NSW

SAMPLING PROGRAMME TO ASSESS SCRAPING IMPACTS ON ASSEMBLAGES OF BEACH MACRO-FAUNA

Prepared for Byron Shire Council

By

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July 2009

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INTRODUCTION

There has been considerable research in recent years into improving sampling designs and analyses to measure the effects of environmental impacts, taking into account the large spatial and temporal variability that occurs naturally in undisturbed habitats (Clarke, 1993; Mapstone, 1995; Underwood, 1991; 1992; 1993; 1994). The detection of impacts needs to be measured as an interaction between spatial and temporal components of variation against a highly variable background (Underwood, 1992; 1993). The experimental designs and logic required to quantify these types of disturbances have been discussed in great detail in the marine ecological literature (Stewart-Oaten et al., 1986; 1992; Underwood, 1991; 1992; 1994; Underwood et al., 2003).

A scientifically rigorous environmental monitoring programme is required to assess the potential impact of beach scraping on beach macro-faunal assemblages at New Brighton and Southern Golden Beach, Byron Bay. Beach scraping is defined as the movement of sand from the lower part of the littoral beach system to the dunes using mechanical means. Beach scraping is usually done to accelerate lower beach accretion and reduce the erosion of sand dunes.

As a minimum, the temporal components require that sampling be done at least two times before and two times after scraping. The general hypothesis being tested is that any measurable differences in beach macro-fauna from before to after scraping will be similar to those changes shown in independent reference locations.

As part of this programme the following tasks would be required:

- Conduct a review of relevant literature relating to the scope of the project and incorporate relevant findings into the investigation as appropriate.
- Undertake field assessments to quantify the beach macro-fauna at appropriate spatial and temporal scales, before and after beach scraping.
- Undertake statistical analyses of all data and prepare a report on the ecological impacts associated with beach scraping on macro-faunal assemblages.

METHODS

Field surveys would be required to identify and assess the beach macro-faunal assemblages within each of two treatments (beach scraped) and two reference (beach not scraped) locations. This would be done at least two times before and two times after beach scraping. All collections of beach macro-fauna would need to be done in accordance with Section 37, of the NSW Fisheries Management Act 1994, using a current Scientific Collection Permit.

Collection of Samples

At each of two randomly nested sites within each of the 4 treatment locations, five replicate core samples would be collected using a 10cm benthic corer. This would result in 40 samples collected per sampling event, with a total of 160 samples collected during the entire project. The beach sediment samples would be washed through a 0.5 mm mesh sieve, fixed with 7% buffered formalin/seawater (v/v) and placed into pre-labelled plastic bags. In the laboratory, each sample would be rinsed to remove the formalin before sorting under a binocular microscope. All organisms would be counted and identified to family level where possible using a stereomicroscope. Specimens would be stored in 70% alcohol solution and a voucher collection prepared for the study.

Data Analyses

Both univariate (ANOVA) and multivariate (e.g. PRIMER) statistical routines would be used to analyse the data. Prior to analysis of variance, the data sets would be examined for homogeneity of variances using an appropriate test, eg. Cochran's test, and if necessary, transformations would be done to stabilise the variances (Underwood, 1981). Finally, "impacts" may alter variances, rather than mean measures. Variability of univariate measures can be identified in "Beyond BACI" designs using 2-tailed F-ratios (Underwood et al., 2003). Variability in assemblages can also be measured using Bray-Curtis measures of dissimilarity, calculated between pairs of replicates with no replacement. These dissimilarities are then independent univariate measures, which can be used in analyses of variance (Underwood et al., 2003). Multivariate statistical techniques would also be used to examine patterns in assemblages using an appropriate software package.

Multivariate methods such as PRIMER (Clarke, 1993) allow comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance. Non-metric multidimensional scaling (nMDS) ordinations allow a graphical illustration of relationships between samples. The significance of any apparent differences among sites can be determined using ANOSIM (analysis of similarities) or PERMANOVA (Anderson, 2001). SIMPER (similarity of percentages) procedures can be used to examine the contribution of taxa to the similarities (or dissimilarities) among sites.

Reporting

A technical report will be required that details the literature review, methods used, statistical analyses, results, interpretation, discussion and recommendations in relation to the scope of the works.

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